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NPRB PROPOSAL SUMMARY PAGE

(To be filled in by applicant)

Project Title: Essential Habitat for Blue King Crab, Phase I: Development of cultivation techniques for blue king crab larvae *Paralithodes platypus*

Project Period: From Date: 1 July, 2003 to 30 July 2004

Name, Address, Telephone Number and Email Address of Applicant:
National Marine Fisheries Service, Alaska Fisheries Science Center
Kodiak Fisheries Research Center, 301 Research Ct., Kodiak, AK 99615

Principal Investigator(s): (Include full contact information here or in CVs, including email address)
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Research Priorities Addressed:

Identify up to three priorities from list in RFP (a-g): a. Marine ecosystem structure and processes, b. Endangered and stressed species, c. Essential Fish Habitat

Summary of Proposed Work (250 words or less):

The population of blue king crab (BKC) in the Pribilof Islands, Alaska, has declined precipitously and is now defined as overfished. However, the decline is more likely a result of natural factors that affect survival in the first year of life, than of fishing interactions. In their first few years of life BKC are restricted to limited habitats around the Pribilof Islands that are critical to their survival. We seek to understand the relationship between Essential Fish Habitat (EFH) for Pribilof Islands BKC and survival in the first year of life. We plan a three-year laboratory study of habitat utilization by juvenile blue king crabs, in which we will study settlement behavior and habitat selection, survival of larval and juvenile blue king crabs, and competitive interactions with juvenile red king crabs. This proposal is for Phase I; Cultivation and settlement of blue king crab larvae, during which we will verify our ability to raise them in the laboratory as we have done with red king crab, and determine the optimum conditions for cultivation. Phase II will involve habitat selection and preference studies with larval and juvenile BKC, and Phase III will involve competitive interactions and survival in optimal habitats. If possible, a separate proposal will be submitted in Y2 for a field study to identify and characterize EFH for BKC around the Pribilof Islands, using sonar, underwater video, and geographic information systems (GIS).

Funding: Total NPRB Funding Requested: \$ 85,561

Total Matching Funds Used: \$ 54,768

Legally Binding Authorizing Signature and Affiliation:

Douglas DeLaster for AFSC

(NOT TO EXCEED ONE PAGE)

Project Title: Essential Habitat for Blue King Crab, Phase I: Development of cultivation techniques for blue king crab larvae *Paralithodes platypus*

Submitted to: North Pacific Research Board

Dates: July 2003 to July 2004

Principal Investigator: Bradley G. Stevens, NMFS, Kodiak Fisheries Research Center

Associate Investigator: Sara Persselin, NMFS, KFRC

Requested Amount (Year 1): \$85,561

Proposal Summary:

The population of blue king crab (BKC, *Paralithodes platypus*) in the Pribilof Islands, Alaska, has declined precipitously, and is now defined as overfished. However, the decline is more likely a result of natural factors that affect survival in the first year of life, than of fishing interactions. In their first few years of life BKC are restricted to limited habitats around the Pribilof Islands that are critical to their survival. We seek to understand the relationship between Essential Fish Habitat (EFH) for Pribilof Islands BKC and survival in the first year of life. We plan a three-year laboratory study of habitat utilization by juvenile blue king crab, in which we will study settlement behavior and habitat selection, survival of larval and juvenile blue king crab, and competitive interactions with juvenile red king crab. This proposal is for Phase I; Cultivation and settlement of blue king crab larvae, during which we will verify our ability to raise them in the laboratory as we have done with red king crab, and determine the optimum conditions for cultivation. Phase II will involve habitat selection and preference studies with larval and juvenile BKC, and Phase III will involve competitive interactions and survival in optimal habitats. If possible, a separate proposal will be submitted in Y2 for a field study to identify and characterize EFH for BKC around the Pribilof Islands, using sonar, underwater video, and geographic information systems (GIS).

Project Responsiveness to NPRB Research Priorities

This project will address the following research priorities:

Marine ecosystem structure and processes. Factors affecting productivity, including habitat structure and use by juvenile BKC.

Endangered and stressed species. St. Matthew BKC has suffered a severe population decline and is classified as overfished by the MFCMA.

Essential Fish Habitat. The study will determine how and why juvenile crab select critical habitats. A separate field study would involve characterization of EFH around the Pribilof islands.

Stock assessment and recruitment processes. Selection of habitats at settlement is a critical function for larvae of marine species. Understanding the functional aspects of this behavior will provide important insights into the recruitment process. Research on interactions with

competitive species (red king crab) may help us understand the ecological relationships between these two species.

Project Design and Conceptual Approach

Background

The blue king crab (BKC) has supported valuable commercial fisheries in the Bering Sea, concentrated around the Pribilof Islands and St. Matthew Island. The most recent peak occurred in 1997, when the total landings of BKC were 5.2 million lbs, valued at \$12.0 million, of which \$1.5 million represented landings in the Pribilofs. However, the St. Matthew stock declined precipitously in 1999 and was subsequently declared “overfished” according to stipulations in the Magnusen-Stevens Fishery Conservation and Management Act. That fishery has been closed since then. The Pribilof Islands stock has been declining since 1995, and was declared “overfished” in 2002 (Fig. 1) (NPFMC, 2002). However, this term is a misnomer; the changes in population abundance are more likely the result of natural causes. Both islands had historically supported valuable fisheries, with peak landings >8 million lbs. While such high levels were unusual, the long term average landings for the years prior to 1985 were 3.7 and 3.2 million lbs for the Pribilofs and St. Matthew, respectively. Both populations declined during the mid-1980's, and began to rebuild in the early 1990's. Fisheries for BKC in the Pribilofs had been closed from 1988-94, and again from 1999 to the present; during the interim from 1994-1999, fisheries were conducted at about 50% of the previous exploitation rate. In contrast, the population of red king crab (RKC, *P. camtschaticus*) in the Pribilof Islands has been increasing since 1991, relative to its long term history. Inhabitants of the Pribilof Islands are highly dependent on local fisheries such as BKC, and their community has suffered economic displacement as a result of these fisheries closures. They have a long-term, vested economic and cultural interest in the conservation and stewardship of these resources.

Adult female BKC live primarily in the rocky nearshore areas around the Pribilof Islands and St. Matthew Island, whereas males tend to be farther offshore (Blau, 2000). Trawling for groundfish has been prohibited in the nearshore area surrounding the Pribilof Islands since 1994, so no bycatch of crab has occurred there in 8 years. Red king crab have historically been caught primarily as bycatch in the BKC fishery, and no directed fishing for RKC or Tanner crab has occurred in the Pribilofs district since 1998. Population declines at St. Matthew and the Pribilof Islands occurred almost simultaneously in the early 1980's and late 1990's. All of these factors indicate that abundance of BKC has fluctuated as a result of environmental factors rather than as a result of fishing.

Little research has been conducted on the biology of blue king crab. Some general studies on reproduction and general biology were conducted by Japanese and Russian authors (Sasakawa, 1973a; Sasakawa, 1973b; Sasakawa, 1975; Slizkin and Bukin, 1988). Later studies focused on reproductive biology (Somerton and MacIntosh, 1983a; Somerton and MacIntosh, 1983b; Jensen et al., 1985; Somerton and MacIntosh, 1985; Jensen and Armstrong, 1989). BKC have a biennial spawning cycle; at any time of the year, a large portion of the adult females are carrying developing external eggs, while the remainder carry empty egg cases. Larvae generally hatch in the late winter or early spring (April-June) in the Pribilofs, but may not hatch until autumn at St. Matthew Island. Unlike female RKC which immediately molt, mate, and extrude a new clutch of eggs within a day or two of hatching, BKC carry the empty egg cases for another

year until they subsequently molt the following spring. During this time, their ovary develops slowly, requiring two years to produce fully mature oocytes. After molting, females mate and extrude eggs, which develop for a year and hatch a year later. BKC at other locations can become infected by the rhizocephalan parasite *Briarosaccus callosus*, which makes them infertile (Johnson et al., 1986), but this has never been observed in the Bering Sea populations.

Research on the habitats of BKC was conducted by Armstrong et. al in the early 1980's (Armstrong et al., 1985; Palacios et al., 1985). They used scuba divers, rock dredges, beam trawls, and sidescan sonar to study the distribution of BKC around St. Paul and St. George Islands. Scuba diving was not productive because it was very labor intensive, and only one BKC was collected by divers. Most juvenile BKC were found at depths between 40-60 m, greater than divers could work. Sidescan sonar was used to examine the seafloor around the islands, but the resolution of the equipment was only about 0.5 m. As a result, it could distinguish rock and cobble from sand and gravel, but could not distinguish shell hash, which was the most common habitat of juvenile BKC. Beam trawls were used on sandy habitats, where only adults and older juveniles (3 years old (yo) or greater) were found. Rock dredges were the most productive gear for finding young-of-the-year (YOY) BKC and small juveniles up to 2 yo. Virtually all such juveniles were found in a habitat consisting of "type I shell hash", a mixture of dead but intact bivalve and snail shells, which usually occurred in pockets among otherwise rock, cobble, or gravel habitats. However, these habitats were only found by random sampling with the rock dredge. Wherever the dredge hit bare rock, no samples were obtained. Thus their maps of habitat distribution are crude, and based on a few randomly located samples. Attempts to classify epibenthic ecological communities from the dredge samples showed that crab tended to be associated with particular bottom types (shell hash) and the organisms that lived in those habitats.

Research on the life history of red king crab has been much more extensive, and much of it is applicable to BKC. RKC develop through four zoeal and one postlarval stage before metamorphosis to the first juvenile crab (C1) stage (Sato and Tanaka, 1949a), whereas BKC typically have only 3 zoeal stages. The transitional postlarval stage is traditionally referred to as a glaucothoe (Marukawa, 1933; Sato and Tanaka, 1949b; Kurata, 1961; Nakanishi et al., 1974; Nakanishi, 1981; Haynes, 1982; Donaldson et al., 1992). Most research on RKC larvae has been directed toward swimming, feeding, growth, and survival of the zoeae (Shirley and Shirley, 1988; Paul et al., 1989; Shirley and Shirley, 1989; Paul and Paul, 1990), or aquaculture (Nakanishi, 1981; Nakanishi and Naryu, 1981; Nakanishi, 1987). The behavioral aspects of settlement and habitat selection by glaucothoe have been largely overlooked. This process may be critical in establishing the abundance of recruits, especially in habitat limited areas, and is essential knowledge prior to considering the potential for stock enhancement.

YOY RKC and juveniles up to 1yo commonly occur in contact with seastars (Dew, 1990), sponge and bryozoan colonies (Sundberg and Clausen, 1977), hydroid and mussel colonies, stalked ascidians, and polychaete tubes (Stevens and MacIntosh, 1991), and among shell debris and cobble (McMurray et al., 1986; Loher and Armstrong, 2000). RKC glaucothoe also settle readily on various types of artificial collectors (Donaldson et al., 1991). In Kodiak, 1.5 yo RKC commonly occur on wooden pilings covered with these fouling community fauna (Stevens et al., 2002). After reaching 25 mm carapace length, RKC start to exhibit aggregative

(podding) behavior (Powell and Nickerson, 1965; Dew, 1990). Biological structure is scarce in the Bering Sea, yet is typically the only location where YOY RKC are found. Therefore, the distribution of early stage RKC is due to either high mortality of those which settle in open habitats, or selective settlement in complex habitats. The latter hypothesis is supported by the observations that they prefer highly complex substrata such as hydroids or plastic mesh filter material over less complex substrata like gravel or sand (Stevens and Kittaka, 1998; Stevens, in press). Loher and Armstrong (2000) found that settlement of YOY RKC was three times higher in rocky cobble than in shell hash, and no glaucothoe or early stage crab were found in silty mud. Selection for structurally complex habitats by settling larvae is common among decapod crustaceans including Florida spiny lobsters *Panulirus argus* (Herrnkind and Butler, 1986; Herrnkind et al., 1988; Butler and Herrnkind, 1997) and American lobsters *Homarus americanus* (Wahle, 1991).

Juvenile king crab probably select habitats strictly on the basis of their physical structure rather than their biological properties (Stevens, in press). Suitable habitats are those which have a high fractal dimension (Beck, 2000; Lohrer et al., 2000). In nature, these consist of biological structures such as hydroids, bryozoans, colonies of mussels and tube worms (collectively referred to as epifauna). As the crab grow, they move to habitats with lower fractal dimensions, including shell hash and cobble, and eventually migrate to sandy habitats with low fractal dimensions.

Juvenile BKC have been found among the epifauna associated with type I shell hash, so probably have habitat requirements similar to RKC. However, the two species rarely overlap as 1-2 yo juveniles. RKC tend to be found in nearshore areas where epifaunal assemblages form isolated oases among sandy-mud plains, whereas juvenile BKC tend to be found strictly among shell hash pockets in rock or cobble environments. In addition, BKC are rarely found where bottom temperatures exceed 4 C, whereas RKC can tolerate temperatures up to 10 C. Somerton (1985) proposed that the disjunct distribution of BKC was caused either by competition with juvenile RKC, or by different temperature tolerances. Juvenile RKC have large spines which may deter predation, and often form pods on otherwise open habitats, whereas juvenile BKC have a flatter body with fewer spines, a better conformation for living among shell hash.

Both RKC and BKC have been cultivated in the laboratory (Abrunhosa and Kittaka, 1997; Stevens and Kittaka, 1998; Kittaka et al., 2002; Stevens, in press). Both can be raised on a diet of *Artemia*, alone or in combination with diatoms (Kittaka et al., 2002). The P.I. has cultured them in Japan, and has cultivated RKC at the Kodiak Fisheries Research Laboratory, so it should be relatively easy to cultivate BKC there as well.

Proposed Research

This will be a collaborative endeavor, with the participation of scientists from NMFS, ADF&G and the University of Alaska. The fishermen of St. Paul Island will provide in-kind resources and traditional knowledge. Student interns from St. Paul will gather and compile traditional and scientific information and post it to an on-line library.

Laboratory Study

This proposal is Phase I of a 3-year research project. Phase I will address the cultivation of BKC larvae, with the goal of insuring that methods of cultivation will work at the KFRC

laboratory in Kodiak. Research on settlement behavior cannot be conducted if cultivation efforts fail. The goal will be to insure that we can produce enough glaucothoe and juveniles (approximately 1000) for research on settlement behavior. Experimental work will be conducted to determine the best diets, temperatures, and densities for culture. Laboratory work will be conducted by KFRC staff with assistance from a student intern. If possible we will try to recruit a Native Alaskan.

Phase II would be conducted in 2004. Using culture techniques developed in Phase I, we will cultivate BKC larvae to the postlarval stage, and conduct experiments to determine their habitat preferences, using artificial and natural habitats typical of the Pribilof Islands areas. Laboratory research will be conducted by an MS-level graduate student supervised by KFRC staff.

In Phase III, research would be conducted on competitive interactions between juvenile RKC and BKC, using the preferred habitats determined during Phase III. Do they both select the same habitats? Does one species eat or out-compete the other? What are their temperature preferences and requirements?

Field Study

If funding is available, a field research component would be added as a separate research proposal during Phase II and III. We would identify and characterize essential fish habitat for BKC around the Pribilof Islands, using sonar bottom typing (QTC), remotely operated vehicles (ROV's), and geographic information systems (GIS). Field work will be conducted by an PhD-level graduate student supervised by UAF faculty, and staff of the NMFS and ADF&G. Traditional Ecological Knowledge (TEK) about fishing patterns, locations of catches, environmental changes, and other relevant knowledge would be compiled by two interns from St. Paul, and made available to the public on-line.

Objectives of Laboratory Study

Phase I

1. Obtain broodstock. Adult female BKC with eyed eggs will be obtained during the 2003 NMFS Bering Sea Crab survey, and shipped alive in coolers back to the Kodiak Fisheries Research Center, where they will be held in chilled seawater until the eggs hatch in the spring of 2004.
2. Cultivate larvae. Larvae will be cultivated in the laboratory under a variety of conditions, as follows:
 - a) Diet: several experimental diets will be used including *Artemia* alone, diatoms alone, and *Artemia* and diatoms (*Thalassiosira* or *Isochrysis*) in combination. We now have both diatom species in cultivation. Ten zoea will be placed in each of 5 replicate 500 ml beakers (a density of 20/liter) and fed daily, with water changes at 2-3 day intervals. Cultivation will occur at 8 C. These methods have been used successfully for cultivation of RKC in our laboratory.
 - b) Temperature: as above, five replicates of 10 larvae will be cultivated at 2, 5, and 8 C, at fixed levels of density (20/L) and diet (*Artemia*).

c) Density: five replicates will be cultivated at densities of 10, 20, and 40 per liter, using fixed temperature (8 C) and diet.

3. Cultivate glaucothoe and juveniles. Larvae should require 3 weeks to develop to the glaucothoe stage at 8 C. If survival to that stage is good, they will be cultivated until they reach the juvenile stage.

4. Success of these efforts will be measured by survival to the glaucothoe and first crab stage (C1) as follows; unsuccessful, <10%; marginal, 10-25%; adequate, 25-50%; good, 50-75%; survival over 75% would be exceptional.

Phase II

BKC larvae will be raised to the glaucothoe stage in larger quantities, using the most successful cultivation methods determined in Phase I. We can culture 500 larvae in 20-l containers (at a density of 25/l). In this manner, we can raise 5,000-10,000 larvae, with the goal of providing 1000-2000 glaucothoe for study (with a minimum of 10-20% survival). Glaucothoe will then be placed in replicate aquaria where they will choose between available substrata for settling. Such substrata may include sand, gravel, shell hash (type I and type II), hydroids, worm colonies, and artificial habitats (aquarium filters or kitchen scrubbers). These methods and substrata have been used previously in the study of RKC settlement behavior (Stevens and Kittaka, 1998; Stevens, in press). This work would be conducted at the KFRC by an MS-level graduate student under the guidance of Dr. Stevens and Sara Persselin.

Phase III

Phase III will be a continuation of phase II into 2005. In the laboratory, glaucothoe of both RKC and BKC will be cultivated, and allowed to compete for settlement sites. As juveniles, they will be placed in aquaria together and allowed to compete for habitat, food, and cannibalism. May the best crab win! These studies will illuminate the relationship between habitat selection, survival, and competition between the two species.

Objectives of Possible Field study

If funding is available, a field research program would be added to Phase II in 2004, but only a general plan will be outlined at this time. Our goal will be to determine the distribution of EFH for BKC around the Pribilof Islands. For this purpose we would use QTC, a specialized sonar application that uses a standard ship fathometer at a fixed frequency (usually 120 kHz) to compute a habitat classification value related to substratum hardness. Data are positionally referenced and displayed on a computer monitor as color-coded areas along the vessel track, then mapped using standard GIS tools such as ArcInfo. Values would be ground-truthed by examining the bottom at representative locations with a remotely operated vehicle (ROV), and by pinpoint sampling with sediment grabs. The NMFS Alaska Fisheries Science Center (AFSC) owns a QTC system, and has an existing 5-year MOU with the US Navy for support and operation of QTC and sidescan sonar. Under this contract, two technicians and all the equipment would be installed aboard a 150' vessel, calibrated and tested in port, and operated at sea for a specified time period. It would be most cost effective to piggy-back an extra 2-3 week leg to an already scheduled research cruise in the summer of 2004. Field work would be conducted by a

PhD-level graduate student under the guidance of Dr. Stevens and a UAF faculty member (to be determined).

Project Management and Experience of Personnel

Dr. Bradley G. Stevens, Ph.D., National Marine Fisheries Service, Kodiak.

Dr. Stevens has conducted research on king crab, including crab surveys in the Pribilofs and the Bering Sea for 18 years, and now manages the seawater laboratory for NMFS at the Kodiak Fisheries Research Center. In 1996 he studied the cultivation and settlement behavior of king crab larvae with Dr. Jiro Kittaka in Japan, and has continued that research in Kodiak since the KFRC was opened in 1999. His work has resulted in several publications on king crab cultivation and habitat selection (see Bibliography). He also has considerable experience conducting underwater research with sonar, ROV's, and submersibles. In 2002, he served as chief Scientist for the Gulf of Alaska Seamount Exploration, aboard the 275 ft RV *Atlantis*, using the 3-person submersible *Alvin* (<http://oceanexplorer.noaa.gov/explorations/02alaska/welcome.html>).

Sara Persselin, NMFS, Kodiak

Ms. Persselin has been conducting research on culture techniques for crab larvae at the KFRC since 2000. She currently specializes in cultivation of diatoms, *Artemia*, and various other larval food sources.

Coordination and Collaboration

Since the Kodiak Fisheries Research Center opened in 1998, we have developed a research program focused on the early life history of Bering Sea crab species. The foundation of our program is development of techniques for cultivation of commercial crab species, so that we can produce juveniles necessary to conduct research on the behavioral aspects of selection and utilization of essential habitats. In 1999 we began cultivating red king crab, using techniques developed by Kittaka et al. (2002), and later used by Stevens and Kittaka (1998). Cultivated RKC larvae have been used for studies of settlement behavior, habitat selection, and survival (Stevens, in press). With this proposal, we plan to expand this work to include BKC postlarvae and juveniles. We are the only laboratory in the Northwestern US that is conducting research on the behavior of juvenile crab, especially with respect to habitat selection and utilization, and the only laboratory in the world conducting such research with king crab.

The use of QTC for benthic habitat research is only now in it's infancy. The ADF&G has used it for small scale studies of rockfish and crab habitat in the Gulf of Alaska (Dan Urban, ADF&G, Kodiak, pers. com., December, 2002). The NMFS has used it for bottom typing of sediments in the Bering Sea and is planning further research to study coral distribution in the Aleutian Islands (R. McConnaughey, NMFS, AFSC, personal communication, Dec. 18, 2002). We would work directly with both the ADF&G, the AFSC, and the University of Alaska to apply these techniques to areas of the Pribilof Islands that have not yet been explored thoroughly. No other researchers are pursuing these goals.

We would coordinate our activities with the residents of the Pribilof Islands communities, so that they may have direct knowledge of the activities and results. Interns from those locations will help compile and distribute information concerning traditional knowledge, and may be involved directly in the research program. Public outreach would be conducted via website development and presentation of results at meetings.

Milestones (Phase I only)

June 2003 Receive funds from NPRB; begin equipment purchases
July 2003 Obtain adult female BKC broodstock and transfer to KFRC.
July 2003 to March 2004 Hold adult broodstock in tanks at KFRC (Stevens)
December 2003 Submit Y2 proposal and budget
Jan-March 2004 Cultivate food sources for BKC larvae (Persselin)
April 2004 Hatchout of blue king crab larvae (Stevens, Persselin)
May 2004 Cultivate BKC larvae, and study effects of diet, temperature, and density (Stevens, Persselin, Intern)
June 2004 Determine survival to glaucothoe stage (Stevens, Intern)
June 2004 Determine survival to juvenile stage C1 (Stevens, Intern)
July 2004 Obtain new broodstock for Phase II.

Possible Peer Reviewers

Dr. David Armstrong, Director
School of Aquatic and Fisheries Sciences
University of Washington
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Budget Narrative

The attached budget covers only the laboratory study for three years. Salaries are sought for a student intern in Y1 through Y3, and for UAF Faculty and one graduate student in Y2 and Y3. The MS student would receive 1 semester pay at half time (20 hr/wk),

plus tuition, and 60 days full time pay (40 hr/wk) during summer. Benefits are provided for students during summer, and at Faculty rate for 30 d.

Travel is requested for two people to Anchorage for the annual meeting, and to attend one professional meeting in the U.S.

Equipment. In Y1 we will need to assemble an existing 2000-gallon tank for holding crab at the KFRC, and purchase a 1.75 hp chiller to maintain cold temperatures. Funds for plumbing and installing the system will be expended in Y2. Two 180 gal portable tanks with chillers (Minno-cools) would be required for transporting broodstock king crab from St. Paul to Dutch Harbor. Three salmon egg incubators will be used for cultivating juvenile crab. A spectrophotometer is necessary for analysis of algae cultures necessary for feeding BKC larvae, and two controlled environment chambers (refrigerator size) are needed for culturing algae and crab larvae. We plan to purchase one new Mettler micro-balance in each of Y1 and Y2. Shipping costs for all the above are included.

Supplies are mostly miscellaneous lab expenses, including such items as vinyl hoses, valves, adaptors, airstones, aquaria, thermometers, nets, PVC pipe and fittings, small tools, hose clamps, beakers, graduated cylinders, chemicals, Artemia, algae cultures, growth media, water quality test media, etc. The most expensive item is an automated water quality (T, C, DO) monitoring system for the crab tank.

Contracts include funds for development of web pages and information exchange with the Pribilof Island communities.

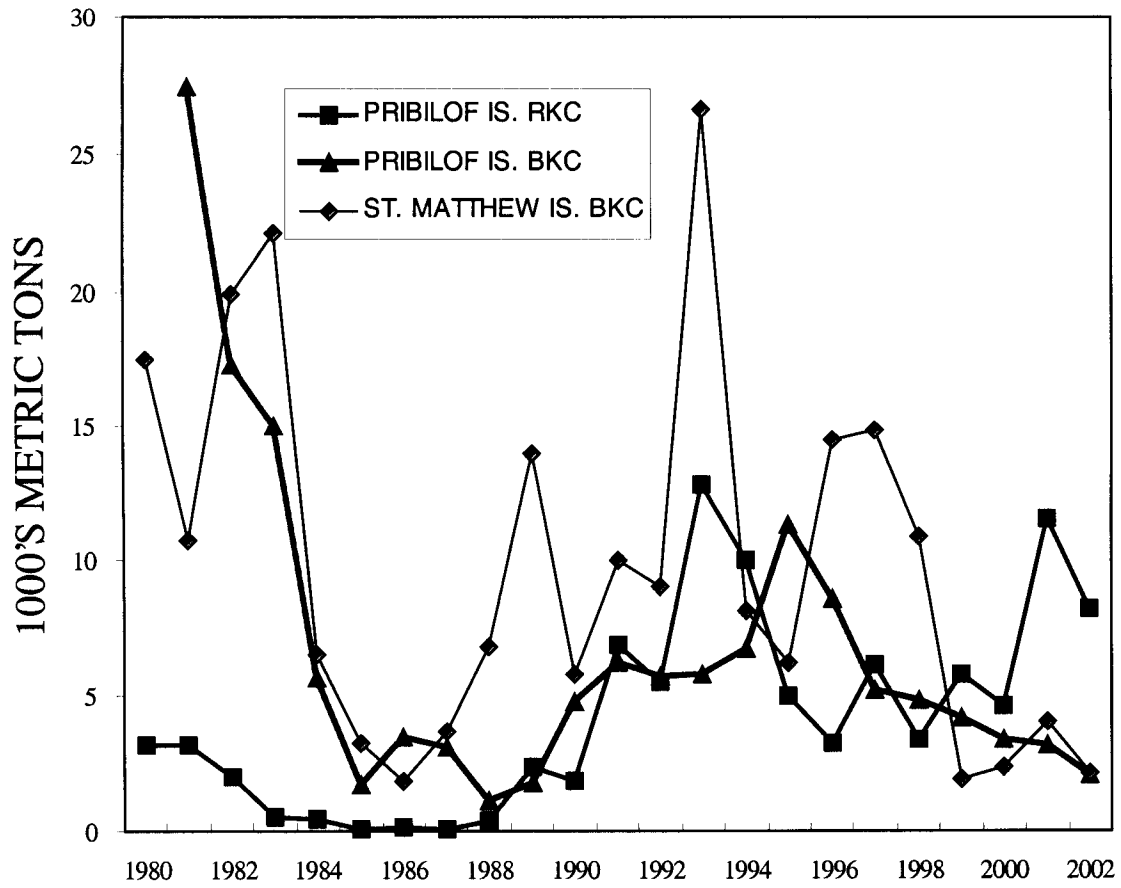


Figure 1. Indices of total spawning biomass for red and blue king crab in the Pribilof and St. Matthew Islands, from NMFS crab survey data.

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- Stevens, B. G., and R. A. MacIntosh. 1991. Cruise Results Supplement, Cruise 91-1 Ocean Hope 3: 1991 eastern Bering sea juvenile red king crab survey, May 24-June 3, 1991. National Marine Fisheries Service, Alaska Fisheries Science Center. Kodiak Fisheries Research Center, 301 Research Ct., Kodiak, AK 99615.

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NPRB BUDGET SUMMARY FORM

PROJECT TITLE: Essential Habitat for Blue King Crab, Laboratory Studies, Phase I
 Development of cultivation techniques for blue king crab larvae, *Paralithodes platypus*
PRINCIPAL INVESTIGATOR: Dr. Bradley G. Stevens, NMFS, Kodiak Laboratory

Annual cost category breakdowns will be requested for matching funds only if project is funded

FUNDING SOURCE	YEAR 1	YEAR 2	YEAR 3	TOTAL
NPRB Funding	85,561	92,263	82,602	260,426
Match/In Kind	33,600	34,608	35,646	103,854
TOTAL	119,161	126,871	118,249	364,281

Cost Categories	NPRB Year 1	NPRB Year 2	NPRB Year 3	NPRB TOTAL	Match/In kind TOTAL (all years)
1. Personnel Salaries	12,000	33,560	35,238	80,798	169,282
2. Personnel Fringe Benefits	6,060	11,400	11,904	29,365	
3. Travel (include 1 trip to review meeting in Anchorage)	7,250	7,250	7,250	21,750	
4. Equipment	37,000	12,650	0	49,650	
5. Supplies	11,750	5,750	5,750	23,250	
6. Contractual/Consultants	4,000	4,000	4,000	12,000	
7. Other (Include \$1500 for education and outreach)	1,500	1,500	1,500	4,500	
Total Direct Costs	79,560	76,110	65,642	221,313	169,282
Indirect Costs	6,001	16,152	16,960	39,114	
TOTAL PROJECT COSTS	85,561	92,263	82,602	260,426	169,282

CURRICULUM VITAE

7 January 2003

NAME **Bradley G. Stevens**
BIRTHDATE 11 June, 1952
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EDUCATION Ph.D. Fisheries, 1982. School of Fisheries, Univ. of Washington, Seattle, WA.
M.S. Marine Biology, 1977. The College of Charleston, Charleston SC.
B.S. Biology, 1973. Univ. of Cincinnati, Cincinnati, OH.

CURRENT POSITIONS

Research Fishery Biologist, Kodiak Laboratory, NMFS
Adjunct Faculty, Kodiak College, University of Alaska, Anchorage.
Affiliate Faculty, University of Alaska, Fairbanks.

RECENT ACTIVITIES

Since the opening of the Kodiak Fisheries Research Center in 1998, I have focused on development of techniques for cultivation of red king crabs, and production of juvenile crab for research on early life history. This has included studies of settlement and substrate use of larval king crab, and growth, molting and feeding of juvenile king crabs. I spent 1996 in Japan, working with Dr. Jiro Kittaka of Tokyo Science University, learning the culture techniques we now use. Since 1991, I have been studying the reproductive and behavioral ecology of Tanner crabs using submersibles and ROV's. In 1991 we discovered that Tanner crabs form high density aggregations in deep water (500 ft). Subsequent work has focused on the timing of aggregation and larval release relative to current patterns and other environmental parameters, and suggests that larval release is cued by tidal cycles. I have led two cruises with the submersible Alvin to study deep-sea crabs on Gulf of Alaska Seamounts, in 1999, and 2002. Other studies include the effects of fish-waste dumping on the benthic ecosystem, and the impacts of derelict crab pots. Recent projects have involved such in-situ equipment as side-scan sonar, a laser line-scanner, and underwater videography. From 1984-2000 my primary assignment was assessment of Bering Sea crab stocks. This involved a 10-week survey of the Bering sea, large database management (>1,000,000 records), analytical software development, analysis of stock abundance indices for 6 crab species-fisheries, and production of an annual stock assessment report.

GRANTS RECEIVED

2002 Ecology of Deep-sea Crabs on Gulf of Alaska Seamounts (DSV Alvin, amount undisclosed)
2002 Effects of environment on timing of hatching of Tanner crabs, Year 2 (\$97,000)
2001 Effects of environment on timing of hatching of Tanner crabs, Year 1 (\$85,000)
1999 Ecology of Deep-sea Crabs on Gulf of Alaska Seamounts (DSV Alvin, amount undisclosed)
1995 Reproductive biology of Tanner crab (Delta Submersible; \$90,000)
ROV observations of crab mating behavior (\$75,000).
Ghost fishing by lost crab pots (\$90,000).
1994 Sidescan Sonar detection of crab pods and derelict pots (\$46,619).
Reproductive ecology of female Tanner crabs (\$96,000).
1993 Observations of crab escapement from crab pots by ROV (\$22,626).
1992 Aspects of a mating aggregation of Tanner crabs (\$80,000).
1991 Characteristics of mating Tanner crabs captured in situ (\$130,000).
Effects of the Kodiak fishwaste dumpsite on benthic habitat and associated water quality (\$60,000).

PROFESSIONAL AFFILIATIONS

American Fisheries Society (Alaska Chapter Sec-Treasurer, 1987-1989); Crustacean Society; Western Society of Naturalists; National Shellfisheries Association

SPECIAL EXPERIENCE

Management of large database systems (> 1 million records). Statistical and graphic analysis on mainframe and micro-computers. Knowledge of Fortran and Visual Basic programming languages. Personnel Management Training, January 1988. SCUBA diver, over 400 dives logged. Certifications include PADI Basic Diver (1975), NOAA Working Diver (1987), NOAA NITROX 1 (1989), NAUI Advanced (1993), and NOAA Divemaster (1994.) Manned research submersibles, 60 dives. Small boat operation (16-32 ft) >600 hours. Research vessel experience, >500 days. Application of ROV's, submersibles, and sidescan sonar to benthic biology. Experience in underwater photography and videography.

POSITIONS HELD

- 2000- **Affiliate Faculty**, University of Alaska, Fairbanks.
- 1984 - Present: **Fishery Research Biologist** (GS-13). NMFS, Kodiak, AK. Conduct and supervise research and modeling studies on life history, growth, and recruitment of crabs and other economically important invertebrates. Supervise and conduct in situ research on mating/reproduction of Tanner crabs using scuba, ROV's, submersibles, and sidescan sonar. Manage Seawater laboratory for multiple agency users. Conduct annual crab stock assessment surveys of Bering Sea. Provide annual input to N. Pacific Fishery Management Council on crab population status. Supervisor: Dr. Robert Otto, NMFS, Kodiak Fishery Research Ctr (907-481-1711).
- 1984 - Present: **Adjunct Faculty**, Kodiak College, Univ. of Alaska. Taught 'Ecology of Kodiak Tidepools' (1990-2000); 'Statistical Computing with Minitab' (1985); 'Trashing the Oceans: Ecology and Economics of Marine Pollution' (1989),
- 1983 **Research Assistant Professor**, Old Dominion University, Norfolk, VA. Research and teaching.
- 1982 **Fishery Biologist**, U. of Washington, Seattle. Bering Sea zooplankton research.
- 1982 **Teaching Assistant**, Univ. of WA. Resource Assessment and Crustacean Biology
- 1980-82 **Research Associate**, Univ. of WA. Ph.D. research on ecology of Dungeness crab.
- 1978-80 **Biologist I, II**, Wash. Dept. of Fisheries. Effects of dredging on Dungeness crab.
- 1978-80 **Commercial Diver** (part-time), Westport, WA. Fishing vessel maintenance.
- 1978 **Fisheries Technician II**, Wash. Dept. Fisheries. Creel census of sportfish data.
- 1977 **Biologist I** (temp), NMFS. Foreign fishery observer on Soviet trawlers.

AWARDS RECEIVED

Department of Commerce Unit Award Certificate, Exxon Valdez Response. January 1992.

Department of Commerce Unit Award Certificate (for Bycatch Research), June 1988.

Sarah Denny Graduate Research Fellowship, Autumn 1981. Egvedt Graduate Research Scholarship, Winter 1981.

N.C. Machinery Company Scholarship, 1981. Egvedt Academic Scholarship, 1978.

COMMUNITY SERVICE

Kodiak State Parks Advisory Board, 2002- present.

Kodiak College Advisory Council, Vice Chairman, 1998-99, Chairman, 2000.

Kodiak Public Broadcasting Corporation, Board of Directors: President, 1993-95; Treasurer, 1992-1993.

Kodiak Womens Resource and Crisis Center, Board of Directors, 1984-1986. President, 1986.

MISCELLANEOUS ACTIVITIES

Since 2000, I have been co-director of Kodiak Island Drummers, a group of 15-20 K-12 students who perform drumming on a variety of hand drums and percussion instruments. In 2002, we traveled to Anchorage to perform at the Anchorage Music Festival, and conducted workshops in many different schools. From 1989-1998 I wrote, performed, and recorded music about life in Alaska with a local musical group "Waterbound". We have released 3 albums on tape and CD: "Life on the Island" (1989), "Sometimes a Great Ocean" (1994), and "Alaskan Animal Tales and Tunes" (1998). In 1990 we received a grant from the National Endowment for the Arts (via the Kodiak Arts Council) to perform in three Kodiak native villages.

SCIENTIFIC PUBLICATIONS

- Stevens, B. G.** in press. Settlement, substrate preference, and survival of red king crab *Paralithodes camtschaticus* (Tilesius, 1815) glaucothoe on natural substrates in the laboratory. *J. Exp. Mar. Biol. Ecol.* VV:00-10.
- Stevens, B. G.** in press. Timing of aggregation and larval release by Tanner crabs, *Chionoecetes bairdi*, in relation to tidal current patterns. *Fisheries Research.* XX:000-000.
- Kittaka, J., **B. G. Stevens**, S. Teshima, and M. Ishikawa. 2002. Larval culture of the king crabs *Paralithodes camtschaticus* and *P. brevipes*. In *Crabs in cold water regions: Biology, Management, and Economics*. Anchorage, AK. 2002. Alaska Sea Grant Program. Rep. No. AK-SG-02-01, p. 189-209.
- Stevens, B. G.** 2002. Molting of red king crab, *Paralithodes camtschaticus*, observed by time-lapse video in the laboratory. In *Crabs in Cold water regions: biology, management, and economics*. Anchorage, AK. University of Alaska Sea Grant. Rep. No. AK-SG-02-01, p. 29-37.
- Stevens, B. G.** 2002. Survival of Tanner crabs tagged with Floy tags. In *Crabs in Cold water regions: biology, management, and economics*. Anchorage, AK. University of Alaska Sea Grant. Rep. No. AK-SG-02-01, p. 551-559.
- Stevens, B. G.** 2002. Checklist of Alaskan Crabs. In *Crabs in Cold water regions: biology, management, and economics*. Anchorage, AK. University of Alaska Sea Grant. Rep. No. AK-SG-02-01, p. 5-8.
- Stevens, B. G.**, J. E. Munk, and P. E. Cumiskey. 2002. A study on the utility of log piling structures as artificial habitats for red king crabs and other fauna. AFSC Processed Report. No. 2002-03. National Marine Fisheries Service. Kodiak Fisheries Research Center, 301 Research Ct., Kodiak, AK 99615. 44 p.
- Loher, T., D. A. Armstrong, and **B. G. Stevens**. 2001. Growth of juvenile red king crab (*Paralithodes camtschaticus*) in Bristol Bay (Alaska) elucidated from field sampling and analysis of trawl-survey data. *Fish. Bull.* 99:572-587.
- Stevens, B. G.**, and P. J. Anderson. 2000. An association between the anemone, *Cribrinopsis fernaldi*, and shrimps of the families Hippolytidae and Pandalidae. *J. Northw. Atl. Fish. Sci.* 27:77-82.
- Stevens, B. G.**, I. Vining, S. Byersdorfer, and W. E. Donaldson. 2000. Ghost fishing of Tanner crabs (*Chionoecetes bairdi*) at Kodiak Alaska: Pot density and catch per trap as determined by sonar, submersible, and pot recovery. *Fish Bull.* 98:389-399.
- Stevens, B. G.**, J. Haaga, and W. E. Donaldson. 2000. Mound formation by Tanner crabs (*Chionoecetes bairdi*): Tidal phasing of larval launch pads? *Crustacean Issues* 12:445-456.
- Stevens, B. G.**, and J. Kittaka. 1998. Postlarval settling behavior, substrate preference, and time to metamorphosis for the red king crab (*Paralithodes camtschaticus*). *Mar. Ecol. Prog. Ser.* 167:197-206.
- Stevens, B. G.** 1996. Crab Bycatch in Pot Fisheries. Pp151-158 in *Solving Bycatch: Consideration for today and tomorrow*. Alaska Sea Grant Program Report No. 96-03, University of Alaska Fairbanks.
- Stevens, B. G.**, J. Haaga, W. E. Donaldson, and S. A. Payne. 1996. Reproductive conditions of prespawning female Tanner crabs, *Chionoecetes bairdi*, in Chiniak and Womens Bays, Kodiak, Alaska. Pp 349-354 in *High Latitude crabs: Biology, management, and economics*. Alaska Sea Grant Program Report No. 96-02, University of Alaska Fairbanks.
- Haaga, J., and **B. G. Stevens**. 1996. Fecundity, reproductive conditions, and size at maturity for the Arctic lyre crab, *Hyas coarctatus*, in the eastern Bering Sea. Pp 443-444 in *High Latitude crabs: Biology, management, and economics*. Alaska Sea Grant Program Report No. 96-02, University of Alaska Fairbanks.
- MacIntosh, R. A., **B. G. Stevens**, J. A. Haaga, and B. A. Johnson. 1996. Effects of handling and discarding on mortality of Tanner crabs, *Chionoecetes bairdi*. Pp577-590 in *High Latitude crabs: Biology, management, and economics*. Alaska Sea Grant Program Report No. 96-02, University of Alaska Fairbanks.
- Stevens, B. G.**, J. A. Haaga, and W. E. Donaldson. 1994. Aggregative mating of Tanner crabs *Chionoecetes bairdi*. *Can. J. Fish. Aquat. Sci.* 51:1273-1280.
- Stevens, B. G.**, and J. A. Haaga. In prep. Ocean dumping of seafood processing wastes: Comparisons of epibenthic macrofauna sampled by submersible in impacted and non-impacted Alaskan bays, and estimation of decomposition rate. (Ms. Report, in review).
- Himelbloom, B., and **B. G. Stevens**. 1994. Microbial analysis of a fish waste dump site in Alaskan marine waters. *Bioresource Technology.* 47:229-233.
- Stevens, B. G.**, W.E. Donaldson, J. A. Haaga, and J. E. Munk. 1993. Morphometry and maturity of male Tanner crabs, *Chionoecetes bairdi*, grasping pubescent and multiparous females in shallow and deepwater environments. *Can. J. Fisheries and Aquat. Sciences* 50:1504-1516.
- Stevens, B. G.**, W.E. Donaldson, and J. A. Haaga. 1992. First report of podding behavior in the Pacific lyre crab, *Hyas*

- lyratus*. J. Crustacean Biology 12(2):193-195.
- Stevens, B. G.**, and J. E. Munk. 1991. Lateral asymmetry in the thoracic segmentation of a king crab, *Paralithodes camtschatica* (Tilesius, 1815)(Decapoda, Anomura), from Kodiak, Alaska. Crustaceana 61(3):317-320.
- Stevens, B. G.** 1990a. Survival of king and Tanner crabs captured by commercial sole trawls. Fishery Bulletin 88:731-744.
- Stevens, B. G.** 1990b. Temperature-dependent growth of juvenile red king crab *Paralithodes camtschatica*, and its effects on size-at-age and subsequent recruitment in the eastern Bering Sea. Can. J. Fish. Aquat. Sci. 47(7):1307-1317.
- Stevens, B. G.**, and J. E. Munk. 1990. A temperature-dependent model for growth of juvenile red king crab *Paralithodes camtschatica*, in Kodiak, Alaska. pp. 293-304 in B. Melteff (ed), Proceedings of the International Symposium on king and Tanner crabs, November 28-30, 1989, Anchorage, Alaska, USA. Alaska Sea Grant College Program Report No. 90-04, Univ. of Alaska, Fairbanks, AK.
- Armetta, T., and **B. Stevens**. 1987. Aspects of the biology of the Hair crab, *Erimacrus isenbeckii*, in the eastern Bering Sea. Fish. Bull. 85(3):523-545.
- Stevens, B.**, and D. A. Armstrong. 1985. Ecology, growth, and population dynamics of juvenile Dungeness crab, *Cancer magister* Dana, in Grays Harbor, WA, 1980-1981. Pages 118-134 in Proceedings of the Symposium on Dungeness crab Biology and Management, Anchorage Alaska, Oct. 9-11, 1984. Univ. of Alaska Sea Grant Publications, Fairbanks, AK, 99701.
- Stevens, B.**, and D. Armstrong. 1984a. Diel activity of an estuarine population of Dungeness crabs, *Cancer magister*, in relation to feeding and environmental factors. J. Crust. Biol. 4(3): 390-403.
- Stevens, B.**, and D. Armstrong. 1984b. Distribution, abundance, and population size of Dungeness crab, *Cancer magister*, in Grays Harbor, Washington. Fish. Bull 82(3): 469-483.
- Stevens, B.** 1982. Distribution, abundance, and feeding habits of Dungeness crab, *Cancer magister*, in Grays Harbor, Washington. PhD. Dissertation, Univ. of Washington. 213 pp.
- Stevens, B.**, D. Armstrong, and R. Cusimano. 1982. Feeding habits of the Dungeness crab, *Cancer magister*, in Grays Harbor, Washington, as indicated by the Index of Relative Importance. Mar. Biol. 72(2): 135-146.
- Stevens, B.**, and D. Armstrong. 1981. Mass mortality of female Dungeness crab, *Cancer magister*, on the southern Washington coast. Fish. Bull. 79(2): 349-352.

TECHNICAL REPORTS

- Stevens, B. G.**, J. E. Munk, and P. E. Cummiskey. 2002. A study on the utility of log piling structures as artificial habitats for red king crabs and other fauna. AFSC Processed Report. No. 2002-03. National Marine Fisheries Service. Kodiak Fisheries Research Center, 301 Research Ct., Kodiak, AK 99615. 44 p.
- Stevens, B. G.**, J. A. Haaga, R. A. MacIntosh, R. S. Otto, and L. Rugolo. 2001. Report to Industry on the 2001 Eastern Bering Sea Crab Survey. AFSC Processed Reports. No. 2001-07. Alaska Fishery Science Center, National Marine Fisheries Service. Kodiak Fishery Research Center, 301 Research Ct. Kodiak, AK 99615 USA. 62 p.
- Stevens, B. G.**, J. Haaga, and R. A. MacIntosh, and R. S. Otto. 2000. Report to Industry on the 1998 eastern Bering Sea Crab Survey. Processed Report 2000-01, NMFS/NOAA, Alaska Fisheries Science Center, 7600 Sand Point Way, Seattle, WA 98115. 59 pp.
- Stevens, B. G.**, J. Haaga, and R. A. MacIntosh, and R. S. Otto. 1998. Report to Industry on the 1998 eastern Bering Sea Crab Survey. Processed Report 98-07, NMFS/NOAA, Alaska Fisheries Science Center, 7600 Sand Point Way, Seattle, WA 98115. 52 pp.
- Stevens, B. G.**, J. A. Haaga, and W. E. Donaldson. 1993. Underwater observations on behavior of king crabs escaping from crab pots. Processed Report 93-06, NMFS/NOAA, Northwest and Alaska Fisheries Center, 7600 Sand Point Way NE, Seattle, WA, 98115.
- Stevens, B. G.**, J. Haaga, and R. A. MacIntosh. 1997. Report to Industry Processed Report 98-02, NMFS/NOAA, Alaska Fisheries Science Center. 52 pp.
- , 1995. Report to Industry... Processed Report 94-07, NMFS/NOAA, AFSC.
- Stevens, B. G.**, J. Bowerman, R. A. MacIntosh, and J. A. Haaga. 1993. Report to Industry Processed Report 93-14, NMFS/NOAA, AFSC. 53 pp.
- , 1992. Report to Industry Processed Report 92-12, NMFS/NOAA, AFSC.
- Stevens, B. G.**, and R. A. MacIntosh. 1991. Report to IndustryProcessed Report 91-17, NMFS/NOAA, Alaska Fisheries Center (AFSC).
- , 1990. Report to Industry....Processed Report 90-09, NMFS/NOAA, NWAFC. 50 pp.

- . 1989. Report to Industry....Processed Report 89-18, NMFS/NOAA, NWAFC. 47 pp.
- Stevens, B. G.**, R. A. MacIntosh, and K. L. Stahl-Johnson. 1988. Report to Industry....Processed Report 88-23, NMFS/NOAA, NWAFC.
- . 1987. Report to Industry ... Processed Report 87-18, NMFS/NOAA, NWAFC.
- . 1986. Report to Industry ... Processed Report 86-17, NMFS/NOAA, NWAFC.
- . 1985. Report to Industry ... Processed Report 85-20, NMFS/NOAA, NWAFC.
- Stevens, B. G.**, and R. A. MacIntosh. 1985. Analysis of crab data from the 1985 NMFS survey of the Northeast Bering Sea and Norton Sound. Processed Report 86-16, NMFS/NOAA, Northwest and Alaska Fisheries Center, 7600 Sand Point Way NE, Seattle, WA, 98115.
- Stevens, B. G.**, R. S. Otto, J. Haaga, and R. A. MacIntosh. 1998. Report to Industry on the 1997 eastern Bering Sea Crab Survey. Processed Report 98-02, NMFS/NOAA, Alaska Fisheries Science Center, 7600 Sand Point Way, Seattle, WA 98115. 55 pp.
- Armstrong, D., **B. Stevens**, and J. Hoeman, 1982. Distribution and abundance of Dungeness crab, Cancer magister and Crangon shrimp, and dredging-related mortality of invertebrates and fish in Grays Harbor, Washington. Final Report to U.S. Army Corps of Engineers and Washington Department of Fisheries, Seattle, WA. 349 pp.
- Stevens, B.** 1981. Dredging-related mortality of Dungeness crab, Cancer magister, associated with four dredges operating in Grays Harbor, Washington. Final Report to U.S. Army Corps of Engineers and Washington Department of Fisheries, Seattle, WA. 148 pp.

POPULAR LITERATURE

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RECENT PRESENTATIONS

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- Sex, Tides and Videotape: Do tidal rhythms control the timing of aggregation and hatching in Tanner crabs? Conference on Life Histories, Assessment and Management of Crustacean Fisheries, A Coruna, Spain, October 2001.
- A Mountain in the Sea: Exploration of Gulf of Alaska Seamounts with the submersible Alvin. AAUS Annual meeting, Seward, AK, September 2001.
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