Asian shore crab, *Hemigrapsus sanguineus*

Background

The brachyuran crab *Hemigrapsus sanguineus* (de Haan 1853), also known under the common names Asiatic, Asian or Japanese shore crab, is a member of the speciose grapsoid group of crabs that is classified either within the family Grapsidae or Varunidae, the latter resulting from a recently elevated subgroup (see Martin and Davies 2001). The species is native to the western Pacific, from Sakhalin Island (Russia) in the north, to Hong Kong and Taiwan in the south, and throughout the Japanese archipelago (Sakai 1976, McDermott 1998a). This crab has recently been introduced to areas of both sides of the Atlantic, most recently in the northeast Atlantic, on the coast of France and the Netherlands in 1999 and 2003, respectively (Breton et al. 2002, Campbell and Nijland 2004), and also in the Mediterranean starting in 2001 (Schubart 2003). In the Northwest Atlantic, it was first reported from near Cape May, New Jersey in 1988 (Williams and McDermott 1990), having since spread rapidly south to northern North Carolina and north to central Maine (Nizinski 2003). Breeding populations are now well established within the northwest Atlantic range (McDermott 1991, 1998b, 1999a), with extremely high densities of up to 150 individuals per m^2 being reported (Brousseau and Baglivo 2005). Primary factors contributing to the success of this invasive species are the differing pattern and lack of restriction in resource use, and the physical and climatological similarities between native and invaded regions (Lohrer et al. 2000a).

It is generally believed that the introduction, rapid dispersal and settlement of *H. sanguineus* was possible through the larval planktonic phase of this adult benthic crab. The larval phase, consisting of five zoeal stages and a megalopa (Kurata 1968, Hwang et al. 1993), has a duration of 16-25 days depending on temperature (Epifanio et al. 1998). This, and a tolerance to a wide range of salinities, would allow survival of long distance inter-ocean transport in ship ballast waters until release in the Atlantic areas of introduction (Carlton and Geller 1993). Beyond the initial human-mediated introduction, the rapid and widespread dispersal from the areas of introduction may also be mediated through larval dispersal. However, the highly mobile nature and low site fidelity of the benthic adult phase of this crab (Brousseau et al. 2002) are other likely contributing factors.

Given its recent introduction and potential effects on prey species, some of which are harvested for human consumption, there is considerable interest in understanding potentail impacts (Lohrer and Whitlatch 2000a) and predicting future range increases of the Asian shore crab (Stephensen 2004). One of the principal factors that determine distribution is environmental temperature (Takahashi et al 1985). For the latter our results indicate that, based on the minimum and maximum temperatures within their existing distribution (0.6 - 26.1ºC), it is likely that the geographic range of *H*. *sanguineus* will expand along the northern coast, even in the absence of climate change. As indicated by the blue areas on maps of all models and scenarios, *H*. *sanguineus* should spread to southern Nova Scotia as well as the Bay of Fundy. These areas also include rocky shore habitats and prey species preferred by this species, making such a geographic expansion likely. An analysis of relative abundance and crab sizes at different sites in New England also suggest a northward range expansion of this crab (Ledesma and O'Connor 2001).

Modelling thermogeograhic data for a 2ºC increase in temperature predicts dramatic changes in the geographic distribution of the Asian shore crab. All models show a loss in the southern range that includes Chesapeake Bay and areas that are immediately adjacent. Under the 4ºC scenario of temperature increase, there is less agreement among models, but the loss would extend further north to an area ranging from Delaware Bay to Long Island Sound, depending on the particular model and scenario.

The southern range loss of *H. sanguineus* is more than offset by an extensive northern range extension. This is predicted by three of the four models, which see *H*. *sanguineus* occurring throughout the coast of Nova Scotia, Gulf of St. Lawrence and parts of Newfoundland and Labrador. An increase in 4 rather than 2ºC for the same three models would not alter the northern range extension substantially; however, the fourth model now predicts a distribution similar to the other models. No matter the model or scenario of the thermogeographic approach, a moderate temperature increase predicts the introduction of the Asian Shore crab throughout the Canadian Atlantic.

The long term ecological impact of *H. sanguineus* to the non-native environments is presently uncertain (Lohrer et al. 2000). However, the introduction of exotic species such as that of the Asian shore crab can have potentially harmful consequences to the ecology of the invaded environments, including effects on indigenous species populations that may also be of commercial importance. At this point the relatively small Asian shore crab (common carapace length 3 cm) has no direct importance to humans in that it is not harvested for commercial purposes. However, there are indirect consequences. Important considerations of possible consequences primarily involve the interaction of *H. sanguineus* with other species.

The Asian shore crab is considered an opportunistic omnivore (McDermott, 1999b, Ledesma and O'Connor 2001) that can survive on a diverse diet of plants, including macroalgae and salt marsh grasses, and animals, consisting of polychaetes, amphipods, barnacles, molluscs. However, when given a choice, the crab has a strong preference for animal food (Brousseau and Baglivo 2005). Molluscans are a favourite prey among species found in the crab habitat, with preference of bivalves over the common gastropod *Littorina littorea* (Bourdeau and O'Connor 2003). Among commercial bivalve prey species are the northern quahog *Mercenaria mercenaria* and the oyster *Crassostrea virginica* (Brousseau et al. 2001). However, based on relative abundance, the primary bivalve prey species relevant in Canadian Atlantic waters would be the soft-shelled clam *Mya arenaria* and the blue mussel *Mytilus edulis*. Both are considered important commercial species. Experimental evidence shows a preference of *Mya arenaria* over *M. edulis*, but even the latter is consumed in large numbers, averaging 13 daily (Brousseau and Filipowicz 2001). While there is a preference of juveniles for mussels, it is not so for *Mya*, this being possibly related to the softer and thinner shell characteristics of that species.

Considering the high densities of *H. sanguineus* in the wild, and its effectiveness as a bivalve predator with large appetite, suggests that this crab will play an important role in restructuring of prey communities in areas of introduction (Broussseau et al. 2001). Evidence by Brousseau and Filipowicz (2001), based on crab densities and prey consumption and recruitment rates, indicates the potential of seriously limiting mussel and soft-shell clam populations in areas where these species co-occur.

However, the interaction with other similar predator species already present in the region must also be considered. Intertidally in the northwest Atlantic, this includes a number of brachyuran crabs (Seed 1980, Ropes 1988) but with the absence of significant populations of blue and mud crabs in Canadian Atlantic waters, this places the green crab *Carcinus maenas* as the principal competition of *H. sanguineus*. *Carcinus maenas* is another exotic crab species introduced to North America in the early 1800s that spread rapidly to encompass an area from Virginia to northern Nova Scotia. In many areas it became the most abundant crab causing ecological and economic harm (Lohrer and Whitlatch 2002a). Recent indications are that in areas of overlap between the two species, a reduction of green crab abundance coincided with the introduction of the Asian shore crab (Casanova 2001, Lohrer and Whitlatch 2002b), primarily because of a differential in predation of newly recruited crabs. However, predation pressure on the native blue mussel has not decreased with declines of the green crab. Possible explanations include greater population densities of the Asian shore crab that make it a more important predator of juvenile mussels. Also, while overlapping intertidally, the green crab is found in a wider range of substrates and also further subtidally. This leads to the conclusion that the substitution of the green crab by the Asian shore crab has an apparent net negative influence on the shared blue mussel prey populations that may lead to population declines of this commercial shellfish (Brousseau and Baglivo 2005, Lohrer and Whitlatch 2002a). This is likely to equally apply to *Mya arenaria*, whose predator-prey relationships are less well understood.

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