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Proceedings of the Maritimes Regional Advisory Process of the Eastern Scotian Shelf Snow Crab

Compte rendu du Processus consultatif régional des Maritimes concernant le crabe des neiges de l'est du plateau néo-écossais

1-2 March 2005
Mic Mac Amateur Aquatic Club
Dartmouth, Nova Scotia

1 et 2 mars 2005
Mic Mac Amateur Aquatic Club
Dartmouth (Nouvelle-Écosse)

René Lavoie (Chair)

Bedford Institute of Oceanography
1 Challenger Drive, P.O. Box 1006
Dartmouth, Nova Scotia
B2Y 4A2

René Lavoie (président)

Institut océanographique de Bedford
1, rue Challenger, C.P. 10006
Dartmouth (Nouvelle-Écosse)
B2Y 4A2

June 2005 / juin 2005

Foreword

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

Avant-propos

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

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http://www.dfo-mpo.gc.ca/csas/

CSAS@DFO-MPO.GC.CA

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ABSTRACT

These proceedings record discussions that were held during the Regional Advisory Process (RAP) meetings for Scotian Shelf Snow Crab stocks in Maritimes Region on 1-2 March 2005. The scientific peer review of Eastern Nova Scotia Snow Crab (Areas 20-24) was conducted. The discussions from this meeting are presented in this document.

RÉSUMÉ

Le présent compte rendu relate les discussions tenues pendant les réunions du Processus consultatif régional (PCR) portant sur les stocks de crabe des neiges du plateau néo-écossais, dans la Région des Maritimes, les 1 et 2 mars 2005. Lors de ces réunions, on a procédé à un examen scientifique par les pairs de l'état des stocks de crabe des neiges de l'est de la Nouvelle-Écosse (Zones 20-24); les discussions auxquelles il a donné lieu sont présentées ici.

INTRODUCTION

The meetings were held the Mic Mac Amateur Aquatic Club, Dartmouth, 1-2 March 2005. The Invitation letter and list of Invitees are in Appendix 1 and 2. The Chairman, René Lavoie, welcomed the participants (Appendix 3), explained the procedure for the meeting, the specific role of scientific referees, industry representatives and observers, and reviewed the agenda (Appendix 4).

The Chairman explained that the objective of the meeting was to conduct a thorough peer review of the stock assessments presented by the Scientist-in-charge, Dr Jae Choi, with input from representatives of the province of Nova Scotia and from the industry. He also clarified that the RAP was NOT the place to discuss management considerations. The Remit for this meeting is in Appendix 5.

In these proceedings, summaries of presentations and comments from referees are the work of the authors and have been reproduced with little or no editing.

SUMMARY OF PRESENTATIONS

Information Papers

Research Mandate Transition -- by John Tremblay

Snow Crab Science Program of the Maritimes Region has greatly benefited from the generous input of the Gulf Snow Crab Group, namely : Mikio Moriyasu, Michel Biron, Elmer Wade, Luc Savoie, Rejean Vienneau et Rita Landry. I wish to thank them publicly for laying the groundwork and smoothing the transition.

The Maritimes permanent team comprises of a Scientist: Dr Jae Choi, Ben Zisserson, survey technician, and Alan Reeves, fishery technician.

Other contributors to the transition in 2004/2005 included Dan Thompson, at-sea technician (3 months); and Kohila Thana and Jerry Black who effected the successful transfer of the database.

In the course of the year, Science expertise was developed in the areas of survey, fishery, data analysis and interpretation. The Gulf data base was transferred and enhanced, protocols for data input were improved. The trawl survey data 1997-2003 was transferred to an ORACLE structured database which should make it easier to access and to maintain in the long term

The trawl survey was conducted on a new vessel, *Gentle Lady*, between September 9 and November 12, 2004. In total, 379 stations were completed including additional stations on the slope and in 4X. In addition to the regular measurements, the weight of all crab species was recorded. Again, the start-up guidance from Moncton staff was very useful. Data handling was done through the Observer Program (Javitech); Javitech now inputs all data from at-sea sampling and the trawl survey. All data flows into the same database as other observer data and crab survey data. It is hoped that this approach will increase efficiency and reduce costs.

In the year ahead, the plan is to consolidate the snow crab team and methodological approaches, continue with trawl survey with support of Joint Project Agreements, and put a renewed emphasis on research

Temperature Conditions on the Scotian Shelf During 2004 Relevant to Snow Crab - by David Brickman

Temperatures during 2004 are presented for the Scotian Shelf waters of Maritime Canada inhabited by snow crab. Data were available from a number of sources including snow crab and groundfish surveys.

In the northeastern Scotian Shelf, bottom temperatures were significantly warmer than in 2003 and close to the long term average (1971-2000). A snow crab habitat index, defined by the area of the bottom covered by waters between -1° to 3°C, was calculated for the Sydney Bight and northeastern Scotian Shelf regions. On the Scotian Shelf, the index remained above the long-term average with the highest value of the time series. In Sydney Bight the habitat index decreased from its 2003 value to near the long-term average. The crabs caught during the annual snow crab surveys were found in warmer waters in 2004 than in 2003, but still well within the typical temperature range.

The 2004 Fishery -- by Alan Reeves

The 2004 Eastern Nova Scotia snow crab fishery (Crab Fishing Areas 20-24, not including 4X) produced total landings of 9331t, on par with a Total Allowable Catch (TAC) of 9357t for the entire fishery. An additional 298t were landed in the Slope areas of CFAs 23 and 24. A breakdown for this season indicates 1417 t were landed in the Northern portion of ENS (CFAs 20-22) and 7914t were landed in the Southern portion (CFAs 23 and 24). The Northern and Southern ENS TACs were reduced by a total of 6% and 10% respectively for 2004 compared to 2003.

Overall catch rates for Northern ENS in 2004 (60.6 kg/trap haul) were the lowest since the pre-2000 period, while the catch rates for Southern ENS (103.0 kg/trap haul) have been variable but generally increasing since 2000. Trends in catch rates by sub-area suggest areas of higher commercial concentrations of snow crab are experiencing stable or increasing catch rates, while areas in the geographic periphery of the fishing grounds appear to be experiencing declining catch rates.

The 2004 Trawl Survey – by Ben Zisserson

A trawl survey using a 20 metre *Nephrops* trawl has been conducted in the Eastern Nova Scotia snow crab fishing areas since 1997 as the primary method of generating snow crab biomass estimates. The spatial distribution and seasonal timing of this survey has varied as has the survey vessel. The 2004 snow crab trawl survey represented the largest single survey in both station numbers and spatial extent since the inception of this survey. The survey was completed aboard the 65 foot stern trawler *Gentle Lady*, a vessel and crew new to this survey, from September 9 to November 12, 2004. A total of 379 stations and almost 16000 snow crab were sampled during this period. A new database and data entry system were successfully used to capture and store the data generated. Some expected difficulties related to weather and net damage were encountered without hindering the completion of the survey. DFO science was extremely pleased with the conduct of the captain and crew of the *Gentle Lady* in the timely completion of this survey.

A short "slide show" of photos taken during the 2004 snow crab trawl survey was presented.

The 2004 Observer Program -- by Ben Zisserson

Target observer coverage of 5% in CFA's 20, 21 and 22 (N-ENS) was met, as was the 10% target in CFA's 23 and 24 (S-ENS). The sampling of at-sea observers was well distributed geographically throughout the CFA's with at-sea samples of 40 randomly chosen male snow crab from a single trap being repeatedly sampled throughout the day. From these sampled male crab carapace width (CW), claw height, shell hardness were measured and carapace condition (CC) determined. Further estimates of the weight of kept and discarded snow crab of all hauled traps were recorded.

Mean CW's of snow crab increased in both N-ENS and S-ENS as did the frequency of CC 4 crab. These increases may represent an increased age of commercially exploitable snow crab in eastern Nova Scotia. Actual retention rates by the commercial fishery are very similar to those allowable using carapace size and shell condition measurements taken by at-sea observers of total catch in both N-ENS and S-ENS. In N-ENS, temporal distribution of observer coverage does not allow the comparison of CPUE data from fisheries logbooks and observer generated estimates. However, it is comparable in S-ENS and these two data sources show CPUE's within 10% of each other. This serves as a validation of observer sampling protocol and proper completion of logbooks by fishers operating in CFA's 23 and 24.

SUMMARY OF WORKING DOCUMENT

An Assessment of the 2004 Snow Crab Populations Resident on the Scotian Shelf (CFAs 20 to 24) – by Dr. Jae Choi

Fisheries exploitation has been at all-time highs for the past 4 years, at TACs of approximately 10000 t/year. Landings (9629 t) nearly met these TACs (9657 t) in 2004 with 1417, 7914 and 298 t landed in the northern, southern and slope areas, respectively. The catch rates for all of the shelf was 93.1 kg/th derived from approximately 100,200 trap hauls. Catch rates in the northern crab fishing areas (CFAs) were at their lowest levels in the past five years (60.6 kg/th), with the exception of CFA 22 Outer (Glace Bay Hole) which exhibited catch rates of 165.0 kg/th. Catch rates in the southern crab fishing areas (CFAs 23 & 24), increased slightly since the year 2000 (103.0 kg/th). The southern fishing areas continued to expand (spatially) in 2004.

The abundance of snow crab on the Scotian Shelf declined in 2004, continuing the downward trend observed since the peak abundances of the late 1990s and early 2000s. Fishable biomass estimates as of the winter of 2005 stands at approximately 29000 t, which comprised of 1600 t in the northern CFAs and 27700 t in the southern CFAs. Other indicators of the status of the stock were also indicative of a continued decline and disequilibrium: sex ratios were dominated by males with extremely few mature females resident on the system for more than 4 years running, ageing of the population with limited signs of rejuvenation, and rapidly increasing exploitation rates (presently, 32 % by biomass). A strong note of caution is advised in the management of this fishery: there are very few signs of recruitment into this fishery for another 3 to 5 years and therefore greater uncertainty in the long to mid-term sustainability of the Scotian Shelf snow crab.

COMMENTS FROM SCIENTIFIC REFEREES

Referee: Bernard Sainte-Marie, DFO – Maurice Lamontagne Institute, Mont-Joli, QC

1) Review of the Working Document

General Comment

Overall, this is a good document with a welcome analytical approach. However, there are some pieces of (critical, at least to me) information that are missing from the document: data on (i) the breakdown of males by maturity stage (morphometrically mature = adult vs morphometrically immature = adolescent), (ii) the abundance and size structure of sublegal adult males, (iii) carapace condition of males, and (iv) the characteristics and abundance of mature females (carapace condition and reproductive status, i.e. primiparous vs multiparous) from the trawl survey in 2004 and previous years. The breakdown of males by maturity and carapace condition is essential for addressing issues such as the supposed "recruitment bottleneck" between R-2's and R-1's, which may simply be a reflection of terminal molting before legal size. Carapace condition in the trawl survey is essential for addressing the issue of natural mortality of the accumulated commercial biomass. Changes in the abundance and characteristics of the mature female population are a confirmation/forewarning of the prospects of recruitment to the commercial biomass.

Note that the authors often refer to early benthic stages (instars 1 to 5) as larvae. The term larvae should be reserved for the pre-metamorphic planktonic stages of the crab life cycle only. I have noted several minor corrections/suggestions directly on the manuscript. More substantive comments follow.

Specific Comments: (note from referee -- please refer to encircled numbers in the margin of my annotated copy of the document)

1. Cannibalism may be important and it appears to be practiced mostly by mature females and intermediate-size adult (morphometrically mature) males (Lovrich & Sainte-Marie 1997; Squires & Dawe 2003).

2. The first cited figure should be Figure 1. How is it known that these brachyuran larvae are mainly or only *C. opilio*? If there is local production/retention of snow crab larvae on the Scotian Shelf, then larvae should be present there starting in June.

3. The terminal molt may occur at smaller (younger) instars.

4. Has soak time or any other fishing variable changed notably in the few recent years? Consider expressing catch rates as number of individuals per trap haul, to account for changes in size/weight of individual crabs.

5. Morphometrically immature (= adolescent) males do not regularly mate and they may do so only in the absence of the more competitive morphometrically mature (= adult) males.

6. "dynamically changing habitat range". I'm not sure what this means. Do you mean to say the range changes over time, or that crab density change over depth and temperature?

7. In N-ENS, CC4-5 represent a greater proportion of the number of males <110 mm CW than of those larger and the reverse is true of CC1-2. This feature can explain why mean size is increasing (large crabs are still recruiting and natural mortality is taking its toll on small crabs) and suggests that the population is at the end of a recruitment wave. However, this pattern of CC is not nearly as clear in S-ENS. Could this difference be due to the different temporal patterns of observer coverage, see last paragraph of p12, or shifting spatial distribution of fishing effort in S-ENS?

8. This geographic gradient of trap CPUE may on the whole be true, but there are possible confounding factors. For example, many fishermen use small Japanese traps in Newfoundland and this is also the case to a lesser extent in some parts of the north Gulf of St. Lawrence.

9. The substantial decrease of mean mature female size is thought to reflect an influx of new females. Was this ascertained through CC as well, i.e. were most of these smaller females primiparous (CC2 or 2+ and no mating scars at time of survey)?

10. Most of the females will probably become mature before reaching instar 11. What part of the females shown in Fig. 18 were mature?

11. Also note that there are more immature year classes of males than of females represented in the population at any given time, an additional factor contributing to bias the immature sex ratio to males. What would the sex ratio be for one instar in which both females and males are always immature (e.g. instar 6)?

12. (a) Larval production may be more a matter of mature female numbers and size/age structure (this is information that is not provided in the document) than of sex ratio, unless the females are poorly serviced (which could be demonstrated by analysis of spermathecal content) and would be expected when sex ratio is sharply biased to females. (b) The “test” will be convincing only in so far as the two systems are not in synchrony.

13. I believe this range of estimated instantaneous mortality rate also includes movement in or out of the study area.

14. The exploitation rates were likely much higher in N-ENS than in S-ENS.

15. Sexual pheromones may be effective over tens of metres, but not over kilometres which is the scale of movements seen in ENS. Do the areas of peak CPUE coincide with areas of concentration of residual mature females?

16. Temperature may be an important factor, which is not sufficiently informed. How has the area extent of snow crab habitat changed in the last decades? Is there a coincidence between the biomass surge and the appearance of a large pool of cold water on the ENS shelf (concomitant with groundfish decline)? See comment no. 19 below.

17. The currently low number of mature females is to be expected, given terminal molt (and limited lifespan thereafter) and a likely cyclic recruitment pattern.

18. Is there any evidence that the density and spatial extent of these other crab species have changed in recent decades?

19. The authors seem to be taking sides with the "top-down control" hypothesis for explaining the initiation and persistence of increased abundance of snow crab in ENS. While there is no doubt that cod and other groundfish predators take a toll on juvenile and premolt snow crab, I feel the environment control hypothesis merits further attention. Consider the following:
    a. Although groundfish biomass peaked in 1985, it did not decline significantly below the long-term 1970–1985 average until about 1988 or 1989 (Fig. 32). Therefore, predation pressure on snow crab probably did not decline substantially until after the ENS shifted to a cold-water system in 1987 (Fig. 31). In this respect, it might be useful to dig up Ken Drinkwater's areal index of snow crab habitat along ENS to see how it relates to temperature trends in Fig. 31.
    b. I see two periods of CPUE increase in Fig. 5 with notable differences among them. The period of increasing CPUE from 1985 to 1991 is almost linear and has a very shallow slope. The period of increasing CPUE starting in 1995 is exponential up to 1998 (after which the fishery started to expand spatially) and has a much steeper slope than the previous. If groundfish predation on juvenile snow crab is a regulatory factor, then the slope of the increase in CPUE from 1985 to 1991 may reflect a recruitment wave and the amplitude of "biomass" change in a "warm"-water and groundfish-dominated system. The much steeper CPUE increase in 1996–1998, after a period of declining or relatively low CPUE in 1993–1995 (a recruitment trough?), may represent productivity in a "cold"-water and groundfish-depleted system. However, 1996 less 9 years to reach legal size from settlement = 1987, which coincides with the environmental temperature shift and is 1–2 years before the groundfish declined to below average abundance. Of course the shift from one regime to the next was gradual, and there are many confounding effects in CPUE, but to me there seems to be no reason to discount environment more than groundfish predation.
    c. Possibly, the increase of snow crab in ENS is a composite effect of reduced predation and increased spatial extent of habitat, due to cooling, that relaxed snow crab intrinsic population controls (cannibalism and competition) and increased productivity (more eggs). For perspective, it should be noted that in the Gulf of St. Lawrence (which is a conservative cold pool through time) the abundance of snow crab (measured by dedicated trawl surveys or trap CPUE) seems to have been as high in the pre-groundfish collapse era as it is nowadays. This can suggest that temperature is the overruling factor, via its effects on snow crab physiology (growth and survival) and the areal extent of snow crab habitat.

20. Recommendations. "A reduction in TACs would likely be prudent." This is a very general statement. (a) Should the reduction differ among areas, since declines of CPUE have been more pronounced in the northern CFAs than in the southern ones? (b) What do we know of the connectivity (through benthic stages) of CFA 20 and 21 to CFA 19? Biomass estimates for CFA19 predict a substantial decline for 2005.

21. Legends of Figs. 26 & 27. The scales should be number of crabs per km^2, not tonnes per km^2.

2) Additional Comments/Interventions made during the Review Process

The lifespan of legal size males after terminal molt can reach up to 7 or 8 years based on a tag-recapture study of the unfished population in the Saguenay Fjord. In this area, crabs reach peak hardness and meat yield in shell condition 3 about 2 years after molting and remain in that condition for another 2 years or so. The shell condition of males subsequently

deteriorates (to SC4 and SC5) and their catchability/commercial value declines. The ageing pattern and the temporal duration of male availability/quality to the fishery may vary among areas due to temperature or other factors.

There are 3 main classes of hypotheses relating to ***density-dependent controls*** that can explain recruitment variability in time and/or recruitment waves and troughs:

- Settlement intensity (year-class strength) and subsequently recruitment 8–10 years later is related to larval production and supply in a given year, which is a function of the number of eggs produced by females which in turn is a function of female nos. × mean size × maturity status × shell condition (this hypothesis was discussed in Sainte-Marie et al. 1996 and by the Moncton snow crab group in their recent SSRs).
- The abundance of large (older) adult males controls recruitment by competition (growth repression) or cannibalism on early benthic stage or immediate pre-recruits. Recruitment occurs only when the biomass of large adult males is low (Elner & Beninger 1995; Conan et al. 1996). However, field and laboratory studies do not support the idea that large adult males prey on early benthic stages or on immediate pre-recruits (Dutil et al. 1997; Lovrich & Sainte-Marie 1997)
- The abundance of intermediate-size (20–60 mm CW) crabs (both female and male) regulates abundance of early benthic stages (instars 1 to 4) through competition for resources and cannibalism (Sainte-Marie et al. 1996). Cannibalism by intermediate-size crabs on early crab instars is well documented through stomach content analyses and laboratory studies (Lovrich & Sainte-Marie 1997; Squires & Dawe 2003; Sainte-Marie & Lafrance 2003).

Male mating capability: large adult males can mate 10–15 virgin (pubescent) females in succession during a breeding season; however the amount of sperm passed to individual females decreases with increasing number of mates. At severely female-biased sex ratios, the amount of sperm passed to individual females may be insufficient for fully fertilizing the immediate egg clutch and/or for future use in “autonomous” fertilizations. Supporting evidence for these statements can be found in Rondeau & Sainte-Marie (2001) and Sainte-Marie et al. (2002)

Sex Ratio Issues:

The sex ratio naturally oscillates over the years due to females and males recruiting to maturity at different average ages and sizes and having a fixed lifespan after terminally molting to maturity (see Sainte-Marie et al. 1996, 2002). Although males and females settle in equal numbers (Lovrich et al. 1995; Comeau et al. 1998), on average females recruit to maturity (become reproductive) at a younger age (smaller size) than males. If the abundance of settlers in each year to the population is periodic (a succession of a few good year-classes alternating with a succession of a few weak year-classes, as seen on the ENS shelf, in the SGSL and NGSL), the sex ratio of the mature (terminally molted) component of a population will naturally oscillate from male to female bias.

Referee: S. Smith - Bedford Institute of Oceanography, Nova Scotia

1. Time trends for R1 numbers in all areas did not seem to follow previous R2 trends or predict adult trends. Apparently, there were different versions of these plots with different scales that confused the issue. Recommendation was to ensure that the research document and SSR had matching and correct figures for the R1 trends.

2. Survey estimates prior to 2004 had been adjusted the area covered in the 2004 survey. It was recommended that the research document include a table of expansion factors those years so adjusted so that we can evaluate the effect this may have had on the estimated trend.

3. Prior to 2002 the survey had been conducted in the spring and afterwards to the present in the fall. Mention had been made of strong temperature associations for the snowcrab. The possible impact of change in season (and thus temperature) on the survey indices should be evaluated.

4. In the original presentation, exploitation rates had been calculated for the eastern Scotian Shelf area as whole despite the fact that trends appear to differ for the different regions. Exploitation rates need to be calculated for each each management subareas (North and South at a minimum). Also an error was detected in how the exploitation rates were calculated and this was pointed out to the lead author who corrected the calculations.

5. The research team indicated that a population model was being developed for this stock(s). This work is encouraged so that future stock assessments can offer quantitative advice on actual changes to harvest rates with an evaluation of impact on the population.

Referee: K. Frank - Bedford Institute of Oceanography, Nova Scotia

Overall the draft research document was quite comprehensive dealing not only with the snow crab fishery and dedicated surveys, but included a variety of other relevant information on the ecology and life history of the species as well as ecosystem level considerations. I did have a few concerns including:

It was shown that CPUE trends exhibited strong spatial differences among CFAs. This makes interpretation of CPUE aggregated across CFAs difficult given the effects of different vessel sizes, gear types, soak times, bait differences, etc. These factors need to be taken into account when any future analyses of CPUE are to be conducted.

Crab distributional ranges were considered to be quite dynamic and can shift to areas where they are not traditionally found. However, for the purposes of Kriging the assumption was made that the past spatial distributions (1997 to present) are comparable to the present. These discrepancy needs to be addressed.

Biomass estimates were based on Kriging which was the previous approach used in the assessment of this stock. The current year estimates were not used to make projections about future stock status and attempts should be made to do so. This will involve assumptions about natural mortality and growth rate.

Further work is required to estimate exploitation or fishing/total mortality rates. One could use the descending limb of the length frequency distributions for this purpose after converting sizes to ages.

A major assumption was made that the stock of snow crab on the eastern Scotian Shelf is self-sustaining. Expertise within the new PED could be assembled to examine the question of snow crab stock structure on the eastern Scotian Shelf, e.g. using a genetic approach.

Quality of the landings data, accuracy of log books, etc – is it very high?

It might be useful to consider a finer taxonomic resolution of the larval crab material collected by the Continuous Plankton Recorder. One might also consider sampling plankton during the conduct of the industry survey.

There did not appear be a good reason for tagging snow crab and if this is true then it should be abandon.

The habitat suitability index should be estimated for each CFA and include factors other than temperature, such as abundance of predators.

A graphic summarization of the various stock, fishery and environmental indices is needed, such as a traffic light table used in the assessment of various shrimp fisheries.

I have given Jae my copy of the draft document that is marked for editorial changes as well other small concerns.

Referee: Michel Biron, Gulf Fisheries Centre, Moncton, New Brunswick

First and Foremost:

I would like to congratulate you and your team for a job well done! There was a lot of information to be processed and digested in a very short time but Jae, Ben and Allan pulled it off very nicely. The assessment was very thorough and results supported the conclusions that the fishery had reached its limit under current conditions and was now decreasing rapidly. Any increase in exploitation rates should not be recommended at this time.

General Comments:

It is obvious from the document that a great deal of hard work and dedication went into the research, analysis, assessment and preparation; however, the document should be thoroughly edited to correct potential errors (grammatical and otherwise). I have seen many typos that should be easily picked up by a spelling and grammar program.

The assessment should make use of discard data from the observer program. Discards could be an important source of mortality especially if CPUE, biomass and abundance indices are in decline while landings are being maintained. I am a strong proponent of maintaining and using a high quality set of observer data. Observer data should be used to monitor fisheries, to calculate fishery induced mortality, the level and quality of discards, and to validate logbook CPUEs. The observers are collecting important scientific data, but this data could be used as a yardstick against which to compare the rest of the fishery.

Specific Comments:

Ecology and Life History:

I appreciated this section very much because it secured me to know that Jae did his homework by reading about the snow crab life history. I would caution however that some of this info may be one sided point of view, while not necessary the latest hypothesis being thrown around. It might be useful to eliminate excess information without losing the final message.

Eg.: p.4 "Just prior to the terminal moult in males, crabs may skip a moult in one year to moult in the next, presumably to sequester more resources to have a larger growth increment."

I would object to this by saying indications are that skip-moulting is related to snow crab density… The highest % of skip-molters is observed during the years of highest biomass levels. But rather than to add more info to try to please everybody, you could achieve the same points simply by saying less:

"*Just prior to the terminal moult in males, crabs may skip a moult in one year to moult in the next."*

Research Survey Data:

The equation (i.e. discriminant function) supplied with the observer database for eastern Nova Scotia by Moncton is the discrimant function for the Gulf Region. However, when we divide the terms in the ENS equation by a constant to see if it is equivalent to the Gulf equation, we noticed that although it is very close (to the third decimal point), it is not exactly the same. Elmer processed a test file (2003 ENS data) to see how both equations differed, and found them to be within 99% of same categorization… It is still something that need to be checked!

It is recommended to reevaluate the male discriminant functions for ENS because it is based on such a small surface sampled in 1998 compared to today's larger survey (characterizing adulthood in females is easily done visually, i.e. without a discriminant function).

Summary of Fisheries Data:

I do not like the way CPUEs from the different Regions are being compared… These are oranges and apples! You can not do that for numerous reasons: different gear, exploitation levels, habitat, effort! Anyhow, CPUEs should be used to described how well a season went, but not to predict the future! It is our experience in the Gulf that CPUE vary little if not even increase as the stock decrease until biomass decrease below a critical level…, then CPUE will decrease in phase with biomass levels.

Research Survey Data:

I don't like the frequency histogram supplied. It is very difficult to read, and there is no division between adolescent and adult. Furthermore, the overall impression when we look at it should be a good reflection of the stock status, and as it is, we have the erroneous impression that the stock increased in 2004. This should be rectified.

There is a lack of tables of the size, composition, shell condition, ect… for the survey. This is somewhat important because we can somehow draw conclusions on exploitation rates (or other things) from ratios between CC1+2 and CC3, 4+5 for instance. Also there are no table showing the history of the assessments and their connection to this year.

CPUE vs Biomass Trend:

I think that even in the best of conditions, you will not get a nice linear regression between CPUE and biomass index. This is mostly that fishermen will always adjust their fishing

pattern as a function of the crab concentrations, and according to information exchange between themselves.

Pre-Recruits:

Things like “reproductive system is in poor condition”, “snow crab population is currently out of balance” or “stabilize the population” are erroneous concepts that do not apply to this species. There is nothing wrong with this particular snow crab population… It is the nature of these beasts to be cyclic… And now we entered a period of increasing adult female while the concentration of adult male will be quickly decreasing. We usually talk about snow crab as a species that has ‘recruitment by platoon’.

Do not view snow crab as victims which may loose prime habitat to other species! During the increasing phase of the adult male population in ENS, I have witnessed many instances where snow crab actually pushed away toad crab from their prime habitat on Sydney Bight… I am more worry of lost of habitat due to environmental changes.

To me, and I agree with Jae on this, the biggest concern is that you need male from the “old generation” to mate with the incoming wave of the “new generation” of female. Keeping enough large males on the grounds where females are appearing should be a major concern for everyone. Although we have no “proven” reason for this specific caution for snow crab, the fact remain that action taken today has consequences that won’t be evident for another 15 years or more. Can we afford to take that chance!

COMMENTS AND QUESTIONS AND ANSWERS: GENERAL DISCUSSION

Bruce Osborne
C: To address sustainability in cyclical stock two factors must be considered: maximize economics and retain males for females to breed. Would like to see outlook of biomass predictions with different exploitation rates. Questions how many males required for breeding and how much effect fishery actually has on the stock.

Mikio Moriyasu
C: Came to see how ex-wife (crab industry) is doing with new husband (BIO Crab team). Encourage industry to give patience to new science team as they will improve on past work with time by developing new approaches.

Don’t spend too much time in analyzing CPUE data. It is very difficult to standardize and I believe that no more information can be extracted than it has been done in the past. Rather it might to be worthwhile in investigating traffic light approach with CPUE as one of the parameters.

You cannot use global sex ratio. More regionalized sex ratio should be explored. Sex ratio without biological measurements is weak. Consideration of spermatical load and reproductive potential (fecundity measures) must be examined to give stronger results.

Scotian Shelf must be assumed to be self-sustaining system. Otherwise exploitation can be infinitely high which is very dangerous if Scotian Shelf is in fact self-sustaining.

I am still wondering if a source of sink population exists between inshore and offshore grounds. Dangerous to believe that offshore can be heavily exploited without affecting inshore regions.

The duration of commercial usability of current exploitable portion of population may not last long enough until next pulses of recruitment arrive. Suggesting exploitation rates is very difficult. Hard to give advice but valuable information for industry.

Pat Fougere
C: A glossary of terms or a terms of reference would be very helpful with industry's understanding of the presented document.

Paul Kehoe
C: CPUE should not be used as an indicator, too many variables such as soak time to be consistent and doesn't consider illegal landings. The incidence of old (Carapace Condition 5) not referenced in document. Believes that Scotian Shelf is a self-sustaining population. Large spatial extent of survey and fishing effort means that entire Scotian Shelf snow crab population is now being exploited.

(Jae Choi) Other elements of stock such as CC5 crab will be included.

(Rene Lavoie) Paul raising an excellent point about 100% monitoring of legal catch. Industry should suggest ways to assess and combat illegal landings.

Herb Nash
Q: You do tows on the entire slope area where there are high concentrations of crab in only limited locations. How can this be an accurate representation of the crab populations on the slope?

A: (Jae Choi) Kriging takes this into account. Analytical methods generate biomass estimates for an entire area based on all parts. Both the high concentration areas and "zeros" are taken into account.

Q: You would have much better results if you monitored the areas where fishermen actually fish. No drops in CPUE are evident where I fish in 23C. How can biomass be falling if everyone is catching more crab all the time.

A: (Jae Choi) You are fishing in small areas relative to the size of the entire shelf. These methods are qualitatively correct for the entire shelf. Global trends need to be examined rather than small scale estimates to get the most accurate picture of the stock.

Paul Patterson
Q: Please explain Kriging and "masks".

A: (Jae Choi) Masks refers to the idea that areas of low or no abundance of crab can be assumed based on temperature and depth. Needed to develop mask to reflect larger area based on temperature, depth, effort and trawl survey results. Kriging interpolates between known survey points. Kriging is computationally expensive and can be unfortunately unreliable but we must be able to calculate areas where no tows are done. Areas near high abundance tows will hence be high. Interpolated results near "zeros" will be near zero.

Q: If these weighting factors cause hypothetical variations that are larger than actually exist, can grids be used to check viability of biomass estimate.

A: (Jae Choi) 1.5 degree grids are used to determine masks.

David Rambeau
Q: The Gulf has numerous recruits to fishery. How can we learn from the cycle in the gulf and move towards this in Eastern Nova Scotia.

A: Gulf has a very different habitat. Need to develop a model for ENS taking into account such factors as sex ratio models for recruits to be able to predict impacts on system (warning signs). Sex ratios are an empirical model whereas biological model is much more relevant.

Neil MacMullin
Q: Because of the isolation of the Glace Bay Hole (GBH), do you believe that the fishermen in the GBH harvest an isolated stock? Do survey results reflect the GBH fishery? Will management receive small scale biomass estimates?

A: (Jae Choi) GBH does behave differently. Unable to say if GBH is its own stock. Will try to produce smaller scale biomass estimates but confidence in these estimates lowers with smaller areas.

Fred Kennedy
Q: Please advise on the suggested TAC reduction stated in document. A 10% biomass estimate drop meant a TAC drop of 10%. Does a 30% biomass drop merit a 30% TAC reduction?

A: (Jae Choi) Current exploitation rates (ER) at approximately 30% with about 2Kt of mortality. If you drop the TAC by 30%, ER will be the same or higher. If you want to maximize long-term fishery, TAC must be lowered further. Hard to give a number with current analyses.

Bob Anderson
Q: CPUE should not be used as an abundance index. Any number known for mortality from discards? Newfoundland underestimated these in past.

A: (Jae Choi) Trying to investigate this but difficult with sampling variability (especially in North) with observers.

C: Reports from Alaska point towards no link between juvenile abundance and future recruitment.

(Jae Choi) The closer these juveniles are to recruitment, the higher the confidence that they will in fact recruit into the fishery.

Ken Frank
C: Survey measurements are the source of biomass estimates but CPUE's will follow. CPUE's do reflect the stock but slower. More helpful to look at breakdown by sub-area with the necessary caveats.

Bernard Ste-Marie
C: CPUE describes fishery performance. I do not like fine scale resolution. Crabs move freely between sub-areas hence fine scale CPUE's are not fairly observed.

Stephen Smith
C: CPUE will show longer term trends. They lag behind survey but will catch up. Important to still separate for North and South.

RESEARCH RECOMMENDATIONS

1. Research should be done to determine which part of the new recruitment comes from the Eastern Nova Scotia populations versus the part which comes from Area 19 in the Gulf of St. Lawrence through larval drift.

2. The question about when various crab larval stages are present in the water column may be answered in part by paying a little extra money to have the data extracted from the Continuous Plankton Recorder data sets.

Appendix 1. Letter of Invitation

Fisheries and Oceans Canada | Pêches et Océans Canada
Science | Sciences

Maritimes Region
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, NS B2Y 4A2

Région des Maritimes
Institut océanographique de Bedford
C.P. 1006
Dartmouth (N-É) B2Y 4A2

25 January 2005

Subject: Peer Review of Snow Crab Stocks

You are invited to participate at the assessment of snow crab stock on the Scotian Shelf which will be reviewed at Mic Mac Amateur Aquatic Club, 192 Prince Albert Road, Dartmouth, N.S., March 1 and 2, 2005 (please see attached agenda and Remit for the meeting).

This meeting will provide results of snow crab stock assessment for the northern (Areas 20, 21 and 22) and southern (Areas 23 and 24) portions of eastern Nova Scotia.

The purpose of this meeting is to conduct a thorough peer review of the stock assessment. Your participation is required to ensure that the review is of the highest quality.

Scientists will provide a brief overview of their assessments that should include the main conclusions, the supporting evidence, any new methods, and major limitations. The presentation will be followed by comments from the scientific referees and then from the invited industry participants. Unfortunately, time does not allow for contribution by observers.

Finalized stock status reports will be prepared at the meeting and the minutes of this meeting will be published as proceedings.

We would greatly appreciate your contribution to this important exercise and look forward to seeing you in March.

René Lavoie
Manager, Invertebrate Fisheries Division
Maritimes Region

Appendix 2. List of Invitees

Chairperson

Dr. René E. Lavoie
Division Manager,
Invertebrate Fish Division
Bedford Institute of Oceanography

Scientific Referees

Michel Biron
Department of Fisheries and Oceans,
Gulf Region

Dr. Kenneth Frank
Bedford Institute of Oceanography

Dr. Bernard Sainte-Marie
Department of Fisheries and Oceans
Mont-Joli, Quebec

Stephen Smith
Bedford Institute of Oceanography

Science Participants

Dr. David Brickman
Bedford Institute of Oceanography

Fisheries Resource Conservation Council (FRCC)

Donald Delaney
Douglas Johnston
Clary Reardon
Arthur Willett

Provincial Governments

Bruce Osborne
NS Department of Fisheries & Aquaculture

DFO Managers

Michael Eagles
Department of Fisheries and Oceans

Alex MacIsaac
Department of Fisheries & Oceans

Paul Gentile
Department of Fisheries & Oceans

Fishermen's Associations

Bob Anderson
Rep., Area / Zone 24

Timothy S. Bagnell
Rep., Area / Zone 23

Nellie Baker Stevens
Eastern Shore Fisherman's Protective Assoc. Zone 24

David Burchell
Rep., Area / Zone 20

Kelly Casey
Guysborough County Inshore
Rep., Area / Zone 24

Pat Fougere
Canso Trawlermens Coop.,Rep.,
Area / Zone 24, P.O. Box 362

Donny Hart
Halifax West Commercial
Fishermen's Association
Area / Zone 24

Anthony Hendricksen
CFA 23 nonadjacents

Kelvin Hussey
CFA 23 nonadjacents

Bill Hutt
East Cape Breton Fish. Assoc.

Paul Kehoe
Rocky Bay Fishermen's Assoc.

Josephine Kennedy
Rep., Area / Zone 23

Gordon MacDonald
Rep., Area / Zone 23

Harvey MacDonald
Rep., Area / Zone 23

Merril MacInnis
Rep., Area / Zone 21

Allan MacInnis
Rep., Area / Zone 22

Neil P. MacMullin
Rep., Area / Zone 22

Herb Nash
Rep., Area / Zone 23

Kevin Nash
Representative Slope

Philip Nash
C.R.A.B. Group

David Rambeau
Aspy Bay Fishermen
Area 20 Association

Ervin Touesnard
Rep., Area / Zone 24

Processing Plant Representative

Christine Penney
Clearwater Seafoods Limited

Science Guest

Dr. Mikio Moriyasu,
Department of Fisheries and Oceans,
Gulf Region Science Branch, Snow Crab Section

First Nation Representatives

Anita Basque
Chapel Island First Nation

Blair Bernard
Eskasoni First Nation

Lance Paul
Membertou First Nation

Brian Arbuthnot
Wagmatcook First Nation

Robert (Bobby) Gould
Waycobah First Nation, P.O. Box 149

Adrian Gloade
Millbrook First Nation

Tim Martin
Native Council of Nova Scotia
Survey Vessel Representative

Willard Grover
W.T. Grover Fisheries Ltd

Observer Company Representative

Troy Quinlan
Operations Manager, Javatech Ltd.

DFO Science Gulf Region

Rita Landry
Crustacean Data Management and Analysis

DFO Science Maritime Region

John Tremblay, Section Head
Jae Choi, Research Scientist
Ross Claytor, Research Scientist
Linda Worth-Bezanson, Admin. Assistant
Alan Reeves, Technician
Ben Zisserson, Technician

Appendix 3. List of Participants

NAME	AFFILIATION	ADDRESS	TELEPHONE	FAX	E-mail
Anderson, Bob	Rep., Area / Zone 24	P.O. Box 251 Canso N.S. B0H 1H0	(902) 366-2391	(902) 366-2391	casi.anderson@ns.sympatico.ca
Baker Stevens, Nellie	Eastern Shore Fisherman's Protective Ass. Zone 24	P.O. Box 55 Musquodoboit Harbour, N.S. B0J 2L0	(902) 889-2564	(902) 889-2633	Esfpa@accesswave.ca
Basque, Anita	Chapel Island First Nation	P.O. Box 574 Chapel Island, N.S. B0E 3B0	(902)535-2191	(902)535-3454	abasque@ns.sympatico.ca
Bernard, Blair	Eskasoni First Nation	P.O. Box 7040 Eskasoni, N.S. B1W 1A1	(902)379-1211	(902)379-1273	
Biron, Michel	Department of Fisheries and Oceans, Gulf Region Science Branch, Snow Crab Section	P.O. Box 5030 Moncton N.B. E1C 9B6	(506)851-6046	(506)851-3682	Bironm@dfo-mpo.gc.ca
Bond, William	Area 24	PO Box 313 Canso, NS B0H 1H0			Bill.Bond@NS.sympatico.ca
Brickman, Dr. David	Bedford Institute of Oceanography	P.O. Box 1006, Dartmouth, NS B2Y 4A2	(902)426-5722	(902)426-9710	BrickmanD@mar.dfo-mpo.gc.ca
Buchanan, Dylan	Javatech	Dartmouth, NS	(902)223-2375		
Choi, Dr. Jae	Research Scientist Invertebrate Fish Division Bedford Inst.of Oceanography	P.O. Box 1006 Dartmouth, N.S. B2Y 4A2	(902) 426-4000	(902)426-1843	ChoiJ@dfo-mpo.gc.ca
Claytor, Ross	Bedford Institute of Oceanography	PO Box 1006, Dart,outh, NS B2Y 4A2	(902)426-4721		*claytorr@mar.dfo-mpo.gc.ca*
Cormier, Pierrette	DFO	Moncton	851-7925	851-3062	*cormierp@dfo-mpo.gc.ca*
Denny, Leon	Eskasoni	Eskasoni	(902)329-1211	(902)329-1273	LeonDenny@hotmail.com
D'Entremont, Jean Guy	FSCC Chairman, Atlantic Breeze Cons. Ltd, Inshore Fisheries Ltd.	PO Box 118, Middle West Pubnico, NS B0W 2M0	(902)762-2522	(902)762-3464	*jean.guy@ns.sympatico.ca*
Donovan, Darrell	Area 23 non-adj	PO Box 44, Ingonish Beach, NS B0C 1L0	(902)285-2350		*sgrant@nshba.ns.ca*
Eagles, Michael	Department of Fisheries and Oceans, Marine House	PO Box 1035, 176 Portland St Dartmouth, N.S. B2Y 4T3	(902) 426-7198	(902) 426-9683	Eaglesm@dfo-mpo.gc.ca
Fougere, Pat	Canso Trawlermens Coop.,Rep., Area / Zone 24	P.O. Box 362 Canso / Guys. Co., N.S. B0H 1H0	(902) 366-2359	(902) 366-2804	caperyan@ns.sympatico.ca
Frank, Dr. Kenneth	Bedford Institute of Oceanography	P.O. Box 1006, Dartmouth, NS B2Y 4A2	(902)426-3498	(902)426-9710	*FrankK@mar.dfo-mpo.gc.ca*
Gerrow, Richard	Area 23	Sydney Mines, NS	(902)736-2505		
Gloade, Adrian	Millbrook First Nation	PO Box 634, Truro, NS B2N 5E5	(902)897-0402	(902)895-1994	
Gloade, Michelle	Millbrook Fisheries	634 Willow St. Truro, NS	(902)890-4143	(902)895-1994	*millbrookfishery@eastlink.ca*

NAME	AFFILIATION	ADDRESS	TELEPHONE	FAX	E-mail
Green, Kevin	Area 20	929 Donkin Hwy, Donkin, NS B1A 6P3	(902)737-5154		
Grover, Willard	W.T. Grover Fisheries Ltd.	RR#1 Larry's River, NS B0H 1T0	(902)525-2423	(902)525-2601	*wtgrover@ns.sympatico.ca*
Sheila Grover	Area 24	Tor Bay, NS	(902)525-2024		
Horne, Kevin	Area 24	RR#2 Guysborough, NS	(902)358-2209		
Hussey, Kelvin	Area 23	P.O. Box 128 Ingonish, N.S. B0C 1K0	(902)285-2326		
Kaiser, Blair	Area 24	Bickerton West< NS	(902)364-7659	(902)364-2010	*B.W.Kaiser@ns.sympatico.ca*
Kehoe, Adolf	CFA 24	PO Box 401, Arichat, NS B0E 1A0	(902)-631-2261		
Kehoe, Paul		942 Rocky Bay Rd Richmond Co., NS B0E 1K0	(902) 226-2115	(902) 226-1194	
Kennedy, Chris	Area 23	Riverview	(902)387-4978	(902)387-4973	*ck@nbnet.nb.ca*
Kennedy, Fred		36 Keefe St. Riverview, NB E1B 4H1	(506)387-4972		*SEASPRAY@NB.A1BN.com*
Kennedy, Josephine	Rep., Area / Zone 23	Box 5602 Louisbourg, N.S. B1C 2L8	(902) 733-2741	(902) 733-2407	ariel@seascape.ns.ca
Landry, Rita	Department of Fisheries and Oceans, Gulf Region Science Branch, Snow Crab Section	P.O. Box 5030 Moncton N.B. E1C 9B6	(506)851-6890	(506)851-3062	Landryr@dfo-mpo.gc.ca
Lavoie, Dr. René	Division Manager, Invertebrate Fish Division Bedford Inst.of Oceanography	P.O. Box 1006 Dartmouth, N.S. B2Y 4A2	(902)426-2147	(902) 426-1843	lavoier@mar.dfo-mpo.gc.ca
MacDonald, Arnold		Louisbourg, NS	(902)733-2596		
MacDonald, Bill	Richmond Co. Inshore Fishermen's Assoc.	RR#1 River Bourgeois, Richmond Co. NS B0E 2X0	(902)884-2524	(902)826-1386	*WJMACDONALD@ns.sympatico.ca*
MacDonald, Joey	Area 23	Louisbourg, Nova Scotia	(902)733-3177		
MacDonald, Gordon		11 Beaumont Avenue Sydney, N.S. B1S 1J4	(902) 564-6566	(902) 564-6906	bnw@ns.sympatico.ca
MacDonald, Harvey	Rep Area 23	4331 Louisbourg Hwy, Albert Bridge, NS B1K 2P4	(902)562-1043	(902)567-0101	*capemacca@yahoo.ca*
MacDonald, Malcolm	Area 23,	Forchu	(902)884-2752	(902)884-2040	
MacInnis, Allan	Rep., Area / Zone 22	Box 53, RR1, Englishtown, Vict. Co., N.S. B0C 1H0	(902)929-2477	(902) 929-2710	allan.m@ns.sympatico.ca
MacInnis, Merril	Rep., Area / Zone 21	Box 53, RR1, Englishtown, Vict. Co., N.S. B0C 1H0	(902) 929-2309		
MacKay, Gordon	RCIFA	St. Peters, NS	535-3535	535-3411	
MacMullin, Neil	Area 22, Outer	172 Lamond St, Sydney Mines, NS B1V 1V9	(902)736-2048?		
Martin, Tim	Native Council of Nova Scotia	P.O. Box 1320	(902) 895-7050	(902) 895-8182	netcomm@ncnsnetcomm.ns.ca

NAME	AFFILIATION	ADDRESS	TELEPHONE	FAX	E-mail
		Truro, N.S. B2N 5N2			
Mombourquette, Gregory	Area 24	L'Ardoise	883-2945		
Moriyasu, Dr. Mikio	Department of Fisheries and Oceans, Gulf Region Science Branch, Snow Crab Section	P.O. Box 5030 Moncton N.B. E1C 9B6	(506)851-6135	(506)851-3682	moriyasum@dfo-mpo.gc.ca
Nash, Herb	Rep., Area / Zone 23	3 Wadman St. Glace Bay, N.S. B1A 1S4	(902) 849-1813	(902) 842-9635	
Nash, Kevin	Representative Slope	7 Davis Street Glace Bay, N.S. B1A 5G9	(902) 849-7043	(902) 842-0527	Email: pgk@seascape.ns.ca
Nash, Philip	C.R.A.B. Group, CFA 23	5 Marshall Street Glace Bay, N.S. B1A 1X3	(902) 842-0684		pnash@ns.sympatico.ca
Nakayama, Munemoto	Japan Fisheries	1209 Duke Tower, Duke St. Hfx. NS B3J 1P3	(902)423-7975	(902)425-0537	*ifahfx@allstream.net*
Osborne, Bruce	NS Department of Fisheries & Aquaculture	5151 George Street P.O. Box 2223 Halifax, N.S. B3J 3C4	(902) 424-0352	(902) 424-1766	*osbornbd@gov.ns.ca*
Patterson, Paul	CFA 23	86 Spanish River Cres, Sydney, NS B1L 1C1	(902)564-6352		*paulpatterson@ns.sympatico.ca*
Pottie, Carl	Area 22 North CRAB	979 Main St. Sydney Mines, NS	(902)736-2172		
Rambeau, David	Aspy Bay Fishermen Area 20 Association	P.O. Box 37 Dingwall, N.S. B0C 1G0	(902) 383-2827		DavidRambeau@ns.sympatico.ca
Rambeau, George	Area 20	Dingwall, NS	(902)383-2953		
Reeves, Alan	Bedford Institute of Oceanography	PO Box 1006, Dartmouth, NS B2Y 4A2	(902)244-6066	(902)426-1843	*reevesa@mar.dfo-mpo.gc.ca*
Sainte-Marie, Bernard	Department of Fisheries and Oceans, Mont-Joli, Quebec	PO Box 1000, Mont-Joli, Quebec G5H 3Z4	(418)775-0617	(418)775-0740	*Sainte-MarieB@dfo-mpo.gc.ca*
Smith, Stephen	Invertebrate Fisheries Division, Science Branch Bedford Inst.of Oceanography	P.O. Box 1006 Dartmouth, N.S. B2Y 4A2	(902) 426-3317	(902) 426-1862	smithsj@dfo-mpo.gc.ca
Tremblay, Dr. John	Research Scientist Invertebrate Fish Division Bedford Inst.of Ocean .	P.O. Box 1006 Dartmouth, N.S. B2Y 4A2	(902) 426-3986	(902)426-1862	TremblayJ@mar.dfo-mpo.gc.ca
Whynot, Larry	Area 24 – Slope	PO Box 1477, Liverpool, NS B0T 1K0	(902)899-1404		
Worth-Bezanson, Linda	Bedford Institute of Oceanography	PO Box 1006, Dartmouth, NS B2Y 4A2	(902)426-7444	(902)426-1506	*worthbezansonl@mar.dfo-mpo.gc.ca*
Zisserson, Ben	Snow Crab Technician Invertebrate Fish Division Bedford Inst.of Oceanography	P.O. Box 1006 Dartmouth, N.S. B2Y 4A2	(902) 426-8039		ZissersonB@dfo-mpo.gc.ca

Appendix 4. Agenda

Tuesday, March 1	**Time**	**Lead**
Introduction	8:30 – 9:00 am	R. Lavoie
Mandate Transition	9:00 – 9:15	J. Tremblay
Oceanographic Overview	9:15 – 9:30	D. Brickman
The Fishery	9:30 – 9:45	A. Reeves/B. Zisserson
The Survey	9:45 – 10:15	B. Zisserson
Health Break	10:15 – 10:30	
Snow Crab Areas 20 -24	10:30 – 12:00	J. Choi
Lunch	12:00 – 1:30	
Examination by Referees	1:30 – 3 :00	R. Lavoie
Health Break	3:00 – 3 :15	
General Discussion	***3:15 – 4:30***	R. Lavoie
Wednesday, March 2		
SSR	9:00 – 10:00 am	R. Lavoie
Health Break	10:00 – 10:15	
SSR and Conclusion	10:15 – 12:00	R. Lavoie

Appendix 5. Meeting Remit

Gulf of St.Lawrence Snow Crab / Crabe des neiges du Golfe St.Laurent

2005 MEETING REMIT (DRAFT)	**DEMANDE DE RENVOI À LA RÉUNION DE 2005 (Brouillon)**
Assess the status of the Gulf of St.Lawrence Snow Crab stocks to the end of September 2004. The assessment should include an analysis of existing fishery and survey information	Évaluer l'état du stock de Crabe des neiges de la Nouvelle-Ecosse jusqu'à la fin de Septembre 2004. Cette évaluation devrait comprendre une analyse des données existantes de la pêcherie et du relevé
Provide advice for the 2005 fishery.	Formuler des conseils sur la pêche pour l'année 2005.
Produce Stock Status Reports for CFA 12 and CFA 19 and supporting Research Document documenting the results of the assessment	Produire des rapports sur l'état des stocks de la APC 12 et APC 19 ainsi que le document de recherche connexe documentant les résultats de l'évaluation.

Appendix 6. Document Tabled

Choi, J.S., Zisserson, B.M. and Reeves, A.R., 2005. Assessment of the 2004 snow crab populations resident on the Scotian Shelf (CFAs 20 to 24). RAP Working Paper 2005/09.