**Strongylocentrotus droebachiensis, green sea urchin**

**Background**

In the western North Atlantic portion of its circumpolar range the green sea urchin is distributed from the Canadian Arctic to New Jersey (Atkinson and Wacasey 1989, Gosner 1978). It is a common occupant of both sheltered and exposed kelp beds and rocky areas of the low intertidal zone and subtidal zone and lives to 1,200 meters in the Atlantic Ocean. Green sea urchins feed on macroalgae and a wide variety of other organisms, and scrape diatoms and coralline algae from rocks. Green sea urchins spawn in March to April in the western North Atlantic, with a smaller spawning in the autumn (Brady and Scheibling 2006). In Nova Scotia spring spawning was found to coincide with the annual temperature minimum while fall spawning coincided with the annual maximum of 8–10°C (Brady and Scheibling 2006). Eggs and sperm are broadcast into the water column where fertilization occurs. Larvae are planktonic from four to 21 weeks (Scheibling and Hatcher 2001) and typically settle in July in Nova Scotia (Balch and Scheibling 2000, in Brady and Scheibling 2005).

Brady and Scheibling (2005, 2006) described the key role that green sea urchins play in the alternating subtidal community states of lush kelp beds and urchin barrens dominated by coralline algae. Mass urchin mortality caused by the amoeba *Paramoeba invadens* occurs during peak seawater temperatures, with the severity related to the magnitude and duration of temperatures exceeding 12°C. Mortality is greatest in the shallowest depths; urchins in waters deeper than 20-25 m experience a thermal refuge from the disease. However, the deeper waters are a food-limiting environment negatively impacting urchin growth and reproduction. With autumn cooling the disease subsides and urchin repopulation of the shallows begins through settlement of planktonic larvae and migration of adults from nearby deeper waters. Green sea urchins can migrate up to several hundred meters a day. Within two to three years following a mass mortality event kelps can grow to dominate the subtidal environment. However, with urchin repopulation the feeding pressure on the kelps grows, reverting the shallows once again to urchin barrens.


**Temperature limits, critical thresholds, vulnerability, and barriers to adaptation**

Sea surface temperatures in the current distribution of *S. droebachiensis* range from a February minimum of -2.1°C to an August maximum of 24.9°C.
This is a cold water species. Critical temperatures are from Scheibling and Hatcher 2001. Green sea urchins are found in our waters from -1°C for all life stages to 18°C for larvae and 20°C for benthic individuals. Though growth rate is not strongly temperature dependent recently settled juveniles grow best at 9–13°C (Pearce et al. 2005). Maximum lethal temperatures are 19°C for larvae and 22°C for settled individuals. Urchins were of average sensitivity compared to other species in our analysis of sensitivity to climate change. The larval stage may be the most critical thermally because of its lower natural and lethal temperatures.

Critical temperatures for the disease-inducing Paramoeba invadens were given by Scheibling and Hatcher (2001). Growth is optimum at 12–20°C with arrested development at 10–12°C (urchins can recover from infection at 8°C or less). The amoeba cannot survive below 2°C, indicating periodic introductions from warmer regions.

**Impacts**

A 4°C rise in global temperature will impact the future distribution of green sea urchins in the western Atlantic. Results from all models and scenarios are generally similar and show potential loss of thermal habitat in waters south of approximately Cape Cod. Model GFDL Scenario A2 shows potential loss in the southern Gulf of St. Lawrence, as well. Model CCSR shows loss off southern to most of Labrador. All other waters generally will remain suitable for this species. No habitat gain is predicted in our study which does not extend to the northern range limit of the green sea urchin. No loss of habitat is predicted where urchins are harvested commercially in the Atlantic provinces and Maine.

Because the green sea urchin is a cold water species the waters in its southern range which do not reach lethal summer temperatures as the climate changes nevertheless will make living conditions suboptimal. The resulting negative effect on growth and reproduction of Laminaria spp., a principal urchin prey, will reduce food quality and quantity for the urchins in southern waters. More importantly, mass urchin mortality caused by the amoeba Paramoeba invadens occurs during peak seawater temperatures, with the severity related to the magnitude and duration of temperatures exceeding 12°C. It is very likely that such mortality events will become much more prevalent and perhaps widespread with global warming. This impact should have a positive effect on the algal prey of urchins.

**References**


Brady, S.M., and R. E. Scheibling. 2005. Repopulation of the shallow subtidal zone by green sea urchins (Strongylocentrotus droebachiensis) following mass mortality in


