Natural Sciences and Engineering Research Council of Canada

Conseil de recherches en sciences naturelles et en génie du Canada

FORM 101
Application for a Grant
PART I

Institutional Identifier			
System-ID (for NSERC use only) 90455000			Date 2008/10/01
Family name of applicant Schneider	Given name David	Initial(s) of all given names C	Personal identification no. (PIN) **Valid** 17993
Institution that will administer the grant Memorial Univ. of Nfld		Language of application [X] English [ ] French	Time (in hours per month) to be devoted to the proposed research / activity 15
Type of grant applied for Strategic Projects		For Strategic Projects, indicate the Target Area and the Research Topic; for Strategic Networks and Strategic Workshops indicate the Target Area. Healthy Environment and Ecosystems / Exceptional Opportunity Outside the Research Topics	

Title of proposal
Reproductive Relative to Economic Value in Sustainable Fisheries Management: Lobsters in Newfoundland

Provide a maximum of 10 key words that describe this proposal. Use commas to separate them.
Sustainability, Lobsters, Fisheries Management, Reproductive Value, Population Biology, Marine Invertebrates, Crustaceans

Research subject code(s)		Area of application code(s)	
Primary	Secondary	Primary	Secondary
4702	7003	400	

CERTIFICATION/REQUIREMENTS

If this proposal involves any of the following, check the box(es) and submit the protocol to the university or college's certification committee.

Research involving : Humans [ ] Human pluripotent stem cells [ ] Animals [X] Biohazards [ ]

Does any phase of the research described in this proposal a) take place outside an office or laboratory, or b) involve an undertaking as described in Part 1 of Appendix B?

[ ] NO [X] If YES to either question a) or b) – Appendices A and B must be completed

TOTAL AMOUNT REQUESTED FROM NSERC

Year 1	Year 2	Year 3	Year 4	Year 5
107,978	139,710	105,896	0	0

SIGNATURES (Refer to instructions "What do signatures mean?")

It is agreed that the general conditions governing grants as outlined in the NSERC *Program Guide for Professors* apply to any grant made pursuant to this application and are hereby accepted by the applicant and the applicant's employing institution.

Applicant

Head of department

Dean of faculty

President of institution (or representative)

Applicant's department, institution, tel. and fax nos., and e-mail

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The information collected on this form and appendices will be stored in the Personal Information Bank for the appropriate program.

PROTECTED WHEN COMPLETED

Version française disponible

Date submitted to RGO: 2008/10/01

Canada

Personal identification no. (PIN)	Family name of applicant
Valid 17993	Schneider

SUMMARY OF PROPOSAL FOR PUBLIC RELEASE (Use plain language.)

This plain language summary will be available to the public if your proposal is funded. Although it is not mandatory, you may choose to include your business telephone number and/or your e-mail address to facilitate contact with the public and the media about your research.

Business telephone no. (optional): 1 (709) 737-8841

E-mail address (optional): a84dcs@mun.ca

The American lobster (Homarus americanus) fishery has a landed value of $ 550 million/year in Atlantic Canada, and has long been a mainstay of inshore fishers. In Newfoundland, the industry has undertaken a number of measures aimed at sustainable harvest, notably the adoption of a maximum size limit in 4 fishing areas and locally-supported closed areas within one of these areas and three other fishing areas. We propose to use reproductive value to evaluate the efficacy of these measures. Reproductive value is an established concept in population biology but has not been applied to fisheries, due largely to data demands. It is thus more suited to evaluation of risks and policy than to ongoing assessment. Reproductive value combines the mortality and fecundity schedule to quantify the value of the individual to the population. It thus differs from standard assessment methods, such as yield per recruit, which focus on biomass and economic value. The goals of this research will be: (1) Calculate stage- age- and size specific reproductive value of lobsters in Newfoundland; (2) Identify major sources of variation, notably geographic variation in fecundity at size, molt schedules, and mortality schedules; and (3) Identify the upper and lower size limits that maximize reproductive value relative to landed value; (4) Estimate the spatial scale at which small closed areas increase reproductive value of lobster populations; (5) Promote stewardship on the science basis of reproductive value relative to economic value.

Second Language Version of Summary (optional).

INTRODUCTION

The fishery for lobster *Homarus americanus* in Atlantic Canada has an economic value of *circa* $550 million/year. In Newfoundland, beyond its landed value of *circa* $22 million/year, the fishery has considerable socio-economic value in rural communities, with 2900 license holders. The North American fishery, like the lobster fishery in Scotland (Lizárraga-Cubedo *et al.*), is regulated by minimum landing size (MinLS). The MinLS is 82.5 mm carapace length in the US, with similar limits in much of Canada set by export requirements to the US. The historic objectives of MinLS have been to maximize yield per recruit and to avoid landing functionally immature individuals. Following recommendations (FRCC 1995) to increase egg production, the industry in Newfoundland has undertaken several resource enhancement initiatives. One is a mandatory maximum landing size (MaxLS) of 127 mm in four lobster fishing areas (LFAs) from Cape Ray northward to Big Brook on the west coast of Newfoundland. Another is small closed areas in 3 LFAs on the east coast of Newfoundland, and in one LFA on the west coast. MaxLS results in a slot fishery –removals within a defined size range. The result has been a management regime with two implicit management objectives: (1) increasing yield per recruit via MinLS; (2) reducing the risk of recruitment overfishing through some combination of MinLS, MaxLS, and local refugia. Because large lobsters produce substantially more eggs than do small lobsters, MaxLS can be expected to far outweigh MinLS in avoiding recruitment overfishing.

The science basis for management of lobsters, like other crustacean capture fisheries, has historically relied more on assessment of trends in indices of abundance than on assessment of the underlying dynamics (Smith and Addison 2003). The use of age-structured analytic models has been limited by problems of aging animals that regularly moult the exoskeleton, leaving no permanent record as with the otolith of a fish. Dynamic age-structured models require catch at age (or catch at length or stage, as these are related to age). Projections of catch from age-structured models are built on the matrix formulation and equilibrium concepts of Leslie (1945). The principal impediment to application of this approach is the absence of a relation between recruitment and number of spawners (Wahle 2003). Leslie's demographic formulation was drawn from the earlier non-equilibrium (evolutionary) formulations of Fisher (1930), who combined survival and fecundity at age x to estimate reproductive value R_x. This quantifies the value of an individual to the population, as a function of fecundity appropriately discounted for expected mortality. R_x increases up to a characteristic age (size), then decreases. In contrast, economic value continues to increase with size (age). When considering resource sustainability in a capture fishery the value of the individual to the population is an appropriate complement to the use of dollar value of the individual.

The principal impediment to the application of this novel approach to science based sustainability in a crustacean fishery is aging of individuals. Because of the substantial literature on lobster fecundity at size, molt schedules, and mortality schedules in the northwest Atlantic, it is feasible (Incze *et al.* 2003) to estimate stage specific survival and hence reproductive value. Our goal will be to compare stage specific R_x to economic value to evaluate the combined economic and sustainability objectives of two locally adopted management regimes (closed areas and MaxLS). Recognizing the substantial socio-economic value of the lobster fishery, we will use this novel approach to foster stewardship on the science basis of reproductive value relative to economic value.

RESEARCH PLAN

Objectives. The long term objective of the project is to develop the science basis for considering both economic and sustainability objectives in capture fisheries by calculating reproductive value relative to economic value. Reproductive value of the individual to the population addresses sustainability by providing an appropriately weighted measure of the contribution of the individual to the population. The short term objective is to apply this approach to lobsters in Newfoundland. The first specific objective is to calculate stage- age- and size-specific reproductive value of lobsters. The two components of R_x are the survival l_x and fecundity m_x schedules. The latter is easily estimated while the former is difficult when individuals cannot be aged directly. The feasibility of constructing life tables has been demonstrated for both the European lobster *Nephrops norvegica* (ICES 2001a) and *H. americanus* (French McCay *et al.* 2003). Several methods (French McCay *et al.* 2003, Incze *et al.*, Chen *et al.* 2005) have been used to construct the mortality schedule. French McCay *et al.* (2003) used average l_x and m_x schedules to quantify the impact of an oil spill on lobster population on lifetime egg production. R_x weights offspring (*e.g.* egg) production by expected survival, resulting in a measure of the value of an individual to the population. The approach we propose does not require knowledge of survival from first stage pelagic larvae to settlement, for which there is no known relation. Pre-settlement survival is critical to any attempt at projecting biomass response to a management intervention. It is not critical to the approach we propose, provided depensatory mortality does not occur. Recruitment to the benthic stage is independent of first stage larval production, and thus not depensatory.

The second specific objective is to identify the major sources of variation in reproductive value. In the northwest Atlantic fecundity at size (Ennis 1981, Ennis 1985, Estrella and Cadrin 1995), molt schedules (Comeau and Savoie 2001, Caddy 2003), and mortality schedules (Incze *et al.* 2003) vary spatially and temporally. The relative contribution of fluctuations in these components to fluctuation in R_x is unknown.

The third specific objective is to identify the upper and lower size limits that maximize reproductive value relative to landed value. Despite the relevance of the $l_x m_x$ schedule to evaluation of slot fisheries, a search of the literature failed to turn up any references with explicit treatment of the topic.

The fourth specific objective is to estimate the spatial scale at which small closed areas increase reproductive value of lobster populations. Within the Eastport marine protected area (MPA) in eastern Newfoundland, lobster population density, size, and proportion of ovigerous females increased in one closed area; density increased in a second closed area with no increase in female size of proportion of ovigerous females (Rowe 2002). At another closed area in eastern Newfoundland (Leading Tickles, Notre Dame Bay) the 13mm difference in average size between closed areas compared to open areas resulted in a 43% increase in eggs per individual (Jones *et al.* 2007, unpublished reports to DFO). While this achieves the goal of increased egg production (FRCC 1995) the impact of this increase on population recruitment cannot be calculated in the absence of a relation of recruitment to spawners (Wahle 2003). In contrast, the impact on reproductive value can be calculated. A rough calculation suggests that the reproductive value of lobsters inside a closed area will be equivalent to the reproductive value of lobsters in 10^2 -10^3 times that of the closed area.

The fifth specific objective is to promote stewardship on the science basis of reproductive value relative to present and future economic value. In recent years, fish harvesters and their organizations have been given greater control over science and management as fish harvester ecological knowledge has received more attention than in the past (Gendron *et al*. 2002; Neis and Felt 2002). These changes have been accompanied by reduced economic and scientific support from government and thus greater accountability among harvesters for biological and economic outcomes. Lobster harvesters' continuing investment in stewardship initiatives is mediated by local leadership, b y effective communication between harvesters, scientists, and managers, by co-management structures, by early and appropriate intervention, and by indications that these investments are paying off (Acheson 2003; Rowe and Feltham, 2002; Davis, Whalen and Neis 2006). At present, in many areas, rising fuel and equipment costs, low prices and retirements are threatening to undermine the collective ability and willingness of harvesters to continue to make these investments in stewardship in some areas, thereby increasing the need for evidence of their economic and biological effectiveness.

Core Group Expertise. The core group will consist of the principal investigator (Schneider), social science co-investigator (Neis, attached SSHRC data form), industry collaborator (Jarvis, attached letter of support), field coordinator (Wilke, attached data form). Schneider and Neis have a 15 year record of productive collaboration, as evidenced by co-publication at the interface of marine ecology and dynamics of rural communities. The proposed research is an extension of the CURRA (Community University Research for Recovery Alliance) funded to Neis by SSHRC. Neis and Schneider have been working with Jarvis for two years under the auspices of CURRA, with less formal interactions before that. The work will be carried out within the geographic locus of the CURRA project, centered at the Bonne Bay Marine Station of Memorial University on the west coast of Newfoundland. Wilke (attached data form) has been responsible for project management of 3 seasons of community based lobster research at Leading Tickles and Eastport, including managing the field effort, liaison with the community and DFO Oceans, analysis of data, and writing of technical reports. Schneider, Neis, and Wilke (since 2006) have together a successful record of integrating students into community based research. The substantial level of collaborative experience within the core group will allow new personnel (post-doc, MSc students, summer students) to be easily and productively integrated into the project. Roles and contributions of the core group, FFAW personnel (responsible to Jarvis), and students (supervised by Schneider and Neis) are listed in the research design narrative.

Research Design. The first specific objective will be met by constructing R_x from field and literature data (post-doc, Schneider), evaluating sensitivity to assumptions (post-doc, Schneider), comparison to alternative modes of estimation (post-doc, Schneider), field verification of the model (Wilke, MSc student, FFAW technicians), and finally construction of R_x in five zones extending along most of the coast of western Newfoundland from south of Port Aux Basques to nearly the northern end of the Great Northern Peninsula (post-doc, Schneider),. The zones are LFA12 (no MaxLS), LFA13A (MaxLS), LFA13B (MaxLS and closed area), LFAs 14a and 14B (MaxLS). The modeling effort will start with the highly parameterized approach of French McCay *et al.* (2003), which will be used to investigate overall sensitivity to components and to parameter values. In particular we will investigate the effects of the available range of values of a parameter, the effects of improved estimation (Chen *et al.* 2005), and rank components of the model as to effects on R_x. We will also consider alternative parameterization of components, such as that for moult schedule (Caddy 2003). We will also determine how much depensatory mortality is required to nullify any gains in reproductive value relative to objectives 3 and 4.

The m_x schedule will be parameterized in the conventional way, as a regression of fecundity on size. Estimates are already available for LFAs on the west coast of Newfoundland (Ennis 1981). Our experience (Jones *et al.* 2007) has been that current data (from LFA6) are consistent with published estimates. The results of the modeling effort will guide us in whether to parameterize the l_x schedule in preference to using l_x from size-specific catches in a fishery with a high exploitation rate.

At the same time as this effort, we will begin field efforts (Wilke, Jarvis, Schneider, post-doc and students) to measure components that we know are lacking, most notably fecundity schedules at sizes above 140 mm CL, and survival after settlement (40 – 80 mm CL). This will be undertaken as a focused study using one to three FFAW fishermen (drawn by lot) to deploy traps modified to retain lobsters less than 80 mm CL, or to allow entry of lobsters larger than 140 mm CL. We anticipate no difficulty in obtaining data on relative abundance of small lobsters (and incidentally confirming low % ovigerous at these sizes). Discussions with fishermen indicate that large lobsters will be more readily obtained in the southern than the northern LFAs. All lobsters captured will be obtained under an experimental license, measured either by trained students or by experienced FFAW technicians, and then released. We plan to obtain preliminary estimates of fecundity schedule from 16 large lobsters that were successfully captured and are currently held in tanks at the Marine Institute of Memorial University under a cooperative venture with FFAW.

Field verification of the model will occur in the second year. The second year of data will allow comparison of annual to spatial variation over a latitudinal range of nearly 400 km (LFA12 through 14B). Catch data from year 1 and 2 will be combined with prior data to calculate R_x in LFAs 12 through 14b.

The second specific objective will be met by assembling and comparing parameter estimates of fecundity at size, molt schedules, and mortality schedules (post-doc, summer student, Schneider). Estimates from the literature will be compared from estimates of fecundity at size and mortality schedules from field data.

The third specific objective will be met (post-doc, DCS) by systematically altering the slot interval (from below and above), calculating the resultant change in reproductive value of the population, and identifying maxima relative to MinLS and MaxLS.

The fourth specific objective will be met (post-doc, DCS) by calculating the reproductive value of the population inside and outside closed areas using data already gathered from closed areas at Eastport and Leading Tickles (Rowe 2002, Jones *et al.* 2007). Estimates of lobster density over a fully fished season, with negligible catch at the end of the season, will be used to estimate area for which the population reproductive value in small closed areas matches that outside closed areas.

The fifth specific objective will be met (Neis, MSc student, Wilke) by a combination of interviews,and feedback sessions structured to allow coastal communities and commercial fishers to shape an evolving science agenda. Interviews, which lie in the scope of this project, will aim at understanding evolving fishing practice and elucidating the values and community dynamics responsible for adoption of MaxLS in some LFAs. It is anticipated that discovery of mutual values (fishers, scientists) together with regular communication of science results, as shaped by community concerns, will foster stewardship of lobster populations by those that benefit from this resource .

Project Plan and Management. The project will be managed by the principal investigator (Schneider) and co-investigator (Neis), working closely with our industry collaborator (Jarvis) and with the project coordinator (Wilke). Students will be joining a cohesive group with a history of success in collaborative research. Further cohesion derives from alignment of this project with the goals and activities of a larger SSHRC funded project (CURRA) that is now in its second year. This project is led by Neis, with Schneider being an active participant. In addition to secretarial support and logistics of community meetings, CURRA provides a larger community of social and natural scientists working on similar resource based issues on the west coast of Newfoundland. The key feature of the management plan is the 6 month review cycle built into the milestones, which were developed in discussion with FFAW (H. Jarvis). We will use this cycle to bring in 3 outside advisors to work with us in conjunction with CURRA activities. Two leading lobster biologists (Dr. Lew Incze, Dr. Robert Steneck) have confirmed their interest in traveling to Newfoundland as advisors. We expect to recruit as a third advisor, a leading researcher in the social organization of fishing communities, Dr. Jim Acheson, who has worked with Dr. Steneck in Maine. Roanne Collins (Science Branch, DFO) has confirmed her interest (attached letter of support) in participating in the research. She will play an important role in planning and review meetings outlined in the Milestones. Our assessment of costs of field work is based on similar activity that has been funded by DFO Oceans over the past three summers. The milestones were developed to allow interplay of the modeling effort with field work in the relatively short time frame of 3 years.

TRAINING OF HIGHLY QUALIFIED PERSONNEL. Students will undertake their degrees within the larger intellectual community of CURRA, which consists of *circa* 20 social and natural scientists addressing sustainability issues on the west coast of Newfoundland, centered at the Bonne Bay Marine Station of Memorial University. The post doc will be responsible for developing the model, working with the principal investigator. The MSc and BSc honours students will be undertaking field projects that are critical to the modeling effort. There are several ways in which the priority research needs can be allocated among students. The most likely arrangement is that one MSc student will focus on fecundity (large lobsters), while the other focuses on survival during ontogeny. The honours student (first year of project) will likely focus on survival of small lobsters. The meeting cycle outlined in the Milestones is expected to facilitate identification and planning of suitable projects with high priority relative to the success of the project, as it evolves. The post-doc and students will be working closely in the field with fishermen and with FFAW technicians, thus creating a collaborative research effort. All students will participate in the community feedback sessions described below. Students will be participating in research directly related to a clear public good, stewardship of natural resources.

COLLABORATION. The collaborative arrangements in this project are a natural extension of the CURRA project, in which University researchers have been working closely with fishing communities on issues of resource sustainability and survival of rural communities. The supporting organization for this project (FFAW) is a key component of the CURRA project. FFAW (Jarvis, Spingle) participated in setting the science agenda for both CURRA and this project. Roanne Collins (Lobster Biologist, Science Branch, DFO) will participate in the research and link it to management activity at Fisheries & Oceans Canada. The Province of Newfoundland and Labrador, through IBES (Institute for Biodiversity, Ecosystem Science & Sustainability), has expressed interest in funding a student in the project. We have been collaborating with Dr. Richard Wahle on measuring recruitment, and while that is not the focus of this project, we expect to continue this. In our discussions with FFAW, we felt that a 6 month cycle of project review would best address continued collaborative planning of the research. A key component of knowledge transfer will be community feedback sessions organized by CURRA, for which we have budgeted the travel of people from this project. Feedback sessions will be undertaken within the larger scope of the CURRA project. Lessons learned will be incorporated into marine ecology and stewardship training modules for professional fish harvesters to be developed through the CURRA. Similarly, information about the research and its findings will be disseminated to harvesters and others through community radio broadcasts and new fisheries curriculum for high school students that will be developed through the CURRA. We see this project as a novel approach to stewardship, in that it begins with an industry initiative (closed areas and MaxLS) and from there develops an appropriate science basis. There is no intellectual property agreement.

BENEFITS TO CANADA AND THE FISHING INDUSTRY. The fishing industry in this province has changed radically since the collapse of cod stocks. Of particular note has been the development of collaborative arrangements among university and DFO scientists, and with this, has come growing science capacity within the FFAW. This project furthers the trend of collaborative research arrangements, and we thus expect both a long-term and a short-term benefit from the project. The short-term benefit will be providing science-based answers to the question of whether community-driven resource enhancement initiatives (closed areas, MaxLS) are effective. The longer-term benefit is the increased capacity of both industry and academia to undertake collaborative activity involving university students in research relevant to people make a living from the sea.

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