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Proceedings of the Regional Peer Review of the Assessment of Northern and Striped Shrimp

April 6-8, 2016
St. John's, NL

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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

A Regional Peer Review Process for Northern Shrimp (*Pandalus borealis*) in Shrimp Fishing Areas (SFAs) 4 to 6 and Striped Shrimp (*Pandalus montagui*) in SFA 4 was held April 6-8, 2016 in St. John's, Newfoundland and Labrador (NL). This Regional Peer Review Process was requested following the February 2016 Stock Status Update of Northern and Striped Shrimp in SFAs 4, 5 and 6 which reported declines in key indices of the Precautionary Approach (PA) Framework for Northern Shrimp for SFAs 4 and 6 in 2015. The purpose of the April 2016 peer-review process was to assess the status of the Northern Shrimp resource in SFAs 4 to 6 (NAFO Divisions 2G to 3K), as well as Striped Shrimp in SFA 4.

Participation included Fisheries and Oceans Canada (DFO) Science and Fisheries Management Branches (Newfoundland and Labrador, Central and Arctic, Quebec, National Headquarters, and Maritimes Regions), the fishing industry, the Provincial Department of Fisheries and Aquaculture, academia, and Aboriginal communities and organizations.

This Proceedings includes summaries of meeting discussions, as well as a list of research recommendations. The advice resulting from the meeting is published in the Science Advisory Report series.

Compte rendu de la réunion d’examen régional par les pairs sur l’Évaluation de la crevette nordique et de la crevette ésope

SOMMAIRE

Une réunion du processus d'examen régional par les pairs sur la crevette nordique (*Pandalus borealis*) dans les zones de pêche de la crevette (ZPC) 4 à 6 et la crevette ésope (*Pandalus montagui*) dans la ZPC 4 s'est tenue du 6 au 8 avril 2016 à St. John's (Terre-Neuve-et-Labrador). Ce processus d'examen régional par les pairs a été demandé à la suite de la mise à jour de l'état du stock de crevette nordique et de crevette ésope dans les ZPC 4, 5 et 6, qui a eu lieu en février 2016; cette mise à jour a signalé un déclin des indices importants du cadre de l'approche de précaution pour la crevette nordique dans les ZPC 4 et 6 en 2015. L'objectif du processus d'examen par les pairs tenu en avril 2016 était d'évaluer l'état des ressources de crevette nordique dans les ZPC 4 à 6 (divisions 2G à 3K de l'Organisation des pêches de l'Atlantique Nord-Ouest [OPANO]) et de crevette ésope dans la ZPC 4.

Parmi les participants figuraient des représentants de la Direction des sciences et de la Direction de la gestion des pêches de Pêches et Océans Canada (MPO) [régions de Terre-Neuve-et-Labrador, du Centre et de l'Arctique, du Québec et des Maritimes], de l'industrie de la pêche, du ministère provincial des Pêches et de l'Aquaculture, du milieu universitaire et des collectivités et organisations autochtones.

Ce compte rendu comprend des sommaires des discussions de la réunion, de même qu'une liste des recommandations relatives à la recherche. L'avis découlant de la réunion est publié dans la série des avis scientifiques.

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INTRODUCTION

A Regional Peer Review Process for Northern Shrimp (*Pandalus borealis*) in Shrimp Fishing Areas (SFAs) 4 to 6 and Striped Shrimp (*Pandalus montagui*) in SFA 4 was held April 6-8, 2016 in St. John's, Newfoundland and Labrador (NL) to assess the status of the Northern Shrimp resource in SFAs 4 to 6 (Northwest Atlantic Fisheries Organization [NAFO] Divisions 2G to 3K), as well as Striped Shrimp in SFA 4. The Terms of Reference, meeting agenda, and list of participants are provided in the Appendices.

Participation included Fisheries and Oceans Canada (DFO) Science and Fisheries Management Branches (NL, Central and Arctic, Québec, National Headquarters, and Maritimes Regions), the fishing industry, the Provincial Department of Fisheries and Aquaculture, academia, and Aboriginal communities and organizations.

This Proceedings includes summaries of meeting discussions. The Science Advisory Report (SAR) from the meeting which summarizes the information and advice resulting from the meeting is posted on the Canadian Science Advice Secretariat's (CSAS) website.

PRESENTATIONS

BIOLOGICAL OCEANOGRAPHY OVERVIEW

G. Maillet, P. Pepin, S. Fraser, G. Doyle, A. Robar, J. Higdon, and S. Lewis, E.

Presenter: G. Maillet

Abstract

In general, large-scale ocean colour imagery over the northwest Atlantic indicates a general reduction in the extent and delay in the timing of the spring bloom in 2015. The overall summary of metrics of the spring bloom over the NL statistical sub-regions generally indicate lower standing stocks of phytoplankton, delayed onset and reduced duration of the spring bloom in 2015. Water-column integrated phytoplankton biomass observed during the 2015 spring survey was consistent with the delayed spring bloom inferred from remote sensing. Upper water column (0-50 m) inventories of silicate and nitrate were near normal over the Newfoundland and Labrador Shelf in 2015, although deep inventories of these macronutrients also increased in 2015 compared to recent years, deep inventories still remain well below the reference period (1999-2010). The observed changes in spring bloom dynamics in recent years has been linked to greater ice extent and delay in timing of ice retreat. Abundance trends in key functional zooplankton indicate continuing decline in abundance of *C. finmarchicus* (important prey to planktivores and early life stages of fish) into 2015 but other functional taxa such as *Pseudocalanus spp.* (also important prey item) showing highest standing stocks observed in the time series. Large positive anomalies have been observed in copepod and non-copepod taxa since 2009 and remain ongoing into 2015. Zooplankton biomass is trending downward in recent years and inventories along standard AZMP sections were at the lowest levels observed in the 17-year time series in 2015. Larval decapod relative abundance has varied with peaks during the mid-1990s and 2010-11 but has declined by ~40% in recent years (2012-14) compared to the reference mean (1991-2010).

Discussion

It was stressed that DFO is looking at stock assessments from an ecosystem approach and therefore oceanographic and environmental information are necessary.

An explanation of the oceanography data collection methods and timing was requested. It was stated that oceanographic and biological parameters are sampled along set lines as part of the Atlantic Zonal Monitoring Program (AZMP). This data collection is conducted during three oceanography surveys that take place within the spring, summer and fall. Data on temperature, salinity, nutrients, oxygen, light, pH, and plankton are collected during these surveys across all regions. Biological and chemical analyses are also conducted on water that is collected and this is compared to the physical oceanography data. This program captures seasonal, annual, and decadal data, and looks at patterns of consistency. Data on salinity, temperature, and depth, and water samples are also collected via CTD and Niskin bottles during multi-species surveys in the spring and fall. These data are collected at all stations as the trawl descends. Data are also collected 40-50 times per year at Station 27. This station, located off Cape Spear, is the most frequently sampled station. Additionally, data from ships of opportunity along shipping routes are used. A question regarding the confidence in the data collection arose and it was explained that these surveys capture the time scales of variation in the ocean environment very well. As the patterns of variation are broad, there is confidence in the annual values computed from the data sets.

A question was raised regarding the potential for primary production nutrient limitation. It was explained that there are primary production data from satellite information; however, this has not been explored. Use of the chlorophyll satellite data to infer primary production was also questioned by one participant. It was explained that the Bedford Institute of Oceanography has developed algorithms based on satellite data to estimate surface productivity. The estimates from satellite data have been compared to isotope data in the NL Region and the results of the comparisons are pretty good. Nevertheless, it is a model estimate and difficult to obtain this information. It was noted that the coverage of productivity information is limited and that chlorophyll information is not a synonym for growth. Additionally, a participant stressed that ice coverage limits the observation of blooms.

PHYSICAL OCEANOGRAPHY OVERVIEW

E. Colbourne, K. Skanes, J. Holden, D. Senciall, W. Bailey, and S. Snook

Presenter: E. Colbourne

Abstract

The North Atlantic Oscillation Index, an indicator of the direction and intensity of the winter wind field patterns over the Northwest Atlantic, remained in a positive phase in 2015, reaching a record high resulting in a strong arctic air outflow in the northwest Atlantic during the winter months and consequently lower than normal winter air temperatures. Sea ice extent increased substantially during winter 2014 with the first positive anomaly (higher-than-normal extent) observed in 16 years and in 2015 the total extent was about normal except for March and April when it was above normal. Annual sea-surface temperatures based on infrared satellite imagery across the NL Shelves ranged from near-normal to below normal in some areas. The annual bottom (176 m) water temperature at the inshore monitoring station (Station 27) was below normal in 2015 by -0.7 standard deviations (SD), a significant decrease from the record high in 2011. The cold-intermediate layer (CIL; volume of <0°C) in both 2014 and 2015 was at its highest level since 1985 on the Grand Bank during the spring. Fall bottom temperatures in 2J, 3K and 3LNO decreased from 2, 2.7, and 1.8 SD above normal in 2011 to 0.2 and 0.8 SD above normal in 2J and 3K and to -0.4 SD below normal in 3LNO in 2015, a significant decrease in the past four years. A standardized climate index derived from 28 meteorological, ice and ocean temperature and salinity time series declined for the 4th consecutive year, reaching the 7th lowest in 66 years and the lowest value since 1993.

Analyses show that >80% of fishable biomass of shrimp during the fall surveys are associated with relatively warm/salty Labrador slope water in a temperature range of 2-4°C. The area of the bottom in this temperature range, referred to as the 'Shrimp Thermal Habitat Index' increased to above normal values during the mid-1990s and have ranged from normal to above normal since then, with the 2015 value about normal in 2J and above normal in 3K. Some indices of shrimp abundance show strong associations with climate variations during the same year and at lags corresponding to early life stages.

Discussion

A figure was presented correlating Catch per Unit of Effort (CPUE) in SFA 6 to thermal habitat. It was noted that this correlation is not statistically significant and that the relationship is not very clear. There is a much clearer relationship between fishable biomass in SFA 6 and composite climate (also presented); however, the drivers for the biomass change are unclear. It was recommended that caution should be used when interpreting the CPUE and thermal habitat figure.

OVERVIEWS OF THE DFO FALL MULTI-SPECIES SURVEY AND THE SHRIMP FISHERY

Presenter: D. Stansbury

Abstract

Analyses were presented based on data from the DFO fall multi-species survey, the Northern Shrimp Research Foundation (NSRF) summer shrimp survey and from both the large and small vessel fishery.

Surveys

- The 2015 Fall Multi-Species Survey was deemed successful in all areas.
- Variability in timing (October-December) and duration spent in each zone may affect comparable catchability (Table 1).
- Wind force and direction is recorded to ensure that this doesn't alter catchability year to year or between sites.

Table 1. Timing and duration of DFO multi-species surveys 2005-15 for various NAFO divisions.

NAFO Division	Survey Year	Start Date	End Date	Duration (Days)
2H	2006	05-Oct	20-Oct	15
2H	2008	04-Oct	18-Oct	14
2H	2010	07-Oct	23-Oct	16
2H	2011	12-Oct	27-Oct	15
2H	2012	07-Oct	26-Oct	19
2H	2013	07-Oct	25-Oct	18
2H	2014	06-Oct	13-Oct	7
2H	2015	18-Oct	24-Oct	6
2J	2005	17-Nov	16-Dec	29
2J	2006	20-Oct	14-Nov	25
2J	2007	01-Nov	30-Nov	29
2J	2008	07-Nov	07-Dec	30
2J	2009	05-Nov	23-Nov	18
2J	2010	21-Oct	15-Nov	25
2J	2011	28-Oct	26-Nov	29
2J	2012	14-Oct	24-Nov	41
2J	2013	25-Oct	18-Nov	24
2J	2014	18-Oct	14-Nov	27
2J	2015	08-Oct	14-Nov	37
3K	2005	24-Nov	28-Jan	65
3K	2006	06-Nov	21-Dec	45
3K	2007	22-Nov	16-Dec	24
3K	2008	11-Nov	21-Dec	40
3K	2009	18-Nov	13-Dec	25
3K	2010	15-Nov	17-Dec	32
3K	2011	11-Nov	19-Dec	38
3K	2012	12-Nov	20-Dec	38
3K	2013	10-Nov	18-Dec	38
3K	2014	08-Nov	06-Dec	28
3K	2015	13-Nov	13-Dec	30

Fishery

An analysis of fishery data was presented for both the large vessel and small vessel shrimp fishing fleets, by SFA. Large vessel commercial data is mainly based upon observer data while small vessel data is based on logbooks. Visual representation of catch (kg) and effort (hours fished) were provided; a demonstration of outliers within the data provided to DFO Science. Maps of research survey locations vs. fishing locations were also presented, along with seasonality and spatial changes in CPUE for each fleet's fishery.

Discussion

Figures of cod catches in relation to shrimp catches were presented and there was discussion pertaining to the interpretation of these figures. It was explained that the figure examines the possible displacement of shrimp by cod; however, it concludes that even with high cod catches, the RV survey is still getting some high shrimp catches. There does not appear to be a relationship between shrimp and cod catches.

A participant noted that more capelin has been observed in SFA 6 shrimp sets than in the past. They also stated that more capelin than shrimp has been observed in cod stomachs.

NEWFOUNDLAND AND LABRADOR ECOSYSTEM ANALYSES

Mariano Koen-Alonso, Pierre Pepin, Nadine Wells, Geoff T. Evans, Jennifer Mercer, and Denise Holloway

Presenter: M. Koen-Alonso

Abstract

Northern Shrimp has become an important forage species in the NL Bioregion (2GHJ3KLNOP), and in order to understand its dynamics, it is key to understand the structure and dynamics of the ecosystem where it is embedded. Functionally, this bioregion can be described in terms of four major Ecosystem Production Units (EPUs): Labrador Shelf (2GH), Newfoundland Shelf (2J3K), Grand Bank (3LNO), and Southern Newfoundland (3Ps). SFA 6 mostly corresponds to the Newfoundland Shelf EPU, while SFA 7 corresponds to the Grand Bank EPU. These EPUs are not isolated, and the northern Grand Bank (3L) represents a transition zone. Still, these EPUs describe major ecosystem functional units from a production perspective. In this context, analyses have been focused on these EPUs, but also integrated whenever possible to the 2J3KL area. Shrimp in 2J3KL (~SFA 6 and 7) would not constitute independent stocks; there is sufficient connectivity among components so that impacts in some sub-areas would be expected to have measurable effects outside them.

Ecosystem Production Potential (EPP) models are simple food web models which are driven by independent estimates of primary production (e.g. satellite derived primary production) and allow estimating the potential productivity of large aggregates of species at different trophic levels. These models are not dynamic, and provide an estimate of the potential productivity of the system under ideal conditions (i.e. fully functional and healthy ecosystem). EPP models for the 2J3K and 3LNO EPUs were used to define guideline values for Total Catch Ceilings (TCCs) in these areas. These TCCs are candidate Limit Reference Points (LRPs) for total catches, and were estimated on the basis of the Fisheries Production Potential (FPP) of the ecosystem derived from the EPP models in combination with estimates of the current productivity state of these systems. TCCs are calculated for two major aggregates of species: Standard Demersal Components (SDC) and Other Components (OC). The SDC aggregate includes all groundfishes and commercial shellfish like Northern Shrimp and snow crab. The estimated TCCs for 2J3K and 3LNO for SDC indicate that these EPUs are near full exploitation, but total catches have been above TCC levels in recent years (2000-10). This suggests some degree of ecosystem level overfishing has been occurring, especially in 2J3K.

In terms of trends in the fish community in the 2J3K and 3LNO EPUs, the ecosystem changes observed in the 1990s involved the collapse of the groundfish community, not just cod, and the increase in shellfish. The collapse period also involved a decline in fish size. Consistent signals of rebuilding of the groundfish community appeared in the mid-late 2000s.These signals are also associated with an increase in fish size. Changes in the fish community show a coherent internal structure: small fish and shellfish vs forage and large fishes. In the 2010s the overall biomass has shown a moderate decreasing signal linked to a reduction in shellfish; the dominance of groundfishes has increased, and shellfish decreased. The overall biomass of the groundfish community has been stable in the 2010s; recent increases in cod imply a higher dominance within groundfishes, mostly at the expense of plankpiscivores (redfish). This increase in cod without additional buildup of overall fish biomass suggest that the general groundfish rebuilding trends observed in the mid-late 2000s have slowed down or stalled in recent years. This slowdown in groundfish rebuilding appears associated with the lack of further rebuilding in capelin. Capelin biomass showed important increases in the mid-late 2000s in relation to the extreme low level observed in the 1990s, after a major collapse of the stock in the

early 1990s. Although in recent years capelin has remained at higher levels in comparison with the 1990s, it still remains well below its pre-collapse level.

The improvements in capelin levels, and the associated rebuilding of the groundfish community, have had important impacts on Northern Shrimp predation mortality. Total annual food consumption by the fish community was delineated using a suite of models based on estimating food requirements and/or average consumption rates for different taxa. These approaches were chosen based on generality, ease of application, and low data demands, so that they could be applicable to all (or most) species in the RV survey. They were not fine-tuned for specific species and/or conditions. This analysis was intended to produce an envelope for the order of magnitude of food consumption by the entire fish community. Key assumptions/limitations of this analysis include:

a) consumers actually met their expected annual requirements;

b) the estimated RV biomass was a reasonable approximation to the actual biomass (i.e. no correction for catchability was made, which implies that estimations of consumption by pelagic species like capelin would be underestimated); and

c) temperature dependence of consumption rates was not included.

In NAFO Divs. 2J3KL, consumption of food by those fish functional groups that can be considered predators of shrimp (medium and large benthivores, piscivores, and plank-piscivores) has increased significantly since the mid-1990s. This total consumption reached its lowest level in the early 2000s. Current estimates are coarsely three times higher than in the early 2000s. Since 1995, consumption of shrimp and capelin has been between 30-50% of the total food consumption by predators. Total food consumption by predators has been relatively stable since 2011. However, predation on shrimp showed an increasing trend until 2011, and has decreased since. This decrease is associated with an increase in capelin consumption. This translates into predation mortality for shrimp increasing rapidly in 2008-11, and decreasing afterwards. Still, current predation rate on shrimp is around double of the level estimated for the mid-1990s and early 2000s.

Following up on earlier studies, changes in shrimp productivity in 2J3KL were investigated in terms of potential driving factors. Shrimp productivity was characterized on the basis of the per-capita production rate (P) estimated from the shrimp RV Fall survey total biomass index (B) and nominal annual shrimp catches (C_t) as $P_t=(B_t+C_t-B_{t-1})/ B_{t-1}$. The candidate factors considered as potential drivers of shrimp production were shrimp stock size, fishing, environment, and predation. Analyses involved non-parametric correlations (Spearman correlation coefficient *Rho*) between per capita shrimp production rate (P) and candidate drivers considering different time lags (impact on rates is mediated by prior changes in population state). Lags 1-5 were examined. Direct effects on the standing stock should manifest with short lags (e.g. 1-2 years), while effects on recruitment should manifest themselves with longer lags (e.g. 3-4 years).

Results indicate that shrimp per capita production has significantly declined since the mid -1990s (p-value <0.05 with both, a t-test comparing 1996-2008 vs 2009-15, and Spearman correlation between P and time). Multiple drivers were detected as having significant lagged correlations with shrimp per capita production. Fishing has detectable indirect impacts on shrimp production with lags of 2-4 years. Predation has impacts on shrimp production with lags 1-3. Environmental forcing is also a significant driver of shrimp production, and this effect appears to be strongly linked to the timing of the phytoplankton bloom. For most drivers, a lag of 3 years is the most significant. Based on this observation, some drivers suggest improving conditions in the coming years, while others suggest a continuation of current conditions.

As an initial attempt of putting all the pieces together a preliminary “Back of the Envelope” (BOE) model was put together to describe the impacts on fishing predation and environmental drivers on Northern Shrimp dynamics in 2J3KL. The model describes the biomass dynamics of shrimp as follows:

$$B_{t+1}=B_t + f_r\left(1 + f_e x_{env(t-3)}\right) r_0 B_t \left(1 - {}^{B_t}/_{K}\right) - f_Q x_{Q(t)} - C_t$$

where:

$x_{env(t-3)}$: normalized negative composite environmental index (upper limit of f_e is set as $\left|1/min\left(x_{env(t-3)}\right)\right|$. This effect is lagged 3 years based on the results of the per capita production correlation analyses.

r_0: P/B ratio (1.7)

K: shrimp carrying capacity (upper limit 5 million tonnes).

$x_{Q(t)}$: predation effect; uses RV Biomass of predators for 1981-94, and the estimated shrimp consumption for 1995-2015 (f_Q is estimated as two parameters, one per each data series).

C_t: Catch

f_r ,f_e and f_Q: estimated scaling coefficients for the intrinsic growth rate (P/B), the effect of the environment on growth, and predation

Parameter estimation was made by minimizing $SS = \sum_t \left(ln(B_{model}) - ln(B_{obs})\right)^2$.

This BOE model provides a reasonable fit to the data, and the three key drivers considered (environment, predation, and fishing) have measurable impacts on the shrimp dynamics. The regulatory effect of predation appears stronger than fishing, and the increase of shrimp appears strongly linked to favorable environmental conditions, in addition to reduced predation.

This model was used to explore different exploitation scenarios by using stochastic simulations. The composite environmental index is lagged 3 years, so the first three simulated years used actual values and the following ones were simulated as an auto-correlated process with uniform variability mimicking the observed ranges. Predation was simulated as an auto-correlated process with uniform variability mimicking the observed fractions of increase/decrease between consecutive years. Catch was setup as a series of scenarios, from status quo to no fishing. The results from these exploratory stochastic simulations suggest that even without fishing, shrimp would not be expected to increase in the short term. Medium term prospects are conditional to catch levels.

Discussion

There was discussion regarding whether the ecosystem models presented could be used during the assessment. There was concern from participants that they had not seen the technical documents relating to the models. It was suggested that the models should go through a peer-review process before being adopted. It was noted that the ecosystem production model used has been peer-reviewed and that the consumption model has been used within other DFO assessments. Therefore, only the Back of the Envelope (BOE) model requires peer-review. It was explained that the ecosystem model (BOE model) integrates previous models and follows an ecosystems approach. It was clarified for participants that the results from the BOE model would not be used during the assessment as it is currently only an exploratory model and is not in a predictive state yet. The model looks at associations and relationships between metrics to

determine trends and patterns. This shows what is occurring in the environment and what the consequences may be.

There was concern that a lot of the inputs, particularly the environmental and biological data, were only collected in NAFO Div. 2J3KL or from RV surveys. It was explained that the environmental data presented was peer-reviewed by DFO scientists across the Atlantic regions. It was also explained that an annual survey is an adequate tool for standing stock biomass information. The largest bottleneck for ecosystem analyses is obtaining details on the ecological mechanisms that link the variables. Additional sampling will need to be designed based on an understanding of the mechanisms involved and therefore the timing of the annual survey should be reviewed. The predation estimates could possibly benefit from more seasonal sampling, however, fall is the best time of year to be sampling and RV surveys are already conducted in the fall. It was further explained that there have been some comparisons performed between spring and fall data and that the comparisons indicated similar patterns.

ASSESSMENT OF SFA 6 NORTHERN SHRIMP

Presenters: D. Stansbury and K. Skanes

Abstract

A presentation was given on SFA 6 Northern Shrimp and was based on analysis of research survey and commercial data. The items presented included: total allowable catch, commercial catch to date, maps of fishery catch and effort, fishable biomass and abundance indices, female spawning stock biomass and abundance indices, abundance indices at shrimp carapace length and updates to the PA Framework.

- Commercial catch has been about 50,000 t over the past two years. It is expected that the 2015/16 TAC of 48,196 t will be taken.
- Large and small-vessel standardized CPUE have varied without trend since 2010 around the long-term mean.
- Fishable biomass index declined from 785,000 t in 2006 to 138,000 t in 2015 which is the lowest in the time series. There was a 41% decline between 2014 and 2015.
- Female spawning stock biomass (SSB) index declined from 466,000 t in 2006 to 89,000 t in 2015 which is the lowest in the time series. There was a 35% decline between 2014 and 2015.
- The exploitation rate index ranged between 5.5% and 21.4% from 1997 to 2015/16, and has averaged 18.3% in the last five years. The 2015/16 exploitation rate index will be 20.7% if the TAC is taken.
- The female SSB index is currently close to the LRP, in the Cautious Zone of the Integrated Fisheries Management Plan (IFMP) PA Framework, with a 20% probability that it is in the Critical Zone. If the 48,196 t TAC is maintained and taken in the 2016/17 season, the exploitation rate index will be 34.9%.

Discussion

It was noted that there were two differences between the current and previous shrimp assessments:

1. Instead of using estimated catches from logbooks, the dockside monitoring program data was used in the current stock assessment; and

2. Bycatch data were excluded during the current assessment as this affects the percentage of the catch used by the model.

Information was presented on the inshore fleet in SFA 6 and the logbook program used for data collection. There was discussion of the distribution of the fleet over time and how the area fished appears to be decreasing. A participant noted that the spatial distribution of fishing effort was larger in the earlier years of the time series presented. This was thought to be due to fishers having higher quotas and fishing occurring in more areas to allow for quotas to be filled.

There was information presented regarding the offshore fleet in SFA 6 and the large vessel observer program used for data collection. One participant questioned the low coverage of the observers. Due to a change in data providers, there is now more than one company providing observer service and therefore there is a lack of consistency. This has resulted in many logistical issues and problems with data quality. It was suggested that logbooks could be used for data collection in the offshore fleet (i.e. as is used in the inshore fleet). There was also discussion regarding the suggestion that the offshore fishery has truncated to the St. Anthony Basin. It was explained by a participant that the fishery is not necessarily contracting to the St. Anthony Basin; instead the area that is being called the St. Anthony Basin has changed. In the early1990s, a smaller portion of the St. Anthony Basin was fished (Stratum 617); not the area that is now known as St. Anthony Basin (north St. Anthony Basin to Funk Island Deep). The fishery today is covering substantially more area in the St. Anthony Basin than was covered in the past. A participant also commented that they do not think shrimp are moving from SFA 5 to SFA 6 because in SFA 5 there is a mix of Northern and Striped Shrimp, but there is just Northern Shrimp in SFA 6.

There was discussion among participants regarding unusual catch rates in 2015/2016. Some participants stated that fishers were experiencing their best catch rates near the beginning of August; however, catch rates flattened quickly by the end of August. One participant suggested that bottom temperatures could be affecting catch rates. It was stated that offshore catch rates appeared to be high at the start of the season, low by October and November, and then bounce back during January. There was concern among multiple participants that the SFA 6 RV survey was conducted during a period with low catch rates. It was explained that since the RV survey occurs each fall it detects trends over time. Furthermore, annual fall RV survey data catch rates have been consistently low for most years. It was stated that it is not possible to change the timing of the RV survey as it is part of a long time-series. There was also some discussion as to whether vertical and lateral movement (migrations) present an obstacle to data collection from the RV survey. As the RV survey covers the entirety of SFA 6 and is conducted annually, it was concluded that even with these movements the shrimp would be caught in the trawls. As DFO surveys operate 24-hours per day, the effects of diel vertical movements should not be an issue. A participant commented that shrimp may have moved into the water column due to other species and are not being caught in the trawl; however, a figure from the presentation on the multi-species survey showed that there was no correlation between cod and shrimp in the catch and therefore it is unlikely that shrimp had moved up the water column due to other species. It was suggested that DFO find a way of using industry observations on catch in the assessments.

One participant questioned the number of observations that were entered into the general linear model for SFA 6 as they seemed much lower than the collected observations. It was discovered that the analysis used summed numbers and the participant was looking at total numbers.

Concern over the use of CPUE was also raised, as the trends in CPUE did not seem to match catch rates. It was suggested that the change in CPUE could be examined in more specific locations. As opposed to a matrix presenting the CPUE for each year via stratum, it was suggested to look at each stratum throughout the year. A participant believed that by doing this,

it may show similar trends to the RV survey. Another participant noted that CPUE is not the best measure for stock status, and that it is a better measure of fisher behaviour.

One participant raised the question of whether it is possible that there are local depletions due to fishing pressure. Another participant disagreed with the idea of local depletions in SFA 6.

SCIENCE ADVISORY REPORT (SAR) BULLETS FOR SFA 6

A question was raised regarding whether further work had been done on the PA Framework. One participant noted that in the future it may be appropriate to re-evaluate the PA reference points.

ASSESSMENT OF SFA 5 NORTHERN SHRIMP

Presenters: D. Stansbury and K. Skanes

Abstract

A presentation was given on SFA 5 Northern Shrimp and was based on analysis of research survey and commercial data. The items presented included: total allowable catch, commercial catch to date, maps of fishery catch and effort, fishable biomass and abundance indices, female spawning stock biomass and abundance indices, abundance indices at shrimp carapace length and updates to the PA Framework.

- Commercial catch has been about 23,000 t over the past five years. It is expected that the 2015/16 TAC of 23,300 t will be taken.
- Standardized large-vessel CPUE over the last four years has been stable at high levels.
- Fishable biomass index has been relatively stable since 2010, and was 148,000 t in 2015.
- Female SSB index has changed little since 2010, and was 83,000 t in 2015.
- The exploitation rate index has varied without trend around 15% from 1997-2015/16.
- Female SSB index is in the Healthy Zone within the IFMP PA Framework. If the 23,300 t TAC is maintained and taken in 2016/17, then the exploitation rate index will be 16%.

Discussion

One participant noted that there was no peak in the length frequency figures around 8 mm which was seen in SFA 6 figures. It was explained that fewer small shrimp are seen as you move farther north. The reasons for this difference are unknown.

There was discussion regarding the unusual survey results for 2013. Participants were surprised that the population appeared to decrease by approximately 50% and then increase again during the following year. It was suggested that this might be a year effect. However, it was noted that this trend was also reported in the diet data, which suggests effects in addition to year effects.

SCIENCE ADVISORY REPORT BULLETS FOR SFA 5

There was discussion over the inclusion of a proposed bullet that climate-driven changes and increases in predation suggest low recruitment to fishable biomass. A bullet on the topic was included for SFA 6, but participants felt it should not be included for SFA 5 due to lacking ecosystem and predation data. While there are phytoplankton bloom data that shows the same

results as SFA 6, it was decided that this information would be captured in the body of the SAR rather than in a bullet.

OVERVIEW OF THE NORTHERN SHRIMP RESEARCH FOUNDATION SURVEY

Presenter: D. Stansbury

Abstract

The survey in SFA 4 was conducted by the *Cape Ballard* from 2005 to 2011. Beginning in 2012, the *Aqviq* was used. The vessel changed again subsequent years; in 2014 the *Kinguk* was used and in 2015 the *Katsheshuk II* was used. Because vessel specifications were similar and there was no change in the survey gear or design, it was assumed that any effect of this change in the survey vessel would not be significant. However, no inter-calibration was conducted. The relative catch efficiency is assumed to be consistent because sampling protocol, including tow speed, sampling gear, and fishing time, are consistent across survey vessels. All samples are collected from stratified random survey sites. The mean number of annual sets is 74, with 77 completed in 2015.

Discussion

It was noted that there were different vessels used for the NSRF survey over the time series, and that the vessel which was used in 2015 was a more powerful vessel than those used previously. Science participants did not feel this would affect the results; it only affected the process of standardizing the tow length.

One participant questioned whether the results of the DFO multi-species survey and the NSRF survey are comparable since they are conducted during different seasons. Even though the multi-species survey is conducted in the fall and the NSRF survey is conducted in the summer, the seasonal difference should not affect the results as the surveys are repeated yearly during the same season.

ASSESSMENT OF SFA 4 NORTHERN AND STRIPED SHRIMP

Presenters: D. Stansbury and K. Skanes

Abstract

A presentation was given on SFA 4 Northern and Striped Shrimp and was based on analysis of research survey and commercial data. The items presented included: total allowable catch, commercial catch to date, maps of fishery catch and effort, fishable biomass and abundance indices, female spawning stock biomass and abundance indices, abundance indices at shrimp carapace length and updates to the PA Framework for SFA 4 *Pandalus borealis* only.

- Commercial catch increased from approximately 10,000 t from 2005/06-2011/12 to about 15,000 t in the past three years.
- Large-vessel standardized CPUE fluctuated without trend near the long term mean.
- The fishable biomass index varied without trend from 2005 to 2015 with the 2015 point estimate at 91,000 t, which represents a decrease of 13% from 2014.
- The female SSB index for 2015 was 58,000 t, representing a decrease of 18% from 2014.
- The exploitation rate index reached 16.5% by 2015/16.

- Female SSB index in 2015 was in the Healthy Zone within the IFMP PA Framework with a 40% probability of having been in the Cautious Zone.

The agreed upon summary bullets for SFA 4 Striped Shrimp are:

- Commercial catch of *P. montagui*, taken as bycatch in the *P. borealis* fishery, increased from 280 t in 2008 to 4,700 t in 2012 and declined to 2,135 t in 2015. The bycatch limit of 4,033 t has not been taken in the past three years.
- Fishable biomass index for 2015 was 47,000 t, an increase of 52% from 2014.
- Female SSB is unknown.
- If the bycatch limit had been taken, the exploitation rate would have been 8.6% in 2015/16.

There is no IFMP PA Framework for this resource.

Discussion

There was discussion regarding the use of Ogmap versus STRAP computations. It was noted that the smoothing of Ogmap is more useful than the rigid assumptions of STRAP. However, Ogmap tends to overestimate biomass more than STRAP, which can lead to two different biomasses being presented in the same report. The reason for this discrepancy is that STRAP does not calculate a stratum where it cannot calculate variance (when there is only one set in a stratum). Due to this function of STRAP, computations omitted a large catch set that was the only set in a stratum. After re-running the STRAP computations, it was found that the STRAP results agree with the Ogmap results that there was a decrease in biomass in 2014.

There was some discussion regarding the possibility of a year effect in SFA 4 for 2013; however it was not as pronounced as in SFA 5. This effect was only obvious in the distribution data, not the biomass data. It was suggested that this result could be because the stratum in this area were quite small. It was noted that the unusual results for 2013 in both SFA 4 and 5 were collected by two different vessels at different seasons and therefore the results do not appear to have a consistent year effect. It was explained that if there was a year effect within in the survey data, one would expect species caught to show the same trend (e.g. all species catches decrease), which did not happen for 2013.

One participant questioned the large error bars relative to the means on the fishable biomass figure for SFA 4, and noted that the error bars were much smaller in southern areas. It was explained that this discussion had occurred at pervious assessments and that the size of the error bars were not considerably different in the areas; it is the biomass that is different. It was suggested that this could be because the survey sampling was not evenly distributed across the area, or because there was more riding on each large set which led to less confidence.

One participant suggested targeting Striped Shrimp in shallow waters in the RV survey; however, it was explained that the survey samples all depth strata, therefore the Striped Shrimp in shallower waters should be caught in the survey.

The similarity between the total biomass and total abundance indices figure and the fishable biomass and fishable abundance indices figure was questioned. After re-running the analysis, this issue was corrected.

SCIENCE ADVISORY REPORT BULLETS FOR SFA 4

There was discussion surrounding a bullet for Striped Shrimp female SSB. This bullet stated that female SSB was unknown. Some participants questioned why there were female SSB results for Northern Shrimp in this area but no female SSB results for Striped Shrimp. One

participant explained that due to the effects of high tides in the area, a lot of the spawn could be coming from outside the SFA, and therefore female SSB could not be calculated. As well, one participant suggested that Striped Shrimp are distributed further north (i.e. where this effect is more prominent), while Northern Shrimp have a northern and southern distribution in SFA 4.

It was discovered during plenary that the area used to integrate in Ogmap for SFA 4 was not correct. It was explained that the NAFO Div. 2G area should be used instead of the SFA 4 area because the survey is only conducted in NAFO Div. 2G. When the analysis was re-run, the results were not as extreme.

GENERAL DISCUSSION

There was discussion regarding the goal posts of the PA Framework. It was noted that the goal posts were based on 2005-09 data and were oriingally determined using a previous version of Ogmap. A participant questioned why goal posts from a previous version were being used for results from a newer version of Ogmap. It was agreed that the goal posts should have been adjusted when the new version of Ogmap was used and would now be adjusted to the new version for all SFAs. During a break the figures were updated to include the revised goal posts.

During the peer-review process, it was discovered that not all of the length frequency data from SFA 4 were used in the analyses so some of the data for fishable-sized shimp had been inadvertently omitted from the analyses during the February stock status update. This was because the statistical program stopped reading data once the program read a zero. This resulted in the exclusion of multiple sets from the data set. This issue was resolved and the analyses were revised.

There was discussion regarding the increased variability of shrimp as one moves farther north (SFA 4). It was explained that this is a common pattern and has been seen in other regions. Even though the survey coverage is greater in SFA 4 than the other SFAs, the variability is still higher. It was suggested that the survey design could be reworked to assign more sets to the areas of high variability.

SCIENCE ADVISORY REPORT DISCUSSION

There was discussion regarding the inclusion of information from the ecosystem analysis presentation in the SAR. It was decided that figures illustrating the correlations between shrimp production and environmental drivers, as well as shrimp production over time were important results to accompany the assessment.

Clarification was requested regarding a proposed bullet which stated that data relevant to shrimp in groundfish diets were lacking for SFA 4. It was explained that the data were not lacking; rather the data does not exist because stomachs are not collected from bycatch in the NSRF survey for SFA 4.

There was also discussion surrounding a proposed paragraph in the management considerations section of the SAR regarding the effects of ecosystem changes and climate change on shrimp resources. It was concluded that the paragraph could not be related to fishable biomass. It was decided that a research recommendation should be developed pertaining to whether environmental variables could be used with recruitment studies to produce resource status predictions.

RESEARCH RECOMMENDATIONS

- There is a need to conduct more research to determine whether environmental variables could be used in conjunction with recruitment studies to produce resource status predictions.
- Further work is encouraged on the BOE ecosystem model. A peer-review process will need to validate this model for use within shrimp assessments.
- There is an effect of temperature on shrimp catches which might in principle be due to mortality, change in lateral distribution, or changed availability to the trawl. It would be useful to separate these possible causes.
- A fully integrated population model for Northern Shrimp should be developed.

REFERENCES CITED

DFO. 2016. An assessment of Northern Shrimp (*Pandalus borealis)* in Shrimp Fishing Areas 4-6 and of Striped Shrimp (*Pandalus montagui)* in Shrimp Fishing Area 4 in 2015. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/028.

APPENDIX I: TERMS OF REFERENCE

Assessment of Northern and Striped Shrimp

Regional Peer Review - Newfoundland and Labrador

April 6-8, 2016[1]
St. John's, NL

Chairperson: Ben Davis, Division Manager - Aquatic Resources, Science Branch, NL Region

Context

In the past, the Zonal Peer Review (ZPR) for Northern Shrimp (*Pandalus borealis*) in Shrimp Fishing Areas (SFAs) 2-6 and for Striped Shrimp (*Pandalus montagui*) in SFAs 2-4 occurred biennially, in odd numbered years. In even years, updates on the status of Striped Shrimp and the key indices of the Precautionary Approach (PA) framework for Northern Shrimp in SFAs 2-6 were requested by Fisheries and Oceans Canada (DFO) Resource Management to inform management considerations. The status of Northern and Striped Shrimp was last fully assessed in February, 2015 (DFO 2015). An update was completed in February, 2016 (DFO 2016).

Fisheries Management requested the current Regional Peer Review Process for Northern and Striped Shrimp in SFAs 4-6 as the basis for harvest advice for the 2016/17 fishing season. This full Regional assessment was triggered as a result of declines in Northern Shrimp in SFAs 4 and 6, as concluded during the stock status update meeting (DFO 2016).

Objectives

- Assessment of Northern Shrimp in SFAs 4 to 6 (NAFO Div. 2G to 3K), as well as Striped Shrimp in SFA 4.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document

Participation

- Fisheries and Oceans Canada (DFO) (Science, and Fisheries Management)
- Provincial and Territorial Governments
- Aboriginal communities/organizations
- Academia
- Fishing Industry
- Other invited experts

[1] April 11-12, 2016 will be used to finalize the Science Advisory Report. All attendees are invited to participate. Summary bullets for each stock will be agreed upon in plenary during the April 6-8, 2016 meeting.

References

DFO. 2015. Assessment of Northern Shrimp (*Pandalus borealis*) in Shrimp Fishing Areas 4-6 (NAFO Divisions 2G-3K) and of Striped Shrimp (*Pandalus montagui*) in Shrimp Fishing Area 4 (NAFO Division 2G). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2015/018.

DFO. 2016. Stock Status Update of Northern and Striped Shrimp in SFAs 4, 5 and 6. DFO Can. Sci. Advis. Sec. Sci. Resp. 2016/013.

APPENDIX II: AGENDA

Regional Peer Review – Assessment of Northern and Striped Shrimp

Newfoundland & Labrador Region

Chair: Ben Davis, Division Manager – Aquatic Resources, Science Branch, DFO

April 6-8, 2016

Memorial Room - Northwest Atlantic Fisheries Centre
80 East White Hills Road, St. John's

April 11-12, 2016[2]

April 11 - Memorial Room
April 12 – EB Dunne Boardroom (am) and Memorial Room (pm)

Wednesday - April 6, 2016

Time	Activity	Presenter
9:00	Welcome/Opening	B. Davis (Chair)
-	Presentation: Biological and Physical Oceanography Overview	G. Maillet and E. Colbourne
-	Presentation: Overviews of the 2015 DFO Fall Multi-species Survey and the Shrimp Fishery	D. Stansbury
-	Presentation: Ecosystem Considerations	M. Koen-Alonso
-	Presentation: Assessment of SFA 6 Northern Shrimp	K. Skanes
-	Drafting of Science Advisory Report (SAR) bullets for SFA 6	All

Thursday - April 7, 2016

Time	Activity	Presenter
9:00	Presentation: Assessment of SFA 5 Northern Shrimp	K. Skanes
-	Drafting of SAR bullets for SFA 5	All
-	Presentation: Assessment of SFA 4 Northern and Striped Shrimp	K. Skanes
-	Drafting of SAR bullets for SFA 4	All

[2] April 11-12, 2016 will be used to finalize the Science Advisory Report. All attendees are invited to participate. Summary bullets for each stock will be agreed upon in plenary during the April 6-8, 2016 meeting.

Friday - April 8, 2016

Time	Activity	Presenter
9:00	Discussion	
-	Summary Bullets and SARs	
-	Conclusions	
-	Closing/Next Steps	B. Davis (Chair)

Notes:

- Health breaks will occur at 10:30 a.m. and 3 p.m. on Wednesday, Thursday and Friday. Coffee and tea can be purchased from the cafeteria in the NWAFC.
- Lunch (not provided) will normally occur 12:00-1:00 p.m.
- Agenda remains fluid – breaks to be determined as meeting progresses.
- This agenda may change.

APPENDIX III: LIST OF PARTICIPANTS

Name	Affiliation
Nicolas LeCorre	Academia
Brian Johnson	Academia – Canadian Centre for Fisheries Innovation (Marine Institute)
Bruce Chapman	Canadian Association of Seafood Producers
Catherine Boyd	Clearwater Seafoods
Pierre Pepin	DFO – Science
Kathleen Martin	DFO – CSA Office, C&A Region
Erika Parrill	DFO – CSA Office, NL Region
Dale Richards	DFO – CSA Office, NL Region
Jim Meade	DFO – CSA Office, NL Region
Paul Regular	DFO – Science, NL Region
Annette Rumbolt	DFO – Resource Management, NL Region
Wayne King	DFO – Resource Management, NL Region
Jennifer Buie	DFO – Resource Management, National Capital Region
Kevin Hurley	DFO – Science, C&A Region
Wojciech Walkusz	DFO – Science, C&A Region
Dave Hardie	DFO – Science, Maritimes Region
Tim Siferd	DFO – Science, C&A Region
Eugene Colbourne	DFO – Science, NL Region
Darrell Mullowney	DFO – Science, NL Region
Christina Bourne	DFO – Science, NL Region
Brian Healey	DFO – Science, NL Region
Mariano Koen-Alonso	DFO – Science, NL Region
Elaine Hynick	DFO – Science, NL Region
Darren Sullivan	DFO – Science, NL Region
Elizabeth Coughlan	DFO – Science, NL Region
Don Stansbury	DFO – Science, NL Region
Katherine Skanes	DFO – Science, NL Region
Julia Pantin	DFO – Science, NL Region
Ben Davis	DFO – Science, NL Region
Geoff Evans	DFO – Science, NL Region
Hugo Bourdages	DFO – Science, Quebec Region
Gary Maillet	DFO – Science, NL Region
Keith Sullivan	FFAW
Erin Carruthers	FFAW
Roland Hedderson	FFAW/Unifor
Phil Barnes	Fogo Island Co-op
Ken Budden	Fogo Island Co-op
Tom Dooley	Govt. of NL – Dept. of Fisheries and Aquaculture
Bev Sheppard	Harbour Grace Shrimp Co.
Chad Strugwell	Harvester
Roy Ward	Harvester
Heather Starkes	Harvester
Rendell Genge	Harvester
Robbie Green	Harvester
Mark O'Connor	Makivik Corp.
Mark Hartery	Newfound Resourced Ltd.
Brian McNamana	Newfound Resources Ltd.
Todd Broomfield	Nunatsiavut Government
Todd Russell	NunatuKavut Community Council
Jerry Ward	Qikiqtaaluk Corporation
Edgar Coffey	Quinsea
John Furlong	Seawatch
Keith Watts	Torngat Fish Producers Co-op
Julie Whalen	Torngat Secretariat