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

8-9 March 2006

**Mic Mac Amateur Aquatic Club
Dartmouth, Nova Scotia**

Robert O'Boyle (Chair)

Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, Nova Scotia
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February 2007

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

8-9 mars 2006

**Mic Mac Amateur Aquatic Club
Dartmouth, Nouvelle-Écosse**

Robert O'Boyle (Président)

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février 2007

FOREWORD

The purpose of these 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 misleading, 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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ABSTRACT

A two-day meeting was held in the Maritimes Region on 8-9 March 2006. The purpose was to review the scientific advice on the status of Crab Fishing Area (CFA) 20-24 snow crab up to the end of 2005, and to evaluate the consequences of different harvest levels during the 2006 fishery on stock abundance and exploitation rate.

These proceedings document the presentations, record discussion and recommendations, and include written reports from the scientific referees, the agenda, and the participants.

RÉSUMÉ

Une réunion s'est tenue dans la Région des Maritimes les 8 et 9 mars 2006. Elle avait pour but d'examiner les avis scientifiques sur l'état des stocks de crabe des neiges des zones de pêche du crabe (ZPC) 20 à 24 jusqu'à la fin de 2005, et d'évaluer les conséquences de différents niveaux de capture sur l'abondance des stocks et sur le taux d'exploitation pour la saison de pêche de 2006.

Ce compte rendu fait état des exposés, des discussions et des recommandations de la réunion et inclut les rapports écrits des arbitres scientifiques, l'ordre du jour et la liste des participants.

INTRODUCTION

A two-day meeting was held in the Maritimes Region on 8-9 March 2006. Chair, Robert O'Boyle, opened proceedings with a moment of silence for eastern Nova Scotia (ENS) snow crab fisher representative, the late Pat Fougere. Chair then set time line for reports – to the Minister by April 30th, with a tentative Advisory Committee meeting on March 24th.

The purpose was to review the scientific advice on the status of CFA 20-24 snow crab up to the end of 2005, and to evaluate the consequences of different harvest levels during the 2006 fishery on stock abundance and exploitation rate. This is not the forum to discuss management considerations.

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

SUMMARY OF PRESENTATIONS

Information Papers

Physical Environmental Conditions on the Eastern Scotian Shelf during 2005

David Brickman and Roger Pettipas

- Air temperatures cold in January; in spring and summer close to normal; warm in fall.
- Wind:
 - Annual and monthly average wind speed (WS) magnitude slightly weaker than climatology, especially late in the year.
 - Direction: general counterclockwise shift relative to climatology throughout the year (i.e., more southerly than climatology (vs. W, WNW, NW)) – 2nd year in a row (at least).
- Ice (not shown):
 - Ice appeared slightly later with overall shorter duration than normal (on eastern Scotian Shelf (ESS)).
- Ocean temperatures:
 - July bottom waters - normal pattern on Scotian Shelf (SS); anomalies small; Gully and Emerald Bank (EB) area warmer than normal.
 - Relative to 2004: Gully, EB, western Scotian Shelf (WSS) warmer.
 - Fall survey bottom T - generally warmer than 2004.
 - Water column vertical structure (not shown):
 - ESS - area 24 colder than normal, area 23 warmer (depth>50m, summer).
 - Areas 20-22 above normal (depth>50m, most of year).
- Habitat index (Scotian Shelf):
 - Index returned to normal in 2005 (vs. 2003, 2004 = v.high).
 - The mean temperature within the habitat area remained approximately normal in 2005 (as in 2004, but much greater than 2003 = the minimum value of the time series).
- Habitat index (Sydney Bight area):
 - The index in 2005 remained near the long term average.

- The mean temperature within the habitat area increased again in 2005, and is above long term average (although within habitat index T range).
- Catches vs. temperatures:
 - Fall survey T: 2005 warmer than 2004.
 - Snow crabs in 2005 were generally caught in warmer waters than in 2004.
 - In 2005, about 79.6% of all of the crabs were caught in temperatures less than 3.5°C (c.f. about 83.5% in 2004).

Discussion

Comment - Mikes are required.

Question - Do you see a correlation between Catch-Per-Unit-Effort (CPUE) and temperature?
 Answer - Better data would help; author states strong relationship, see research document.

Question - Regarding minilog temperature recorders, cost to fishers?
 Answer - None, provided by Department of Fisheries and Oceans (DFO).

Question - Could better temperature data availability (i.e., web based, real time) be bad for crab (higher exploitation)?
 Answer - Presenter unsure, really looking more for anomalies at larger temporal scale.
 Comment (Chair) - re: scallop fishing industry, higher efficiency.

Question - Were temperatures presented from fishing activity or survey?
 Answer - Both (?), actually just various surveys.

Question - Regarding minilog deployment by fishers, where would they be kept?
 Answer - Traps.
 Comment - Fisher kept minilog for five years, no results back to him.
 Answer - New program will better utilize data and provide useful products (Web, other communication).

Question - In addition to temperature, are there datasets on bottom topography and geology? Plankton?
 Answer - Experts at BIO – info available; emphasis is on increased data collection and aggregation.

Comment - Should do more tagging to determine influence of temperature on movement.
 Answer - Good topic for upcoming science committee designed to address, prioritize and implement projects of interest.

Question - Could a longer time series of temperature data be provided?
 Answer - To come in other presentations.

Summary of ENS 2005 Snow Crab Fishing Season

Ben Zisserson

- Decreased landings in all areas corresponding to decreased Total Allowable Catches (TAC).
- Decreased catch rates in area N-ENS and stable (slightly increased) catch rates in both CFAs 23 and 24.

- Target observer coverage met in all areas (5% in N-ENS and 10% in CFAs 23 and 24.
- Increased percentage of CC1 and CC2 crab, coupled with a decrease in CC3 crab in all areas.
- Increased soft-shell incidence in 2005, as compared to 2004, in all areas but more substantial increase in N-ENS. Increased soft-shell incidence found with both low and high catch rates.
- Expected soft-shell incidence to increase in future as new wave of recruitment begins to enter fishery.
- Industry-driven soft-shell protocol needs to be further developed to avoid mortality of soft-shell crab, allowing these crabs to mature into ideal commercial size and condition.

Discussion

Comment - Presentation order does not follow research document.

Answer - Presentation just an overview, more details in research document.

Question - Do landings tables presented contain all catch?

Answer - No, just landings; see observer data for other stock components.

Question - Does movement of fishery match increases in CPUE?

Answer - Data from Dockside Monitoring Program (DMP) logs limited.

Comment - Catch rate from log may be lower than actual due to white crab (ex. slope in 2005).

Question - Why are they more (observer) sampled traps in CFA 24?

Answer - Lower CPUE results in more traps sampled, due to observer coverage being based on percentage of TAC.

Question - Could you (geographically) compare soft-shelled catch from observer data to survey data?

Answer - Yes, did compare well but difficult to display in presentation – chart “too busy”;

Comment - White crab appear to have been on CFA slope earlier in 2005.

Question - Does slide on soft-shelled crab catches include all crab?

Answer - Yes, not just mature, legal crab.

Comment - Would like to see longer time series on soft-shelled crab from observer data.

Comment - Would like to be able to get information from observers on the trip from their own vessel.

Answer - Thought it was available, will see that it is; rapid feedback is essential for soft-shell protocol.

Comment - Soft-shell would be provided more protection with an earlier season.

Answer - Authors agree, season extensions problematic (for survey also).

Question - Can presentations be provided on Web?

Answer - Yes.

Comment - Require better reference to soft-shell protocol in research document.

Summary of 2005 Snow Crab Trawl Survey Presentation

Ben Zisserson

- Survey completed using same nets, sampling protocol, survey vessel and crew as 2004.
- Forty-four days fished for 389 successful stations.
- High winds throughout survey period hampered progress of survey.
- Largest (most stations and spatial extent) single snow crab trawl survey ever in ENS.
- A total of 23,803 snow crab were caught on this year's survey: 12624 male and 11179 female.
- Of these males, 2458 were legal commercial size (95mm carapace width (CW) or greater).
- DFO extremely pleased with conduct and knowledge of captain and crew of survey vessel.
- Snow crab season extensions complicate survey logistics, resulting in additional days being required to complete survey.

Discussion

Question - What is the relationship between survey results and habitat index (temperature)?

Answer - Snow crab are generally found where expected; area well covered by stations, many stations outside suspected range.

Question - How are survey stations selected?

Answer - Carry over from Moncton (fixed), by 10-minute grid; new stations selected "pseudo-randomly".

Comment - Addition of chafing gear on top of net changes weight, therefore performance.

Answer - No it does not, cod-end always on bottom; comments.

SUMMARY OF WORKING DOCUMENT

Working Paper: Choi, J.S., and B.M. Zisserson. 2006. Assessment of the 2005 snow crab resident on the Eastern Nova Scotia Shelf. RAP Working Paper 2006/20.

Referees: Dr. R.K. Mohn, Dr. C. Purchase, and Dr. M.J. Tremblay.

Rapporteurs: M. Covey and A. Reeves.

Abstract

For the 2005 fishing season, landings of snow crab were 562 and 6407 t for N-ENS and S-ENS, respectively. Relative to 2004 landings, this represents a decline of 61 and 24%, respectively. These declines were due to reductions in TACs, which were attained by both areas. Most landings were obtained from offshore areas. Catch rates were 30.6 and 109.4 kg/trap for N-ENS and S-ENS, respectively. N-ENS catch rates have declined 50% relative to 2004 levels, while those of S-ENS have increased marginally. However, due to the removal of sub-area lines, higher catch rates were expected, apriori. The offshore slope areas were minimally exploited. Discard rates of soft-shelled crab were high, as was the exploitation of immature crab.

Mature female numbers have increased from the maturation of the leading edge of juvenile female pulses observed for the past three years. Mature male numbers have declined, resulting in increasingly more balanced sex ratios. The abundance of snow crab on the Scotian Shelf declined in 2005, 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 1200 and 20,800 t, in N-ENS and S-ENS, respectively. They represent declines of 11 and 29%, respectively, even with the large TAC reductions of the 2005 season. Recruitment to the mature fishable biomass expected for 2006 was very low, whereas recruitment to the immature fraction of the fishable biomass is expected to be large. Forecasts of potential future trends indicate that soft-shell incidence will be a major issue in the 2006 season. The 2007 season should see the beginning of a recovery of the fishery.

Due to the: (1) continued declines in fishable biomass, even though exploitation rates were reduced in the 2005 season; (2) Scotian Shelf snow crab entering a reproductive mode with dwindling numbers of large adult males; (3) high likelihood of soft-shell incidence in the 2006 season; and (4) untested nature of the (optimistic) projections of future fishable biomass, a conservative approach to the fishery is recommended for the 2006 season.

Discussion

Comments from reviewers (Chair suggested organizing comments into fishery or survey related, then comments on indicators). All reviewers began comments with positive remarks on the quality of the documents and presentations.

Fishery:

Question - Were DMP logs compared to observer data?

Answer - Yes, logs provide fishery data and compare well with observer data for last two years (only years compared).

Question - Is fishery mortality (e.g., where fishing mortality for CC5=1) instantaneous?

Answer - No, annual; CC5 very low in fishery and survey.

Question - Good document, but must be more clear on data sources; ex. where do we get biomass data from? Percentage soft?

Comment - Regarding Tables 5 and 6 - does not account for natural mortality.

Comment - Regarding potential catch, would yield per recruit models be useful?

Answer - Will try, mortality data limited.

Comment - Documents should contain more emphasis on potential problems with interpretations of catch rate data with respect to abundance. Should emphasize gain from leaving immature of CC2 crab in the water, even a single additional season. Also, should clarify calculated trap hauls reference.

Question (Chair) - TAC refers to landings or catch?

Answer - Landings.

Comments from Floor

Question - Is the estimate (biomass) from kriging confirmed by extra sampling?

Answer - No, not required; misinterpretation of "local neighbourhood".

Question - What measures are needed in S-ENS?

Answer - To be biologically conservative, should reduce exploitation rate (ER) and target only CC3 and 4 (not immature).

Question - Why can ER in Gulf Region be much higher? Why is a larger scale fishery? How can we return to larger size crab?

Answer - More uniform environment and traditionally high recruitment; should allow more CC2 (soft) crab to escape fishery - increase in yield and mating; also do not take immature crab.

Question (FAM) - Referring to page 12, high ER suggested from low percentage of CC5 - is this calculated for just "fishable crab"?

Answer - No, from all of catch (not just landed crab).

Comment - There is more mortality associated with fishing than represented by landings.

Comment - Should provide more figures/tables for data on CC5 crab (see page 12).

Comment - Should conduct port sampling to confirm amount of white crab landed.

Survey:

Comment: Need to show more work (ex. variograms); ex. Table 5 could be 2 tables – break up empirical and model results.

Question - How do changes in habitat index change estimates of biomass index (could you test ranges of input variables beyond know levels or test at extremes)?

Answer - Multiple iterations of variable ranges too time consuming.

Question - How can there be a higher amount of multiparous than primiparous females?

Answer - Multiparous for four years (compared to one for primiparous) - build up; also possible sampling bias.

Question - Regarding survey design, would multiple tows per station reduce sampling variability?

Answer - Variations associated with sampling error overcome by geo-spatial process of kriging (spatial auto-correlation).

Question - Regarding trawl survey, what is the catchability of different size crabs over different bottom?

Answer - 100% for fishable portion over towable bottom, variable for other size groups; in the past only provided numerical indices, this year tried to assess biomass of other portions of population; might not be possible to quantify catchability of various categories.

Question - With respect to temperature ranges, do crab move or die?

Answer - They move; density is inversely proportional to habitat index.

Question (Chair) - Can you "cross validate" previous kriged numbers with measured values?

Answer - Not really feasible.

Comments from Floor

Question - How does adding stations affect stations (e.g., more stations in some grids)?

Answer - If we only looked at means - yes; geo-spatial resolution is more accurate, high cost associated with additional stations would provide minimal benefit; coverage of survey is very good now.

Question - Could time series of various CCs be provided?

Answer - OK.

Critical Indicators (Biomass, Recruitment, ER, Reproduction):

Question - Use to think ENS crab (recruitment) was overflow from Gulf; is ENS now considered closed system?

Answer - Yes, currents, larval transfer, etc. - see previous research document.

Comment - Can consider natural mortality to be effort/F.

Comment - Regarding predictions, need more background for model (goodness of fit, etc.); also suggest looking at Armstrong plots and virtual population analysis (VPA).

Comment - Must clarify definitions of fishable biomass and fishery recruits.

Question - Regarding Fig. 26 in the research document, why are there only error bars on some?

Answer - Some are too small to see.

Comment - Reiterated need for more background for model.

Comment - Why are predictions given to 2010 if you are only comfortable to 2008?

Answer - Again, projections are only to given context of trends; these numbers only represent current level carried through (no recruitment).

Comment - Glad to see comments in text on potential genetic limitations created by a fishery which targets only large, mature males (i.e., mating strategies).

Comment (Chair) - "homework" - retrospective analysis.

Question - Could you provide more info regarding transition matrix?

Answer - 1998 to recent survey data included; catchability ignored - inherent to time series variation.

Comment - Regarding Table 10, to calculate next year's biomass, move up recruitment column 1 row, although it belongs to following year.

Comments from Floor

Question - Could you explain Fig. 27?

Answer - Fishery is more efficient than survey at capturing legal CC3 and CC4 animals.

Question - Are there CC5 females?

Answer - Very low numbers.

Question - Female egg color?

Answer - New eggs are orange, darker as they develop (eyespots).

Question - Why can't CPUE be used to set TAC?

Answer - Refer to presentations and reports; now incorporating catch rates into biomass estimates.

Comment - Predictive model "giant step forward"; ER targets good methodology for management, also should work towards reducing ER on CC2 and immatures (reiterated by many).

Comment - Should increase mesh size (Gulf going to 70mm?) as way to reduce ER.

Question - What is the average size of landed crab?

Answer - Will find and provide.

Day 2 – Species at Risk (SAR) Review (bullets only)

Comment - Add table of size ranges of instars.

Comment - Add new table - total recruits to fishable biomass.

Comment (Chair) - Move context of bullets to recommendations section (or other bullet?) and just provide numbers/rates.

Suggestion - Consider current ER to be maximum to set next years TAC.

Comment - Must check ER numbers - vary in documents.

Comment - Must be cautious of increasing ER on small segment (ex. size increase).

Comments from Floor

Comment - Should provide comments in bullets regarding increase in predators.

Comment - Would like to see potential impact of size increase.

Question - Which biomass numbers will be used (documents differ)?

Answer - SAR values are correct; do not use research document values or projections.

Comment - Should add sources of uncertainty with respect to future recruitment (ex. changes in juvenile survival).

Comment - Matching reduction in biomass with proportionally reduced TAC not effective, actual ER increase for other years (ex. 2005 S-ENS).

Comment: Science advice should come from science.

Comment (FAM) - Appear to be off track with respect to agenda – back to bullets: (1) max. ER current levels!?!; (2) reproductive potential should be maximized, and (3) reduce mortality on CC2 and immatures.

General themes from Day 2 discussion:

- Current level of ER should be considered maximum.
- Industry generally supportive of science recommendations; some comments suggested support regardless of immediate fishery impact, more concerned with long term sustainability.
- Potential mortality (harvesting) of soft and immature (but legal size) crab must be reduced.

The proceedings concluded on Day 2 at 12:00 pm. Discussion and consensus on SAR bullets appeared to be incomplete. A suggestion was put forth to have a mail out of revised bullets for comment by participants, but it was generally agreed that the time frame for advice made this unfeasible, as well as the problem with not having feedback on successive revisions.

APPENDICES

Appendix 1. List of Invitees

Distribution

Mr. Robert O'Boyle, Chairman

Scientific Referees

Dr. Robert Mohn
Bedford Institute of Oceanography

Dr. Craig Purchase
Bedford Institute of Oceanography

Dr. John Tremblay
Bedford Institute of Oceanography

Science Participants

Dr. David Brickman
Bedford Institute of Oceanography

Fisheries Resource Conservation Council (FRCC)

Donald Delaney
Arthur Willett
Jean Guy D'Entremont

Provincial Government

Bruce Osborne
Douglas Johnston
Clary Reardon

DFO Managers

Michael Eagles
Marine House

Gus vanHelvoort
Area Director, ENS Area

Paul Gentile
Area Director, ENS Area

Fishermen's Association Representatives

Bob Anderson
Rep., Area 24
Timothy S. Bagnell
Rep., Area 23

Nellie Baker Stevens
Rep., Area 24

Darrin Baker
Rep., 4X

Virginia Boudreau
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Kevin Green
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Donny Hart
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Anthony Hendricksen
Rep., Area 23

Kelvin Hussey
Rep., Area 23

Bill Hutt
Rep., Area 23

Adolf Kehoe
Rep., Area 25

Paul Kehoe
Rep., Area 24

Josephine Kennedy
Rep., Area 23

Bernie MacDonald
Rep., Area 23

Gordon MacDonald
Rep., Area 23

Harvey MacDonald
Rep., Area 23

Merril MacInnis
Northern ENS

Allan MacInnis
Northern ENS

Neil P. MacMullin
Northern ENS

Herb Nash
Rep., Area 23

Kevin Nash
Rep., Area 24

Philip Nash
Rep., Area 23

Paul Patterson
Rep., Area 23

David Podanovitch
Northern ENS

Ervin Touesnard
Rep., Area 24

Processing Plant Representative

Christine Penney
Clearwater Seafoods Limited Partnership

Science Guest

Jean-Maurice Coutu
DFO, Ottawa

First Nation Representatives

John Amirault
Shubenacadie First Nation

Anita Basque
Chapel Island First Nation

Preston Bernard
Wagmatcook First Nation

Tom Johnson
Eskasoni First Nation

Lance Paul
Membertou First Nation

Adrian Gloade
Millbrook First Nation

Morley Googoo
Waycobah First Nation

Tim Martin
Native Council of Nova Scotia

Survey Vessel Representative

Willard Grover

Observer Company Representative

Troy Quinlan

Oil and Gas Representatives

Noval Collins
CEF Consultants
Patrick Rousell
Coastal Ocean Associates

DFO Science Maritime Region

Dr. Jae Choi
Dr. Ross Claytor
Linda Worth-Bezanson
Alan Reeves
Ben Zisseron
Jim McMillan

Appendix 2. Invitation Letter

Fisheries
and Oceans

Pêches
et Océans

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

Feb 15, 2006

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 8 and 9, 2006 (please see attached Agenda and Remit for the meeting). We would greatly appreciate your contribution as a Scientific Referee.

This meeting will provide results of snow crab stock assessment for the northern 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.

A Science Advisory Report will be prepared at the meeting and the minutes of this meeting will be published as proceedings.

Looking forward to seeing you in March.

Original signed by:

Dr. René Lavoie, Chairman*

* Dr. Lavoie was scheduled to chair the review at the time of mailout. Mr. Robert O'Boyle replaced him.

Appendix 3. Meeting Agenda

**Peer Review of Snow Crab Stocks
Eastern Nova Scotia**

Mic Mac Amateur Aquatic Club,
192 Prince Albert Road, Dartmouth, N.S.

March 8- 9, 2006

Proposed Agenda

Wednesday, March 8	Time	Lead
Introduction	8:30 – 9:00 am	Chair
Oceanographic Overview	9:00 – 9:45	D. Brickman
The Fishery	9:45 – 10:15	B. Zisseron
Health Break	10:15 – 10:30	
2005 Snow Crab Survey	10:30 – 10:45	B. Zisseron
Eastern Nova Scotia CFAs	11:00 – 12:30 pm	J. Choi
Lunch	12:30 – 2:00	
Examination by Referees	2:00 – 3 :00	Chair
Health Break	3:00 – 3 :15	
General Discussion	3:15 – 4:30	Chair
Thursday, March 9		
SAR	9:00 – 10:00 am	Chair
Health Break	10:00 – 10:15	
SAR and Conclusion	10:15 – 12:00 pm	Chair

Appendix 4. Meeting Remit***Eastern Nova Scotia Snow Crab
Crab Fishing Areas 20 - 24***

Meeting of the
Maritimes Regional Advisory Process
8-9 March 2006

Remit**Background**

The snow crab fishery on the eastern Scotian Shelf occurs annually during June to November, dependent upon the Crab Fishing Area (CFA). In support of the fishery, DFO Maritimes Fisheries Management requests Science for an assessment of resource status and the consequences of various harvest levels for the coming fishing season. The current meeting is a scientific review of the assessment and projections undertaken in support of the 2006 fishery.

Objectives

- Assess the status of CFA 20 – 24 snow crab up to the end of 2005, using the following indicators:
 - Abundance
 - Snow crab survey biomass index of males greater than 95 cm (commercial sizes)
 - Recruitment
 - Snow crab survey R-1 relative abundance
 - Exploitation Rate
 - Incidence of CC5 crab in the survey
 - Relative exploitation rate from the survey
 - Report on
 - Commercial catch rates in the 2005 fishery, compared to those in previous years
 - Abundance of female crab from the survey
- Evaluate the consequences of different harvest levels during the 2006 fishery on stock abundance and exploitation rate

Products

CSAS Science Advisory Report for CFA 20 - 24
CSAS Proceedings summarizing the discussion
CSAS Research document

Participation

Participation at the RAP meeting will be solicited from the following:

- DFO Science
- DFO Fisheries Management
- Nova Scotia Government
- Industry

Appendix 5. List of Participants

Participant	Affiliation/Address	Telephone	Fax	E-mail
Fred Kennedy	Area 18	506-387-4972		
Anthony Hendricksen	Area 23	506-674-2242		another.hendricksen@ns.sympatico.ca
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Philip Nash	Area 23	842-0684		pnash@ns.sympatico.ca
Bernie MacDonald	Area 23	737-5430	737-1530	
Herb Nash	Area 23	849-1813	842-9635	
Kelvin Hussey	Area 23	285-2326	285-2657	
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Appendix 6. Reviewers Written Comments**COMMENTS FROM SCIENTIFIC REFEREES**

Referee: Robert Mohn, DFO – Bedford Institute of Oceanography, Dartmouth, Nova Scotia

The authors are complimented on good preparation and presentation of their science.

From a reviewer's perspective, the main problem with the draft research document was that the authors did much more work than they showed. The missing steps and analysis could not be critically reviewed. The author's Markov chain model had some very attractive elements, mainly the fusion of q (the catchability) and M (natural mortality) into the transition probabilities, thereby obviating the need to estimate them separately. Also, many of the standard outputs for stock assessment (mostly from finfish traditions) would have been helpful to summarize and communicate results. A few which come to mind are Armstrong Plots (a one-year projection of SSB and exploitation over a range of harvests), yield per recruit analysis and perhaps some risk plots. Yield per recruit is a standard means to assess the interaction among growth, natural mortality and harvest rates and the isopleths it provides would be useful in assessing the trade-offs between harvest intensity and minimum size of capture. I have arranged with Dr. Choi to discuss the development of some of these models for snow crab.

As well as the manuscript itself, the presentation at the RAP were well done and made lucid often complicated analyses. I agree with a comment made at the meeting that the (PowerPoint) presentations should have been made available and where possible the figures should match those in the ResDoc.

A few specific points:

Tables of the model results would have helped. I am thinking of numbers and biomass at age (or instar) and year. These tables then could have been extended for the projection period and 'cohorts' could have been followed from the data through the projections.

There were insufficient diagnostics for the fits of the various models, e.g. goodness of fit values, residuals, etc.

Take more care on what comes from data and what comes from model and how well one fits the other. As an example the growth curves in Figure 6. What is the data these are based on? How well were the fit?

Once the growth model is determined, the survey and catch data could be sliced into age blocks and even an untuned VPA would give some insights into the catchability as a function of size.

The standard term for catch over a biomass index is relative fishing mortality, not exploitation rate as in Figure 39 and elsewhere.

Referee: Craig Purchase, DFO – Bedford Institute of Oceanography, Dartmouth, Nova Scotia

General impression

The snow crab team are to be commended for putting together a very thorough system to monitor the status of the stock.

The working document contains the necessary breath and depth to report on this work, but does need some modification.

Recommendations

I agree with the recommendations of this document

Major concerns relating to the science

I do not have any major concerns pertaining to the content of this document nor the science that went into preparing it.

1-Abstract

1. Line 3. The declines were at least partially due to reductions in TACs. The way it is worded, it seems that is the only way possible.
2. Third line from the bottom, what is a reproductive mode?
3. Last paragraph. Should it be 2005 season?

4-Ecology and life history

1. Page 3, para 2, line 1. What is O. Fabricius????
2. Page 3, para 2, line 4. If at 7 degrees, metabolic costs match gain what happens to the crab? Do they die or do they move?
3. Page 3, para 3, line 3. Aren't "other worm-like invertebrates" also "small benthic invertebrates"?
4. Page 3, para 3, line 5. The second Hyas should be H.
5. Page 3, para 3, line 6. There is a) missing after modiolus
6. Page 3, para 3, line 10. What is a morphometrically mature crab?
7. Page 3, para 4, line 1. The order of importance of predators, is this by species or by individuals?
 - This list is for large/medium crabs, not larvae
8. Page 3, para 4, line 4. "...thorny skate have suggested they have the capacity to control..."
9. Page 3, para 4, last line. Does the differentially targeted mean they were targeted more or less?
10. Page 3, para 5, last line. This statement is strange. How does one look at an adult crab and give a CW of APPROXIMATELY 57.4mm? That is a very precise measurement, but gives a fairly broad range in fecundity.
11. Page 4, para 1, line 3. "Eggs hatch from April to June and larvae become pelagic, feeding upon plankton for 3 to 5 months"
12. Page 4, para 2, line 8. What is the legal size?
13. Page 4, para 3, line 2. In para 2, it is said that moulting takes place in the spring, and then here it says mating occurs in December while the shell is still soft. This doesn't really make sense.
14. Figure 2. Why are there 2 peaks? Why doesn't the X axis scale continue below 50? The title says biomass but the Y axis is not biomass. Number of stations and trap hauls are apples and oranges.

15. Figure 4. The Y axis is not biomass, but the title refers to it as such. Degrees are missing from the X axis label
16. Figure 5 is too complicated for the description given. I do not follow what is going on here.
17. Figure 6. Why are there no error bars?
18. Page 4, para 2, 3 lines from the bottom. The body is still probably primarily water (as even a human is) in the hard shell phase

5-The fishery

1. Page 5, para 3, line 4. to the south-east should be in the south-east
2. Page 5, para 3, line 6-7. “.....fishing grounds outside of the traditional fishing areas”
3. Page 5, para 3, line 8. Figure 9 does not show the additional allocations that are referred to.
4. Page 5, para 3. Why not show the TACs?
5. Page 5, para 4, last line. “TACs and total landings.....”
6. Page 5, para 4, last line. What is the % change from 6919 to 6968?
7. Table 2. Why is the season considered extended when no original end date is given?
8. Figure 8. I do not agree with showing this figure unless there are more substantial warnings that the temporal relationships are not trustworthy
9. Figure 9. The bars are higher than the Y axis
10. Figure 10. The colour is of too low quality to clearly see the points.
11. page 5, para 2, line 3. It took me a while to figure out that the 93,000 t is all snow crab from all of Canada
12. Figure 17. Are landings actually kg? Is this per trip or per boat???

6-Methods

6.1-Analytical tools

1. Page 5, last para, line 1. What is GMT?
2. Page 5, last para, last line. If these were not kriged wouldn't it be better to tell us now what kriging is, instead of later on?
3. Page 6, para 1. The explanation for the analytical tools is inadequate to enable an understanding of what was done.
4. Page 6, para 2, last line. Computing total trap hauls by dividing landings by catch rate seems to be

6.2-Fisheries data

1. Page 6, para 3, last line. Why is there a difference in observer coverage?
2. CPUE – I have issues with the way in which catch rates are presented in this document. CPUE is a function of catchability (influenced by many factors) and population size. If catchability is not constant then CPUE is totally inappropriate for comparing temporal or spatial trends in abundance (if that is not the intention it is still a problem if the appearance is there). Even if catchability is constant, spatial variability in density creates other major problems with CPUE. For instance, if crabs follow an ideal free (or despotic) distribution, then CPUE in prime habitats may be constant over time even if the total population is continually declining.
 - a. Plots of catch rates are very powerful visual tools, and when trends cannot be trusted this can be a big concern. I suggest either removing them altogether, as they cannot be interpreted as presented, OR for every situation where they are presented make a clear warning statement that temporal or spatial trends CANNOT be made.
 - b. Page 6, para 2. The catch rates are biased indicators as discussed.
 - c. Page 10, para 2, line 4-5. this comes up again here, catchability changes and therefore temporal comparisons of CPUE cannot be made

6.3-Research survey data

1. Page 7, para 1, line 3. use instead of used
2. Page 9, para 2, line 3. what are the individual variables?
3. Figure 14. Y axis has different precision on the top versus bottom two panels
4. Figure 11. The data points are not clear
5. Page 7, para 3, line 1. Direct inter-annual comparisons of the data are made difficult. This is a very important point. Either the data should not be presented in a manner in which one makes a temporal connection OR for every situation where multiple years are presented there should be clear warning statements where temporal trends CANNOT be made (e.g., pre and post 2002)
6. Catchability of the trawl is assumed to be 100%. However large and not so large crabs occur in different habitats and the trawl is likely not as efficient in all areas. Therefore, if large crabs do have a catchability of close to 100% then the survey results for them are likely more accurate than the results for smaller crabs, which based on catchability would be relatively higher.
7. The survey description on pages 6-7 is clear and impressive
8. Page 8, equations 4 and 5. ex ratios - These are not sex ratios, as the definition usually pertains. Sex ratio would be $\text{num F} / \text{num M}$, not the proportion of the entire catch that is F. Even if you wanted to call these sex ratios, you should indicate that they are female oriented or biased sex ratios
9. Page 9, para 1. If I understand correctly, you get a mean density of crabs and apply it to all areas. If temperature influences total area, then you assume more suitable area (temp) will mean more crabs? I need more explanation on this as I don't know what happens to crabs if the temperature is not appropriate. Do they die, or do they move to a desired temperature?
10. Page 9, para 4, line 2. If I understand this correctly, there are a mean number of crabs per square km. I would assume that the number of crabs is very variable spatially, so wouldn't it be better to take a geometric mean instead of an arithmetic mean?
11. A 5 minute tow in 389 stations is a great deal of work but doesn't seem like a lot of raw data when variability among stations is likely to be very high. Some of that variability is going to be real, and some will be sampling variability. It appears to me that the greatest time and costs involved with the survey are related to moving between stations, etc. If say two (or more) 5 minute trawls were done immediately after each other in the same area, the additional time for the extra trawl should be relatively very small. A mean value would cut down on some sampling variability and thus the survey estimates could be improved. The catches of both trawls could even been pooled before sampling to reduce processing effort, and still get a large improvement.

7-Environmental conditions

1. Page 10, para 3, line 2. Figure 13 should come before 15
2. Figure 15. What do the error bars represent?

8-Fishery performance

8.1-Effort

1. Figure 16. I see the reduction of effort inshore, but I do not see the increase offshore
2. Page 11, lines 1-2. suggest rewording to remove a respectively

8.2-Landings

1. Page 11, para 2. The wording of the first few lines is awkward

8.3-Catch rates

8.4-Discard rates and soft-shelled crab

1. Page 11, last para. The reference to Figure 10 doesn't make a whole lot of sense, as the figure doesn't show anything in relation to the proportion of the quota that was observed.
2. Page 12, first line. The sentence implies that the discard is entirely due to undersized crabs, is this true?
3. Page 12, para 2, lines 1-4. These first sentences are awkward
4. Page 12, para 1 and 2. It is unclear to me whether the mortality on discards is referring to only soft-shell or undersize as well

8.5-Carapace condition in observed data

1. Page 12, para 5, last sentence. I think this should be given more attention. Expand on why harvesting virgin crabs of poor meat yield and is problematic. Ok, I see it. However, there should still be some mention of their age and the likelihood of them surviving for one extra year, versus a new crab surviving that long from egg.
2. Figure 19. The colour coding for this figure doesn't come out clear enough to enable me to see the different groups
3. Page 12, para 4, last line. Doesn't the comment about very low levels of CC5 males being indicative of high exploitation rates depend on whether one is referring to a low percentage versus a low number? A low percentage could easily be due to a recruitment pulse.

8.6-Landings of immature snow crab

1. Page 13. The analyses of the immature discards are very useful and informative. They could be a more detailed description of exactly what was done here.
2. Table 5 and 6.
 - a. How was the survey and fishery performance combined to make numerical abundance?
 - b. I fail to see how there can be a 100% exploitation rate over several years and still something there to catch in the next year
3. Table 7 appears before Table 6 in the text
4. Table titles generally appear on the top not bottom

8.7-Summary

1. Page 13, summary. Landings of CC1 and CC2 were significant. However, the term significant could refer to an overall small biomass, the landings of these crabs were substantial and thus a problem needing to be addressed

Resource status

1. I like the way you have put together the sections on resource status

9.1-State variables

Size structure

1. Page 14, para 2, last sentence. It is not that there won't be any significant natural mortality, just no significant extra natural mortality than what normally takes place

Sex ratios

1. Page 16. I was glad to see the inclusion of the comment about harvest selection and populations evolving to a smaller size. This is not an issue that should be dismissed because it doesn't have an immediate effect.

2. Page 15, Figure 23. “This more balanced sex ratio may be indicative of the ENS crab entering an important reproductive mode” What is a reproductive mode? I think you meant to say that the stock is entering a phase where high reproductive output is expected.
3. I am surprised to see such a large spatial segregation of males and females. What causes this?
 - a. How much do they move?
 - b. How is sex determined? If it is temperature driven for example, are the pockets due to temperature variability in different areas, and the crab stay in the same area from settlement until reaching maturity
4. Page 15, first line. Very low sex ratios is uninformative, what you are really trying to say is that a very small proportion of the population were females.
5. Figure 22. What are the error bars based on? Spatial variation?
6. Choi 2004 is not in the reference list
7. Figure 24 appears before Figure 23 in the text
8. Page 15, para 2, line 9. What does differential predation have to do with catchability of the trawl?

Numerical abundance

1. Page 16, para 3. I do not see the consistent decline of immature male crab in Fig 30. Perhaps you should be specific about the time period referred to.
2. How does one tell if a crab has skipped moulting?
3. Page 16, para 4, line 2-3. How can early maturation increase the number of crab?
4. Page 16, para 2, line 2. Figures 28 and 29 are not immature females as the text implies.
5. Page 16, para 2, line 2. How can an increase in total mature females be due to an accumulation of older multiparous females who must have already been mature?
6. Several panels on figure 26, and none of Figure 29 are mentioned in the text
7. Figures 30-31, 32-33, 34 are condensed too much to see what is going on.

Fishable biomass

1. Page 16, last para. How was fishable biomass determined?
2. page 16, last para, Figure 35. If there has been virtually no recruitment into the fishery for several years (Figures 30 to 33), and 100% fishing mortality (Tables 5 and 6) on what was there, how can there be any fishable biomass at all? I am probably missing something, but if so that is an indication that the text may not be clear enough.

9.2- Inputs and outputs

Recruitment

1. Page 17, para 1. The suggestion that the Scotian Shelf snow crab population may stabilize due to an increase in the number of mature females is true based in theory what would be expected to happen. I think it is important to point this out, as there is no guarantee that this will happen.
2. Page 17, para 1, line 8. Reproductive system would be more accurately described as reproductive potential
3. Page 17, para 1, line 12. Reword the sentence beginning with However

Natural mortality

1. Page 17, para 2, last line. What is meant by the turnover rate of crab?

Fishing mortality

9.3- Scenarios and decision rules

1. Page 18, para 4, line 1. I don't follow what that statement refers to. How was this done?
2. The scenarios, decision rules, and summary all seem appropriate.

9.4 – Summary

10-Other considerations

Appendix

1. Page 72, para 1, line 5. I think it would be better to say 11 years or more, than 9 years or more from the time of settlement.
2. Page 72, para 1. I suggest rewording the second last sentence
3. Page 72, para 2, last line and Figures 42 and 43. One cannot say there is a trend in increasing biomass based on two years.
4. Page 73, para 2, line 3. overlaps

OTHER

1. I did not see Tables 9 and 10 in the text
2. There is no reference in the text to the appendix
3. How does one tell a primiparous female from a multiparous female?
4. I would have liked to see line numbers on the draft document, as it would make it easier to make these suggestions.

Referee: John Tremblay, DFO – Bedford Institute of Oceanography, Dartmouth, Nova Scotia

The document provides good ecological context for the snow crab population on the Scotian Shelf and the authors have introduced innovative approaches and analytical tools for evaluation. I like the fact that the entire Scotian Shelf is included (rather than doing 4X in a separate document).

While all the pieces are here I found it a challenge in some places to discern what exactly was done. Clear definitions and more elaborations are needed in several areas. Graphics are generally of high quality and very efficient but some changes to shading are needed in some of the figures.

The main points of the document are (i) continued declining biomass of commercial sizes in the next 1-2 years; (ii) a strengthening in the numbers of females and pre-recruits; (iii) soft-shelled crab likely to be in increasing portions of the trap catch in the coming years. I think these points are well substantiated and I agree.

I will provide a marked copy to Jae. Section by section points follow.

3. Introduction.

Useful to provide a bit more context here. The analytical approach has evolved since the assessment mandate was transferred from GFC to BIO. Can you summarize in a paragraph?

4. Ecology & life history

Generally comprehensive. Provide reference for habitat association indicated in last sentence of paragr. 1

p. 4 paragr. 2.

The impression is that growth is quite invariant among individuals. Is this really the case? For lobster it is thought that different individuals from the same year class will reach legal size over several years.

Is it known that skip-molting only occurs in the molt prior to terminal molt? Reference?

The reference to Fig. 5 is helpful but I think another figure delineating actual size ranges of instars.

With regard to understanding what's coming in to the fishery I'm not sure instars are as helpful as the scheme that has been used by others for some years e.g.l:

- R-4: 56-69 mm CW - adolescent at the time of the survey.
- R-3: 69-83 mm CW - adolescent at the time of the survey.
- R-2: 83-94 mm CW - adolescent at the time of the survey
- R-1: CW \geq 95 mm adult with a soft-shell at the time of the survey.

This scheme could be added here or in the research survey section.

6.3 Research Survey data

p. 7, paragr. 4. Were the Netmind data ever used to reject tows in the field and/or in the office? Or was it always obvious during the survey when a tow needed to be repeated?

p. 8-9. Most probable snow crab habitat and extrapolation to predict biomass ----

I assume the survey usually went beyond this calculated area...any cases where snow crab were found outside of it? If so how was this accounted for?

p. 9 last paragr. Need to elaborate here on exploitation rate estimates...something like "Exploitation rates for exploited size classes were then estimated by dividing the landings per size class (from observer measurements applied to landed catch) in year i by the estimated abundance during the survey in year $i-1$." Also helpful to note assumptions and biases: Exploitation rates would be over-estimated if there was mortality or emigration; exploitation rates would be underestimated if there catchability in the trawl was low relative to traps and/or if there was immigration.

Clarify definition of fishable biomass & consider calling it something else ("Survey biomass of CC2-5"?). I gather it refers to those crab above the legal size that are not in Carapace Condition (CC) 1 (durometer reading $<$ 68) during the survey. This differs from the Gulf Fisheries Centre term "biomass index" which referred to adult males only.

Along the same lines it would be helpful if recruitment was defined.

7. Environmental Conditions

The estimated snow crab potential habitat has fluctuated strongly (decline by 45% from 2004 to 2005). Do you think that the crab respond that quickly? I suspect not but there are probably few crab outside of the “core habitat” (say < 3-4 C) in any case. What are the consequences to the biomass estimate of using this fluctuating habitat to extrapolate to? Have you looked at what the effect would be of using (i) a constant area; (ii) different temperature and depth limits?

Have you been able to demonstrate increased density when the potential habitat area shrinks?

8.3 Catch rates

Authors note that catch rates in SNS were expected to remain high because of a contraction in snow crab range (higher temps). Can the area fished be quantified and did it decrease?

8.4 Discard rates and soft-shelled crab

Clarify that observed means observed at-sea. It is in the methods but a reminder doesn't hurt.

p. 12 paragr. 2. soft-shell was “21% by biomass”. What biomass do you mean? The weight of legal sizes captured on the observed trips?

8.5 Carapace condition in observed data

Suggest changing to “Carapace condition determined during trips with at-sea observers”. OR just “Carapace Condition”

Define fishable crab. The percentages cited do not match what is in the Fig. 19. Re Fig. 19 and other histograms: alter the pattern/shading so that the classes can be more clearly seen.

8.6 Landings of immature snow crab

Section title should match the previous one i.e., same data source but different category of crab. Suggest “Immature crab captured during trips with at-sea observers” or just “Immature Crab”

Agree strongly with contents of this. Could yield/recruit be calculated directly? Targeting mature crab only would require a claw gauge.

8.7 Summary

“Landings of recently-matured (CC1-CC2) was significant”. Clarify what you mean by landings. I take it this is the at-sea observer data so it is what came up in the traps & does not say anything about landings (retained & brought to shore).

9.1 State variables

Fig. 20 & 21. Revealing figures. Ability to see modes develop and progress lends confidence in the survey & the interpretation.

paragr. 1 last sentence. Projections also assume no skip-molting?

Sex ratios

Fig. 22 caption. Modify to reflect increasing trend in recent years.

Paragr 2. "Stabilization of such strong oscillations in abundance into the future would be prudent"

This may be over-selling what management can do. Suggest changing to "Reducing such strong oscillations...."

Paragr. 2. Does the Inshore concentration of immature females & offshore of immature males hold for the smallest sizes? Any suggestions as to how this might arise? Unlikely to be due to differential drift. Does the literature suggest any migration of small juveniles? Differential survival related to sex?

Numerical abundance

Fig. 26- 1998 is excluded ---rationale?

Fishable biomass

Important: Include a clear and concise definition of fishable biomass (biomass at time of survey of male crab > 95 that are not CC1?).

See comment/questions earlier about effect on biomass estimates of using a variable snow crab habitat.

9.2 Inputs and outputs

Recruitment

"Unfortunately the Scotian Shelf snow crab's reproductive system has been in poor condition..."
Not a very precise statement. Modify to indicate that females were in low density and larval production on the Scotian Shelf was likely low.

Notion of stabilizing recruitment...evidence indicates population will likely continue to cycle and management can only dampen.

Natural mortality

Can you comment on natural mortality of legal sized animals by comparing survey abundance across years and accounting for fishery removals?

Fishing mortality

Recount assumptions about exploitation rate estimates.

9.3 Scenarios and decision rules

Agree with the points in this section.

rephrase the 1st sentence. Sounds like the indicators themselves are not useful.

Re fishable biomass definition and inclusion of immature animals. Why not provide two estimates, one excluding the immature animals (i.e., adult males > 95 only)?

What is the soft-shell protocol? Was it actually used? Has there been an evaluation?

9.4 Summary

“Fishable biomass continued to decline with the immature segment of the landed catch becoming a rather significant portion of the total landings”

-Definition of fishable biomass important again, as is a clarification that the immature crab were in the traps of trips observed at-sea, not necessarily in the landed portion.

10. Other considerations

snow crab as top-level predators?

How might Misaine Bank act as a refuge for snow crab from predators (aside from the fishery)?

“The snow crab population is currently in a critical state”.

To me this statement suggests the population is in danger... Is this the meaning you want to impart? With the signs of recruitment I don't think the population is in a critical state but I agree that the future population's health is very sensitive to how the fishery is prosecuted in the coming years. There are some critical management decisions to be made regarding how best to protect the incoming recruitment.

11. Recommendations

Agree with this section for the most part.

Paragr. 3 “Little additional recruitment into the mature segment...into the foreseeable future”. Clearly the increased recruitment will lead to increases in the number of mature crab (unless they are fished before becoming mature...). I think you could take a stab at when in the future, particularly when statements are made about poor recruitment beginning in the early 2010's because of low female abundance in the early 2000's (p. 15).

Last sentence & reference to stabilization...again I think this may be raising expectations. Snow crab population cycles might be dampened but stocks on the Scotian Shelf are unlikely to be stabilized.