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Summary Of The Interagency Crab Research Meeting Held December 15-17, 2004

by

Peter G. van Tamelen

and

Doug Woodby

May 2005

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

Symbols and Abbreviations

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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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PURPOSE

This report summarizes the eleventh annual interagency crab research meeting, held December 15–17 in Anchorage at the Hilton Anchorage Hotel. 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[1]," an agreement between the National Marine Fisheries Service (NMFS) and the Alaska Department of Fish and Game (ADF&G). This meeting continued the tradition of providing an informal opportunity for researchers from each of the active crab research centers to present their latest work on Alaskan crab species among peers. The meeting opened with a half-day session devoted to larval ecology and dynamics with particular reference to crabs and fisheries issues.

PARTICIPANTS

The 2004 meeting was attended by over 50 participants representing ADF&G, NMFS, the North Pacific Fishery Management Council (NPFMC), the School of Fisheries and Ocean Sciences of the University of Alaska Fairbanks (UAF), University of Alaska Southeast (UAS), Oregon State University (OSU), the Prince William Sound Science Center (PWSSC), and the United States Geological Survey (USGS). A list of participants and contact information is included in Appendix 1.

PRELIMINARIES

The meeting was jointly chaired by Doug Woodby, Russ Nelson and Peter van Tamelen, with audio-visual operations managed by Peter van Tamelen. Following staff 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 faithfully summarize the material presented. The authors of this report accept responsibility for errors in interpretation.

SUMMARY OF PRESENTATIONS

The order of presentations follows the agenda (Appendix 1), which was organized roughly by topic and then agency and region.

SPECIAL TOPIC: LARVAL ECOLOGY AND DYNAMICS

An overview of life histories and larval ecology—Ginny Eckert (University of Alaska Southeast/University of Alaska Fairbanks)

Many marine life histories, including crabs, are complex involving both planktonic and benthic phases. Larvae are usually planktonic while adults are often benthic. Settlement is the instantaneous and irreversible transition from a planktonic existence to a benthic one. Recruitment is defined by ecologists as the first appearance of settlers whereas the fisheries definition of recruitment is when individuals first appear in the fishery. The question that should be addressed in most studies, both ecological and fisheries, is what are the critical stages in the

[1] Appendix A of the Fishery Management Plan for the Commercial King and Tanner Crab Fisheries of the Bering Sea/Aleutian Islands, July 18, 1998.

life histories of the organism in question. In many cases this will probably be the larval and recruitment (ecological sense) stages. Another important question that can be addressed with larval ecology is to what degree populations are connected with each other and with the "outside". Two types of marine life histories can be identified, open, where larvae are broadcast into the ocean, and closed, where larvae or young maintain a benthic existence. All Alaskan crab species have open life cycles and have reproductive strategies involving many small eggs with long planktonic duration and high mortality. The planktonic phase is often "blamed" for many population fluctuations but there is little empirical evidence to support the notion that either adult populations or recruit populations (ecological sense) vary with longer planktonic durations. It may be that closed populations also vary greatly for other reasons, and that variations in open populations are dampened by connections with other populations. An additional point is that population variation may be related to fecundity with high fecundity leading to large population variation. Ginny is currently investigating the relationship between larval supply and recruitment in Dungeness crabs in Glacier Bay. In many species strong recruitment (ecological sense) leads to higher adult populations but there are also many cases where this does not hold true. There are 4 models that can explain variation in recruitment that are based upon postsettlement competition and whether recruitment is modified by postsettlement processes.

Oceanography and larval behavior: larvae as clever balloonists— Alan Shanks (University of Oregon, Oregon Institute of Marine Biology)

The life cycle of a barnacle is similar to that of a crab except the barnacle larval stage lasts only about 2 weeks and swimming speeds are slower (mm/s) compared to crabs (cm/s). Even with the relatively fast swimming speeds of crab larvae, it would seem that larvae are at the mercy of the currents. There are several problems facing a larva including 1) avoid being eaten, 2) find enough to eat, and 3) control transport by currents. But how can they control transport by currents if they swim so slowly? Why should they control transport? One reason to control transport is to avoid the bottom that is usually full of predators and current speeds are slower. Larvae also do not want to disperse too far from future settlement sites, but what is too far? Too far can be thought of as both cross shore (out to sea and back) and along shore (up and down the coast). Species have been around for long enough to develop tricks to increase the chance of larval survival especially given the strong selective pressure. Although larval swimming speeds are much slower than horizontal current speeds, they are generally faster than vertical current speeds. Currents in the ocean often go in opposite directions at different depths, so larvae may be able to take advantage of this like a balloonist. Therefore, we need to know where larvae are found over a day or over their ontogeny. Cross shore transport features and techniques include Langmuir circulation cells driven by diurnal winds and katabatic winds. *Cancer* crab larvae in California and possibly in Oregon migrate vertically but the pattern changes with larval ontogeny and place (on vs. off the shelf). This brings the larvae first out in the ocean and then back inshore over their planktonic period. Upwelling and downwelling can occur nearshore and larvae may or may not be drawn offshore or pushed onshore depending on behavior and specific characteristics of each event. Internal tides are waves that occur below the surface of the water due to tidal action and these may transport larvae effectively. There are other cross shore transport mechanisms that were not discussed. Alongshore transport has received less attention and is a more difficult topic. The problem with alongshore transport is that species will tend to be carried away from suitable habitats over successive generations if the transport is always in the same direction. It appears that organisms have developed local methods of reducing alongshore transport including larval timing and behavior. In summary, larvae are similar to balloonists and have come up with many different methods of utilizing the complex, but somewhat predictable, oceanography in which they find themselves. In some ways larval dispersal may be better thought of as a periodic cyclic movement or migration rather than dispersal where larvae are simply scattered. Working with oceanographers can be frustrating because many biological problems involve non-standard oceanography (particles are not passive vertically, internal tides are important, as are currents at the surface, near the bottom, and right next to shore). Thus, the biologist needs to drive the oceanography rather than just using the standard oceanographic measurements.

Larval perspectives on fisheries— Steve Gaines (University of California Santa Barbara, Marine Science Institute)

Why do we care about larvae? Larvae are probably a major contributor of the variation we observe in natural populations. Many fisheries models were developed with the notion of a good correlation between the number of adults and the subsequent number of babies, as you might expect with deer. However, this is rarely the case with fish and this is possibly due to the fact that we do not know where the larvae come from and that we often look at things on the wrong spatial scale. Currently there are 3 approaches to determining the appropriate scale of observation based upon larval dispersal distances, 1) genes, 2) math, and 3) chemistry. Genetic techniques have been worked out long ago but they fail when dispersal is large. Dispersal distances of fish are probably the largest of all groups of organisms. Seaweeds and invertebrates have generally lower dispersal distances than fish and terrestrial dispersal distances are less than marine over all taxonomic scales. Dispersal also appears to increase with trophic level and varies among competitors. Using math, people have modeled larval transport with some success. A promising technique, however, is to use microchemical tracking in otoliths or other hard parts. For example, as a fish grows so does its otoliths that incorporate trace elements of the water body in which the fish is swimming. Theoretically, a person could determine the geographic course a fish has taken just from careful examination of its otolith. Given the large disparity of dispersal distances, what scale is appropriate for measuring stock and recruitment? If we measure on the appropriate scale we may see a stock recruitment relationship but we may not because variation can be produced by many other factors, particularly physical factors. Many ecological experiments have been carried out over a very limited scale, but recently Steve and others (PISCO) have been doing the same experiments over larger scales from Washington to southern California. Recruitment of many organisms varies over the latitudinal gradient and can be related to physical oceanography. This variation has surprisingly little effect on adult abundance of species that are not harvested. The main reason is that the variation in recruitment drives variation in the abundance of predators. These patterns in unfished populations have important implications when humans are the predator since the rate of harvesting must scale with the rate of recruitment. When we are ignorant of the spatial pattern of recruitment, setting rates of harvest is difficult task. Recruitment also varies over time and is also related to physical oceanography, but the response has not been consistent along the entire coastline and was only observed in the central portion. So can we use model species? There are groups of species that all seem to do the same thing but then there are other species that do not fit the pattern or whole other groups that do things completely differently. The key is to find model species that have similar patterns to your target species.

Clearly, larval supply is a very complex topic and there are several different approaches marine organisms can utilize to solve problems. Studying larvae is very difficult. Marine reserves can function to encompass this variation and may be a good method to incorporate various life history patterns and dispersal distances into a management scheme. Reserves that are designed on scales that are similar to the dispersal distances of the majority of species you are managing may have the greatest positive impact on the most species.

CONTRIBUTED TALKS

Roomful o' blues: hatch timing and embryonic development of the blue king crab, *Paralithodes platypus*— B. Stevens (NMFS-AFSC)

Using female blue king crabs (BKC) from the Pribilof Islands, the research objectives were to observe the embryonic development of BKC eggs, hatching timing, and length of hatching. Egg size decreases for about 90 days and then steadily increases. The embryo is distinguishable around day 120, and eye pigment appears after day 180. Staging the embryos is difficult as there is no standard system. Females were individually held at 3 temperatures (2, 3.5, and 5°C) and hatched larvae were collected daily. Larvae counts were estimated using volumetric methods. Hatching started at the end of February and lasted until mid May and required an average of 28 days for each individual. Crabs held at warmest temperatures (5°C) hatched earlier, but the results may be confounded by capture date and holding time. There was no difference between crabs held at 2°C and 3.5°C. An average of about 140,000 larvae were released per crab. King crabs have the longest hatching time of any crab and BKC fit this pattern. Is this due to oxygen gradients in egg masses or a strategy of "diversified bet hedging"? Brad is planning on testing the oxygen gradient idea next year.

Development of cultivation techniques for larval blue king crab, *Paralithodes platypus*—S. Persselin (NMFS-AFSC)

Collected 720 larvae from 3 females and cultured under different conditions of food, larval density, and water temperature. Diet treatments included *Artemia* enriched on the live diatom *Thalassiosira nordenskioeldii* or on frozen *Isochrysis* paste, *T. nordenskioeldii* fed in conjunction with newly-hatched *Artemia*, and larvae receiving no food. There were six temperature treatments at 6°C, one treatment at 3°C, and one at 9°C. Finally, larval density treatments included one at 20 larvae/beaker, one at 40 larvae/beaker, and six at 10 larvae/beaker. All unfed larvae died (therefore, BKC larvae are not lecithotrophic), and larvae fed *Artemia* in conjunction with *T. nordenskioeldii* had the best survival (92%). There seemed to be an upper density limit of about 16/L because the highest density treatment fell to a density similar to the mid-density treatment. Larvae at lower temperatures and higher densities had longer development times, but there was no effect of high temperatures and food type on development rates. The study indicates that a 6°C temperature is adequate, a density of 16 larvae/liter is sustainable, and a diet of diatoms fed along with *Artemia* results in a high rate of survival. The diatoms may also increase survival rates by decreasing nitrogenous wastes and carbon dioxide and enhance oxygen in beakers.

The effect of temperature on embryonic development, hatching, and spawning of eastern Bering Sea snow crab— J. Webb (UAF)

Collected embryos monthly from female snow crabs held at temperatures ranging from minus 1° C to 6°C and determined their developmental stage. Also followed hatching of larvae. Embryos held at lower temperatures took longer to develop than embryos at higher temperatures. There was some evidence of diapause at 1°C and 3°C, but all crabs conformed to an annual cycle suggesting a cycle is established early on by the females. There was no consistent effect of temperature on hatch duration and this averaged about 10 days. There was considerable individual variation in the pattern of larval release with the highest release rates occurring at the beginning, end, and middle of the hatch period. Subsequent egg extrusion was successful at intermediate temperatures but failed at both highest (6°C) and lowest (-1°C) temperatures.

Supply and settlement of *Cancer magister* megalopae in Glacier Bay National Park—H. Herter (UAF)

Most adult Dungeness crabs are found near the mouth of the bay. During a summer survey, few Dungeness larvae were found in the bay using light traps, but megalopae are abundant in Bartlett Cove in fall so it appears that zoea migrate out of the bay in early summer and megalopae enter in fall. Using a combination of light traps and settlement collectors (Tuffies), several questions will be addressed including an assessment of the geographic supply of megalopae and settlement rates, the vertical distribution of megalopae, the tidal timing of megalopae immigration, and the relative importance of settlement and post-settlement processes in determining adult densities. Study sites are Bartlett Cove, the North Beardslee Islands, and the South Beardslee Islands. Preliminary work has found that megalopae are most abundant in Bartlett Cove, are found near the surface, and enter the bay at night during flood tides.

Northward transport of Dungeness crab larvae to Alaska from the west coast of the U.S. and Canada—W. Park (UAF)

Dungeness crab larvae were sampled in Icy Strait near Glacier Bay and off Icy Point in outside waters in southeastern Alaska and classified into 2 groups: early stage (ZI-ZII) and late stage (ZIV-M). There was a higher proportion of late stage larvae offshore compared to Icy Strait while temperatures were similar. Current and wind patterns suggest that these late stage larvae are transported from southern areas rather than originating in northern southeast Alaska. Buoy drift tracks confirm that larvae released off Washington and British Columbia during the peak hatching season will be late stage larvae found while larvae in southeast Alaska start to hatch. The peak hatching season is much later in northern southeast Alaska. There was a large amount of interannual variation in the proportion of late stage larvae near Icy Point.

Circulation into Kachemak Bay: does it affect crab populations?—S. Pegau (Kachemak Bay Research Reserve, Homer)

There have been several crab population crashes in Kachemak Bay and we do not know much about the circulation patterns. There are some eddies and some input from the Alaska Coastal Current. Modeling work by Dave Musgrave and Kate Hedstrom have shown there are seasonal variations in flow patterns around Kachemak Bay with intrusions from the ACC occurring periodically in late summer and fall. Oceanographic sampling supports the idea that there is little connection between the Gulf of Alaska/Lower Cook Inlet and Kachemak Bay in spring but that a connection may occur later in the summer. Crab larvae were most evident in Cook Inlet and Kachemak Bay in September, and this would be the appropriate time if larvae were to be successfully transported in Kachemak Bay prior to settlement.

Recruitment variation of eastern Bering Sea crabs: 'climate-forcing' or 'top-down' effects?—J. Zheng (ADF&G, Juneau)

Recruitment in Bering Sea crab stocks is highly variable and are mostly uncorrelated with each other. However, the recruitment of some stocks are correlated with environmental indices (e.g., Bristol Bay red king crab with the Aleutian Low index). Crab distributions have changed over the years and these may be related to regime shifts, and these distributional changes may make it difficult for larvae to recruit back to the stock. Tanner crab recruitment is correlated with NE wind speeds, giving more support for climate forced recruitment levels. A very large portion of juvenile snow and Tanner crabs are eaten by Pacific cod and this may affect recruitment as well. Upon review of juvenile crab abundance and distributions relative to major predator abundances and distributions, it is quite possible that predators control recruitment levels to some extent. In the 1960s, all 6 crab recruitment levels were strong when groundfish were rare. There is a negative relationship between Bristol Bay red king crab and Pacific cod and yellowfin sole. Most strong snow/Tanner crab year classes might result from a spatial mismatch between Pacific cod and snow/Tanner crabs. Sometimes (e.g. Pribilof Islands blue king crab) one predator may be replaced by a different predator, limiting recruitment. Recruitment in crab stocks is a function of many things including spawning biomass, fishing, larval supply, and predation and no one factor can fully explain recruitment variation.

Seledang Ayu wreck—F. Bowers (ADF&G, Dutch Harbor)

Forrest gave a brief slideshow and overview of the recent freighter wreck near Unalaska Island. The freighter has spilled close to one-half million gallons of bunker C fuel so far since it ran aground and broke in half. It looks like both sections are collapsing under their own weight and may sink. In addition to the oil, the spilled soy beans may also constitute a threat to marine organisms in the future. The helicopter crash was probably caused by water entering the air intakes as the helicopter was hovering over the wreck. The wreck and subsequent spillage may affect the upcoming Tanner crab fishery in this area. *(Editor's note: Makushin and Scan Bays on Unalaska Island were closed to Tanner crab fishing because there were undetermined amounts of oil in those bays).*

Status and future of industry cooperative crab research—G. Stauffer (NMFS-AFSC)

There is strong support for cooperative research projects form various groups including NMFS, Congress, ICES, NRC-NAS, US Commission on Ocean Policy, and the NPFMC. There have been some mandates and funding to initiate cooperative research. Starting in 1995 there has been interest in Bering Sea crab cooperative research and this interest has resulted in the formation of the Bering Sea Fisheries Research Foundation (BSFRF) with the first survey conducted in July 2004. BSFRF is composed of 100 vessels, 8 processors, 4 CDQ groups, and 1 community. The board has 12 members. Their goal is to determine the best scientific approach for management of crab fisheries to conserve and produce optimum yield over the long-term. They are a significant source of funds, contributing $100,000 in 2004 and project $200,000-300,000 in 2005. NMFS is also contributing $100,000/year. BSFRF has outlined a number of research objectives that are mostly focused on improving stock assessment techniques.

Hematodinium: past, present and future—F. Marado (NMFS-AFSC)

Diseases similar to bitter crab syndrome can now be found in most oceans in the world and is apparently spreading to other species and becoming more prevalent. Pam Jensen and Frank are developing molecular methods to identify the number of species involved and for improved disease diagnosis and characterization of the parasites life history. Pam and Frank are currently focusing on comparing sequences of the SSU rDNA for species identification and development of a PCR protocol for diagnostics. Thus far, genetic analysis suggests that there is just one species of *Hematodinium* that exists worldwide. In the eastern Bering Sea, bitter crab is most prevalent among both Tanner and snow crabs as juveniles. This is also apparently the case in Newfoundland, but prevalence levels there are highly variable geographically.

Westward region research roundup—D. Pengilly (ADF&G, Kodiak)

Doug gave a quick rundown of recent projects in the Westward region

Bering Sea-Aleutian Islands

- 2004 triennial St. Matthew blue king crab pot survey: Leslie Watson
- 2004 Bering Sea test fish projects: Skip Gish

  Pribilof Island king crab pot survey not done this year but will be done next year.

  Tag recoveries from 2004 Bristol Bay red king crab fishery
- NMFS-ADFG opilio study finishing analyses of reproductive cycle, biennial spawning, molt timing, terminal molt, stock reproductive potential, data collection: Kirsten Gravel, Doug Pengilly, Lou Rugolo, and Rich MacIntosh
- Completed *Biological Field Techniques for Lithodid Crabs*: Susie Byersdorfer
- Many reports are out or are coming out.
- Observer Database Management and Analysis–database updated: Ryan Burt, Rachel Alinsunurin, Ric Shepard, Dave Barnard
- Shellfish Observer Program: Mary Schwenzfeier, Shari Coleman, Melissa Salmon

Regional Biometrics

- Annual abundance estimates for Bering Sea king crabs: Ivan Vining
- Analyses for proposed revision of harvest strategy for peninsula Tanner crab: Ivan Vining, Dan Urban

Gulf of Alaska Research, Dan Urban and Carrie Worton

- Tanner crab as prey for groundfish
- Kodiak Dungeness size at maturity
- Hydroacoustic marine habitat mapping
- Annual Westward bottom trawl survey: Kally Spalinger

  Tanner crab, tagging, egg clutch sampling, and hemolymph sampling

St. Matthew Island blue king crab surveys—L. Watson (ADF&G, Kodiak)

This was the 4th Triennial pot survey to determine distribution and abundance on a finer scale than the trawl survey, determine female reproductive timing, examine onshore-offshore breeding migrations, and continue tagging studies. This survey consisted of 702 pots in 176 stations in three strata, 1) offshore, 2) high density near island, and 3) shallow on south shore. Despite an increase in the area fished, 2004 had the lowest abundance of all 4 surveys. Males were concentrated on the outer (western) side of the near island strata, while females were closer to the island. Mature females were more concentrated than immatures. Over the entire survey, they caught mostly males (about 80%) and about 66% of these were legal. They also caught both male and female snow crabs. During the first survey in 1995, they tagged almost 2,300 crabs and have since recovered 22.6%. In 1995, most crabs were recovered in the nearshore strata, but in subsequent years most were recovered offshore. Crabs were tagged in roughly equal numbers in the 2 strata. Crabs were also tagged in 1998 and these were caught in roughly the same place in the 1998 fishery. These crabs seem to be highly mobile with seasonal migration patterns from inshore to offshore in late summer. Therefore, summer surveys in offshore areas may not sample crabs that will be harvested in the fishery. There may be some effect of temperature on distribution as well with warmer water in 1998 compared to 1995.

Haphazard collection of Dungeness molting information—D. Urban (ADF&G, Kodiak)

Over the past few years, Dan has collected molted Dungeness shells from Pasagshak Bay that supports a commercial fishery. This is not a systematic or scientific collection, but is the result of casual beach walks. The shells probably do not last long on the beach and represent recent molting events. He has found mostly larger shells and mostly between April and October. Shells may wash ashore more frequently under certain wind conditions and he can get this weather information from the Kodiak Launch Complex.

Tanner crab soak time experiment in Southeast Alaska—J. Rumble (ADF&G, Douglas)

There have been limited studies of the effect of soak time on escape ring effectiveness on soak times of less than 24 hours. The preseason survey soak times range from 16 to 20 hours. Because of the short and intense Southeast Tanner crab fishery, soak times are much less than 24 hours and with the current commercial limit of 80 pots, pots may be pulled and set 3 times in a day. The conservation concern is for leg loss and handling mortalities. This 2 year study was designed to 1) determine if escape rings are effective in releasing nonlegals at different soak times, 2) determine when the nonlegals leave the pots, and 3) describe catch rates of 7’ conical pots for various soak periods. They had soak times of 3, 9, 18, and 24 hours with and without escape rings and conducted in 2 different areas (back side of Douglas Island and west of Pleasant Island) with 6 replicates of all treatments. They have just begun to analyze the data and have looked at the catch per pot of nonlegal crabs and the catch of nonlegal crabs per pot hour. It appears that the catch of nonlegal crabs is less with escape rings than without, especially over longer soak times, but the data are highly variable. More analyses need to be conducted to draw any sort of conclusions.

Central region crab work—B. Bechtol (ADF&G, Homer)

Central Region is using a variety of electronic data collection techniques on all surveys in which crab are encountered. Staff conducted a trawl survey of Cook Inlet in 2004, although systematic gear problems affected the survey catchability. As a result, size composition was similar to anticipated, particularly for prerecruit crab, but abundance was less than expected. However, estimated population abundance remains well below a level to support fishing mortality. Dungeness crab abundance, although only an index, also remains low. In Prince William Sound, there were no Dungeness or Tanner crab surveys in March 2004, but a golden king crab survey occurred in response to user group requests to reopen the fishery. The survey involved 158 pulls of square 6' x 6' pots in Knight Island Passage. Although a randomized survey design was considered, a systematic deployment scheme was used to better capture crab distribution by depth within the 100-600 m survey depth range. Bathymetric and habitat data obtained from NOAA facilitated the survey design. The survey caught both golden king and Tanner crabs, although Pacific cod was the most abundant species caught. Of the golden king crab, 75% were legal size with an average catch rate of 2 crab/pot; male golden king crab were tagged. A follow-up survey is scheduled for 2005.

Developing a quantitative assessment model for a data poor stock: golden king crabs in the eastern Aleutian Islands—S. Siddeek (ADF&G, Juneau)

The eastern Aleutian Island golden king crab fishery has increased from about 1.5 million pounds/year during the 1980s to about 3 million pounds per year now. There is 100% observer coverage, port sampling, and a triennial pot survey. The model examined only male dynamics with prerecruits being 101-135 mm CL and recruits ranging from 136-185 mm CL. Assumptions include: 3 levels of natural mortality (0.2, 0.3, and 0.38), constant handling mortality of 20% (0 and 50% also examined), a single selectivity curve for pots, a single molt probability model, gamma distributed growth, the growth period occurring immediately after the mortality period, and constant catchability. The model was optimized using least squares and estimated 15 parameters. Growth model fit tagging results. New shell estimates fit data well, but the old shell fit was not as good. Model runs with different weighting factors for effort in relation to CPUE estimated increasing abundance of legal males, but variable recruitment.

Electronic collection and storage of crab data—P. van Tamelen (ADF&G, Juneau)

Electronic data collection eliminates data entry and editing, may produce better data by reducing the number of data transfer steps, increases sampling speed, and may make training faster and easier with more intuitive design and readily available help menus. Overall, this may standardize some subjective methods and lay the groundwork to incorporate new technologies. He has addressed problems identified previously using a handheld device by using a tablet type PC with a large touchscreen. The system worked well in a test situation, but there were some software bugs. Most bugs have been fixed. The programming is complex and he relied on a programmer to write the software. His new system would cost about $3,000 but could replace a laptop computer, but he still needs to finalize the software and perform some more serious field tests. After collecting data, they needed a place to store the data. Currently, there is no statewide data storage standard and every ADF&G region differs in this regard, as does NMFS. There is little metadata being recorded in an organized fashion. He and Steve Gebert are working on a new data storage system that could be implemented statewide, but the biologists have to agree on the system. The data storage system could easily be implemented with the new data collection system. The future directions of data collection may include automatic scanning of caught crabs and autonomous underwater vehicles that are just being developed. Implementing these new technologies, however, will require working closely with engineers of various sorts.

Air and water: on being exposed to air and living in water—P. van Tamelen (ADF&G, Juneau)

Previous modeling and observations have shown that legs and eyes can cool much more rapidly than crab bodies when exposed to cold air, raising the question of what are the non-lethal effects of cooling? He investigated the circulatory system and the nervous system of snow crabs. The circulatory system of snow crabs is very complex. He measured blood flow in the legs and heart rate and showed that there is little effect of severe cold air exposure on the circulatory system. In one leg blood continued to flow right up until it was autotomized. There was a highly variable response of heart rate to cold air exposure. Originally, the intent was to examine the nervous system in snow crab legs, but he could not find enough activity where other crabs have abundant activity. Hence, nerve activity was measured in eyestalks instead. Analysis is not yet complete, but there seems to be some degradation of neural activity associated with cold air exposure, so cooling may disrupt prey and predator detection. However, crabs may have other sensory systems that may or may not be affected by aerial exposure, allowing crab to survive. Crabs can hear well in water and can easily navigate to or away from various sounds and this sense is probably not easily damaged by exposure. Crabs, particularly king crabs (but probably not snow or Tanner crabs), may also detect vibrations in the sediment through their legs allowing them to find food resources. There has been some discussion of how far crabs drift after being thrown overboard. Based upon simple calculations, crabs will drift a maximum of 8 km (depending on depth). The distance traveled is increased with depth, decreased sinking rate, and horizontal currents.

Remote sensing of crab habitat using hydroacoustics—D. Urban (ADF&G, Kodiak)

Population size is determined by density and habitat area, but we know little about the actual amount of habitat out there. Hydroacoustics can be an easy way to gather information about the seafloor habitat in addition to depth and has been investigated by Kodiak staff for more than a decade. Around Kodiak Island, Tanner crabs are assessed in large rectangles based upon a single trawl, but the actual Tanner crab habitat in those rectangles may be much less than the total area. Some hydroacoustic information has been used to reassess GHLs recently. Dan has also tried to map the habitat around the Pribilof Islands during a recent pot survey on a chartered vessel. Generally, the results look encouraging and they were able to separate out areas of mud, sand, and rocks. However, there were some inconsistent results with one area being classed as sand and then as mud 2 days later. Could be due to the roughness of the sea on the second day causing the boat to move substantially. But this was done with single beam and the NOAA coast survey is now mapping the bottom with multibeam sonar that has a much wider track and is able to correct for vessel instability. Hydroacoustics may be a cost effective method of determining seabed habitat types, but careful attention must be used with the equipment and settings and vessel instability can affect the quality of data. Ground truthing is essential and it takes a lot of time to analyze the data.

Measuring circulating ecdysteroids to predict molting probability in crabs—S. Tamone (UAS)

Crabs need to molt to grow and may have either determinate or indeterminate growth. Snow and Tanner crabs are thought to have determinate growth with a terminal molt. There are many indicators of the molt stage of crabs including hormone levels. Molting is controlled by ecdysteroids and these increase dramatically just before a molting event. Ecdysteroids are controlled by a molt inhibiting hormone produced in the eyestalk so one can control molting in crabs by removing their eyestalks. Mature female and male snow crabs have very low levels of ecdysteroids and this is not increased when eyestalks are removed, indicating a terminal molt. In male *Chionoecetes* males with large claws are thought to be terminally molted and in fact all large clawed individuals had very low ecdysteroid levels regardless of crab size. In both Glacier Bay and the Bering Sea, blood samples have been taken along with morphometric measurements to determine if ecdysteroids are related to claw size or shell condition. In Glacier Bay, all large clawed males have low levels of ecdysteroids as did all very old shell crabs. The Tanner crab fishery harvests only the largest 40% of mature male crabs and this may lead to selection for crabs that terminally molt to smaller sizes. In the Bering Sea, ecdysteroid levels are greatest in the winter.

Hemolymph ecdysteroid concentrations in wild and captive Alaskan Dungeness crabs—J. Thomton (UAF)

The currently accepted reproductive cycle of Alaskan female Dungeness crabs (*Cancer magister*) maintains that females molt and mate during summer months, extrude eggs in the fall, and incubate eggs for approximately 9 months through the winter until larval hatching in May/June. In this model, molting and mating are coincident with ovarian maturation. Recently, however it has been shown that a percentage of females skip the annual molt for at least one year and extrude viable eggs using sperm stored from a previous molt/mate event. Additionally, some females may molt and mate in the summer and delay extrusion until the following year. The goal of this study was to quantify hemolymph ecdysteroid (20-HE) concentrations using an enzyme-linked immunosorbent assay (ELISA), validated for the species, to assess the growth and reproductive status of wild and captive crabs. In wild crabs collected during May, June, and July 2004 (n=171) 100% exhibited intermolt 20-HE concentrations (<150 ng/ml), 80% displayed old, worn shells and only 65% had evidence of a previous clutch (blackened pleopods) since the last molt. Therefore, according to current theory a percentage of these crabs should molt and mate prior to fall egg extrusion, however, none of these females were in premolt. Additionally, female crabs sampled in May 2004 were retained and housed in aquaria to facilitate longitudinal hemolymph collection. Of these captive crabs, 43% exhibited a steady increase in 20-HE concentrations indicative of premolt (>150 ng/ml), with one crab molting during August. It is unclear at this time whether the increased elevation of 20-HE during late summer/fall will lead to delayed molt and egg extrusion or reproductive failure for one annual cycle.

PLANS FOR 2005

The annual Alaskan crab research meetings have continued to be productive and valuable for free exchange of scientific results, ideas, and perspectives. A 12th annual meeting is expected to be scheduled for the approximate dates of December 14–16, 2005 in Anchorage.

PROPOSALS FOR NEXT YEAR'S SPECIAL TOPIC

Several proposals were put forth and the top contender appears to a review of east coast crab research with particular emphasis on blue crabs.

Proposals for other special topics are welcome. Please submit these to Russ Nelson and/or Doug Woodby.

APPENDIX

Appendix 1.–List of participants at the 2004 interagency crab research meeting.

Last Name	First Name	Affiliation	Location	Email
Barnard	Dave	ADF&G	Kodiak	david_barnard@fishgame.state.ak.us
Bechtol	Bill	ADF&G	Homer	bill_bechtol@fishgame.state.ak.us
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Schoch	Carl	PWSSC	Cordova	cschoch@pwssc.gen.ak.us
Shanks	Alan	OIMB	Charleston, OR	ashanks@darkwing.uoregon.edu

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Appendix 1.–Page 2 of 2.

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Appendix 2.–Final agenda for the 2004 interagency crab research meeting.

INTERAGENCY CRAB RESEARCH MEETING

December 15–17, 2004

Hilton Anchorage

3rd and E Streets

Anchorage, AK

907-272-7411

WEDNESDAY, DECEMBER 15: UNDERSTANDING LARVAL DYNAMICS

Afternoon Session: 1:00–5:00 pm

I. Introductions

II. Opening remarks: Doug Woodby, Russ Nelson

III. Meeting agenda: Modify and Adopt

IV. Workshop on larval dynamics

- A. Introduction to workshop—Peter van Tamelen, ADF&G, Juneau
- B. Stock and recruitment: an overview of life histories and larval ecology—Ginny Eckert, UAS, Juneau
- C. Oceanography and larval behavior: larvae as clever balloonists—Alan Shanks, University of Oregon, Oregon Institute of Marine Biology

Coffee: 2:50–3:20 pm

- D. A larval biologist's perspective on fisheries management—Steve Gaines, University of California Santa Barbara, Institute of Marine Science
- E. Discussion

Crabby Hour and Dinner at the Snow Goose: 6:00–10:00 pm

THURSDAY, DECEMBER 16: RESEARCH REVIEW

8:00–8:30 am Coffee

Morning Session: 8:30–11:30 am

V. Highlights of ongoing and planned crab research (All presentations will be 20 minutes unless noted. All coauthors have been omitted)

- A. Larval Research: Various Agencies
  1. Embryonic development and hatch timing of blue king crab, *Paralithodes platypus*—Brad Stevens, NMFS, Kodiak (25 minutes)

2. Development of cultivation techniques for larval blue king crab—Sara Persselin, NMFS, Kodiak
3. The effect of temperature on embryonic development, spawning, and hatching of Eastern Bering Sea snow crab (*Chionoecetes opilio*)—Joel Webb, UAF, Juneau
4. Spatial and temporal supply of *Cancer magister* postlarvae to Glacier Bay National Park—Heidi Herter, UAF, Juneau

Coffee: 10:00–10:30 am

5. Northward transport of Dungeness crab larvae to Alaska from the west coast of the United States and Canada—Won Park, UAF, Juneau
6. Circulation into Kachemak Bay: does it affect crab populations? —Scott Pegau, Kachemak Bay Research Reserve, Homer
7. Recruitment variation of eastern Bering Sea crabs: 'climate-forcing' or 'top-down' effects? —Jie Zheng, ADF&G, Juneau (25 minutes)

Lunch: 11:30 am–1:00 pm

Afternoon Session: 1:00–5:00 pm

B. NMFS—Seattle

1. Update and future directions of the joint AFSC and Bering Sea Fisheries Research Foundation—Gary Stuaffer, NMFS, Seattle
2. Bitter crab syndrome research: past and future—Frank Morado, NMFS, Seattle

C. ADF&G

1. Westward region research roundup—Doug Pengilly, ADF&G, Kodiak
2. The St. Matthew 2004 blue king crab survey and tag recoveries 1995–1998—Leslie Watson, ADF&G, Kodiak
3. Haphazard collection of Dungeness molting information—Dan Urban, ADF&G, Kodiak

Coffee 2:50–3:20 pm

4. Tanner soak time experiment in Southeast Alaska—Jan Rumble, ADF&G, Douglas
5. Central region update—Bill Bechtol, ADF&G, Homer
6. A modified catch-length analysis model for golden king crab stock assessment in the eastern Aleutian Islands—Shareef Siddeek, ADF&G, Juneau
7. Electronic data collection of crab data and data storage—Peter van Tamelen, ADF&G, Juneau

VI. Next Year's Meeting and Special Topic Suggestions

FRIDAY, DECEMBER 17: RESEARCH REVIEW

8:00–8:30 am Coffee

Morning Session: 8:30 am–12:00 noon

C. ADF&G (continued)

8. Water and air: on living in water and being exposed to air—Peter van Tamelen, ADF&G, Juneau
9. Hydroacoustic mapping of crab habitat—Dan Urban, ADF&G, Kodiak

D. Universities

8. Measuring ecdysteroids to predict molting probability in crabs—Sherry Tamone, UAS, Juneau
9. Hemolymph ecdysteroid concentrations in wild and captive Alaskan Dungeness crabs—Jamie Thomton, UAF, Juneau

Coffee 10:00-10:30 am

VIII. Revised Research Plan and Discussion—Doug Woodby, ADF&G, Juneau

IX. Other Business