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BLUEPRINTS

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Blue Crab Aquaculture in Ponds

Potentials and Pitfalls

North Carolina's Blue Crab Fishery

As North Carolina's number one fishery, blue crabs, *Callinectes sapidus*, are part of an important industry for numerous coastal communities. The fishery supports commercial fishermen, dealers, gear providers and processors throughout the year. Fluctuations in landings have led to concerns over crab populations and the livelihood of the commercial crabbers they support.

Continued demand for blue crab, coupled with fishery concerns, have driven some to consider the species for aquaculture, either for restoration efforts or for food production. Further, crabbers have expressed interest in using farm ponds as holding areas for shedding operations and for growing smaller, lower-grade crabs for more profit.

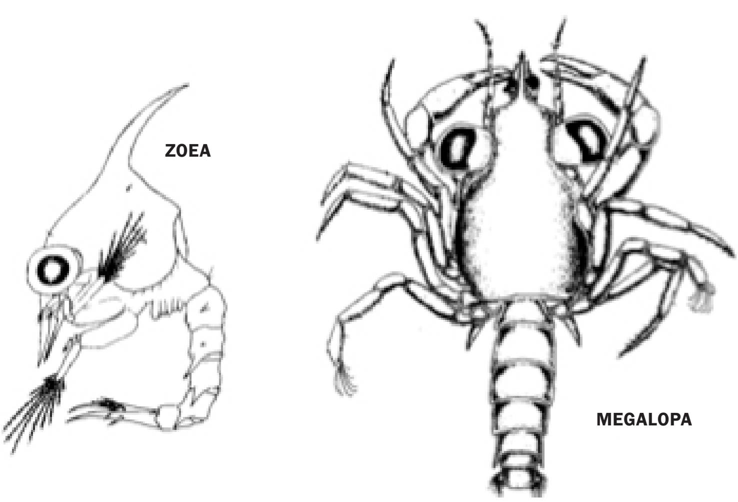
Although various forms of crustacean aquaculture have succeeded, mainly for shrimp, commercial blue crab aquaculture has yet to be proven viable. To date, such efforts have been limited to research projects, several of which are outlined in this report.

Supplying Juveniles

Commercial production of any species relies on a supply of larvae or juveniles for growing to market size. For most marine species, producing larvae or juveniles is difficult because of the numerous developmental stages that occur during their early life history. Blue crabs are no different, spending 31 to 49 days as zoea and 6 to 20 days as megalopa before becoming juvenile crabs (Figure 1).

The first successful attempt at mass producing juvenile blue crabs was completed in 2005, by researchers at the Center for Marine Biotechnology, University of Maryland Biotechnology Institute (Zmora et al., 2005). Over four culture cycles, 40,000 juvenile blue crabs were produced. The major limitation was cannibalism during the megalopal and early juvenile stages of production. Additional work has also been conducted at Southern Mississippi University's Gulf Coast Research Laboratory. However, there have been no commercial efforts to create a supply of juvenile blue crabs.

Figure 1. Two larval stages of the blue crab, Callinectes sapidus *(Stuck and Perry, 1982).*



Producing Market-Size Crabs in North Carolina

Blue crabs harvested from North Carolina waters are sold as soft or hard crabs, with dramatically different market value. Depending on grade and availability, soft crabs may cost substantially more than hard crabs. For this reason, and because soft crabs may be legally sold at a smaller size (male hard crabs must be 5 inches or greater in North Carolina), production of soft crabs will likely be the targeted product for aquaculture.

Producing market-sized crabs from juveniles has been accomplished, with varying success, in farm or aquaculture ponds. While it is common for candidate aquaculture species to be first evaluated in tanks, pond aquaculture was evaluated primarily for cost savings, in addition to the availability of farm ponds in Eastern North Carolina, where interest was present. Further, it was assumed that cannibalism posed less of a risk to production because of the space advantage present in ponds.

Between 2001 and 2007, the North Carolina Blue Crab and Shellfish Research Program (BCSRP), administered by North Carolina Sea Grant, supported four projects evaluating the growth and survival of juvenile blue crabs reared in ponds. The results are summarized below.

Metamorphosis of Wild-Caught Crab Megalopae and Transfer for Pond Growout

During 2001 and 2002, two BCSRP projects were funded (01-STOK-03 and 02-STOK-02, see Eggleston et al., 2004a,b) to determine if wild-caught blue crab megalopae would successfully develop into juveniles in the lab, and evaluate their growth and survival in freshwater ponds.

From 2001 to 2003, approximately 143,000 megalopae were collected using plankton nets fished near Oregon Inlet. Megalopae were held in 132-gallon fiberglass tanks with window screens. Juvenile crabs could settle on the screens after molting from megalopae. The tanks were held at 24 ppt salinity using artificial seawater and half of the tank volume was exchanged daily.

Seagrass and macroalgae collected during sampling were also added to each tank in bags to mimic potential cues normally experienced in the wild, and for food. Of the megalopae collected, approximately 13,800 (9.7%) successfully molted to early juvenile crabs. Although low, this level of survival is common during metamorphosis, and follows a similar trend as other cultured marine species.

Following molting, two pond studies were conducted for growout evaluation using juveniles captured from the Pungo and Pamlico rivers using small mesh crab pots and otter trawls. In 2002, the first study utilized two farm ponds (0.2 and 0.8 acres, average depth of 3 to 5 feet) located in Belhaven. During stocking of juvenile blue crabs (25 to 90 mm carapace width, or CW), mass mortality occurred, some within two to three hours. Follow-up studies using various water sources, including pond water from the stocked ponds, were conducted. These studies suggested that the lack of sodium content in the water was potentially the reason for the poor survival.

In 2004, a second attempt at pond trials was conducted using four different farm ponds with known sodium levels (02-STOK-02). Ponds were stocked with an average of 415 wild-caught juvenile crabs per acre, also captured from the Pungo and Pamlico Rivers. Crabs were graded based on size, and each pond was randomly stocked with a given size. The pond data is summarized in Table 1.

All ponds were known to contain natural populations of largemouth bass, bluegill, freshwater eels and other predators. However, no predators or aquatic weeds were removed from the ponds prior to stocking. Crabs were not fed during the study. After 130 days, crabs were removed using six to seven baited crab pots (one standard pot with cull rings closed, and five to six pots with small mesh of approximately 0.39 x 1.0 inches). Total survival from each pond ranged from 9.7% to 24.7%, with crabs averaging 135.8 to 171.9 mm CW. This was the first farm-pond trial to result in crabs produced from juveniles. And despite the relatively low overall survival rate (15.7% for all ponds), the results provide proof of concept, even in the presence of predators.

Table 1. Pond characteristics, stocking rates, and production values of four ponds used in the production of blue crabs.

	Pond 1	Pond 2	Pond 3	Pond 4
Area (acres)	0.51	1.41	1.41	0.92
Start Salinity (ppt)	0.3	1.3	1.9	1.5
Final Salinity (ppt)	0.2	1.0	1.5	1.3
# Crabs Stocked	220	581	368	159
Crab Density (#/acre)	431	412	414	400
# Crabs Harvested	30	71	57	91
Total Survival (%)	13.6	12.2	9.7	24.7
Average Initial Size (mm CW)	34.7	15.5	24.0	44.6
Average Final Size (mm CW)	135.8	155.1	171.9	172.9
Average Growth (mm CW/day)	0.75	1.04	1.10	0.96

Growth of Hatchery-Reared Juvenile Crabs in Ponds

In 2005, a follow-up pond study (05-STOK-06) was funded to build on the results of the previous two projects. Two research ponds at the Tidewater Research Station in Plymouth, each 0.25 acres with an average depth of 4.5 feet, were stocked with approximately 4,800 hatchery-reared juvenile blue crabs obtained from the Center of Marine Biotechnology, University of Maryland. Juvenile crabs were approximately 11.5 mm CW. Ponds were filled with well water, averaging 0.4 to 0.5 ppt salinity.

In the first pond, artificial seagrass squares (Figure 2) were placed around the perimeter of the pond, approximately 3 feet from the pond edge. The artificial seagrass was a substrate for the juvenile crabs to colonize.

Artificial substrate was added to the second pond. However, additional substrate was provided by barnyard grass (*Echinochloa spp.)* that was present when the ponds were dry (Figure 3). Crabs were fed a commercial shrimp diet (Zeigler feeds, Catawissa, PA) starting at rate of 13.5% of the biomass, which was gradually reduced to 2.2% by the end of the study. Periodic sampling monitored crab growth, and a final harvest was conducted after 96 days. All samples were taken using

Figure. 2. Artificial grass squares used as substrate in test ponds during a blue crab production trial.

Photo: D. Eggleston

peeler pots. The final harvest was carried out by draining the pond and netting all remaining crabs.

From the two ponds, a total of 1,960 crabs were harvested between 62 and 96 days after stocking, with an overall survival rate of 20.4%. The majority of crabs came from the pond with barnyard grass (1,253) and the least were from the pond with artificial substrate (707). The reduced mortality in the second pond was partly attributed to a hybrid striped bass removed from the pond during harvest. Average crab size for both ponds was 106.3 mm CW, and growth ranged from 1.0 to 1.9 mm CW per day during the study. The bulk of the crabs harvested ranged from 81 to 110 mm CW.

A follow-up study (07-STOK-01) was funded in 2007 to evaluate growout of hatchery-reared blue crabs in six, 0.25-acre ponds (identical to those used in project 05-STOK-06), located at the Tidewater Research Station in Plymouth. Three ponds contained significant coverage of barnyard grass, while the remaining three ponds were void of any vegetation. Each pond was stocked with approximately 3,742 crabs (average size of 9.6 mm CW), and they were given feed similar to that in 05-STOK-06.

Of the six ponds, valid data could only be obtained from three (one pond without grass and two ponds with grass) because of the presence of predators. Crab harvest began 77 days after stocking, with overall survival rates of 18.8% for the unvegetated pond, 16.1% and 13.6% for the two vegetated ponds. Crab size for the three ponds averaged 109.2 mm CW at project completion.

Removal of Peeler Crabs from Growout Ponds

Because soft crabs are often more valuable than hard crabs, the ideal scenario for blue crab culture would be to remove peeler (pre-molt) crabs from the pond and place them into a shedding system to produce the soft crabs. This additional step requires capturing crabs during the pre-molt phase, rather than drain-harvesting the pond.

Project 07-STOK-01 also evaluated three techniques to remove peeler crabs from the ponds. The crabs were harvested using a peeler crab pot wrapped in window screen, a brush trap of six 8-inch brush cuttings tied together at one end, or a mop trap made from a commercially available 16-inch mop head (Figure 4). All traps were placed on the bottom, or slightly off the bottom, using a float. Three of each trap type were deployed in each pond and checked for 10 days during the harvest period.

All traps effectively captured crabs, although few were peeler crabs. A total of 254 crabs were captured from all pots during the test period, of which 40 were pre-molt, soft or recently molted (paper shells). The remaining crabs were hard crabs. The modified peeler pot produced the most peeler crabs, providing approximately 55% of the total peelers captured.

Figure. 3. Test pond with one-third coverage of barnyard grass, Echinochloa spp.*, used as a substrate for the production of blue crabs.*

Photo: G. Plaia

Future Potential and Pitfalls for Blue Crab Aquaculture

The future for blue crab aquaculture is not without question. These project results provide both potential possibilities and pitfalls. Blue crabs have been shown to possess tremendous growth potential when cultured in low-salinity ponds.

Growth rates ranged from 0.42 to 1.50 mm CW per day for all studies combined. Growth rates of 1.0 to 1.5 mm CW per day are some of the highest ever recorded for blue crabs. The highest growth rates however, appear to be density dependent, where the largest crabs were harvested from ponds with the least number of crabs. While the exact reason for this is not known, blue crabs have shown highly cannibalistic behavior, which may be a reason for fewer, larger crabs overall.

Survival is a concern for blue crab aquaculture because of cannibalism, as well as a lack of additional replicated production studies. From the studies described here, the overall average survival rate was approximately 15%, including ponds with predators. Removal of predators likely will result in higher survival, but to what level is unknown. Additional studies are required to determine more specific

Figure. 4. Three trapping methods used to harvest peeler, or pre-molt, crabs in shedding ponds (clockwise from left): modified peeler pot, brush trap and mop trap.

Photo: G. Plaia

survival figures. Production estimates should be based on conservative values because of this behavior. Regardless, the combination of a high growth rate and tolerance for low salinity is appealing for aquaculture, in particular because of the availability of farmland in Eastern North Carolina with access to suitable water supplies.

Producing soft crabs would be the ideal scenario for crab aquaculture because of their marketability. Unfortunately, a major bottleneck to pond culture of soft crabs is removing pre-molt peeler crabs from the ponds for shedding. Hence, survival estimates provided in this report are for all crabs harvested from the ponds rather than peeler or soft crabs. The use of modified peeler crab pots provided some promise for peeler harvest, but more efficient methods (timing, baiting or equipment) are needed to maximize yield.

Crab aquaculture, from a marketing standpoint, is attractive. A supply of soft crabs, when none are available from the wild fishery, could result in improved pricing. This market scenario would need further research because soft crab prices fluctuate within the season as well as out-of-season, in part, because crabs from numerous states compete in similar markets.

Finally, all new species being evaluated as aquaculture candidates must first answer the question of seed supply. For blue crabs, there currently is no available supplier of juveniles for pond growout. Blue crabs have been mass produced for research (Zmora et al., 2005), so there is precedent for hatchery production, should crab growout prove viable. However, in the short term, researchers and or first adopters will need to depend on wild megalopae or juveniles to stock their operations.

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