Regional Operational Plan CF.2A.2013.03

Operational Plan: Shell Hardness and Meat Yield in Kachemak Bay Tanner Crab, *Chionoecetes bairdi*, 2013-2015

by

Dr. Kenneth J. Goldman and Jan Rumble

July 2013

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

Symbols and Abbreviations

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

Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, 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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Alaska Department of Fish and Game, Division of Commercial Fisheries, Homer

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Division of Commercial Fisheries

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Signature Page

Project Title:	Shell hardness and meat yield in Kachemak Bay Tanner crab, *Chionoecetes bairdi*, 2013-2015.
Project leader(s):	*Dr. Kenneth J. Goldman and Janet Rumble*
Division, Region and Area	Commercial Fisheries, Region II, Lower Cook Inlet
Project Nomenclature:	
Period Covered	May 2013
Field Dates:	May through October each year
Plan Type:	Category I

Approval

Title	Name	Signature	Date
Project leader	Dr. Kenneth J. Goldman		6/27/13
Project leader	Jan Rumble		6/27/13
Research Coordinator	Lowell Fair		6/27/13

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PURPOSE

The goal of this study is to document the relative shell hardness and meat fill (or yield) of Tanner crab in Kachemak Bay on a monthly basis from May through October. The department has concerns about handling and discard mortality associated with non-commercial Tanner crab fisheries in Kachemak Bay when crab are either soft-shelled or in the process of hardening their shells and filling in their meat. The physiological process of filling in their meat after molting coincides with the hardening of the shell. So in addition to measuring the hardness of each of the Tanner crabs with a durometer, we will determine the relative degree of meat fill or meat yield.

Key words: Tanner crab, shell hardness, durometer, meat yield, Kachemak Bay.

BACKGROUND

Cook Inlet has historically supported both commercial and non-commercial Tanner crab fisheries in the Southern and Kamishak districts (Figure1). However, since the late 1980s, commercial fishing has remained closed and most recently, there have been non-commercial fishing closures due to the reduced abundance of legal males. This reduction of legal males has been estimated in the annual trawl surveys conducted by ADF&G, Division of Commercial Fisheries, Central Region staff. Using historical results of the surveys and commercial and non-commercial harvest data, a Cook Inlet Tanner crab harvest strategy was developed (5 AAC 35.408 Registration Area H Tanner crab harvest strategy). Since the strategy was adopted in 2002, defined commercial thresholds have not been attained and non-commercial seasons were opened between 2008 and 2011 but closed again in 2012.

The non-commercial seasons currently run from July 15 through March 15 in both Southern and Kamishak districts, with a two week mid-season closure from December 31 through January 15 in the Southern District. Shell condition data collected from department large-mesh trawl surveys in Kachemak Bay between 1990 and 2012 indicates that Tanner crab undergo a protracted molt from late March to early June with crabs in a soft shell condition for one to two months following the molt. This molting and soft shell period overlaps with the beginning of the non-commercial season. Additionally, this period overlaps with the department trawl survey, which is demonstrated by shell condition data, a relative shell hardness measurement. The survey timing is not ideal but has to take into account the non-commercial fishery start date, crab recruitment, and acceptable weather conditions for trawling operations.

Handling crab during the period when their shell is hardening and the meat is filling in has been shown to increase mortality for many different species of crabs (Kruse et al. 1994, Hicks and Murphy 1989, Tegelberg 1972) including Tanner crab (Blackburn and Schmidt 1988, Carls and O'Clair 1990, Kimker 1994, Stevens and MacIntosh 1993). Handling crabs also increases the likelihood of limb loss which can inhibit molting and decrease the increment of growth in the subsequent molt (Bennett 1973). Although there are regulations in the non-commercial fishery requiring escape rings in Tanner crab pots, sublegal male and female crab are caught and brought to the surface in either a soft shell condition or with a new shell that is not yet hardened and then released, which may have deleterious effects. The department has serious concerns about handling and discard mortality associated with these fisheries when Tanner crab are either soft-shelled or in the process of hardening their shells and filling in their meat.

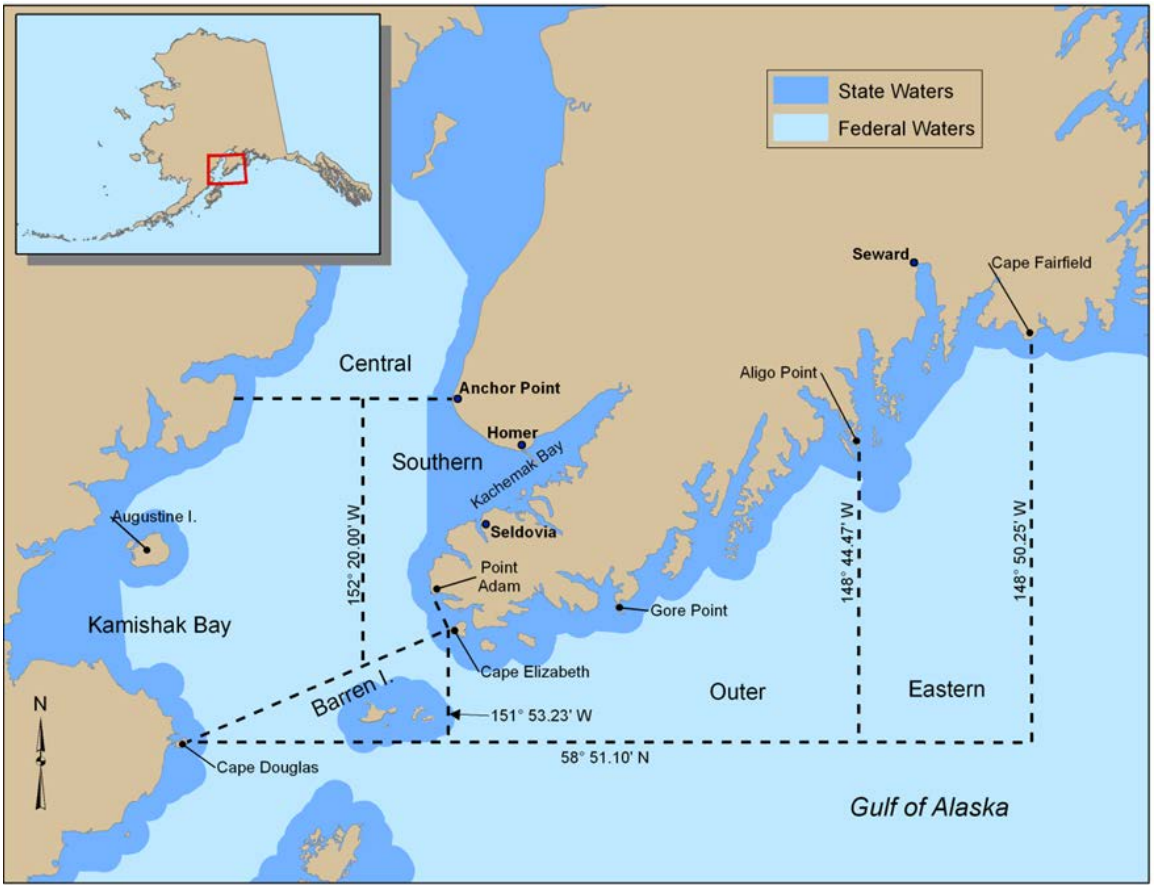

Figure 1.–Alaska Department of Fish and Game, Central Region, Lower Cook inlet and outer coast map showing commercial fishing Districts.

In the Kachemak Bay large mesh trawl survey, each crab is measured and has an associated shell condition code recorded: soft, new or old. Although this gives a good idea of shell hardness, a less subjective and more quantifiable method of recording shell hardness is required. A durometer, which is a hardness measuring gauge (Hicks and Johnson 1999, Stevens 2009), will be used for this study. In Washington, durometers have been used to test the hardness of Dungeness crabs, influencing the timing of commercial fishery openings. The physiological process of filling in their meat after molting coincides with the hardening of the shell (Dufour et al. 1997, Foyle et al. 1989). So in addition to measuring the hardness of each of the Tanner crabs with a durometer, we will determine the relative degree of meat fill or meat yield. This will allow us to determine if there are differences in meat yield over several months as the shell hardens. The objectives of this study are to document monthly the shell hardness and relative meat fill or yield of Tanner crab in Kachemak Bay from May through October, with the goal of determining a level of shell hardness acceptable for opening non-commercial fisheries with reduced discard mortality.

OBJECTIVES

The objectives of this study are to

1) Document the relative shell hardness of Tanner crab in Kachemak Bay between May and October.
2) Document the accompanying relative level of meat yield of Tanner crab in Kachemak Bay between May and October.

METHODS

Tanner crab in Kachemak Bay will be captured in non-commercial style crab pots (4' x 4' x 2', pyramid with an 18" tunnel and ¾" stretch mesh). Pots will be set at the end of each month from May through October with the exception of June where Tanner crab will be sampled during the ADF&G annual large-mesh trawl survey. Pot locations were determined from historical trawl survey stations that have provided large numbers of Tanner crab in the larger pre-recruit size classes and would, therefore, potentially provide the largest pool of crab to choose from for this study; locations are shown in Figure 2. Sex and shell condition will be determined and carapace width (CW) of all crab will be measured with electronic calipers to the nearest 0.1 mm. Chela height of all male crab will also be measured. Shell hardness of crab will be measured on soft and new shell condition crab using a durometer specifically made for Chionoecetes crab (Model #307HF, PTC Instruments, Los Angeles, CA). We will also take a few measurements from old-hard shell crab for comparison. Three durometer readings (in DU or durometer units; to the nearest DU) will be obtained from male crab and two from female crab. Both male and female crab will have durometer measurements taken from a center point on the right chela and from the ventral side of the carapace near the maxillipeds (Figure 3). Males will have an additional durometer measurement taken from the second Sternite Plate (Figure 3) (Foyle et al. 1989, Hicks and Murphy 1989, Hicks and Johnson 1999). That measurement will not be taken on female crab as the Sternite location requires lifting the abdominal flap (which is wider) on females, which can damage it. At each sampling event, durometer measurements will also be obtained from several old shell crabs for relative comparison to new shelled crab. As the sampling routine for this study is opportunistic, our goal is to achieve as many durometer measurements as possible on new shell crab.

Least-squares and maximum likelihood regression will be used to fit durometer readings to date of capture. We will also examine durometer readings separately for juvenile and adult females and for all recruit class categories to see if differences exist in the rate at which the shell hardens after molt between these groups. Additionally, we will test two models used in previous durometer studies (Hicks and Johnson 1999, Stevens 2009) to fit durometer data. The first is the cumulative of the logistic regression function:

$$Y= \beta0/(1+ e(X-\beta1)/ \beta2), \quad (1)$$

and the second, a hyperbolic regression,

$$Y=X/(\beta0+ \beta1X), \quad (2)$$

where X = calendar day and Y = hardness (in Durometer Units; DU) (Hicks and Johnson 1999, Stevens 2009).

While the shell hardness portion of this project will focus on all sizes of female and male crab, the relative meat fill (or yield) portion of this project will focus only on mature male crab that would be recruits to the non-commercial fishery (>140 mm). Our goal is to use six to seven males per month for the meat fill study. The meat fill for crab collected each month will be

determined following the methods of Dufour et al. (1997) and Dutil et al. (2009). The total meat yield values for a given crab will be calculated using methods and equations based on Dufour et al. (1997):

(1) Crab will be weighed whole to the nearest gram (Equal to the wet weight of crab before cooking).
(2) Crab will be boiled for 7-10 minutes to allow separation of the meat from the shell.
(3) All meat will be removed from the crab and weighed to the nearest gram.
(4) Crab meat will be bagged, labeled and frozen.

The following equation will be used to calculate the relative percent of meat yield:

$$\text{Percent meat yield} = 100 \text{ X } \frac{\text{Total weight of the meat extracted}}{\text{Wet weight of the crab before cooking}}.$$

Resulting data will be analyzed via regression and logistical statistics analogous to those used by Dufour et al. (1997). To assess temporal changes in the general condition of individuals from the same species, condition factors are often used. The Fulton index, the most widely used index of condition (Ricker 1975) corresponds to the ratio of the animal's weight to its cubic size. The greater an animal's weight is at a given size, the better its condition. The index can also reveal certain changes in condition related to different fishing seasons and sites. The Fulton index will be calculated for all crabs used in this study, as follows:

$$\text{Fulton Index} = \frac{\text{Total weight of the meat extracted (mg)}}{\text{Carapace width (mm)}^3}.$$

A second method of tracking relative meat fill will be conducted following Dutil et al. (2009). The volume of the merus from the second walking leg will be determined from the merus length, width, and height. The merus will then be cut lengthwise and the whole muscle mass dissected out. The apodemes will be scraped clean with a scalpel and removed before weighing the remaining tissues to the nearest gram. The ratio of merus muscle mass to merus volume (expressed in g mm^{-3}) will be used as an index of muscle mass size in crab. Additionally, we will determine the volume of the removed merus meat (to the nearest ½ ml) via a graduated cylinder and examine the ratio of wet weight volume to merus volume over the time of this study.

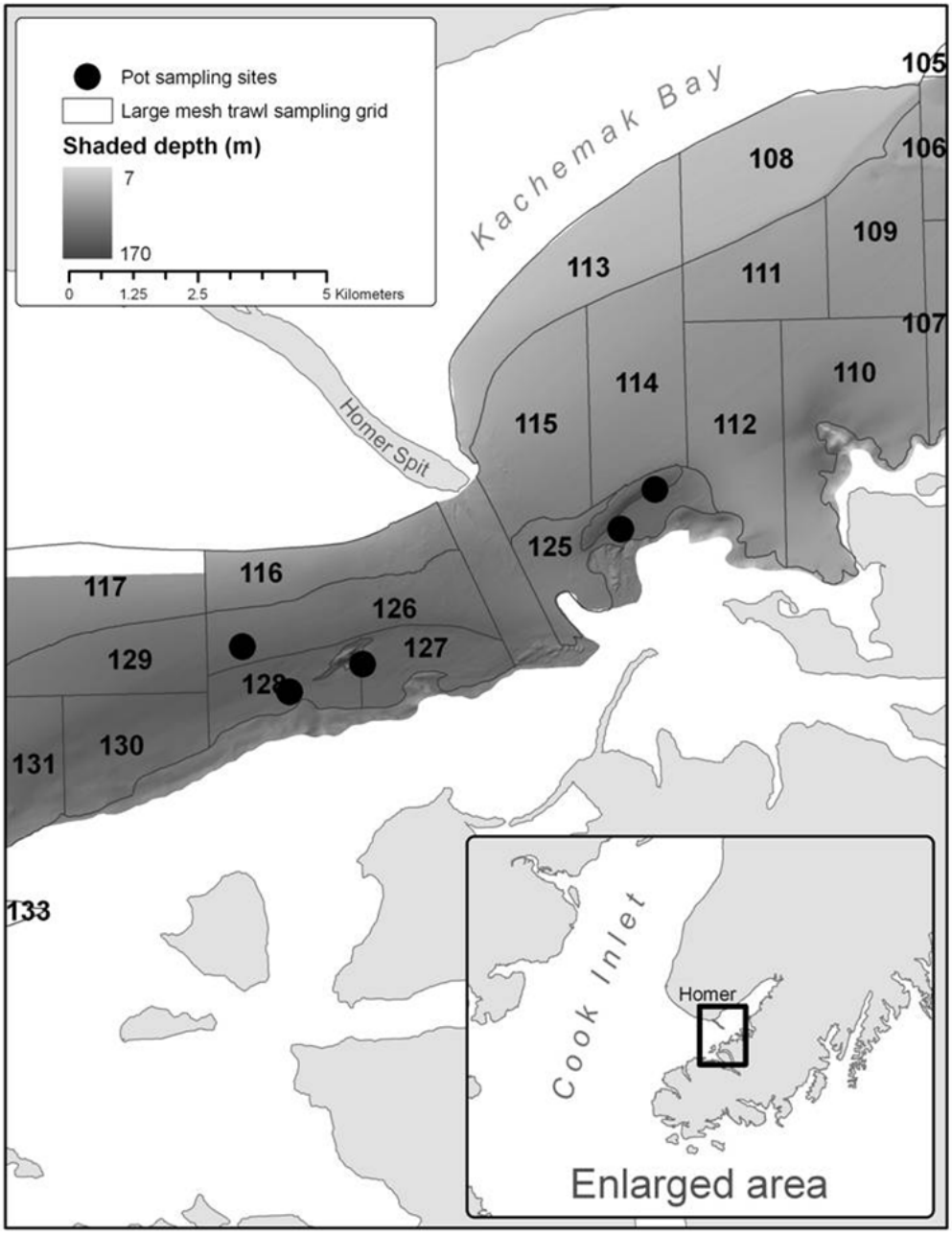

Figure 2.–Locations of pot drops for shell hardness and meat yield study.

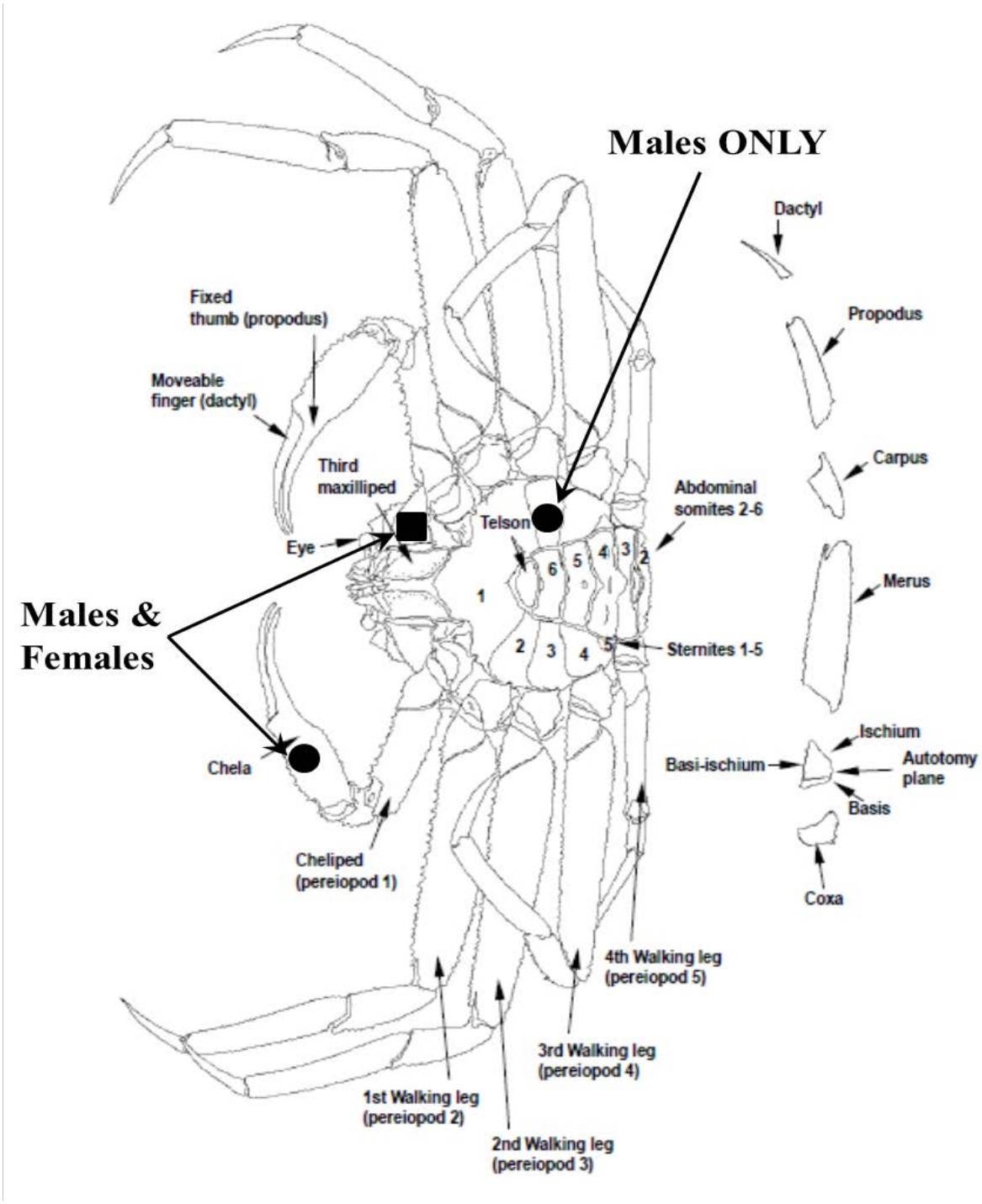

Figure 3.–Locations where durometer measurements will be taken from Tanner crab (image modified from Jadamec et al. 1999). Arrows point to three locations for measurements from males and two locations for measurements from females (Sternite plate location is difficult to access on females and may cause damage to their abdominal flap if lifted to take durometer measurements).

SCHEDULE AND DELIVERABLES

All sampling events will take place at or near the end of each month from May through October. The annual schedule of activities for the 2013-2015 sampling seasons is as follows:

Table 1.–Sampling schedule for 2013-2015.

Date(s)	Activity
April	Prepare pot sampling gear
May through October each year	One sampling event per month*
November through January	Data analysis

*Crab from the annual ADF&G trawl survey in Kachemak Bay will be used for the June sampling event.

Upon conclusion of this study, all final research results will be compiled in a State of Alaska Fisheries Data Series Report and subsequently submitted for publication in a primary literature journal.

Table 2.–Latitudes and longitudes of pot set locations.

Location	Deg	Min	Deg	Min
1	59	35.3508	-151	21.4008
2	59	33.7356	-151	28.311
3	59	34.218	-151	29.262
4	59	34.0062	-151	26.796
5	59	35.7564	-151	20.6796

RESPONSIBILITIES

Division of Commercial Fisheries Personnel:

Dr. Kenneth J. Goldman, Fishery Biologist III: Project planning and oversight. Assist with field work, lab work, data collection and analysis.

Jan Rumble, Fishery Biologist III: Project planning and oversight. Assist with field work, lab work, data collection and analysis.

Josh Mumm, GIS Analyst II: Assist with field work, lab work, data collection and conduct data analysis.

Mike Byerly, Fishery Biologist II: Assist with field work, lab work, data collection and conduct data analysis.

Rich Gustafson, Fishery Biologist I: Assist with field work, lab work and data collection.

Elisa Russ, Fishery Biologist II: Assist with field work, lab work and data collection.

Chris Russ, Research Analyst I: Assist with field work, lab work and data collection.

Andy Pollak, Fish and Wildlife Technician III: Assist with field work, lab work and data collection.

Lowell Fair, Regional Research Biologist: Review and approve project operational plan.

Division of Sport Fish Personnel:

Carol Kerkvliet, Fishery Biologist II: Assist with field work, lab work and data collection.

Mike Booz, Fishery Biologist I: Assist with field work, lab work and data collection.

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