

2021 Southeast Alaska Red King Crab Stock Health Assessment and Management Plan for the 2021/2022 Season

by

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and

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February 2022

Alaska Department of Fish and Game

Division of Commercial Fisheries



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Weights and measures (metric)		General		Measures (fisheries)	
centimeter	cm	Alaska Administrative		fork length	FL
deciliter	dL	Code	AAC	mid-eye-to-fork	MEF
gram	g	all commonly accepted		mid-eye-to-tail-fork	METF
hectare	ha	abbreviations	e.g., Mr., Mrs., AM, PM, etc.	standard length	SL
kilogram	kg			total length	TL
kilometer	km	all commonly accepted			
liter	L	professional titles	e.g., Dr., Ph.D., R.N., etc.	Mathematics, statistics <i>all standard mathematical signs, symbols and abbreviations</i>	
meter	m	at	@		
milliliter	mL				
millimeter	mm	compass directions:			
		east	E	alternate hypothesis	H _A
		north	N	base of natural logarithm	e
		south	S	catch per unit effort	CPUE
		west	W	coefficient of variation	CV
		copyright	©	common test statistics	(F, t, χ^2 , etc.)
		corporate suffixes:		confidence interval	CI
		Company	Co.	correlation coefficient	
		Corporation	Corp.	(multiple)	R
		Incorporated	Inc.	correlation coefficient	
		Limited	Ltd.	(simple)	r
		District of Columbia	D.C.	covariance	cov
		et alii (and others)	et al.	degree (angular)	°
		et cetera (and so forth)	etc.	degrees of freedom	df
		exempli gratia		expected value	E
		(for example)	e.g.	greater than	>
		Federal Information		greater than or equal to	≥
		Code	FIC	harvest per unit effort	HPUE
		id est (that is)	i.e.	less than	<
		latitude or longitude	lat. or long.	less than or equal to	≤
		monetary symbols		logarithm (natural)	ln
		(U.S.)	\$, ¢	logarithm (base 10)	log
		months (tables and		logarithm (specify base)	log ₂ , etc.
		figures): first three		minute (angular)	'
		letters	Jan,...,Dec	not significant	NS
		registered trademark	®	null hypothesis	H ₀
		trademark	™	percent	%
		United States		probability	P
		(adjective)	U.S.	probability of a type I error	
		United States of		(rejection of the null	
		America (noun)	USA	hypothesis when true)	α
		U.S.C.	United States	probability of a type II error	
			Code	(acceptance of the null	
		U.S. state	use two-letter	hypothesis when false)	β
			abbreviations	second (angular)	"
			(e.g., AK, WA)	standard deviation	SD
				standard error	SE
				variance	
				population	Var
				sample	var
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	pH				
(negative log of)					
parts per million	ppm				
parts per thousand	ppt,				
	‰				
volts	V				
watts	W				

REGIONAL INFORMATION REPORT NO. 1J22-02

**2021 SOUTHEAST ALASKA RED KING CRAB STOCK ASSESSMENT
AND MANAGEMENT PLAN FOR THE 2021/2022 SEASON**

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February 2022

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This document should be cited as:

Palof, K., and J. Stratman. 2022. 2021 Southeast Alaska red king crab stock assessment and management plan for the 2021/2022 season. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 1J22-02, Douglas.

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ABSTRACT

This report provides an overview of the stock assessment, harvest strategy, and regulations for the 2021/2022 season Southeast red (*Paralithodes camtschaticus*) and blue king crab (*P. platypus*) commercial and personal use fisheries. The personal use red and blue king crab fishery opened July 1, 2021, in non-surveyed areas, while Section 11-A (Juneau Area) opened on August 20 for three and a half days. For the commercial fishery the guideline harvest level is 90,973 lb, less than the 200,000 lb regulatory threshold; therefore, the commercial fishery did not open for the 2021/2022 season.

Keywords: red king crab, *Paralithodes camtschaticus*, stock assessment, catch per unit effort, CPUE, Southeast

OVERVIEW

The Alaska Department of Fish and Game (ADF&G) annually evaluates stock status and establishes the guideline harvest levels (GHLs) for the Southeast Alaska red (RKC; *Paralithodes camtschaticus*) and blue (*P. platypus*) king crab (BKC) fishery using data from fishery independent surveys (pot gear), commercial fishery catch per unit of effort (CPUE) data, and biological data (length, weight, and shell condition) from the surveys and fishery. The Southeast management area (Registration Area A) consists of all waters defined in 5 AAC 34.100 (Figure 1).

Projected estimates of regional mature male biomass for the 2021/2022 season are 1.73 million lb, using available (none for the Juneau area) mark-recapture adjustments and the historical expansion factor applied to the non-surveyed areas. However, this value is only 32% of the mature baseline level (defined as the average mature biomass from 1993–2007; 5.4 million), suggesting the regional stock remains in a low or depressed state.

The 2021/2022 Southeast commercial RKC fishery season GHL is 90,973 lb (Table 7), less than the 200,000 lb minimum threshold [5 AAC 34.113]; therefore, the fishery did not open for the 2021/2022 season. The personal use RKC and BKC fishery opened July 1, 2021, in non-surveyed areas with bag and possession limits of one RKC or BKC per person per day. Results from the annual stock assessment survey in the Juneau Area (Section 11-A) showed overall stock health to be at above average levels, with legal biomass estimated to be above the long-term average and mature biomass estimated to be below the long-term average. The personal use summer fishery in Section 11-A opened on August 20, 2021, for three and a half days with a seasonal household limit of two crab and daily bag and possession limit of two crab (Table 2) to target 13,198 lb (1,601 crab) in the summer fishery.

2021 SOUTHEAST RED KING CRAB STOCK ASSESSMENT

SUMMARY OF STOCK STATUS

The Southeast RKC stock assessment regional biomass estimates for the 2021/2022 season are 1.44 million lb of legal crab and 1.73 million lb of mature crab, using the historical expansion factor (Tables 2–4). The legal biomass estimate decreased 5.32% from the previous year using the 2021 model estimates (Figure 3) while the mature biomass estimate decreased 3.0%.

Survey area biomass is estimated using a 3-stage catch survey analysis model (CSA) and adjusted using the mark-recapture expansions when available (Stratman et al. 2019). Port Frederick and Holkham Bay have not been surveyed since 2015 due to reductions in survey funding and therefore are no longer included in determining survey biomass estimates. The legal crab component is composed of both recruit and postrecruit crab and defined as those greater than 178 mm in carapace width, whereas mature crab are prerecruit, recruit, and postrecruit crab, or those greater than 129

mm in carapace width. Biomass estimates from the survey areas (Table 2, Figure 2) are then expanded based on assumptions of how representative these areas are to the entire population in Southeast.

Both mature and legal survey biomass declined an average of 7.0% annually from 2001–2013 (Figure 3). Legal and mature biomass showed regionwide increases for the first time in 2015 since 2008, however, this year only three of the seven survey areas (Lynn Sisters, Juneau, and Peril Strait) had increases in either legal or mature biomass (Figures 4, 6, 8, 10, 12, 14, 16). Since 2017, in the absence of a commercial fishery, legal biomass has declined an average of 2% annually and mature biomass has declined an average of 6% annually.

Significance in long-term or short-term trends is defined as a p-value <0.05 . Long-term trends compare the current year's mean to the long-term baseline value (1993–2007); short-term trends regress the last four years of survey data to determine if a significant increasing or decreasing trend is present (Stratman et al. 2019). Compared to historical levels in most areas (with the exception of Juneau, Lynn Sisters and Gambier Bay), CPUE of juvenile and female size and sex classes are at below average levels, suggesting that either this portion of the population is declining or that the current year's survey does not adequately represent their abundance. The CPUE of some portions of the mature male size and sex classes are still below average for all the survey areas except Lynn Sisters. Pybus Bay, Seymour Canal, and Excursion Inlet had significantly low values in all mature male CPUEs, Gambier Bay had two of three mature male recruit classes below their long-term averages, and Peril Strait and Juneau had one of three mature male recruit classes below the long-term average.

Overall, recruitment, in the form of prerecruit CPUE, is significantly below average levels for five of the seven survey areas, with only Lynn Sisters and Peril Strait near their long-term average, suggesting that regionwide improvements to mature and legal male biomass are still underway and may take a few more years even with the absence of fishing in most of the survey areas. In most survey areas, prerecruit biomass is still below average compared to the 1990s and early 2000s and is visualized as the small difference between mature and legal biomass in the area figures (Figures 4, 6, 8, 10, 12, 14, 16). A matrix of stock health indicators for the past five years provides an objective and repeatable evaluation of the survey data (Table 4), discussed below (Table 5).

MARK-RECAPTURE EXPERIMENT ADJUSTMENTS

All survey areas (Excursion Inlet, Lynn Sisters, Peril Strait, Pybus Bay, Gambier Bay, and Seymour Canal; Figure 2), except Juneau, due to its expansive area, have a biomass adjustment that is calculated from mark-recapture studies (Table 1). Two of the six survey areas have a single mark-recapture event, while the other four have two events; therefore, the estimate of biomass using this method does not take into account extensive inter-annual variability or variability in population size for all areas and should be applied with caution. The department has completed work on a second mark-recapture estimate for the four larger survey areas, and does not plan at this time to continue with additional mark-recapture studies. Mark-recapture attempts in 2013 and 2014 (Lynn Sisters and Excursion Inlet) did not have sufficient sample sizes (Robson and Regier 1964) to produce usable biomass estimates. Pybus Bay, Seymour Canal, Excursion Inlet, and Gambier Bay were successfully resampled in 2014, 2015, 2016, and 2017 respectively.

For three of the areas, resampling efforts yielded an adjustment factor similar to the first estimate (Table 1). Adjustments based on a weighted average of the two sampling events were used to

determine the mark-recapture adjustment applied to this year's CSA (Table 1). The biomass estimates presented in this analysis are the 2021 CSA model estimates adjusted by these values.

EXPANSION OPTION FOR NON-SURVEYED AREAS

Regional biomass is estimated from the seven survey areas and extrapolated to the entire region using an expansion factor defined as the proportion of the population that lies within the non-surveyed areas (Tables 2–4, Figure 3). In 2015, the surveyed areas were adjusted because surveys in Port Frederick and Holkham Bay were discontinued due to lack of funding. The removal of Port Frederick from the survey is accounted for by placing it in the non-surveyed area designation. A biomass estimate has never been produced for Holkham Bay due to the inconsistency of the data and therefore, it has always been included as a non-surveyed area, thus no changes to the biomass estimation were needed in removing Holkham Bay from the survey.

The expansion factor, or an estimate of the percentage of the population found in the non-surveyed areas using historical harvest data, has been inconsistent over time (Palof and Stratman 2020). In the past, two expansion factors have represented historical harvests from 1974–1984 (with 47.2% of the harvest coming from the non-surveyed areas), and harvests in a more modern time during the baseline years from 1993–2007 (with 36.1% of the harvest coming from the non-surveyed areas). Both options involve assumptions about the spatial distribution of the RKC population and the spatial effort of the fleet. The baseline time frame represents both a high and low period in the RKC biomass and is used as a baseline time frame for other metrics in our assessment. However, this time frame is influenced by management actions, such as spatial closures, that greatly influenced the spatial effort of the fleet. The historical harvest time frame (1974–1984) is considered to be the most appropriate for the 2021 assessment because it includes harvest years before management actions dictated spatial closure or influenced fleet behavior. However, this time frame assumes that the spatial distribution of the RKC in Southeast has remained consistent over time, specifically since 1974, and with varying population sizes.

Expanding to the non-surveyed areas using the historical harvest time frame results in a regional biomass of 1.44 million lb for legal crab and 1.73 million lb for mature crab (Table 2).

HARVEST RATES

Determining an appropriate harvest rate for RKC in Southeast has been challenging due to inconsistent recruitment and varying levels of population health. As a result, in 2018, Palof and Stratman (2020) reviewed and implemented harvest rate strategies that yielded two options for appropriate harvest rates that can be applied to mature male biomass, each having its own associated risk.

Option 1, using the equilibrium harvest rates, is considered the most risk neutral option with an equal probability of the mature male biomass decreasing or increasing in the following year after applying this level of harvest pressure when the population is at average or above average stock health. For a sustainable population these should be considered maximum appropriate harvest rates for each of the surveyed areas. This option uses a regression model that incorporates both the variability in the harvest rates and their relationship to changes in mature male biomass. In theory, these harvest levels will maintain the equilibrium population size when the population is at equilibrium, or more realistically at average stock health levels (> moderate, Tables 5, 6). However, a disadvantage to this method as currently applied is that it does not account for time-varying trends in survival or other factors such as environmental change, temperature, etc. that

affect biomass. For our purposes, equilibrium could be defined as the average baseline population size (Figure 3) or a biomass that is sustainable over time. When the population is below equilibrium, harvesting at these rates will either maintain low population levels or, more likely, cause a decrease in population size. The resulting GHL for option 1 is 137,807 lb (Table 2).

Option 2, using the average harvest rate for years in which the mature male biomass increased, is considered a lower risk option with a high probability of the mature male biomass increasing in the following year after applying this level of harvest pressure. This option only uses the average of the harvest rates that resulted in population increases, and therefore does not incorporate variability as well as option 1. In theory, these harvest levels will increase the population size regardless of health of the stocks. However, during depressed stock health conditions, where biomass levels are below baseline values, even small harvest levels may still result in a decrease in population size. The resulting GHL for option 2 is 51,842 lb (Table 3).

STOCK ASSESSMENT CONCERNS AND RECOMMENDATIONS

Recovery in most of the survey areas, except for the Juneau area and Lynn Sisters area, appears to be slow. Most areas, except for Peril Strait, had increasing biomass estimates from 2015–2017, however, in 2018 a decrease in both legal and mature biomass occurred in all survey areas that experienced personal use and commercial harvest in the previous season (2017/2018). The impact of the commercial fishery opening in the 2017/2018 season is confounded by potential increased personal use harvest in the survey areas, but this is hard to quantify since we do not currently have an estimate of personal use harvest in any area except Section 11-A, although estimates of personal use harvest are currently being collected with the implementation of the regional king crab personal use harvest permit in 2018 with a database system to query and analyze harvest still in progress.

Regional biomass levels have decreased from 2020 and are still below the baseline levels (Figure 3). The Juneau Area and Lynn Sisters are the only survey areas where legal or mature biomass are above their baseline levels.

Slow recovery since 2001, which may be due to poor or inconsistent recruitment, and declines in the survey areas after the last commercial fishery opening (2017/2018 fishing season), suggest that harvesting at the equilibrium harvest levels (those used in the 2017/2018 GHL calculations, option 1 here) from these areas would increase the probability of continued population declines or stunt population growth. Thus, removals at the levels presented in options 1 and 2 (Tables 2 and 3) are not recommended for the upcoming season. None of the harvest options presented here resulted in a GHL that is above the 200,000 lb threshold required for a fishery opening [5 AAC 34.113].

SURVEY AREA STOCK STATUS AND HARVEST RATE RECOMMENDATION

STOCK STATUS BY SURVEY AREA (TABLE 4, FIGS. 4–17)

Significance in long-term or short-term trends is defined as a p-value <0.05. Long-term trends compare the current year's mean to the long-term baseline value (1993–2007); short-term trends regress the last four years of survey data to determine if a significant increasing or decreasing trend is present. Estimates of legal and mature mark-recapture biomass (adj.legal / adj.mature) for the entire biomass time series for each area were added to the legal biomass graphs, along with their associated long-term baseline (1993–2007; solid black line for legal and grey dotted line for mature) estimates (Figures 4 – 17). Raw sample sizes for each area are reported in Table 6. Graphs for each area reflect biomass estimates from the 2021 CSA model.

Pybus Bay (below average)

Pybus Bay stock health decreased and remained in below average status (Figures 4, 5). Mature female CPUE is below the baseline average, but not significantly so. Postrecruit, recruit, prerecruit, juvenile male and juvenile female CPUEs are significantly below their baseline averages. There are no significant short-term trends in CPUEs. Legal biomass decreased 25% from the 2020 model estimate and mature biomass decreased 31%. Both decreased and remain low compared to historical levels in this area. Egg percentage is at a normal level and the percentage of poor clutches is significantly below the baseline value. The mature biomass estimate is -72% below the baseline value.

Due to the aforementioned concerns and the low level of the stock biomass in Pybus Bay, no harvestable surplus is recommended for the 2021/2022 season.

Gambier Bay (below average)

Gambier Bay stock health increased from poor to below average status (Figures 6, 7). Prerecruit, recruit, and mature female CPUEs are significantly below their baseline averages. Juvenile males, juvenile females, and postrecruits remain below average but not significantly so. In the short-term (last four years), there is a significant increase in juvenile male CPUE. Juvenile and female portions of this population are still low compared to the higher levels observed in 2017, but juveniles are increasing in the last two years. The proportion of females with poor clutches is at the baseline of 10% and the overall average clutch fullness is back up to typical levels. Legal biomass decreased 9% and mature biomass decreased 9% from the 2020 model estimate. Additionally, the legal and mature biomass estimates remain low compared to historical levels for this area. The mature biomass estimate is -78% below the baseline value.

Stock health has been low in Gambier Bay the last three years and is categorized as below average. Half of the sex/size classes remain significantly below their baseline averages, while the other half are below but not significantly so. Considering these negative trends in Gambier Bay, no harvestable surplus is recommended for the 2021/2022 season.

Seymour Canal (poor)

The overall stock health for Seymour Canal decreased from below average to poor (Figures 8, 9). All the sex/size classes are significantly below their baseline averages, and there are no prerecruit or recruit male crab sampled in the survey pots in 2021. There are no significant short-term trends. In general, portions of this populations have been undersampled in the last few years of the survey; this year specifically, no juvenile females, prerecruit, or recruits were caught (Table 6), and therefore caution should be taken in interpreting any of the indicators of stock health. Based on the survey results for the past few years it may be appropriate to reexamine the survey footprint and methods for this area. The estimate of legal biomass decreased 28% and the mature biomass decreased 29% from the 2020 model estimates. The mature biomass estimate is -88% below the baseline value.

Mature male CPUEs were under sampled in this year's survey, and those that were sampled are significantly low. No short-term increases are evident. Due to the aforementioned concerns and the low level of the stock biomass in Seymour Canal, no harvestable surplus is recommended for the 2021/2022 season.

Peril Strait (below average)

The Peril Strait stock status improved but remained at below average status (Figures 10, 11). Most sex/size classes, except prerecruit and postrecruit males, are significantly below their baseline averages. There is a significant short-term increasing trend in juvenile male and prerecruit CPUEs, and a significant decreasing trend in the portion of poor clutches. Female and juvenile portions of the population increased compared to the last three years. The proportion of females with poor clutches was significantly less than 10%, and the total egg clutch percentage was at typical levels for this area. The legal biomass estimate remained the same as the 2020 model estimate and the mature biomass estimate increased 218% due to the large increase in prerecruit CPUE. The CPUE for prerecruit males is substantially larger than has been recorded since 2008, and postrecruit CPUE is larger than has been observed in the past 10 years, both indicate potential signs of some recovery in this area. The mature biomass estimate is -62% below the baseline value.

Nearly all size/sex classes are significantly below their baseline averages, but short-term trends in juvenile and prerecruit males provide some hope for future improvement. Legal and mature biomass estimates remain below baseline averages; therefore, no harvestable surplus is recommended for the 2021/2022 season.

Juneau (above average)

The stock status for the Juneau area increased to above average from moderate in 2021 (Figures 12, 13). Only prerecruit CPUE remains significantly below the baseline average, while juveniles (both male and female) and postrecruits are significantly above the long-term averages. Mature female and recruit CPUEs are at their baseline average. There is a significant short-term increasing trend in both juvenile male and female CPUE. Estimates of legal biomass increased 4.0% while mature biomass increased by 2% since 2020 (based on the 2021 model output). When compared to the 2020 model estimate, legal biomass increased 2.5%, while mature biomass increased 4.5%. Indicators of female stock health remain good as indicated by the low proportion of poor clutches and high clutch fullness. Legal biomass is still at its baseline value, but mature biomass fell to -7% below the baseline.

The annual 11-A red king crab stock assessment survey found both the legal and mature biomass had small increases compared to last year. All sex/size class CPUEs, with the exception of postrecruit CPUE, increased from the 2020 survey. Due to stable trends in the mature size/sex classes, the decision was made in July to set the harvest rate at 7.0% for the 2021/2022 personal use season.

Lynn Sisters (moderate)

Stock health in the Lynn Sister's area remained at a moderate status in 2021 (Figures 14, 15). CPUEs for all size and sex classes are near their baseline averages. There is a significant increasing short-term trend in postrecruit CPUE. Indicators of female stock health are good, as seen by the low proportion of poor clutches and high clutch fullness. Legal biomass increased 20%, while mature biomass increased 17% from the 2020 model estimates. Both legal and mature biomass are above their baseline values, with mature biomass 54% above the baseline value.

Positive trends in stock health are evident. Legal and mature biomass estimates are above long-term baselines for the third time in nine years. Most size/sex classes are at or above baseline averages. Positive trends in stock health have become evident after an eight-year closure to all

fishing, but the adjusted legal biomass estimate is smaller than seen in all other survey areas except for Peril Strait (Table 2).

Excursion Inlet (poor)

The stock health of Excursion Inlet did not improve from poor status (Figures 16, 17). CPUEs of all sex/size classes are significantly below their baseline averages. There are no significant short-term trends. The percentage of poor clutches is significantly lower than the 10% baseline, suggesting an improvement in female health compared to last season. Overall clutch fullness rebounded this year from low levels the last two years, indicating a potential improvement in female reproductive capacity. Estimated legal biomass decreased 11%, while mature biomass decreased 16% from the 2020 model estimates. The mature biomass estimate is -62% below the baseline value.

Stock health has declined in Excursion Inlet as evident from negative trends in stock health. CPUEs of all mature male sex/size classes have remained below baselines for the third consecutive season. Mature and legal biomass estimates have decreased, and both are now below baselines. Given these trends in Excursion Inlet, there is not a harvestable surplus of RKC for the 2021/2022 season.

Port Frederick (unknown since 2014)

Port Frederick was removed as a survey area in 2015 due to budget constraints and is now considered part of the non-surveyed areas in Tables 2–4. From 1979 to 2004 (the years used to expand the survey biomass to the non-surveyed areas), Port Frederick contributed to 2.4% of the harvest. The previous percent expansion of 65.2% survey areas and 34.8 % non-surveyed areas was adjusted. Excluding Port Frederick, 62.8% of the harvest is from survey areas and 37.2% from non-surveyed areas. Adjusting the expansion factor allows for consistency between previous year estimates and the current year, all comparisons regionally were performed with a time series of estimates that were adjusted to not include Port Frederick. For the purposes of assessing the upcoming commercial fishery, Port Frederick is considered part of the non-surveyed areas.

Holkham Bay (unknown since 2014)

Holkham Bay was removed as a survey area in 2015 due to budget constraints. The decision to drop Holkham Bay from the survey was based on difficulties in interpreting survey results from this location. Holkham Bay had consistently been surveyed since 2002, however, the data were not always adequate to use in the CSA to produce a biomass estimate; the area was only useful as an index of biomass and the estimates were never included in the regionwide biomass estimate and continues to be part of the non-surveyed areas.

Non-Surveyed Areas

Information used to assess non-surveyed areas for the 2021/2022 commercial fishery recommendation include the current CSA and historical harvest data, by statistical area, from fish tickets. The percentage of historical harvest that occurred within the surveyed areas from the 1974/1975 to 1984/1985 seasons was used to expand the harvestable surplus from the surveyed area to non-surveyed areas. Since 2015, when Port Frederick was removed from the survey, a historical harvest of 52.8% from surveyed areas has been used, the remaining 47.2% of harvest is targeted from the non-surveyed areas. Summing up the mature biomass estimates for the surveyed areas, and using this 52.8%/47.2% ratio, yields an adjusted mature biomass estimate of 814,141 lb for non-surveyed areas. Applying a 10.0% harvest rate (a percentage which is close to the average

equilibrium harvest rate for all surveyed areas in combination) to this estimate, less a 1,000 lb personal use catch estimate, provides a harvestable surplus of 80,414 lb in the non-surveyed areas (Table 7).

2021/2022 RKC FISHERY MANAGEMENT ACTIONS

The department completed its analysis of 2021 red and blue king crab stock assessment survey results in September, which indicated that the regionwide harvestable biomass of mature red and blue king crab did not exceed the 200,000 lb threshold. The legal biomass estimate decreased 5.3% and mature biomass decreased 3.0%. Lynn Sisters and Juneau are the only areas with an increase in both legal and mature biomass from 2020. Compared to historical levels in most areas (except for Juneau, Lynn Sisters and Gambier Bay), CPUE of juvenile and female size and sex classes are at below average levels. Overall, recruitment, in the form of prerecruit CPUE, is significantly below average levels for five of the seven surveys areas.

For the Juneau Area, in July 2021, the harvest rate was set at 7.0% for the 2021/2022 season and according to the allocation plan prescribed in 5 AAC 34.111, summer and winter personal use fisheries were structured to target 1,601 crab and 320 crab respectively. A permit requirement for personal use fishing outside of Section 11-A was implemented in 2018 and as harvest information continues to be collected this will improve the application of harvest rates as it relates to stock health. All surveyed areas with exception of the Juneau Area will be closed to personal use fishing.

Non-Surveyed areas have an estimated mature male biomass of 814,141 lb or 47.2% of the regionwide estimate (using historical harvest from the 1974/1975 to 1984/1985 seasons). Stock health in non-surveyed areas may be exhibiting the same trends in stock health seen in surveyed areas, such as decreasing mature and legal male biomass. Geographically, non-surveyed areas encompass a much larger area than surveyed areas and generally see less fishing effort than surveyed areas. Some fishermen have noted improved catch rates of RKC in non-surveyed areas, while others have witnessed declines in areas they fish. The non-surveyed areas, which include Port Frederick and Holkham Bay, can likely withstand a low level of harvest in the near term and will remain open with a minimal bag and possession limit.

As announced September 13, 2021, all areas open to personal use red and blue king crab fishing outside of Section 11-A will maintain the reduced daily bag and possession limit of one king crab per day as prescribed in regulation [5 AAC 77.664(b)].

FISHERY MANAGEMENT CONCERNS

The RKC and BKC commercial fishery and personal use fishery outside of Section 11-A are managed separately and there are no regulatory allocations that combine estimated harvest for both user groups. The newly implemented permit system for the personal use fishery will provide managers better information on the level of personal use harvest outside of Section 11-A, improve future CSA estimates, and inform potential Alaska Board of Fisheries decisions.

REFERENCES CITED

- Robson, D. S., and H. A. Regier. 1964. Sample Size in Petersen Mark-Recapture Experiments. *Transactions of the American Fisheries Society* 93 (3):215–226.
- Palof, K., and J. Stratman. 2020. 2019 Southeast Alaska red king crab stock assessment and management plan for the 2019/2020 season. Alaska Department of Fish and Game, Regional Information Report No. 1J20-09, Douglas.
- Stratman, J., A. Messmer, K. Wood, T. Bergmann, and K. Palof. 2019. Operational plan: Southeast Alaska red king crab pot survey, 2018-2022. Alaska Department of Fish and Game, Regional Operational Plan No. ROP.CF.1J.2019.02, Douglas.

TABLES AND FIGURES

Table 1.—Biomass adjustments based on the ratio of Chapman mark-recapture estimates to catch survey analysis (CSA) estimates of legal crab. The ratio of legal to mature crab from the current year is used to scale the adjustment from biomass of legal crabs to biomass of mature crabs.

Survey area	Mark-Recapture Study (lb)		
	CSA	M-R	Adjustment
Lynn Sisters ^a	39,886	69,674	1.75
Pybus Bay ^{b,d}	80,807	236,042	2.92
	17,635	67,220	3.81
	Weighted avg.		3.08
Gambier Bay ^{b,g}	42,104	180,433	4.29
	25,294	84,394	3.34
	Weighted avg.		3.93
Excursion Inlet ^{b,f}	20,066	97,232	4.85
	17,184	12,501	0.73
	Weighted avg.		2.95
Seymour Canal ^{c,e}	6,387	58,002	9.08
	29,062	267,233	9.20
	Weighted avg.		9.17
Peril Strait ^c	19,023	52,377	2.75
Port Frederick ^c	12,523	53,436	4.27

Adjustments were calculated using CSA estimates of the year the mark/recapture occurred: a = 2009, b = 2010, c = 2011, d = 2014, e = 2015, f = 2016, and g = 2017.

Table 2.–Option 1: Maximum appropriate / risk neutral – model-based equilibrium harvest rates. Summary of 2021 commercial red king crab fishery GHL calculations (lb) for the seven surveyed areas and non-surveyed areas. Risk neutral option based on 2018 calculated equilibrium harvest rates (K.Palof, WIP RKC harvest rate determination memo Sept. 2018). The harvest rate for the non-surveyed areas is a weighted average of the surveyed areas harvest rates (shown below) and the average mature male biomass for each area over the entire time series (1979–2018). Biomass estimates apply the adjustment in Table 1 to the CSA biomass output. Biomass of non-surveyed areas was expanded using historical years (1974–1984), where 47.2% of the population is estimated to be in the non-surveyed areas. Personal use catch for non-surveyed areas is mean catch estimated from 2008–2018 statewide survey data. Blue king crab (BKC) is estimated as 1.06% of the surveyed areas based on historical catch, and its GHL contribution is an expansion of the surveyed areas GHL using the same percentage.

Survey area	Legal biomass (adj)	Mature biomass (adj)	Equilibrium HR	Total GHL	PU catch	2021 Commercial GHL (lb)
Pybus Bay	116,874	122,427	0.12	14,691	0	14,691
Gambier Bay	53,293	58,281	0.04	2,331	0	2,331
Seymour Canal	158,946	158,946	0.01	1,589	0	1,589
Peril Strait	15,963	58,947	0.04	2,358	0	2,358
Juneau	308,746	377,095	0.17	64,106	38,464	25,642
Lynn Sisters	46,965	69,252	0.09	6,233	0	6,233
Excursion Inlet	54,550	65,785	0.06	3,947	0	3,947
BKC	8,007	9,654	–	–	0	602
Non-surveyed areas	675,226	814,141	0.10	81,414	1,000	80,414
Total	1,438,571	1,734,528	–	–	0	137,807

Table 3.—Option 2: Risk adverse – high probability of mature male biomass increasing

Summary of 2021 commercial red king crab fishery GHL calculations (lb) for the seven surveyed areas and non-surveyed areas. Risk adverse option based on 2018 calculated average harvest rates when the mature male biomass was increasing (K.Palof, WIP RKC harvest rate determination memo Sept. 2018). The harvest rate for the non-surveyed areas is a weighted average of the surveyed areas harvest rates (shown below) and the average mature male biomass for each area over the entire time series (1979–2018). Biomass estimates apply the adjustment in Table 1 to the CSA biomass output. Biomass of non-surveyed areas was expanded using historical years (1974–1984), where 47.2% of the population is estimated to be in the non-surveyed areas. Personal use catch for non-surveyed areas is mean catch estimated from 2008–2012 statewide survey data. Blue king crab (BKC) is estimated as 1.06% of the surveyed areas based on historical catch, and its GHL contribution is an expansion of the surveyed areas GHL using the same percentage.

Survey area	Legal biomass (adj)	Mature biomass (adj)	Avg Inc HR	Total GHL	PU catch	2021 Commercial GHL (lb)
Pybus	116,874	122,427	0.020	2,449	0	2,449
Gambier	53,293	58,281	0.020	1,166	0	1,166
Seymour	158,946	158,946	0.005	795	0	795
Peril	15,963	58,947	0.040	2,358	0	2,358
Juneau	308,746	377,095	0.070	26,397	15,838	10,559
Lynn Sisters	46,965	69,252	0.030	2,078	0	2,078
Excursion	54,550	65,785	0.010	658	0	658
BKC	8,007	9,654	–	–	0	213
Non-surveyed areas	675,226	814,141	0.040	32,566	1,000	31,566
Total	1,438,571	1,734,528	–	–	0	51,842

Table 4.—Total stock health designations and associated scores for 2017–2021 by survey area (Stratman et al. 2019).

Survey Area	2017	2018	2019	2020	2021
Pybus Bay	Moderate (0.50)	Below Average (-3.0)	Below Average (-3.75)	Below Average (-2.50)	Below Average (-4.00)
Gambier Bay	Moderate (0.00)	Poor (-5.25)	Poor (-6.00)	Poor (-6.25)	Below Average (-2.75)
Seymour Canal	Moderate (1.25)	Below Average (-3.0)	Poor (-5.0)	Below Average (-3.50)	Poor (-5.00)
Peril Strait	Poor (-6.0)	Poor (-5.0)	Poor (-6.25)	Below Average (-4.25)	Below Average (-2.25)
Juneau Area	Above Average (2.5)	Moderate (1.25)	Below Average (-3.50)	Moderate (-0.50)	Above Average (3.50)
Lynn Sisters	Moderate (-1.50)	Moderate (-0.75)	Moderate (0.50)	Moderate (1.50)	Moderate (1.25)
Excursion Inlet	Below Average (-4.25)	Moderate (1.00)	Below Average (-2.75)	Poor (-4.75)	Poor (-5.00)

Table 5.—Stock health scores and their associated categories used for the previous (2006–2008) and current (since 2008) seasons. Scores are calculated in 0.25 increments.

Score	Previous Categories	Current Categories
-7.00 to -4.50	Poor	Poor
-4.25 to -1.75	Poor	Below Average
-1.50 to 1.50	Moderate	Moderate
1.75 to 4.25	Healthy	Above Average
4.5 to 7.00	Healthy	Healthy

Table 6.—Sample sizes for the 2021 survey by area.

	Peril Strait	Excursion Inlet	Gambier Bay	Juneau	Pybus Bay	Seymour Canal	Lynn Sisters
Juvenile	168	103	87	1,826	56	18	260
Small Females	169	42	78	1,818	28	0	131
Large Females	96	89	115	1,474	174	46	194
Prerecruit	72	27	6	327	9	0	66
Recruit	12	14	6	367	10	0	40
Postrecruit	38	29	101	793	27	13	55
Effective Number of Pots	53	54	53	218	46	49	27

Table 7.—Summary of 2021 commercial red king crab fishery GHL calculations (in pounds) and harvest rate recommendations for the 7 surveyed areas and non-surveyed areas. Mature biomass is adjusted with the mark-recapture experiment. Biomass of non-surveyed areas was expanded to be 47.2% of the region.

Survey area	Legal biomass (adj)	Mature biomass (adj)	Mature HR	Total GHL	Personal Use catch	2021 Commercial GHL(lb)
Pybus Bay	116,874	122,427	0	0	0	0
Gambier Bay	53,293	58,281	0	0	0	0
Seymour Canal	158,946	158,946	0	0	0	0
Peril Strait	15,963	58,947	0	0	0	0
Juneau ^a	308,746	377,095	0.07	26,397	15,838	10,559
Lynn Sisters	46,965	69,252	0	0	0	0
Excursion Inlet	54,550	65,785	0	0	0	0
BKC	8,007	9,654	n/a	—	—	0
Non-surveyed areas	675,226	814,141	0.10	81,414	1,000	80,414
Total	1,438,571	1,734,528				90,973

^aThe Juneau area was open to personal use harvest in summer 2021 at a harvest rate of 7%.

“n/a” represents data that is not available or readily estimable from the other bays.

Commercial Crab Management Registration Area A

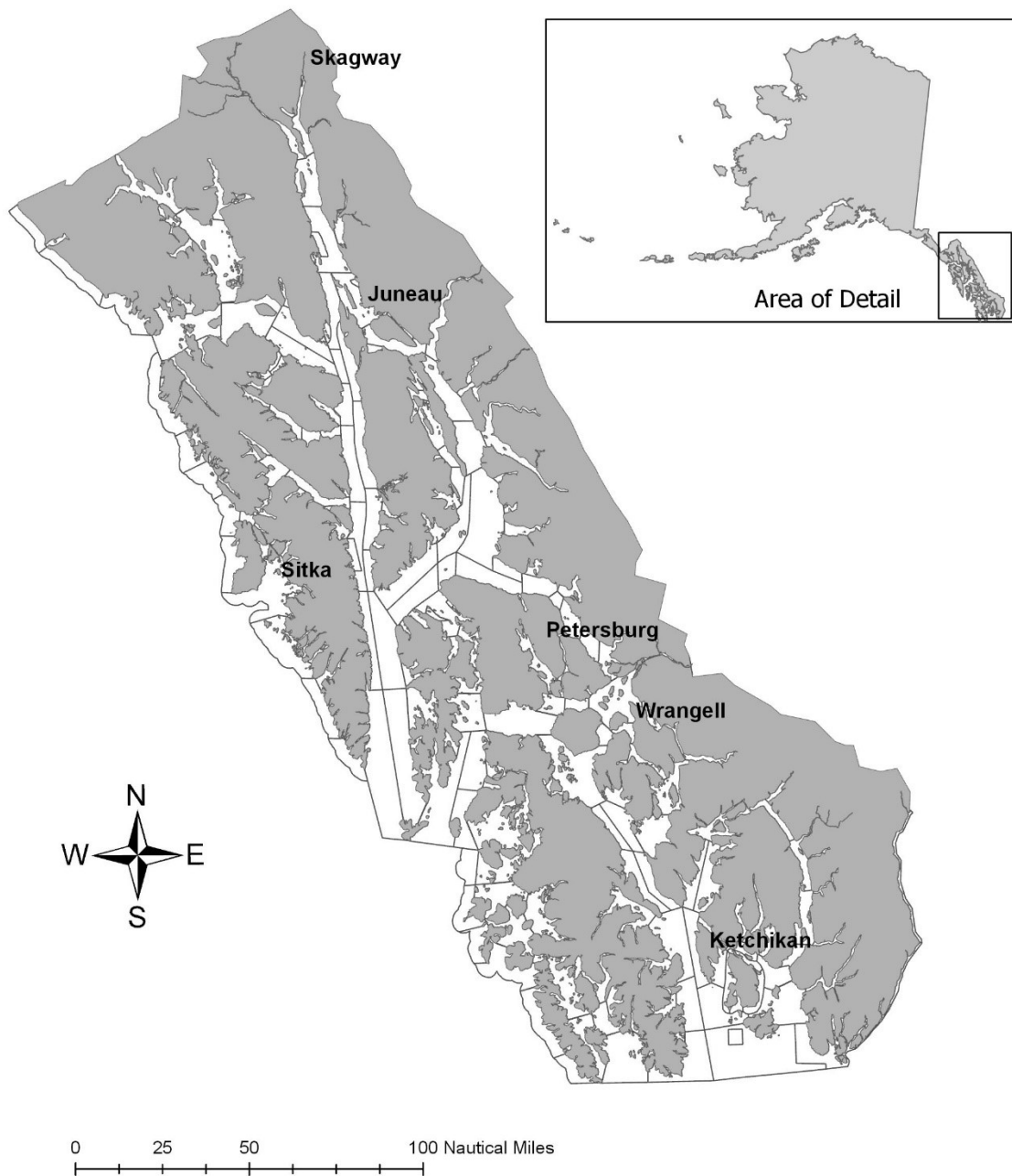


Figure 1.—Map of Southeast Alaska (Registration Area A).

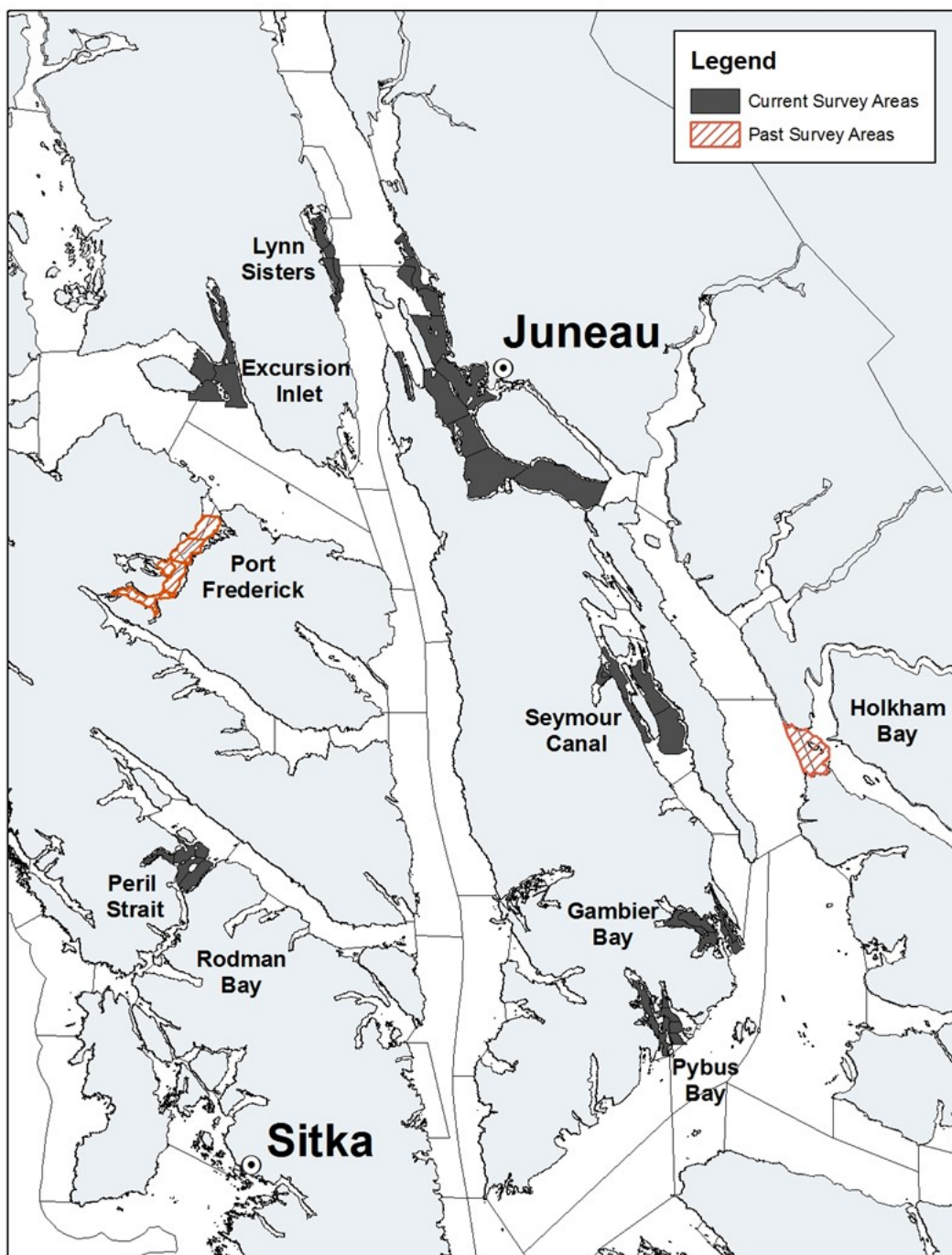


Figure 2.—Current year's red king crab survey areas in Southeast Alaska. In 2015, Port Frederick and Holkham Bay were removed as survey areas but are shown here for reference.

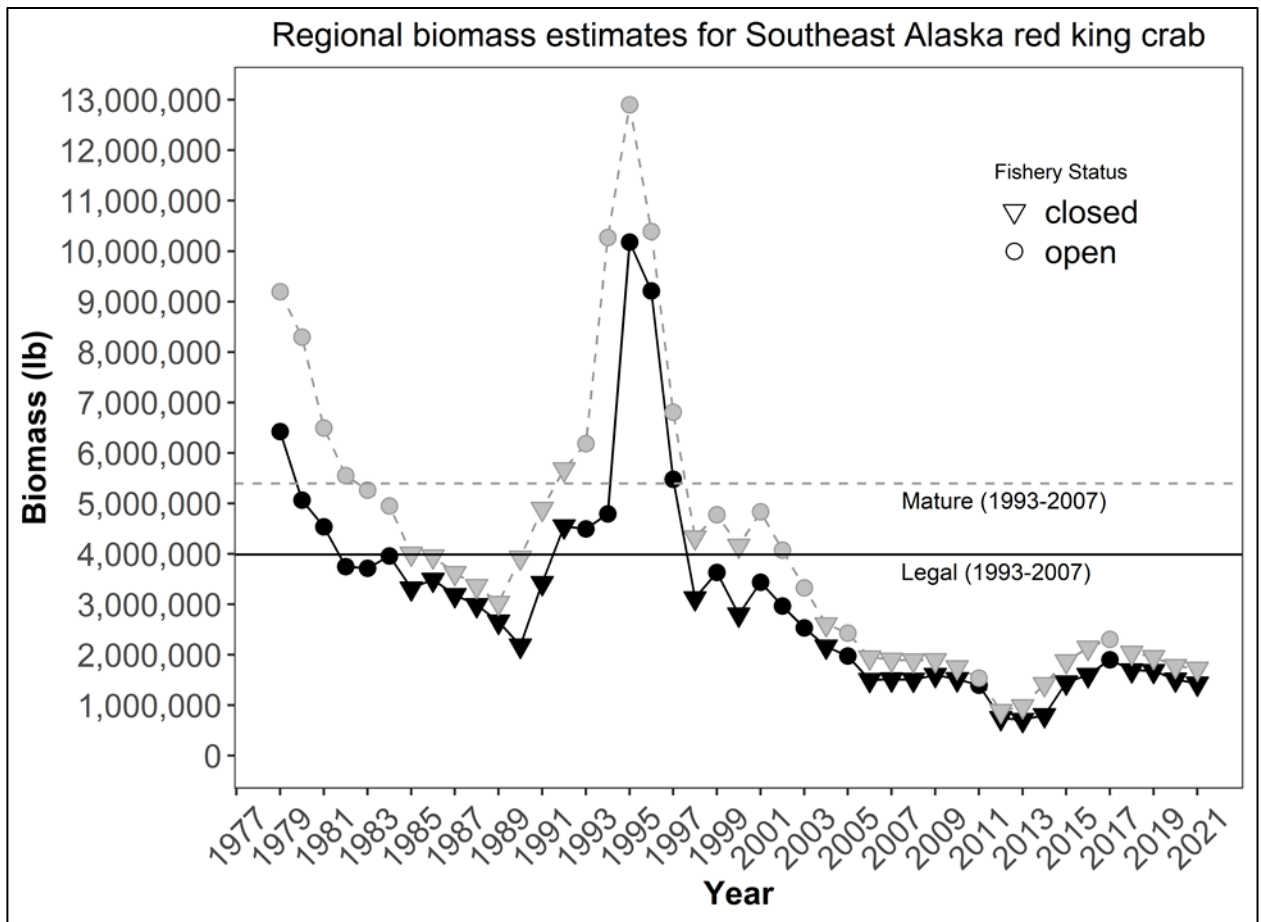


Figure 3.—Total biomass estimates (expanded regional estimates) of mature (gray points and line) and legal (black points and line) red king crab in Southeast Alaska. Estimates based on catch survey analysis (CSA) methodologies adjusted using mark-recapture study results (Table 1), then further expanded to include non-survey areas. Reference lines represent baseline (1993–2007) average of legal and mature biomass estimates. Triangles represent years without a commercial harvest.

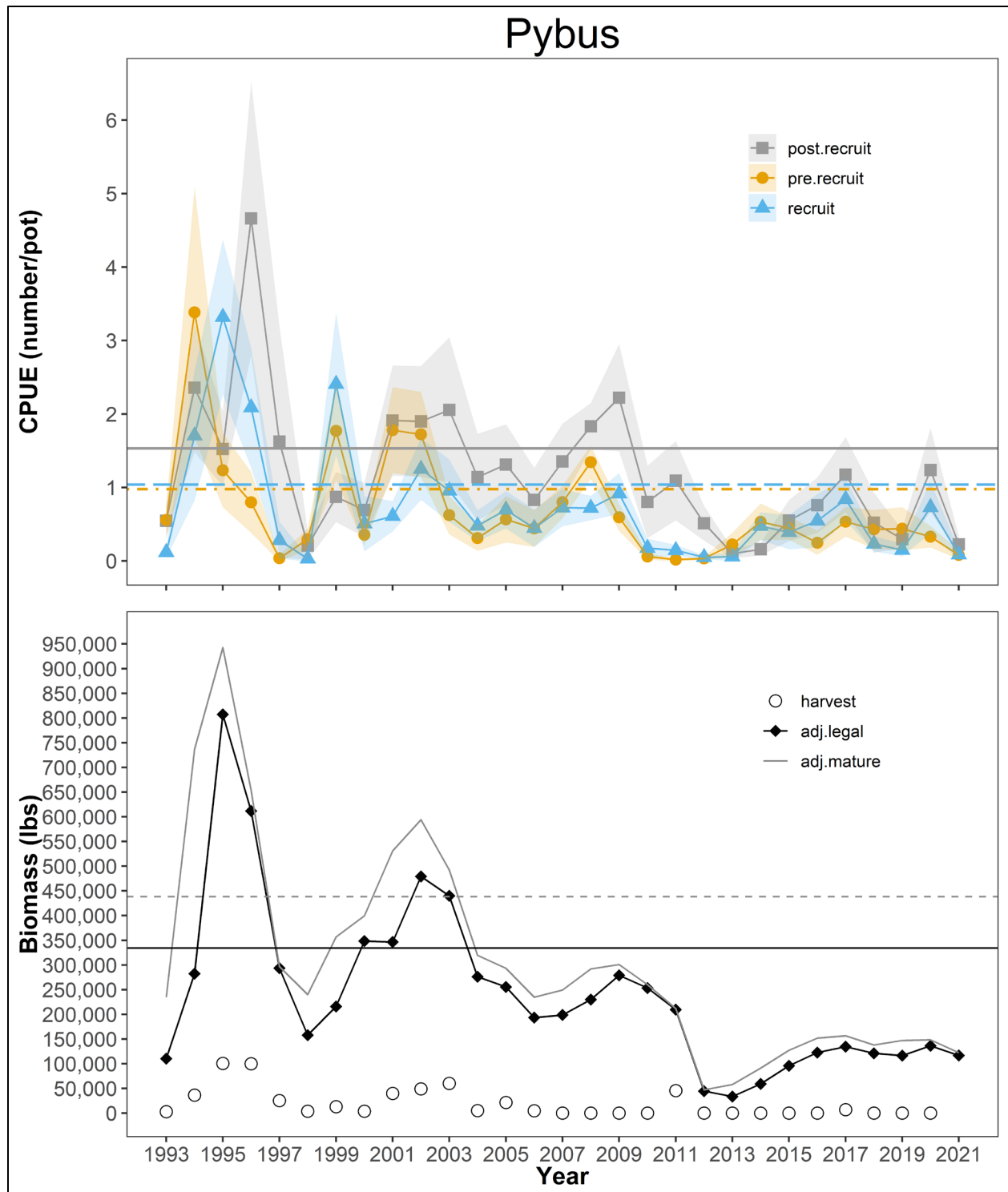


Figure 4.—Pybus Bay CPUEs for male size/sex classes of red king crab, biomass estimates from the current year's CSA model and harvest data. Reference lines represent baselines for each parameter (1993–2007). Gray dotted reference line in the biomass figure represents the baseline for mature biomass, while the solid black refers to the legal biomass. There are no significant short-term trends in mature male CPUEs this year.

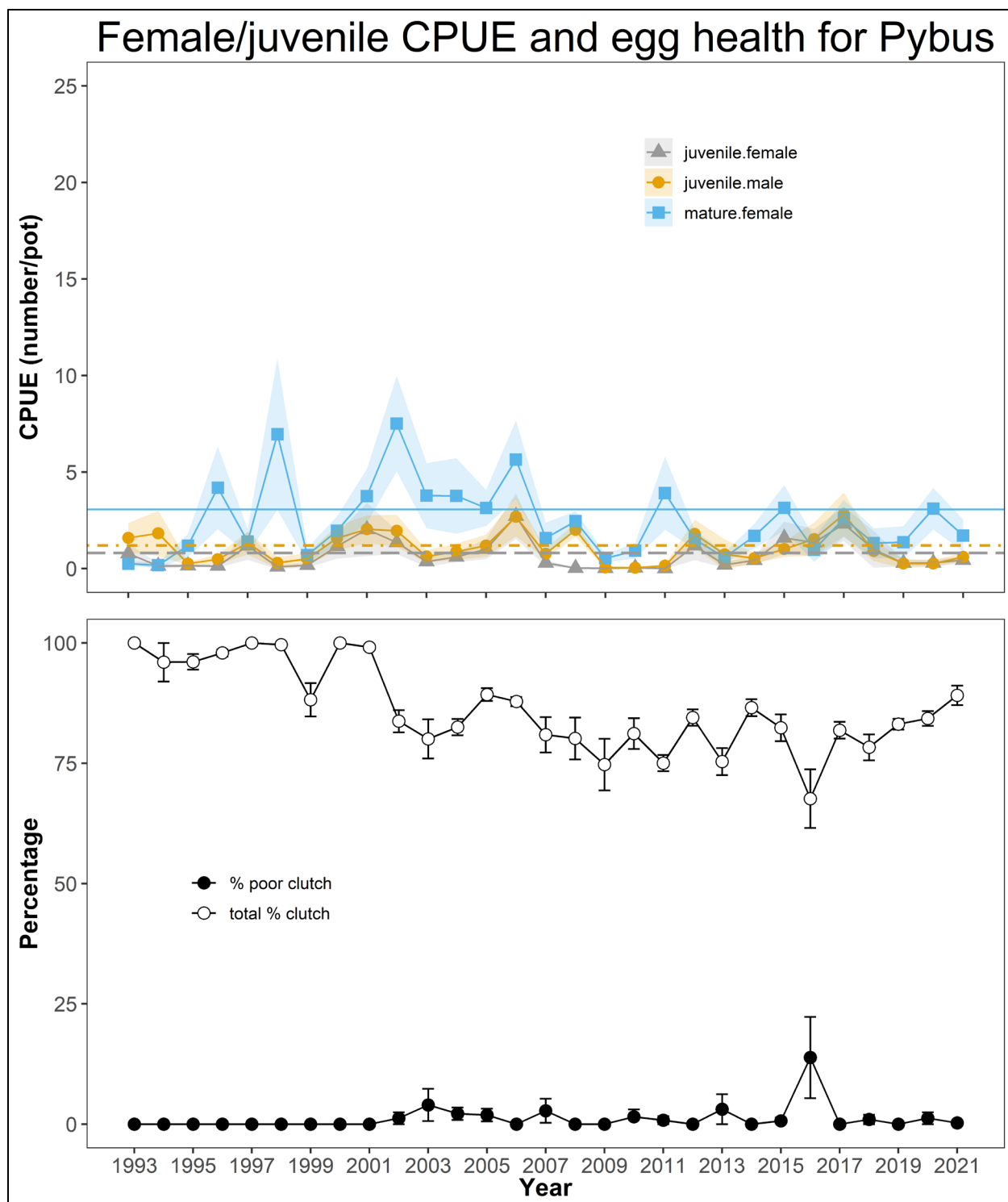


Figure 5.—Pybus Bay CPUEs for female and juvenile male size/sex classes of red king crab, clutch fullness and proportion of poor clutches. Reference lines represent baselines for each parameter (1993–2007). There are no significant short-term trends this year.

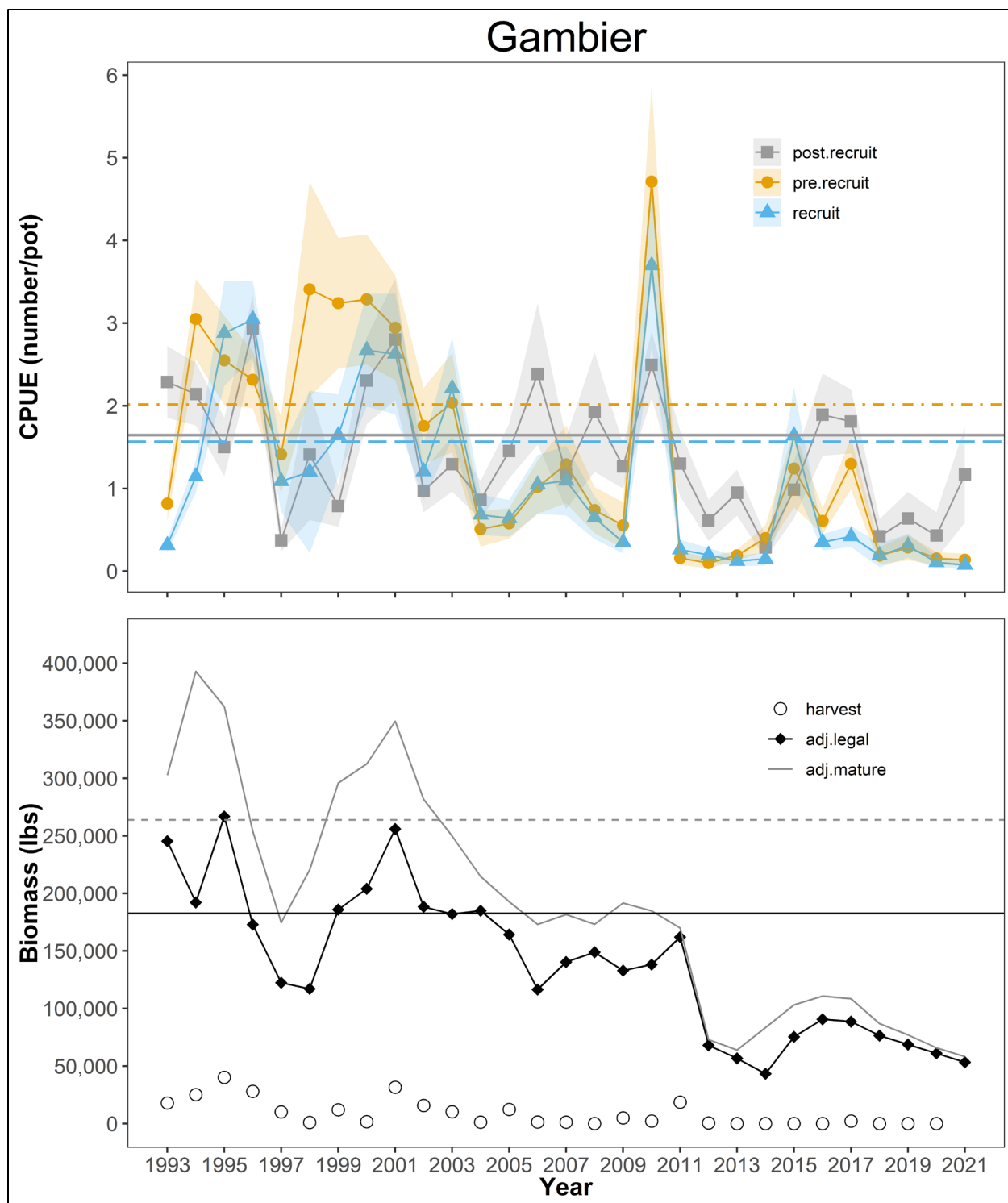


Figure 6.—Gambier Bay CPUEs for male size/sex classes of red king crab, biomass estimates from the current year's CSA model and harvest data. Reference lines represent baselines for each parameter (1993–2007). Gray dotted reference line in the biomass figure represents the baseline for mature biomass, while the solid black refers to the legal biomass. There are no significant short-term trends in mature male CPUEs this year.

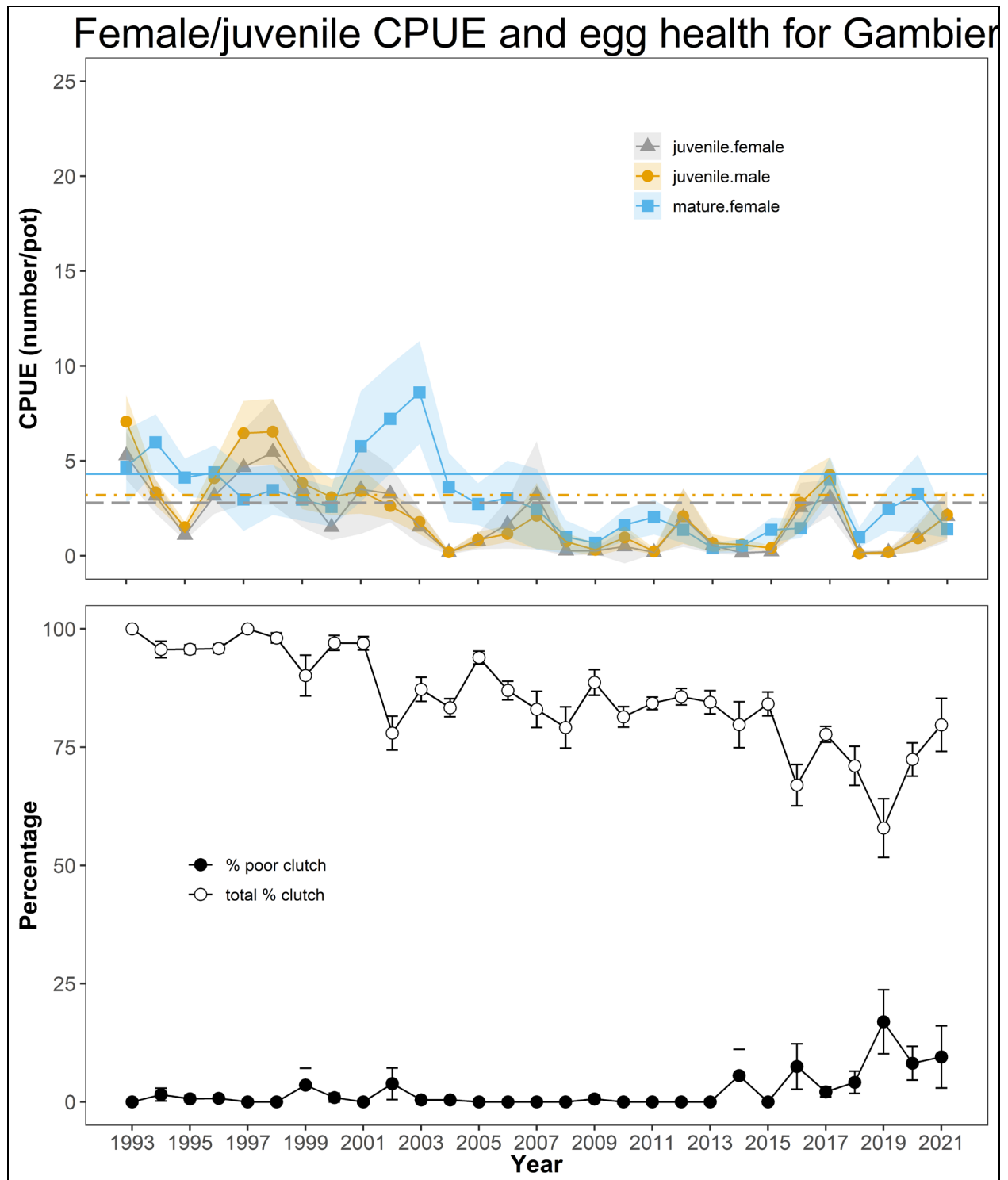


Figure 7.—Gambier Bay CPUEs for female and juvenile male size/sex classes of red king crab, clutch fullness, and proportion of poor clutches. Reference lines represent baselines for each parameter (1993–2007). There is a significant short-term increasing trend in juvenile male CPUE.

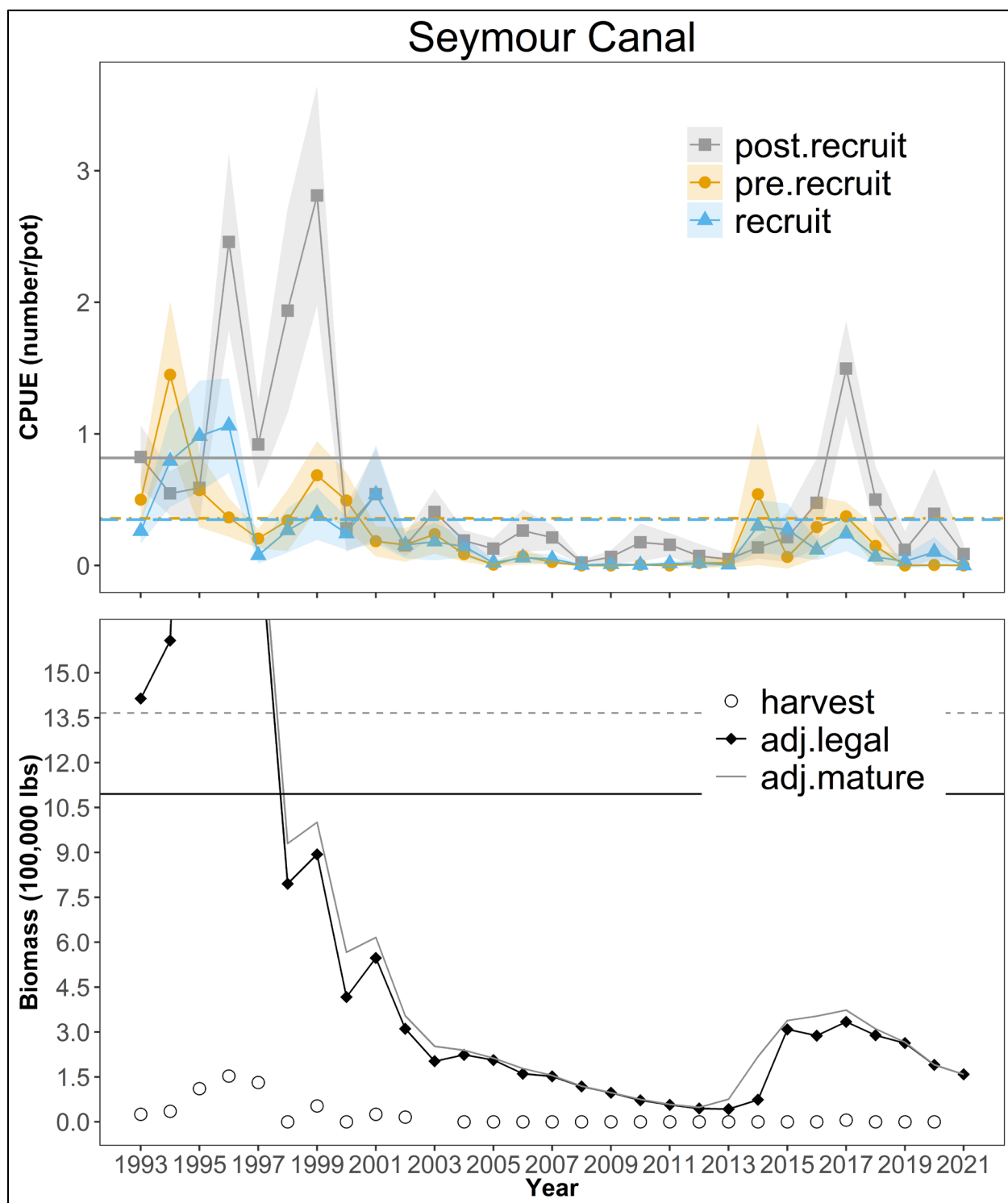


Figure 8.—Seymour Canal CPUEs for male size/sex classes of red king crab, biomass estimates from the current year's CSA model and harvest data. Reference lines represent baselines for each parameter (1993–2007). Gray dotted reference line in the biomass figure represents the baseline for mature biomass, while the solid black refers to the legal biomass. There are no significant short-term trends in mature male CPUEs this year.

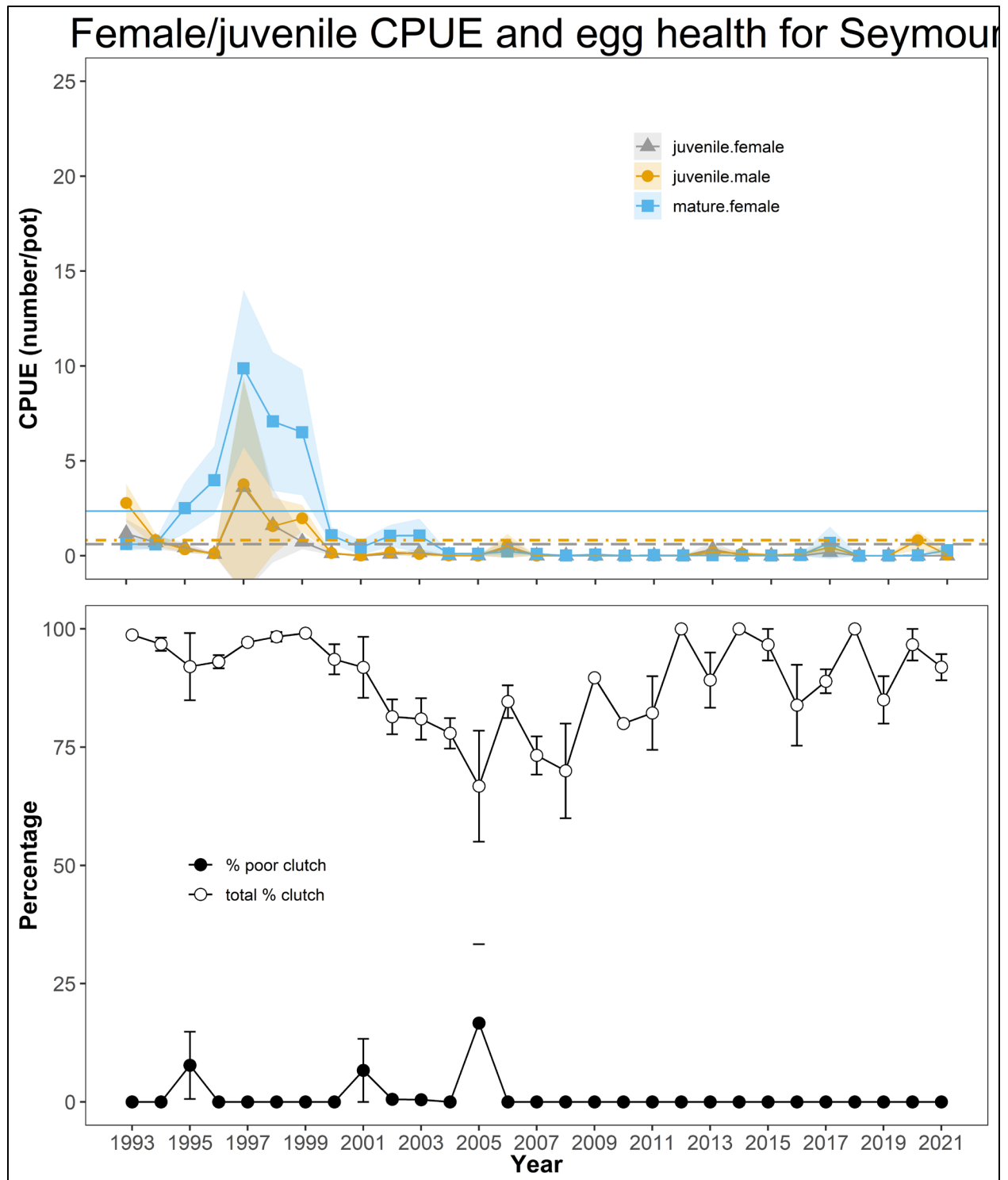


Figure 9.—Seymour Canal CPUEs for female and juvenile male size/sex classes of red king crab, clutch fullness, and proportion of poor clutches. Reference lines represent baselines for each parameter (1993–2007). There are no significant short-term trends this year.

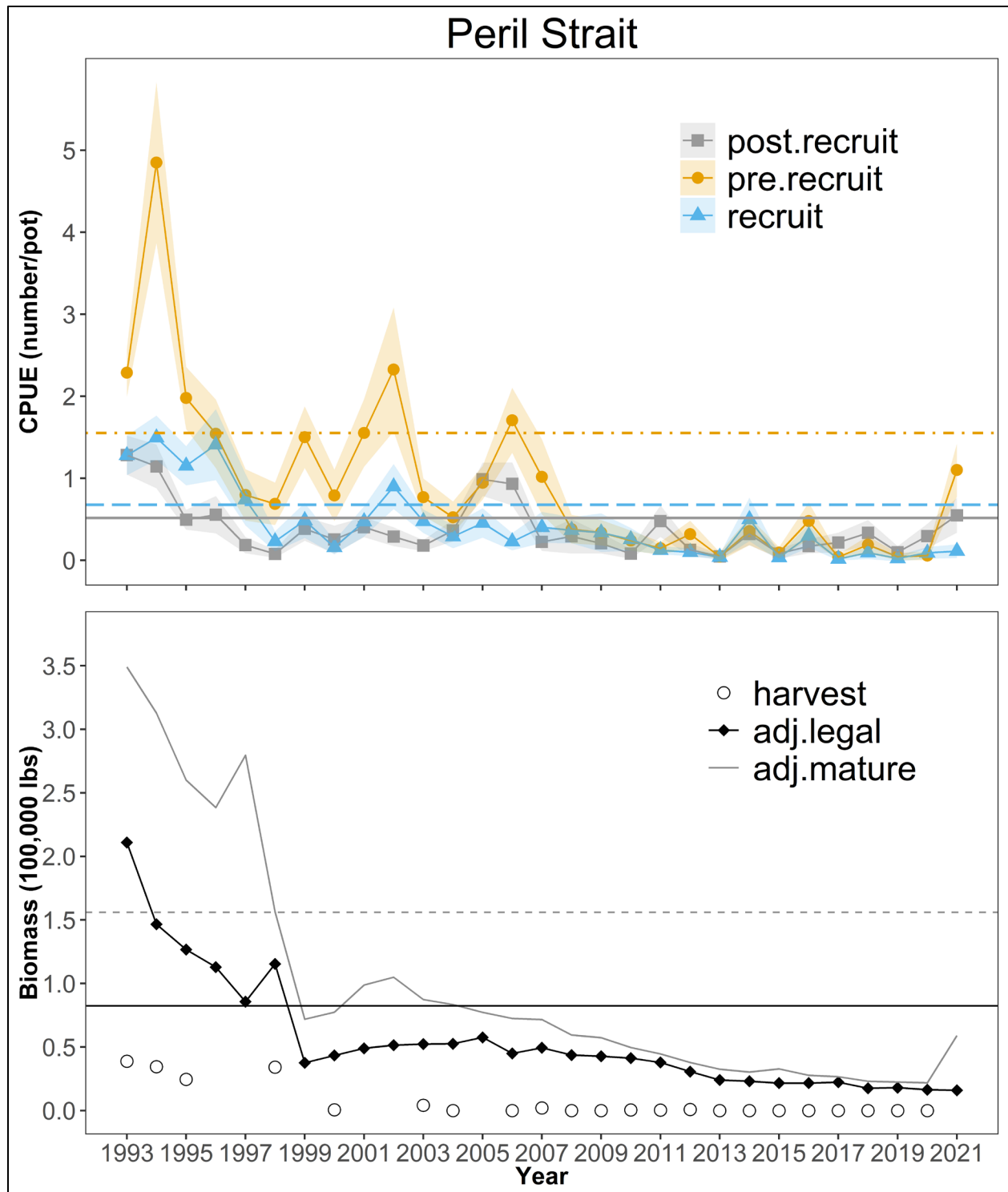


Figure 10.—Peril Strait CPUEs for male size/sex classes of red king crab, biomass estimates from the current year's CSA model and harvest data. Reference lines represent baselines for each parameter (1993–2007). Gray dotted reference line in the biomass figure represents the baseline for mature biomass, while the solid black refers to the legal biomass. There is a significant short-term increasing trend in prerecruit male CPUE.

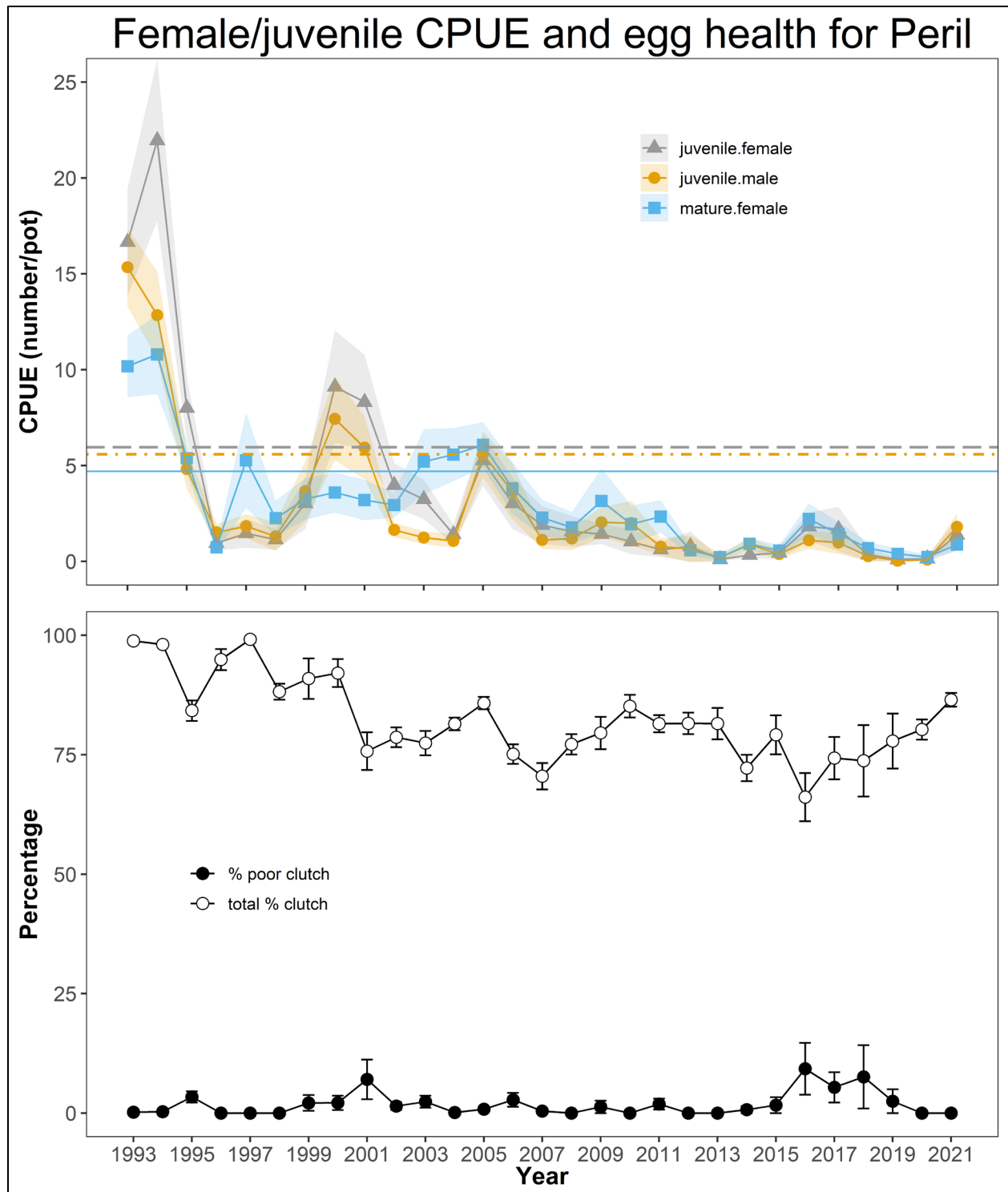


Figure 11.—Peril Strait CPUEs for female and juvenile male size/sex classes of red king crab, clutch fullness, and proportion of poor clutches. Reference lines represent baselines for each parameter (1993–2007). There is a significant short-term increasing trend in juvenile male CPUE and a significant decreasing trend in the percentage of poor clutches (>25%).

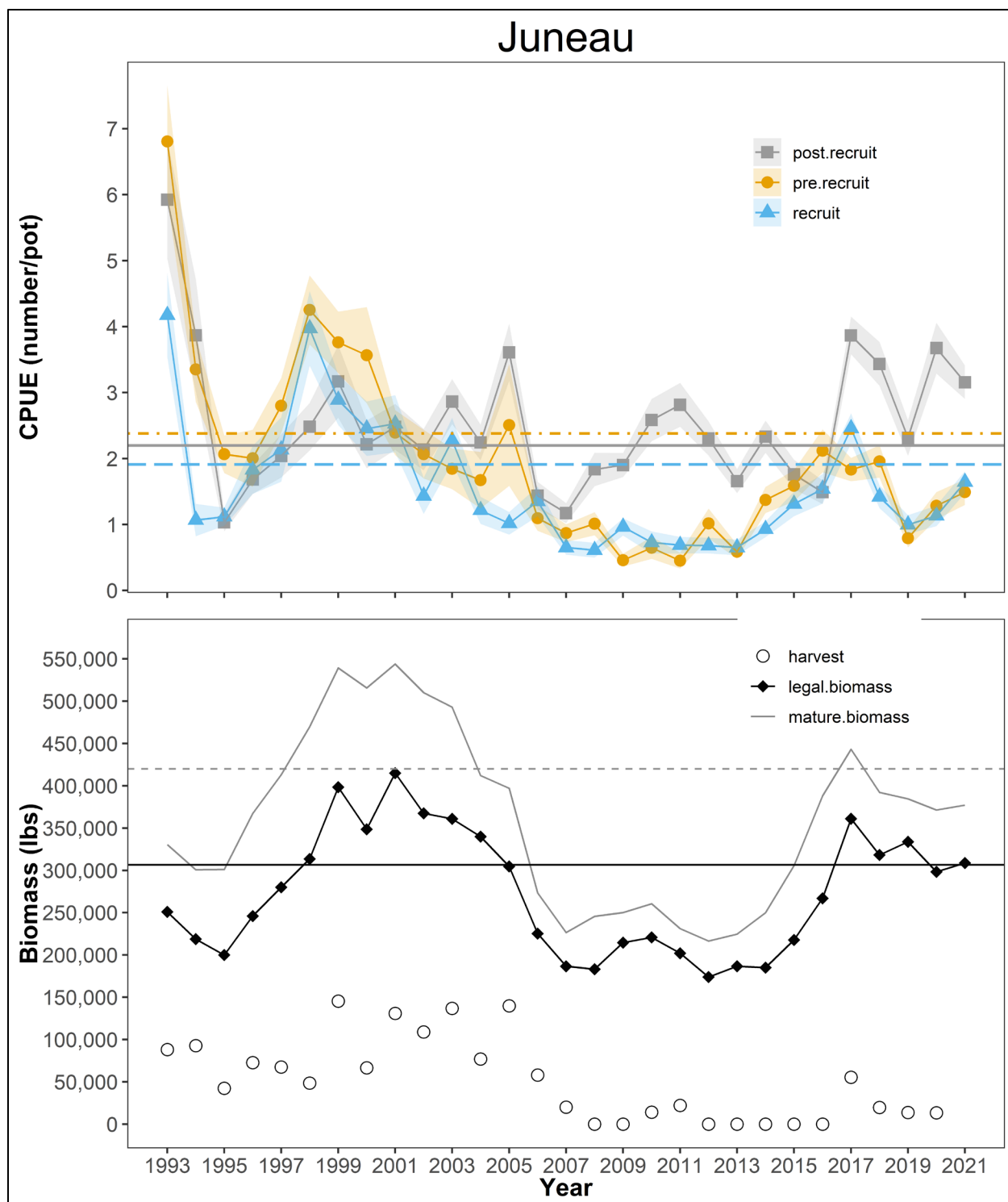


Figure 12.—Juneau area CPUEs for male size/sex classes of red king crab, biomass estimates from the current year's CSA model and harvest data. Reference lines represent baselines for each parameter (1993–2007). Gray dotted reference line in the biomass figure represents the baseline for mature biomass, while the solid black refers to the legal biomass. There are no significant short-term trends in mature male CPUEs this year.

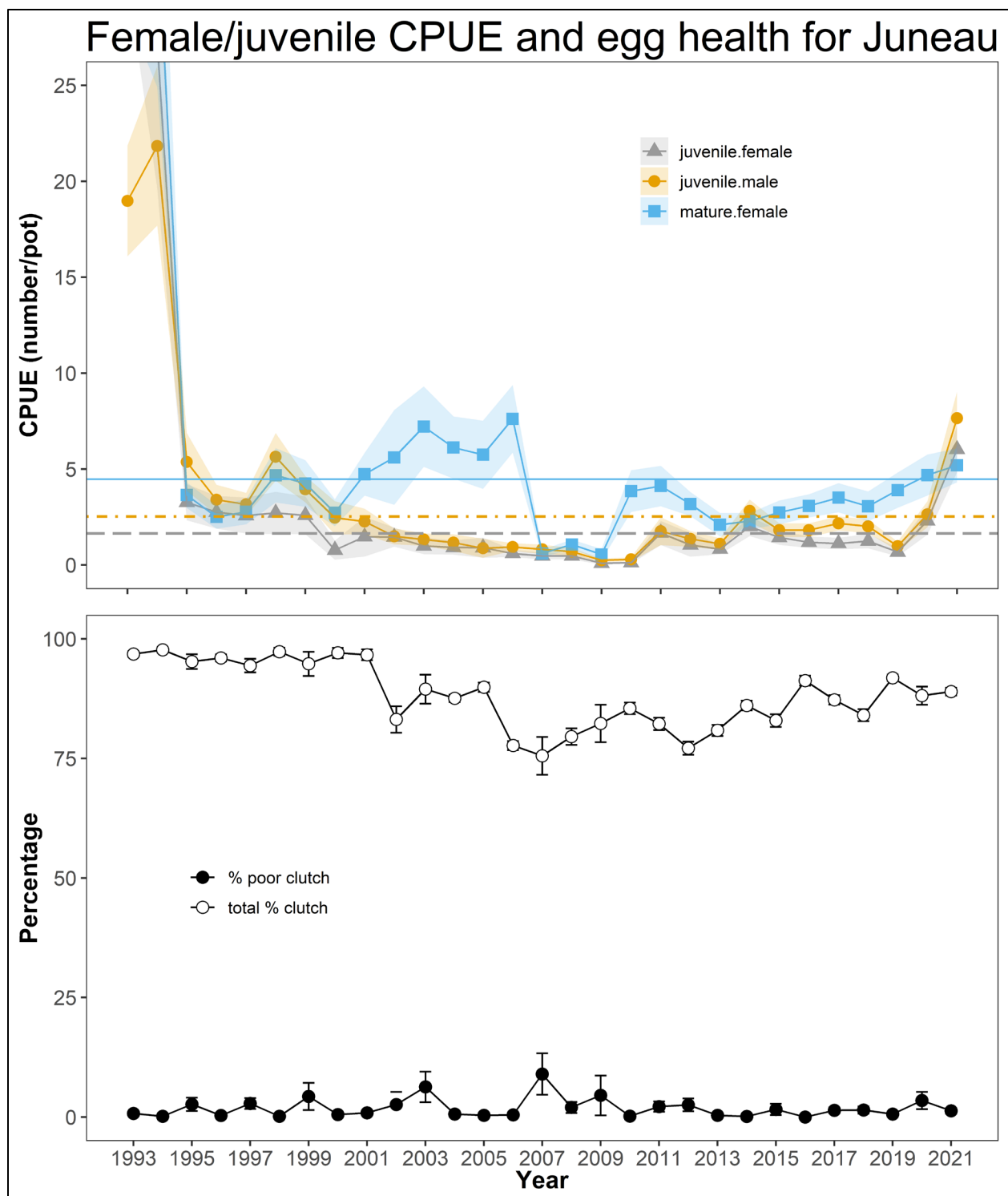


Figure 13.—Juneau area CPUEs for female and juvenile male size/sex classes of red king crab, clutch fullness, and proportion of poor clutches. Reference lines represent baselines for each parameter (1993–2007). There are significant short-term increasing trends for juvenile male and female CPUEs this year.

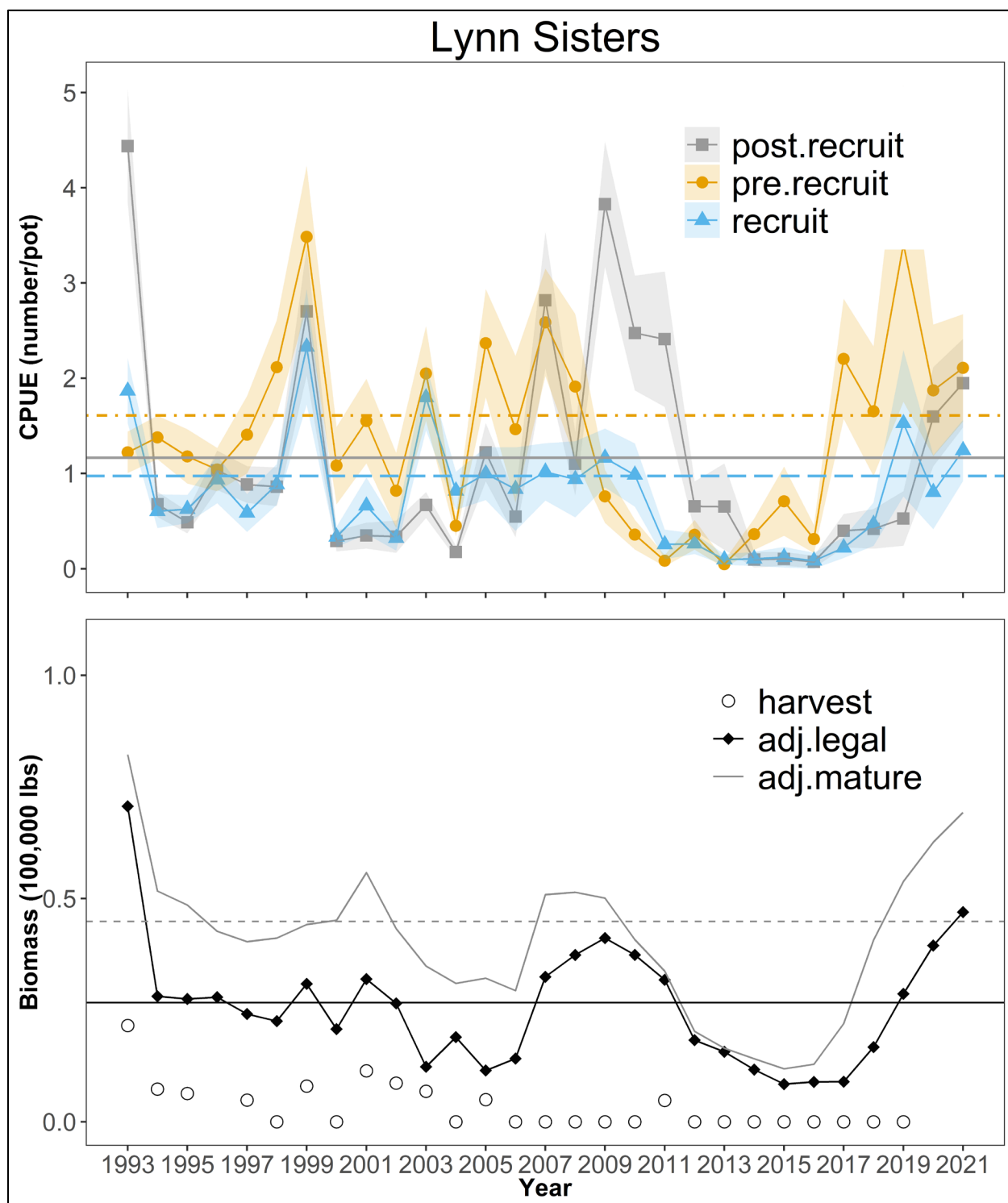


Figure 14.—Lynn Sisters CPUEs for male size/sex classes of red king crab, biomass estimates from the current year's CSA model and harvest data. Reference lines represent baselines for each parameter (1993–2007). Gray dotted reference line in the biomass figure represents the baseline for mature biomass, while the solid black refers to the legal biomass. There is a significant short-term increasing trend in postrecruit male CPUE.

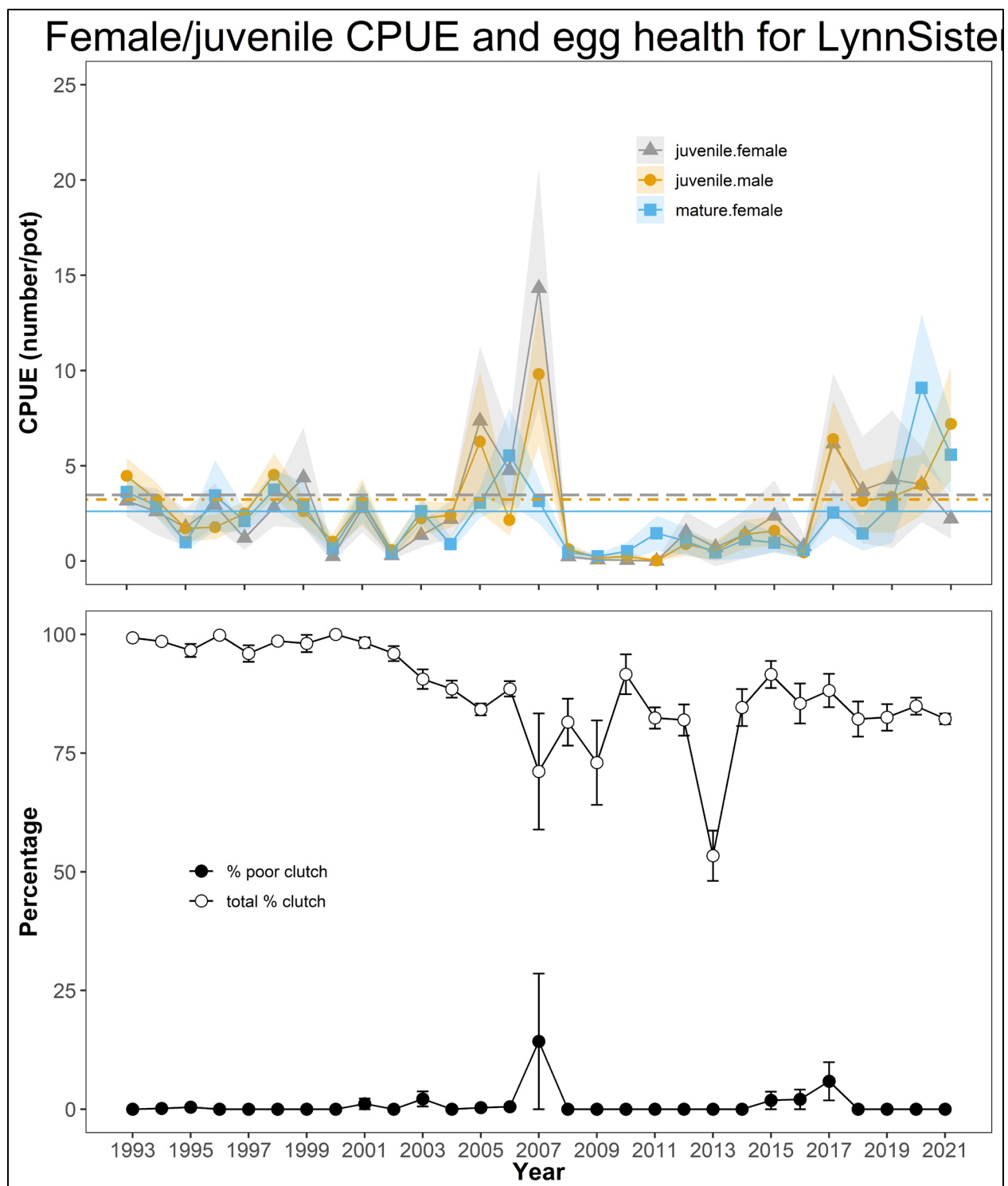


Figure 15.—Lynn Sisters CPUEs for female and juvenile male size/sex classes of red king crab, clutch fullness, and proportion of poor clutches. Reference lines represent baselines for each parameter (1993–2007). There are no significant short-term trends for juveniles or females this year.

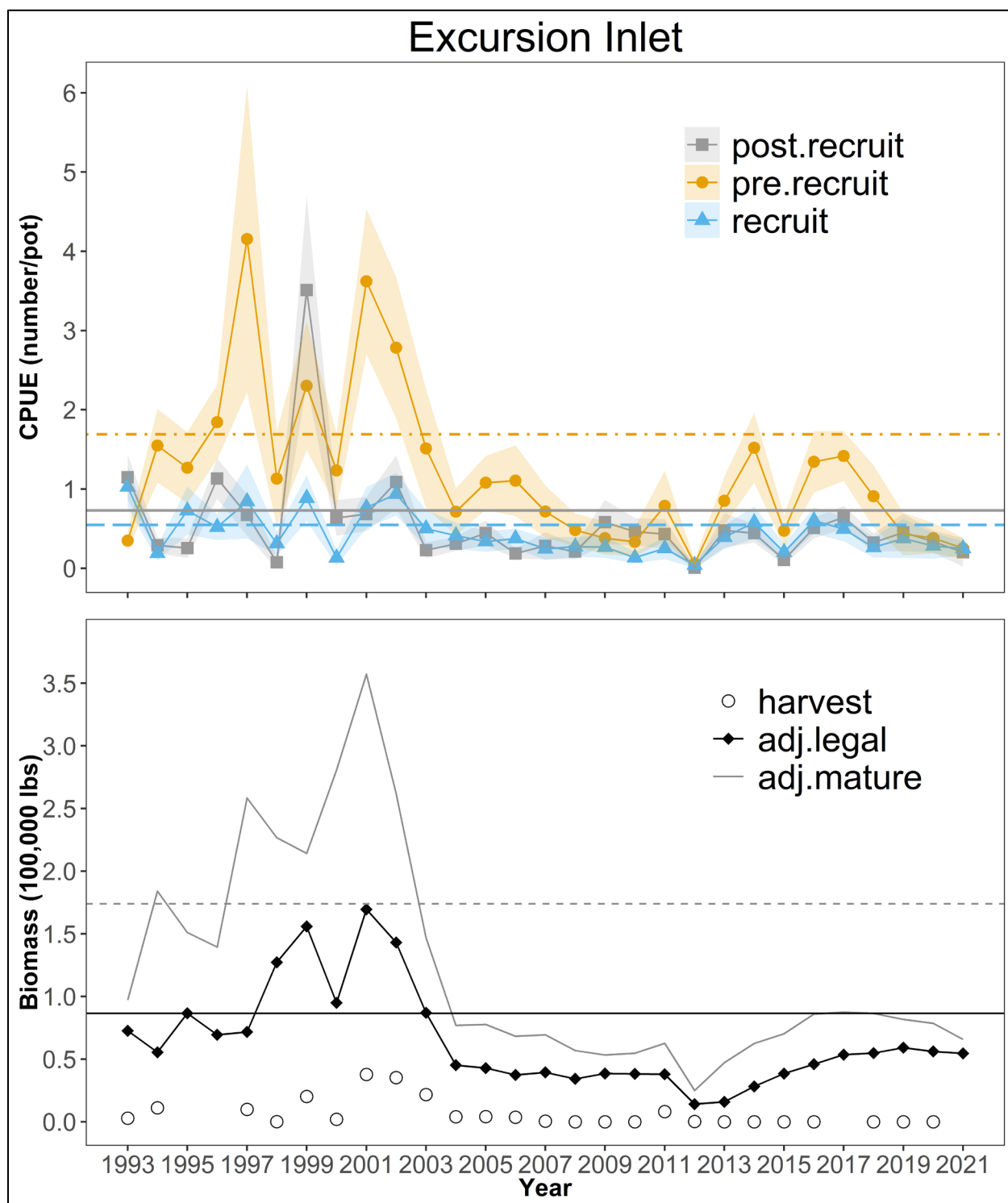


Figure 16.—Excursion Inlet CPUEs for male size/sex classes of red king crab, biomass estimates from the current year's CSA model and harvest data. Reference lines represent baselines for each parameter (1993–2007). Gray dotted reference line in the biomass figure represents the baseline for mature biomass, while the solid black refers to the legal biomass. There are no significant short-term trends in mature male CPUEs this year.

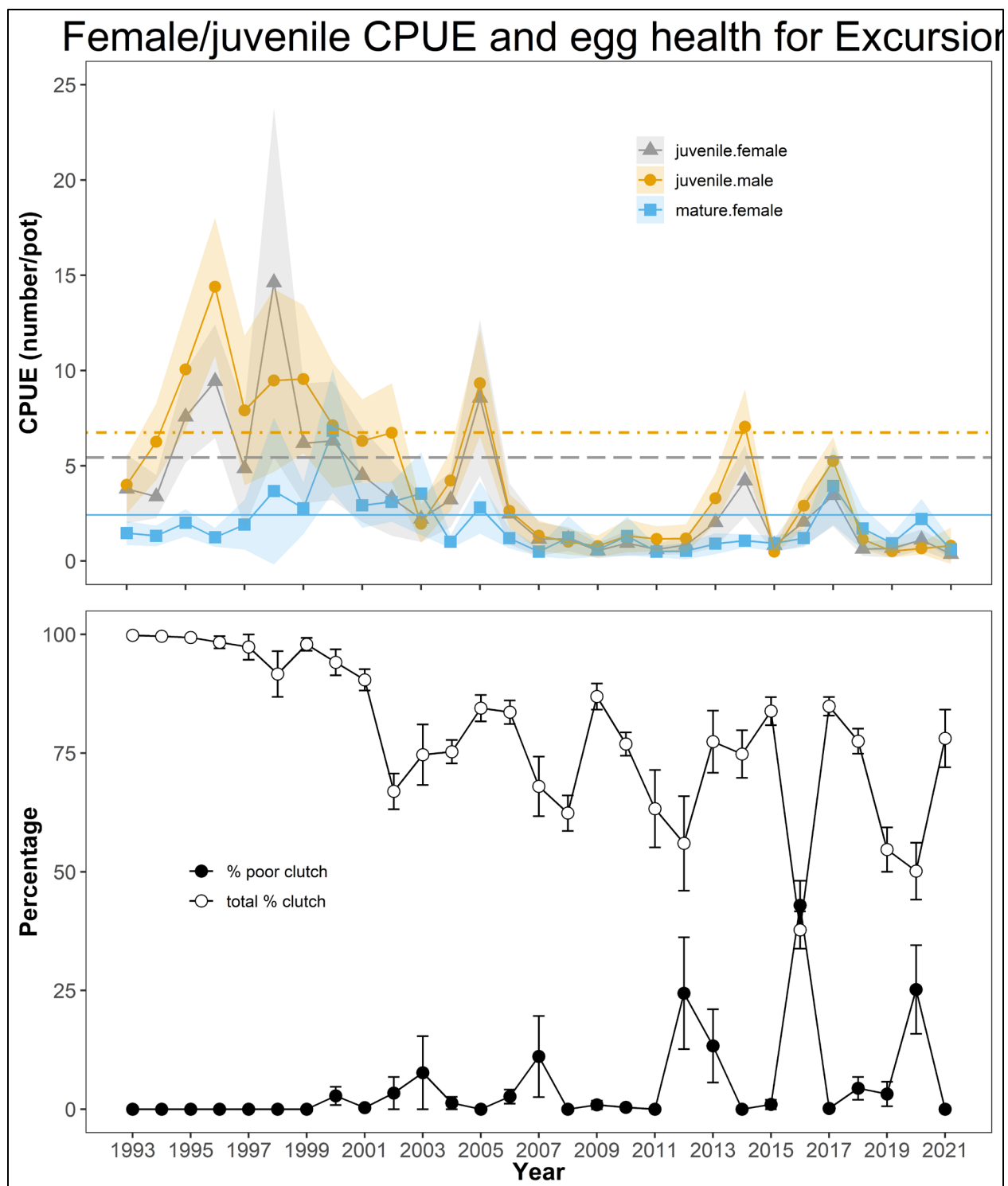


Figure 17.—Excursion Inlet CPUEs for female and juvenile male size/sex classes of red king crab, clutch fullness, and proportion of poor clutches. Reference lines represent baselines for each parameter (1993–2007). There are no significant short-term trends in juvenile or female CPUEs this year.