An examination of methods: Hand picking red crabs and keeping them alive on shore

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An examination of methods:
Hand picking red crabs and
keeping them alive on shore.

Dan Kauffman (Virginia Tech)
Bob Fisher (Virginia Institute of Marine Science)

Revised October 2010
Summary

In the fall and winter of 2008 and 2009, cooking and picking trials of deep sea red crab were undertaken in Newport News, VA at blue crab picking house. In addition initial experiments on keeping red crab alive in tanks on shore were done at another packing house.

The red crab fishery was relatively new in Virginia. Previously most of the catch was landed in Falls River, MA. In 2007 red crab was unloaded for the first time in Newport News, VA, and the catch was then shipped to Canada for processing into generic minced body meat and whole leg meat. Because Virginia already has infrastructure to process and pick blue crab, experiments were undertaken to determine whether a higher quality, more profitable red crab product could be produced. Additional experiments were undertaken to see whether the red crab could be kept alive on shore for profitable sale into the live seafood market, dominated by Asian-American consumers.

Cooking trials indicated that boiling red crab produced better yield and taste compared with steaming, which is the most common cooking method for blue crab. The study also indicated that labor cost for producing red crab claw and leg meat would allow this meat to be sold at a profit. However, picking the body meat proved more problematic. Labor costs for this process dissuaded the picking house involved in the study from making additional capital investments necessary to expand into this market. Taste trials indicated that the red crab would be accepted in regional Virginia market.

During the picking and taste trials, another unloading facility attempted to keep the crabs alive on shore and sell them into the live seafood market. Small tank tests indicated that crab mortality decreased dramatically by making modest improvements in water quality, especially by maintaining the water pH at 7. Maintaining the pH at 7 probably reduced the highly toxic unionized ammonia (NH₃) in the water. The viability of crabs held at this pH was superior to those crabs held in the commercial tank at a pH of 8 or more.

Brief history of the red crab fishery

Red crabs (Chaceon quinquedens—formerly Geryon quinquedens) are a deep-water crab living at depths of 200 to 1800m on the continental shelf break and slope (Steimle, 2001). Red crab’s Atlantic Ocean habitat is primarily in the northwest Atlantic, but it ranges from Nova Scotia down to the Gulf of Mexico.

The red crab fishery is relatively new. The first recorded scientific catch of red crab was by Sidney Smith in 1879. Fisherman started deep-sea trawling in the 1880’s, and red crab occasionally showed up in the nets (McRae, 1961). But red crabs were not caught regularly until the advent of deep sea trawling and potting for lobsters in the 1950’s (Schroeder, 1959).

However, no commercial fishery developed, and there where only sporadic scientific attempts to document the crab’s range and commercial possibilities (McRae, 1961; Meade and Gray, 1973). A National Marine Fisheries Service (NMFS) camera and trawl survey in that year assessed a nearly unexploited red crab biomass (Wigley, 1975). Thirty years later, Wahle (2008) compared this 1974 biomass survey to a similarly designed biomass study he and colleagues did between 2003 and 2005. They found that in the intervening time of almost 30 years, red crab biomass increased by 250 percent. The authors found this increase was attributable to an increase in abundance of smaller crabs, including mature females, that were estimated to be more than two times the biomass they were in 1974. The size composition for the females was little changed between the two surveys. However, large male
crabs (≥114mm carapace width) decreased by 42 percent.

In the 1990’s there were boats as large as a 150 feet, some of which had come from Alaska, targeting red crab, and by the turn of the century, there was concern that the stock was being overfished. So a Fishery Management Plan (FMP) was instituted in 2002, which limited number of licenses in the fishery and only permitted the catch of male crabs. (Males and females stay mostly at different depths, so the sex of the captured crab can be controlled by setting the pot at an appropriate depth.) By 2009, the FMP reduced the total allowable catch to 3.56 million pounds (Federal Register Feb 19, 2010), about half of the average annual catch in 2000.

**The Virginia Project**

Beginning in 2007, 80 to 100-foot fixed-gear red crab boats began packing into in the Newport News, VA boat harbor for part of the year. All of these vessels were members of the New England Red Crab Harvesters Association and most were controlled by Benthic Fishing Corporation. The boats landed up to 60,000 pounds of crab at a time. At that time the fishery was allowed to catch more than 6 million pounds of crab per year, but they were not filling the total allowable catch (TAC) because there wasn’t demand.

The majority of the red crab landed in Virginia was packed during the winter or early spring, when local crab houses were all but idle. The Virginia-packed red crab was then put on tractor-trailers and sent to a snow crab plant in Nova Scotia for processing into lower-value, generic crabmeat, primarily for the Darden Restaurant Corporation. Because red crab was mostly processed into mince or salad meat, it had to compete in the low-value world commodity market.

Because all the red crab licenses were held by Association members—and Benthic owned the majority of those—the fishery became almost a defacto individual quota system with a days-at-sea (DAS) overlay. This meant that license owners had economic incentives to self-manage the fishery for sustainability. Overfishing would make their licenses worth less. Additionally, technical developments and efforts to develop the market, which would allow them to escape the commodity market in which they were currently trapped, could not be expropriated by free-riders because all the licenses were held within the Association.

One of the ways they could differentiate the red crab from its competitors in the world commodity market was to seek Marine Stewardship Council (MSC) sustainability certification. A third party took 15 months to examine red crab fishing effort and red crab stocks. The examiners found red crab was being fished in a sustainable manner. On September 3, 2009, the U.S. Atlantic red crab fishery became the first East Coast fishery certified as sustainable by the Marine Stewardship Council (Marine Stewardship Council 2009). Such certification opened additional marketing opportunities with organizations like Whole Food and Walmart. Corporate policies for both companies require purchase of MSC certified product whenever possible. But getting out of the commodity trap would also require moving away from the minced crab meat product toward higher-quality, hand-picked crab meat.
Can Virginia provide high quality picked red crab and pioneer a live market?

There was potential for Virginia's facilities to profitably process red crab, allowing the product to be sold into the differentiated, as opposed to generic, market. Virginia’s crab picking houses already produce high-quality handpicked blue crab meat. These same crab houses were mostly idle in the winter when the red crab was being landed in Newport News. Additionally, if red crab could be processed here it would eliminate the cost of transporting the catch to the Canadian processing facility. However, methods for processing red crab and the profitability of doing so in Virginia needed to be verified.

There was also potential for expanding the demand of red crab through Virginia’s local live seafood market dominated by Asian-American consumers. When the red crab boats came to the docks in Newport News distributors would come to buy live and steamed red crabs. However they complained about the crab mortalities they experienced and started to reduce purchases. Dungeness and other cold-water crabs were already being sold live in tanks in metropolitan Asian-American markets. To expand into this market, methods need to be developed to reduce live red crab mortality during transport.

In the summer, fall, and winter of 2008 and 2009, a study was undertaken, sponsored by the Commercial Fish and Shellfish Technology Group at VA Tech, to determine whether handpicking or live holding of red crab could potentially be done profitably in Virginia.

Examining Cooking Methods

A Comparison of Different Cooking Methods

When it came to processing red crab in Virginia, the first problem was a mismatch the traditional cooking methods for processing red crab and blue crab. Virginia blue crab is traditionally steamed and red crab, like other crab cooked in Canada, is boiled. Generally Virginia processors believe that boiling produces meat that is too wet and has an inferior texture and taste compared to steamed crab, and to our knowledge, no Virginia processors boil crab meat during pasteurization. Yet New Englanders believe that best quality red crab is produced by boiling. When Holmsen and McAllister (1974) tried to encourage the development of a red crab processing industry in New England by examining production methods, they did not even consider steaming. Because of the strong preference for steaming in Virginia and the preference on the part of the New England boat owners for boiling, both methods would have to be examined if all the parties were going to agree on how to proceed with respect to cooking.

Effects of Cooking on Meat Weight and Shelf-Life

The first cooking trials were held on July 15, 2008 at Casey’s Seafood in Newport News, VA. Red crabs were either pressure
steamed or boiled and then cooled in a slush ice bath. Then the crabs were drained and cooled overnight. Two rims (large cylindrical stainless steel baskets) of each method were prepared. Because there was the possibility of selling whole cooked crab into the Asian market, the number of legs missing from the body after cooking was tabulated—distributors said they would not take whole cooked red crab with more than two legs missing. The data generated through this experiment are presented in Table 1. Interestingly, the steamed crab reabsorbed moisture from the ice bath, making their post-cooking weight very close to their initial green weight. However, by the next morning whole weight yield for steamed was less than their boiled counterparts.

Subsequently both the steamed and boiled crabs were refrigerated for shelf-life sniff tests and plate counts. There was very little difference in smell as they aged; however, at the end of the test, plate counts for boiled grew faster than those of the steamed (see Table 2). This data indicate that whole cooked crab may have a shelf life of about 11 days.

Effects of Cooling Method on Meat Quality

When picked, steamed crab body meat was judged to be too wet for a commercial product. Another cooling method had to be tried because the slush ice bath allowed the body meat to take too much water. Leg meat, pressed out by rollers, was judged to be of decent quality regardless of whether it was boiled, pressure steamed, or atmospheric steamed.

Effects of Cooking Method on Taste

On July 18, 2008, 23 untrained tasters were asked to rate the leg meat on seven attributes using on a seven-point scale that went from “like extremely” to “dislike extremely”. A mark of 7 represented “like extremely” and 1 represented “dislike extremely”. The tasters preferred the boiled leg meat to either of the steamed methods in six of the seven attribute categories. The summarized results of the tasters’ opinions are in Table 3.
For each of the six categories, tasters rated the boiled meat somewhere between “like extremely” and “like moderately”. Not only was the preference for the boiled meat clear, but the taster’s opinions of the boiled meat was less variable compared with the other two cooking methods. The standard deviation, a measure of the how wide the range of opinions were, was much smaller for the boiled meat than the other two cooking methods.

Effects of Cooking Method on Picking Yield

Yields of the various cooking methods were then established. On September 8 and 9, in 2008, boiled and pressure-steamed picking trials were undertaken on a small scale. Although this first picking test was small and the pickers were still learning to pick red crab, initial results favored the boiled method on both taste and yield (Table 4).

On September 18, yields from atmospheric steam and boiled were compared (Table 5). Again boiled produced better yield than steaming. In all tests to date, boiled red crabs produced higher yields than other processing methods and tasters liked it more. Based on these results it was decided to proceed with further tests, using boiled meat only.

In October three additional boiled picking tests were done to see whether pickers could learn to pick the crab more efficiently and get more consistent yields (Table 6).

All together there were five yield tests done on boiled meat during the trials. The weighted average yield for these five test was 19.2 percent.

Boiled, high-quality leg meat could be obtained using mechanical rollers and pincer meat and the upper arm on the claw could also be effectively hand picked. The body meat proved tougher to hand pick at costs that would allow it to be sold profitably, even in a differentiated market. Hand picking would make it possible to sell in markets other than the generic minced markets.

In a October 30 test, two pickers took four hours to produce 4.6 pounds of meat from bodies while in five hours they produced 17.2 pounds of pincer/claw and arm meat (Table 7).

<table>
<thead>
<tr>
<th>Cooking Method</th>
<th>Green Weight (lb)</th>
<th>Morning Cooked Weight (lb)</th>
<th>% Body Yield</th>
<th>% Claw Yield</th>
<th>% Leg Yield</th>
<th>% Total Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure Steamed</td>
<td>120</td>
<td>115</td>
<td>7.5</td>
<td>4.5</td>
<td>5.5</td>
<td>17.5</td>
</tr>
<tr>
<td>Boiled</td>
<td>129</td>
<td>128</td>
<td>7.9</td>
<td>7.1</td>
<td>6.0</td>
<td>21.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cooking Method</th>
<th>Green Weight (lb)</th>
<th>% Body Yield</th>
<th>% Claw Yield</th>
<th>% Leg Yield</th>
<th>% Total Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure Steamed</td>
<td>64.3</td>
<td>4.5</td>
<td>5.1</td>
<td>5.5</td>
<td>15.1</td>
</tr>
<tr>
<td>Boiled</td>
<td>64.9</td>
<td>6.5</td>
<td>7.7</td>
<td>6.2</td>
<td>20.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Green Weight (lb)</th>
<th>% Body Yield</th>
<th>% Claw Yield</th>
<th>% Baader Mince Yield</th>
<th>% Claw Finger Yield</th>
<th>% Leg Yield</th>
<th>% Total Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Oct.</td>
<td>177.7</td>
<td>6.9</td>
<td>(no data)</td>
<td>7.3</td>
<td>6.4</td>
<td>20.6</td>
<td></td>
</tr>
<tr>
<td>21-Oct.</td>
<td>300.9</td>
<td>4.5</td>
<td>2.6</td>
<td>4.1</td>
<td>5.5</td>
<td>16.7</td>
<td></td>
</tr>
<tr>
<td>30-Oct.</td>
<td>300</td>
<td>3.6</td>
<td>7.0</td>
<td>3.6</td>
<td>5.6</td>
<td>19.8</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crab Part</th>
<th>Hours Worked</th>
<th>Meat Processed (lbs)</th>
<th>Processing Rate (lbs/hr)</th>
<th>Processing Cost ($/lb)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Claw/Upper Body</td>
<td>5</td>
<td>17.2</td>
<td>3.44</td>
<td>2.25</td>
</tr>
<tr>
<td>Body</td>
<td>4</td>
<td>4.6</td>
<td>1.15</td>
<td>6.74</td>
</tr>
</tbody>
</table>

* Processing Cost based on labor rate of $7.75 per hour.
The body produces the lowest value meat and took the most labor to produce. Body meat that cost $6.74 in labor would be difficult to sell. Even the best picker produced only 2.85 pounds of body meat in two hours, a labor per pound cost of $5.45. Mechanical picking could be more cost effective, but the capital costs for mechanical pickers seemed a high-risk investment to local crab houses.

**Effects of Salting Method on Taste**

Because boiling allows salt to be added to the cooking water, tests were undertaken to see whether there was a detectable difference and preference between the salted and unsalted boiled red crab.

Ten employees at Casey Crab were asked to sample three different cups of crabmeat on a plate. None of the employees were trained tasters.

In this test, two samples that are alike and one that is different are placed on a plate. Respondents are asked to identify the one that was different. In multiple tests, the different sample was identified correctly nearly two-thirds of the time. This is significant at the 0.05 level, indicating that people could taste a difference between the salted and non-salted product. However, the preference for salt or no salt was not so clear in this test. Six of the respondents preferred the crab cooked in salt water and four preferred no salt.

**Reducing Mortality for Live Market through Altering Water Chemistry**

While the picking and taste trials occurred at the crab processing plant, a dock experiment was conducted with the red crab live market. A commercial-sized crab holding tank with a chiller from a shrimp boat was installed in order to try to maintain the water in the tank at temperatures between 3.3-7.0°C (38-45°F). These temperatures approximated the ambient temperatures of the crab’s natural environment and the temperature the crab was held at on the boats. However, such low temperatures make biological filters, which are normally used in aquaculture to manage ammonia, inefficient. Filters large enough to control ammonia in this commercial tank would have to be too big and expensive and were deemed financially impractical. However, without good ammonia control in the commercial sized tank, crab mortality was unacceptable high.

Lowering the pH is another and cheaper way to reduce the toxic ammonia (NH₃), which is a by-product of crab metabolism and biological debris in the water. Nitrogen enters the water system largely from crab waste. In the water, it is converted to one of two nitrogen-based forms: NH₃ and NH₄⁺. Toxicity of aquatic animals to nitrogen is primarily attributable to the un-ionized ammonia (NH₃) and not the ionized ammonium (NH₄⁺) (U.S. Environmental Protection Agency 2009). By neutralizing the pH, NH₃ could be reduced. Though ammonia

A commercial holding tank with red crabs.
toxicity is reduced in marine environments compared to freshwater (Canadian Council of Ministers of the Environment, 2009), the effects of both temperature and pH on un-ionized NH$_3$ concentration in marine water is important (Soderberg and Meade, 1991). In general, more NH$_3$ and greater toxicity exists at higher pH. Temperature also plays a large role in NH$_3$ toxicity, with increasing toxicity associated with increasing temperature.

The effects on crab mortality resulting from manipulations of the water pH were evaluated in a small system separate from the commercial sized tank because it was deemed too risky to perform these water manipulations in the commercial tank.

Holding water temperature was maintained at 3.3-7.0°C (38-45°F) throughout trials to simulate ambient water temperatures on the fishing grounds. This lower water temperature helped control the formation of toxic NH$_3$. With low water temperatures, the manipulation of water pH could be evaluated more easily. To evaluate the effect of pH levels on the health of red crab, an initial trial was performed by maintaining three 50 gallon aerated holding tanks each at different water pH values (8.0, 7.0, 6.0). The red crab is a deep water species that shares many qualitative and quantitative physiological functions with shallow water crab species, however, they are reported not able to survive in salinities lower than 20 ppt (Henry et al., 1990). Therefore, water used for this study was obtained at sea on fishing grounds (34ppt) and held in fishing vessel hold until return to dock (<2 days). Water temperature on all tanks was held at ~7°C (44°F). Muriatic acid and baking soda was used to adjust and maintain the approximate pH levels throughout the trial.

Crabs for this study were removed from the purge tank that was loaded the previous day directly off the boat. Twelve red crabs were introduced into each holding tank and held for 7 days. Each day crabs were evaluated and water pH re-adjusted to targeted levels if needed.

Mortality was observed beginning day 4 in both the pH 8.0 and 6.0 tanks. In the pH 8.0 tank, there was only 1 dead crab; however the remaining crabs were very lethargic. In the pH 6.0 tank, there were 3 dead crabs, with the remaining crabs in good condition. Comparatively, tank with pH 7.0 water had no mortalities and all crabs in good condition. By Day 7, all crabs in pH 8.0 tank were dead, while crabs in the pH 6.0 tank experienced no further mortalities; however, the remaining crabs were in poor condition, lethargic with dull coloration. The tank with pH 7.0 experienced no mortalities throughout the experiment, and after 7 days, the

Crabs in pH 6.0 treatment (top) had mostly folded legs and were observed to be light in color and lethargic. Crabs in pH 7.0 treatment (bottom) had legs extended and some stood on walking legs. Color and energy of this group was observed to be greater than the ph 6.0 treatment group.
crabs were in very good condition, lively and with good coloration. These results demonstrated that red crabs can tolerate pH levels as low as 6, but pH 7.0 was demonstrated as a promising target level for holding red crabs.

The results from this small-scale trial gave promise to the practice of using pH as a means to control toxic ammonia in holding water. In combination with low water temperatures, adjusting the water to pH 7.0 can possibly create a positive environment for holding red crabs.

To further investigate this potential, a trial was conducted at a larger scale, attempting to mimic a commercial practice. An 800-gallon holding tank was equipped with a protein skimmer to help remove some nitrogen from the system and polish the water to aid in viewing crabs. An acid pump was also added to maintain pH level. Upon filling the tank, water was adjusted to pH 7.0 and temperature to ~8°C (46°F); 500 pounds of red crabs were placed in the tank and held for 8 days. Initial ammonia (TAN) of holding water was 0.75 mg/l. (NOTE: Crabs used were from boat that sat at dock for 2 days prior to off-loading due to weather conditions; at time crabs were transferred, ammonia level of boat holding water was 32.80 mg/l.) Water quality and crab condition was monitored daily. Crab condition evaluation included sub-sampling for mortality estimates as well as crab liveliness, color retention, and presence of off-odors.

Crab mortality was highest during the first 2 days of holding with 18 and 17% mortality estimated for days 1 and 2 respectively. Mortality declined from day 3 and 4 to 9.5% and 7.7% respectively. Observations of live crabs throughout study estimated 90% lively and 10% weak/lethargic. On day 4, a distinct foul odor was detected from the holding water. Upon a more extensive sub-sampling of remaining crabs, many (68%) of the dead crabs possessed this odor, which was evaluated as decaying crabs visceral mass. This observation, and given the cold temperature of the water, suggests that these crabs probably died close to the initiation of the study (day 1) and were not culled out by the sub-sampling practice. Ammonia levels steadily increased throughout the study (See Table 8). At the completion of the study (day 8), the tank was drained and all remaining crabs were separated and weighed.

For the 8 day holding period holding water pH at 7.0 and temperature at ~8°C, a total of 26% mortality was experienced. Though the mortality was high, remaining live crabs were highly marketable. And due to the compromised initial condition of the crabs because of delayed off-loading and inability to assess the individual crab vigor before loading into the test tank, mortality rates may be inflated.

By the time the results of this encouraging preliminary data were available, the fishing vessels had moved north again and the distributor removed his commercial tank. However, boat owners and urban distributors to live Asian-American markets all remain interested if water quality and shipping parameters can be developed so the red crab mortality experienced during initial marketing attempts can be decreased.

Subsequent to these tests, the fishery management plan was changed, reducing the allowable catch of male red crabs and opening an experimental red crab fishery. Asian-American distributors have expressed more interest in live female red crabs than in live males. Because of their size females are less desirable in the processed market. Thus, the live market would seem to be a natural

<table>
<thead>
<tr>
<th>Day</th>
<th>Concentration of Ammonia (NH₄⁺) (%)</th>
<th>% Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.3</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>5.4</td>
<td>17</td>
</tr>
<tr>
<td>3</td>
<td>7.36</td>
<td>9.5</td>
</tr>
<tr>
<td>4</td>
<td>14.71</td>
<td>7.7</td>
</tr>
<tr>
<td>5</td>
<td>24.85</td>
<td>(no data)</td>
</tr>
<tr>
<td>8</td>
<td>28.46</td>
<td>26</td>
</tr>
</tbody>
</table>

Table 8. Ammonia and Crab Mortality When Held at pH 7.0
fit for female red crabs.

**Conclusion**

In the end, Benthic Fishing Corporation and local blue crab picking houses were not able to come to a mutually beneficial agreement that would bring red crab processing to Virginia. Local crab processors felt the investment in new boiling and picking equipment was too great given their judgments about potential returns. There was also concern that the batch nature of the process would require inconsistent amounts of labor, with several intensive days followed by several lax ones. Local processors didn’t believe the labor pool that would be able to meet such fluctuations.

Benthic Fishing Corporation subsequently bought a scallop processing plant in New Bedford, MA and remodeled it to process red crab. In late 2009, they began to process red crab there, producing higher quality meat than the minced meat that was formerly produced in Canada. Body meat, however, is being machine picked (the company found that body meat was difficult to hand pick profitably). Benthic Fishing Corporation still plans to pack crabs in Virginia when the boats are fishing in the southern end of the red crabs range and they remain interested in developing the live market.

**References**


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Photos: All Photos ©Dan Kauffman/Virginia Tech and ©Bob Fisher/Virginia Institute of Marine Science-Virginia Sea Grant.