The Development of Underutilized Invertebrate Fisheries in Eastern Canada

Workshop Proceedings
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November 23-25 1993

Editors

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ABSTRACT

Gendron, L. and S. Robinson (eds.) 1994. The development of underutilized invertebrate fisheries in Eastern Canada. Workshop proceedings. Can. Manuscr. Rep. Fish. Aquat. Sci. 2247: vii + 129 p.

A workshop was held from November 23 to 25, 1993 in Moncton, New Brunswick, to discuss several aspects of the development of fisheries for underutilized marine species. Participants were present from the science (government and university) and management sectors. The specific objectives of the meeting were to examine the approaches to research and management of underutilized species in each DFO Region of eastern Canada, to examine the ongoing research activities for various groups of invertebrate species and to discuss the possibility of establishing some general guidelines for a rational and controlled development of fisheries for underutilized species. A total of 17 presentations were given in 5 sessions: (1) management and research approaches; (2) case studies - Crustaceans; (3) case studies - Molluscs and Echinoderms; (4) biological and sociological concerns in the development of new fisheries; and (5) a final round table discussion on guidelines and recommendations for the development of new fisheries. This document presents the content of the papers presented at the meeting as well as the results of the round table discussions.

Many common problems were found among all the fisheries examined, the major one being the lack of good biological information on which to base a management plan. This lack of information coupled with a high value, virgin resource often leads to a rapid expansion of the fishery in which industry and political pressures can jeopardize its rational development. Three recommendations were made in the ensuing discussions. (1) A formal, fixed-term financial commitment should be made by upper management to scientists involved in research on underutilized species. To do so, it is suggested that a certain proportion of any developmental funding should be directed into scientific activities. (2) Baseline data on the populations should be gathered before the fishery is initiated so that information on the pre-harvest state is known. In addition to traditional sampling techniques, consideration should be given to establish unharvested areas which could serve as refuges or sanctuaries. (3) The exchange of information between administrative regions on the development of fisheries for new species could be improved and facilitated through new organizational structures.

RÉSUMÉ

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Un atelier de travail a eu lieu à Moncton au Nouveau Brunswick, du 23 au 25 novembre 1993, au cours duquel des présentations et des discussions ont porté sur différents aspects du développement de l'exploitation d'espèces marines sous-utilisées. Cet atelier regroupait des scientifiques gouvernementaux et universitaires ainsi que gestionnaires des pêches du gouvernement fédéral et des gouvernements provinciaux. Les objectifs spécifiques de cet atelier étaient d'examiner les approches de gestion et de recherche concernant les espèces sous-utilisées mises de l'avant dans chacune des régions de l'est du Canada, d'examiner les activités de recherche présentement en cours pour différents groupes d'invertébrés sous-utilisés et de discuter de la possibilité d'établir des lignes directrices pour un développement rationnel et contrôlé de ces nouvelles exploitations. Au total, 17 communications ont été présentées à l'intérieur de 5 différentes sessions, soit: (1) approches de gestion et de recherche; (2) étude de cas - Crustacés; (3) étude de cas - Mollusques et Échinodermes; (4) considérations biologiques et sociologiques liées au développement de nouvelles exploitations, et finalement (5) une table ronde sur l'établissement de lignes directrices et de recommandations pour le développement de nouvelles exploitations. Le présent document fournit le contenu des présentations ainsi que les résultats des discussions en table ronde.

Un certain nombre de problèmes communs à l'ensemble des pêcheries d'invertébrés sous-utilisés sont apparus, le plus important étant celui du manque d'information biologique pertinente au développement d'un plan de gestion. Cette absence d'information sur des ressources vierges et lucratives, se traduit assez souvent par un développement trop rapide de leur exploitation, auquel s'ajoutent les pressions politiques et de l'industrie qui peuvent en compromettre davantage le développement rationnel. Trois recommandations ont été faites suite aux discussions. (1) Un engagement financier fixe et formel devrait être pris par les gestionnaires de haut niveau afin d'assurer un soutien aux scientifiques impliqués dans la recherche sur les espèces sous-utilisées. Pour ce faire, il est recommandé qu'un certain pourcentage des fonds attribués au développement de nouvelles pêcheries soit dirigé vers des activités scientifiques. (2) Des données biologiques de base sur les populations devraient être obtenues avant que ne se développe l'exploitation, de façon à ce que l'on puisse connaître l'état de la ressource avant qu'elle ne soit exploitée. Outre le recours à un système d'échantillonnage standard, il serait pertinent d'envisager l'établissement de zones inexploitées, servant de sanctuaires ou de refuges. (3) Une structure organisationnelle devrait être mise en place, dans le but d'améliorer et de faciliter l'échange d'information entre les scientifiques des différentes régions, impliqués dans le développement de nouvelles exploitations.

INTRODUCTION

The meeting on the "Year of the Underutilized Species" was held from November 23 to November 25, 1993 at the Department of Fisheries and Oceans in Moncton, New Brunswick. This was the third thematic meeting organized under the auspices of the Inter-regional Scientific Committee of Invertebrates and Marine Plants and was initiated due to the rapidly growing interest in underutilized species in all Atlantic Regions. Many scientists, in addition to their usual work on stock assessment and biological research on traditional commercial species, are also asked to provide scientific advice on the development of fisheries for underutilized species. The recent downturn in many traditional fisheries and the increase in demand for new species from international markets has significantly increased the frequency of these information requests. Because of the small scale of the fisheries and their current low commercial value, relatively little attention has been given to these species and most of the advices given have been on a Regional rather than an Atlantic zonal basis. It was felt that a forum for consultation between the Atlantic Regions was necessary, in order to share different scientific and management approaches. This was felt to be especially important as increased pressure on the development of underutilized fisheries can be expected in the near future. To get an integrated view of the scientific and management approaches and actions taken in the development of new fisheries, a special invitation was addressed to regional managers to attend the meeting. The specific objectives of the meeting were (1) to examine each Region's research and management approaches to the development of underutilized species fisheries, (2) to examine the research activities in a number of case studies for various groups of invertebrate species and (3) to discuss the possibility of establishing some general guidelines for a rational and controlled development of fisheries for underutilized species.

A total of 17 papers were presented within 4 sessions. A fifth session was organized to discuss general concerns regarding the development of new fisheries and develop research and management recommendations. The summaries of each session are presented in the following section.

SUMMARY OF THE SESSIONS

SESSION 1. Overview of the Fisheries of Underutilized Species - Management and Research Approaches. Rapporteur : Howard Powles

Overviews of fisheries for underutilized species in Québec, Gulf and Scotia-Fundy Regions were presented, and some of the major management and research issues were identified and described. Rock crab, arctic surf clam, and green sea urchins are currently the major species of interest, but a number of other crustaceans, echinoderms, molluscs, plants and planktonic species have been targeted for development over the years. A DFO policy for development of underutilized species was published in 1988, and Regions subsequently developed action plans based on public and DFO consultations, on which development of fisheries for underutilized species is based.

Decline in stocks of traditional species and increased demand due to development of a world market in fisheries products are combining to increase demand for underutilized species. While demand is increasing, management is constrained by lack of biological knowledge: underutilized species biology is generally little known, and budgets for research on underutilized species are very restricted. Most research funding has come from short-term programs with pressure for rapid results; there is practically no funding support for long-term studies. Management thus has to be iterative, starting with "best-guess" biological knowledge and available market and socio-economic information. The tendency is to be conservative in the early stages. Underutilized species fisheries may not become large compared with traditional fisheries, but may have considerable small-scale importance in communities.

Access is a major issue in managing fisheries for underutilized species, both in the initial (developmental or exploratory) and later stages. Approaches to issuing developmental permits vary among Regions, from issuing scientific permits (which can be done rapidly), to going through a public advertisement and draw process. There was some discussion as to whether those fishers who participated in the developmental phase should be, or can be, favored for the issue of long-term permits. Issuing scientific permits to associations rather than individuals may limit later individual demands for favored access to the long-term fishery. Interactions with species exploited by high-value fisheries (bycatch, ecological interactions) and habitat issues (gear damage to habitat) are some of the scientific issues requiring attention in developing underutilized fisheries.

SESSION 2. Case studies - Crustaceans. Rapporteur : Mikio Moriyasu.

An overview of the biological and fishery information on the rock crab *Cancer irroratus* in the southern Gulf of St. Lawrence was presented. Despite ten years of rock crab commercial fishing activity, with an increasing landing trend in the southern Gulf of St. Lawrence lobster fishing areas, very little scientific information is available to date. Preliminary biological and fishery data analyses revealed a tremendous variation of size structure, spatio-temporal distribution, catch rate as well as reproductive and molting cycles among the different fishing areas. Reasonable financial support for continuation of research and assessment activities on the species is required for the establishment of sound management strategies. Preliminary biomass estimation of rock crab by means of geostatistical analysis (kriging) suggested a dynamic seasonal movement of the species in the central Northumberland Strait. A similar pattern for commercial size male crab was also observed in Baie des Chaleurs relative to molting cycle. It was noted that kriging is a promising technique for estimating biomass and exploitation rate for rock crab. The inter-specific relationship between rock crab and lobster was discussed from the biological and ecological perspectives. An extensive study of literature and preliminary laboratory experiments suggested that lobster prefer rock crab as food. Rock crab is a high quality prey in terms of energy and protein content and may greatly contribute to somatic growth and gonadal development of lobster. Decrease in rock crab recruitment by exploitation could induce: (1) decrease of rock crab availability to lobster as food; (2) increased consumption of other species by lobsters with lower nutritive value, affecting growth and reproduction of lobsters and (3) increased vulnerability of lobsters to predators by increasing foraging duration. It was suggested that preventive and cautious management strategies be taken for the rock crab fishery. The Québec Region has adopted such a strategy by limiting the entry to this fishery, putting restrictions on fishing gear and season, establishing a minimum catchable size and setting a preventive TAC.

Information on the false southern king crab *Paralomis granulosa* stock in South America, which is under no restrictive management regime, was presented. It was pointed out that an increasing exploitation trend together with a scarcity of knowledge of the biology makes stock management extremely difficult. In addition, the stock can be easily depressed because of a long life expectancy, low fecundity and presumably high fishing rate. A preventive management approach by setting a minimum size and prohibiting the catch of females to protect reproduction, determining fishing season to avoid mating and molting seasons and making a logbook system mandatory was strongly suggested. The comparison of biological and fishery related characteristics of the dungeness crab *Cancer magister* among several fisheries with graduated exploitation regimes from lightly exploited to heavily exploited in British Columbia was presented. The hypothesis that a high exploitation rate on the male population negatively affects the unexploited female population, then recruitment, was discussed from the growth and reproductive point of view. Population studies in several fisheries with a range of exploitation levels may provide precious information to quickly understand stock response to different exploitation intensities thus to the development of sound management strategies. The importance of an experimental, trial and error type management approach for underutilized species compared to a cautious preventive type approach was further discussed.

SESSION 3. Case studies - Molluscs and Echinoderms
Rapporteur : Bruce G. Hatcher

Molluscs support major fisheries, so there are many precedents of a general nature for underutilized species of this group. Echinoderms by contrast are more rarely fished, and thus the basis for development of their fisheries are less well established. In both cases however, considerable bodies of biological and ecological knowledge exist for the relatively sedentary benthic species which comprise stocks with potential for harvest. Indeed, much of our understanding and many theoretical models of marine ecology have come from the study of unharvested benthic molluscs and echinoderm populations and the communities they form. The papers presented here identified four basic concepts of relevance to the goal of sustainable development of new fisheries for benthic invertebrates: (1) life cycles must be closed before the effects of fishing can be predicted, (2) knowledge of local patch-scale dynamics is crucial to effective prosecution of the fishery and conservation of the stock, (3) experimental ecological research at the level of the community is an essential part of the knowledge required to develop sustainable fisheries for underutilized benthic populations, and (4) socio-political and economic pressures often force overexploitation in the face of inadequate or inappropriate research.

In discussing Thomas Landry's description of the undermanaged, but not underutilized fishery for intertidal clams, it became clear that a new method of harvesting was superior by all criteria to a traditional method, but that management would have to cope with both until more effective communication with the fishermen was achieved (i.e. the major management problem is social, not biological). The error of allowing commercial exploitation to proceed under the guise of recreational activity was explicitly recognized. Assessment of the effects of harvesting on recruitment was precluded by incomplete knowledge of the dynamics of highly mobile juveniles at the spatial and temporal scales of harvesting.

Discussion of Jean Lambert and Michel Giguère's report on the development of a subtidal clam fishery focused on the exceptional efficiency of the drag gear in catching 90% of the fishable stock in a patch, and damaging most of the remaining 10%. Consideration of the virtual absence of recruits in any of the extremely patchy aggregations sampled led to speculations that either they recruit elsewhere and migrate to the patches at fishable size, or the recruitment is a trickle and these virgin stocks are accumulations of many (old) cohorts, and are thus highly susceptible to overfishing by effective gear. If the latter case applies, this species may go from underutilized to commercially extinct in very short order.

Consideration of the consultant-conducted survey for fishable sea urchin stocks off NE New Brunswick described by Marc Lanteigne emphasized our comparative ignorance of large scale echinoderm distributions and their causes. It also demonstrated that sound science must be part of industry-forced, publicly-funded research. The information obtained might have been more efficiently obtained through exploratory fishing by the industry, and the data collected appear to contribute little to improving our understanding of correlations between substrate variables and the distribution and aggregation of the species.

Discussion of the sea urchin fisheries and research in SW New Brunswick summarized by Shawn Robinson probed the great diversity of stock characteristics and fishing methods in the best-developed of the Maritime echinoderm fisheries. The large size of the urchins and their distribution on sedimentary bottoms contrasts markedly with the species on the Atlantic coast. Extreme variation in gonad indices between patches and depths is of primary relevance to the fishery, but is even less well understood than the variation in numbers. The use of several harvest methods complicates management and research, but there is not yet enough data to support the belief that the highly selective diver harvest is the most likely to produce sustainability. Despite its proven potential, and the clear lessons from its uncontrolled and understudied counterpart in Maine, the Fundy sea urchin fishery is desperately short of the ecological research necessary for informed management advice.

Dynamics of sea urchin populations on the Atlantic coast of Nova Scotia were described by Bob Scheibling and Bruce Hatcher, and the implications of the research for management of the fishery were apparent. There is no substitute for long-term, experimental approaches to understanding the mechanisms of population dynamics. Such knowledge can form a sound basis for the development of a fishery. Does the mechanism exist to transfer it out of the ivory tower?

SESSION 4. Biological and sociological concerns in the development of new fisheries
Rapporteur : Louise Savard

A session was held on the concerns that should be addressed when discussing the development of a new fishery and establishing provisional management measures. Case studies were presented on some biological and sociological consequences that the development of a new fishery could have on the communities - marine invertebrates and humans. The different talks showed different levels of concerns : (1) the ecosystem level where multispecies assemblages interact at different trophic levels (the case of the exploitation of amphipods), (2) the population level for which concerns on the protection of the genetic diversity were expressed, and (3) the human community level, where an example of the impact of the development of a new fishery on a small community was illustrated.

The concerns expressed at each level were found very interesting from a theoretical point of view. It is certainly a goal to minimize the negative impacts that a new fishery could have on the diversity of the marine ecosystem and on the human communities. However, it is still uncertain how to deal with those concerns when discussing and establishing management measures. It is foreseeable that harvesting a new species will lead to a new equilibrium at the ecosystem level by modifying the abundance of the targeted species. It may also create a new equilibrium at the community level, where new types of fishing activities will be introduced, which may modify the income structure. The challenge in the development of a new fishery is to orient those changes to produce positive social and economic impacts while the conservation of the marine resource is still ensured. It was felt that the development of underutilized species fisheries offers opportunities to take new approaches and implement new models in the establishement of management and harvesting strategies.

Most of the underutilized invertebrate species are coastal. It is likely that their exploitation leads to the development of inshore fisheries by communities close to the resource. Also, fishable biomass of most underutilized invertebrate species is very limited so the allocation of the resource will likely have an impact on the income or social structure of the communities. Therefore, the impact of the development of new fishing activities could be very important for numerous small communities on the coastline. When the potential impacts are described and options are elaborated, it is essential that a multi-disciplinary approach is taken to maximize the benefits and minimize the negative fallouts at all levels. This multi-disciplinary approach should include a greater participation of the members of the involved community to allow them first, to elaborate the options and then, to fully understand the risks involved in each scenario. It was felt that the implication of community members along with scientific advisors (biologists, economists and sociologists) and fishery managers would give the necessary input to make enlightened decisions.

SESSION 5. Guidelines for the development of new fisheries - Discussion Session
Rapporteurs: Louise Gendron and Shawn Robinson

This session was organized so that participants could have a chance to exchange ideas on questions relevant to the development of new fisheries. A number of questions had been previously prepared by the organizers to help focus the discussions. Participants were divided into two different discussion groups, with representatives from government and university scientists, managers, foreign scientists and anthropologists. The ensuing discussions did not follow the question outline verbatim and therefore, the summary of the discussions was grouped in two themes: (1) the development of a new fishery and (2) the acquisition of biological data.

1. Development of a new fishery

General considerations

Developing new fisheries requires regular interactions between managers and scientists. A strong management plan must be prepared which reflects a common position taken by both management and science. This will allow the fishery to develop in a logical manner and not from a series of individual requests from the industry. The biological risk of harvesting a given species should be addressed at this point by the scientists and explained to the managers. In addition, the managers need to know the state of existing knowledge and what other fisheries or situations apply to their case. Some managers feel there is a need for a reference document of some sort, containing basic information on biological characteristics of potentially exploitable species. It was recognized by all parties involved, that any effective effort on the development of new fisheries will require the use of a significant amount of government financial and human resources presently directed toward more traditional species.

Interaction with the industry is extremely important so that the management objectives are clearly understood by all parties. Although there have been some successful industry-science linkages with respect to development, this aspect could be strengthened. In agriculture for example, these important linkages are much more prevalent and could probably be developed more with the fishing industry.

In developing a new fishery, we have to acknowledge the fact that we do not know all the risks and that we can not predict how the stock will react to exploitation. As happened with fisheries which are already developed, such information must be gathered through a trial and error process to some extent. The decline of a number of fish stocks suggests a cautious approach is warranted. It was agreed that the development of a fishery should initially proceed on a small scale. The participants felt it was important to adopt a conservative approach, since the high yields often observed at the beginning of a fishery by the exploitation of the virgin biomass may not be sustainable over time, particularly if the stock is not very productive, with respect to growth or recruitment.

Access to a new fishery

During the development of a new fishery, access should be given to those individuals that show strong initiatives and interest in the project. The "lottery" type of licence delivery (i.e random draws), although providing general and democratic access to a new resource, may in certain cases inhibit the development of a fishery, by poeple obtaining and holding onto licenses in the hope that they will become valuable commodities in the future. Suggestions were made on giving the permits or licenses to the processing industry to ensure that the development of a new fishery would be made only by those who wish to get seriously involved. The importance of having fishing communities more involved in the process of developing and managing their fishery was emphasized as a way of achieving a sustainable and more equitable development of the resource.

2. Acquisition of biological data

Although biological knowledge on population parameters of underutilized species is generally scarce, it was felt that some information existed in the "grey" literature (i.e. internal reports, manuscript reports etc.), which could be used to a greater extent by fisheries scientists. In addition, it was felt that to address the ecological impacts of the new fishery, a more thorough consultation of fundamental research on benthic ecology, such as simple food web diagrams, should be made. From this type of inferential information, a more informed judgement on the biological risk of harvesting a given new species could be made before initiation of the fishery.

It was unanimously recognized that baseline data should be collected from the initiation of the fishery. This will probably be the only chance to collect information on the state of the virgin stocks. A concerted effort should be undertaken to ensure that the pertinent biological information will be made available for future research, whether it be from collected samples for later analysis or real-time surveys.

Strategy for data acquisition

Because of the generally low commercial value of underutilized species during the initial developmental phase, research funds directed towards these species have been low. Lack of continuity in financial support have not permitted sustained science programs to develop and in many cases, the only acquisition of biological data is made through monitoring of the fishery. There is, however, a possibility that additional information could be obtained by making better use of data on the by-catch from other surveys or other sampling programs. Suggestions were made to better coordinate the different sampling programs among the various research institutions (i.e. federal, provincial, university etc.). In addition, it was also felt that acquisition of some basic biological data could be accomplished by developing partnerships with selected fishermen. This could be favoured by formalizing the collection of data into the management plan, in which research objectives, and the type of information needed, could be explicitely stated.

One trait of developing fisheries is that there are often financial incentives involved to help the industry get started. The general feeling of the group was that some proportion of any developmental money given to a fishery should go to science in order to collect the very basic biological information needed. This would ensure that the fishery would develop in a symmetrical fashion (technological vs biological information). It was suggested that a formal, fixed-term, financial commitment should be made over a 3-4 year period to biologists concerned with the possible fishery, specifically for developmental work.

The wealth of talent and resources of the local universities should be better utilized in the development of new marine species. This might be achieved through funding vehicles such as the Science Subvention Program and would ensure that universities would have closer ties to the problems at hand in the current fishing industry.

Nature of the data

Some basic level of knowledge is essential at the beginning of the fishery and therefore, some fundamental research will have to be done. It is important to have indications on the abundance of the resource to determine the scope of the fishery. However, biomass should not be considered solely, i.e. without considering its production, so that long-term sustainability of the fishery can be addressed. Distribution of the resource, discrimination of stocks and patterns of aggregation should be studied at the start of the fishery, so that the trends observed in fishery monitoring programs can be properly interpreted. Data on reproductive biology, such as the size at sexual maturity was considered of prime importance, in the establishment of a minimum legal size as a conservation measure. This was considered most important for species with direct development (i.e. without a pelagic dispersion phase). Potential impacts of gear should be considered.

Data on the virgin biomass are considered of prime importance, to examine how stocks react to exploitation and to monitor natural fluctuations occuring apart from exploitation. An option that was considered was to put aside one or more areas as a sanctuary, providing the opportunity to monitor virgin stock characteristics.

It was felt that developing fisheries provided an interesting opportunity to develop large scale experiments with testable hypotheses. Experimental management was unanimously recognized as being one of the best forms of large-scale experiment that could provide us with a great amount of information on how these new resources respond to exploitation. A certain amount of scepticism was expressed regarding the possibility of promoting experimental management and it was felt that the overall opportunities to undertake such an approach may be scarce. The designation of areas of lower exploitation rates could kill the incentive and profitability of a new fishery, and be considered discriminatory for some fishermen. Other opinions were nevertheless expressed that there is a willingness in the fishing community to accept this kind of approach. A partnership with the fishing industry could help organize such experimental programs, including the determination of sanctuaries, and provide the strong and determined involvement required.

CONCLUSIONS AND RECOMMENDATIONS

The establishment of a cautious and conservative management plan, involving scientists and managers does not generally pose a problem, as long as the profits from the resource are low. Problems arise when the value and profits from the resource increase and when pressure from the industry to get access to the resource intensifies. It was recognized that in all developmental projects, pressure from the industry as well as political pressure can jeopardize the rational development of the fishery. Information is the key to rationally controlling the development of a fishery and it must be acquired in the early stages. Resources to collect these data are extremely limited so all avenues must be explored and utilized to the maximum.

A new policy on underutilized species is currently being developed by the Operations Branch in Ottawa. We hope that the ideas put forward in this meeting will be considered during their deliberations. In a more operational way we recommend the following actions.

1. A formal, fixed-term, financial commitment should be made to scientists mandated to provide biological advice on developing fisheries. Some proportion (10-25 %) of development funds for new fisheries should be directed into scientific activities in order to develop the pertinent, stock-specific knowledge as well as technical knowledge.

2. Baseline data should be collected on populations before a fishery is initiated and efforts should be undertaken to ensure that the pertinent biological information on the virgin stocks will be available for future research and management purposes. This might be accomplished through sampling the virgin population or setting aside areas to act as sanctuaries, thereby providing data on unharvested stocks at a later date.

3. Because of limited funding for research and the short-term nature of many research projects on underutilized species, information exchange is particularly important for rational development of these fisheries. Mechanisms should be developed to facilitate this. Research teams from the various Regions could set up groups and a Regional coordinator for underutilized species could be assigned.

EXTENDED ABSTRACTS OF CONTRIBUTED PAPERS

SESSION 1

Overviews of the Fisheries of Underutilized Invertebrate Species

Management and Research Approaches

Overview of the Development of Underutilized Species Fisheries in the Québec Region

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1. Retrospective

In 1988, the Department of Fisheries and Oceans developed a policy for the exploitation of underutilized species in Atlantic Canada. This policy offered guidelines to orderly develop new resources, while safeguarding traditional fisheries. The same year, the Québec Region developed a procedure for the evaluation of projects submitted by the industry on underutilized species, and for the subsequent delivery of licences. At the same occasion, a preliminary list of potential species, on which effort could be directed was also prepared. The state of knowledge on the biology of each species was determined, and the constraints (biological or environmental, economic or technical) to their development were evaluated.

A working group was then formed to prepare and deliver an action plan which would orient for the 5 following years, the actions taken for the development of underutilized species. The working group was asked to determine the species and the type of study that should be priorized (biology, fishing technology, processing, marketing). Species were separated into two groups, conventional species for which quotas were not fully exploited, and non-conventional species, for which no exploitation was known in the Region. The exercise of priorisation was made by surveying the opinion of 250 persons involved in the fishing industry throughout the Region. Answers obtained from the survey (10 % participation) indicated a strong interest in increasing the exploitation of the conventional resources (mackerel and herring, mostly), by investing more efforts on marketing, and processing (for herring especially). Among the non-conventional resources, an interest was identified for capelin, rock crab, skate, and dogfish. Priorities on market studies were also identified for all species. Research efforts on fishing technology for capelin and in biology for rock crab were considered important. These priorities were reconfirmed during a consultation workshop with the industry that was held in March 1990 and the action plan that evolved from this series of consultations reflected these priorities. At that time, except for rock crab, little interest was expressed for invertebrate species.

Since then, different funding programs have helped the industry to get involved in the development of new invertebrate fisheries. The Québec Federal Fisheries Development Program - Programme Fédéral de Développement des Pêches du Québec, and the Fisheries and Aquaculture Testing and Experimentation Program - Programme d'Essai et d'Expérimentation Halieutiques et Aquicoles provided substantial support ($1,04 M and $0,96 M respectively) to the industry and the Science Branch activities during the last 5 years. This money was invested on a number of invertebrate species for exploration and biological research, initiated either by the industry itself or by the Science Branch, and for studies on processing and marketing operations (Table 1). Also, additional funding ($0,38 M) was made available through these programs to investigate the potential of traditional invertebrate resources (snow crab, lobster and scallops for example) in new territories. These fundings helped develop some new research programs, adding significantly to the regular program on underutilized species.

Table 1. Distribution of DFO special funding ($ 000) on underutilized invertebrate species, between 1988-1993, for exploration and biological research and for fishing, processing and marketing operations.

	Biology	**Operations**
Crustaceans		
Rock crab	312,8	257,7
Amphipods	-	112,8
Copepods/Euphausids	-	23,0
Molluscs		
Arctic surf clam	322,0	95,9
Razor clam	-	31,7
Echinoderms		
Green sea urchin	-	182,2
Sea Cucumber	-	21,7
Marine plants	27,0	233,2
TOTAL	661,8	958,2

2. Management approaches

These funding programs significantly increased industry's access to new fisheries. From some preliminary knowledge of initial resource conditions (localisation, abundance) and initial operation conditions (catch, processing, marketing), a number of requests for fishing licences were addressed to DFO. Although it was decided to give some access to the resource while gathering additional information, the approach of managers to the development of new fisheries has been very cautious, and a number of principles have been established in order to control their development. Access to new resources was organized according to these principles, setting the basis for a management plan, at least provisional. It was therefore decided (1) to consider these new fisheries as complementary so that the fishermen involved would not concentrate all their efforts on an uncertain resource, (2) to give priority to those inshore fishermen, presently dependent on declining resources, and operating near the resource. Most of the underutilized invertebrate species are considered inshore and are concentrated in many but small areas. (3) To give access to inshore vessels with a limited catching capacity in order to better control the effort, (4) to favour types of fishing gears that would avoid overcapitalization and that would be affordable to fishermen with already low income, and (5) to develop local markets at first, considering that the fishermen and processors would not be faced with high volume contracts to meet at the start of the fishery, giving them more time to develop the harvesting and processing techniques.

3. Provision of scientific advice

The development of a provisional management plan involves choices concerning the proper conservation and exploitation strategies. At this point, scientific advice is generally requested to support the implementation of either an effort control, a catch control or an escapement control. In most cases however, generally because of the lack of knowledge concerning the characteristics of the resource or species, quantitative advice is seldom given. The scientific advice given to the managers is often strictly qualitative, consisting of the expression of some concerns on resource conservation (reproduction, recruitment) and on potential ecological impacts (multispecies and habitat interactions). This situation translates generally in a "best-guess" management plan. As mentioned above, provision of advice on underutilized invertebrate species is limited because of a number of constraints linked to the lack of knowledge of the resource. In a few cases, however, where the development of research program was made possible (i.e. rock crab and Arctic surf clam), a better knowledge of the characteristics of the resource led to the establishment of more precise regulations.

A number of new fisheries are presently in development in the Québec Region. The establishment of a provisional management plan for these species has been done taking into consideration some level of scientific advice, i.e. mainly concerns on resource conservation, on possible ecological impacts, and on the eventual status of the fishery (sustained or opportunistic). In most of the cases, the set of regulations established for these new fisheries reflect to a certain extent these concerns (Table 2).

Table 2. Biological concerns expressed in the scientific advice provided to the managers, and regulations included in the provisional management plan, for each species or group of species considered in the last 5 years.

	Scientific Advice Conservation and Ecological Concerns	**Provisional Management Plan Regulations**
Rock crab *Cancer irroratus*	Reproductive Potential Lobster by-catch Rock crab - lobster interactions	Male directed fishery Limited entry Exploratory permits Preventive TAC Gear restrictions (number,type) Minimun size Season
Spiny crab *Lithodes sp.* **Spider crab** *Hyas sp.*	Reproductive potential Impact on traditional fishery (snow crab by-catch)	Limited entry Exploratory permits
Amphipods **Copepods** **Euphausids**	Low trophic level species Multispecies exploitation (different life cycles) Optimal exploitation rate Decrease prey density for predators Shrimp by-catch Disturbance of marine mammals	Limited entry Closed zones Season Limited catches (feasibility level)
Arctic surf clam *Mactromeris polynyma* **Molluscs** **Bivalves**	Virgin Biomass Slow-growing species Low Natural mortality High longevity Low yield at equilibrium	Limited entry ITQ
Urchin *Strongylocentrotus droebachiensis* **Sea Cucumber** *Cucumaria frondosa*	Impacts of gear on habitat	Limited entry Minimum size Gear limitation
Marine plants *Laminaria sp.* *Ascophyllum nodosum*	Low trophic level species Habitat deterioration	Limited entry Limited exploitation rate Unharvested zones

4. Present status of the underutilized invertebrate fisheries

In the past 5 years, despite all the efforts invested, especially on the rock crab, no sustained fishery has developed yet (Table 3). The main reason is the scarcity of interesting markets for these new species. Several species may present a good potential for a sustained exploitation, at least at a local scale (crabs, sea urchins). A number of species however, show high levels of biomass, which either consist of accumulated biomass from stocks with a low level of productivity (Arctic surf clam), or a low trophic level biomass, that may have a significant ecological role (ex. amphipods, copepods and euphausids). In the former case, these species could support an opportunistic or pulse fishery. For the moment, it is not possible to predict how these new fisheries will evolve in the future, and if they will be able to sustain long-term exploitation at an interesting level, once the accumulated biomass of these virgin stocks will be removed. Although we have tackled the development of underutilized species with a rather cautious approach, namely by severely controlling fishing effort, we cannot ascertain that the fishing pressure permitted is not already too high for these stocks. The provisional management plan established for these species should evolve and adapt as new information is gathered. Gathering of information will mainly depend on relevant long-term monitoring programs, and on a certain level of basic research made possible by occasional special funding programs.

Table 3. Reported landings (t, fresh weight) of underutilized invertebrate species in the Québec Region, between 1984 and 1992.

	Rock crab	Arctic & Atlantic surf clams	Razor clam	Green Sea Urchin
1984	0	30	0	6
1985	0	15	0	0
1986	0	65	0	0
1987	13	40	0	0
1988	615	60	0	0
1989	400	60	0	0
1990	120	60	0	0
1991	3	50	0	70
1992	1	115	20	0

Overview of the Development of Underutilized Species Fisheries in the Gulf Region

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Fishers and plant processing owners in the Gulf Region have always indicated their interest in developing commercial fisheries for non traditional invertebrate species or invertebrate species experiencing very limited exploitation. Sporadic trials and studies were conducted in the early 1970's aimed at developing viable commercial fisheries for some unexploited species (i.e. whelk and rock crab). However, programs aimed at the development of underutilized invertebrate species fisheries only started to appear in the early 1980's. This interest for the underutilized species was stimulated by the changing fishery's economy and in part by the creation of the Gulf Region in 1984. The market for fish products was expanding worldwide and buyers from other countries, particularly Japan, were presenting attractive business opportunities. In the near future, further interest in the underutilized species is expected with the decrease of the groundfish stocks.

The increasing interest in underutilized species in the Gulf Region resulted in the creation and implementation of broad management policies following the management directions and objectives identified in the document "Policy for Underutilized Species in Atlantic Canada". The invertebrate species presenting a potential in the Gulf Region were identified as the rock crab (*Cancer irroratus*), the bar clam (*Spisula solidissima*), the Arctic surf clam (*Mactromeris polynyma*), the softshell clam (*Mya arenaria*) the green sea urchin (*Strongylocentrotus dröebachiensis*), and the whelk (*Buccinum undatum*). Other species were also identified (i.e. spider crab, ocean quahog, sea cucumber, periwinkle), however little interest has been shown by the industry for these species. Although a written management strategy for the Gulf Region does not exist for underutilized species, the development of commercial fisheries for these species is being conducted with cautious management decisions involving scientific recommendations to insure the conservation of sustainable stock levels.

In 1993, developmental fishery activities represented a total value of approximately \$4,500,000. Of these, rock crab accounted for the greatest landed weight (>2,100 t worth \$800,000 at landing) but was surpassed in landed value by quahogs, softshell clams and bar clams, each exceeding \$1,000,000 in landed value. It should be noted that traditional fishing activities exist for quahogs, softshell clams and bar clams but these species are still considered as underutilized. Rock crab nonetheless seems to hold the greatest promise of becoming a regular commercial industry.

The activities and programs concerning the development of the underutilized species in the Gulf Region are conducted and controlled at the level of three Department of Fisheries and Oceans (DFO) Area offices reporting to the headquarters in Moncton. These Area offices are strategically located in each maritime province:

- Tracadie (New Brunswick)
- Charlottetown (Prince Edward Island)
- Antigonish (Nova Scotia)

This arrangement facilitates communication related to local concerns within each province. It also allows groups, associations and agencies to obtain funding under the three different Provincial-Federal Cooperative Agreements to conduct scientific explorations and marketing activities aimed at promoting underutilized species. However, this arrangement may also present some difficulties due to inconsistencies in fishing regulations established by the different Area offices. Each Area office acts in a certain way as an independent management unit that is responsible for requesting and managing developmental licences for its jurisdiction delimited mainly by provincial boundaries. The management of the underutilized fisheries is conducted within these boundaries and regulations are determined by the Area office. This type of autonomy can lead to different management directives within a common fishing area, for the same species. This has been the case for the rock crab fishery where fishing seasons for a particular fishing area are different depending on which area office issued the developmental licence.

Since 1990, attempts have been made to standardize the approach in managing underutilized species between Areas and eventually between Regions. For instance, in 1993, a monitoring approach for the developmental fisheries in the Gulf Region was proposed, stating compliance requirements for applicants (fishers) and monitoring responsibilities within DFO (Table 1). Unfortunately, the financial constraints of federal and provincial budgets allocated to fisheries activities have made it difficult to implement the proposed monitoring approach. For 1994, it is expected that the lack of funding may not allow DFO to efficiently monitor and collect data related to underutilized fisheries.

To continue the development of fisheries for underutilized species in a wise manner, comprehensive monitoring programs need to be implemented in collaboration with Science Branch and management policies need to be standardized throughout the Gulf Region and eventually with neighbouring Regions.

Table 1. Components of the monitoring approach for the developmental fisheries in the Gulf Region - 1993.

COMPLIANCE REQUIREMENTS FOR THE APPLICANT OR FISHER:

- each fisher must fill a logbook during each fishing trip and must make it available to Fisheries and Oceans via local fishery officers.

- each fisher is required to comply with Maritime Fisheries Regulations and conditions of licence.

MONITORING RESPONSIBILITIES:

Area offices

- Report the number of licences requested, number of licences issued and the number of licences used in actual fishing activities.
- Take action if the licence holder is not participating in the fishery.
- Monitor the fishing gear used and the location of the fishing activities.
- Monitor and collect the logbooks.
- Monitor and report by-catch problems.
- Monitor the utilization and processing of the landed products.
- Provide field activity reports by species.

Science Branch

- Establishes harvesting protocol in collaboration with the areas.
- Conducts sea sampling for size, sex, resource distribution, growth data, etc...
- Analyses logbook data and report on the catch per unit of effort.
- Recommends management approach for each fishery.

Overview of the Development of Underutilized Species Fisheries in the Scotia-Fundy Region

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Every species which is now exploited or has been exploited started off as an underutilized species. The suite of invertebrate species in the Scotia-Fundy Region being considered for their fishery potential are similar to other Maritime areas and include various species of crabs, sea urchins, sea cucumbers, whelks, clams, annelids and algae etc. The role of studying and documenting the biology of the species under exploitation has generally fallen to the scientist. In the past, the task was often divided with government scientists looking at applied research, the universities looking at process-oriented research and other groups (such as consultants) studying applied problems in the short-term. The division among these groups has recently been reduced as all groups are now being encouraged to work on applied topics pertinent to the fisheries.

The 1970's were prosperous for Science in Scotia-Fundy as budgets were generally adequate to allow thw initiation of new projects. This meant that more information could be collected on new species which had potential for harvesting. There was also a high level of interaction with graduate students and post-doctoral fellows from the university programs. In the mid- to late 1980's operating budgets were reduced, programs were down-sized and the amount of money from A-base operating funds which went into fisheries ecology research on new species dropped to an estimate of 10-20% or lower in some cases. Interactions with post-doctoral fellows and graduate students have been significantly reduced.

The resurgence of the Pacific Asian Rim and some European countries have led to increased attention being focussed on invertebrate species and the recognition in coastal communities of the Scotia-Fundy Region that there are relatively valuable species to be harvested in their local waters. The available biological information or stock survey information on these species generally dates back to the 1970's if it is available at all. Present studies on new species are now generally being carried out with developmental money (i.e. Atlantic Fisheries Adjustment Program (AFAP), Canada-New Brunswick Cooperative Agreement(COOP)), volunteers from various communities and some A-base money from DFO.

The communication between management and science has generally been fairly good and a cautious approach has usually been chosen. Comparisons between the developmental programs for underutilized species in the United States and Canada has shown that Canada has taken a more pro-active approach in that detailed management plans are usually developed at the earliest stages of the fishery.

Current management direction for underutilized species is being set by two documents, ie; Policy for Underutilized Species in Atlantic Canada and an Action Plan developed from an underutilized species workshop in Yarmouth, Nova Scotia in January 1990. Although some successes have been realized, it is essential that these policies and direction are updated to reflect realities in the various fisheries. A summary of these problems and concerns that must be addressed are:

- Eligibility Criteria: Who will get access to available licenses and who will decide?

- "Third Party" control of licenses is putting licenses in the hands of enterprises that do not meet the eligibility criteria (i.e. an individual who has controlling interest in a vessel but is not allowed to fish). DFO is not party to these type of agreements.

- Everyone wants their name on a "wish-list" for licenses.

- Participation Criteria: It is difficult to get little used or never used licenses in the hands of those who are willing to conduct a truly "developmental" fishery. Limited-entry licenses have an "investment" value and some of the early participants are hoping to cash in on this aspect at some point in the future.

- Political: The will is not always there to stick to the strict participation requirements for license renewals etc.

- The consultation process for development of a management plan, in many instances, is simply a lobbying by interest groups

- Shrinking budgets no longer support monitoring and development of underutilized species. For example, many times enforcement concerns can not be met. License holders for underutilized species will have to assume a higher support role financially to provide some or all of these monitoring and assessment-type activities associated with these licenses.

SESSION 2

Case Studies - Crustaceans

The Rock Crab *Cancer irroratus* Fishery in the Maritime Provinces (Gulf Region): Results from the 1993 Commercial Fishery Sampling Program

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INTRODUCTION

A developmental rock crab (*Cancer irroratus*) fishery was initiated in the Gulf of St. Lawrence in 1974. Since the beginning of this developmental fishery, it has been managed under no quota limitations. Landings have fluctuated between 103 t in 1974 to a high of 1,663 t in 1988. The 1993 landings were around 1,400 t valued at $600,000 (Table 1). The is presently no regulation on minimum carapace size. However, processors have set a minimum size which varies between 95 mm (3.75 inches) and 102 mm (4 inches) carapace width (CW) depending on the fishing area. The fishing season starts in July and ends in December for lobster fishing zones (LFA) 23, 24, 26A and 26B (Figure 1). In LFA 25 there are two seasons, from May to July and October 15 to December 31.

Three types of traps are commonly used to catch rock crab. These are the modified lobster trap, the conical trap (1.2 m base diameter) and the pyramidal trap. Trap limits vary between 100 and 150 depending on the fishing area (Table 2). Being a developmental fishery, all rock crab fishers are requested to fill a daily logbook. Although participation in the logbook program is not 100 %, the information received has shown large catch per unit of effort (CPUE) fluctuations without defined seasonal trends. For the 1992 season, the CPUE ranged between 3.2 kg/trap and 9.2 kg/trap (values not standardized for trap type). According to fishermen, the most productive grounds for rock crab in the Gulf are found at depths ranging from 2 to 20 meters.

Rock crab is probably the most promising underutilized species that may develop into a regular fishery. However, management plans and regulations within each fishery management area need to be standardized, and provincial discrepancies should be eliminated.

MATERIAL AND METHODS

1. Logbook data

Catch and effort data were compiled from the fisher's logbooks. The resulting data consisted of entries containing the following information: a) Canadian fisheries vessel number (CFV), b) dates fished, c) fishing position (Loran C or latitude/longitude), d) number of traps hauled, e) catch estimate in pounds by the fisherman. From these data, CPUE (daily catch/ number of trap hauls per day) were calculated.

2. Sea sampling

Sea samples were taken regularly by observers going on commercial rock crab fishing vessels during regular fishing activities. In 1993, a total of 15 samples (7 in LFA 25, 6 in LFA 26A and 2 in LFA 24) were collected. The procedure consisted of sampling as many traps as possible during the fishing trip. For each trap selected, all the crabs in the trap were set aside and morphometrical measurements as well as descriptive information were taken on 20 crabs selected randomly. If more than 20 crabs were present in the trap, the rest was counted and reported on the sampling sheet. Information on fishing effort distribution, CPUE, carapace condition (quantity of epibionts, hardness and colour of the carapace) and sex ratio were also collected. In addition, the presence/absence and colour (orange, brown, black) of external eggs was noted for females. Sub-samples were brought to the laboratory to collect more information on the molt and reproductive cycle as well as the length-weight relationship. Size frequency distributions were produced for male and female crabs caught during sea sampling. The mean size and the percentage of soft and hard carapace specimens were also calculated.

Live samples were collected during each sea sampling session using a stratified sampling method. For each sex, a minimum of 5 crabs per 5 mm size class (CW) were kept and transported in coolers. In the laboratory, the carapace width, total weight and sex of each crab was recorded. In addition, female crabs were inspected for the presence or absence of sperm plugs, egg mass colour and weight.

3. Molt stages and gonad development

Crabs brought to the laboratory were dissected, a gonad and a piece of the carapace were fixed in Bouin fluid for 48 hours for histological observations. After the fixation, the tissues were dehydrated through graded ethanol, cleared in xylene and embedded in paraffin. Serial sections (5-7) were mounted on glass slides and stained with Mallory triple stain (Gabe, 1968) and observed under the microscope. Molt stages were determined according to criteria described by Skinner (1962) and gonad stage according to Johnson (1980).

4. Calculation of catch per unit of effort from sea sampling

For each LFA, the carapace width and total body weight measurements collected from samples transported to the laboratory were used to calculate male and female length-weight allometric equations. For each sea sampling session, an average CPUE was calculated with the following equation:

$$CPUE_x = \frac{\sum ((a \times CW_i^b) \times (\frac{f_i \times N_{tot}}{N_{sample}}))}{traps_x}$$

where,

$CPUE_x$ = catch per unit of effort for the sea sampling session x,
CW_i = carapace width (mm) of the size class i,
a and b = constants of the allometric equation,
f_i = absolute frequency of the size class i (males and females combined),
N_{sample} = total number of crab measured in the traps sampled during the sea sampling session x,
N_{tot} = total number of crab caught in the traps sampled during the sea sampling session x,
$Traps_x$ = total number of traps sampled during the sea sampling session x.

This equation applies the allometric equation to the crab carapace width frequency distribution adjusted to the total number of rock crabs caught in all the traps sampled during a sea sampling session. As there is presently no commercial minimal size, the effect of applying a size limit on CPUE was estimated by considering 4 scenarios; no minimal size, 76 mm (3 inches), 89 mm (3.5 inches) and 102 mm (4 inches).

RESULTS

1. Fishing effort and catch per unit of effort

For the 1992 fishing season, logbook records from 26 fishers from LFA's 25 and 26A were received and the total catch from these logbooks was 516,012 kg. The total fishing effort was 66,574 trap hauls which represents a CPUE of 7.75 kg/trap haul. The weekly CPUE varied between 3.2 kg/trap haul (week 19) and 9.2 kg per trap haul (week 8) (Table 3). From the 1993 sea sampling, if no minimum carapace size is enforced, the CPUE varies from 4.3 kg/trap to 24.1 kg/trap hauled. At a minimum carapace size of 102 mm the CPUE could range between 3.7 kg/trap and 17.3 kg/trap respectively (Table 4).

2. Biological information from sea sampling

Between June 22 and August 18 1993, 15 trips at sea (7 in LFA 25, 6 in LFA 26A and 2 in LFA 24) were conducted and 143 traps sampled (Figure 2). A total of 2,781 crabs (2,151 males and 630 females) were measured. The mean size of all male crabs measured was 109.7 mm (CW) and the percentage of soft shell crabs was 9.8 %. The mean size of all females crabs measured was 84.0 mm (CW) and the percentage of soft shell crabs was 2.5 % (Figure 3).

3. Biological information from laboratory samples

During the sea sampling program, 1,101 crabs (717 males and 384 females) were brought to the laboratory. The mean size of male crabs examined was 106.3 mm (CW) and 82.2 mm for females (Figure 4). For females, 43.5 % had white gonads, 32.7 % had orange gonads and 23.0 % had red gonads. The percentage of females with visible sperm plugs was 78.3 %.

Histological observations were performed on 249 crabs (180 males and 69 females). The percentage of newly molted crabs (molt stages C1 to C3) was 29.3 % (28.5 % for males and 2.9 % for females). The percentage of crabs in intermolt (molt stage C4) was 63.8 % (52.8 % for males and 92.7 % for females) and the percentage of premolt (molt stages D0-D2) was 6.8 % (7.8 % for males and 4.3 % for females). The monthly percentage of newly molted crabs was 8.3 % in May, 36.1 % in June, 76.6 % in July and 44.0 % in August. Sixty seven percent (67 %) of the female gonads observed by histology were in previtellogenesis stage, 6.1 % were in early vitellogenesis and 26.5 % were mature.

DISCUSSION AND CONCLUSION

Rock crab landings in 1993 were considerably higher than in 1992 (Table 1). The 1993 landings were 1418 t compare to 958 t in 1992 which represent a 32.5 % increase. The increase in landings may be attributed to an increase in fishing effort due to market demand and better price at landing. The CPUEs have shown a slight increase during the fishing season. Assuming that the CPUE measurements are indices of the biomass, the rock crab population was not affected by the limited fishing effort in 1993. The low CPUEs observed at the beginning of the fishing season are assumed to be attributed to different fishing patterns as fishers focus their fishing effort near the shore and to low catchability due to cold waters in early spring. As a result, we assume that the present exploitation rate is not high enough to induce measurable fluctuations or reductions in the population biomass.

The monthly percentage of newly molted crabs is at its maximum in July. It is suggested that the peak molting period is in that month as observed by Moriyasu et al. (1985). The low frequency of the sampling conducted in 1993 did not allow precise determination of the molting season.

The rock crab fishery is still in development. It is not yet a well-established fishery. From the information collected in 1993, the limited fishing effort, the increase in CPUEs during the fishing season and the somewhat localized effort distribution, it is suggested that the exploitation rate could be increased without detrimental effects on the rock crab biomass. As a safe management strategy, any increase in fishing effort would have to be evenly distributed along the coastal areas, by focusing in areas with known populations of crabs but experiencing little or no exploitation.

ACKNOWLEDGEMENTS

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Table 1. Rock crab historical landings (t) in the Gulf of St.-Lawrence between 1974 and 1993.

Year	P.E.I.	N.B.	N.S.	Total
1974	54.2	46.8	1.5	102.5
1975	25.3	1.0	0	26.3
1976	6.2	74.9	2.7	83.8
1977	23.4	103.9	10.1	137.4
1978	0	0	227.5	227.5
1979	0	5.5	0.7	6.2
1980	0	90.4	50.5	140.9
1981	0	56.8	88.2	145.0
1982	0	122.1	0	122.1
1983	89.0	209.1	158.1	456.2
1984	36.1	174.2	389.1	599.4
1985	59.3	290.9	239.7	589.9
1986	242.1	140.6	119.6	502.3
1987	620.9	703.3	182.7	1506.9
1988	858.3	612.1	192.8	1663.2
1989	778.0	458.8	72.0	1308.9
1990	405.3	310.0	27.0	742.3
1991	591.2	467.5	21.8	1080.5
1992	508.2	327.4	122.8	958.5
1993*	907.4	206.4	304.6	1418.4

* Preliminary

Table 2. Rock crab fishing seasons and trap limits by fishing area and province for 1993 (Gulf Region).

Fishing areas (LFA)	Provinces	Fishing seasons	Trap limits
23	New Brunswick	August 23 to October 30	125
24	Prince Edward Island	July 10 to December 31	150
25	New Brunswick Prince Edward Island	May 1 to July 30 May 1 to August 5 October 15 to December 31	125
26A	Nova Scotia Prince Edward Island	July 15 to December 31 July 20 to December 31	100
26B	Nova Scotia Prince Edward Island	July 5 to December 31 July 10 to December 31	100

Table 3. Weekly CPUE calculated from the 1992 log books.

Week	Traps hauled	Landings (kg)	CPUE (kg/trap)
1 (May 25-31)	167	616	3.7
2 (June 1-7)	106	465	4.4
3 (June 8-14)	251	953	3.8
4 (June 15-21)	686	2,538	3.7
5 (June 22-28)	648	3,369	5.2
6 (June 29-July 5)	550	3,738	6.8
7 (July 6-12)	481	2,359	4.9
8 (July 13-19)	3,663	33,701	9.2
9 (July 20-26)	7,504	56,277	7.5
10 (July 27-Aug. 2)	7,489	54,666	7.3
11 (Aug. 3-9)	7,718	61,741	8.0
12 (Aug. 10-16)	5,993	49,146	8.2
13 (Aug. 17-23)	6,161	51,755	8.4
14 (Aug. 24-30)	4,459	39,686	8.9
15 (Aug. 31-Sept. 6)	5,275	45,894	8.7
16 (Sept. 7-13)	3,750	33,379	8.9
17 (Sept. 14-20)	3,452	26,928	7.8
18 (Sept. 21-27)	2,908	19,773	6.8
19 (Sept. 28-Oct. 4)	1,079	3,453	3.2
20 (Oct. 5-11)	778	3,499	4.5
21 (Oct. 12-18)	927	5,931	6.4
22 (Oct. 19-25)	1,104	8,058	7.3
23 (Oct. 26-Nov.1)	537	3,380	6.3
24 (Nov. 2-8)	888	4,707	5.3
Total	66,574	516,012	7.75

Table 4. Catch per unit of effort (CPUE) calculated for each sea sampling session in 1993, without consideration of a minimum size and with three scenarios of minimum carapace size limit.

Date	CPUE (kg/trap) no minimal size	CPUE (kg/trap) 76 mm	CPUE (kg/trap) 89 mm	CPUE (kg/trap) 102 mm
Lobster fishing Area 25				
June 22	19.6	19.5	18.4	17.3
June 29	11.0	11.0	10.3	9.4
July 7	13.4	13.3	12.4	9.2
July 14	20.0	19.9	19.2	16.3
July 14	10.6	10.5	9.6	8.9
July 22	9.2	9.1	8.5	8.3
July 22*	15.0	14.9	14.0	12.4
Lobster fishing Area 26A				
August 18	4.3	4.3	4.1	3.7
August 18*	24.1	24.1	23.3	16.6

* two soaking days

Table 5. Date of the sea sampling sessions conducted aboard rock crab commercial fishing vessels in the different fishing areas, during the summer of 1993.

Date	Number of traps sampled	Total number of rock crabs caught	Total numer of crabs measured	Average carapace width (mm) of females (SD)	Average carapace width (mm) of males (SD)
Lobster fishing Area 24					
August 04	10	430	200	60.3 (-)	106.0 (8.70)
August 11	5	427	99	75.0 (5.66)	104.8 (9.37)
Lobster fishing Area 25					
June 22	14	1,485	280	84.1 (7.35)	111.9 (8.26)
June 29	5	221	100	82.3 (3.66)	111.8 (10.65)
July 7	16	1,402	320	80.0 (4.75)	102.8 (7.27)
July 14	11	1,325	220	80.4 (5.14)	105.1 (7.20)
July 14	13	759	226	82.3 (6.19)	112.0 (14.30)
July 22	11	517	214	81.7 (5.12)	114.2 (7.96)
July 22*	91	183	177	80.2 (7.23)	105.7 (9.64)
Lobster fishing Area 26 A					
August 04	6	299	110	82.8 (7.08)	106.8 (13.73)
August 04	7	360	140	90.3 (7.26)	118.6 (14.65)
August 11	5	183	100	83.0 (6.76)	118.3 (10.05)
August 12	9	184	181	84.7 (2.95)	108.6 (9.61)
August 18	12	232	211	88.9 (6.62)	119.9 (11.23)
August 18*	10	1,382	203	92.5 (4.76)	109.4 (11.24)
Total	143	10,389	2,781	84.0 mm	109.7 mm

* Two soaking days

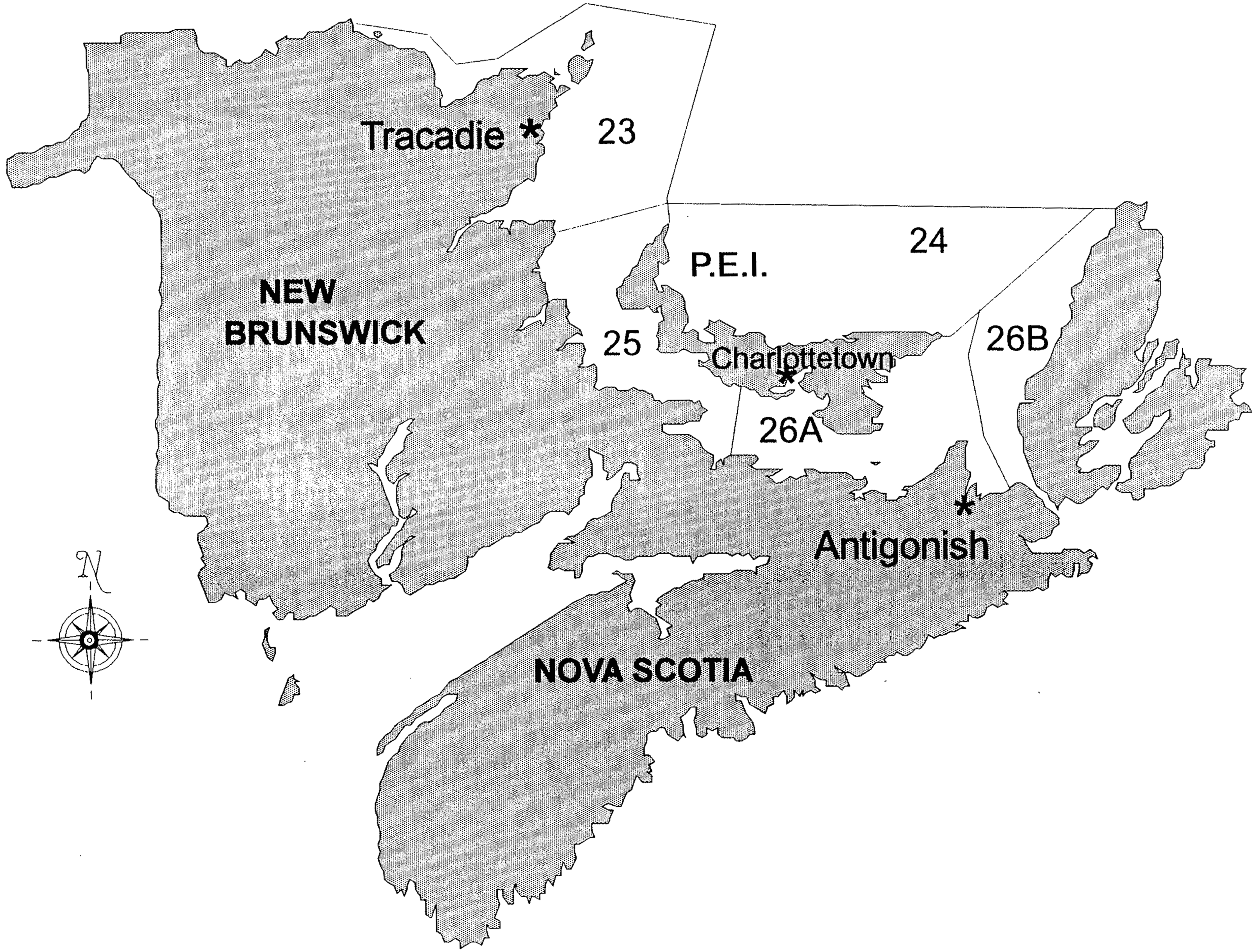


Figure 1. Lobster fishing areas (LFA) in the southern Gulf of St. Lawrence also used for the management of rock crab fisheries.

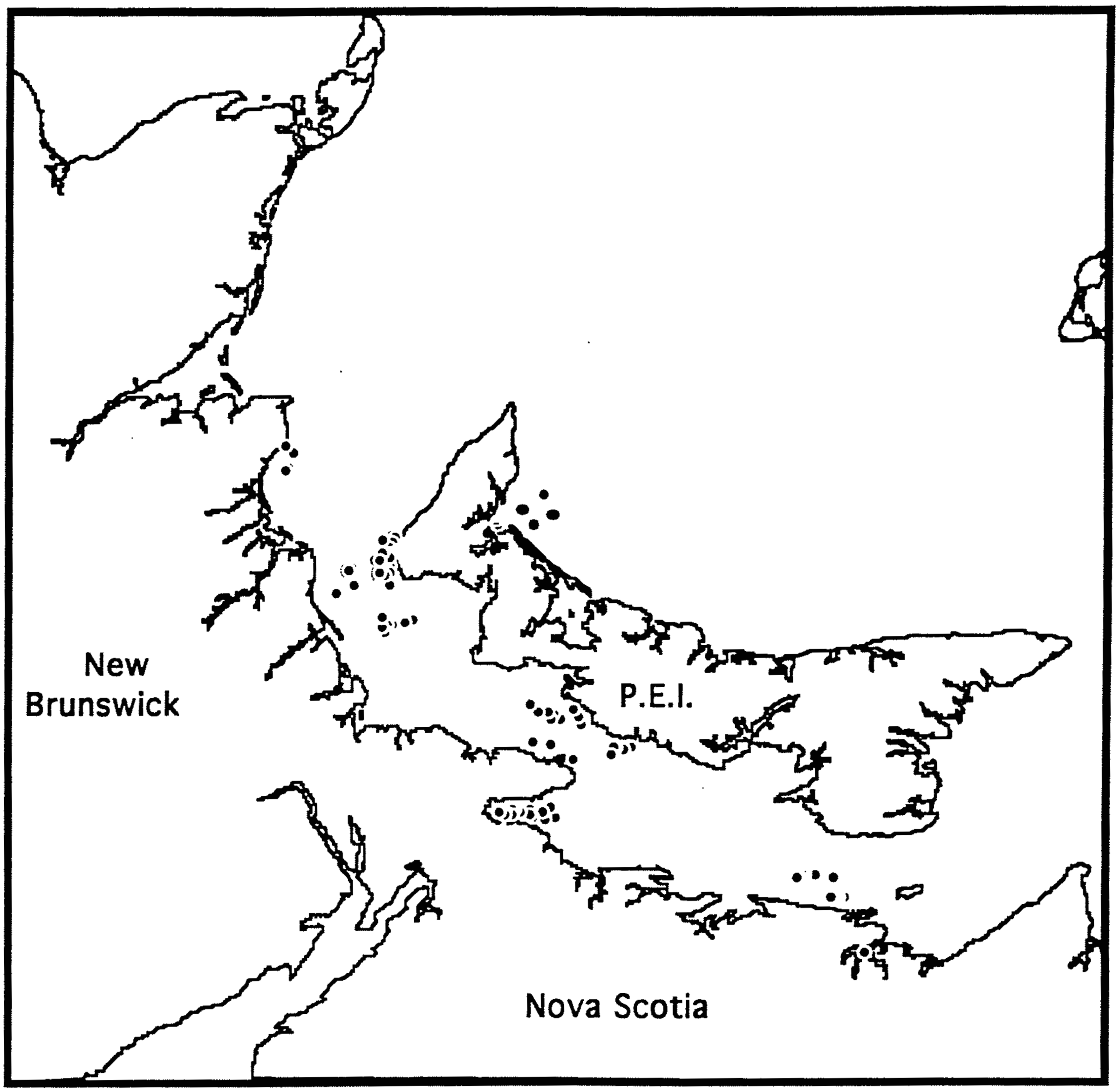
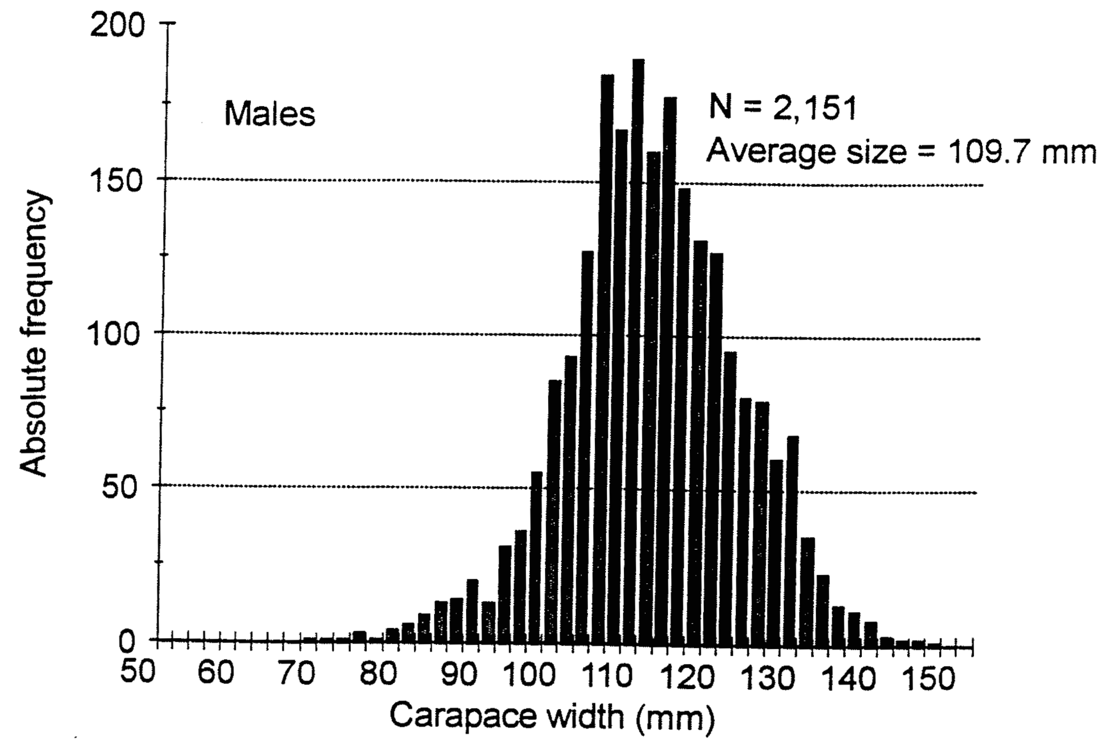


Figure 2. Distribution of all traps sampled at sea during the 1993 fishing season. Each dot can represent more than one trap.



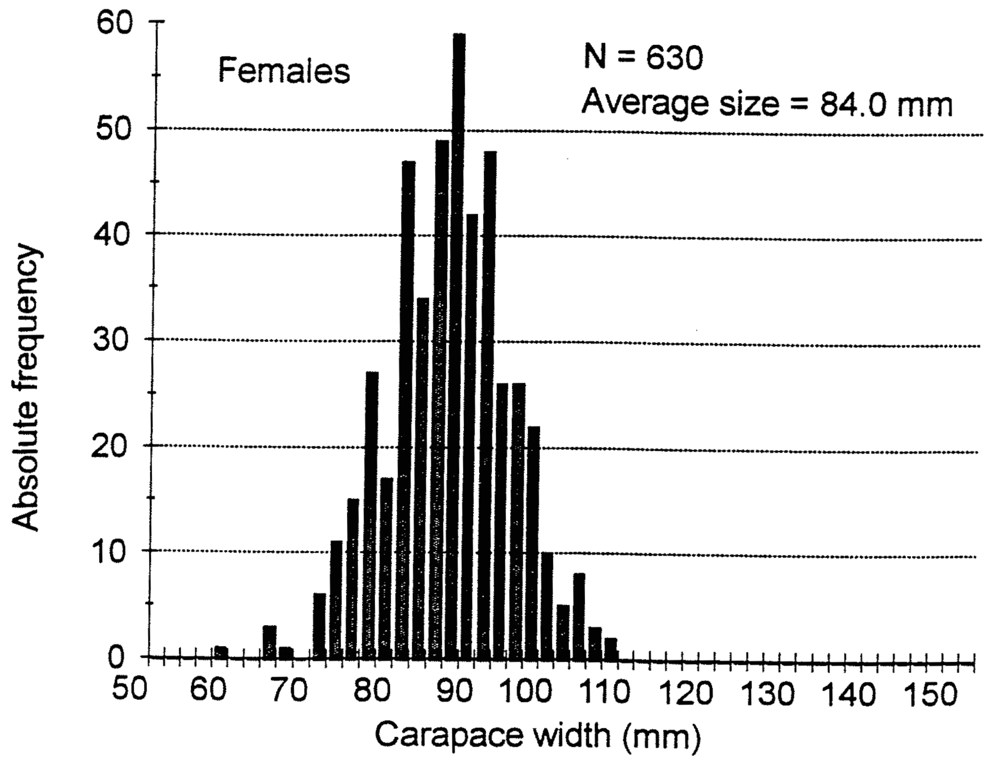


Figure 3. Size frequency distributions for male and female rock crabs sampled at sea in 1993.

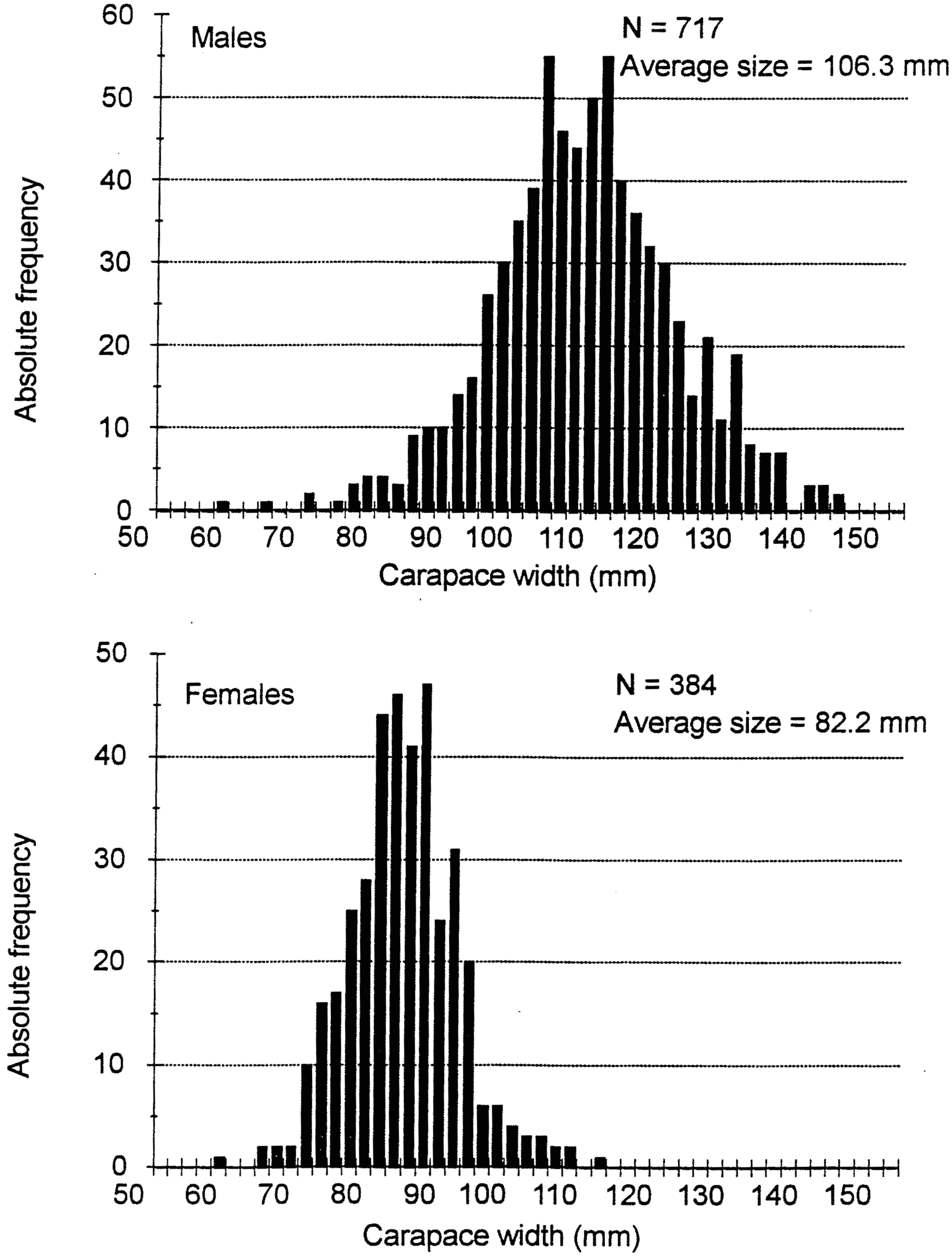


Figure 4. Size frequency distributions for male and female rock crabs sampled at sea and brought in the laboratory for further analysis in 1993.

Distribution and Biomass Estimate of the Rock Crab *Cancer irroratus* in the Western Northumberland Strait (LFA 25) using Geostatistics

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INTRODUCTION

The rock crab (*Cancer irroratus*) is harvested in the Gulf of St. Lawrence as a developmental fishery since 1974. In 1992, a total of 959 t of rock crab, valued at $338 352, were landed. Throughout the years, the landings fluctuated from 103 t in 1974 to a high of 1663 t in 1988. A total of 9 fishermen participated in the 1993 season in the western Northumberland strait (Lobster Fishing Area 25). The rock crab fishing season was open from May 1 to August 30, prior to the lobster season (August 10 to October 10), and from October 15 to December 31 (only for fishermen from Prince Edward Island). Lobster fishermen use modified lobster traps or small conical traps to fish for rock crab. A minimal legal size ranging from 95 to 102 mm of carapace width is set by the processors. The number of traps is regulated and limited to 125. The rock crab fishery can be considered as a supplementary fishery to lobster.

The rock crab fishery is not regulated by a quota and no biomass surveys have been made. This paper provides geostatistical estimates of the biomass and the distribution of the rock crab over a portion of the western Northumberland strait (LFA 25) from May to July .

AREA SURVEYED AND METHODOLOGY

Three surveys were conducted in LFA 25 during the 1993 fishing season using modified wooden and wire lobster traps. The modification to the lobster trap consisted in obstructing the escape mechanism. A total of 48, 49 and 46 traps were used on May 26, June 22 and July 13, respectively. Rock crabs were counted in each trap and their location was noted. The estimates and spatial distribution of CPUE presented in this report are from the total count of each trap, as crabs sampled were not separated by size or sex.

The rock crab density (number of individuals/surface unit), denoted $Z(\mathbf{x})$ was computed for each survey. Using trawl data available from the same area, we calculated the attraction area of a trap as approximately 1000 m^2. The similarity of population densities at locations $\mathbf{x}_i$, $\mathbf{x}_j$ set at a distance $\mathbf{h}$ apart can be described by a semivariance function $2\gamma(\mathbf{h})$. In practice, $2\gamma(\mathbf{h})$ is estimated by an experimental semivariance (Matheron 1971). The range of the semivariance function is related to the size of the patches in which the populations are structured (Sokal and Oden 1978, referring to the correlogram). For mapping the density of *C. irroratus*, the value of the densities was computed at the nodes of an arbitrary fine mesh grid set over the sampled area in each survey. The estimated values Z* were computed by point kriging (Matheron 1971) after modeling the experimental semivariogram by a theoretical semivariance function. Models of theoretical semivariance which comply with certain conditions of positive-definiteness, and thus suitable for kriging, are readily available in the geostatistical literature (Matheron 1971). Global estimates of abundance of the resources within an area defined by the extent of the sampling points were obtained by block kriging (Matheron 1971). Kriging produces an estimation variance (σ^2_e) associated to each global estimate (Matheron 1971). We use (σ^2_e) to compute a standard deviation for our global estimates.

RESULTS

The CPUE of the number of crabs per trap haul were calculated at 80.3, 64.0 and 81.0 for the first, second and third survey respectively. A spherical model (Matheron 1971) was fitted to the experimental semivariogram for each survey. Figure 1 shows the experimental semivariogram computed for each survey and the models and parameters fitted.

Populations of rock crab are structured spatially in patches of approximately 1 to 4.5 km radius. Maps of rock crab density within the sampling boundaries are presented in Figures 2, 3 and 4, with global estimates of abundance obtained by block kriging. The location of high-density patches varied greatly from survey to survey.

DISCUSSION

Patch size, as defined from variogram range (Figure 1), may have varied seasonally and may reveal changes in the aggregation patterns related to mating and molting. It may also be the result of mixing different biological categories with different spatial aggregation patterns (as suggested by Conan *et al.* 1988 for snow crab) and from the relative contribution of each category to the overall range. The proportion of females, for instance, varied throughout our survey. Further research should investigate the possibility of different spatial structures characterizing different biological categories. The shifting of high-density patches (Figures 2, 3 and 4) from month to month suggests mobility of *C. irroratus*. The general movement observed in the study area is an offshore/inshore migration in the spring, as rock crab migrated from a rocky offshore location, at depths ranging from 15 to 20 m, to a shallow (5 m) muddy inshore location from May to July. Heafner (1976) and Krouse (1980) described the same pattern of migration for *C. irroratus* from the mid-Atlantic Bight and Maine, respectively. It should be further investigated whether individual patches of high density are related to aggregations by biological categories or are determined primarily by substrate conditions or food availability.

Global estimates produce consistent figures for the available abundance of rock crab in the study area ranging from 65 to 76 thousand crabs . km^{-2}, with S.D. representing 10-20 % of average. These estimates should be considered as conservative since the traps were recovered full most of the time. A trawl survey would provide a more appropriate means of sampling this population of rock crab and would produce more accurate global estimates of the biomass. The lower estimates obtained in June may be attributed to molting.

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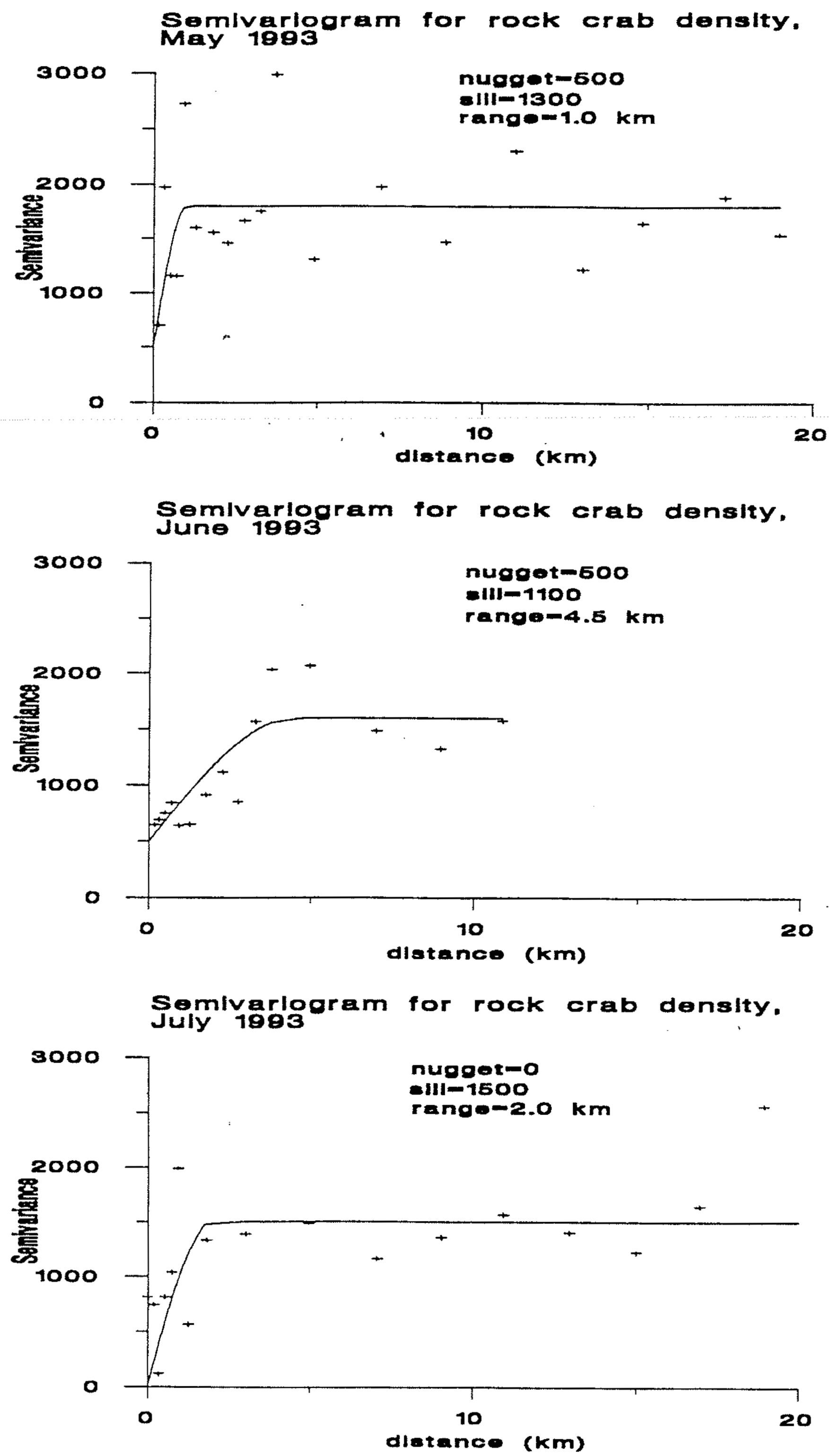

Figure 1. Semivariograms for rock crab (*Cancer irroratus*) in May, June and July 1993 used in the kriging calculations.

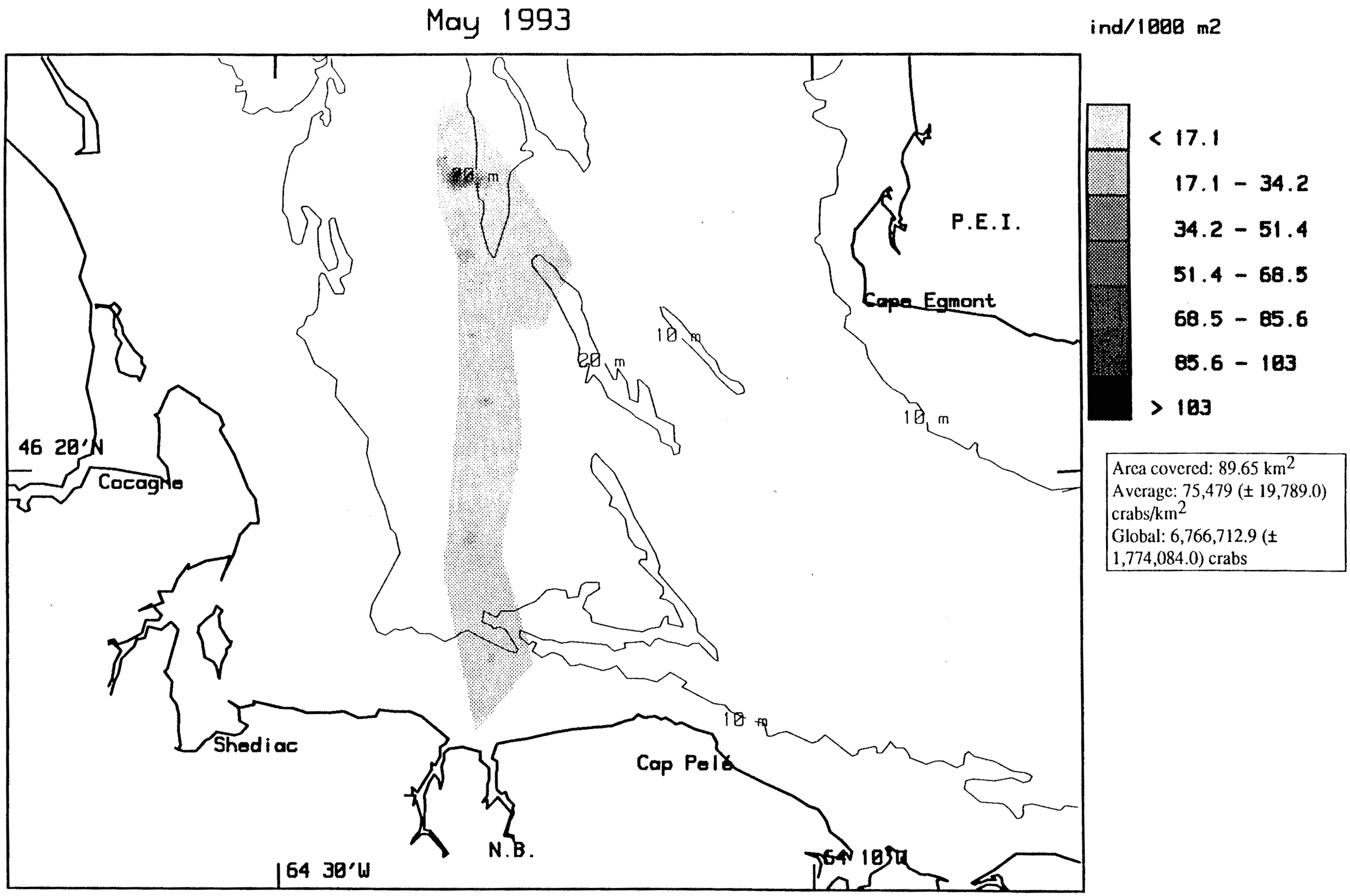

Figure 2. Density countours for rock crab (*Cancer irroratus*) in a portion of Western Northumberland Strait (LFA 25) calculated by kriging for May 1993.

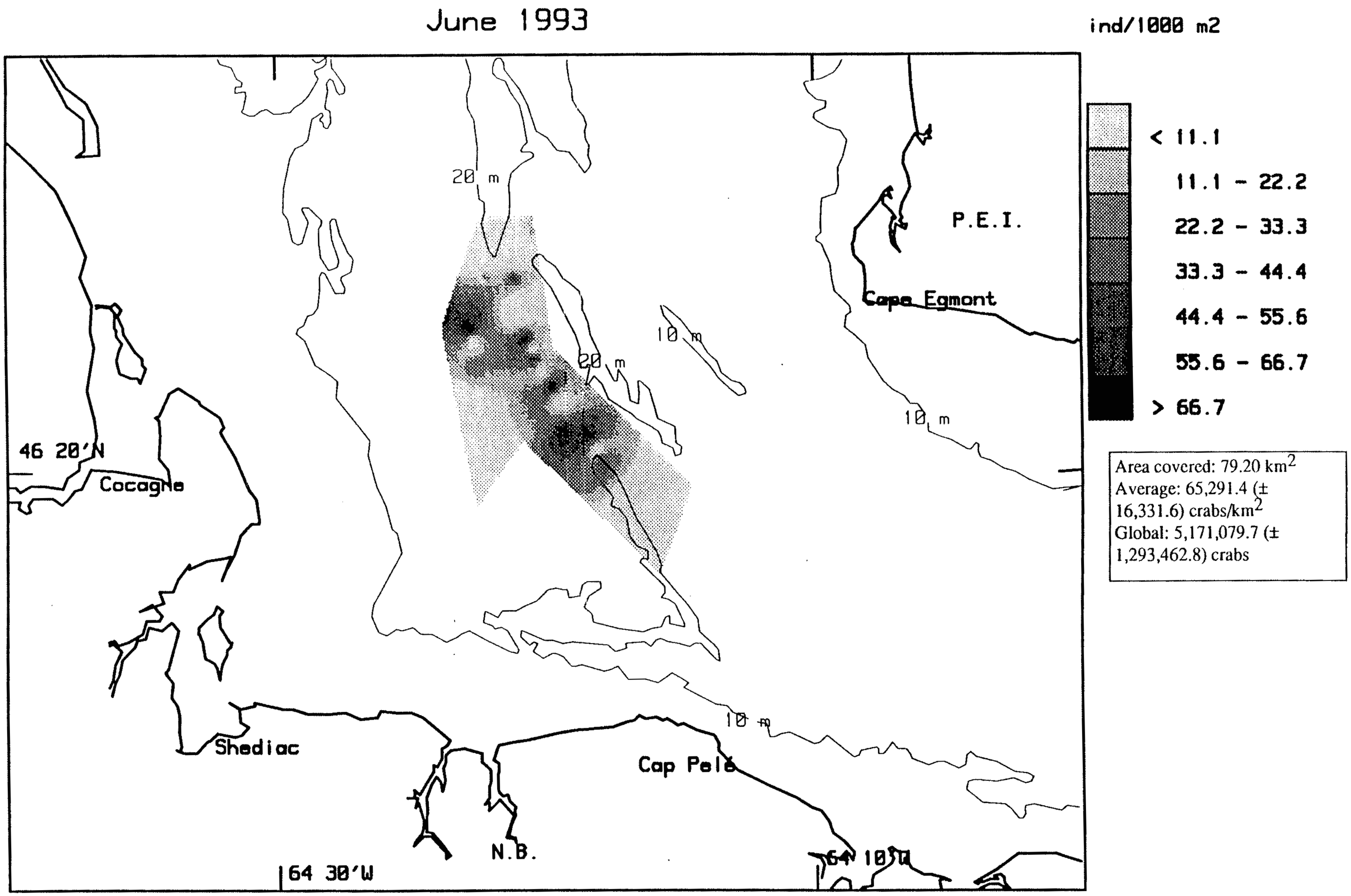

Figure 3. Density countours for rock crab (*Cancer irroratus*) in a portion of Western Northumberland Strait (LFA 25) calculated by kriging for June 1993.

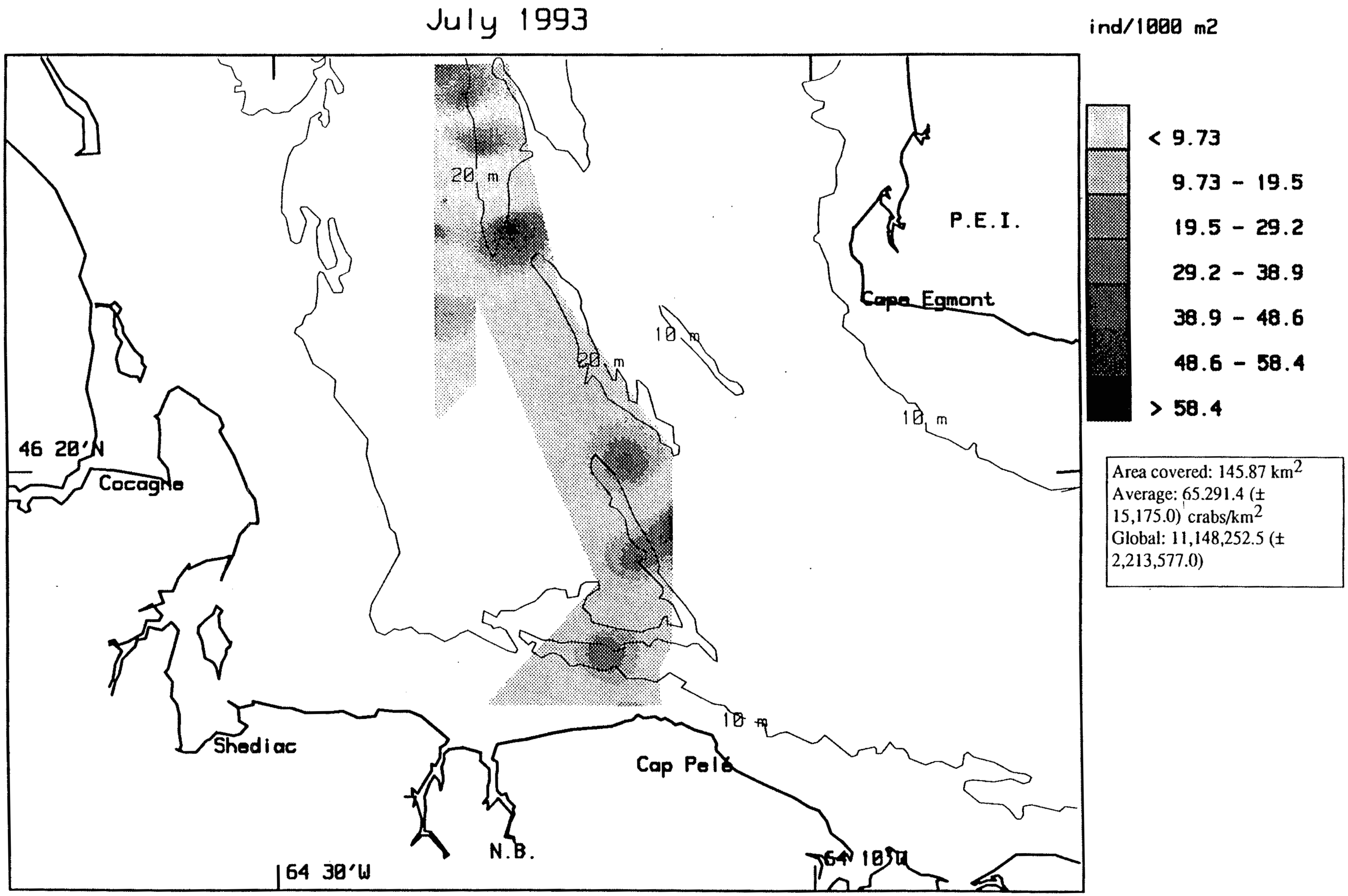

Figure 4. Density countours for rock crab (*Cancer irroratus*) in a portion of Western Northumberland Strait (LFA 25) calculated by kriging for July 1993.

A Review of the Interactions between Rock Crab *Cancer irroratus* and Lobster *Homarus americanus* and Examination of the Possible Impacts of Rock Crab Fishing on Lobster Resource

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In the context of the development of a rock crab fishery in the Québec Region, several research projects were initiated to obtain basic information on rock crab population dynamics, in order to provide some biological basis to the development of a management plan. Research efforts were also concentrated on the examination of the relationships between rock crab and lobster. Some concerns as to whether rock crab exploitation could affect lobster populations were expressed by a number of fishermen. A study was initiated to better understand the interactions between the two species, in terms of space occupation, feeding patterns and strategies and role in the benthic community. These aspects were examined by reviewing the literature. The relative importance of rock crab in the diet of the lobster is presented here, as revealed by the litterature review and by an experiment that we recently conducted to determine if somatic growth and gonad development of lobster could be affected by variable quantities of rock crab in its diet. Some possible impacts of rock crab exploitation on lobster populations are presented.

1.The relative importance of rock crab in the diet of lobster

Throughout the geographic range of the lobster, from Newfoundland to Long Island Sound, rock crab constitutes one of the main prey items found in lobster stomachs. Rock crab figures among the 5 most important prey species, and is often the first in importance (Figure 1). Echinoderms, mussels and polychetes are other prey species common to all studies. Occurrence of rock crab in lobster stomachs shows seasonal patterns, that may differ depending on the regions (Scarratt, 1980; Weiss 1970, Ennis 1973). For example, in Northumberland Strait, there is an increase in the occurrence of rock crab at the end of the summer (Scarratt 1980). Variations are also observed with the molt cycle. During molt, until claws have sufficiently hardened to capture a prey, lobster eat very few mobile species such as rock crab (Ennis, 1973, Scarratt 1980, Weiss 1970, Elner and Campbell 1987). Afterwards, the occurrence of rock crab in the stomachs has been shown to increase markedly (Scarratt 1980, Carter and Steele 1982). Ontogenic changes are observed in the relative proportions of preys in stomach contents (Scarratt 1980, Weiss 1970). As size increases, and lobster reach sexual maturity, the ingestion of rock crab is relatively more important. Females maintain a high consumption of rock crab throughout the autumn, which could be important for the development of the gonads (Ennis 1973).

Juveniles and adult lobsters strongly select rock crab, more than other species also selected for (McLeese 1970, 1973, Reddin 1973, Carter and Steele 1982, Ojeda 1987). Lobster can detect the odor of rock crab. In contact with metabolites of rock crab, lobster shows a strong food-searching response, greater than for other species (Carter and Steele 1982). Lobster appear to prefer rock crab to other species. Lobster was shown to limit its consumption of urchins relatively to rock crab (0.6 g urchin/g rock crab), even when the species was abundant (5g urchin/g rock crab)(Evans and Mann 1977). Lobster attack and eat rock crab in the field or in the lab with in a relatively constant fashion (Reddin 1973, Weiss 1970). Lobster ingest 23 to 41 % of the weight of a rock crab (Reddin 1973, Carter and Steele 1982). There is a positive relationship between lobster size and rock crab size (Ojeda 1987), although adults seem to prefer small crabs (<20 mm CW) (Carter and Steele 1982, Ojeda 1987).

Like other mobile decapods, lobsters tend to select preys with a high energetic content, such as the rock crab (Ojeda 1987, Evans and Mann 1977). The energetic value of rock crab is high, compared to other important preys. Other preys could be a good souce of energy, but are rarely dominant preys (Table 1). In terms of energy intake, the contribution of rock crab reaches 44 % during the principal growth phase of juveniles, in autumn, compared to 13 % in spring. This contribution could be greater for adult lobsters which consume more crabs (Scarratt 1980). In basin, lobster get more than 80 % of their energy from rock crab, when rock crab and urchins are offered (Evans and Mann 1977). Rock crab is the most important source of energy for lobster but also its most important source of proteins (Castell and Budson 1974). Protein content of crab is high (15.4 % / g fresh weight), compared to mussel (9.6 % / g fresh weight) or urchin (1.2 % / g fresh weight) (Boghen et al. 1982). The diet of lobster has a high protein/energy ratio (Leavitt et al. 1979, Logan and Epifanio 1978). Proteins account on average for 27 % of the diet. The constancy of this ratio seems to play a determinant role in lobster feeding. In captivity, growth of lobster is directly linked to the amount of protein offered (Castel and Budson 1974). Lobster fed with proteins extracted from rock crab yield better growth and survival rates than with proteins extracted from sea urchin, blue mussel or shrimp (Boghen et al. 1982).

Benefits from consuming rock crab appeared also in the recent experiment that we have conducted (L. Gendron and P. Fradette, unpublished data). Our experiment has shown that following molt, somatic growth was slower when lobsters were fed with diets containing no crab, compared to a diet where crab was the dominant prey item, representing 80 % of energy intake. Females fed no crabs showed a reduction in ovarian growth. Significant differences were observed after 111 days of captivity. Our experiment showed that consumption of blue mussels and green sea urchins did not have the same nutritional benefits as rock crab, even when energy and protein content of the diets were maintained constant. In the northern part of the Gulf of St.

Lawrence, there are no alternative crustacean prey species as much in abundance and accessible as rock crab. In the absence of rock crab, lobster will have to compensate by preying on other resources. Our results show that consumption of other preys (mussels and urchins), in as much quantity (weight, proteins and energy) as rock crab does not appear equivalent.

Past studies have concentrated on the benefits for lobsters of consuming rock crab. It may however be costly energetically to capture and handle rock crab. Evans and Mann (1977) estimated that in captivity, a lobster had to pursue an average of 42 crabs before succeeding to consume one. In nature, the rate of success could be lower because of greater possibilities of escape.

In conclusion, the review of the literature indicates that rock crab constitutes a key-prey to the lobster. Throughout its range, lobster feeds abundantly on rock crab and this prey predominates in the lobster stomachs. Lobster shows a strong preference for rock crab, when offered a choice. Lobster strongly selects rock crab, more than other species also selected for. Rock crab is a high-quality prey. It is the most important source of energy for lobster and also its most important source of proteins. Growth and reproduction appear to be affected by the amount of rock crab ingested.

2. Possible impacts of rock crab exploitation on lobster populations

Exploitation of rock crab will decrease the abundance of large size animals. This reduction is not expected to have an immediate negative effect on lobster populations since those crabs are not readily accessible to lobsters by predation. Positive impacts on lobster can even be expected as suggested by Cobb et al. (1986). Negative impacts could be expected if the number of smaller rock crab, i.e. those preferably eaten by lobsters, decreases to a level where the availability to lobster is significantly reduced. Although a reduction of rock crab might increase the availability of other prey species on which lobster also feeds, it seems, from what was presented above, that the quantity could apparently not compensate for the quality of a prey such as rock crab. Assuming that the benefits for lobsters of consuming rock crab observed in our experiment are representative of the natural situation, a reduction in somatic growth and in gonadal development could be expected. The reduction of rock crab available to lobster could also increase the vulnerability of lobster to predation (by fishes such as sculpins or ravens), either by an increase in feeding time or by an increased consumption of lobster because of crab scarcity. The extent to which rock crab numbers would have to decrease to have significant effects on growth and reproduction of lobsters is unknown and will be hard to quantify.

A cautious approach in the development of rock crab fishery was adopted in the Québec Region, and a number of regulations have been set at the start of the fishery, limiting the effort, the catch, and providing a certain level of escapement. In our present state of knowledge however, we cannot predict how rock crab populations will react to exploitation and to what extent the regulations put forward will be effective in preventing recruitment overfishing, which could be a cause of a reduction of rock crab availability to lobsters.

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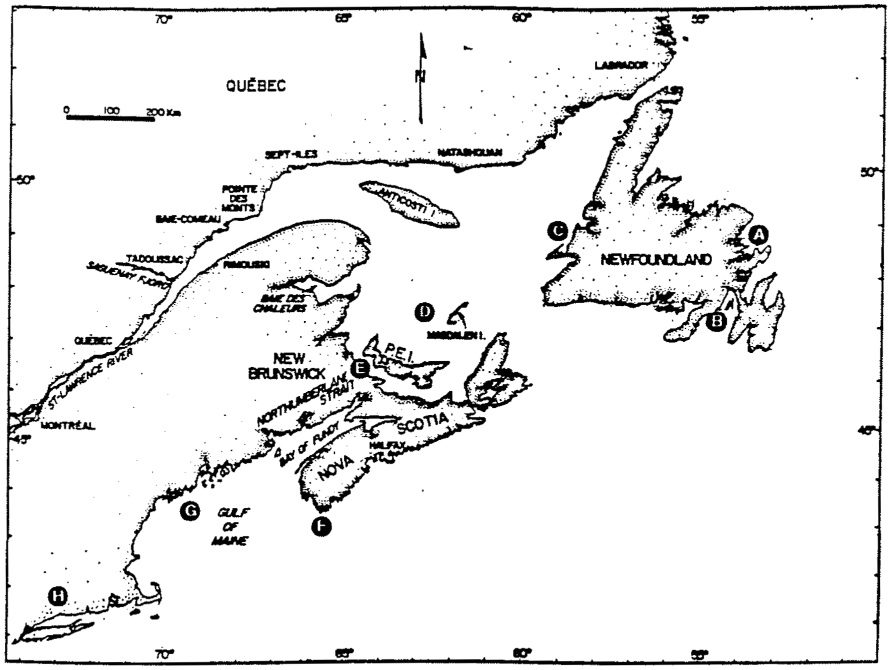
Table 1. Energy content (kJ/g, fresh weight) of different prey species encountered in lobster stomachs (From Ojeda 1987).

	Energy content KJ/g	**Source**
Cancer **sp.**	4.6-7.0	Scarratt 1980 Duarte et al. 1980
Mytilus edulis	1.92-2.09	Scarratt 1980 Petersen 1981
Strongylocentrotus droebachiensis	1.21-1.25	Brawn et al. 1968
Ophiopholis aculeata	0.10	Scarratt 1980
Amphipods	5.90	Strong and Daborn 1978
Isopods	4.39	Brawn et al. 1968
Whelk	> 7.11	Reddin 1973



Method			Zostera marina	Hydroida	Littorina littorea or Lacuna vincta	Mytilus edulis or Modiolus modiolus	Polychaeta (polynoida or neredeida)	Pagurus sp.	Cancer irroratus or boeralis	Hyas araneus or coarctatus	Aster ias vulgar is	Ophiuroidea or O. aculeata	S. droebachiensis	Ascidiacea or Molgula sp.
	Ennis 1973 (47-113 mm)	A							1				2	
Vol. & occ.	Carter & Steele 1982 (12-73 mm)	B				2	5		1			4	3	
Occ.	Squires (1970) (66-113 mm)	C			3		1		1					
Vol.	Hudon & Lamarche 1989 (8-50 mm) barrens	D		2		1			2					
Vol.	Hudon & Lamarche 1989 (8-66 mm) algae	D			3	1			2					
Occ.	Scarratt 1980 (15-158; juv.)	E	1			5	1		3		5	4	5	5
Energy	Scarratt 1980 (juv.) spring	E				5	1		4		1		3	
Energy	Scarratt 1980 (juv.) fall	E				4			1		2		3	
Vol.	Elner & Cambell 1987 (50-133 mm) algae	F				2		4	2				3	1
Vol.	Elner & Cambell 1987 (8-142 mm) barrens	F				1		4	3			2	5	
Weight	Ojeda (1987) (63-107 mm)	G				2	3		1					
Occ.	Weiss 1970 (20-100 mm)	H			2	4	3		1					

Figure 1. Mean rank for the dominant taxa found in lobster stomachs, from Newfoundland to Long Island. The method used to analyse the stomach contents is indicated (vol. refers to volume and occ. to the frequency of occurrence) as well as the size (LCT) of the lobsters examined.

The Possible Consequences of a High Exploitation Rate of Male Dungeness Crabs (*Cancer magister*) on Population Egg Production: what Might be Learned from Experimental Management

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History

In British Columbia (BC) much of the coastline is inaccessible by land and good Dungeness crab (*Cancer magister*) habitat is discontinuous. As a consequence there are several geographically distinct regional trap fisheries for Dungeness crab. These fisheries are conserved by a minimum legal size limit set at 165 mm (spine-to-spine) carapace width (Jamieson 1985). Although it is legal to retain female crabs (regardless of their reproductive state) few are retained because they rarely attain legal size, they have a poorer meat yield than males, and fishermen believe it is poor conservation policy. Consequently, these fisheries land male crabs almost exclusively. Despite large distances separating many of these fisheries, there does not appear to be a marked difference in the growth rates between fisheries as distant as Tofino and Dixon Entrance (Smith and Jamieson 1989c). Also the traps used in these fisheries, and fishing practices, are similar throughout the province.

There are also trap fisheries for Dungeness crab in Washington, Oregon and northern California. In these states only males greater than 159 mm (notch-to-notch) carapace width (CW) can be retained legally. Along the coasts of these states there have been intense fisheries for *C. magister* for many years. For the period 1951-1977, Methot and Botsford (1982) estimated F to range from 0.8-3.2 for the northern California fishery. Thus, at least this fishery has experienced a consistently high exploitation rate.

The conventional wisdom in both Canada and the US has been that an essentially male-only fishery, and the use of a minimum legal size limit, protects female egg production and thus prevents "recruitment-overfishing" (Cleaver 1949, Poole and Gotshall 1965, Methot 1986). This belief is supported to some degree for BC fisheries by sampling (Smith 1988; Jamieson unpub. data) that shows that in intensely fished areas such as near Tofino, BC, all sexually mature females appear to have been inseminated at least once, and egg-bearing females are abundant during the normal period for release of eggs during winter. It is also true that few females attain legal size, and egg bearing females of all observed sizes above the size-at-maturity are relatively common.

Hypothesis

On the basis of our published (Smith 1988, Smith and Jamieson 1989a, 1989b, 1989c, 1990, 1991, 1992) and unpublished (Jamieson unpub. data) work, and that of other scientists (in particular Hankin et al. 1985, 1989), we argue that this information can be deceptive and that the intense exploitation of males in some fisheries in the US and BC might result in reduced population egg production. We were led to consider this possibility when we recognized that four regional fisheries in BC which were experiencing quite different exploitation rates showed quite different female size frequency distributions. This has led us to hypothesize that a high exploitation rate of males greater than the legal size limit denies the larger females in the population a mating partner and causes these females to skip-moult (Smith and Jamieson 1991). Since females must mate with a male considerably larger than themselves, and only when they are in a soft-shelled condition immediately after moulting (Butler 1960), the lack of a large male for mating can possibly deny a female an opportunity to mate, and perhaps to moult. Consequently, (1) these females will produce fewer eggs over their life span, (2) the distribution of female size frequencies will shift toward smaller sizes, and (3) population egg production will be reduced.

Specifically, we noticed that despite females not being landed in BC fisheries, the negative slope of the catch curves (Ricker 1975) for females sampled in four regional fisheries was steepest for the most heavily fished region, and shallowest for the most lightly fished region (Figure 1, Table 1). The catch curve for each fishery in Figure 1 combines commercial samples from the two consecutive years when each of these fisheries were sampled. Combining samples from consecutive years was suggested by Ricker (1975) to reduce the influence of a possibly dominant age-class. Prior to plotting the catch curves the samples were standardized to obtain virtual catch rates (Smith and Jamieson 1989a) as was done in Smith and Jamieson (1989b). It is apparent from Figure 1 that the survivorship of females to larger instars in the heavily fished Fraser delta fishery is much lower than that for the lightly fished Holberg Inlet fishery, while the catch curves for the other two regions are intermediate.

Table 1 compares fishing intensity for the four regional fisheries (as defined by their Statistical Area (SA) designation) considered in Figure 1. These statistical areas do not differ markedly in area thus comparisons of fishery statistics among Statistical Areas is fair. The quantity of males landed, the number of days fished, the number of vessels fishing, and the number of sales in these regional fisheries are relative indicators of fishing effort. The degree of exploitation and the virtual catch rate of legal-sized males are indicators of fishing impact. These impacts were determined as described in Smith and Jamieson (1989a,b). The degree of exploitation is the percent of legal-sized males (i.e. >154 mm CW) in the 155 mm instar (Smith and Jamieson 1989b) that has been removed by fishing. The virtual catch rate is the rate at which legal-sized males would enter a trap if entry rates were not modified by changes in bait effectiveness over time and agonistic interactions among crabs. The Fraser delta fishery appears heavily exploited, while the Holberg Inlet fishery is lightly exploited. Two other fisheries, near Tofino and in Dixon Entrance experience intermediate fishing intensity, except that Smith and Jamieson (1989b) show that in 1985-1986 the *C. magister* population near Tofino has experienced heavy fishing.

This comparison of female catch curves with fishing intensity allows us to interpret that in an intensely exploited fishery both large males and large females were rare but in a lightly exploited fishery both males and females were abundant. In addition, data on the carapace widths of males and females forming mating pairs (Smith and Jamieson 1991) suggested to us that females greater than about 140 mm CW would have difficulty finding a male partner in heavily exploited fisheries since males greater than the minimum legal size limit would be rare. Since a female moults while involved in a mating ritual with a larger male (Butler 1960), who might be absent in a heavily fished population, we further interpreted the catch curves as evidence of reduced mating activity, and female growth stagnation due to heavy fishing on males.

We think it is unlikely this pattern results from increased mortality due to trapping and excessive handling in an intensive fishery, although others disagree (see Butler and Hankin 1992 and Smith and Jamieson 1992). Mortally injured or dead crabs were seldom seen in traps or trawls during this study. If mortality in traps is low, despite the artificially high density of crabs in traps, then trapping and handling induced mortality outside traps would be expected to be lower. On the basis of these observations we judge that cumulative female mortality over the fishing season is likely to be low.

It also seems unlikely this pattern results from legal-sized females having been harvested (since it is legal to harvest females in BC) because the size frequency distributions do not show a discontinuous decrease in abundance at legal size. Differences in growth and mortality related to habitat and geographic differences among the populations cannot be entirely ruled out, but there is no evidence of marked differences in these rates from northern BC to northern California (Smith and Jamieson 1989c).

Reproduction dynamics

It is typical for female brachyuran crabs to require a larger and hard-shelled male to form a mating embrace (Butler 1960, Snow and Neilsen 1966, Hartnoll 1969, Elner et al. 1985, 1987, Taylor et. al. 1985). As already mentioned, Smith and Jamieson (1991) suggest that female *C. magister* larger than about 140 mm CW might not have an opportunity to mate and moult in the more heavily fished populations. In support of this hypothesis, Hankin et al. (1985, 1989) report that annual moulting probabilities for females in central California decline precipitously from near 1, for a female 130 mm CW, to near 0, for a female 145 mm CW. We suggest this could result from the unavailability of large males since California fisheries remove a large portion of legal-sized males each year (Methot and Botsford 1982).

So even though sampling might show that all females in a heavily fished population might have been mated at least once (Smith 1988; Jamieson, unpub. data), population egg production might still be reduced relative to an unfished population. This would result from (1) the distribution of female size frequencies shifting toward smaller sizes, with smaller females producing fewer eggs than larger females, and (2) reduced fecundity each year a female fails to moult (Hankin et al. 1985). Both result from a decrease in potential matings by the male population. It is noteworthy, however, that Brown and Bennett (1980) suggested that large female *C. pagurus* failed to undergo an annual moult because the presence of sperm inhibited moulting. However, one can not interpret from their results whether the moulting of females might have been inhibited by the absence of males large enough to mate with the larger females.

To date, there is insufficient information for us to usefully debate whether a female carrying sperm does, or does not, moult annually. However, we can propose an evolutionary argument to guide our thinking on this topic. For example, if we use total egg production of an individual female crab as a measure of its relative fitness (Stearns 1976, 1977), the better reproductive strategy is the one that yields the higher expectation for future egg production. If mating, moulting and producing a larger clutch of eggs is a higher risk for a female already carrying sperm, in terms of lost future population egg production, than not moulting and producing fewer eggs, then the suggestion of Brown and Bennett (1980), for *C. pagurus*, that females do not moult if they carry sperm is the more favourable evolutionary argument. On the other hand, if mating and moulting has the lower risk (i.e. greater life-time egg production), then the more favourable argument is that a female should not moult without mating.

We suggest that in an unfished Dungeness crab population with an abundance of large males, a female can reasonably expect to be mated. Therefore we argue that it would be unwise for her to moult without mating since, with a high natural mortality rate (M>2.0, Hankin et al. 1985), she has little chance of surviving to mate and moult the following year. In this circumstance it seems that the more fit female, in terms of future population egg production, would be the one that delays moulting until a suitable mate is found. This evolutionary argument suggests that in a heavily fished population females would not molt until a male partner became available. Since these females would not be expected to find a mate they also would not be expected to moult to a larger size. The consequence of this strategy in a heavily fished population would be for the distribution of female size frequencies to shift toward smaller sizes. Is this really what happens ?

To date, we have no answer for this complex question about Dungeness crab reproduction dynamics. Our starting point is the evolutionary argument and some knowledge of the physiological interactions between mating males and females, and the factors that control mating. The physiological argument for brachyuran crabs in general is that a female secretes a pheromone to attract males when she is preparing to moult (Hartnoll 1969, Christy 1987). Once a suitable mate is found, the mating ritual and subsequent mating occur. For "female centered competition", which is the label Christy (1987) applies to the mating behavior of *Cancer* spp., this means that males competitively search and aggressively defend their female partners for a few days before, and perhaps after, the actual mating. The release of a pheromone to attract males has been described for a few portunid crabs (Christy 1987), and Edwards (1966) has suggested this might also occur for *C. pagarus*. There is some indirect evidence that cancrid females release a water-borne pheromone in their urine in the days prior to moulting (Christy 1987).

It would be valuable to know if *C. magister* has a similar reproductive biology and if the endocrinology of moulting and reproduction is different between females that do and don't carry sperm. It needs to be explained why population information suggests females do not moult if suitable males are not available, yet mature females carrying sperm have been observed to moult in the absence of males in laboratory tanks (P.W. Wild cited in Hankin et al. 1985). Also, the suggestion of Brown and Bennett (1980) that female *C. pagurus* carrying sperm do not moult does not explain how females carrying sperm attain the larger instars. In this study, all mature *C. magister* females, of all sizes, carried sperm.

To summarize, reproductive biology (e.g. age-at-maturity, fecundity, seasonality of egg hatching) has been described for many crab species but information on reproductive behavior in nature (e.g. the number of females mated by each male during a mating season, duration of mating activity, female moulting physiology and behaviour) is more elusive to researchers and remains poorly understood for crustaceans in general. Increased knowledge of reproductive behavior is not only important for understanding the population dynamics of *C. magister*, but might contribute to explanations of the sharp declines in landings of the red king crab (Blau 1986) and the Atlantic snow crab (Elner and Bailey 1986).

Experimental management

Clearly several mechanisms, both natural (e.g. regional differences in growth and mortality) and fishing induced (e.g. mortality due to poaching and handling), can conceivably produce the results we present here (Figure 1) for females, but we focus here on introducing the hypothesis that intense fishing of males denies females an opportunity to mate and moult thus stagnating their growth. Testing this hypothesis requires (1) studies of the biology and endocrinology of mating and moulting, and (2) population experiments to determine if the correlations observed reflect cause and effect. Understanding this phenomenon might be crucial to good management of this species. Because the evidence supporting this hypothesis occurs at the population level, testing this hypothesis must also include experimentation at the population level.

An 'experimental management' approach (see Walters 1986), where the sex ratio is deliberately altered by varying the minimum legal size limit for males, and prohibiting the landing of females, would also help improve our understanding of *C. magister* reproduction dynamics. Some questions regarding reproductive behavior can be addressed only by experimentation at this scale. Experiments to test for possible changes in female population structure resulting from harvesting males above a relatively low minimum legal size limit, thereby eliminating mating opportunities, cannot be performed in a laboratory or in small field experiments.

Without large scale experimentation one cannot be certain that the relationship observed between the degree of exploitation of males and the absence of larger females is cause and effect. Uncertainty about the cause of our observations has important implications for management of *C. magister*, and is the basis of a poignant argument for the serious consideration of experimental management policies as learning exercises. Consider that along the coasts of Washington, Oregon and California harvesting rates have been consistently high and, unlike BC, have provided no opportunity to learn that there might be a relationship between the harvest rate of males and female population structure.

General advice

We were fortunate in BC to have several regional populations experiencing contrasting exploitation rates on males which provided us the informative female size frequency data which led us to formulate this hypothesis. These regional fisheries could also provide us with an opportunity to test this hypothesis. Such opportunities are rare in established fisheries. We believe it would be wise, therefore, that when new fisheries are established for underutilized invertebrate species scientists be involved to set up exploitation rate experiments. These experiments can help us learn how the structure and processes of a population can change as a result of exploitation. An understanding of the relationships between exploitation rates and population responses is likely only to be obtained if we deliberately provide experimental contrast across a broad range of exploitation rate possibilities.

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Table 1. Comparisons among different measures of fishing effort, and fishing impact, on male *C. magister* populations in four regional fisheries defined by Statistical Area (SA). Annual fishing statistics include the metric tonnes landed (t) and the number of days fishing (DF).

					Annual fishing statistics					
	Degree of Exploitation[a]	Virtual entry rate[b]	Number of vessels[c]	Number of sales[c]	1983		1984		1985	
Region					t	DF	t	DF	t	DF
Holberg Inlet (SA 27)	17[d]	641	10	37	3	73	5	116	5	185
Dixon Entrance (SA 1)	45[e]	84	25	135	136	394	146	457	160	474
Near Tofino (SA 24)	≈75[f]	103	27	434	136	1869	110	1228	152	1391
Fraser delta (SA 29)	86[g]	49	119	1307	274	2341	341	3636	353	3662
British Columbia Total	-	-	-	-	959	12987	1155	15731	1165	16851

[a]The percent of the legal-sized males in the 155 mm instar taken by the fishery near the end of the season. See Smith and Jamieson (1989b) for an explanation of this estimate.

[b]The number of legal-sized male crabs that would enter 100 traps if the entry rate was not reduced (1) by crabs within traps inhibiting the entry of more crabs, and (2) changes in bait effectiveness over time. See Smith and Jamieson (1989a) for an explanation of this rate.

[c]In 1984.

[d]In December 1984.

[e]Mean of October 1983 and 1984.

[f]From Smith and Jamieson (1989b).

[g]Mean of October 1984 and 1985.

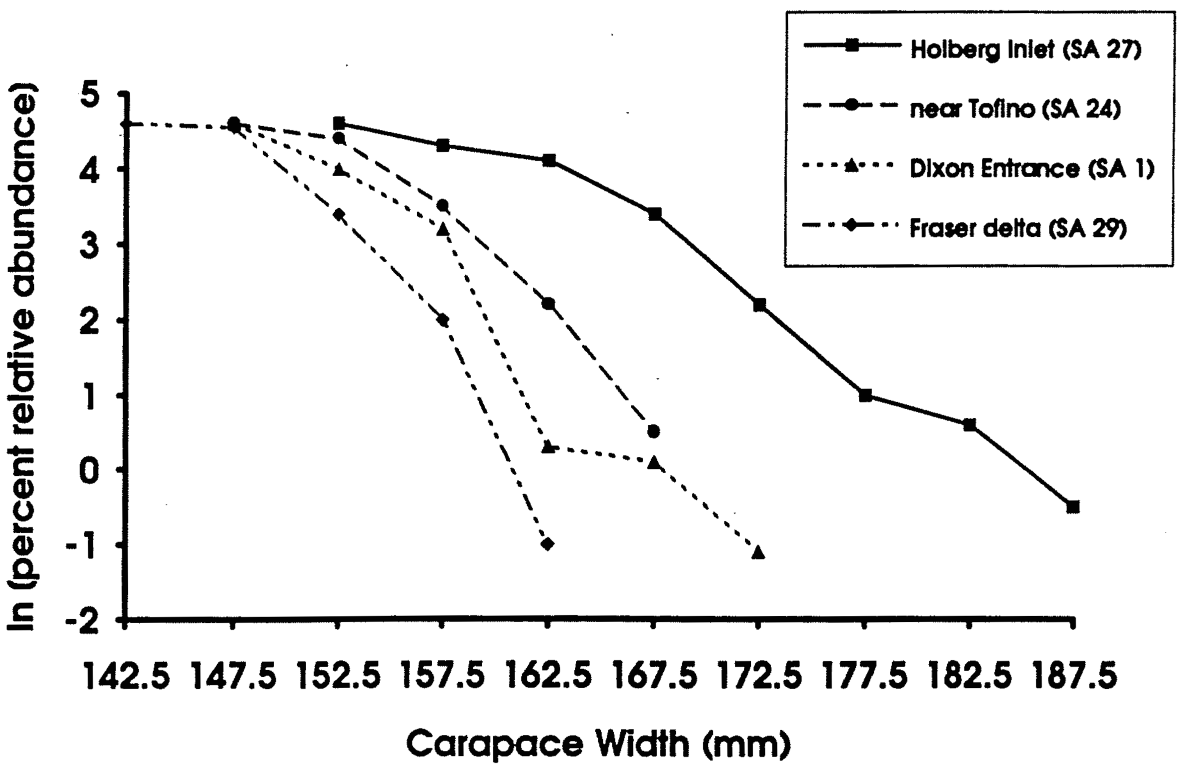

Figure 1. Comparison of catch curves (Ricker 1975) for females from four regional *C. magister* fisheries defined by Statistical Area in British Columbia.

Evolution of an Unmanaged Crab Resource in South America: the False Southern King Crab *Paralomis granulosa*

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In southern South America, two lithodid species constitute a mixed crab trap fishery on both the Pacific and Atlantic coasts. The Chilean fishery is located on the Pacific coast, mainly in Magellan Strait, near Punta Arenas (53° 10' S; 70° 54' W), whereas the Argentinean fishery is more restricted geographically, occurring mainly to the South of Tierra del Fuego, in the Beagle Channel, near Ushuaia (54° 50' S; 68° 15' W). The fishery for the false southern king crab (FSKC, *Paralomis granulosa*) is the more recent of the two fisheries, having started in the late 1970s when landings of the southern king crab (*Lithodes santolla*) began to decline. The data for the FSKC fishery are few and discontinuous. Consequently, in Argentina, the regulations for the FSKC fishery were put in place based on *L. santolla* biology.

The biology of *Paralomis granulosa*

During October, the reproductive cycle begins with the courtship and mating between an old-shelled male and a recent molted female (Figure 1). The fecundation is external and the female keeps the embryos in her incubation chamber (space between the cephalothorax and the folded abdomen) between 18 to 22 mo. Fecundity varies between 800 to 8500 eggs, depending on female size. Larval hatching occurs mainly during winter (June to August), after almost two years since mating (Lovrich and Vinuesa 1993). For each individual, the whole larval development (through two zoeae and one megalopa stages) lasts approximately 40 days (Campodónico and Guzmán 1981). However, there is no information about the larval duration in the natural environment.

There is no information on growth from the first crab stage (of about 3 mm carapace length, CL) to the stage of 10 mm CL (figure 1). In the laboratory (conditions similar to those of the natural environment), growth is slow during the immature phase. The relatively smaller crabs (< 40 mm CL) moult twice a year: in winter and summer. Crabs > 40 mm CL moult only in summer. During the immature phase, percentage of growth per molt is constant and of 12.4 % (Lovrich 1991). If the same pattern of growth would occur in nature, gonadal maturity would be reached after 7-10 years.

In males, gonadal maturity (defined as presence of spermatozoids in the vasa deferentia) is reached at 50.2 mm CL and in females (defined as the presence of embryos in the abdomen) is reached at 60.6 mm CL (Figure 1). Morphometrical maturity (defined as the change in the allometric relationship between carapace and claw size) is reached at 57 mm CL in males and at 66.5 mm CL in females (Lovrich and Vinuesa 1993). Males attain morphometric maturity one molt after they have reached gonadal maturity. Male molting is supposed to be annual and probably biennial when males are older. However, there is no information about growth rates in mature crabs, thus the time required to attain legal size (80 mm CL) remains unknown. Moreover, at mating, crab size and maturity condition is unknown, thus it is difficult to evaluate the role of each category of crabs (gonadically or morphometrically mature, commercial) in the reproductive process and recruitment.

The fishery of *Paralomis granulosa*

From 1976 to 1986 total landings of FSKC by Argentina and Chile oscillated from 300 to 1,000 t/yr (Figure 2a). After 1986 landings increased to about 2,000 t/yr and reached a maximum of 3,500 t in 1991. Of the total landings, Chile has harvested about 91% and Argentina about 9%. Thus, the pattern of landings reflects mainly the Chilean fishery. In the Beagle Channel, Argentinean landings were rather stable between 1985 and 1991, at about 150t (Figure 2b). During the last four years of the Argentinean fishery only larger males were kept (Lovrich, unpublished data).

Despite having few data, we have enough information to present the Magellan Strait and the Beagle Channel fisheries as examples of a heavily exploited "managed" fishery and a lightly exploited "unmanaged" fishery, respectively. From the analysis of data presented by Campodónico et al. (1983) and Diaz and Alvarado (1986), the Magellan Strait fishery is characterized by: (1) a decrease in CPUE from ~9.5 kg/trap in 1979 to ~4 kg/trap in 1984-86 (Figure 3), (2) a decrease of ~60% in the biomass of legal sized-crabs from 1979 to 1983 (Figure 3), (3) a slight decrease in the mode of female size distributions from 68 mm carapace length (CL) in 1980 to 64 mm CL in 1982 (Figure 4), and (4) a decrease in the mode of male size distributions from 92 mm CL to 74 mm CL from 1979 to 1982 (Figure 4). In contrast, the Beagle Channel fishery is characterized by: (1) a lower CPUE that decreased from ~4 kg/trap in 1981 to ~2 kg/trap in 1983 and then remained almost constant (Figure 5), (2) a stable mode of female size distributions (Figure 6), and (3) a relatively stable mode in male size distributions (Figure 6).

How to regulate a fishery without enough fishery data ?

We know that heavy fishing rates can lead to important and undesirable changes in the FSKC population over a short time, as occurred in Magellan Strait as soon as the fishery started. With an apparently long generational time (~10 yr), and uncertainty about recruitment patterns and stock abundance in Beagle Channel, we suggest some management regulations based on reproductive features. These regulations are designed to preserve the reproductive potential of the FSKC population in Beagle Channel until reliable fishery data can be acquired. These are:

(1) prohibition against landing females,
(2) setting a minimum size limit of 80 mm CL for males that will allow them to reproduce at least once,
(3) establishing a legal fishing season from January to August, that avoids the periods when crabs are molting and reproducing and,
(4) mandatory detailed fishing logs that allow a detailed following of the fishery.

We also suggest that management regulations should be frequently updated on the basis of the future biological studies and the fishery monitoring.

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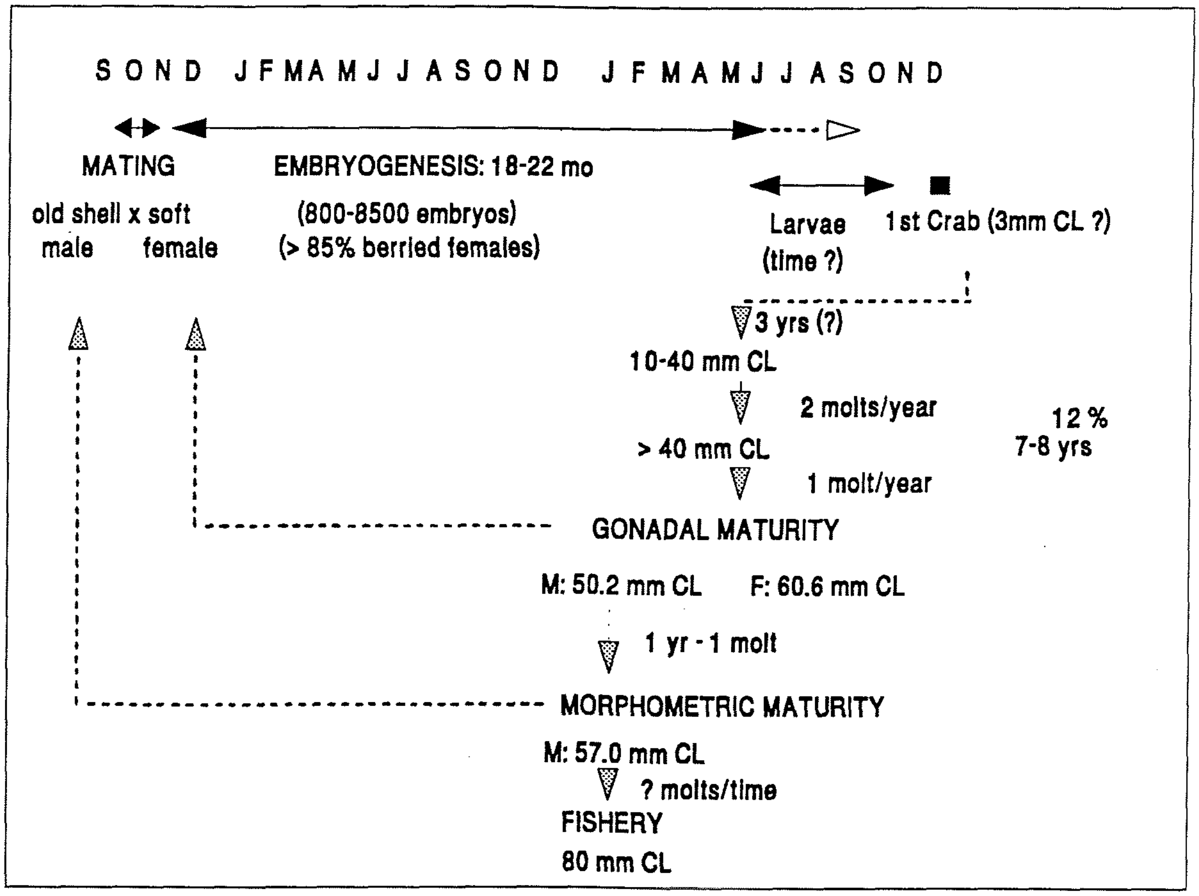
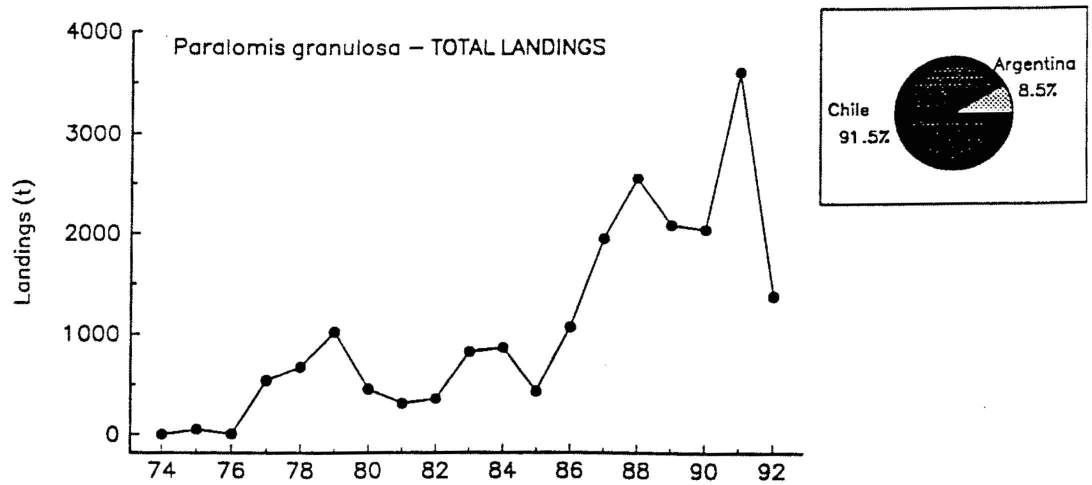


Figure 1. Main features of the life cycle of *Paralomis granulosa* in the Beagle Channel. The first line is a time scale in months. CL: carapace length. ? and dotted lines: unknown.

A



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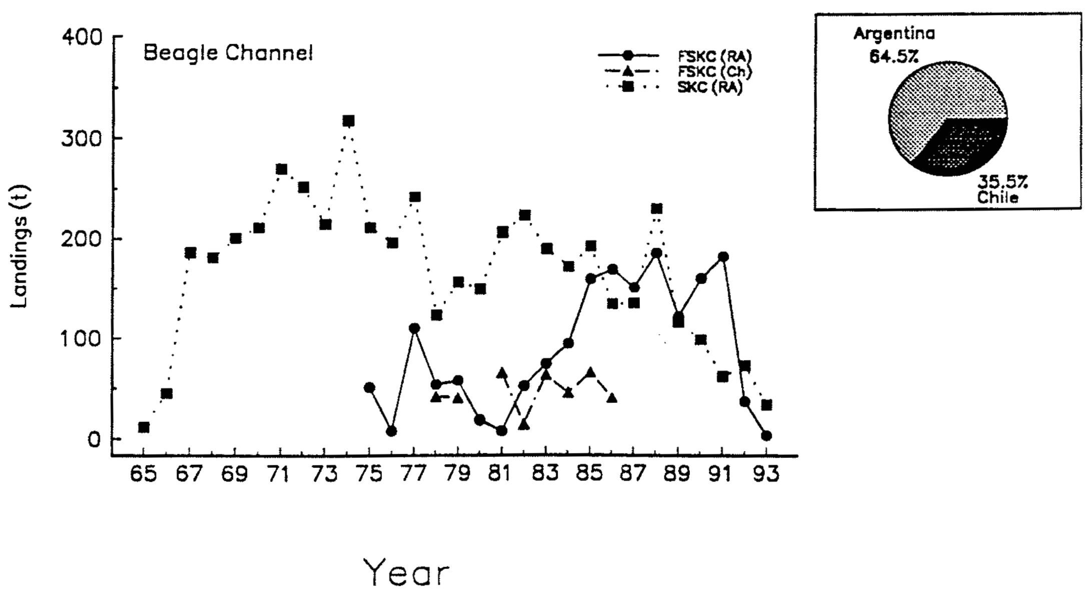

Figure 2. A) Total landings of *Paralomis granulosa* for Chile and Argentina. The pie-graph represents the proportions of the total landings that correspond to each country over the time period. B) Landings of *Paralomis granulosa* (FSKC) and *Lithodes santolla* (SKC) in the Beagle Channel, from the Argentinean fishery (RA) and of *P. granulosa* in the same area, from Chilean fishery (CH). The pie-graph represents the proportions of landings for each country for the period 1977-1986.

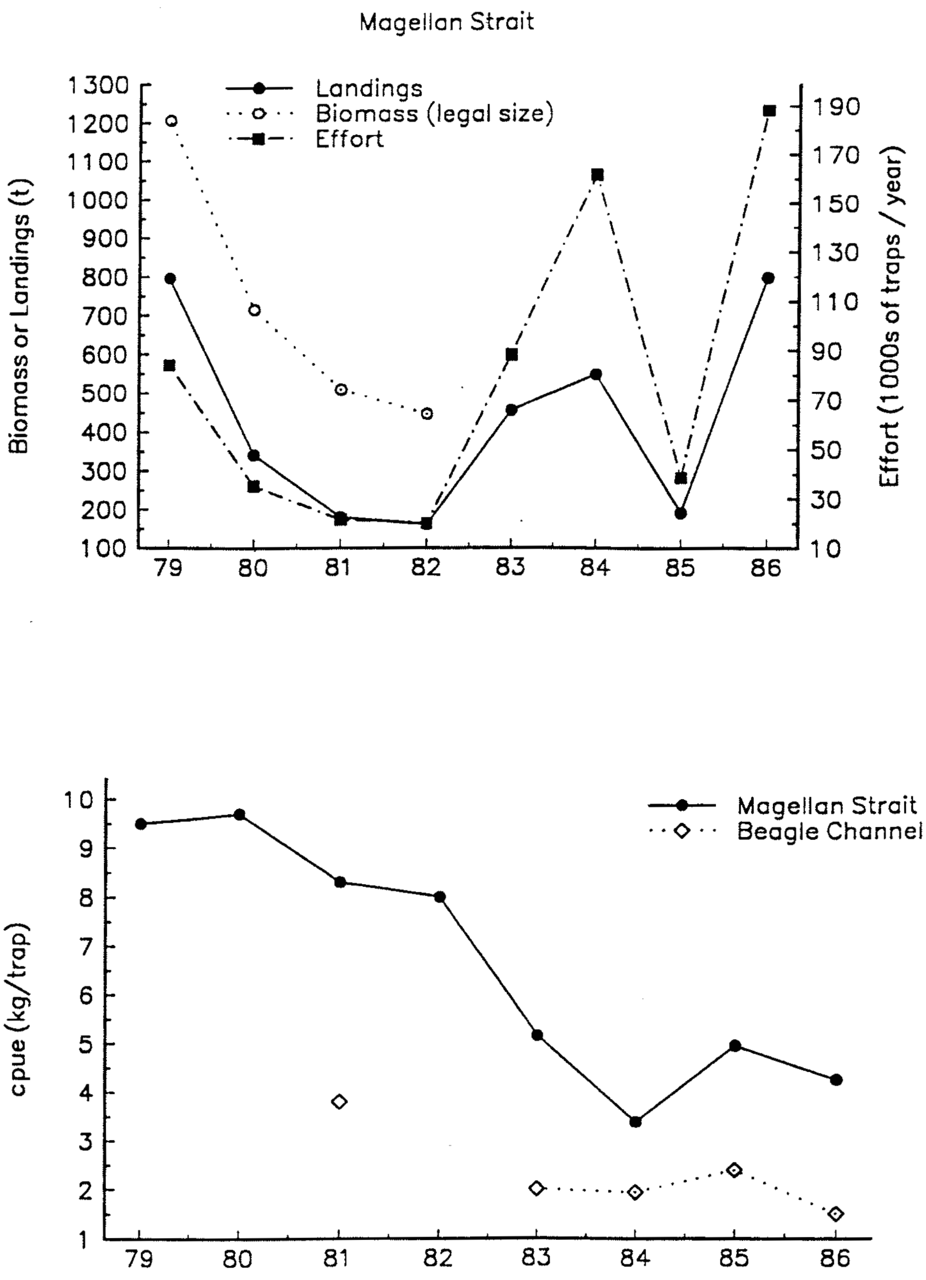

Figure 3. Landings, biomass of legal-sized crabs, total effort for the fishery of Magellan Strait (above) and catch per unit effort (CPUE) for both fisheries: Magellan Strait and Beagle Channel (below). Data are from Campodónico et al. (1983) and Diaz and Alvarado (1986).

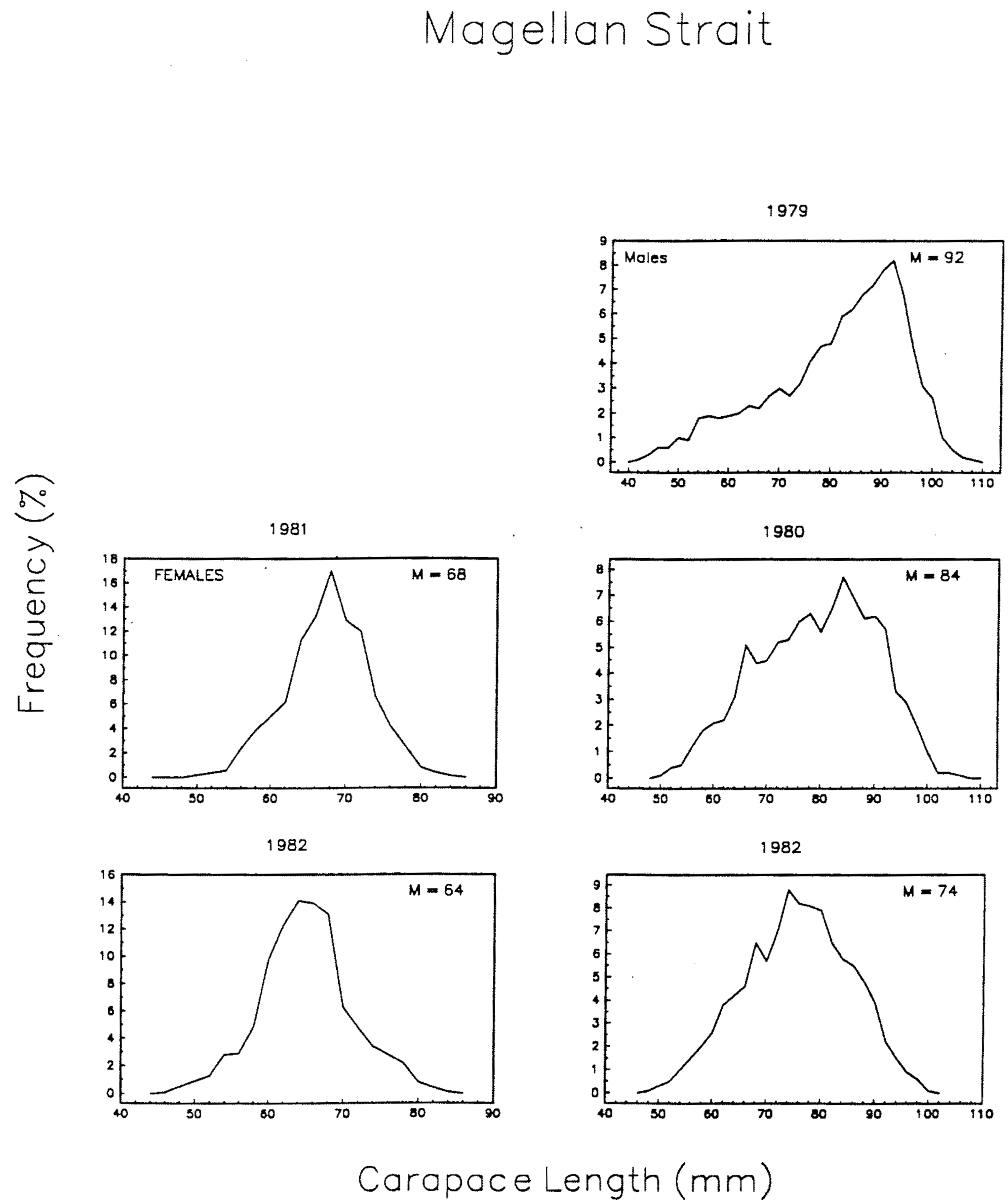

Figure 4. Population structure in Magelllan Strait from trap surveys. The year of survey is indicated at the top of each figure. M: modal size. Data from Campodónico et al. (1983).

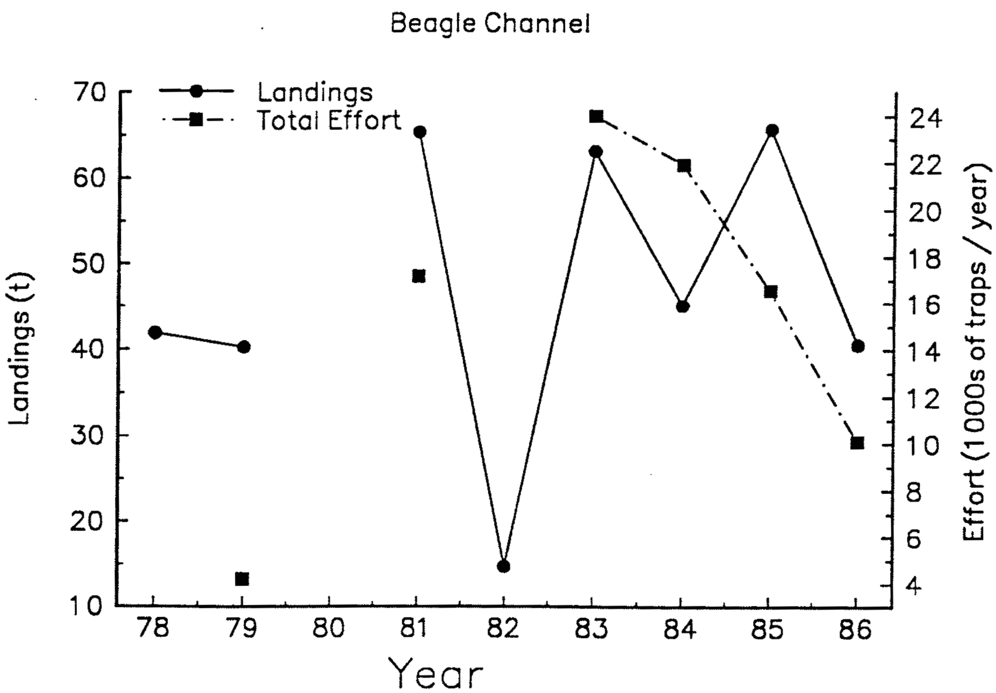

Figure 5. Landings and total effort for the fishery of Beagle Channel. Data from Campodónico et al. (1983) and Diaz and Alvarado (1986).

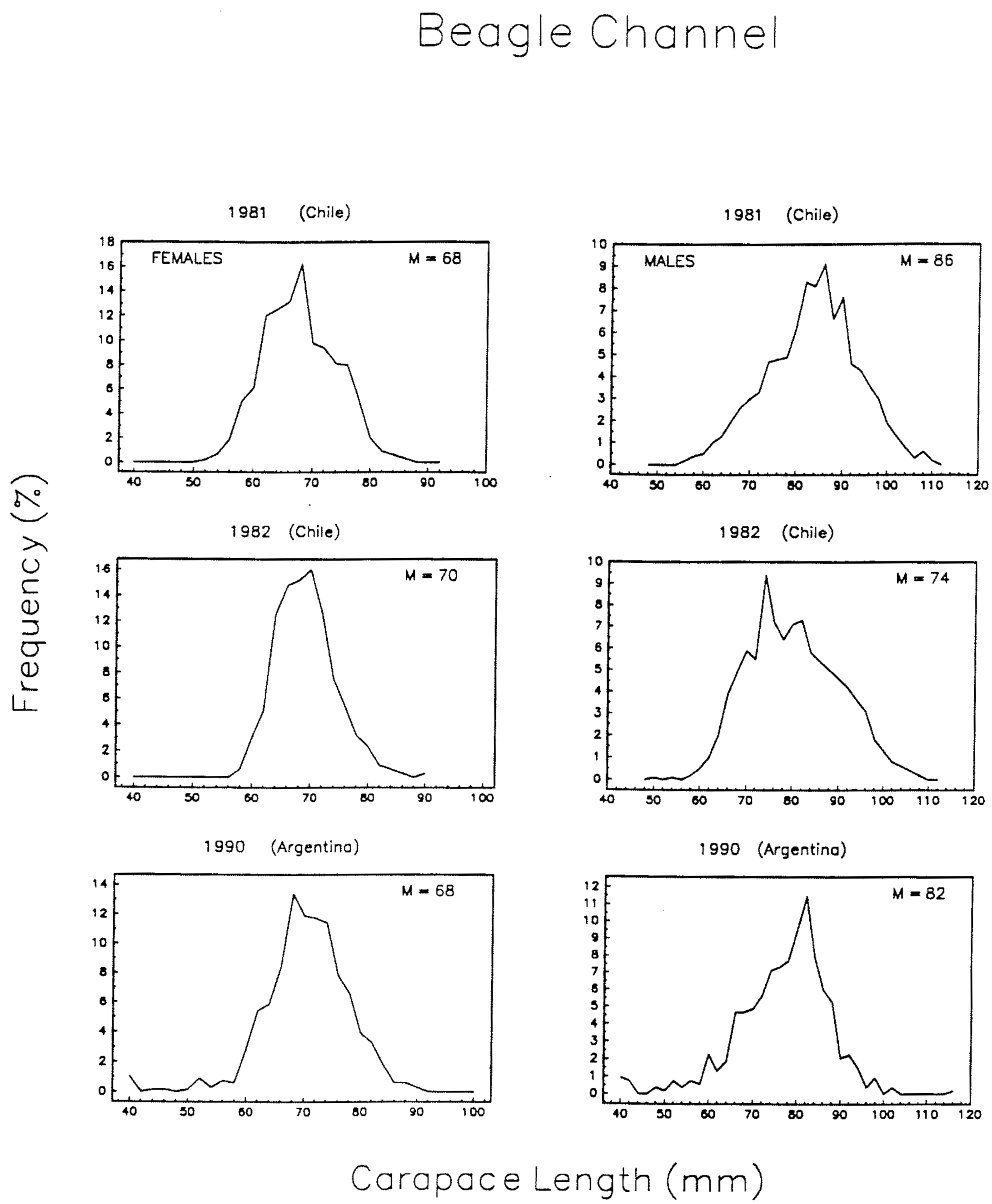

Figure 6. Population structure in Beagle Channel from trap surveys. The year of survey is indicated at the top of each figure. M: modal size. Chilean data from Campodónico et al. (1983). Argentinean data from Lovrich (1991).

SESSION 3

Case Studies - Molluscs and Echinoderms

Bivalve Fishery in the Gulf Region

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Although the soft-shell clam (*Mya arenaria*) fishery in the southeastern part of the Gulf of St. Lawrence has an annual value of over $1 million, it has long been considered as a recreational commercial fishery and is still managed in a manner typical of some underutilized species that are being considered for developmental fisheries. In 1994, new regulations on the clam fisheries will require soft-shell clam fishers in New Brunswick and other areas inside the Gulf Region to be licensed if they want to harvest more then 100 clams per day, per person. The licensing of commercial fishers will become an important tool for managing and monitoring the soft-shell clam fishery throughout the Region.

A controversial issue facing Fisheries Managers will the regulation of the type of gear to be used in this fishery, particularly with the possible re-introduction of hydraulic rakes which have been under moratorium in New Brunswick since 1985 because of user group conflicts. Over the past two years, small scale research projects were conducted in New Brunswick, to evaluate and document the potential impact of the hydraulic rake. Results to date have shown that the catch per unit of effort (CPUE) of the hydraulic fishery is approximately three times that of the traditional hack (fork/shovel) fishery. The effort (time) required by a hydraulic fishing team of four persons to harvest a clam bed was estimated at half of that required by four hack fishers with harvesting efficiencies of 75% and 60% respectively. The indirect mortality applied on the remaining clams is reported to be three (3) times greater for a hand (hack) harvested population compared to the hydraulic harvesters. Fishing simulations with the above information show that although the catch from a hydraulic fishery would be 25% higher than that from a hack fishery from a hypothetical clam population, the overall mortality on that population would be approximately 20% higher for the hack fished population.

Développement de la Pêche à la Mactre de Stimpson (*Mactromeris polynyma*) au Québec et Efficacité de la Drague Hydraulique de Type Nouvelle-Angleterre

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Dans le golfe du Saint-Laurent, la mactre de Stimpson est une ressource sous-utilisée dont la pêche est en développement. Au Québec, l'exploitation de ce mollusque intéresse particulièrement quelques pêcheurs de poissons de fond qui veulent en faire une pêche complémentaire. Cependant, les connaissances actuelles sur l'état et la biologie de cette ressource dans le golfe du Saint-Laurent sont encore partielles. Il est donc difficile d'établir des stratégies de gestion et d'exploitation qui assureraient la pérennité de l'espèce. Le présent document est un résumé de l'information qui est présentement disponible sur cette pêche. Une attention particulière a été portée aux résultats d'une étude sur l'efficacité de la drague hydraulique utilisée pour la récolte de la mactre de Stimpson au Québec.

1. Développement de la pêche

La découverte de gisements exploitables dans le golfe du Saint-Laurent est relativement récente. Ce n'est qu'en 1990 que les gisements situés dans la région des Iles-de-la-Madeleine et de Miscou ont été découverts (Figure 1). L'année suivante, des gisements intéressants ont été découverts dans les régions de Sheldrake et de Natashquan. Ces quatres gisements constituent encore aujourd'hui les principaux gisements connus. La superficie varie de 45 km^2 pour le gisement de Natashquan à 9.5 km^2 pour celui de Miscou. La plus forte densité, estimée d'après les missions d'exploration de 1990 et 1991, a été retrouvée sur le gisement de Sheldrake avec une valeur de 3.5 mactres/m^2. La taille moyenne des mactres capturées variait entre 89 et 104 mm sur les différents gisements. L'utilisation de dragues non doublées ne permettait pas d'obtenir une bonne évaluation du recrutement, i.e. de l'abondance de mactres sous la taille commerciale.

Une mission d'exploration effectuée en 1993 a révélé la présence de mactres de Stimpson sur une large portion de la Haute et Moyenne Côte-Nord du Québec. La même année, une mission de recherche confirmait la présence de trois concentrations de faible superficie près de Sept-Iles. Lors de cette mission, l'échantillonnage à l'aide d'une drague doublée, avec du vexar de 19 mm de diamètre, a permis d'obtenir une meilleure estimation de la structure de taille de ces concentrations. Dans ces trois sites, 44 % des mactres étaient de tailles inférieures à 80 mm et 13 % mesuraient moins de 50 mm (Figure 2). La taille moyenne était de 81 mm.

En 1993, il y avait quatre zones définies pour la pêche à la mactre de Stimpson dans le golfe du Saint-Laurent. Ces zones de pêche englobaient l'un ou l'autre des principaux gisements connus. Les limites des zones, situées au Québec, dépassaient largement les limites connues des gisements (Figure 1). Pour l'année 1993, sept pêcheurs québécois possédaient un permis expérimental pour exploiter cette ressource dans l'une ou l'autre des zones de pêche au Québec. Deux pêcheurs du Nouveau-Brunswick détenaient un permis leur donnant accès à toutes les zones de pêche. Ces derniers n'ont pas été actifs en 1993 à cause d'un problème de marché tandis que seulement deux pêcheurs du Québec ont atteint leur quota de 34 tonnes.

L'examen de données provenant des journaux de bord de deux pêcheurs indiquait que ces derniers avaient exploité chacun un secteur situé à l'extérieur des gisements connus, l'un dans la zone de Sheldrake et l'autre dans la zone de Natashquan. Les prises moyennes par unité d'effort de ces pêcheurs ont été de 543 et 515 kg par heure par mètre de largeur de drague dans les zones de Sheldrake et de Natashquan respectivement. Chacun a exploité une superficie approximative de .04 km^2 pour effectuer des prises totales de près de 34 tonnes.

2. Efficacité de la drague hydraulique

En 1993, une étude sur l'efficacité de la drague hydraulique de type Nouvelle-Angleterre a été effectuée en 1993 dans la région de Sept-Iles sur des gisements de mactres de Stimpson. Ce travail visait principalement à estimer le pourcentage d'efficacité de la drague pour la récolte de mactres de Stimpson sur un gisement commercial. Les dommages causés aux mollusques par l'utilisation de la drague ont aussi été évalués. Seize stations ont été échantillonnées et des données ont été recueillies sur 13 d'entre elles. Deux de ces traits furent effectués avec une drague doublée avec du vexar de 19 mm de diamètre. Après chaque trait, deux plongeurs descendaient récolter les mollusques non recueillis par la drague. L'efficacité de la drague était évaluée en divisant la quantité de mactres pêchées par la drague par le total des mactres observées en plongée sous-marine sur la surface échantillonnée.

La drague hydraulique de type Nouvelle-Angleterre s'est avérée très efficace pour capturer la mactre de Stimpson. L'efficacité de la drague, en terme de nombre d'individus a été de 91%, lorsque la drague n'était pas doublée (Figure 3). Sur 7 des 10 traits, l'efficacité a été supérieure à 90 % (Tableau 1). Un seul trait s'est avéré d'une efficacité inférieure à 80 %. À cette station, les plongeurs ont remarqué un fort courant transversal. Aucune corrélation significative n'a pu être démontrée entre la vitesse de dragage et l'efficacité de la drague. Les deux traits réussis avec la drague doublée ont démontré des valeurs d'efficacité de 86 et 95 % . Il est important de noter ici que l'échantillonnage de la station 14 n'a pas été complété parce que les plongeurs ont constaté une trop grande quantité de mactres de chaque côté des sillons. Il a été présumé que la drague avait pu avancer de travers, qu'un fond ferme associé à une forte pression auraient été responsables du rejet des mactres ou qu'une accumulation de roches et d'organismes à l'intérieur de la drague doublée aurait empêché la circulation de l'eau à travers la drague, réduisant ainsi la pénétration des mollusques.

Parmi les mactres de Stimpson non capturées par la drague, doublée ou non, plus des deux tiers avaient au moins une des deux coquilles brisée (Tableau 2). La proportion de coquilles brisées parmi les autres espèces de mollusques était beaucoup plus faible. Ainsi, mis à part la mactre de Stimpson, seul le couteau (*Ensis directus*), présent en quantité restreinte, était représenté par une proportion d'individus à la coquille brisée supérieure à 50%.

Bien qu'en faible proportion par rapport au total des mactres récoltées, les mactres endommagées, laissées sur le fond, ne survivraient pas pour la plupart et seraient perdues pour la population. Aucune statistique n'a été présentée ici au sujet des mactres endommagées que l'on retrouve parmi les captures. Il semble cependant que celles-ci constituent un pourcentage appréciable de la récolte et qu'elles soient systématiquement rejetées à la mer. Cela implique que les taux d'exploitation seraient sous-estimés. La drague hydraulique de type Nouvelle-Angleterre, ajustée pour la récolte de mactre de Stimpson, ne devrait pas être utilisée pour la capture du couteau. Des modifications, notamment au niveau de la hauteur de la lame, devraient être apportées à l'engin avant d'effectuer des essais dirigés vers cette espèce.

La grande efficacité de la drague pour capturer la mactre de Stimpson et les dommages restreints causés aux autres mollusques laissent croire que l'utilisation de la drague hydraulique de type Nouvelle-Angleterre a un impact mineur à court terme sur les organismes vivant dans ce milieu. Une étude à plus long terme serait nécessaire pour estimer l'effet de ce dragage sur les sédiments et sur l'écosystème en général.

Des mactres de toutes les tailles ont été capturées par la drague hydraulique. Cependant, la proportion de mactres de moins de 90 mm est plus élevée parmi les individus non récoltés par la drague (Figure 3). L'absence de mactres de moins de 85 mm parmi celles qui n'ont pas été capturées avec la drague doublée (Figure 4) suggère que cette dernière est plus efficace pour capturer les petits individus et moins efficace pour capturer les plus gros que ne l'est la drague non doublée. Il est important de noter que le peu de mactres de taille inférieure à 80 mm sur les sites d'échantillonnage n'a pas permis d'effectuer une véritable étude de sélectivité.

Tableau 1. Efficacité de la drague hydraulique de type "Nouvelle-Angleterre" pour la récolte de la mactre de Stimpson, observée à différentes stations.

	Quantité capturée		**Quantité non capturée**		**Efficacité (%)**	
Station	**Nombre**	**Poids (kg)**	**Nombre**	**Poids (kg)**	**Nombre**	**Poids**
1	374	53.0	9	1.2	98	98
2	Échantillonnage raté					
3	54	6.5	8	0.9	87	88
4	461	67.0	18	1.7	96	98
5	466	39.0	188	20.5	71	66
6	397	67.0	5	0.7	99	99
7	578	83.0	19	2.7	97	97
8	458	59.5	39	5.0	92	92
9	Vidéo					
10	60	8.5	13	2.6	82	77
11	128	19.3	9	0.8	93	96
12	80	11.0	6	0.7	93	94
13	712	103.5	31	5.6	96	95
14	Échantillonnage incomplet					
15	17	2.5	2	0.4	89	86
16	Échantillonnage raté					

Tableau 2. Nombre d'individus brisés et intacts, par espèce de mollusques, qui ont été recueillis après le passage de la drague hydraulique, pour l'ensemble des traits effectués.

	Intérieur des sillons		Extérieur des sillons		Total	
Espèce	**Intacts**	**Brisés**	**Intacts**	**Brisés**	**Intacts**	**Brisés**
Coque d'Islande *Clinocardium ciliatum*	8	0	0	0	8	0
Coque du Groenland *Serripes groenlandicus*	15	5	10	4	25	9
Couteau *Ensis directus*	15	18	3	3	18	21
Mactre de Stimpson *Mactromeris polynyma*	48	130	65	104	113	234
Clovisse *Mesodesma arctatum*	27	0	11	0	38	0
Mye tronquée *Mya troncata*	123	16	23	9	146	25
Pilot *Cyrtodaria siliqua*	48	10	22	6	70	16

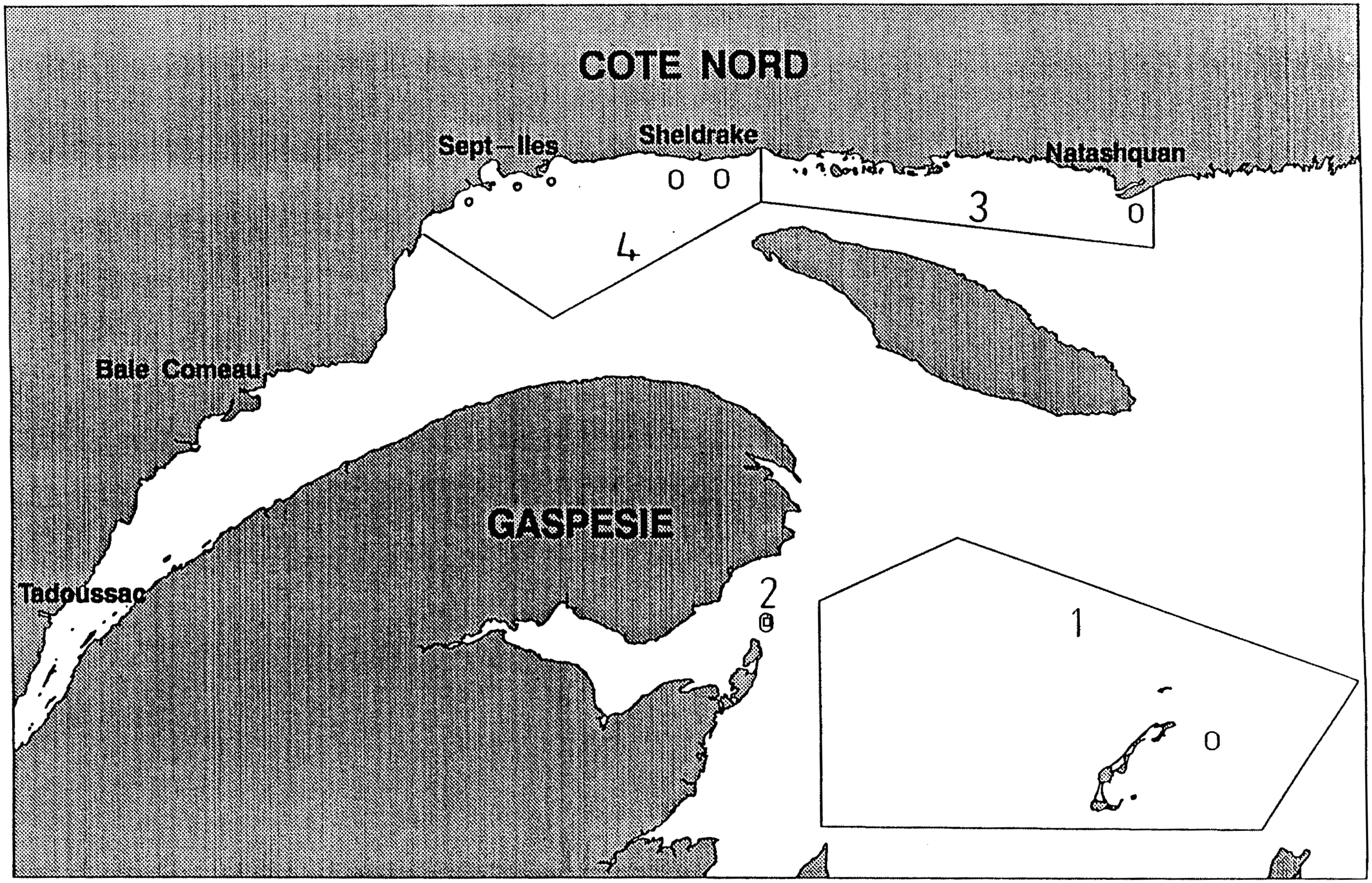


Figure 1. Position des gisements de mactres de Stimpson et zones de pêche en vigueur pour l'année 1993 (zone 1: Iles-de-la-Madeleine, zone 2: Miscou, zone 3: Natashquan et zone 4: Sheldrake).

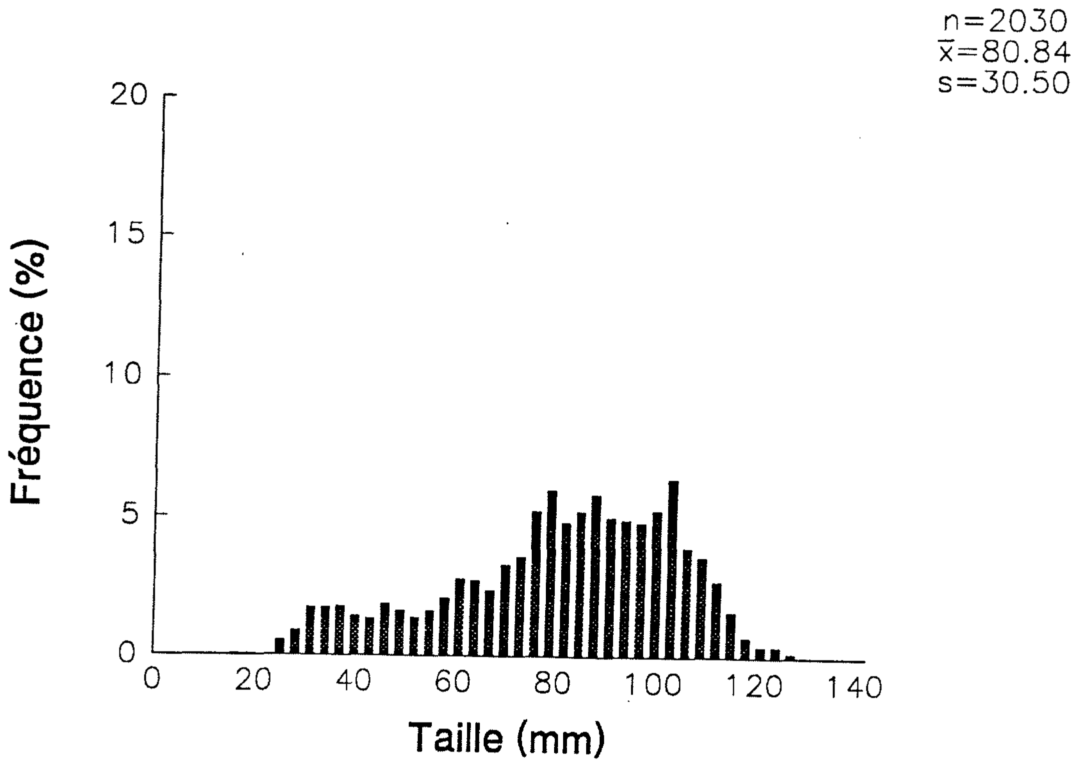


Figure 2. Distribution des fréquences de taille des mactres de Stimpson capturées avec la drague hydraulique doublée (classes de 3mm), pour l'ensemble des traits effectués dans la région de Sept-Iles en 1993.

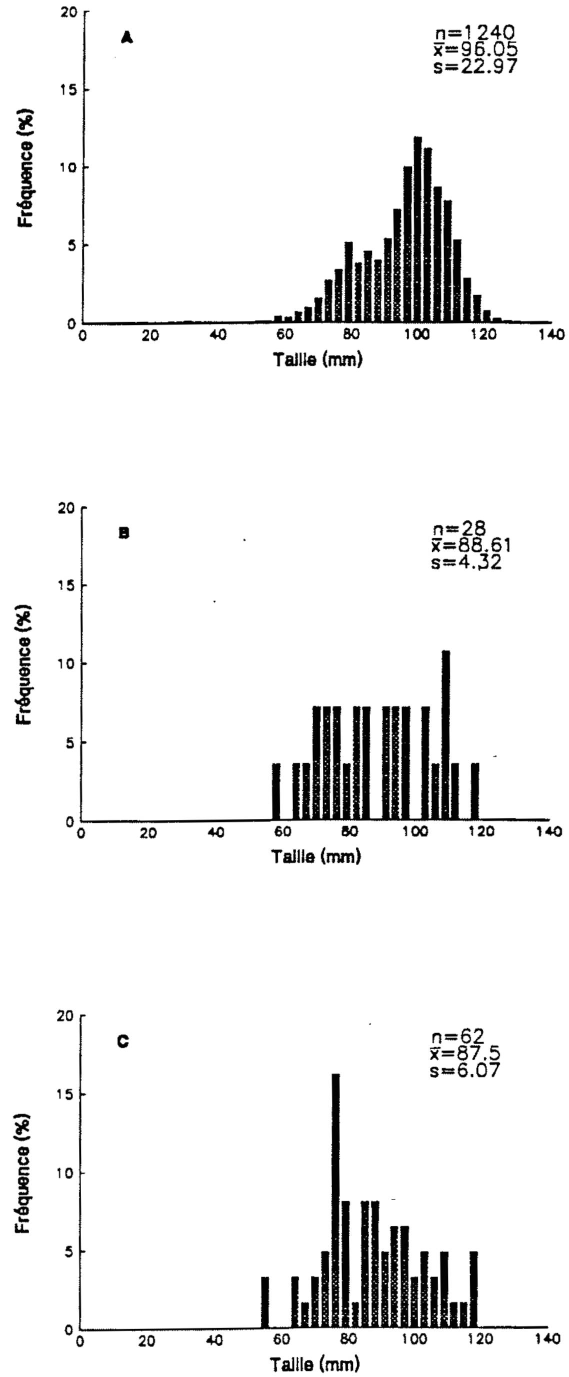
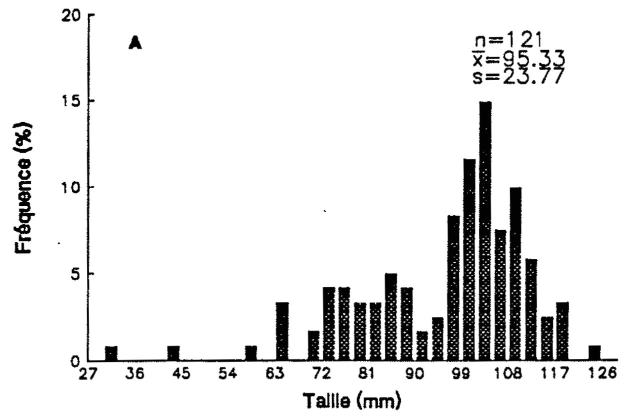


Figure 3. Distribution des fréquences de taille des mactres de Stimpson (classes de 3 mm), A) capturées avec la drague hydraulique non doublée, B) non capturées et recueillies à l'intérieur du sillon laissé par la drague et C) non capturées et recueillies à l'extérieur du sillon, à la surface des sédiments. Ensemble des traits.



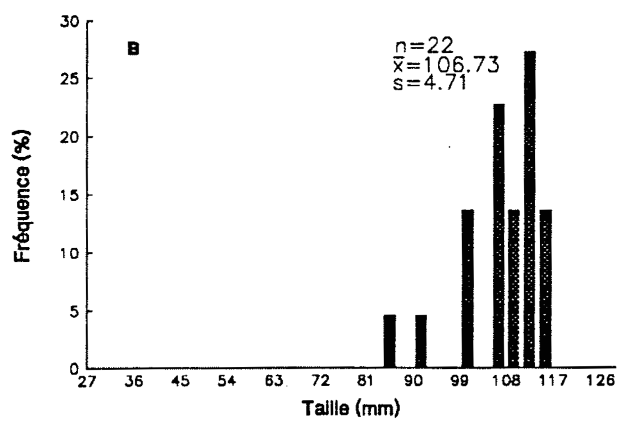


Figure 4. Distribution des fréquences de taille des mactres de Stimpson (classes de 3 mm) A) capturées avec la drague hydraulique doublée et B) non capturées et recueillies à l'intérieur du sillon laissé par la drague doublée. Ensemble des traits.

In Search of Green Sea Urchins along the Northern and Eastern Coasts of New Brunswick: is there a Potential for a Commercial Fishery?

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INTRODUCTION

The green sea urchin (*Strongylocentrotus dröebachiensis*) is widely distributed along the Atlantic coast from the Arctic Sea to Cape Cod. The species is found in considerable abundance in the coastal zone of the Atlantic Provinces and is harvested commercially in some areas. Well established fisheries exist in Southwestern New Brunswick (Bay of Fundy) and along the eastern coast of Newfoundland. Because of the high market value of sea urchin roe, more and more fishers and private enterprises are showing interest in that species, requesting more work in finding new fishing beds and expanding the traditional harvesting areas (Cameron, 1992; Prince Edward Island Fisherman's Association, 1992).

In 1991, a project on the green sea urchin was initiated with the collaboration of the federal Department of Fisheries and Oceans, the New Brunswick Department of Fisheries and Aquaculture and the Maritime Fishermen's Union. The objective was to assess the potential of a commercial sea urchin fishery on the northern and eastern coasts of New Brunswick. In a first phase, a sample of lobster and scallop fishers was requested to fill a questionnaire. The objective of the questionnaire was to locate the sea urchin populations along the coast (Lanteigne et al., 1992). The qualitative information gathered from that questionnaire was used in 1992 as the basis for the second phase of the project. The objective was then to conduct a quantitative inventory of the resource. The results of that second phase are presented and discussed from a commercial fishery point of view.

MATERIAL AND METHODS

The coastal area surveyed for sea urchin was between Heron Island in Baie des Chaleurs and Cap Lumière in the Northumberland Strait (Figure 1). Only areas that were identified to have high densities of sea urchin during the initial phase of the project (Lanteigne et al. 1992) were selected.

SCUBA divers estimated sea urchin densities and collected samples along transects set perpendicularly to the coast. From July 31 to October 25, 1992, a total of 45 transects was visited, ranging between 700 m and 9,400 m in length. For each transect, a preliminary examination was conducted by the divers swimming along the transect. When sea urchins were seen, a physical inventory was conducted at every 100 m by setting a quadrat (1m x 1m) from which all sea urchins were collected and brought to the surface for measurements (test diameter). The divers also recorded qualitative information on the type of algae and fauna found along the transects. From the samples collected, gonosomatic indices were obtained in the laboratory by calculating the ratio of the gonad wet weight over the total wet weight.

RESULTS

The results obtained during the sea urchin survey are presented in Table 1. The overall distribution of sea urchin in the area surveyed was heterogenous. Densities ranged from 0 to 14.7 sea urchins/m^2 (all sizes combined) and the presence of sea urchins on the substrate could not be related to the type of algae or fauna also present. The quantitative information collected during the divers assessment did not corroborate with the qualitative information collected during the first phase of the study (Lanteigne et al., 1992).

The proportion of commercial size sea urchins (test diameter ≥50mm) ranged from 0% to 53.6%. The size frequency distributions of the sea urchin and the commercial proportion in numbers are presented in Figure 2. Divers observed that the size of the sea urchins was somewhat homogeneous within a transect but was fluctuating between transects. This observation is confirmed by analyses of the size frequency distributions (Figure 2).

The GSI averages ranged between 5% and 7% in July and August (Figure 3). These indices started to increase in September, reaching 9.8% at the end of the survey (October 25).

DISCUSSION

The green sea urchin resource assessment on the northern and eastern coasts of New Brunswick using SCUBA divers revealed heterogenous distributions throughout the studied area. Densities and size distributions varied widely between adjacent transects. Similar observations were mentioned by Miller and Bishop (1973), MacKay (1976), Gendron (1984), Himmelman et al., (1983), Lavergne and Himmelman (1984) and Prince Edward Island Fishermen's Association (1992) along the coast of the Maritime provinces and Québec.

The heterogenous distribution complicates analyses and interpretation of the results for assessing the potential for commercial exploitation. MacKay (1976) suggested that a typical commercial fishing ground is characterized by sea urchin densities ≥25 animals/m^2. For a fishing bed to be commercially viable, one fishing enterprise evaluated that it should be able to yield 1.5 t of sea urchins per day (Gendron 1984). A study conducted by the Prince Edward Island Fisherman's Association (1992) indicated that different fishing enterprise scenarios could be profitable with the sea urchin densities observed along the coast of Prince Edward Island.

Fishing beds with densities of 25 to 50 sea urchins/m^2 could be profitable for 5 SCUBA divers (including the captain of the vessel). These findings suggest sea urchin density requirements much higher than the sea urchin densities observed in the present survey. The maximum average density of 14.7 sea urchins/m^2 (all sizes combined) observed during the survey suggests very limited potential for commercial venture using SCUBA divers.

The temporal evolution of the gonosomatic index (GSI) shows values approaching 10% by the end of October. Gendron (1984) mentioned that sea urchins with GSI values of 10% or more are of commercial interest. This suggests that any commercial venture in the studied area would require a late fall harvesting season. These results corroborate findings from Himmelman (1975, 1978) and the Prince Edward Island Fisherman's Association (1992).

From the results of the survey conducted, the overall prospects for a sea urchin fishery along the northern and eastern coast of New Brunswick seem remote. All the commercial assumptions were based on using SCUBA divers for harvesting. Using a surface controlled harvesting gear (i.e. dredge) may change the commercial potential significantly. A different fishing gear could reduce the operation cost and allow harvesting in depth of water outside the profitable limits for divers. Dredges are presently being used in southern New Brunswick (Grand Manan Island) for sea urchin harvesting. However, there are concerns about the environmental impact of using such a fishing gear. If a harvesting technique other than SCUBA diving is suggested for the northern and eastern coasts of New Brunswick, further studies will be required to fully assess its potential.

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Table 1. Summary of the results obtained for each transect visited during the sea urchin population assessment along the northern and eastern coast of New Brunswick.

Transect number	Transect length (km)	Depths (m) near shore	Depths (m) far shore	Algae	Fauna	Average* density urchins/m² (*sd*)	Proportion of** commercial size (%)
1	1.9	4.0	7.4		C	0	
2	1.8	8.0	3.9	L	C	6.1 (6.9)	9.3
3	1.8	8.4	4.3	L,F	Lo	0	
4	2.2	4.1	7.1	L,F	Lo	0	
5	2.3	4.5	8.9	L	Lo	0	
6	1.8	3.7	8.1			0	
7	2.4	5.0	15.4			0	
8	1.5	7.2	11.7	L		0	
9	1.4	3.6	13.6			7.6 (8.9)	4.2
10	0.9	3.8	10.3	F,A		4.3 (5.8)	
11	0.7	3.3	13.2	F,A		0.3 (0.5)	
12	1.5	3.4	8.6	F	S	1.6 (1.6)	
13	0.9	4.1	12.1	F	S	0.3 (0.5)	53.6
14	1.6	3.5	12.2		S	2.0 (2.4)	
15	1.6	3.7	8.8		S	2.9 (3.0)	
16	1.3	3.0	9.9		S	1.8 (2.2)	
17	0.8	2.9	9.2		M,S	0	
18	1.0	4.1	8.2		M,S	1.4 (0.8)	
19	1.7	3.5	7.9			3.2 (7.8)	
20	2.1	5.0	12.1		S	3.5 (4.5)	
21	2.2	8.9	9.4			8.3 (7.3)	45.8
22	0.9	4.8	9.1	L		14.7 (4.7)	4.7
23	1.2	4.5	7.6			0	
24	1.5	8.9	12.3			7.6 (5.9)	20.4
25	0.7	5.3	7.2			0	
26	2.3	10.7	13.3	L		4.7 (3.7)	
27	2.9	6.4	8.9	L		0	
28	9.4	5.5	12.7	L	M	3.6 (3.5)	9.7
29	1.7	4.8	8.4		M	9.5 (10.5)	0
30	1.3	4.0	7.7	L	M	3.2 (3.7)	20.6
31	1.4	4.5	8.4			10.5 (10.8)	3.2
32	1.7	4.1	8.1	L	M	3.7 (5.5)	30.3
33	1.2	3.5	7.9			0	
34	2.3	4.2	10.0	L	S	3.1 (4.8)	4.3
35	1.8	4.0	9.8			10.2 (9.1)	4.3
36	1.4	3.7	5.1			0	
37	2.4	2.9	9.8			0	
38	1.9	5.2	11.5			0	
39	1.5	5.3	8.4			0	
40	1.8	10.1	11.4	L		0	
41	1.4	3.1	3.4		Q	0	
42	1.7	1.7	14.3	L	C	9.7 (6.9)	
43	2.1	2.4	14.7	L		10.1 (10.9)	2.7
44	1.3	14.2	15.1			5.5 (6.3)	
45	1.4	2.8	4.9	L	Lo	6.1 (7.0)	0

Algae: L = Laminaria sp., A = Ascophyllum sp., F = Fucus sp..
Fauna: C = Crabs, Lo = Lobster, M = Blue Mussel, Q = Quahog, S = Scallops.
* = all sizes combined, ** = calculated for a selected number of transects

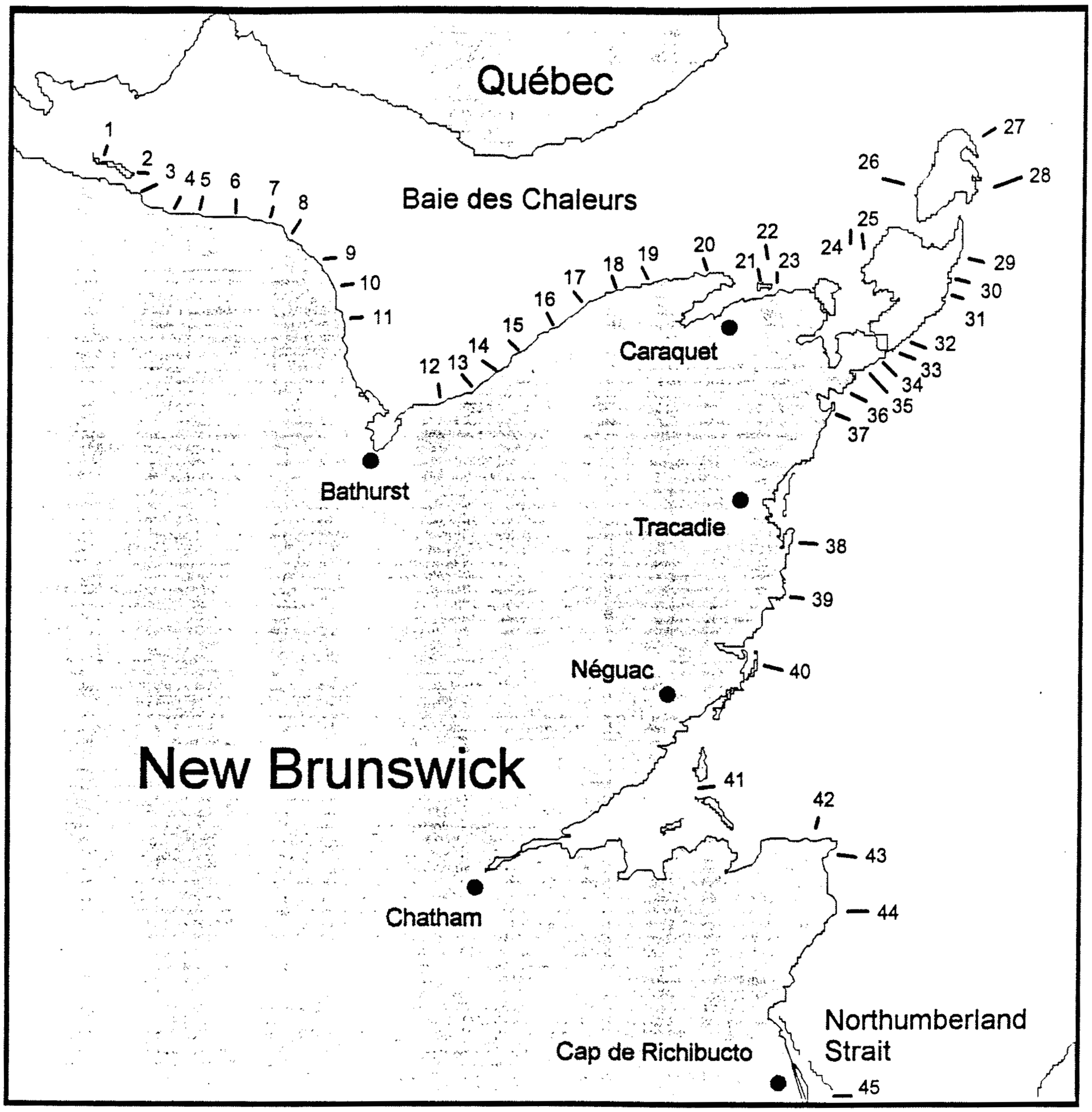

Figure 1. Relative positions of the transects visited by SCUBA divers during the 1992 green sea urchin survey along the north and east coasts of New Brunswick. The transect numbers are the same as indicated in Table 1.

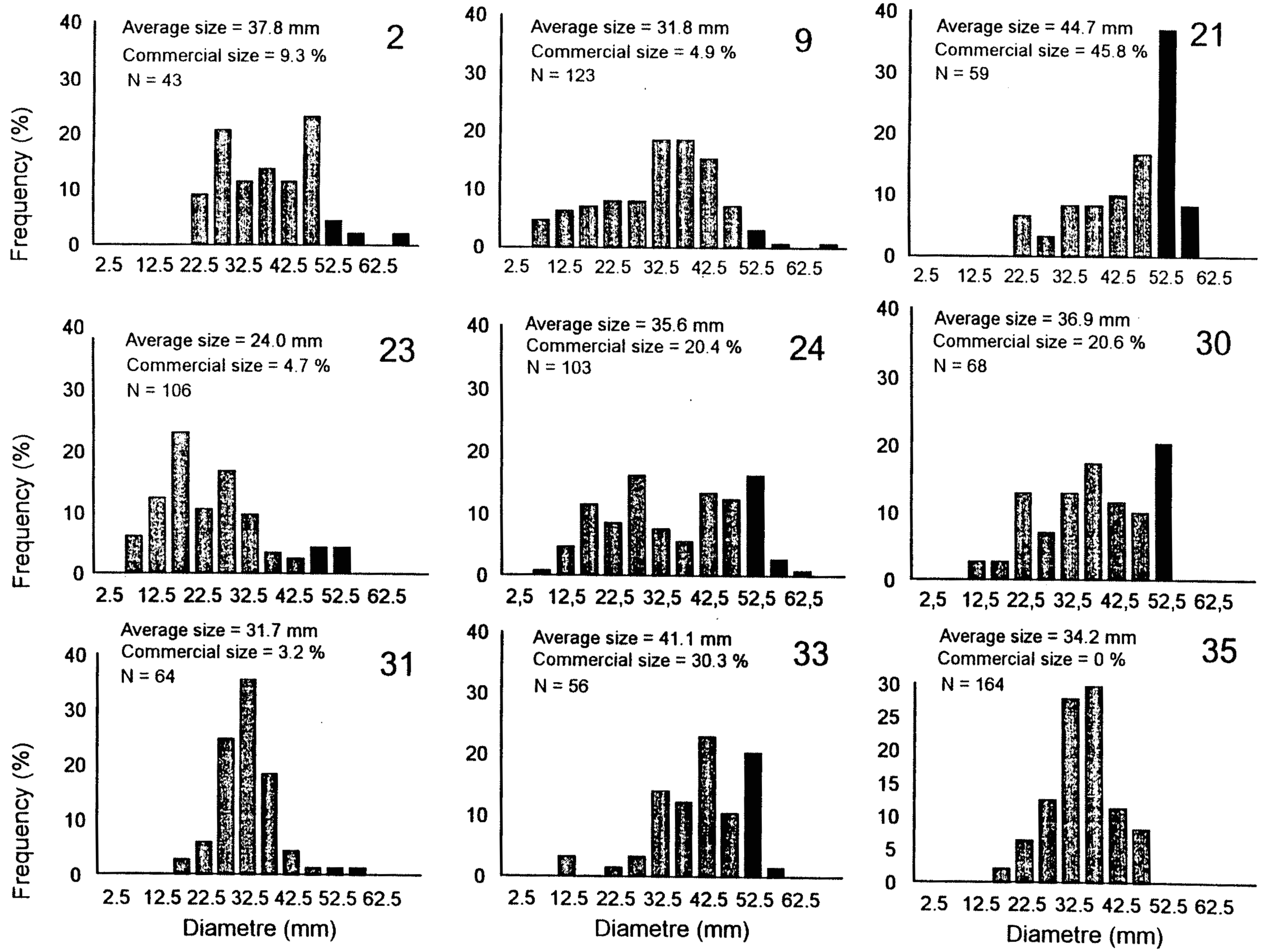

Figure 2. Sea urchins size frequency distributions (%) for some of the transects visited by SCUBA divers. Only transects that have shown densities ≥7 sea urchins/m^2 or proportions of commercial size sea urchins ≥ 20 % are presented (see Table 1 for more details).

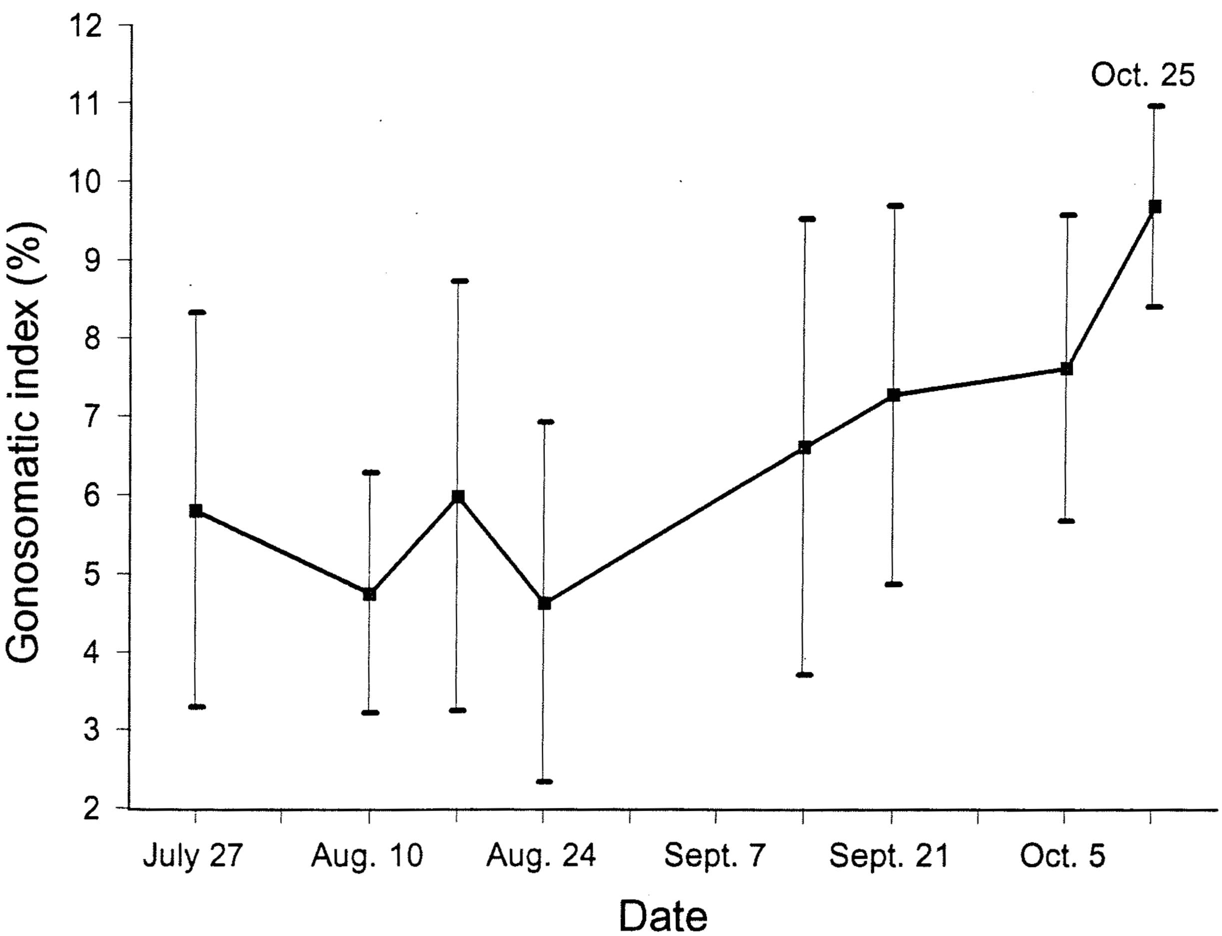

Figure 3. Seasonal evolution of the gonosomatic indices from the sea urchins collected along transects on the northern and eastern coasts of New Brunswick. The average values and the 95% confidence intervals are presented.

The Green Sea Urchin, *Strongylocentrotus droebachiensis*, Fishery in the Bay of Fundy

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The green sea urchin fishery began in the Bay of Fundy in the early 1970's in southwest New Brunswick (SWNB). A processing plant was initially established on Grand Manan, but it eventually failed and the industry became centred around Campobello Island where it supplied sea urchins to the American market in Lubec, Maine. Landings in the fishery were sporadic until 1986 when increasing demand from the American market and increased interest in Canada fuelled an increase in fishing activity. Some early survey and research work in the 1970's was done in the SWNB area in response to concerns that an urchin die-off might be occurring, similar to the one on the eastern shore of Nova Scotia (Neish 1973; MacKay 1976). However, little work has been done since.

The annual landings from the fishery have continued to increase since 1976. The majority of these landings are from SWNB and for the 1992-93 fishing season, this accounted for 90% of the landings worth an estimated $1,019,343 to the fishermen (Figure 1). Landings in this area have increased in an exponential fashion from 47 t for the 1986 fishing season to 822 t in 1992 (Figure 2). There are some indications that these figures may actually be under-estimates of the actual production figures.

Regulation of the fishery is based on exploratory permits which are restricted to lobster fishing areas (LFA's). These are currently in the process of being converted to limited entry fishery licenses. To-date there are a total of 26 permits in the fishery. The permits are distributed as follows: LFA 38 (Grand Manan) - 6; LFA 36 (Fundy Isles [Campobello, Deer Island & mainland]) - 18; and LFA 35 (Maces Bay) - 2. Methods of harvesting sea urchins are based on either divers or drags in SWNB and divers only in Nova Scotia. Several different drags have been tried in the past, but the standard Digby scallop drag (usually with teeth) has produced the highest catch rates so far. Divers mostly harvest sea urchins by hand using an assortment of bags, cages etc., but one boat is using a suction harvester which uses a Venturi principle to lift the sea urchins from the bottom to the boat. Completion of logbooks are a mandatory part of the permits and involve monthly reports on every fishing trip detailing location, effort, catch, buyer, and any pertinent information the fishermen feels is important (i.e. bottom type, roe yield, unusual observations).

A biomass survey was conducted in the SWNB area in 1992 using divers and a spooling transect survey technique. In total, 199 transects were surveyed by the divers between 0 and 20 m of water depth and approximately 60,000 sea urchins were measured. The results indicated that Deer Island and the archipelagoes had the most sea urchins (approximately 1.4 billion), but the majority of these were very small and below the fishable size of 50 mm. Campobello Island had 170.5 million sea urchins which were only slightly larger than those of Deer Island. Grand Manan supported approximately 763.5 million sea urchins, but these were much larger than those found on either Deer Island or Campobello Island (Figure 3). The larger sizes of urchins on Grand Manan resulted in a much higher fishable biomass for this region of 29,879 tonnes as compared to Campobello with 1,934 tonnes and Deer Island with 5,255 tonnes (Figure 4). Significantly more harvestable biomass was found in water less than 10 m. With respect to productivity of the three regions in the more productive shallow waters (less than 10 m), Grand Manan supported 414 tonnes/km^2, Deer Island supported 371 tonnes/km^2, and Campobello Island supported 203 tonnes/km^2 (Figure 5). Survey work is continuing in 1993 on other areas of sea urchin harvesting.

The positive developments in the industry include: new fishing gear being developed; the industry becoming firmly established in SWNB; and income for the fishermen being generated during a slow period of the year. The negative developments, so far, include: a "gold rush" mentality; harvesting and selling the product at a time of year when the price is low; possible misreporting of landings; and slow gathering of the pertinent biological information required to manage the fishery.

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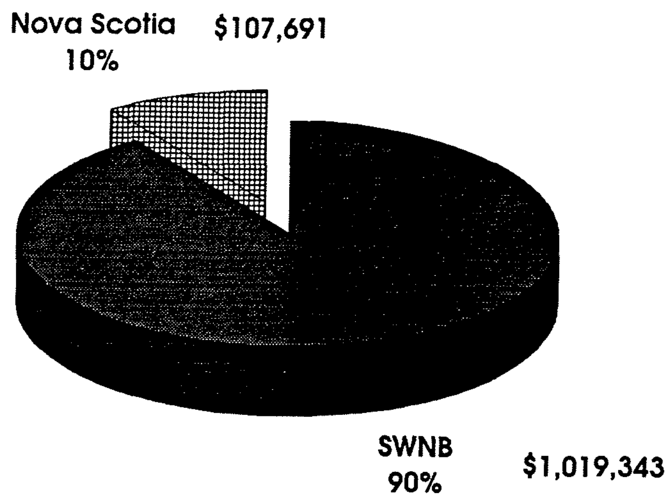

Figure 1. Percentage of sea urchin catch landed in southwestern New Brunswick and Nova Scotia in 1992-1993. Data are from the Statistics Branch, Department of Fisheries and Oceans.

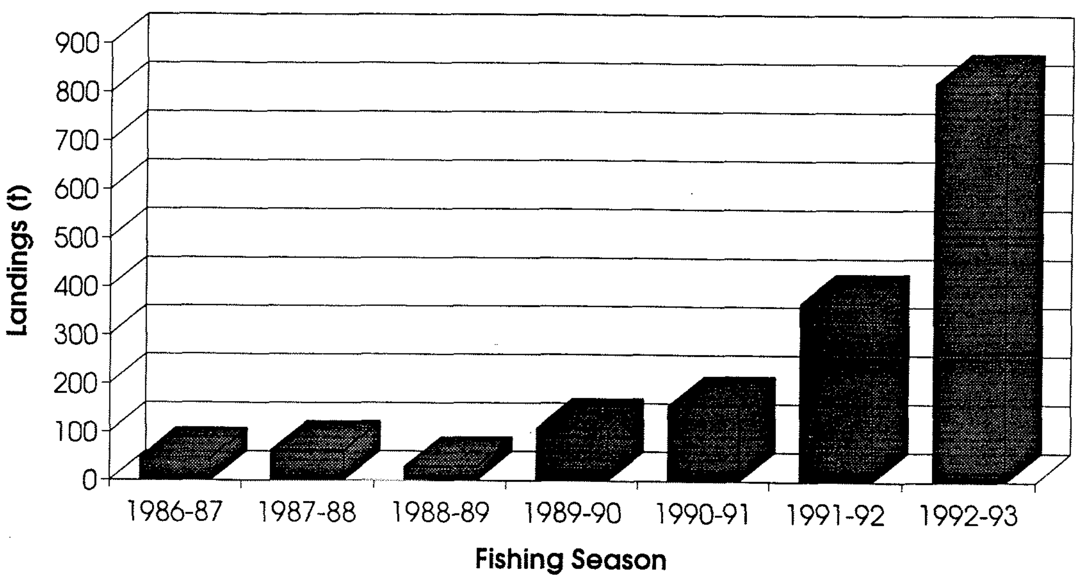

Figure 2. Sea urchin landings from southwestern New Brunswick. Data are from the Statistics Branch, Department of Fisheries and Oceans.

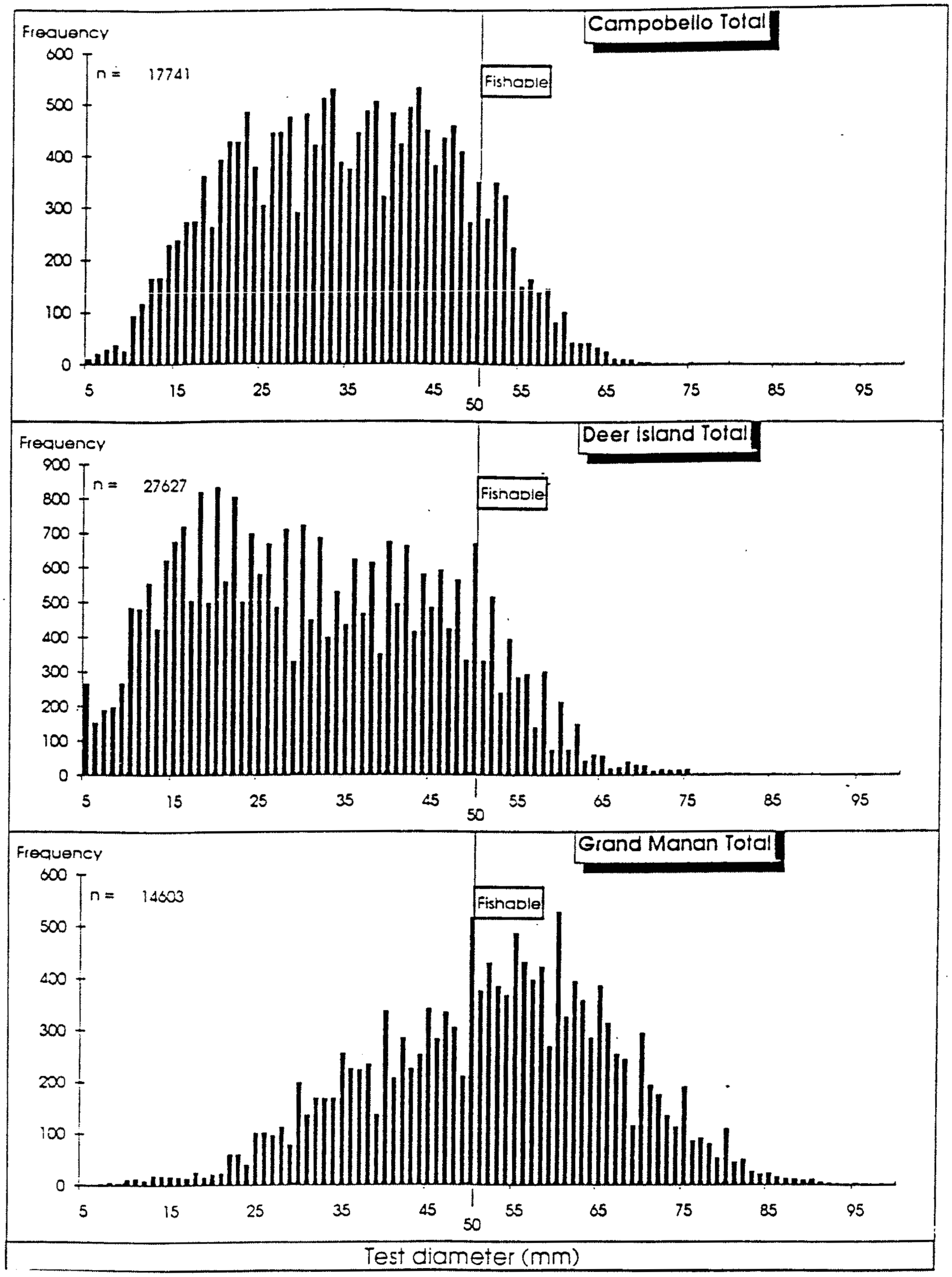

Figure 3. Size-frequency histograms of all sea urchins measured during the 1992/93 survey in Campobello, Deer Island and Grand Manan.

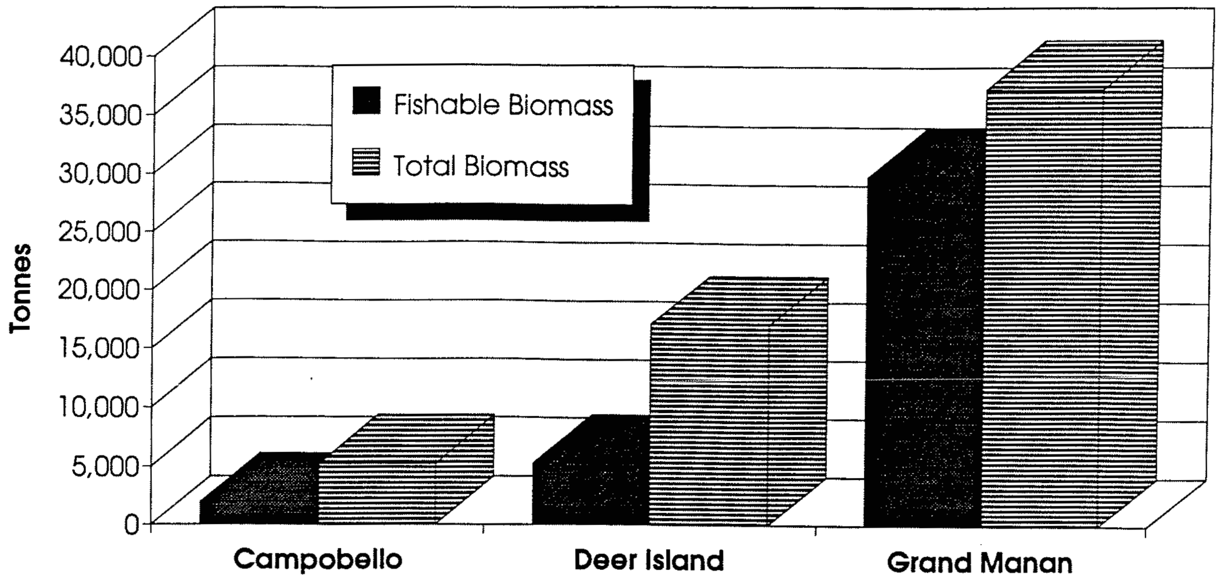

Figure 4. Fishable biomass compared to total biomass for each of the three regions surveyed.

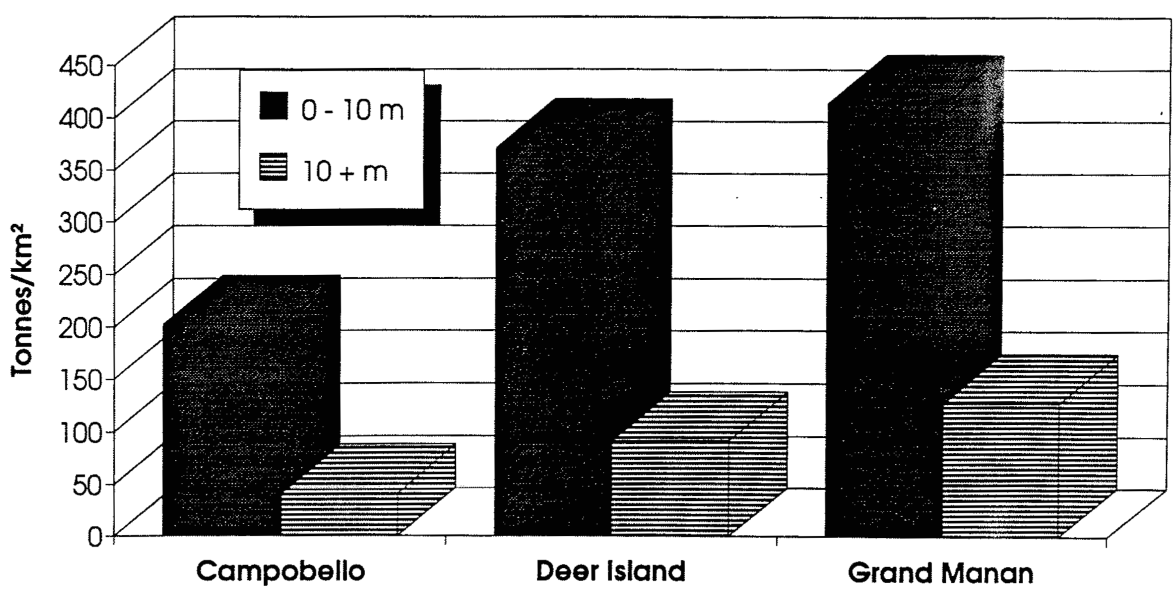

Figure 5. The fishable biomass densities calculated for sea urchins observed between 0 and 10 m depth from Mean Low Water and at depths greater than 10 m. Columns reflect average densities for all combined locations at each region surveyed.

Prospects for the Sea Urchin Fishery Off the Atlantic Coast of Nova Scotia: Boom or Bust

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The rocky subtidal ecosystem off the Atlantic coast of Nova Scotia exhibits large scale shifts between two alternative states, sea urchin dominated barren grounds and kelp beds, each of which persists on the order of decades. Transitions between these states are characterized by extreme fluctuations in the abundance of the green sea urchin *Strongylocentrotus droebachiensis*. Understanding the dynamics of the transitions is crucial to the sustainable development of a sea urchin fishery along this coast. Outbreaks of an amoebic disease associated with anomalously high seawater temperatures cause mass mortality of sea urchins and drive the system from the barren ground to the kelp bed state. The eventual recolonization of the subtidal zone by sea urchins may be regulated by recruitment via the planktonic larval stage and/or migration of adults from deeper water (where they have a thermal refuge from the disease). The transition from kelp beds to barren grounds is characterized by the formation of dense aggregations of sea urchins which destructively graze the kelp. These moving aggregations, or grazing fronts, are the target for the sea urchin fishery in Nova Scotia, which has expanded rapidly since 1990. The sea urchin fronts are comprised of large individuals with high gonad indices and therefore present an optimal harvesting situation for this SCUBA-based fishery. Judicious harvesting of grazing fronts (e.g. on a rotational basis) may reduce the rate of kelp bed destruction and maximize the long-term yield from the fishery. However, the fishery is vulnerable to catastrophic mortality due to outbreaks of disease. These disease events are probably contingent on large-scale oceanographic features (such as intrusions of Gulf Stream water) and therefore are largely unpredictable at time scales relevant to the fishery. Since the rate of repopulation of the shallow subtidal zone by sea urchins following these natural die-offs is on the order of years to decades, this can truly be considered a boom or bust fishery.

SESSION 4

Biological and Sociological Concerns in the Development of New Fisheries

The Nascent Amphipod Fishery in Québec: Exploiting a Low-Trophic Level, Multispecies Resource

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INTRODUCTION

Some effort has been devoted to the development of a trap fishery for gammaridean amphipods (Crustacea), in northern parts of the Saint Lawrence Estuary, Québec. The species targeted by the fishery belong to the superfamilies Gammaroidea and Lysianassoidea, but the majority of individuals and species which are effectively captured in baited traps are lysianassoids. This fishery concentrates on a low-trophic, multispecies benthic resource. The following report provides a brief account of the biology of lysianassoids and documents some major biological/management issues at stake in the development of this fishery.

DISCUSSION

1. The Lysianassoidea

The Lysianassoidea form the largest superfamily of marine gammaridean amphipods (Bousfield 1983; Barnard and Karaman 1991). Lysianassoids are predominantly free-living, benthic organisms associated with soft sediments. However, there also exist strictly pelagic, commensal or epi-parasitic forms (Bousfield 1987). Many lysianassoid species are strong swimmers, capable of extensive vertical (Thurston 1990) and horizontal (Sainte-Marie 1986a) excursions which they usually perform at night.

Lysianassoids, as almost all other gammaridean amphipods, are dioecious. Fertilization is external and embryos undergo direct development within the female's brood chamber (Schram 1986). At adulthood, most lysianassoids measure only 8-40 mm in total body length, but some deep-sea species reach up to 340 mm in total body length (Barnard and Ingram 1986; DeBroyer and Thurston 1987).

The superfamily Lysianassoidea is notorious for the exceptional scavenging capabilities of some its members (e.g. Sainte-Marie 1986a, 1986b, 1992a). In many fisheries which depend on fixed gear, scavenging lysianassoids are considered to be pests because they can rapidly destroy bait and/or catch (e.g. Templeman 1954; Vader and Romppainen 1985; Sainte-Marie *et al.* 1989).

At least 57 species of lysianassoids, among which approximately half are scavengers, occur in the Estuary and in the Gulf of the Saint Lawrence River (L. Bossé, Institut Maurice-Lamontagne, pers. comm.). Within this broad area, scavenging species segregate spatially by depth, sediment type and geography. Moreover, the spatial distribution of some infralittoral lysianassoids varies temporally due to seasonal in- and off-shore migrations (Bregazzi 1972; Sainte-Marie *et al.* 1990).

2. The Lysianassoid Fishery

The lysianassoid fishery started in 1988 on a small experimental scale, mainly on the north shore of the Saint Lawrence Estuary (Anonymous 1992). Various simple trap designs have been successfully tried, mostly in late-summer and in the fall. Traps are deployed and hauled in shallow water directly from the shore, at low tide, or fished from small boats in water depths of 10-20 m (Anonymous 1992). Traps are baited with herring, mackerel or other cheap animal remains. Catches have typically averaged 0.5-10 kg amphipods trap^{-1} day^{-1}, depending on the site and the time of year. So far, exploited lysianassoid species belong to the genera *Anonyx* and *Orchomenella*. Lysianassoids are marketed frozen or dried, mainly as fish food. Market tests suggest that fishers could sell their catches for about $0.80 per kg and that fishing operations would be profitable (Anonymous 1992).

3. Problems in Assessing and Managing the Lysianassoid Resource

The lysianassoid resource has several biological characteristics which combine to make it different from all other currently exploited resources. The most important of these features are (1) the multispecies nature of the resource, (2) extreme vulnerability of lysianassoids to baited traps, (3) low female lifetime fecundity due to direct development of embryos, and (4) the rôle of lysianassoids in the benthic food chain. The implications of these characteristics for ressource assessment and management are reviewed below.

The experimental lysianassoid fishery has been geographically restricted and limited to shallow coastal waters, so only 4-5 species of lysianassoids were harvested. However, if the fishery were to expand geographically or bathymetrically, or vary seasonally, the number of species would undoubtedly change. Keeping track of the species in catches might then become a problem. Indeed, the identification of lysianassoid species is laborious and requires special training and equipment. The genus *Anonyx* perfectly illustrates all of the hurdles which confront the would-be identifier: the number of species in this genus is high, differences between species are subtle and fade with decreasing size (age), and there are hybrids (Steele and Brunel 1968; Gagnon 1983). Discriminating between lysianassoid species in catches could be important in assessing the impact of the fishery on the lysianassoid resource, because individual species differ considerably in reproductive bionomics and catchability (Sainte-Marie 1986a, 1992b).

Scavenging lysianassoids occupy a peculiar niche: they are mainly detritivorous or phytophagous as juveniles, but they gradually shift to a scavenging (carnivorous) habit as they grow and hence increase their capability for horizontal excursions (Bregazzi 1972; Sainte-Marie 1986a, 1992a; Sainte-Marie and Lamarche 1985). Nevertheless, scavenging lysianassoids are considered to occupy a low trophic level, given their juvenile diet. Several scavenging lysianassoid species are extremely vulnerable to baited traps (Sainte-Marie 1986b), probably more so than any other exploited marine carnivore. The attraction of lysianassoids to baited traps occurs over distances of at least 5 to 30 m in shallow coastal waters (Busdosh *et al.* 1982; Sainte-Marie 1986b and unpubl. observ.) and of hundreds to thousands of metres in deep waters (Sainte-Marie and Hargrave 1987; Sainte-Marie 1992a). In the Saint Lawrence Estuary, fishers have reported average lysianassoid catches of 0.5 to 10 kg $trap^{-1}$ day^{-1} (Anonymous 1992). These quantities would represent about 5,000 to 100,000 individuals based on length-weight relationships for *Anonyx* and *Orchomenella* (Sainte-Marie *et al.* 1989).

Recruitment overfishing and protection of reproductive potential should be major concerns in the development of the lysianassoid fishery. For many scavenging lysianassoid species, every developmental stage is attracted into baited traps, with the possible exceptions of the smallest juveniles and of females carrying late broods (Sainte-Marie *et al.* 1990). Therefore, because amphipods have no larval dispersal stage (Schram 1986), sustained fishing might locally deplete populations. Replenishment of local populations would then occur only through immigration of subadults and adults from neighbouring areas which offer refuge from the fishery. In order to prevent the problem of recruitment overfishing, mortality of juvenile lysianassoids might be reduced by installing escape vents on baited traps. However, the prospects for protecting reproductive potential appear slim. Adult females generally are larger than adult males (Sainte-Marie 1992b), precluding the use of escape vents to reduce adult female mortality, and fishers cannot sort the harvest because of the small size and great abundance of lysianassoids in traps.

The problem of reproductive potential in lysianassoids is compounded by very low female lifetime fecundity. All amphipod species have direct development: eggs are spawned in a ventral brood chamber where they develop into adult-resembling juveniles (Schram 1986). Correlates of direct development are large eggs and reduced fecundity. Among the presently harvested lysianassoid species, female *Anonyx sarsi* produce only 1 clutch with ≈90 eggs during a 2-yr lifespan, while female *Orchomenella pinguis* produce a maximum of 3 clutches with a total of ≈120 eggs during a 1-yr lifespan (Sainte-Marie *et al.* 1990; Sainte-Marie 1992b). Recruitment may be more clearly related to parental stock size in species with direct development than in those with planktonic larvae.

Finally, the possible negative effects of a large-scale lysianassoid fishery on other well established fisheries must be critically evaluated. There is mounting evidence to suggest that gammaridean amphipods play a major rôle in the diets of juveniles and adults of commercially important groundfish (e.g. Hacunda 1981; Wakabara *et al.* 1982; Collie 1987; Gibson and Ezzi 1987; Martell and McClelland 1992). In particular, adult groundfish may prey heavily on gammaridean amphipods when they swarm into the water column to mate (Sainte-Marie and Brunel 1985; Sudo *et al.* 1987). However, the contribution of lysianassoids, relative to other gammaridean amphipods, to the diets of groundfish is yet unclear, and may be marginal (e.g. Macdonald and Green 1986).

CONCLUSION

The Lysianassoidea, a large superfamily of gammaridean amphipods, has recently been the object of a directed experimental fishery in Québec. This exploitation poses new challenges to fisheries biologists and resource managers. Because of the multispecies nature of the lysianassoid resource and of taxonomic difficulties, the identity and proportions of species in the harvest might prove to be untractable, especially if the fishery were to expand. Maintenance of reproductive potential is a major concern, given the low fecundity and high vulnerability of females to baited traps. Finally, there is a potential for negative impacts of the amphipod fishery on other traditional fisheries. A conservative management approach is therefore in order, pending more information on relevant biological issues, notably productivity and species interactions.

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Conservation of Genetic Diversity of Marine Organisms

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Genetic variability can be defined as the range of phenotypes for a particular character produced by alternative alleles of one or more genes. Genetic variation arises in a population by mutation of a gene or by immigration. Genetic variation of a species can be partitioned into variation within and among populations. Any factors that will contribute to reduce the overall genetic variability, may compromise the capacity of a species to adapt to environmental changes and may even compromise the long term survival of that species. Indeed, if genetic variation within individual populations is reduced, there will be less of a basis for future adaptation within a given population. Loss of variation among populations will result in convergence of populations towards one type and a narrower range of options for the species.

Different human activities such as exploitation, introductions, hatchery practices, pollution, and habitat destruction can alter the gene pool of marine species. The genetic effects of these activities may be difficult to evaluate, as more than one of them may occur simultaneously. Different activities may also have a similar genetic effect. Furthermore, the human impacts on the genetic diversity of marine organisms will differ depending on whether they take place in oceanic or coastal systems. Indeed, in an oceanic system, the genetic impact may largely consist in a reduction of genetic diversity due to overfishing of populations of oceanic species and in the reduction of intra-specific genetic variability caused by selective harvesting. On the other hand, human impacts on genetic diversity could be more important in coastal systems where the effects of overfishing, pollution, disruption of life cycles and introductions are more pronounced. Furthermore, the susceptibility of marine species to human activities will also vary as a function of the degree of population structuring of those species. Indeed, for marine species, population structuring can vary from almost isolated populations, as in anadromous salmonids, to nearly panmictic ones. Induced directional genetic changes in life history characters such as growth, maturity as well as in allele frequencies are more likely to occur in those highly genetically structured species where gene flow is reduced and population size usually small. Furthermore, if subdivision of a species into populations represents adaptative characteristics of a species, the loss of such populations can be considered as a loss of genetic diversity (Thorpe *et al.* 1881; Windsor and Hutchinson 1990). This presentation does not intend to be a thorough review on the conservation of marine genetic resources. Its goal is rather to point out some of the potential threats that human activities represent to the genetic variability of marine species.

The genetic effects of exploitation can arise from selective harvesting of the most valuable species in a mixed-fishery, causing a succession of species and thus a decrease of the overall genetic diversity (Nelson and Soulé 1987 and references therein). However, it appears that the major effect of exploitation on marine species is the reduction of intra-specific variability, either through the elimination of more or less reproductively isolated populations or from the selective harvesting of specific classes of individuals. Indeed, it has been suggested that selective harvesting of older and more heterozygous individuals from the virgin stocks was responsible for the reduction observed in the genetic variability of the orange roughy (*Hoplostethus atlanticus*) (Smith *et al.* 1991). Further studies will be necessary to confirm the existence of a relationship between heterozygosity and performance traits in this species and to describe the temporal variability of the genetic structure of orange roughy. There are some observations indicating that exploitation can exert a selective pressure on exploited species that can result in genetic changes in the life history of the species (Sutherland 1990) although it is very difficult to separate genetically based changes from those caused by variations of environmental factors. Ricker (1981) has attributed the decreasing trends in British Columbia pink salmon body size observed between 1959 and 1975 to selective fishing of larger individuals combined with heritability of growth rate. However, these changes have also been attributed to other factors such as changes in oceanographic conditions, increased intra- or inter-specific competition, or selective depletion of stocks with larger mean body size (McAllister *et al.* 1992 and references therein). Some experiments have been carried out with *Daphnia magna* in order to show that selective harvesting can alter the life history characteristics of a species. In these laboratory experiments, several populations of *D. magna* were subjected to different culling regimes. The larger individuals were removed from some populations, the smaller from others. After approximately 150 days, selective culling produced genetic changes in life-history characteristics such as growth rates. Reproduction also shifted to size classes that were not culled (Edley and Law 1988). The extent to which such changes occur in exploited populations depends on the heritability of important life history traits and on the intensity of selection. Highly structured populations will also be more vulnerable to exploitation and a sound understanding of the genetics of the exploited species will be necessary to evaluate the effects of exploitation on natural populations.

Introductions can have serious impacts on the genetic diversity of natural populations but their effects are very difficult to monitor (Ferguson 1990, Allendorf 1991). They have been classified as (1) exotic, when an organism is introduced from a foreign country; (2) transplant, when an organism is moved outside its native range; (3) transfer, when an organism is moved to different sites within its native range and (4) transgenic, when DNA is introduced and integrated from one organism into another (Shafland and Lewis 1984; Ferguson 1990). The primary genetic effect of introduction is the reduction of genetic diversity that can occur by elimination of populations, subspecies and species through competition or predation. The genetic impact of transplants and transfers on native species is the homogenization of gene pools by hybridization. The hybridization resulting from transplants and transfers may cause the lost of locally adapted populations and outbreeding depression. Pertinent information needed to evaluate the potential genetic impact of transgenic aquatic organisms on natural populations is lacking. Stocking of transgenic fish in natural waters should be opposed (Kapuscinski and Hallerman 1991).

Most of the documentation about the genetic effects of aquaculture on wild populations comes from salmon aquaculture. With the rapid development of this industry over the last few decades, the number of fish that have escaped from closed aquaculture operation or that have been intentionally released has dramatically increased. In Norway, it has been estimated that 1 million farmed salmon have escaped to the wild in 1988 and 1989 (Windsor and Hutchinson 1990). In addition to accidental release, farm stock are often released intentionally into river already containing native species or for restocking. Assessing the genetic effects of such releases (intentional or accidental) on native populations is very difficult and there is considerable disagreement among scientists regarding the consequences of genetic interactions between farmed and wild populations (Saunders 1991). Recently, Hindar *et al.* (1991) have compiled findings considered to be directly or indirectly related to genetic effects of farmed fish on recipient populations. The genetic consequences observed when cultured fish come in contact with wild stocks vary from complete introgression to no detectable effects. To what extent the released individuals will influence the genetic constitution of wild populations depend on several factors such as the importance of genetic differences between the wild and farmed populations. The genetic constitution of the cultured populations has frequently been altered through inbreeding, selective breeding, or domestication and the genetic variation of hatchery stock is often reduced compared to that of the wild populations (Cross and King 1983; Skaala *et al.* 1990; Stahl 1983). If wild populations are genetically adapted to their natural environments, the release of hatchery stock and the subsequent hybridization with indigenous populations may reduced total amount of genetic variation of a species and affect the fitness of wild stocks (Skaala *et al.* 1990; Stahl 1983). Another potential threat to genetic variability of wild stock may occur if farmed fishes are released on a large geographical scale. In such cases, locally adapted populations can be lost through convergence of population structures towards a common gene pool.

Some potential genetic impacts are common to both introductions and aquaculture practices. Indeed, there is a serious risk that diseases and/or parasites may be transferred to natural populations from introduced, released fishes or from those that have escaped from aquaculture operations. Another potential impact is that intra- and inter-specific interactions may take place after introduction or accidental or intentional release. These interactions between exogenous and wild stocks and transfer of parasites or diseases to the natural populations may reduce the size of the natural populations. This reduction in population size may result in inbreeding and loss of genetic variability. In extreme cases they may cause a reduction of genetic diversity through elimination of local populations and their gene pools.

Pollution can affect genetic diversity at different levels of the biological organization. Indeed, it has been shown that the taxonomic diversity at polluted sites is reduced (Klerks and Weis 1987). Intra-specific genetic variability may also be reduced by pollution because many populations fail to survive in polluted areas (Klerks and Weis 1987). Environmental pollutant may also exert strong selective pressures on natural populations without causing their extinction. Indeed, several studies have shown differential survivorship of allozyme genotypes exposed to contaminants. Such selective effects of contaminants were observed on several taxa such as mollusc (Lavie and Nevo 1982; 1988), crustaceans (Ben-Shlomo and Nevo 1988) and several fish species (Strittholt *et al.* 1988; Chagnon and Guttman 1989; Diamond *et al.* 1989; Heagler *et al.*

1993). These studies indicate that anthropogenic contaminants can reduce the genetic variability of natural populations by the elimination of sensitive genotypes and the reduction of overall variability (heterozygosity). It has also been suggested that the response of populations to such directional selection can be very rapid and may occur over a few generations (Klerks and Levinton 1989). The mechanisms that cause the selective elimination of specific allozymes are not fully understood and it should be noted that allozymes may not be directly under selection but may simply mark the other loci that are actually producing the differential effects. The selection due to anthropogenic contaminants may reduce the capacity of the species to adapt to environmental changes and can even change its distribution range. Furthermore the loss of sensitive alleles in affected populations may seriously alter the capacity of these populations to resist other environmental stress (of human or natural origin) because genotypes resistant to one pollutant may be sensitive to another (Ben-Shlomo and Nevo 1988).

Habitat destruction, for example, through the construction of hydro power dams, or the destruction of spawning sites may lead to a reduction of genetic variability by the eradication of local populations and the replacement of native species. In several cases, human constructions have disturbed the life cycle of marine species.

As mentioned previously, a prerequisite to the assessment of the genetic effects of human activities on natural populations is a sound understanding of the genetic structure of the species. Indeed, understanding how genetic variation is distributed within a species (e.g., within or among stocks) is critical for the development of a management scheme. It is important that the description of the genetic structure of marine species should not be restricted to a geographical scale as is often the case but must be carried out on temporal scale. Under-utilized and unexploited species may represent an interesting challenge and they may be particularly useful to monitor changes due to exploitation. Because the exploitation of these species can be anticipated, base-line information on the genetic variation of pre-exploited stocks can be established. Such base-line information which is usually not available for exploited species because exploitation, introduction and intended or accidental releases have occurred before information on pre-exploited stock could be obtained, should include data on life cycle characteristics, taxonomy (unrecognized sibling species may exist), population structure, and genetic and morphological variations. Over the last decades, several biochemical and molecular techniques such as protein electrophoresis, RFLP, PCR, and mt-DNA analysis have been developed and used to describe genetic variability across taxa or species as well as the degree of structuring in species and to determine the importance of gene flow among natural populations. These techniques are available and should be used, as a priority, to collect information for unexploited or under-exploited species with no apparent dispersion phase (direct development) because they may be more vulnerable to human activities.

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Conséquences Économiques et Sociales de l'Introduction de la Pêche au Crabe à St. Paul's River, Basse Côte-Nord

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INTRODUCTION

La crise que traversent actuellement les pêcheries atlantiques est l'objet de multiples débats et analyses au sein des institutions universitaires et gouvernementales. Générant un retour critique sur l'utilisation de paradigmes jusque là en constante consolidation, elle comporte aussi des réflexions prospectives axées sur la recherche de solutions qui ne sont pas toujours faciles à identifier et à concrétiser. Parmi celles-ci, semble se dessiner un intérêt croissant pour une meilleure connaissance et la mise en valeur de ressources jusqu'à maintenant peu utilisées à l'aide d'approches qui reconnaissent davantage l'importance de l'interdisciplinarité, tel que le souligne l'invitation à participer à ce colloque.

En tant qu'anthropologue fortement intéressé par l'impact de l'industrialisation sur les systèmes pêche depuis plusieurs années, j'aimerais apporter un exemple qui souligne que l'insertion d'un groupe de pêcheurs dans la capture d'une nouvelle espèce n'est pas un processus neutre, définissable strictement par des critères bioéconomiques centrés sur le prélèvement d'une partie du stock disponible et la création de nouvelles valeurs monétaires. Il s'agit aussi d'un processus éminemment social, qui s'insère, tout en les transformant, dans les normes et la quotidienneté de groupes de producteurs et modifient leurs relations avec l'appareil bureaucratique qui supervise leurs activités. Il serait de plus illusoire de prétendre que la complexité de ce phénomène peut être saisie seulement à l'aide d'une approche synchronique, axée sur le moment même et un léger suivi de l'intervention. Elle présuppose aussi une information minimale sur l'évolution du contexte dans lequel prend forme l'innovation.

Aux fins de la démonstration, j'utiliserai l'exemple de l'introduction de la pêche au crabe des neiges dans une petite communauté de la Basse Côte-Nord du Saint-Laurent au milieu des années 80. La première partie de l'article y soulignera brièvement l'évolution des pêches, surtout à partir des années 60, identifiant les mécanismes qui ont façonné de manière particulière cette communauté avant que n'y soit introduite la pêche au crabe. Dans la deuxième partie, je m'attarderai aux modalités d'insertion de la nouvelle activité, insistant sur ses conséquences économiques et sociales. Je terminerai par quelques remarques sur l'importance d'une vision "sociale" des systèmes-pêche dans une perspective aménagiste. [1]

1. St-Paul's River 1960 - 1980: un système halieutique en transition

A l'instar de plusieurs communautés côtières de la région, le démarrage des activités de pêche sur une base commerciale à St.Paul's River remonte en gros au milieu du siècle dernier. Sous l'instigation de compagnies jersiaises et terre-neuviennes, principalement intéressées par la capture de la morue, a progressivement pris forme une sédentarisation qui, malgré sa lenteur, a permis le façonnement de la communauté actuelle. Le nombre d'habitants est passé de 120 en 1897 à 438 en 1967 (Figure 1). [2]

C'est d'ailleurs dans cette région qu'a été inventée la trappe à morue, engin qui s'est ensuite généralisé sur les deux rives du détroit de Belle-Isle. Pratiquée dans un archipel qui donnait lieu à une transhumance significative entre le village d'hiver, à l'embouchure de la rivière, et les diverses stations de pêche durant l'été, la pêche à la morue a été jusqu'au début des années 80 l'activité économique principale. Les unités de production qui se retrouvaient dans la communauté au moment de notre premier séjour sur le terrain à la fin des années 60 se caractérisaient par des patrons de résidence et de coopération fortement patrilinéaires. Étant donné le coût élevé de la trappe à morue, le principal engin de pêche, et les difficultés d'accumulation pour les jeunes pêcheurs, la plupart des équipages étaient composés de pères oeuvrant avec leurs fils, leurs relations étant agencées au sein d'un système de parts basé sur le capital et le travail, cette dernière catégorie donnant lieu à des formules variées selon l'âge des pêcheurs. Tel que l'indique le Tableau 1, on comptait à St-Paul's River 35 équipages en 1967, les liens entre les capitaines et les engagés découlant à plus de 85% de relations familiales et de parenté agnatique. D'après nos estimations et les informations recueillies auprès des producteurs, ce nombre constituait une limite presque maximale en fonction des possibilités productives de l'archipel. La

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[1] Les données proviennent de projets de recherche subventionnés par le Conseil Canadien de Recherche en Sciences Humaines du Canada. Un premier séjour à St.Paul's River, d'une durée d'un an, a eu lieu au cours de 1967-68; diverses données sont disponibles dans Breton, Y. 1970 et 1973. Au milieu des années 70, Pierre Bernier a effectué un séjour de trois mois dans le cadre d'un thèse de maîtrise (Bernier 1979). Au cours de la période 1988-89-90, une équipe de recherche composée de Marie Giasson, Hélène Marchand, Sylvie Poirier, Jean-Marc Darveau et Daniel Roy, tous anthropologues, ont effectué diverses enquêtes dans la partie-est de la Basse-Côte-Nord, principalement durant la période estivale. Je tiens particulièrement à remercier Daniel Roy, qui m'a donné accès à ses données sur la communauté de St.Paul's River (Roy 1990).

[2] La plupart des compagnies ont commencé à connaître des difficultés financières à la fin du siècle dernier et sont progressivement disparues à partir de 1910. Les pêcheurs ont alors développé une organisation économique plus locale, combinant pêche à la morue, au loup-marin, au saumon, piégeage et chasse au caribou à l'intérieur de leur cycle annuel, tout en maintenant une dépendance sur des commerçants de l'extérieur pour l'acquisition de certains produits et l'écoulement de leur poisson. Vers 1950, avec l'ouverture des centres miniers sur la Haute et Moyenne Côte-Nord, se produisit une émigration temporaire qui déstabilisa quelque peu la pêche à la morue. Ce n'est qu'avec l'arrivée progressive de l'assistance sociale et de divers programmes de paiements de transfert, quelques années plus tard, que la communauté parviendra à maintenir tant bien que mal son équilibre démographique.

trappe devant être fixée dans un endroit profond mais à proximité du rivage, tous les bons emplacements, connus après une expérimentation significative, étaient alors occupés, et les emplacements se transmettant jalousement au sein des groupes familiaux.

Tableau 1. Les relations de parenté dans les groupes de pêche à la morue: St.Paul's River, 1967.

Capitaines	Engagés							
	Fils	Frère	Gendre	B. Frère	Neveu	Cousin	Autre	Total
35	48	7	2	1	5	1	4	68

Source: Breton, Y. 1970

Sans entrer dans une description exhaustive de l'organisation économique des pêcheurs à cette époque, il importe de souligner quelques éléments dans l'optique de la démonstration qui va suivre. Le premier a trait à la consommation. Quiconque aurait séjourné dans la communauté à la fin des années 60 et qui se serait fié aux stéréotypes existants sur les petites communautés de pêcheurs serait rapidement venu à la conclusion qu'il s'agissait d'un groupement très homogène, encore peu touché par l'idéologie de la modernisation, replié sur lui-même et somme toute, peu enclin à l'innovation. Effectivement, vu l'isolement relatif de la communauté, sa faible démographie, et l'absence d'un marché interne de biens de consommation [3], la majorité des familles vivaient dans des conditions semblables et avaient un niveau de vie peu élevé. Mais l'obtention d'informations généalogiques permettant de reconstituer le tissu social de la communauté, l'observation prolongée des activités de pêche axée sur l'obtention de données sur les volumes de production et l'interaction continue avec les pêcheurs m'ont amené progressivement à découvrir l'existence d'une stratification sociale dont la visibilité, bien que restreinte à cette époque, comportait beaucoup d'éléments virtuels qui ont par la suite acquis une importance très grande.

En effet malgré leur homogénéité apparente, certaines familles parvenaient à produire plus sur une base régulière. En fait, il existait une rente différentielle entre les emplacements de trappe à morue, certains étant non seulement plus productifs que d'autres pour la morue mais permettant aussi, lorsque localisés à proximité de baies sablonneuses, des captures additionnelles de saumon qui représentaient un revenu d'appoint important. Ces surplus monétaires, pouvant difficilement être investis dans la communauté même, servaient plutôt à faire instruire, à l'extérieur, des membres de la famille. Plusieurs de ces jeunes ont alors eu l'occasion, contrairement aux membres de familles moins bien nanties, de suivre des cours spécialisés dans le domaine des

[3] Le magasin de la Baie d'Hudson n'offrait pas une gamme très élaborée de produits et le recours aux commandes de l'extérieur, avec les catalogues Eaton et Simpson constituait plutôt une démarche sporadique, liée à des occasions spéciales.

pêcheries. Cette situation aura un impact important lors de l'adoption ultérieure des cordiers dans les années 70.

L'autre élément important à souligner est, malgré la prédominance de la trappe à morue comme technique de pêche et catalyseur du membership familial dans les unités de production, l'avènement des filets-maillants à la fin des années 60. Ce furent surtout des jeunes pêcheurs, provenant de groupes familiaux relativement productifs, qui se sont engagés dans l'utilisation de cette nouvelle technique. Non seulement présupposait-elle la familiarisation avec une zone de pêche quelque peu différente, (généralement basée sur une légère extension des zones productives liées à l'utilisation de la palangre à la fin de la saison estivale), mais surtout le recours à de nouvelles technologies de locomotion comme le moteur hors-bord et des embarcations plus légères. Les capitaines d'un certain âge furent réticents à s'y engager et leur indifférence relative face à cette nouvelle technique amena une déstabilisation progressive du système d'autorité qui prévalait antérieurement au sein des unités de production. [4] Graduellement, la trappe donna des rendements moindres et le filet-maillant acquit de la popularité, situation qui provoqua une tendance au regroupement générationnel au sein des équipages. Nous y reviendrons un peu plus tard lorsque nous discuterons de la pêche au crabe.

L'autre élément qui influença l'évolution des pêches à St.Paul's River à la fin des années 70, fut l'adoption des cordiers, embarcations plus grandes et plus polyvalentes, permettant d'exploiter des zones plus étendues, de prolonger la saison de pêche et de diversifier la production . Leur utilisation exigeait des connaissances techniques additionnelles mais permettait, à l'aide de treuils mécaniques, de réduire considérablement les efforts de manutention des engins de pêche. Cette innovation technologique s'accompagna aussi de la mise sur pied de petites usines de salaison, élément qui provoqua un abandon significatif de la pratique du séchage de la morue et réduisit considérablement la transhumance estivale des familles dans les îles et anses côtières.[5]

Ce qui précède souligne, malgré la brièveté des informations qui y sont présentées, que durant les quelques vingt années qui ont précédé l'introduction de la pêche au crabe à St.Paul's

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[4] L'avènement des moteurs hors-bord, reposant sur des embarcations plus légères mais plus rapides, causa d'abord beaucoup de réticences chez les plus vieux pêcheurs qui de surcroît, étaient conscients que la morue captive dans les filets maillants pour plus de vingt-quatre heures était de moins bonne qualité que celle qui provenait de la trappe. Les jeunes par contre l'adoptèrent d'emblée. Non seulement son utilisation leur permettait de franchir plus rapidement les distances à des fins d'activités sociales les fins de semaine, mais elle devint aussi un élément de compétition axé sur la vitesse et la performance des embarcations au plan régional. Par manque d'expérience, plusieurs y ont laissé leur vie. S'insérant progressivement dans la capitalisation avec ces nouvelles techniques, les jeunes pêcheurs ont ainsi progressivement miné le contrôle antérieur et presqu'absolu des plus vieux producteurs.

[5] Élément anodin en soi, la fin de la transhumance estivale eut néanmoins des conséquences importantes au plan de l'organisation sociale de la communauté. Elle diminua la cohésion interne de certains groupes familiaux étendus qui antérieurement résidaient une partie de l'été dans des endroits relativement isolés et développaient des interactions continues. Une fois que la majorité des familles se sont retrouvées dans l'emplacement du village d'hiver sur une base permanente, la vie communautaire reposa sur des relations sociales à la fois plus diversifiées et plus diffuses.

River, cette communauté avait connu des changements significatifs au plan de son organisation économique et sociale. Éléments peu visibles au plan démographique, ils l'étaient par contre devenus plus tangibles au plan de la technologie et de la capitalisation. C'est dans ce contexte social mouvant, transitionnel, qu'il importe d'analyser les modalités et conséquences de l'introduction de la pêche au crabe.

2. L'introduction de la pêche au crabe au cours des années 80

J'ai été extrêmement frappé par l'importance qu'avait acquise la ressource "crabe" lors de mon retour à St.Paul's en 1987. Lors de mon séjour antérieur, cette ressource n'était pas l'objet de capture, ne donnait lieu à aucune consommation et était souvent l'objet d'attitudes de dédain et de vociférations de la part des pêcheurs lorsque prise au filet-maillant. Vingt ans plus tard, elle était devenue l'une des principales ressources économiques dans la communauté, générant des emplois tant pour les hommes que pour les femmes et servait même de plat de choix pour les occasions spéciales et les invités de l'extérieur. Elle s'était somme toute transformée en une source d'identité et de fierté pour les producteurs et avait modifié des schèmes culturels existants.

Ce retour sur le terrain nous a donc mis en présence d'une communauté passablement différente de celle que nous avions connue antérieurement. L'élément de différenciation le plus visible était sans doute l'adoption de cette nouvelle activité, les infrastructures plus élaborées qu'elle avait générées et les revenus accrus qu'elle procurait. Nous avons alors reconstitué, à la lumière des informations en notre possession, ses mécanismes d'introduction, centrant nos préoccupations sur ses conséquences au plan des relations économiques et sociales entre les individus.

Ce qui a d'abord retenu notre attention a été l'identification des individus détenteurs des permis d'exploitation. L'attribution des permis fut un processus démocratique puisque les producteurs disposaient d'une bonne information à l'avance sur le nombre de permis disponibles et sur les exigences techniques et juridiques qui s'y rattachaient. Nous avons toutefois rapidement pris conscience que, resitués dans la stratification sociale à laquelle nous nous sommes référés antérieurement, les 17 détenteurs appartenaient presque tous à des unités familiales ou de production qui antérieurement, à cause de l'existence d'une rente différentielle entre les emplacements de trappe à morue, avaient des revenus plus élevés et comportaient des membres plus instruits, somme toute qui, malgré l'ampleur réduite de la communauté, se retrouvaient dans les catégories les plus élevées de la stratification sociale (Voir les Figures 2 et 3). L'introduction de la pêche au crabe s'est donc inscrite dans un contexte social existant caractérisé par certaines asymétries et ne peut être tenue responsable des clivages sociaux qui y prévalaient avant qu'elle ne se consolide. Mais par contre, et c'est là que réside l'essentiel de l'argumentation, elle n'a pas été un simple phénomène de transformations techniques et économiques, une innovation "neutre" ou normale s'inscrivant dans l'idéologie plus large de la modernisation, mais aussi un phénomène qui a eu d'énormes conséquences sur l'organisation sociale de la communauté.

Lors de la première année d'expérimentation en 1984, les revenus des pêcheurs de crabe furent légèrement supérieurs à ceux qui étaient demeurés engagés dans la morue. Cette situation ne provoqua pas de perturbations majeures, les morutiers sachant bien que l'adoption de la nouvelle activité impliquait des coûts additionnels d'amortissement. Toutefois, dans les années qui suivirent, le prix de la ressource crabe augmenta drastiquement, provoquant une différenciation socio-économique très grande au sein de la communauté , situation qui suscita un fort ressentiment au sein des producteurs qui n'avaient pas accès à la nouvelle ressource. [6] Qui plus est, l'avènement du crabe engendra la création de nouveaux emplois dans le secteur de la transformation, principalement réservés à la main-d'oeuvre féminine. Dans un contexte occupationnel où les possibilités de travail salarié étaient restreintes et où le travail en usine donnait aussi accès à des paiements de transferts durant une bonne partie de l'année, on peut facilement s'imaginer que ce type d'emploi fut l'objet d'une compétition féroce entre les familles. Or les producteurs de crabe considéraient comme normal, vu qu'ils approvisionnaient l'usine, que ces emplois revinrent aux membres de leurs familles, soit à leurs femmes et à leurs filles. Les tensions générées par les transformations dans le secteur d'acquisition furent amplifiées par ses ramifications dans le secteur de la transformation, les deux ayant un poids déterminant dans le revenu des familles.

D'autres conséquences ont découlé de l'introduction de la pêche au crabe. D'abord au plan de la composition des équipages; contrairement à une dimension bigénérationnelle significative en 1967, elle a progressivement reposé sur des groupes d'âge beaucoup plus homogènes dans lesquels la collaboration entre frères devint dominante. Cette caractéristique n'est pas sans conséquence pour l'évolution de la pêche puisqu'elle posera des problèmes particuliers au plan de la répartition future du capital au sein des équipages, plusieurs jeunes producteurs voyant dès le départ réduire leur chance d'y accéder dans un avenir rapproché en fonction du nombre limité de permis.

Tableau 2. Les relations de parenté dans les groupes de pêche à la morue: St.Paul's River, 1987.

Capitaine	Engagés								
	Fils	Frère	B. Frère	Neveu	Cousin	Épouse	Soeur	Aut.	Tot.
27	14	30	5	3	4	2	1	8	67

Source D. Roy, 1990

[6] Selon nos estimations, le revenu moyen des engagés dans la pêche à la morue était d'environ 3,000 dollars tandis que ceux qui participaient à la pêche au crabe parvenaient à gagner plus de 20,000 dollars. Il importe d'objectiver ces différences dans un contexte social restreint où tout le monde se connaissait intimement et dans lequel, à venir jusqu'à cette époque, les différences n'étaient pas aussi marquées.

Une autre conséquence fut que les frustrations des pêcheurs confinés à la morue se traduisirent par une insertion illégale dans la pêche au crabe. Bien que ne possédant pas de statistiques précises sur le sujet, puisque ces événements se produisirent au moment ou n'étions pas sur le terrain, plusieurs producteurs nous l'ont subséquemment affirmé sans hésitation, justifiant leur action par des arguments liés aux inégalités existantes. Voilà un bon exemple de conséquences liées à une innovation devant censément prendre forme dans un cadre opérationnel respectueux d'un certain cadre juridique mais qui a généré des actions déviantes. D'autre part, les revenus additionnels procurés par la pêche au crabe se sont traduits par une forte consommation improductive chez plusieurs familles, notamment dans le domaine de l'habitation et du transport, ces éléments modifiant la stratification sociale. A titre d'exemple, sans compter la prolifération du nombre de motoneiges par famille, 28 nouvelles autos ont été acquises par les habitants de St.Paul's River au cours de l'année 1988. Quand on prend en considération, si l'on fait abstraction de la possibilité de traverser sur l'île de Terre-Neuve, le fait qu'un tronçon de route d'environ 70 kilomètres est praticable entre la communauté et celles du Labrador terre-neuvien, et ce, seulement une partie de l'année, on peut se poser des questions sur la rentabilité de tels investissements.[7]

Finalement, ces différences accentuées au plan de la consommation ont influencé la morphologie et l'organisation sociale de la communauté à un niveau plus large. Avec seulement quelques dizaines d'habitants additionnels, soit 438 en 1967 et 468 en 1987, St.Paul's River compte maintenant 125 maisonnées au lieu des 70 antérieurement. Cette situation, qui ne fait qu'illustrer la déstructuration et l'atomisation des réseaux sociaux antérieurs peut certes être comprise à l'intérieur de schèmes de valeur qui évoluent dans l'ensemble du contexte québécois et canadien. Mais dans une communauté de dimension restreinte et caractérisée antérieurement par une solidarité sociale plus manifeste, les conséquences sont éminemment plus visibles. Plus d'une quinzaine de personnes vivent maintenant seules et il existe une compétition accrue entre les familles. Dans un contexte où les gouvernements cherchent à rendre moins marginales ces communautés en les intégrant davantage à l'ensemble national et font des efforts pour créer des consciences municipales qui amèneraient les individus à se prendre davantage en charge, l'atomisation sociale génère plusieurs éléments centrifuges qui risquent à moyen terme de nuire à leur développement.[8] L'introduction de la pêche au crabe à St.Paul's River a donc amplifié des

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[7] Il n'est pas de notre intention de porter un jugement négatif sur cette consommation improductive. Ayant connu les conditions de vie très difficiles sur la Basse-Côte-Nord au cours des décennies antérieures et ayant été sensibilisé aux nombreuses revendications et frustrations qui s'y rattachaient, il m'est apparu normal que l'entrée d'un numéraire accru dans la communauté ait donné lieu à une consommation ostentatoire. Certains informateurs ont toutefois souligné qu'une partie de l'argent aurait pu être investi dans des projets plus productifs, notamment dans la mise sur pied d'une scierie qui aurait desservi les localités avoisinantes, la communauté de St.Paul's River étant la seule, à l'est de la Basse-Côte-Nord, à posséder une forêt-galerie capable de supporter une telle activité.

[8] Les premiers efforts d'intégration politique formelle des communautés de la Basse-Côte-Nord remontent en 1963 au moment où le gouvernement du Québec crée la Municipalité régionale du Golfe à la tête de laquelle se retrouvait un administrateur nommé par le gouvernement et des conseils locaux consultatifs. Depuis quelques années toutefois, les divers villages sont en train d'être regroupés en de véritables municipalités, avec des représentants élus localement.

transformations antérieures en conférant une intensité accrue à certains de leurs volets. Directement visibles dans l'organisation halieutique proprement dite, ces transformations ont affecté l'ensemble du tissu social de la communauté et auront des impacts importants sur son évolution future.

3. Innovation et vision "sociale" des systèmes-pêche

La démonstration qui précède avait comme objectif de souligner que toute innovation technologique (dans ce cas-ci liée à l'utilisation d'une espèce sous-exploitée) ne comporte pas seulement des conséquences au plan de la technologie ou de la dimension économique au sens strict mais a aussi des incidences sur les relations sociales au sein du groupe récepteur. Trop souvent, sous le couvert d'une idéologie formaliste et progressiste, axée sur la promotion d'une diversification de la production ou d'une augmentation de la productivité, des changements sont introduits avec une conception qui réduit l'importance du vécu antérieur des individus et du contexte social qui façonne leurs relations. En d'autres termes, l'innovation, censée générer des effets dynamisants et positifs sur l'économie, s'inscrit dans une planification normalisée qui surestime la valeur explicative et la portée des modèles à notre disposition. L'histoire du développement dans les pêcheries, comme dans bien d'autres secteurs liés à l'exploitation des ressources naturelles, souligne bien cependant que les mêmes innovations n'ont pas les mêmes conséquences dépendamment des milieux sociaux dans lesquels elles prennent place.

L'introduction de la pêche au crabe à St.Paul's River s'est déroulée à un moment précis de la trajectoire halieutique de la communauté, soit une phase dans laquelle elle se caractérisait, depuis quelques années avec l'avènement des cordiers, par une différenciation accrue entre les producteurs de morue. Qui plus est, nous avons même souligné que les clivages sociaux entre ces producteurs, quoique beaucoup moins visibles antérieurement, étaient néanmoins repérables à travers l'existence d'une rente différentielle entre les emplacements de trappe à morue avant les interventions étatiques plus structurées des années 70. Il serait donc faux d'affirmer que leur cause principale réside, comme pourrait le faire croire une lecture rapide et trop synchronique de la situation, dans l'introduction de la pêche au crabe. Par contre, il est clair que l'avènement de cette dernière s'est inscrite en continuité avec une tendance antérieure à la différenciation et qu'elle lui a conféré une intensité et une visibilité accrues. C'est en ce sens qu'il importe d'analyser et de comprendre ses conséquences.

Une telle orientation analytique nous apparaît importante. Elle démontre que cette innovation n'a pas pris forme dans le vide et ne peut être jugée, évaluée strictement en tenant compte des volumes et valeurs supplémentaires de production qu'elle a suscités. Il s'est agi d'un phénomène beaucoup plus large et complexe dont la signification, même strictement visualisée au plan économique, nous resitue d'emblée dans la reproduction quotidienne d'individus et de leur communauté, avec toute une série de conséquences plus larges pour son développement futur. Sans nier la procédure démocratique d'allocation des permis pour le crabe, il nous semble que, dans une véritable perspective de développement économique, elle aurait pu être enrichie par une lecture "sociale" plus approfondie de la situation, misant sur une meilleure connaissance de la répartition du capital dans la communauté et sur une meilleure prévision des retombées rattachées aux emplois indirects dans le secteur de la transformation. Il aurait probablement alors été possible de mettre sur pied une stratégie différente d'allocation des permis dans laquelle même une formule du tirage au hasard aurait pu être l'objet d'un contrôle pondéré, permettant l'accès aux permis non seulement aux producteurs mieux nantis, mais aussi à ceux qui étaient en moins bonne posture financière. Même si une telle procédure aurait présupposé un temps et un coût supplémentaires, elle se serait traduite par des économies d'énergie au plan de la gestion et de la surveillance de l'activité, réduisant l'importance des captures illégales et des dépenses indirectes qu'elle génère. Elle aurait enfin, tout en raffermissant positivement l'image de l'intervention étatique dans la région, maintenu un certain niveau de cohésion sociale indispensable à l'évolution future de la communauté, surtout si on prend en considération la dimension réduite de sa population, son isolement relatif, les coûts élevés d'opportunité en termes d'emploi et son insertion dans un processus de consolidation municipale au sein d'un contexte halieutique régional nettement négatif.

L'exemple qui précède, si on le resitue dans le développement général des pêches dans l'est canadien au cours des deux ou trois dernières décennies, n'est pas unique.[9] Basé sur le paradigme de la "tragédie des communaux", approche dans laquelle le producteur halieutique est d'abord perçu comme un agent, une variable neutre au même titre que les autres facteurs de production dans l'activité pêche, ce développement a permis des efforts sophistiqués de modélisation , efforts dont la validité a été proportionnelle au maintien et à l'augmentation des volumes de capture. Mais le contexte halieutique récent, caractérisé par une diminution drastique de la biomasse de certaines espèces, nous fait redécouvrir la fragilité et la portée limitée de modèles dans lesquels les éléments humains, en dépit de leur complexité, demeurent confinés au statut de variables indépendantes. Il est à souhaiter que dans les efforts futurs de développement des pêcheries, possiblement par la mise en valeur de ressources jusqu'à maintenant sous-utilisées, l'importance des éléments sociaux des systèmes-pêche soit davantage reconnue et qu'au lieu de se voir confiné dans la catégorie d'agent économique individuel, le pêcheur soit perçu comme membre d'une maisonnée, faisant partie d'une communauté, entretenant des relations avec d'autres pêcheurs et la communauté bureaucratique plus large. En d'autres termes, "la biomasse sociale" fait elle aussi partie intégrante de l'effort-pêche et doit être modélisée à travers des schèmes qui en privilégient les divers mécanismes de reproduction. A l'intérêt actuel des chercheurs pour les espèces sous-utilisées, doivent s'ajouter des préoccupations pour les caractéristiques sociales méconnues des communautés de pêcheurs. C'est dans la combinaison de ces orientations que réside le futur d'une meilleure recherche orientée et d'une saine gestion des pêches au Canada.

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[9] Voir par exemple les travaux récents de Davis (1992); Kearney (1992); Apostle et Barrett (1992) pour la Nouvelle-Écosse et ceux de Neis (1991) et Sinclair (1985) pour Terre-Neuve.

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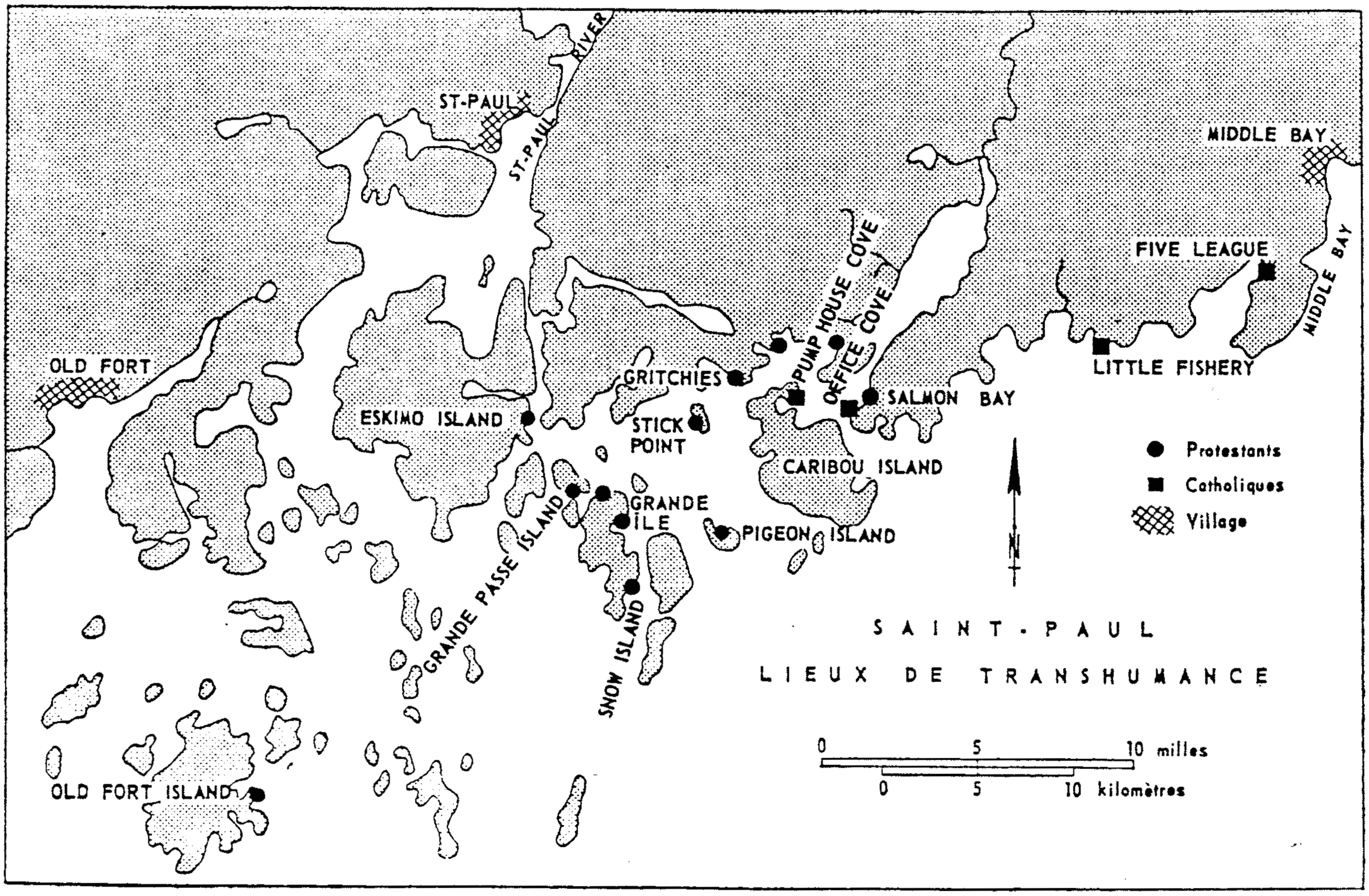

Figure 1. Archipel de St. Paul's River: village d'hiver et lieux de transhumance.

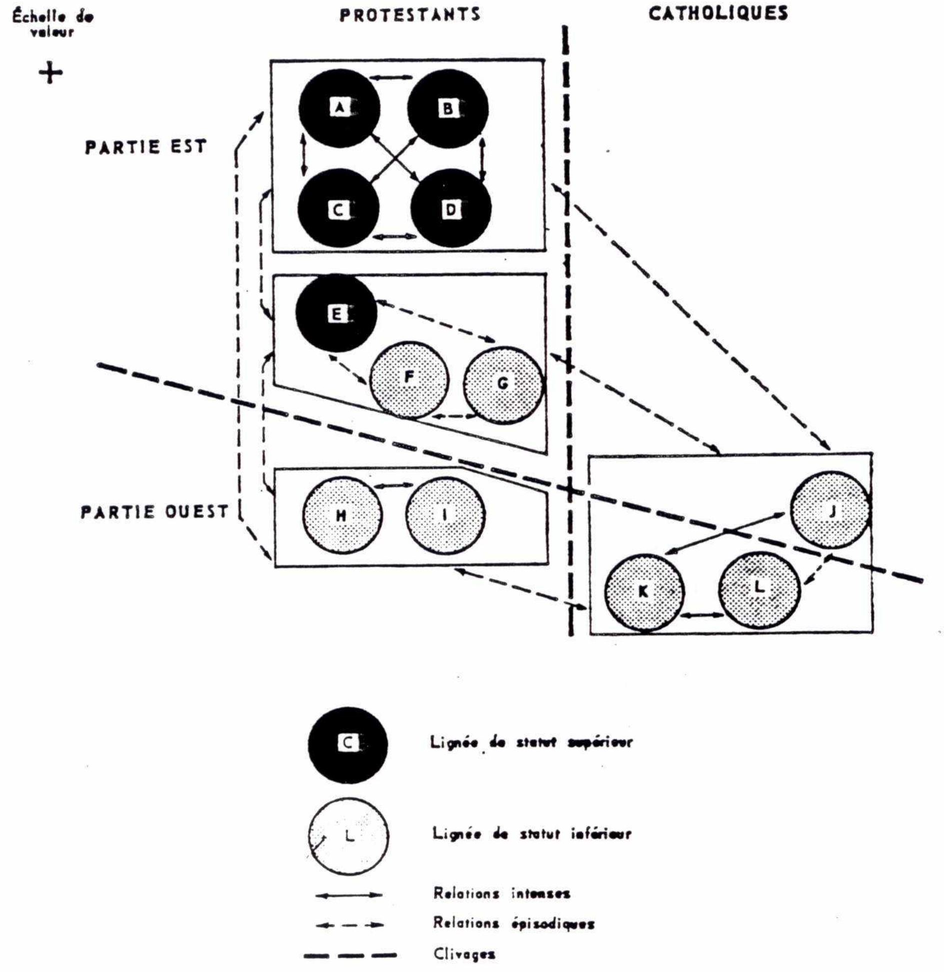

Figure 2. Stratification sociale, St. Paul's River: 1967.

Note: Les critères utilisés sont multiples: date d'arrivée des premiers ancêtres dans la région, dimension numérique des lignées, appartenance religieuse, avoir économique, accès aux emplois salariés et lieu de résidence dans la communauté.

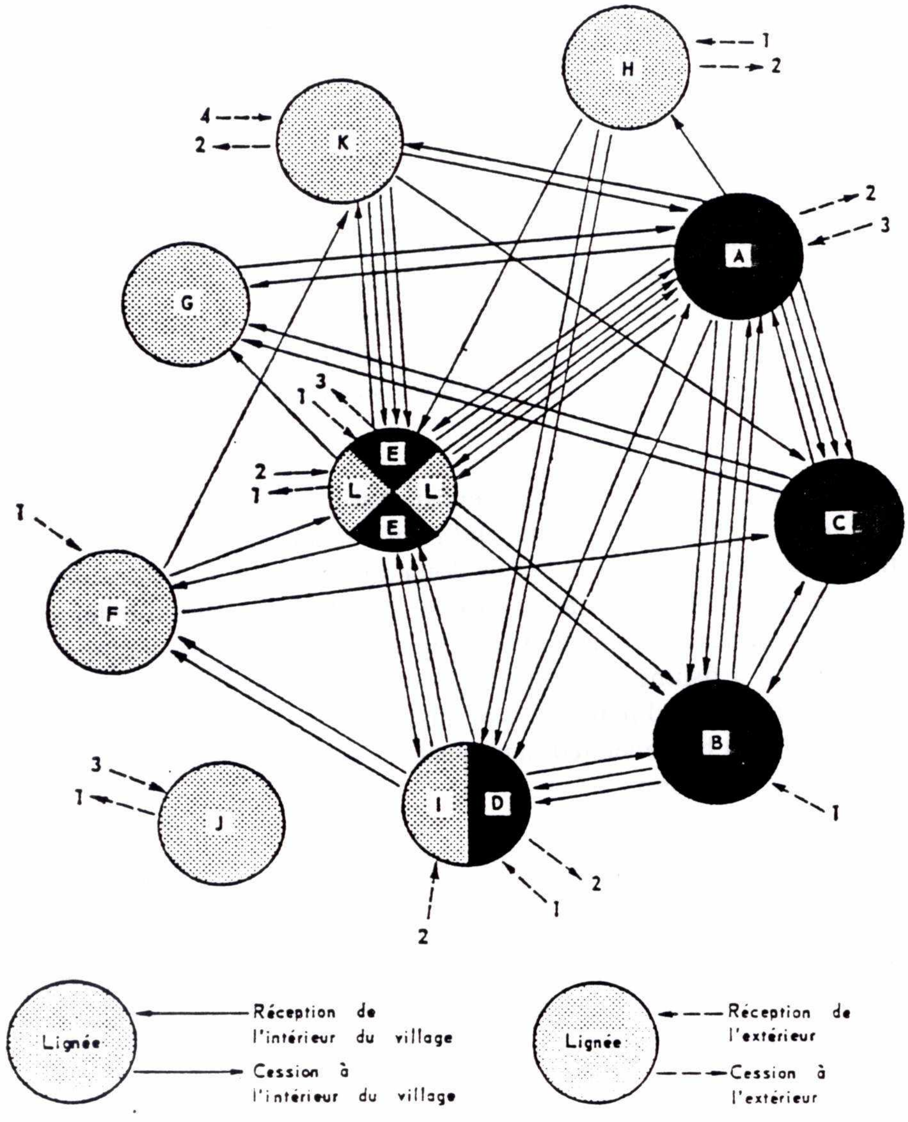

Figure 3. Mariages et relations familiales, St. Paul's River, 1967.

Note: Ce graphique illustre les échanges matrimoniaux qui se sont produits entre les groupes familiaux existant dans la communauté au moment de notre enquête. Soulignons les fortes relations et la tendance aux mariages endogamiques entre groupes ayant un statut supérieur. Les groupes de statut inférieur devaient plus fréquemment recourir à l'extérieur pour contracter des alliances.

Social Considerations in the Development of Underutilized Species Fisheries

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This paper examines the question of the development of underutilized species fisheries from an anthropological perspective. From the outset, it is important to delineate how this perspective differs from that of a biologist, ecologist, or economist when approaching the issue of fisheries development. To highlight these differences, it is useful to describe how each discipline might typically treat the notion of sustainability when dealing with underutilized species.

Thus, for example, the natural scientist, that is, the biologist, ecologist, or oceanographer, would be primarily concerned with the ability of a natural population of an underutilized species to sustain itself under different rates of exploitation and what the effect of that exploitation might be on other organisms in the marine environment and on total environment itself. The economist would be largely interested in the ability of a particular rate of exploitation to generate sufficient revenues to sustain a fishing enterprise. The economist would also examine such questions as how many enterprises could potentially be sustained by that exploitation rate, how many sea and land-based jobs could be generated, and what the market potential for that species would be in both the short and long-term.

While recognizing the importance of the notions of sustainability as treated by natural scientists and economists, the anthropologist has a responsibility to introduce still other elements to the concept of sustainability. Thus, I have put forward a three-fold notion of sustainability: the sustainability of natural resources, the sustainability of livelihoods, and the sustainability of communities. Each of these dimensions of sustainability is integral to a total concept of sustainability and any one dimension is not viable without the other two.

Therefore in elaborating further on this three-fold notion of sustainability, the first dimension, the sustainability of natural resources, would include a consideration of all the elements treated by natural scientists, but the anthropologist would also include human beings and their marine activities as an integral part of the marine ecosystem and its interactions. The interjection of this social dimension into marine ecology can be further understood in relation to the two other dimensions of sustainability.

The sustainability of livelihoods refers to all those socio-economic activities which sustain or could potentially sustain individuals and households in coastal communities. Livelihood means much more than the number of jobs that exist in a community at any given point in time. It encompasses the ability of women as well as men to have meaningful work in a community and the ability of children and young adults to look forward to a viable economic existence in that community over the course of a lifetime. The sustainability of livelihoods takes into account the total social and economic resources of a community and the ability of community residents to respond in a flexible manner to changing resource and market conditions. The sustainability of livelihoods includes such intangibles as quality of life and the capacity of residents to enhance the livelihoods of each other through informal exchanges such as bartering and community projects. In sum, the sustainability of livelihoods, rather than focusing on the jobs available to isolated individuals in an area, emphasizes instead the capacity of entire households in discrete communities to enjoy a reasonable quality of life over a long term frame.

One graphic example of a failure to distinguish between jobs and livelihoods was the decision, in December 1992, of the Minister of Fisheries and Oceans to cancel all inactive groundfish licences on the Atlantic coast. As a result of a decline in groundfish stocks in recent years, many multi-purpose inshore fishers had chosen no to fish groundfish and concentrated instead on other species such as lobsters, scallops, or herring. This is part of an ecologically adaptive response that is intrinsic to the livelihood strategies of inshore fishers. By cancelling these licences, the Minister mistook employment considerations, that is, the absence of activity in a particular fishery at a particular time, for livelihood considerations,that is, the importance of groundfish fishing in an overall adaptive strategy to sustain marine resource over the long-term. At the same time, this specific example speaks to the importance of including human activities in the analysis of marine ecosystems. Fishers employing a multi-purpose fishing strategy are less likely to exert excessive pressure on groundfish stocks during periods of decline than those pursuing a specialized groundfish strategy.

The third dimension of sustainability, the sustainability of communities, refers to the critical role played by the collective will and actions of community residents to sustain resources and livelihoods in order to ensure the long-term survival and viability of the community itself. In fact, it can be argued that only a community-based approach to fisheries management, grounded in providing sustainable livelihoods, offers any real hope for sustaining natural resources. Resource management based on government intervention and regulation has proven itself too inflexible and unwieldy in responding to the complex interactions both within and between fishing communities and the marine ecosystem. Resource management based on individual or private ownership of the resource, as seen in individual transferable quota (or ITQ) systems, can bring some benefits in terms of a very narrow definition of economic efficiency, but the *raison d'être* of such systems is rent maximization. They have yet to prove themselves as intrinsically oriented toward resource conservation, and they pose serious problems relative to the social distribution of resource benefits. Indeed, the current collapse of groundfish stocks was preceded by the massive conversion of the offshore and midshore fisheries to a full ITQ system while in certain regions many inshore harvesters were withdrawing from the groundfishery altogether.

On the other hand, a community-based management system can potentially overcome some of the problems encountered in the regulatory approach since these communities have a better knowledge of local conditions and have proven themselves capable of a high degree of flexibility in responding to micro-level variations in resources and markets. At the same time, a community-based management system offers an intrinsic potential to ensure the conservation of resources and a more equitable distribution of resource wealth since it is in the long-term interest of the community to do so.

The lobster fishery throughout Atlantic Canada is probably the closest example to what a community-based management regime would look like. Management practices and regulations have largely been generated from the grassroots up and have widespread support among the fishing population. Despite fluctuations, the lobster fishery has proven itself to be sustainable for over 100 years, and those management practices which are oriented toward an equitable distribution of resource benefits have not overly compromised the individual gain to be derived from participation in the fishery.

At the very least, community-based management, is necessary to balance the excesses of two extremes: one based entirely on state management of the fishery, the other based entirely on individual management of the fishery. At the very most, community-based management will be the key to developing sustainable fisheries strategies where human communities are integrated into a more holistic understanding of the marine ecosystem.

However, to more fully understand this notion of community-based management and its implications for the development of underutilized species fisheries, it is necessary to highlight one further aspect of fishing communities. Up until this point I might have given the impression, or you might have jumped to the conclusion, that coastal communities are relatively homogeneous entities of uniform characteristics and a common collective will. Nothing could be further from the truth. One of the reasons for the failure of fisheries management is the view that this homogeneity exists and that management plans can be developed that are a "good fit" for all fish harvesters. Even the widely heard dictum that "there are too many fishermen chasing too few fish" implies that all fishers are more or less the same and that the removal any one of them would be a step in the right direction toward fleet rationalization.

The expression that 100 fishers in a room will express 100 different points of view on any issue comes closer to the reality of coastal communities. For, in fact, fishing communities are characterized by a very high degree of diversity and this diversity occurs at a number of levels. Within a particular community, this diversity can be seen in the types of fisheries production, in the social relations of production, in household organization and gender relations, in the cultural representation (or ideology) of fishing, and in the political practices and organization of the residents. The diversity found at these different layers of social, economic, and political life leads to highly complex interactions and outcomes within the community.

For example, the diversity existing at level of the forms of production and social relations in inshore fishing enterprises is particularly relevant to a consideration of underutilized species development. From an anthropological perspective, inshore enterprises (that is, vessels under 45 feet in length) can be broadly classified as falling into one of two forms of production; either petty commodity production or capitalist production. The distinguishing features of these two forms of production are not so much in the scale of their operations but in the social relations that exist within the enterprise. Thus in the case of petty commodity production there is a more equal sharing of the returns to the enterprise among the captain/owner and rest of the crew and less hierarchical relations among crew members than is found in a capitalist enterprise. In a study I conducted in Digby County, Nova Scotia, the net incomes of captain/owners in enterprises that were of the petty commodity form of production were as low as only one-third greater than the non-owning crew on the vessels. In a few cases, inshore fishers formed partnerships where there was a completely equal sharing of returns. In contrast, the net incomes of captain/owners in capitalist enterprises were typically two to four times that of the other crew working on the vessels. In short, petty commodity production is oriented toward providing a comparable livelihood for all fishers on the vessel and has thus been referred to by some as a livelihood fishery whereas capitalist production is oriented toward accumulating an economic surplus for the owner, and the economic needs of the crew come second to servicing the needs of capital.

While the external appearance of these two types of enterprises may not seem greatly different to the outside observer, these two forms of production and their associated social relations have a direct and significant role in determining the differing responses and views of fish harvesters concerning fisheries development, the role of government and fish buyers in this development, and the need for fisher organizations. In addition, other independent socio-cultural variables, such as community egalitarianism and an exploitative relation to the women in the fishing households, result in still deeper layers of differentiation and complexity in the views and responses of fishers. And finally, many fishing enterprises exhibit a mix of features from both petty commodity and capitalist production, and thus these intermediate forms contribute further again to the diversity of social, economic, and political organization in fishing communities.

Thus, in reference to the development of underutilized species, this discussion leads to one simple but crucial point. Fishing communities must not be treated as homogeneous entities, and how and where underutilized species fisheries are inserted into these communities will very much influence the eventual outcome of their development. Are licences for underutilized species to be given to petty commodity producers or capitalist producer or both? Will their distribution depend on chance or political influence? It is argued here that it is not for natural scientists, economists, or anthropologists to decide. Nor is it a decision to be made by fisheries managers. Consistent with the three-fold notion of sustainability described above, it is a decision that must be made by the community itself in order to ensure the sustainability of that community and the livelihoods and resources associated with it.

Some might argue that the diversity existing in these communities would make consensus and collective decision-making impossible. In fact, this diversity is the greatest asset of these communities. The flexibility and resiliency exhibited by these communities over decades and centuries are directly attributable to this diversity. And it is this diversity that can potentially empower them to seek a variety of social and economic options for a sustainable future. For over four decades, this empowerment has been thwarted by the reality that the decisions most affecting these communities have been made elsewhere, and community residents have resorted to competing with each other to find the favour of distant decision-makers to act in their individual interest. Initially, this entrenched dependence on government benefactors and the trend toward individual self-interest may pose serious obstacles to the fruition of community-based management and community-driven development. But with the delegation of substantial decision-making powers to communities and the establishment of appropriate mechanisms for consensus-building and local decision making, community-based management may offer the only viable path toward a comprehensive and meaningful realization of sustainability.

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