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Southeast Alaska Tanner Crab Survey and Stock Health Prior to the 2010/11 Season

by

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and

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August 2011

Alaska Department of Fish and Game **Division of 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)

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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The Regional Information Report Series was established in 1987 and was redefined in 2007 to meet the Division of Commercial Fisheries regional need for publishing and archiving information such as project operational plans, area management plans, budgetary information, staff comments and opinions to Board of Fisheries proposals, interim or preliminary data and grant agency reports, special meeting or minor workshop results and other regional information not generally reported elsewhere. Reports in this series may contain raw data and preliminary results. Reports in this series receive varying degrees of regional, biometric and editorial review; information in this series may be subsequently finalized and published in a different department reporting series or in the formal literature. Please contact the author or the Division of Commercial Fisheries if in doubt of the level of review or preliminary nature of the data reported. Regional Information Reports are available through the Alaska State Library and on the Internet at: http://www.sf.adfg.ak.us/statewide/divreports/htlm/intersearch.cfm.

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ABSTRACT

Two pot surveys are conducted annually to produce data used to assess the commercial Tanner crab fishery in Southeast Alaska. During June/July and October 2010 surveys, 535 eighty-eight-inch diameter conical crab pots were set and soaked for 19 h on average in 14 survey areas. For each pot, commercially important crabs were measured for carapace width or length, and shell age and parasitism determined; reproductive condition was determined for females, and chela height measured for a subsample of male Tanner crabs. Pots were subsampled when very full. Various ancillary data, including bottom temperature and temperature/salinity profiles, was collected as time allowed. Survey CPUE data was modeled using 3-stage catch-survey methods to produce estimates of mature and legal male biomass. Survey CPUE by size and sex class was also compared to long-term average values to determine stock health. Stock health is used to recommend an exploitation rate. Exploitation rates from 0–20% of mature, or a maximum of 40% of legal, were applied to the population estimate by survey area to determine harvestable surplus. Regional biomass estimates are at an historic low for the 2010/11 season. Harvestable surplus is less than 240,000 lbs and stock health is "poor" or "below average" for six areas, "moderate" for seven areas and "above average" in only one area. The Tanner crab survey has only a 10-year time series, and several survey and assessment improvements are under consideration, these include studies of interaction between red king crab and Tanner crab catchability, restratification of the Tanner survey, logbook verification, and developing a method to assess the unsurveyed area. An exploitation rate-based harvest strategy should be developed for this fishery.

Key words: Tanner crab, *Chionoecetes bairdi*, pot survey, stock assessment, Southeast Alaska

INTRODUCTION

Two surveys currently provide stock assessment information for the Tanner crab fishery in Southeast Alaska. A fall pot survey targeting Tanner crab (*Chionoecetes bairdi*) (Rathbun 1924) was established in two survey areas in 1997 and has been conducted annually since that time. The current survey protocol was not fully developed until 2001 when the last of the six survey areas was added. Tanner crabs are also indexed by an annual summer pot survey, which targets red king crab. The red king crab survey was established in 1978 and provides information on 10 survey areas (Clark et al. 2003), two of which are also indexed during the Tanner crab survey. Together the two surveys provide information on 14 unique areas throughout Southeast Alaska (Figure 1).

This Tanner and red king crab survey data is used to assess the health of Tanner crab stocks in Southeast Alaska by survey area. The goal of the survey is to produce unbiased estimates of catch per unit effort (CPUE) by recruit class in order to 1) determine stock health by survey area and 2) provide input data for a three-stage catch-survey model (Siddon et al. 2009; Zheng et al. 2006). The catch-survey model is used to estimate mature and legal population sizes while the stock health by survey area is used to determine appropriate mature exploitation rates. This information is used to produce an annual biological recommendation of the harvestable surplus for the Southeast Alaska commercial Tanner crab fishery, in order to provide for sustainable harvest of stocks and minimize the risk of recruitment failure—as mandated by the Alaska Board of Fisheries' "Policy on King and Tanner Crab Resource Management" (Hodson 1990). Other information currently used in the biological recommendation for the fishery is catch and effort reported on fish tickets.

The long-term goal of the survey is to provide information on the spatial distribution and long-term health of the stocks. Information produced by the survey to achieve these goals includes CPUE, stock composition, female clutch fullness, female maturity, male length/weight relationship, male chela height/carapace width relationship and visual detection of disease and limb loss.

The objectives of this report are to describe the methods and findings of the 2010 Tanner crab surveys and stock assessment analyses.

METHODS

As Tanner crab survey methods have been described in detail elsewhere (Bednarski et al. 2008), only a brief overview will follow here.

FIELD

Sample Design

Pot locations are selected through a stratified random sampling design. The number of pots within each stratum is determined using a Neyman allocation (Cochran 1977). The total number of pots within each survey area is determined based on logistics and the time needed for staff to efficiently sample and set pots. Pot locations for the 2010 Tanner survey are shown below (Figures 2–7). Red king crab survey pot locations for the 2010 season are reported elsewhere (Siddon et al. 2010).

Gear Description

Eighty-eight-inch diameter conical crab pots without escape rings are used for the survey in order to catch all size classes of crab. Pots are baited with jar and hanging bait. For jar bait, frozen winter-caught Alaska bait herring, caught the year of the survey, thawed and chopped within 12 hours is used. Half a pink salmon is also used for hanging bait. Chopped herring is loosely filled in two 2-quart bait jars, and the half pink salmon is secured to one with a bait hook. Bait jars are suspended at the same height as the top weight ring on opposite sides of the pot.

Temperature sensors, HOBO® TidbiT data loggers, are attached to each pot to record bottom temperatures in degrees Celsius at 1-h intervals.

Setting and Pulling

Pots are set between 13:00 and 18:00 h and pulled between 08:00 and 13:00 h allowing a range of 18 to 22 h for soak times.

Sampling

Crab from each pot are counted and classified into size/sex categories by quantifying carapace width, sex, and shell condition (Jadamec et al. 1999). Females were sometimes subsampled when there were time constraints.

Extra Projects

During the Tanner crab survey, an effort was made to accommodate extra projects. Projects were prioritized based upon their relevance to stock assessment and management of commercially important crab and shrimp species in Southeast Alaska. The 2010 extra projects are described as follows.

Tanner Crab With Spine CW Measurement

For each survey area except Excursion Inlet, Port Frederick, and Peril Strait; approximately 50 male, shell condition 3 or 4, Tanner crabs were randomly selected and sampled to measure CW with spines in addition to the usual biological CW measurement (Jadamec et al. 1999), which excludes spines.

Red King Crab CH Measurement

For each survey area, approximately 15 male RKC of small size and any shell condition were randomly selected and measured for chela height (Donaldson and Byersdorfer 2005) to determine a Southeast Alaska-specific size at functional maturity.

Bitter Crab Hemolymph Sampling

Approximately 100 hemolymph samples from randomly selected Tanner crabs were taken from each survey area to determine bitter crab syndrome (BCS) prevalence using molecular methods (Freidman et al. 2005). Each day, crabs were randomly selected from at least five pots regardless of sex, size, and shell condition and hemolymph was extracted using a syringe and preserved in 95% EtOH. PCR assays will be conducted by NOAA Fisheries' Alaska Fisheries Science Center, Pathology Laboratory. These will allow ADF&G to check the accuracy of visual determination of BCS prevalence as well as to monitor trends in BCS prevalence.

Red King Crab Female Broodstock Collections

Twenty egg-bearing RKC were collected from the Stephens Passage survey area for use as brood stock by the UAF/AKCRRAB reproduction and larval husbandry project in Seward, AK.

Briarosaccus callosus ***Sampling***

Samples of the parasitic barnacle *Briarosaccus callosus* were taken from red and golden king crab whenever present and labeled with date and location and preserved in 95% EtOH for further analysis. These samples were requested by Dr. Henrik Glenner, a crustacean geneticist in Norway.

Conductivity/Temperature/Depth (CTD)

During the 2010 Tanner and red king crab survey 18 CTD casts were made at 15 established stations throughout Southeast Alaska (Figure 8; Table 1), with three stations being occupied twice. Casts were made using a Seabird 19 plus CTD with conductivity, temperature, and depth sensors; the instrument is calibrated annually. Stations were occupied in transit and the CTD was dropped at a speed of 1 m/s to a maximum depth of 250 m and retrieved. Surface water samples were taken at every third station for inseason calibration of conductivity. Data was uploaded and archived at the National Oceanic Data Center and can be retrieved online at http://www.nodc.noaa.gov.

Side-Scan Sonar

A portion of the Icy Strait Tanner crab survey area was surveyed using a Marine Sonics dual frequency (150/600 kHz) side-scan sonar as part of an ongoing project aimed at improving the stratification of that area to allow the department to reduce the density of survey pots set in hard bottom (low Tanner crab productivity) habitat. Camera drops were employed at six locations throughout the scanned area to ground truth the collected data.

Tanner Crab Reproductive Condition

Forty female Tanner crabs each in Thomas Bay and Glacier Bay were collected for studies of reproductive potential by ADF&G staff. Data collected from this study will clarify factors contributing to variability in female reproductive condition and potentially help explain historic differences and/or trends in reproductive condition of female Tanner crab.

Bitter Crab Survivorship Collections

Thirty-four visually BCS-infected and sixty visually BCS-non-infected Tanner crabs were collected in Stephens Passage for a laboratory survivorship study conducted jointly by ADF&G and NOAA Pathology Lab Staff. The goal of this study is to determine the temporal lethality of BCS.

ANALYSIS

Stock Health

Stock health is determined by examining crab CPUE by sex and recruit class and female reproductive condition. The five response variables are: mature female clutch fullness (percent females with clutch fullness less than 25%) and catch rate (CPUE), and prerecruit, recruit, and postrecruit male CPUE. Short-term (4-yr) and long-term trends in these response variables are evaluated. Short-term trends are evaluated with linear regression, while long-term trends are evaluated by a T-test comparing the current year's mean to an established baseline (determined as the mean of the first 10 years of available data from 1997–2010 for the Tanner crab survey and for 1993–2002 for the red king crab survey). Short-term trends are scored -0.25 for significantly declining, 0.00 for no trend, and +0.25 for significantly increasing while long-term trends are scored -1.00 for significantly below baseline, 0.00 for no difference from baseline, and +1.00 for significantly above baseline. The range of possible scores (-6 to +6) is divided into five ranges, corresponding to stock health categories of "Healthy" (>3.24), "Above Average" (1.25 to 3.24), "Moderate" (-1.25 to 1.24), "Below Average" (-3.25 to -1.26), and "Poor" (<-3.26). Corresponding exploitation rates are 20%, 15%, 10%, 5%, and 0% of mature male crab or a maximum of 40% of legal male crab.

Exploitation Rate

A fairly simplistic and preliminary analysis was conducted to determine an appropriate regional base exploitation rate (ER). The legal and mature ERs for the past 6–10 years were regressed against population change. The ER at which population change was 0 for each surveyed area was designated as that which would maximize sustainable commercial harvest. Finally, the weighted average of survey areas ERs was determined as the regional ER (Appendix A). This analysis indicates that the regional ER should not exceed 20% of the mature or 40% of the legal estimated biomass. This is less conservative than methods used in Kodiak and the Eastern Bering Sea where tiered ERs of 0, 10 or 20% of molting mature, with a cap of 30% of legal are used [5 AAC 35.507, 5 AAC 35.508]. Harvest at this maximum rate would equate to a GHL of 0.58 million lbs. Harvest above this level will increase the probability of further population declines and may produce biomass estimates below the 2.3 million-lb threshold in the near future.

Catch-Survey Modeling

The catch-survey model utilizes both survey and commercial catch data to estimate the total abundance of crab for each area where a survey was conducted (Collie and Sissenwine 1983). This approach was expanded to three stages (pre-recruits, recruits, and post-recruits; (Collie and Kruse 1998) and applied to Tanner crab (Siddon et al. 2009; Zheng et al. 2006). Here we continue the use of the three-stage catch-survey modeling methods to estimate the biomass of legal (≥138 mm CW) and mature (>109 mm CL) male Tanner crab at the time of the survey. Inputs to this model are commercial harvest, and survey CPUE for prerecruit, recruit, and postrecruit crabs. An instantaneous rate of natural mortality of M=0.3, which translated to an annual natural mortality rate of 26%. These methods, and the rationale for the assumptions regarding natural mortality and growth, are described in more detail by (Zheng et al. 2006).

Significant improvements have been made to the methods used to determine the harvestable surplus of Tanner crab over the past three seasons. The catch-survey model now converges for all survey areas and increased survey effort has resulted in improved model fits. Both of these have allowed a sustainable ER to be determined. The harvestable surplus is now calculated based upon the percent of mature crabs rather than the percent of legal crabs, which has the advantage of adjusting the ER of legal crabs using the abundance of prerecruit crabs. This increases our confidence in stock assessment recommendations.

RESULTS

A total of 535 pots were set and pulled over 50 days during the 2010 red king crab and Tanner crab surveys—from 22 to 152 in a survey area (Table 2). The red king crab survey was conducted in three legs. The first leg was conducted from June 9 through 17 and St. James Bay and the Juneau area were fished, the second leg from June 23 through July 2 fished Peril Strait, Port Frederick, and Excursion Inlet and the third leg, from July 12 through 23 fished Pybus Bay, Gambier Bay, Seymour Canal, and Holkham Bay. The Tanner crab survey was conducted in two legs, the first leg was conducted from September 29 through October 7 and fished Stephens Passage, Icy Strait, and Glacier Bay, while the second leg was from October 12 through 21 and fished Thomas Bay, Port Camden, and Holkham Bay. During these surveys soak times ranged from 18.4 to 19.8 h, and the mean depth of pots from 66.3 to 217.1 m (Table 2).

REGIONAL OVERVIEW

Catch-survey modeling of 2010 fishery and survey data yields a biomass estimate of 2.89 million lbs mature or 1.82 million lbs legal Tanner crab (Table 3). This is a decline of 0.60 million lbs legal crab (22%) from the 2009 estimate and is due to declines in 9 of 14 areas. This is predominantly due to biomass declines in Icy Strait (-7%) and Holkham Bay (-6%). Seymour Canal, Pybus Bay, and Excursion Inlet showed modest improvements (1–3% increases).

For the past five years stock assessment data has raised concerns for the long-term sustainability of this fishery. These concerns include:

- Regional biomass estimates are at their lowest levels since 1997 (Table 3, Figure 9).
- Continued below average stock health. Stock health is “poor” or “below average” for six areas, “moderate” for seven areas and “above average” in only one area (Tables 4 and 5).
- Fishing above harvestable surplus. The 2009/2010 commercial harvest exceeded the maximum estimated harvestable surplus by 250,000 lbs (35%) (Figure 10).

BAY BY BAY

Tanner Crab Survey Areas

Icy Strait, Below Average 5%

The Icy Strait stock score declined markedly since the 2009 survey. It is currently scored -3.00, down from -2.75 in 2009 (Table 2). This score decline was driven by the postrecruit CPUE dropping below the long-term average. Prerecruit and recruit CPUE remained significantly below the long-term average. However short-term trends showed no significant results (Figure

11). This area provided 12.0% on average of the commercial harvest over baseline years, and 12.1% in the 2009/10 fishery.

Glacier Bay, Below Average 5%

The Glacier Bay stock score improved slightly since the 2009 survey. It is currently scored -2.00, up from -3.00 in 2009 (Table 4). This score increase was driven by the CPUE of postrecruit crab no longer being below the long-term average. CPUE of mature females as well as prerecruit and recruit crab remain below the long-term average, while the percentage of bad clutches was below the long-term average. Short-term trends showed no significant results (Figure 12). This area provided 8.2% on average of the commercial harvest over baseline years, and 8.2% in the 2009/10 fishery.

Stephens Passage, Moderate 10%

The Stephens Passage stock score remained the same since the 2009 survey. It is currently scored -1.00 (Table 4). The CPUE of mature females is no longer below the long-term average, while the percentage of bad clutches is below the long-term average. The CPUE of recruits remained below the long-term average, and CPUE of postrecruit crab dropped below the long-term average. No other long-term or short-term trends showed any significant results (Figure 13). This area provided 9.5% on average of the commercial harvest over baseline years, and 10.5% in the 2009/10 fishery.

Thomas Bay, Below Average 5%

The Thomas Bay stock score declined slightly since the 2009 survey. It is currently scored -3.00, down from -2.50 in 2009 (Table 4). This score decline was driven by the percentage of bad clutches no longer being below the long-term average, but was moderated by the percentage of bad clutches no longer showing a significant four-year increase, and the CPUE of postrecruit crab no longer showing a decreasing four-year trend. CPUE values remain below the long-term average for large/mature females, prerecruits and recruits (Figure 14). Thomas Bay has showed a consistently declining stock score for the last three years. This area provided 4.8% on average of the commercial harvest over baseline years, and 3.3% in the 2009/10 fishery.

Holkham Bay, Moderate 10%

The Holkham Bay stock score improved since the 2009 survey. It is currently scored 0.25, up from -0.75 in 2009 (Table 4). This score increase was driven by the CPUE of mature females no longer being below the long-term average. The CPUE of postrecruit crab remains below the long-term average, while the percentage of bad clutches remains below the long-term average, and the four-year trend in recruit crab CPUE continues to show a significant short-term increase, though it is still not above the long-term average (Figure 15). This area provided 7.1% on average of the commercial harvest over baseline years, and 10.4% in the 2009/10 fishery.

Port Camden, Below Average 5%

The Port Camden stock score remained the same since the 2009 survey. It is currently scored -3.00 (Table 4). The CPUE of mature females, recruits, and postrecruits remained below the long-term average (Figure 16). Port Camden has shown marked declines in stock score for the last three years (Table 6). This area provided 3.8% on average of the commercial harvest over baseline years, and 0.2% in the 2009/10 fishery.

Red King Crab Survey Areas

Seymour Canal, Below Average 5%

The Seymour Canal stock score declined markedly since the 2009 survey. It is currently scored -2.25, down from -0.75 in 2009 (Table 5). This score decline was driven by CPUE of recruit and postrecruit crab being significantly below the long-term average, and CPUE of female crab showing a significant short-term decrease (Figure 17). This area provided 4.8% on average of the commercial harvest over baseline years, and 4.7% in the 2009/10 fishery.

North Juneau, Moderate 10%

The North Juneau stock score increased since the 2009 survey. It is currently scored -1.00 up from -1.75 in 2009 (Table 5). This score increase was driven by the percentage of bad clutches dropping below the long-term baseline, and the CPUE of prerecruits no longer being below the long-term baseline. This improvement was temporized by the CPUE of postrecruit crab dropping below the long-term baseline, and no longer showing a short-term increase. CPUE of recruit crab remained significantly below the long-term average (Figure 18). This area provided 6.3% on average of the commercial harvest over baseline years, and 3.4% in the 2009/10 fishery.

Excursion Inlet, Above Average 15%

The Excursion Inlet stock score increased markedly since the 2009 survey. It is currently scored 1.25, up from -0.25 in 2009 (Table 5). This score increase was driven by the CPUE of postrecruit crab no longer showing a significant short-term decline, and CPUE of recruit crab now showing a significant short-term increase. The percentage of poor clutch fullness became significantly below the long-term average (Figure 19). Excursion Inlet has now shown three years of consistent improvement. This area provided 6.3% on average of the commercial harvest over baseline years, and 5.6% in the 2009/10 fishery.

Pybus Bay, Moderate 10%

The Pybus Bay stock score declined slightly since the 2009 survey, while maintaining a moderate stock health. It is currently scored -0.50, down from 1.00 in 2009 (Table 5). This decline was driven by prerecruit male CPUE no longer being significantly above the long-term average, and both prerecruit and postrecruit male CPUEs showing significant short-term declines (Figure 20). This area provided 1.2% on average of the commercial harvest over baseline years, and 2.8% in the 2009/10 fishery.

Gambier Bay, Moderate 10%

The Gambier Bay stock score increased slightly since the 2009 survey. It is currently scored -1.00, up from -1.75 on 2009 (Table 5). This increase was driven by CPUE of postrecruit males no longer being significantly below the long-term average, as well as the percentage of poor clutch fullness becoming significantly below the long-term average. These improvements were moderated by CPUE of prerecruit males dropping significantly below the long-term average, and CPUE of females no longer showing a significant short-term increase (Figure 21). This area provided 1.8% on average of the commercial harvest over baseline years, and 1.0% in the 2009/10 fishery.

Peril Strait, Moderate 10%

The Peril Strait stock score increased markedly since the 2009 survey. It is currently scored 1.00, up from -1.25 in 2009 (Table 5). This increase was driven by CPUE of postrecruit males no longer being below the long-term average, nor significantly decreasing over the short-term, and CPUE of females becoming significantly greater than the long-term average (Figure 22). Peril Strait has now shown three years of improvement. This area provided 0.7% on average of the commercial harvest over baseline years, and 1.0% in the 2009/10 fishery.

Lynn Sisters, Below Average 5%

The Lynn Sisters stock score declined since the 2009 survey. It is currently scored -3.00, down from -2.00 in 2009 (Table 5). This decline was driven by CPUE of postrecruits and females becoming significantly below the long-term average, and was moderated by recruit CPUE no longer being below the long-term average. Prerecruit CPUE remains below the long-term average (Figure 23). The Lynn Sisters area has now shown three years of large declines. This area provided 1.6% on average of the commercial harvest over baseline years, and 2.5% in the 2009/10 fishery.

Port Frederick, Moderate 10%

The Port Frederick stock score declined since the 2009 survey. It is currently scored -1.00, down from 0.25 in 2009 (Table 5). This decline was driven by the percentage of poor clutch fullness no longer being significantly below the long-term average, and CPUE of females being below the long-term average, and no longer increasing significantly in the short-term. This was moderated by recruit male CPUE no longer being significantly below the long-term average (Figure 24). This area provided 0.5% on average of the commercial harvest over baseline years, and 0.6% in the 2009/10 fishery.

EXTRA PROJECTS

There is currently a five-year time series of temperature tidbit data and 2010 is the first year of CTD data collection. Mean bottom temperatures for these five years ranged from 4 to 8.5 °C. The coldest long-term average bottom temperature was measured in Lynn Sisters at 4.75 °C and the warmest in Port Camden at 7.9 °C. Temperatures in 2010 were above average for all survey areas (Figures 25 and 26). Although CTD profiles cannot yet be used to detect interannual trends, large differences between locations are evident. The water column was very well stratified during the June/July red king crab survey for all areas except Holkham Bay, with the primary difference between areas being in the depth of the thermo and haloclines, which deepened as time progressed, however; by the time of the October Tanner crab survey, the thermocline had largely degraded for most survey areas, although the halocline remained—with the exception being Glacier Bay (Figures 27, 28, and 29).

Chela height data have been analyzed elsewhere to provide information on size at maturity for Tanner crab in Southeast Alaska (Siddon and Bednarski 2010) although interannual trends have not yet been examined. Likewise, trends in bitter crab prevalence have been described elsewhere (Bednarski et al. 2010) and will not be updated for 2010.

DISCUSSION

Despite the availability of good information for management, Tanner crab stock health in Southeast Alaska is poor and declining; this is due in large part to the lack of an abundance-based harvest strategy, but environmental variables, such as climate change and bitter crab syndrome may also play a part. In 2006 a 3-stage catch-survey model was developed for this fishery. Biomass estimates from the model, along with stock health determinations from survey data, have been used to determine harvestable surpluses for each of the past five years. However, these harvestable surpluses have not yet been used to set and target guideline harvest levels (GHLs) and harvestable surplus has been consistently exceeded by 20 to 270% each season. As a result, 6 of 14 survey areas have "poor" or "below average" stock health and mature biomass is declining. The Tanner crab fishery in Southeast Alaska is the only one in the state for which there is a population estimate that does not have an abundance-based harvest strategy. As such, the fishery for this long-lived crab species is unlikely to perform well over the long-term, and revising the harvest strategy is a high priority. Even a fairly simple application of "Tier IV" methods (NMFS 2008), or transplanting the harvest strategy currently used for Kodiak, along with calculation of a Southeast Alaska-specific B_{MSY}^{proxy}, would be an improvement.

Bottom temperature information suggests that climate change may be affecting Tanner crab distribution and/or abundance. The mean temperature of 7.9 °C measured at Port Camden was the highest in the region and may be approaching the limits of Tanner crab tolerance, suggesting that increases in bottom temperature may be implicated in the decline of the Port Camden Tanner crab stock. Although the upper thermal limit of Tanner crabs has yet to be described, both Somerton (1981) and Nielsen et al. (2007) found effects of temperature on Tanner crab distribution. Somerton in the EBS, where he postulated that temperature not only influenced the distribution of Tanner crab but might also be responsible for much of the regional variability in size. Nielsen et al. (2007) in Glacier Bay found crabs distributed in waters 4–8 °C, suggesting that 8 °C is an upper temperature limit to *C. bairdi* distribution. Further evidence of temperature regulating distribution is indicated in that mean pot depth was, in all cases, at or below the depth of the seasonal thermo and haloclines in CTD profiles. If mean pot depth can be inferred to be a rough proxy for mean crab depth, this may be because summer water temperature above the thermocline forms a barrier to crab depth distribution. This is consistent with the above-mentioned findings (Nielsen et al. 2007; Somerton 1981).

A thorough review of bitter crab prevalence in Southeast Alaska Tanner crab was recently published (Bednarski et al. 2010). While interannual trends were identified within only a few survey areas, the Southeast Alaska distribution of bitter crab has increased over the past 20 years and may be contributing to stock declines in some areas. Bitter crab may also need to be considered in estimating natural mortality.

Several stock assessment improvements are currently under consideration. First, the current survey sample design utilizes random pot placement within strata whose boundaries only roughly describe commercial grounds in each area. As a 10-year time series now exists for most survey areas, existing data could be used to conduct a coarse restratification of grounds. Besides increasing sample size, restratification has the highest potential to decrease the CV of survey CPUE and increase the precision of population estimates. To assist with the restratification effort, we have begun pilot work to collect sidescan sonar bottom composition data. Although this added data layer has the potential to greatly accelerate the progress of restratification, difficulties experienced during this pilot work suggest that subcontracting data collection and post-processing using a multi-agency cooperative approach, is likely to yield better results. Second, biomass estimates for survey areas from the catch-survey model are currently expanded to all of Southeast Alaska based upon the proportion of harvest which occurs in unsurveyed areas. A method of estimating population size of the unsurveyed area is needed. Methods which employ fishery data such as change-in-ratio (Claytor and Allard 2003), or mark-recapture (Skalski and Robson 1992) should be explored. Finally, confidence limits for the catch-survey model are in the process of being determined and may help us to focus additional survey and analytic efforts on the least precise survey areas. Recent inseason observations obtained from Glacier Bay National Park (NPS) staff suggest that imprecision in at least one survey area, Glacier Bay, may be a result of misreporting location of harvest. The simple, yet time consuming, work of verifying logbook data could improve model estimates.

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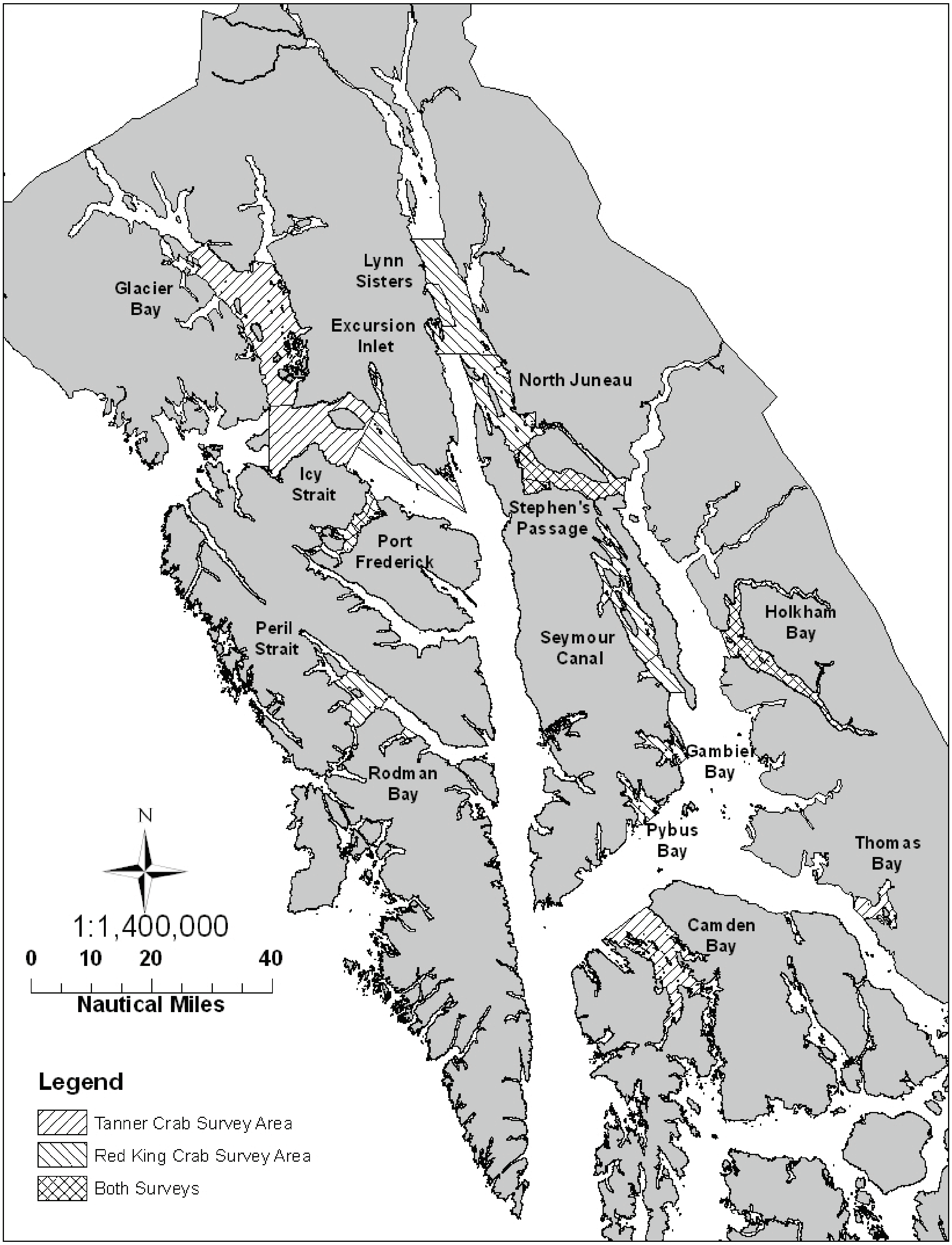

Figure 1.–Tanner and red king crab survey areas in Southeast Alaska.

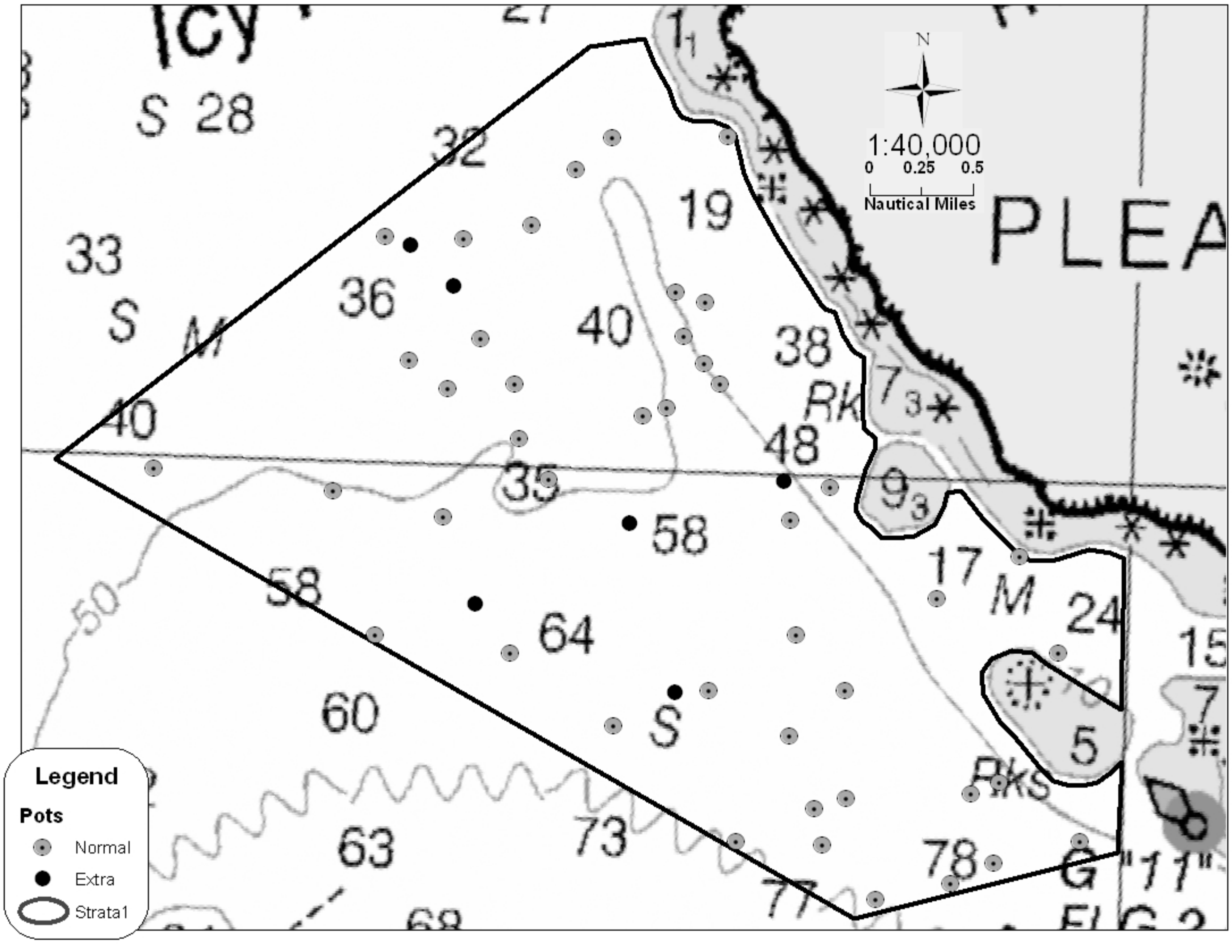

Figure 2.–Tanner crab survey pot locations in Icy Strait, Southeast Alaska, 2010.

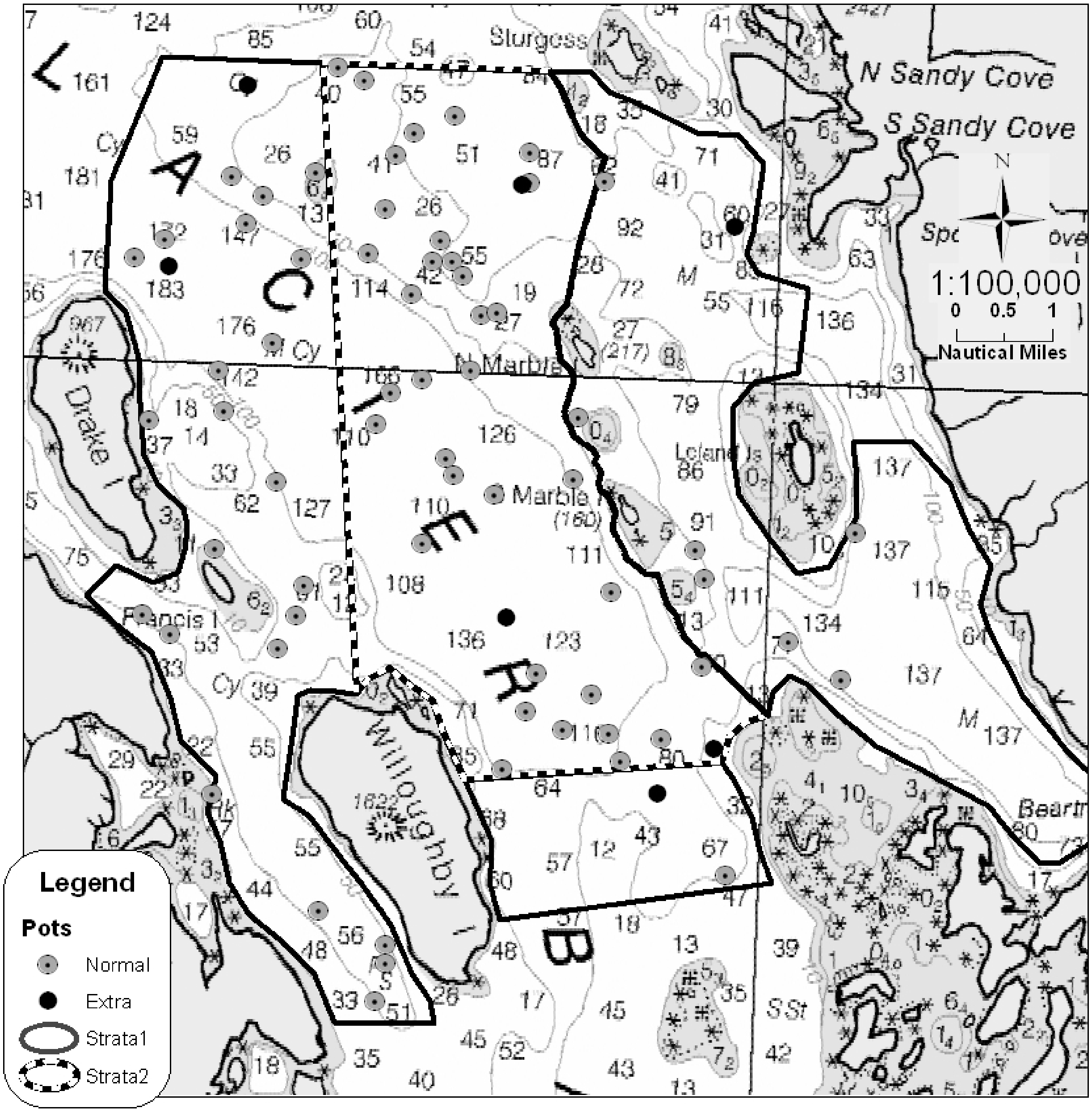

Figure 3.–Tanner crab survey pot locations in Glacier Bay, Southeast Alaska, 2010.

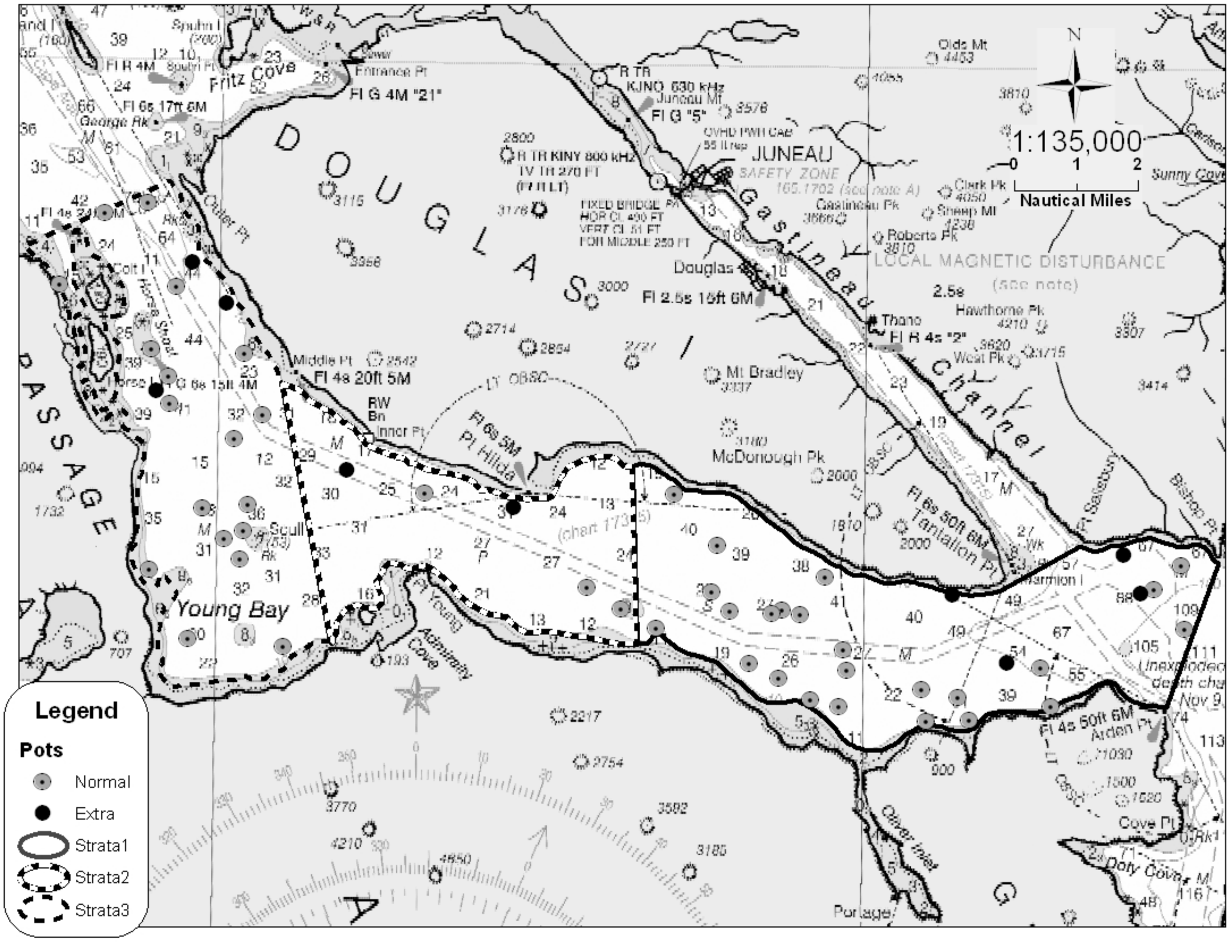

Figure 4.–Tanner crab survey pot locations in Stephens Passage, Southeast Alaska, 2010.

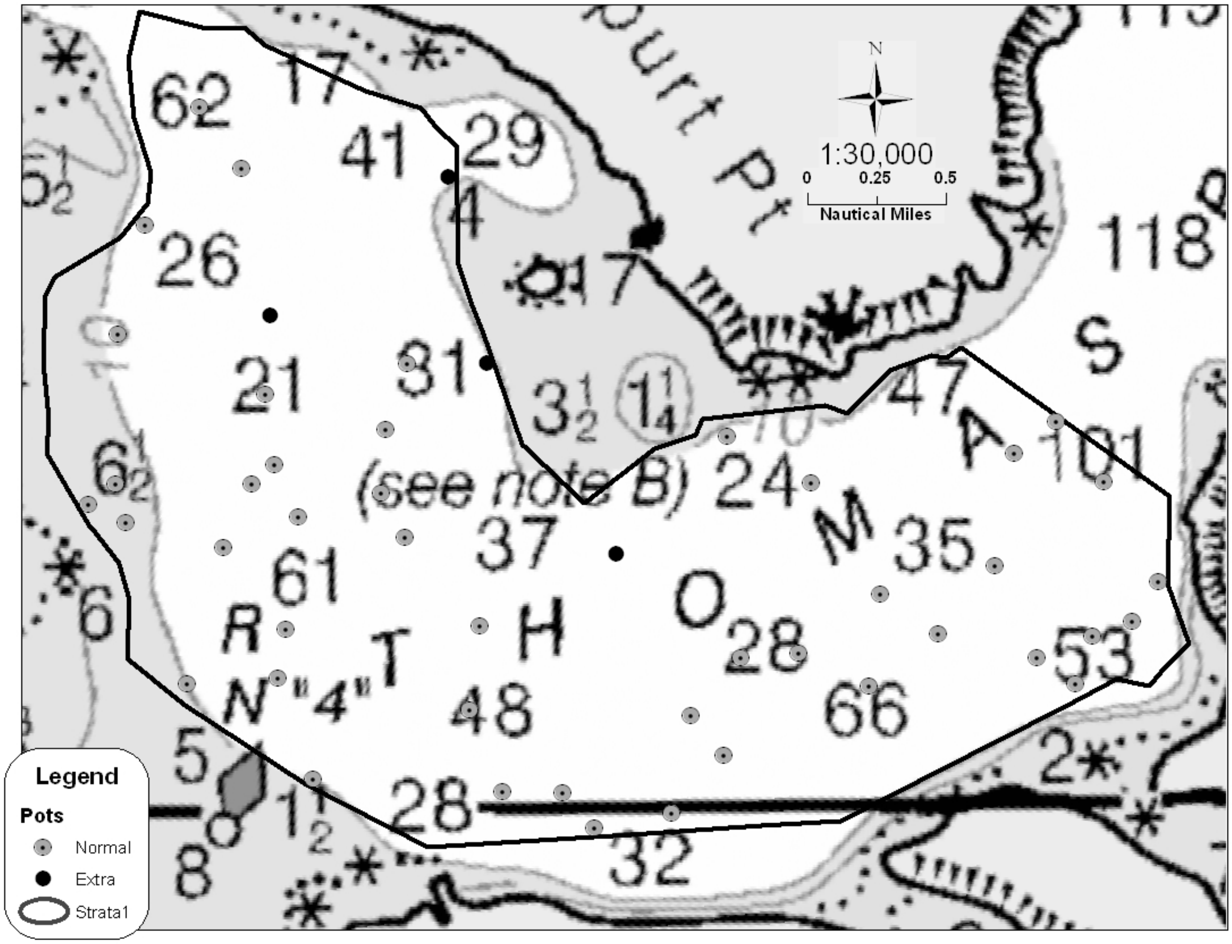

Figure 5.–Tanner crab survey pot locations in Thomas Bay, Southeast Alaska, 2010.

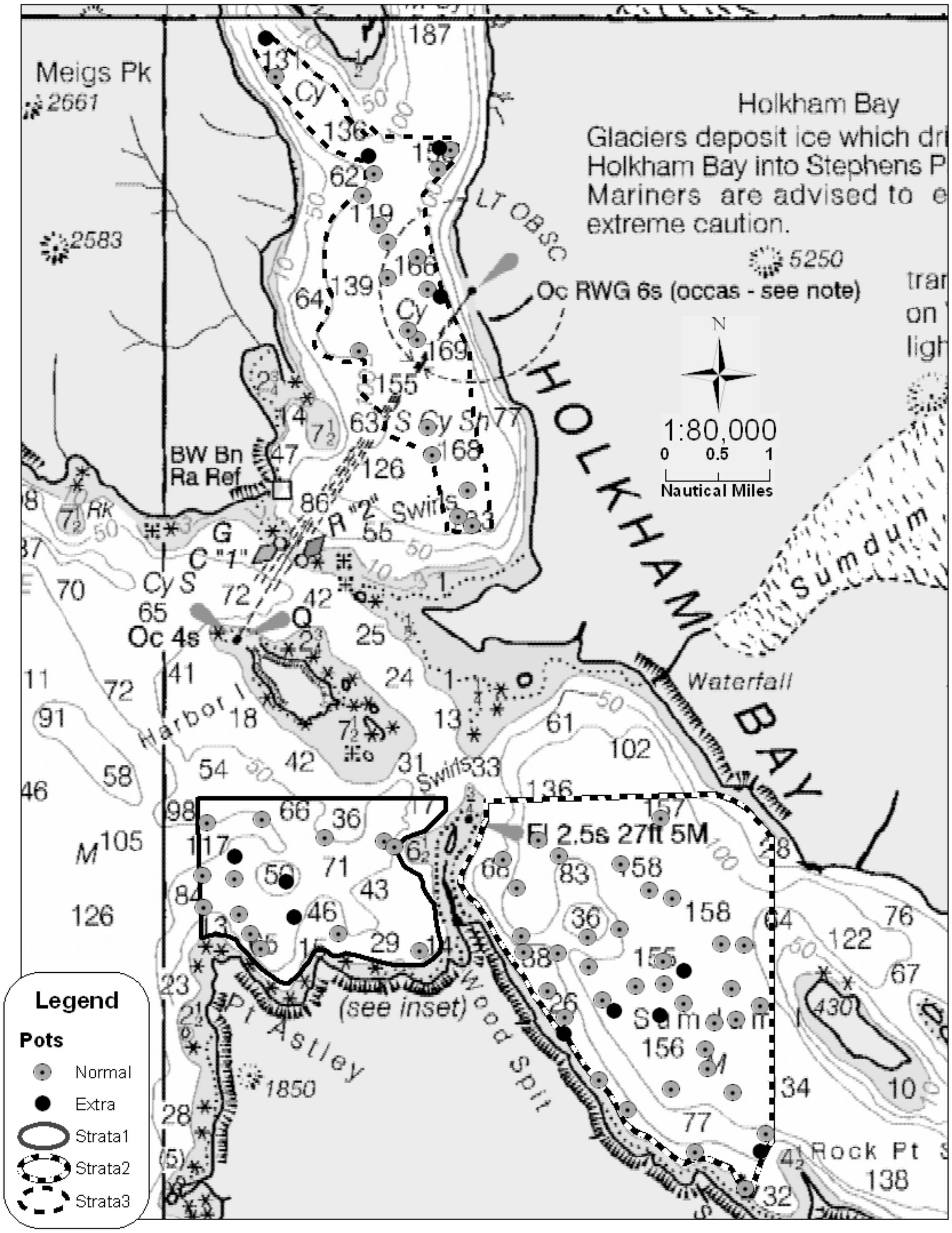

Figure 6.–Tanner crab survey pot locations in Holkham Bay, Southeast Alaska, 2010.

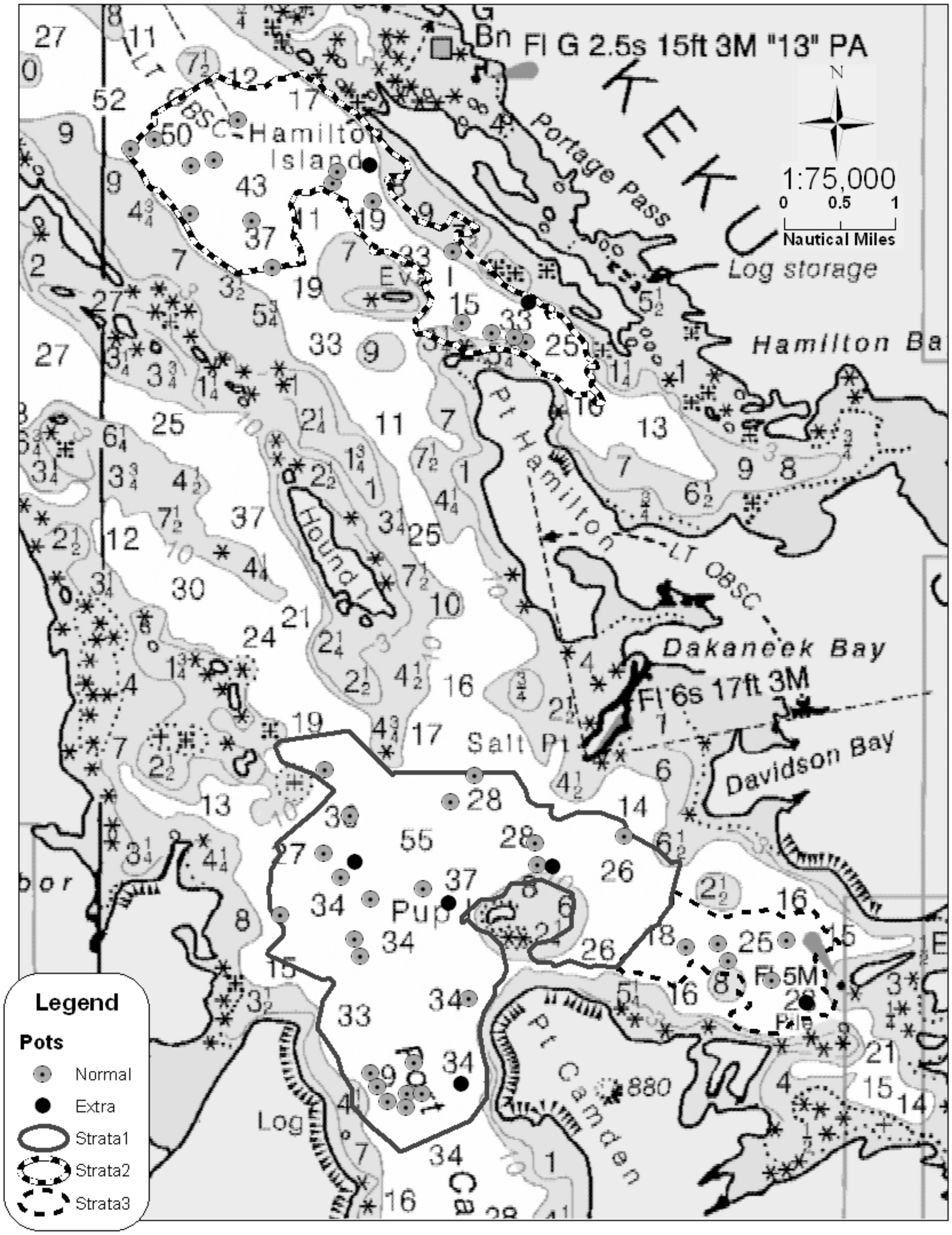

Figure 7.–Tanner crab survey pot locations in Port Camden, Southeast Alaska, 2010.

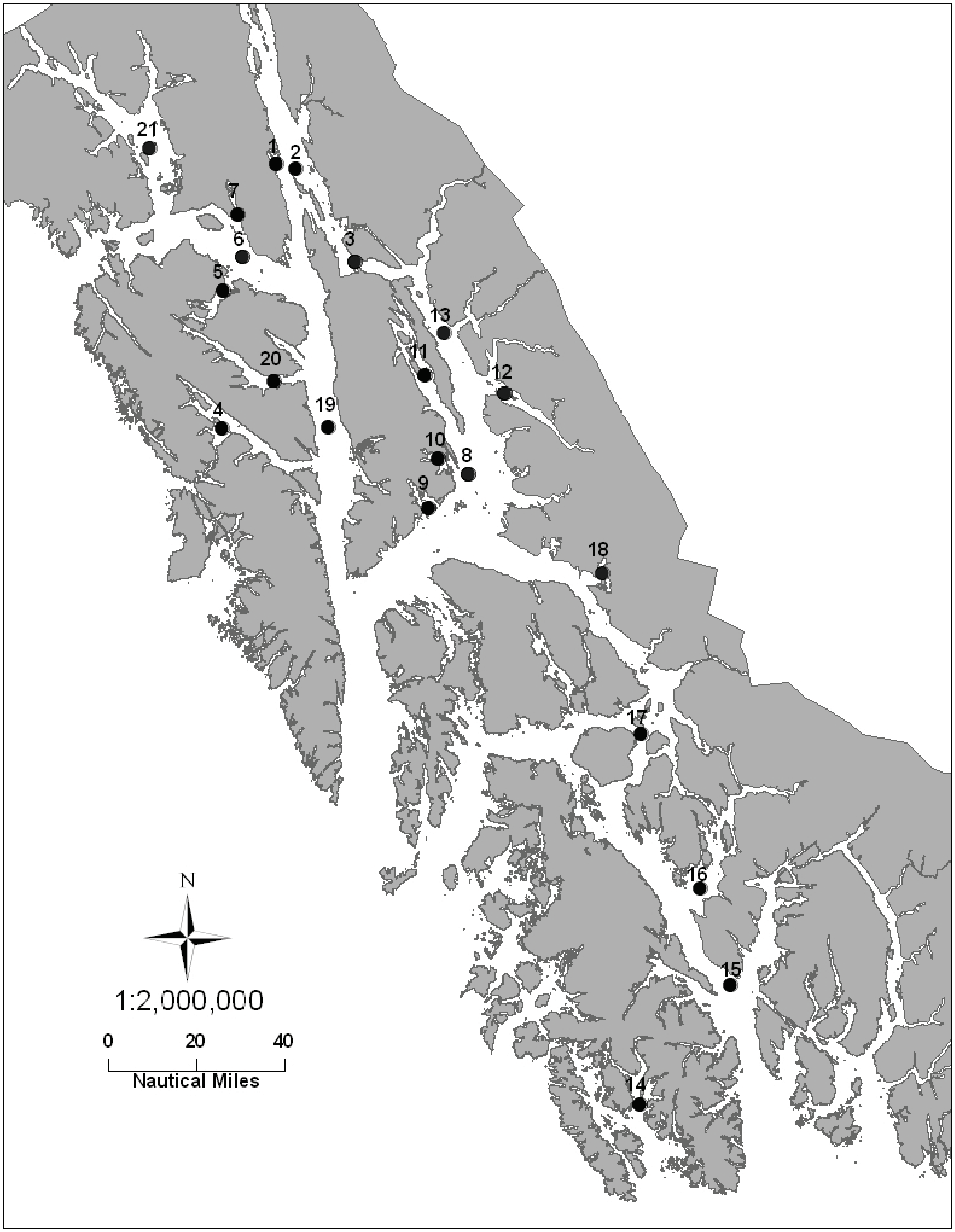

Figure 8.–CTD stations sampled during the 2010 shellfish surveys in Southeast Alaska. Stations 3, 6, 10, 12, 13, 18, and 21 were sampled during the 2010 Tanner crab survey and Stations 1–12 during the 2010 red king crab survey.

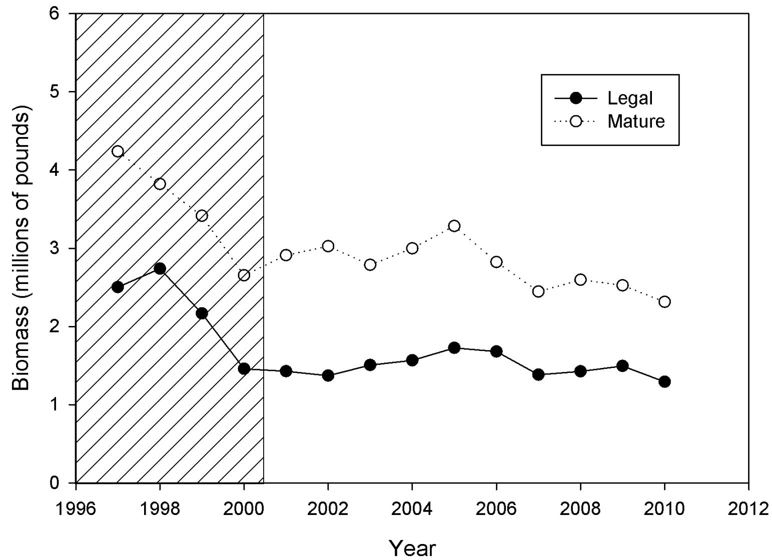

Figure 9.– Trends in mature and legal Tanner crab biomass in surveyed areas, estimated by catch-survey modeling of pot survey data for Southeast Alaska, 1997–2010 surveys. Hatched area is where biomass of areas not surveyed (Port Camden, Thomas Bay, Glacier Bay) are estimated by their minimum biomass of all subsequent years.

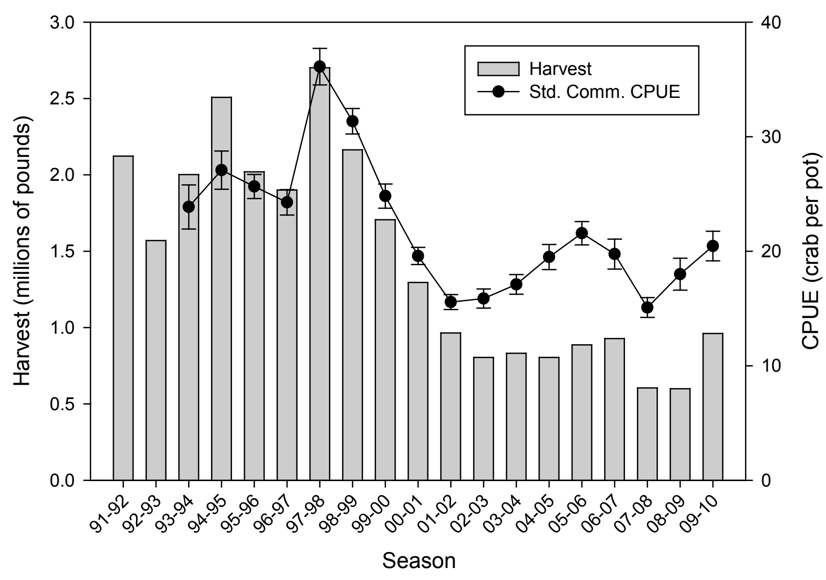

Figure 10. – Southeast Alaska commercial Tanner crab harvest and standardized commercial catch per unit effort (CPUE) for 1991/92 through 2009/10 seasons. CPUE was calculated using logbook data, which began during the 1993/94 season. Standardize CPUE was calculated by using a similar number of potlifts for each year, based on the year (2008/09) with the fewest number of potlifts (12,521).

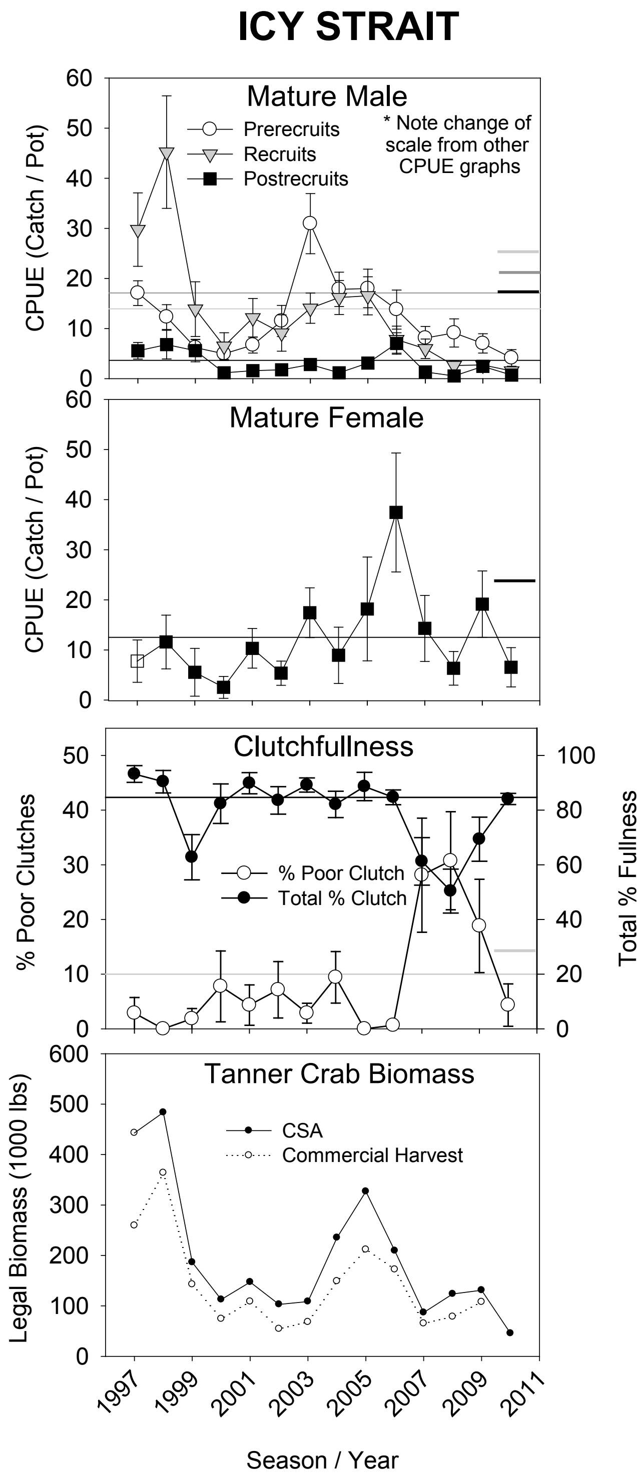

Figure 11.–Tanner crab CPUEs for all size/sex classes, clutch fullness, and proportion of poor clutches, and legal biomass estimates from catch survey analysis (CSA) and harvest data in Icy Strait, Southeast Alaska, 2010. Symbols on the right side of plots represent a significant increase ($p < 0.05$, up arrow) significant decrease ($p < 0.05$, down arrow), or no significant change ($p > 0.05$, straight line) from linear regression analysis over the last 4 years. Reference lines represent long-term average (benchmark) (1997–2006).

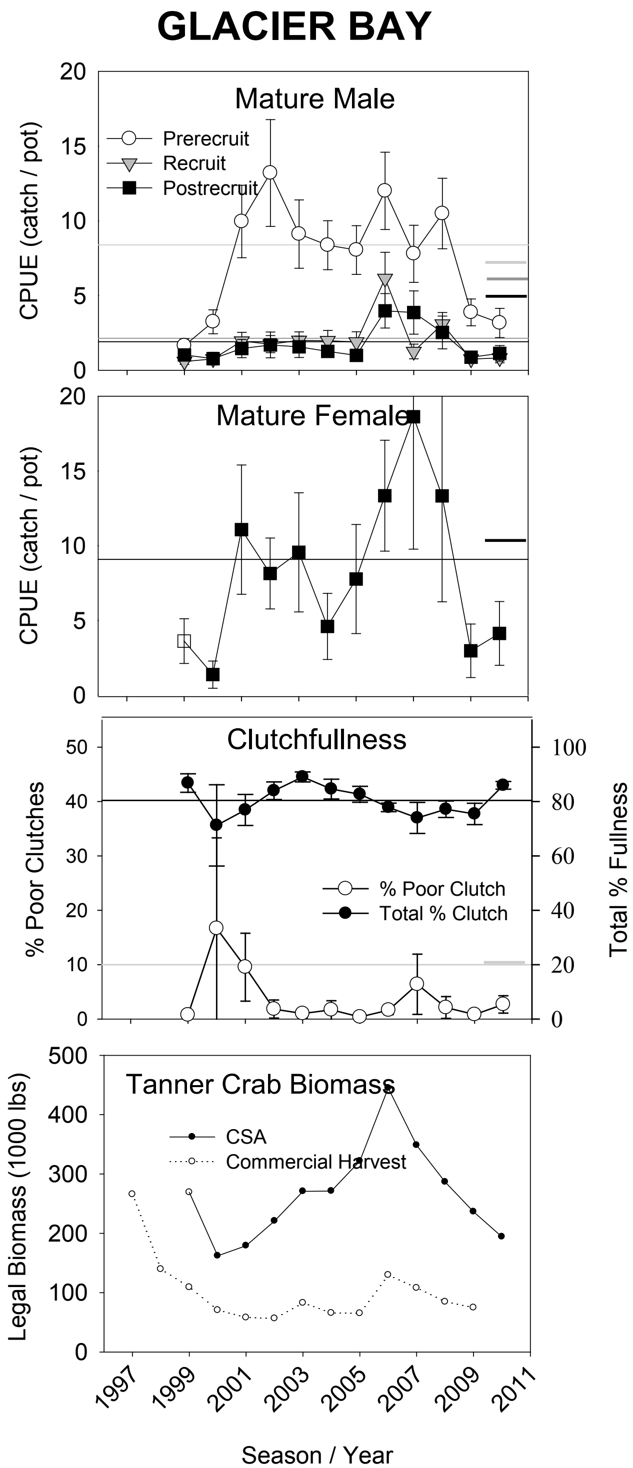

Figure 12.–Tanner crab CPUEs for all size/sex classes, clutch fullness, and proportion of poor clutches, and legal biomass estimates from catch survey analysis (CSA) and harvest data in Glacier Bay, Southeast Alaska, 2010. Symbols on the right side of plots represent a significant increase ($p < 0.05$, up arrow) significant decrease ($p < 0.05$, down arrow), or no significant change ($p > 0.05$, straight line) from linear regression analysis over the last 4 years. Reference lines represent long-term average (benchmark) (1999–2008).

STEPHENS PASSAGE

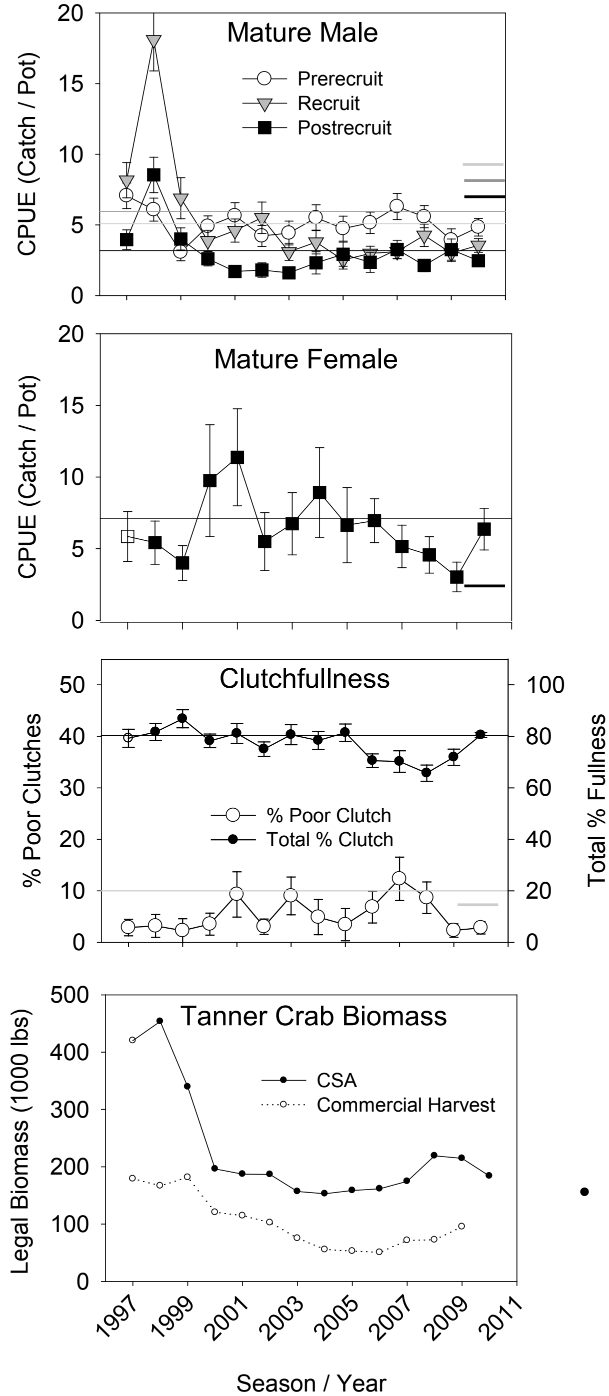

Figure 13.–Tanner crab CPUEs for all size/sex classes, clutch fullness, and proportion of poor clutches, and legal biomass estimates from catch survey analysis (CSA) and harvest data in Stephens Passage, Southeast Alaska, 2010. Symbols on the right side of plots represent a significant increase ($p < 0.05$, up arrow) significant decrease ($p < 0.05$, down arrow), or no significant change ($p > 0.05$, straight line) from linear regression analysis over the last 4 years. Reference lines represent long-term average (benchmark) (1997–2006).

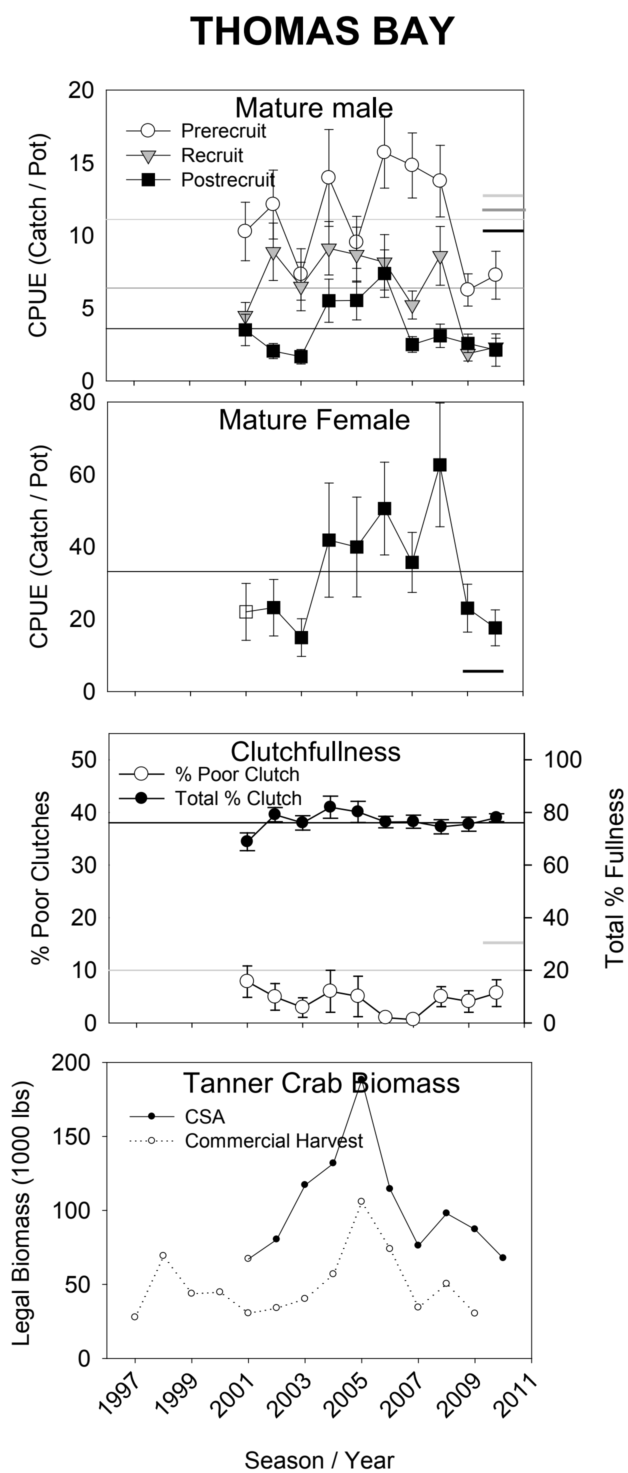

Figure 14.–Tanner crab CPUEs for all size/sex classes, clutch fullness, and proportion of poor clutches, and legal biomass estimates from catch survey analysis (CSA) and harvest data in Thomas Bay, Southeast Alaska, 2010. Symbols on the right side of plots represent a significant increase ($p < 0.05$, up arrow) significant decrease ($p < 0.05$, down arrow), or no significant change ($p > 0.05$, straight line) from linear regression analysis over the last 4 years. Reference lines represent long-term average (benchmark) (2001–2010).

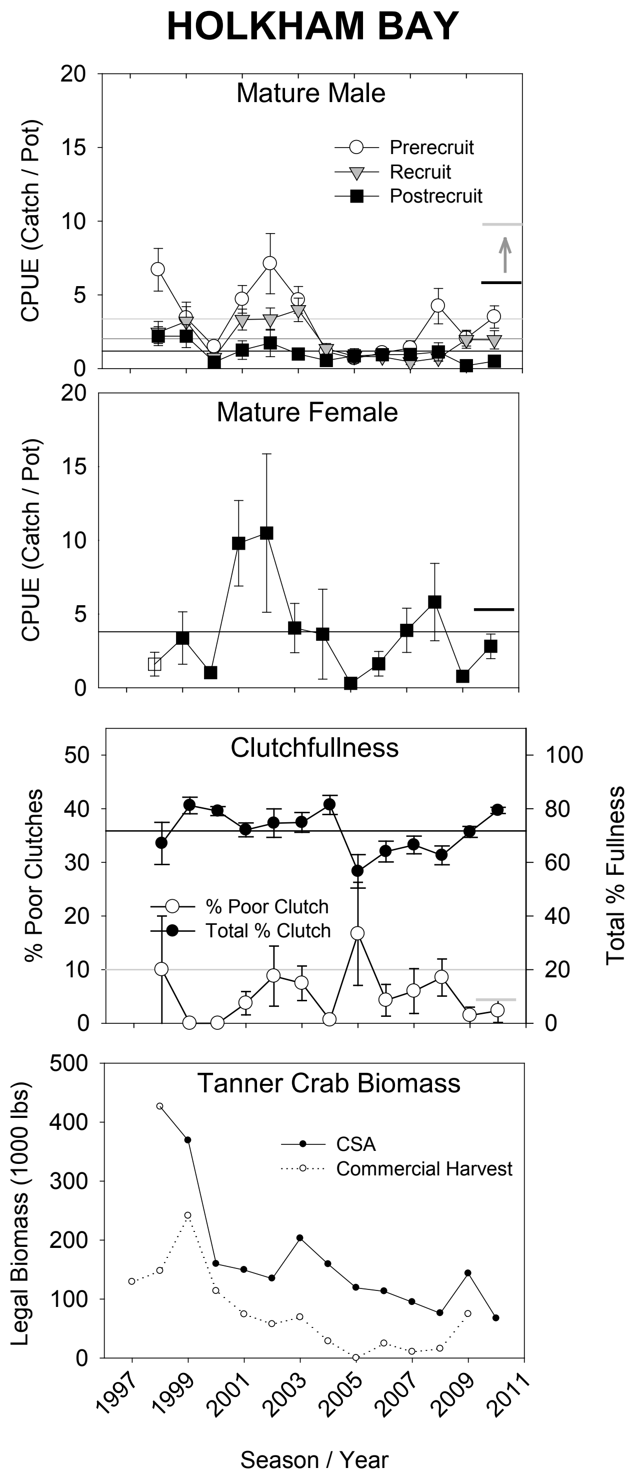

Figure 15.–Tanner crab CPUEs for all size/sex classes, clutch fullness, and proportion of poor clutches, and legal biomass estimates from catch survey analysis (CSA) and harvest data in Holkham Bay, Southeast Alaska, 2010. Symbols on the right side of plots represent a significant increase ($p < 0.05$, up arrow) significant decrease ($p < 0.05$, down arrow), or no significant change ($p > 0.05$, straight line) from linear regression analysis over the last 4 years. Reference lines represent long-term average (benchmark) (1998–2007).

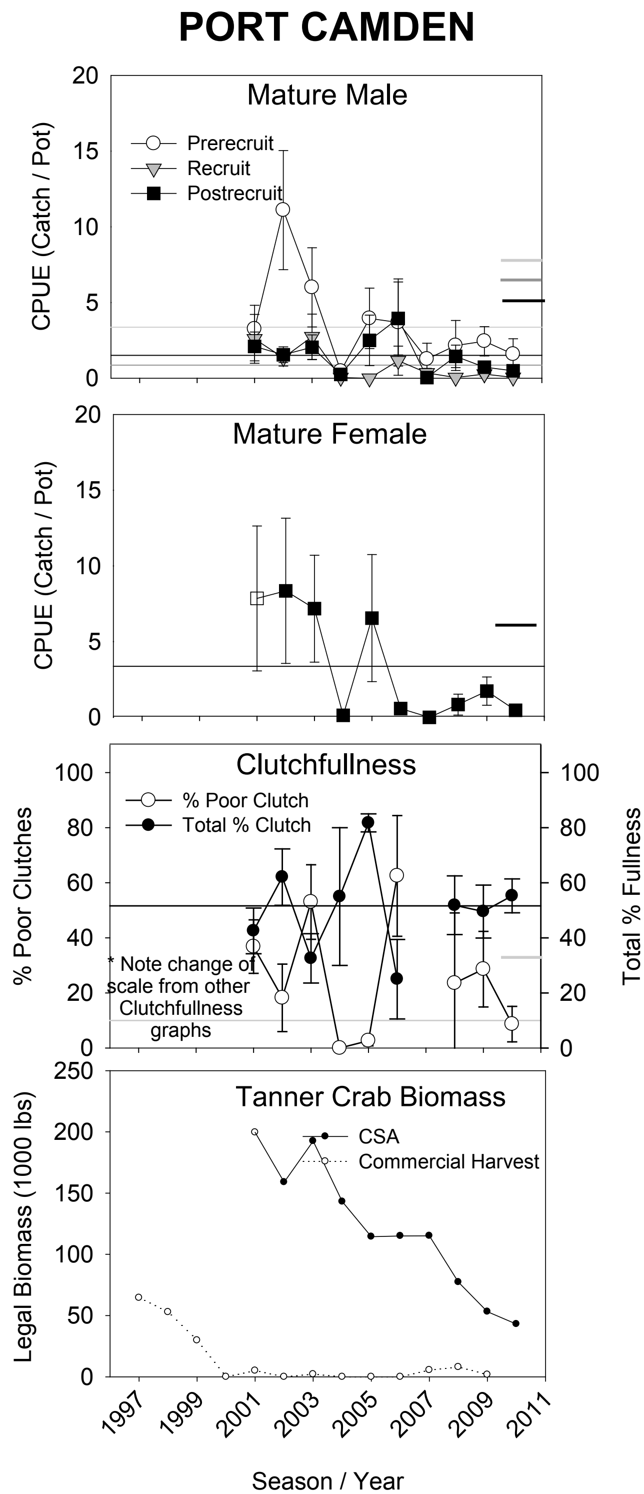

Figure 16.–Tanner crab CPUEs for all size/sex classes, clutch fullness, and proportion of poor clutches, and legal biomass estimates from catch survey analysis (CSA) and harvest data in Port Camden, Southeast Alaska, 2010. Symbols on the right side of plots represent a significant increase ($p < 0.05$, up arrow) significant decrease ($p < 0.05$, down arrow), or no significant change ($p > 0.05$, straight line) from linear regression analysis over the last 4 years. Reference lines represent long-term average (benchmark) (2001–2010).

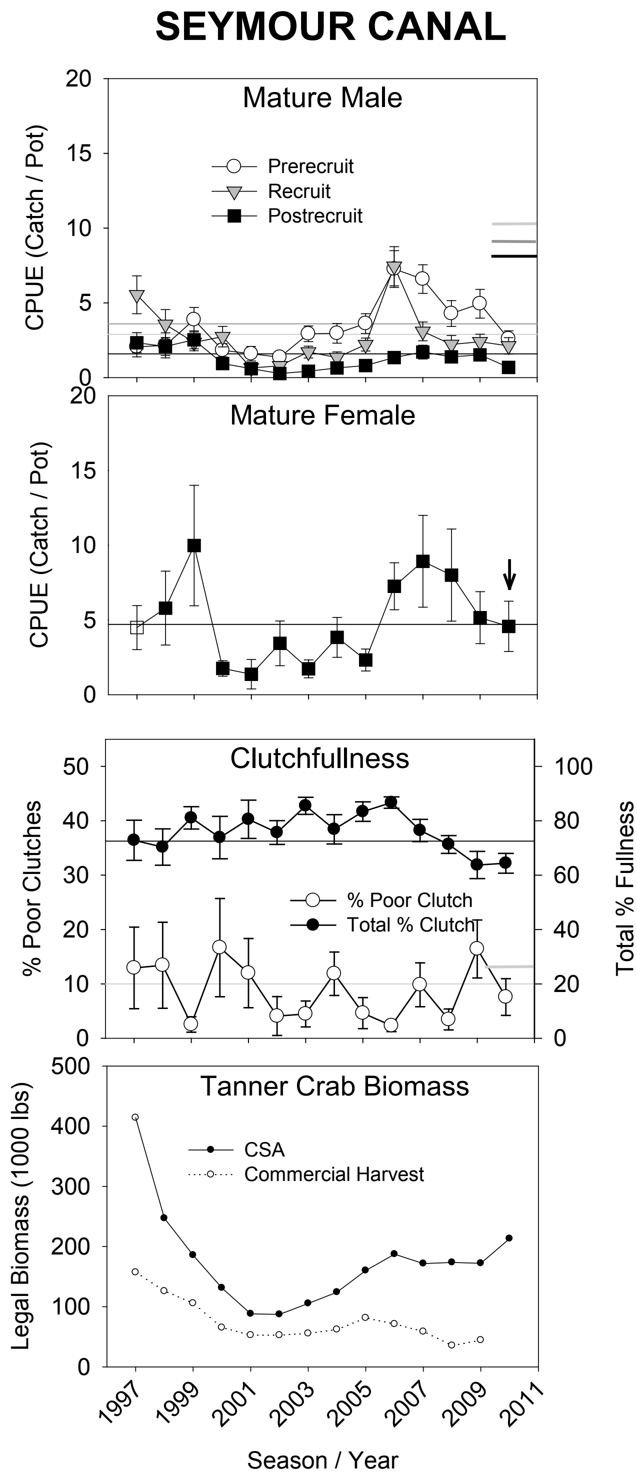

Figure 17.–Tanner crab CPUEs for all size/sex classes, clutch fullness, and proportion of poor clutches, and legal biomass estimates from catch survey analysis (CSA) and harvest data in Seymour Canal, Southeast Alaska, 2010. Symbols on the right side of plots represent a significant increase ($p < 0.05$, up arrow) significant decrease ($p < 0.05$, down arrow), or no significant change ($p > 0.05$, straight line) from linear regression analysis over the last 4 years. Reference lines represent long-term average (benchmark) (1993–2002).

NORTH JUNEAU

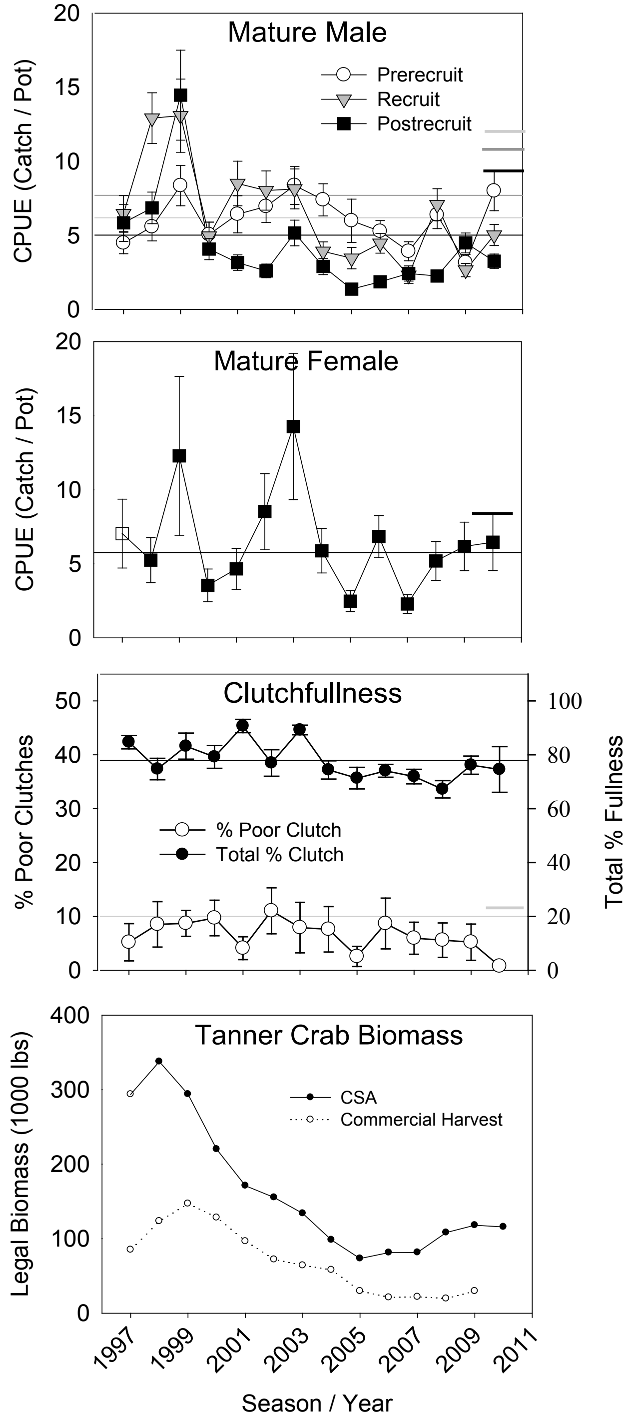

Figure 18.–Tanner crab CPUEs for all size/sex classes, clutch fullness, and proportion of poor clutches, and legal biomass estimates from catch survey analysis (CSA) and harvest data in North Juneau, Southeast Alaska, 2010. Symbols on the right side of plots represent a significant increase ($p < 0.05$, up arrow) significant decrease ($p < 0.05$, down arrow), or no significant change ($p > 0.05$, straight line) from linear regression analysis over the last 4 years. Reference lines represent long-term average (benchmark) (1993–2002).

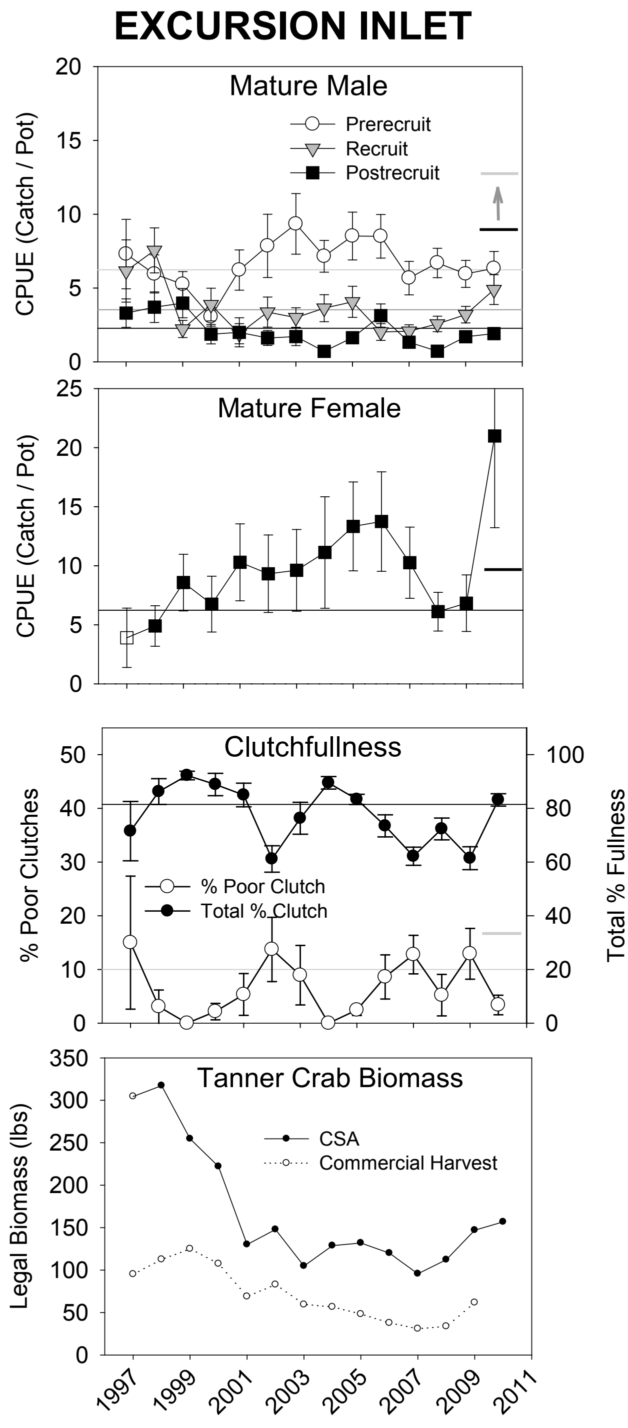

Figure 19.–Tanner crab CPUEs for all size/sex classes, clutch fullness, and proportion of poor clutches, and legal biomass estimates from catch survey analysis (CSA) and harvest data in Excursion Inlet, Southeast Alaska, 2010. Symbols on the right side of plots represent a significant increase ($p < 0.05$, up arrow) significant decrease ($p < 0.05$, down arrow), or no significant change ($p > 0.05$, straight line) from linear regression analysis over the last 4 years. Reference lines represent long-term average (benchmark) (1993–2002).

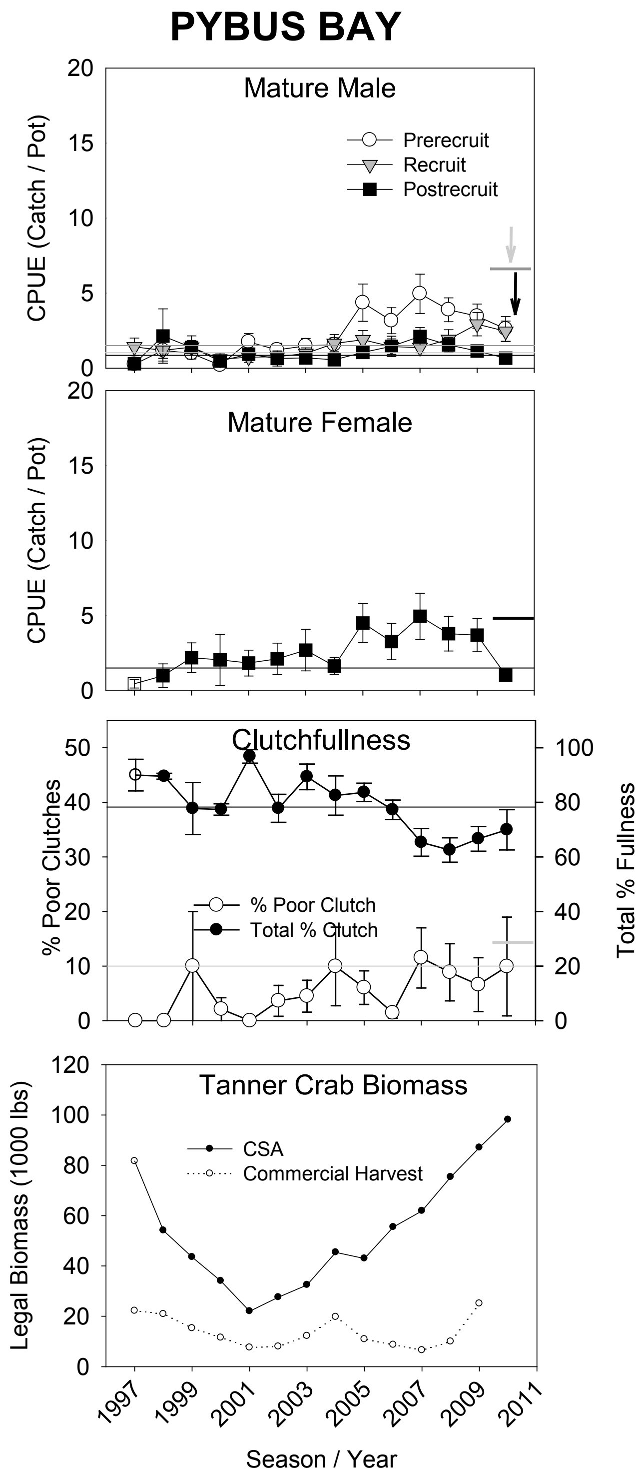

Figure 20.–Tanner crab CPUEs for all size/sex classes, clutch fullness, and proportion of poor clutches, and legal biomass estimates from catch survey analysis (CSA) and harvest data in Pybus Bay, Southeast Alaska, 2010. Symbols on the right side of plots represent a significant increase ($p < 0.05$, up arrow) significant decrease ($p < 0.05$, down arrow), or no significant change ($p > 0.05$, straight line) from linear regression analysis over the last 4 years. Reference lines represent long-term average (benchmark) (1993–2002).

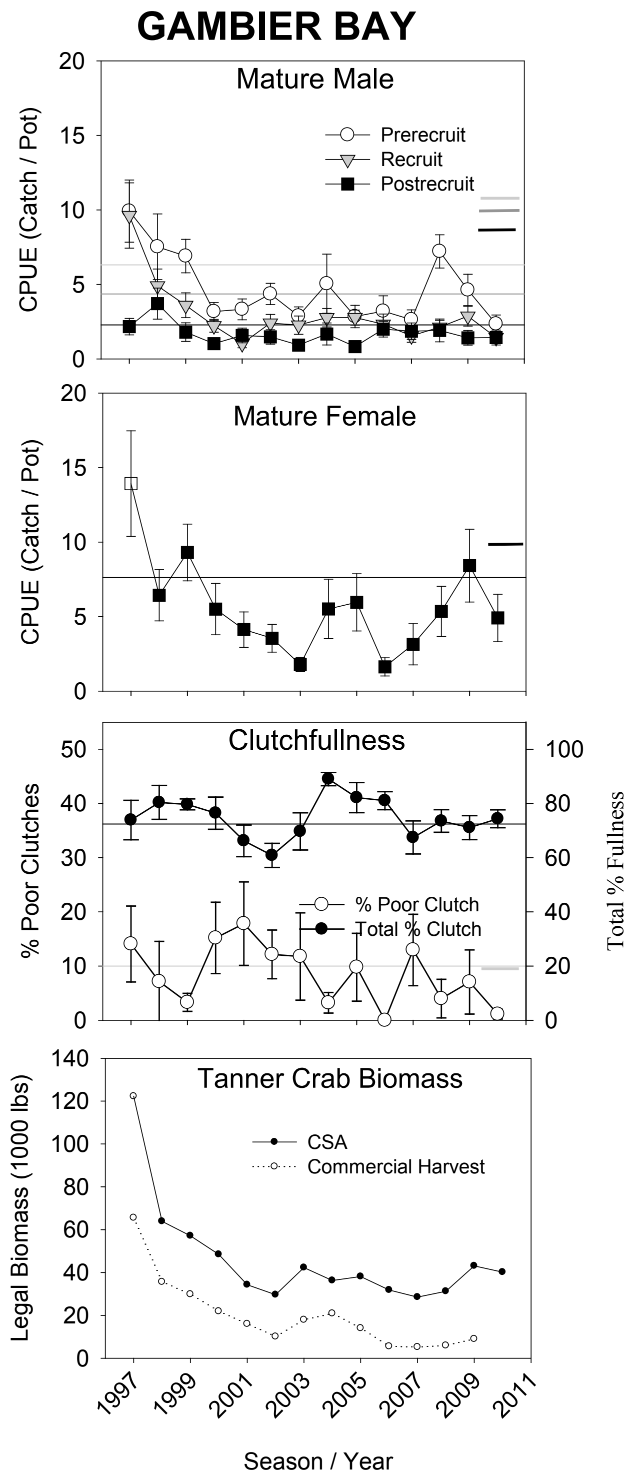

Figure 21.–Tanner crab CPUEs for all size/sex classes, clutch fullness, and proportion of poor clutches, and legal biomass estimates from catch survey analysis (CSA) and harvest data in Gambier Bay, Southeast Alaska, 2010. Symbols on the right side of plots represent a significant increase ($p < 0.05$, up arrow) significant decrease ($p < 0.05$, down arrow), or no significant change ($p > 0.05$, straight line) from linear regression analysis over the last 4 years. Reference lines represent long-term average (benchmark) (1993–2002).

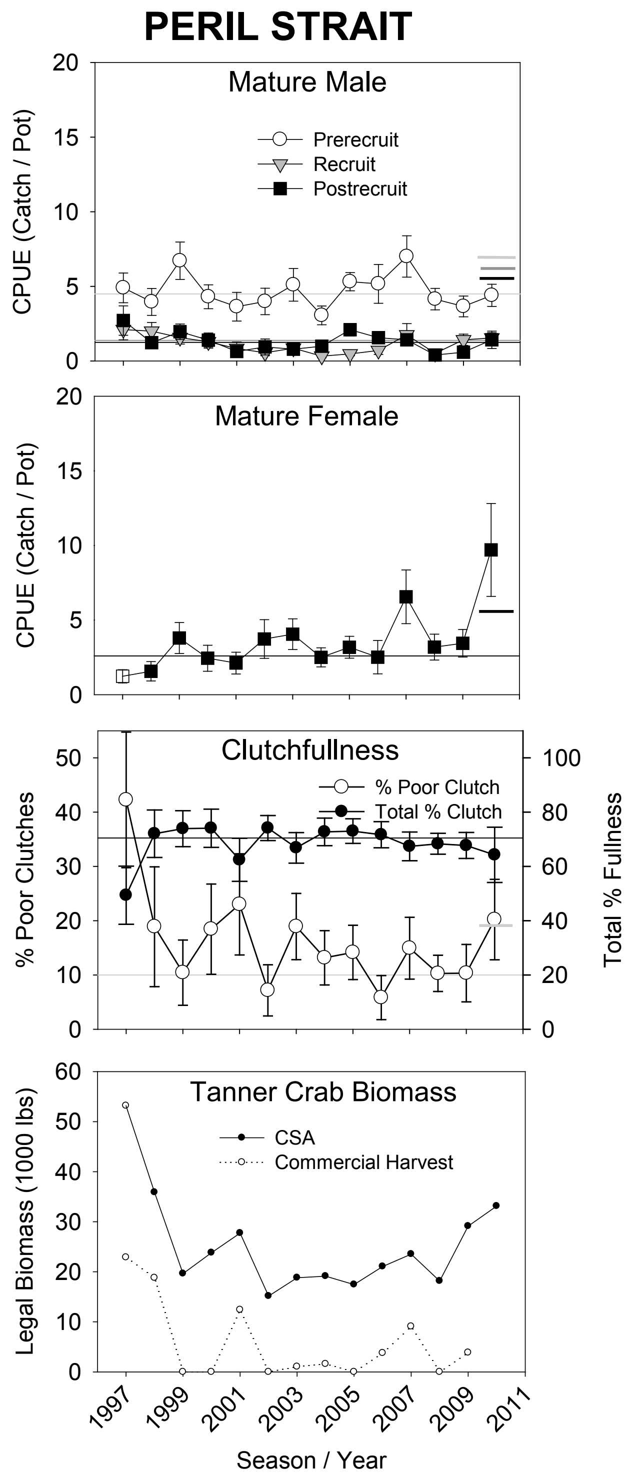

Figure 22.–Tanner crab CPUEs for all size/sex classes, clutch fullness, and proportion of poor clutches, and legal biomass estimates from catch survey analysis (CSA) and harvest data in Peril Strait, Southeast Alaska, 2010. Symbols on the right side of plots represent a significant increase ($p < 0.05$, up arrow) significant decrease ($p < 0.05$, down arrow), or no significant change ($p > 0.05$, straight line) from linear regression analysis over the last 4 years. Reference lines represent long-term average (benchmark) (1993–2002).

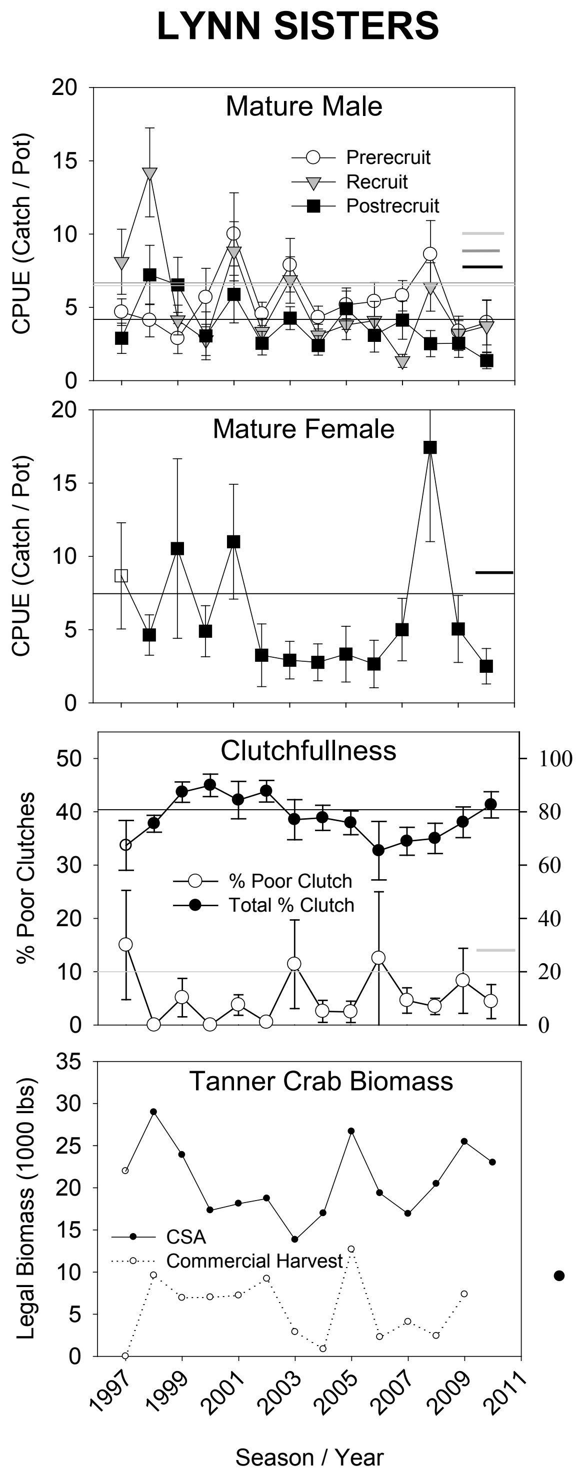

Figure 23.–Tanner crab CPUEs for all size/sex classes, clutch fullness, and proportion of poor clutches, and legal biomass estimates from catch survey analysis (CSA) and harvest data in Lynn Sisters, Southeast Alaska, 2010. Symbols on the right side of plots represent a significant increase ($p < 0.05$, up arrow) significant decrease ($p < 0.05$, down arrow), or no significant change ($p > 0.05$, straight line) from linear regression analysis over the last 4 years. Reference lines represent long-term average (benchmark) (1993–2002).

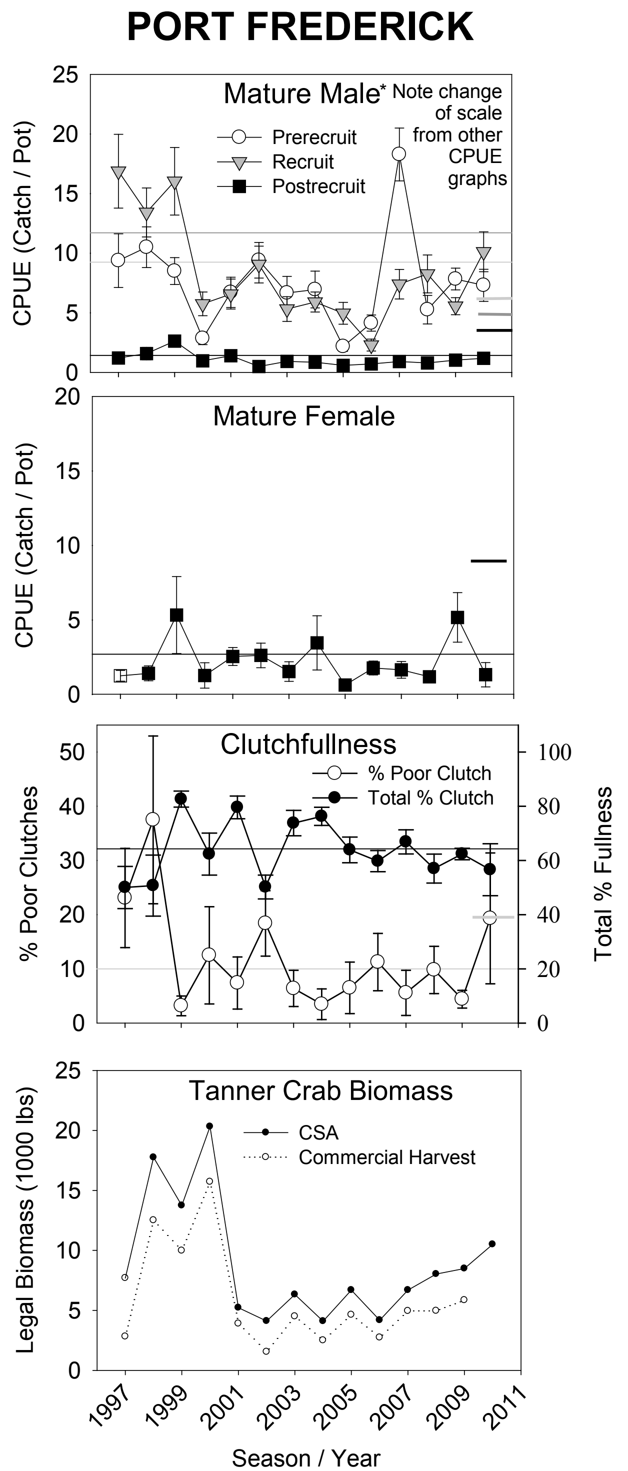

Figure 24.–Tanner crab CPUEs for all size/sex classes, clutch fullness, and proportion of poor clutches, and legal biomass estimates from catch survey analysis (CSA) and harvest data in Port Frederick, Southeast Alaska, 2010. Symbols on the right side of plots represent a significant increase ($p < 0.05$, up arrow) significant decrease ($p < 0.05$, down arrow), or no significant change ($p > 0.05$, straight line) from linear regression analysis over the last 4 years. Reference lines represent long-term average (benchmark) (1993–2002).

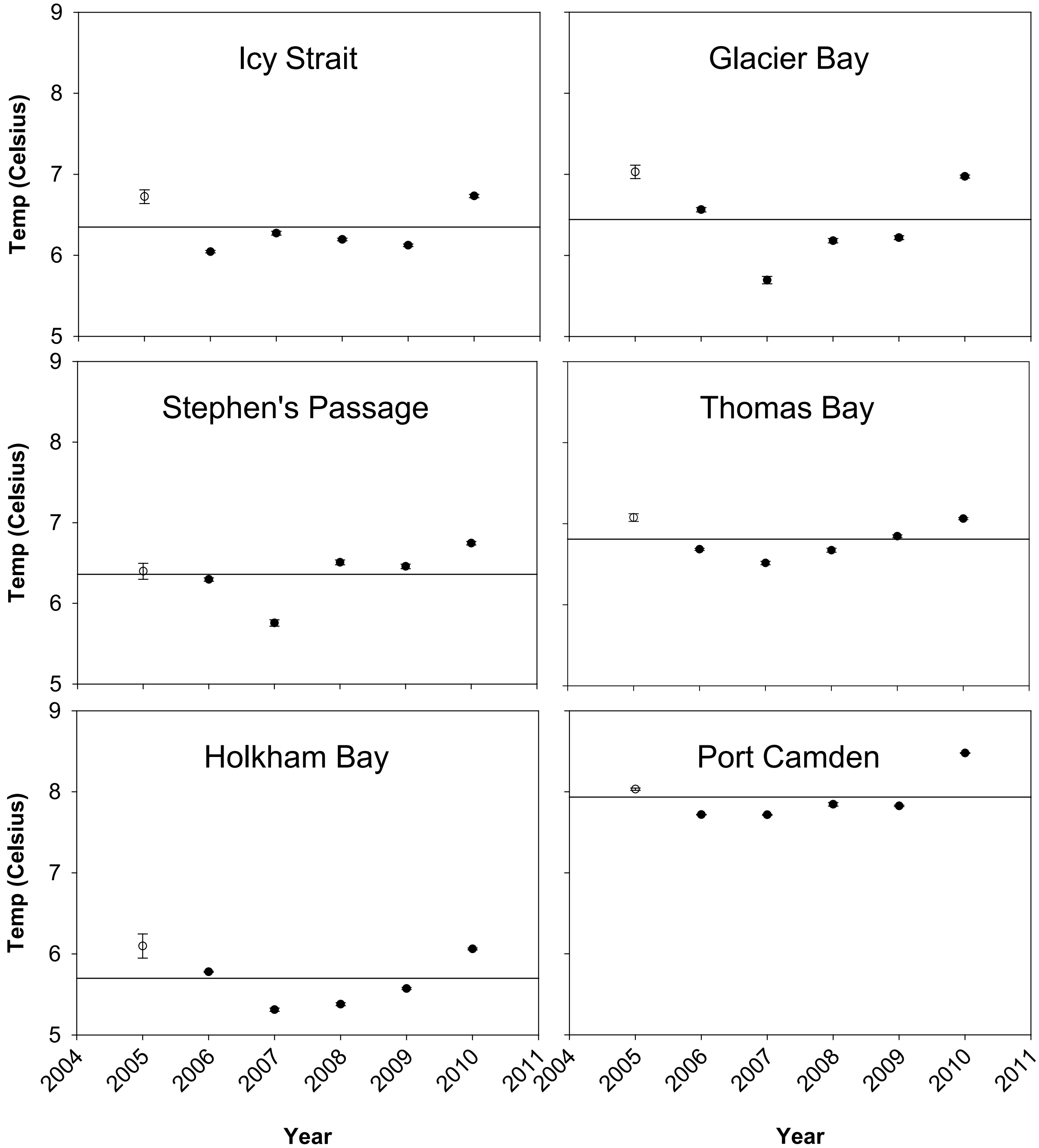

Figure 25.– Mean bottom temperature from 2005–2010 for each area surveyed during October Tanner crab surveys. Line represents mean of all years shown.

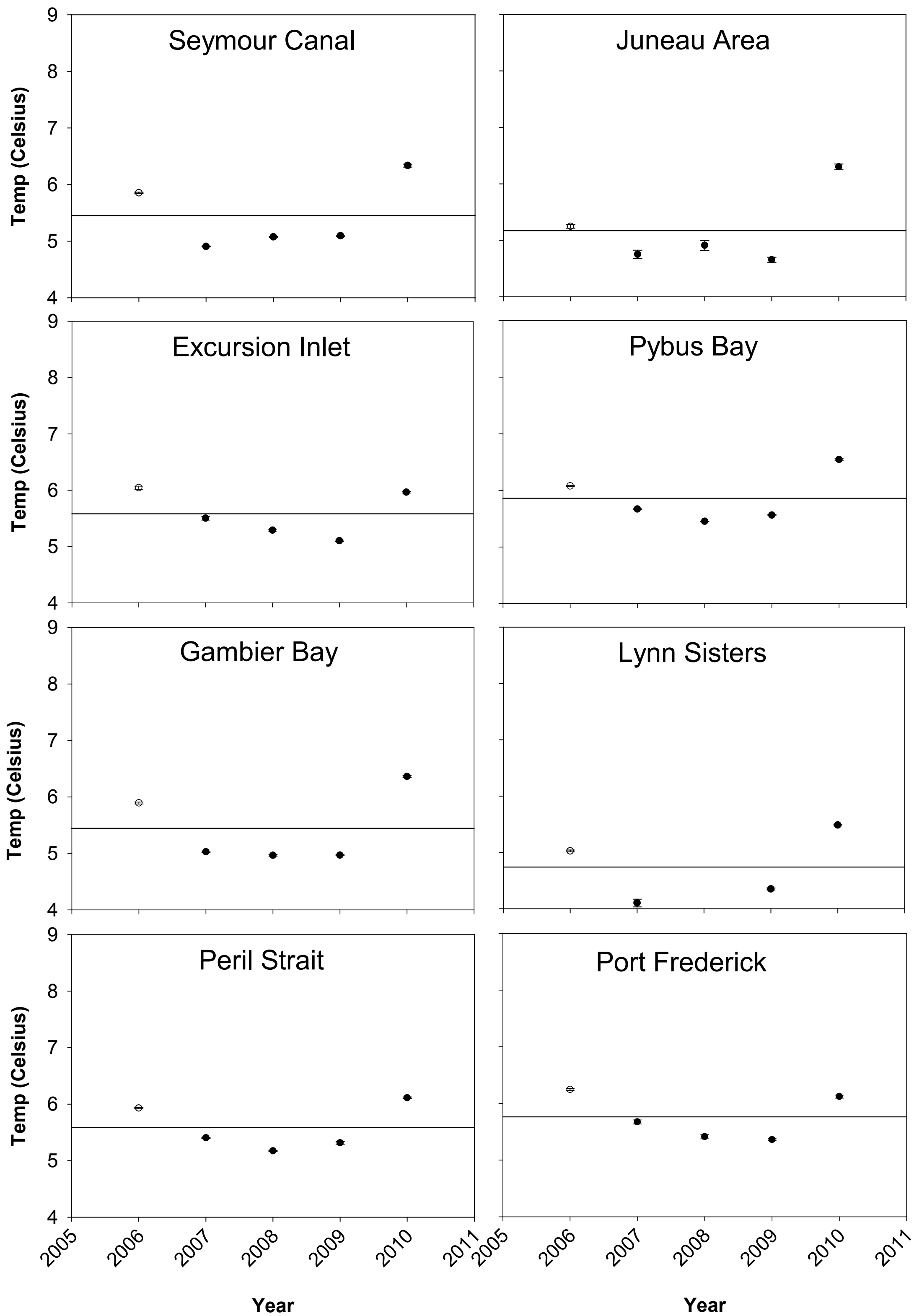

Figure 26.–Mean bottom temperature from 2006–2010 for each area surveyed during June and July red king crab surveys. Line represents mean of all years shown.

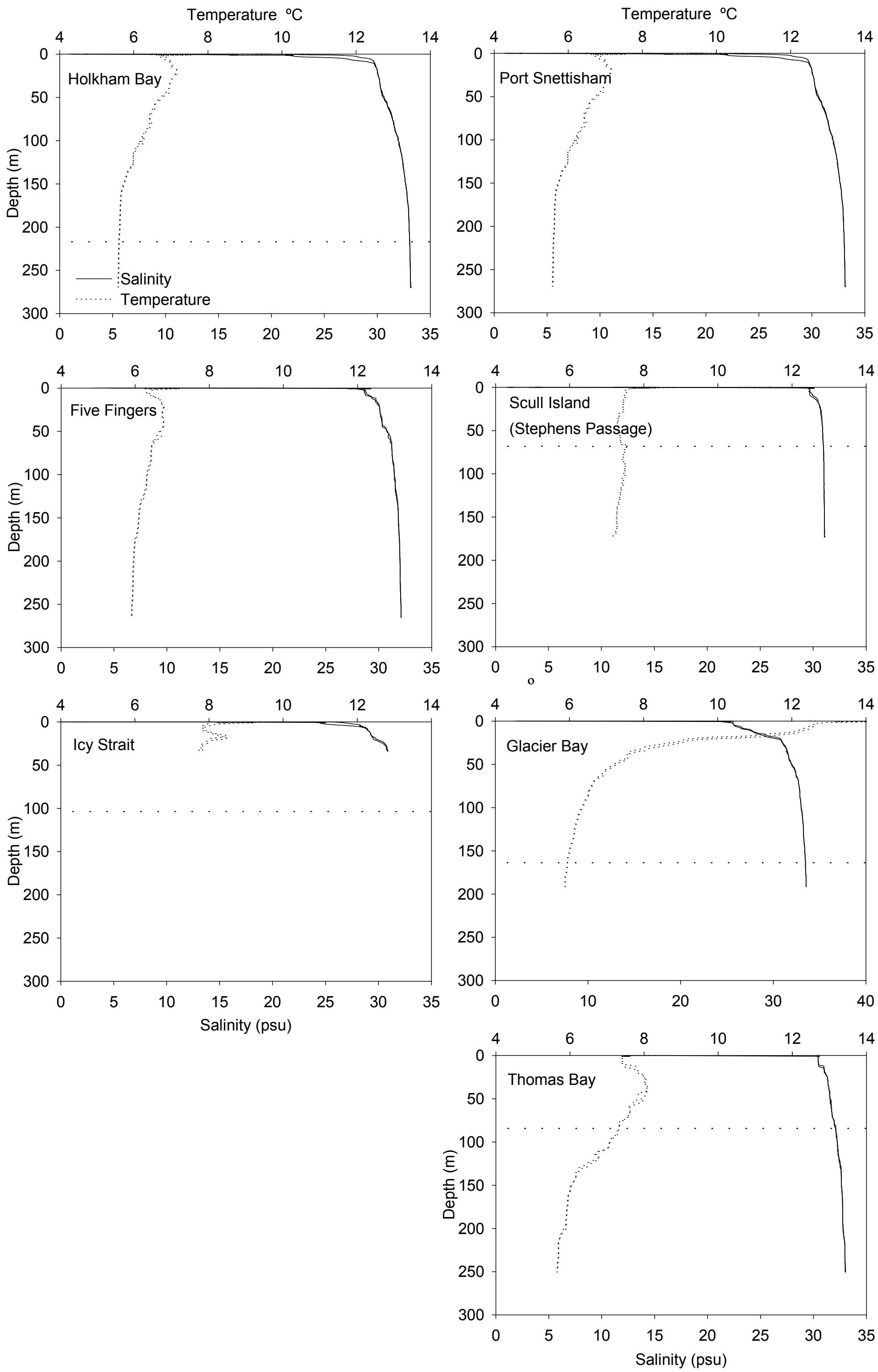

Figure 27.– Temperature profiles taken by CTD during the 2010 October Tanner crab survey at seven oceanographic stations. Dashed reference line is mean depth of pots in each survey area.

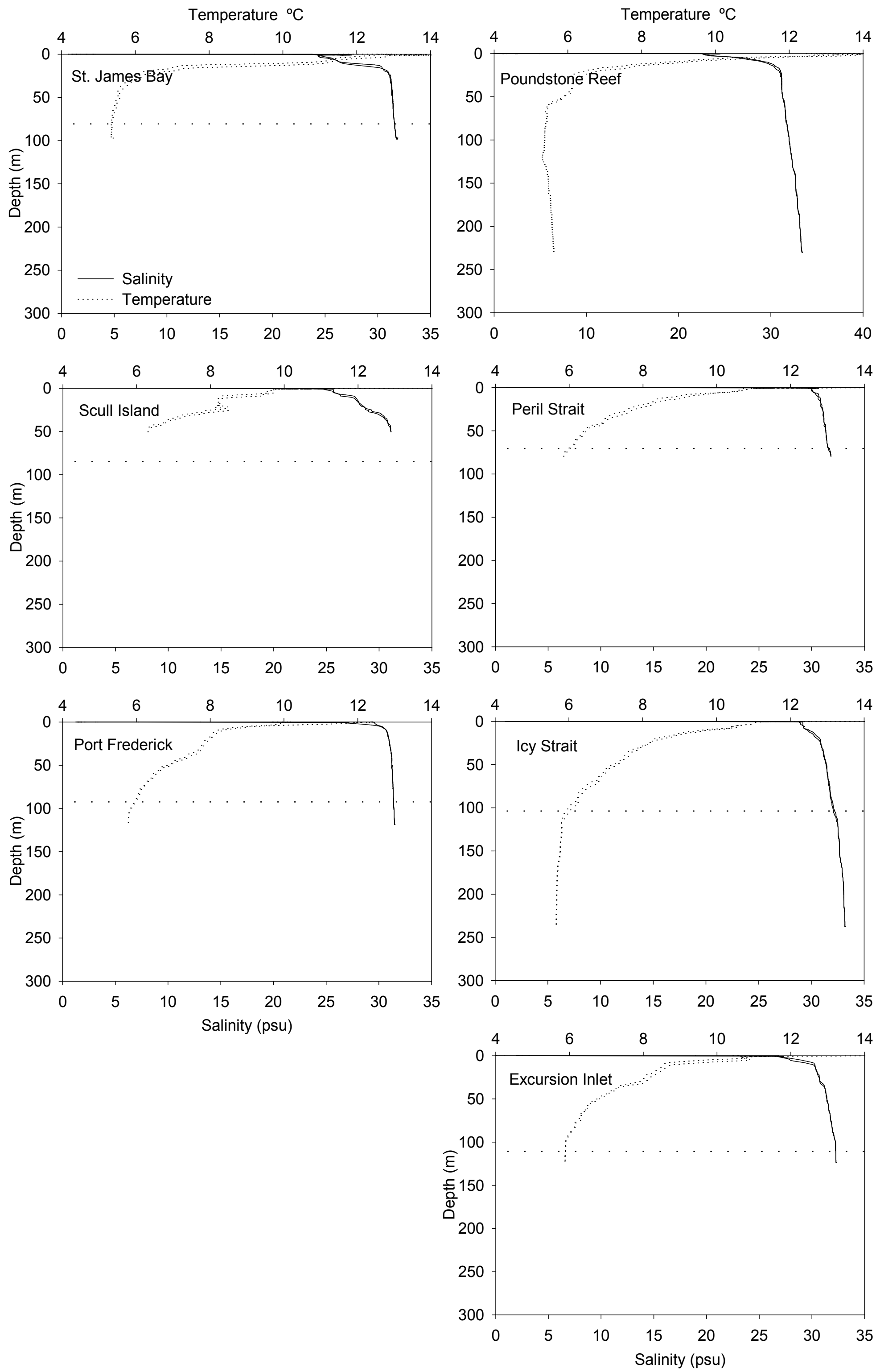

Figure 28.– Temperature profiles taken by CTD during the 2010 June/July red king crab survey for 7 of 12 oceanographic stations. Dashed reference line is mean depth of pots in each survey area.

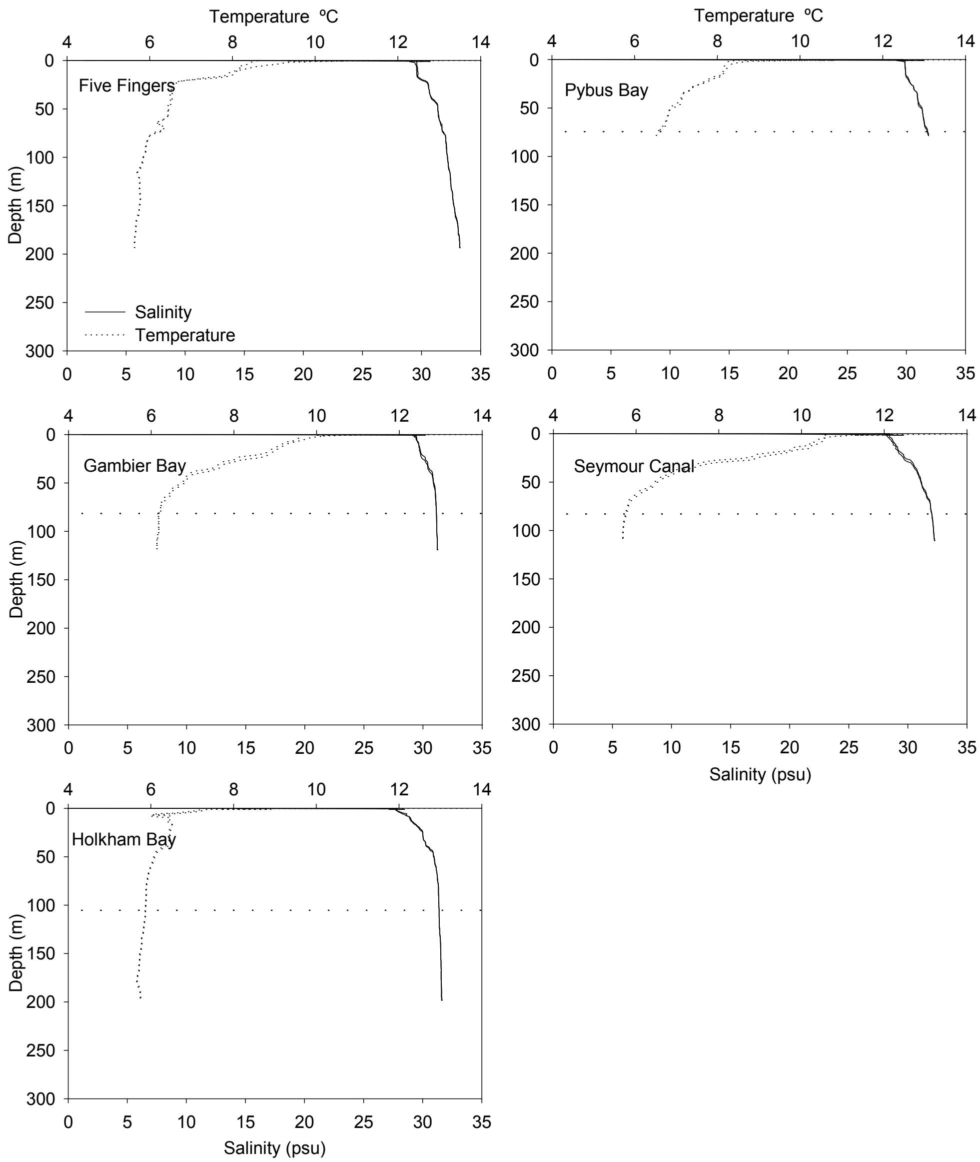

Figure 29.–Temperature profiles taken by CTD during the 2010 June/July red king crab survey for 5 of 12 oceanographic stations. Dashed reference line is mean depth of pots in each survey area.

Table 1.–Latitude and longitude of oceanographic stations where CTD drops are conducted during annual shellfish surveys. Stations 3, 6, 8, 10, 12, 13, 18, and 21 were sampled during the 2010 Tanner crab survey and Stations 1 through 12 during the 2010 red king crab survey.

Station no.	Station name	Decimal degrees	
		Latitude	Longitude
1	Lynn Sisters	58.34504	135.09472
2	Poundstone Reef	58.33415	135.01425
3	Scull Island	58.12432	134.35402
4	Peril Strait	57.34296	135.30175
5	Port Frederick	58.05745	135.31514
6	Icy Strait	58.13470	135.23392
7	Excursion Inlet	58.23021	135.25955
8	Five Fingers	57.24821	133.46168
9	Pybus Bay	57.17193	134.02926
10	Gambier Bay	57.28348	133.58998
11	Seymour Canal	57.47281	134.04936
12	Holkham Bay	57.43343	133.30916
13	Port Snettisham	57.57224	133.57854
14	Cordova Bay	55.01726	132.38238
15	Clarence Strait	55.28312	132.01446
16	Ernest Sound	55.50478	132.12752
17	Stikine Strait	56.42844	132.58716
18	Thomas Bay	57.02204	132.50305
19	Chatham Strait	57.58943	134.76149
20	Tenakee Inlet	57.75844	135.14554
21	Glacier Bay	58.37468	136.04897

Table 2.–Overview of effort by survey area during the 2010 red king crab and Tanner crab surveys.

Project	Location	Dates	Pots pulled	SE soak time (hrs)		Depth (m)	
			n	Mean	SE	Mean	SE
Tanner survey	Icy Strait	10/06-10/07	38	18.6	0.18	103.8	4.79
	Glacier Bay	10/02-10/05	61	19.3	0.15	163.8	10.72
	Stephens Passage	9/29-10/01	44	19.2	0.08	68.3	5.72
	Thomas Bay	10/12-10/14	42	18.6	0.15	84.4	5.44
	Holkham Bay	10/18-10/21	66	18.8	0.24	217.1	10.72
	Port Camden	10/15-10/17	41	18.8	0.28	66.3	2.56
	TOTAL	19	292	18.9		117.3	
RKC Survey	Seymour Canal	7/17-7/19	66	19.1	0.07	83.0	4.78
	Juneau area	6/11-6/17	152	19.2	0.04	85.0	2.97
	Excursion Inlet	7/01-7/02	46	18.3	0.22	110.7	5.53
	Pybus Bay	7/12-7/14	44	19.8	0.10	74.6	3.50
	Gambier Bay	7/15-7/16	32	19.1	0.08	81.7	6.58
	Peril Strait	6/23-6/26	43	19.7	0.11	70.5	2.23
	St. James Bay	6/09-6/10	22	18.4	0.11	80.8	6.93
	Port Frederick	6/28-6/30	43	19.1	0.11	92.5	6.24
	Holkham Bay	7/20-7/23	59	18.8	0.17	105.5	7.07
	TOTAL	31	243	19.1		87.1	
	GRAND TOTAL	50	535	19.0		99.2	

Table 3.–Results of catch-survey modeling estimation of legal and mature Tanner crab biomass and GHL calculations using exploitation rates based upon stock health for each of 14 surveyed areas and other areas. See matrices below for a more detailed look at the basis of stock health determinations. The expansion factor of 71% (29% for non-surveyed areas) for the total legal and mature crab biomass was based on the percent of commercial harvest taken from 1980–2000 in surveyed areas. The 1993–2002 average harvest represents a mean historical baseline (long-term average) of harvest.

Survey area	Biomass of legal crab	Biomass of mature crab	Stock health	Mature exploitation rate	Legal exploitation rate	Total GHL	1993-2002 Average catch	1993-2002 Est. mature biomass
TCS								
Icy Strait	45,525	76,538	Below average	5%	8%	3,827	185,166	740,664
Glacier Bay	194,183	346,303	Below average	5%	9%	17,315	255,482	1,021,928
Stephens Passage	183,957	259,463	Moderate	10%	14%	25,946	144,241	576,964
Thomas Bay	67,594	110,673	Below average	5%	8%	5,534	59,356	237,424
Holkham Bay	67,038	133,162	Moderate	10%	20%	13,316	245,541	982,164
Port Camden	43,066	107,273	Below average	5%	12%	5,364	39,239	156,956
RKCS								
Seymour Canal	213,128	276,646	Below average	5%	6%	13,832	115,719	462,876
North Juneau	115,791	177,326	Moderate	10%	15%	17,733	83,188	332,752
Excursion Inlet	156,736	258,409	Above average	15%	25%	38,761	79,705	318,820
Pybus Bay	98,085	128,025	Moderate	10%	13%	12,802	23,783	95,132
Gambier Bay	40,165	51,555	Moderate	10%	13%	5,156	53,615	214,460
Peril Strait	33,136	69,479	Moderate	10%	21%	6,948	16,184	64,736
Lynn Sisters	22,975	30,325	Below average	5%	7%	1,516	9,400	37,600
Port Frederick	10,496	14,412	Moderate	10%	14%	1,441	13,920	55,680
Other Areas	527,446	838,772				69,229	541,009	2,164,036
Total	1,818,781	2,892,318				238,720	1,865,548	7,462,192

Table 4.–Matrix of stock health determination for all size/sex classes of Tanner crab form the 2010 Tanner crab surveys. The long-term average is defined as the first 10 years of available data from 1997–2010. Short-term trends are based on individual regression analyses over the past 4 years (including the current year). Total score is the sum of scores (+1, 0,-1 for long-term; +.25, 0, -.25 for short-term) for each response variable. NT=No trend.

	Icy Strait		**Glacier Bay**		**Stephens Passage**		**Thomas Bay**		**Holkham Bay**		**Port Camden**	
	% of Baseline	**Score**	**% of Baseline**	**Score**	**% of Baseline**	**Score**	**% of Baseline**	**Score**	**% of Baseline**	**Score**	**% of Baseline**	**Score**
Large/Mature Females												
Percent clutch fullness < 25%												
vs. long-term average	-57%	0	**-73%**	**1**	**-72%**	**1**	-43%	0	**-77%**	**1**	-13%	0
short term trend	NT	0	NT	0	NT	0	NT	0	NT	0	NT	0
CPUE vs. long-term average	-48%	0	**-55%**	**-1**	-11%	0	**-47%**	**-1**	-26%	0	**-86%**	**-1**
CPUE vs. short-term trend	NT	0	NT	0	NT	0	NT	0	NT	0	NT	0
Prerecruit Males												
CPUE vs. long-term average	**-70%**	**-1**	**-62%**	**-1**	-5%	0	**-35%**	**-1**	4%	0	-56%	0
CPUE short-term trend	NT	0	NT	0	NT	0	NT	0	NT	0	NT	0
Recruit Males												
CPUE vs. long-term average	**-91%**	**-1**	**-62%**	**-1**	**-40%**	**-1**	**-64%**	**-1**	-3%	0	**-94%**	**-1**
CPUE short-term trend	NT	0	NT	0	NT	0	NT	0	**Sig. inc**	**0.25**	NT	0
Postrecruit Males												
CPUE vs. long-term average	**-81%**	**-1**	-41%	0	**-23%**	**-1**	-41%	0	**-58%**	**-1**	**-68%**	**-1**
CPUE short-term trend	NT	0	NT	0	NT	0	NT	0	NT	0	NT	0
2008 Total score	-5		1		-1		0.75		-0.5		-2	
2008 Stock health	Poor		Moderate		Moderate		Moderate		Moderate		Poor	
2008 Legal exploitation rate	0%		10%		10%		10%		10%		0%	
2010 Total score	-3		-2		-1		-3		0.25		-3	
2010 Stock health	**Below average**		**Below average**		**Moderate**		**Below average**		**Moderate**		**Below average**	
2010 Mature exploitation rate	10%		10%		10%		10%		10%		10%	

Note: low % and sig. dec. are "good" for clutch fullness < 25%

Table 5.–Matrix of stock health determination for all size/sex classes of Tanner crab from the 2010 red king crab surveys. The long-term average is defined from 1993-2002. Short-term trends are based on individual regression analyses over the past 4 years (including the current year). Total score is the sum of scores (+1, 0,-1 for long-term; +.25, 0, -.25 for short-term) for each response variable. NT = No trend.

	Seymour Canal		**North Juneau**		**Excursion Inlet**		**Pybus Bay**	
	% of Baseline	**Score**	**% of Baseline**	**Score**	**% of Baseline**	**Score**	**% of Baseline**	**Score**
Large/Mature Females								
Percent clutch fullness < 25%								
vs. long-term average	-24%	0	**-92%**	**1**	**-66%**	**1**	-1%	0
short term trend	NT	0	NT	0	NT	0	NT	0
CPUE vs. long-term average	-3%	0	12%	0	237%	0	-31%	0
CPUE vs. short-term trend	**Sig. dec**	**-0.25**	NT	0	NT	0	NT	0
Prerecruit Males								
CPUE vs. long-term average	-10%	0	29%	0	26%	0	156%	0
CPUE short-term trend	NT	0	NT	0	NT	0	**Sig. dec**	**-0.25**
Recruit Males								
CPUE vs. long-term average	**-41%**	**-1**	**-35%**	**-1**	38%	0	63%	0
CPUE short-term trend	NT	0	NT	0	**Sig. inc**	**0.25**	NT	0
Postrecruit Males								
CPUE vs. long-term average	**-58%**	**-1**	**-35%**	**-1**	-16%	0	-22%	0
CPUE short-term trend	NT	0	NT	0	NT	0	**Sig. dec**	**-0.25**
2009 Total score	-0.75		-1.75		-0.25		1	
2009 Stock health	Moderate		Below Ave		Moderate		Moderate	
2009 Legal exploitation rate	10%		5%		10%		10%	
2010 Total score	-2.25		-1		1.25		-0.5	
2010 Stock health	**Below average**		**Moderate**		**Above average**		**Moderate**	
2010 Mature exploitation rate	10%		10%		10%		10%	

Note: low % and sig. dec. are "good" for clutch fullness < 25%

-continued-

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	Gambier Bay		Peril Strait		Lynn Sisters		Port Frederick	
	% of Baseline	**Score**	**% of Baseline**	**Score**	**% of Baseline**	**Score**	**% of Baseline**	**Score**
Large/Mature Females								
Percent clutch fullness < 25%								
vs. long-term average	**-89%**	**1**	102%	0	-56%	0	93%	0
short term trend	NT	0	NT	0	NT	0	NT	0
CPUE vs. long-term average	-36%	0	**272%**	**1**	**-66%**	**-1**	**-51%**	**-1**
CPUE vs. short-term trend	NT	0	NT	0	NT	0	NT	0
Prerecruit Males								
CPUE vs. long-term average	**-63%**	**-1**	-2%	0	-39%	0	-21%	0
CPUE short-term trend	NT	0	NT	0	NT	0	NT	0
Recruit Males								
CPUE vs. long-term average	**-67%**	**-1**	11%	0	-44%	0	-14%	0
CPUE short-term trend	NT	0	NT	0	NT	0	NT	0
Postrecruit Males								
CPUE vs. long-term average	-37%	0	14%	0	**-67%**	**-1**	-17%	0
CPUE short-term trend	NT	0	NT	0	NT	0	NT	0
2009 Total score	-1.75		-1.25		-2		0.25	
2009 Stock health	Below Ave		Moderate		Below Ave		Moderate	
2009 Legal exploitation rate	5%		10%		5%		10%	
2010 Total score	-1		1		-2		-1	
2010 Stock health	**Moderate**		**Moderate**		**Below average**		**Moderate**	
2010 Mature exploitation rate	10%		10%		10%		10%	

Note: low % and sig. dec. are "good" for clutch fullness < 25%

Table 6.–Total stock health scores for the 2007–2010 survey seasons for each survey area.

Survey area	**Year**			
	2007	**2008**	**2009**	**2010**
Icy Strait	-4.50	-5.00	-2.75	-3.00
Glacier Bay	0.25	1.00	-3.00	-2.00
Stephens Passage	-1.00	-1.00	-1.00	-1.00
Thomas Bay	-1.00	0.75	-2.50	-3.00
Holkham Bay	-2.25	-0.50	-0.75	0.25
Port Camden	-4.25	-2.00	-3.00	-3.00
Seymour Canal	2.00	-1.00	-0.75	-2.25
North Juneau	-4.25	-0.75	-1.75	-1.00
Excursion Inlet	-1.25	-1.25	-0.25	1.25
Pybus Bay	3.25	1.00	1.00	-0.50
Gambier Bay	-3.00	-0.75	-1.75	-1.00
Peril Strait	2.50	-2.25	-1.25	1.00
Lynn Sisters	-0.75	0.25	-2.00	-3.00
Port Frederick	-0.75	-2.50	0.25	-1.00

APPENDICES

To estimate an appropriate exploitation rate (ER) where the crab biomass does not change in the following year (i.e., where population growth rate is zero), the ER of a given year was correlated with the change in estimated biomass between that year and the next using the general linear model:

$$HR_{yr} = m(\Delta B_{yr+1}) + b ,$$

where HR_{yr} is the ER of a given year, ΔB_{yr+1} is the change in biomass in the next year, and m and b are parameters to be estimated (slope and intercept, respectively).

ERs for each year were estimated by dividing the commercial harvest by the biomass estimate for a given year:

$$HR_{yr} = \frac{Comm.Catch_{yr}}{Biomass_{yr}} .$$

The change in biomass was estimated as:

$$\Delta B_{yr+1} = \frac{(B_{yr+1} - B_{yr})}{B_{yr}} .$$

The biomass estimates (*B*) were from the 2007 CSA analyses (biomass estimates change slightly each year due to the additional data added to the model).

The proposed ERs were estimated based on the results of the correlation analyses. If there was a significant relationship between the previous year's ER and the current year's biomass estimate, then the proposed ER was simply calculated by setting the change in biomass to zero and solving for the corresponding ER. If, however no relationship exists between the two variables, the average ER and the average biomass change was examined. Three possibilities arise: 1) if the average change in biomass is positive (the population is growing), then the average ER is too low, 2) if the average change in biomass is negative (population decline) the average ER is too high, or 3) the average change in biomass is zero, then the ER is correct. Therefore to predict an appropriate ER for those surveyed areas that do not have a strong relationship between ER and change in biomass, the sum of the average ER and the average biomass change is used.

Results from these analyses show that ER and change in biomass was strongly correlated for 5 (out of 14) surveyed areas for mature Tanner crab and 3 surveyed areas for legal Tanner crab (Appendix A). Proposed maximum mature ERs ranged from 3% in Peril Strait to 34% in Icy Strait with and overall average of 19%. The regionwide proposed mature ER is 20%, calculated as a weighted average with each surveyed area weighted by its average commercial harvest from 1997–2006. The proposed maximum legal ER ranged from less than 0% to 69% with an average of 32%. The regionwide proposed legal ER is 38% (based on the weighted average).

Appendix B.–Rationale for time series used for baseline. Baseline values calculated for prerecruit, recruit, and postrecruit crab, as well as for mature female crab and total clutch fullness in the Tanner crab surveys are defined as the mean value of the means for each category in each of the first ten years data is available. The baselines for these categories in the red king crab survey are defined as the mean of means for the years 1993-2002. Thomas Bay and Port Camden's baselines were completed this year.

Project	Survey area	Baseline years
Tanner crab survey	Icy Strait	1997-2006
	Glacier Bay	1999-2008
	Stephens Passage	1997-2006
	Thomas Bay	2001-2010
	Holkham Bay	1998-2007
	Port Camden	2001-2010
Red king crab survey	Seymour Canal	1993-2002
	North Juneau	1993-2002
	Excursion Inlet	1993-2002
	Pybus Bay	1993-2002
	Gambier Bay	1993-2002
	Peril Strait	1993-2002
	Lynn Sisters	1993-2002
	Port Frederick	1993-2002