**Special Publication No. 10-15**

# Summary of the Interagency Crab Research Meeting held December 16–18, 2009

**by**

**Joel Webb**

**and**

**Doug Woodby**

**November 2010**

**Alaska Department of Fish and Game** **Divisions of Sport Fish and Commercial Fisheries**

## Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

**Weights and measures (metric)**

| | |
|---|---|
| centimeter | cm |
| deciliter | dL |
| gram | g |
| hectare | ha |
| kilogram | kg |
| kilometer | km |
| liter | L |
| meter | m |
| milliliter | mL |
| millimeter | mm |

**Weights and measures (English)**

| | |
|---|---|
| cubic feet per second | $ft^3/s$ |
| foot | ft |
| gallon | gal |
| inch | in |
| mile | mi |
| nautical mile | nmi |
| ounce | oz |
| pound | lb |
| quart | qt |
| yard | yd |

**Time and temperature**

| | |
|---|---|
| day | d |
| degrees Celsius | °C |
| degrees Fahrenheit | °F |
| degrees kelvin | K |
| hour | h |
| minute | min |
| second | s |

**Physics and chemistry**

| | |
|---|---|
| all atomic symbols | |
| alternating current | AC |
| ampere | A |
| calorie | cal |
| direct current | DC |
| hertz | Hz |
| horsepower | hp |
| hydrogen ion activity (negative log of) | pH |
| parts per million | ppm |
| parts per thousand | ppt, ‰ |
| volts | V |
| watts | W |

**General**

| | |
|---|---|
| Alaska Administrative Code | AAC |
| all commonly accepted abbreviations | e.g., Mr., Mrs., AM, PM, etc. |
| all commonly accepted professional titles | e.g., Dr., Ph.D., R.N., etc. |
| at | @ |
| compass directions: | |
| east | E |
| north | N |
| south | S |
| west | W |
| copyright | © |
| corporate suffixes: | |
| Company | Co. |
| Corporation | Corp. |
| Incorporated | Inc. |
| Limited | Ltd. |
| District of Columbia | D.C. |
| et alii (and others) | et al. |
| et cetera (and so forth) | etc. |
| exempli gratia (for example) | e.g. |
| Federal Information Code | FIC |
| id est (that is) | i.e. |
| latitude or longitude | lat. or long. |
| monetary symbols (U.S.) | $, ¢ |
| months (tables and figures): first three letters | Jan,...,Dec |
| registered trademark | ® |
| trademark | ™ |
| United States (adjective) | U.S. |
| United States of America (noun) | USA |
| U.S.C. | United States Code |
| U.S. state | use two-letter abbreviations (e.g., AK, WA) |

**Mathematics, statistics**

| | |
|---|---|
| *all standard mathematical signs, symbols and abbreviations* | |
| alternate hypothesis | $H_A$ |
| base of natural logarithm | *e* |
| catch per unit effort | CPUE |
| coefficient of variation | CV |
| common test statistics | (F, t, $\chi^2$, etc.) |
| confidence interval | CI |
| correlation coefficient (multiple) | R |
| correlation coefficient (simple) | r |
| covariance | cov |
| degree (angular ) | ° |
| degrees of freedom | df |
| expected value | *E* |
| greater than | > |
| greater than or equal to | ≥ |
| harvest per unit effort | HPUE |
| less than | < |
| less than or equal to | ≤ |
| logarithm (natural) | ln |
| logarithm (base 10) | log |
| logarithm (specify base) | $\log_2$, etc. |
| minute (angular) | ' |
| not significant | NS |
| null hypothesis | $H_O$ |
| percent | % |
| probability | P |
| probability of a type I error (rejection of the null hypothesis when true) | α |
| probability of a type II error (acceptance of the null hypothesis when false) | β |
| second (angular) | " |
| standard deviation | SD |
| standard error | SE |
| variance | |
| population | Var |
| sample | var |

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by

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and

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November, 2010

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*This document should be cited as:*
*Webb, J. and D. Woodby. 2010. Summary of the interagency crab research meeting held December 16-18, 2009. Alaska Department of Fish and Game, Special Publication No. 10-15, Anchorage.*

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# PURPOSE

This report summarizes the sixteenth annual interagency crab research meeting, held December 16–18, 2009 in Anchorage at the Hotel Captain Cook. The interagency crab meetings began in 1993 and are held annually as prescribed in the State/Federal Action Plan for Management of Commercial King and Tanner Crab Fisheries (Revised March, 2006, and available from the authors), an agreement between the National Marine Fisheries Service and the Alaska Department of Fish and Game. This meeting continued the tradition of providing an informal opportunity for researchers from each of the active crab research centers to present their work on Alaskan crab species among peers. The meeting included a special session on ocean acidification dynamics and potential biological responses in Alaskan waters.

Key words: Alaska crab research, red king crab, snow crab, Tanner crab, Dungeness crab, golden king crab, ocean acidification

# PARTICIPANTS

The 2009 meeting was attended by approximately 70 participants representing the Alaska Department of Fish and Game (ADF&G), National Marine Fisheries Service (NMFS), The School of Fisheries and Ocean Sciences of the University of Alaska Fairbanks (UAF), University of Alaska Southeast (UAS), Norton Sound Economic Development Corporation (NSEDC), Alaska Deep Ocean Institute, Bering Sea Fisheries Research Foundation (BSFRF), and Alaska Sea Grant (ASG). A list of participants and contact information is included in Appendix A.

# PRELIMINARIES

The meeting was jointly chaired by Doug Woodby and Russ Nelson and audiovisual operations were run by Joel Webb. Following introductions and welcoming remarks, the draft agenda (Appendix B) was adopted without change.

# SUMMARY OF PRESENTATIONS

The order of presentations followed the agenda (Appendix B), which was organized roughly by contributing group, University, Alaska Deep Ocean Science Institute, NSEDC, NMFS, and ADF&G.

## SPECIAL TOPICS: OCEAN ACIDIFICATION

### Ocean acidification: the other $CO_2$ problem

*Richard Feely, National Oceanic and Atmospheric Administration, Seattle, WA*

Levels of dissolved $CO_2$ in oceanic waters are related to atmospheric $CO_2$ concentrations which have increased with the burning of fossil fuels and land use changes in recent decades. Levels of $CO_2$ in seawater are measured in biologically meaningful terms as the saturation state of aragonite or calcite. Supersaturated conditions (>1) are associated with precipitation of calcium carbonate while dissolution of calcium carbonate occurs in more acidic, undersaturated conditions (<1). Aragonite saturations are expected to decrease with concomitant decreases in the calcification rates of marine organisms during the next century. Species, community, and ecosystem-level responses to ocean acidification, such as decreased survival and abundance of calcifying organisms are expected, but these responses are likely to be complex and difficult to predict with high certainty. Ocean acidification may also vary in coastal waters with input of calcium-poor freshwater, upwelling of low calcium deep water from the deep ocean, or in response to input of organic carbon from primary production. Upwelling of undersaturated aragonite waters into productive coastal areas was observed during the summer on the west coast

of the United States in 2007. Field studies have indicated that ocean acidification is affecting calcifying marine organisms. Decreased coral calcification rates have been observed temporally on the Great Barrier Reef off Australia since 1990, shell dissolution has been observed in pteropods and other calcifying phytoplankton in undersaturated aragonite conditions, and development and physiology of marine invertebrate larvae can be impaired. As ocean acidification affects species in the food web, these effects are likely to be observed at multiple trophic levels. Trophic modeling has suggested that body weights of pink salmon in the north Pacific could decrease by as much as 20% through the effects of increasing water temperature and ocean acidification on pteropods and copepods, two primary diet components. Species-specific responses to ocean acidification are variable—some taxa respond positively (e.g. increased photosynthesis rates in some sea grasses), while many respond negatively (e.g. decreased reproductive success and calcification in mollusks). These results underscore the need for well-designed experimental approaches which consider the specific life history characteristics and dynamics of the species under investigation. An ocean acidification research plan has been implemented through the National Oceanic and Atmospheric Administration to monitor, predict ecosystem responses, model possible outcomes, and develop adaptive responses to ocean acidification. An improved ocean acidification observational network is under development with future priorities to expand monitoring and develop integrated models of ecosystem responses based on biological and oceanographic data.

## Ocean acidification: controls and potential in the marginal seas of Alaska

*Jeremy Mathis, University of Alaska Fairbanks, Fairbanks, Alaska*

Increasing atmospheric $CO_2$ from anthropogenic sources has resulted in increased $CO_2$ concentrations in oceanic waters. This process decreases pH and the portion of the water column with optimal conditions for calcifying marine organisms to form shells from calcium carbonate. The calcium and aragonite saturation (compensation) depth defines the portion of the water column in which calcifying marine organisms are exposed to optimal shell-building conditions. Due to cold temperatures, high mixing rates, and high production, the waters of coastal Alaska have high native $CO_2$, higher acidity, and lower aragonite saturation conditions than other world oceans. Field studies have shown that undersaturated conditions are observed in deeper offshore waters in the spring in the northern Gulf of Alaska. As stratification and primary production occur through the summer, the aragonite saturation states increase in the surface water but decrease in deeper water both near and offshore as dissolved inorganic carbon fluxes downward and $CO_2$ is produced in remineraliztion processes. Aragonite saturation profiles in the eastern Bering Sea also vary seasonally. Shelf waters are generally supersaturated in the spring with a nearshore decrease due to riverine input of $CO_2$ rich waters. By the fall supersaturated surface waters and undersaturated deeper waters are observed over the middle shelf due to seasonal stratification and high primary production which produces dissolved inorganic carbon. In the Arctic Ocean, dissolved $CO_2$ levels are generally low, but decreasing ice cover is likely to increase $CO_2$ in at least two ways. First, a lack of ice cover will increase the atmosphere-ocean $CO_2$ exchange rate—resulting in increasing $CO_2$ levels or decreased aragonite saturation levels. Second, higher primary production in warmer, ice-free waters will result in the export of organics from the surface, which through the remineralization processes in deeper waters will decrease aragonite saturation and pH. Carbonate saturation states of oceanic waters in Alaska are a function of terrestrial discharge, seasonally pulsed primary production, and sea-ice melt dynamics. Continued increases in anthropogenic $CO_2$ and warming, which will increase primary

production in Arctic and subarctic waters, are likely to increase ocean acidification. Improved understanding of species-specific responses and improved monitoring will result in increased knowledge of mechanisms and variability of ocean acidification in Alaskan waters.

### Alaska Fisheries Science Center ocean acidification research on shellfish: past, present, and future

*Robert Foy, National Marine Fisheries Service, Kodiak, Alaska*

Ocean acidification (decreasing seawater pH) associated with increased atmospheric carbon dioxide concentrations is likely to affect both vertebrate and invertebrate taxa in the North Pacific and Bering Sea, with consequences for commercially important crab stocks. Experimental investigation of the effects of changing pH on king and Tanner crabs at the National Marine Fisheries Service, Alaska Fisheries Science Center, Kodiak Laboratory, began with pilot studies on growth and survival of juvenile blue king crab in 2006 and 2007. Studies with juvenile blue king crab demonstrated that decreasing pH in the range of 8.20 to 7.70 resulted in differences in larval and juvenile calcium content, dry mass, and survival. Improved techniques for measurement of seawater chemistry and minerals and an effective $CO_2$ delivery system for manipulation of seawater pH in the laboratory were developed at the Kodiak Lab in subsequent years. An ocean acidification research plan was developed in 2008. The North Pacific Ocean was identified as a region likely to be particularly susceptible to the effects of ocean acidification where decreased pH could result in physiological stress to organisms and disruption of trophic linkages due to decreased abundance of calcareous plankton. Research priorities were to understand species-specific physiological response, forecast the possible population and ecosystem consequences, and to evaluate the economic impacts of these changes. Experiments are investigating larval growth and survival of red king crab and responses of mature golden king crab to increased seawater $CO_2$ concentration. Research results have suggested that mixed responses to ocean acidification may be expected among diverse taxa of marine organisms. Future experiments will examine physiological responses of Tanner crab larvae and adults to acidification.

## CONTRIBUTED TALKS

### Factors leading to stock collapse of Kodiak red king crabs and their failure to recover

*Bill Bechtol and Gordon Kruse, University of Alaska Fairbanks, Juneau, Alaska*

Harvests of red king crab, *Paralithodes camtschaticus*, around Kodiak Island peaked in the 1960s, varied through the 1970s, and collapsed dramatically in the early 1980s. The stock has failed to recover despite continued fishery closure for several decades. This study modeled male and female population dynamics using a length-based model, analyzed stock-recruit relationships, and investigated environmental and ecological factors affecting recruitment variability. High recruitment and rapid fishery development in the 1960s led to overcapitalization and unrealistic expectations of stock production. As recruitment declined, the stock was subject to high fishing mortality and skewed sex ratios leading to reproductive failure and further decreases in recruitment. Overfishing of the declining stock was associated with the stock collapse in the early 1980s. Stock-recruit analysis indicated a density-dependent relationship with decreasing stock productivity regimes from the 1960s to mid-1980s. Natural mortality appears to have increased from the mid-1980s into the 1990s. Low stock abundance, possible increased predation mortality, and poor oceanographic conditions for larval survival may act together to explain the lack of stock recovery since the fishery closure. Details are explained in three publications resulting from this work.

## Research update on studies of bitter crab syndrome in Tanner crab

*Sherry Tamone, University of Alaska Southeast, Juneau, Alaska*

Recent research in the Tamone lab has focused on molting, reproduction, metabolism and disease in crustaceans. The studies presented represent collaborative studies between Drs. Tamone and Morado on the dynamics of bitter crab syndrome (BCS), a fatal disease in Tanner crab. Dr Tamone also presented preliminary results from field studies in Prince William Sound. Hemolymph samples were collected from Tanner crab sampled throughout Prince William Sound during the 2009 ADF&G large-mesh trawl survey. The prevalence of BCS in these individuals was determined using a polymerase chain reaction assay designed to specifically identify *Hematodinium* DNA Definitive results are forthcoming but visual examination of blood yielded an estimate of <3% prevalence. Collaborative laboratory studies are characterizing *Hematodinium* life history dynamics and biochemical effects in the host Tanner crab through use of eyestalk ablation which appears to trigger the later disease stages. Other preliminary experiments were focused on utilization of techniques for *in situ* measurement of metabolic rate in crabs which can provide insight into potential metabolic effects of environmental changes such as ocean acidification.

## Molting and its effect on reproductive indices of male snow crab, *Chionoecetes opllio*

*Molly Zaleski, University of Alaska Fairbanks, Juneau, Alaska*

The abundance and catch of snow crab in the eastern Bering Sea has fluctuated greatly over the past three decades. Harvest is limited to large males, and for fisheries management it is critical to understand the effect of harvest on mating success and the abundance of mature males. Male snow crab have a terminal molt to maturity at which claw size increases allometrically to body size. Males that have not recently molted (old-shell) may be more likely to participate in mating than those that have (new-shell). Our study objectives were to characterize differences in reproductive hormones, mating behavior, and gonadosomatic index between recently molted (new-shell) and those which have not recently molted (old-shell) of varying claw size (small versus large-claw). Male snow crab were collected from the eastern Bering Sea in 2008 and 2009 and the gonadosomatic index was calculated for each male. Old-shell males (both small- and large-claw) had significantly greater gonadosomatic index in than new-shell males, indicating that old-shell males likely have greater reproductive potential. Characterization of differences in reproductive hormones between groups and experiments investigating mating success among groups of mature males will provide further insight into patterns of male reproductive potential and components of the male population participating in mating.

## Strength of the Aleutian Low determines interannual variation in Dungeness crab larval recruitment to Glacier Bay, Alaska

*Heidi Herter, Alaska Sea Grant, Nome, Alaska*

Catches of Dungeness crab, *Cancer magister*, have been highly variable and differ among regions in Southeast Alaska. Studies have suggested that in some locations on the west coast of North America, post-larval supply, which varies interannually with the timing of the seasonal onset of onshore transport mechanisms, may regulate these fluctuations. The possibility of similar dynamics in northern Southeast Alaska was investigated by comparing indices of environmental variability with a time series of data on supply of Dungeness crab megalopae from monitoring by light traps in Bartlett Cove, Glacier Bay for eight years. Total annual

megalopal supply was significantly correlated with the Aleutian Low Pressure Index. High mean daily supply within a year was associated with strong downwelling, low sea surface temperature, and high wind velocity during half and new moon phases.

## Morphometrics, fecundity, and hatch patterns of blue king crabs from Little Diomede, Alaska

*Heidi Herter, Alaska Sea Grant, Nome, Alaska*

Historically, annual catches of blue king crab in the eastern Bering Sea were highly variable and due to low abundance in the 1990s, fisheries were closed. To investigate the feasibility of culture and possible differences in genetics, life history, and reproductive biology among blue king crab stocks (Pribilof Islands, St. Matthew Island, and northern Bering Sea), female blue king crab were collected by handline and crab pot through the ice at Little Diomede Island. Blue king crab from Little Diomede were smaller than conspecifics from the Pribilof Islands, fecundity ranged from 20,000 to 85,000 eggs, the duration of embryo development was estimated at 13 months with extrusion in April or May, and egg clutch weight comprised ~10% of female body weight. This information will be included in further comparisons among stocks.

## A tethering field study to identify predators of early juvenile king crab, preliminary video results

*Jodi L. Pirtle, University of Alaska Fairbanks, Juneau, Alaska*

After supporting high harvests from the 1960s to early 1980s red king crab stocks collapsed statewide in Alaska and have remained closed or supported historically low harvests for two decades. Predation and habitat preferences during the early benthic stages (age-0 and age-1) may have important roles in survival and abundance dynamics for red king crab. Laboratory experiments investigating habitat preferences suggested that juvenile red king crab preferred complex, biogenic habitats and association with these habitats conferred greater survival in the presence of predatory Pacific cod. To further understanding of interactions between habitat and predation, early juvenile (age-0 and age-1) red king crab were tethered *in situ* in habitat treatments with varying structural complexity and continuously monitored by underwater video. Scuba surveys indicated the presence of a variety of potential fish and invertebrate predators, and preliminary video analyses revealed predation of tethered juvenile red king crab by greenling, sculpins, ronquils, and sunflower seastars. Further analyses will be conducted to quantify survival differences among habitats, predation and interactions by species of predator, and crab response behavior to predators.

## Hatchery production of red king crab produces 100,000 juveniles for crab research

*Ginny Eckert, University of Alaska Fairbanks, Juneau, Alaska*

The Alaska King Crab Research Rehabilitation and Biology project was initiated in 2006 to determine whether stock enhancement was feasible for red and blue king crabs in Alaska. Experiments and large-scale culture were conducted at the Alutiq Pride Shellfish hatchery in Seward, Alaska. Red king crabs were reared from hatching to juvenile crab stages. Changes in rearing densities and diets improved survival rates from hatch to stage two zoeae from ~10% in 2007 to ~50% in 2009. Juvenile production also increased from <1,000 to 100,000 between 2007 and 2009. Juvenile red king crab produced at the hatchery have been used in investigations of the roles of diet, substrate, and density in culture success. Studies of habitat preference, growth, predation, tagging, and energetics have also been conducted with hatchery-reared juveniles.

## Effects of diet and size-grading on survival, growth, and coloration of juvenile red king crab, *Paralithodes camtschaticus*

*Ben Daly, Alaska Sea Grant/University of Alaska Fairbanks, Seward, Alaska*

Red king crab have been cultured from the egg to juvenile stage at the Alutiq Pride shellfish hatchery in Seward, Alaska, for development of large-scale culture methods. Juvenile culturing challenges include high rates of cannibalism, maintaining color similar to wild conspecifics, and maintaining high growth rates. Experiments investigating effects of diet, stocking density, and size grading were conducted to investigate the potential for improved juvenile culture methods. The addition of astaxanthin, a carotenoid pigment, increased crab survival and resulted in darker, redder juveniles. Diets including calcium and astaxanthin significantly increased crab growth. Grading juveniles by size into groups of large and small individuals reduced cannibalism and increased juvenile survival with no variation in diet. These findings will benefit efforts to maximize survival, growth, and maintain color of juvenile red king in large-scale culture.

## Growth physiology of juvenile red king crab, *Paralithodes camtschaticus*

*Miranda Westphal, University of Alaska Fairbanks, Juneau, Alaska*

Limited information is available on juvenile growth rates of the commercially important red king crab, *Paralithodes camtschaticus*. Understanding variability in growth rates and relationships with environmental variables is essential for efforts to culture juveniles for potential stock rehabilitation. This study will combine monitoring of molt increments, intermolt duration, and growth hormones in juveniles with additional experiments exploring behavioral differences for both cultured and wild-caught individuals. Preliminary results indicated that mean intermolt duration ranged from 20 to 55 d over the first four instars of wild and hatchery juveniles and growth per molt ranged from 0.5 to 1.0 mm per molt and increased with increasing size. Hemolymph samples are also collected from juveniles at regular intervals and will be analyzed to characterize cycles in the hormones controlling the molt cycle. Behavioral experiments will focus on potential differences in behavior between wild-caught and cultured juveniles in foraging behavior, competition, and the presence of predators.

## Pribilof king crab habitat mapping: testing multibeam backscatter technology for fine-scale seabed classification

*Michelle Ridgway, Alaska Deep Ocean Science Institute, Juneau, Alaska and Terrasond LLC*

The Pribilof Islands stock of blue king crab, *Paralithodes platypus*, has failed to recover to historical levels despite being closed to fishing for over a decade. Previous research, which mapped and sampled juvenile blue king crab in habitats near the Pribilof Islands, suggested that gravel and shell hash benthic habitats may be important for survival and growth of the early benthic stages of blue king crab. In a collaborative effort with a hydrographic vessel chartered by the National Ocean Service, benthic habitats to the east and northeast of the St. Paul and St. George Islands were mapped with multi-beam sonar in 2009. Collaboration with a previously chartered vessel was a cost-effective solution to obtaining high-resolution maps of benthic habitat across a range of depths and distances from shore. These maps can be used to guide further sampling for comparison of possible spatiotemporal changes in the distribution of favorable habitats for blue king crab.

## Marine research in Norton Sound and the Bering Strait Region

*Wes Jones, Norton Sound Economic Development Corporation, Nome, Alaska*

Since 2003, the Norton Sound Fisheries Research and Development Department of the Norton Sound Economic Development Corporation has conducted marine research in the Norton Sound and Bering Strait region to assess marine resources important for subsistence and commercial use. Research activities have included continuation of the Norton Sound/Bering Strait trawl survey, pot surveys of blue king crabs at King and Diomede Islands, and benthic camera sled work around Saint Lawrence Island. The northern Bering Sea is projected to warm with climatic variation and these surveys provide important information on the status of fishery resources and the benthic community. Future work will include tagging studies to examine movement of red king crab, continuation of pot and trawl surveys, and extensive camera sled work in the Norton Sound/Bering Strait region.

## Funding opportunities for crab research in Alaska

*Earl Krygier, KEE Biological Consultants, Anchorage, Alaska*

Since 1980, the Saltonstall-Kennedy program has awarded grants to encourage collaborative fisheries research between industry, academia, and state or local governments. Aquaculture, optimum resource management, fisheries socioecomics, and conservation engineering are focus areas for the program. Bycatch reduction, essential fish habitat, and improved utilization of target species, and studies which integrate understanding of interactions between fisheries and trophic structure are all examples of studies considered for funding. Applications will be accepted in 2010 with approximately $5 million in total grants available.

## Twenty years of bitter crab syndrome research

*Frank Morado, National Marine Fisheries Service, Seattle, Washington*

The past several decades have seen increases in the geographic distribution and number of species affected by *Hematodinium* the causative agent of bitter crab syndrome (BCS) which causes mortality and reduces product quality in commercially important crab stocks. The prevalence of BCS has been monitored in Tanner and snow crab in the eastern Bering Sea since 1989 and in Southeast Alaska Tanner crab since 2004 by both hemolymph smears and PCR detection of *Hematodinium* in crab hemolymph. The prevalence of BCS varies spatiotemporally with increased incidence at small sizes for snow and Tanner crab in the eastern Bering Sea and indications of higher incidence at warmer temperatures for snow crab. Mean BCS prevalence by species, sex, and year ranged from ~1% to 10% in the eastern Bering Sea. The prevalence of BCS also varied between sexes, years, and locations in Southeast Alaska Tanner crab. The prevalence of BCS was much higher, as high as 45% in one location, than Tanner crab observed in the eastern Bering Sea. Data from snow crab in Newfoundland has indicated that variability in prevalence of BCS in small crab is associated with variability in the time-lagged recruitment of males to the commercial fishery. Increased awareness of the importance of BCS has resulted in increased research and collaborations seeking to characterize the life history and dynamics of the organism.

## Updates to size-weight relationships for eastern Bering Sea commercial crab species

*Liz Chilton, National Marine Fisheries Service, Kodiak, Alaska*

Size-weight relationships for commercially important crabs are key inputs for stock assessment models and are used to establish biomass estimates and in overfishing limit calculations. The size-weight relationships currently used are from unpublished sources, were collected several decades ago, or are based on small sample sizes. To improve estimation of these relationships, size-weight date were collected during the eastern Bering Sea crab and groundfish bottom trawl survey for both male and female red and blue king, snow, and Tanner crabs from 2000 to 2009. Linear regression was used to obtain slope and intercept estimates for the log transformed weight and size for each species and sex. Sample sizes per species/sex group ranged from 200 to over 1000 individuals measured. Estimates of mean weight at legal size generally increased when estimated from the current data versus previous estimates—with the exception of Tanner crab, which decreased slightly. Updating stock assessments with the relationships estimated from this project will increase the accuracy of biomass-related parameters in stock assessment models and reference points for management.

## Identifying juvenile red king crab habitat in Old Harbor, Kodiak Island

*Chris Long, National Marine Fisheries Service, Kodiak, Alaska*

The red king crab, *Paralithodes camtschaticus*, has a complex life cycle and little is known about factors affecting survival during the early life history stages. Due to low abundances and lack of recovery, recent studies have focused on development of enhancement methods for this species through aquaculture. A key step to enhancement efforts is identifying suitable locations to maximize survival of cultured individuals after release. Ideally, release habitats would protect juveniles from predation, provide resources to support high growth rates, and would be below carrying capacity for juvenile red king crabs. A dive study was conducted in Cozy Cove near Old Harbor on Kodiak Island to determine whether this location was a suitable site for release of cultured red king crab. Substrate, cover, and macrofauna were examined by quadrat sampling along transects. Deeper parts of the cove were primarily muddy and relatively free of macrofuana while the shallower, sloping portion of the cove was a mix of mud, rocky, and shell habitats with a variety of small macrofauna. No juvenile red king crab were observed during the study. Cozy Cove was concluded to be a high quality habitat for juvenile red king crab with few wild crab present and could be a suitable site for enhancement.

## Embryo quality and larval fitness of Bristol Bay red king crab

*Kathy Swiney, National Marine Fisheries Service, Kodiak, Alaska*

Stock assessment and management of Bristol Bay, Alaska red king crab *Paralithodes camtschaticus* does not currently incorporate recruitment potential based on embryo or larval production. To improve upon this, data on fecundity, embryo quality, and larval quality variability due to maternal size is needed. From 2007 to 2009, fecundity and embryo dry mass from females with 85 to 145 mm carapace length was determined. Fecundity significantly increases with maternal size. Embryo dry mass did not differ significantly with maternal size or by year; however, the interaction of year and maternal size was significant. In 2009, embryo carbon and nitrogen content were determined from females with 86 to 145 mm carapace length in the early stages of embryo development, and no effect of maternal size with embryo quality was found. In 2008, larval quality based on dry mass, carbon content, nitrogen content, and time

to 50% mortality under starvation conditions was assessed as a function of maternal size from crab with 93 to 135 mm carapace length. No effect of maternal size with larval quality was found. Larger females likely have a higher recruitment potential due to higher fecundity, but embryo and larval quality do not appear to vary with maternal size. To incorporate recruitment potential into stock assessment, the maternal size influences on fecundity is the most important factor to consider.

## Variability in fecundity of eastern Bering Sea snow crab, *Chionoecetes opilio*

*Joel Webb, Alaska Department of Fish and Game, Juneau, Alaska*

Estimates of reproductive potential for fisheries management based on abundance or biomass may be biased if stock reproductive potential is influenced by the size-age distribution of the spawning stock. Female eastern Bering Sea snow crab were sampled in the summer of 2007 and 2008 to investigate differences in fecundity among females of varying size and age relative to the terminal molt to maturity. Fecundity increased significantly with increasing females size, and varied significantly between years for females bearing the first clutch of ontogeny (primiparous) and the second or later (multiparous). Estimated fecundity also declined with increasing female age indexed by wear of the exoskeleton and epibiont load. These results indicated that stock egg production may be affected by female demography and should be integrated into development of biological reference points for this stock.

## The Cook Inlet noncommerical Tanner crab fishery: characteristics and management

*Nicky Szarzi, Alaska Department of Fish and Game, Homer, Alaska*

Commercial fisheries for king, Tanner, and Dungeness crabs have been closed in Cook Inlet since the mid-1990s due to low abundance. Noncommercial harvests have also been closed intermittently and all have been closed since 2003, except for a single opening for Tanner crab in 2008. Harvest primarily occurred within Kachemak Bay (94%) and was split inside (20%) and outside (74%) the Homer spit. Harvest regulations include a seasonal closure from March 16 to July 14, male-only harvest, and a minimum legal size of 5.5 in carapace width. The possession limit per day was reduced from 20 to 5 and the pot limit from 4 to 2 in an effort to reduce effort and harvest when the noncommercial fishery was opened in 2008, but total harvests were near the historical highs and effort in days crabbed was greater than double that previously observed. The current harvest strategies for the noncommercial fishery in both Kachemak Bay and the remaining areas in southern Cook Inlet include fishery closures at threshold abundance levels and harvest rates that decrease with decreasing abundance. Changes in possession limit in the noncommercial fishery were effective, resulting in harvests that were near the guideline harvest levels. Improved estimates of noncommercial catch, abundance, and improved criteria for reference points would benefit management of the noncommercial Tanner crab fishery.

## Field guide to marine fishes and invertebrates of Alaska

*Suzie Byersdorfer, Alaska Department of Fish and Game, Kodiak, Alaska*

A field guide to the marine fisheries and invertebrates of Alaska will soon be available through Alaska Sea Grant. The book contains a visual guide to for identifying taxa accompanied by high quality images, text descriptions of key features for species identification and notes on species distribution. The volume has received positive reviews and may be of interest for researchers, fishery observers, and others with an interest in Alaska marine life.

## The current status of the fisheries and biological knowledge of *Chionoecetes* spp. crab in Alaska waters

*Alaska Department of Fish and Game, Division of Commercial Fisheries staff:*
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*J. Zheng and J. Webb, Juneau*
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Crabs of the genus *Chionoecetes*, particularly snow crab, *Chinoecetes opilio*, and Tanner crab, *C. bairdi*, support important commercial fisheries in the state of Alaska. Grooved Tanner crab, *C. tanneri*, and triangle Tanner crab, *C. angulatus*, are also landed in the state but at very low levels compared to *C. opilio* and *C. bairdi*. Tanner crab fisheries are distributed from Southeast Alaska through the Gulf of Alaska into the eastern Bering Sea, while the snow crab fishery is confined to the eastern Bering Sea. Historically, statewide landings of both species have fluctuated, with peak harvest of Tanner crab in the 1970s, and peak harvest of snow crab in the 1990s. Peak landings of Tanner crab were associated with high catches in the eastern Bering Sea versus the Gulf of Alaska. Management for both species incorporates male-only harvest rules, minimum size at harvest, and seasonal closures. Stock assessments for snow and Tanner crab are typically based on abundance estimates from fishery-independent pot or trawl surveys, with additional assumptions of natural mortality and bycatch/discard mortality for the eastern Bering Sea stocks, which are managed under federal fishery management plans and overfishing limits. Tanner crab in the Gulf of Alaska are distributed in nearshore waters and managed under state harvest regulations which—in addition to sex, size, season rules—frequently include abundance thresholds, target exploitation rates of 10% to 20% based on mature male biomass, maximum exploitation rates for legal-size males, and area closures for stocks with low estimated abundance. Both male and female *C. bairdi* and *C. opilio* undergo a terminal molt to maturity that is characterized by an increase in the size of the abdomen relative to the body for females and in the height of the chelae relative to the body for males. Among locations in the Gulf of Alaska and the eastern Bering Sea, size at maturity varies for both male and female Tanner crab. For female snow crab, size at maturity varies with latitude, likely in response to temperature-mediated variability in growth rates. Monitoring of female spermathecal load, which varies with male availability at the time of mating, has also been initiated to determine whether it is useful to detect fishery-dependent variability in reproductive potential. Female fecundity is monitored by visual estimation of the fullness of the egg clutch relative to the abdomen during stock assessment surveys and in laboratory studies. In addition to harvest effects, abundance of *Chionoecetes* crabs may vary in response to environmental variability, distribution in relation to retention or advection mechanisms, and predation. Characterization of the varying strength and role of these factors would likely result in improved fisheries management for these species.

## Rebuilding analysis of the eastern Bering Sea Tanner crab stock: consideration of new overfishing definitions and bitter crab disease

*M. S. M. Siddeek and J. Zheng, Alaska Department of Fish and Game, Juneau, Alaska; J. F. Morado, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, Washington; G. H. Kruse, and W. R. Bechtol, University of Alaska Fairbanks, Juneau, Alaska*

The fishery for eastern Bering Sea Tanner crab has been frequently closed due to low abundance or has had historically low quotas since the mid-1990s. The fishery is managed as two stocks, eastern and western, divided at 166°W longitude. Biological and fishery justifications for this division are maturity length for the western stock appearing to be smaller than that of the eastern stock, and additional snow crab fishery bycatch mortality on the western stock. A length-based simulation model was used to investigate rebuilding probabilities for these stocks under scenarios incorporating variable levels of natural mortality, additional mortality due to the fatal disease bitter crab syndrome, and management under an $F_{35\%}$ fishing mortality control rule. Simulation results suggested that at the low bitter crab syndrome prevalence levels (<4%) observed historically across the size-range bitter crab syndrome did not significantly alter median rebuilding times for the two stocks. The $F_{35\%}$ control rule was adequate to rebuild the stock within a reasonable time period. Median rebuilding times to the maximum sustained yeild stock level under the $F_{35\%}$ scenario ranged from four to thirteen years for both the eastern and western stocks, but were dependent on recruitment variability.

## The 2009 ADF&G Westward Region crab research roundup

*Doug Pengilly, Alaska Department of Fish and Game, Kodiak, Alaska*

Westward region personnel are involved in research and management of crab fisheries near Kodiak Island, the Alaska Peninsula, Aleutian Islands, and eastern Bering Sea. A primary focus of the region is working with the state and federal co-managed eastern Bering Sea crab stocks. This involves preparing stock assessments for some stocks and participation in deliberations to determine overfishing limits at the federal level and then setting the total allowable catch under the state harvest strategies. Total allowable catches are always set at a level below the overfishing limit. In 2009/10 the Pribilof Island red and blue king crab fisheries were closed due to low stock abundance. Total allowable catches were 16 million pounds for Bristol Bay red king crab, 48 million pounds for eastern Bering Sea snow crab, 1.35 million pounds for eastern Bering Sea Tanner crab, and 1.17 million pounds for St. Matthew Island blue king crab. Abundance of crab stocks is characteristically variable and management may be improved by increased knowledge of the relationship between harvest and stock dynamics and observed (survey) versus true density. Other vital population parameters, including natural mortality, growth, and variability in reproductive potential, are also poorly known and are the focus of ongoing research.

# POSTER PRESENTATIONS

1. Kodiak Island crabs and crab habitat, 2009 CamSled Images
   *Gregg Rosenkranz and Ric Shepard, ADF&G, Kodiak, Alaska*
2. The size and sex class distribution by depth and survey location of red king crab in Southeast Alaska
   *Andrew Olson, ADF&G, Juneau, Alaska*
3. Genetic population structure of snow crab in the Bering Sea and Arctic Ocean
   *Greg Albrecht, UAF/SFOS, Fairbanks, Alaska*
4. Effect of temperature and rearing density in golden king crab, *Lithodes aequispinus*, larval cultivation
   *Scott Van Sant, NMFS, Kodiak, Alaska*
5. Rescue and retrieval of historical Bering Sea crab data
   *Beverly A. Malley, NMFS, Kodiak, Alaska*
6. Crab abundance and depth distribution along the Continental Slope of the eastern Bering Sea
   *Jan Haaga, NMFS, Kodiak Alaska*
7. Distribution and habitat characteristics of mature female Tanner crab, *Chionoecetes bairdi*, in the Bering Sea
   *Jon Richar, UAF, Juneau, Alaska*

# PLANS FOR 2010

The annual Alaskan crab research meetings continue to be productive and valuable for free exchange of scientific results, ideas, and perspectives. A 17$^{th}$ annual meeting is expected to be scheduled for the approximate dates of December 15–17, 2010, in Anchorage.

# PROPOSALS FOR NEXT YEAR'S SPECIAL TOPIC

1. Effects of male-only fishing on crab stocks
2. MPAs and effectiveness for crustaceans
3. Alternative survey methods
4. Essential fish habitat and technology for assessment
5. International experiences with shellfish enhancement
6. Changes in Arctic Ocean crab populations with climate change
7. Experiences with introduced red king crab in Norway and Russia

# ACKNOWLEDGEMENTS

The authors thank the presenters for providing us with electronic copies of their slide presentations, allowing us to faithfully summarize the material presented. The authors of this report accept responsibility for errors in interpretation.

# APPENDICES

Appendix A.–List of participants at the 2009 Interagency Crab Research Meeting.

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-continued-

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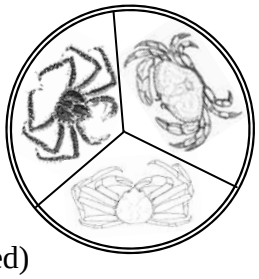
Location: All sessions will be held in the Endeavour Room (downstairs from the lobby) at the Captain Cook Hotel



**WEDNESDAY, DECEMBER 16**

I. Afternoon Session: 1:00–5:00 PM
II. Introductions
III. Opening remarks: Doug Woodby, Russ Nelson
IV. Meeting agenda: Modify and Adopt
V. Research Review (All presentations will be 20 minutes unless noted)

A. University of Alaska

1. Factors leading to stock collapse of Kodiak red king crabs and their failure to recover
   *Gordon Kruse, UAF/SFOS, Juneau, AK*
2. Update on bitter crab syndrome research in Prince William Sound
   *Sherry Tamone, University of Alaska Southeast, Juneau, AK*
3. Molting and its effect on reproductive indices of the male snow crab, *Chionoecetes opilio*: a project preview
   *Molly Zaleski, UAF/SFOS, Juneau, AK*
4. Strength of the Aleutian Low determines interannual variation in Dungeness crab larval recruitment to Glacier Bay, Alaska 2000–2007
   *Heidi Herter, UAF/Alaska Sea Grant, Nome, AK*
5. Morphometrics, fecundity and hatch patterns of blue king crabs (*Paralithodes platypus*) from Little Diomede, Alaska
   *Heidi Herter, UAF/Alaska Sea Grant, Nome, AK*

*Coffee: Midafternoon (15 minutes)*

6. A tethering field study to identify predators of early juvenile red king crab: preliminary video results
   *Jodi Pirtle, UAF/SFOS, Juneau, AK*
7. Hatchery production of red king crab (*Paralithodes camtschaticus*) produces 100,000 juveniles for crab research
   *Ginny Eckert, UAF/SFOS, Juneau, AK*
8. Effects of diet, stocking density, and size grading on growth, survival, and coloration of juvenile red king crab (*Paralithodes camtschaticus*)
   *Ben Daly, UAF/SFOS, Seward, AK*
9. Growth physiology of juvenile red king crab, *Paralithodes camtscaticus*
   *Miranda Westphal, UAF/SFOS, Juneau, AK*

B. Alaska Deep Ocean Science Institute and Terrasond LLC

1. Pribilof king crab habitat mapping: testing multibeam backscatter technology for fine-scale seabed classification
   *Michelle Ridgway, Juneau, AK*

C. Norton Sound Economic Development Corporation

1. NSEDC Crab research in Norton Sound and the Bering Strait region
   *Wes Jones, Nome, AK*

**THURSDAY, DECEMBER 17**
*Coffee: 8:00 – 8:15 AM*
*Morning Session: 8:15–11:30 AM*

D. Special Topic: Ocean Acidification
    1. Dick Feely (45 min)
    2. Ocean acidification: controls and potential impacts in the marginal seas of Alaska (30 min)
       *Jeremy Mathis, University of Alaska Fairbanks, Fairbanks, AK*
    3. Alaska Fisheries Science Center ocean acidification research on shellfish: past, present, and future
       *Bob Foy, NMFS/AFSC, Kodiak, AK*

*Coffee: Mid-Morning (10 minutes)*

    4. Ocean acidification, question and answer session (30 min.)
    5. Funding opportunities for crab research in Alaska
       *Earl Krygier*

E. National Marine Fisheries Service
    1. Recent developments in Bitter Crab Disease research
       *Frank Morado, NMFS/AFSC, Seattle, WA*
    2. Updates to size-weight relationships for EBS commercial crab species
       *Liz Chilton, NMFS/AFSC, Kodiak, AK*

*Lunch: 11:30 AM–1:00 PM*
*Afternoon Session: 1:00–5:00 PM*

F. National Marine Fisheries Service (continued)
    1. Identifying juvenile red king crab habitat in Old Harbor, Kodiak
       *Chris Long, NMFS/AFSC, Kodiak, AK*
    2. Egg quality and larval fitness of Bristol Bay red king crab
       *Kathy Swiney, NMFS/AFSC, Kodiak, AK*

G. Alaska Department of Fish and Game
    1. Variability in fecundity of Bering Sea snow crab
       *Joel Webb, ADF&G, Juneau, AK*

*Coffee: Midafternoon (15 minutes)*

    2. Cook Inlet noncommercial crab fishery characteristics and management
       *Nicky Szarzi, ADF&G, Homer, AK*
    3. Field Guide to Marine Fishes and Invertebrates of Alaska
       *Suzie Byersdorfer, ADF&G, Kodiak, AK*
    4. The current status of the fisheries and biological knowledge of *Chionoecetes* spp. crab in Alaskan waters (30 min)
       *Gretchen Bishop, ADF&G, Douglas, AK*

5. Eastern Bering Sea crab fisheries update
   *Doug Pengilly, ADF&G, Kodiak, AK*
6. Rebuilding analysis of the eastern Bering Sea Tanner crab stock: Consideration of new overfishing definitions and bitter crab disease
   *Shareef Siddeek, ADF&G, Juneau, AK*

VI. Next Year's Meeting and Special Topic Suggestions
VII. Other Business

*Dinner: Glacier Brewhouse. Reservations for 30 people in groups of 10 at 5:45 PM, 6:00 PM, and 6:15 PM*