King Crab Aquaculture and Enhancement in Alaska

Project Performance Report
NA08OAR4170766
12/1/08 to 5/31/09

Accomplishments

Large-scale king crab culture is ongoing at the Alutiiq Pride Shellfish Hatchery, in Seward, Alaska, with the aim to develop the technology and evaluate the feasibility of mass rearing juvenile king crab for stock enhancement purposes. In combination, we are examining the population genetics at the University of Alaska in Juneau to better understand genetic consequences of potential releases.

Specific milestones reached with this research include (1) successfully acquiring and holding red (*Paralithodes camtschaticus)* and blue (*Paralithodes platypus)* king crab broodstock; (2) evaluating effects of larval diet, culturing equipment, and techniques on survival of larval red and blue king crab; (3) evaluating effects of larval stocking density of red and blue king crab in a hatchery setting; (4) evaluating suitable substrate for settlement of red and blue king crab post-larvae and juveniles; (5) evaluating optimal stocking densities and diets for early red and blue king crab juveniles; and (6) investigating red king crab genetics to better understand potential impacts of stock enhancement.

Milestone 1: Broodstock acquisition and holding technology.

Red king crab broodstock were acquired from Bristol Bay, Alaska, in fall 2007 and 2008, and blue king crab broodstock were acquired from Little Diomede Island, Alaska, in spring 2008. Broodstock were successfully held until larval hatching began for both species. Husbandry techniques were developed to maintain healthy broodstock for long-term holding (several months).

Milestones 2 and 3: Evaluating effects of diet and stocking density on larval rearing.

Experiments in 2009 refined larval rearing techniques and built on the success achieved in 2008. Hatchery-scale experiments investigated the effects of stocking density, diet, and water temperature on growth and survival. Specific stocking densities, diets, and temperatures were developed to optimize survival. Enrichment media proved to be essential in the larval diet to produce healthy post-larvae and juveniles. Stocking densities of approximately 50 larvae L^{-1} is optimal. Water temperature from 8 to 10°C optimizes larval development by decreasing intermolt duration, and prevents excess bacteria buildup. Successful larval rearing yielded more than100,000 red king crab juveniles in 2009.

Milestone 4: Evaluating suitable substrate for post-larvae and juveniles.

In 2008, we demonstrated that glaucothoe prefer artificial seaweed for settlement over other artificial substrates such as biofilter media, burlap, and gillnet. We further investigated settling behavior of red king crab glaucothoe using artificial seaweed in large-scale production tanks. Once larvae molted from Z4 to glaucothoe, black and green artificial seaweed were added to

rearing tanks. In all cases, considerably more glaucothoe were found on the black seaweed. The black seaweed was "conditioned" and may promote better attachment than the "unconditioned" green seaweed. Overall survival from G to C1 was 40% in 1200 L larval rearing tanks; however, survival was 70% in 60 L containers. Increased survival may be due to the alternate tank design such as a flat mesh bottom and no aeration.

Milestone 5: Evaluating optimal stocking densities and diets for early juveniles.

Juvenile red king crab obtained from 2009 larval experiments are currently being used in mass-rearing experiments to understand effects of diet, stocking density, and size grading on survival, growth, and coloration. In addition to data collected from 2008 juvenile experiments, data will suggest best practices for rearing juvenile red king crab in a large-scale hatchery setting. Diets will be supplemented with calcium and astaxanthin to understand effects of diet on growth, cannibalism, and coloration

Milestone 6: Investigate genetics to better understand potential impacts of stock enhancement.

A genetic component of the AKCRRAB project focuses on developing tools to understand any genetic impacts of out-planting. The main objectives of the current research are to (1) determine population structure of red king crab in Alaska with regard to unique genetic stocks, effective population sizes, and migration rates, and (2) determine the mating scheme of red king crab (i.e., single vs. multiple paternity). Preliminary results suggest that female red king crab caught in Bristol Bay in 2007 were each mated by a single male, as the brood from no single female contained more than two non-maternal alleles at a given locus. Long-term genetic research aims to determine a genetic baseline of wild stocks, develop a mass mark with full parental genotype, and assess any potential genetic risks of releasing hatchery crabs.

Products

Hatchery-raised juvenile red king crabs have been sent to Al Stoner (NOAA Newport), Ginny Eckert (UAF Juneau), and Sherry Tamone (UAS Juneau) for growth, survival, and habitat selection experiments. These studies will help us understand how hatchery-raised crabs may perform in the wild.

A research article on results of juvenile rearing experiments in 2008 was published in *Aquaculture*, a peer-reviewed scientific journal. The paper is titled "Effects of diet, stocking density, and substrate on survival and growth of hatchery-cultured red king crab (*Paralithodes camtschaticus*) juveniles in Alaska, USA," and is co-authored by Benjamin Daly, James S. Swingle, and Ginny L. Eckert.

Impacts

Developing technology for successful king crab hatchery rearing is important to Alaska's long-term economic development and sustainability. The first step in establishing a successful enhancement effort is perfecting strategies for hatching and rearing king crab to a stage where they can be released into the wild and contribute to reversing low wild stock abundance in Alaska. Understanding red king crab genetics is also critical for assessing consequences of potential out-planting. Acquiring this knowledge base will aid policymakers in making informed

decisions about whether to one day pursue active rehabilitation of depressed wild king crab stocks through hatchery enhancement.

After a third year of research, successful large-scale cultivation of king crab juveniles was achieved. Techniques developed in 2008 were fine tuned to increase overall production. In 2009, more than 100,000 first-stage juvenile instars were produced, which is a dramatic increase over 2008. With large-scale cultivation as a possibility, policymakers can now decide if active rehabilitation of depressed crab stocks through hatchery enhancement should be further implemented. The preliminary success and early establishment of hatchery technology may inspire investors to contribute to a crab enhancement effort in Alaska.

Publications

Daly, B., Swingle, J., Eckert, G. 2009. Effects of diet, stocking density, and substrate on survival and growth of hatchery-cultured red king crab (*Paralithodes camtschaticus*) juveniles in Alaska, USA. Aquaculture. 293:68-73.

Leroux, C. (in prep). Nutrition and technique for large scale larval culture of the red king crab (*Paralithodes camtschaticus*) and blue king crab (*Paralithodes platypus*). M.S. thesis, University of Alaska Fairbanks, Fairbanks, Alaska

Swingle, J., Daly, B., Eckert, G. (in prep). Large-scale larval rearing of red king crab (*Paralithodes camtschaticus*). Aquaculture.

Daly, B., and Swingle, J. (in prep). Embryo monitoring as a method to predict larval release of *Paralithodes camtschaticus* for aquaculture purposes. Aquaculture.

Presentations

Lowell Wakefield Fisheries Symposium, Anchorage, AK, March 2009, Ginny Eckert, Contributed Talk: King crab aquaculture in Alaska, USA

Lowell Wakefield Fisheries Symposium, Anchorage, AK, March 2009, Ben Daly, Contributed Talk: Effects of diet, stocking density, and substrate on survival and growth of hatchery-cultured red king crab (*Paralithodes camtschaticus*) juveniles in Alaska, USA

Lowell Wakefield Fisheries Symposium, Anchorage, AK, March 2009, Celeste Leroux, Contributed Talk: Food for Naught: Findings in Biochemical Analysis of Red and Blue King Crab Larvae

Lowell Wakefield Fisheries Symposium, Anchorage, AK, March 2009, Scott Vulstek, Poster: Genetic mating system of red king crab (*Paralithodes camtschaticus*) in Alaska.

National Shellfisheries Association Annual Meeting, Savannah, GA, March 2009, Ginny Eckert, Contributed Talk: King crab aquaculture in Alaska, USA

National Shellfisheries Association Annual Meeting, Savannah, GA, March 2009, Ben Daly, Contributed Talk: Effects of diet, stocking density, and substrate on survival and growth of hatchery-cultured red king crab (*Paralithodes camtschaticus*) juveniles in Alaska, USA

Students Supported

Celeste Leroux, master's student, expected graduation: Dec. 2009.

Leroux, C. (2009) Nutrition and technique for large scale larval culture of the red king crab (*Paralithodes camtschaticus*) and blue king crab (*Paralithodes platypus*). M.S. thesis, University of Alaska Fairbanks, Fairbanks, Alaska

Benjamin Daly, Ph.D. student, expected graduation: May 2012.

Daly, B. Ecological fitness of hatchery-reared red king crab (*Paralithodes camtschaticus*) juveniles in Alaska USA. Ph.D in progress 2008-present, University of Alaska Fairbanks, Fairbanks, Alaska.

Scott Vulstek, master's student, expected graduation: May 2010.

Vulstek, S. Alaskan red king crab (*Paralithodes camtschaticus*) population structure and mating system. M.S. in progress 2008-present, University of Alaska Fairbanks, Fairbanks, Alaska.