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Project Title: Quantification of unobserved injury and mortality of Bering Sea crabs due to encounters with trawls on the seafloor

Project Period: from June, 2007 to June, 2009

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Research Priority:

Bycatch estimation

Summary of Proposed Work:

The potential for unobserved mortality of crabs encountering bottom trawls, but not brought aboard the fishing vessel, has long influenced the management of Bering Sea groundfish fisheries. Our research will address the lack of data on the mortality rates of such crabs for at least two principal commercial crab species of the Bering Sea, red king crab and either Tanner crab or snow crab. We will apply and improve existing methods for collecting crabs immediately after trawl encounters (Rose 1999). Assessments of reflex impairment will be used to more efficiently estimate delayed mortality rates with reduced requirements for long-term holding (Davis 2006). This proposal leverages pilot funding from the NMFS cooperative research program. Pilot fieldwork in early Summer 2007 will establish recapture net designs and handling, as well as procedures for holding crabs onboard. Reflex and reflex impairment observations of captive animals at the Kodiak NMFS laboratory will provide information needed for field assessments of crab condition. The principal fieldwork in Summer 2008 will combine these developments to assess the mortality probabilities of crabs that have passed the sweeps, wings and central footrope of a commercial groundfish trawl as well as control animals collected identically without trawl encounters. Mortality estimates will be derived by combining condition assessments based on reflex impairments with the delayed mortality rates of retained animals.

Total Funding Requested From NPRB:

$ 211,848.00	Alaska Fisheries Science Center - RACE
$ 10,000.00	Marine Conservation Alliance Foundation
$ 221,848.00	

Total Other Support:

$ 138,531.00	Alaska Fisheries Science Center - RACE
$ 138,531.00	

Legally Binding Authorizing Signature and Affiliation:

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A. Project Title

Quantification of unobserved mortality of Bering Sea crabs due to encounters with trawls on the seafloor

Short title - Unobserved, trawl-induced mortality of Bering Sea crabs

B. Proposal Summary

The potential for unobserved mortality of crabs encountering bottom trawls, but not brought aboard the fishing vessel, has long influenced the management of Bering Sea groundfish fisheries. Our research will address the lack of data on the mortality rates of such crabs for at least two principal commercial crab species of the Bering Sea, red king crab and either Tanner crab or snow crab. We will apply and improve existing methods for collecting crabs immediately after trawl encounters (Rose 1999). Assessments of reflex impairment will be used to more efficiently estimate delayed mortality rates with reduced requirements for long-term holding (Davis 2006). This proposal leverages pilot funding from the NMFS cooperative research program. Pilot fieldwork in early Summer 2007 will establish recapture net designs and handling, as well as procedures for holding crabs onboard. Reflex and reflex impairment observations of captive animals at the Kodiak NMFS laboratory will provide information needed for field assessments of crab condition. The principal fieldwork in Summer 2008 will combine these developments to assess the mortality probabilities of crabs that have passed the sweeps, wings and central footrope of a commercial groundfish trawl as well as control animals collected identically without trawl encounters. Mortality estimates will be derived by combining condition assessments based on reflex impairments with the delayed mortality rates of retained animals.

C. Project Responsiveness to NPRB Research Priorities or Identified Project Needs

This proposal directly responds to the last sentence under priority c. Fish and Invertebrates ii. Bycatch estimation and gear induced injury and mortality, which states: **"NPRB is also looking for proposals that will lead towards a more accurate quantification of gear induced injury and mortality, particularly to species not brought onboard."** The proposed study will provide such quantification for the unaccounted mortality issue that arguably has had the largest effect on the management of North Pacific Fisheries – that of mortality to three major commercial crab species (red king crab *Paralithodes camtschatica*, tanner crab *Chionoecetes bairdi* and snow crab *Chionoecetes opilio*) from encounters with bottom trawls.

This project addresses a long established need to better understand the unobserved mortalities of Bering Sea crabs due to encounters with trawls (see background below), giving it a very strong correspondence to the NPRB priority cited above. It will also develop methods for estimating such mortality rates, allowing further study, including the modification of trawls to reduce impacts and the variability of mortalities by any of a number of potentially important factors, such as season, fishery, and seafloor type.

D. Soundness of Project Design and Conceptual Approach

Rationale and Problem Background

The current set of management measures to control and reduce bycatch of the major Bering Sea crab species in Alaska groundfish fisheries is based on year-round trawl closure areas and bycatch caps applying to wide areas outside the these no-trawl zones. The year-round closed areas were designed to protect areas of known concentration of female and juvenile crab. Additionally, bycatch caps (based on numbers caught) are used to close additional areas on a seasonal basis if the crab species-specific (and sometimes area-specific) caps are attained. Catch sampling done by full time observers on groundfish vessels over 125 feet, and 30% coverage on vessels between 60-124 feet is used to estimate crab bycatch numbers on an in-season basis (Witherell et al. 2000).

The species-specific crab bycatch caps (in estimated numbers of crabs brought aboard) are thought to have a biologically insignificant effect on the different crab populations because caps represent as little as 0.113 % of the abundance index (for C. opilio) and 0.5-1.0% of abundance for red king and C. bairdi (Witherell and Pautze, 1997). With these limits in place to control crab bycatch, managers have tended to view consideration of minor adjustments to these caps as "allocation" decisions to be negotiated between the groundfish and crab industries or between different sectors of the groundfish fishery. These negotiated adjustments to the crab bycatch caps have therefore occurred in the context of an amount of bycatch that reduces the directed fishery (however minimally) rather than a resource management concern. As such, small adjustments have been made to such things as the percentage of abundance that the caps represent, the areas against which the caps are monitored, and seasonal allocations of the bycatch caps between different groundfish target fisheries (Witherell and Pautzke, 1997).

Critics of the existing framework of crab bycatch management measures have from time to time asserted that bycatch caps, while appearing to be sufficiently conservative, represent only a fraction of the actual mortality on different crab species caused by groundfish fisheries. These criticisms are typically based on the notion that crabs and other marine life encountering trawl footropes are injured or killed and this unobserved mortality is not accounted for completely. While managers did take into account that not all crab encountering trawl footropes are landed in the initial establishment of the crab bycatch caps, particularly in the establishment of caps as number of animals brought aboard, even though some crab are thought to survive being caught (Witherell and Pautzke, 1997), the most outspoken critics believe these effects on crab populations are grossly underestimated under the current bycatch management regime (AMCC, 2004).

Some crab researchers in Alaska have underscored the need for additional research on injury rates and unobserved/unaccounted mortality from both directed crab fisheries and groundfish trawl fisheries. One paper alleges that excessively high mortality rates on male Bristol Bay red king crab from the directed fishery and unaccounted mortality on females crab from the groundfish fisheries better explains the population trajectory than the more accepted scientific hypothesis that the low population levels are explained by unfavorable climate conditions (Dew and McConnaughey 2005). Additionally, crab managers have prioritized study of unobserved mortality on king and tanner crab species by bottom and pelagic trawls (trawls meeting the "pelagic" gear definition yet fished in contact with the seafloor) (NPFMC 1999).

In addition to the prioritization of research on unobserved mortality by crab managers, accounting for all bycatch mortality is one of the research priorities set out in the 2006 research priorities of the North Pacific Fishery Management Council (NPFMC 2006). This priority is also embraced in NPFMC's implementation plan for the management priorities established in the recently concluded Programmatic Supplemental Environmental Impact Statement. Specifically, under the section header "*Manage Incidental Catch and Reduce Bycatch and Waste:*, implementation item states*:* " Continue to account for bycatch mortality in total allowable catch accounting and improve the accuracy of mortality assessments for target, prohibited species catch, and noncommercial species". This priority was developed from the recognition in the Programmatic SEIS that estimated numbers of animals taken observed as bycatch in groundfish fisheries could be viewed as minimum estimates. (NMFS, 2004)

Finally, the Alaska groundfish industry has expressed support for and interest in additional research into unobserved mortality of crab by bottom trawls. The Cooperative Research Program of the Marine Conservation Alliance Foundation, whose members include nearly all groundfish fishing companies and fishing, processing, and fishing community organizations in the Bering Sea and Gulf of Alaska, have prioritized research in this area for 2007-2008 field research projects. Cooperative research to improve our understanding of effects of bottom trawls on crabs was highlighted both by MCAF's Cooperative

Research Advisory Panel (October 17, 2006 minutes, http://www.mcafoundation.org/coop.html) and MCAF's board under the assumption that it will be beneficial if it serves to improve management of groundfish and crab resources. This research was considered important due to its potential to provide a scientific basis for resolving a controversy affecting the management of the groundfish trawl fisheries vis a vis their effects on crab populations. MCAF's Cooperative Research Director, John Gauvin, will coordinate industry participation in this project, including convening two industry workshops.

Project Design

This project will provide estimates of the mortality rates of Bering Sea crabs that encounter bottom trawls but are not brought aboard the trawling vessel as catch.

Hyopthesis – Some crabs encountering bottom trawls, but not brought aboard, are injured and die. This will be contrasted with the null hypothesis of no injuries or mortality. Hypothesis tests will be conditioned on the components of the trawl encountered (mid-footrope, wings, sweeps/bridles) and the species, gender and size of the crabs

The recognition of unaccounted mortalities as a potentially significant element in the fishing industry and by fishery managers has increased the number of studies addressing such mortalities and the range of methods used in their estimation. Broadhurst et al. provides a recent, thorough review of such studies. While the largest number of studies estimated mortalities for discarded catch, the next most numerous group dealt with mortalities of escaping animals not brought aboard the fishing vessel. The authors note that studies of escaping animals, almost exclusively fish, have lately emphasized methods that recapture animals in cages that are released from the fishing gear at fishing depths and then are moved slowly to shallower depths, where they are maintained by divers for long enough to assess delayed mortalities (e.g., Lehtonen et al. 1998). Earlier methods recaptured escaping animals in auxiliary nets before bringing them aboard and holding them long enough to evaluate the proportion of mortalities. However, stress and injury from recapture, extended towing time and holding could easily mask or exacerbate the effects of the escape process, particularly for animals subject to abrasion damage. The more recent methods also retain the experimental subjects in an environment more similar to what they would experience after actual escape. The cost of these gains is that each collection of affected animals requires an extended series of activities that are time-consuming, and labor and resource-intensive. This greatly restricts experimental sample sizes and hence the number of experimental factors that can be addressed.

As an experimental subject, crabs are significantly different from the fish for which the *in situ* capture, transfer and holding methods were developed. Exoskeletons protect crabs from the type of abrasion damage to which fish are susceptible during net capture and crowded holding. Fish also continue swimming, often to exhaustion, to avoid contact with nets and other animals. Another difference is the nature of interactions with the fishing gear. Broadhurst et al. 2006 note that "Because most experiments have quantified escape mortality at the codend, the potential for mortalities as a result of collisions and escape through other parts of the gear have largely been ignored" Because of the relative dimensions of Bering Sea crabs and the mesh sizes of Bering Sea bottom trawls, most crab escape occurs in the forward parts of trawl systems and interactions typically only last a few seconds as the crab passes the components of the net that directly contact the seafloor. Two of the few studies evaluating escape mortalities in the forward sections of trawls addressed Alaska red king crabs (Donaldson 1990 and Rose 1999).

Donaldson (1990) secured rows of large, hard-shelled red king crabs in the path of trawl and evaluated the condition of those that remained on the seafloor. Problems were encountered when 32.5% of the crabs escaped from the study area and could not be found by divers for evaluation. The operation of the trawl at the shallow depths required for diver operations appeared to have caused abnormal trawl performance. Nevertheless, based on the crabs that were observed, Donaldson estimated that only 2.6% of the crabs remaining on the seafloor were injured.

Rose (1999) compared visible injuries to red king crab resulting from passing under different trawl footrope designs. The crabs were recaptured in an auxiliary net fished behind the main footropes. A control footrope, suspended with floats to allow crabs to pass beneath with minimal damage was also used. A low rate of injuries for control crabs indicated that recapturing crabs and bring them aboard could be done without greatly increasing damage to the crabs. The principal limitations of this study were that the observed injuries were not related to mortality, particularly delayed mortality, (crabs were not held beyond the injury assessments), and results were limited to the center section of the footrope, a small portion of the area swept during trawling. Both of these issues will be addressed in the proposed study.

For our proposed study of the unobserved mortality of Bering Sea crabs, the ability to achieve substantial sample sizes and to examine a full range of relevant factors outweighed concerns about the effects of added handling on mortality. Sacrificing the ability to adequately consider conditions of size, species, condition and the nature of their contact with the trawl would compromise the usefulness of this study more than the potential effects of using recapture and onboard handling methods. Handling and holding effects will be dealt with through carefully designed controls, using crabs captured with identical nets (without prior contact with a trawl), which are then evaluated, held and handled identically to experimental animals. The success of this method will depend on achieving a relatively low rate of injuries and mortalities for control animals. Rose (1999) achieved this with recapture nets with few modifications to net design or handling to minimize such damage. Such refinements will be developed and evaluated during the pilot fieldwork in addition to evaluating alternatives for holding crabs (deck totes, partitioned crab tanks, seafloor cages) without inducing additional mortality.

The limiting factor of most studies of escape mortality has been the capacity to hold recaptured animals long enough to evaluate delayed mortality. To most efficiently use this project's resources, we will use a two-stage sampling procedure where all of the subject animals are immediately assessed for selected condition attributes and a much smaller sample will be held long enough to relate those attributes to eventual mortality rates. Stevens (1990) effectively applied a simple version of this strategy on crabs discarded from trawl catches. Since that time, such methods have been expanded and improved.

Background on the use of behavioral indices to predict mortality

During the last 10 years the Alaska Fisheries Science Center has made enormous strides, through a large range of experimental studies, in understanding relationships between capture related stressors and delayed (and often undetected) mortality in marine groundfish. Key principles for understanding fish discard mortality were described by one of us in a review article (Davis 2002), and development of behavioral indices for predicting mortality in discarded and escaped fish has also been reported recently (Davis 2005, 2006, Davis & Ottmar 2006). This recent research shows that simple, easily acquired measurements of reflex behaviors in fish provide excellent predictions of mortality related to both physiological (e.g., thermal stress, air exposure, etc.) and physical (such as wounding) stressors. Complex behaviors such as feeding and predator avoidance may also be used as indices of fish condition, but reflex actions tend to be less variable and are easier to measure without large tanks or apparatus. We have also learned that blood chemistry is not generally a good predictor of mortality because many of the traditional measures (e.g., cortisol or lactase) do not provide a graded response to stress (rather, the response is on or off) (Davis et al. 2001, Davis & Schreck 2005), and fish respond differently to physiological stress and physical injury. Davis (2006) coined the term RAMP (Reflex Action Mortality Predictor) for the general concept of using the relationship between a composite index of simple reflexes and mortality. The latter is generally observed through long-term holding or use of tag returns to observe delayed mortality. The shape of the curve is often sigmoid. The RAMP approach is now being adopted for use in bycatch-related field experiments with a variety of species around the United States, Canada, and Europe.

While RAMP has not been explicitly used for crabs, stress-related behavioral impairments are known. The most notable case for Alaska crabs is the observation that righting behavior (ability to turn from ventrum up to normal ventrum-down orientation) provides a sensitive indicator of cold-related stress in opilio crabs (Warrenchuk & Shirley (2002a). Van Tamelen (2005) suggested that this reflected muscle and nerve damage, and that righting behavior could be used as an index for predicting mortality. We also know that the mortality effects of cold stress, which occur during handling of crabs on the deck of fishing vessels in winter, is related to both size and species. Carls and O'Clair (1990, 1995) have shown that small crabs are more sensitive to cold, and that tanner crabs are more sensitive than the typically larger red king crabs. However, Stevens (1990) reported that delayed mortality in red king crabs following trawl injury decreased with body size. While temperature and wind chill are the most widely studied stressors for Alaska crabs, behavioral responses could also provide good predictors of mortality resulting from mechanical stress and physical injury encountered in contact with fishing gear.

A small group of field (Rosenkranz 2002 – snow & tanner crabs) and laboratory (Zhou & Shirley 1995 – king crab) studies exist exploring relationships between externally visible physical injuries in Alaska crabs and mortality, but the most thorough analysis of physical injury and mortality to date was conducted shipboard by Stevens (1990). He found that trawl-related mortality varied with species (tanner vs red king crab), crab size, and shell condition. The most fundamental discovery, however, was that: "..if the object were to predict survival using the quickest and most efficient method of assessment, then use of vitality alone might be the best choice…". Vitality was an index of condition scored on the basis of behavioral criteria. In Stevens' models for mortality, inclusion of injury information did not contribute significant power to predictions over the behavioral observations. Stevens noted that thorough assessment of injuries was time consuming, and that minor but potentially fatal injuries such as finely cracked carapaces were easily missed. Further, we would add that internal injuries and bleeding, not evident on the body exterior, may also contribute significantly to mortality. We hypothesize that behavioral indices (discussed below) will reflect crab condition and likelihood of survival independent of injury type – internal, external, and physiological (e.g., thermal stress).

A RAMP curve is species specific and can vary with size (Davis & Ottmar 2006). Three critical kinds of information are required to develop the curve for a new species – an understanding of normal reflex actions, whether and how the reflexes respond to stressors, and how mortality is correlated with some composite index of the reflexes. In the majority of studies conducted with Alaska crabs, emphasis has been placed upon the relationship between the stressor (e.g., cold or wind chill) and mortality. Two studies explore the relationship between behavioral indices of condition and mortality for tanner and red king crabs: Carls & O'Clair (1990) found significant correlations between righting behavior and mortality in both the red king crab ($R^2 = 0.83$) and tanner crab ($R^2 = 0.67$), and Stevens (1990) used a more general assessment of vitality (see above). The proposed project will yield progress in each of the three areas of interest through a combination of laboratory and field experimentation, and initiate development of RAMP curves with observations on a wide range of behavioral responses to stress in the subject species.

Behavioral responses for consideration in predicting crab mortality

Behavior of animals is influenced by and reflects a host of internal and external conditions, providing a neurological integration of both physiological stress and physical wounding. While some studies on crab mortality have included measures of feeding and growth or weight loss (Carls & O'Clair 1990, 1995, Zhou & Shirley 1995) and aspects of ecdysis (molting) (O'Brien et al. 1986, Carls & O'Clair 1990), Davis (2005) has shown that the simplest most fundamental reflexive behaviors provide the best predictors of mortality. Reflex actions are easy to test without long holding or elaborate apparatus, and can be assessed quickly at sea. Here we discuss some of the behavior types that we expect to explore with Alaska crabs, with the ultimate goal of developing a near instantaneous calculation of mortality probability.

1) Righting behavior - The ability of a crab to turn to proper orientation after being placed on its back has been used in studies of capture-related mortality for king, tanner and snow crabs (Carls & O'Clair 1990, 1995, Stevens 1990, Zhou & Shirley 1995, Warrenchuk & Shirley 2002a,b). Both Stevens (1990) and van Tamlen (2005) suggest that this may be the best indicator of crab condition. Preliminary experiments conducted at the AFSC Kodiak Laboratory confirm that righting behavior in tanner crabs is a good predictor of mortality even when the injury is not visible externally. Righting is observed in water and over a time period ordinarily not exceeding 2-5 minutes.

2) Leg movement –Warrenchuk & Shirley (2002a) noted that cold-stressed crabs unable to right themselves often survived, but all surviving snow crabs exhibited at least some level of movement in the primary locomotory limbs and chelae. Their observations suggest that we can classify limb movements in three basic levels: a) flaring of the limbs and chelae in defensive posture when grasped, b) leg action resulting in net crab movement, c) sporadic, uncoordinated leg motion not resulting in net movement. Stevens (1990) tested for limb movement by bending or prodding the legs.

3) Mouth movement & responsiveness – When in good condition, various mouth parts of crabs are almost constantly in motion. Stevens (1990) classified crabs as moribund (but not dead) when the mouth parts were not moving spontaneously, but they did respond to his systematic pattern of manual flicking. Carls & O'Clair (1990) classified crabs as dead only after the scaphognathites (gill bailers - mouthparts used to circulate water over the gills) were motionless. Maxillipeds, various exopods, and other mouthparts may hold promise for reflex testing.

4) Eye stalks and antennules – In a thermal model developed for cold stress in snow crabs, Van Tamelen (2005) explored temperature changes in various body parts including eye stalks. Not unexpectedly, the eyes were sensitive to damage. Consequently, as with a variety of animals, reflex actions associated with the eyes or antennules may be sensitive indicators of stress.

5) Abdomen – Crabs in good condition are usually motivated to adduct the abdominal segments under the carapace. Resistance to abdomen extension represents a potential test of stress.

All of these and other simple tests can be applied and elaborated with experience both in the laboratory and field.

Objectives

The project is divided into the following objectives, which combine to provide the ultimate goal of estimates of unobserved mortalities of crabs encountering Bering Sea bottom trawls. They include acquiring the necessary information for developing a mortality predictor based on reflex impairments (understanding normal reflex actions, whether and how the reflexes respond to stressors, and how mortality is correlated with some composite index of the reflexes), developing gear to collect and evaluate animals in the field and combining these to gather and analyze the necessary observations.

Objective A: Evaluate reflex behaviors in Alaska crabs that hold potential as predictors of stress

Close observations and simple experiments on behaviors of tanner, snow and king crabs (see above) will be made both in the laboratory and in the field. The first step will be to establish a baseline of normal reflexes in crabs with the lowest possible stress levels. Two sources of crabs will be used for these tests: a) tanner and red king crabs will be collected by diving and by fishing with crab pots in Kodiak. Preliminary observations will be made in the field. The crabs will then be transported to the Kodiak Laboratory and held for subsequent testing after the crabs have acclimated to the laboratory setting and are feeding well (a reliable indicator of healthy condition). Some observations will also be possible on crabs that are already being held in Kodiak. b) King crabs and snow crabs will be collected in the Bering Sea using the modified trawl described below during the pilot cruise. These crabs will be inspected carefully for physical damage and tested with methods perfected in Kodiak. Tests with tanner crabs made in Kodiak should serve as a reasonable proxy for the congeneric snow crabs.

Effort will be made to perform observations with the widest range of species, genders, size, and shell condition – all of which have been shown to affect survivorship. Baseline observations will be used to develop what is considered a "perfect" composite behavioral score for condition. For example, reflexive behaviors will be scored as present (1) or absent (0) and totaled for groups of at least 10 crabs in each test class. Then a Maximum Potential Reflex Action (MPRA) will be standardized to 1.0 using the combination of reflexes identified in the baseline testing. A Reflex Action Mortality Predictor (RAMP) will depend upon experiments and observations on injured crabs. RAMP development is described in full by Davis (2006).

Objective B: Assess the sensitivity of behavioral indices to stress

Testing relationships between reflex actions and stress requires experimental evaluation of crabs exposed to different levels of stress. Preliminary experiments will be conducted in Kodiak to test sensitivity of various reflex behaviors to controlled levels of injury, but such experimentation requires large numbers of crabs available only through a substantial fishing effort. Cold stress is relatively well studied for the three primary subject species (Warrenchuk & Shirley 2002a, van Tamelen 2005) and models provided in those papers allow predictions of mortality based upon exposures to cold. These models will guide tests of reflex impairment in laboratory-held crabs to seek out the least and most sensitive indicators. However, trawl-related stress does not ordinarily involve cold or windchill shocks, particularly when the crabs are not landed on deck. As with cold stress, preliminary experiments can be conducted in the laboratory, but the bulk of experiments will rely upon shipboard testing. Two kinds of experiments will be conducted: a) We will apply controlled limb and carapace breakage levels, similar to those observed in typical trawl-fishing operations and the experimental fishing proposed for this project. These injuries will then be followed with observations on reflex impairment using methods developed under Objective A. b) We will evaluate reflex impairment in crabs using levels of injury occurring "naturally" in the experimental fishing effort. Injuries will be scored as based on Stevens (1990). As described earlier, variation in responses will be evaluated on the basis of species, gender, size classes and shell condition.

Objective C: Evaluate relationships between behavioral indices (vs. physical injury) and mortality

Links between injury, behavioral impairment and ultimate mortality are the most important aspect of this project. Crabs will be assessed systematically for injuries and for reflex impairment in the course of experimental fishing. Then, crabs in specific species and test classes will be followed individually for survival. This will be done primarily at sea using 0.75 m^3 live boxes secured on the deck of the ship and supplied with flowing seawater. (Holding crabs in retrievable nets within the vessel's live-tanks will be attempted during the pilot cruise. If successful, this could supplement or replace deck holding.) Holding methods will be developed and refined during the 2007 pilot study. This work will also provide preliminary data on the relationship between reflex measures and mortality, allowing refined planning of the distribution of effort between holding and reflex evaluations for the 2008 principal study. Sea trials conducted by Stevens (1990) with red king crabs and tanner crabs have shown that on-deck holding for 2 days provides a good index for ultimate survival, and Carls & O'Clair (1995) found that 50% of all mortality occurred in tanner crabs in just 1-2 days following experimental cold exposures. Therefore, we will hold individually marked crabs for 2 days to evaluate immediate and longer term probabilities of mortality with the maximum numbers of crabs possible. Limb loss will also be evaluated. During the 2-day "recovery" period, repeat tests of reflex actions can be made; however, Carls & O'Clair (1995) have shown that recoveries in righting behavior do not usually occur except after the lowest levels of injury. Those recoveries ordinarily occurred within 2 days, helping us to set this as the maximum holding time, and allowing us to maximize numbers of crabs tracked. Holding period of up to 12 days during the pilot study will permit a direct evaluation of the scale of delayed mortality. Development of a full-scale RAMP for crabs is beyond the scope of the proposed project, but the first major cruise should provide the basic framework for such in the future.

Objective D: Develop methods for capturing and crabs affected by trawls and appropriate control animals and making them available for evaluation and holding aboard the study vessel.
To make realistic assessments of the effects of trawl contact on probabilities of immediate and delayed mortalities, we will collect crabs that have encountered full scale bottom trawls and bring them aboard the vessel for evaluation and holding. Our collection methods will expand those of Rose (1999), using auxiliary nets fished behind the trawl components to capture affected crabs after contact and deliver them to the vessel with minimal additional stress and damage. While that study collected crabs from behind the center of several trawl footropes, that part of the trawl system only represents a small portion of the area swept during trawling. A complete assessment of crab mortality requires collection of crabs affected by the wings of the net and the sweeps and bridles. We will develop similar net systems for use behind these other trawl components as well as improving the nets to minimize damage to retained crabs. Net modifications, focused on protecting crabs from crushing as the net is towed and brought aboard, will add structure and support to the codends and handling lines to control their orientation during retrieval.

An identical net will be fished clear of the trawl gear to collect unaffected crabs to evaluate any handling effects, including net retention and handling. A unique requirement for this control net will be selective retention of crab relative to groundfish. While the trawl itself will limit access of fish to the other test nets, the control net will be susceptible to larger and potentially crab-damaging fish catches. Modifications that exploit the greater mobility and herding tendencies of fish relative to crabs will be applied to moderate fish bycatch in the control net.

Design and rigging of the recapture nets will initially be modeled with a trawl simulation program (DynamiT) and then tested during the 2007 pilot fieldwork, using both underwater video and sonar to assure the intended fishing characteristics. Crabs, particularly from the control net, will be captured, assessed for injuries and reflex impairment and held to test for delayed mortalities (up to 12 days). This will also provide opportunities to refine assessment and holding methods.

Objective E: Estimate mortality rates for Alaska crabs encountering different components of bottom trawls.
The principal fieldwork in this project focuses on collecting crabs that have encountered bottom trawls and applying the methods developed above to relate their condition and behaviors to probabilities of immediate and delayed mortalities. A survey of trawl characteristics that was distributed through observers through out 2006 (Rose, unpublished data) and a workshop with Bering Sea groundfish trawlers will be used to select representative specifications for the study trawl. Recent observer and trawl survey records will be examined to select sites that provide sufficient numbers and compositions of crabs. Because of handling limitations, we will work on only one species at a time, selecting sites optimized for each of the three principal Alaska crab species, red king, tanner and snow crabs. Sites will require a mixture of gender and size classes. Based on recent distribution trends, while the tanner and red king crab sites may be relatively near each other, likely in outer Bristol Bay, the snow crab site will likely require travel north of the Pribilof Islands.

Trawl tows will be limited to less than 15 minutes to minimize damage to recaptured animals. Nets will be deployed on each tow to collect crabs passing sweeps, wings and footrope center as well as a control net. All crabs will be immediately released into holding tanks and assessed for reflex impairment within two hours. A sample, stratified by size, sex, condition and trawl component encountered will be assessed for injuries, individually marked and held for at least 48 hours. All crabs sampled from the same tow will be held under identical conditions until final assessment.

Mortality estimation will follow the methods of Davis 2006. We will attempt preliminary RAMP models for major categories, based on the mortality rates of the retained crabs and expanded by the reflex classifications on all crabs. A preliminary estimate of sample sizes is to hold at least 50 crabs for each size/sex/gear category and to reflex assessments on 4 times that number. Even with only two size classes, this means holding 800 crabs and assessing 3200 individuals per species. As a starting point for planning, Rose (1999) captured approximately 100 crabs per tow, so tows with 4 nets would take approximately 8 tows to achieve 3200 crabs taken. The time for assessments and handling may be the limiting factor. Some preliminary work by Al Stoner and Eric Munk at our Kodiak laboratory identified a series of reflex assessments that could be made at around 1 crab per minute. With two assessment teams working 8 hours on assessments per 12 hours workday we would generate just under 2900 assessments for the 3 days at each site. Having 5 scientists and at least 4 crew available for that and the other needed tasks; the 3200 samples are achievable, if ambitious. We will plan 3 days at each species site to allow for delays or low catch rates and will assess the feasibility of expected sample rates and the adequacy of sample sizes at each site before moving to the next.

Data from the 2007 pilot study will allow much more specific evaluations of sample size requirements, assessment rates and holding capabilities. Based on those, we will make refined plans for sampling and holding rates and times for each species during the 2008 principal fieldwork. While current plans are to generate mortality estimates for all three major species, should pilot study data or problems encountered during the principal fieldwork indicate that is not feasible, then we will consider dropping Tanner crab work in favor of better estimates for king and snow crabs.

Objective F: Communicate Results and Follow-up

The final scientific results and conclusions from this study will be presented at the 2009 Marine Science Symposium, followed by publications submitted to peer-reviewed journals. Investigators will be available to the NPFMC as well as its committees and plan teams for detailed presentations when relevant actions are considered. Outreach to the affected fishing industry will include a second industry workshop in November 2008, where we will present results to the groundfish fleet and begin discussions of the potential for possible gear modifications to reduce crab damage. Future work should develop more complete RAMP predictors of crab mortality and apply them to trawl improvement studies and to any species, size, condition classes that were underrepresented in our initial work.

E. Timeline and Milestones

DATE	Milestone
June 1, 2007	NPRB funding notification
June 2007	Pilot fieldwork (supported by matching funding)
January 2008	First industry workshop
January 2008	Presentation at Marine Science Symposium (MSS) 2008
May 2008	Lab tests complete
April 2008	Charter of vessel for principal fieldwork
May - August 2008	Principal fieldwork
December 2008	Mortality assessments and analysis complete
December 2008	Fishing industry workshop
January 2009	Presentation at MSS 2009
May 2009	Submission of results for peer-reviewed publication

Project progress will be tracked by the accomplishment of the milestones listed above. Key deliverables include:

1) the 2008 MSS presentation, verifying that recapture and holding procedures have been successfully developed and detailing study progress,
2) the initial industry workshop, briefing participants on study plans and soliciting feedback on appropriate trawl gear and procedures,
3) the 2009 MSS presentation detailing the analyses of mortality rate estimates, based on data from the principal fieldwork, and study conclusions,
4) the second industry workshop, presenting results to the trawl fleet and holding discussions of how best to reduce trawl effects on crabs,
5) submissions of scientific papers to appropriate journals, making the results available to the wider scientific community.

Regular financial and progress reports will also be submitted in accordance with NPRB requirements.

F. Project Management

Rose – Craig Rose has >29 years experience researching the marine fish and fisheries of Alaska and conducting field research aboard trawlers in Alaskan waters. Since 1990, he has lead the Conservation Engineering (CE) project of the Alaska Fisheries Science Center, finding ways to improve fishing gear through better understanding the interaction of fish behavior and fishing gear performance. The CE project has focused on bycatch reduction and, more recently, mitigating the effects of fishing on marine habitats. Nearly all of that research has been conducted in cooperation with the fishing industry, accessing their wealth of practical knowledge and facilitating the real-world application of research results. The project is a world leader in the development and application of video and sonar systems to observe fish behavior in relation to fishing gears, including an NPRB project to apply high-resolution sonar to reducing salmon bycatch in Alaska pollock fisheries. Since 1991, Dr. Rose has participated as a member of the Working Group on Fishing Technology and Fish Behavior of the International Council for the Exploration of the Seas. From 2002-2005, he led the analysis of the effects of fishing on essential fish habitat (EFH) for the Alaska EFH Environmental Impact Statement. Dr. Rose will lead this NPRB project as principal investigator and will be chief scientist on both Bering Sea field operations. He will also be responsible for development and testing of the recapture nets.

Stoner - Allan Stoner has >25 years experience researching the ecology and behavior of economically significant species in Atlantic, Pacific and Caribbean regions. He has been the leader for collaborative, multi-disciplinary marine studies; including projects funded by NURP, NSF and NOAA Fisheries since 1984, and has published more than 100 peer-reviewed papers in the fisheries ecology of marine fishes, crustaceans and molluscs. He has spent the last the last 6 years working on the behavior and ecology of Alaska species, including extensive field and laboratory work on fish behavior as it relates to fishing gear and the ecology of habitat use. He has abundant shipboard experience including the Gulf of Alaska and Bering Sea. Dr Stoner will assist in the design, execution, and analysis of behavioral experiments. He will lead laboratory experimentation and participate in sea-going operations.

Davis - Michael Davis has >20 years experience in the behavioral ecology of Pacific fish species. He has experience with design, construction and use of unique specialized experimental seawater systems, including video and computer-aided observation of invertebrates and fishes. Other contributions have included publications of research on the role of behavior in distribution, recruitment and ecosystem dynamics including responses to physical and chemical factors, feeding, growth, predator/prey interactions and social interactions of invertebrates and fish. Davis has more than 10 years experience working with bycatch-related stress and is the primary developer of the Reflex Action Mortality Predictor (RAMP) concept. Dr Davis will serve as an advisor in the design and analysis of behavioral experiments made for this project.

Munk - Eric Munk has >28 years experience as a field biologist studying shellfish resources in Alaskan waters and has participated in the annual crab-groundfish survey in the eastern Bering Sea since 1979. He has been a diver since 1980 and currently conducts research on reproduction, maturity and growth of Tanner crabs in Kodiak waters. In the past he has participated in research on trawl induced mortality of red king and Tanner crabs (both Donaldson 1990 and Stevens 1990). In this proposed study he will assist in the design and execution of laboratory experiments and participate in sea-going operations.

Gauvin - John Gauvin has been a prominent force linking the Alaska marine fishing industry to fisheries researchers for at least 16 years. As chief economist of the Alaska Factory Trawlers Association, the executive director of the Groundfish Forum and, now, as the Marine Conservation Alliance Foundation's Cooperative Research Director, John has bought academic and government researchers together with fishermen to find solutions to the problems facing the commercial fisheries of Alaska. His work was recognized in 2000 when he was awarded the NOAA Environmental Hero Award. Mr. Gauvin will be responsible for arranging communication and resources from the fishing industry for this project, especially coordinating the two industry workshops.

Financial Management - The Alaska Fisheries Science Center's Operations, Management and Information Services Division will support the financial management of this project. The AFSC has been one of the largest financial managers of NPRB funded projects since NPRB's inception.

G. References

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NPRB BUDGET SUMMARY FORM

PROJECT TITLE:	Unobserved, trawl-induced mortality of Bering Sea crabs				Annual cost category breakdowns will be requested for other support only if project is funded
PRINCIPAL INVESTIGATOR:	Craig Rose, Al Stoner, Eric Munk				
FUNDING SOURCE	**YEAR 1**	**YEAR 2**	**YEAR 3**	**TOTAL**	
NPRB Funding	174,840	37,008	0	211,848	
Other Support				180,486	
TOTAL	174,840	37,008	0	392,334	

Cost Categories	**NPRB** **Year 1**	**NPRB** **Year 2**	**NPRB** **Year 3**	**NPRB** **TOTAL**	**Match/In kind** **TOTAL (all years)**
1. Personnel Salaries		15647		15,647	90,966
2. Personnel Fringe Benefits				0	26,275
3. Travel (include 1 trip to review mtg in Anchorage each year plus for the year following project conclusion)	7,440	12,635		20,075	8,895
4. Equipment				0	
5. Supplies	18,000			18,000	2,500
6. Contractual/Consultants				0	
7. Other (Include $2000 for education and outreach)	149,400			149,400	51,850
Total Direct Costs	**174,840**	**28,282**	**0**	**203,122**	**180,486**
Indirect Costs		8,726		8,726	
TOTAL PROJECT COSTS	**174,840**	**37,008**	**0**	**211,848**	**180,486**

NPRB BUDGET SUMMARY FORM

PROJECT TITLE:	Unobserved, trawl-induced mortality of Bering Sea crabs				Annual cost category breakdowns will be requested for other support only if project is funded
PRINCIPAL INVESTIGATOR:	John Gauvin (collaborator)				
FUNDING SOURCE	**YEAR 1**	**YEAR 2**	**YEAR 3**	**TOTAL**	
NPRB Funding	5,000	5,000	0	10,000	
Other Support				0	
TOTAL	5,000	5,000	0	10,000	

Cost Categories	**NPRB Year 1**	**NPRB Year 2**	**NPRB Year 3**	**NPRB TOTAL**	**Match/In kind TOTAL (all years)**
1. Personnel Salaries	4,000	4,000		8,000	
2. Personnel Fringe Benefits				0	
3. Travel (include 1 trip to review mtg in Anchorage each year plus for the year following project conclusion)				0	
4. Equipment				0	
5. Supplies				0	
6. Contractual/Consultants				0	
7. Other (Include $2000 for education and outreach)	1,000	1,000		2,000	
Total Direct Costs	**5,000**	**5,000**	**0**	**10,000**	**0**
Indirect Costs				0	
TOTAL PROJECT COSTS	**5,000**	**5,000**	**0**	**10,000**	**0**

NPRB BUDGET SUMMARY FORM - MULTIPLE ORGANIZATIONS

PROJECT TITLE:	Unobserved, trawl-induced mortality of Bering Sea crabs				
PRINCIPAL INVESTIGATOR(S):	Craig Rose, Al Stoner, Eric Munk; John Gauvin (collaborator); PI names from 3rd organization; PI names from 4th organization				
FUNDING SOURCE	**YEAR 1**	**YEAR 2**	**YEAR 3**	**TOTAL**	
NPRB Funding	179,840	42,008	0	221,848	
Other Support				180,486	
TOTAL	179,840	42,008	0	402,334	

Annual cost category breakdowns will be requested for other support only if project is funded

Cost Categories	**NPRB Year 1**	**NPRB Year 2**	**NPRB Year 3**	**NPRB TOTAL**	**Match/In kind TOTAL (all years)**
1. Personnel Salaries	4,000	19,647	0	23,647	90,966
2. Personnel Fringe Benefits	0	0	0	0	26,275
3. Travel (include 1 trip to review mtg in Anchorage each year plus for the year following project conclusion)	7,440	12,635	0	20,075	8,895
4. Equipment	0	0	0	0	0
5. Supplies	18,000	0	0	18,000	2,500
6. Contractual/Consultants	0	0	0	0	0
7. Other (Include $2000 for education and outreach)	150,400	1,000	0	151,400	51,850
Total Direct Costs	**179,840**	**33,282**	**0**	**213,122**	**180,486**
Indirect Costs	0	8,726	0	8,726	0
TOTAL PROJECT COSTS	**179,840**	**42,008**	**0**	**221,848**	**180,486**

ALLAN W. STONER

Employment

Manager, Fisheries Behavioral Ecology Program (2000 to present)

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Professional Training

Ph.D. in Biological Science, Florida State University, Tallahassee, Florida - 1979
M.S. in Oceanography, Florida State University, Tallahassee, Florida - 1976
B.S. in Zoology, Ohio State University, Columbus, Ohio – 1974

Relevant Publications (last 5 years, from >100 peer reviewed papers)
(**bold** type: from NPRB-funded project)

Ryer, C.H., A.W. Stoner, M.L. Spencer and A.A. Abookire. (in press). Predation threat modifies habitat preference by age-0 northern rock sole *Lepidopsetta polyxystra*. Mar. Ecol. Prog. Ser.

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Stoner, A.W., M.L. Spencer and C.H. Ryer. 2006. Flatfish-habitat associations in Alaska nursery grounds: use of continuous video records for multi-scale spatial analysis. J. Sea Res. (in press)

Rose, C.S., A.W. Stoner and K. Matteson. 2005. Use of high-frequency imaging sonar to observe fish behaviour near baited fishing gears. Fish. Res. 76:291-304.

Spencer, M.L., A.W. Stoner, C.H. Ryer and J.E. Munk. 2005. A towed camera sled for estimating abundance of juvenile flatfishes and habitat characteristics: comparison with beam trawls and divers. Estuar. Coastal Shelf Sci. 64:497-503.

Stoner, A.W. 2004. Effects of environmental variables on fish feeding ecology: implications for the performance of baited fishing gear and stock assessment. [review paper] J. Fish Biol. 65:1445-1471.

Stoner, A.W. and E.A. Sturm. 2004. Temperature and hunger mediate sablefish (*Anoplopoma fimbria*) feeding motivation: implications for stock assessment. Can. J. Fish. Aquat. Sci. 61:238-246.

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Stoner, A.W. 2003. What constitutes essential nursery habitat for a marine species? A case study of habitat form and function for queen conch. [review article] Mar. Ecol. Prog. Ser. 257:275-289.

Stoner, A.W. and R.H. Titgen. 2003. Biological structures and bottom type influence habitat choices made by Alaska flatfishes. J. Exp. Mar. Biol. Ecol. 292:43-59.

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Stoner, A.W., J.P. Manderson and J.P. Pessutti. 2001. Spatially explicit analysis of habitat for juvenile winter flounder: combining generalized additive models and geographic information systems. Mar. Ecol. Prog. Ser. 213:253-271.

Other Professional Positions

Professor (courtesy) – Department of Zoology, Oregon State University, Corvallis, OR – 2003 to present
Editorial Board - Marine Ecology Progress Series - 1993-2002
Chief, Behavioral Ecology Branch - Ecosystem Processes Division, Northeast Fisheries Science Center, National Marine Fisheries Service, Highlands, New Jersey – 1996-2000
Visiting Scholar and Graduate Faculty Member - Institute of Marine & Coastal Sciences, Rutgers University, New Brunswick, NJ - 1996-02
Senior Scientist, Marine Ecology Program - Caribbean Marine Research Center
Resident at Lee Stocking Island field station (Bahamas) - 1988-92
Vero Beach, Florida - 1992-96
Associate Editor - Proceedings of the Gulf and Caribbean Fisheries Institute - 1991-95
Senior Scientist, Center for Energy and Environment Research - University of Puerto Rico
Mayaguez, Puerto Rico - 1984-88
Assistant Professor of Oceanography and Staff Scientist - Sea Education Association
Woods Hole, Massachusetts - 1980-1984

Recent Research Collaborators

Alisa Abookire – Alaska Fisheries Science Center
Peter Auster – University of Connecticu
Lorenzo Ciannelli – Oregon State University
Ian Fleming – Memorial University of Newfoundland
Daniel Grunbaum – University of Washington
Thomas Hurst – Alaska Fisheries Science Center
Benjamin Laurel – Alaska Fisheries Science Center
Keith Matteson – Oregon Department of Fish and Wildlife
Steve Parker - Oregon Department of Fish and Wildlife
Juan Posada – Universidad Simon Bolivar, Venezuela
Clifford Ryer – Alaska Fisheries Science Center
Waldo Wakefield – Northwest Fisheries Science Center
Mary Yoklavich – Southwest Fisheries Science Center

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Education:

1979-1983 — **Bachelor of Science**, University of Michigan, Ann Arbor
(European History/Geology)

1984 — **Universidade Federal de Santa Catarina**, Florianopolis, Brazil
(Course work in History, Literature, and Economics)

1985-1988 — **Master of Science in Resource Economics**
University of Rhode Island, Kingston, Rhode Island.
(Natural Resource Economics, Fisheries Economics, Econometrics, and Statistics)

Professional Experience:

Jan 2003-present — **Consulting on various aspects of fisheries development and management**
J.R. Gauvin and Associates, L.L.C. Burien, WA

- Current projects include: 1) Development of cooperative research in areas of pressing fishery management problems (for the Marine Conservation Alliance Foundation via NOS funding); 2) Development of a bycatch reduction device that allows Pacific salmon to escape uninjured from a pollock trawl fishery (for the North Pacific Fisheries Research Foundation); 3) Conducting an assessment of economic and conservation benefits of fishing cooperatives formed via the American Fisheries Act (for National Marine Fisheries Service, Alaska Fisheries Science Center); 4) Analysis of methods to increase utilization in Gulf of Alaska flatfish fisheries (for Alaska Fisheries Development Foundation); 5) Development of viable solutions to habitat effects of trawling (for the H&G Environmental Workgroup)

Nov 1996- Dec 2002 — **Executive Director**, Groundfish Forum, Seattle, WA

- Development of fishing gear technology and management systems to reduce incidental catch rates and increase utilization in flatfish and other North Pacific trawl fisheries.
- Representation of 11 member companies with 19 freezer trawler vessels before the North Pacific Fishery Management Council, NMFS, U.S. Coast Guard, media, Washington and Alaska Legislatures.

Aug 1993-1996 — **Fishery Economist**, American Factory Trawler Association (currently known as the At-sea Processors Association), Seattle, WA

- Development of bycatch reduction systems for crab and halibut via the Sea State program
- Analysis of economic incentives programs and regulatory factors affecting production.
- Review of North Pacific Fishery Management Council analyses of regulatory impacts of proposed management measures.

1989-1993 **Fishery Economist**, South Atlantic Fishery Management Council, Charleston, SC

- Formation of an individual transferable quota program for the Wreckfish (Polyprion americanus) fishery
- Benefit/Cost Analysis of the economic implications of proposed management measures for all Council fishery management plans.

Academic Awards:

1983	Graduated with High Honors, University of Michigan
1989	Northeastern Agriculture and Resource Economics Association's "Outstanding Master's Thesis Award"
1989	Sea Grant's "Excellence in Research Award" (in the Economics, Policy, Law, and Social Science Category)

Publications and Presentations:

Gauvin, J. R. 2003. Development of viable protections for benthic habitat in the federal-waters fisheries off Alaska. An invited address at Managing our Nations Fisheries national conference. Washington, DC, October 2003.

Karp, W.P., C. Rose, J. Gauvin, S. Gaiches, and G. Stauffer, 2002. Cooperative Fisheries Research in the North Pacific under the MSFCMA. Marine Fisheries Review vol.63 pp 40-46.

Gauvin, J.R. and Craig S. Rose, 2000. The effectiveness of a halibut excluder devise and consideration of tradeoffs in its application. In: *Micro-behavior and Macro-results: Proceedings of the Tenth Biennial Conference of the International Institute of Fisheries Economics and Trade*. Oregon State University Press.

Gauvin, J.R. and Rose, C.S., 1998. Experimental fishing permit (EFP #98-01) to test the effectiveness of a halibut excluder in flatfish trawls. Available from North Pacific Fishery Management Council, Anchorage, AK.

Gauvin, John R., Haflinger, Karl, and Nerini, Mary, 1995. Implementation of a voluntary bycatch avoidance program in the flatfish fisheries of the eastern Bering Sea. *Solving Bycatch: Solutions for Today and Tomorrow.* Alaska Sea Grant College Program Report No. 96-03, University of Alaska, Fairbanks, pp.79-85.

Current Research collaborations: Two exempted fishing permits (EFP) with Dr. Craig Rose of the AFSC and one includes John Gruver of United Catcher Boats Association.

J. ERIC MUNK

Employment

Research Fisheries Biologist (1978-present)

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Professional Training

B.A. in Zoology, University of South Florida, Tampa, Florida 1978

Publications

Spencer, M.L., A.W. Stoner, C.H. Ryer and J.E. Munk. 2005. A towed camera sled for estimating abundance of juvenlie flatfishes and habitat characteristics: comparison with beam trawls and divers. Estuarine Coastal Shelf Sci. 64:497-503.

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Stevens, B.G., W.E. Donaldson, J.A. Haaga, and J.E. Munk. 1993. Morphometry and maturity of paired Tanner crabs, Chionoecetes bairdi, from shallow- and deepwater environments. Can. J. Fish. Aquat. Sci. 50:1504-1516.

Munk, J.E. 1992. Reproduction and growth of green urchins Strongylocentrotus droebachiensis (Muller) near Kodiak, Alaska. J. Shellfish Research 11:245-254.

Stevens, B.G and J.E. Munk. 1990. A temperature-dependent growth model for juvenile red king crab, Paralithodes camtschatica, in Kodiak, AK. in Proceedings of the Int. Smyp. on King and Tanner Crab. AK Sea Grant College Program Rep. No. 90-04 p. 293-304.

Recent Research Collaborators

Alisa Abookire - Alaska Fisheries Science Center
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Benjamin Laurel - Alaska Fisheries Science Center
Mara Spencer - Alaska Fisheries Science Center
Bradley Stevens - Alaska Fisheries Science Center

Alan Stoner - Alaska Fisheries Science Center

CRAIG S. ROSE

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Resource Assessment and Conservation Engineering
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Present Position:
Fisheries Biologist (Research), NOAA Fisheries, Alaska Fisheries Science Center, Seattle, WA. 1977 to Present. Since 1990 – Lead for Conservation Engineering Project

Education:
B.S. Fisheries (1979) Humboldt State University, Arcata California
M.S. Fisheries (1982) University of Washington, Seattle, Washington
Ph.D. Fisheries (1993) University of Washington, Seattle, Washington

Relevant Publications:

Rose, C.S., A.W. Stoner & K. Matteson 2005. Use of high-frequency imaging sonar to observe fish behaviour near baited fishing gears. Fisheries Research 76: 291-304.

Rose, C.S. and Jorgensen, E.M. (2005) Spatial and temporal distributions of trawling intensity off Alaska: Effects of spatial scale on perceptions of the distribution and magnitude of fishing effects. pp. 679-690 *In* Benthic Habitats and the Effects of Fishing. Am. Fisher. Soc. Symposium No. 41.

Abookire, A.A. & C.S. Rose. 2005. Modifications to a plumb staff beam trawl for sampling uneven, complex habitats. Fisheries Research 71: 247-254.

Karp, W.A., C.S.Rose, J.R. Gauvin, S.K. Gaichas, M.V. Dorn and G.D. Stauffer. 2001. Government-Industry cooperative fisheries research in the North Pacific under the MCFCMA. Mar. Fish. Rev. 63(1) 40-46.

Rose, C.S.and Gauvin J. 2000. Effectiveness of a rigid grate for excluding halibut from groundfish trawl catches. Mar. Fish. Rev. 62(2) 61-66.

Rose, C.S., Carr, A., Ferro, D., Fonteyne, R., & MacMullen, P. 2000. Using gear technology to understand and reduce unintended effects of fishing on the seabed and associated communities: background and potential directions. Report of the Fish Beh. & Fish. Tech. Wk. Grp., Int. Coun. Expl. Seas 24 pp.

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Rose, C.S. 1999. Injury rates of red king crab, Paralithodes camtschaticus, passing under bottom trawl footropes. Mar. Fish. Rev. 61(2) 72-76.

Recent Collaborators
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Clifford Ryer – Alaska Fisheries Science Center
Keith Matteson – Oregon Department of Fish and Game
Elaina Jorgensen - Alaska Fisheries Science Center

MICHAEL DAVIS

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Present Position:

Oceanographer (Research), NOAA Fisheries, Hatfield Marine Science Center, Newport, OR. November, 1984 to Present.
Research Associate, Courtesy Appointment - College of Oceanic and Atmospheric Sciences, Oregon State University, 1984 to Present.

Education:

B.S. (1973) Marlboro College, Marlboro, Vermont
M.S. (1975) University of Vermont, Burlington, Vermont
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Relevant Publications:

Davis, M.W. 2006. Fish bycatch discard and escapee mortality rates can be predicted using reflex impairment. ICES J. Mar. Sci. (in press).
Davis, M.W. and M.L. Ottmar. 2006. Wounding and reflex impairment may be predictors for mortality in discarded or escaped fish. Fish. Res. 82:1-6.
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Olla, B.L., Ryer, C.H. & Sogard, S.M. (1996) Behavioral determinants of distribution and survival in early stages of walleye pollock, *Theragra chalcogramma*: a synthesis of experimental studies. Fisheries Oceanography: 5(Suppl. 1):167-178.

Relevant Research Extension

Invited outside reviewer - Workshop on bycatch release research on American plaice, Memorial University of Newfoundland, St. John's, Nwfd. March 2006

Invited participant - Discard mortality workshop, Rhode Island Sea Grant, W. Alton Jones Conference Center, RI. August 2006

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