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Proceedings Series 2011/020 | **Compte rendu 2011/020**

Regional Advisory Process on European Green Crab, (*Carcinus maenas*), Populations and Mitigations in the Newfoundland and Labrador Region

March 17, 2010
Clovelly Golf Club, St. John's, NL

Meeting Chairperson
Earl Dawe

Rapporteur and Editor
N. D. Templeman and T. Wells

Processus de consultation scientifique régional sur les populations de crabes verts Européens (*Carcinus maenas*) et sur les mesures d'atténuation à Terre-Neuve

Le 17 mars 2010
Clovelly Golf Club, St. John's, T.-N.-L.

Président de la réunion
Earle Dawe

Rapporteur et éditeur
N. D. Templeman et T. Wells

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September 2011 | **Septembre 2011**

Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings include research recommendations, uncertainties, and the rationale for decisions made by the meeting. Proceedings also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

Avant-propos

Le présent compte rendu a pour but de documenter les principales activités et discussions qui ont eu lieu au cours de la réunion. Il contient des recommandations sur les recherches à effectuer, traite des incertitudes et expose les motifs ayant mené à la prise de décisions pendant la réunion. En outre, il fait état de données, d'analyses ou d'interprétations passées en revue et rejetées pour des raisons scientifiques, en donnant la raison du rejet. Bien que les interprétations et les opinions contenus dans le présent rapport puissent être inexacts ou propres à induire en erreur, ils sont quand même reproduits aussi fidèlement que possible afin de refléter les échanges tenus au cours de la réunion. Ainsi, aucune partie de ce rapport ne doit être considéré en tant que reflet des conclusions de la réunion, à moins d'indication précise en ce sens. De plus, un examen ultérieur de la question pourrait entraîner des changements aux conclusions, notamment si l'information supplémentaire pertinente, non disponible au moment de la réunion, est fournie par la suite. Finalement, dans les rares cas où des opinions divergentes sont exprimées officiellement, celles-ci sont également consignées dans les annexes du compte rendu.

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ISSN 1701-1272 (Printed / Imprimé)
ISSN 1701-1280 (Online / En ligne)

Published and available free from:
Une publication gratuite de :

Fisheries and Oceans Canada / Pêches et Océans Canada
Canadian Science Advisory Secretariat / Secrétariat canadien de consultation scientifique
200, rue Kent Street
Ottawa, Ontario
K1A 0E6

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

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Correct citation for this publication:

DFO. 2011. Proceedings of the Regional Advisory Process on Green Crab, *Carcinus maenas*, Populations and Mitigations in the Newfoundland and Labrador Region; March 17, 2010. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2011/020.

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SUMMARY

The European green crab, *Carcinus maenas*, was first discovered in Newfoundland in 2007. Over the last several years, green crab populations in the Region have become established in areas where they have the potential to cause significant ecological and economic impact if left uncontrolled. The potential impacts associated with establishment of green crab in Newfoundland have gained the attention of communities, governments, stakeholders and the media. A Regional Advisory Process was organized to bring together all available scientific information on green crab in Newfoundland, and to inform and guide Regional policy makers, managers, stakeholders and communities.

The process compared scientific experiences from other Canadian Regions and outside of Canada. The status and trends of green crab populations in Newfoundland were summarized, compared with other areas of invasion, and information on potential mitigations, control mechanisms, and areas requiring further research were identified.

This advisory process was held on March 17, 2010 at Clovelly Golf Course Gazebo in St. John's, NL. Participants included those from Science, Policy and Economics, and Oceans, Habitat and Species at Risk Branches of the Department of Fisheries and Oceans, as well as individuals from Provincial governments, academia, and communities. Special participation included those that attended via internet from California and Oregon, USA and Dalhousie University, Canada.

SOMMAIRE

Le crabe vert (*Carcinus maenas*) a été observé pour la première fois à Terre-Neuve en 2007. Au cours des dernières années, les populations de crabes verts se sont établies dans la région dans des zones où elles peuvent avoir un impact écologique et économique important si elles ne sont pas gérées. Les impacts potentiels associés à l'établissement des crabes verts à Terre-Neuve ont retenu l'attention des collectivités, des gouvernements, des intervenants et des médias. On a organisé un processus de consultation scientifique régional pour rassembler l'information scientifique disponible sur le crabe vert à Terre-Neuve ainsi que pour informer et orienter les décideurs régionaux, les gestionnaires, les intervenants et les collectivités.

Le présent processus a permis de comparer les expériences scientifiques acquises dans d'autres régions au Canada et à l'étranger. Il résume aussi l'état des populations de crabes verts à Terre-Neuve et les tendances qu'elles affichent, comparativement à d'autres zones envahies, et on a relevé l'information sur les mesures d'atténuation potentielles, les méthodes de lutte et les secteurs pour lesquels de plus amples recherches sont nécessaires.

Le présent processus de consultation scientifique a eu lieu le 17 mars 2010 au pavillon du Clovelly Golf Club, à St. John's, T.-N.-L. Parmi les participants, mentionnons des reperésentants des Directions des sciences, des politiques et de l'économie et des océans, de l'habitat et des espèces en péril du ministère des Pêches et des Océans ainsi que des gouvernements provinciaux, des universités et des collectivités. Au nombre des participants spéciaux figurent ceux qui ont pris part à l'exercice *via* Internet et qui proviennent de la Californie et de l'Oregon, aux États-Unis, ainsi que de l'Université Dalhousie, au Canada.

INTRODUCTION

Dr. Atef Mansour, acting Division Manager of Environmental Sciences, opened the meeting by welcoming meeting participants on behalf of the Regional Director of Science and the Regional Science Branch of the Department of Fisheries and Oceans (DFO). Thanking everyone for attending the meeting, he encouraged a productive meeting with respect to the Terms of Reference (Appendix 1). Dr. Mansour also outlined the CSAS guidelines for advisory processes, reminding participants that discussions and conclusions throughout the day should be limited to issues pertaining to science and the provision of science information and advice related to green crab. Management considerations were not an aspect of the terms of the day's plenary.

The Chair also welcomed and greeted meeting participants and suggested a roundtable of introductions before formally addressing the items of the agenda. Following introductions the Chair referred to the agenda, pointing out that the focus of the morning session would be on green crab populations and impacts while the focus of the afternoon session would be on control measures and mitigations. It was recognized that the agenda was ambitious and that there was much information to be covered through the course of the meeting. The patience and understanding of participants was requested should items have to be addressed slightly out of order or timing to that of the agenda. Again, it was noted that the purpose of the meeting was not to provide advice to management on management measures, but to define potential impacts of green crab and determine the effect of measures/options for green crab control in NL.

At the start of the meeting it was briefly noted that this issue (referring to a species population that has yet to be fully assessed, and that aims to explore and provide information on potential mitigations) in comparison with previous CSAS Regional Advisory Processes (that include mainly stock assessments) would largely be new territory in providing information and advice to Regional managers. It was also expressed that this could be an opportunity to assist in setting the standard for how meetings of this nature could be carried out in the future in the Region.

MORNING SESSION – GREEN CRAB POPULATIONS AND IMPACTS

ECOLOGICAL ASSESSMENT OF THE INVASIVE EUROPEAN GREEN CRAB, *CARCINUS MAENAS*, IN NEWFOUNDLAND: 2007-2009 POPULATION DYNAMICS & ECOLOGICAL IMPACT

Presented by Cynthia McKenzie

Green crab was first discovered in Newfoundland in North Harbour, Placentia Bay by Earle Johnson in August of 2007. Earle quickly contacted the Department of Fisheries and Oceans who confirmed its identification. An initial rapid assessment of the area indicated the presence of a large population. Upon this discovery an ecological assessment was carried out generally in the months of June and September from 2007-2009. The assessment, initiated by DFO Science, resulted in a large collection of data from various sources, including Memorial University Ocean Sciences Centre (OSC) and Marine Institute (MI), the Department of Fisheries and Aquaculture (DFA), Fish, Food and Allied Workers (FFAW), stewardship partners and local groups.

The primary focus for the green crab ecological assessment in Newfoundland was to explore population dynamics (distribution and abundance, habitat preference, behaviour, and

reproduction), ecological impact in high concentration areas (on biodiversity and habitat), and potential mitigation or control methods. The assessment made use of traps, diver transects, shoreline surveys, beach seine, tagging experiments, gut content analysis, eelgrass surveys, and discussions with fish harvesters, harbour authorities and the general public. Environmental data was also collected during the assessment.

Surveys in 2007-2008 confirmed the existence of green crab populations in other northern areas of Placentia Bay, however, surveys targeting other areas of the province (south, west and northeastern coasts) did not detect the presence of green crab at that time. Dive transects in North Harbour found most of the green crab population was present in inshore waters (<10m). It was suggested that substrate changes (from sandy substrate with patchy eelgrass to rocky habitat after 50 + m) may discourage this species from moving further offshore.

The ecological assessment in North Harbour in 2007 indicated the presence of a large green crab population and biomass, and provided the motivation to create and carry out a mitigation plan in 2008. The traps used during the DFO survey in 2007 were modified whelk pots, but were switched to the more standardized Fukui traps during mitigation in 2008.

In 2008 a standardized longline experiment was initiated and was based on similar longline studies of green crab in British Columbia. The size distribution of green crab collected through the longline experiment suggested they have been present in Placentia Bay (specifically North Harbour) for at least 4-5 years. Literature suggesting a growth increment of ~20% each year correlates with this theory.

The genetic origin of the green crab population in NL is currently under investigation. Previous studies by Roman et al. (2006) suggest green crab populations in the NE USA were earlier introductions to North America from warmer Mediterranean climates and differ from those introduced to the Maritimes (from a colder, northern European population). Initial results from the genetic analysis of NL green crab samples suggest that these populations are most closely linked to those from Halifax, NS.

Complex circulation patterns in Placentia Bay are highly dependant on wind pattern (Ma et al 2010) and may aid in dispersal of green crab populations throughout the bay.

In 2009, reports of green crab in Bay St. George on the west coast of NL were confirmed by DFO Science. The largest population of green crab in the Bay St. George Region was observed in Little Port Harmon and the greatest concentrations were encountered in an eelgrass and mussel bed. Comparatively, the catch in Little Port Harmon was much lower than that in North Harbour. Key concerns in the Bay St. George area include the potential for green crab to suppress existing initiatives for the protection of the Banded Killifish and lobster and eel fishing areas.

In Placentia Bay juvenile green crab hide primarily among kelp and rocks in the intertidal zone, while adults are typically caught in shallow subtidal areas. Male:Female ratios are closer to 50:50 in September, more males typically appearing in June.

An analysis of Atlantic rock crab (*Cancer irroratus*) and green crab gut contents found clams and polychaetes in both species, but as major components of green crab stomachs. What appeared to be juvenile lobster leg joints were also found in the stomachs of both species.

Aerial photos taken of 3 locations in northern Placentia Bay for comparison to historical eelgrass surveys show decreases in eelgrass habitat in Goose Cove and the head of the Bay in North Harbour where green crab exist.

Discussion

Questions arose surrounding the absence of 35 mm green crab in the population distribution and whether or not this could be due to a bad year class or environmental influence. The presenter explained that the cause of absence of this size class is uncertain, but it was suggested that the mesh size in the traps was too large and/or predation targeting that specific size of green crab.

Discussions moved to whether or not there exists a density by size or by depth relationship for green crab in Newfoundland. As this information was not available through the current monitoring program, consideration of modifying the sampling design to better standardize gear and effort was recommended to obtain more accurate population density estimates. The presenter stated that green crab numbers are so high in some Newfoundland locations that getting a gradient has been difficult. Population density was highlighted by the group as a key information gap and will need to be addressed further in order to move forward with mitigation efforts.

ACOUSTIC TELEMETRY TO TRACK GREEN CRAB

Presented by Curtis Pennell

Summary

Green crab collected in Placentia Bay, NL during the fall of 2007 and early summer of 2008 indicated a much greater % of males in traps than females. Movement of female green crab was a concern, particularly during the fall/winter following mating. In 2008, a study was conducted to determine whether female green crab migrated to deeper water for the winter OR remained in shallow water in the area of release and burrowed in the sand/sediment.

Observations during the 2007 and 2008 surveys suggested that the native rock crab, *C. irroratus*, had an overlapping range with the invasive green crab and were potentially being displaced or becoming a prey species for this invader. Reports of green crab being found in lobster traps either consuming the bait or the trapped lobster led to concerns regarding the overlap in range for green crab and American lobster (*Homarus americanus*) in the area. The objective of the 2009 study was to determine the overlap in range between green crab, rock crab and lobster in Goose Cove.

Tagging studies in 2008 targeted 14 recently moulted female green crab in an attempt to determine female movement and their possible overwintering strategies. Tagging studies in 2009 targeted 8 rock crab, 3 green crab (both male and female) & 2 lobsters in Goose Cove. Vemco acoustic transmitters, with signals transmitted every 4 minutes, and a detection range of 200-400 m were used in both study periods. Periodic tracking using a manual Vemco VR100 tracker was also conducted to provide more precise locations.

Female green crab tended to stay in shallow water close to the release site, moving to deeper water in the fall but remaining in or near the coves. Crabs released on one side of the bay moved to the other side days later, which could correspond with mating/moulting of females

and/or freshwater inputs. There also appears to be a correlation with temperature decrease and decreased movement (a question of potential burrowing) in the winter. Movement to deeper water was correlated to sharp temperature decreases during the study period. Tagged rock crab showed more movements than green crab and moved to deeper water (2-3m+). Whether this was due to natural inclination or avoidance could not be determined. Both tagged lobster stayed in Goose Cove – lobsters stayed in the general area of release and moved less overall.

Discussion

In comparing the 2008 and 2009 tracking efforts, it was questioned whether or not tracked animals were all females – and whether or not they were carrying eggs. If this was not the case, a set difference in the results presented could exist.

To ensure tag retention in the females, soft shelled – recently moulted female green crab were captured and held in secured cages in North Harbour until their carapace hardened. When fully hardened, acoustic tags were secured to the dorsal side of the carapace. Crabs were then released back into the study area.

With respect to results presented on rock crab movements it was discussed whether or not this species was moving more due to the presence of green crab in the area. The presenter explained that there was no clear indication of why this was happening in the results to date.

Corey M. stated that this type of experiment really requires 50-60 tags to get an accurate representation of movement patterns due to the natural variability in movements of some species. For example, movement variability has been demonstrated during cod tagging experiments that have been ongoing for several years now. In that, subsequent steps could tease out movement patterns for further investigation from initial tracking efforts. The presenter concluded the discussion by stating that information gathered from this acoustic work on green crab is expected to improve with the increase in the number of transmitters available for use beginning this year.

DEMONSTRATED EFFECT OF EELGRASS LOSS UPON NEARSHORE NEWFOUNDLAND FISH COMMUNITIES IN THE CONTEXT OF INVASIVE GREEN CRAB

Presented by Corey Morris

Eelgrass is declining and disappearing around the world in distribution and abundance – however eelgrass in Newfoundland appears stable or increasing. Eelgrass habitat can be found all around the island of Newfoundland, particularly in sheltered areas. Eelgrass generally occurs in shallow water, but can occur down to 11m around Newfoundland. Habitat provided by eelgrass along the coast is highly productive and a haven for juvenile fish of many species, with most fish found in the 3-5m zone.

One of the many benefits of eelgrass in Newfoundland is that it provides cover, which greatly reduces mortality rates of inhabiting species. However, eelgrass has many functions and values in addition to providing preferred nursery habitat to juvenile fish, including cod and others – eelgrass also contributes to primary production, oxygen production, epibenthic and benthic production, sediment stabilization, and nutrient uptake and storage. In turn, eelgrass beds improve water quality and support the food web. Eelgrass has recently been identified as an ecologically significant species by DFO in Canada.

To demonstrate the effect of eelgrass on NL fish communities information was presented based on the combined work of multiple individuals and projects related to eelgrass habitat, predator-prey interactions and fish community interactions that were conducted in the region. Long term monitoring of nearshore habitat and communities, paired with manipulation experiments have been carried out on the east coast of NL at Newman Sound. Results have shown that communities associated with eelgrass are fairly stable; and age 0 gadoids along the NL coast are most abundant in complex habitats such as eelgrass compared to non-complex habitats such as sandy and mud substrates. Eelgrass removal and enhancement experiments have shown that cod densities decreased in the absence of eelgrass, and abundance increased with the presence of artificial eelgrass. Similar effects were observed for other members of the fish community, including larger cod, Rock Cod, hake, and cunner. However, three species, Winter Flounder, Rainbow Smelt, and sculpins, were unaffected or negatively affected by eelgrass.

Scientific literature indicates that green crab behavior can negatively affect eelgrass habitat. While green crab are not directly attracted to eelgrass, their behavior can negatively impact eelgrass. They tend to burrow around the eelgrass, disrupting the roots allowing the eelgrass to float away. Green crab may also cut the shoots, destroying the eelgrass blades. A study by Davis et al (1998) found that 39% of viable eelgrass shoots were lost within one week of exposure to high green crab densities (4-15 crab per square meter) during a mesocosm study in Great Bay Estuary, New Hampshire. While there is little experimental or scientific measurement of green crab effects upon eelgrass in Placentia Bay or elsewhere in NL, the behavior of green crab and their effect on habitat is probably similar across areas. However, the habitat value of eelgrass could be different across areas. For example, eelgrass is generally not used by Atlantic Cod in New Hampshire whereas eelgrass is perhaps a preferred habitat for juvenile Atlantic Cod in Newfoundland.

Discussion

Although this presentation was based on eelgrass research as opposed to green crab research, it was felt that the information provided was highly relevant to identifying ecological impacts of green crab invasions in Newfoundland and Labrador.

Since eelgrass beds have been demonstrated to support increased biomass of juvenile fish in coastal habitats in NL and green crab behavior has been demonstrated to negatively affect eelgrass beds it is intuitive that green crab may have a negative impact on many fish species.

Participants wanted to know what the overall percentage of survival for juvenile Atlantic Cod is in eelgrass habitat in Newfoundland. The presenter explained that through studies of cod survival in various habitat types, it has been shown that the survival of juvenile cod in eelgrass is much greater than non-complex sandy or barren substrates. The 90 day survival rate of juvenile cod in eelgrass, compared to coarse and/or barren bottoms is ~17,000 to 1, as suggested by Dr. Robert Gregory.

EUROPEAN GREEN CRAB IN BRITISH COLUMBIA - POPULATION AND IMPACT

Presented by Tom Therriault

The European green crab is ranked among the 100 worst invaders by the IUCN. This species arrived on the West Coast of North America in packing material in San Francisco in 1989, and invaded British Columbia (BC) waters in 1998/99 through natural weather events (El Nino) that transported larvae up the coast. Dedicated tracking of this species in BC did not begin until

2006, although pre-2006 distribution information (mainly for West Vancouver Island) does exist from anecdotal reports.

Dedicated coastwide trapping surveys in BC began in 2006 making use of the Fukui folding trap baited with herring. Distributions have been found to be concentrated along the west coast of Vancouver Island with pockets/hotspots within, especially at the northern and southern limits. Notably, high catch rates are correlated with decreased salinity, and no green crab have been obtained from inside or mainland waters (Strait of Georgia and Johnstone Strait). Male size frequency in 2006 and 2007 found most crabs to be between 50-70 mm carapace width. Poor recruitment in 2007 has been anecdotally linked to a coastwide event, and recruitment appeared to be better in 2008, but lessened again in 2009.

The Genetic Algorithm for Rule-set Production (GARP) model for determining environmental niches for species (green crab in this case) found that much of the BC coast is potentially suitable habitat for green crab invasions. Particle tracking models also show the potential for dispersal along the coast of BC to be northward in winter months and southward in summer months.

Spatial distribution studies in Pipestem Inlet in BC, an area similar in size to North Harbour, NL, accounted for 5 crab species – 4 native *Cancer spp.* and the invasive green crab. In BC, concerns exist about potential impacts of green crab on Dungeness crab (*Cancer magister*) which has a substantial commercial fishery in the area. It was observed that the niche for green crab in this area is up to 5 m (only larger green crab moving into deeper waters on occasion). Most green crab are found substantially shallower in the intertidal zone where few native crab species are found. While there is some overlap in distribution with the graceful crab (*Cancer gracilis*), *C. gracilis* are unable to cope in lower salinity waters. Therefore it is likely that salinity more so than depth or temperature determines the potential for interactions between the two species.

Tagging studies conducted in BC found that larger Floy tags (3") inserted into the right gill chamber along the suture line can be removed by green crab. Therefore, smaller Floy tags (3/4" anchor) which last for one or more moults have been used for these studies recently. However, this type of monitoring requires many tags out and many tags in to obtain significant results.

Green crab risk assessments have shown that the highest impacts are on marine and estuarine biodiversity and shellfish aquaculture – and therefore should be priority directions for future research (Therriault, 2008). On the west coast, other risks of spread include the potential for bivalve shellfish products to act as a potential vector in the Region, and natural events such as El Nino which have been linked to the arrival of green crab in BC in the past.

Discussion

With respect to the use of Floy tags for studies on green crab in BC, participants asked what percentage of tags were recovered during their mark recapture study. The presenter stated that tag recovery in these studies was about 15% - with approximately 400 tags recovered. Sex, size, color, joint color, shell thickness, and damage (to shell and/or claws) were recorded, similar to protocols carried out for studies on Dungeness crab in the Pacific Region. Further to the BC protocol, traps were typically set for 18 hours. Typically 4 to 6 groundlines with 6 traps per groundline at 10 m spacing were set. Most groundlines were set parallel to shore to encompass most of the intertidal zone where the majority of green crab are known to occur but

an additional line or two are set cross-shore to confirm presence/absence with confidence during sampling.

It was also noted during the discussions that the red rock crab (*Cancer productus*), a species of the same genus as the Atlantic rock crab that occur in NL, are caught during this sampling.

With respect to the Genetic Algorithm for Rule-set Prediction (GARP) model for determining environmental niches for species distribution (green crab in this case) on the BC coast, it was further explained that 10 variables (4 temperature, 4 salinity, annual oxygen, and annual chlorophyll a) were used to formulate BC risk assessments. The risk assessment model is used to determine potential spread and to better focus monitoring activities.

Notably, the GARP model showed the entire province of NL is susceptible to invasion by green crab during a 2008 analysis.

Focusing on the movement of green crab, it was questioned how far green crab would travel to reach baited pots and whether or not increasing effort (number of traps) would be worthwhile. According to the presenter this is unknown on the west coast given the sampling design. However, from observation, movement of green crab into traps during the Newfoundland sampling program is quick (e.g. often less than 30 minutes in areas with high relative density). From this discussion, it was noted that in NL there IS a saturation point to increasing the number of traps set. Again, gradients are unable to be determined in areas where green crab relative density is high in NL.

A HISTORY OF GREEN CRAB IN THE SOUTHERN GULF OF ST. LAWRENCE

Presented by Erica Watson

The study of green crab in the southern Gulf of St. Lawrence (sGSL) follows the premise of that for other Regions: the potential for serious impacts on ecosystem, fisheries, and aquaculture through predation, competition, and habitat modification; ranges that continue to expand; and uncertainty surrounding potential vectors and impacts.

In Atlantic Canada, the first wave of invasion originated from Maine and occurred between 1951 and 1954 in the Bay of Fundy. In approximately 30 years green crab had spread north along the Atlantic coast of Nova Scotia. A new invasion of green crab from the northern part of the European range likely occurred during in the late 1980s. This strain appears to be much better adapted to colder temperatures than the original strain – a likely explanation for their rapid spread throughout Cape Breton Island, PEI, the Northumberland Strait, the Magdalen Islands and Newfoundland during the 1990s and early 2000s.

Researchers at McGill University predicted that temperatures are suitable for green crab spread throughout most of Newfoundland and Labrador in addition to the entire sGSL (www.geog.mcgill.ca/climatechange). In Atlantic Canada (up to and including 2007) the annual rate of spread has been quite variable with an average value of 23 km per year, yet this species is capable of larger jumps in dispersal, e.g. 100 km in a year, from hitchhiking or dispersal of the planktonic larvae by currents.

Common patterns in the sGSL have been noted from the literature and recent studies. Protected embayments are occupied in all invasions and the most significant effects are observed in embayments/estuaries. All green crab invasions that have been studied have

shown effects on bivalve mollusks, most have shown effects on native crabs, and few have shown (or measured) effects on fishes. Prey preferences have also been consistent: Mollusks > crustaceans > polychaetes > green algae; and among mollusks: bivalves > gastropods. Green crab have not been found to eat echinoderms in these studies.

Adverse effects of green crab invasions from Atlantic studies include: reduction in densities of prey species (158 genera, including several commercially important ones), competition with other predators (e.g. decapods and shorebirds), damage to coastal habitat (sediment burrowing and eelgrass destruction), and interference with trap fisheries (e.g. American Eel fishery). Positive effects of the presence of this species include scavenging discards, some biofouling control in aquaculture, and fisheries (in other countries).

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The sGSL green crab ecosystem impacts study ran from 2001-2003 and had two objectives: 1) to determine the distribution of green crab in the sGSL; and 2) to test predictions for sGSL estuaries with respect to green crab effects on invertebrate prey, effects on competition with other crabs, shrimps and fishes, and effects on habitat (specifically eelgrass meadows). A synoptic survey of 24 estuaries, focusing on those with eelgrass meadows in lagoon environments, was the basis of this study. Biodiversity of nearshore fishes and above-ground invertebrates was significantly reduced, but confounded by eelgrass biomass effects. It was unclear what percentage reduction was due to green crab vs. unrelated eelgrass decline. Enclosure experiments in Caribou Harbour, NS were carried out and aimed to determine the cause and effect of green crab presence. Results indicated that green crab presence in the enclosures significantly reduced invertebrate biomass and a number of taxa, but there was no significant effect of green crab on eelgrass biomass. The most significant reduction in total invertebrate biomass occurred in 8 of 19 taxa studied, including 4 gastropod, 1 polychaete, 1 crab, and 2 shrimp species. Notably, there was no effect on bivalves, *Tellina sp*. and *Macoma sp*.. Significant avoidance (movement away from green crab) was demonstrated by the gastropod *Nassarius trivittata* and shrimps of the genus Palaemonetes. The main taxa in gut contents were gastropods and polychaetes.

Other research in the sGSL focused on the predation of green crab on bivalves. Enclosure experiments in Pomquet, NS showed densities as low as 1 crab/m^2 could remove 80 percent of soft shell clams smaller than 17mm (Floyd & Williams, 2004). Lab experiments on mortality of bivalves showed a reduction in biomass of a variety of prey species (Miron et al., 2002).

In studying the possible impacts of green crab on fisheries in the sGSL, anecdotal information related to the eel fishery supports the idea that the effects of green crab on this fishery tend to be confined only to areas of high green crab densities such as eastern PEI. In the meantime, no evidence of any impact of green crab on rock crab and lobster fisheries exist. Lab experiments carried out in the Maritimes region also concluded that the presence of green crab did not reduce trappability of rock crab. Since there is very little habitat overlap between green crab and lobster there have been no formal studies on this topic.

Management measures in the sGSL include issuance of “nuisance species“ permits for the removal of green crab in an effort to protect vulnerable fishery resources. Other potential management requirements may be necessary given that green crab have spread to areas with strong American oyster wild fisheries and bottom culture. At the same time, work on product development for green crab has not yet resulted in a viable product or market; there is also pressure for and against the commercial fishing of this species.

The presenter provided an example of an unsuccessful introduction of green crab in Malpeque, PEI. Reportedly, green crab were accidentally introduced into an eel pound with incoming eels, but were spotted by local fishermen and destroyed. Since that time no additional sightings of green crab have been reported from that area. The fishermen spotting them, identifying them, and taking immediate action probably prevented what might have been an introduction event.

Discussion

Based on the presentation, conclusions from the sGSL studies are preliminary. Caution should be taken in assuming that no loss of eelgrass occurred in areas occupied by green crab in the green crab ecosystem impacts study. Green crab in this region were very small and might not have as significant an impact as has been demonstrated in other studies in other areas.

In an effort to compare populations between Regions it was questioned whether or not significant numbers of rock crab were caught at the same time as green crab in the sGSL studies, since there is an obvious inverse relationship between the presence of green crab and rock crab in NL. This was not the case in the sGSL. Studies were conducted in habitats that either didn't have, or had very few, rock crab so they represented a very small portion of the bycatch.

MORNING SESSION – SUMMARY AND DISCUSSION

In addressing the bullets for the conclusions resulting from the meeting, it was noted that the NL Region is wary of speaking to the cause of introduction of green crab by ballast water. However, the Newfoundland Region has a substantial shipping industry; millions of tons of ballast water had been discharged in the Placentia Bay region during the years experts agree green crab may have been first introduced (McKenzie et al., 2010). Additionally, literature sources have indicated ballast water as a vector in green crab introduction. It was agreed that evidence of introduction of green crab by ballast water is not concrete; green crab were likely introduced by anthropogenic means, probably through vessel traffic. In the ensuing Science Advisory Report (SAR) introduction by anthropogenic means through vessel traffic should be highlighted as the most likely transport vector for green crab to Newfoundland.

It was discussed whether or not it would be more appropriate for summary bullets relating to the comparison of green crab populations and mitigation studies across Regions to be addressed in detail by presenters following the meeting discussions. However, it was determined as the meeting progressed that as much detail as possible would be noted through the subsequent discussions throughout the remainder of the day and would be featured in the Proceedings documentation. Later confirmation from presenters would be most useful to confirming the bullets derived within.

Before the morning session came to a close participants formed a consensus on 2 key points: i) green crab are a new and recent aquatic invasive species in NL. They have become established, continue to spread, and require continued monitoring; ii) the biology and ecology of green crab within Placentia Bay is consistent with other Regions/areas (e.g. BC) but several orders of magnitude greater in relative abundance.

Additional conclusions from the morning session were expected to be integrated with the discussions in the afternoon and with confirmation from presenters following the meeting.

AFTERNOON SESSION – GREEN CRAB MITIGATIONS AND CONTROL

The afternoon session welcomed meeting participants from University of California, Davis, Portland State University, and Dalhousie University through the use of WebEx (an internet based conference tool). This technology allowed the new participants to actively see, hear, and participate in presentations and discussions taking place at the meeting venue in St. John's, NL.

GREEN CRAB CONTROL – MITIGATION EXPERIMENTS IN PLACENTIA BAY, NL

Presented by Cynthia McKenzie

The Newfoundland and Labrador Region AIS Science Strategy is based on the AIS Rapid Response Framework developed through Regional collaboration within Fisheries & Oceans Canada (Locke et al., 2009).

Mitigation Options include:

- Contain the problem to a given area;
- Suppress the population to slow its spread;
- Develop management strategies to keep the species at an abundance below an economic or ecological threshold;
- Learn to adapt with the problems caused by the species

Eradication of green crab is no longer considered as an option in Placentia Bay. Efforts are now focused on the above mitigation options. After investigating the potential of biological and chemical control methods, a 2008 Workshop on Green Crab Mitigation in NL recommended control methods utilizing 1) local fish harvesters to remove green crab from affected areas; and 2) community groups or school groups as part of a communication and "beach clean up" program in affected areas. From these recommendations, control methods including experimental harvesting (2008-09), education and communication (through schools, harbours, and stakeholders), and experimental licenses and stewardship have been utilized.

A targeted removal experiment in 2008-09 was led by the Fish, Food and Allied Workers (FFAW) in collaboration with federal and provincial fisheries and Memorial University of Newfoundland. Traps were provided by DFO. Participants were allowed 20 traps each at 2 sets per day. Mitigation areas included Area 1 (North Harbour), Area 2 (Goose Cove), Area 3 (west side of the head of North Harbour), and Area 4 (east side of the head of North Harbour). Phase 1 (P1) in July 2008 = 12 days; Phase 2 (P2) in Sept 2008 = 10 days; and Phase 3 (P3) in July 2009 = 9 days (targeting berried females). P1 and P2 removed a total of 25,000 pounds of green crab, while P3 removed a total of 6,000 pounds.

Decreases in catch rate and size over time occurred in both Areas 1 and 2 (e.g. decreased by half in 9 days in 2009) and there was a significant increase in the longline catch of rock crab following removal of green crab. In 2009, likely due to warmer environmental conditions, green crab were observed earlier in the spring (May vs. June) and ovigerous females also appeared earlier in the year (July vs. September). The experimental removal exercise supported the concept of reducing green crab numbers through overexploited fishing. It also provided evidence that rock crab presence increases in the absence of green crab (likely through release of competition), and provided information on the behavior of green crab (e.g., seasonal biological cycles; habitat preferences, especially in the case of reproductive females; determining most effective time of year yielding the maximum catch, etc.)

Through the education and communication strategy students from Swift Current Academy took part in a beach zone survey/cleanup of green crab in North Harbour. 2 students were assigned an area of 100 m in which green crab were collected. Other organisms encountered were counted and recorded. This survey provided information on local green crab (especially the juvenile population) and other coexisting flora and fauna populations. Results from the survey found only green crab, amphipods and seaweed existing on test beaches compared to nearby control beaches that contained other organisms (e.g. periwinkles, etc).

Experimental licences were issued in 2009 to concerned fish harvesters that wanted to assist with green crab surveys and mitigation. One dedicated fisherman in Long Hr. set 10 traps/day for 1 month to gain green crab population information from the eastern side of Placentia Bay. While DFO captured < 25 individuals in 2007 in the same area, total green crab numbers from this effort totaled 25,000 – and provided trends data indicating a decrease in green crab catch rate over time.

It was noted during plenary that there is some variability in the results as they are presented because experimental licence data was displayed as catch per hour, yet the removal experiment results were presented as pounds per hour.

Discussion

It was questioned whether or not correction factors were used in the analysis of targeted harvests when mean weight was going down over time. For example, were larger, heavier crab taken out first? The principle investigator felt that larger crab were removed first as they are more aggressive and territorial. Over time, results show that trapped crabs did decrease in size. As a matter of interest it was noted that it would take approximately 75 of the smallest crab to make one pound.

The discussion moved to the subject of the elusive female green crab. In 2007 information on females was very much a mystery. Females comprised only a small portion of the total catchable population (~10%). Through the mitigation experiments much more information has been obtained on females in the population. Late July to early September has been identified as the period most likely to catch female green crab (however it is still uncertain how attractive bait is to berried females).

It was highlighted that in some other Regions sampling does not catch berried females at all, even through employing 50-60 traps. In NL females were usually caught specifically at -1 to +2 feet. Previous surveys have shown females will not approach traps when large males are present. When females do occur in traps, it is theorized that they entered the trap first, with males entering later, thus males and females are then found in those traps. Cover (shelter) in traps also appears to be an attractive feature for female crab. Seining or setting traps filled with *Ulva sp.* are reportedly the best methods for capture of females or small juveniles, and minnow traps can be better suited for females and smaller juvenile crab by keeping larger crab from entering.

It was recommended that in reporting on mitigation, the interpretation of data must take into consideration that size distribution decreased as the mitigation progressed. As larger adult crab are removed from the population, juvenile crab numbers may increase due to decreased predation. For this reason a multi-year (at least 2-3 year) mitigation would be necessary.

GREEN CRAB MANAGEMENT: A REMOVAL EFFORT IN A SHALLOW CALIFORNIA ESTUARY

Presented by T. Grosholz

A removal effort in Bodega Hr., California, USA (a harbour similar in size to Goose Cove, Placentia Bay, NL) investigated the feasibility of removing a locally established population of green crab. Green crab have occupied the area since 1993 and trapping in Bodega harbour has been taking place for 13 years – with intensive removal efforts for 3 years (2006-2009).

Removal efforts in Bodega Hr. made use of hand capture, seine, open coast trapping, snorkeling, baited traps and habitat traps (with *Ulva sp.,* eelgrass and pipe traps). While many methods were tested in Bodega Hr., baited traps (Fukui and minnow traps) were most successful. Minnow traps excluded larger crab and allowed better access to berried females and juveniles. 13,770 green crab were captured in 2 years (much lower number than that found in NL surveys) after which a significant drop in abundance was observed. Overall, the population was 85% smaller a year after removal began; with decreased effort, the population in Bodega Hr. is now 1/3 its original size.

Notably, during the effort catch per trap dropped by 66% within 6 weeks, similar to that observed in Placentia Bay efforts. Also similar to NL, a spike in juveniles was noticed after taking out larger adults due to predation release. Based on this, removal efforts should continue for at least 3 yrs to target influx of these juveniles.

Mark-recapture methods have also been used in Bodega Hr. Mark IV wire tags were injected into green crab and can last through several moults. These tags are expensive and cannot differentiate between more than two sites or dates. Elastomer tagging is cheap and easy but does not last as long as wire tags. In total, 1477 green crab were marked. However, results of mark recapture population estimates (11,930) were less than first year removals (12,794).

Discussion

At the request of participants an explanation of compensatory recruitment was provided again by the presenter. For a number of species, there exists this relationship: through the substantial reduction in the adult population there is a resulting reduction in the predation on juveniles (i.e. mortality decreases significantly for juveniles). In turn, by end of year 3 there should be a significant reduction in the number of reproductively mature adults. It was felt that this was a key point in addressing removal efforts during the meeting.

GREEN CRAB CONTROL EXPERIMENT AT BASIN HEAD

Presented by Erica Watson

The Basin Head Marine Protected Area (MPA) in PEI in the sGSL consists of a lagoon that is connected to the Northumberland Strait by a narrow neck. It has a long “arm” that extends for a few kilometers inside a barrier dune. A science review in 2009 suggested two scenarios that could explain a recent decline in the Irish Moss (*Chondrus crispus*) beds in the MPA. One scenario was increased nutrient input (possibly from land agriculture) leading to an increase in algal blooms and poor water quality; the other was predation of the mussel population (which acts to anchor the Irish Moss) by green crab. The goal of the experiment at the Basin Head

MPA was to reduce green crab abundance, allowing an increase in the blue mussel population, thus encouraging an increase in Irish Moss abundance.

Experiments at Basin Head used Fukui, minnow and modified eel traps at 5-6 sites. Minnow traps were dropped from the survey when they caught only Mummichogs. Manual removal was used in the arm of the MPA to avoid further disturbance of existing Irish Moss. A gradual decline in CPUE was observed until catch rates spiked in October and November. Green crab were still active in December, although in low numbers. The October/November increase is similar to that observed in other areas and could be due to outmigration from the arm during this time. Total catch in 2009 was almost 12,500 crab (compared to 2000 during a 2001 ecological assessment of the lagoon).

Mussel recruitment seemed to have been negatively impacted during this time. A very low proportion of <55 mm length mussels were observed. This size is known to be vulnerable to green crab predation. Abundance was not measured during this study, but qualitatively appeared low. Low numbers of soft shell clams in the 20-65 mm range were also evident which was consistent with mussels of a similar size range. Investigators are waiting to receive results on possible effects of disease on mussel and clam health. Mussel and soft shell clam work done during the same time has provided results indicative of recruitment failure.

Further research in the upcoming year is planned for Basin Head including: continued trapping and removal of green crab with the addition of earlier spring trapping, attempts to estimate abundance, and possibly acoustic tagging.

Discussion

No discussion ensued following this presentation.

GREEN CRAB CONTROL IN KEJIMKUJIK SEASIDE NATIONAL PARK

Presented by Kristina Benoit

Green crab research was conducted in Little Port Joli Bay, in a south shore lagoon in Kejimkujik Seaside National Park, Nova Scotia. Little Port Joli Bay is a mudflat, sandy, lagoon system that extends up into Basin Lake. Valued ecosystem components in the area include eelgrass and soft-shelled clams. Eelgrass is declining annually; with a 43% decline in 2008-09 and a total loss of 90% since 1987. A gap in the population structure of soft shell clams has also been detected recently indicating low recruitment.

2009 was the first sampling year in Little Port Joli Bay. The current green crab monitoring protocol includes 14 permanent sampling sites. Sampling periods were conducted during August, September and October with 4 consecutive 24 hr periods per month using modified eel and modified minnow (opening widened to 2 cm) traps. Modified minnow traps were removed from the long-term monitoring protocol as smaller size classes were still reflected in the larger traps. Still, small minnow traps may be useful for capturing green crab with a carapace width of roughly 10 to 45 mm. Other sampling techniques were deemed not feasible in Little Port Joli Bay.

A 50% reduction in CPUE from that observed in 2009 has been set as an arbitrary threshold baseline for effective management of green crab in this area. CPUE was calculated for each trap and annual averages were determined over a 3 month sample period. Protocols and

thresholds will be adjusted as more ecosystem information is obtained after 3-5 years of monitoring.

Due to the lack of baseline data no mass removal effort has been carried out; however, Parks Canada is investigating mitigation possibilities. Mark Release Recapture studies in 2008 using visible implant elastomer provided very few recaptures (9 out of 1816) and more males captured than females.

Discussion

Participants were interested in how CPUE was calculated using the Little Port Joli Bay protocol. The presenter explained that the minimum distance between traps was 25 meters, reducing the interaction/proximity factor. CPUE was calculated both on an hourly and daily scale. The hourly data was easier to communicate to the public as it was given in whole numbers; it was also useful since some trapping days were more or less than the ideal 24±2 hours (discrepancy due to weather events). Additionally, in questioning what information was obtained on bycatch, it was noted that very few rock crab were encountered during monitoring in this area. Again, the question arose as to why females are so elusive in this area, similar to experiences from other areas. Again, there was a slight increase in the observation of females in the fall.

MORNING AND AFTERNOON SESSIONS – SUMMARY AND DISCUSSION

The group felt that the day's presentations provided significant information and background to draw general conclusions about the biology and behavior of invasive green crab populations in various environments; and to make specific recommendations for monitoring, mitigation and research in the NL Region.
The green crab situation in NL does not appear to be mimicked in any other of the reported areas with respect to biomass. Could this result in the need to re-evaluate the potential for chemical options in mitigation? Currently there is not enough known about the chemical method to comment on the potential of this. However, it is anticipated that chemical control might be an "uphill battle" if recommended.

In highlighting the benefits of current activities with respect to green crab mitigation, it was felt strongly that continued fishing efforts are of utmost importance in this challenge – as proven through repeated reports of declines in CPUE. While this program is largely dependant on funding for removals, it was noted that amounts in the range of 10-20 K provided significant results and removal efforts should remain a key activity for mitigation, monitoring, and continued research.

Another option for control of this species includes trying to promote green crab removal as a commercial fishery as in some European locations (although not currently in North America). This concept has been considered, and inquiries surfaced from local restaurants that would like to try to use them. Unfortunately minimal interest was given to the idea. Interest was also expressed in using this species as bait. Reportedly, some harvesters on the southern shore of New Brunswick have yielded greater lobster catches using green crab as bait. During the discussion a fish harvester from Placentia Bay pointed out that there is no fishery (e.g. lobster) in Newfoundland, that timewise, would be able to support significant use of such baiting practices. Additional anecdotes from fish harvesters from the west coast (Bay St. George) stated that in their experience green crab are useless as even secondary bait.

Fish harvesters expressed their concerns on the impact of green crab on the scallop fishery, lobster fishery, eelgrass, clam and mussel beds. Earl J. reported the presence of green crab in lobster traps in North Harbour (finding occasional lobster eaten, or partially eaten). He also expressed concern about local scallop beds.

Over the course of the day's discussions a consensus was reached on the key points that should be communicated from the meeting through the Science Advisory Report. At a minimum the SAR should include:

1. A summary of the benefits of current mitigation efforts (i.e. changes in population structure; increased knowledge of green crab biology and behaviour).

2. A summary of the potential impacts of discontinuing current mitigation efforts in NL (i.e. increased ecological impacts – also potential threats to existing fisheries). Emphasis should be given to effects on native species (e.g., rock crab and clams) and on habitat, including eelgrass.

3. A summary of future strategies for the management of green crab in NL. For example, although baseline data is available for the last three years; it is important to indicate that through the AIS monitoring and survey program we are beginning to build a foundation of essential data which will continue to improve our understanding of this species in introduced habitats and how to effectively manage it. Making use of indicators based on conservation objectives might also be an important next step in the management of this AIS.

4. A summary of recommended next steps, specifically related to increased knowledge and population control. As an example, if we are to apply thresholds and determine the impact of green crab on eelgrass, do we simply want to minimize the destruction of eelgrass beds or do we want to set a recovery target? This is a complex issue which would require development of an intricate strategy. In the meantime, continued reporting on green crab presence/absence is an important aspect of identifying research and management requirements, and therefore, continued education and stewardship is key.

5. Green crab have been flagged as a high risk species both ecologically and economically through the National Green Crab Risk Assessment (Therriault, 2008). Given the invasive nature of green crab and currently identified impacts, the application of a precautionary approach is crucial to dealing with local populations. That is, lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation and the further spread of green crab.

6. Uncertainties – some effects of green crab invasions can be anticipated, but may not be observed immediately – for example, effects on lobster, scallops and other shellfish. There are many additional existing questions. For example, is there an effect on sticklebacks in North Harbour? There is potential for secondary and cumulative effects of green crab invasions that may not be fully quantifiable at this time.

While this meeting focused on the science related to green crab, participants from a client sector communicated that from a socioeconomic standpoint we have to be responsive as we now have an idea of the potential economic impact of green crab. Ted G. stated that a paper evaluating the economic impact of green crab on the west coast is in progress. East coast data

will not to be published at this point. In addition to the science presented during the meeting, the anecdotal evidence is also important and useful to consider in this respect.

Overall, meeting participants concurred that the benefits of having socioeconomic assessments with biological assessments (of risk) are important. Therefore, identifying and providing funds for some of these issues now could be a key activity in addressing this issue in a timely manner thereby minimizing the biological and socioeconomic impact later.

RESEARCH RECOMMENDATIONS FROM THE 2010 REGIONAL ADVISORY PROCESS ON EUROPEAN GREEN CRAB, *CARCINUS MAENAS*, POPULATIONS AND MITIGATIONS IN NEWFOUNDLAND

1. Continued reporting on green crab presence/absence is an important aspect of research on green crab populations in NL. In addition to continued education and stewardship, other methods of reporting should be investigated. Suggestions include making use of logbooks for existing fisheries (e.g. lobster fisheries) to determine distribution (as opposed to catchability) through a tick box or presence/absence record for green crab.

2. Population density is a key information gap in addressing mitigation efforts. Reporting on the level of effort required for, or the level of removal that can be achieved through various control measures requires knowledge of the absolute density of green crab populations which has not been determined in NL to this point. Risk assessments identifying areas not suitable for habitation by green crab, paired with controlled experiments, may provide some indication of required effort. This should be used as a first step only as there are many micro areas in the true environment where larval stages can settle in and then move out as they become adults.

3. Due to natural variability in movements, information gathered from acoustic tagging of green crab in NL requires improvement through increasing the number of tags to at least 50-60. In that, subsequent steps could tease out movement patterns for further investigation from the initial tracking effort.

4. Increased knowledge and understanding of the biology and ecology of female green crab is required to further understand population dynamics and potential mitigation options in NL. Since fishing down males may make females more catchable, this effort should continue; this may allow a better assessment of catchability of females using this method.

5. An investigation of secondary vector spread within and between bays is required to increase knowledge and understanding of green crab populations and potential mitigations in NL.

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APPENDIX I: TERMS OF REFERENCE

Regional Advisory Process on Green Crab Populations and Mitigations in the Newfoundland and Labrador Region

March 17, 2010
Clovelly Golf Club, St. John's NL

Chairperson: Earl Dawe

Background

Many of the science issues facing Fisheries and Oceans Canada (DFO) are associated with significant knowledge gaps and uncertainties. This, however, does not relieve the Department of the need to make decisions on these issues. Under these conditions, decisions must balance the risks and uncertainties while ensuring the sustainability of Canada's aquatic ecosystems. With the potential for Aquatic Invasive Species (AIS) to impact species at risk (SAR), biodiversity, aquaculture or fisheries resources, AIS are now considered one of the lead threats to native biodiversity (Sala et al. 2000, Dextrase and Mandrak 2006).

The Green Crab, *Carcinus maenas*, native to Europe and Africa, has been reported in the Maritimes since the 1950s, but was only reported for the first time in Newfoundland in 2007 (Klassen & Locke 2007). A highly invasive species, Green crab has yet to be formally assessed for the extent of its distribution, potential impact, or potential for control through various mitigative measures in the Newfoundland environment.

In February 2008 DFO conducted a National risk assessment to determine the potential risk posed by European green crab in Canada (see Therriault et al. 2008). This assessment included evaluating the probability of arrival, survival, reproduction and spread and potential consequences to determine a risk level based on the best available information on their biology, potential vectors of introduction, and impacts in both native and introduced ranges. The assessment concluded that European green crab generally posed a moderate to high risk on both coasts depending on the ecological endpoint assessed.

Building on the existing National risk assessment, and in recognition of the increasing threat of Green Crab in the Newfoundland Region, a peer review meeting will gather experts on these species to discuss and provide information relevant to Green Crab distribution in Newfoundland, and to explore experiences in Green Crab science and mitigations from other sources and Regions that can contribute to the assessment of Green Crab distribution, potential impacts and potential mitigations for Green Crab populations in Newfoundland. Conclusions from this process will provide DFO Policy makers and Oceans managers with the information required to refine current licensing policies and to feed into stewardship initiatives and integrated management plans for the NL Region.

Objectives

To provide an overview of current scientific knowledge related to Green Crab populations in Newfoundland.

To assess potential biological impacts of Green Crab populations in Newfoundland on native species and habitats based on current knowledge of Regional life history characteristics and distribution.

To report on mitigation measures to control Green Crab populations in Canada and assess their effectiveness in Newfoundland.

Outputs

A CSAS Science Advisory Report (SAR) and associated Research document(s) will be produced. A Proceedings document will record the meeting discussions.

Participants

Participants will include those from within and outside DFO with relevant expertise or experience in the species being discussed or other invasive invertebrates; including other Federal and Provincial government organizations, non-government organizations, academia, industry, stakeholders, and Aboriginal groups.

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APPENDIX II: MEETING AGENDA

Meeting of the Newfoundland Regional Advisory Process (RAP)
European Green Crab, *Carcinus maenas*

Clovelly Golf & Meeting Centre, St. John's, Newfoundland & Labrador
March 17, 2010

Chair: Earl Dawe

0830	Preliminaries	
0845	Greetings from the Chair	Earl Dawe
0900	European Green Crab in Newfoundland – Population and Impact	Cynthia McKenzie
0930	Using Acoustic Telemetry to Track Green Crab Movement in North Harbour, Placentia Bay	Curtis Pennell
0950	Demonstrated Effect of Eelgrass Loss Upon Nearshore Newfoundland Fish Communities in the Context of Invasive Green Crab	Corey Morris
1010	***BREAK***	
1030	European Green Crab in British Columbia- Population and Impact	Tom Therriault
1100	A history of Green Crab in the southern Gulf of St. Lawrence	Erica Watson
1120	Science Advisory Report Bullets on Population and Impact	Cynthia McKenzie
	Roundtable and Discussion	ALL
1200	***LUNCH***	
1300	Green Crab Control – Mitigation Experiments in Placentia Bay, Newfoundland	Cynthia McKenzie
1320	Green Crab Control: A Removal Effort in a Shallow Central California Estuary	Ted Grosholz/ Catherine de Rivera
1350	Green crab control experiment at Basin Head Marine Protected Area, PEI	Erica Watson
1410	Green Crab Control In Kejimkujik Seaside National Park	Kristina Benoit
1440	***BREAK***	
1500	Science Advisory Report Bullets on Mitigation/Control	Cynthia McKenzie
1520	Roundtable	ALL
1600	Discussion	ALL
1730	***ADJOURN***	

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