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Proceedings of the Offshore Lobster (LFA 41), Jonah Crab and Rock Crab Stock Assessments Meeting Regional Advisory Process Maritimes Region

February 7-11, 2000
Wandlyn Hotel, Halifax, Nova Scotia

E. Kenchington, Chairperson

Department of Fisheries and Oceans
Bedford Institute of Oceanography
PO Box 1006
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B2Y 4A2

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ABSTRACT

The Offshore Lobster (LFA 41) and Jonah and Rock Crab Stock Assessments Meeting was held at the Wandlyn Inn, Halifax, Nova Scotia from February 7-11, 2000. The terms of reference for the meeting requested an update on the status of the lobster resource in the LFA 41 management area; a resource which had not been fully reviewed since 1995. Further, a number of questions were asked concerning the interactions between lobsters in LFA 41 and those in the inshore areas, particularly LFA 34. Those were addressed through reviews of data on larval distributions and tagging studies. Preliminary results from a model of larval drift off southwest Nova Scotia were also presented. Additionally, the exploratory fisheries for Jonah and rock crabs from Cape Breton to the Bay of Fundy were reviewed with regard to the sustainability of current fishing practices. In total, nine working papers were presented over the five days. Seven of those will be prepared for publication as Research Documents. Stock Status Reports summarizing these fisheries will also be produced.

RÉSUMÉ

Des réunions d'évaluation des stocks de crabe commun, de crabe nordique et de homard de haute mer (ZPH 41) ont eu lieu au Wandlyn Inn de Halifax (Nouvelle-Écosse) du 7 au 11 février 2000. Les participants avaient pour mandat de mettre à jour l'état du stock de homard dans la zone de gestion ZPH 41, stock qui n'avait pas fait l'objet d'un examen intégral depuis 1995. Par ailleurs, diverses questions se posaient au sujet des interactions entre les homards de la ZPH 41 et ceux des zones côtières, en particulier de la ZPH 34. On les a traitées en examinant les données sur la distribution des larves et sur les expériences de marquage. On a également présenté les résultats préliminaires d'un modèle de dérive des larves au large du sud-ouest de la Nouvelle-Écosse. De plus, on a procédé à un examen de la pêche exploratoire du crabe commun et du crabe nordique du Cap-Breton à la baie de Fundy, pour déterminer la viabilité des méthodes de pêche actuelles. En tout, neuf documents de travail ont été présentés au cours des cinq jours de réunion. Sept d'entre eux seront publiés sous forme de Documents de recherche. Des Rapports sur l'état des stocks rendant compte sommairement de la situation des ressources en question seront également produits.

INTRODUCTION

The Offshore Lobster (LFA 41) and Jonah and Rock Crab Stock Assessments Meeting was held at the Wandlyn Inn, Halifax, Nova Scotia from February 7-11, 2000 and attended by 43 participants (Appendix 1). Letters of invitation (Appendix 2) were sent to a scientific review panel of eleven recognized experts in relevant fields, as well as to thirteen authors/coauthors and scientific observers, seven government observers and twelve industry observers. The meeting schedule is presented in Appendix 3.

The terms of reference for the meeting (Appendix 4) requested an update on the status of the lobster resource in the LFA 41 management area; a resource which had not been fully reviewed since 1995. Further, a number of questions were asked concerning the interactions between lobsters in LFA 41 and those in inshore areas, particularly those in LFA 34. Those were addressed through reviews of data on larval distributions and tagging studies. Preliminary results from a model of larval drift off southwest Nova Scotia were also presented. Additionally, the exploratory fisheries for Jonah and rock crabs from Cape Breton to the Bay of Fundy were reviewed with regard to the sustainability of current fishing practices. In total, nine working papers (Appendix 5) were presented over the five days. Seven of those will be prepared for publication as Research Documents. Stock Status Reports summarizing these fisheries will also be produced.

Each working paper was assigned at least two reviewers who were to be given the paper in advance of the meeting. One author presented the salient points of the paper after which the chairman asked the assigned reviewers for comments. Those were addressed by the author and, if appropriate, by others at the table. When the reviewers had completed their questioning, questions from the observers were entertained. In some cases, reanalysis of data was asked for before the results could be accepted. All such new results were presented on the last day of the meeting. Consensus wording of the summary conclusions for the Stock Status Reports was developed by committee. There was no official rapporteur. Notes taken by the Chairman and by one of the authors (Cheryl Frail) formed the basis of this report. No minority reports were filed, although an opportunity was given to all participants to do so. A list of research recommendations in included in Appendix 6. Written comments provided by the reviewers are presented in Appendix 7.

Offshore Lobster (LFA 41)
Stock Structure

1. Knowledge of lobster stock structure in the Gulf of Maine and the evidence of linkages between various offshore and inshore areas.

There is a need for some assumption of stock structure when assessing lobster resources. The review panel and observers felt that reference to the “LFA 41 lobster stock”, and questions regarding various metrics and reference points to this unit of the resource are misdirected and lead to an inability to evaluate current information. The effects of population biology and interactions of the fisheries should be considered in relation to a biological stock, not a

management region. To discuss measures of lobster status (e.g., mortality, egg production, or size structure) on a portion of the resource defined by biologically-arbitrary boundaries leads to erroneous conclusions, because the effects of events in adjacent management areas are decoupled. A more appropriate approach would be to determine the status of stock units, and then attempt to address the effects of individual management components, using the stock as a focal point.

Remit: Is there an exchange or migration of lobster larvae between coastal, midshore and offshore areas?

- **Based on knowledge of larval behaviour and oceanographic conditions, what is the pattern of larval drift from known hatching areas on Browns, George's and German Bank, and Lobster Bay?**
- **What is the likely contribution of larvae hatched on Browns and George's Bank to settlement in offshore, midshore and nearshore areas?**

Working Papers:

G. Harding, K. Drinkwater, P. Vass, J. Pringle, A. Fraser, J. Prena, J. Loder, C. Hannah and J. Shore (2000). Ecological and distributional studies on larval lobster in relation to their dispersal in the Canadian sector of the Gulf of Maine. *DFO RAP Working Paper* 2000/01.

J. Loder, C. Hannah, J. Shore, K. Drinkwater and G. Harding (2000). Modelling lobster larval drift off Southwest Nova Scotia. *DFO RAP Working Paper* 2000/02.

Referees: Fred Page, Department of Fisheries and Oceans, St. Andrew's, N.B.
Chris Taggart, Oceanography Department, Dalhousie University, N.S.

Larval lobster studies to date indicate that there is prolific lobster larval release inshore throughout much of the Canadian sector of the Gulf of Maine. However, settling-stage lobsters (Stage IV) are notably absent or in reduced numbers in nearshore waters in Lobster Bay. Further offshore, Stage IV lobsters appear to be ubiquitous but with higher densities observed off the northern edge of Georges Bank and along the warm water side of a cold water front that extends from Browns Bank northwards past German Bank and Lurcher Shoals. Larvae in these warmer waters are also in better physiological condition, judging from their relative lipid energy reserves. Previous studies and surveys indicate that the cold water front off southwestern Nova Scotia presents a barrier to larval penetration into the inner German Bank and into Lobster Bay, at least in the surface layers. There is some indication from past surveys that settling stage larvae are distributed towards shore on either side of Lobster Bay, near Cape Sable and Cape Forchu.

Present lobster management areas bear no relationship to the distribution of the resource, which appears to be determined by water depth, temperature and availability of shoal areas for moulting, mating, extruding eggs and hatching larvae.

A **3-dimensional numerical model** of the mean summertime circulation of the southwestern Scotian Shelf and Gulf of Maine, including the average climatological density field, mean wind forcing and the M_2 tides, was used to investigate possible drift patterns of lobster larvae. The

model did not include nearshore areas with depths shallower than 10 m and the coastline was highly idealized. However, the model currents capture the primary observed circulation features over the continental shelf.

Particles were injected into the model at four known lobster release sites (northern Georges Bank, southwest Browns Bank, German Bank and the Lobster Bay vicinity). These particles were then passively advected by the climatological circulation either at 10 m depth or in one of two near surface flow fields (currents averaged over 0-1 m or 0-5 m) for upwards of 60 days. Particles that reached the model shoreline were assumed to remain there. Modelled drift showed strong dependence upon the vertical and horizontal release positions. Wind direction had an important effect on the particle drift tracks, especially those particles released within the top 5 m. The model does not yet include realistic time-dependent winds or any life history strategies of the lobster larvae (vertical migration, depth-dependent stages, temperature-dependent stage durations, or possible directional swimming of stage IV larvae).

If the lobster larvae behaved as passive particles, then 30-day particle tracking at a constant depth layer by the climatological circulation model suggests very few lobster larvae released on northern Georges Bank are transported towards southwest Nova Scotia or into the central Gulf of Maine. Most of the larvae in the upper 5 m on **Georges** are advected offshore to the eastward while the vast majority of those released at 10 m remain on the Bank. Lobster larvae released in the upper 5 m on southwestern **Browns Bank** are advected predominantly eastward to the Scotian Shelf or else offshore. The majority of larvae released at 10 m are transported to LFA 34 seaward of the 60 m isobath. Most of the lobster larvae released in the upper 5 m on **German Bank** are advected into the inshore area of St. Marys Bay, whereas those released at 10 m move to the mouth of the Bay of Fundy or are advected to the southwestward off the coast of Maine. The majority of the larvae released in the top 10 m at the outer reaches and within the confines of **Lobster Bay** remain in the inshore region with the majority being advected to the St. Marys Bay area. Releases at 10 m also showed a significant number advected into the Bay of Fundy and to the coastal region of Maine. Significant numbers of larvae released at all three depths remain within the inshore area between Cape Sable and Cape Forchu, including Lobster Bay. This, coupled with the lack of larvae advected into this region from the other three release areas suggests that the primary source of larvae in the Bay may be local production.

The predominant seaward circulation in the near-surface layers offshore of the Bay, as indicated by both the model and observations from drift bottles and drogued buoys, provides further support for the conclusion that few lobster larvae are likely to be advected into Lobster Bay from offshore locations. Drift bottles released offshore, however, were regularly collected from the areas east of Cape Sable and north of Cape Forchu. The model also indicates convergence and strong northward flow associated with a hydrographic front located approximately over the 75 m depth contour offshore from Lobster Bay. This too contributes to the difficulty of moving inshore for larvae released seaward of the front.

The above conclusions regarding possible lobster larval drift and potential settlement areas from the model must be viewed with caution because of the idealized flow fields, the lack of time-dependent winds and the absence of lobster larval behaviour. These will be modelled in future studies under the CLAWS II program.

Remit: Is there an exchange or migration of juvenile and/or adult lobsters between inshore and offshore areas?

- **What are the movement patterns of juvenile and adult lobsters tagged in offshore, midshore and nearshore areas?**
- **Can existing tagging data provide estimates of exchange rates? If so what are they? If not, what further work is needed?**

Working Paper:

P. Lawton, D.S. Pezzack, M.B. Strong and D.A. Robichaud (2000). Benthic movement as a component of stock structure in Gulf of Maine lobsters. *DFO RAP Working Paper* 2000/03.

Referees: Michel Comeau, Department of Fisheries and Oceans, Moncton, N.B.
Trevor Kenchington, Gadus Associates, Musquodoboit Hbr., N.S.
Joseph Idoine, National Marine Fisheries Service, Woods Hole, MA

There is an extensive published literature on **movement** of lobsters in the Gulf of Maine area, as revealed by mark-recapture studies, that contributes to our present understanding of stock structure in the Gulf of Maine. However, use of that literature faces several difficulties. Most published studies have used broad size categories to analyze movement (e.g., < 95 mm; > 95 mm carapace length). Most historical studies have examined movement by periods at large that are not explicitly partitioned with respect to open fishing seasons in the potential areas where returns were to be expected. Although there is general consistency within successive papers by particular authors, analytical approaches and presentation of results vary between studies.

Long-distance movement (> 50 nautical miles; 92.6 km) is generally restricted to large lobsters, and may involve recaptures up to 5 years following release. There is clear evidence for interchange between adjacent areas in the nearshore, as well as for dispersal from nearshore and midshore release sites off southwestern Nova Scotia and in the Bay of Fundy, to offshore fishing grounds and U.S. fishing grounds. There is generally little evidence for return movement to the nearshore following offshore dispersal, although one U.S. tagging study showed significant movement from Jordan Basin into nearshore areas. Interchange between offshore bank and basin areas occurs, including indications of long-distance migration within the offshore area.

Movement between different depths (both inshore and offshore) has been linked to requirements for particular thermal regimes to complete reproductive development, although there may be some inter-annual variability in the timing and extent of such movement. Offshore, Browns Bank is an area where lobsters migrate onto shoal areas over summer months. The Closed Area on Browns Bank does not fully encompass this seasonal movement range of the lobsters.

The working paper reported on a consolidation (not yet completed) of historical data into a single relational database and geographical information system that will permit future reanalysis at multiple spatial and temporal scales. Emphasis in the current paper was placed on reporting basic recapture data for a series of hitherto unpublished Canadian studies in offshore areas. Those yielded more than 6000 recaptures from releases in seven offshore localities, but showed very few returns within LFA 34 and none from the Bay of Fundy (LFA's 35, 36, and 38) or LFA

33. A total of 19 LFA 34 recaptures occurred from releases in Crowell Basin, Browns Bank Closed Area and SE Browns. No inshore returns were reported from releases in Corsair Canyon, NE Georges, Georges Basin or SW Browns Bank. The recapture series was not decomposed into recapture periods immediately following release. However, substantial movement of lobsters from LFA 41 into the exploited resources in LFA 34 appears very unlikely. However, they may enter that area in the summer and withdraw before the LFA 34 season opens in November.

Historical data are not amenable to the derivation of quantitative estimates of exchange rates. This is due to the application of diverse experimental designs in the original studies (some of which were targeted at questions on lobster growth as opposed to movement), and lack of comprehensive information on the distribution of fishing effort and tag reporting rates contemporary with the tagging studies. Additionally, with time-at-large of more than a few months, the basic mark-recapture approach used in historical studies does not permit discrimination between residents and return migrations, except where multiple recaptures of the same individual lobster are involved, as is the case with a number of studies involving berried lobsters.

As mentioned previously, seasonal closure of the LFA 34 fishery encompasses a period between June and November during which inshore movement of lobsters from midshore and offshore areas could occur, but may not be identified through returns from commercial fishing activity. Seasonal depth-related migration in the offshore, and movement between offshore banks may be resolvable as the fishery in LFA 41 is prosecuted year-round, and high-resolution data exists on the distribution of fishing effort. Resolution of the question of seasonal inshore movement by midshore and offshore lobsters may require directed trapping studies outside the regular commercial season. It was recommended that alternate approaches be used to examine lobster movement such as following waves of lobsters using detailed catch rate data or through morphometric or genetic approaches.

Remit: What do we know about lobster stock structure in the Gulf of Maine?

- **What do past studies of genetic, electrophoretic and morphometric data indicate about the stock structure**

Working Paper:

D.S. Pezzack, P. Lawton, C.M. Frail, M.B. Strong, D.A. Robichaud, R. Claytor, P.J. Carroll and R.A. Valiente (2000). Status and health of the LFA 41 fishery and offshore lobster stock. *DFO RAP Working Paper* 2000/04.

Referees: Matt Jones, Biology Department, Dalhousie University, Halifax, N.S.

A table compiling the few published results on the **genetic structure** of the American lobster was presented. The reviewer felt that all of the genetic work published to date is inconclusive due to the techniques used and the small sample sizes employed. A project is currently underway which will provide a more comprehensive assessment of genetic structure in this species, however results will not be available until 2001-02. Morphometric and meristic data show potential in discriminating stocks.

The Fishery

2. Status and health of the LFA 41 fishery and offshore lobster stock in support of the 2000-2001 fishery.

Remit: Has the fishery affected the size of the LFA 41 lobster stock? (Fishing down a stock typically reduces catch rates.)

- **What is the trend in catch rate data, 1980-1998?**
- **Is the trend indicative of a change in stock size or are there other possible causes?**
- **Do the US and Canada research groundfish trawl surveys indicate a change in stock size?**
- **Are there changes in the distribution of fishing effort indicative of changes in stock size?**
- **What is the trend in fishing mortality (F)?**

Working Paper:

D.S. Pezzack, P. Lawton, C.M. Frail, M.B. Strong, D.A. Robichaud, R. Claytor, P.J. Carroll and R.A. Valiente. 2000. Status and health of the LFA 41 fishery and offshore lobster stock. *DFO RAP Working Paper* 2000/04.

Referees: Jeff Hutchings, Biology Department, Dalhousie University, Halifax, N.S.
Bob Mohn, Department of Fisheries and Oceans, Dartmouth, N.S.
Trevor Kenchington, Gadus Associates, Musquodoboit Hbr., N.S.
Joseph Idoine, National Marine Fisheries Service, Woods Hole, MA
Michel Comeau, Department of Fisheries and Oceans, Moncton, N.B.

Catch rates (kg/trap haul) were analyzed for the fall-spring (Oct. 8 - Apr. 7) and spring-summer seasons of the 1985-86 to 1998-99 fishing years, using a multiplicative model with main effects being area, season and fishing year. Data for August and September 1999 were not available and hence full year data were not analyzed. However, the fall-spring period represents the majority of the catches and the highest catch rates and the authors believed events in that season to be indicative of trends the fishery. These data were analyzed for the whole of LFA 41 and latterly, for each of five areas within this larger unit.

The development of Jonah crab bycatch during and after 1995-96 resulted in significant changes in effort, grounds and fishing strategies which have complicated the analysis of the CPUE data. In the analysis only “full lobster” trips were used, while all trips with any crab bycatch were discarded.

The reviewers were not confident in the analyses of the catch rate data. They felt that the data selection process and analytical protocols might have introduced a pronounced bias into the analyses. For example, no attempt was made to separate the catch rates of the various boats and crews, thereby confounding differences among the fishing powers of the boats with changes in the calculated catch rates of the fleet. It was recommended that vessel information be used as a main effect in future multiplicative modeling. Further, the discard practices of the vessels were

felt to be an important factor, particularly if there was a tendency to discard all crabs when lobsters are abundant but to retain some crabs when lobsters are too scarce to provide a full load from even a lobster-directed trip. Soak time was another factor not included in the analyses. Further, it was pointed out that the data collected were landings data and not actual catch data and so differences in culling over time may have affected the catch rate index. It was recommended that interviews with the captains take place in order to establish their past fishing patterns and practices.

With respect to the analyses, the fact that no residual patterns were observed (a point stressed in the presentation) might only be a function of the large number of parameters in the analyses and not assurance of the appropriateness of the model to the data. Further, it was felt that outliers should not be removed, as they may be informative, e.g., if they are clustered in one geographic area. In reanalysis, each of the five areas should be analyzed separately as there is no rationale for combining areas; combining areas will introduce confounding factors due to differing movement behaviour of the animals in the different areas in winter. It was suggested that the data could be subdivided into categories of crab catch, which would be analyzed separately, rather than excluding all data where crab were landed. A suggestion of using trips with less than 50% crab caught was proposed and expanded to suggest three categories for analyses of 0%, 1-50% and 50%+ crab or removal from the data set of dedicated crab boats. A suggestion that crab bycatch be incorporated into the model as either an effect or covariate was also made. In terms of presentation the reviewers felt that plots of catch vs. effort were not meaningful; plots of CPUE vs. catch and/or effort are more informative. Most of the reviewers provided extensive written comments on these concerns (Appendix 7).

During the course of the meeting *a major discrepancy* was identified between the data presented in Tables 1 and 5 of the working paper, especially with respect to Area 4 within LFA 41. The data therefore required reanalysis before any conclusions could be drawn. During this reanalysis, the data were analyzed separately for each of the five areas, and for all areas combined. This was one of the recommendations arising from the meeting. Unfortunately, by the time this reanalysis was presented, only one of the original reviewers was present. However, the results were circulated to the other reviewers for comment.

The review panel also noted that the data should be viewed as **two catch rate series** and that *only the results from the last four years* should be examined. Technological changes in navigation and depth sounders may have increased effective effort in recent years compared to those of the early 1980s. Conversely, prior to the removal of trap limits in 1994 trap hauls may have been under estimated by 20-50%. After 1994-95 effort reporting improved and present log records accurately report the number of traps fished. In 1995-96 the Jonah crab bycatch was introduced creating a two species fishery with some vessels targeting crab while others fishing both crab and lobster. As a result, there are difficulties in comparing recent catch rates with those from earlier years. When the data were reanalyzed a separate analysis consisting of only data from the 1994-95 to 1998-99 period was therefore performed. This indicated that the 1998-1999 CPUE was 50% or less than that of 1996-1997 and 20-100% less than the 1994/95-1997/8 mean and were the lowest observed since 1994. Percentage differences in each area between the 1998-99 catch rates and the mean of the 1994-95 to 1997-98 seasons ranged from -184% to –44%.

Interpretation of these trends was further exacerbated by statements regarding the preliminary analysis of the fall 1999 LFA 41 landings, which were the highest ever observed in this fishery. If the corresponding catch rates are also high the negative signals put out by the current trends may prove to be largely determined by cold bottom temperatures in 1998 and 1999, which have since returned to normal conditions. Given all of these factors it was recommended that the catch rate analysis be revisited during the next lobster RAP, scheduled for the fall of 2000.

The meeting agreed on a consensus statement on catch rates:

> We have just come through a period where we have seen catch rates drop while the TAC has not been caught despite an increase in effort. Therefore we should be cautious over the short term.

American groundfish trawl surveys indicate no change in lobster abundance on Georges Bank and an increasing trend in much of the Gulf of Maine over the last 15-20 years. The increase is consistent with the recruitment pulse observed in lobsters stocks in the northwest Atlantic in the 1980s and 90s. Canadian groundfish survey data were not used in any analyses due to inconsistent reporting of lobsters over time.

In the absence of survey data and knowledge of population size structure, estimates of **fishing mortality (F)** and **total mortality (Z)** rates are not available. However the high average sizes suggest that Z is relatively low. The total mortality rate is a combination of **natural mortality (M)**, directed fishing mortality in LFA 41 and fishing mortality in other fisheries, both lobster fishing in other areas (e.g., LFA 34, USA) and bycatch. It is not possible to separate out the directed LFA 41 fishing mortality rates.

Remit: Is there any evidence of change in biological characteristics for the LFA 41? (Fishing down a stock should change these indices.)

- **What is the trend of sex ratio in the offshore fishery and from samples in the US research survey? What are likely underlying causes for this?**
- **What is the trend in size frequencies and median size in the offshore fishery and from samples in the US research survey? What are likely underlying causes for this?**

Working Paper:

D.S. Pezzack, P. Lawton, C.M. Frail, M.B. Strong, D.A. Robichaud, R. Claytor, P.J. Carroll and R.A. Valiente (2000). Status and health of the LFA 41 fishery and offshore lobster stock. *DFO RAP Working Paper* 2000/04.

Referees: Jeff Hutchings, Biology Department, Dalhousie University, Halifax, N.S.
Trevor Kenchington, Gadus Associates, Musquodoboit Hbr., N.S.
Joseph Idoine, National Marine Fisheries Service, Woods Hole, MA
Michel Comeau, Department of Fisheries and Oceans, Moncton, N.B.

Sex ratios in LFA 41 catches shifted in the late 1970's to early 1980's with an increase in the proportion of females. Such ratios are consistent with moderate fishing under the partial

protection for females provided by the ban on landing berried lobsters. It was noted that the percentages of males determined from the American groundfish trawl surveys were higher than those reported for the commercial LFA 41 catches.

It was recommended that the sex ratio data be broken into size groups to see the proportional shifts within each. This was seen to be important since large male lobsters are required to mate with the large females, and large deviations from 1:1 sex ratio also have the potential to lower genetic diversity in the population.

Data on the **average size** and **size distribution** of males and females by area and quarter were also presented. However it was pointed out during the meeting that *data were missing* for some quarters on Georges Bank. The size distribution has remained relatively stable on most grounds (Georges Bank, SE Browns and Georges Basin) since the fishery began in 1972. The most stable size frequencies are observed on Georges Bank, SE Browns and in Georges Basin. SW Browns and Crowell Basin have more inter-annual variability, with the median size decreasing during the last few fishing seasons. This decrease appears to be due to a larger proportion of the catch constituting smaller sizes and no significant change was noted in the general distribution at larger sizes.

There is seasonal variation in the size structure in the areas that border LFA 34 and in the U.S. fishery.

The shift in median size could result from a number of causes such as seasonal movement of animals through the grounds, change in size-related catchability due to the recent cold water conditions, a recruitment pulse increasing the numbers in the smaller sizes (as observed in the Bay of Fundy fishery), or subtle changes in fishing practices, areas and gear. The review panel was concerned that this trend might indicate that the fishery was increasingly tapping into immature or first time spawners. A long-term stability in the overall size distribution could arise through a combination of several factors:

- the fishery may be having little impact on the population,
- size structure may be a dynamic response to patterns of offshore dispersal of lobsters, and
- catchability and trap selectivity may mask changes in the population size structure.

It was recommended that these data be analyzed by examining the changes over time within size groups. It was noted that the females are returned to the water; therefore it is possible that the data includes multiple captures of the same animals. Using only non-berried females in the data set would alleviate but not solve this problem.

The percentage of the catch in the first moult group (moult groups based on average female growth increment of 11 mm) ranges from 13% in Crowell Basin to 0.7% on Georges Bank. This contrasts with most coastal lobster fisheries that have >70 % of the catch in the first moult group. The large median size, which is one to three moult groups (11-33 mm) above the size of 50% maturity, and the wide size distribution in the catches mean that a high percentage of animals reproduce at least once prior to capture and most reproduce twice.

The report also included **Q-Q plots** of the size distribution. Some showed a decrease in the number of larger animals over time (e.g., Crowell Basin 1st quarter females, 1998 vs. 1987),

however just about every possible pattern could be seen amongst the many comparisons presented. It was recommended that the Q-Q plots be used to examine specific questions rather than in the exploratory fashion presented in the report.

3. What are the implications of linkage between offshore and inshore lobster on the management of the western Nova Scotia lobster fishery?

Remit: Is there evidence that the expanded midshore lobster fishery of LFA 34 has had any impact on the LFA 41 fishery?
Remit: Is there any evidence that the LFA 41 fishery has had any impact on the LFA 34 fishery?

- **What are the comparative landings trends for LFA 34 and LFA 41?**
- **Is there any evidence of impact on the size structure or sex ratios of these fisheries?**

Working Paper:

D.S. Pezzack, P. Lawton, C.M. Frail, M.B. Strong, D.A. Robichaud, R. Claytor, P.J. Carroll and R.A. Valiente (2000). Status and health of the LFA 41 fishery and offshore lobster stock. *DFO RAP Working Paper* 2000/04.

Referees: Trevor Kenchington, Gadus Associates, Musquodoboit Hbr., N.S.
Joseph Idoine, National Marine Fisheries Service, Woods Hole, MA
Michel Comeau, Department of Fisheries and Oceans, Moncton, N.B.

There is no evidence that LFA 41 fishery has affected the landings in LFA 34. LFA 34 landings have increased from 3000t in 1976 to over 13,000t in 1998-99 while the offshore landings have remained relatively constant, averaging 600t. While accurate information on the extent of midshore LFA 34 landings does not exist, it is possible that they exceed those of the offshore in the Crowell-West Browns Bank area where the grounds exploited by the two fisheries abut. The midshore fishery has developed since the early 1980's and could have an effect on size and catch rates of lobsters in parts of LFA 41. The midshore size structure is similar to the offshore but detecting changes is difficult because of the lack of a time series of sampling.

Remit: What is the relative importance of the nearshore, midshore and offshore resources to the overall egg production?

- **What is the relative impact of the nearshore, midshore and offshore fisheries on egg production?**
- **What is the egg per recruit (e/r) estimates under different levels of linkage?**
- **What has been the impact of historic shifts in exploitation rates on the e/r levels?**

Working Paper:

D.S. Pezzack, P. Lawton, C.M. Frail, M.B. Strong, D.A. Robichaud, R. Claytor, P.J. Carroll and R.A. Valiente (2000). Status and health of the LFA 41 fishery and offshore lobster stock. *DFO RAP Working Paper* 2000/04.

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Joseph Idoine, National Marine Fisheries Service, Woods Hole, MA
Michel Comeau, Department of Fisheries and Oceans, Moncton, N.B.

Most of the questions in this remit *were not addressed* at the meeting as no data were presented. The **egg per recruit** level was addressed in the Working Paper but that material was not presented fully to the meeting. The reviewers did not provide written comments on this topic. The importance of the offshore and the various inshore LFAs to the overall egg per recruit level of the Gulf of Maine area is one of the topics of the fall 2000 Gulf of Maine RAP. At that time these remit questions will be more fully addressed.

Remit: How has the introduction of the offshore Jonah crab bycatch provisions affected the offshore lobster fishery?

- **Has there been a change in the timing and distribution of the fishery?**
- **Have the changes had any impact on lobster catches?**

Working Paper:

D.A. Robichaud, D.S. Pezzack, P. Lawton, C. Frail, M.B. Strong and D. Duggan (2000). Review of Jonah Crab, *Cancer borealis*, fishery in Canadian offshore Lobster Fishing Area 41, 1995 to 1999. *DFO RAP Working Paper* 2000/09.

Referees: Joseph Idoine, National Marine Fisheries Service, Woods Hole, MA
Michel Comeau, Department of Fisheries and Oceans, Moncton, N.B.

The authors concluded: 1) the introduction of the **Jonah crab fishery** resulted in expansion of areas fished (most of the new area saw crab directed effort), 2) the crab fishery has not resulted in any major changing of timing of the lobster fishery, which is determined by availability, markets and proportion of TAC caught, and 3) the crab fishery has complicated assessments as trips can be directed for crab or lobsters or both.

The review panel identified *major discrepancies* in the data calling for reanalysis of the bycatch data. Assessment of the magnitude of this error during the course of the meeting suggested that approximately 100t were not entered into the database. It was established that the document would be presented again and sent out to the reviewers for comment.

Separately, the following points were made:

- It is critical to include all of the available information, excluding data with lobster landings severely reduces the data set.

- In the King Crab fishery there is a high deck-related mortality of females; this could be an issue for this species and may require research.
- How are directed trips evaluated? What are the criteria used in data selection and were they consistent over time (authors unable to answer this question, leading to discovery of error).
- The reproductive biology of this species requires more research and should be incorporated into the interpretation of size distribution data. It has been shown that generally larger males mate with smaller females however not enough is known of mating behaviour.

Jonah and Rock Crab Stock Assessments

The review of the crab stock assessments identified many common themes. It is clear that, for every fishery except the LFA 33 Jonah crab fishery, the lack of information on what is believed to be a substantial crab bycatch by the lobster fishery prevents any assessment of sustainability. We lack basic biological information on these animals to define stock boundaries. Further, we know very little about their reproductive and early life history biology required to permit interpretation of fishery statistics. Until this situation is remedied, biologically-based TACs cannot be calculated.

Remit for all Papers:

- **What is known about rock and Jonah crab stock structure.**
- **Landings and catch rate trends including bycatch by the lobster fishery where possible.**
- **What is the long-term sustainability of these fisheries? Can they be managed by reference points or, in the absence of reference points, is the 'Traffic Light' approach an appropriate assessment method for these fisheries?**
- **A statement or assessment of ecosystem considerations i.e. impact on the ecosystem, species interactions and food chain considerations.**
- **Evaluation of science needs to provide a biologically-based quota for the offshore Jonah crab bycatch fishery (and assessment of impact on the inshore Jonah crab fishery).**
- **Recommendations on seasons, trap types and design, trap numbers, minimum carapace sizes (currently, there are different practices from area to area). Provide comment on whether or not there is room for increased effort and whether or not the current licences should be converted.**

Eastern Nova Scotia (LFAs 27-32)

Working Papers:

M. J. Tremblay (2000). Review of rock and jonah crab distribution off eastern Nova Scotia and the Gulf of Maine, with notes on stock structure. *DFO RAP Working Paper* 2000/05.

M.J. Tremblay and A. Reeves (2000). Rock crab off Eastern Nova Scotia: Stock Status and Evaluation of Exploratory Fishery. *DFO RAP Working Paper* 2000/06.

Referees: Peter Koeller, Department of Fisheries and Oceans, Dartmouth, N.S.
Michel Biron, Department of Fisheries and Oceans, Moncton, N.B.

Richard Wahle, Bigelow Marine Laboratory, Maine, USA

Rock crab landings by the directed fishery off Eastern Nova Scotia (**LFAs 27-32**) increased five-fold from its inception in 1994 to 1999. Removals of rock crab by the lobster fishery as a bycatch and as bait are difficult to quantify but could easily equal those by the directed fishery. Until these removals are known, the biological sustainability of the directed fishery cannot be evaluated.

There are contrary indicators of rock crab stock status in Eastern Nova Scotia based on the trap catches by the directed fishery. Assuming that trap catch rate is an index of abundance, there are areas of local depletion of rock crab. However in these same areas the **size composition** of the rock crab catches did not change from 1996-1999, suggesting that exploitation has not altered rock crab size structure, assuming such a change would be detectable by traps.

In the directed fishery, more fishing **effort** (e.g. increased participation rates, additional permits or additional traps) should be targeted to lightly fished areas to better evaluate the potential for a rock crab directed fishery.

The reviewers raised a number of issues (Appendix 7), many of which had previously been raised with respect to lobsters (see above). In particular, it was emphasized that not enough was known about the early life history, reproductive biology and behaviour of these crabs to advise on fishery impacts. We do not have enough information on these species to state where the **stock boundaries** are likely to be, although the offshore rock crab population appears to have a disjunct distribution from the inshore stocks and could be a separate unit.

The **traffic light** approach was addressed and the review panel thought that there was some misunderstanding in the remit concerning its application to fisheries with little or no data. It was recommended that J. Tremblay and D. Pezzack join a DFO working group established to review this approach to fisheries management.

Other issues raised include:

- How does the productivity of rock crab compare with that reported in the Gulf?
- Can CPUE be used as an indicated of abundance?
- Does trap saturation occur?
- How does the minimum size designation compare to the onset of maturity?
- How do we weight different indicators in the “Traffic Light” approach?
- Where are the small males? Do they not enter the traps?
- Is there movement within or between LFAs?

As far as the directed fishery is concerned, **management provisions** such as trap design should remain flexible to reflect the developing nature of this fishery. More study is needed of trap designs that limit lobster bycatch. More fishing effort (e.g. increased participation rates, additional permits or additional traps) should be targeted to lightly fished areas to better evaluate the potential for a rock crab directed fishery.

Jonah Crab on the Scotian Shelf (LFA 33)

Working Paper:

B. Adams, A. Reeves and R. Miller (2000). Exploratory Jonah Crab, *Cancer borealis*, Fishery in Lobster Fishing Area 33 (1997-1999). *DFO RAP Working Paper* 2000/07.

Referees: Michel Biron, Department of Fisheries and Oceans, Moncton, N.B.
Richard Wahle, Bigelow Marine Laboratory, Maine, USA

A short-lived, directed Jonah crab fishery operated on the Scotian Shelf in 1983-84. The present exploratory fishery in LFA 33 began in 1997 with 13 active participants. From 1997 to 1999 **landings** of Jonah crab in LFA 33 averaged 159 t per year, **catch per unit effort** (CPUE) from logbook data averaged 2.8 kg per trap haul, and effort averaged 54,000 trap hauls. Catch rates remained stable across months within years and among years from 1997-99, however reviewers raised concerns over the interpretation of the CPUE figures. It was recommended that CPUE be calculated across a common area so as to compare inter-annual variation. Further, there was discussion of the influence of fishing practices (especially in a new fishery such as this), gear type and temperature on CPUE. It was recommended that the CPUE be divided into series based upon the above.

Crab **size frequencies** remained uniform from 1997 to 1999 and were in close agreement with sizes obtained by a trap fishery in the early 1980s. Assuming catch rates indicate relative abundance and traps are sensitive to changes in **size composition**, these data suggest low fishing impact on the stock to date. Hard-shelled males of commercial size averaged 54% of crabs caught.

Bycatch of other species is extremely low due to gear type and geographic location. For example, only one lobster, one snow crab, 23 red crabs and no cod or haddock were captured in 6000 trap hauls. Conversely, this species does not constitute a significant portion of the bycatch of other fisheries in this area and so it is the one stock for which the data are amenable to analyses.

There is no biological basis for lowering the **minimum size** from 130 to 121 mm carapace width. Decreasing the size of escape gaps increased the weight of legal catch by only 6%, while increasing the female-catch by one-third.

As with the other crab stocks, the stock boundaries for Jonah crab are not known and so interpretation of the data from landings in LFA 33 cannot be used to assess sustainability or to determine biologically-based TACs at this time.

Southwest Nova Scotia and New Brunswick and the Bay of Fundy (LFS 34, 35, 36, 38)

Working Paper:

D.A. Robichaud, P. Lawton and M.B. Strong (2000). Exploratory fisheries for Rock Crab, *Cancer irroratus*, and Jonah Crab, *Cancer borealis*, in Canadian Lobster Fishing Areas 34, 35, 36, and 38. *DFO RAP Working Paper* 2000/08.

Referees: Michel Biron, Department of Fisheries and Oceans, Moncton, N.B.
Richard Wahle, Bigelow Marine Laboratory, Maine, USA

Jonah crab landings in the exploratory fishery in Southwest Nova Scotia **(LFA 34)** peaked at 146 t in 1997. Preliminary landings in 1999 were 119 t. Based on logbook analysis, annual average **catch rate** ranged between 4.1 and 4.8 kg. per trap haul (kg/trap haul) from 1996 to 1998 and increased to 6.3 (kg/trap haul) during the 1999 season. Reported landings of Jonah crab under the **bycatch** provision in the inshore lobster fishery surpass those of these new exploratory fisheries. Removals through this bycatch and in the bait fishery are considered to be underestimated. This was recognized as a major impediment to the assessment of the exploratory crab fisheries. Until the quantity of Jonah crab removals by the lobster fishery is evaluated, biological **sustainability** of the directed fishery cannot be evaluated. However, risks of overfishing of Jonah crab by the directed fishery are low given current effort levels and the high protection for broodstock provided by minimum-size regulation.

Jonah crab landings in **LFA 38**, after addition of four more permits in 1998, increased to 61 t. Preliminary landings, in 1999 were 51 t. Based on logbook analysis, annual **catch rates** ranged between 4.8 and 6.5 kg/trap haul from 1995 to 1999.

Although no commercial concentration of **Jonah crab** was found in **LFA 35**, preliminary exploratory fishing results (up to 0.7 kg/trap haul) in the southwestern part of LFA 36 shows some potential. Based on at sea sampling of trap contents, monthly mean size of males and females were larger in LFA 34 than in LFA 38. This is due to different trap types and smaller minimum legal size in LFA 38. **Lobster bycatch** in the inshore Jonah crab fishery is negligible.

Commercial concentrations of **rock crabs** were found in only a few specific areas: St. Marys Bay (**LFA 34**), Annapolis Basin (**LFA 35**) and off southwestern New Brunswick (**LFA 36**). Removals of rock crab as a bycatch in the lobster fishery are currently underreported but in LFAs 34 and 35, landings statistics have shown that bycatch of rock crab surpassed landings from the directed fishery in 1999. Until the quantity of rock crab removals by the lobster fishery is better documented, biological **sustainability** of the directed fishery cannot be evaluated. Risks of overfishing of rock crab by the directed fishery are low given current effort levels and the high protection for broodstock provided by minimum size regulation.

Based on logbook analysis, annual **catch rates** were higher in Annapolis Basin (from 5.6 to 8.1 kg per trap haul) compared to St. Marys Bay (from 1.7 to 4.3 kg/trap haul) and southwest New Brunswick (from 2.3 to 3.5 kg/trap haul). Data collected to date are insufficient to detect trends.

Based on **at-sea sampling** of trap contents, monthly mean **size** of males and females were similar in all areas and between years. The percentage of berried females in the traps was low (<2 %).

Lobster bycatch, as reported in logbooks from the inshore rock crab fishery, was a problem in St. Marys Bay (LFA 34) and Annapolis Basin (LFA 35), during 1996 and 1997. However, generally low numbers of lobsters per trap haul were reported during 1999 (< 0.01). In limited sea sampling in St. Marys Bay and Annapolis Basin (4 samples), the number of lobster per trap haul was 0.1 and 0.4 compared to 0.2 and 2.0 in 1996, respectively. Fishermen added that illegal lobster fishing in St. Marys Bay also contributes to the under-reporting of crab, and that the bait fishery is substantial in some areas.

The reviewers felt that the crab fisheries in these areas have similar constraints to their assessment as the rock crab fishery in Eastern Nova Scotia. All of the problems identified in that Section apply here.

Appendix 1. List of Participants

Participant	Affiliation/Address	Telephone	Fax	E-mail
Gareth Harding	DFO Oceans/Maritimes Region	902-426-2692		HardingG@mar.dfo-mpo.gc.ca
Jack MacLean	Clearwater	902-875-2018	902-875-3108	jmaclean@cffi.com
Roger Meisner	Clearwater	902-656-2414	902-656-2379	rmeisner@cffi.com
Ian Dempsey	DFO, Science/Maritimes Region	902-426-7815	902-426-1862	dempseyi@mar.dfo-mpo.gc.ca
John Tremblay	DFO Science/Maritimes Region	902-426-3986	902-426-1862	tremblayj@mar.dfo-mpo.gc.ca
Alan Reeves	DFO Science/Maritimes Region	902-426-4999	902-426-1862	reevesa@mar.dfo-mpo.gc.ca
Bruce Osborne	NSDFA	902-424-0352	902-424-4671	osbornbd@gov.ns.ca
Robert Miller	DFO Science/Maritimes Region	902-426-3108	902-426-1862	millerr@mar.dfo-mpo.gc.ca
Michael Eagles	DFO Fisheries Management/Maritimes Region	902-426-7239	902-426-3986	eaglesm@mar.dfo-mpo.gc.ca
Renee Valiente	DFO Science/Maritimes Region	902-426-2273	902-426-1862	valienter@mar.dfo-mpo.gc.ca
Patrick Carroll	DFO Science/Maritimes Region	902-426-2273	902-426-1862	carrollp@mar.dfo-mpo.gc.ca
Cheryl Frail	DFO Science/Maritimes Region	902-426-5448	902-426-1862	frailc@mar.dfo-mpo.gc.ca
Doug Pezzack	DFO Science/Maritimes Region	902-426-2099	902-426-1862	pezzackd@mar.dfo-mpo.gc.ca
Paul Fraser	Cold Water Fisheries Ltd	902-862-3102		
Neil Morse	Grand Manan Fisheries Association	506-662-8668	506-662-3742	
Klaus Sonnenberg	Grand Manan Fisheries Association	506-662-8481	506-662-8336	gmfa@compuserve.ca
Laurence Cook	Grand Manan Fisheries Association	506-662-3414	506-662-8460	shadrack@nbnet.nb.ca
David Robichaud	DFO Science/Maritimes Region	506-529-5931		robichaudd@mar.dfo-mpo.gc.ca
Peter Lawton	DFO Science/Maritimes Region	506-529-5919		lawtonp@mar.dfo-mpo.gc.ca
Ashton Spinney	LFA34 Lobster	902-643-2490	902-643-2654	
L. Wayne Spinney	LFA34 Lobster	902-645-2564	902-645-3456	melanjo@klis.com
Jeff Hutchings	Biology Department, Dalhousie University	902-494-2687	902-494-3736	Jeff.Hutchings@dal.ca
Michel Biron	DFO Science/Gulf Region	506-851-6046		BironM@dfo-mpo.gc.ca
Michel Comeau	DFO Science/Gulf Region	506- 851-6136		ComeauM@dfo-mpo.gc.ca
Joseph Idoine	NMFS, Woods Hole, MA	508-495-2217		jidoine@whsun1.wh.whoi.edu
Matt Jones	Biology Department, Dalhousie University	902-494-2260		mwjones@is2.dal.ca
Trevor Kenchington	Gadus Associates, Musquodoboit Hbr, NS	902-889-9250	902-889-9251	gadus@istar.ca
Peter Koeller	DFO Science/Maritimes Region	902-426-5379	902-426-1862	KoellerP@mar.dfo-mpo.gc.ca
Bob Mohn	DFO Science/Maritimes Region	902-426-4592		MohnR@mar.dfo-mpo.gc.ca
Fred Page	DFO Science/Maritimes Region	506-529-8854		PageF@mar.dfo-mpo.gc.ca
Richard Wahle	Bigelow Marine Laboratory, ME	207-633-9659	207-633-9661	rwahle@bigelow.org
Eric Roe	Clearwater	902-443-0550	902-443-8443	Eroe@cffi.com
Jim Jamieson	DFO Fisheries Management/Maritimes Region	902-426-8981	902-426-9683	Jamiesonj@mar.dfo-mpo.gc.ca
Winfred Risser	LFA 33 Jonah Crab/Lobster	902-766-4030		Wrisser@ns.sympatico.ca

Participant	Affiliation/Address	Telephone	Fax	E-mail
Chris Jones	DFO Fisheries Management/Maritimes Region	902-426-1782	902-426-9683	Jonesc@mar.dfo-mpo.gc.ca
Greg Roach	NSDFA	902-424-0348	902-424-4671	Roachg@gov.ns.ca
Anne Harrington	DFO Fisheries Management/Maritimes Region	506-529-5850	506-529-5858	Harringtona@mar.dfo-mpo.gc.ca
Greg Kenney	DFO Conservation and Protection/Barrington	902-637-2851		KenneyG@mar.dfo-mpo.gc.ca
Beth Guptill	DFO Conservation and Protection/Pubnico	902-762-2978		GuptillB@mar.dfo-mpo.gc.ca
Jamie Small	Grand Manan Fisheries Association	506-662-3591	506-662-3591	
Odette Murphy	DFO Fisheries Management/Maritimes Region			MurphyO@mar.dfo-mpo.gc.ca
Ken Drinkwater	DFO Science/Maritimes Region	902-426-2650		DrinkwaterK@mar.dfo-mpo.gc.ca
Ellen Kenchington	DFO Oceans/Maritimes Region	902-426-2030	902-426-1862	Kenchingtone@mar.dfo-mpo.gc.ca
Ross Claytor	DFO Science/Maritimes Region	902-426-4721	902-416-1862	Claytorr@mar.dfo-mpo.gc.ca

Appendix 2. Invitation Letters

Maritimes Region
Science Branch
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, Nova Scotia B2Y 4A2

January 26, 2000

Distribution

Subject: DFO peer review of 1) offshore lobster stock assessments, 2) evidence for exchange or migration between inshore and offshore Lobster in Southwest Nova Scotia, and 3) Rock and Jonah Crab stock assessments

The assessments of offshore lobster, evidence for their interaction with the inshore, and assessments of Rock and Jonah Crab stocks in Maritimes Region will be reviewed in Fleet Room A, Wandlyn Inn, Bedford Hwy, Halifax, February 7-11, 2000. The phone number for the hotel is 902-443-0416. Hot beverages will be provided in the mornings and afternoons, and the hotel restaurant is open for meals. All participants will have a table setting and there are ample electrical outlets for computers.

The purposes of peer review are: to examine the scientific approaches of the stock assessments; to identify any weaknesses in methodology or data quality; to help improve the clarity of assessments; to ensure that any conclusions are well supported; and to make research recommendations where appropriate.

The following will be evaluated in support of fisheries management decisions on the Southwest Nova Scotia offshore lobster resources: 1) knowledge of lobster stock structure in the Gulf of Maine and the evidence of linkages between various offshore and inshore lobster stocks, and 2) status and health of the LFA 41 fishery and offshore lobster stock in support of the 2000-2001 fishery. Background information on LFA 41 lobsters can be downloaded from the DFO web site at: http://www.ncr.dfo.ca/csas/csas/status/Invert.htm

Rock and Jonah Crab are presently exploratory fisheries. The 1996 Emerging Fisheries Policy states that conversion of exploratory to commercial licences may occur once sustainability of the fishery has been demonstrated. DFO Fisheries Management requires information on the appropriateness and timeliness of conversion of all or a portion of the current exploratory licences to regular limited entry licences in 2000. To determine whether or not current fishing activities are sustainable and to provide scientific advice on this issue to management, the following resources will be reviewed: LFA 27 Rock Crab, LFA 29 – 32 Rock and Jonah Crab, LFA 33 Jonah Crab, LFA 34 Jonah Crab, LFA 34 & 35 Rock Crab, LFA 36 – 38 Rock and Jonah Crab, the offshore ENS directed Jonah Crab fishery, and the bycatch Jonah Crab fishery in LFA 41.

Copies of the draft assessments and the draft stock status reports will be sent to the referees by the authors one week before the meeting to allow them time to become familiar with the material when possible. Others wishing advance copies should contact the authors directly. At the meeting, science staff will provide a brief overview of their

assessments, which should include the main conclusions, the supporting evidence, any new methods, and major limitations. The presentation will be followed by comments from the designated scientific referees and then from any of the observers. Finalised stock status reports will be prepared at the meeting if time permits. Otherwise, copies will be sent to all members of the review panel for comment prior to submission. The minutes of this meeting, including minority views, will be published as a proceedings document. All scientific reviewers are asked to send their comments to Ellen Kenchington electronically (Kenchingtone@mar.dfo-mpo.gc.ca) for inclusion in the proceedings. Reviewers are encouraged to contact the authors directly for clarification of points prior to the meeting.

We greatly appreciate your contribution to this valuable exercise.

Original was signed by Ellen Kenchington on January 25, 2000

E. Kenchington
Regional Advisory Process Meeting Chairman

c.c. : M. Sinclair
R. O'Boyle
M. Chadwick

Distribution:

Scientific Referees/ Review Panel	***Scientific Observers/Authors***	***Government Observers***	***Industry Observers***
Michel Biron, DFO	Patrick Carroll, DFO	Ron Cronk, NB	Bernie Berry
Michel Comeau, DFO	Ross Claytor, DFO	Mike Eagles, DFO	Bernd Christmas
Jeff Hutchings, Dalhousie	Doug Cook, Dalhousie	Jim Jamieson, DFO	Paul Fraser
Joseph Idoine, Wood's Hole	Ken Drinkwater, DFO	Chris Jones, DFO	Louise Goodwin
Matt Jones, Dalhousie	Cheryl Frail, DFO	Bruce Osborne, NS	Jack McLean
Trevor Kenchington, Gadus Associates	Gareth Harding, DFO	Carol Ann Rose, DFO	Calvin Mallock
Peter Koeller, DFO	Peter Lawton, DFO	Tim Surette, DFO	Roger Meisner
Bob Mohn, DFO	John Loder, DFO		Winfred Risser
Fred Page, DFO	Bob Miller, DFO		Eric Roe
Chris Taggart, Dalhousie	Doug Pezzack, DFO		Klaus Sonnenberg
Richard Wahle, Bigelow	Alan Reeves, DFO		Ashton Spinney
	David Robichaud, DFO		Offshore Lobster Captain
	John Tremblay, DFO		

Contact Information for Referees and Authors:

Scientific Referees and MS Number(s) being Reviewed	***Email***	***Telephone***
Michel Biron, DFO (5,6,7,8)	BironM@dfo-mpo.gc.ca	506-851-6046
Michel Comeau, DFO (3,4,9)	ComeauM@dfo-mpo.gc.ca	506- 851-6136
Jeff Hutchings, Dalhousie (4)	Jeff.Hutchings@dal.ca	902-494-2687
Joseph Idoine, Wood's Hole (3,4,9)	jidoine@whsun1.wh.whoi.edu	508-495-2217
Matt Jones, Dalhousie (4)	mwjones@is2.dal.ca	902-494-2260
Trevor Kenchington, Gadus Associates (3,4)	gadus@istar.ca	902-889-9250
Peter Koeller, DFO (5,6)	KoellerP@mar.dfo-mpo.gc.ca	902-426-5379
Bob Mohn, DFO (4)	MohnR@mar.dfo-mpo.gc.ca	902-426-4592
Fred Page, DFO (1,2)	PageF@mar.dfo-mpo.gc.ca	506-529-8854
Chris Taggart, Dalhousie (1,2)	taggart@Phys.Ocean.Dal.Ca	902-494-7144
Richard Wahle, Bigelow (5,6,7,8)	rwahle@bigelow.org	207-633-9659
Contact Authors for each MS Number(s)	***Email***	***Telephone***
Gareth Harding (1)	HardingG@mar.dfo-mpo.gc.ca	902-426-2692
Ken Drinkwater (2)	DrinkwaterK@mar.dfo-mpo.gc.ca	902-426-2650
Peter Lawton (3)	LawtonP@mar.dfo-mpo.gc.ca	506-529-8854
Doug Pezzack (4)	PezzackD@mar.dfo-mpo.gc.ca	902-426-2099
Ross Claytor (4) Catch Rate Analysis	ClaytorR@mar.dfo-mpo.gc.ca	902-426-4721
John Tremblay (5,6)	TremblayJ@mar.dfo-mpo.gc.ca	902-426-3986
Alan Reeves (7)	ReevesA@mar.dfo-mpo.gc.ca	902-426-4999
David Robichaud (8,9)	RobichaudD@mar.dfo-mpo.gc.ca	506-529-8854

Appendix 3. Meeting Schedule

Peer Review of Lobster, Jonah Crab and Rock Crab Stocks
Proposed Timetable Subject to Change

Monday February 7	***Time***	***Authors (*Speaker)***	***Scientific Reviewers***
Welcome and Opening Remarks	900-910	E. Kenchington	
Overview of Lobster Assessment Framework	910-915	R. Miller	
Overview of Lobster Distribution, LFA's Areas and Terminology	915-930	D. Pezzack	
Introduction to Session I	930-935	E. Kenchington	
Ecological and distributional studies on larval lobster in relation to their dispersal in the Canadian sector of the Gulf of Maine (1)	935-1100	Gareth Harding*, Ken Drinkwater, Peter Vass, John Pringle, Angus Fraser, Jens Prena, John Loder, Charles Hannah and Jennifer Shore	Chris Taggart, Fred Page
Modeling lobster larval drift off Southwest Nova Scotia (2)	1100-1230/ 1330-1430	J. Loder, C. Hannah, J. Shore, K. Drinkwater* and G. Harding	Chris Taggart, Fred Page
Benthic movement as a component of stock structure in Gulf of Maine lobsters (3)	1430-1800	P. Lawton*, D.S. Pezzack, M.B. Strong and D.A. Robichaud	Trevor Kenchington, Michel Comeau, Joseph Idoine
Tuesday February 8	***Time***	***Authors (*Speaker)***	***Scientific Reviewers***
Proceedings Review	900-930	E. Kenchington	
Introduction to Session II	930-935	E. Kenchington	
Status and health of the LFA 41 fishery and offshore lobster stock (4)	935-1230/ 1330-1800	D.S. Pezzack*, P. Lawton, C.M. Frail, M.B. Strong, D.A. Robichaud, R. Claytor*, P.J. Carroll and R.A. Valiente	Jeff Hutchings, Trevor Kenchington, Bob Mohn, Matt Jones, Michel Comeau, Joseph Idoine
Wednesday February 9	***Time***	***Authors (*Speaker)***	***Scientific Reviewers***
Proceedings Review	900-930	E. Kenchington	
Review of Offshore Lobster	1000-1230	Group	
Stock Status Report(s)/Open	1330-1800	Group	

Thursday February 10	***Time***	***Authors (*Speaker)***	***Scientific Reviewers***
Proceedings Review	900-930	E. Kenchington	
Review of Rock and Jonah crab distribution off eastern Nova Scotia and the Gulf of Maine, with notes on stock structure (5)	930-1100	Tremblay, M.J.*	Richard Wahle, Michel Biron, Peter Koeller
Rock crab off Eastern Nova Scotia (LFAs 27-32): Stock status and evaluation of the exploratory fishery (6)	1100-1230	Tremblay, M.J.* and A. Reeves	Richard Wahle, Michel Biron, Peter Koeller
Status of the LFA 33 Jonah crab fishery, 1997-99 (7)	1330-1430	A. Reeves*, Blair Adams and R. Miller	Richard Wahle, Michel Biron
Exploratory fisheries for Rock Crab, *Cancer irroratus*, and Jonah Crab, *Cancer borealis*, in Canadian Lobster Fishing Areas 34, 35, 36, and 38 (8)	1430-1600	David Robichaud*, Peter Lawton and Mike Strong.	Richard Wahle, Michel Biron
Review of Jonah Crab, *Cancer borealis*, fishery in Canadian offshore Lobster Fishing Area 41, 1995 to 1999 (9)	1600-1800	David Robichaud*, Doug Pezzack, Cheryl Frail, Peter Lawton and D.R. Duggan	Michel Comeau, Joseph Idoine
Friday February 11	***Time***	***Authors (*Speaker)***	***Scientific Reviewers***
Proceedings Review	900-930	E. Kenchington	
Revisit of Rock and Jonah Crab	1130-1230	Group	
Stock Status Reports Crab/Lobster	1330-1630	Group	
Closing Business	1630-1730	E. Kenchington	

Appendix 4. Meeting Remits

In support of fisheries management decisions on the Southwest Nova Scotia offshore lobster resources, the following will be evaluated:

1. Knowledge of lobster stock structure in the Gulf of Maine and the evidence of linkages between various offshore and inshore lobster stocks

    - What do we know about lobster stock structure in the Gulf of Maine?
        - What do past studies of genetic, electrophoretic and morphometric data indicate about the stock structure

    - Is there larval exchange between coastal, midshore and offshore areas?
        - Based on knowledge of larval behaviour and oceanographic conditions, what is the pattern of larval drift from known hatching areas on Browns, George's and German Bank, and Lobster Bay?
        - What is the likely contribution of larvae hatch on Browns and George's Bank to settlement in offshore, midshore and nearshore areas?

    - Is there juvenile or adult exchange between inshore and offshore areas?

        - What are the movement patterns of juvenile and adult lobsters tagged in offshore areas, midshore areas and nearshore areas
        - Can existing tagging data provide estimates of exchange rates? If so what are they? If not, what further work is needed?

2. Status and health of the LFA 41 fishery and offshore lobster stock in support of the 2000-2001 fishery

- Has the fishery affected the size of the LFA 41 lobster stock? (Fishing down a stock typically reduces catch rates.)
    - What is the trend in catch rate data, 1980-1998?
    - Is the trend indicative of a change in stock size or are there other possible causes?
    - Do the US and Canada research groundfish trawl surveys indicate a change in stock size?
    - Are there changes in the distribution of fishing effort indicative of changes in stock size?
    - What is the trend in fishing mortality (F)?

- Is there any evidence of change in biological characteristics for the LFA 41? (Fishing down a stock should change these indices.)
    - What is the trend of sex ratio in the offshore fishery and from samples in the US research survey? What are likely underlying causes for this?
    - What is the trend size frequencies and median size in the offshore fishery and from samples in the US research survey? What are likely underlying causes for this?

- How has the introduction of the offshore Jonah crab bycatch provisions affected the offshore lobster fishery?
  - Has there been a change in the timing and distribution of the fishery?
  - Have the changes had any impact on lobster catches?

3. What are the implications of linkage between offshore and inshore lobster on the management of the western Nova Scotia lobster fishery?

- Is there evidence that the expanded midshore lobster fishery of LFA 34 has had any impact on the LFA 41 fishery?

- Is there any evidence that the LFA 41 fishery has had any impact on the LFA 34 fishery?

  - What are the comparative landings trends for LFA 34 and LFA 41?
  - Is there any evidence of impact on the size structure or sex ratios of these fisheries?

- What is the relative importance of the nearshore, midshore and offshore resources to the overall egg production?

  - What is the relative impact of the nearshore, midshore and offshore fisheries on egg production?
  - What is the egg per recruit (e/r) estimates under different levels of linkage?
  - What has been the impact of historic shifts in exploitation rates on the e/r levels?

4. One Stock Status Report, with associated research documents, will be produced. Issue one will be summarised in a Stock Structure section. Issue two will be summarised in Fishery, Resource Status and Outlook sections, while issue three will be summarised in a Management Considerations section.

The 1996 Emerging Fisheries Policy states that conversion of exploratory to commercial licences may occur once sustainability of the fishery has been demonstrated. To determine whether or not current fishing activities are sustainable and in support of a decision by DFO Fisheries Management regarding the appropriateness and timeliness of conversion of all or a portion of the current exploratory licences to regular limited entry licences in 2000, the following issues will be reviewed for the following resources: LFA 27 Rock Crab, LFA 29 – 32 Rock and Jonah Crab, LFA 33 Jonah Crab, LFA 34 Jonah Crab, LFA 34 & 35 Rock Crab, LFA 36 – 38 Rock and Jonah Crab, the offshore ENS directed Jonah Crab fishery, and the bycatch Jonah Crab fishery in LFA 41.

- What is known about rock and jonah crab stock structure.

- Landings and catch rate trends including bycatch by the lobster fishery where possible.

- What is the long-term sustainability of these fisheries? Can they be managed by reference points (or in the absence of reference points, is the 'Traffic Light' approach an appropriate assessment method for these fisheries?

- A statement or assessment of ecosystem considerations i.e. impact on the ecosystem, species interactions and food chain considerations.

- Evaluation of science needs to provide a biologically based quota for the offshore Jonah Crab bycatch fishery (and assessment of impact on the inshore Jonah Crab fishery).

- Recommendations on seasons, trap types and design, trap numbers, minimum carapace sizes (currently, there are different practices from area to area). Provide comment on whether or not there is room for increased effort and whether or not the current licences should be converted.

- One Stock Status Report, with associated research documents, will be produced. Issue one will be summarised in a section on Stock Structure. Issue two will be summarised in sections on the Fishery and Resource Status. These might be aggregated for all management units or separate, dependent upon discussions at the RAP meeting. Issue three will be summarised in the Outlook section. Issue four will be summarised in the Ecosystem Considerations section. The Management Considerations section will summarise comments relating to issues five and six.

Appendix 5. List of Documents Tabled

G. Harding, K. Drinkwater, P. Vass, J. Pringle, A. Fraser, J. Prena, J. Loder, C. Hannah and J. Shore. (2000). Review of the Distributional and Ecological Studies on Larval Lobster as it Pertains to their Dispersal in the Canadian Sector of the Gulf of Maine. *DFO RAP Working Paper* 2000/01.

K. Drinkwater, C. Hannah, J. Loder, G. Harding and J. Shore (2000). Modelling the Drift of Lobster Larvae off Southwest Nova Scotia. *DFO RAP Working Paper* 2000/02.

P. Lawton, D.S. Pezzack, D.A. Robichaud, and M.B. Strong (2000). Benthic Movement as a Component of Stock Structure in Gulf of Maine Lobster. *DFO RAP Working Paper* 2000/03.

D.S. Pezzack, P. Lawton, C.M. Frail, M.B. Strong, D.A. Robichaud, R. Claytor, P.J. Carroll and R.A. Valiente (2000). The American Lobster, *Homarus americanus*, fishery in LFA 41 Part 1, Part 2 + Table. *DFO RAP Working Paper* 2000/04.

M. John Tremblay (2000). Review of rock and jonah crab distribution off eastern Nova Scotia and the Gulf of Maine, with notes on stock structure. *DFO RAP Working Paper* 2000/05.

M.J. Tremblay and A. Reeves (2000). Rock crab off Eastern Nova Scotia: Stock Status and Evaluation of Exploratory Fishery. *DFO RAP Working Paper* 2000/06.

B. Adams, A. Reeves and R. Miller (2000). Exploratory Jonah Crab, *Cancer borealis*, Fishery in Lobster Fishing Area 33 (1997-1999). *DFO RAP Working Paper* 2000/07.

D.A. Robichaud, P. Lawton and M.B. Strong (2000). Exploratory fisheries for Rock Crab, *Cancer irroratus*, and Jonah Crab, *Cancer borealis*, in Canadian Lobster Fishing Areas 34, 35, 36, and 38. *DFO RAP Working Paper* 2000/08.

D.A. Robichaud, D.S. Pezzack, P. Lawton, C. Frail, M.B. Strong and D. Duggan (2000). Review of Jonah Crab, *Cancer borealis*, fishery in Canadian offshore Lobster Fishing Area 41, 1995 to 1999. *DFO RAP Working Paper* 2000/09.

Appendix 6. List of Research Recommendations

The present fishing boundaries are ecologically untenable. It is impossible to manage inshore and offshore fisheries separately. An over-riding recommendation is that research into stock identification be undertaken in order to provide the framework for future assessment questions. As at least some of these stocks extend into US waters, an appropriate forum for this discussion would be the USA-Canada Gulf of Maine lobster meeting scheduled for 2001.

Offshore Lobster (LFA 41): Stock Structure

- Swimming behaviour, vertical distribution (stage dependent depths), satellite data, and 7-day winds should be included in future modelling of larval movement.
- Occurrence of late stage larvae in an area is not conclusive of settlement or post-settlement retention. Further research is need to link these life history stages possibly through direct tracking techniques.
- A survey for newly settled lobsters is recommended both where the stage IV concentrations have been observed and where drifters and drift modelling indicate they should occur (ie., off the northern edge of Georges Bank and along the warm-water side of the frontal zone between inshore and offshore Southwestern Nova Scotia).
- Research into lobster movement is required. Existing tagging data does not document what proportion of the population moves long distances. It was recommended that detailed data on catch rates or other techniques such as morphometrics or genetics be used to examine local movement.
- It was recommended that a tagging study be undertaken in the nearshore and midshore portions of LFA 34 during the closed season, when mature lobsters are at their shallowest depths for growth, moulting, extruding and hatching eggs. This would help to resolve the interdependence of the "populations" in LFAs 34 and 41 because one would expect movement to deeper waters during winter. This is feasible because the offshore fleet is good at returning tags.
- It was recommended that a carefully targeted genetic study be undertaken, based on what we know of adult movements and larval drift.

Offshore Lobster (LFA 41): The Fishery

- It was recommended that follow up discussions with captains take place to capture information on fishing practices for use in determining CPUE.
- The multiplicative model used in the CPUE analyses should include vessel information, soak time and bottom temperature as main effects or covariates; outliers should remain in the analyses and should be explored for geographic affinity or other interpretation.
- Each of the five areas should be analyzed separately as there is no rationale for combining areas; combining areas will introduce confounding factors due to differing movement behaviour of the animals in winter.
- The data could be subdivided into categories of crab catch and analyzed separately rather than excluding all data where crab were landed. A suggestion of using trips with less than 50% crab landed was made and further expanded to suggest three categories of 0%, 1-50%

and 50%+ crab. A suggestion that crab bycatch be incorporated into the model as either an effect or covariate was also advanced.

- Catch rate analysis should be revisited in the next lobster RAP scheduled for the fall of 2000.
- It was recommended that the sex ratio and size distribution data be broken into size groups to see the proportional shifts within each. This was seen to be important in view of the fact that large male lobsters are required to mate with the large females.
- It was recommended that the Q-Q plots be used to examine changes in size distribution within and between specific areas and times.
- Canadian groundfish surveys need to include the measuring and sexing of lobsters as part of the basic protocol. With such data, scientists will be able to use the surveys to track changes in fishing mortality, sex ratios and relative abundance. Lobsters were measured during the groundfish surveys in 1999 as part of a special program but that should be continued as standard practice.
- Improved monitoring of LFA 41 lobsters with emphasis on the SW Browns-Crowell Basin area, including at-sea sampling, is recommended in order get data on seasonal changes in size frequency and abundance in these areas.
- Improved monitoring of LFA 34 fishing activity in the deep-water regions near the offshore line is required in order to assess interaction with adjacent areas.
- Research on the catchability at size by season and area is required in order to interpret catch rate statistics. This could be achieved through a properly designed mark-recapture program.
- Logbooks should be amended to include identification of the target species for each location.

Jonah and Rock Crab Stock Assessments

Until the level, location and size composition of crab bycatch in the lobster fisheries can be reliably determined, scientists will be unable to make recommendations on the sustainability of the directed fisheries. Additionally, these fisheries are being managed by management units designed for another species (lobster) which may or may not be appropriate for rock or Jonah crab. Identification of stock boundaries is a prerequisite for many of the management objectives. Further:

- It was recommended that CPUE for the LFA 33 Jonah crab fishery be calculated across a common area so as to compare inter-annual variation.
- More study is needed of trap designs that limit lobster bycatch.
- Fishery-independent surveys of both species (rock and Jonah crab) are required in order to realize the distribution of the species and its production potential. This information will help to establish the stock structure of the resource, at least to the point of creating hypotheses for further testing.
- Research into the early life history stages, including growth and habitat preference, is required in order to provide advice on the sustainability of these fisheries.
- Research into the movement of these species is required to establish stock boundaries and determine whether the present management units (lobster LFAs) are appropriate.
- Research into the reproductive biology of these species is required in order to provide advice on size limitations and to interpret changes in sex ratios.

Appendix 7. Reviewers written comments.

Manuscript Title: Review of the distributional and ecological studies on larval lobster as it pertains to their dispersal in the Canadian sector of the Gulf of Maine

Authors: Gareth Harding, Ken Drinkwater, Peter Vass, John Pringle, Angus Fraser, Jens Prena, John Loder, Charles Hannah and Jennifer Shore

Reviewer: Fred Page

The following is a brief account of some of the issues raised by the reviewer and others, and the comments provided by the presenter and participants as a whole.

- Although most of the work reported in the manuscript is historical in nature, the development of the interpretations and the manuscript is preliminary. Apparently, the manuscript is intended as a work in progress and will not be submitted as a Research Document at this stage. The authors' intentions are to submit it as a Res. Doc. associated with an upcoming CLAWS workshop.
- The manuscript is a reasonable review of the historical information on larval lobster distributions in the Georges Bank and southwestern Nova Scotia area. Results indicating results from research conducted as part of the CLAWS I program are introduced at the end of the working paper but figures supporting the indications are not included. The figures were included in the presentation and should be incorporated into the manuscript. The information pertained to fieldwork conducted of southwestern Nova Scotia. It included limited sampling of the horizontal and vertical distribution of lobster larvae.
- Considerable effort is devoted to describing Stasko's data and the resulting conceptual evolution of larval distributions. It is noted that these distributions were derived from neuston samples only, a sampling protocol that under samples the early stage larvae during the daytime because of diurnal migrations. Despite this limitation, more recent sampling that does not suffer from this problem does not change the concept.
- Stage IV larvae are larvae that will settle to the bottom. Most of these larvae are found away from the coast, in the near surface waters over relatively deep regions. The bottom type in these deep regions is presumably muddy and not preferred by the larvae. Hence, are major distributional areas of late stage larvae being missed by the sampling? Are the distributions those of larvae that will not survive? Do the late stage larvae undergo subsequent behavior that will take them to preferred bottom types? Are the larvae supporting the lobster populations distributed differently?
- The manuscript shows data on the vertical distribution of lobster larval stages obtained from Browns Bank. No information is given to indicate how representative is this pattern of other geographic areas. In the presentation and following question and answer session, additional information obtained from the southwest Nova Scotia area was presented that indicated the vertical distribution during the day on Browns Bank was typical of lobster larvae from other areas. Since, the data was only collected during the day no information was available to determine whether nighttime distributions were also similar. It was suggested that, unlike fish larvae, the vertical distribution of lobster larvae is reasonably consistent. The larvae are

largely above the thermocline, undergo day-night migration during the early stages (at least I and II) and remain near the surface as stage IVs.
- The authors present information indicating that late stage larvae are located in the deeper water north of Georges Bank and on top of Browns Bank. Early stage larvae are located only on Georges Bank. They suggest the late stage larvae originated from the western part of Georges Bank or the Nantucket shoals area and that, at least under some conditions, they may make their way to Browns Bank. Present knowledge of the water circulation in the area does not support this inference.

Manuscript Title: Modelling the drift of lobster larvae off southwest Nova Scotia

Authors: J. Loder, C. Hannah, J. Shore, K. Drinkwater and G. Harding

Reviewer: Fred Page

The following is a brief account of some of the issues raised by the reviewer and others, and the comments provided by the presenter and participants as a whole.

- The work reported in the manuscript is really a progress report. The authors acknowledge there are additions yet to be made to the model, such as larval vertical migration. As such the conclusions are preliminary and perhaps subject to change as the modeling becomes more mature. Given this, the manuscript is intended as a work in progress and will not be submitted as a Research Document at this stage. The authors' intentions are to submit it as a Res. Doc. associated with an upcoming CLAWS workshop.
- Is the story in the detail or are the particle trajectories sensitive to the details? The circulation model does a reasonable job of reproducing the mesoscale seasonal mean circulation features. It attempts to incorporate to some degree time varying winds but more refinements are needed and it does not yet include larval behavior. Hence, it is not clear at this stage whether the model results will prove to be robust to the inclusion of the greater temporal resolution and behavioral components. An area of particular concern is how, or if, the larvae can transit the tidal fronts along the northern flank of Georges Bank and off southwest Nova Scotia. Can the fronts be transited by physics or is biology needed, and if so what physics and biology are required. In addition to including vertical migration behavior, the model should eventually include vertical mixing of the larvae so enhanced surface generated turbulence influences both the circulation and the vertical distribution of the larvae.
- The model particle trajectories at 10m have been compared to some degree with the tracks of drifters drogued at 10m. However, most the larvae are nearer the surface and some effort should be made to compare model and observed tracks at shallower depths, e.g. top 1m.
- Since the model suggests a critical area of the model is whether the larvae/particles transit the fronts, a comparison of how well the model represents the physics of the fronts would be very useful.

- The model does not give strong support for transit of particles from Georges Bank or off the northern flank of Georges Bank to Browns Bank and SWNS. As such it does not support a suggestion made in the Harding et al. Manuscript that late stage lobster larvae found over Browns Bank during one survey may have come from the Georges Bank vicinity. The model may be incorrect since local observations indicate surface particles lost over Georges Bank can make it to the SWNS coastline.
- The model is acknowledged to not resolve the circulation in the nearshore area and hence comments pertaining to the trajectories of particles released near the shore in the manuscripts Lobster Bay release area must be treated cautiously.
- Despite the lack of these features in the model, it is interesting that the model particle trajectories in the SWNS area do seem to qualitatively agree with observed drift bottle returns and lobster larvae distributions.

Manuscript Title: Benthic movement as a component of stock structure in Gulf of Maine lobsters.

Authors: Lawton, P., D.S. Pezzack, D.A. Robichaud and M.B. Strong

Reviewer: Michel Comeau

General Comment

This paper in an attempt to study lobster movement by making an inventory and reanalyzing approximately 20 years of tagging data from the Gulf of Maine, Bay of Fundy and the offshore of the Scotia Shelf, including Browns and Georges Bank. The main purpose of this exercise seems to focus on lobster exchange over the entire area in relation to the very fashionable and new concept of the Gulf of Maine lobster stock as a metapopulation. The authors show that there is still a long verification process of the historical data files before any conclusions can drawn from them.

Detailed Comments

P. 7- under the section “Adjusting Tagging Returns for Effort Distribution”, the authors attempt to adjust the tag returns to effort. The reason to adjust data is normally based on a bias. The source of the bias and the reason for the adjustments has to be explained. For example, why only effort distribution was singled out? How about effort distribution in relation to catch? The authors have to present a justification for that adjustment and what knowledge would be gain from it compared to the simple tag returns.

In the Summary section- the authors should elaborate on the possibility of the historic tagging data to answer the exchange rate between different location of the Gulf of Main and offshore. More precisely, they as indicated throughout the paper the large number of lobster tagged, however how good are those data to map lobster movement? This is mostly in reference to the third paragraph on page 10. For most of the tagging projects done in Canadian waters, it is

practically impossible to study lobster movement *per se*, because the recapture period is confine to the fishing season in place in each LFA (except LFA 41 which is opened the entire year). Hence, knowledge of movement is restricted to the dispersion of lobsters from a release site to a recaptured location over a time period, with no information on movement during the off season due to the nonexistence of a recapture method. Comparison of lobster movement based on data compiled from tagged animal recaptured from areas with a 12 months recovery period (LFA 41) and a restricted recovery period (LFA 33 to 39), have to be made with caution. This difference in recovery periods between LFA's will bias the interpretation, i.e. although few lobster from offshore are recapture inshore, they might be there during the off season for possible physiological reasons such as reproduction or growth, but could not be detected and moved out of the LFA before the following fishing season.

In conclusion, historical tagging projects will not allow mapping of lobster movement of the Gulf of Maine in order to study lobster exchange in a metapopulation concept, as lobsters may move to different locations without being detected (due to fishing seasons). However, the historical tagging data will allow studying lobster dispersion in relation to the fishery, as the data collected arefishery-base.

Reviewer: Joseph Idoine

Review Notes:
It is important to note that the consolidation/archiving of historic tagging data an important step in characterizing possible information (and value) available in those studies. A GIS based system is appropriate for these data, and will facilitate whatever further analyses might be gleaned from this source.

Questions/Comments:

- It is unlikely that this archiving process will shed any new light on the lack of differential capture rates, since there are only historic "effort" data for the offshore areas (from LFA 41).
- Since the rates of recapture are more appropriately correlated to fishing mortality rates, it is questionable that there are any data to adjust information for any of the studies (no mortality rates were provided).
- The archival process should include information on the original purpose of the study and/or experimental design.
- Since the inshore portions of GOM are generally closed to fishing during a portion of the year (including egg release), it is difficult to know, without fishery independent sampling, if the lack of recaptures is due to their absence or the non-sampling.
- Using general tagging studies to define migration requires relatively high capture rates to get sufficient returns. However, high capture rates often decrease to time at large, and subsequently, the distance traveled.
- Multiple recaptures have shown that tagged lobsters may make long migrations and be recaptured in the same location of the original release. This could be misidentified as no movement.

- There is no clear definition of proposed (assumed) stock areas. There is reference to Gulf of Maine, offshore and inshore regions, but there are also references to management areas (LFAs). Since LFA 41 includes portions of GOM and Georges Bank (among others) clarification would help in defining the thesis.
- There is little reference to the title of the paper (with respect to any stock structure). Perhaps a different title, or a section on the assumed stock area (with sub-areas, e.g., inshore; offshore) would clarify.

Comments added after the discussion:

- There appears to be little evidence (as presented) to evaluate the question of movement in this region. This should not be interpreted to mean there is none, for evidence in other regions show movement from offshore to inshore, and fishermen are know to fish "migrations" of lobsters in both inshore and offshore directions.
- What is apparent is that the existing summary of the data are insufficient to shed light on this question, and even less helpful in determining exchange rates (for whatever utility those might have).

Reviewer: Trevor Kenchington

The *Working Paper* prepared by Lawton *et al.* was not intended for upgrading into a *Research Document* and hence I will not attempt to provide editorial comments on its text. Furthermore, the *Working Paper* was not an account of a finished project but rather a progress report on an initiative that is still in the data-compilation phase. Thus, most of the comments which follow refer to methodology and approaches, with less attention to conclusions.

- I applaud Lawton *et al.* for examining patterns of post-settlement movement in Gulf of Maine lobsters. For more than a decade, DFO's management of the LFAs in that region has neglected such movements (tacitly assuming that they amount to negligible exchanges of biomass between LFAs), while focusing on putative linkages through larval drifts. The research initiative reported in the *Working Paper* should go far towards restoring some balance.
- I am, however, concerned that a broad question posed to the RAP ("Is there an exchange or migration of juvenile and/or adult lobsters between inshore and offshore areas?") should have drawn the response of a *Working Paper* reporting on a specific research project. I would have hoped to see a more direct attempt to answer the question in a manner that would provide useable advice for fisheries managers, which would involve collating existing scientific knowledge rather than the research orientation taken by Lawton *et al*.
- Turning to the work reported: While I have some doubts about the specific approaches used, I do strongly approve of Lawton *et al.*'s compilation and re-interpretation of existing tagging data. There is a great deal more information in the results from former studies than has been provided in past published reports, while a "meta-analysis" spanning multiple data sets promises revelations that could not be constructed from any summary of separate, study-by-study analyses. Moreover, the project now underway promises to provide that knowledge

much more quickly and far more cheaply than it could be obtained through a new round of tagging.

- That being said, compilations of disparate databases always carry the risk that their very convenience will result in them being used incautiously. It was clear during the RAP that Dr. Lawton is well aware of this problem but it should also be forcefully communicated to other future users of the data.
- Besides the many, usual uncertainties involved in combining data from any studies that had different methods and objectives, Lawton *et al.* are linking recent data, based on *Sphyrion* tags, with that from earlier ("pre-*Sphyrion*") studies which could only mark lobsters until their next moult. Used without due care, the disparate tag types could introduce serious errors into any quantitative conclusions drawn from the database.
- There will also be a tendency to treat the compiled data as though it was synoptic. In reality, the movement patterns of lobsters may have changed significantly during the decades of tagging studies. It seems almost certain that the lobsters' environment changed substantially in the 1980s, at least in inshore waters, allowing the dramatic increase in recruitment and production that has been such a feature of this resource in recent decades. The very intensive fishery may also have caused changes, beyond the direct effects of increased mortality rates, through selective fishing on certain components of the lobster populations. Analyses that disregarded such changes might go seriously astray.
- Lobster tag data will almost invariably show that the average animal does not live long, nor travel far, after tagging. While that can be a valuable result for some purposes, answering the important questions about exchanges of individuals among areas will always require heavy emphasis on the rare "outliers" in the data – the few tag returns that did indicate substantial movement. Outliers are more normally ignored in analyses of biological systems for the good reason that they are heavily influenced by random factors of many kinds. In the case of tagging studies, there is also the persistent worry that they represent aberrant behaviour triggered by the tagging process itself and thus are artifacts. Once again, great care will be essential in the interpretation of the compiled data – as tagging specialists well understand but others may not.
- Tagging results are also frequently misleading because they offer the appearance of population-wide patterns of movement. In reality, tags can only move away from their release points and, with very rare exceptions, can only move into areas (and seasons) with intense fisheries. Unless re-capture rates are high (which is rarely the case), it is not possible to say whether the movements detected are purely artifacts of the locations and seasons of releases and fisheries, plus the aberrant movements of a few individuals, or whether they are truly representative of the broad direction of mass movements.

  Lawton *et al.* are evidently aware of this and have gone so far as to begin compiling information on the seasons and areas of those fisheries that were available to recover tagged lobsters. Whether sufficient data are available on the distribution of fishing effort remains uncertain, however. Even if they are, what are really required are season- and area-specific estimates of the fishing mortality rate applied to lobsters, whereas the best that might be reconstructed would be data on nominal fishing effort. It is far from clear that there is a close

relationship between the two in a trap fishery, particularly considering the long period and wide variety of habitats involved when interpreting the historical tagging results.

The principal data on fishing distributions presented to the RAP in association with this *Working Paper* were indicative of one particular problem: They were drawn from a new LFA 34 logbook program which commenced in 1998-99 – the year most affected by the recent sharp cold event in the Gulf of Maine region. Fishermen are well aware that the LFA 34 "midshore" fleet moved its effort into shallower water once the effects of that cooling were realized. Hence, the mapped distribution of LFA 34 effort in that one year probably bears little relation to fishing patterns either earlier or later. It is unlikely to be even indicative of the distribution of the fishing effort which recaptured tags from any tagging study.

I would also suggest that the seasonality of the fisheries should be used to group the data by seasons of re-capture and not, as Lawton *et al.* have done so far, by those of release (their Figures 2 to 7). Groupings based on release dates would be better illustrated on a study-by-study basis.

Despite these many limitations, I would urge Lawton *et al.* to go beyond data compilation and interpretation to statistical analysis. While that would raise still further risk of misleading results, with the calculations probably impenetrable and thus unquestioned, properly used statistical analysis could generate confidence intervals around estimates that would show whether, in fact, any reliable conclusions whatsoever can be drawn from the available data. If they can, it would provide quantitative estimates of exchange rates among various fishing grounds.

While the animal and the spatial scales concerned are very different, a substantial effort has been devoted to using tagging data to answer questions about interactions among tuna fisheries – questions that are essentially the same as those confronting managers of the Gulf of Maine lobster fisheries. The approaches used in analysis of tuna tagging studies by both FAO and the Secretariat of the Pacific Community would be worth close examination and might provide a model for work on the lobster database.

I remain concerned about the frequently-repeated claim (page 4 of the *Working Paper*) that there is evidence of both homing and return migrations of lobsters in offshore areas. That both occur inshore seems a reasonable conclusion [though Haakonsen and Anoruo have disagreed: Tagging and migration of the American lobster *Homarus americanus*. *Reviews in Fisheries Science* 2: 79-93 (1994)] but coastal areas provide spatial cues to aid navigation on a much finer scale than is found offshore. Simple extrapolation from the one environment to the other is insufficient.

Published evidence for return migrations of American lobsters in offshore areas is confined to a single study [Pezzack & Duggan (1986) Evidence of migration and homing of lobsters (*Homarus americanus*) on the Scotian Shelf. *Can.J.Fish.Aquat.Sci.* 43: 2206-2211] in which 6285 lobsters were tagged in the Browns Bank area, 2486 of which were recaptured, 361 of them more than once. Only eight of those animals were taken at least three times and at roughly six-month intervals – that being the minimum requirement to map return migrations from tagging data. Of the eight, three were only taken on the southeast Browns ground, though their final recaptures indicated some degree of local return towards their tagging sites after being further away in the intervening months. Three others moved within the southeast Browns ground and were then captured to the westward at about the season of tagging, thus showing no evidence of return

movements at all. The final pair moved 110 to 150 km between the southeast Browns and western Browns grounds before returning to near their tagging sites, a year after being released, and thereby showed apparent annual migratory behaviour. However, one of those two summered to the southeast of Browns Bank and wintered to the west while the other had the reverse preference – and one of them was later captured a fourth time, while wintering in its "summer" area. Moreover, because the shoal water of Browns is closed to lobstering (as LFA 40), all of these captures were made at much the same depths and thus seem to have involved individuals which, for whatever reason, did not undertake the usual seasonal pattern of moving shallower for the summer. Yet it is on these results alone that the claim of offshore return migrations is based. That claim may have been a reasonable conclusion from the one study on which it was based but its frequent and uncritical repetition is apt to mislead.

The evidence for offshore homing is less easily summarized but it is based on movements of tagged lobsters that were displaced inshore before release. Without statistical analysis and a carefully-formulated null hypothesis, it is not possible to say whether those observed movements can only be explained by a homing capability or whether a simple preference for the depths at which they were first caught, combined with the shape of underwater slopes in the vicinity of the release point, is a sufficient explanation. No such analysis has been undertaken and so homing is, at best, unproven.

The *Working Paper* was structured and presented as a report on a work in progress and thus cannot be expected to offer much in the way of conclusions. The RAP was, however, tasked to comment on exchanges of juvenile and adult lobsters among various areas. In that context, my reading of the published literature on past lobster tagging studies would suggest that some initial conclusions can be drawn, pending future analyses of Lawton *et al.*'s new database, which may assist in answering the questions posed:

- Post-settlement juveniles seem to make only limited movements. Exchanges among management areas of such animals are almost certainly negligible.
- Only a tiny proportion of the recaptures of tags applied in LFA 41 have ever been taken in the inshore LFAs and most of those have represented short-distance movements across the boundary lines, particularly in the Crowell Basin area. Considering the good multi-year recovery rates offshore and the greater intensity of the inshore fisheries, it seems highly unlikely that any significant number of lobsters move from LFA 41 to the inshore LFAs for the seasons when the inshore fisheries are active. (Some may move inshore for the summer, particularly into the midshore region of LFA 34, and may release their larvae there.)
- As shown by multiple offshore recoveries of tags applied inshore, at least some adult lobsters do disperse from inshore areas to LFA 41 by what appear to be uni-directional, ontogenetic movements. The quantitative significance of such movements to either the inshore or the offshore resources remains quite unknown.
- Such movements could link the lobsters of the Bay of Fundy and those of LFA 34 to the resource in LFA 41 but there is no apparent interchange between offshore areas and coastal waters to the eastward of roughly Shelburne.

- Seasonal depth changes and random foraging movements will carry lobsters to-and-fro across the boundary of LFA 41. In the Browns Bank area, such movements rarely provide exchanges between the inshore and offshore zones because of the presence of LFA 40. In Georges and Crowell basins, however, such short-range movements may lead to substantial interactions between the offshore and midshore fisheries when both are working close to the line.
- LFA 41 likely also sees substantial exchange of lobsters across the ICJ Line into and from U.S. waters. On Georges Bank, the seasonal movement into shoal water may carry a substantial fraction of the Canadian resource onto heavily-dragged grounds west of the boundary.
- Within LFA 41, each major ground is linked to the others by movements of adult lobsters, though those are likely to fall far short of free exchange. In particular, the lobsters on Georges Bank (which do not appear to regularly contribute larvae to inshore areas) are linked, by adult movements, to the spawners on Browns Bank (which may well be major contributors to recruitment in LFA 34).
- Management of the lobster fisheries in the general Gulf of Maine region should take account of these movements and should not be based on any notion that the various management areas represent biological units.

During the RAP, it became clear that a major outstanding doubt about lobster movements concerns whether or not substantial numbers of females move from the Crowell and Georges basins portion of LFA 41 into LFA 34 during the summer, withdrawing again before the inshore season opens in November. Such a movement cannot be directly investigated by tagging, since there is no summer fishery in LFA 41 capable of returning large numbers of tags. However, summer tagging in the “midshore” area could strongly indicate the existence of an inward movement by documenting a corresponding offshore migration in the fall. Conversely, the lack of a movement off, when combined with the near-absence of LFA 41 tags taken during the LFA 34 fishery in the past, would make a seasonal inward migration highly unlikely. I therefore recommend that a lobster tagging program be undertaken in the “midshore” area in summer.

The work presented in the *Working Paper* was confined to the tagging approach, yet tags are but one means to approach an answer to the question posed to the RAP. I would recommend, alongside continued work on the tagging database, a parallel effort based on an interview survey to gather fishermen’s understanding of lobster movements. Such a survey should be designed to elucidate not only their understanding but also its foundation – the specific relevance, and even validity, of fishermen’s knowledge being dependent on the means by which it is derived. Once a picture of movements was been constructed from interview data, it should be tested by some combination of size-compositions, seasonal movements of areas of high catch rates, morphological studies and further tagging, each being carefully targeted around hypotheses of lobster movements derived from fishermen’s knowledge.

Manuscript Title: Status and health of the LFA 41 fishery and offshore lobster stock. Parts 1 and 2, + Table.

Authors: Pezzack, D.S., P. Lawton, C.M. Frail, M.B. Strong, D.A. Robichaud, R. Claytor, P.J. Carroll and R.A. Valiente

Reviewer: Michel Comeau

For Part 2 of that paper I have no comment of importance. Part 2 reports uncertainties that should be of concern when one trys to speculate on what is happening in the fishery of LFA 41 (this is of great concern for Part 1). Finally, I agree in principal with the general conclusions.

For Part 1: It was a good exercise to analyze the amount of fishery-base data available from that fishery using a new approach (multiplicative analysis). Based on some comments during the presentation, little more analysis is needed. However, I am highly skeptical that a mathematical model (method) would remove all the uncertainties created by the numerous changes observed in that fishery throughout its evolution, and single out lobster abundance (without any prove) as being the sole and unique parameter explaining the variation of the catch per unit of effort (CPUE) observed between 1985 and 1999. Speculating that the decline in CPUE is explained by a decline in lobster abundance commands nothing less than a blind leap of faith as there is no prove of such of cause and effect link. It is always astonishing how variations in landings from a certain effort (CPUE) are (automatically) linked (directly) to abundance in a fishery using solely traps as a mean of capture. There has been numerous papers dealing with the problem of trap selectivity. There is simply to many uncertainties to speculate on which parameter or the combination of parameters that influenced CPUE. Furthermore, with the evolution of that fishery the major parameters influencing the CPUE 5, 10 or 15 years ago might not be those influencing CPUE in more recent years. Based on the lack of residual from the analysis presented it would be safe to say that CPUE is an index of similar annual conditions, whatever those conditions are. The variation of CPUE between 1985 to 1999 might have been influenced by (in no particular order) (1) change from wooden to wire traps, (2) introduction of escape vents, (3) use of conical traps, (4) longer soak period, (5) stock wide recruitment pulse, (6) colder bottom water, (7) depth fished, (8) change in bait, (9) changes in trap design, (10) overall fishing strategies, (11) removing of the trap limit, (12) type and length of fishing boats, (13) expansion of the inshore fleet to the deepwater in the midshore area, (14) expansion of the offshore fishery to shallower water near the midshore area, (15) bycatch of Jonah crab, (16) change in lobster abundance. All of these parameters could and have undoubtedly influenced CPUE throughout the years. For example, it is known that low temperature reduces the lobster's metabolism and influence negatively lobster catch. In recent years low temperature was observed on the lobster fishing ground. Furthermore, changing the effort to capture Jonah crab starting in 1995 has certainly resulted in a negative bias of the CPUE for lobster, as fisherman have landed lobster while targeting the Jonah crab reducing artificially CPUE for lobster. But simply removing trips with Jonah crabs, would not standardized effort. Bottom line, the fishery-base data on hand cannot allow the use of CPUE as an index of abundance.

If Part 1 of this paper is to be upgraded to a Res. Doc. (in my opinion it should not) the statement on page 15 first paragraph of the discussion "Thus, if CUE …since 1990-91" should be deleted.

It can be found that CPUE has decline, but its real cause(s) is (are) unknown. I would reluctantly upgrade this Part 1 as a research document. There are enough information on the uncertainties in Part 2 and Part 1 does not shed any light on the state of that fishery. A small section on catch rate should be included in Part 2 with the conclusion that it has been variable and that there are too many uncertainties to elaborate on the reason for those variations. Furthermore, the figures and table of this paper should be condensed to be of a reasonable size.

Reviewer: Joseph Idoine

LFA 41 Lobster fishery working paper review comments:

1. The major question addressed in Part 1 refers to the effects of the fishery in one management area, interacting with, at least, two stocks. The answer to the literal interpretation of the question seems to be that the fishery has had minimal effect on the LFA 41 "stock", and there is little evidence presented to refute that conclusion. In the absence of stock analyses (i.e., GOM and GB) one can only infer as to the effects of this fishery on the overall resource. The comments directly below reference only the condition of the LFA 41 portion of the resource.

    a) The LFA 41 reported landings have remained fairly stable over the last decade, due largely to a TAC (quota?) of 720 mt. However, in recent years, there has been a decline in landings, from 100% of the quota from 1993 through 1996 seasons to 548 mt (76% of the quota) in the 1998-99 season. This is in addition to at least some real expansion of the fishing grounds. The current season, landings have been back up, similar to previous record years.
    b) It is recognized that some effort changes may be due to a newly developing Jonah crab fishery, however, given the price differential between the two species, it is difficult to imagine a boat forgoing lobster catches for crabs. There are two boats that target crab but land lobster as well.
    c) There is the possibility that the fleet is trying to fill up the fishing season for some reasons unrelated to availability of lobsters (high grading, preserving the status quo on the season, not wanting to bring in gear once the quota is reached).
    d) The adjacent US portion of the resource (Georges Bank and offshore GOM) do not show similar trends between each other, nor necessarily to the Canadian LFA 41. Offshore GOM, in terms of abundance estimates and landings are showing a flat or declining trend over the last 5-6 years. The US GB resource is showing a flat trend in abundance and a decline in landings.

2. A technical issue: There are some concerns, and a lack of clarity with the way mixed trips of lobster and Jonah crab were evaluated to get at removal rates of lobster. The proportion of landings from "pure" lobster trips varies significantly year to year (between 48% and 85%), as does the ratio of the number of "pure" trips to all trips (30% - 68%). However, these relationships do not vary with each other. There is a bit more consistency of trips landing greater than 50% lobster. Analyses with varying levels of bycatch might clarify.

3. To focus on what we can say from this assessment, it must be noted that LFA 41 contributes about 3% to the landings of the Canadian GOM/GB total, and not much more than 1% to the

overall landings from the two stocks (including US). While there are some concerns about the health of this portion of the resource, there is no evidence presented that the current status of LFA 41 is an overwhelming factor in the health of the stock-wide resources (which includes LFAs 31-41 in Canada, and the US portion of the GOM and GB. Additionally, the current maximum of 8 boats fishing this area are dwarfed by the 2500+ (?) Canadian boats and 3500+ US boats. It should be reasonable to assume the current status of the GOM (specifically, to the questions posed, LFA 34) is more influenced by the near and midshore fishery than what is occurring in LFA 41. Although there were limited data presented to address, and no questions directed at the issue, it would also be reasonable to assume that the current exploitation in the GOM outside of LFA 41 are having a significant influence on the Canadian offshore area.

Reviewer: Jeff Hutchings

Review of "The American Lobster, *Homarus americanus*, Fishery in LFA 41, Parts 1 & 2" co-authored by DS Pezzack *et al.*

General comments

1. I would like to underscore the fact that a meaningful review of any document cannot be undertaken when that document is not made available to reviewers at least one week in advance of the RAP meeting. To suggest, and to behave otherwise, perpetuates a charade that does not do justice to the biological and socio-economic importance of the issues at hand.

I, for one, shall no longer be taking time away from my teaching commitments, my research, and my other, non-University responsibilities to attend DFO RAP sessions for which assessment documents are distributed for review on the day of the meeting.

As a consequence of this sort of "same-day" distribution of Part 2 of the LFA 41 assessment document, a couple of comments have come to mind since the review, *i.e.*, that were not expressed (by me) during the meeting, that appear below.

2. Perhaps this was discussed in detail on the first day of the meeting, but I was disconcerted with the lack of attention given to the possibility that the lobsters in LFA 41 were the primary source of recruitment for the inshore lobster fisheries. The high exploitation rates experienced by the inshore fishery (70-80%) coupled with the relatively old age at maturity in lobsters (8-10 yr) make it evidently clear that the inshore lobsters are <u>not</u> providing the bulk of the recruitment to the inshore fishery.

I would have thought that the most parsimonious, and <u>precautionary</u>, scenario would be one in which it was assumed that the LFA 41 lobsters were part of the same stock as the inshore lobsters and that the LFA 41 lobsters constitute a primary source of recruitment to the inshore fishery.

Under these circumstances, coupled with the declines in catch rates and median sizes discussed below, a prudent course of action might be to close the offshore lobster fishery. Overall, the

socio-economic benefits the LFA 41 lobster fishery provides to society (8 vessels, 2 large companies holding the licences) are small, while the biological risks to the inshore fishery of mis-managing the offshore lobster fishery are potentially large.

Specific comments:
1. The catch rate analysis is a valuable contribution to the assessment of the LFA 41 Fishery and it should be maintained in future assessment documents. Notwithstanding the ever-pervasive arguments that catch rate analyses must be particularly mindful of the specific temporal, spatial, and technological peculiarities of each fishery (all of which can never be known), the C/R analyses presented by Ross Claytor have the potential to offer insight into temporal trends in abundance for a stock of invertebrates for which temporal indices of abundance are few.

Details:
(a) A comparison of Tables 1 and 4 reveal that a great deal of catch data prior to 1993 in Area 4 (and possibly other areas as well?) were not included in the C/R analysis.
(b) Rather than grouping Areas 1, 2 and 3, the C/R analysis should be done on each area separately.
(c) There is a need to incorporate the crab-directed lobster catches in future C/R analyses. For example, a simple C/R analysis from the 4 years of crab/lobster information provided on pages 9-10 of the Assessment document (Part 1) yields the following information:

% crab in catch	Year	Catch Rate (kgs lobster / no. trips)	
0	1995/96	4900	
	1996/97	4195	
	1997/98	3211	
	1998/99	2965	(a 39% decline in 4 years)
>50%	1995/96	915	
	1996/97	1099	
	1997/98	1140	
	1998/99	1127	(a 23% increase in 4 years)

QUESTIONS: Why should catch rates from the "0%-crab" vessels have declined 39% in 4 years while that experienced by vessels for which crab constituted more than 50% of the catches have increased 23% (or arguably remained stable) during the same 4-year period?

(d) The decline in catch rates noted in (c), coupled with the observation that LFA catch rates in the most recent years (from Ross' analysis) are the lowest in the time series, should be cause for concern.

Specific (Part 2):
(a) There have been declines in the median sizes of the catches in some areas. The notable ones are (years in parentheses):

Area	Lowest Median Size	Highest Median Size
Crowell Basin (1st quarter) males	95 mm (1998)	117 mm (1985)
SW Browns (3rd quarter) males	101mm (1999)	121 mm (1979)
SW Browns (4th quarter) females	100mm (1998)	115 mm (1979)
SW Briowns (4th quarter) males	96mm (1998)	123 mm (1979)

I found the explanations given for these declines at the meeting to be weak. Of greater concern, however, was the lack of objectivity expressed by some assessment practitioners when discussing possible reasons for these declines.

(b) Page 46 (Fig. 12b): Data for males and females are the same!

(c) There have been rather dramatic changes in the length frequency distributions of catches in some areas. The shift has been to a greater proportional representation of smaller lobsters (80-100 mm carapace length) in the catches, notably in:

Crowell Basin 1st quarter males & females
SW Browns 3rd quarter females
SW Browns 3rd quarter males
SW Browns 4th quarter males
SW Browns 4th quarter females

Based on these shifts, I would conclude that the number of immature spawners, or at least 1st-time spawners, in the commercial catches has increased in recent years. I would have thought that this would be a cause for concern.

Reviewer: Trevor Kenchington

Pezzack, D.S., P. Lawton, C.M. Frail, M.B. Strong, D.A. Robichaud, R. Claytor, P.J. Carroll & R.A. Valiente "The American lobster, *Honarus americanus*, fishery in LFA 41", Parts 1 & 2.

General
Pezzack *et al.* presented a very large amount of material in their two-part *Working Paper*. Collectively, their comments on the development of the fishery and on time trends in landings, effort, catch rates, extent of fishing grounds, research-vessel survey indices, lobster size compositions in commercial catches and fishing mortality rates comprise the first substantial assessment of the lobster resource in LFA 41 since 1995 and only the fifth since the offshore fishery began. Despite any weaknesses, this major upgrade is much to be welcomed. I would also strongly approve of Pezzack *et al.*'s efforts to directly respond to the questions posed to the RAP (including ones somewhat outside the normal scope of stock assessment), though I hope that the finished version of their paper will also draw more general conclusions about the state of the resource by integrating across what, at the time of the RAP, were rather unconnected studies of disparate datasets.

Assessment Methodology

Although supportive of the approaches taken by Pezzack *et al.*, I am concerned that their assessment (*sensu stricto*) was confined to examination of time series. That is a robust technique and has a proper place in any assessment but to rely on it alone confines the conclusions to ones of trends in abundance. It might, for example, be possible to say that the fishery was stable but not whether it is underfished, steadily overfished or somewhere near providing its optimal yield. Also, the time series approach can only detect resource declines (or increases) after they have been in progress for a number of years, leaving management responding to former conditions – and often with a fatally-long lag. To avoid these problems, it would be necessary to supplement the present assessment with some form of model-based extrapolation, as has long been done in finfish assessment.

I am well aware of the dangers of relying too closely on particular models (as in past Canadian groundfish assessments). However, used with due caution, they can potentially reveal information that will never be seen by interpreting any number of time series. The proper application of model-based assessments to lobsters is, of course, an area of active research [cf. Breen, P.A. (1994) Population dynamics and stock assessment of lobsters: A review. *Crustaceana* 67: 239-255; Hilborn, R. (1997) Lobster stock assessment: report from a workshop; II. *Mar.Freshwater Res.* 48: 945-947; Pitcher, C.R., D.M. Dennis & T.D. Skewes (1997) Fishery-independent surveys and stock assessment of *Panulirus ornatus* in Torres Strait. *Mar.Freshwater Res.* 48: 1059-1067] and it may be premature to undertake such an assessment for the resource in LFA 41 at this time. Nevertheless, there has been some progress on suitable techniques in the past [e.g. Caddy, J.F. (1977) Approaches to a simplified yield-per-recruit model for crustaceans, with particular reference to the American lobster, *Homarus americanus*. *Fish.Mar.Serv.MS Rep.* 1445: 14p; Caddy, J.F. (1979) Notes on a more generalized yield-per-recruit analysis for crustaceans, using size-specific inputs. *Fish.Mar.Serv.MS Rep.* 1525: 40p; Fogarty, M.J. & J.S. Idoine (1988) Application of a yield and egg production model based on size to an offshore American lobster population. *Trans.Amer.Fish.Soc.* 117: 350-362] and even, ten years ago, one preliminary attempt to apply them to LFA 41 [Pezzack, D.S. & D.R. Duggan (1990) Growth rate and preliminary Y/R values for lobsters in the offshore regions of the Gulf of Maine and southern Scotian Shelf. *CAFSAC Research Document* 90/78]. I would like to have seen at least some indications of further progress on model-based assessment, not only for what it could tell of the offshore fishery itself but also as a prototype for the application of such techniques to the more intractable problems of assessing the inshore lobster resources around the Maritimes.

Preconceptions and Conclusions

In reading earlier assessments of the lobster resource in LFA 41, it seemed that DFO's scientists had "formed a picture" of the fishery during the early 1980s (particularly that the fishing mortality rate was low and the resource stable) and that, subsequently, new information was forced to fit that preconception, rather than used to test the hypothesis of stability. Indications of declining catch rates, for example, have too easily been "explained away" by the supposed effects of improved reporting of catch rates. This sense of the assessments serving only to bolster existing conclusions is much reduced in the new *Working Paper*, though discussions during the RAP left me with the uncomfortable impression that something of the former "mind-set" may still linger.

Suffice to say that "forming a picture" and then continuing to accept it uncritically is one of the great mistakes of stock-assessment work. All concerned with LFA 41 should take care that they are not making it.

Other General Points

- The whole perspective of the *Working Paper* revolves around the fishery and the resource in LFA 41 and their interactions with the Canadian inshore zone, particularly LFA 34 – an orientation clear set by the questions asked of the RAP. While perhaps of less immediate concern to the Government of Canada, there are also strong links between the lobster resource in LFA 41 and fishing activity on the U.S. side of the ICJ Line. Terminating consideration at that line, as Pezzack *et al.* largely did, is likely to lead to incorrect conclusions.
- The expansion of Jonah crab catches in LFA 41, along with the tight integration of the crab and lobster operations, has resulted in there no longer being an "LFA 41 lobster fishery" while there never really was an "LFA 41 crab fishery". Rather, there is a complex "LFA lobster and crab fishery", with some boats specializing in one species, some in the other and some landing a mixture. Yet this two-species fishery is markedly distinct from all others in the Gulf of Maine (even if its resources are shared across several boundaries). This situation clearly calls for the LFA 41 fishery to be managed as a unit. It is, therefore, unfortunate that DFO's practice of dividing its programs along taxonomic lines has led to the lobster element of this fishery being examined in isolation from its crab aspect.
- The terminology used in discussions of lobsters in the general Gulf of Maine region has become so tangled that it tends to obscure more than communicate. During the RAP, attempts were made to distinguish between different meanings of "inshore" and "offshore" but the *Working* Paper also offers a new term, "West Browns", to cover what was formerly "Southwest Browns" (an area actually west and northwest of Browns Bank), plus Georges and Crowell basins – which have little to do with Browns Bank at all.
- In another unfortunate choice of terminology, it is becoming popular to speak of the lobsters in the Gulf of Maine region as a "metapopulation". That they are not, in the strict sense of the word. More seriously, there is little reason to suppose that they form a series of semi-discrete units, whether inter-linked or not. Rather, the available data suggests a very large number of discrete individuals, each with ranges and behaviour patterns that partially-overlap those of its neighbours. The linkages between them vary from year to year, particularly as wind events alter the drift of planktonic lavae. This is a far more complex reality than any "metapopulation" concept can embrace. Yet ideas are all too easily constrained by the words used to express them and I am much concerned that the abuse of terminology will lead to seriously-incorrect conclusions being drawn.
- I would repeat the warning that I made at the RAP concerning the data from the last two years of the LFA 41 fishery: The cooling event that reached the lobster grounds early in 1998 clearly had major impacts on the availability of the lobsters to trapping and probably on their migration routes and productivity too. Although the water returned to more normal temperatures through 1999, there is no guarantee that lobster availability immediately tracked temperature. Rather, it may have "overshot" during the recovery phase. Thus, data from the

1999/2000 fishing year may not be directly comparable with that from 1997/98 and earlier years. This will cause considerable difficulties when interpreting time-series data and will continue to do so until a few years of post-cold-event data are available.

Finally, although the extensive *Working Paper* is to be upgraded into a *Research Document*, the version presented was very far from being a final draft and thus there would be little value in offering editorial comments here. I will therefore confine my further points to matters of rather more substance.

Fishing Locations

The *Working Paper* (Part 1, p. 13) notes changes in the fishing grounds following establishment of the ICJ Line and, later, as the Jonah crab fishery expanded. Pezzack and Duggan's previous assessment (*DFO Atlantic Fisheries Research Document* 95/91) remarked on more subtle moves in the intervening years, with lobster effort shifting away from the continental slope and into the basins, eventually concentrating in Crowell Basin. That shift has been remarked on (to me) by fishermen involved in this fishery. I would also suggest that it is detectable in Pezzack *et al.*'s (Part 1) Figure 17, where the area in which 75% of the LFA 41 lobster were caught is shown as decreasing quite markedly from 1990 until the advent of the Jonah crab fishery in 1997 – a decrease consistent with an increasing proportion of the lobster catch being taken from Crowell Basin. The pattern is less obvious in the *Working Paper*'s (Part 1) Figures 15 and 16 but that may only be an artifact of the coarse scale used to portray the effort in, and catch from, each ten-minute rectangle: Many rectangles exceeded 15,000 trap-hauls and 50,000 kg of catch but few reached 30,000 or 100,000 (respectively) and thus there could be a substantial shift in the fishery without much change in the plotted symbols.

I suggest below that, during the 1990s, Crowell Basin saw a different trend in catch rates from the other LFA 41 lobster grounds. If so, any concentration of effort in that one area will have had major effects on the overall performance of the fishery. Unless Pezzack *et al.* have specific reasons for abandoning Pezzack and Duggan's previous conclusions about the inter-annual movements of the fishery, I would strongly suggest that the shift into Crowell Basin be fully explained in the *Research Document*. The more dramatic changes since the Jonah crab fishery began should not be taken as reason to pass over the relatively small, but still important, shifts in previous years.

Landings

One of the disturbing indicators of the status of the LFA 41 fishery is its failure to achieve the TAC in many of the years since that came into force. Some of the shortfalls have been minor and may represent no more than a decrease in lobster availability in late summer interacting with the industry's desire to spread the catches throughout the year. However, landings fell below 90% of the TAC in 1985/86, 1987/88, 1988/89, 1989/90, 1991/92, 1992/93, 1997/98 and 1998/99. While shortfalls in the last two years were most likely due to the unusual cooling event of 1998, in most fisheries such failures to fill the quota would be seen as a warning that all was not well with the resource. Pezzack *et al.* did not draw that conclusion, however, and did not even draw attention to this feature of their data.

I suggest that the matter should be addressed in their final *Research Document* and, unless there are specific reasons why not, the offshore fleet's inability to fill its TAC in eight of the past fifteen years should be treated as a caution that the lobster resource on the offshore grounds may not be as productive as some have supposed.

Catch Rates

Pezzack *et al.* offered a new analysis of trends in catch rates in the LFA 41 fishery, based on the multiplicative model, in place of the relatively-simplistic calculations used in earlier assessments. That was a valuable and advance. The analysis needed substantial corrections during the RAP meeting, however, and the approach would benefit from still further refinement during the coming months. I here offer some suggestions for that refinement and also some conclusions which might be drawn from the revised results.

Approach

- The multiplicative CPUE analysis has, to date, used data only for the months October to July, since the figures for August and September 1999 were not available when the *Working Paper* was being prepared. While that limitation was appropriate for the RAP, the calculations should be re-run with full-year data before a final *Research Document* is prepared. While that will probably not materially change the results, it will be easier for non-specialists to comprehend and will be more comprehensive.

- The analyses have been confined to those trips which landed zero bycatch of crabs and thus can be said, with certainty, to have been "lobster directed". That may, however, have introduced a pronounced bias into the data. For one thing, no attempt has been made to separate the catch rates of the various boats and crews (no "boat effect" was built into the model though it could have been). Yet it is likely that some of the captains are more inclined to land crabs than are others. As the decline in lobster catch rates makes landing some crab bycatch more attractive, a specialized selection of the fleet will do so, while other captains and their vessels will continue to land only lobsters (at least on most trips). Thus, the "zero crab" choice will confound differences among the fishing powers of the boats with changes in the calculated catch rates of the fleet.

  More seriously, if the captains and crews opt to discard all crabs when lobsters are abundant but to retain some crabs when lobsters are too scarce to provide a full load from even a lobster-directed trip, use of only "zero crab" trips will seriously bias the catch-rate index, under-estimating the true decline in lobster abundance.

  In his written comments, Dr. Hutchings has pointed out that the lobster catch-per-trip on trips landing more than 50% crab has been increasing, when that on "zero crab" trips has decreased (though it is still higher than when above half the landed catch is crab). There are many possible explanations for that observation but one would be that a proportion of lobster-directed trips are now landing more than 50% crab – increasing the calculated lobster catch rate on these "crab trips" while also biasing the rates on "zero crab" trips upwards by moving the least-successful lobster trips out of the "zero crab" category.

  Thus, before much reliance can be placed on these catch rates, a way must be found to identify lobster-directed trips (since catch rates from bycatch species are rarely indicative of

resource abundance). As the focus of that search is on human choices (of what to direct for), it should start by asking fishermen and then proceed to build some technique for separating trips into "lobster" and "crab" based on what the captains say they do.

It should be remembered, however, that both whole trips and even single strings of gear may no longer be set for one species or the other but rather for an optimal mixture of the two. If so, there would no longer be any such thing as a purely "lobster-directed" trip and it might be necessary to resort to quite other means of developing a catch-rate index from the data if the latter were to be useful as an index of resource biomass.

- The eventual *Research Document* should emphasize that the catch rates calculated are actually landings (not catch) per unit effort. Thus they will have been influenced by inter-annual changes in any culling practices followed by the fleet. Various and conflicting opinions on the past prevalence of culling have been expressed by the offshore lobster industry. Suffice to say that a reduced tendency to discard one-clawed and other sub-standard lobsters could mask a considerable decline in true CPUE when the "catch" data are only available as landings.
- The CPUE analyses presented at the RAP had a confusion of alternative options, all of which led to the same general conclusions. I would recommend using only the full dataset, including the outliers (confusingly termed "residuals" in the *Working Paper*), and just one time step (e.g. 14 days), while noting in the text that the other alternatives were tried but not used.
- Conversely, I think it is important that the catch-rate series are broken out for each of the five established sub-areas. (Still finer division might be desirable but is probably not practical.) The 1995 assessment showed a markedly different trend in CPUE in the Crowell Basin area from those elsewhere; a difference which seems also to be indicated by the revised analysis run during the RAP. It will be important to examine and explain this difference in the time trends and not to hide it by lumping data from Crowell with those from Georges Basin and the "southwest Browns" grounds, as was done in the *Working Paper*.
- During the RAP, Mr. Pezzack stated that he wanted to meet with the offshore-lobster captains and so to document what changes in fishing techniques they had made and what trends in catch rates they had seen. In particular, he wished to gather more information on the supposed misreporting of trap hauls during the early 1990s. I would strongly support such an initiative (indeed would question why it has not already been done), though I would also suggest that it take a wide-ranging approach, rather than being limited to the mis-reporting issue alone.
- On a small point of clarity: The usual abbreviation for catch per unit effort, or catch rate, is "CPUE". I have not previously encountered the "CUE" used in the *Working Paper* and its use did nothing to aid this reader's understanding.

Conclusions

- The *Working Paper* drew a number of invalid conclusions from plots of catch against fishing effort. A supplementary document produced during the RAP included more useful catch rate *vs.* effort plots. Those for the October–April and April–July periods show no relationship

whatsoever between those two variables, suggesting that directed fishing effort in the LFA 41 lobster fishery has not affected the measured catch rates.

The CPUE *vs.* effort plot for October–July hints at the expected inverse relationship for the years 1985/86–1987/88 and 1989/90–1995/96 (with 1988/89 anomalous) and again for 1996/97–1998/99, though the catch rates in the latter three years appear to have been depressed by about 50% compared to those in the earlier period at the same intensity of fishing effort. That depression might suggest an impact of directed fishing on resource biomass, coupled to a substantial reduction in resource productivity during 1996. However, in light of the lack of relationships in the two seasonal plots, it seems more likely that the apparent pattern arose through some combination of chance, inter-annual changes in the seasonality of fishing effort and the known cooling event in 1998.

Since the LFA 41 lobsters are vulnerable to fishing over a number of years, the catch rate should really be compared against the average effort over a period of time preceding the measurement of the rate, rather than the effort in the year that the rate was estimated. Doing so does not, however, seem to change the impression of a lack of any meaningful relationship in these catch rate *vs.* fishing effort plots.

- The re-calculated catch-rate index for all areas and for the October–July period (in the supplementary document) showed a decline of more than 50% between 1990/91 and 1998/99, though that proceeded as an initial rapid decline, followed by stability or a slight increase from 1993/94 to 1995/96 and then a further drop. Arguably, 1998/99 was no lower than 1997/98. The plot for the October–April period follows a similar trend, though the initial decline merged more gradually into a longer period of stability. Conversely, the April–July period showed a more pronounced recovery to 1995 and a sharp increase from 1998 to 1999.
- Examined by area, and for the October–April season only (no plots for the April–July period and for individual areas being provided), Georges Bank (Area 5) has seen stable catch rates through the 1990s, save for a drop in 1998/99. The Southeast Browns ground (Area 4) had stable CPUE in the late 1980s and through to 1992/93 but thecatch rate there has since declined. Georges Basin (Area 3) has seen catch rates decline very substantially since 1990/91 with only a slight increase during 1995. CPUE on the “Southwest Browns” ground (Area 2) has been declining irregularly since the mid-1980s at least. Only in Crowell Basin (Area 1) did catch rate show a marked positive trend through the 1990s, reaching a peak in 1994/5 and 1995/96 before dropping by more than 50% to 1998/99. Thus, the apparent stability and increase in overall CPUE in the mid-1990s likely resulted from a shift in effort into the temporarily-rich area in Crowell Basin (a shift that has been reported by the fishermen concerned). That movement by the fleet apparently served to mask CPUE declines in most other parts of LFA 41 until the later 1990s.
- There are a number of possible explanations for the catch-rate increase in Crowell Basin in the mid-1990s. Considering its location, it is rather better placed than is the rest of LFA 41 to receive lobsters walking out from inshore grounds. The pulse of recruitment that has been seen inshore in the last 20 years may have led to a marked increased supply of adult lobsters to Crowell Basin sufficient to cause the trend in catch rates.

- Catch rates in trap fisheries are never good indicators of resource biomass and there are a range of additional factors that prevent the overall decline in CPUE from being interpreted as an equal decline in the resource. Those include the small number of vessels, the mobility of the lobsters, their marked responses to changes in water temperature and major doubts concerning the use of "zero crab" trips as a foundation for catch-rate estimations. The sudden cooling event early in 1998, followed by a rapid re-warming late in 1999, will have caused severe disruption of the end of the time series. All that aside, there seems little reason to doubt that the usual pattern of increasing efficiency (and so a catch rate that falls more slowly than does biomass) has acted in the offshore lobster fishery, as it has in so many others. The one substantial reversal in that trend, before the recent re-warming, was probably the ending of misreporting of trap hauls in the period 1993/94 through to 1996/97. Those were not, however, years when the recorded catch rate dropped markedly, save on the Southeast Browns ground, and indeed they saw a surge in CPUE in Crowell Basin.

  Thus, while it would be wrong to suggest that the recorded catch rates accurately reflect trends in biomass, the overall decline probably does indicate that the lobster resource in LFA 41 has diminished markedly over the last ten years.

- The questions posed to the RAP meeting carried a clear presumption that any such trend in biomass must be linked to fishing effort in the LFA 41 lobster-directed fishery. I would suggest that that was a very misleading starting point and one that, in other fisheries, has led to serious misinterpretations of fishery status. With the lobster resource in LFA 41, there is nothing to suggest that the directed fishery in the offshore area was a major contributor to the probable decline in biomass. Indeed, the lack of a relationship between directed fishing effort and catch rate indicates that the fishery did <u>not</u> cause the decline.

- During the RAP, data from the NMFS groundfish surveys was informally presented. It indicated that the pulse of lobster recruitment, which began in the Gulf of St. Lawrence around 1970 and which may only now be at its peak in the Bay of Fundy, has not been seen on the coast of Massachusetts nor on Georges Bank. One might therefore hypothesize that the resource in Crowell Basin (and to a lesser extent that in Georges Basin) benefited from the recruitment pulse in the mid-1990s. Southeast Browns may have received increasing numbers of adult lobsters from inshore areas in the years up to 1990, when catches in LFA 33 passed their peak. Otherwise, the lobsters in LFA 41 seem to have been in long-term decline, presumably primarily due to fishing pressure in other areas or by gear directed towards other species.

  The data from Georges Bank do not show any clear signal of the cut-backs in the groundfish fisheries, on both sides of the ICJ Line, during the mid- and late-1990s – suggesting either that it has not been intensive groundfish fishing that has caused the LFA 41 lobster resource to decline or else that the available catch-rate indices are too crude to detect even such major changes in the fisheries.

Size Frequencies

In earlier stock assessments, supposed stability in the sizes of lobsters taken in various parts of LFA 41 has been the primary evidence advanced for the conclusion that the resource is stable. From the current *Working Paper*, it appears that the catch-rate time series are now being given relatively more weight, a change which I would strongly support. While the catch rates are

certainly highly-dubious indicators of resource biomass in LFA 41 (and were rejected for assessment use for essentially that reason fifteen years ago – se: *CAFSAC Research Document* 85/89), most of their problems are equally applicable to the use of time series of size compositions. At least, the latter have analogous problems to those of catch rates. Moreover, there are a solid theoretical grounds for supposing that catch rates should approximate (however poorly) to indices of biomass. There is no such link between biomass and size composition, while the latter's relationship with total mortality rate is tenuous and complex. Faced with two such dubious indicators of resource status, I would suggest giving close attention to both, rather than primacy to either. That appears to be what Pezzack *et al.* now intend.

The *Working Paper* (Part 2) and discussions at the RAP covered some of the problems with the available size-composition information. I would also emphasize::

- The irregular sampling in the past (with some areas and seasons seeing no sampling for periods of over ten years) seriously limits the conclusions which can be drawn. More regular sea sampling should be carried out in future.
- There is a serious doubt about what type and degree of change in the length frequencies would indicate that fishing pressure was rising to unacceptable levels. A moderate fall in mean length might do so (though it could also show increased recruitment) but the fishing mortality rate might have to be excessive long before such a fall was seen. A reduction in the relative abundance of very large animals might be a more sensitive indicator of fishing pressure but that would also be likely to be affected by random chance (since there are never many large lobsters), by minor changes in gear design (excluding larger animals) and by fishermen's targeting practices (since the very large animals are too uncommon to be targeted themselves).
- Pezzack *et al.* discussed the effects of gear selectivity on these length frequencies but they did not touch on the fishermen's targeting practices, which have the potential to more strongly influence the disagreement between the size compositions of the resource and the catches.
- The Stasko hypothesis, that static lobster sizes in LFA 41 are a dynamic result of an "offshore walk" by adults (resulting in larger sizes further out), has never been satisfactorily dismissed. While it remains a possible explanation for the constancy of average sizes, the observed stability in each area may represent nothing more than a stability in the pattern of ontogenetic offshore migration. If so, it would not be indicative of mortality rates, let alone biomass levels, at all.

In sum, the length-frequencies presented in the *Working Paper* give little indication of on-going change in the lobster resource in LFA 41. That lack of evidence of change should not be too-readily accepted as evidence of a lack of change.

A few tentative conclusions may still be drawn from the available size compositions:

- The only parts of LFA 41 in which mean size has declined detectably, Crowell and Georges basins, are also the only ones that showed an increase in catch rate in the mid-1990s. It is

possible that those areas receive occasional pulses of stronger recruitment (increasing catch rates and reducing average sizes) in a manner not seen in the other parts of the LFA.

- Elsewhere in LFA 41, the size compositions in the catches have remained much more stable through the initial and subsequent development of the directed fishery than in other lobster fisheries (either inshore Canadian or offshore U.S.). That is some sort of indication that the LFA 41 lobster resource is not experiencing very high total mortality rates.

However, these lobsters were vulnerable to groundfish dragging, including deepwater dragging for redfish, from at least the 1930s onwards and thus may not have had a "virgin" size composition when the Canadian LFA 41 fishery began in the 1970s. Nor are very large lobsters (greater than 150 mm carapace length) as frequent in the catches from Georges Bank as they once were. It would be easy to dismiss that change as caused by the adoption of rectangular traps in place of the earlier conical design, were it not for the dangers of "explaining away" data that conflicts with current perceptions of the fishery.

Sex Ratios

The *Working Paper* drew some comfort from sex ratios in the catches that are skewed towards an excess of females. As Pezzack *et al.* rightly say, such ratios are consistent with moderate fishing under the partial protection for females provided by the ban on landing berried animals. While one can reasonably conclude that these sex ratios provide no evidence of undesirable trends in the lobster resource in LFA 41, I am less sure that they offer much support for the idea that there are no such trends:

- Interactions between the biology of the animals and targeting practices within the LFA 41 fishery will skew the sex ratios in the catches relative to those in the available resource, quite possibly by enough to produce the apparent shortage of males. If the sex ratio in the resource were really 50:50, as it might be, it would be consistent with heavy fishing (and also with very light fishing).

- The sex ratio provides, at best, an indication of a different survival rate in each of the two sexes. Along with natural factors, those survival rates must relate to the effects of all fisheries that kill lobsters which would otherwise have reached LFA 41, not simply to the directed LFA 41 fishery. Whatever deductions can be drawn from the observed sex ratios should not be misapplied to the directed fishery alone.

Fishing Mortality Rates

Part 2 of the *Working Paper* offered some limited information on mortality rates but the only information of much substance came from the United States. At the RAP, it was explained that the time series of fishing mortality illustrated in Figure 21 (of Part 2) was actually based on research-survey data collected from all of the waters on U.S. side of the ICJ Line southwestwards to the waters off Carolina, save only the inner Gulf of Maine (though most of the lobster caught were likely from the Georges/Cape Cod area, the species being relatively scarce further south). Also, the figure really represented a plot of the total mortality rates (calculated from abundance-at-size data), with the origin shifted to allow for an assumed rate of natural mortality. Thus, the illustrated rate of "fishing mortality" may have little to do with

directed lobster fishing and none at all to that in LFA 41. I recommend that it be deleted from the *Research Document* and not cited in the *Stock Status Report*.

It might, however, be pointed out that the fixed TAC (supposing that it is taken each year) will inevitably result in increasing directed fishing mortality rates in LFA 41 if the biomass is indeed falling, as the catch-rate time series appears to indicate. Of course, that mortality rate may be increasing and yet still be low if it was, in 1990, as very low as has been supposed.

Genetics & Morphology

The summary of published literature on genetic and morphological studies of lobsters, presented at the RAP, was really not adequate to answer the relevant questions posed to the meeting. However, it does appear that past studies have been unable to find evidence of substantial barriers to gene flow in lobsters within the general Gulf of Maine region. That is as might be expected from the model-based indications of substantial exchange of larvae between the various sub-areas of that region.

Stock Status and Management Implications

Overall, I would agree with Pezzack *et al.* that the directed fishing effort being exerted on lobsters in LFA 41 is probably light (except, perhaps, in a few local areas such as the eastern side of Crowell Basin). I would suggest, however, that the evidence supporting such a conclusion is weak and may in time prove incorrect.

I would also suggest that the catch-rate information points to a long decline in the lobster resource offshore and a shorter, sharper decline in Crowell Basin. If the LFA 41 fishing effort is as light as it seems, those declines are unlikely to have been caused by the Canadian offshore lobster fleet, though it must have contributed. Rather, those declines must reflect either environmental change, the effects of other fisheries or else some combination of both of those plus directed effort in LFA 41. Attempts to identify a specific cause cannot be much more than speculation.

In summary, I would paint a rather bleaker picture of the LFA 41 lobster resource than Mr. Pezzack did at the RAP. He there presented a “stop light” summary of stock status indicators in which he found fourteen points meriting “positive evaluation”, two of uncertainty and no “concerns”. I would have flagged the offshore fleet’s frequent failure to take its TAC as a point of uncertainty, while I would rate the substantial fall in measured CPUE since 1990, the lack of any reliable indices of resource biomass or of mortality rates, and the heavy fishing pressure in adjacent areas as matters of concern.

If the biomass of offshore lobsters is indeed falling, inshore-fishery interests will justifiably be concerned that the LFA 41 fishery, or at least that portion of it around Browns Bank, is taking spawners that might otherwise contribute to recruitment in LFA 34 and in the Bay of Fundy. With equal reason, those in the offshore fishery could complain that the inshore fisheries are exploiting concentrations of small lobsters on nursery grounds, a proportion of which would walk offshore to support the LFA 41 resource if they were not first intercepted by the very heavy fishing pressure on the inshore grounds. Recently, Fogarty (“Implications of migration and larval interchange in American lobster (*Homarus americanus*) stocks: spatial structure and resilience”.

In: G.S. Jamieson & A. Campbell (eds.) Proceedings of the North Pacific Symposium on Invertebrate Stock Assessment and Management. *Can.Spec.Publ.Fish.Aquat.Sci.* 125: 273-283, 1998) produced an analysis of a model system comprised of "inshore" and "offshore" areas, linked by larval drift into the inshore area and by adults walking offshore, with each population driven by stock/recruitment dynamics (rather than the more-relevant yield-per-recruit dynamics). His analysis led to some conclusions that may aid understanding of the management issues which underlay the questions posed to the RAP:

- Even with a low level of larval exchange between offshore and inshore areas, an unfished offshore resource can prevent the expected consequences of gross over-fishing inshore.
- An unexploited inshore resource would similarly protect an offshore fishery from the consequences of its own bad management, through an on-going supply of adults walking offshore. That effect is particularly marked if the movement of the lobsters is related to their density on the inshore grounds (with more walking when their density inshore is high), as it may well be.
- In both cases, the "protection" would be removed from one area by even a moderate fishery in the other.
- The overall catch, summed across both inshore and offshore areas, cannot be maximized without an offshore fishery. If not fished, animals offshore would "go to waste" from a catch-production perspective. Optimal fishing effort in each area is lower if both are fished than if there is no fishery in the other area.

To the limited extent that such model results can be trusted, it seems that participants in the Canadian inshore and offshore fisheries have reason to object to one-another's fishing since each may be removing the other's "safety net" and leaving it vulnerable to the full consequences of its own overfishing. Whether either should be restricted in order to save the other from stricter conservation limits is, however, a policy question beyond the purview of scientists.

Manuscript: Review of Rock and Jonah crab distribution off eastern Nova Scotia and the Gulf of Maine, with notes on stock structure.

Author: Tremblay, M.J.

Reviewer: Richard Wahle

• What is the northern limit of the distribution of these crabs? There is little information on the abundance of these species north of the Gulf of St. Lawrence. Interested in how cold temperature may influence the distributional limits of these crabs.

• Questions regarding the trawl survey
  How was the survey stratified?
  What is the mesh size?
  How does catch efficiency change with crab size & substrate type?
  Why no trawls in depths <30 m?

• It is stated that Jonah crabs prefer warmer water - based on geographic range, but they are found in deeper, colder water than Rock crabs which isn't consistent with that statement.

• Note in size-frequency distributions of the two species from trawl surveys that juvenile Jonah's (<30 mm CW) are present, but Rock crabs <30 mm are not. Is that indication that Jonah's settle in deeper water? From prior research in the Gulf of Maine (Palma et al. (1998) we know that rock crabs settle in shallow water, but newly settled Jonah crabs are extremely rare.

Reviewer: Peter Koeller

1. need more than distribution data for this problem - what about lfs (size structure)
2. why this paper? It's really the same problem as lobsters, where we don't worry about stocks
3. Jonah distribution looks like 4 subpopulations, rock like one large population like lobsters - could come to opposite conclusion.
4. Compare fishery and survey LFs

Manuscript: Rock crab off Eastern Nova Scotia (LFAs 27-32): Stock status and evaluation of the exploratory fishery.

Authors: Tremblay, M.J. and A. Reeves

Reviewer: Peter Koeller

Rock crab off eastern N.S.: stock status and evaluation of exploratory fishery

1. crab bycatch in lobster fishery: any reporting at all? Is it voluntary or mandatory? Can we estimate it roughly, say from interviews?
2. of the 28 active licences, how "active" were they. Most of the catch may have been taken by a few fishers.
3. location data in 96-98 - can't it be inferred approximately from the home port, since they don't go that far from it?
4. Sampling is very low (12 samples from 96-99 total
5. Landed value <200K i.e. <10K per boat, who got most of it (i.e. as in 2 above)
6. Not trend in CPUE hard to say it went down last year
7. Lfs are suspect (low sampling, trap selectivity)
8. Compare Gulf and Quebec productivity, catches, effort.
9. Traffic light - still needs data! (sow's ear => silk purse)
10. Restriction of new licences to unfished areas - but some fished areas may still be underfished

Reviewer: Richard Wahle

• Can the use of CPUE be justified as an index of crab abundance given the potential for trap saturation, competitive effects of lobsters, seasonal and sexual differences in trapability? Would not landings be a better indicator since effort tends to track abundance?

• The absence of trawl data in shallow water (<30 m) leaves no fishery-independent measure of abundance for rock crabs.

• What are the consequences of a male biased harvest to the reproductive performance of these crab populations? Minimum harvestable size limits are such that most females escape harvesting and most males do not. Onset of maturity is at a larger size in males than females (the reverse is true for lobsters). Males therefore get fewer opportunities to reproduce. The larger size of males and the observation that females mate with males larger than themselves suggests there is a mating advantage to larger males. Would cropping large males from the population leave functionally immature males unable to successfully mate? This boils down to a question of whether sperm limitation may occur in an intensely harvested population.

• The "Traffic Light" approach - How are the different indicators weighted?

Manuscript: Status of the LFA 33 Jonah crab fishery, 1997-99.

Authors: B. Adams, A. Reeves and R. Miller

Reviewer: Richard Wahle

• The same questions regarding CPUE raised in Review 2 apply here. Note (p.6) that effort correlates spatially with landings, but CPUE does not .

• The same questions regarding the consequences of male biased fishing raised in Review 2 apply here.

Manuscript: Exploratory fisheries for Rock Crab, *Cancer irroratus*, and Jonah Crab, *Cancer borealis*, in Canadian Lobster Fishing Areas 34, 35, 36, and 38.

Authors: David Robichaud, Peter Lawton and Mike Strong.

Reviewer: Richard Wahle

• What depths are the Jonah crabs harvested from? The question stems from interest in how the colder waters in the Grand Manan/Fundy region may influence the depth distribution of Jonah crabs.

• What are the practical considerations of having a single permit for both crab species, but requiring different trap configurations for each species?

• The same questions regarding CPUE raised in Review 2 apply here.

• The same questions regarding the consequences of male biased fishing raised in Review 2 apply here.

Manuscript: Review of Jonah Crab, *Cancer borealis*, fishery in Canadian offshore Lobster Fishing Area 41, 1995 to 1999

Authors: David Robichaud, Doug Pezzack, Cheryl Frail, Peter Lawton and D.R. Duggan

Reviewer: Michel Comeau

This paper to a straight forward review of the Jonah crab fishery. I only have one comment directed to the text on page 12-13. The authors mention on page 12 that soft shell on Georges Bank is observed in July and on page 13 that low meat yield for the same area is observed during October and November. As those two events should be closely related, why is there 3 to 4 months separating these events? I do not think that any project was done specially to establish the moulting period of that species in LFA 41. Hence, it should not be mentioned in this report. It seems that the sketchy information reported does not allow us to speculate on the moulting season. The last paragraph of the "General biological information" section should be deleted.

My general comment is that the interpretations throughout the document are based solely on observations of fishery-base data and they should be done with caution and written accordingly. Knowing the numerous uncertainties and the fact that this fishery is not a directed fishery, attributing the variations and trends mainly on the abundance of crab is not correct. Within a fishery using solely traps as a mean of capture and the unit of effort, variation in landings should not be attributed to abundance. Traps are highly selective and the species targeted is not actively captured. Hence, the seeming reduction in the overall catch rate might be related to something else than crab abundance (see first half of the first paragraph of the conclusion). I agree with the last paragraph of the conclusion, and perhaps new directed research projects should also be encouraged to increase knowledge of that species in that area.