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Summary of the 2014 Interagency Crab Research Meeting Held December 16–17, 2014, and Updated Research Priorities for Tanner Crab in Alaska

by

Joel Webb

April 2015

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

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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)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

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, χ^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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SUMMARY OF THE INTERAGENCY CRAB RESEARCH MEETING HELD DECEMBER 16–17, 2014, AND RESEARCH PRIORITIES FOR TANNER CRAB IN ALASKA

by

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Division of Sport Fish, Research and Technical Services
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TABLE OF CONTENTS

Page

LIST OF APPENDICES

Appendix

PURPOSE

This report summarizes the 19th annual interagency crab research meeting, held December 16 and 17, 2014, in Kodiak, Alaska at the Best Western Kodiak Inn. 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. One objective of the interagency crab research meeting is the review, development, and prioritization of research priorities. The special topic of the 2014 meeting was a review of research progress and discussion to identify priority research directions for Tanner crab in Alaska. Researchers contributed talks to three themes: population estimation, stock productivity, and harvest. 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.

Key words: Alaska crab research, red king crab, blue king crab, golden king crab, Tanner crab, snow crab, Dungeness crab, spot shrimp, research priorities

PARTICIPANTS

The 2014 meeting was attended by approximately 60 participants representing the Alaska Department of Fish and Game (ADF&G), the National Marine Fisheries Service (NMFS), the Bering Sea Research Foundation, the School of Fisheries and Ocean Sciences of the University of Alaska Fairbanks (UAF), and the University of Alaska Southeast (UAS). A list of participants and contact information is included in Appendix 1.

PRELIMINARIES

The meeting was jointly chaired by Chris Siddon and Bob Foy and audiovisual operations were run by Joel Webb. Following introductions and welcoming remarks, the draft agenda (Appendix 2) was adopted without change.

ACKNOWLEDGEMENTS

The authors thank the presenters for providing us with electronic copies of their slide presentations, allowing us to summarize the material. The author of this report accepts responsibility for errors in interpretation where a presentation abstract was not submitted or review of the presentation summary by the presenter was not available at the time of publication.

SUMMARY OF PRESENTATIONS

The order of presentations followed the agenda (Appendix 2) which was organized by the themes of the topic session and then by agency (University of Alaska, ADF&G, and NMFS).

SPECIAL TOPIC: WHAT ARE THE PRIMARY BIOLOGICAL AND ECOLOGICAL FACTORS AND KEY UNCERTAINTIES ASSOCIATED WITH VARIABILITY IN ABUNDANCE OF TANNER CRAB?

Speakers were invited to address this question in four themes: population estimation, stock productivity, stock structure, and mortality and to identify priority research items within each. No presentations were submitted within the stock structure theme.

1. Population Estimation

A brief overview of biological processes in the Eastern Bering Sea Tanner crab assessment model

William (Buck) Stockhausen, National Marine Fisheries Service, Alaska Fisheries Science Center, Sand Point Laboratory, Seattle, Washington

Stock assessment of eastern Bering Sea Tanner crab stocks is conducted in an integrated assessment model framework in which catch/bycatch and abundance data are integrated with quantitative descriptions of biological processes mortality to estimate biological processes of growth and mortality along with recruitment and the population trajectory over time. When an acceptable model fit is achieved, these estimates are then used to predict future observations and to determine harvest levels within a biological reference point framework. Key topics for biologically focused research with the potential to improve the Tanner crab stock assessment process include: the role of spawning stock and environmental factors as drivers of recruitment variability; age determination methods to better resolve cohorts; growth rates and factors potentially associated with growth variability in the EBS; the effects and relative importance of disease, predation, and environmental variability on natural mortality rates; and temporal variation in weight-at-size and identification of associated environmental drivers.

Tanner crab stocks in the Kodiak, Chignik, and South Peninsula districts of the Westward Region

Kally Spalinger, Alaska Department of Fish and Game, Kodiak, Alaska

Tanner crab stocks in the Westward Region are monitored with a large-mesh bottom trawl survey conducted annually by ADF&G. This survey has been conducted since 1988 and also provides data for management of commercially important groundfish and crab stocks. Survey estimated abundances of Tanner crab are highly variable with greater than five-fold variation in abundance among years. In the Kodiak area variability in abundance since the late 1990s has been driven by the recruitment of three abundance cohorts at approximately six-year intervals. Dramatic reductions in cohort abundance (>90%) appear to occur between the size-class at which small crab are effectively sampled by the trawl, and when the cohort contributes to harvest—a lag of about five years. Short-term priorities of the assessment and management program are to improve the estimation of abundance and harvest levels by reducing sources of uncertainty in the area-swept calculations from the trawl survey. Longer-term priorities are to improve understanding of processes that contribute to high mortality (e.g., predator-prey relationships) and the implications of large-scale oceanographic processes (such as warming temperatures and ocean acidification) which impact stock productivity.

Improving survey methods for Southeast Alaska Tanner crab using a stratified design

Katie Palof, Kelli Wood, and Andrew Olson, Alaska Department of Fish and Game, Juneau, Alaska

The annual Tanner crab stock assessment survey monitors the health of Tanner crab stocks in six locations in Southeast Alaska. Prior to 2013, pot locations were chosen based on a random sampling

design in each bay. In an effort to improve the efficiency and decrease the variability of this survey, stratification based on crab density and habitat was suggested. A similar stratification technique was used in 2005 to stratify the red king crab sampling locations in Southeast Alaska. This effort has increased sampling efficiency and decreased the variability in CPUE estimates from the survey. Stratified sampling can increase the precision of measured variables, in this case the number of crab per pot or CPUE, and therefore reduce the variability of the abundance estimates based on these variables. For each study area in the Tanner crab survey there are at least 10 years of sampling data; this data along with depth data for each area was used to develop a crab density prediction map in ArcGIS using Geostatistical Analyst tools. The prediction map was then divided into five density strata (low to high) which will be used to choose random pot placement in future surveys. We will present an overview of the Tanner crab fishery, prior survey methods, and the methods used to establish a stratified survey design, along with a discussion of the challenges to changing a survey design and evaluating its effectiveness.

2. Stock Productivity

Differences between primiparous and multiparous Tanner crab reproductive cycles

Katherine Swiney, National Marine Fisheries Service, Alaska Fisheries Science Center, Kodiak Laboratory, Kodiak, Alaska

Reproductive cycles of primiparous and multiparous southern Tanner crab (*Chionoecetes bairdi*) females were compared by rearing crab of both reproductive states under identical conditions. Dates of egg extrusion were recorded, eggs were sampled monthly to determine embryological stage, and larvae were collected daily during larval hatching to determine timing and duration of hatching. Primiparous females extruded eggs on average 103 days earlier than multiparous females and embryos developed similarly between groups. Both groups exhibited an embryonic developmental diapause at the gastrula stage; however the length of diapause was approximately six months for the primiparous group and three months for the multiparous group. This diapause appears to synchronize hatching, likely to enhance larval survival in response to timing of plankton blooms. Hatching was relatively synchronous between the two groups, however the mean hatch date was 10 days earlier for primiparous females and on average, hatching took 7 days for primiparous females and 12 days for multiparous females. Primiparous crabs have an average brooding duration of 489 days which is 92 days longer than the average multiparous female brooding duration of 397 days. Results of this study illustrate that reproductive cycles differ between primiparous and multiparous southern Tanner crabs. The differences are likely due to biological constraints: multiparous females cannot extrude a new clutch until their old clutch hatches and primiparous females are constrained by the timing of their molt to maturity. Future research should examine the effects of environmental changes on length and number of embryonic diapauses, brooding duration, and timing of extrusion and hatching.

Tanner crab growth: data supporting Bering Sea stock assessment

Robert J. Foy, National Marine Fisheries Service, Alaska Fisheries Science Center, Kodiak Laboratory, Kodiak, Alaska

Growth in Tanner crab is a function of both molt increment and frequency (intermolt), which may vary with size/age and maturity. The length-based integrated assessment model applied to the eastern Bering Sea (EBS) stock of Tanner crab models growth as a function of both growth increment and probability of molting, but sex-specific growth data from Kodiak Tanner crab is used to inform (i.e., constrain) model growth. Comparison of growth data for Tanner crab near Kodiak, with limited data for the EBS,

suggests that growth rates are similar between those stocks, while growth rates may be higher in Southeast Alaska. Additional empirical data on growth and variability in growth of both male and female Tanner crab in the EBS—particularly related to maturity—would improve understanding of the suite of density-dependent and density-independent factors which may influence growth rates. EBS Tanner crab were collected in 2012 with support from the Bering Sea Research Foundation and held in saltwater aquaria in Dutch Harbor through molting. This experiment increased the available information on growth increment for EBS Tanner crab but mortality rates during molting in captivity were high, perhaps due to holding conditions.

The Bering Sea Fisheries Research Foundation and Tanner crab growth experiments

Scott Goodman, Bering Sea Fisheries Research Foundation, Seattle, Washington

The mission of the Bering Sea Fisheries Research Foundation (BSFRF) is to work in a productive manner with all stakeholders in collaborative scientific research by helping determine and develop the best scientific approach for gathering information for management of eastern Bering Sea (EBS) fisheries. Research projects completed or supported by BSFRF in the past decade have included use of alternative survey design/sampling gear for fishery independent surveys of crab in the EBS, several species-specific gear selectivity experiments, surveying areas outside the coverage of the standard survey for EBS crab stocks, tagging for examination of crab movement, and collecting crab for experiments to improve knowledge of crab growth. In 2015, BSFRF will be collaborating with federal and state agencies to collect additional Tanner crab from the EBS for further growth rate studies to improve biological information in stock assessment.

Variation in size at maturity of eastern Bering Sea Tanner crab: implications for fishery management

Douglas Pengilly, Alaska Department of Fish and Game, Division of Commercial Fisheries, Kodiak, Alaska; and Jie Zheng, Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau, Alaska

Early analyses of spatial variation in size at maturity showed an east-to-west trend of decreasing size at maturity for mature female and male Tanner crab, and suggested that two subareas east and west of 167°15'W longitude accounted for much of the regional variation in female size at maturity. This provided a useful division for management purposes. Subsequent analyses of data from the NMFS EBS confirmed the east-to-west trend of decreasing size at maturity, but also showed that size at maturity was negatively correlated with depth, that data collected after 1979 do not support the use of 167°15'W longitude as consistently partitioning the EBS into two subareas, and that a decrease in size at maturity has occurred since the early 1990s—and it is related to a shift in the longitudinal and depth distribution of mature crab. We present additional data collected from the fishery and the EBS trawl survey and discuss the implications of spatial-temporal trends in size at maturity for fishery management, the attempts to address those trends in fishery management measures (i.e., a harvest strategy with separately determined harvest levels and different size limits for eastern and western portions of the EBS), and the problems that those trends can pose to fitting survey size-composition data in a stock assessment model for EBS Tanner crab. We also note that the spatial-temporal trends in size at maturity have been interpreted both as supporting and not supporting the hypothesis that EBS Tanner crab comprise two distinct stocks or substocks (*Bristol Bay* and *Pribilofs*), and review the needs for future research to better understand the factors effecting those trends and their implications for fishery management and stock assessment.

Reproductive potential of Tanner crab in Alaska

Laura Stichert[1], Joel Webb[2], Phillip Tschersich[1], and Douglas Pengilly[1]

[1]Alaska Department of Fish and Game, Division of Commercial Fisheries, Kodiak, Alaska
[2]Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau, Alaska

Research in the 1980s and 1990s contributed to our understanding of the reproductive biology of Tanner crab and the differences in key aspects of reproductive biology between primiparous and multiparous females, including the timing of mating; the dynamics of male vs female mate choice; the influence of sex ratio on which crab participate in mating and the volume of sperm transferred during mating (e.g., based on male size and maturity status as well as parsimony for males mating with multiple females); the ability of females without access to males to fertilize successive clutches by utilizing stored sperm when held; and the effects of age postterminal molt on fecundity. Preliminary results from recent research in three areas of Alaska, including southeast (SE), Kodiak Island waters (KI), and the eastern Bering Sea (EBS), has expanded our understanding of female reproductive potential and how this may vary across the state. Consistent trends in sperm reserves across all areas included an increase in spermathecal load (SL) from primiparous to multiparous females and a positive size-SL relationship for multiparous females, indicating most females participated in mating after producing their first clutch and larger females received more sperm. Differing trends between areas include mean SL, which was lowest in SE and highest in KI, and trends in estimated sperm cells by ontogeny. Subareas were examined over multiple years in KI (i.e., three fishery sections) and EBS (i.e., east or west of 166°W); preliminary analyses indicate year, but not area, were important in the EBS while both factors may be important in KI. Size-fecundity relationships showed an expected increase in fecundity from primiparous to multiparous females, though this difference was the smallest in the EBS. It appears there were differences in the relationship between mean egg weight and size between areas. Other contributions in recent years included findings that 1) visually scoring spermathecae for presence of fresh ejaculate can serve as an indicator of recent mating and an associated significant increase in sperm cells; 2) among subareas within SE, SL of multiparous females was positively correlated with male-biased sex ratios and SL of primiparous females was negatively correlated with fishery exploitation rates on males; 3) an increase in egg diameter occurs after embryonic development stage 9; 4) the clutch fullness index used during stock assessment surveys performs well for estimating fecundity at size; and 5) most eggs in the clutches of EBS females collected during the summer are viable and clutches of unviable eggs are rare. Future research recommendations include continued examination of both natural variability as a basis for evaluating fishery effects, and the impacts of sex ratio and exploitation rate on measures of female reproductive potential.

Effects of ocean acidification on different life history stages of Tanner crab

Katherine Swiney, W. Christopher Long, and Robert J. Foy, National Marine Fisheries Service, Alaska Fisheries Science Center, Kodiak Laboratory, Kodiak, Alaska

Ocean acidification, a decrease in ocean pH due to absorption of anthropogenic CO_2, has variable effects on marine species. The effects on southern Tanner crab embryo development, hatching success, calcification, survival, morphology, condition, and growth were examined by rearing different life stages in ambient pH (~8.1), pH 7.8, and pH 7.5 waters. Ovigerous females were exposed to pH treatments for two years and experiments were conducted both years on hatched larvae. Embryos and larvae in year one were from oocytes developed in the field whereas embryos and larvae in year two were from oocytes developed under laboratory acidified conditions. Differences in embryo morphology were slight (<3.6%) in year one but in year two, embryos in the pH 7.5 treatment had 10% larger yolks and 6%

smaller embryos than the ambient treatment. The number of viable larvae hatched did not differ with treatment in year one; however, in year two, 71% fewer viable larvae hatched in the pH 7.5 treatment. In year two, larvae were smaller, had lower calcium contents and lower metabolic rates as evidenced by longer starvation-survival times. Therefore, exposure to acidified conditions at the larval stage alone had minimal effects on the larvae, while exposure during oogenesis and embryogenesis resulted in significant carryover effects. At the end of the experiment, percent calcium in the adult female's carapaces was lower in pH 7.5 than the other treatments. Juvenile survival assessed in a separate experiment decreased with decreasing pH, and growth and Ca content were reduced at pH 7.5. Based on the results of these laboratory experiments, projected ocean pH levels within the next two centuries will likely have a pronounced impact on southern Tanner crab populations unless the crab are able to acclimatize or adapt to rapidly changing conditions.

3. Mortality and Harvest

Prevalence of *Hematodinium spp.* in southern Tanner crab in the eastern Bering Sea vs. southeast Alaska

Pamela Jensen, Vanessa White, Christie Lang, Frank Morado, National Marine Fisheries Service, Alaska Fisheries Science Center, Sand Point Laboratory, Seattle, Washington; and Robert Foy, National Marine Fisheries Service, Alaska Fisheries Science Center, Kodiak Laboratory, Kodiak, Alaska

Hematodinium is a genus of parasitic dinoflagellates that infects decapod crustaceans worldwide. In *Chionoecetes* spp., the disease state caused by *Hematodinium* sp., termed Bitter Crab Syndrome (BCS), results in unmarketable meat and likely leads to host mortalities, although the duration of infection and mortality rate is uncertain. The Alaska Fisheries Science Center (AFSC) has monitored the prevalence of BCS in the eastern Bering Sea (EBS) southern Tanner crab (*C. bairdi*) for the last 25 years, collecting samples during the annual AFSC crab and bottom fish trawl surveys conducted each summer. Additionally the AFSC has collaborated with various partners, most notably ADF&G, in efforts to understand *Hematodinium* infections in Alaskan crabs. Our annual prevalence estimates for BCS in EBS *C. bairdi* range from approximately 1% to 5%. In the southeastern EBS (includes Bristol Bay), the *Hematodinium* infection rate over the 25-year monitoring period is 0.6%, with small, SC (shell condition) 1 or SC2 crabs most likely to be infected. In the northwestern EBS (includes the Pribilof Islands), the infection rate over the 25-year monitoring period is 3.7%, with small, female, and SC2 crabs being most likely to be infected. In contrast, samples collected during ADF&G pot surveys from 2004 to 2012 at 16 sites in Southeast Alaska reveal infection rates of 1.0 to 66.1%, with males more likely to be infected at 8 of the 12 sites. Because both surveys undersample small crabs, and the pot survey also undersamples females, the infection estimates do not represent estimates of population infection rates. Data from summer sampling in Alitak Bay, Kodiak Island, from 2005 to 2010 are also presented and show that prevalence rates can change dramatically over a short period of time: from 4% up to 16% and down to a 1% prevalence within a six-year period. Difficulties associated with *Hematodinium* research and critical gaps in our understanding of this parasite and its impact on Alaskan southern Tanner crab stocks are also presented.

Incorporating disease effects in Tanner crab stock assessment

Chris Siddon, Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau, Alaska

Bitter crab disease (BCD), caused by parasitic dinoflagellates of the genus *Hematodinium*, is known to cause high rates of mortality in infected Tanner crab. In Southeast Alaska prevalence or infection infection rates vary from 0 to more than 40% among areas and experiments suggest that mortality occurs

for all or nearly all infected crab within one year. However, there is an apparent mismatch between these observations since Tanner crab stocks have persisted in locations despite these high prevalence rates. A holding experiment of infected and noninfected adult males in 2014 demonstrated that mortality rates were much higher for infected males. Nearly all infected males were dead within nine weeks while approximately 60% of noninfected males survived. To improve understanding of disease effects on mortality, greater knowledge is needed of within (seasonal) and among (interannual) variation in infection rates, potential transmission vectors, and potential mechanisms (e.g., immunity) by which some individuals may survive infection. Audience discussion was that for stock assessment purposes natural mortality (M) should be scaled to measures of disease prevalence rather than estimation or application of a disease-specific component of M.

Estimating discard mortality in the Bering Sea Tanner crab fishery

Dan Urban, National Marine Fisheries Service, Alaska Fisheries Science Center, Kodiak Laboratory, Kodiak, Alaska

Bycatch/handling mortality can be an important, but frequently difficult to estimate, source of mortality in exploited crab stocks. Due to limited information and contrasting results among studies, a default bycatch mortality rate of 50% has been applied for stock assessment of the eastern Bering Sea Tanner crab fishery. Bycatch mortality has both short- and long-term components. Development of a suite of reflex actions that could be assessed to reliably predict short-term mortality (reflex action mortality predictor; RAMP) facilitated studies to develop empirical estimates aboard vessels during commercial fishing for eastern Bering Sea Tanner crab. Average predicted bycatch mortality was 11.5% during three fishing seasons across a range of catch sorting times and temperature. Bycatch rates were relatively stable across both sorting times and on deck temperatures. A mean bycatch injury (e.g., cracked carapace or leg break) rate of 4.2% was also estimated. A final bycatch mortality rate of 31.5%, considering both short- and long-term mortality, was adopted for stock assessment and management purposes in May of 2014.

CONTRIBUTED TALKS

1. University of Alaska

Spatial variability in size at maturity and reproductive timing for golden king crab (*Lithodes aequispinus*) in Southeast Alaska

Andrew Olson, University of Alaska Fairbanks, School of Fisheries and Ocean Sciences, Juneau, Alaska

Size at morphometric maturity (SAM) was established for golden king crab (*Lithodes aequispinus*) in Southeast Alaska (SEAK) by comparing the relationship between the right chela height and carapace length in males and on the presence or absence of eggs in females. Spatial variability in SAM was analyzed in SEAK and compared with published information throughout the geographic range which includes Russia, the Bering Sea, and British Columbia, Canada. Russian and Bering Sea golden king crab SAM decreased as latitude increased, while SEAK SAM increased as latitude increased. To coincide with SAM, spine morphometric measurements were taken to examine spine length variability to determine if the current legal size is appropriate across all management areas within SEAK. Reproductive timing will be investigated in SEAK by taking egg samples to predict potential hatching events.

Development of biochemical measures of age in the Alaskan red king crab: validation, refinement, and initial assessment

Ginny Eckert and Alexie Pinchuk, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Juneau, Alaska; and Rodger Harvey, Old Dominion University, Ocean, Earth, and Atmospheric Sciences, Norfolk, Virginia

Age determination of marine organisms is a central metric for understanding the timing and magnitude of spawning, recruitment and habitat use, juvenile duration, and population age structure. For the commercially important red king crab (RKC), *Paralithodes camtschaticus*, size-based models are used in lieu of age-based models for estimating population dynamics and for fishery management. Yet we know that crab growth, and thus size, is not a linear process, but typically is seen as a step function with intermittent molts of varied periodicity—thus, using carapace size alone complicates the estimation of population dynamics and timing of key life history parameters. We have developed an alternative approach based on analysis of specific age pigments (lipofuscins) to assess red king crab age, which will provide a more robust metric of age than carapace size measurements alone. A combination of preliminary validation of the presence and utility of these biochemical markers for known age animal ages (0–4 years), a long-term experimental assay to assess effect of temperature on age pigment accumulation rates in juvenile red king crab hatched in captivity, and lipofuscin measurements on wild-caught individuals, provide solid ground for usability of our technique to help answer a variety of questions raised by fishery management.

Influence of temperature and congener presence on blue king crab (*Paralithodes platypus*) habitat preference and fish predation

Courtney Lyons and Ginny Eckert, University of Alaska Fairbanks, School of Fisheries and Ocean Sciences, Fairbanks, Alaska

The Pribilof Islands, Alaska, USA, benthic ecosystem has changed over the past several decades from a cold-water system populated by blue king crabs (*Paralithodes platypus*) to a warmer area with increased groundfish and red king crab (*Paralithodes camtschaticus*) biomass and a much-reduced blue king crab biomass. To explore how these factors might interact to suppress blue king crab population growth, we conducted a suite of laboratory experiments to assess the effects of temperature changes and the presence of red king crab on blue king crab habitat preference and predation survival. Age-0 blue king crabs exhibit plasticity in habitat preference mediated by changes in water temperature and presence and density of juvenile red king crabs. While blue king crabs are often associated with shell hash habitat, increases in water temperature, as well as the presence of red king crab at high densities, caused blue king crab juveniles to shift into habitats with more vertical structure present, a habitat type shown to reduce the predation efficacy of red king crabs. In addition, while red king crabs typically prefer habitats with more vertical structure, they were more likely to use shell hash habitat in the presence of blue king crabs, perhaps drawn by the predation opportunities. Thus blue king crabs are behaviorally plastic, switching from strategies of predator avoidance when predator encounter rates are likely low, to predator deterrence strategies when encounter rates are higher. Fish predation trials further support the idea that blue king crabs are more focused on predator avoidance than are red king crabs. In fish predation trials run separately for the two crab species, blue king crabs had higher survival (60%) than red king crabs (33%) when exposed to fish predators. A similar pattern was observed when the two species were mixed and then exposed to fish predators (71% and 12% survival for blue and red king crabs, respectively). Fish predators were most efficient on red king crab prey, with a higher ratio of crabs eaten per strike and target as well as a lower ratio of strikes per target. Our results indicate that

age-0 blue king crabs may be less vulnerable to fish predation than red king crabs. Future research should assess how fish predation rates change when presented with higher densities of red and blue king crab in mixed assemblages, as the habitat shifts we observed in our study could affect predation survival.

Reproductive physiology of the northern spot shrimp, *Pandalus platyceros*

Esther Bower, University of Alaska Southeast, Biology Department, Juneau, Alaska

Spot prawns (*Pandalus platyceros)* are a highly valued commodity in Southeast Alaska for 1) the commercial fishing industry, 2) subsistence and recreational fisheries, and 3) foraging marine species within Alaskan ecosystems. Understanding recruitment processes of the spot prawn has been understudied but is important for management decisions and ecosystem processes. Our study goals were to describe life history reproductive traits of spot prawns from Southeast Alaska by determining whether females produced multiple clutches in the summer months or just one. In February, shrimp were collected near Juneau, Alaska, housed at the University of Alaska Southeast wet lab, and critically observed from April through August. Results indicated that each reproductive female was fertilized, extruded eggs and carried the eggs until hatching once per summer season. After hatching, females molted. In summary, we found that spot prawns reproduce one time during the spring and molt prior to fall and winter. Further observations are currently being made to identify fall and winter life history traits

Diet and trophic role of arctic snow crab snow crabs using stomach content and stable isotope analyses

Lauren Divine, Katrin Iken, and Bodil Bluhm, University of Alaska Fairbanks, School of Fisheries and Ocean Sciences, Fairbanks, Alaska

Snow crab are a dominant benthic species in the Arctic Ocean and a target of valuable commercial fisheries in the adjacent Bering Sea. To improve understanding of the diet and trophic role of snow crab in the Arctic Ocean, individuals of both sexes and a range of sizes were collected from locations in the Chukchi and Beaufort Seas for stomach content and stable isotope analysis. Stomach content analysis indicated differences among locations in prey with polychaetes dominant in some locations, while crabs, amphipods, fish, and bivalves were more frequent in others. Preliminary results of stable isotope analysis also suggested variation in the trophic role of snow crab among locations.

2. National Marine Fisheries Service

Crab divers and hatchery red king crab – a short film

Pete Cummiskey, National Marine Fisheries Service, Alaska Fisheries Science Center, Kodiak Laboratory, Kodiak, Alaska

When the Kodiak fishery for red king crab collapsed in the early 1980s and failed to recover, local fisherman, researchers, Native leaders, industry officials, and others met to evaluate the feasibility of enhancing local stocks through the release of hatchery-cultured juveniles. The Alaska King Crab Research, Rehabilitation, and Biology (AKCRRAB) program was formed to conduct research on cultivation techniques and crab ecology, and to develop release and monitoring strategies. NOAA divers at the Kodiak NMFS Lab conducted a series of field studies, which are documented in this short film produced by Marina Cummiskey, an eighth-grade home-school student.

The film explores the two field studies conducted by the dive team: the preliminary habitat surveys in the spring and fall of 2011, and the first experimental release of red king crab near Old Harbor Alaska in fall 2013. Utilizing underwater video and photographs, the viewer is guided though the field techniques

used to conduct both field experiments. Local crab researchers provide commentary on the project and discuss its implications for the future of rehabilitation of local crab stocks in Alaska waters.

Effects of density on release success for hatchery-reared red king crabs

Chris Long, National Marine Fisheries Service, Alaska Fisheries Science Center, Kodiak Laboratory, Kodiak, Alaska

Stock enhancement is one potential method for restoring depleted stocks of red king crab in locations where, despite lengthy fishery closures, there little indication of increased abundance. An experimental release of young-of-year hatchery-reared red king crab at varying densities was conducted in Trident Basin on Kodiak Island in August of 2014 to investigate the influence of predation and habitat on survival and monitor emigration. Crab were released into plots at four density levels (0, 25, 50, and 75 m^2) and sampling was conducted by divers to monitor survival. Tethering experiments and dive transects for predator monitoring were also conducted to examine the influence of predation. Regardless of outplanting density, initial mortality was high (65–70% at ~10 days postrelease) and decreased dramatically thereafter (~80% at 3 months postrelease). These levels are consistent with wild stocks and include emigration which was detected at 3 to 4 days release. Tethering showed that predation rates decreased through the fall while predator abundance remained the same. These results show that releases can occur at high densities without increasing mortality, loss, or predation risk. Further experiments investigating predator exclusion, conditioning crab to predators, crab size at release, and variation in the timing of release, also have potential for maximizing release success of hatchery-reared crab.

Larval advection in the eastern Bering Sea: research update

Ben Daly and Robert Foy, National Marine Fisheries Service, Alaska Fisheries Science Center, Kodiak Laboratory, Kodiak, Alaska

In the eastern Bering Sea, crab larvae spend months in the water column, implying that they may be transported significant distances from release locations before reaching the settling stage. As such, recruitment of juveniles to a given area is thought to depend on larvae hatched elsewhere. The location of larval release relative to oceanographic processes may be a key determinant in recruitment fluctuations, yet specific transport mechanisms are largely unknown. Oceanographic conditions (temperature, currents, internal waves, fronts, eddies, freshwater runoff, etc.) are linked to climate and thus, temporally variable. These physical processes interact with crab biology (i.e., release location, hatch timing, larval behavior), which makes understanding mechanistic causes for population fluctuations daunting. I highlight the power of biophysical and hydrodynamic simulation modeling as a research tool for improving our understanding of population connectivity and provide an overview of recent and ongoing research that models larval advection trajectories for crab species in the eastern Bering Sea.

***Hematodinium spp.* in Alaska: an overview of parasite distribution, alternate hosts, and research gaps**

Vanessa White, Pamela Jensen, Christie Lang, and Frank Morado, National Marine Fisheries Service, Alaska Fisheries Science Center, Sand Point Laboratory, Seattle, Washington; and Robert Foy, National Marine Fisheries Service, Alaska Fisheries Science Center, Kodiak Laboratory, Kodiak, Alaska

Bitter Crab Syndrome is a disease affecting commercial Tanner crab species, *Chionoecetes bairdi* and *C. opilio.* The causative agent of this disease is a yet to be identified parasitic dinoflagellate species of the genus *Hematodinium*, first reported in Alaskan waters in 1985. Through extensive monitoring efforts in

the eastern Bering Sea over the last 25 years, we identified infected *Chionoecetes* spp. in every year that sampling occurred (19 years); however, the prevalence of *Hematodinium* in these crab populations remains low, rarely exceeding 2%. Additionally, we found that *Hematodinium* has a broad range; infected Tanner crabs were identified in the Arctic Ocean, eastern Bering Sea, Gulf of Alaska and southeast Alaska. In recent years, our sampling efforts have expanded to identify alternate hosts of *Hematodinium* because this parasite is a generalist and other commercially important species could be affected. For example, infections have been confirmed in king crabs (*Paralithodes* spp.) in Russian waters. Over multiple years, we screened several hundred king crabs of *Paralithodes camtschaticus* and *P. platypus* from the eastern Bering Sea and did not identify any *Hematodinium* infections. However, we present data on a potentially important alternate host genus, *Hyas*. Alternate hosts may act as reservoirs aiding in the maintenance in and spread of a parasite to host populations. The range of infected *Hyas* spp. overlaps with that of *Chionoecetes* spp. in the Arctic Ocean, eastern Bering Sea, Gulf of Alaska and southeast Alaska, and the prevalence of *Hematodinium* in both *Hyas lyratus and H. coarctatus* in the eastern Bering Sea exceeds that which has been historically found in *Chionoecetes* spp. in the same region, suggesting potential as a reservoir host. Many crustacean species worldwide are affected by *Hematodinium* spp. associated diseases, but despite decades of research on this parasitic dinoflagellate, significant knowledge gaps still exist including mode of transmission, significance of the disease on various host populations, and the role of environmental cues on disease progression within an individual host and host populations.

3. Alaska Department of Fish and Game

Estimation of size-transition matrices with and without molt probability for Alaska golden king crab using tag–recapture data

M. S. M. Siddeek and J. Zheng, Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau, Alaska; A. Punt, School of Aquatic and Fishery Sciences, College of the Environment, University of Washington, Seattle, Washington; and Vicki Vanek, Alaska Department of Fish and Game, Division of Commercial Fisheries, Kodiak, Alaska

Size-structured models are used for stock assessment of hard-to-age invertebrate populations such as crabs, and size transition matrices play an important role in modeling growth in those models. Crabs grow by moulting and then incrementing in size. Therefore, the size transition matrix estimator should contain the moult and the growth increment submodels. Size transition matrices were estimated using tag–recapture data in an integrated model setting. Unless tag–recaptures are separated by moult and non-moult stages, it will be difficult to estimate the moult probability unequivocally. We have that situation with the golden king crab (*Lithodes aequispinus*) tag–recapture data from the eastern Aleutian Islands region. We considered a logistic moult probability and normal growth increment models for the size transition matrix estimator. We used a number of diagnostic statistics (e.g., covariance matrix, AIC, L^2 (Euclidean) cell-by-cell distance metrics; tag recapture, CPUE, mature male biomass, and length frequency fits) to investigate the estimator without the moult probability (scenario 1) and with the moult probability (scenario 2) submodel. The two size transition matrices describe different patterns and scenario 2 estimate of size transition matrix is biologically plausible and fits the data significantly better than scenario 1.

Growth, movement, and habitat of Norton Sound red king crab

Jenefer Bell, Alaska Department of Fish and Game, Division of Commercial Fisheries, Nome, Alaska

We examined spring/summer movement, size composition, potential essential habitat, and handling of Norton Sound red king crab *Paralithodes camtschaticus.* From 2012 to 2014*,* a total of 19,489 crab were tagged and released, of which 1,384 were recovered over three years by crab fishermen and observers. Examination of tag recovery locations suggests Norton Sound red king crab is a single population that is harvested throughout regional commercial fishing areas. Contrary to prior understanding, our evidence suggests not all legal crab move from nearshore winter habitat to offshore summer habitat in a given year. Consequently, brood stock remaining in nearshore waters may be protected from harvest because regulatory closures prohibit summer commercial fishing within nearshore waters. We examined size composition data and found the proportions of legal crab within size classes were consistent with prior assumptions. However, we collected growth information over two years and have demonstrated that sublegal crab have a larger molt increment than legal crab, which may help redefine the carapace lengths used to establish prerecruit size classes to more accurately predict future recruitment into the fishery. We have identified potential essential habitat and locations of higher abundances of nontarget crab: waters around Cape Nome and between Topkok Head and Rocky Point. These areas have higher incidences of sublegal and female crab than other areas in eastern Norton Sound, suggesting possible breeding/rearing areas. We have also located areas with higher abundances of nontarget crab on the commercial fishing grounds. Incorporating this information into fisheries management may enable us to refine fishing locations to minimize the handling of nontarget red king crab.

Temporal changes in spatial distribution of Bristol Bay red king crab in the eastern Bering Sea and their implications for fisheries management

Jie Zheng and M. S. M. Siddeek, Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau, Alaska; and Gordon H. Kruse, School of Fisheries and Ocean Sciences, Juneau Center, University of Alaska Fairbanks, Juneau, Alaska

Annual summer trawl survey data show that spatial distributions of Bristol Bay red king crab, *Paralithodes camtschaticus*, changed greatly over time. Large mature female red king crab (≥105 mm carapace length) primarily occurred in southwestern Bristol Bay before 1977, and their distributions shifted to central and northeastern Bristol Bay in the late 1970s and early 1980s. Mature female red king crab have been found primarily in central Bristol Bay since the early 1980s. The distribution centers of large mature females moved south slightly from 1988 to 1990, 1999 to 2000, 2009, and 2012 to 2013, but did not reach the southern locations previously occupied in the 1970s. Temporal changes in spatial distribution appear to be associated with changes in bottom water temperature; northward movements occurred during a warm period. Shifts in spatial distribution may be confounded somewhat with a sharp decline in abundance during the early 1980s, but the distribution shifts occurred before the large decline. Northward shifts of mature females may partly explain recruitment variation. Ocean currents likely favor delivery of larvae to prime nearshore nursery areas from hatching sites in southern Bristol Bay. Northward shifts in spatial distributions of mature females make it difficult to supply larvae to the southern portions of their range, and a proportion of the larvae hatched in central Bristol Bay may be carried beyond the northern boundary of the juvenile nursery areas. The northward spatial shifts resulted in a decline in productivity associated with lower recruitments, low spawning biomasses, and reduced total allowable catches.

Mapping Tanner crab habitat in the Kodiak area of the Gulf of Alaska

Carrie Worton, Alaska Department of Fish and Game, Division of Commercial Fisheries, Kodiak, Alaska

This project used the wide-angle seafloor sonar profiler (WASSP) multibeam system and a towed benthic imaging system (CamSled) to deliver full-coverage maps of bathymetry and seafloor acoustic backscatter and to provide both classified substrates and biological observations for Tanner crab habitat for two important areas northeast of Kodiak Island in the Gulf of Alaska. The WASSP multibeam system worked as expected, delineating substrate types and bottom features consistently, while the CamSled delivered high-resolution images of the bottom for ground truthing. Classification tree analysis was used to predict substrate type from acoustic data. Depth was the main parameter for delineating substrate types, although hardness, slope, rugosity, and aspect also contributed to the final classifications. Mud-mud and mud-sand were the preferred substrate types for Tanner crab (*Chionoecetes bairdi*) in Marmot Bay, while they were found exclusively in mud-mud substrates in Chiniak Bay. As a result, Tanner crab habitat was estimated at 85% of the survey area for Marmot Bay and 56% of the survey area for Chiniak Bay. Mud sediments and epifauna play an important role in Tanner crab presence. For a benthic species like Tanner crab, understanding the relationships between habitat and abundance is essential for extrapolating population density estimates to larger scales. This information will be used to increase understanding of the spatial distribution of Tanner crab and their habitat and will aid in interpretation of stock assessment data.

Feasibility of direct age determination in commercially important crustaceans in Alaska

Raouf Kilada[1], Joel Webb[2], Laura Stichert[3], Quinn Smith[2], and Kevin McNeel[2]

[1] University of New Brunswick, Biology Department, St. John, New Brunswick, Canada
[2] Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau, Alaska
[3] Alaska Department of Fish and Game, Division of Commercial Fisheries, Kodiak, Alaska

Management of commercially important crab and shrimp stocks in Alaska has been hindered by the inability to directly determine individual age. A lack of comprehensive age information leads to poor understanding of life history schedules, difficulty in estimation of parameters necessary for modeling population dynamics, and uncertainty in the determination of appropriate harvest levels. This study evaluated the feasibility of applying a novel direct age determination method based on band counts in thin sections of gastric mill ossicles of red king crab (*Paralithodes camtschaticus*) and Tanner crab (*Chionoecetes bairdi*), and in the eyestalk of spot shrimp (*Pandalus platyceros*). Molting in captivity confirmed that the gastric mill of red king and Tanner crab were retained through ecdysis. The endocuticle region of the cuticle, where bands are formed, was identified in the gastric mill of the crabs and eyestalks of both crab and shrimp by histological staining. Gastric mills of crab and eyestalks of shrimp were processed by standard techniques similar to otoliths or scales in fish. Visible bands were present in these structures and band counts generally increased with increasing body size in all species. Controlled experiments to understand the band formation processes and application of this technique to known-age individuals will be necessary to validate band counts as indicators of chronological age.

Dungeness pot survey and spatial monitoring of sea otter bycatch in the Kodiak area

Carrie Worton, Alaska Department of Fish and Game, Division of Commercial Fisheries, Kodiak, Alaska

In a collaborative effort between ADF&G and the U.S. Fish and Wildlife Service, we conducted a Dungeness crab *Metacarcinus magister* pot surveys on the east side and south side of Kodiak Island

using an ADF&G research vessel to document Dungeness crab presence and sea otter bycatch in Dungeness pots. The goal was to assess Dungeness crab population distribution and abundance and concurrently determine the extent of sea otter bycatch and interactions with Dungeness crab pot gear. Little information is available on the current condition of the Dungeness stocks in the Kodiak Area, as the last Dungeness crab survey was done in 1986. In 2005, the U.S. Fish and Wildlife Service listed the Southwest Alaska distinct population segment of northern sea otter *Enhydra lutris kenyoni*, which includes the sea otters occupying the Kodiak Archipelago, as threatened under the 1973 Endangered Species Act. The recovery plan for the Southwest Alaska sea otter stock cites incomplete information regarding the level and incidence of bycatch in directed fisheries, but it's known that shallow-water pot fisheries have potential to entrap otters. Our approach was to conduct a Dungeness pot survey in three areas important for the Kodiak Area commercial Dungeness fishery: Ugak Bay, the Trinity Islands, and Alitak Bay. Dungeness crabs were enumerated, and biological data from Dungeness crabs as well as any sea otters observations and gear interactions were recorded. Sea otter surveys were conducted to determine presence of sea otters in the area during the pot survey for Dungeness crabs. Additional projects conducted during the survey included using a small trawl net to supplement abundance data information of Dungeness crabs, tagging of Dungeness crabs to determine movements and growth increments, and ancillary data on temperature and salinity conditions in the area. A Dungeness crab survey will supply baseline information about Dungeness crab stocks in important areas fished around Kodiak Island and the potential for sea otter bycatch. Preliminary results will be presented.

PLANS FOR 2015

The annual Alaskan crab research meetings continue to be productive and valuable for free exchange of scientific results, ideas, and perspectives. A twentieth annual meeting is scheduled for the approximate dates of December 15–16, 2015, in Anchorage, Alaska.

PROPOSALS FOR NEXT YEAR'S SPECIAL TOPIC

1. Oceanographic modeling and crab recruitment
2. Effects of disease/parasites on crab
3. Existing data and methods for investigation of stock structure
4. Methods for tagging/marking crustaceans
5. Application of habitat indices in assessment for crab stocks

RESEARCH PRIORITIES FOR TANNER CRAB IN ALASKA

This section summarizes research priorities Tanner crab stocks in Alaska. These priorities were identified by managers/researchers during the topic session or during group discussion at the 2014 Interagency Crab Meeting and reviewed by stakeholders following the meeting. These priorities build on prior summaries for commercially important crab stocks in Alaska (Webb and Woodby 2011) and a workshop which identified hypothetical physical and biotic drivers of year-class strength for Tanner crab in Bristol Bay (Tyler and Kruse 1997).

POPULATION ESTIMATION

1. Develop age determination methods for conversion from the length to age-based stock assessment methods.
2. Improve abundance estimates by addressing uncertainties in area-swept estimates related to setting harvest quotas for Kodiak/Peninsula area Tanner crab.

3. Evaluate survey methods and reduce uncertainty in assessment for Southeast Alaska Tanner crab.

STOCK PRODUCTIVITY

1. Determine sex-specific growth rates and potential variation in both growth rates and weight-at-size with environmental variability for the eastern Bering Sea.
2. Examine the effect of temperature on duration of embryo development and hatching success, and the potential importance of offset in primiparous/multiparous hatch timing in relation to *in situ* food availability and larval survival.
3. Elucidate the role of density-dependent and density-independent drivers in recruitment variability for the eastern Bering Sea.
4. Continue examining size at maturity including differences among stocks, temporal trends, harvest effects, environmental factors influencing growth, and age or size at which molt to maturity is determined.
5. Determine how long-term changes in temperature and ocean acidification will affect productivity of all stocks.
6. Investigate natural fluctuations in pH, and interactive effects of pH and temperature on survival and condition across life stages, along with possible adaptation to acidification.
7. Improve understanding of recruitment variability and potential covariates among stocks in Southeast Alaska.
8. Characterize natural variability in female reproductive potential as a context for understanding potential fishery effects on mating success, including sex ratio at the time of mating, resilience to sperm limitation, and fertilized egg production in the eastern Bering Sea.

STOCK STRUCTURE

1. Improve understanding of population genetic structure among stocks in Alaska (Southeast Alaska, Gulf of Alaska, Alaska Peninsula/Aleutian Islands, and east vs. west of 166°W in the eastern Bering Sea) using modern nucleotide-based techniques.
2. Evaluate development of a spatial stock assessment model for eastern Bering Sea Tanner crab to better align the federal annual catch limit determination process with the State of Alaska harvest strategy (which manages this population as two unit stocks east and west of 166°W), and include a tagging study to investigate potential movement of Tanner crab these areas.
3. Re-evaluate current use of $F_{35\%}$ as an overfishing proxy for stocks with a terminal molt (i.e., snow and Tanner crabs).
4. Conduct tagging studies to elucidate movement patterns for stocks in Southeast Alaska.

MORTALITY AND HARVEST

1. Continue to investigate the impact of *Hematodinium spp.* on mortality including prevalence, intensity, transmission, chronic (sublethal) vs. acute effects, and the role of environmental covariates.
2. Examine predator-prey relationships and their influence on survival of juveniles to harvestable size for all Tanner crab stocks.
3. Investigate the contribution of predation, disease, and environmental factors to natural mortality for all stocks.

REFERENCES CITED

Tyler, A. V., and G. H. Kruse. 1997. Modeling workshop on year-class strength of Tanner crab, *Chionoecetes bairdi*. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Regional Information Report 5J97-02, Juneau.

Webb, J. B., and D. Woodby. 2011. Long-term Alaska crab research priorities, 2011. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 5J11-04, Juneau.

APPENDICES

Appendix A.–List of participants at the 2014 Interagency Crab Research Meeting.

Last Name	First Name	Affiliation	Location	Email
Armistead	Claire	NMFS	Kodiak	claire.armistead@noaa.gov
Baechler	Britta	ADF&G	Dutch Harbor	britta.baechler@alaska.gov
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Bevaart	Kayla	ADF&G	Kodiak	kayla.bevaart@alaska.gov
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Ridgway	Michelle	ADOSI	Juneau	lridgway@alaska.edu
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Siddon	Chris	ADF&G	Juneau	chris.siddon@alaska.gov

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Last Name	First Name	Affiliation	Location	Email
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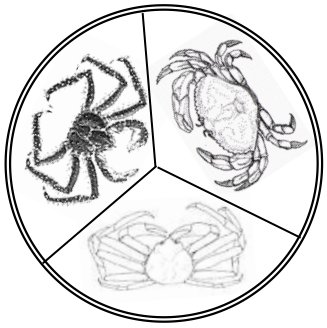
Zheng	Jie	ADF&G	Juneau	jie.zheng@alaska.gov

Interagency Crab Research Meeting
December 16th -17th, 2014



All sessions will be held in Harbor Room on the ground floor of the Best Western Kodiak Inn. All talks are scheduled for 20 minutes unless otherwise noted.

TUESDAY, DECEMBER 16

Morning Session 8:00 AM – 12:00 PM

I. Introductions
II. Opening Remarks: Chris Siddon, Bob Foy
III. Meeting Agenda: Modify and Adopt
IV. Research Review
   A. Special Topic Session – Primary drivers and key uncertainties affecting Tanner crab abundance and fishery management in Alaska.
      1. Population Estimation
         (1) Eastern Bering Sea Tanner crab – Buck Stockhausen, National Marine Fisheries Service, Seattle, WA
         (2) Kodiak/Peninsula Tanner crab – Spalinger/Stichert, Alaska Department of Fish and Game, Kodiak, AK
         (3) Southeast Alaska Tanner crab – Katie Palof, Alaska Department of Fish and Game, Juneau, AK
      2. Stock Productivity
         (1) Differences between primiparous and multiparous Tanner crab reproductive cycles – Kathy Swiney, National Marine Fisheries Service, Kodiak, AK
         (2) Tanner crab growth: data supporting eastern Bering Sea stock assessment – Bob Foy, National Marine Fisheries Service, Kodiak, AK

Mid-morning Coffee (10 minutes)

         (3) Bering Sea fisheries research foundation and Tanner crab growth experiments – Scott Goodman, Bering Sea Fisheries Research Foundation, Seattle, WA
         (4) Variation in size at maturity of eastern Bering Sea Tanner crab: Implications for fishery management – Doug Pengilly, Alaska Department of Fish and Game
         (5) Tanner crab reproductive potential – Laura Stichert, Alaska Department of Fish and Game, Kodiak, AK
         (6) Effects of ocean acidification on different life history stages of Tanner crab – Kathy Swiney, National Marine Fisheries Service, Kodiak, AK
      3. Mortality and Harvest
         (1) Prevalence of *Hematodinium sp.* in southern Tanner crab in the eastern Bering Sea vs. Southeast Alaska – Pam Jensen, National Marine Fisheries Service, Seattle, WA

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Lunch Break (1.5 hours)

Afternoon Session (1:30 – 4:30 PM)

(2) Incorporating disease effects in Tanner crab stock assessment – Chris Siddon, Alaska Department of Fish and Game, Juneau
(3) Estimating discard mortality in the Bering Sea Tanner crab fishery – Dan Urban, National Marine Fisheries Service, Kodiak, AK
(4) Discussion of Tanner crab research priorities (30 minutes)

B. University of Alaska

(1) Spatial variability in size at maturity and reproductive timing for golden king crab (*Lithodes aequispinus*) in Southeast Alaska – Andrew Olson, University of Alaska Fairbanks, Juneau, AK
(2) Development of biochemical measures of age in the Alaskan red king crab: validation, refinement and initial assessment – Ginny Eckert, University of Alaska Fairbanks, Juneau, AK

Mid-Afternoon Coffee (10 minutes)

(3) Dietary lipids improve the nutrition and condition of red king crab larvae (*Paralithodes camtschaticus*) – Asia Beder, University of Alaska Fairbanks, Juneau, AK
(4) Influence of temperature and congener presence on blue king crab (*Paralithodes platypus*) habitat preference and fish predation – Courtney Lyons, University of Alaska Fairbanks, Juneau, AK
(5) Reproductive and molting physiology of the northern spot shrimp, *Pandalus platyceros* – Esther Bower, University of Alaska Southeast, Juneau, AK
(6) Diet and trophic role of Arctic snow crab – Lauren Divine, Univerisity of Alaska Fairbanks, Fairbanks, AK

5:00 PM – Good times! Social opportunity to be announced.

WEDNESDAY, DECEMBER 17

Morning Session 8:30 AM – 11:30 AM

C. National Marine Fisheries Service

(1) Crab divers and the hatchery red king crab - A short film – Pete Cummiskey, National Marine Fisheries Service, Kodiak, AK
(2) Effects of density on release success for hatchery-reared red king crabs – Chris Long, National Marine Fisheries Service, Kodiak, AK
(3) Larval advection in the eastern Bering Sea: research update – Ben Daly, National Marine Fisheries Service, Kodiak, AK

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(4) *Hematodinium sp.* in Alaska: an overview of parasite distribution, alternate hosts and research gaps – Vanessa White, National Marine Fisheries Service, Seattle, WA

D. Alaska Department of Fish and Game

(1) Estimation of size-transition matrices with and without molt probability for Alaska golden king crab using tag–recapture data – Shareef Siddeek, Alaska Department of Fish and Game, Juneau, AK

(2) Growth, movement, and habitat of Norton Sound red king crab – Jenefer Bell, Alaska Department of Fish and Game, Nome, AK

Mid-morning Coffee (10 minutes)

(3) Temporal changes in spatial distribution of Bristol Bay red king crab in the eastern Bering Sea and their implications for fisheries management (25 minutes) – Jie Zheng, Alaska Department of Fish and Game, Juneau, AK

(4) Mapping Tanner crab habitat in the Kodiak area of the Gulf of Alaska – Carrie Worton, Alaska Department of Fish and Game, Kodiak, AK

(5) Feasibility of direct age determination in commercially important crustaceans in Alaska – Joel Webb, Alaska Department of Fish and Game, Juneau, AK

(6) Dungeness pot survey and spatial monitoring of sea otter bycatch in the Kodiak area – Carrie Worton, Alaska Department of Fish and Game, Kodiak, AK

V. Next Year's Meeting and Special Topic Suggestions

VI. Other Business