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Foreword

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

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SUMMARY

The Regional Peer Review process to assess Iceland Scallop (*Chlamys islandica)* in Northwest Atlantic Fisheries Organization (NAFO) Division 4R and Snow Crab (*Chionoecetes opilio)* in 2HJ3KLNOP4R was held February 19-21, 2019 in St. John's, Newfoundland and Labrador. This Proceedings Report includes abstracts and discussion summaries of all presentations at the meeting.

In addition to these Proceedings, additional publications to be produced from this meeting include a Science Advisory Report and two Research Documents for each of the two species. All publications will be made available online by the Canadian Science Advisory Secretariat (CSAS).

INTRODUCTION

The status of Iceland Scallop in the Northwest Atlantic Fisheries Organization (NAFO) Division 4R was last assessed in 2009. The status of Divisions 2HJ3KLNOP4R Snow Crab was last assessed in 2018. The current assessments were requested by Fisheries Management to provide current information on the status of the resources and to provide the science advice that will be used in the 2019 Snow Crab Management Plan.

The Regional Peer Review process to assess Iceland Scallop (*Chlamys islandica)* in Northwest Atlantic Fisheries Organization (NAFO) Division 4R and Snow Crab (*Chionoecetes opilio)* in 2HJ3KLNOP4R was held February 19-21, 2019 in St. John's, Newfoundland and Labrador. This Proceedings Report includes abstracts and discussion summaries of all presentations at the meeting.

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PRESENTATIONS

DIVISION 4R ICELAND SCALLOP

Presenter: Elizabeth Coughlan

Abstract

The directed fishery for Iceland scallop (*Chlamys islandica*) in the Strait of Belle Isle (Div. 4R) has been prosecuted annually since 1969 with the exception of four years (1975-79). Populations in the Strait of Belle Isle are found on three beds at depths from 30-120 m. They are usually on hard bottom with variable substrate composition consisting largely of sand, gravel, shell fragments and stones. Resource status is evaluated on trends in fishery catch per unit effort (CPUE), biomass and mortality indices. Data are derived from harvesters' logbooks and DFO scallop surveys. Landings have averaged approximately 250 t since 2009 with lower than average landings of 115 t and 127 t in 2017 and 2018. The Total Allowable Catch (TAC) of 1,000 t has not been taken since 2000. CPUE over the last decade has remained stable. The number of active licenses has declined in recent years to the lowest level. Since 2006 more than 90% of the landings have been taken from Bed 3 (southern bed). DFO research surveys from September 2011 and 2018 resulted in minimum dredgeable biomass (MDB) estimates of 4,123 (t, round) and 3,432 (t, round) respectively. For the duration of the survey time series since 1995 the MDB estimates have varied without trend. The natural mortality estimate was 0.26 in 2018 which was the highest in the survey time series.

Discussion

Discussion focused on the impact of fishing predominantly in Bed 3. The presenter indicated Bed 3 is likely close to home for harvesters and may be why it is fished most extensively. The impacts of fishing this bed more than the other two beds has not been specifically examined. It was highlighted that in beds with little fishing there seem to be higher numbers of starfish (higher natural predation). Another participant questioned why the TAC is not taken each year. It was clarified that the amount taken is driven by markets. Scallop is one of the longest standing fisheries and many harvesters may have moved onto other opportunities.

It was asked when the commercial fishery occurs and when the DFO survey is conducted. It was explained that the DFO survey occurs in September while the commercial fishery takes place from May to September or October.

Another participant questioned the change in scallop size (#/500 grams) between the three beds (appear to be increasing in Bed 1, stable in other 2 beds). It was indicated the reasons for this are not clear.

SEISMIC IMPACTS ON SNOW CRAB

Presenter: Corey Morris

Abstract

Abstract not provided.

Discussion

A participant asked if research into the effects of seismic work has been conducted in other areas. The presenter indicated that work has been completed off Cape Breton in the 2000s looking at larvae, caged crab, etc., but the study was plagued with design issues and received criticism. The current study was designed to overcome many of those criticisms.

Discussion took place on the ways crab movement was considered within the study; there was a suite of movement types studied that were not presented. Crab position was measured every few minutes and it was noted that other researchers are currently looking more closely at these movements as well as crab behavior. There are few studies examining natural crab behavior and therefore it is difficult to determine if seismic is having an impact on behavior.

A participant asked if the findings of this study are consistent with results of other studies. It was pointed out that a literature review published as a CSAS Research Document (Moriyasu et al. 2004) found no strong evidence of effects of seismic on invertebrates but the authors advised caution as studies were limited. There has been additional work on invertebrates since then but most studies have not taken place in the offshore environment. The presenter stated that these studies have found similar results.

It was indicated that some participants still have concerns about the impacts of seismic exploration but it was appreciated that this study was undertaken. The presenter indicated that further work on other fish species are planned to be undertaken in the future and study design and locations are now being determined.

OVERVIEW OF THE PHYSICAL OCEANOGRAPHIC CONDITIONS ON THE NL SHELF

Presenter: Frederic Cyr

Abstract

Physical environment conditions for 2018 (large-scale atmospheric forcing and hydrographic response) are presented. Although the North Atlantic Oscillation (NAO) index was high, annual air temperature average was normal for five cities around the Labrador Sea. This however masks a warmer than normal winter (especially March) and a colder than average spring (May and July) caused by abnormal patterns in sea level pressure fields in the northern hemisphere. Ocean physical conditions in NAFO Divs. 2J3KLNOPs generally exhibited cold anomalies at the surface and warm anomalies near the bottom. For example, the sea surface temperature (SST)

was colder than normal in the Labrador Sea, despite warmer than normal temperature in coastal Newfoundland and south of 47°N. The cold intermediate layer core temperature (defined as the minimum temperature within the monthly average profile) was about normal, but continues its cooling trend since about 2012. This recent cooling was preceded by a warming period that started after the cold conditions between the mid-1980s to the mid-1990s and driven by the winter North Atlantic Oscillation. After nearly two decades of warmer ocean conditions that caused a contraction of the bottom thermal habitat <2°C (a range typically inhabited by Snow Crab) in many NAFO divisions, this bottom temperature habitat has returned to normal values over the last five to seven years. At the coastal Station 27, integrated temperature over the water column (0-176 m) was normal, but the salinity exhibited its largest negative (fresh) anomaly since the beginning of the time series in 1948.

Discussion

A participant questioned what the presenter meant by pre-conditioning of the Cold Intermediate Layer (CIL). It was clarified that the thermal energy or cooling in one year builds from year to year so multiple cool years help establish a CIL.

A participant questioned why a plot was presented showing correlation of crab biomass and the six to eight year lagged NAO. The presenter indicated this was included for exploratory purposes. The plot is part of a set of larger analyses looking at correlations of oceanographic conditions and crab species.

There was discussion and some questions on different oceanographic dynamics occurring in the Laurentian channel and the Grand Banks.

OVERVIEW OF THE CHEMICAL AND BIOLOGICAL OCEANOGRAPHIC CONDITIONS ON THE NL SHELF

Presenter: David Belanger

Abstract

In 2018, the biomass of chlorophyll-a in the first 100 m of the water column was back to above normal levels for the first time in 10 years. Positive chlorophyll-a anomalies were associated with an increase in recent years of nitrate concentration in the deeper layers (50-150 m) of the ocean. However, low concentrations of deep nitrate across the shelf in 2018 may negatively affect next phytoplankton spring bloom productivity. Spring bloom indices derived from satellite data indicate that surface phytoplankton production for 2018 was below the long-term average. Blooms were of normal duration but occurred later than normal across the NL shelf in 2018. Zooplankton biomass was lower than normal across the NL shelf for a fourth consecutive year, whereas abundance anomalies were among the highest in 20 years. Changes in the size-structure of the zooplankton community resulted in a decrease in the abundance of large, energy-rich, copepods (*Calanus finmarchicus*) and an important increase in the abundance of small copepod taxa (*Pseudocalanus spp*. and *Oithona spp*.) in the fall. Overall, there is less biomass in the system at trophic levels with potential impacts on energy transfer to higher trophic levels.

Discussion

It was discussed that it would be helpful to examine data collected along the Hamilton Bank to Greenland line in addition to the data presented. Data from this line are collected in the Maritimes Region and could be examined in the future.

There was a discussion on changes in primary production over time and whether trends are similar in other regions. A longer time series would be useful to further examine trends. Zooplankton biomass and abundance were presented as stacked bar plots and a participant indicated that if particular sections are missing in some years due to lack of sampling, this would impact the figure. The presenter clarified that the anomalies shown are consistent across tracks and the important thing is to focus on trends across the entire region.

Several questions were asked regarding zooplankton (e.g. why small copepods have shifted to a fall bloom and why *Calanus finmarchicus* abundance has decreased). The reasons for this are unclear and it was indicated that there are many processes that impact zooplankton dynamics. A participant also asked which zooplankton are consumed by Snow Crab and it was indicated that Snow Crab eat a suite of zooplankton.

SOFT-SHELL ENCOUNTER PROTOCOL ANALYSIS

Sana Zabihi-Seissan, Krista Baker, Darrell Mullowney, Eric Pedersen

Presenter: Sana Zabihi-Seissan

Abstract

Due to the high levels of mortality associated with handling soft-shell crab, a soft-shell monitoring program was implemented in some crab fishing areas around NL in 2004. Assessment divisions (ADs) covered by the soft-shell protocol consist of 2J3KLNO offshore and 3KLPs4R inshore. Each AD is sectioned into a grid (70 nM^2 cells offshore and 18 nM^2 cells inshore). Observers onboard crab fishing vessels sample catches within fished grid cells with a minimum of three pots in the fleet (ideally one at the beginning, middle and end). Samples that meet the minimum sample size of 130-135 legal sized crab offshore and 43-45 legal sized crab inshore are eligible for closure. Subsequently, if the proportion of legal sized soft-shell crab in the catch is above 20% in ADs 2J3KPs4R or 15% in ADs 3LNO, the corresponding grid cell is closed for the remainder of the season.

The purpose of this analysis was to look at the effectiveness of the soft-shell protocol to close grid cells when necessary, and if the protocol adequately covers the ADs. For the offshore divisions, the observers covered between 7%-65% of fished cells from 1999 to 2017 with most years being between 20%-30%. As for the inshore divisions, observers covered between 2%-43% of fished cells from 1999 to 2017, with most years being between 10%-20%. The median sample size for offshore divisions was below the minimum sample size, suggesting that more than half of the observed samples are not large enough to be eligible for the soft-shell protocol even with a high proportion of soft-shell crab present. This was less problematic for the inshore divisions where the median sample size was above the minimum sample size. Suggestions to allow for more closures when necessary are to include all sized crab to the minimum sample size or reduce the overall minimum sample size down to 60 for offshore divisions and 30 for inshore divisions. A minimum soft-shell crab count could be added (20 for offshore and 10 for inshore) to ensure that cells are not closed due to a few soft-shell crab. More work needs to be conducted to address the lack of spatial coverage of the soft-shell protocol with some options consisting of increasing the number of observers in certain ADs, increasing cell sizes or managing closures using depth contours.

Discussion

It was explained that this work was presented to enable the group to discuss potential changes to the soft-shell protocol. The protocol currently in place should be modified as sample sizes are often too small (i.e. soft-shell crabs are being found in certain cells but not enough are being

sampled to close the cells). The presentation also described why the current protocol is not an effective management technique and provided participants an opportunity to highlight ways to improve the protocol. A participant explained some areas have both hard shell and soft-shell in the same block and is a current challenge for industry.

One of the issues discussed by participants was the lack of observer coverage. It was noted that it is difficult to determine if soft-shell are present if there are not enough observers, and also that there are costs associated with increasing observer coverage. Several participants commented that there was little or nothing to be gained by changing the protocol. It was explained that better sample sizes are necessary and a change in the protocol could potentially result in more effective observer coverage. Currently, soft-shell can be present and are being missed because the sample size of legal sized crab may be too high and therefore even if observers check those samples that information is not provided to DFO with the current protocols that are in place. A participant noted that multiple observer reports were submitted this year that did not meet the sample size and closures could not occur – it was indicated that it would be useful if harvesters could be notified somehow that these areas appear to be unproductive.

A participant pointed out that enforcing closures based on depth would be very difficult so changing grid sizes may be more effective.

A participant asked what information is available on the proportion of soft-shell mortality as a result of capture/handling. It was stated that some experiments were undertaken in the past but they were limited. Previous work has shown that mortality is lessened by correct handling processes but it can vary. One study has shown that mortality is ~5% but it was recommended that caution should be used with this percentage. It was pointed out that the Nunatsiavut Government has tagged soft-shell crab and this information could be obtained by DFO. It was explained that DFO proposed to conduct a mark/recapture study of soft-shell crab in the future but no funding has been secured.

TJFB-DFO COLLABORATIVE POST-SEASON TRAP SURVEY IN AREA 2HJ NORTH

Presenter: Craig Taylor

Abstract

The Torngat Joint Fisheries Board (TJFB) was established as part of the 2005 Labrador Inuit Land Claims Agreement (LILCA). Through consultation with stakeholders and scientists, TJFB identified a gap in knowledge used to assess the health of Snow Crab stocks in and adjacent to the Labrador Inuit settlement area. Since 2013, the TJFB post-season Snow Crab trap survey (PSTS) has been a collaboration with DFO and represents an example of co-management led research contributing to the self-determination of Inuit Snow Crab fishers.

The survey consists of 20 stations on a grid system that varies by depth. Each station is sampled with a string of 11 pots, nine with commercial mesh size and two pots fitted with a finer mesh to enable the collection of undersized juveniles. Data from undersized males are used to extrapolate recruitment prospects, and data from female crab are used to estimate larval production. Adult commercial-sized males are tagged to gather information on movement, mortality rates, and abundance in the region.

The latest analyses indicate the fishery is capturing a high percentage of recruits before maturity. There is also evidence many crabs terminally molt before reaching exploitable size. Catch rates during the 2018 survey indicate a downward trend in abundance.

Over the past three years, DFO has combined PSTS data with its own multi-species trawl survey data to share in a Regional Peer Review Process, complete an annual stock advisory report, and implement a crab management plan. Results of the 2017 stock assessment have shown the trap survey has significantly improved the wealth and quality of data used to assess the 2HJN Snow Crab resource. PSTS outcomes are discussed with industry stakeholders at the TJFB annual fisheries workshop and inform TJFB recommendations to the DFO Minister on the crab management plan process.

Discussion

A participant commented that the PSTS outcomes are valuable and should continue in the future. There were several questions about the survey methods and design and it was explained that the survey is conducted immediately following commercial fishing in late-August/early-September, stations remain the same each year and the stations sampled are not completely random. Stations were most dense in the south as that is where commercial biomass was thought to be concentrated. The sampling mostly follows a fixed station design with some exceptions.

The Crab Post-Season (CPS) survey by the Fish, Food and Allied Workers Union (FFAW) is moving to half random-stratified and there was discussion that both surveys feed into same assessment process but are using different designs. In the CPS survey, it was identified that one of the problems has been the avoidance of shallow areas and it was explained that more vertical distribution is needed. This PSTS tried to take these issues into account by having shallow and deep stations. It also uses Ogive MAPping (OGMAP) to spatially expand survey points for analysis as this program is robust despite differences in study design. In assessments, the data are separated (Torngat Secretariat data separated from CPS data) for the calculation of size frequencies and CPUE.

FISHING PATTERNS DURING A PERIOD OF SNOW CRAB RESOURCE DECLINE

D. Mullowney, K. Baker, E. Pedersen

Presenter: D. Mullowney

Abstract

There has been repeated public attention drawn to a disconnect between fishery data and stock assessment findings in recent years, with frequent claims that the fishery information does not support the degree of resource decline found in recent stock assessments. In this presentation we examine patterns in harvester fishing effort and catch from commercial logbooks to qualitatively assess the extent to which fishing patterns and harvester behaviours support or refute a resource decline. We examine spatiotemporal patterns in effort expenditure and catch in relation to economic factors. We conclude that an emergent ‘race to fish’ characterized by more rapid deployment of more gear, longer soak times, and increased levels of fishery abandonment under favourable economic circumstances (i.e. high prices) reflect the conclusions of recent stock assessments and do not support claims of a disconnect between harvester data and stock assessment findings.

Discussion

Some comments were provided on individual experiences in the fishery. It was commented that soak times were longer in 2018 due to wind, and that there were differences in fishing success among harvesters due to different fishing practices. It was also highlighted that at certain times during the 2018 fishing season there was a phenomenon known locally as “dirty water” which

may have impacted capture rates. It was also stated that earlier start up is partly because harvesters are encouraged to get out early in the season before softshell crab arrive. The response to these comments was that more gear is deployed in the beginning of season as shown in logbook data and the CPUE model is standardized by time which can partially account for slub in the water at certain times of the year. 2018 was windy; while this is not directly accounted for, there is an underlying assumption that conditions are relatively the same each year although it is known that conditions can vary among years.

MOLT AND GROWTH DYNAMICS OF NEWFOUNDLAND AND LABRADOR SNOW CRAB

D. Mullowney, K. Baker, E. Pedersen, M. Koen-Alonso, E. Colbourne

Presenter: Darrell Mullowney

Abstract

This analysis focuses on modelling size-at-maturity (terminal molt) in Snow Crab populations occurring in different areas of the NL continental shelves. We review biological processes associated with molting and growth and introduce a suite of logistic and linearized models to estimate size-at-maturity and examine plausible factors affecting growth dynamics including population density, fishery exploitation rates, thermal habitat, and predation. Among a host of novel and unique findings, we highlight a recent large decline in size-at-maturity in male crab along all examined parts of the NL continental shelf. Exploratory models reveal all examined factors could be affecting this phenomenon but are inconclusive in determining the extent to which any given factor or synergies among them are driving the outcome. Nonetheless, the presentation highlights a major biological concern occurring in the NL Snow Crab stock and serves as a strong basis for further research toward better understanding the major concern in this valuable fishery resource.

Discussion

There were multiple questions and discussion to clarify specifications in the model presented. The exploitation rate used in the models was defined as landings in the current year divided by the survey biomass in the previous year. Temperature was included in the models as a habitat index. The data for the models is from trawl surveys and DFO inshore trap surveys from 1997-2018.

It was noted that the biggest shift in size-at-maturity occurred around 2010-12. A participant indicated that this was before exploitation rates ramped up and indicates that multiple factors are driving this shift. It was reiterated that the models indicated there is a confluence of four factors impacting crab size-at-maturity and no factor can be dismissed.

A participant stated that exploitation rate should be calculated before the crab molt as there can be considerable year over year differences in exploitation rates in certain areas. In response it was indicated that this was completed in previous analyses but the same factors came out as important. It was explained that the analyses presented should be viewed as exploratory and correlational. If there was an evolutionary effect of high predation or high exploitation impacting size at maturity, it would occur over a long period of time and cumulative effects of each factor would have to be determined. It was recommended that exploitation rate be re-examined or re-defined in the models.

Ecological theories regarding exploitation were discussed; in one case a high exploitation rate removes big animals and reduces competition and could lead to promotion of smaller size-at-

maturity. In another case, ‘stunting’ can occur where organisms occurring at high densities are unable to grow further and as they are removed there is more available habitat and food sources and these organisms can grow to larger size. This has happened with some organisms but there’s not necessarily evidence to indicate that this is happening with crab. High exploitation via removal of the largest individuals can lead to reduced size over time as evolutionarily there is less incentive to grow. This has been seen in other fisheries such as Northern Cod where after the collapse cod mature at a smaller size. Multiple competing processes could be impacting crab size-at-maturity.

It was stated that many harvesters use a larger mesh pot now (5.5 inch) and it was pointed out that this has led to an increase in the mean size of crab in the fishery. The trend of smaller size at maturity would not be seen in cases where a larger mesh size is used but it is still occurring. The impact of the timing of surveys was questioned as some surveys occur after the fishery (which targets larger males) and this could be impacting the ability of DFO surveys to detect these large animals. In response it was pointed out that not all surveys occur after the fishery.

There was discussion on the behavior of terminally molted crab. There are different theories as to whether or not these crab occupy different depths or move away from the breeding population. In Alaska, studies indicate large terminal molts move away from breeding females.

DEPLETION METHODS FOR ESTIMATING BIOMASS

Presenter: Eric Pedersen

Abstract

Abstract not provided

Discussion

There were some questions focused on clarifying the statistical methods. A participant asked why the presenter focused on trap saturation rather than another factor such as temperature. The presenter indicated that it is one of the factors that can bias estimates upward. Other factors such as temperature have an impact but don’t necessarily result in a directional bias in estimates. It was stated that the model is looking at relative patterns and the rate of change of CPUE within and between years.

It was explained that the model assumes there is a linear relationship between CPUE and the number of crab in the system. The catchability of crab will vary with distance but the model will still work as long as catchability doesn’t change with the density of crab in the area. There are some crab that never go in traps or places where traps cannot be placed that are missed with this method.

A participant suggested that the model is too simplistic and there are many factors not considered that impact crab catchability. The presenter indicated that temperature, day of the year, type of gear and other factors will impact specific traps and that is why it is necessary to use a suite of time data from a wide area (i.e. why it is necessary to have a lot of data and a long time series for these models) in order to average out biases over a wide area. Crab abundance may go up and down in some areas but will average out over time.

It was pointed out that the Delury methods discussed in the presentation are used to scale crab biomasses that are calculated using survey data and OGMAP. The reason for this is that the trawl survey used has poor catchability of crab and the raw estimates of biomass obtained from these surveys are much lower than the landings in the fishery. Exploitation rates are much higher than the biomass obtained from trawl data; this means q (catchability in the trawl survey)

is unknown, but low. The methods outlined in the presentation describe efforts to develop an analogous comparable biomass using depletion methods to re-scale the trawl survey biomass estimates into realistic biomass estimates.

A participant stated that underwater camera work has shown that various crab species show differences in catchability based on abundance. For some species, when there are few individuals, very few individuals enter traps whereas for other species, when there are few individuals, they aggregate and catchability can increase.

CHRONOLOGY AND RECENT HIGHLIGHTS OF NL SNOW CRAB PRECAUTIONARY APPROACH PROCESS

D. Mullowney, D. Osborne, K. Baker, E. Pedersen

Presenter: Darrell Mullowney

Abstract

This presentation briefly describes some of the history surrounding development of a Precautionary Approach Management Framework for the NL Snow Crab fishery, including dates of significant milestones and meetings. The presentation elaborates on outcomes of a PA Framework meeting held in June, 2018, including models used for projection of focal metrics of CPUE and fishery discards. We formally present new CPUE and discard standardization models for review and inclusion into the stock assessment and PA framework. Similarly, we present new CPUE and discard prediction models for inclusion into the stock assessment and PA framework. Despite advances to models, overall changes to CPUE and discard estimates are deemed minimal and no changes to the proposed PA framework are necessary stemming from these updates and advancements.

Discussion

A participant stated that the fishery discard prediction model was based on observer coverage but there are few observers and they only cover a small area. It was recognized that this is a concern and observer coverage needs to be improved.

A participant questioned if mesh size is factored into models. Different sized mesh pots are used by harvesters and this affects the number of discards. It was indicated that mesh size is not accounted for in the models.

There were concerns regarding the use of models for a precautionary approach without better observer coverage and incorporation of mesh size into the models. It was acknowledged that this is far from complete but the scientists are using the best available data.

It was pointed out that the Limit Reference Point has been established and that the Upper Stock Reference Point has been proposed by DFO Science.

ASSESSMENT OF NEWFOUNDLAND AND LABRADOR SNOW CRAB (*CHIONOECETES OPILIO*) IN 2018

K. Baker, D. Mullowney, E. Pedersen, W. Coffey, F. Cyr, and D. Belanger

Presenter: Krista Baker

Abstract

The status of the Snow Crab (*Chionoecetes opilio*) resource surrounding NL NAFO Divs. 2HJ3KLNOP4R is assessed using a variety of metrics. Data from multi-species bottom trawl surveys conducted during fall in Divs. 2HJ3KLNO and spring in Divs. 3LNO and Subdiv. 3Ps provide information on trends in biomass, recruitment, production, and mortality over the time series. Multi-species trawl survey indices are compared with other relevant indices toward inferring changes in resource status for 2018 and beyond. These other indices are derived utilizing data from harvester logbooks, at-sea observers, the dockside monitoring program, and inshore and offshore trap surveys, as well as oceanographic surveys.

Snow Crab landings remained near 50,000 t from 2007 to 2015, but have since steadily declined to a two-decade low of 27,700 t in 2018. Overall effort remained at approximately 3.5 to 4.5 million trap hauls per year over that time. Overall CPUE was at a time-series low in 2018. Despite modest increases in the past two years, the trawl survey exploitable biomass index has remained at its lowest level for the past four years. Meanwhile, the trap survey index has declined by nearly 60% in the last two years to a time-series low. Despite modest increases in some divisions in the past two years, overall recruitment into the exploitable biomass will remain low in most divisions in 2019. Total mortality in exploitable crab is estimated to be near time-series' averages in most divisions. It has declined from very high levels in most divisions during the past two years, with the exception of Div. 3K, where it remains at a time-series high. Exploitation rate indices were at or near time-series highs in most divisions in 2017. In 2018, exploitation rates subsequently increased to a new high in Div. 3L Inshore, remained high in Divs. 2HJ, 3K, and 3LNO, and declined to be near or below long-term average levels in Subdiv. 3Ps and Divs. 4R3Pn.

Elements of the proposed PA Framework presented in this assessment are tentative. LRPs defining the critical zone have been established by a peer-reviewed Science process, but USRs defining the cautious and healthy zones remain under development. In 2019, most divisions are projected to fall within the cautious zone of the proposed PA Framework. Div. 3L Inshore would be in the critical zone. These projections assume status-quo landings.

The thermal habitat index (defined as the areal extent of < 2°C bottom water) has returned to near-average conditions in all divisions in recent years. Broad-scale climate indices appear favourable for improved recruitment to occur in most major areas of the stock range over the next few years. Ecosystem conditions in the NL Bioregion are indicative of an overall low productivity at the lower trophic levels (phytoplankton and zooplankton) in recent years and changes in zooplankton community structure that may impact the transfer of energy to higher trophic levels. A sharp decline in size-at-maturity (i.e. terminal molt size) of male Snow Crab in most divisions in recent years may dampen short-term prospects for recruitment into the exploitable biomass.

Discussion

A participant stated that the graph showing trends in crab discards is based on observer data which is limited/deficient and asked if additional observer coverage would affect the trends shown in the graph. The presenter responded that it is unknown what additional data would

show but it would definitely improve overall confidence in the validity of these data. Another participant suggested that it would be interesting to model how much additional data would be needed to change the results from what is currently seen. It was concluded that while the picture may not be complete, it is doubtful that the addition of more data would change the trends being seen.

It was questioned why the proposed PA Framework was included in the presentation as some participants thought it would not be used in 2019. It was explained that there was a CSAS meeting in June 2018 titled "D*evelopment of a Precautionary Approach Framework for Snow Crab in the NL Region"* and the information and the outcomes from that peer-reviewed meeting will assist with the finalization of a PA Framework. It was clarified that LRPs defining the critical zone were established by a peer-review CSAS process, and that USRs defining the cautious and healthy zones remain under development. It was further explained that the *proposed* cautious and healthy zones (i.e. zones created by a *proposed* USR) would not be used by Resource Management for the 2019 fishing season as they are tentative. Several participants stated that Resource Management should consult harvesters to finalize the PA Framework. DFO Science indicated that the proposed PA Framework includes the best science advice available and that *proposed* cautious and healthy zones will be included in all science advice going forward.

It was pointed out that all fishers in attendance at the meeting were not in agreement with the inclusion of the PAF or bullets related to it into the Science Advisory Report (SAR). It was agreed that the lack of consensus from fishers with the inclusion of PA-related bullets into the SAR would be noted in the proceedings document. In order to further address fisher concerns a research recommendation (see below) was drafted to examine the influence and sensitivity of each metric used in the PA framework. As well, all bullets related to the "cautious zone" were changed to "provisional cautious zone" in the SAR.

A participant asked for an explanation on recruitment changes in Assessment Division 3Ps (i.e. appeared to be no new recruits in 2016, improvement in 2017, bigger improvement in 2018). DFO Science indicated that the assessment document from two years ago (2016) outlined that there was much uncertainty regarding a mode of crabs that were coming. This was due to the CPS survey not occurring for two years and losing the signal in the traps. Those crab were then detected in cod stomachs but could not be located in an ongoing survey. It was indicated in CSAS Research Document, Mullowney et al. (2017), that more crab could be coming, but most evidence suggested they were gone. What was subsequently learned in 2018 was that there was a lot of skip molting occurring that wasn't expected. This skip-molting delayed everything and then crabs showed up as recruits. There was some discussion on where crabs go when they skip molt and why they are not detected until they return as recruits.

A participant expressed concern that the proposed PA Reference Points may be too high, particularly in light of rebounding groundfish populations and their predation on crab. A participant stated that although crab numbers are showing a downward trend, there were still approximately 63 million pounds of crab landed in 2018 and the fishery has not collapsed. It was also suggested by a participant that landings will never return to those seen in 1999/2000s as groundfish are increasing. DFO Science responded that the proposed PA Framework will take this into account as it is not biomass based. Some participants stated that the metrics in the proposed PA Framework may not be accurate and they suggested that the proposed PA Framework should be revisited.

A participant indicated that seal predation is not incorporated in the assessment of Snow Crab. The participant stated that that they feel harvesters are being portrayed as a big factor in the downward trend in crab stocks and that seals could also be impacting crab. It was explained

that available information indicates that the current abundance of Snow Crab is largely being driven by fishing pressure and climate.

RESEARCH RECOMMENDATIONS

ICELAND SCALLOP

- Determine fishing mortality for Iceland scallop.
- Examine the effect of fishing on scallop given that there is no fishing in two of the beds. Appears that natural mortality is higher in beds with less fishing; also may be differences in scallop quality and sea star density amongst the beds.
- Investigate options for assessing Iceland scallop in other areas in and outside (e.g. Nunatsiavut settlement area) 4R.

ECOSYSTEM

- Examine chemical and biological data for Hamilton Bank to Greenland line – data collected by the Bedford Institute of Oceanography (BIO).

SNOW CRAB

- Complete a mark/recapture study of crab across the stock range to estimate movement, mortality and post-release survival.
- Explore options for smoothing total mortality.
- Continue efforts to model factors affecting small terminal molt size.
- Investigate other potential outcomes from small male size.
- Continue to develop the saturating trap model. Extend it to include potential for new recruits entering the population during harvest.
- Map incidence of bitter crab disease in 3K using trawl survey data.
- Within the PA framework there are three metrics: standardized indices of CPUE, % discards, and clutch size. It should be determined how sensitive these metrics are to the availability of data (the influence of each metric) particularly when that metric is pulling the stock estimate into the critical or cautious zone.
- Explore options to better estimate discards to address concerns with poor observer coverage.
- Investigate larval dispersal between areas to improve our understanding of stock structure, population dynamics and connectivity.
- Investigate effects of escape hatches and mesh size on discards and estimate distribution of different mesh sizes in the fishery.
- Investigate methods to increase efficiency of softshell protocol for management advice.

REFERENCES CITED

Moriyasu, M., Allain, R, Benhalima, K., and Claytor, R. 2004. Effects of Seismic and Marine Noise on Invertebrates: A Literature Review. DFO Can. Sci. Advis. Sec. Res. Doc. 2004/126. iv + 44 p.

Mullowney, D., Coffey, W., Baker, K., Evans, G., Fiander, D., Colbourne, E., Maddock Parsons, D., Koen-Alonso, M., and Wells, N. 2017. An Assessment of Newfoundland and Labrador Snow Crab (*Chionoecetes opilio*) in 2016. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/081. viii + 172 p.

APPENDIX I – TERMS OF REFERENCE – ICELAND SCALLOP

4R Iceland Scallop Assessment

Regional Peer Review - Newfoundland and Labrador Region

February 19, 2019
St. John's, NL

Co-Chairs: Hannah Murphy and Derek Osborne

Context

The status of Iceland Scallop in the Northwest Atlantic Fisheries Organization (NAFO) Division 4R was last assessed in 2009. The current assessment was requested by Fisheries Management to provide current information on stock status and to provide the science advice that will be used in the management of the resource.

Objectives

- To assess the status of Iceland Scallop resource on NAFO Division 4R; and
- To determine the impact of maintaining the current harvest level.

Expected Publications

- Science Advisory Report
- Proceedings[1]
- Research Document

Participation

- Fisheries and Oceans Canada (DFO) Science and Fisheries Management
- Province of Newfoundland and Labrador Department of Fisheries and Land Resources
- Indigenous groups
- Academia
- Fishing Industry

[1] Joint Proceedings with the February 19-21, 2HJ3KLNOP4R Snow Crab Assessment.

APPENDIX II – TERMS OF REFERENCE – SNOW CRAB

2HJ3KLNOP4R Snow Crab Assessment

Regional Peer Review Process - Newfoundland and Labrador Region

February 19-21, 2019
St. John's, NL

Co-Chairs: Hannah Murphy and Derek Osborne

Context

The status of Divs. 2HJ3KLNO, Subdiv. 3Ps and Div. 4R Snow Crab was assessed in 2018. The current assessment was requested by Fisheries Management to provide current information on the status of the resource and to provide the science advice that will be used in the 2019 Snow Crab Management Plan.

Objectives

- To assess the status of Snow Crab in Divisions 2HJ3KLNOP4R; and
- To determine the impact of maintaining the current harvest levels.

Expected Publications

- Science Advisory Report
- Proceedings[2]
- Research Document

Participation

- Fisheries and Oceans Canada (DFO) Science and Fisheries Management
- Province of Newfoundland and Labrador Department of Fisheries and Land Resources
- Academia
- Indigenous Groups
- Fishing Industry
- Other invited experts

[2] Joint Proceedings with the February 19, 2019 Assessment of 4R Iceland Scallop.

APPENDIX III – AGENDA

Regional Peer Review Process: Stock Assessments of 4R Iceland Scallop and 2HJ3KLNOP4R Snow Crab

Memorial Meeting Room, Northwest Atlantic Fisheries Centre, St. John's
February 19-21*, 2019

Chairpersons: Hannah Murphy and Christina Bourne

Tuesday, February 19 (0900-1700)

Activity	Presenter
Opening, Terms of Reference and Introductions	Co-Chairs
4R Iceland Scallop Assessment	-
Presentation: Division 4R Iceland Scallop	E. Coughlan
Science Advisory Report Bullets	ALL
2019 Snow Crab Assessment	-
Presentation: Overview of the physical oceanographic conditions on the NL Shelf	F. Cyr
Presentation: Overview of the chemical and biological oceanographic conditions on the NL Shelf	D. Belanger
Presentation: Seismic impacts on Snow Crab	C. Morris
Presentation: Soft-shell encounter protocol analysis	S. Zabihi-Seissan
Presentation: Updates on Post-Season Trap Survey in Area 2HJ North	C. Taylor
Presentation: Patterns and trends in fishing activities	D. Mullowney

Wednesday, February 20 (0900-1700)

Activity	Presenter
Presentation: Changes in size at maturity	D. Mullowney
Presentation: Changes to depletion curve	E. Pedersen
Presentation: Precautionary Approach for NL Snow Crab	D. Mullowney
Presentation: Divisions 2HJ3KLNOP4R Overview – Standard Assessment	K. Baker

Thursday, February 21 (0900-1700)

Activity	Presenter
Science Advisory Report Bullets	ALL
Research Recommendations (Scallop & Snow Crab)	ALL
Upgrading of Scallop & Snow Crab working papers to research documents	ALL
ADJOURN	Co-Chairs

*** Friday, February 22 (0900-1700)** – February 22 has been added in the event of winter weather related delays, NAFC building closure due to a storm, and/or extra time is required for discussion.

Notes:

- This agenda is fluid and may change.
- Breaks will occur at 10:30 and 2:30.
- Lunch will occur from 12:00-1:00 and is not provided. Food and beverages can be purchased from the cafeteria.

APPENDIX IV – LIST OF PARTICIPANTS

Name	Affiliation
Allister Russell	Harvester
Andy Careen	Harvester
Ben Davis	DFO Science NL Region
Brett Favaro	Marine Institute
Brian Careen	Harvester
Brittany Beauchamp	DFO Science National Capital Region
Calvin Young	Harvester
Connie Korchoski	DFO Centre for Science Advice NL Region
Craig Taylor	Torngat Secretariat
Darrell Mullowney	DFO Science NL Region
Darren Sullivan	DFO Science NL Region
David Belanger	DFO Science NL Region
David Small	DFO Resource Management Grand Falls Windsor
Derek Butler	Association of Seafood Producers
Derek Osborne	DFO Science NL Region
Don Stansbury	DFO Science NL Region, Emeritus
Dwight Petten	Harvester
Elizabeth Coughlan	DFO Science NL Region
Ellen Careen	DFO Resource Management NL Region
Eric Pedersen	DFO Science NL Region
Erika Parrill	DFO Centre for Science Advice NL Region
Erin Carruthers	FFAW
Frederic Cyr	DFO Science NL Region
Geoff Evans	DFO Science NL Region, Emeritus
Glen Newbury	Harvester
Hannah Murphy	DFO Science NL Region
Jenn Duff	DFO Communications NL Region
Julia Pantin	DFO Science NL Region
Katherine Skanes	DFO Science NL Region
Keith Watts	Torngat Fish Producers Corporation
Kevin Guest	DFO Communications NL Region
Krista Baker	DFO Science NL Region
Kristin Loughlin	DFO Science NL Region
Laura Wheeland	DFO Science NL Region
Laurie Hawkins	DFO Resource Management Corner Brook
Martin Henri	DFO Resource Management NL Region
Michael Hurley	DFO Science NL Region
Miranda McGrath	FFAW
Nancy Pond	Fisheries and Land Resources, Govt NL
Nelson Bussey	Harvester
Nicholas Le Corre	DFO Science NL Region
Rob Coombs	Nunatukavut Community Council
Sanaollah Zabihi-Seissan	DFO Science NL Region
Stephanie Boudreau	DFO Science Gulf Region
Tony Doyle	Harvester
Trevor Jones	Harvester
Wayne King	DFO Resource Management Goose Bay
William Coffey	DFO Science NL Region