Alaska King Crab Research, Rehabilitation and Biology

AKCRRAB Program

Draft Strategic Plan
2010 – 2014

September 8, 2011

Introduction

The Alaska King Crab Research, Rehabilitation and Biology (AKCRRAB) program is a coalition of university, federal and stakeholder groups, formed in 2004 with the goals of adding to the scientific understanding of crab life history and ecology, and rehabilitating depressed king crab stocks in Alaska. AKCRRAB intends to develop scientifically sound strategies for hatching, rearing and outplanting king crab in Alaska, to help restore self-sustaining populations. The initial focus is on red king crab in the Kodiak Island region, and on blue king crab near the Pribilof Islands. The partners view the AKCRRAB efforts as important to the affected regions' long-term economic development and sustainability.

AKCRRAB's goals will be accomplished in two phases. In 2011, AKCRRAB is nearing completion of its initial phase, as research to date has largely succeeded in developing and improving methods of hatchery rearing of juvenile king crab from wild-caught broodstock, to the point where large-scale production has been shown to be feasible. Parallel field and laboratory studies of crab ecology and population genetics have begun, with much work still to be done before large-scale releases will be possible.

In the second phase, hatchery studies will focus on increasing the speed and efficiency of larval production. Also, emphasis will increase on the parallel studies essential to understanding optimal breeding and release strategies, appropriate habitat, and potential impact on existing ecosystems. The work will provide the science necessary for responsible permitting decisions. Increased knowledge will allow scientists and managers to assess the feasibility of ecologically sound rehabilitation of depressed stocks, with potentially substantial benefits to Alaskan fishing communities and industry.

Ultimately, AKCRRAB is intended to evolve from the current, research-oriented coalition, to a formal entity focused on transitioning hatchery techniques and outplanting technologies to communities and industry as part of statewide efforts to help rehabilitate depleted king crab stocks. As Phase 2 develops, the program will require increased support and guidance from communities and industry. The transition from feasibility to implementation will be dependent on this political and financial support, as well as a new guidance structure to reflect the participants and their work toward common goals.

Current Structure

AKCRRAB is guided by a steering committee, made up of a representative from each of the major groups that founded, funded and continue to support the program, and by a science committee made up of researchers from the University of Alaska and the National Marine Fisheries Service (See Appendix 1). The co-chairs of the steering committee are the Director of the Alaska Sea Grant program, Dr. David Christie, and Heather McCarty from Central Bering Sea Fishermen's Association (CBSFA). The chair of the science committee is Dr. Ginny Eckert of the School of Fisheries and Ocean Sciences, University of Alaska Fairbanks (Juneau).

AKCRRAB Partners

Community/Industry

Alaskan Shellfish Growers Association
Aleutian Pribilof Island Community Development Association
Alutiiq Pride Shellfish Hatchery
Central Bering Sea Fishermen's Association
Chugach Regional Resources Commission
Gulf of Alaska Coastal Communities Coalition
Norton Sound Economic Development Corporation
United Fishermen's Marketing Association

Government/University

NOAA Aquaculture Program
NOAA National Marine Fisheries Service
University of Alaska Fairbanks School of Fisheries and Ocean Sciences
University of Alaska Southeast

Supporters

Alaska Bering Sea Crabbers
Bering Sea Fisheries Research Foundation
Groundfish Forum
Santa Monica Seafoods

Duration

This Strategic Plan is intended to provide an overview of the goals and major tasks of AKCRRAB for five years, from 2010 through 2014. It is accompanied by the study plans for the first two years, and will continue to be supplemented each year by annual study plans; these plans contain the details of implementation of the program elements. This Strategic Plan and future study plans are contingent on continued funding for the AKCRRAB program.

SECTION 1: PRODUCTION

I. Broodstock Collection.

Broodstock collection will continue on a yearly basis for both red king crab and blue king crab in order to hatch individuals from wild parents each year. Initially, the population must be large enough to allow for production-scale hatchery research and to supply juvenile crab for laboratory studies. Multi-year maintenance of broodstock and mating is not planned.

As Phase 2 of AKCRRAB approaches, in which crabs may be released into the wild, it will become increasingly important to maintain a hatchery population that is as genetically representative of the target wild population as possible.

Broodstock requirements will be identified in consultation with ADF&G.

A. Collection Methods

Previously, broodstock collection has been accomplished with cooperation of commercial fisherman. However, this can be unpredictable, difficult to plan and not cost efficient. Broodstock can also be obtained opportunistically in subsistence fisheries or during state and federal trawl surveys,

Goal: Collect broodstock under carefully controlled, cost efficient methods that minimize harm to wild stocks.

Task: Broodstock collection will be coordinated with state and federal crab stock surveys whenever possible. When this is not feasible, industry or community partners will be enlisted in the collection efforts.

Timeline: 2010-2014

B. Stock Origin

Ideally, broodstock would originate from populations ultimately targeted for enhancement. Currently, in Phase 1, broodstock are obtained from stocks open to commercial fishing for use in hatchery experiments. However, broodstock may be acquired from depleted stocks as seen around Kodiak Island and the Pribilof Islands if field experiments are to be conducted in those areas.

Goal: Obtain king crab broodstock intended for enhancement activities from the genetic pools of targeted wild stocks.

The proposed regions for king crab stock rehabilitation have shown a substantial decline in king crab abundance based on historical time series data. To have the least impacts on depleted crab stocks, broodstock for initial rehabilitation research on all laboratory aspects

of life history and production assessment has been obtained from stocks that are abundant. After methods are established for production scale culturing, broodstock from the targeted rehabilitation regions will be required for research to ensure a full understanding of the parent stock to be rehabilitated.

Through 2011, broodstock for experimental laboratory use has been collected from the Bristol Bay red king crab stock, the St. Matthews Island blue king crab and Little Diomede blue king crab stocks. Also, in 2011, red king crab broodstock were obtained from Southeast Alaska to culture juveniles to be used in field predation studies.

Task #1: Obtain broodstock – 20 female crabs of each stock – from stocks of red king crab in the Eastern Bering Sea and Southeast Alaska and blue king crab in the St. Matthews Island or Little Diomede regions for experimental production, life history, and outplanting research in the laboratory and hatchery.
Timeline: 2010-2014

Task #2: Red king crab broodstock in the appropriate numbers will be obtained from the nearshore areas of Kodiak Island from stocks targeted for rehabilitation and suitable for hatchery-produced juvenile research and controlled releases.
Timeline: 2011, 2012

Task #3: Blue king crab broodstock in the appropriate numbers will be obtained from the nearshore areas of the Pribilof Islands from stocks targeted for rehabilitation and suitable for hatchery-produced juvenile research and controlled releases.
Timeline: 2012, 2013

C. Collection Timing.

Goal: Collect broodstock at a time as close as practical to release of larvae, and when the wild adults are in good condition for transport.

This goal will balance the needs for efficient broodstock collection and production goals with the need to ensure that the biological diversity of the host stock is represented in the broodstock. Larval development periods for best broodstock collection will be based on historical literature data and from data collected during survey and fishery observations where in situ temperature data will be considered.

Task: Broodstock collection will avoid molting periods whenever possible, and will ideally take place in late fall or early winter (October-December).
Timeline: 2010-2014

II. Broodstock Holding

To date, red king crab broodstock have proven to be generally hardier and more able to be held in the laboratory with higher rates of success than blue king crab. Previous mortality of blue king crab

broodstock was likely due to aerial cold exposure during collection, shipping stress, and the difficulty of chilling water to ambient temperatures, approx -1 to 2°C. Generally, wild blue king crabs are found in deeper and colder waters than red king crab. In summer months, seawater temperatures in Seward can reach 12°C, resulting in a difference of 10°C to reach a target of 2°C, which creates logistical constraints when using flow through seawater systems.

Bacterial infections occasionally develop on clutches when broodstock are held in the laboratory long term. It is unknown whether bacteria enter the laboratory system with the broodstock or enter after the broodstock arrive in the laboratory.

Goal: Refine broodstock holding methodologies to increase broodstock holding success for both red and blue king crab.

Task #1: The presence or absence of bacteria on clutches will be monitored. The applicability of a topical disinfection such as an iodophore swab will be investigated using different exposure concentrations and times. The need for strict sterilization of holding tanks and influent treatment will be further explored.
Timeline: 2011-2013

Task #2: Larval hatch timing will be manipulated by holding broodstock at varying temperatures with the objective of producing multiple crops within the same year.
Timeline: 2011– 2013

Task #3: Monitor embryonic development to determine health of the eggs and predict hatch dates with weekly measurements of eyespot and yolk size. Monitor any bacterial growth on egg membranes.
Timeline: 2010-2013

III. Larval, Glaucothoe, Juvenile Rearing

Successful production began in 2007 and has been continually refined through 2011. As a result, larval rearing protocols for red king crab can now be applied at production scale. A draft production manual is available to be used as the template for future production, realizing refinements will continue. The protocols for blue king crab hatchery production have not yet been developed to the same level as red king crab, due to difficulties in obtaining and holding blue king crab broodstock.

Glaucothoe rearing is separate from larval rearing and requires different protocols and bio-criteria. We have not yet determined the best way to rear glaucothoe on a large scale and survival with some treatments has been low. Experiments to determine optimal temperature, tank design, substrate type, substrate configuration, flow rate, light intensity, aeration, etc are ongoing.

Production scale juvenile nursery experiments completed from 2008 to 2010 focused on the effects of diet, stocking density, substrate, size grading and conditioning potential on juvenile rearing, and much still needs to be learned. Future experiments will determine optimal rearing conditions, conditioning

strategies, and timing strategies for release into the marine environment. There will also be an ongoing need to produce animals for additional research needs.

Goal: Refine rearing protocols for red and blue king crab and incorporate them into production manuals.

Rearing conditions (artificial substrate, flow conditions, diet, and lighting) may impact morphology such as coloration and spination or reduce brain development. Alternatively, crabs may be better fed in the hatchery causing higher growth rates than wild individuals of the same age. Phenotypic plasticity, as seen in other hatchery-reared crustaceans, may occur with red king crab. Any potential phenotypic or behavioral plasticity may be advantageous to a stock enhancement effort if deficiencies are able to be alleviated prior to release by exposure to specific environmental parameters.

Task #1: Manuals describing hatchery operations protocol will be developed for red and blue king crab. The manual will cover all stages of hatchery production from broodstock holding through juvenile rearing. The red king crab manual will be completed first, and a blue king crab manual will be developed as protocols are more thoroughly tested and fully understood.
Timeline: 2011 for the red king crab manual, and 2012 for blue king crab.

Task #2: Continue to optimize rearing conditions and hatchery techniques to improve survival rates and reduce production costs. Techniques will be refined by exploring physical and biological parameters such as diet, stocking density, substrate preference, tank design, flow conditions, and temperature regimes.
Timeline: 2010-2014

Task #3: Compare bioenergetics between hatchery cultured and wild king crab to better understand health and energy allocation of hatchery crabs compared to their wild counterparts. This comparison should help identify specific nutritional or energy deficits if any in the hatchery reared larvae relative to their wild counterparts.
Timeline: 2010-2014

Task #4: Optimize rearing conditions and hatchery techniques to reduce behavioral, morphological, and physiological differences between hatchery and wild crabs to minimize potential competitive interactions with future outplanting.
Timeline: 2010-2014

SECTION 2: POPULATION AND STOCK DIFFERENTIATION

I. Genetics

Understanding population genetic structure is critical for assessing and monitoring any potential outplanting. Long-term genetic research aims to determine a baseline of wild stock population genetic structure, develop markers to distinguish hatchery and wild populations, and further assess the risks and benefits of releasing hatchery-reared crab. Thus far, we have determined that female red king crab mate with only a single male.

Goal: Understand population genetics of Alaskan red and blue king crab.

Task #1: Determine size and location of genetically distinct crab populations in Alaska and how much genetic exchange occurs among crab populations.
Timeline: 2010-2014

Task #2: Evaluate how many individuals contribute genetically to wild populations and how many individuals are needed for broodstock to maintain adequate levels of genetic variation for outplanting.
Timeline: 2010-2014

II. Marking

Goal: Develop methods of differentiating hatchery-produced king crab from their wild counterparts.

Task #1: Experiment with physically or chemically tagging juvenile king crab for short-term, small scale experimental purposes.
Timeline: 2010-2012

Task #2: Identify genetic markers that will allow hatchery-produced king crab to be distinguished from wild crab stocks (see genetics section above).
Timeline: 2010 ongoing

SECTION 3: PRE-RELEASE STUDIES

This section addresses the transition of moving cultured juvenile king crab into the wild through assessment of in situ habitat requirements, biological and environmental interactions, and design of nursery scale habitats.

I. Hatchery – Wild Interactions

Enhancement success may depend upon the competency of hatchery-produced crabs to compete for resources and survive in the natural environment without negative competitive interactions with wild king crabs. For example, hatchery-reared crabs may experience higher rates of mortality than wild crabs, or may be more aggressive, outcompeting wild crabs for resources. Competitive interactions arising from morphological, behavioral, or physiological variability between hatchery and wild juvenile king crab should be identified and experimentally tested prior to large-scale enhancement.

Goal: Understand behavioral, morphological, and physiological differences between hatchery-reared and wild juvenile king crab and potential competitive interactions.

Task #1: Determine if morphological and behavioral differences are present between hatchery-reared and wild king crab juveniles and identify any potential competitive interactions.
Timeline: 2010-2014

Task #2: Compare bioenergetics of hatchery-reared and wild king crab juveniles to understand health and energy allocation and identify any potential competitive interactions
Timeline: 2010- 2014

II. Nursery Habitat

Optimal nursery habitats should maximize growth and survival of juvenile king crab. Growth and survival are likely influenced by food and shelter availability relative to competition and predation pressure. Furthermore, nursery requirements for juvenile crab may shift seasonally, and with crab size or age.

An approach that combines laboratory and field studies is most useful to test mechanisms of nursery habitat function for juvenile king crab. Laboratory experiments involving close observations have identified preferred habitats of juvenile crabs, foraging behavior, habitat-specific survival, and interactions with predators. Field experiments have investigated habitat associations and survival in natural habitats, including tethering studies to identify predators. Laboratory and field studies will continue to improve our understanding of king crab nursery habitat function toward the goal of outplanting and enhancement success.

Large-scale outplanting will require successful transportation of juveniles from hatchery facilities to the release site. While transports of juvenile crab from Seward to Juneau and Newport, OR have not raised concerns about mortalities to date, it could be a major cause of mortality as the number of juveniles involved increases. Refinement of transportation protocols for large numbers of juvenile crabs will be critical for an enhancement effort.

Goal #1: Determine optimal nursery habitats to maximize growth and survival of juvenile king crab.

Task #1: Identify the habitat requirements of juvenile king crab through their first year of life, including foraging, structural and biological habitat attributes, and ontogenetic shifts, with continued laboratory and field studies.
Timeline: 2010-2012

Task #2: Determine habitat function for juvenile king crab to support growth and survival during the first year of life, with continued laboratory and field studies.
Timeline: 2010-2012

Task #3: Determine habitat requirement shifts due to predator pressure and prey availability, with continued laboratory and field studies.
Timeline: 2010-2012

Task #4: Develop king crab habitat suitability models based upon laboratory and field studies for research use, as a guide to selecting potential release sites, and to identifying potential marine nursery locations near Kodiak (red king crab) and the Pribilof Islands (blue king crab).
Timeline: 2010-2012

Task #5: Deploy artificially prepared habitats, including cages, small mesh devices, and arranged natural substrates (e.g., cobbles and shells), where juvenile king crab are found at potential release sites near Kodiak Island and the Pribilof Islands. Settlement, growth and survival rates of juvenile crab on these prepared habitats will be compared to wild crab in nearby natural habitats.
Timeline: 2010-2014

Task #6: Develop best practices for transporting large numbers of juvenile king crab to remote sites without incurring high mortalities or harming their health.
Timeline: 2010-2012

Task #7: Develop means to minimize differences in family size of all hatchery-reared crab. This will help equalize the genetic contributions of each broodstock female to the outplanted crab stock and minimize any negative effects of hatchery rearing on wild stocks.
Timeline: 2010 - ongoing

Goal #2: Assess likelihood of outplanting success based on biological and environmental interactions.

Task #1: Foraging studies will be conducted to identify the importance of prey type and biomass required for juvenile king crab growth and survival.
Timeline: 2010-2011

Task #2: Tethering experiments will be conducted in the field to assess optimal crab size and seasonal conditions for outplanting success.
Timeline: 2010-2012

Task #3: Methodology will be developed to assess predation pressure, food availability and competitive interactions at potential release sites for hatchery-produced juvenile king crab.
Timeline: 2010-2012

Task #4: Determine the carrying capacity of potential release sites based on experimental studies on known crab stocks to assess outplanting stocking densities.
Timeline: 2010-2013.

Task #5: Monitor predation, prey availability, and competitive interactions before and after controlled release events.
Timeline: 2011-ongoing.

Goal #3: Design and test marine nurseries to maximize survival of hatchery-produced juvenile king crab during initial stocking phases.

Task #1: Design and test in the lab, nursery structures that will provide an artificial habitat for hatchery-produced juvenile king crab in the marine environment.
Timeline: 2012-2014

Task #2: Stock hatchery-produced juvenile king crab in enclosed nursery structures deployed in marine waters near Kodiak Island (red kings) and the Pribilof Islands (blue kings).
Timeline: 2012-2014

Task #3: Assess behavior and marine survival of small numbers of hatchery-produced juvenile king crab released into the wild at sites with appropriate habitat near Kodiak Island and the Pribilof Islands.
Timeline: 2013-2014

SECTION 4: OUTPLANTING AND FEASIBILITY STUDIES

The structural, regulatory and funding issues faced by the private sector or government agencies in pursuing a rehabilitation program will be unique to each region, stock, and user group.

A key long term goal of AKCRRAB is to facilitate self-sustaining populations of targeted king crab stocks, and to transfer the techniques and technologies developed for effective implementation by industry and/or communities. The details of each transfer will vary according to region and to target species.

It is anticipated that any crab outplanted by the AKCRRAB program in both the Bering Sea and the Gulf of Alaska would be managed by the State of Alaska, and available for harvest, when appropriate, under the same management systems and guidelines as the wild crab stocks, and by the same user groups who utilize the wild stocks.

In the Bering Sea, commercial harvest rights to all the king crab stocks, including the Pribilof blue king crab, are allocated under the crab rationalization program. These harvest rights are held by individuals and by the western Alaska CDQ (Community Development Quota) entities. Subsistence and personal use crab fisheries are also important. The crab fisheries are managed by the State of Alaska, as delegated by the federal government.

In the Gulf of Alaska including Kodiak, and in Southeast Alaska, the commercial crab fisheries are not rationalized and are open to participation by permit holders. Subsistence and personal use crab fisheries are also important. The crab fisheries are managed by the State of Alaska.

While AKCRRAB's efforts are currently focused upon rebuilding stocks of red king crab in Kodiak and blue king crab in the Pribilof Islands, the technology developed in the project might be utilized across the state, including for research on, and rehabilitation of, other depressed crab stocks such as opilio crab in the Bering Sea and red king crab in Southeast.

Goal #1: Apply crab aquaculture technology in Alaska to help rebuild depressed wild king crab stocks.

The following potential tasks represent the beginnings of a transition for AKCRRAB from a sole research focus to initial implementation of a stock rehabilitation/enhancement program. The timelines will depend on research progress and regulatory considerations.

Potential Task # 1: Release and carefully monitor juvenile red king crab in one or more Kodiak bays with depressed wild red king crab populations. The goal would be to help rebuild the spawning populations to a point where they may support directed commercial, subsistence and personal use fisheries.

Potential Task # 2: Stock hatchery-produced juvenile blue king crab at one or more strategic locations near the Pribilof Islands and carefully monitor success and

survival. The goal would be to help rebuild the spawning population sufficiently to allow the incidental catch of blue king crab in commercial fisheries directed at stronger red king crab stocks. Ultimately, the blue king crab stocks might be strong enough to allow for the reopening of a blue king crab fishery.

Potential Task # 3: Supplement depressed wild stocks of red king crab in Kachemak Bay or Southeast Alaska with releases of hatchery-produced juveniles. The goal would be to help reopen personal use and commercial fisheries on the rehabilitated stocks.

Goal #2: Project operational costs for producing juvenile red and blue king crab for enhancing depressed wild crab stocks, including hatchery, nursery, and stocking phases.

Task # 1: Document hatchery operational costs from acquiring broodstock through production of C3 juveniles.
Timeline: 2010-2014

Task #2: Develop cost projections for the culture of C3 juveniles for different survival rates and levels of production.
Timeline: 2010-2011

Task # 3: Develop projected costs of operating stocking and nursery projects.
Timeline: 2010-2011

Goal #3: Determine facility design requirements and production costs.

Task # 1: Analyze facility requirements based on production efficiency achieved during larval and post-larval culture experiment.
Timeline: 2011 ongoing

Task # 2: Develop a model design for a model remote king crab hatchery and estimate construction costs.
Timeline: 2011 ongoing

Goal # 4: Analyze the cost effectiveness of potential red and blue king crab enhancement projects in the Kodiak area and in the Pribilof Islands respectively.

Task #1: With advice from an expert panel, examine the results of AKCRRAB's controlled releases and other research, known survival rates for wild king crab, capital and operations costs (including regulatory compliance), project potential impacts to wild stocks of enhancement programs, and determine under what scenarios enhancement projects for red or blue king crab could be cost effective.
Timeline: 2012-2013

Goal #5: Determine funding mechanisms and identify potential changes in state law and regulations which would be necessary to allow crab harvesters and coastal communities to conduct king crab enhancement activities.

Task # 1: Work with interested legislators and state agencies to research whether there is a legal framework for crab harvesters or coastal communities to form an association, such as a private-nonprofit corporation, to conduct enhancement activities.

Timeline: 2010-2012

Task # 2: Work with interested legislators and state agencies to research the following: Who will pay? What changes to state law are necessary to provide for a voluntary assessment similar to the salmon enhancement program? Is it possible to have cost recovery harvests of enhanced king crab to offset costs? If so, what changes in statutes are necessary?

Timeline: 2010-2012

Goal #6: Provide assistance to potential users of the technology developed during the AKCRRAB project.

Task # 1: Work with potential user groups to develop preliminary collaborations with community or industry groups interested in forming rehabilitation associations.

Timeline: 2010-2014

Appendix 1

AKCRRAB Steering Committee

Dr. David Christie, Director, Alaska Sea Grant Program, University of Alaska Fairbanks, Co-chair
Heather McCarty, Central Bering Sea Fishermen's Association, Co-chair

Dr. Ginny Eckert, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks (Juneau)
Dr. Robert Foy, Director, Kodiak Laboratory, National Marine Fisheries Service, NOAA
Jeff Hetrick, Director, Alutiiq Pride Shellfish Hatchery, Seward
Chris Mierzejek, Aleutian Pribilof Island Development Association
Rodger Painter, Alaskan Shellfish Growers Association
Jeff Stephan, Executive Director, United Fishermen's Marketing Association, Kodiak
Gale Vick, Gulf of Alaska Coastal Communities Coalition (GOAC3)

AKCRRAB Science Committee

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