The northern front: Population dynamics and ecological impacts of a green crab invasion in Newfoundland

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BACKGROUND and OBJECTIVES

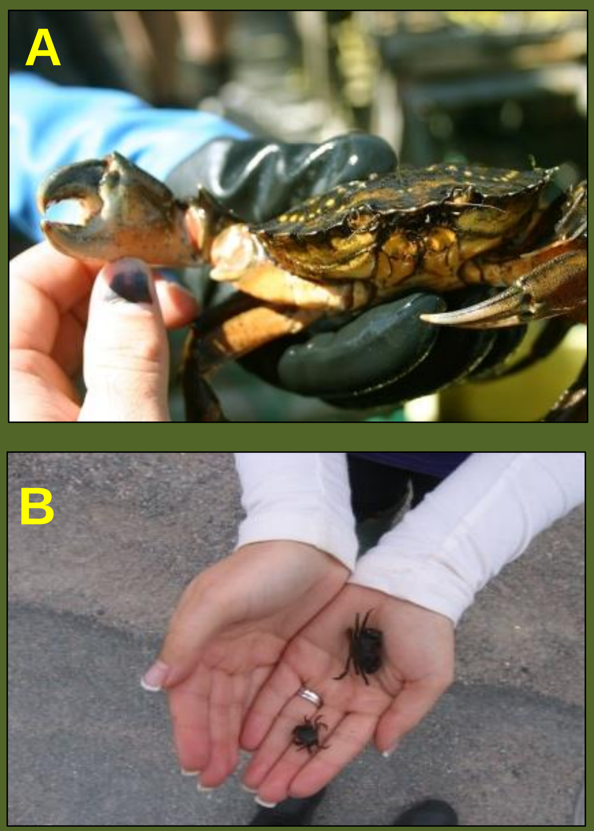


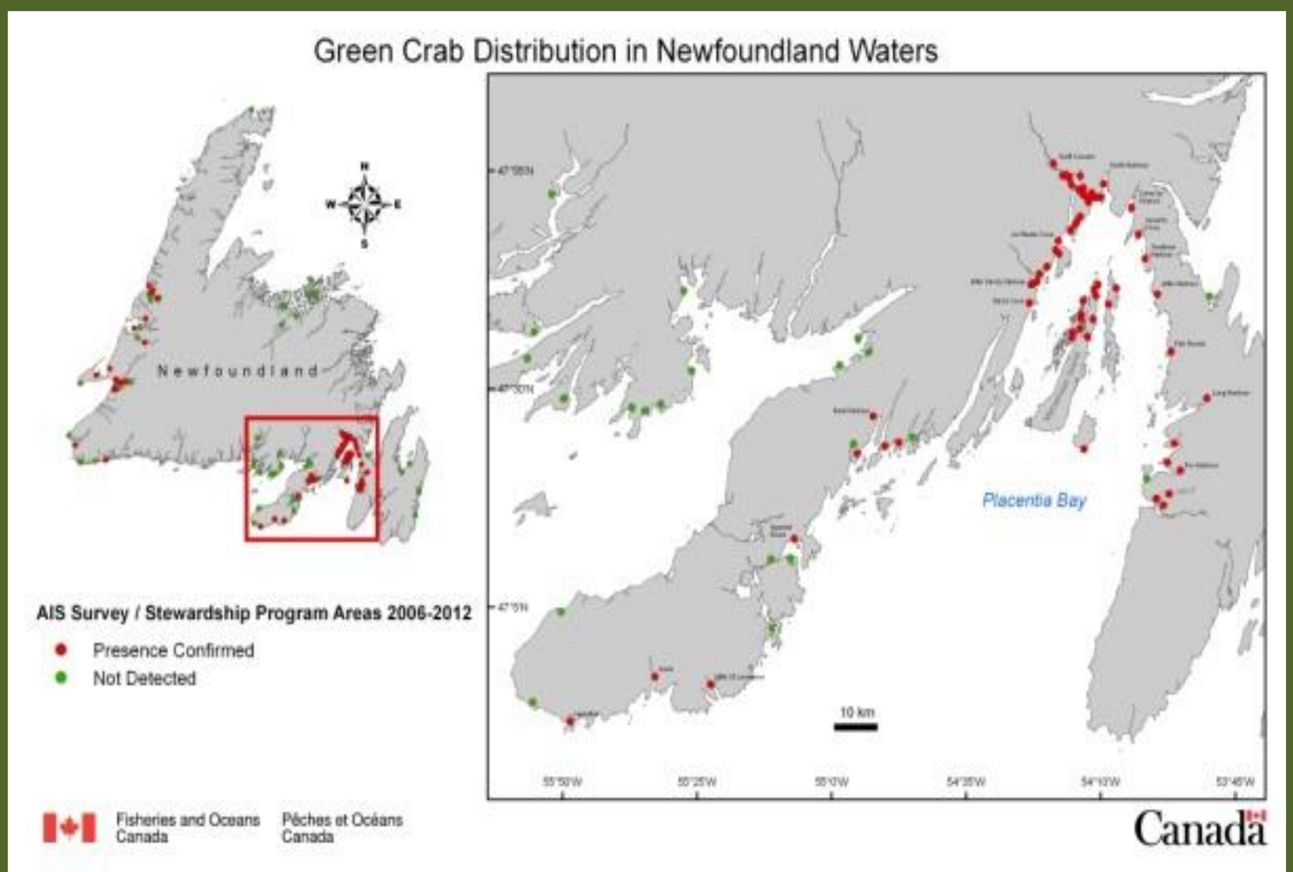
Fig. 1. Photographs of [A] adult and [B] juvenile green crab, *Carcinus maenas*.

The European green crab (*Carcinus maenas* L.) is a notorious global invasive species and has been present in coastal Atlantic Canadian waters since the 1950s. Green crab are voracious predators with a broad diet with particular preference for bivalves (1). They may also outcompete indigenous crustaceans for prey and shelter (2, 3). Invasions by green crab are partly due to its broad tolerance to changes in temperature and salinity. Early studies in its native and introduced range suggested limited northward range expansion by green crab in the northwest Atlantic because of reduced growth, reproduction, predation, and increased mortalities at cold temperatures. However, green crab was discovered in the predominantly cold water ecosystems of Placentia Bay, Newfoundland (NL) in 2007. Genetic analyses suggest that green crab successfully invaded NL as a result of separate introductions from disparate European origins (4).

Green crab presents a high risk to coastal ecosystems of NL which has raised concern about impacts to populations of indigenous species and associated fisheries (5). The DFO Aquatic Invasive Species (AIS) program works to monitor and survey population dynamics in addition to research ecological impacts of the green crab invasion in NL to determine threshold abundances of impact and develop management and mitigation strategies to maintain or decrease abundances below such an economic or ecological threshold.

POPULATION DYNAMICS

Since the discovery of green crab in the northern most regions of Placentia Bay, NL populations have spread rapidly and abundances have increased to several times those reported elsewhere in Canada and the United States (traps have captured up to 47 crab $trap^{-1}$ h^{-1}). A separate introduction likely led to the discovery (and spread) of green crab on the west coast of NL since 2009 (5).



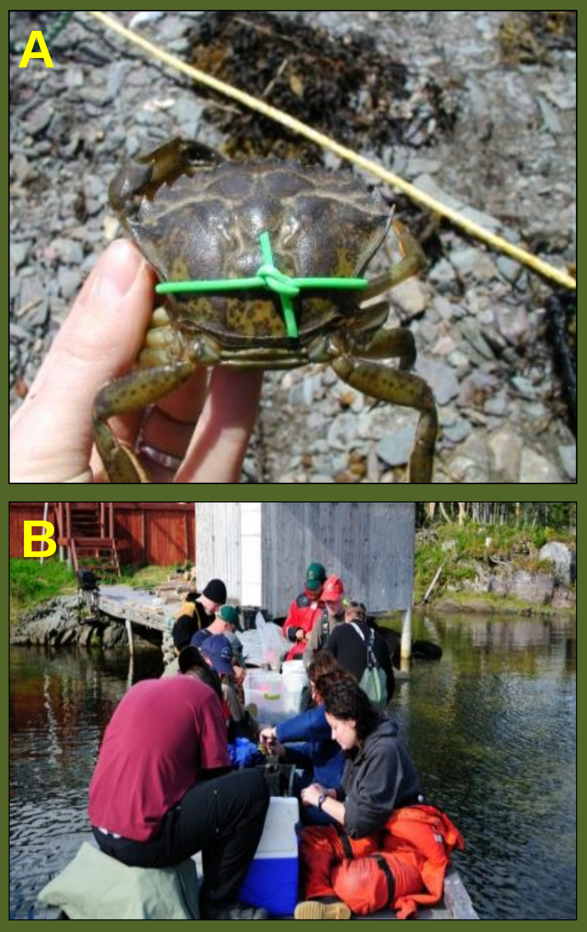


Fig. 2 (above). Map of survey locations from 2006-2012 showing the presence and absence of green crab.

Fig. 3 (right). Photographs of [A] tags used in mark-recapture study and [B] field team tagging crabs.

Mark-Recapture research: Information on green crab population density is a critical knowledge gap that can assist determining the effectiveness of mitigation attempts and threshold densities for negative impacts. In 2010, two locations in Placentia Bay were selected for mark-recapture studies to determine green crab population density. Unfortunately, low recapture rates (< 5%) of tagged green crab (3353 tagged) led to weak estimates of green crab population density in the two study areas. Future research examining population densities is required.

Acoustic telemetry: Identifying small-scale movements in green (particularly female) crab and overlap with indigenous crustaceans is critical to research seasonal and reproductive behaviours and potential interspecific interactions. Studies using acoustic telemetry showed female green crab to generally remain in shallow water, but move to deeper water and decrease further movement (possible burrowing behaviour) with declines in temperature. Rock crab moved more than green crab and moved into deeper waters (> 2-3 m) (possibly natural or avoidance behaviours).

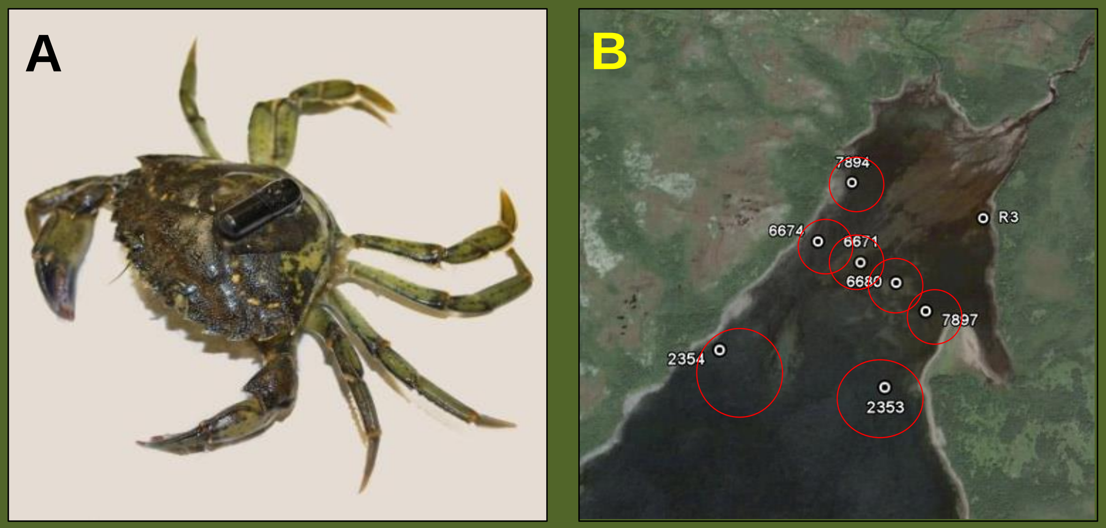


Fig. 4. Photographs of [A] acoustic tag attached to green crab using underwater epoxy and [B] example of hydrophone set-up used in North Harbour, Placentia Bay.

ECOLOGICAL IMPACT

Shellfish predation: The impact of green crab on NL shellfish, particularly juvenile scallops, is a major concern of local fish harvesters and scientists (5). Laboratory experiments showed that large green and rock crabs captured similar numbers of scallops, selected medium sized scallops (30-40 mm), and avoided small (10-20 mm) scallops. Small green crab only captured small scallops. Large green crab preferred soft-shell clams and blue mussels over scallops.

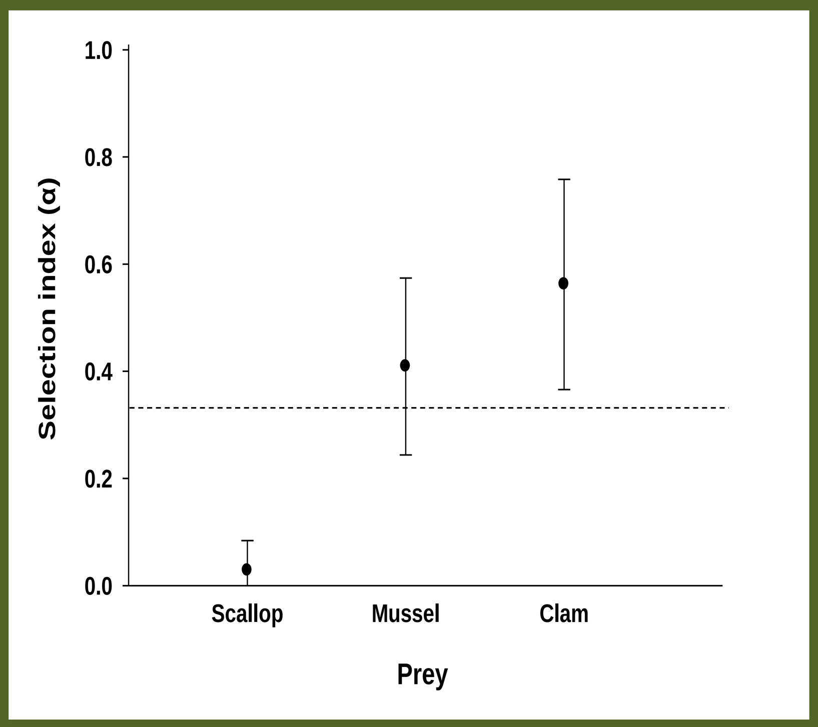


Fig. 5 (right). Mean selection index (α) in green crab for sea scallop, blue mussel, and soft-shell clam. Dashed line indicates (0.33) no size selection. α ± 95 CI above or below the line indicates significant selection or avoidance, respectively.

Fig. 6. Photograph of green crab preying on sea scallop.

Competition: Results from laboratory experiments examining competitive foraging between green and rock crab from NL suggest green crab can reduce foraging in rock crab, especially during interactions between green crab and small rock crab and in warmer waters (6). Another study demonstrated that green crab from NL are more effective foragers than long-established and genetically different populations in Nova Scotia and New Brunswick (7).

Impacts to eelgrass: In Canada, eelgrass (*Zostera marina*) is an ecologically significant species because its spatially complex structure is vital habitat for sustaining species abundance and biodiversity (8). Field surveys before and after green crab invasion indicated changes in eelgrass presence and coverage was negatively associated with green crab abundance. In fact, localized disappearance of eelgrass occurred at sites with highest abundances and longest established green crab populations. Fish abundance and biomass generally decreased and community assemblages changed at locations most impacted following green crab invasion.

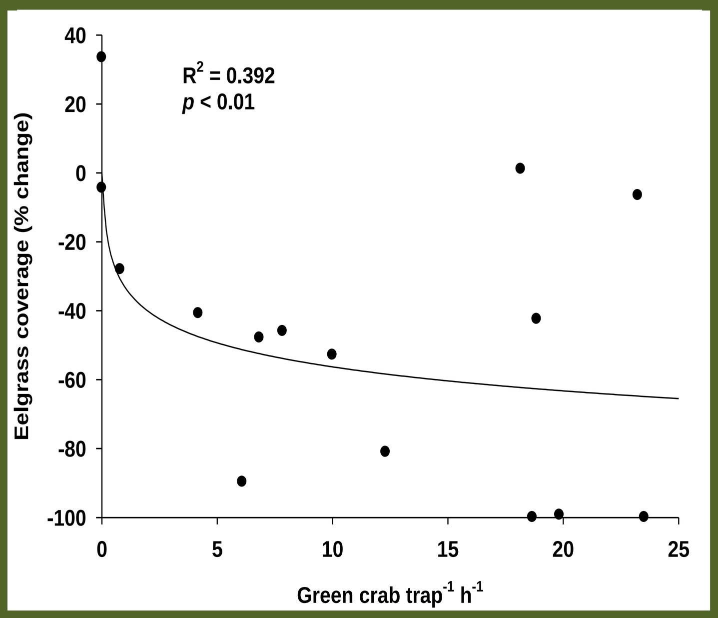
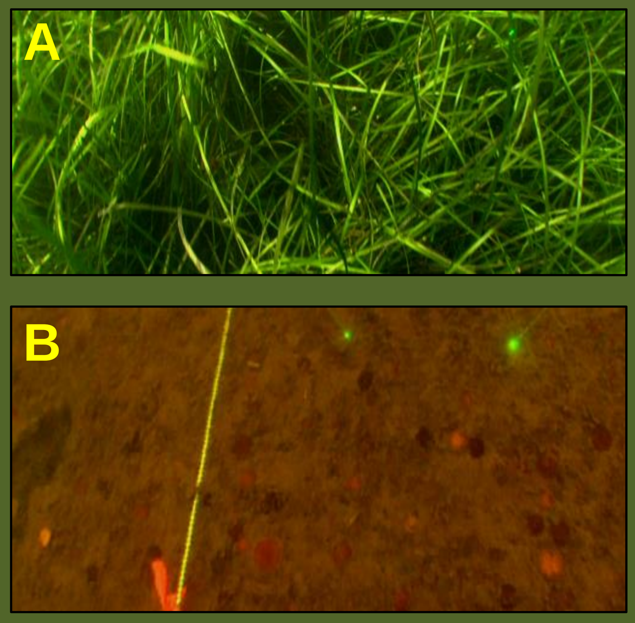


Fig. 7 (left). Relationship between percent change (1999 – 2012) in eelgrass percent coverage and green crab abundance at each site. The line is a logarithmic fit to the data. n=15

Fig. 8 (right). Example photographs of eelgrass at sites with [A] no green crab and [B] localized loss of eelgrass at site with high abundance of green crab.



MITIGATION

Fish harvesters were randomly selected from North Harbour, Placentia Bay to participate in an experimental green crab control fishery (2008 and 2009). In 2008, 11 304 kg of green crab (1752 trap hauls) were removed over 24 days. In 2009, 2 957 kg of green crab were removed (899 trap hauls) over 9 days. A general negative trend in green crab capture rate was observed during the experimental fishery. The average carapace width of captured green crab also decreased by the end of the fishery and numbers of captured rock crab increased with decreases in green crab catch rate.

Fig. 9 (right). Photographs of fish harvesters collecting Fukui traps during green crab control fishery.

SUMMARY AND FUTURE DIRECTIONS

This program aims to assist in development of management and mitigation efforts to maintain or decrease abundances below economic or ecological thresholds. Future projects will continue monitoring green crab invasion and research current knowledge gaps (i.e. population density and early stage biology, relationships between green crab and juvenile lobster, and population genetics) and establish baseline information and continue to monitor critical ecosystems before or in early stages of invasion.

ACKNOWLEDGEMENTS

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