Claw removal and its impacts on survivorship and physiological stress in Jonah crab (*Cancer borealis*) in New England waters

Preliminary data submitted to the Atlantic States Marine Fisheries Commission

Submission Date: January 25, 2016

Investigators: Joshua Carloni, Marine Fisheries Biologist
University of New Hampshire & New Hampshire Fish & Game
Phone: 603.868.1095
Email: Joshua.Carloni@wildlife.nh.gov

Jason S. Goldstein, PhD.
University of New Hampshire
Department of Biological Sciences
42 College Road, Durham, NH 03824
Phone: 603.892.7135
Email: jsgoldstein2@gmail.com

Technician: Rebecca Kibler
Email: rebecca.kibler@gmail.com

Synopsis

Found in coastal and shelf waters along the Atlantic coast of North America, from Newfoundland to Florida, Jonah crabs (*Cancer borealis*) have been captured as incidental bycatch in the New England lobster industry for over 80 years. In the last 20 years however, Jonah crabs (*Cancer borealis*) have become an alternative fishery target and landings have more than quadrupled. This has necessitated evaluation of the current status and prospective long-term health of the fishery. In addition, the biological implications of harvesting Jonah crabs through the live removal of claws remain mostly unknown. The goal of this ongoing research is to evaluate current harvest practice (claw removal) and its impacts on the health and behavior of Jonah crabs. Preliminary results from laboratory trials (n = 232 total crabs) suggest that double-claw removal incurs markedly more mortality (~74%) compared with single-claw removal (~56%) and control animals (~19%). Physiological stress, assessed through concurrent haemolymph (blood) analyses suggest elevated levels of glucose and lactate in declawed crabs. Continued studies on behavior (feeding) and growth are ongoing in an effort to better understand Jonah crabs and manage this developing fishery in New England waters.

1. Introduction

Found in coastal and shelf waters along the Atlantic coast of North America, from Newfoundland to Florida, Jonah crabs (*Cancer borealis*) have been captured as incidental bycatch in the New England lobster industry for over 80 years. More recently, Jonah crab has become an alternative fishery target in Southern New England. The majority of these landings are occurring concomitantly with the decline in lobster populations (Reardon 2006, ASMFC 2014). As a result of the increased targeted fishing pressure on Jonah crab, the long-term health of this fishery is quickly becoming questioned (Seafood Watch 2004, ASMFC 2014). Moreover, the biological implications of harvesting through the live removal of claws (one preferred method) remain mostly unknown. Claw removal (declawing) occurs in other crab fisheries where live animals have their claw(s) removed before they are returned to the sea (e.g., Robinson 2008, Gandy et al. 2015). In addition, claw removal results in markedly dramatic physiological stress responses (claws may be > 40% of crab total weight) in many crustacean species, as noted by changes in blood chemistry (e.g., glucose and lactate, Patterson et al. 2007). Our overall goal in this ongoing study is to evaluate 1) the survivorship of crabs post-claw removal; 2) short- and long-term physiological impacts (stress) can be assessed from claw removal and; 3) how claw removal impacts overall foraging behavior in these crabs?

2. Methods

Animals and treatments

Market sized Jonah crabs (average carapace width = 139 ± 1.08 mm) were collected by local fishermen in traps during normal fishing operations off the coast of New Hampshire in both state and federal waters. Crabs were held live in recirculating seawater tanks at the University of New Hampshire (UNH) Coastal Marine Lab (CML) and used to test the hypothesis that crabs that are declawed will be compromised with respect to their overall survival and growth. Crabs were subjected to one of three treatments (one, two, or no claws removed) over five trials from December 2014 through January 2016. Each trial was conducted for a period of four weeks and consisted of 20 crabs for both single and double declawing treatments, with fewer controls as these animals were previously observed to do well in laboratory conditions. The number of control crabs (no claws removed) was increased following trial two due to a higher than anticipated mortality rate.

Claw removal (declawing) techniques were demonstrated to researchers during two instructional sessions by local fishermen with considerable experience in this harvesting practice. Additionally, techniques used to remove claws from stone crabs (a current fishery practice) were investigated to ensure proper breaking and handling methods were incorporated into the experimental design. Also recorded were the size (mm) and location of break (Figure 1) during declawing as well as pre- and post-declawing weight (g), claw weight, and shell condition (old or new shell).

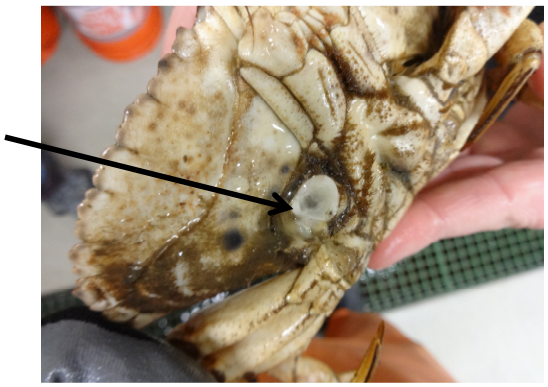

Figure 1. Example of a declawed Jonah crab with visible wound (arrow).

Laboratory trials

Upon claw removal, each crab was placed in an individual holding cage within a series of large flow-through seawater trays at ambient conditions. Environmental data (temperature and oxygen, not included in report) were logged over each trial period and downloaded for analysis. Crabs were evaluated approximately every 48-72 hours with respect to survival and activity levels. Additionally, all three treatments were fed both a cooked mussel with shell removed (soft food item) and a live mussel (hard food item) to evaluate foraging effects twice during each trial. The initial feeding was conducted immediately following the declawing and a second feeding was conducted at the two-week mark. Crabs were evaluated as to the type and amount of each food item that was eaten.

Field trials

We conducted two field trials (during lab trials 4 and 5) of crab mortality with the goal of comparing our lab-based mortality rates to crabs that were kept in the field and handled similarly. A total of 48 crabs were measured and declawed as described above. Crabs were placed into individual compartments within standard vinyl-coated lobster traps (1.2 m x 0.6 m x 0.4 m, 3.8 cm square mesh) constructed without vents or entrances and divided into eight sections by the insertion of additional coated mesh wire. Traps were weighted with concrete blocks to minimize excessive movement and were fastened to the UNH CML research pier at a depth of ~5 m. Traps were pulled and all crabs were checked in the same manner and time interval as described for the laboratory work.

Stress response

Physiological stress response in de-clawed crabs was also evaluated using two key assays: glucose and lactate. A subset crabs (n = 25/treatment x 2 trials) from each treatment were examined for stress responses over both short- (5-10 min post-claw removal) and then again ~24-36 hours later (long-term). For each crab, a small blood (haemolymph) sample was withdrawn from the sinus at the base of the fifth walking leg

using a 2-ml syringe and a 25-gauge needle. Blood samples were stored in labeled 2-ml microcentrifuge tubes and snap-frozen before being stored at -80℃. Both glucose and lactate (µM/L) were quantified colorimetrically using commercially-available biochemical assay kits (Eton Bioscience, San Diego, CA). All samples were checked against a standard curve and examined with a microplate reader at λ = 490-500 nm.

3. Preliminary Findings

To-date, we have carried out a total of five laboratory trials using 232 crabs

Mortality

Across all trials, 19% of crabs died when no claws were removed (control), 56% when one claw was removed and 74% when both claws were removed. Mortality rates between trials ranged from 30 to 75% when one claw was removed, and from 45 to 95% when two claws were removed (Figure 2). A majority of the mortality for crabs with one or two claws removed occurred within the first 6 days after initial declawing (Table 1).

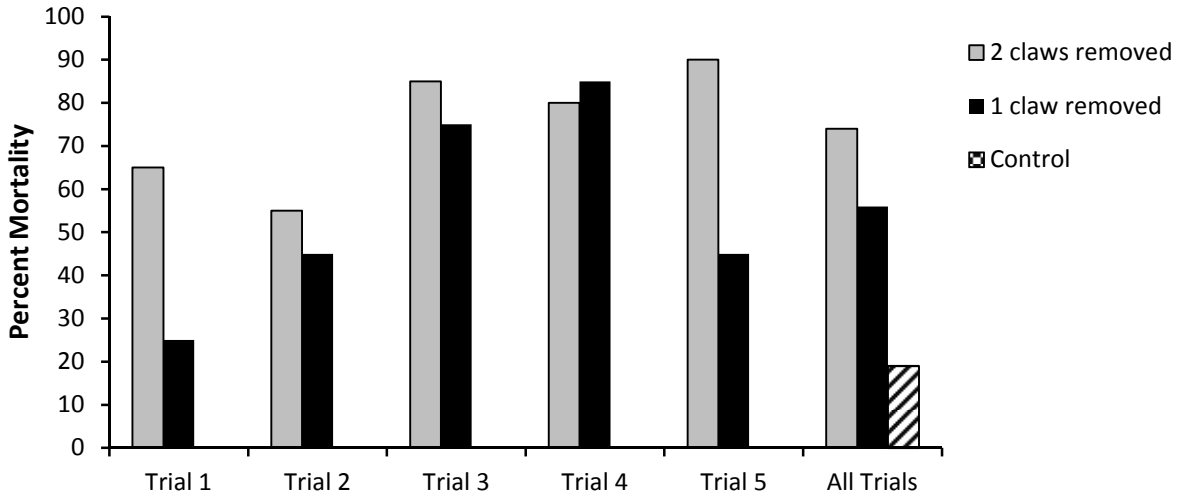

Figure 2. Mortality rates for Jonah crabs subjected to one of three treatments during five laboratory trials from December 2014 through January, 2016.

Time	Control	One Claw Removed	Two Claws Removed
~72 Hours	0.0	33.9	58.7
~144 Hours	0.0	64.3	69.3

Table 1. Percentage of total mortality that occurred within the first 72 and 144 hours (6 days) post-declawing for Jonah crabs subjected to one of three treatments, all trials combined.

Feeding

Across all trials during the initial feeding, 63% of control crabs fed on both the hard (shelled) and soft (shucked) food item, and 87% of the crabs foraged on at least one of the food items (Table 2). In contrast, 55% of crabs with one claw removed and 32% of crabs with two claws removed foraged on at least one food item.

Treatment	Ate Nothing	Ate Shucked	Ate Shelled	Ate Both	Ate Something
Control	13	23	0	63	87
One Claw Removed	45	32	3	19	55
Two Claws Removed	68	29	2	0	32

Table 2. Percent of Jonah crabs subjected to one of three treatments that foraged during the initial feeding, all trials combined.

Across all trials during the secondary feeding, 96% of control crabs fed on both the hard (shelled) and soft (shucked) food item and 96% of the crabs foraged on at least one of the food items (Table 3). In contrast, 74% of crabs with one claw removed and 47% of crabs with two claws removed foraged on at least one food item.

Treatment	Ate Nothing	Ate Shucked	Ate Shelled	Ate Both	Ate Something
Control	4	0	0	96	96
One Claw Removed	26	29	0	46	74
Two Claws Removed	53	35	0	12	47

Table 3. Percent of Jonah crabs subjected to one of three treatments that foraged during the secondary feeding, all trials combined.

Field Trials

A total of two field trials were conducted concurrently with laboratory trials four and five to compare with lab results. This data still has not been entered or evaluated and is thus not available for presentation. However, preliminary review of this data suggests results comparable to the laboratory trials.

Blood Work

Analyses of our biochemical work are not yet complete, however some of our results suggest a trend of increasing glucose and lactate levels in crabs that have had their claws removed. Both short- and long-term efforts of these parameters are apparent through at least two of our trials. Lactate, for example, is a very good indicator of stress response in crustaceans (Figure 3) and is the major end product of anaerobic metabolism; higher concentrations indicate attempts by

the animal to mediate the effects of a stressor (Albert and Ellington 1985). These effects appear over both short- (minutes) and long-term (> 24 hr.) periods. This has been reported in other crustaceans as well (Patterson et al. 2007). Further analysis of the these biochemical markers is ongoing.

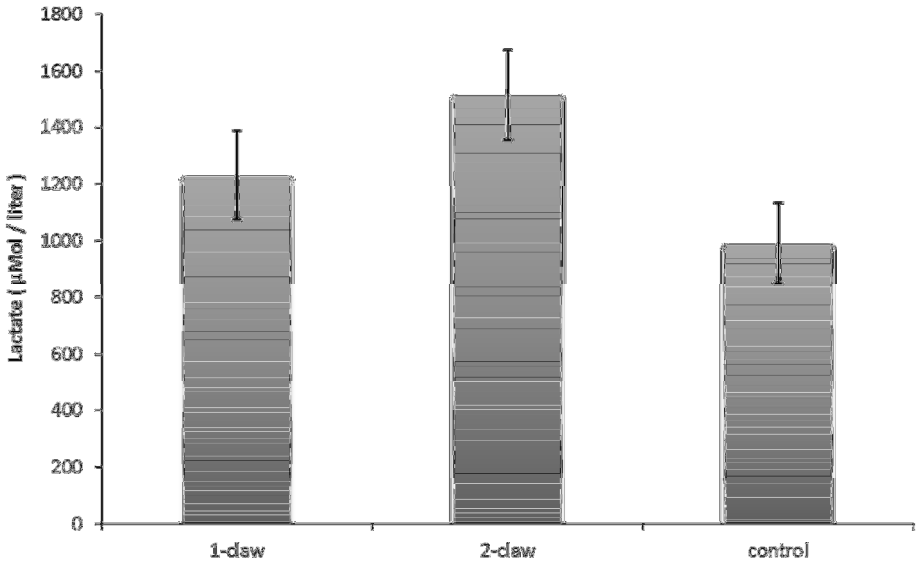

Figure 3. Lactate levels in crab haemolymph sampled at 24-hours post declawing for a subset crabs (n = 25/treatment x 2 trials, control = 8) from each treatment. Total lactate is an indicator of physiological stress.

Ongoing and future work

Our goal is to complement our existing work with other components that include:

- Complete our analysis of blood parameters (glucose and lactate) for all crabs.
- Evaluate feeding and activity behavior of declawed crabs vs. controls using time-lapse video and accelerometers (some of our preliminary trials that suggest behavior is altered considerably).
- Investigate growth and regeneration in crabs where claws have been removed.
- Consider how temperature may affect mortality for each of our trials.
- Determine how wound size, break location and shell condition affect mortality in crabs that have had claws removed.

4. References

Albert, J.L. and W.R. Ellington. 1985. Patterns of energy-metabolism in the stone crab, *Menippe mercenaria*, during severe hypoxia and subsequent recovery. J. Exp. Zool. 234:175–183.

Atlantic States Marine Fisheries Commission (ASMFC). 2014. Jonah Crab Fishery: A briefing. Report downloaded from: http://www.asmfc.org/.

Gandy, R., C. Crowley, D. Chagaris, and C. Crawford. 2016. The effect of temperature on release mortality of declawed *Menippe mercenaria* in the Florida stone crab fishery. Bull. Mar. Sci. 92: http://dx.doi.org/10.5343/bms.2015.1036

Patterson, L., J. T. A. Dick, and R. W. Elwood. 2007. Physiological stress response in the edible crab, *Cancer pagurus*, to the fishery practice of de-clawing. Marine Biology. 152: 265-272.

Reardon. K. 2006. Development, assessment, and management of a potential directed fishery for Jonah crab (*Cancer borealis*), in the near shore Gulf of Maine. Master's thesis, University of Maine, 136 pp.

Robinson, M. 2008. Minimum landing size for Northeast Atlantic stocks of deep-water red crab, *Chaecon affinis* (Milne Edwards and Bouvier, 1894). ICES J. Marine Science. 65: 148-154.

Seafood Watch. 2014. American lobster, Atlantic rock crab, Jonah crab: *Homarus americanus, Cancer irroratus, Cancer borealis.* Monterey Bay Aquarium. Report downloaded from: www.seafoodwatch.org.