Ecdysteroid Levels in Glacier Bay Tanner Crabs: Evidence for a Terminal Molt

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Abstract. Tanner crabs are commercially important crabs harvested in Alaska. Males are harvested after attaining a carapace width of 140 millimeters, which requires multiple molting events. It is not clear whether Tanner crabs undergo a terminal molt after which they are incapable of further growth. Male Tanner crabs do undergo a morphometric molt that results in an allometric change in claw size and thus a larger chelae size. This study was conducted to determine whether male Tanner crabs undergo a terminal molt by investigating the concentration of circulating molting hormones in hemolymph of crabs at different stages of their life history. Circulating hormones were significantly lower in large clawed males when compared to small clawed males. The results of this study indicate that large clawed males are not going to molt and that those terminally molted male crabs smaller than 140 millimeters will not recruit into the fishery.

Introduction

Tanner crabs, *Chionoecetes bairdi,* are commercially fished throughout Alaska including parts of Glacier Bay. In 1999, specific regions of Glacier Bay were restricted from commercial fishing of Tanner crabs—creating a network of marine reserves. Successful management of Tanner crabs, including evaluating the effectiveness of the marine reserves, will be aided by a complete understanding of the life history of the animal, in particular, the occurrence of molting in adult crabs. If adult males undergo a terminal molt at sublegal sizes, then the size frequencies of sublegal males should be greater in a fished population than in non-fished populations. The influence of management plans for fishing Tanner crabs could be observed by noting the size distribution of Tanner crab males from fished and non-fished populations.

Juvenile crabs increase in size by shedding their old exoskeleton in a process known as molting. Molting is regulated by steroids (ecdysteroids) that circulate in crustacean hemolymph and promote the synthesis of the exoskeleton and the regeneration of lost appendages prior to molting (Chang, 1985). Ecdysteroid levels can be measured in a growing crab, and levels can indicate whether the crab is in intermolt or premolt (fig. 1; Tamone, 1993). Reproductive adults can continue to grow and reproduce or may cease molting to invest all energy into reproduction. In species that cease molting, the final molt is called the "terminal molt" and is indicated by a change in physiology and a depression in the secretion of ecdysteroids (Tamone and others, 2005).

Female Tanner crabs are known to undergo a terminal molt that coincides with sexual maturity (Paul and others, 1983). Males, on the other hand, molt more times than females and can thus attain larger carapace widths than females.

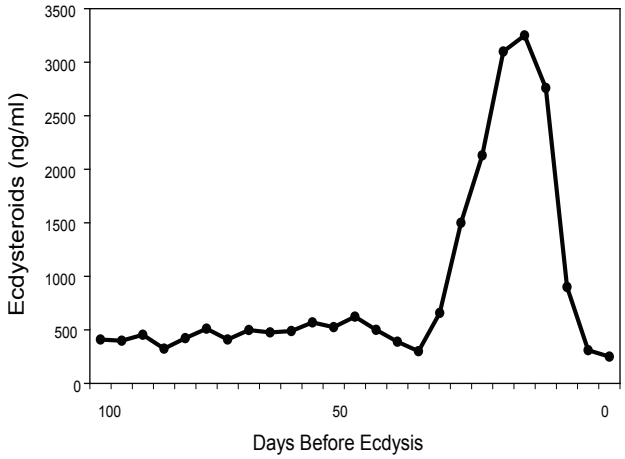

Figure 1. Circulating ecdysteroids during the molt cycle of a Dungeness crab (*Cancer magister).* Note the increased concentrations of ecdysteroids during premolt. Premolt is indicated by the increase in circulating ecdysteroids 42 day prior to ecdysis (E), which is defined by the shedding of the exoskeleton

Males undergo a morphometric change in chelae size that is not linked to reproductive maturity, but is hypothesized to occur during the male's terminal molt. Male Tanner crabs with morphometrically large chelae occur over a broad size range of carapace widths (55-200 mm) and are harvested at carapace widths greater than 140 mm. If Tanner crabs undergo a terminal molt then the removal of the larger males selects for retention of smaller males that will not recruit into the fishery. The broad range in the carapace width of Tanner crabs suggests variation in the size at which the terminal molt occurs that might be due to either a genetic or an environmental component.

This study was conducted to better understand the life history of Tanner crabs (whether crabs undergo a terminal molt) and to see if present techniques could be used in the future to monitor changes in population structure of Tanner crab in Glacier Bay as a function of creating the marine protected area.

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Methods

Animal Sampling: In October 2003, 48 stations in Wachusett Inlet and Scidmore-Charpentier Inlet were sampled using a systematic, 750 m grid (fig. 2).

To target juvenile and female crabs, a 1 m-diameter commercial shrimp pot (with 4.4 cm mesh) was attached to each of the conical Tanner crab pots with a 20 m tether. All pots were baited with chopped herring and salmon hanging bait. We collected morphometric data on all male Tanner crabs collected. We measured the carapace width and the chelae height to the nearest tenth of a millimeter. Shell condition was determined to be soft, new, old, or very old according to described methods (Jadamec and others, 1999). If a limb bud was present we defined the crab as a premolt crab. One mL of hemolymph was sampled from a subpopulation of the males that included a broad range of carapace widths of both small and large clawed males and included crabs of all shell conditions except for the premolt condition. Premolt was established if a crab was regenerating an appendage, which could be clearly seen as a new limb bud. Premolt crabs with large claws were never observed and therefore large clawed males in premolt were not collected. Hemolymph was sampled from a total of 456 crabs using a tuberculin syringe with a 26-guage needle and frozen until analyzed for ecdysteroids.

Hemolymph Extraction: 50 µL of thawed hemolymph was extracted with 150 µL of methanol. Samples were centrifuged and the supernatant separated and evaporated to dryness. Samples were reconstituted in 125 µL assay buffer and 50 µL was assayed in duplicate for ecdysteroids. Some samples required further dilution.

Ecdysteroid ELISA. Samples were assayed using an ecdysteroid enzyme-linked immunoassay (ELISA) previously developed using 20-hydroxyecdysone as the standard (Kingan, 1989). Data were analyzed using a one-way ANOVA followed by post-hoc unpaired t-tests (OriginPro 7.5).

Results

Males sampled in this study ranged in carapace width from 37 to 180 mm (fig. 3). Tanner crab males were divided into two groups: one having a large claw (LC; as defined by a chela height to carapace width ratio greater than 0.175, and one having a small claw (SC; as defined by a chela height to carapace width ratio less than 0.175). This ratio was established by plotting the ratio of chela height to carapace width against circulating ecdysteroids and choosing a ratio that clearly distinguished crabs with consistently high ecdysteroid levels to those with consistently low circulating ecdysteroids. The range in carapace width of LC males was 78-174 mm and the range of carapace widths for SC males was 47-161 mm; therefore a wide range in sizes of the two male morphotypes was sampled.

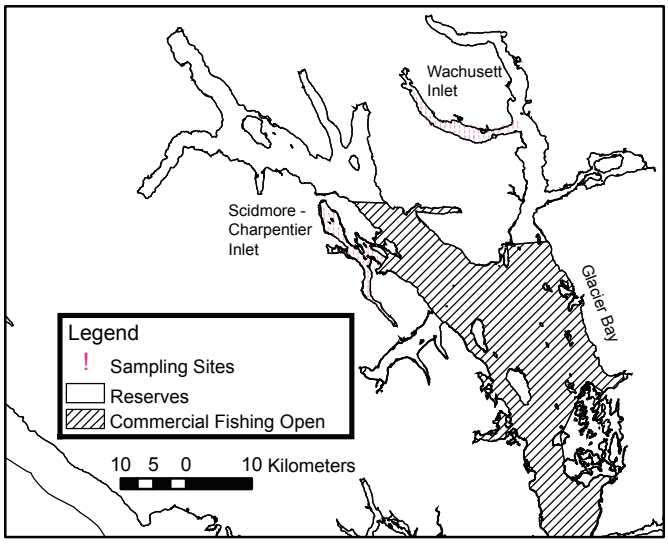

Figure 2. Sampling sites for Tanner crabs in Wachusett and Scidmore-Charpentier Inlets, Glacier Bay, Alaska. Both inlets have been closed to the commercial harvest of Tanner crab since 1999.

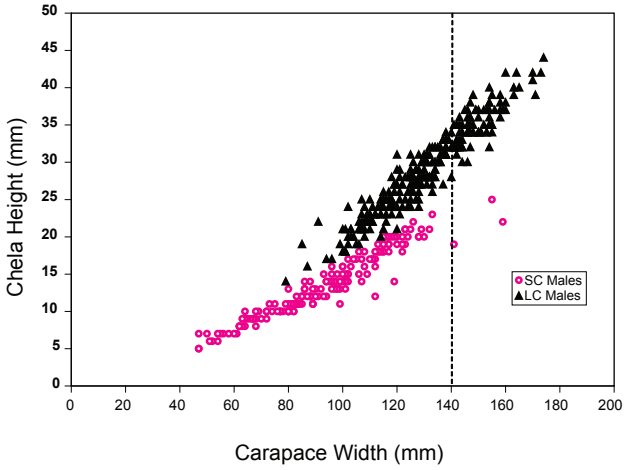

Figure 3. Morphometrics of 456 male Tanner crabs collected in October 2003 in Glacier Bay. Large clawed (LC) males have a CH:CW>0.175. Small Clawed (SC) males have a CH:CW ratio <0.175. The line represents the crabs that can theoretically be harvested during a Tanner crab fishery and include all crabs greater than 140 mm in carapace width.

We measured circulating ecdysteroids in all of 456 Tanner crabs and figure 4 shows the concentrations of circulating hormones as a function of claw type and shell condition. The SC portion of the male population had varying levels of circulating ecdysteroid (fig. 4) indicating that there are SC crabs in all stages of the molt cycle. Ecdysteroid levels were correlated with shell condition in SC crabs. In contrast, significantly lower levels of circulating hormones were

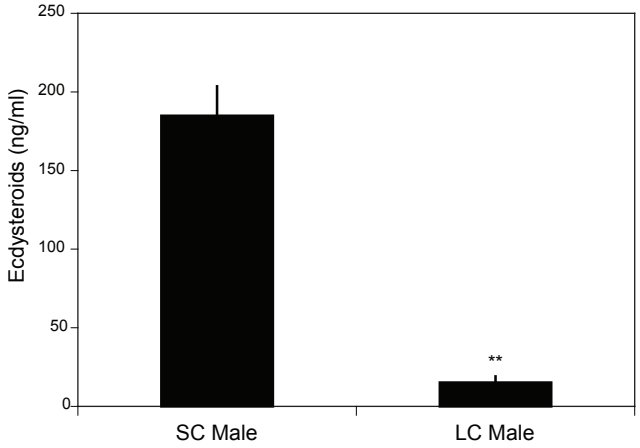

Figure 4. Circulating ecdysteroids (Mean±SE) of field caught large-clawed (LC) and small-clawed (SC) male Tanner crab. **=P<0.0001.

detected in LC males than in SC males and this difference was independent of carapace width or shell condition (fig. 4). These data indicate that the LC male population is unlikely to undergo another molt.

Discussion and Conclusions

Circulating ecdysteroids were significantly lower in large clawed Tanner crabs which suggests that this species, like its congeneric snow crab (*Chionoecetes opilio*), undergoes a terminal molt. The terminal molt is associated with an allometric change in claw size that is independent of reproductive maturity. In fact, under laboratory conditions, SC Tanner crab males are capable of mating with mature females (Paul and Paul, 1996). Significantly lower molting hormones are measured in terminally molted snow crabs and are due to a reduction in size of the endocrine tissue that produces the ecdysteroids (Tamone and others, 2005).

Our data suggest that Tanner crabs can undergo the terminal molt at a broad range of sizes (carapace widths). However, it is unknown what governs the size at which a male undergoes the terminal molt. If the genetics of the animal drives the size of the crab at terminal molt, then removal of large (>140 mm) LC males by the commercial fishery would select for crabs to terminally molt below legal size and thus not recruit into the fishery. Size selective fisheries have been experimentally demonstrated to select against fast growth in other species (Conover and Munch, 2002). Alternatively, the size at which males terminally molt could be mediated by interactions with conspecifics. In other words, the removal of the larger LC males favors males terminally molting at smaller sizes due to a removal of competition for females. In either case, we should see decreased proportions of smaller males in non-fished Tanner crab populations when compared to fished populations.

Management Implications

This research strongly suggests that Tanner crabs undergo a terminal molt. Tanner crab populations throughout Alaska have decreased to the extent that fisheries have been closed or minimized. In the future, Glacier Bay can serve as a non-fished area to look at size and morphotype distributions within a population of Tanner crabs. These data would be compared to population structure in a commercially fished region of southeastern Alaska to better understand the effects of fishing on size distributions of large clawed males.

Acknowledgments

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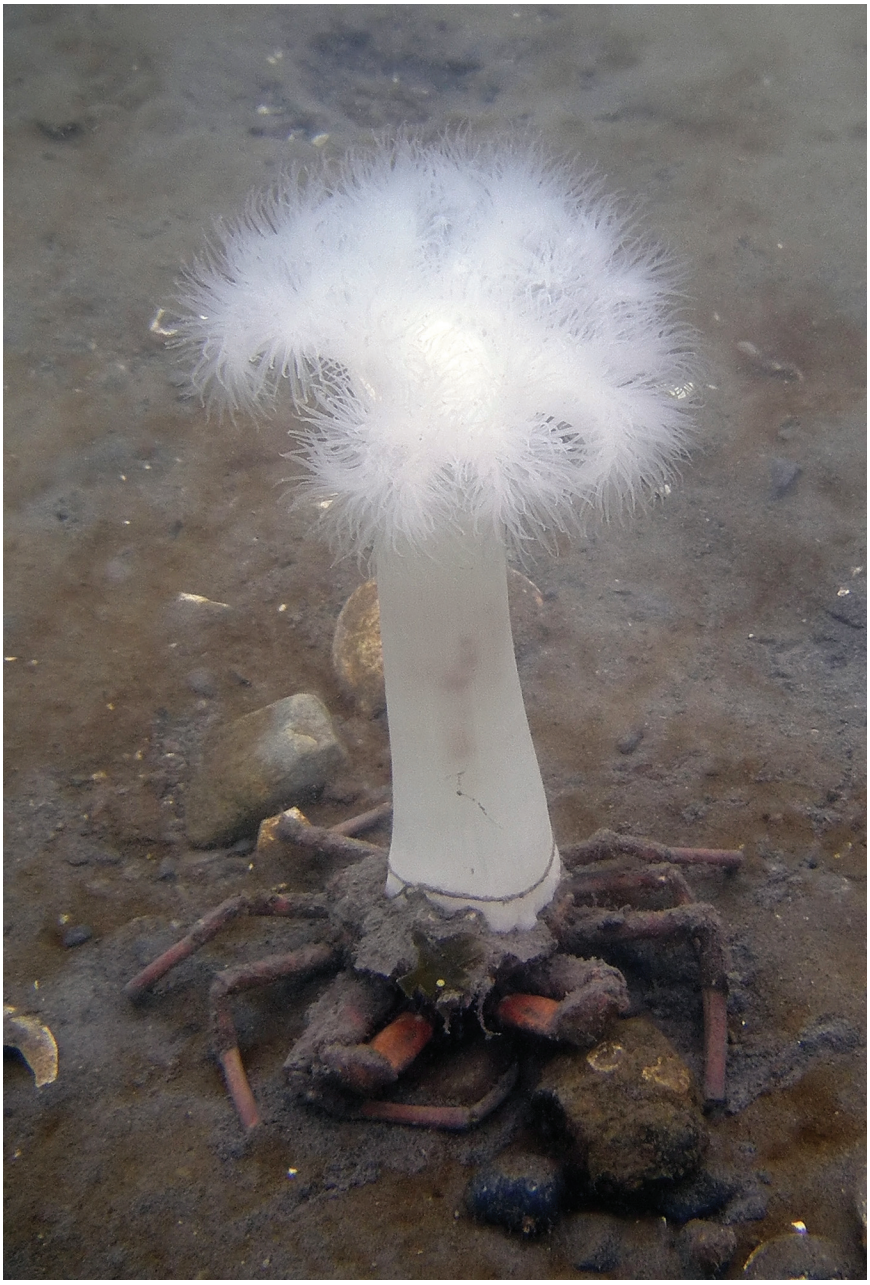

Sea anemone growing on a crab carapace. (Photograph by Bill Eichenlaub, National Park Service.)