FRED Special Report

Alaska Department of Fish & Game
Division of Fisheries Rehabilitation,
Enhancement and Development

King Crab Enhancement Initiative Opportunity and Potential for a Program in Alaska

Prepared for

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TABLE OF CONTENTS

Section	Page
BACKGROUND	1
Historical Fisheries	1
Economic Profile of the Fisheries	1
INITIAL RESPONSE TO CRISIS	1
Major Fishery Management Actions and Research Efforts	4
REASONS FOR THE DECLINE	4
Reason 1: Overfishing Resulting from the Common-Property Dilemma	5
Reason 2: Changes in Habitat Quality, Predation, and Food Abundance	5
INITIATIVE	6
How the FRED Division Would Approach the Problem	6
Phase I	6
1. Document current technology and coordinate with researchers and other agencies	6
2. Initial contact with user groups, industry, and communities	7
3. Design and implement a pilot hatchery and investigation	8
4. Site selection and design for Kodiak king crab development	9
Phase II	9
1. Kodiak King Crab Development Center	9
2. Evaluation of the crab rehabilitation program	10
3. Requirements for fish health support for a crab program	12
4. Genetic stock identification	12
5. Nearshore marine habitat survey and crab habitat improvement	13
6. Nearshore habitat structure evaluation	14
Phase III	14
1. Production-level king crab facility	14
ECONOMIC CONSEQUENCES OF A CRAB ENHANCEMENT AND REHABILITATION PROGRAM	15
REFERENCES	16
APPENDIX: Cost Summary	17

LIST OF FIGURES

Figure		Page
1.	King crab harvests in Westward and Cook Inlet	2
2.	Historic king crab harvests, combined Bristol Bay and Bering Sea	3

BACKGROUND

Historical Fisheries

Statewide harvests of king crab have experienced two periods of dramatic growth and decline (Figure 1). In the early 1960s, the Kodiak king crab fishery was becoming the dominant crab fishery in the state. A steady decline in abundance and harvest of the Kodiak stocks followed in the late 1960s.

Except for a small resurgence in the 1970s, the Kodiak fishery has never recovered. In 1969, Bristol Bay and Bering Sea crab stocks began an unprecedented period of growth that continued through 1980. Harvests more than tripled, culminating in record catches of 185.7 million pounds as the fleet shifted much of their gear to this lucrative new area from the Kodiak fishery. Growth in the Bristol Bay fishery management area was largely responsible for the boom during this period, as Bristol Bay harvests rose from 8.6 million pounds in 1970 to the record catch of 130 million pounds in 1980. Within three years, however, the industry had collapsed again. King crab stocks were so scarce that the Alaska Department of Fish and Game (ADF&G) ordered complete closure of the Bristol Bay crab fishery in 1983. Statewide harvests plummeted to 26.9 million pounds. Catch dropped an additional 10 million pounds by 1985 (U.S. Department of the Interior 1947-1975; ADF&G 1969-1983 and 1970-1985). Depressed stock conditions for king crab in Alaska's state and federal waters still persist today (Figure 2).

Economic Profile of the Fisheries

The economic impact of this collapse has been extensive, involving virtually every participant in the fishery. Between 1980 and 1983, ex-vessel revenues to fishermen fell by more than 50%, dropping by $93.2 million. Processor sales dropped by $178.0 million (a 60% reduction), while sales from wholesalers declined by $304.2 million (a 66% reduction). Multimillion dollar fishing vessels were idle, others shifted into different fisheries, processing plants closed, and an industry-wide restructuring commenced.

The significance of the collapse may be placed in perspective by considering the fact that the king crab fishery was the second most valuable Alaska seafood industry between 1968 and 1983. Only the combined value of all five salmonid species harvested in Alaska exceeded that of king crab (ADF&G 1969-1983); yet, the statewide king crab catch rarely exceeds one-third of the total catch of salmon, by weight.

INITIAL RESPONSE TO CRISIS

In the early 1980s, ADF&G managers and the National Marine Fisheries Service (NMFS) took a number of actions to stop the decline in king crab harvests. These actions included

Figure 1.

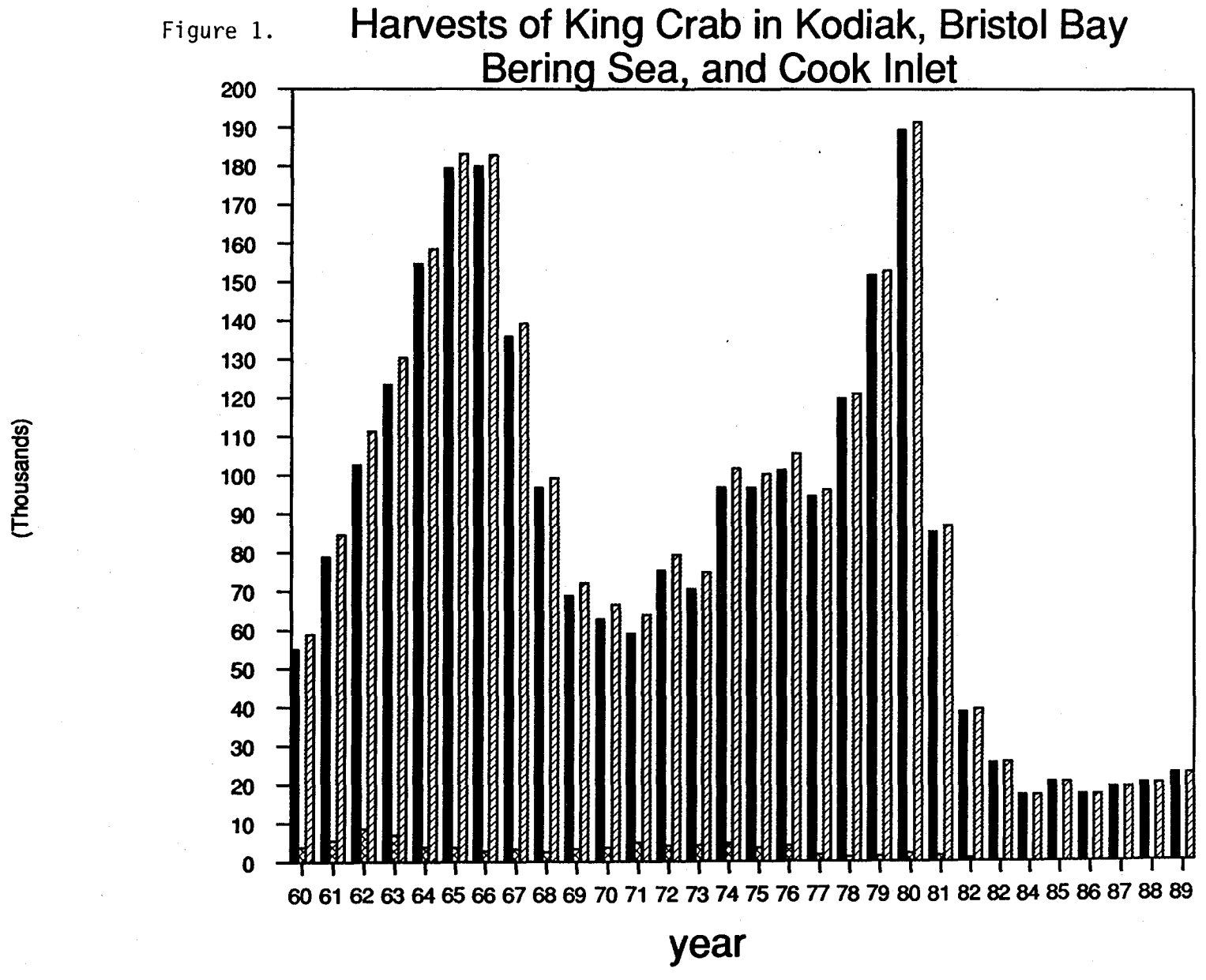
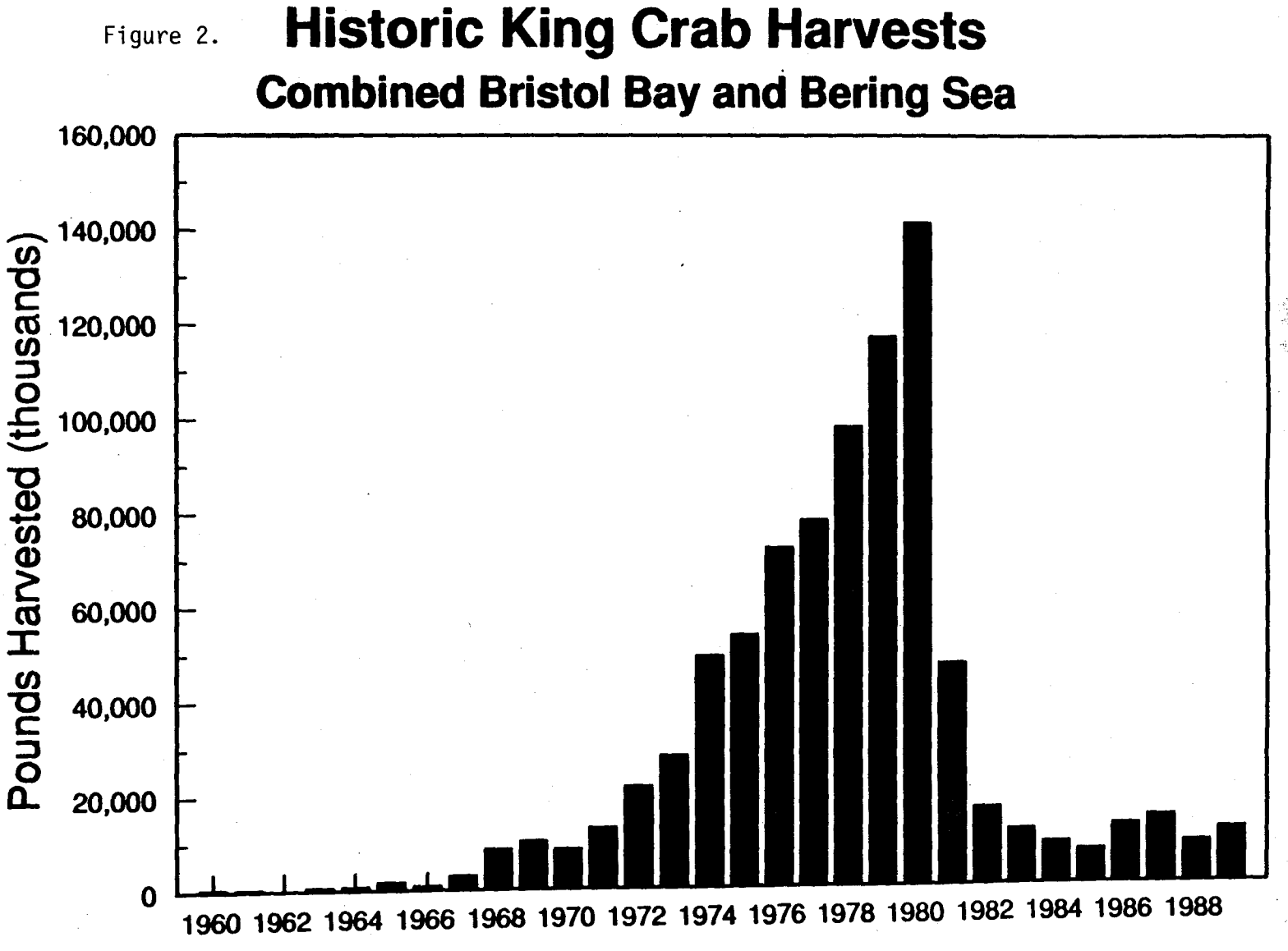

Harvests of King Crab in Kodiak, Bristol Bay
Bering Sea, and Cook Inlet
(Thousands)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 82 84 85 86 87 88 89
year

Figure 2.


Historic King Crab Harvests
Combined Bristol Bay and Bering Sea
Pounds Harvested (thousands)
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1960 1962 1964 1966 1968 1970 1972 1974 1976 1978 1980 1982 1984 1986 1988

reducing fishing effort, changing size limits, increasing the level of research into population and stock identification, and bioeconomic modeling of fishery management decisions.

Major Fishery Management Actions and Research Efforts

- Currently, of the top four historical producing areas, only Bristol Bay has been reopened to commercial red king crab fishing since the 1983/1984 season. The other three (Kodiak, Dutch Harbor, and Alaska Peninsula) have been closed for five consecutive years. Matulich[1] (personal communication) predicts another large Bristol Bay red king crab stock crash in the early 1990s, based on recruitment data.

- Blue king crabs have experienced reduced historic population levels similar to the red king crab, and many of the same producing areas are either closed or the harvesting effort dramatically curtailed.

- Brown king crab (also referred to as golden crabs) have been heavily exploited in the Adak area during the last five years. It is too soon to tell if these stocks, located in extremely deep waters, can continue to sustain this level of exploitation.

- ADF&G and NMFS have undertaken new research programs and surveys to learn more about the distribution and behavior of crab stocks. Activities, such as habitat studies at Womans Bay, Trident Basin, and Anton Larson Bay, are focusing on juvenile king crab and development of settlement indices for juveniles in Chinak Bay (ADF&G). The University of Alaska has conducted additional studies on early life-history survival parameters.

- Cooperative symposiums, such as the International Symposium on King and Tanner Crabs, have been undertaken to focus scientists from many agencies on problems in the fishery.

- ADF&G and Washington State University developed bioeconomic modeling and age-structure models for the purpose of understanding consequences of management actions.

REASONS FOR THE DECLINE

Most of the reasons offered to date for the decline in king crab populations fall in the realm of informed opinion, and there is still much disagreement between scientists about the cause. Some of the potential causes follow.

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[1] Scott Matulich, Washington State University, Department of Agricultural Economics, Pullman, Washington.

Reason 1: Overfishing Resulting from the Common-Property Dilemma

The rise and fall of both the Bristol Bay/Bering Sea crab stocks and Kodiak crab stocks are highly similar to the behavior of hundreds of open-access fisheries in the United States, where too much fishing effort has been applied too quickly in a fishery that is difficult to monitor and restrain. King crab fisheries in Alaska have open access; thus, anyone with an interest and capital can participate in the fisheries. Short of full-scale closures, effort is difficult to precisely regulate with the restraints now in place. Historically, many regulated, open-access fisheries supply too much fishing effort to fish stocks, eventually overharvesting below the optimal economic yield (Matulich 1988). There are several ways that overfishing may affect crab populations and net benefits to fishermen, including:

1. Reducing the numbers of sexually mature crab by overharvesting of sexually mature male and female age-classes;

2. Reducing the fecundity of female crab through handling related to pot pulls; and

3. Reducing the optimal ratio of males to females by selective gear or regulation that selects too many of one sex.

Reason 2: Changes in Habitat Quality, Predation, and Food Abundance

Because of the duration of the crash in certain areas of the state, some scientists do not believe that overfishing can fully explain the lack of stock rebuilding in recent years, and that environmental factors may explain much of the decline (Greenberg 1990). Crab pot surveys conducted by the ADF&G, Division of Commercial Fisheries, have revealed that the number of small (generally younger) crab are present in greatly reduced proportions in the samples. Some research indicates that the first benthic life stage is not being delivered to nursery areas. Suggested reasons for this change include:

1. Reduced recruitment of larval crab as a result of fishing pressure and handling. (Related to 1, 2, and 3 above.)

2. Existence of significant predation, as the abundance of certain marine predator- fish species may be contributing to the slow or nonexistent stock rebuilding;

3. Improper type and amount of food organisms to return juvenile numbers to a sustainable population threshold; and

4. Reduction in quality and quantity of habitat for juveniles or adults.

INITIATIVE

How the FRED Division Would Approach the Problem

A number of similarities exist between the present state of king crab fisheries in Alaska and the state of salmon fisheries in the early 1970s. Two decades ago, harvest levels of most salmon species were extremely low, fishery managers had implemented reduced fishery openings and an increased number of closures, and scientists were not sure of the exact reasons for the decline in salmon populations. The fishery itself had been structurally damaged from an economic perspective, and significant economic dislocation to fishermen and processors occurred in the early 1970s. In many respects, the decline of the king crab fishery has been even more economically devastating, with many stocks literally decimated in population numbers. Management actions to correct low population numbers have been applied for a longer period of time compared to those taken following the salmon crash of the 1970s.

Some of the actions taken in the early 1970s in order to implement a major salmon enhancement development program were clearly a correct response to an emergency situation, and have led to an economically viable program with significant net benefits for Alaskan residents. With some modification, the salmon rehabilitation model of the 1970s could be applied to the present, seriously depleted crab fisheries to restore the economic viability of this fishery.

Phase I:

1. *Document current technology and coordinate with researchers and other agencies*

   Considerable scientific research has been conducted by Japanese and United States scientists on the culture of juvenile king crab. As part of an Alaska Science and Technology Foundation (ASTF) proposal, FRED Division staff are compiling scientific literature. Since many of the references are in Japanese, it is important to summarize this information in the form of an annotated bibliography. Additional literature searches and interpretations will be carried out as part of the first and second phases of the initiative.

   A key element of the statewide salmon enhancement program's success has been its early investments in technical expertise and information. FRED staff made a concerted effort to seek out and, in some cases, to hire specialists in the field in order to collect the best technology available. Much of the early phases of the program involved interaction with specialists in cultural technology, king crab biology, fish health, genetics, evaluation, lake fertilization, etc. FRED staff are presently following this general approach in cooperation with the ADF&G, Division of Commercial Fisheries, and must continue to do so during the early phases of the king crab initiative.

The FRED Division recently developed a cooperative agreement with Chile for the purpose of sharing knowledge and personnel in order to accelerate training and learn crab enhancement techniques. Outright sharing of personnel during opposing Northern and Southern Hemisphere summer periods might make better use of limited experimental periods and staff skills. There would also be additional interaction with researchers in Japan that have experience in the culture of various crab species.

A critical review of crab enhancement proposals by professional management agencies and universities with a high profile in fisheries will be an important aspect of the initial planning for the crab enhancement program. This approach has been applied to the ASTF proposal. Project-site selection, brood-source availability, management considerations, and evaluation techniques will be issues that the following agencies will be asked to participate in:

Fisheries Industrial Technology Center (Kodiak)
University of Alaska (Sea Grant)
ADF&G, Division of Commercial Fisheries
NMFS (Kodiak and Auke Bay Laboratory, Juneau)
University of Alaska-Anchorage (Kodiak College)
University of Alaska-Fairbanks (Juneau Center for Fisheries and Ocean Sciences)
University of Alaska-Seward
Washington State University
University of Washington, School of Fisheries
University of Magellen, Patagonian Institute, Chile

2. *Initial contact with user groups, industry, and communities*

Much of the success of the statewide salmon enhancement program can be attributed to the active approach taken to resolve enhancement issues relevant to fishery user groups. Large and diverse fishing interests exist in the salmon fishery, in which a formal mechanism has been required to understand and respond to users seeking enhanced fishing opportunities. The mechanism used to accomplish this was the creation of regional planning teams and regional aquaculture associations. Additionally, a combination of user group and public meetings were used to air specific issues, such as funding and goal development for the salmon program.

This general model of public participation, incorporating the interests of existing crab user groups, is considered essential to the success of a crab enhancement program. Several structured public and user group meetings would be undertaken during this phase of the program. These meetings would provide interaction with members of the harvesting and processing industry as well as community and regional interests that could be impacted by the program. This would require an increment in planning not currently found in the FRED Division's budget.

The following is a list of user groups and other parties interested in crab rehabilitation that would be invited to participate:

Alaska Mariculture Association
The Crab Coalition
North and Northwest Alaska Mayors' Conference
Southwest Municipal League
United Fishermen of Alaska
United Fishermen's Marketing Association
City of Ketchikan
Kodiak Island Borough
City of Port Lions
City of St. Paul
City of Sand Point
City of Unalaska

3. *Design and implement a pilot hatchery and investigation (ASTF proposal)*

The goal of the pilot hatchery in fiscal year (FY) 1992 is to culture pelagic king crab larvae until they are ready to settle-out of the water column and begin their benthic life history. Staff will capture a total of 100 adult female king crab in early March using standard crab pots and hold the crabs in special net pens. As crab larvae (zoeae) are released from the female king crabs, they will be placed into tanks and other fine-mesh net pens. A total of 25 million zoeae can be projected from 100 average-size female crabs.

Research in Japan has shown that 80 zoeae/liter is the proper density for culture. This will require 312,500 liters, or 312.5 m^3, of rearing area. The zoeae will be fed a mixed diet of diatom and *Artemia* for 90-120 days. A target of 50% survival is projected to produce 12.5 million benthic larvae (glaucothoe). These larvae will then be released into Trident Basin and Women's Bay, areas that have historically supported juvenile king crab.

Evaluation will be based upon crab settlement index equipment developed by the ADF&G, Commercial Fisheries Division. As juvenile crab have limited migratory behavior, all 2-year-old crabs in the settlement/release area will be tagged with pit tags during the second year of the project in order to ascertain adult life- history survivals.

The basic hypothesis surrounding the culture of king crab larvae is that predation and feeding are key factors governing early life survival.

The costs for a minimal study with temporary facilities for research amount to $110,000. Costs for a more permanent facility that will give staff both the ability to conduct further tests on this technique and allow for a full-scale evaluation of the rehabilitation effort are $320,000.

4. *Site selection and design for Kodiak king crab development*

If conventional hatchery rehabilitation techniques for king crab prove to be successful, a larger-scale production program for these facilities in key fisheries could be constructed and operated. The size of such facilities would be dependent on the bioengineering requirements of the juvenile life stages that are determined to be biologically optimal for production of harvestable adults. If production-level applications of the present culture trials are to proceed in the near future, initial investigations of potential sites must be undertaken during FY 92. This increment would allow regional site investigations to begin in preparation for production facilities.

Culture and other rehabilitation techniques for king crab may be subject to regional biological constraints that require applied development projects in major nursery areas. Also, many rehabilitation techniques for king crab will require lab-based controlled studies. One major purpose of the production/development centers would be to develop these techniques for the unique habitats in each region.

Spinoffs from the crab development center for common-property fishery enhancement:

Many commercial fishing fleets are facing reduced catches of finfish and shellfish, for which culture techniques are either available or in the process of being developed in North America. Affected species include sablefish, halibut, herring, and crab (other than king crab). As an insurance policy against manmade and environmental damage to fish habitat and fish populations, culture practices could be developed and tested, and rehabilitation programs initiated to offset reductions in catch.

Phase II:

Given the economic state of the crab industry, the prognosis for poor crab recruitment of stocks in future years, and the current results of conventional management practices, it is important that corrective rehabilitation efforts begin immediately. The conditions of the present fishery and the state-of-the-art for propagation suggest that an aggressive rehabilitation program in the future should be undertaken.

The following is a list of crab rehabilitation projects that should be undertaken for the long-term success of a king crab rehabilitation program.

1. *Kodiak King Crab Development Center*

One feature of the crab hatchery feasibility study, proposed in Phase I, is that a relatively small capital investment is required for a physical plant with large-scale production potential. A water supply of less than 500 gpm would be required to support a benthic life stage (glaucothoe) facility of over 200 million releases (at 80 organisms/liter and 0.33 to 0.66 water exchanges per day). The physical rearing area for this facility could occur outdoors in most climates, and would typically require a

rearing area of 10,000 ft^2-12,000 ft^2 (approximately 22,000 ft^2 of working area). Large, estuarine-based rearing containers may also prove to be a feasible production design. Expansion of the lab facility from Phase I would involve outside rearing for an additional 175 million organisms to the glaucothoe life stage. This would increase the total inside rearing space from approximately 2,000 ft^2 to 10,000 ft^2 to 12,000 ft^2 (covered and uncovered).

Contingent on the verification of these techniques and bioengineering requirements of juvenile crab, typical production facility costs could range from $2.0 million to $3.5 million. Operating costs are expected to be $500,000, annually.

Initial efforts to design and construct a production-scale hatchery would occur in the Kodiak area. This area would be the site of proposed ASTF investigations, and the site of an existing lab.

Spinoffs for the Kodiak King Crab Development Center

- The Kodiak King Crab Development Center could be the site for conducting king crab habitat improvement research and culture development.

- The center could be used to develop shellfish and finfish techniques for applied rehabilitation aimed at improving damaged common-property fisheries.

- A module of the Kodiak King Crab Development Center could be dedicated to shellfish (aquaculture) and marine shellfish and finfish (enhancement and ocean ranching) development.

2. *Evaluation of the crab rehabilitation program*

A. Biological and fishery evaluation of king crab enhancement

A new technique has been developed for evaluating populations of recently settled populations of juvenile crabs. The sampling equipment involves a settlement trap for benthic life stages and the computation of a crab abundance index. The ADF&G, Division of Commercial Fisheries is refining this procedure; the procedures would be used to evaluate population changes in Kodiak from the ASTF proposal. Funding for applying the technique to this project is included in the proposal; however, additional funds, found in the operating budget under planning and evaluation, would be required for applying these techniques to production lots of juveniles. Currently, the ASTF budget is $209,994 and project expenditures would occur over the three-year study. The FY 92 budget request is for $111,330.

While certain other physical tagging techniques could be experimented with, the bulk of the evaluation to adult harvest would be carried out through the

application of electrophoretic techniques. These are described in more detail in the section under Genetic Stock Identification.

B. Economic evaluation of crab enhancement and rehabilitation for Phase II

- Purpose of the economic assessment:

  1. This would be the first king crab rehabilitation program in North America. To date, no economic feasibility studies have been applied to the rehabilitation or enhancement of crab. This work would apply current fishery and culture findings to determine the probable return on investment for production-scale facilities.

  2. A crab rehabilitation program in Alaska would benefit the common-property fishery. The extent with which program investments would provide Alaskans with net benefits should be determined as part of the Phase II work.

  3. Federal, state, and private funds would establish the program and, as such, the public should have information on economic consequences.

- Type of economic analysis that would be conducted:

  1. Cost/benefit analysis is one type of economic analysis that would be applied to a full-scale crab rehabilitation program using conventional culture techniques. Current market modeling for crab is being applied to management of crab stocks, so it would not be necessary to develop new models from scratch.

  2. Economic impact assessment is another type of economic analysis to apply to a full-scale crab rehabilitation program using conventional culture techniques.

- Costs of economic analysis:

  1. A short-term economic assessment of market prices, fleet costs, public production, and private production costs would amount to $8,000.

  2. A long-term economic evaluation of each component of the program over five years, from FY 92 to FY 96, would cost approximately $3,000, annually, and would update economic-impact models and cost-benefit analysis with new biological,

cultural, and fishery data as it is revealed from studies in Phase I.

3. *Requirements for fish health support for a crab program*

Long-term support by FRED Division fish pathology laboratories for a crab rehabilitation program in Alaska would be analogous to existing support programs for salmon and trout enhancement. This would involve examination of 30 animals from a given broodstock and diagnostic analysis of any captive larval of adult mortalities. However, since the methods for such examinations are presently limited to histology, the effort in preparation and interpretation would be somewhat greater than for normal hatchery support.

Approximate annual costs would amount to $5,000.

4. *Genetic stock identification (GSI)*

A. GSI and hatchery evaluation

GSI is a technique used by many salmon management agencies to identify component stocks in mixed-stock fisheries. The ADF&G, Commercial Fisheries Division is currently developing a database for the genetic identification of major red king crab stocks in the western Bering Sea and Gulf of Alaska. The division has identified 7 naturally occurring genetic markers in populations inhabiting these waters using protein electrophoresis. The frequency of one or more of these markers could be modified in the enhanced crab stocks (a process termed, "genetic marking"), permitting the use of standard GSI procedures and Peterson mark/recapture formulae to evaluate the hatchery program.

B. Genetic marking for Phase I (Year 1)

Each year, staff would spawn approximately 100 gravid females from the wild stock in order to produce approximately 25,000,000 larvae for hatchery production. These females would be selected from over 1,000 female crab, captured in Alitak Bay during late February and early March. The captured females would be tagged with an externally visible tag, and muscle biopsies would be collected and delivered to the FRED Division genetic laboratory in Anchorage for genotyping. The genetic data would be collected within two weeks, prior to the time that adult females shed their larvae. The females would then be selected for hatchery production based upon their carrying one or more identifiable genetic markers that would be passed on to their progeny. The enhancement progeny would be distinguishable from native crabs based upon their unique genotypic frequencies. Crabs spawn in the spring and carry fertilized eggs for several months before larvae become pelagic. The operational costs of this program are expected to be $50,000-$70,000.

C. Hatchery evaluation

The contribution of the enhancement crabs to local production would be monitored by periodic samplings from early development through commercial harvest. The selection effort of 1 crab spawned per 10 crabs genotyped (above) would permit accurate identification of enhancement crab in the mark/recapture analysis (standard errors of less than 5% in samples of approximately 300 individuals).

The genetic marking process would be repeated at each site during Year 2 and in following years, if required.

5. *Nearshore marine habitat survey and crab habitat improvement*

A. Critical evaluation of nearshore environment and estuarine productivity

This project would study the role of primary productivity and its relationship to the availability of food organisms for juvenile crab, and eventual changes in adult populations. Plankton sampling in selected nursery areas would establish food biomass and nutrient loading throughout the year. This would be related to crab abundance to identify when food organisms are limited.

Eventually, this data would be used to establish the need for increasing food abundance as a method of enhancement and rehabilitation.

B. Rehabilitation survey opportunities to increase estuarine productivity

If dissolved nutrients appear to be limiting larval survival in the selected study areas, then a survey of potential enhancement techniques would be initiated to augment nutrient concentrations for larval development. The following techniques are examples of proposed techniques.

- Enrichment through the application of organic or inorganic fertilizer:

  Lake enrichment techniques applied to salmon in Alaska could also be applied to king crab by enriching nearshore environments with either organic or inorganic fertilizer. This project would test the feasibility of improving the survival of king crab juveniles by improving local estuarine and marine rearing conditions that have been ecologically constrained by food abundance. Estuaries and marine nursery grounds typically receive energy inputs from terrestrial detritus and phytoplankton, which supports production of zooplankton. A lack of terrestrial decomposition in Alaska may limit the amount of detritus exported from watersheds into the nearshore environment. Enrichment of estuaries with a combination of inorganic and organic fertilizers may stimulate the seasonal production of zooplankton food organisms.

Selected stocks of king crab would be rehabilitated by comparing the effects of controlled additions of nitrogen and phosphorous inorganic fertilizers, with organic fertilizers applied to designated nearshore areas. The costs for conducting this study at two sites would be approximately $170,000.

- Ocean-upwelling trials for the purpose of increasing food production of juvenile pelagic life stages in established nursery areas:

  As in the nutrient-addition techniques juvenile stocks of king crab could be limited by food abundance in selected nursery areas. This research would induce plankton blooms during early larval stages of crab development by pumping mineral-rich deep water to the surface of a nursery area with an artificial upwelling pump. This approach has been developed and operated in Hawaii. A version of the wave-driven pump has been conceptually designed by the Bering Sea Marine Institute (Fuhs[2], personal communication). The approximate cost for a trial project would be $150,000.

6. *Nearshore habitat structure evaluation*

Techniques will be developed to enhance nearshore juvenile king crab-rearing habitat. Extensive work has been done in other countries to enhance shellfish habitat through placement of specialized habitat structures in the nearshore environment. This work will be preceded by a survey of potential sites that have biologically limiting natural structures.

Phase III:

Because of the breadth of decline in crab stocks and its broad distribution to crab stocks across the state, a successful production facility or successful application of other enhancement techniques in Kodiak could be applied to other areas of the state.

1. *Production-level king crab facility*

Contingent upon the success of Kodiak king crab culture studies and installation of a full-scale facility in Kodiak, this program could be expanded to other areas of the state. Typical phased production facilities could range in cost from $2.0 million to $3.5 million. Operating costs involve some guesswork at this stage, but are expected to be $500,000, annually.

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[2] Paul Fuhs, Division of Economic Development, Alaska Department of Commerce and Economic Development, Juneau.

Three additional major king crab facilities of the type outlined in Phase II are proposed: One on the Alaska Peninsula/Aleutian Islands, one on Kodiak, one in the Cook Inlet area, and one in southeast Alaska.

Total cost projections for a production program with three additional facilities targeted on the four major king crab-producing areas of the state are approximately $8.0 million to $11.0 million for construction, and $900,000 to $2.0 million, annually, for operations. One aspect of the current hatchery feasibility study is that, at production levels, this represents a relatively small capital investment that would be necessary to produce a physical plant with a production potential of 200 million zoeae.

ECONOMIC CONSEQUENCES OF A CRAB ENHANCEMENT AND REHABILITATION PROGRAM

If the FRED Division and other scientists are technically successful in creating a large increase in sustainable king crab yield, there is a strong potential for net economic benefits resulting from king crab rehabilitation in Alaska. Some of these advantages include:

- Economic demand models developed for red king crab indicate that markets are currently able to accept more king crab with a less-than-proportional reduction in price (Matulich 1988). As such, prices for red king crab do not appear to be sensitive to output levels until catches approach historical harvest levels, similar to those that occurred in 1980.

- There are substitutes for red king crab in the marketplace, but, traditionally, red king crabs have brought the highest product prices and are harvestable at comparatively lower costs than other crabs.

- While there would be additional fishing costs if a rehabilitation program were biologically successful, the crab fleet is generally in place now and could gear up with little new investment and effort. The amount of investment and additional fishing effort required will be determined as part of the Phase II cost-benefit analysis.

- Economic spinoffs in the form of improved management precision and information could be obtained from properly designed rehabilitation projects aimed at understanding the very factors that make crab populations grow and decline. In Alaska's salmon fisheries, enhancement efforts have provided new insights to how salmon populations are affected by improved juvenile recruitment and increased food supplies in specific environments.

Additional economic questions remain, such as the effects of vast Soviet crab catches on Alaskan crab prices, the speed in which crab fleets could spend away the potential benefits of rehabilitation, and the level of government and private costs for rehabilitation. Bioeconomic models exist now that would allow state government to address these questions before

making vast capital and operating investments in production facilities, and to track other regional and community effects of this economic development. These questions will be addressed in the Phase II cost-benefit and economic-impact analyses.

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APPENDIX

Cost Summary

COST SUMMARY

The operational and CIP costs of the King Crab Enhancement Initiative are projected for Phases I, II, and III of the program. Projected dollar amounts are for the costs of facilities and operations in 1991 dollars.

CIP (Development and Construction Cost)

Phase I:		
1.	Kodiak pilot hatchery design and construction	$305,000
2.	Pilot hatchery production and evaluation	180,000
Phase II:		
1.	Design and construction of the Kodiak King Crab Development Center (KKCDC)	3,500,000
2.	Unalaska nearshore upwelling facility	250,000
3.	Nearshore habitat enhancement evaluation	100,000
Phase III:		
1.	Site selection for Southeast, Bering Sea, and Cook Inlet King Crab Development Centers	200,000
2.	Design and construction of Southeast, Bering Sea, and and Cook Inlet King Crab Development Centers	10,500,000
	TOTAL CIP	$15,035,000

Operational Costs

Phase I:	Documentation of current status, public and user group contact, and planning	$50,000
Phase II:		
1.	Operation of KKCDC	500,000
2.	Planning and evaluation	250,000
3.	Crab health support	5,000
4.	Genetic identification	70,000
5.	Unalaska nearshore food production and upwelling evaluation	170,000
Phase III:		
1.	Operation of three additional development centers and KKCDC	2,000,000
2.	Planning and evaluation	500,000
3.	Crab health support	15,000
4.	Genetic identification	120,000
5.	Unalaska nearshore fertilization and upwelling evaluation	170,000
	TOTAL OPERATIONAL	$3,850,000

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If you believe you have been discriminated against in any program, activity, or facility, or if you desire further information please write to ADF&G, P.O. Box 25526, Juneau, AK 99802-5526; U.S. Fish and Wildlife Service, 4040 N. Fairfax Drive, Suite 300 Webb, Arlington, VA 22203 or O.E.O., U.S. Department of the Interior, Washington DC 20240.

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