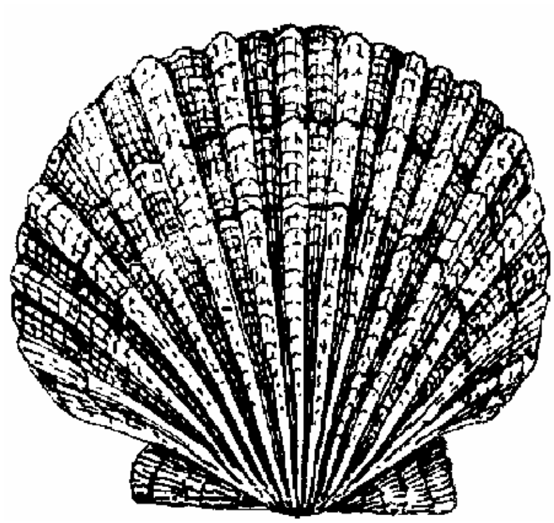
STOCK ASSESSMENT AND FISHERY EVALUATION REPORT

FOR THE SCALLOP FISHERY OFF ALASKA

March 11, 2022

Prepared by:

The Scallop Plan Team



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Executive Summary

An annual Scallop Stock Assessment Fishery Evaluation (SAFE) report is required by the North Pacific Fisheries Management Council's *Fishery Management Plan for the Scallop Fishery off Alaska* (FMP). Under the FMP, the report is prepared by the Alaska Department of Fish and Game (ADF&G) with input from the National Marine Fisheries Service (NMFS) and the Council's Scallop Plan Team (SPT). The SAFE summarizes the current biological and economic status of the fisheries, guideline harvest ranges, and support for different management decisions or changes in harvest strategies.

The Scallop Plan Team met on February 16th, 2022 virtually to update the scallop SAFE report with recent abundance survey information and fishery performance data. Plan Team review was based on presentations by staff from the Council, NMFS, and ADF&G and included opportunities for public comment and input.

New Information in the 2022 SAFE:

- *2021 fishery-independent dredge and trawl survey results for the Yakutat Region*
- *State management region - specific*
  - *2020/21 discard estimates*
  - *2020/21 fishery CPUE*
  - *2020/21 landings*
  - *2021/22 preliminary landings and CPUE estimates*

Scallop Stock Status:
Scallop abundance is estimated for portions of three of the nine registration areas only, therefore, in the absence of stock size and MSST estimates, **the status of the scallop stocks is "unknown"**.

The total catch estimate for the 2020/21 was 238,551 lb (108 t) of shucked meats. This is 20.6% of the ABC (1.156 million lb; 524 t) and 18.6% of OFL. **Overfishing did not occur in 2020/21.**

Scallop *landings-only* in 2021/22 are estimated to be 298,755 lb (136 t), and although discard estimates are not yet available, it is anticipated that **overfishing did not occur in 2021/22**.

Area-specific harvest limits for the 2021/22 season were met in approximately the Yakutat, Prince William Sound, Kodiak Northeast, Shelikof, and Southwest Districts.

Scallop Plan Team Harvest Recommendations for 2022/23:
The Scallop Plan Team recommends that OFL in the 2022/23 season be set equal to maximum OY (1.284 million lb; 582 t) as defined in the Scallop FMP. The Team also recommends that ABC for scallops in 2022/23 be set consistent with the maximum ABC control rule (90% of OFL) and which is equal to 1.156 million lb (524 t).

Definitions

The FMP contains the following stock status definitions:

Acceptable Biological Catch (ABC) is a level of annual catch of a stock that is set below the OFL and accounts for the scientific uncertainty in the estimate of OFL as well as any other scientific uncertainty. The maximum ABC is calculated from the ABC control rule. Annually, the Council's Scientific and Statistical Committee will set a statewide ABC for the weathervane scallop fishery prior to the beginning of the fishing season. The Scientific and Statistical Committee may set an ABC lower than the maximum ABC, but it must provide an explanation for setting the ABC below the maximum ABC.

ABC Control Rule is the specified approach for setting the maximum ABC for weathervane scallops. The ABC control rule calculates a maximum statewide ABC at 90 percent of the OFL, providing a 10 percent buffer to account for scientific uncertainty in estimation of the OFL.

Annual Catch Limit (ACL) is the level of annual catch that, if exceeded, invokes reactive accountability measures. For weathervane scallops, the ACL is set equal to ABC.

B_{MSY} is the total weight of the stock, i.e., biomass (B) that results from fishing at F_{MSY} and is the minimum standard for a rebuilding target when a rebuilding plan is required.

Catch per unit Effort (CPUE) is related to abundance through catchability and for scallops is expressed as lb of meats per dredge hour. CPUE for fishing vessels is monitored through onboard observers.

F_{MSY} Control Rule is a harvest strategy based on fishing mortality (F) which would be expected to result in a long-term average catch approximating MSY.

Guideline Harvest Level (GHL) is specified by the State and represents the pre-season estimated level of harvest that will not jeopardize the sustained yield of a stock. GHL may be expressed as a range of allowable harvests for each State registration area, district, sub-district, or section.

Maximum Sustainable Yield (MSY) is the largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological and environmental conditions. The long-term average stock size obtained by fishing year after year at this rate under average recruitment may be a reasonable proxy for the MSY stock size, and the long-term average catch so obtained is considered a reasonable proxy for MSY.

Minimum Stock Size Threshold (MSST) is the biomass below which the stock is considered to be overfished and is usually equal to one half of B_{MSY}.

Optimum yield (OY) is the amount of fish that will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities and taking into account the protection of marine ecosystems; that is prescribed on the basis of the MSY from the fishery, as reduced by any relevant economic, social, or ecological factor; and, in the case of an overfished fishery, that provides for rebuilding to a level consistent with producing the MSY in such fishery.

Overfishing Limit (OFL) is the catch above which overfishing is occurring and in the absence of an estimate of the statewide weathervane scallop spawning biomass, the default OFL is the MSY.

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1 Introduction

National Standard 2 guidelines (50 CFR 600.315) require regular preparation and review of a Stock Assessment and Fishery Evaluation (SAFE) report, or similar document, for each federal fishery management plan (FMP). The SAFE report summarizes the current biological and economic status of the fishery as well as analytical information used in fishery management such as survey and fishery catch and OFL/ABC. This report was prepared by the Scallop Plan Team (SPT), members of which include biologists and researchers from the Alaska Department of Fish and Game (ADF&G), the National Marine Fisheries Service (NMFS), and the North Pacific Fishery Management Council (NPFMC). The annual SAFE reports are presented to the NPFMC and is also available to the public on the NPFMC web page at: https://www.npfmc.org/fishery-management-plan-team/scallop-plan-team/.

The scallop fishery in Alaska's Exclusive Economic Zone (EEZ; from 3 to 200 miles offshore) is jointly managed under Federal and State of Alaska authority under the FMP. Most aspects of scallop fishery management are delegated to the State, while Federal requirements are maintained within the FMP. The initial FMP was developed by the Council under the Magnuson Stevens Act (MSA) and approved by NMFS in 1995. The Council has adopted several amendments to the FMP with the latest (Amendment 15) being approved in 2012. Scallop fisheries inside 3 miles are managed by the State of Alaska.

Although the FMP covers all scallop stocks off the coast of Alaska, including weathervane scallop (*Patinopecten caurinus*), reddish scallop (*Chlamys rubida*), spiny scallop (*Chlamys hastata*), and rock scallop (*Crassadoma gigantea*), the weathervane scallop is the only commercially targeted stock at this time. Commercial fishing for weathervane scallops occurs in the Gulf of Alaska, Bering Sea, and waters off the Aleutian Islands. State scallop registration areas and general fishing locations are shown in Figure 1.1.

The Alaska Department of Fish and Game has obtained release forms signed by vessel operators in order to display confidential catch information. Whenever possible, unless otherwise indicated as "confidential", catch records have been made available for publication by the State.

1.1 Basis for Optimum Yield

In the original FMP, optimum yield (OY) was established as a range from 0 to 1.1 million lb (~500 t) of shucked scallop adductor muscles (meats) with the upper end being based on the historic high in landings since 1993. Under Amendment 1, in 1996, the upper end for OY was increased to 1.8 million lb (816 t) to account for historic State water landings. A more conservative approach was taken in 1999, when OY was re-defined as 0 to 1.24 million lb (562 t) with the upper end reflecting average rather than maximum catch. The reference period for defining the upper range for OY is 1990-1997 excluding 1995 (Table 1.1). Most recently, in 2012, under Amendment 13, OY was re-defined as 0 to 1.29 million lb (585 t) of shucked meats to include estimated discards over the reference time frame. Alaska scallop harvests have not exceeded OY in any year since it was first established.

In the absence of a stock assessment for scallops off Alaska, OFL and ABC have been set historically and recently based on the above definition of OY such that max OFL = OY. The maximum ABC control rule is defined as max ABC = 90% of OFL = 1.161 million lb.

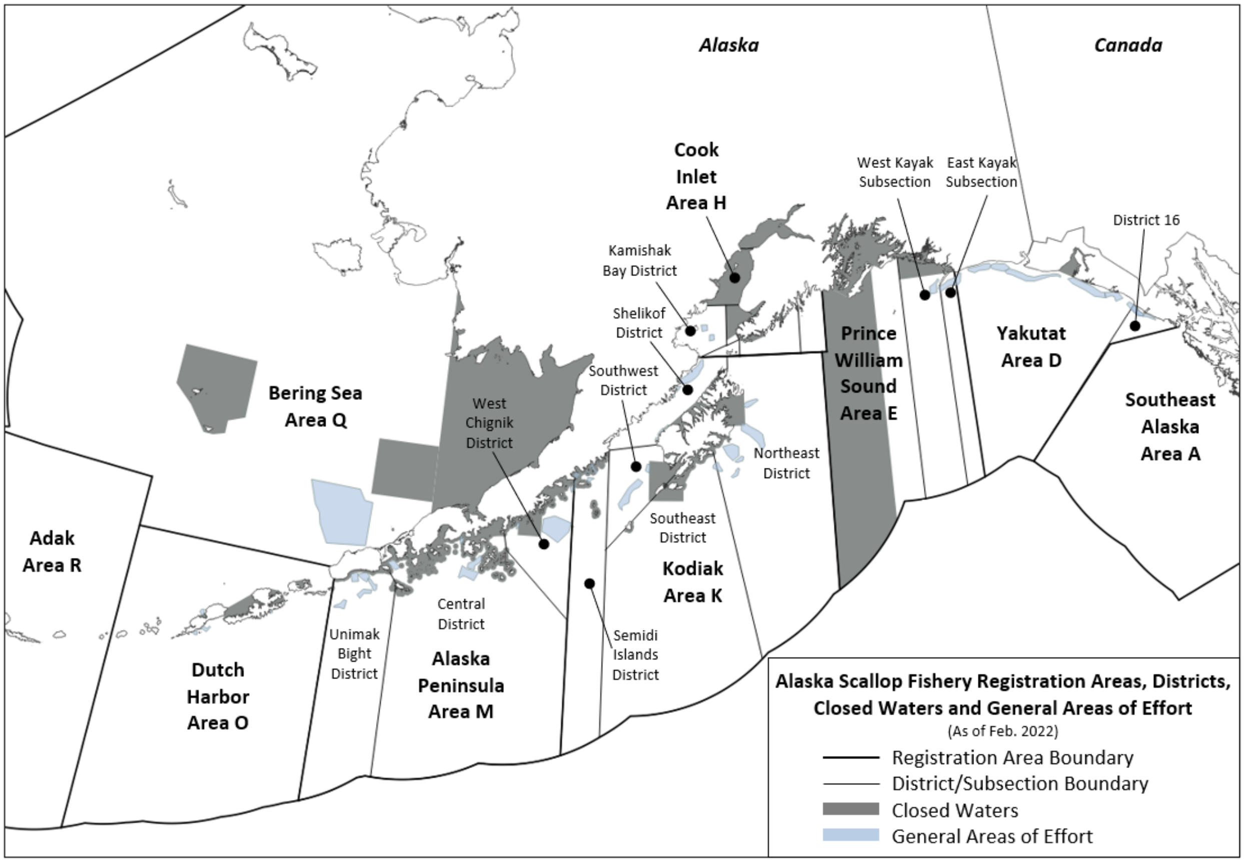

Figure 1.1 Alaska scallop fishery registration areas.*

**General areas of effort are overlaid by blue polygons. Exploratory fisheries in waters normally closed to scallop fishing (gray shading) have been opened by ADF&G Commissioner's Permit in the Alaska Peninsula Unimak Bight District during past seasons.*

Table 1.1 Weathervane scallop harvest 1990-1997 including state and federal waters.

Year	Unique Vessels	Total Pounds	Total Est. Earnings	Unique IUPs	Average Price / lb
1990	9	1,488,737	$5,073,572	15	$3.41
1991	6	1,136,649	$4,279,200	7	$3.76
1992	8	1,753,873	$6,796,699	12	$3.88
1993	15	1,511,539	$6,981,415	22	$4.62
1994	17	1,256,736	$7,039,262	22	$5.60
1995*	10	351,023	$1,847,666	10	$5.36
1996	9	728,424	$4,670,515	10	$6.41
1997	9	802,383	$4,329,752	11	$5.40
Mean all years	10.4	1,128,671	$5,127,260	13.6	$4.81
Mean excluding 1995	10.4	1,239,763	$5,595,774	14.1	$4.73

Adapted from Free-Sloan 2007. Catch differs from catch numbers in Table 2-1 due to the lack of discard mortality accounting.
* From February 23, 1995, until August, 1996, the EEZ was closed to fishing. 1995 federal waters harvest and earnings occurred in January and February prior to closure.

2 Weathervane Scallop Stock Assessment

A functional stock assessment model for weathervane scallops in Alaska does not exist, although efforts to develop an age-based assessment are ongoing. In the absence of a formal stock assessment, State harvest limits (i.e., GHLs) are established using data gathered through the scallop fishery observer program as well as fishery-independent scallop dredge surveys.

2.1 Stock Status Determination

The FMP defines the minimum stock size threshold (MSST) for weathervane scallops as 4.93 million lbs (2,236 t) of shucked scallop meats, however, scallop abundance is estimated for only portions of three of nine registration areas. As such, an estimate of weathervane scallop spawning biomass is not available, and **the status of the scallop stock, relative to “overfished” is “unknown”**. This status determination is not considered to be a conservation concern since scallops are distributed in many areas that have been closed to fishing to protect crab populations and in areas not defined as commercial scallop beds.

Estimated total fishing removals (retained and discarded) for the 2020/21 season was 238,551 lb (108 t) of shucked meats (Table 2.1). This is approximately 20.6% of the ABC/ACL and 18.6% of OFL, therefore, **overfishing did not occur in 2020/21**.

During the 2020/21 season, scallop fisheries were open in Yakutat, Kodiak, AK Peninsula, Dutch Harbor, and Bering Seas Registration Areas. Area-specific guideline harvest levels (GHLs) were achieved in the Kodiak Northeast, and Kodiak Shelikof Districts therein. Total landed catch for the 2020/21 season was 227,270 lb (103 t) shucked meats (82% of total GHL) (Table 2.1; Table 4.1).

For the 2021/22 season, preliminary estimates of scallop removals consist only of retained catch at this time (Table 2.1;Table 4.2). The addition of estimated discard mortality is not expected to substantially increase total removals relative to the ACL.

Table 2.1 Total Alaska weathervane scallop removals (landings + discards) and OY/MSY/OFL, 1993/94 – 2021/22 seasons.

Season	Total Removals (lb meats)	OFL (lb meats)	ABC (lb meats)	%OY	%ACL
1993/94	984,583	1,800,000	1,620,000	54.7	60.8
1994/95	1,240,775	1,800,000	1,620,000	68.9	76.6
1995/96	410,743	1,800,000	1,620,000	22.8	25.4
1996/97	732,424	1,800,000	1,620,000	40.7	45.2
1997/98	818,913	1,800,000	1,620,000	45.5	50.6
1998/99	822,096	1,240,000	1,116,000	66.3	73.7
1999/00	837,971	1,240,000	1,116,000	67.6	75.1
2000/01	750,617	1,240,000	1,116,000	60.5	67.3
2001/02	572,838	1,240,000	1,116,000	46.2	51.3
2002/03	509,455	1,240,000	1,116,000	41.1	45.7
2003/04	492,000	1,240,000	1,116,000	39.7	44.1
2004/05	425,477	1,240,000	1,116,000	34.3	38.1
2005/06	525,357	1,240,000	1,116,000	42.4	47.1
2006/07	487,473	1,240,000	1,116,000	39.3	43.7
2007/08	458,313	1,240,000	1,116,000	37.0	41.1
2008/09	342,434	1,240,000	1,116,000	27.6	30.7
2009/10	512,958	1,240,000	1,116,000	41.4	46.0
2010/11	481,433	1,240,000	1,116,000	38.8	43.1
2011/12	461,924	1,284,000	1,156,000	36	40.0
2012/13	424,492	1,284,000	1,156,000	33.1	36.7
2013/14	408,088	1,284,000	1,156,000	31.8	35.3
2014/15	314,352	1,284,000	1,156,000	24.5	27.2
2015/16	261,939	1,284,000	1,156,000	20.4	22.7
2016/17	236,560	1,284,000	1,156,000	18.4	20.5
2017/18	250,632	1,284,000	1,156,000	19.5	21.7
2018/19	250,460	1,284,000	1,156,000	19.5	21.7
2019/20	246,900	1,284,000	1,156,000	19.2	21.4
2020/21	238,551	1,284,000	1,156,000	18.6	20.6
2021/22[a]	298,755[a]	1,284,000	1,156,000		

[a]Preliminary estimates, discards not included.

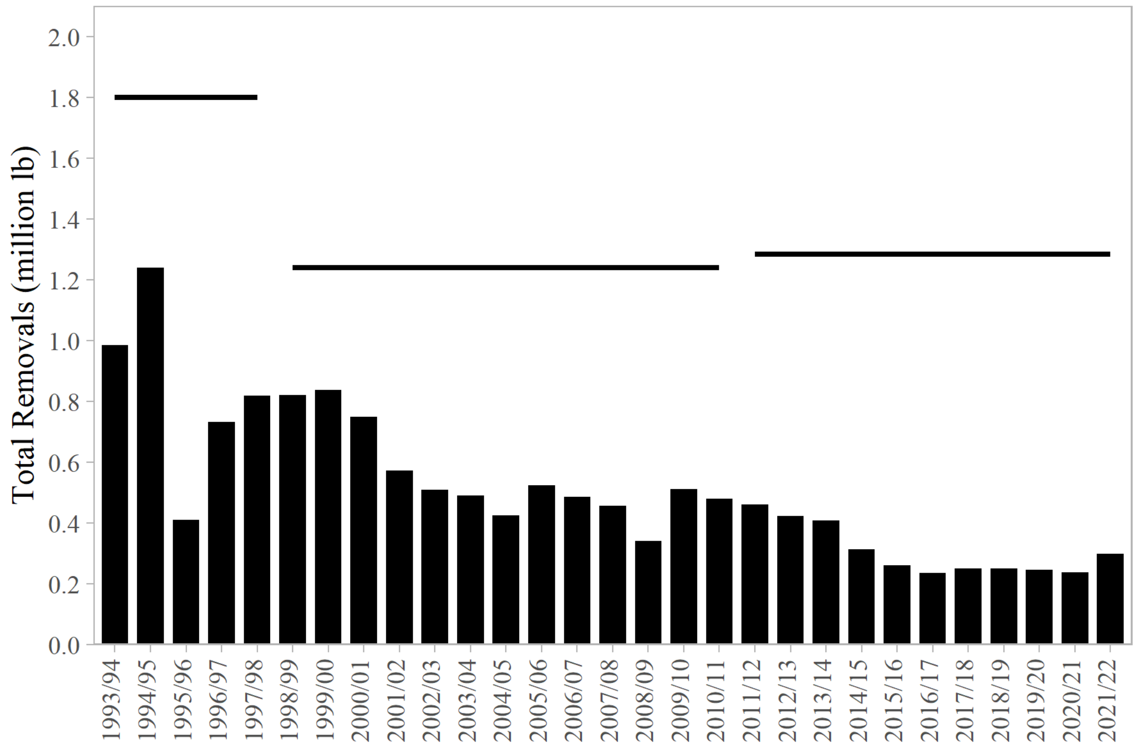

Figure 2.1 Statewide scallop harvest (lb shucked scallop meats) and MSY levels from FMP.

2.2 Fishery Observer Program

Data gathered through the observer program comprise the primary information source for the State in setting harvest limits. These data include time series of scallop harvest and fishery CPUE, fishing location, size and age composition of the catch, scallop discards, and crab bycatch. ADF&G and the SPT recognize inherent weaknesses in using fishery-dependent data for management purposes (i.e., nominal CPUE may be an unreliable index of scallop abundance due to factors such as the general incentive to seek out areas with the highest CPUE, but also market conditions, weather, tides, gear efficiency, bycatch avoidance, captain, and crew performance, etc). Industry participants have noted that the time of year when fishing occurs can affect CPUE considerably due to summer and winter differences in weather and sea state. In addition to nominal trends in CPUE, managers consider a standardized CPUE index to infer trends in scallop abundance at the district scale. Standardized CPUE is estimated via a general additive model in the form of

$$(U + \gamma) = f_1(depth \cdot Bed) + f_2(longitude \cdot Bed) + Month + Vessel + Bed + Season + \varepsilon \quad (1)$$

where *fi* are smoothing functions, and month, vessel, bed, and season are parametric factor effects. Models were fit using gamma distributed error (ε) and a log-link. A small modifier (γ) was added to CPUE estimates to avoid zero values. Standardized CPUE in season *i* was computed as the marginal effect of season *i* ($\beta_{j,i}$), back transformed using

$$\widehat{U}_i = e^{\beta_{j,i} + \frac{\sigma_{j,i}}{2}} - \gamma \quad (2)$$

where $\beta_{j,i}$ and $\sigma_{j,i}$ are the point estimate and standard error of the *j*th season effect in year *i*. It's also important to acknowledge that fishery-dependent size composition data may not be representative of the true size composition of a given scallop bed since fishing location within the bed is non-random and gear does not select all shell sizes.

The spatial scale of the fishery effort and catch also provides necessary insight to interpreting trends in CPUE. For instance, good fishing performance corresponding to intense effort in a small area does not necessarily indicate good health of the stock, or vice versa. Spatial extent of the fishery catch was computed as the average pairwise distance among dredge locations. Using this approach, both the range and density of fishing effort are considered in characterizing spatial extent of the catch. Units are decimal degrees of latitude and longitude, thus the value of spatial extent is not directly interpretable, rather it serves as a relative index over the fishery timeseries. Only hauls contributing the top 90% of a season's catch were included in this analysis, so not to include "exploratory" fishing effort that was not fruitful.

2.3 Fishery Independent Dredge Survey

The Alaska Department of Fish and Game (ADF&G) initiated a weathervane scallop (*Patinopecten caurinus*) dredge survey in 2016 to collect fishery-independent data for use in managing weathervane scallops in Alaska. Prior to 2016, fishery-independent weathervane scallop (hereafter scallop) dredge surveys had been restricted to the Cook Inlet and Prince William Sound registration areas (Table 2.2**.**). Initial surveys were conducted for Kamishak Bay and Kayak Island in 1984 and 1996, respectively (Hammarstrom and Merritt 1985, Bechtol et al. 2003), and were conducted biennially since 1996 (Gustafson and Goldman 2012). These surveys enabled ADF&G to (1) delineate the primary scallop beds; (2) estimate scallop abundance and biomass within these beds; (3) define bed composition through age and shell height data; and (4) estimate bycatch rates of non-target species, particularly Tanner crab (*Chionoecetes bairdi*). All other management areas in the state were reliant on fishery-dependent data gathered from the statewide scallop observer program to inform management decisions (NPFMC 2018). The survey supersedes the previous survey, though follows a similar survey design (Gustafson and Goldman 2012, Smith et al. 2016) in order to provide fishery-independent information for the sustainable management of scallop stocks in Alaska waters.

The 2021 survey included Yakutat and Prince William Sound registration areas. In this report we examine the methods and results of the 2021 scallop dredge survey including (1) catch rates and abundance estimates at the bed level and, (2) the survey abundance estimates from survey sites.

2.3.1 Study Areas

Table 2.2 Scallop bed size, number of available stations and the planned number of stations to sample and sampling rate for the 2021 PWS Outside and Yakutat Districts ADF&G survey. Area is calculated in Alaska Albers projection.

District/Subsection	Bed	Area (nm^2)	Stations	Stations	Sampling rate
East Kayak Is.	EK1	98.2	97	29	30%
West Kayak Is.	WK1	48.7	48	24	50%
Yakutat	EK1	33.4	33	11	33%
	YAK1	52.3	52	18	35%
	YAK2	78.6	78	19	24%
	YAK3	166.6	164	41	25%
	YAK4	127.6	124	31	25%
	YAK5	54.9	53	18	34%

Prince William Sound Outside District

Both the WK1 bed within the West Kayak Subsection and the EK1 bed within the East kayak Subsection of the PWS Outside District were surveyed in 2021 (Figure 2.2). Bottom depths in these beds vary between 30–86 fathoms (55–157 m) throughout the area where commercial fishing occurs. Together, the area of the survey beds is 146.9 nm^2 (Table 2.2). In previous years the most western bed in Area D that abuts EK1 was referred to as YAKB. These beds are considered to functionally be a single bed and are now referred to as EK1 though population parameters will continue to be reported by respective management Districts. The target sampling rate for the larger EK1 bed was 33%. Due to the smaller area and high CV in prior ADF&G surveys was the target sample rate was 50% for the WK1 bed (Table 2.1). Sampling rate in both beds in prior ADF&G surveys has been 33%.

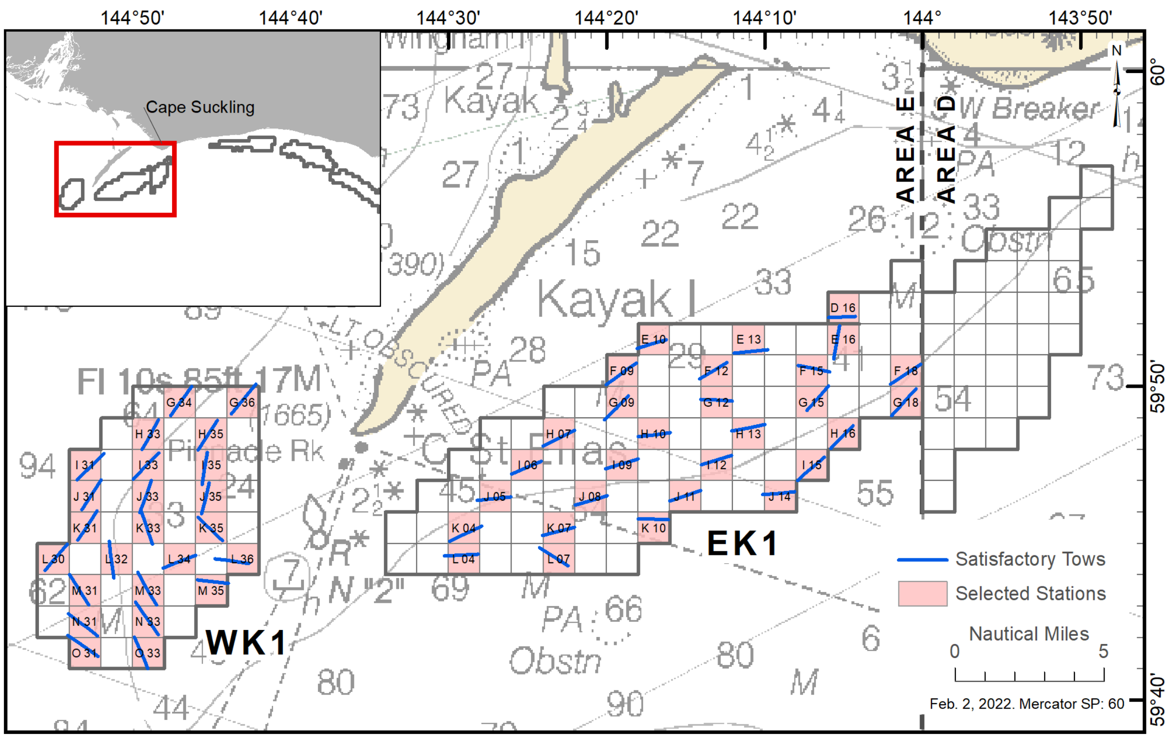

Figure 2.2 **Location of PWS Outside District weathervane scallop beds, WK1 and EK1, sampled in the 2021 ADF&G survey. Blue lines indicate successful survey dredge tow tracks in selected stations. Note that EK1 extends east into Area D and that portion of the bed was formally referred to as YAKB.**

Yakutat District

The Yakutat District (YAK) survey area is a long narrow swath from the northwest to the southeast along the coast of Alaska on either side of Yakutat Bay (Figure 2.3,Figure 2.4,Figure 2.5,Figure 2.6,Figure 2.7). The scallop beds depths vary from 25–80 fathoms (46–146 m). All scallop beds with the Yakutat District were surveyed in 2021. Together the area of the survey beds is 513.4 nm^2 (Table 2.2). One scallop bed occurs predominantly in District 16 at the southeastern extent of Area D and was not surveyed due to time constraints and the lack of commercial effort that has occurred there (Table 2.5). The planned sampling rate for the smaller beds was 33% and 25% for the larger beds due to their size and time constraints (Table 2.2). Sampling rate in all Yakutat District beds in prior ADF&G surveys has been 33%.

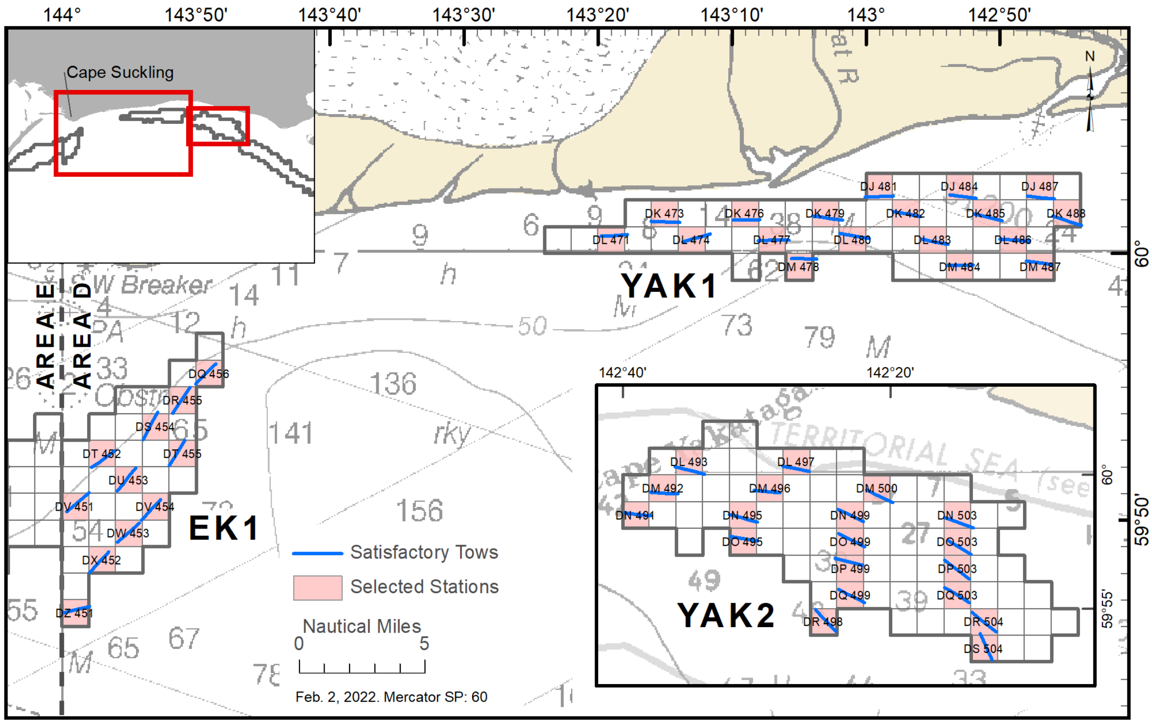

Figure 2.3 Location of Yakutat District weathervane scallop beds EK1, YAK1 and YAK2 sampled in 2021. Blue lines indicate successful survey dredge tow tracks in selected stations. Note that EK1 was formally referred to as YAKB.

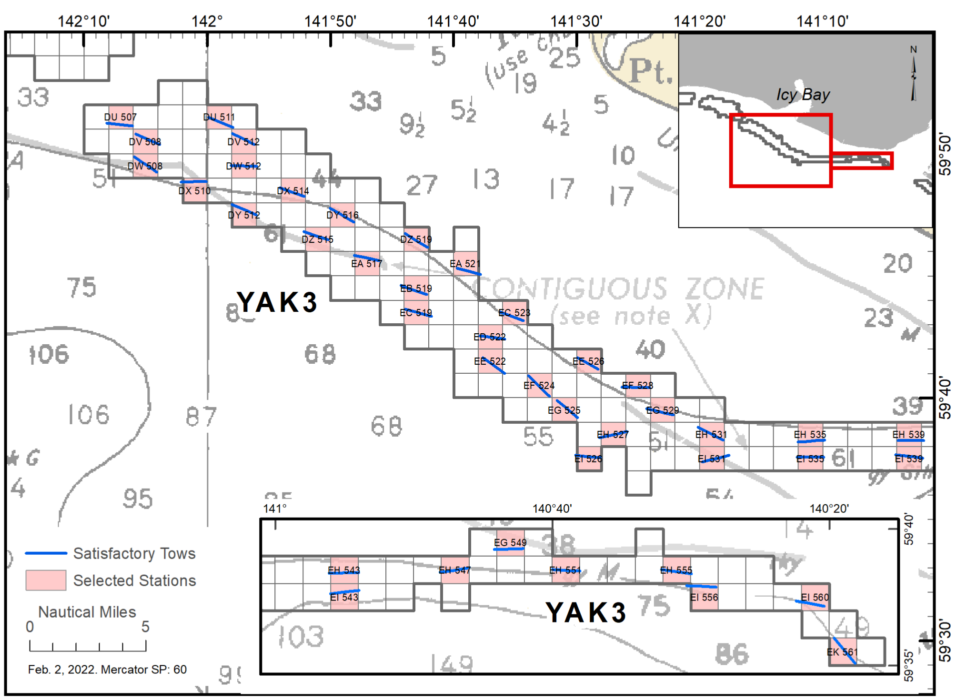

Figure 2.4 Location of Yakutat District weathervane scallop bed YAK3 sampled in 2021. Blue lines indicate successful survey dredge tow tracks in selected stations.

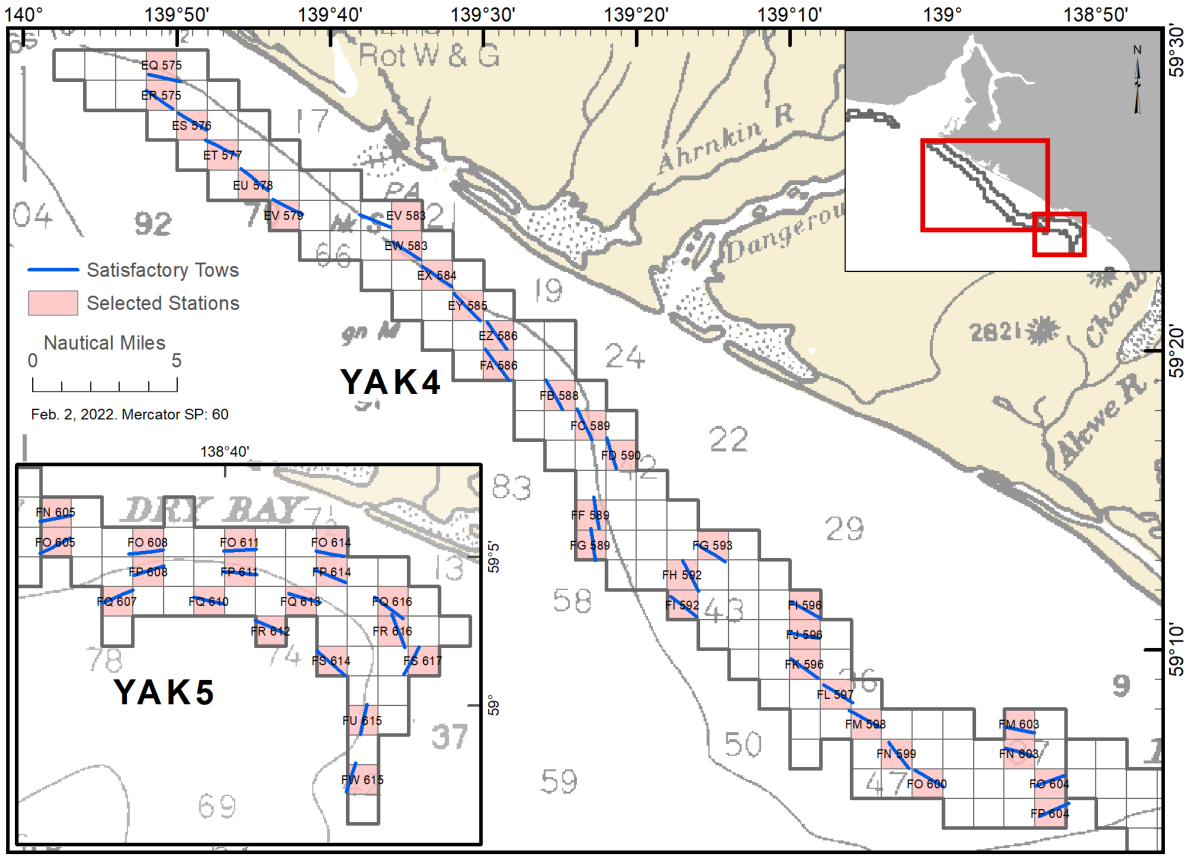

Figure 2.5 **Location of Yakutat District weathervane scallop beds YAK4 and YAK5 sampled in 2021. Blue lines indicate successful survey dredge tow tracks in selected stations.**

2.3.2 Methods

Survey stations within defined scallop beds (Burt et al. 2021) were fished using a New Bedford style scallop dredge. Scallop beds were delineated into a grid of 1 nmi x 1 nmi survey stations. Survey stations were selected for sampling using systematic random sampling independently for each bed. The 2.43 m (8 ft) dredge was equipped with a ring bag composed of rings with an inside diameter of 101.6 mm (4.0 in) additionally a 38.1 mm (1.5 in) mesh liner was used to facilitate the retention of smaller scallops. A single 15–min tow approximately 1.0 nmi in length was made in each selected survey grid. Dredge performance was monitored, and stations were re-towed if performance was judged unsatisfactory. Actual tow lengths, needed for area-swept calculations, were determined by comparing the linear distance between tow start and end points with the distance recorded by the vessel's navigational system, the latter was used if the discrepancy between the two distances exceeded 10%.

Dredge haul contents were processed, and all data were recorded consistent with the protocols detailed in the statewide scallop survey Operational Plan (Burt et al. 2021). Scallops were sorted by size class (shell height < 100 mm; shell height ≥100 mm, 'small' and 'large', respectively), counted and collectively weighed. The two size classes were subsampled for collection of individual biological information including shell height and for the larger size class: round weight, meat weight, i.e., weight of the shucked adductor muscle, meat condition, sex, gonad condition and various measures of shell condition. Shells from a secondary subsample of the large scallops were retained for aging (Siddon et al. 2017).

Abundance and Biomass

Abundance and biomass indices of the surveyed population were based upon area-swept calculations grouped by size class. Scallop density (catch per unit effort, $\overline{U}$) within a given tow (U_i) was calculated as

$$U_i = \frac{c_i}{a_i} \tag{3}$$

where

$$a_i = d_i x q \tag{4}$$

and

$$\overline{U} = \frac{1}{n}\sum_{i=1}^{n} U_i \tag{5}$$

c_i = the catch of scallops, either as a count or weight (lbs), in sample tow i,

a_i = the effective area (nm^2) sampled in tow i,

d_i = the distance (nm) of a sampled tow i,

x = the width of the dredge (nm),

q = dredge efficiency (i.e. catchability),

n = the number of stations sampled.

A preliminary q of 0.83 calculated from the Kayak Island beds in 2004 (Gustafson and Goldman 2012) was used in lieu of bed or size specific dredge efficiencies. It is important to clarify that q used in this analysis is a 'bulk' dredge efficiency applied to all size classes, which likely is not representative of the true catchability. Thus, estimates which include q (e.g., catch per unit effort, abundance, biomass) should be regarded as indices, rather than absolute values. Variance in $\overline{U}$ is estimated as

$$\widehat{Var}[\overline{U}] = \frac{1}{n(n-1)}\sum_{i=1}^{n}(U_i - \overline{U})^2 \tag{6}$$

Surveyed population abundance ($\widehat{N}$) and round weight (i.e., whole animal) biomass ($\widehat{B}$) of large and small scallops was computed by expanding $\overline{U}$ over the entire bed area (A) (nm^2) as

$$\tau = A\overline{U} \tag{7}$$

where τ represents either $\widehat{N}$ or $\widehat{B}$. Variance in $\widehat{N}$ and $\widehat{B}$ were estimated as

$$\widehat{Var}[\tau] = A^2\widehat{Var}[\overline{U}] \tag{8}$$

Although abundance and round weight biomass might be more directly indicative of population dynamics, meat weight biomass (B_M) is an important quantity for interpreting the proportion of biomass that is commercially available, as guideline harvest levels are set and managed in pounds of shucked meats. B_M is estimated via

$$\hat{B}_M = A \cdot \frac{1}{n}\sum_{i=1}^{n} u_i \quad (9)$$

u_i = the meat weight density (catch per unit effort) within sample tow *i,* in which

$$u_i = \frac{\widehat{w}_i}{a_i} \quad (10)$$

$$\widehat{w}_i = c_i \overline{w}_i \quad (11)$$

$$\overline{w}_i = \frac{1}{m_i}\sum_{j=1}^{m_i} w_{ij} \quad (12)$$

c_i = the total number of scallops caught in sample tow i.
m_i = the number of scallops subsampled from sample tow i (i.e., m_i = 10),
w_{ij} = the meat weight (g) of scallop j subsampled from the catch of tow i,
$\widehat{w}_i$ = the estimated total meat weight (g) of scallops per sample tow i.
$\overline{w}_i$ = the average meat weight (g) of scallops sampled per sample tow i.

Variance in $\hat{B}_M$ is then estimated as

$$\widehat{Var}\left[\hat{B}_M\right] = A^2\widehat{Var}[\overline{u}] + \frac{A}{n}\sum_{i=1}^{n} c_i^2\widehat{Var}[\overline{w}_i] \quad (13)$$

$$\widehat{Var}[\overline{w}_i] = \frac{1}{m_i(m_i-1)}\sum_{j=1}^{m_i}\left(w_{ij} - \overline{w}_i\right)^2 \quad (14)$$

$$\widehat{Var}[\overline{u}] = \frac{1}{n(n-1)}\sum_{i=1}^{n}(u_i - \overline{u})^2 \quad (15)$$

Meat weight biomass is only reported for large scallops since scallops (< 100 mm) are not retained in the fishery.

Shell Height Distributions

Measurements of shell height were recorded for at least 40 scallops for both small and large scallops from each tow (Burt et al. 2021). Shell height composition was estimated by bed, weighting the frequency of scallops in 1 mm size bins caught in a tow, by the total catch of scallops in the relevant size class (i.e. small, large) for that tow. For display, histograms were constructed so that bar heights reflect estimated probability density the of the shell height distribution for each bed. Summaries of other biological data collected (e.g., presence of weak meats, sex ratio, shell boring worms, mud blisters) during the survey were used as additional indicators of scallop stock status on surveyed beds.

2.3.3 Results

Survey Performance

A total of 191 successful ~1.0 nm survey tows were completed during the 2021 ADF&G survey representing 100% of the planned sample stations. An alternate station was chosen for one station in YAK4 which was considered untowable. This station will be removed from selection for future surveys. The survey was conducted between April 27 and May 12, 2021 using the charted commercial F/V Provider which has been used for most of the ADF&G surveys.

Abundance and Biomass

The highest CPUE of small scallops in the 2021 survey in numbers and biomass occurred at the YAK1 and YAK2 beds with WK1 being the third highest (Table 2.3) The highest CPUE of large scallops in the 2021 survey in numbers and biomass occurred at the WK1 and YAK1 beds with YAK2 being the third highest (Table 2.4). Large scallop CPUE in EK1, YAK4, and YAK5 beds were much lower than in other beds in the Yakutat District.

In the PWS Outside District, abundance and biomass of small scallops increased slightly in WK1. Abundance and biomass of small scallops increased significantly in EK1 in 2021 over previous years, but remained low compared to WK1 (Table 2.4,Table 2.5;Figure 2.6,Figure 2.7). There was a slight increase in the abundance and biomass of large scallops in the WK1 bed, but levels remained low in EK1 bed for 2021 (Table 2.4,Table 2.5; Figure 2.9,Figure 2.10).

Abundance and round biomass of small scallops decreased in all Yakutat beds since the most recent survey except at EK1 and YAK1 (increase in round biomass) (Table 2.4,Table 2.5;Figure 2.6,Figure 2.7). Tables Abundance and biomass showed approximately the same trends for large scallops in the Yakutat beds (Table 2.4,Table 2.5;Figure 2.8,Figure 2.9,). The YAK1 bed had the largest increase over the previous survey, while YAK3 and YAK4 saw the largest decreases (Figure 2.9,Figure 2.10). Trends in meat biomass estimates mirrored those of round biomass (Table 2.5; Figure 2.10).

Table 2.3 Scallop CPUE (number / nm^2), abundance, associated CV, and lognormal 95% confidence interval by district or subsection and bed for the 2021 ADF&G dredge survey.

Size Class	District/ Subsection	Bed	CPUE	Abundance	CV	95% CI
< 100 mm	EKI	EK1	4,315	423,944	0.23	[273,714, 656,628]
	WKI	WK1	41,299	2,010,338	0.43	[891,083, 4,535,444]
	YAK	EK1	4,202	140,213	0.31	[76,835, 255,869]
		YAK1	72,963	3,818,593	0.22	[2,514,039, 5,800,090]
		YAK2	43,516	3,421,952	0.20	[2,321,854, 5,043,278]
		YAK3	17,429	2,903,297	0.70	[847,036, 9,951,323]
		YAK4	35,319	4,506,202	0.21	[2,999,068, 6,770,721]
		YAK5	5,830	319,927	0.35	[165,056, 620,113]
≥ 100 mm	EKI	EK1	26,182	2,572,207	0.18	[1,817,957, 3,639,387]
	WKI	WK1	144,039	7,011,508	0.28	[4,073,846, 12,067,528]
	YAK	EK1	20,626	688,246	0.12	[541,834, 874,220]
		YAK1	143,168	7,492,893	0.13	[5,783,384, 9,707,715]
		YAK2	100,435	7,897,844	0.14	[5,970,921, 10,446,621]
		YAK3	46,558	7,755,408	0.42	[3,493,676, 17,215,776]
		YAK4	28,602	3,649,161	0.23	[2,324,791, 5,727,990]
		YAK5	23,719	1,301,533	0.25	[796,338, 2,127,222]

Table 2.4 Scallop CPUE (lb / nm2), round biomass, associated CV, and lognormal 95% confidence interval by district or subsection and bed for the 2021 ADF&G dredge survey.

Size Class	District/ Subsection	Bed	CPUE	Biomass	CV	95% CI
< 100 mm	EKI	EK1	400	39,323	0.26	[23,740, 65,133]
	WKI	WK1	3,361	163,618	0.36	[82,663, 323,857]
	YAK	EK1	281	9,374	0.28	[5,428, 16,190]
		YAK1	9,093	475,898	0.20	[323,055, 701,053]
		YAK2	5,157	405,551	0.21	[271,081, 606,725]
		YAK3	2,040	339,824	0.78	[88,510, 1,304,718]
		YAK4	1,370	174,798	0.23	[112,929, 270,563]
		YAK5	487	26,730	0.35	[13,625, 52,439]
≥ 100 mm	EKI	EK1	15,569	1,529,586	0.18	[1,068,794, 2,189,040]
	WKI	WK1	56,338	2,742,422	0.30	[1,555,212, 4,835,920]
	YAK	EK1	13,506	450,686	0.14	[343,431, 591,437]
		YAK1	59,528	3,115,469	0.11	[2,525,660, 3,843,014]
		YAK2	37,729	2,966,889	0.16	[2,164,176, 4,067,335]
		YAK3	17,273	2,877,230	0.37	[1438,151, 5,756,319]
		YAK4	9,889	1,261,690	0.23	[801,510, 1,986,077]
		YAK5	8,463	464,375	0.26	[281,830, 765,158]

Table 2.5 Scallop meat biomass, associated CV, and lognormal 95% confidence interval by district or subsection and bed for the 2021 ADF&G dredge survey.

Size Class	District/ Subsection	Bed	Meat Biomass	CV	95% CI
≥ 100 mm	EKI	EK1	85,571	0.20	[58,441, 125,295]
	WKI	WK1	161,189	0.30	[91,215, 284,841]
	YAK	EK1	22,623	0.13	[17,392, 29,429]
		YAK1	168,934	0.12	[133,576, 213,653]
		YAK2	182,743	0.16	[133,737, 249,708]
		YAK3	167,679	0.36	[85,304, 329,602]
		YAK4	97,861	0.25	[60,316, 158,774]
		YAK5	31,483	0.25	[19,312, 51,324]

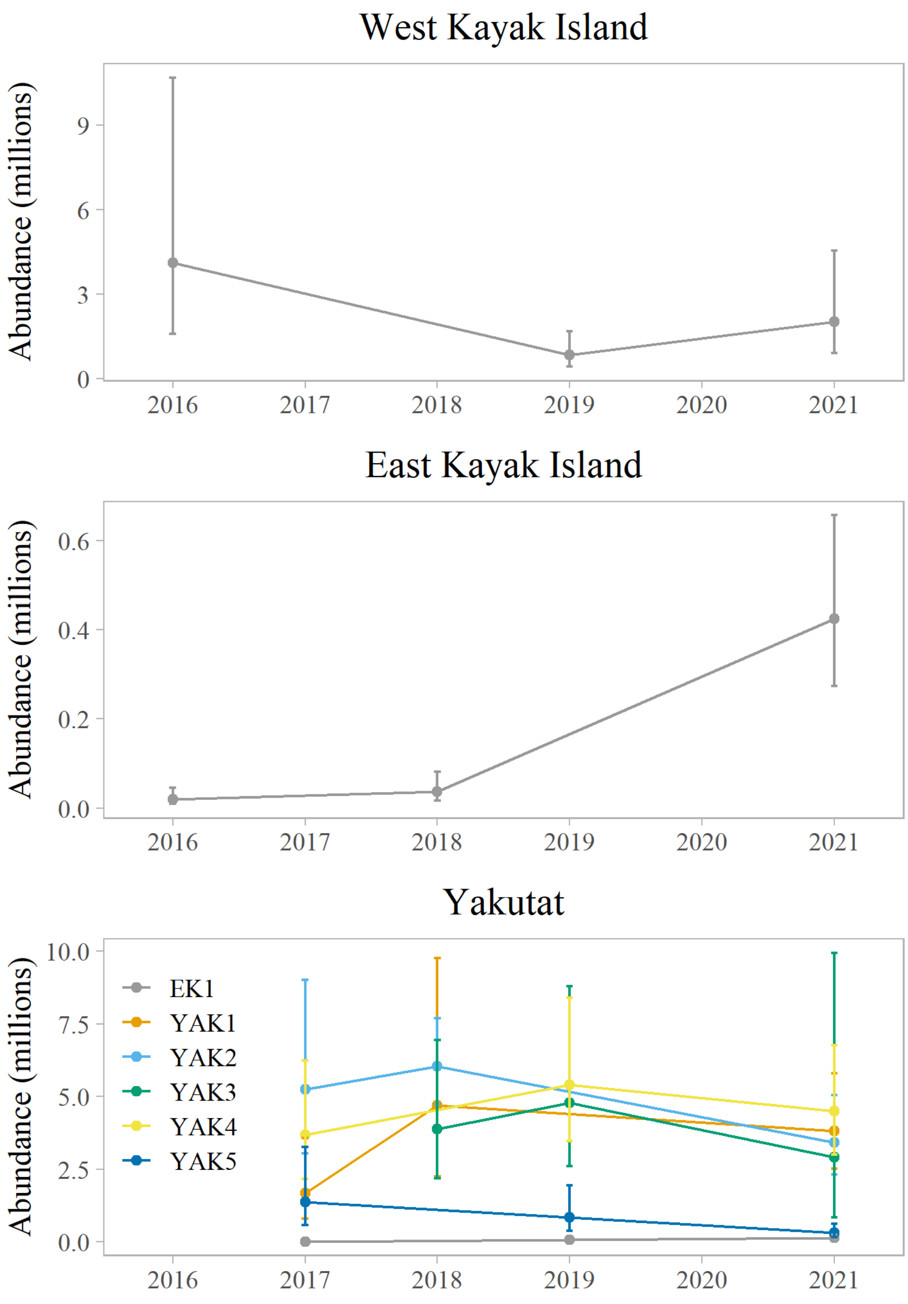

Figure 2.6 **Estimates of small scallop bed abundance for PWS Outside and Yakutat Districts from the ADF&G dredge survey. Error bars represent lognormal 95% confidence intervals. Small scallops are those with shell height <100 mm.**

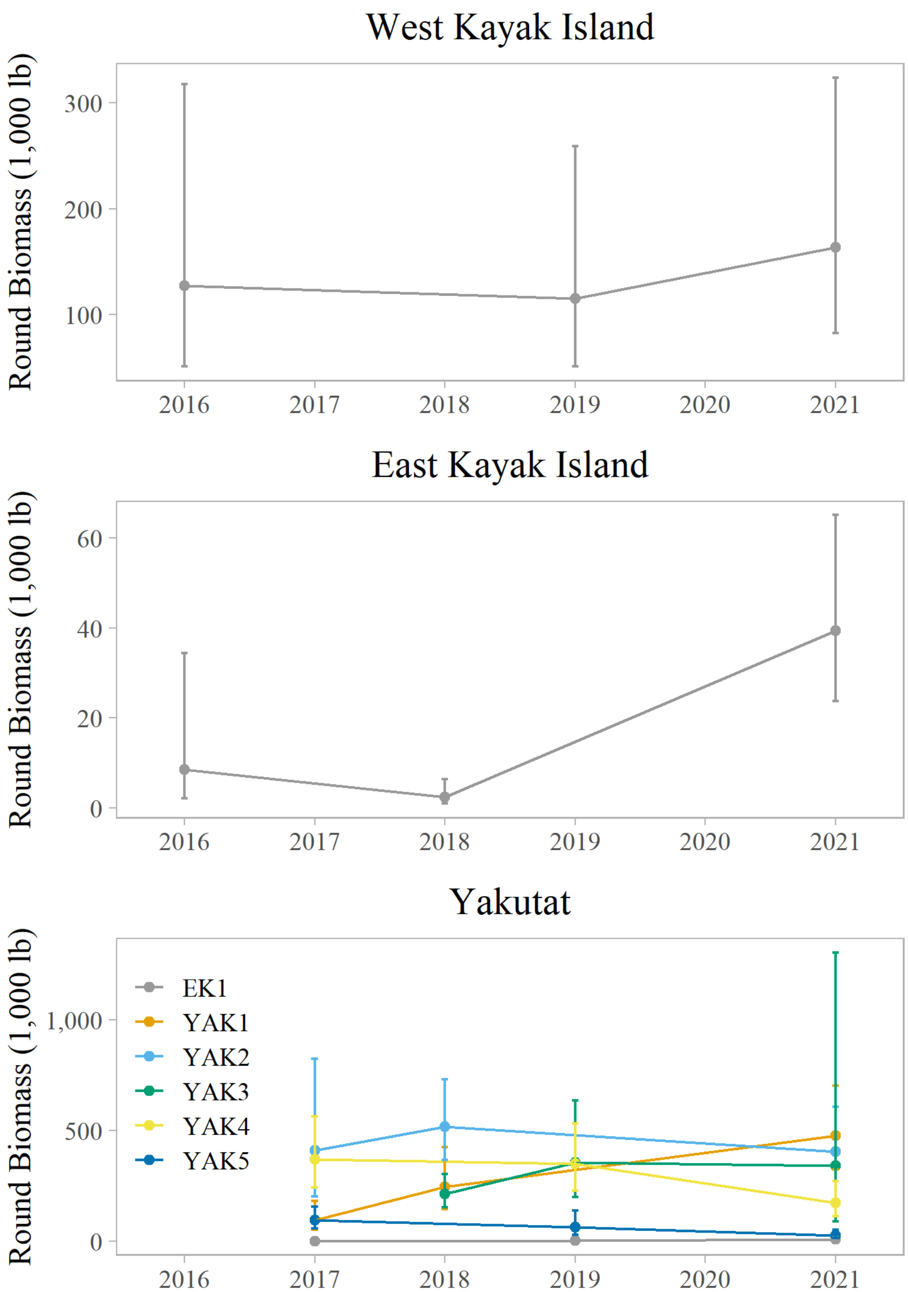

Figure 2.7 **Estimates of small scallop bed round biomass for PWS Outside and Yakutat Districts from the ADF&G dredge survey. Error bars represent lognormal 95% confidence intervals. Small scallops are those with shell height <100 mm.**

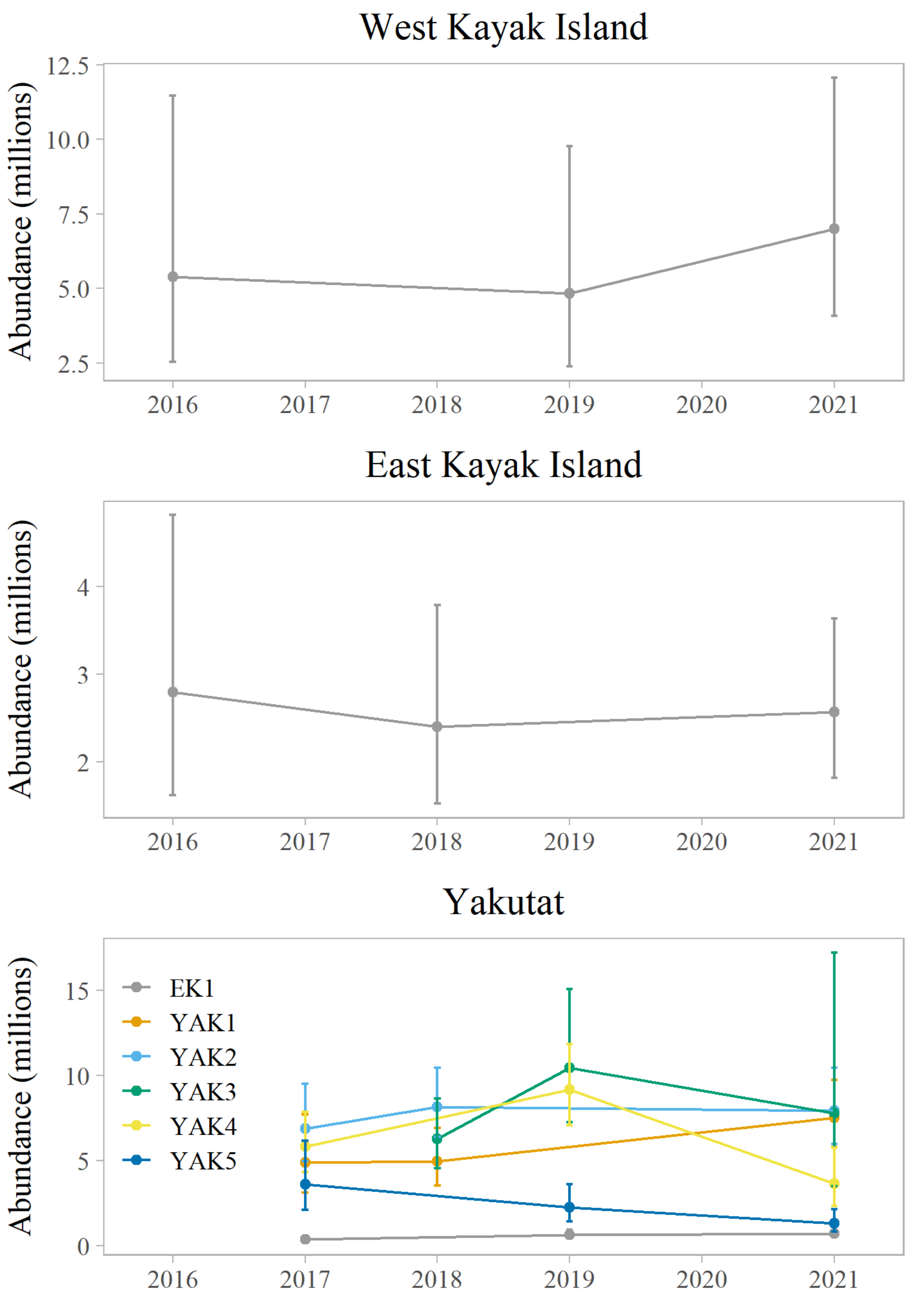

Figure 2.8 **Estimates of large scallop bed abundance for PWS Outside and Yakutat Districts from the ADF&G dredge survey. Error bars represent lognormal 95% confidence intervals. Large scallops are those with shell height ≥100 mm.**

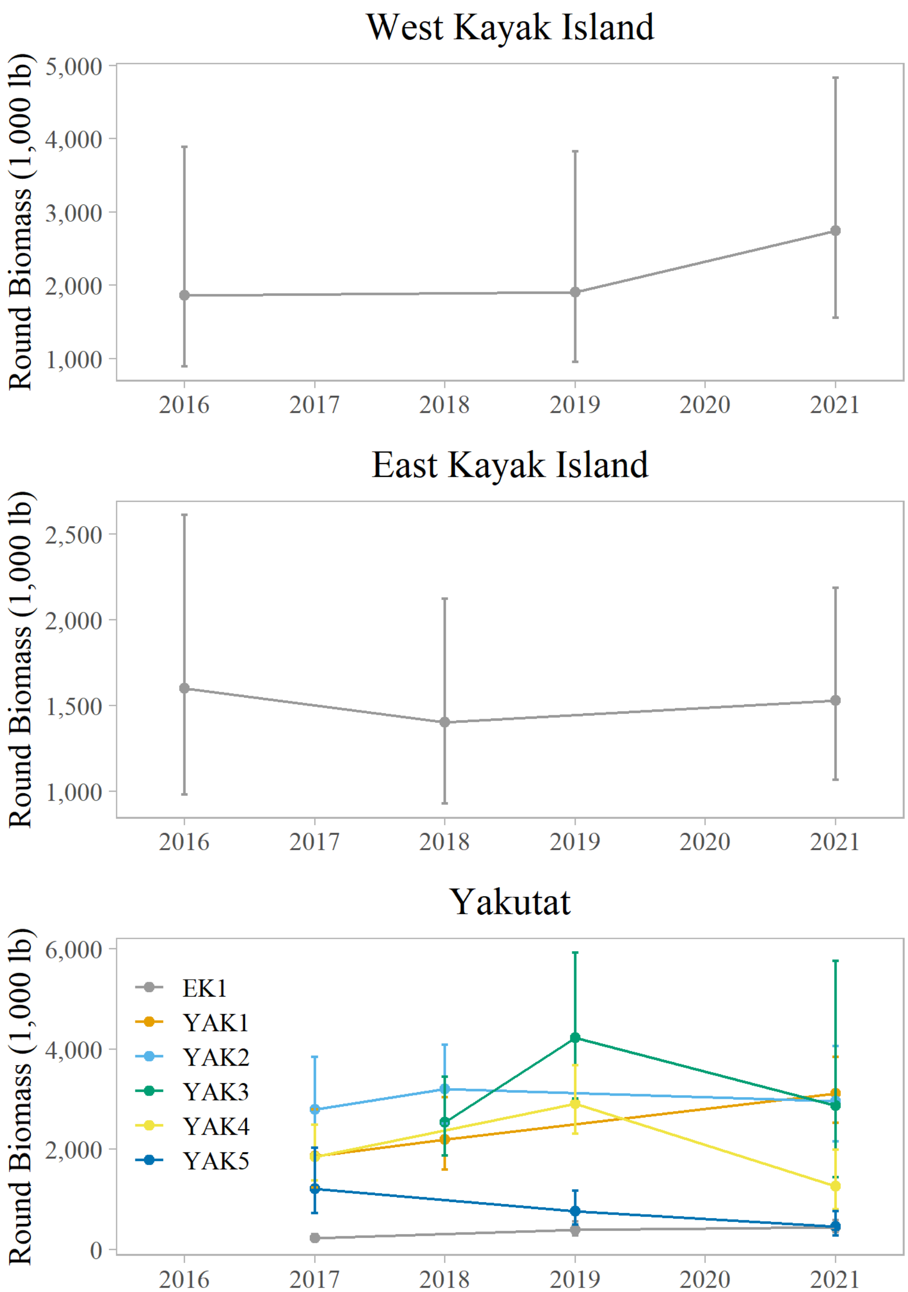

Figure 2.9 **Estimates of large scallop bed round biomass for PWS Outside and Yakutat Districts from the ADF&G dredge survey. Error bars represent lognormal 95% confidence intervals. Large scallops are those with shell height ≥100 mm.**

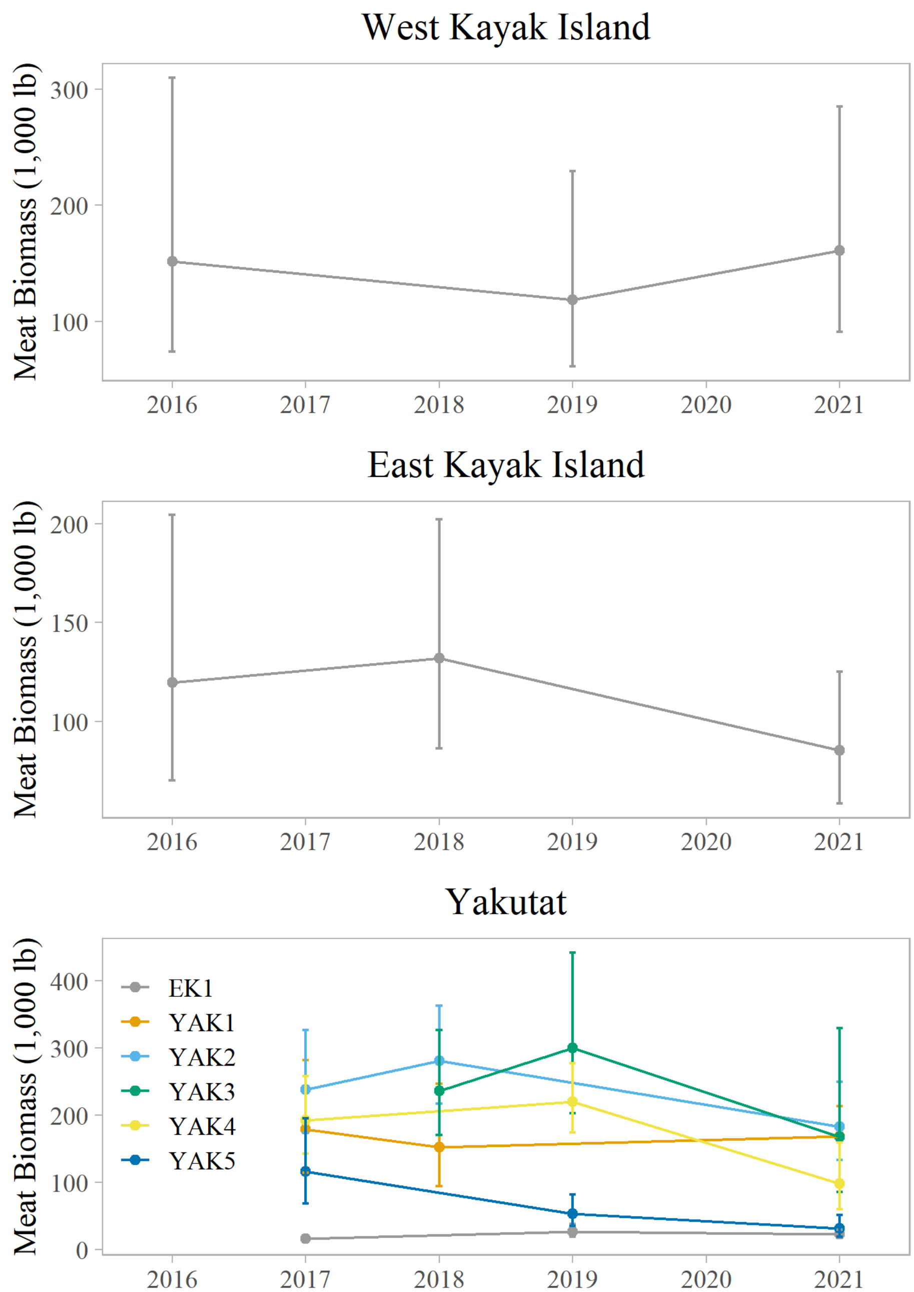

Figure 2.10 Estimates of large scallop bed meat biomass for PWS Outside and Yakutat Districts from the ADF&G dredge survey. Error bars represent lognormal 95% confidence intervals. Large scallops are those with shell height ≥100 mm.

Shell Height Distribution

A larger pulse of possibly two cohorts of scallops < 80mm were observed in the 2016 WK1 survey while few small scallops were captured in the 2019 survey (Figure 2.11). Recruitment of small scallops to the WK1 bed was observed in the 2021 survey but in lower quantities than in 2016. The size distribution of scallops in the EK1 bed was made up of a relatively compressed distribution of larger scallops in all surveys from 2016 to 2021 (Figure 2.12). There was little evidence of recruitment to this bed until low quantities of small scallops were observed in the 2021 survey. Two modes of scallops < 100mm were evident for all years surveyed (2016 to 2021) in the Yakutat District (Figure 2.13). These modes were lowest in the 2021 survey and the largest mode of smaller sized scallops < 50mm occurred in 2018. Among all the Yakutat District beds, scallops in the EK1 bed made up the highest proportions of the largest size classes. Further, comparisons among beds across survey years is difficult due the frequency beds were surveys.

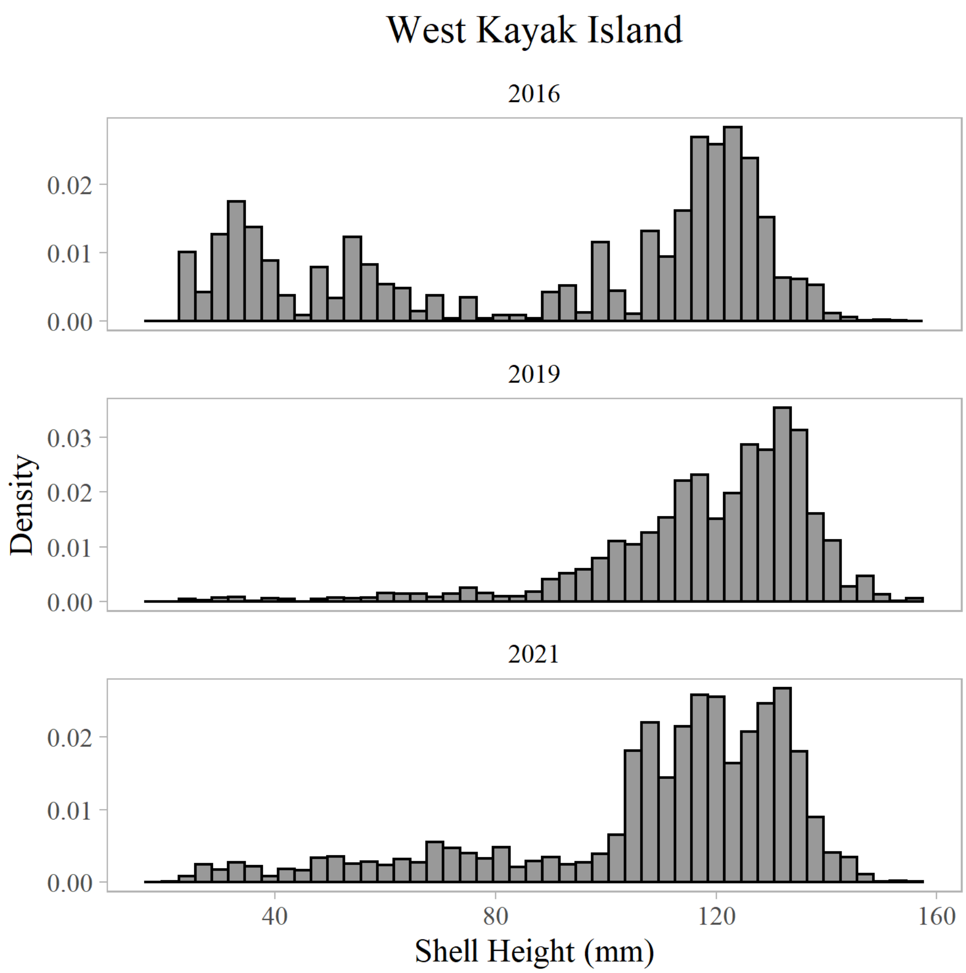

Figure 2.11 Scallop shell height distributions for the West Kayak Subsection from the ADF&G dredge survey. Shell height data have been expanded to the catch.

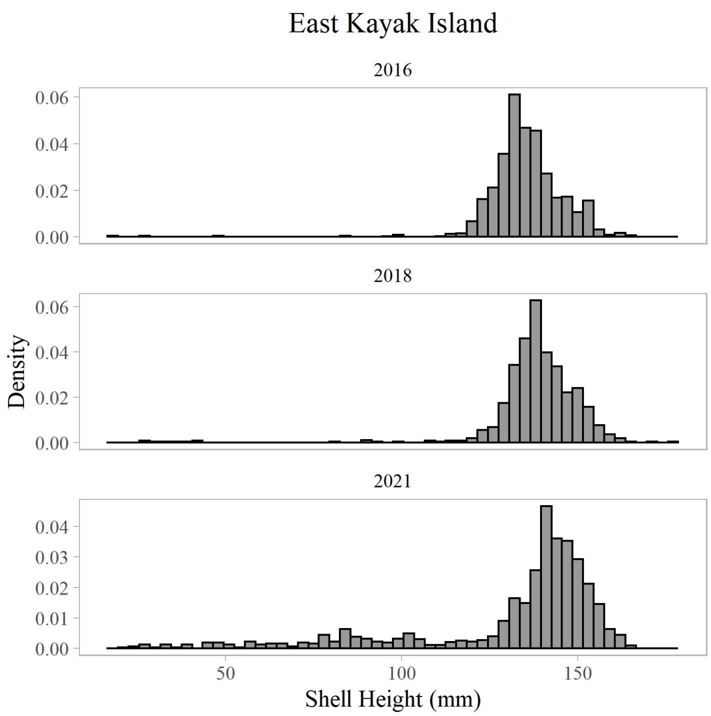

Figure 2.12 Scallop shell height distributions for the East Kayak Subsection from the ADF&G dredge survey. Shell height data have been expanded to the catch.

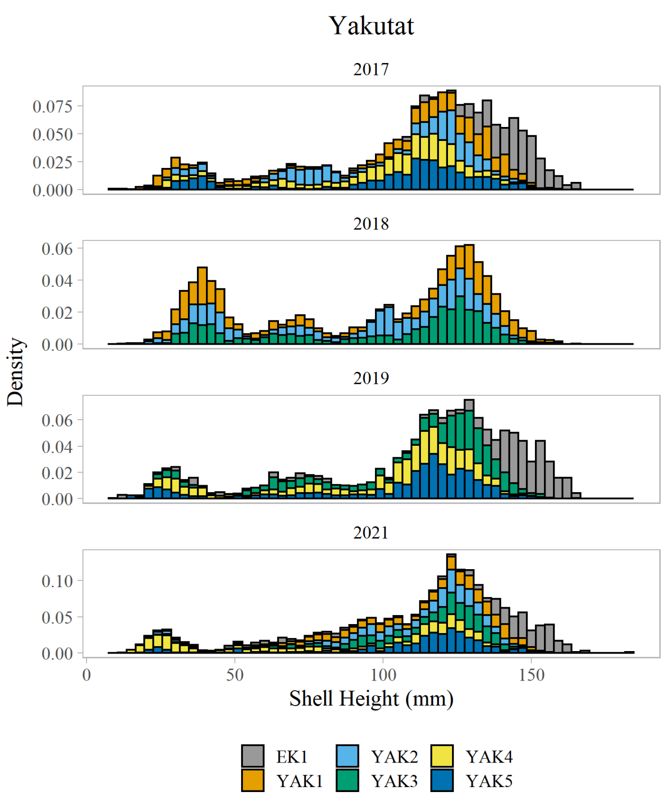

Figure 2.13 Scallop shell height distributions for the Yakutat District beds from the ADF&G dredge survey. Shell height data have been expanded to the catch.

Additional Biological Data

Meat weight to round weight was highest in the 2017 and 2018 surveys being nearly proportional, and lowest in the 2019 and 2021 surveys with 2016 being intermediate (Figure 2.14). These trends were consistent regardless of the District surveyed. All Yakutat surveys were conducted at similar time of the year, all beginning within five days of one another. The same trends were observed in the meat-weight to shell height data (Figure 2.15). Scallop meat weight allometric in relation to shell height. In the 2019 and 2021 surveys meat weight was both smaller at a given shell height and increased at a slower rate than in the 2017 and 2018 data.

The most common gonad condition of scallops larger than immature sizes was filling for all beds and years sampled (Figure 2.16). The highest proportion of scallops in full gonad condition occurred in the 2017 Yakutat District survey. Lower proportions occurred in both the PWS Outside District survey in EK1 and in the Yakutat survey in 2018. Post spawning scallops in either empty or initial recovery condition were observed in most surveys with higher proportions observed since 2018. Proportions among gonad categories were similar for the 2019 and 20121 Yakutat surveys. Since the PWS Outside District is composed of a single bed for each subsection proportions among categories within size classes may be obscured due to lower sample sizes.

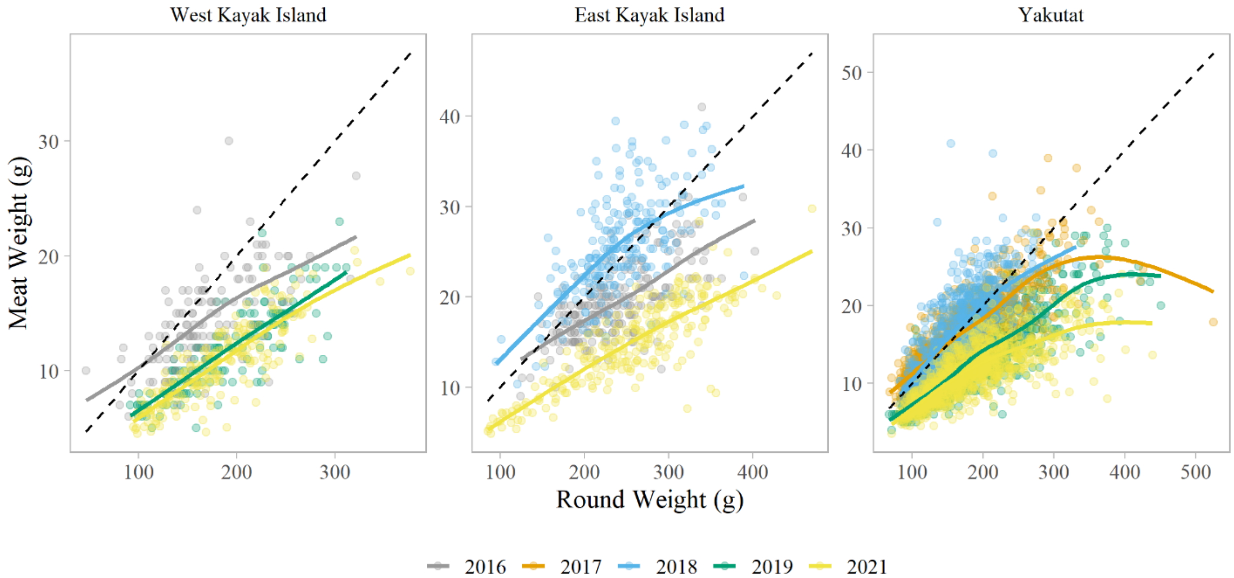

Figure 2.14 Comparisons of meat weight to round weight by district for subsampled large scallops from the PWS Outside and Yakutat Districts ADF&G dredge survey.

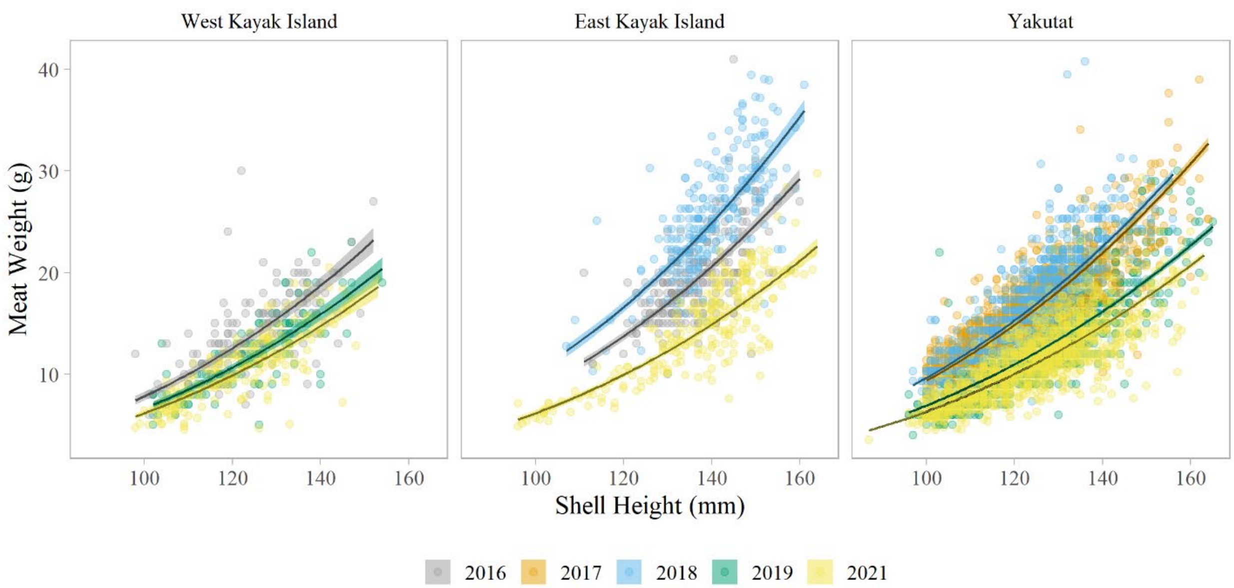

Figure 2.15 Comparisons of meat weight to shell height by district for subsampled large scallops from the PWS Outside and Yakutat Districts ADF&G dredge survey.

Figure 2.16 Scallop gonad condition at size for PWS Outside and Yakutat Districts from the ADF&G dredge survey.

An indicator of scallop stock status of importance with respect to the commercial scallop fishery is the prevalence of weak meats. "Weak meat" is a diseased condition of the adductor muscle characterized by tissue of stringy texture that tears easily during shucking (Brenner et al. 2012). The presence of this condition was recorded for subsampled large scallops in surveyed beds. The highest percent weak-meats occurred in the EK1 bed (12.6%) and occurred in both the PWS Outside and Yakutat Districts (Figure 2-17). The percent weak-meats increased in 2021 for both WK1 (5.1%) and EK1 in the PWS Outside District. In the Yakutat District, YAK1 which is just east of EK1 had the next highest percentage (5%) while the percent weak-meats was < 2.3% for all other Yakutat beds.

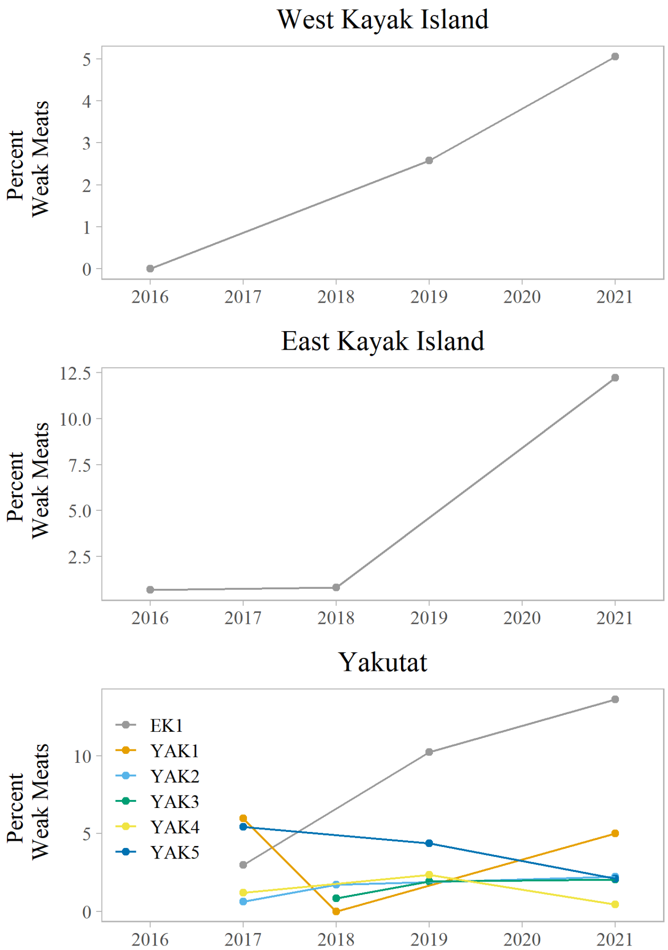

Figure 2.17 Percent of scallops with meat weight for PWS Outside and Yakutat Districts from the ADF&G dredge survey.

Environmental Conditions

CTD casts were made at 33 stations across the entire survey area. Bottom temperature varied by less than a degree throughout the survey area, but was coldest between the east shore of Kayak Island and Icy Bay (Figure 2-18). There was a break in pH ~ 142.5 °W longitude, with slightly more acidic waters being east of that boundary (Figure 2-18). Salinity measurements varied around ~ 1 ppm throughout the survey area and we lowest east of Kayak Island (Figure 2-18).

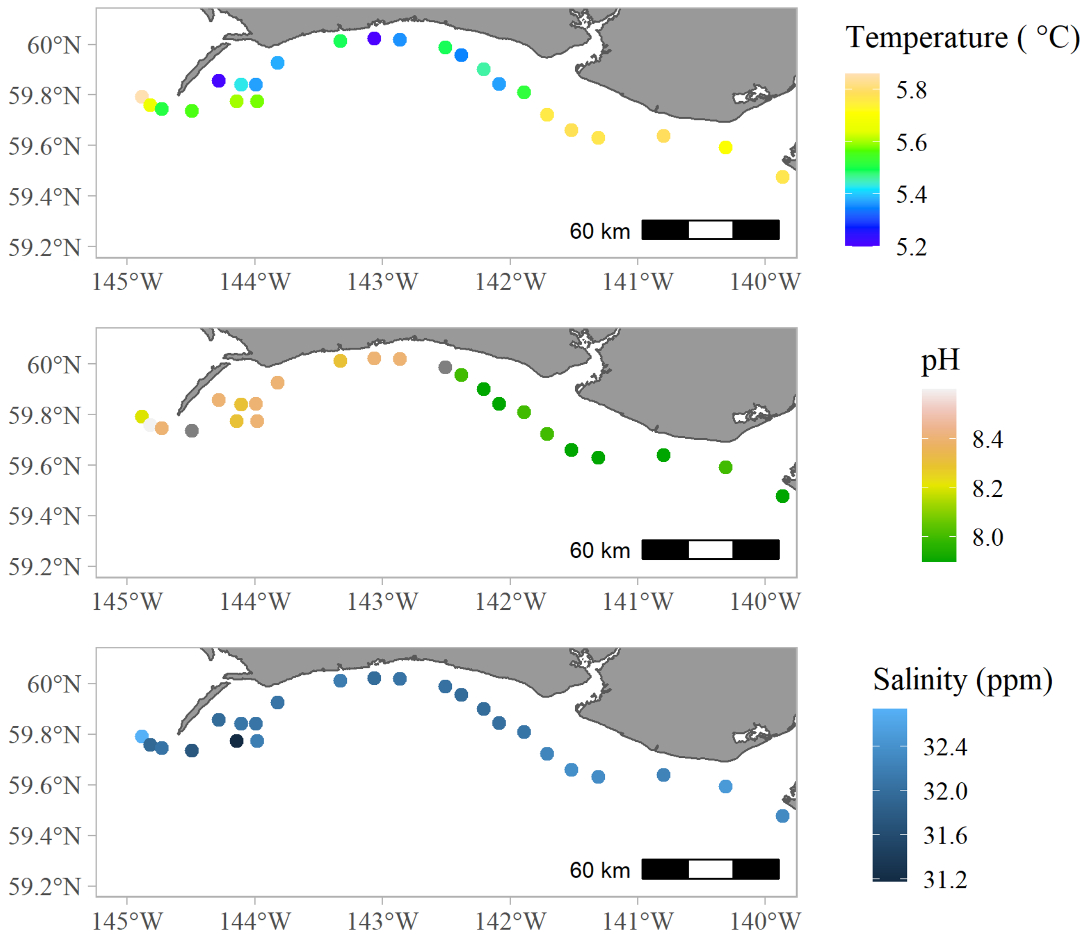

Figure 2.18 Bottom temperature (top), pH (middle), and salinity (bottom) data collected from CTD casts during the 2021 ADF&G dredge survey.

2.3.4 Discussion

The 2021 ADF&G survey was to first to sample all of the PWS Outside and Yakutat Districts in one survey. This provided a measure of stock status, recruitment, and other biological measures for a large spatial extent of the eastern GOA scallop population. To achieve this, slight changes were made to the bed specific sampling rate, reducing it for the largest beds while increasing it for the WK1 bed which has consistently had a higher CV due to a patchy distribution of scallops. Precision in the 2021 survey abundance and biomass estimates for both small and large scallops were comparable to or improved from the average observed in previous surveys for all beds surveyed except for the largest bed (YAK3) where the sampling rate was decreased. Survey precision can vary by a number of factors including sampling design, population size, and how animals are distributed within survey area. On the whole, sampling a larger spatial scale did not have much effect on survey precision.

The EK1 bed in the PWS Outside District continued to have very low abundance and biomass of large scallops. This decline began in 2009 as observed in prior ADF&G Central Region surveys. Abundance and biomass of large scallops in WK1 trended upward in the 2021 survey which was likely a product of higher numbers of recruits from 2016 continuing to grow to larger size. While higher numbers of small scallops were observed in the 2021 survey, there continues to be generally low recruitment to the East Kayak Subsection as observed from previous ADF&G Central Region dredge surveys and the ADF&G

dredge survey which has led to the bed being dominated by a narrower distribution of larger scallops. The West Kayak Subsection has experienced larger recruitment pulses then the East Kayak Subsection though they have been episodic.

While recruitment in Yakutat District has been more consistent than in PWS Outside District there has been a general decline in the magnitude of recruitment pulses observed over the last three surveys. Though no Yakutat beds were surveyed in 2020, there appears to not have been a large recruitment of the smallest sizes captured in the dredge as evidenced in the 2021 shell height data except possibly in the YAK1 bed which had an increase in the biomass of small scallop. As in the East Kayak Subsection, the EK1 bed in the Yakutat District showed in increase in the recruitment of small scallops but this was still low compared to other beds. Also similar to East Kayak Subsection, the size of large scallops in the EK1 bed was skewed toward the larger size classes. Currently there is a trend in both small and large scallop CPUE in biomass being very low in the southern most Yakutat District bed surveyed (YAK5) increasing to north peaking in YAK1, decreasing considerably in the EK1 bed and increasing again in the WKS. Though YAK1 is the smallest bed in the Yakutat District (besides EK1), being ~ a third the size of YAK3 and half the size of YAK4 it presently has the highest estimated biomass of large scallops. However, the YAK3 bed had the lowest precision of all beds surveyed, so there is more uncertainty in the status of large scallops in that bed compared to others.

2.3.5 Acknowledgements

The authors would like to thank Capt. Tom Minio and the crew of the F/V Provider. We would also like to thank Jim Stone and the Alaska Scallop Association for their logistical support.

2.4 Fishery Independent Trawl Survey

The Alaska Department of Fish and Game (ADF&G) has been conducting a standardized large-mesh trawl survey to provide fishery managers with current stock status information for Tanner crab (Chionoecetes bairdi), red king crab (Paralithodes camtschaticus), and commercially important ground fish stocks since 1988 (Knutson and Spalinger 2021). The survey samples 372 stations in the western Gulf of Alaska annually between June and September. Stations span the Kodiak, Alaska Peninsula, and Dutch Harbor scallop registration areas, though catches of scallops are most consistent within the Kodiak registration area.

The R/V Resolution has been used to conduct the survey throughout the standardized timeseries. In 2017/2018 the R/V Resolution underwent upgrades that included repowering and widening the vessel. A paired tow fishing power comparison study from 2015 – 2019 between the R/V Resolution and R/V Solstice suggested fishing power correction was not warranted for most Tanner crab size classes or various commercially important groundfish. The study did not include weathervane scallops, as paired tows did not occur over suitable scallop habitat (Spalinger and Jackson, in review).

In this report we summarize the methods and results of the 2021 survey including (1) CPUE (kg / km) of scallops, and (2) size composition of scallops in the Kodiak (K) and Alaska Peninsula (M) registration areas.

2.4.1 Study Areas

The large-mesh trawl survey samples 372 stations annually under a fixed grid design in which station size is based on habitat type and historic crab densities (Figure 2.19; Knutson and Spalinger 2021). Since not all stations overlap or are proximal to known scallop beds, we subset the stations that are included in this analysis (Figure 2.19; Table 2.6). Our subset of stations cover Kodiak Shelikof, Northeast, Southwest, Southeast districts, as well as the Central and West Chignik districts of Area M. Several stations occur within areas closed to scallop dredging, or in areas that are not actively fished.

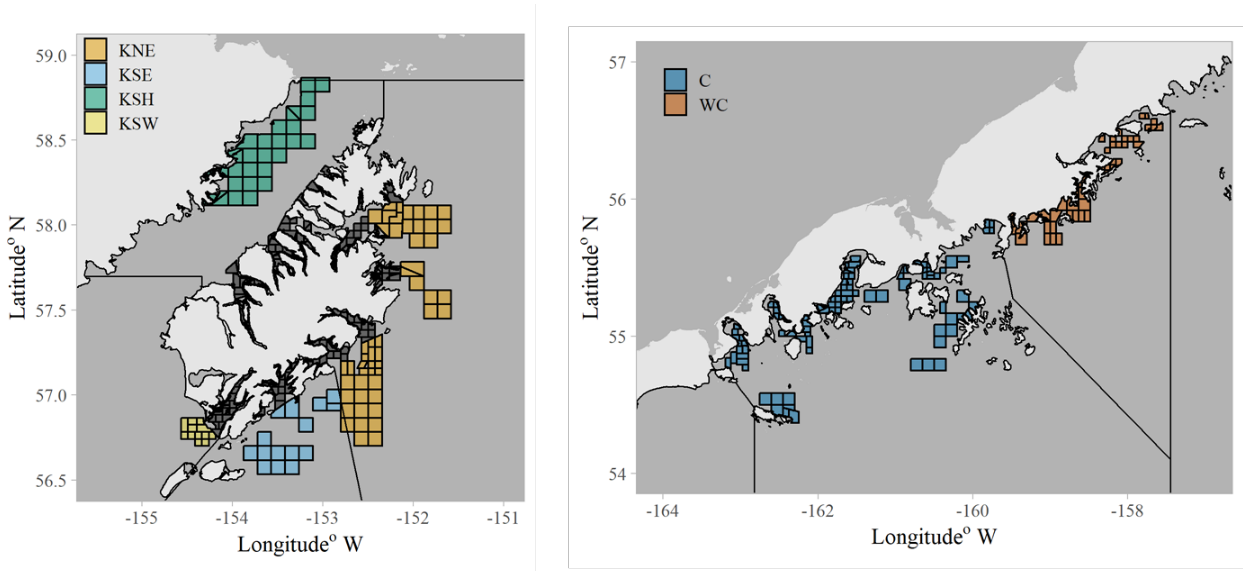

Figure 2.19 Westward Region large-mesh trawl survey stations in the Kodiak Northeast, Southeast, Shelikof, and Southwest districts (left), as well as the Central and West Chignik districts of Area M (right). Stations excluded from scallop analysis are fill grey, while others are color coded by district.

Table 2.6 Number of Westward Region large-mesh trawl survey standard stations and number of stations chosen for indices of scallop biomass by registration area and district, and number of scallop stations towed during the most recent survey.

Registration Area	District	Total Stations	Scallop Stations	Scallop Stations Sampled 2021
Kodiak	Northeast	95	51	50
	Shelikof	62	28	0
	Southwest	28	12	12
	Southeast	27	15	15
AK Peninsula	Central	93	93	81
	West Chignik	46	46	45
Dutch Harbor	Dutch Harbor	21	0	

2.4.2 Methods

The trawl survey net is a 400-mesh eastern otter trawl designed to sweep a 12.2 m path. The net mouth is constructed with 10.2 cm stretch mesh, net body with 8.9 cm stretch mesh, and the codend with a 3.2 cm stretch mesh liner. The net has a 21.3 m headrope with 18 floats 20.3 cm in diameter. The footrope is 29.0 m long with a 1.0 cm diameter chain attached every 25.4 cm to ensure the footrope tends bottom. The dandylines are 45.7 m long, each consisting of an 18.3 m section of 1.5 cm cable and a pair of 27.4 m sections of 1.3 cm cable, one attached to the top and the other to the bottom of each net wing. Astoria "V" type doors weighing 340 kg and measuring 1.5 m x 2.1 m are used to spread the net. Within each station, the trawl net is towed on bottom at an average speed of 4.0 to 4.5 km/h for 1.85 km, equivalent to 1 nmi (Knutson and Spalinger 2021). Catch sampling and shell height measurement were carried out following methods described in the most recent Operational Plan (Knutson and Spalinger 2021). Scallop catches are available in units of abundance (i.e., count) from 1998 – present, and in units of biomass (kg) from 1988 – present.

Since trawl survey gear efficiency for catch scallops is unknown and station areas include non-scallop habitat, catches were not expanded to total abundance. Instead, we report the mean round biomass CPUE ($\bar{U}$; kg / km towed) computed as

$$U_i = \frac{c_i}{d_i} \quad (16)$$

$$\bar{U} = \frac{1}{n}\sum_{i=1}^{n} U_i \quad (17)$$

where c_i is the catch of scallops (kg) and d_i is the distance (km) trawled in tow i of n.

2.4.3 Results

The 2021 Westward Region large-mesh trawl survey sampled 337/372 standard stations, which included 207/245 stations used for estimating scallop indices. Stations that were not sampled were missed due to vessel maintenance issues. Specifically, scallop stations not sampled were within the Shelikof (N = 28), Central (N = 9), and West Chignik (N = 1) districts. Since all the Kodiak Shelikof stations were not sampled, no new results are available for that district.

Scallop CPUE (round kg / km) increased from the previous survey in Kodiak Northeast (1.70 kg/km), Kodiak Southwest (37.23 kg/km), and AK Peninsula West Chignik (1.33 kg/km) districts, while CPUE decreased in slightly decreased in the AK Peninsula Central district (0.49 kg/km) and remained the same in the Kodiak Southeast district (1.28 kg / km) (Figure 2.19). Associated CVs were large, ranging from 0.34 in the Kodiak Southwest district to 0.56 in the AK Peninsula West Chignik district. The trawl survey generally caught few scallops less than 100 mm shell height. Kodiak Southwest, and AK Peninsula districts had size compositions with prominent modes greater than 150 mm shell height, while most scallops in Kodiak Northeast were between 100 – 150 mm shell height (Figure 2.20,Figure 2.21).

2.4.4 Discussion

Although the Westward Region large-mesh trawl survey specifically targets crab and groundfish species, it can be a valuable source of supplementary information because it provides a long, standardized fishery independent timeseries of abundance, biomass, and size composition in areas not covered by the dredge survey. Still, direct inference of population metrics from survey results is obscured by several factors. Trawl gear efficiency and size selectivity are unknown, and there is limited opportunity for empirical data collection. Second, trawl survey stations are not designed to overlap with scallop beds, hence scallop catches can be sparse and are highly variable (CVs > 0.3). As such, trends in CPUE are highly fluctuating and low (commonly < 10 kg / km towed). Additional research is necessary to refine the stations that should be included in abundance and biomass indices, and to inform catchability and size selectivity for use of these data in assessment model development.

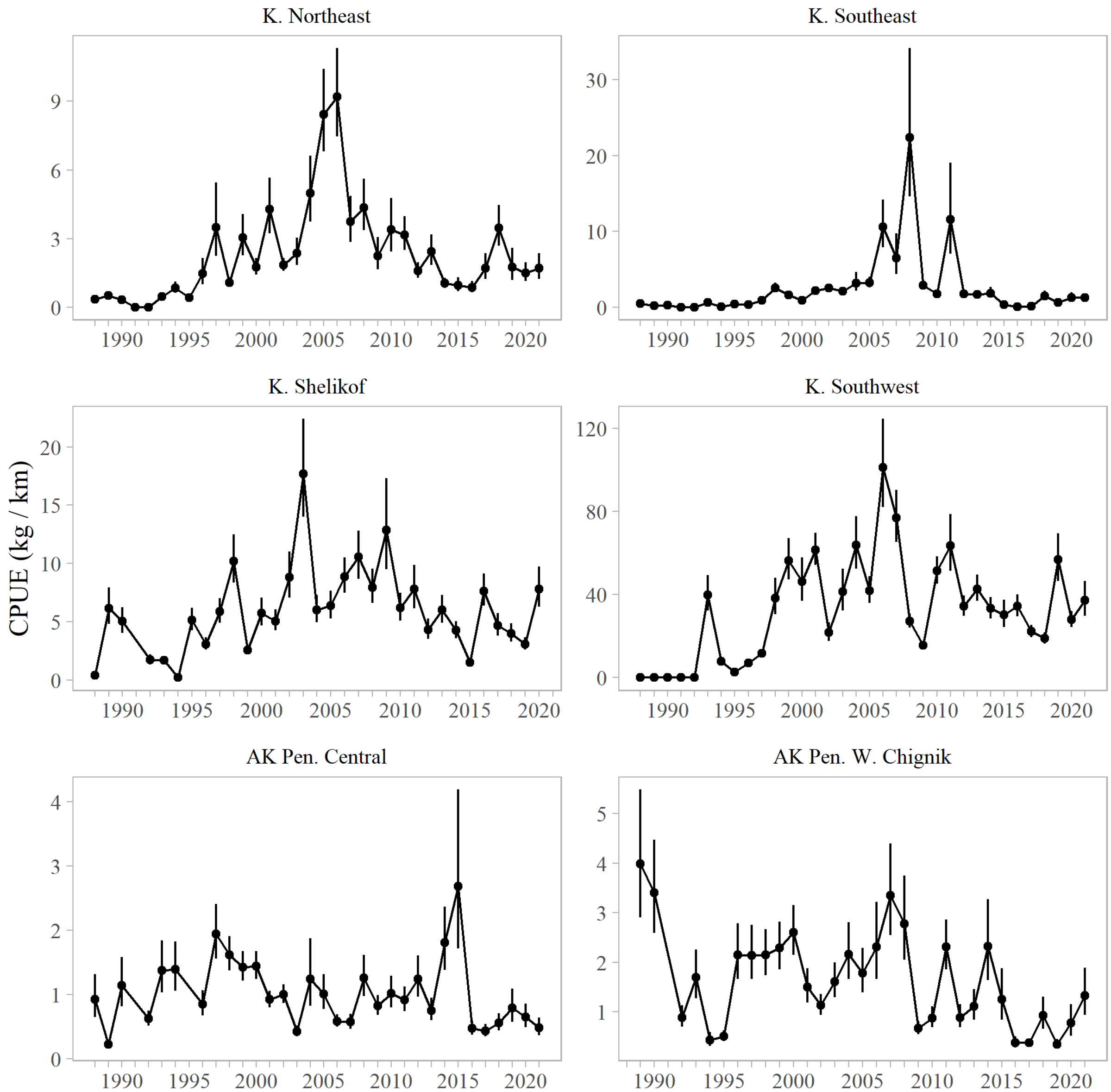

Figure 2.20 Westward Region large-mesh trawl survey CPUE (round kg / km) and associated 50% lognormal confidence intervals by district.

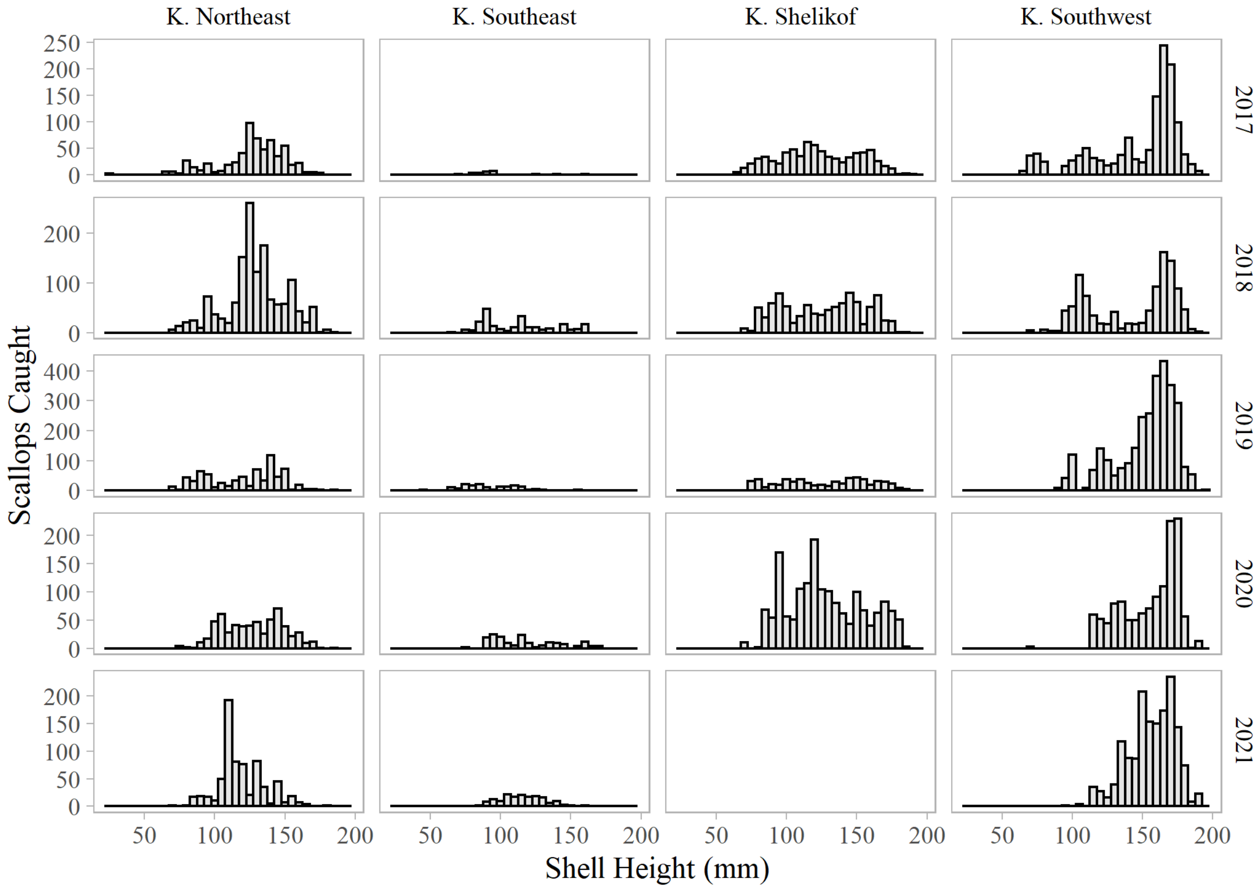

Figure 2.21 Westward Region large-mesh trawl survey shell height composition for the previous five survey years for districts in the Kodiak registration area.

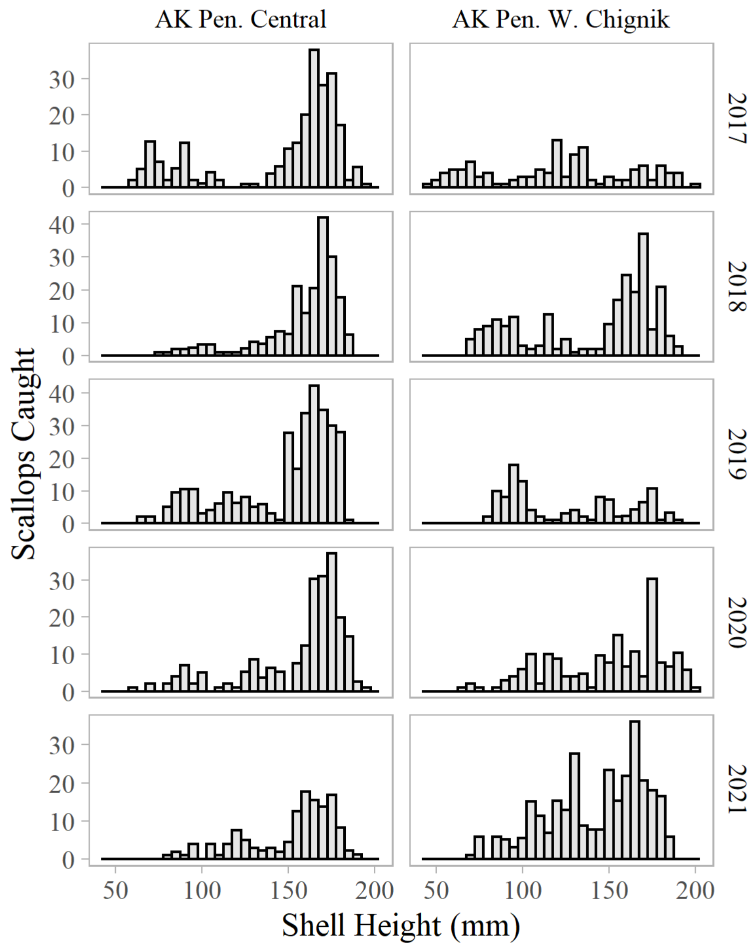

Figure 2.22 Westward Region large-mesh trawl survey shell height composition for the previous five survey years for districts in the AK Peninsula registration area.

3 Weathervane Scallop Fishery and Management

The Alaska weathervane scallop fishery is managed jointly by NPFMC and ADF&G under the Federal FMP for the Scallop Fishery off Alaska. Measures that are fixed in the FMP, implemented by Federal regulation and require an FMP amendment to change include: license limitation program, OY specification, overfishing specification, and EFH/HAPC designation. All other management measures under the FMP are delegated to the State for management under Federal oversight. ADF&G management of the weathervane scallop fishery covers both State and Federal waters off Alaska.

3.1 Alaska State Registration Areas

The State Scallop Fishery Management Plan established nine scallop registration areas in Alaska for vessels commercially fishing scallops (Figure 1.1). These include the Southeastern Alaska Registration Area (Area A); Yakutat Registration Area (Area D); Prince William Sound Registration Area (Area E), which is subdivided into the East and West Kayak Island Subsections; Cook Inlet Registration Area (Area H), which is subdivided into the Northern, Central, Southern, Kamishak Bay, Barren Islands, Outer and Eastern Districts; Kodiak Registration Area (Area K), which is subdivided into the Northeast, Shelikof, Southeast, Southwest and Semidi Islands Districts; Alaska Peninsula Registration Area (Area M), which is subdivided into the West Chignik, Central and Unimak Bight Districts; Dutch Harbor Registration Area (Area O); Bering Sea Registration Area (Area Q); and Adak Registration Area (Area R). Scallop seasons have never been opened in Area A, and effort occurred in Area R during 1995 only.

3.2 Seasons

The regulatory fishing season for weathervane scallops in Alaska is July 1 through February 15 except in the Cook Inlet Registration Area (5 AAC 38.167 & 5 AAC 38.420). In the Kamishak District of Cook Inlet, the season is August 15 through October 31 (5 AAC 38.220 & 5 AAC 38.320). These seasons were developed to limit fishing during scallop spawning periods, to achieve the highest possible product quality, to limit gear conflicts with other fisheries, and to increase vessel safety. Scallop fishing in any registration area in the state may be closed by emergency order prior to the end of the regulatory season. Scallop GHLs are typically announced by ADF&G one month prior to the season opening date.

3.3 Annual Catch Limits

Annual catch limits (ACLs) and accountability measures (AMs) are requirements under the MSA for all fisheries managed by federal fishery management plans. The requirements include provisions intended to prevent overfishing by requiring that: FMPs establish a mechanism for specifying ACLs in the plan; implementing regulations, or annual specifications, at a level such that overfishing does not occur in the fishery; and including measures to ensure accountability (AMs). The MSA includes a requirement for the SSC to recommend fishing levels to the Council and provides that ACLs may not exceed the fishing levels recommended by the SSC. NMFS's National Standard 1 Guidelines state that the ABC is the fishing level recommendation that is most relevant to ACLs. For scallops off Alaska, ACL=ABC.

Accountability measures were established in Amendment 13 such that the sum of the annual GHLs for each scallop management area be established by the State of Alaska at a level sufficiently below the ACL so that the sum of the estimated discard mortality in directed scallop and groundfish fisheries as well as the directed scallop fishery removals does not exceed the ACL. Anytime an ACL is exceeded the overage will be accounted for through a downward adjustment to the GHL during the fishing season following the overage.

Directed fishing only occurs on weathervane scallops (*Patinopecten caurinus*) and the FMP only provides an estimate of MSY/OY for weathervane scallops thus it is defined as being 'in the fishery'. The remaining species of scallops under the Alaska Scallop FMP include reddish scallop (*Chlamys rubida*), spiny scallop (*Chlamys hastata*), and rock scallop (*Crassadoma gigantea*), which are contained in an 'Ecosystem component (EC)' of the FMP. ACLs are not required for EC species provided they are not being explicitly targeted. Ecosystem component species generally are not retained for any purpose, although *de minimis* amounts might occasionally be retained.

Catch in relation to ACLs

Total catch from 2020/21 is reported in Table 1.1and preliminary retained catch from the 2021/22 fishery is provided in Table 1.1. Note that discard estimates are not yet available for 2021/22. Final catch in relation to the ACL for 2021/22 will be provided in the 2022 Scallop SAFE report.

3.4 Guideline Harvest Ranges

ADF&G manages the fishery by registration areas and districts. Guideline harvest ranges (GHRs) are hard caps established in State of Alaska regulations for each registration area and are not to be exceeded. GHLs are pre-season targets set for each fishing area (registration area, district, or statistical area) prior to the season by ADF&G regional managers. Total harvest for each fishing area in a given season is typically near or below the GHL, but may exceed it.

Regulatory GHRs for traditional scallop fishing areas were first established by the State of Alaska in 1993 under the Interim Management Plan for Commercial Scallop Fisheries in Alaska. Regulatory GHRs (pounds of shucked scallop meats) were set at 0–250,000 lb for Yakutat; 0–50,000 lb for Prince William Sound; 10,000–20,000 lb for the Kamishak District of Cook Inlet; 0–400,000 lb for Kodiak; and 0–170,000 lb for Dutch Harbor. These area GHR ceilings were determined by averaging historic catches from 1969 to 1992, excluding years when there was no fishing or a "fishing-up effect" occurred (Barnhart, 2003).

Prior to the August 1, 1996 re-opening of the weathervane scallop fishery, the State of Alaska established GHRs for non-traditional registration areas including: 0–200,000 lb for the Alaska Peninsula; 0–600,000 lb for the Bering Sea; 0–35,000 lb for District 16; and 0–75,000 lb for Adak. The combined total of the upper limits from traditional and non-traditional areas was 1.8 million lb, which was defined as MSY in Amendment 1 to the federal FMP.

In 1998, the scallop plan team recommended a more conservative definition of MSY. Based on average landings from 1990–1997 excluding 1995 when the fishery was closed for most of the year, MSY was subsequently established in Amendment 6 of the FMP at 1.24 million lb, with optimum yield defined as the range 0–1.24 million lb. To accommodate the new definition, regulatory GHR ceilings were reduced by the State of Alaska from 400,000 to 300,000 lb in Kodiak; from 170,000 to 110,000 in Dutch Harbor; and from 600,000 to 400,000 lb in the Bering Sea. Hence, the regulatory GHR ceiling written into Alaska regulatory code is also 1.24 million lb.

3.5 In Season Data Use

Observers, which are required on all vessels fishing for scallops in Alaska outside Cook Inlet, monitor the fishery during the season and transmit data to ADF&G at least three times per week. Fishing may be closed in any area before the GHL is reached if collected data raise concerns about localized depletion, trends in CPUE, or bycatch rates. In-season data are also used by the scallop industry to avoid areas of high crab bycatch.

Following concern over declining harvest within the Kodiak Area during the 2002/03 season, an in-season minimum performance standard (MPS; formerly 'benchmark') was established prior to the 2003/04 season to gauge fishery performance and support in-season fishery closures, if warranted. CPUE of shucked meats is tracked throughout the season by management area and compared to the MPS standard. If the in season cumulative CPUE is less than or equal to the MPS, when approximately half of the GHL is taken, the fishery may close prior to achieving the upper end of the GHL. If CPUE is higher than the MPS, the fishery may continue toward the upper end of the GHL with continued monitoring. This approach has been applied to management areas, major beds within management areas and statistical reporting areas, depending upon the level of concern. It is important to clarify that the MPS is not viewed as a management goal, but rather a low mark around which to base conversation on in-season management actions.

Westward Region adopted the use of an MPS within subunits (e.g., bed, statistical area) of all major harvest areas prior to the 2010/11 season based on the lowest observed meat weight during a historic timeseries including only vessels larger than 80 ft that deploy two 15 ft dredges (Table 3.1). An MPS was also implemented in the Yakutat area prior to the 2013/14 season. MPS have been utilized at the district level in the Kodiak Area since the 2017/18 season and have not been used in the Bristol Bay – Bering Sea Area since the 2014/15 season.

Table 3.1 CPUE minimum performance standards and basis years for major harvest areas.

Area	Minimum Performance Standard (CPUE)	Basis Year	Reference Time Series
Yakutat Area			
Yakutat District	34	2011/12	1998/99 – 2013/14
Kodiak Area			
Northeast District	46	2005/06	2000/01 – 2009/10
Shelikof District	47	2002/03	2000/01 – 2009/10

3.6 Crab Bycatch Limits

Bycatch of crabs in the scallop fishery is controlled through the use of Crab Bycatch Limits (CBLs) that are based on condition of individual crab stocks. CBLs were first instituted by the state in July 1993. Methods used to determine CBLs in 1993 and 1994 were approved by the BOF and the Council and, with few exceptions, remain unchanged. Annual CBLs are established preseason by ADF&G for areas with current crab resource abundance information (surveys). For areas without crab abundance estimates, CBLs may be set as a fixed number of crabs that may be adjusted seasonally.

Statewide CBLs by region are shown in Table 3.2. In the Kodiak Area, the Tanner crab CBLs are set at 0.5% or 1.0% of the total crab stock abundance estimate based on the most recent survey data. In districts where Tanner crab abundance is sufficient to support a commercial crab fishery, the cap is set at 1.0% of the most recent Tanner crab abundance estimate. In registration areas or districts where the Tanner crab abundance is insufficient to support a commercial fishery, the CBL is set at 0.5% of the most recent Tanner crab abundance estimate. Red king crab CBLs in the Kodiak Area are fixed at 25 crab per district. In the Alaska Peninsula Area CBLs are fixed at 25 red king crab and 3,750 Tanner crab. Bycatch limits are expressed in numbers of crabs and include all sizes of crabs caught in the scallop fishery.

Table 3.2 Statewide crab bycatch limits in percentage of crab abundance estimates (where available) or number of crabs.

Area/District	Red King Crab	*C. bairdi*	*C. opilio*
Yakutat District	NE[a]	NE	NA[b]
Prince William Sound	NE	0.5%	NA
Cook Inlet Kamishak District	30 crab	0.5%	NA
Kodiak Northeast District	25 [c]	0.5% or 1.0%	NA
Kodiak Shelikof District	25 [c]	0.5% or 1.0%	NA
Kodiak Southwest District	25 [c]	0.5% or 1.0%	NA
Alaska Peninsula	25 [c]	3,750[c]	NA
Alaska Peninsula Unimak Bight District	25 [c]	3,750[c]	NA
Bering Sea	500 crab[c]	3 tier approach	3 tier approach
Dutch Harbor	0.5% or 1.0%	0.5% or 1.0%	NA
Adak[d]	50	10,000 crab	NA

a Not established.
b Not applicable.
c Fixed CBL.
d Bycatch limit established to provide scallop fleet opportunity for exploratory fishing while protecting crab resources.

In the Kamishak District of the Cook Inlet Registration Area, the Tanner crab bycatch limit is set at 0.5% of the total crab stock abundance from the most recent dredge survey and the red king crab limit was fixed at 60 crabs in earlier years and has since been reduced to 30 crabs commensurate with the reduction in red king crab catch in trawl and dredge surveys in recent years. In 2001, ADF&G set Tanner crab bycatch limits in the Prince William Sound Registration Area at 0.5% of the Tanner crab population estimate from the 2000 scallop survey. This resulted in bycatch limits of 2,700 and 8,700 for the east and west harvest areas. Starting in 2010, the department set crab bycatch limits at 0.5% of the Tanner crab abundance estimated from the scallop survey.

CBLs in the Bering Sea (registration Area Q) have evolved from fixed numbers in 1993 to a three tier approach used in the current fishery. In 1993, Bering Sea CBLs were set by ADF&G to allow the fleet adequate opportunity to explore and harvest scallop stocks while protecting the crab resource. CBLs were established at 260,000 Chionoecetes spp. and 17,000 red king crabs. In Amendment 1 of the federal scallop FMP, the Council approved the CBLs established by ADF&G. The Council also recommended that king crab bycatch limits be set within a range of 500 to 3,000 annually. From the 1996/97 through 1998/99 fishing seasons the CBL for Chionoecetes spp. in the Bering Sea was established annually by applying the percentages established for snow and Tanner crab limits in Amendment 1 of the FMP.

Beginning with the 1996/97 fishing season ADF&G took a conservative approach and set the red king crab limit in Registration Area Q at 500 red king crabs annually. In 1998, consistent with the Tanner crab rebuilding plan in the Bering Sea, crab bycatch limits were modified.

The current three tier approach was established utilizing the bycatch limits established in Amendment 1 of the FMP, 300,000 snow crabs and 260,000 Tanner crabs. The three tiers include (1) Tanner crab spawning biomass above minimum stock size threshold (MSST); bycatch limit is set at 260,000 crabs, (2) Tanner crab spawning biomass below MSST; bycatch limit is set at 130,000 crabs, and (3) Tanner crab spawning biomass is below MSST and the commercial fishing season is closed; Tanner crab limit is set at 65,000 crabs. A similar three tier approach was taken with the snow crab bycatch limits. The three tiers include (1) snow crab spawning biomass above the MSST; bycatch limit is set at 300,000 crabs, (2) snow crab spawning biomass below MSST; bycatch limit is set at 150,000 crabs, and (3) snow crab spawning biomass below MSST and the commercial fishing season is closed; the snow crab limit is set at 75,000 crabs.

Bycatch limits and the estimated number of crabs caught during 2018/19 scallop fisheries of king crab are shown in Table 3-3 and Tanner, Dungeness and snow crabs are shown Table 3.4. Bycatch of snow, king, and Tanner crabs during the Bering Sea scallop fishery tends to be much lower than for other Bering Sea fisheries. Observer data on carapace width for sampled crabs are shown in Figure 3.1.

Scallop fishery closures due to attainment of CBLs have decreased over the years, in part due to decreased crab abundance (Barnhart and Rosenkranz, 2003) as well as a voluntary industry cooperative, which provides the fleet additional flexibility to move from high crab bycatch areas. ADF&G closely monitors crab bycatch rates during scallop fisheries and crab bycatch may affect scallop harvest and CPUE as vessel operators move or cease scallop fishing when crab bycatch rates rise.

Table 3.3 Bycatch of King crabs in the 2020/21 Alaska weathervane scallop fishery.

Registration Area	District/Subsection	King crab bycatch cap	Est number crab
Yakutat		NE	0
Kodiak	Northeast District	25	0
	Shelikof District	25	0
	Southwest District	25	67
	Southeast District	25	0
Alaska Peninsula	Central District	25	0
	Unimak Bight District	25	0
Dutch Harbor		10	0
Bering Sea		500	0
	Statewide total	690	67

Table 3.4 Bycatch of *Chionoecetes* and Dungeness crabs in the 2020/21 Alaska weathervane scallop fishery.

		Tanner crab			Dungeness[b]
Registration Area	District/Subsection	Bycatch cap	Est number crab	Est weight (lb)[a]	Est number crab
Yakutat		NE	688	11	965
Kodiak	Northeast District	9,000	951	178	0
	Shelikof District	20,000	1,308	106	694
	Southwest District	17,500	6,750	864	1,496
	Southeast District	9,000	0	0	0
Alaska Peninsula	Central District	3,750	0	0	0
	Unimak Bight District	3,750	0	0	0
Dutch Harbor		5,000	0	0	0
Bering Sea		65,000	0	0	0
		Snow and *C.* hybrid crab			
Bering Sea		300,000	0	0	0
	Statewide Total	433,000	9,697	1,159	3,155

NE: not established
[a] *Weight estimation for areas outside Cook Inlet uses estimated number crab, carapace width distributions from observer sampling and CW-weight relationship parameters from NMFS Bering Sea crab research. Cook Inlet estimate is based on sampling weight of crab by ADF&G.*
[b] *Bycatch cap not established.*

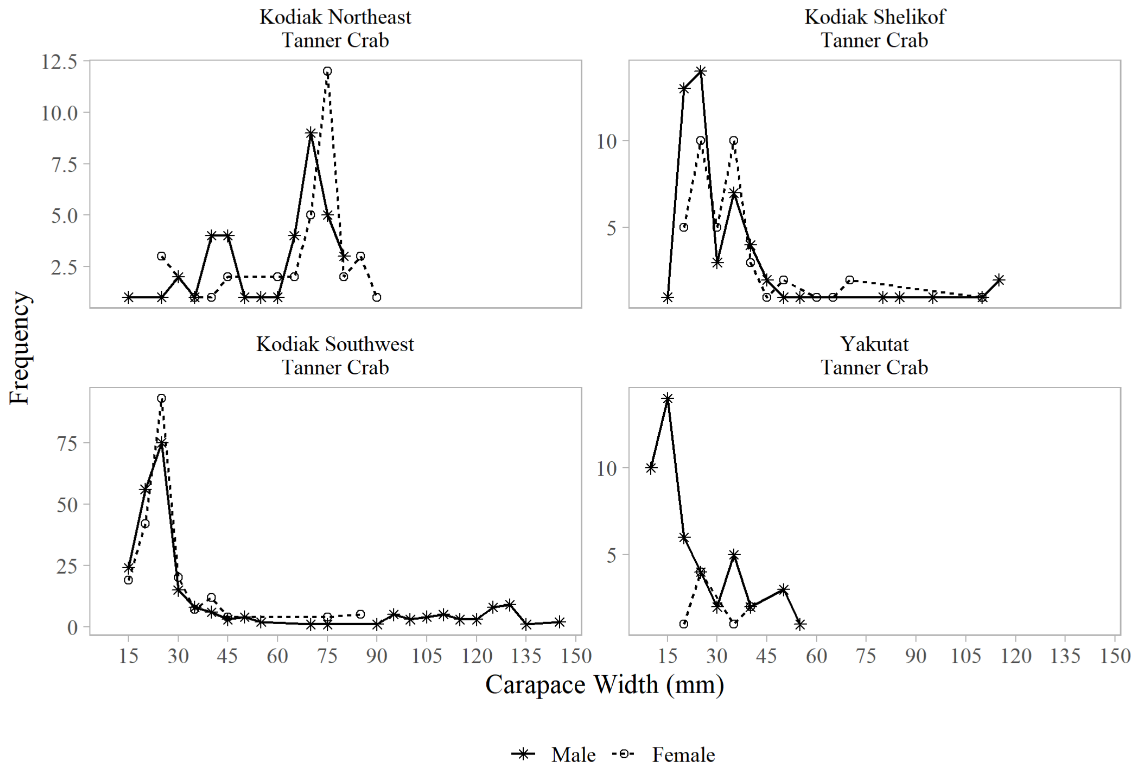

Figure 3.1 Tanner carapace width distributions by management unit from catch sampling during the 2020/21 scallop fishery.

3.7 Vessel Participation in the Scallop Fishery

Commercial weathervane scallop fishing in Federal waters off Alaska is limited by a Federal license limitation program (LLP), while scallop fishing in State waters is open access. The Federal LLP, effective 2001 under Amendment 4, limits participation in the scallop fishery in Federal waters to nine vessels. Seven LLP vessels were permitted to fish statewide outside of Cook Inlet using up to two 10-foot dredges statewide, and two LLP vessels were permitted to fish statewide utilizing single 6-foot dredges. In August, 2005, NMFS implemented Amendment 10 to the FMP, which modified the gear restriction to allow the single 6-foot dredge LLPs to be used with up to two 10-foot dredges outside of Cook Inlet. All 9 licenses allow vessel owners to fish inside Cook Inlet with a single 6-foot dredge. Vessel length for a given LLP is restricted to vessel length during the qualifying period. Unless otherwise restricted by the LLP, vessels fishing in the remainder of the state may simultaneously operate a maximum of 2 dredges that are 15 feet or less in width.

Participating in the Scallop fishery in Alaska state waters (0-3 nautical miles) had been limited by a vessel-based limited entry program until State limited entry expired in 2013 and was not renewed by the Alaska State Legislature. To date, no additional state-only vessels have participated in the open access state water fishery.

Four vessels with Federal LLP permits as well as state vessel-based limited entry permits (when required) have harvested most of the scallop catch outside Cook Inlet over the past several seasons. Only one of these vessels typically participates in the Cook Inlet Registration Area fishery.

Establishment of a Voluntary Scallop Cooperative

In 2000, six of the nine LLP owners formed the North Pacific Scallop Cooperative under authority of the Fishermen's Cooperative Marketing Act, 48 Stat. 1213 (1934), 15 U.S.C. Sec. 521. The cooperative is self-regulated and is neither endorsed nor managed by ADF&G or NMFS. The cooperative regulates individual vessel allocations within the GHL and crab bycatch caps under the terms of their cooperative contract. Non-coop vessels are not bound by any contract provisions. The cooperative does not receive an exclusive allocation of the scallop harvest. Some owners opted to remove their boats from the fishery and arranged for their shares to be caught by other members of the cooperative. Since formation of the cooperative, harvest rates have slowed and fishing effort occurs over a longer time period each season.

Vessel owners within the cooperative have taken an active role in reducing crab bycatch. Vessel operators provide confidential in-season fishing information to an independent consulting company contracted by the cooperative. This firm reviews crab bycatch data, fishing locations, and scallop harvest, which allows for real time identification of high crab bycatch areas. When these areas are identified, the fleet is provided with the information and directed to avoid the area.

4 Regional Fishery Performance

4.1 Overview

The 2020/21 season statewide Guideline Harvest Level (GHL) for weathervane scallops was 277,500 lb of shucked meats. Of this GHL 227,270 lb were retained with an additional 11,280 lb of estimated discard mortality for a total take of 238,551 lb of shucked meats (Table 4.1).

The 2021/22 season statewide Guideline Harvest Level (GHL) for weathervane scallops was 337,500 lb of shucked meats. Of this GHL, 298,755 lb were retained (Table 4.2). Discard estimates have not yet been completed for the 2021/22 fishing year.

Table 4.1 GHLs and summary statistics from 2020/21 Alaska weathervane scallop fishery.

Registration Area	District/Subsection	GHR (lb meat)	GHL (lb meat)	Retained catch (lb meat)	CPUE (lb meat per dredge hr)	Est scallop discard mortality (lb meat)[a]
Yakutat		0-285,000	145,000	146,165	47	9,362
Kodiak	Northeast District	0-300,000 for whole Kodiak Area	15,000	15,095	77.9	615
	Shelikof District		40,000	40,060	92.6	848
	Southwest District		35,000	25,950	44.0	455
	Southeast District		15,000	0		0
Alaska Peninsula	Central District	0-100,000 for whole Alaska Peninsula Area	7,500	0		0
	Unimak Bight District[b]		7,500	0		0
Dutch Harbor		0-110,000	5,000	0		0
Bering Sea		0-300,000	7,500	0		0
Statewide Totals			277,500	227,270	52.6	11,280

[a] Calculated from round weight discard estimates assuming 20% mortality (as previously used in scallop ACL analysis) for discarded scallops and 10% meat recovery
[b] Exploratory fishery prosecuted under ADF&G Commissioner's Permit

Table 4.2 GHLs and preliminary catch from the 2021/22 Alaska weathervane scallop fishery.

Registration Area	District/Subsection	GHL (lb scallop meats)	Retained catch (lb scallop meat)
Yakutat		145,000	144,995
Prince William Sound	West Kayak Island	8,000	8,170
Kodiak	Northeast District	30,000	30,295
	Shelikof District	80,000	80,215
	Southwest District	35,000	35,080
	Southeast District	15,000	
Alaska Peninsula	Central District	7,500	
	Unimak Bight District[a]	7,500	
Dutch Harbor		10,000	
Bering Sea		7,500	
Statewide Totals		337,500	298,755

[a] Exploratory fishery prosecuted under ADF&G Commissioner's Permit.

4.2 Yakutat Registration Area (D)

The 2020/21 Yakutat scallop fishery opened on July 1, 2020 with a GHL of 145,000 lbs of scallop meats. Two vessels participated in the fishery harvesting 146,165 lbs scallop meat with a CPUE of 47.1 lbs meat/dredge hour (Table 4.3; Table 4.1). Total round weight of retained scallops was 1,939,096 lbs with a nominal CPUE of 624 lbs/dredge hour (Table 4.3). Fishing effort was spread throughout much of the district, though most occurred within the YAK2 bed. The spatial extent of the catch was greater than in the 2019/20 season, but still lower than most of the timeseries (Figure 4.1). Round weight CPUE underwent a slight increase from the 2019/20 season across all beds (Table 4.1, Figure 4.2). Using a 20% discard mortality, an estimated 9,362 lb of scallop meat weight was lost to discard mortality in the 2020/21 season (Table 4.3). Estimated shell height distributions from the 2020/21 season are similar to that of 2019/20, with the bulk of the retained scallops remain in the 115–140 mm shell height range (Figure 4.3).

Crab bycatch estimates calculated from 2020/21 Yakutat observer samples were 688 Tanner crabs (Table 3.4), and 965 Dungeness crabs. Tanner crabs sampled by observers ranged from about 10mm to 60mm carapace width (Figure 3.1).

The 2021/22 Yakutat District fishery opened with a GHL of 145,000 lb of scallop meats. Preliminary retained catch was 144,995 lb shucked meats by two vessels, averaging a meat CPUE of 60 lb meat per dredge hour.

Table 4.3 Yakutat Area D scallop fishery summary statistics, 2000/01 – 2021/22.

Season	Number vessels	GHL (lb meat)	Retained catch (lb meat)	Retained catch (lb round)	Dredge hours[a]	Meat weight CPUE[a]	Round weight CPUE[b]	Discard mortality (lb meat)[c]
2000/01	3	250,000	195,699	2,734,559	4,241	46	645	10,401
2001/02	2	200,000	103,800	1,521,537	2,406	43	632	4,809
2002/03	2	200,000	122,718	1,541,867	2,439	50	632	6,326
2003/04	2	200,000	160,918	1,939,004	3,360	48	577	6,940
2004/05	2	200,000	86,950	1,262,499	2,132	41	592	3,869
2005/06	2	200,000	199,351	2,662,031	5,089	39	523	6,988
2006/07	2	150,000	150,041	1,771,229	2,817	53	629	6,715
2007/08	2	150,000	125,960	1,593,223	2,601	48	613	9,184
2008/09	3	150,000	150,289	2,053,912	3,286	46	625	7,361
2009/10	2	185,000	170,016	2,514,004	4,385	39	573	13,966
2010/11	3	185,000	159,268	2,163,050	3,578	45	605	11,901
2011/12	3	185,000	158,240	2,380,618	4,655	34	511	11,347
2012/13	3	145,000	143,395	1,989,071	4,038	36	493	11,503
2013/14	3	145,000	147,400	1,853,114	3,025	49	613	5,042
2014/15	3	145,000	129,493	1,555,495	3,159	41	492	2,774
2015/16	2	145,000	120,690	1,708,707	2,571	47	665	3,656
2016/17	2	125,000	120,380	1,637,710	2,109	57	777	5,024
2017/18	2	145,000	145,080	1,841,714	2,899	50	635	8,150
2018/19	2	145,000	145,083	1,777,744	2,267	64	784	3,973
2019/20	2	155,000	144,245	1,989,202	3,293	44	604	11,282
2020/21	2	145,000	146,165	1,939,096	3,105	47	624	9,362
2021/22[d]	2	145,000	144,995		2,431	60		

[a] lb scallop meat / dredge hour, [b] lb scallop round / dredge hour
[c] Calculated from round weight discard estimates assuming 20% mortality for discarded scallops and meat recovery of 10%.
[d] PRELIMINARY data subject to change.

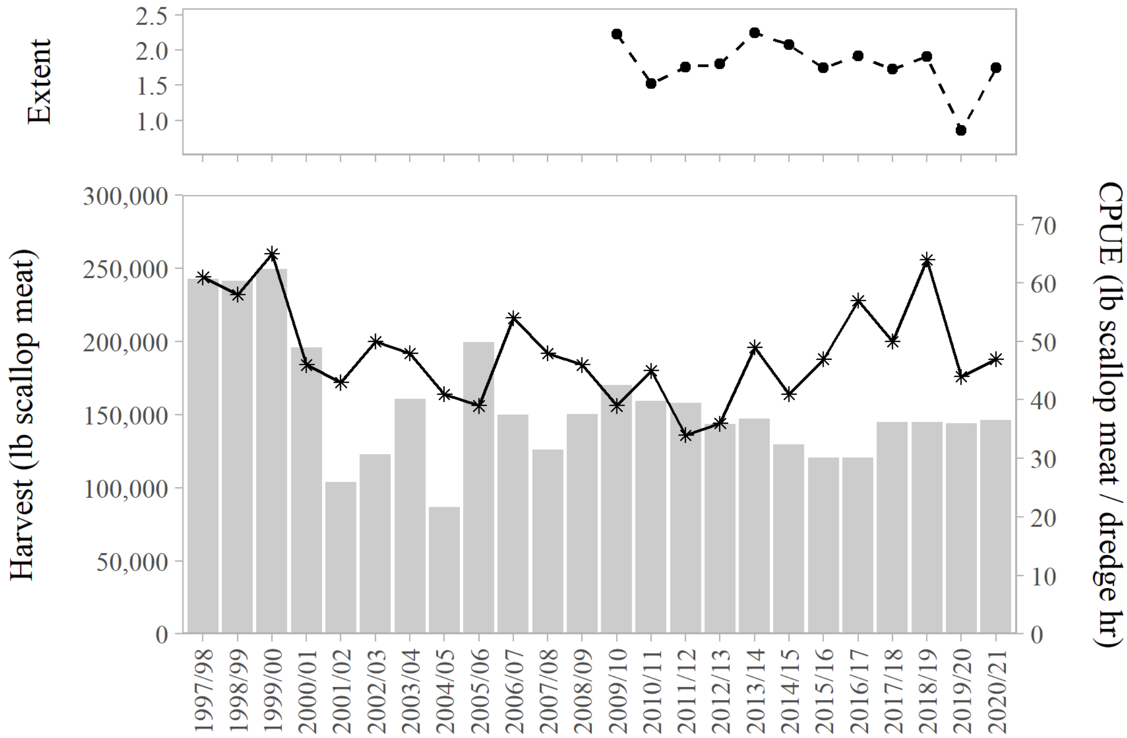

Figure 4.1 Yakutat seasonal scallop harvest (gray bars) and CPUE (points) (Bottom). Index of spatial extent of the catch, for seasons in which dredge location data are available (Top).

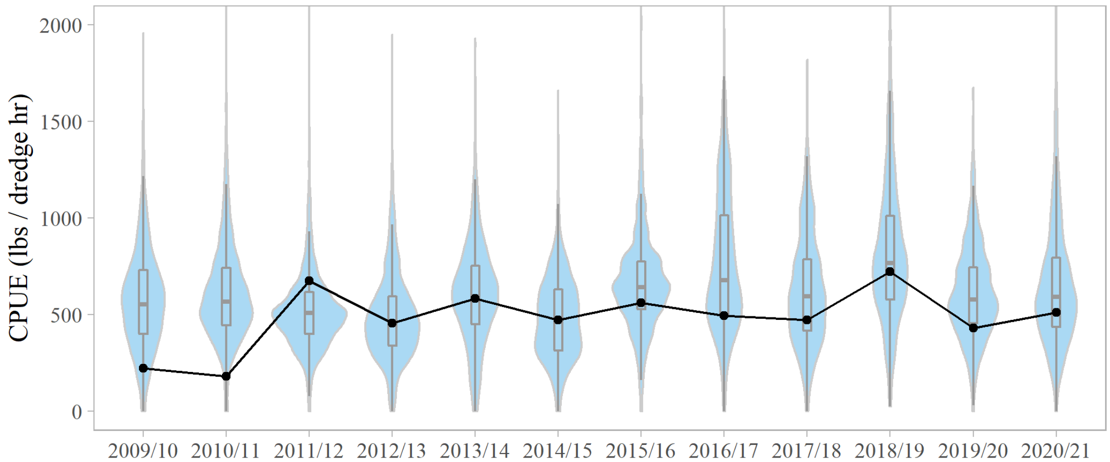

Figure 4.2 **Violin plots of nominal CPUE (round lb / dredge hr) overlaid with standardized CPUE (round lb / dredge hr) by season (black line) in the Yakutat district.**

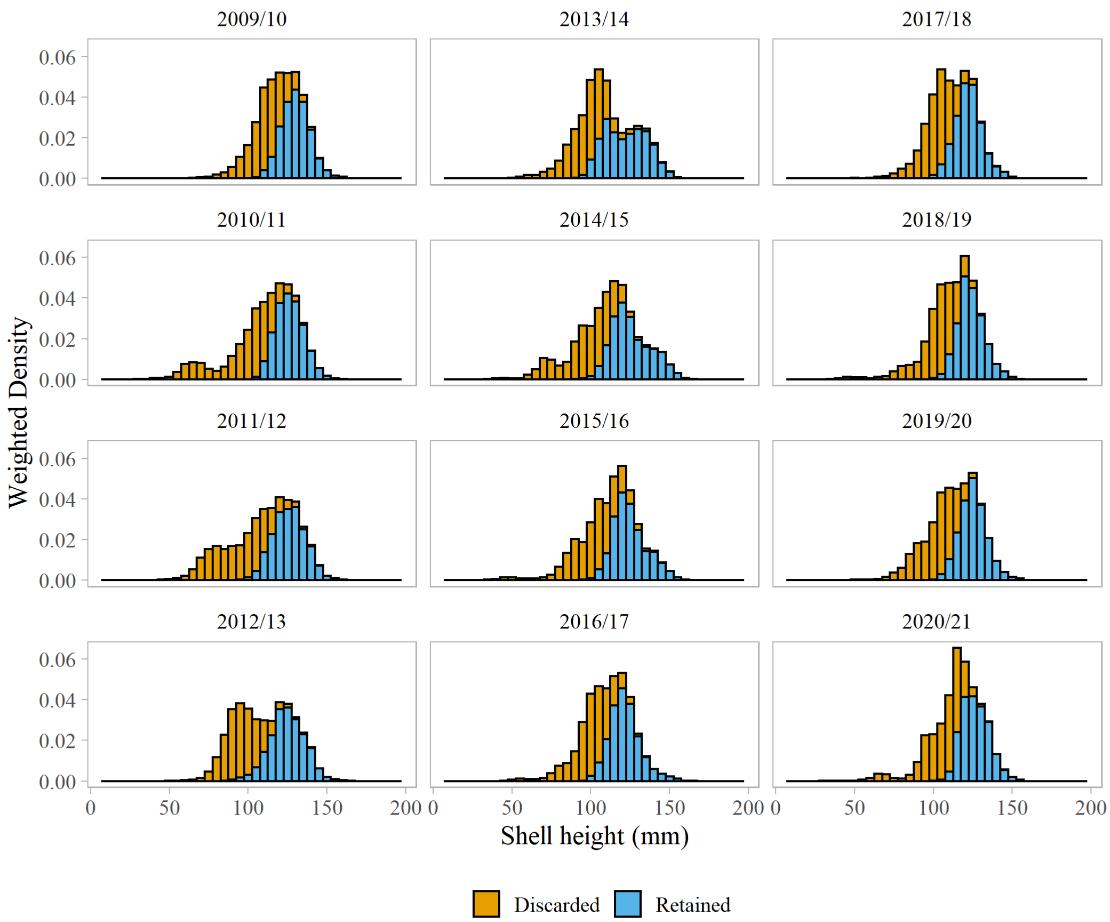

Figure 4.3 **Yakutat District retained and discarded shell height distribution for the 2009/10-2020/21 seasons.**

4.3 Prince William Sound Registration Area (E)

The Prince William Sound (PWS) Registration Area (E) consists of an Inside and Outside waters district. Scallop fishing occurs within the PWS Outside District, which is further subdivided into the West Kayak Island and East Kayak Island Subsections. The West Kayak Island Subsection was closed for the 2020/21 season, and previously last open for fishing during the 2018/19 season, in which 6,420 lb shucked meats were harvested with a GHL of 6,300 lb (Table 4.4; Figure 4.4). The East Kayak Island Subsection was last open for fishing during the 2011/12 season, in which 8,460 lb shucked meats were harvested under a GHL of 8,400 lb (Table 4.5; Figure 4.7).

The 2021/22 West Kayak Island Subsection fishery opened with a GHL of 8,000 lb of scallop meats. One vessel participated in the fishery harvesting 8,170 lb of shucked meats with a meat CPUE of 124 lb / dredge hr (Table 4.4). The East Kayak Island Subsection remained closed during the 2021/22 season (Table 2.5).

Table 4.4 West Kayak Island Subsection scallop fishery summary statistics, 2000/01- 2021/22.

Season	Number vessels	GHL (lb meat)	Retained catch (lb meat)	Retained catch (lb round)	Dredge hours[a]	Meat weight CPUE[a]	Round weight CPUE[b]	Discard mortality (lb meat)[c]
2000/01	3	21,000	21,268		129	164		
2001/02	1	21,000	21,030		124	170		
2002/03	2	14,000	13,961		79	177		
2003/04	1	14,000	14,070		93	152		
2004/05	2	24,000	23,970		185	130		
2005/06	3	24,000	24,781		272	91		
2006/07	2	17,000	17,005		147	116		
2007/08	2	17,000	17,090		225	76		
2008/09	1	5,000	5,010		134	37		
2009/10	2	5,000	4,980	77,571	87	57	892	
2010/11		closed						
2011/12		closed						
2012/13		closed						
2013/14		closed						
2014/15		closed						
2015/16		closed						
2016/17	1	6,300	102,506	112	57	913	102,506	
2017/18	1	6,300	88,328	102	62	864	88,328	
2018/19	1	6,300	85,467	133	48	643	85,467	
2019/20		closed						
2020/21		closed						
2021/22[d]		8,000	8,170		66			

[a] lb scallop meat / dredge hour
[b] lb scallop round / dredge hour
[c] Calculated from round weight discard estimates assuming 20% mortality for discarded scallops and meat recovery of 10%.

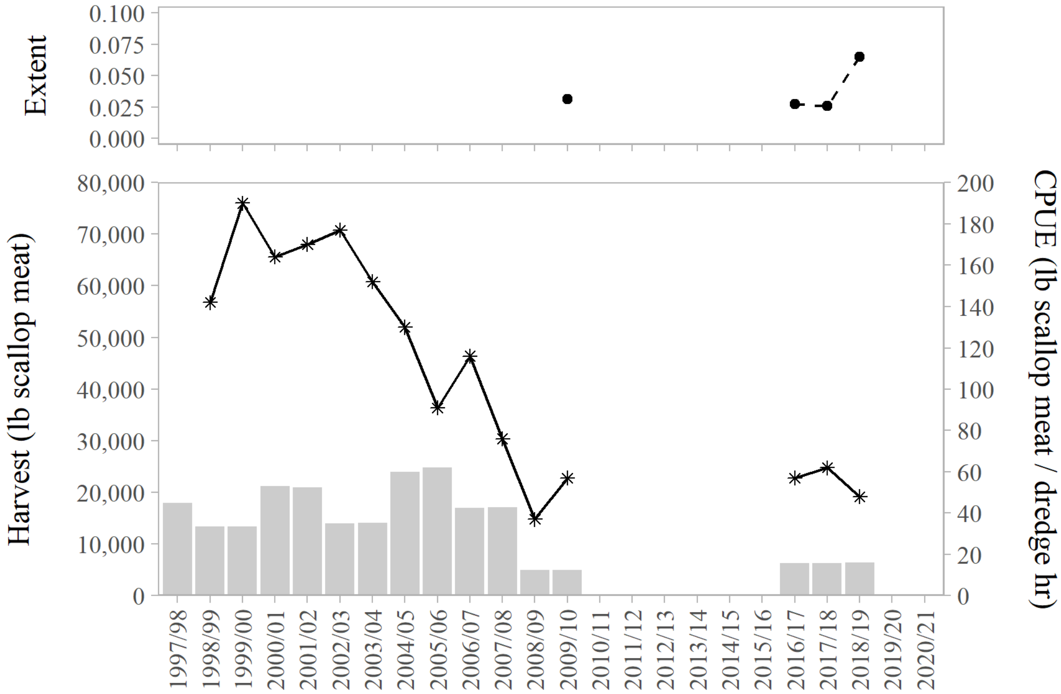

Figure 4.4 **West Kayak Island seasonal scallop harvest (gray bars) and CPUE (points) (Bottom). Index of spatial extent of the catch, for seasons in which dredge location data are available (Top).**

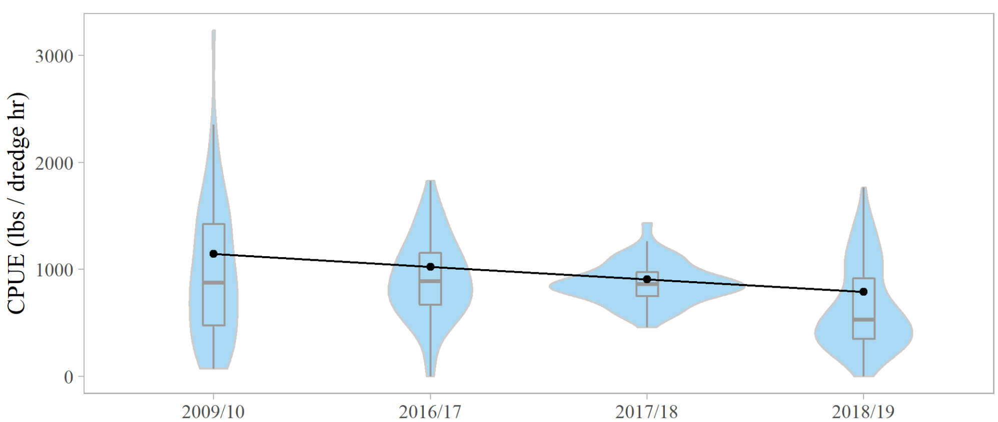

Figure 4.5 **Violin plots of nominal CPUE (round lb / dredge hr) overlaid with standardized CPUE (round lb / dredge hr) by season (black line) in the West Kayak Island subsection.**

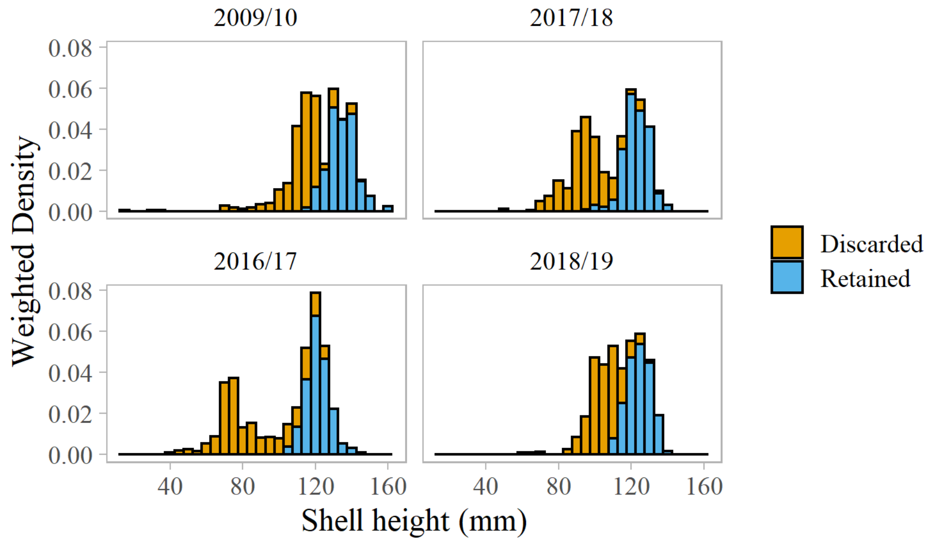

Figure 4.6 West Kayak Island retained and discarded shell height distribution for the 2009/10-2020/21 seasons, when fisheries occurred.

Table 4.5 East Kayak Island Subsection scallop fishery summary statistics, 2000/01- 2011/12.

Season	Number vessels	GHL (lb meat)	Retained catch (lb meat)	Retained catch (lb round)	Dredge hours[a]	Meat weight CPUE[a]	Round weight CPUE[b]	Discard mortality (lb meat)[c]
2000/01	3	9,000	8,998		92	98		
2001/02	1	9,000	9,060		140	65		
2002/03	2	6,000	1,680		43	39		
2003/04	1	6,000	5,910		123	48		
2004/05	2	26,000	25,350		430	59		
2005/06	3	26,000	24,435		219	112		
2006/07	2	20,000	20,010		188	106		
2007/08	2	20,000	20,015		203	99		
2008/09	1	15,000	15,030		197	76		
2009/10	2	15,000	15,005	233,227	339	44	689	
2010/11	1	8,400	8,445	133,502	161	52	828	
2011/12	1	8,400	8,460	134,129	162	52	830	

[a] *lb scallop meat / dredge hour*
[b] *lb scallop round / dredge hour*
[c] *Calculated from round weight discard estimates assuming 20% mortality for discarded scallops and meat recovery of 10%.*

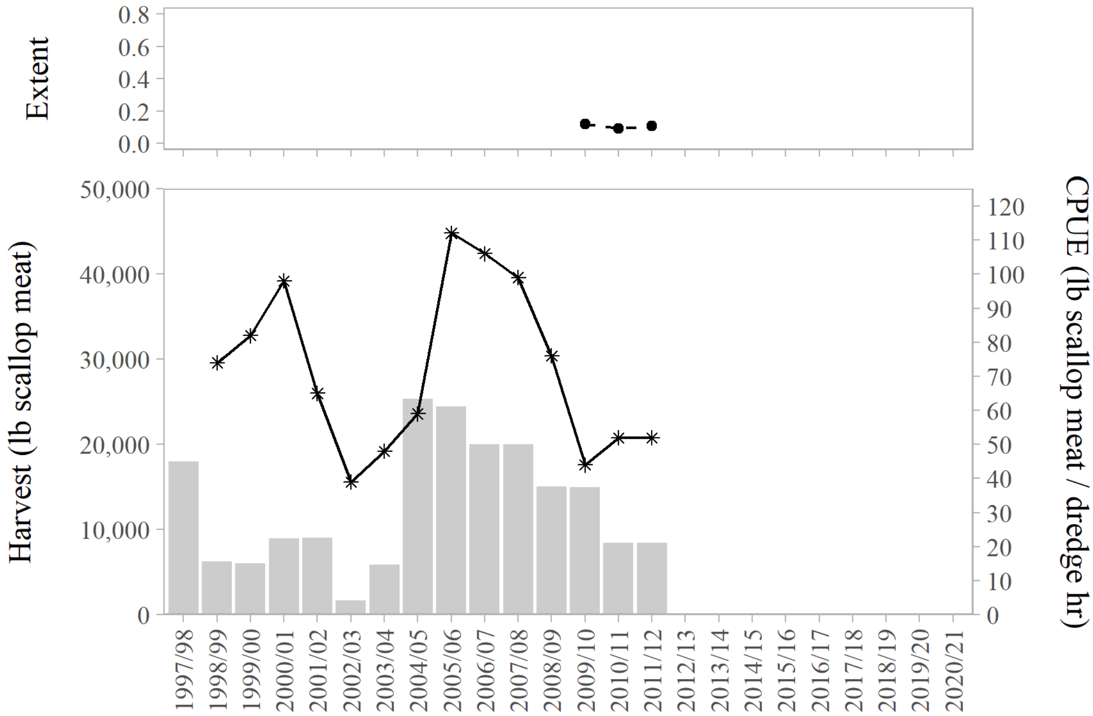

Figure 4.7 East Kayak Island seasonal scallop harvest (gray bars) and CPUE (points) (Bottom). Index of spatial extent of the catch, for seasons in which dredge location data are available (Top).

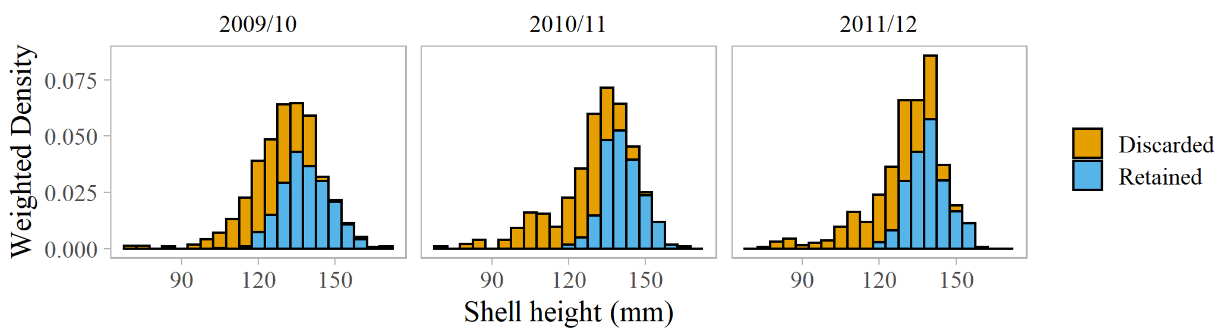

Figure 4.8 East Kayak Island retained and discarded shell height distribution for the 2009/10-2020/21 seasons, when fisheries occurred.

4.4 Cook Inlet Registration Area (H)

The scallop fishery within the Cook Inlet Registration Area (H) occurs within the Kamishak District and is managed on the basis of distinct north (KAMN) and south (KAMS) beds. The south bed has been closed since he 2008/09 season, while the north bed was last open for fishing during the 2017/18 season. Statistics presented in this document are for both beds combined. During the 2017/18 season, the GHL was 10,000 lb shucked meats, and no vessels participated in the fishery. The Kamishak District remained closed for the 2021/22 season (Table 4.6).

Table 4.6 Kamishak District scallop fishery summary statistics, 2000/01- 2021/22.

Season	Number vessels	GHL (lb meat)	Retained catch (lb meat)	Retained catch (lb round)	Dredge hours[a]	Meat weight CPUE[a]	Round weight CPUE	Discard mortality (lb meat)[c]
2000/01		20,000	20,516		275	75		
2001/02		20,000	20,097		325	62		
2002/03		20,000	8,591		311	28		
2003/04		20,000	15,843		896	18		
2004/05		20,000	6,117		364	17		
2005/06		7,000	7,378		372	20		
2006/07		7,000	50		10	5		
2007/08		12,000	0					
2008/09		12,000	0					
2009/10		14,000	0					
2010/11		14,000	9,460		365	26		
2011/12		12,500	9,975		324	31		
2012/13		12,500	11,739		392	30		
2013/14		closed						
2014/15		closed						
2015/16		10,000	9,485		459	21		
2016/17		10,000	3,982		271	15		
2017/18		10,000	0		0			0
2018/19		closed						
2019/20		closed						
2020/21		closed						
2021/22		closed						

[a] lb scallop meat / dredge hour

[c] Calculated from round weight discard estimates assuming 20% mortality for discarded scallops and meat recovery of 10%.

4.5 Kodiak Registration Area (K)

Kodiak Northeast District

The 2020/21 Kodiak Northeast District scallop fishery opened on July 1, 2020 with a GHL of 15,000 lbs of scallop meats. One vessel participated in the fishery harvesting 15,095 lbs scallop meat with a CPUE of 77.9 lbs meat/dredge hour. Total round weight of retained scallops was 180,966 lbs with a nominal CPUE of 934 lbs/dredge hour (Table 4.7). Fishing effort was restricted to two beds in the southern portion of the district, making the spatial extent of effort the smallest since the 2009/10 season (Figure 4.9). Estimated scallop discard mortality meat weight decreased from the previous season and was the third lowest in the timeseries (Table 4.7). Despite the increase in nominal round weight CPUE, standardized CPUE showed a marginal decrease (Figure 4.10). For the second consecutive season, the shell height distribution from the 2020/21 fishery included three distinct cohorts: two that were mostly discarded less than 120 mm and one larger (> 120 mm) that was mostly retained (Figure 4.11).

Crab bycatch estimates calculated from 2020/21 Kodiak Northeast observer samples were 951 Tanner crab (Table 3.4), and no red king crab. Tanner crab sampled by observers ranged from about 20mm to 90mm carapace width (Figure 3.1).

The 2021/22 Kodiak Northeast District fishery opened with a GHL of 30,000 lb of scallop meats. Preliminary retained catch was 30,295 lb shucked meats by two vessels, averaging a meat CPUE of 103 lb meat per dredge hour.

Table 4.7 Kodiak Northeast District scallop fishery summary statistics, 2000/01- 2021/22.

Season	Number vessels	GHL (lb meat)	Retained catch (lb meat)	Retained catch (lb round)	Dredge hours[a]	Meat weight CPUE[a]	Round weight CPUE[b]	Discard mortality (lb meat)[c]
2000/01	4	80,000	79,965	681,198	1,101	73	619	2,269
2001/02	3	80,000	80,470	822,110	1,142	70	720	2,177
2002/03	2	80,000	80,000	871,918	1,350	59	646	3,330
2003/04	2	80,000	79,965	747,517	1,248	64	599	2,270
2004/05	2	80,000	80,105	848,527	1,227	65	692	5,259
2005/06	3	80,000	79,990	831,378	1,759	46	473	4,198
2006/07	2	90,000	75,150	703,388	1,168	64	602	2,707
2007/08	2	90,000	75,105	822,697	1,170	63	703	4,061
2008/09	3	90,000	74,863	808,277	1,356	55	596	2,217
2009/10	1	75,000	69,410	831,709	1,222	57	681	2,396
2010/11	3	65,000	64,475	672,246	1,015	64	662	1,444
2011/12	4	70,000	61,209	667,008	986	62	676	1,734
2012/13	4	60,000	62,496	749,644	1,322	47	567	1,895
2013/14	4	55,000	54,926	526,156	934	59	563	1,257
2014/15	3	55,000	55,659	667,962	752	74	888	1,060
2015/16	3	55,000	55,577	634,481	1,228	45	517	1,668
2016/17	2	55,000	24,401	292,760	1,096	22	267	538
2017/18	1	55,000	14,190	136,295	349	41	391	418
2018/19	1	15,000	15,210	155,334	262	58	593	1,156
2019/20	2	15,000	15,070	165,989	206	73	807	932
2020/21	1	15,000	15,095	180,966	194	78	934	615
2021/22[d]	2	30,000	30,295		294	103		

a lb scallop meat / dredge hour
b lb scallop round / dredge hour
c Calculated from round weight discard estimates assuming 20% mortality for discarded scallops and meat recovery of 10%.
d PRELIMINARY data subject to change.

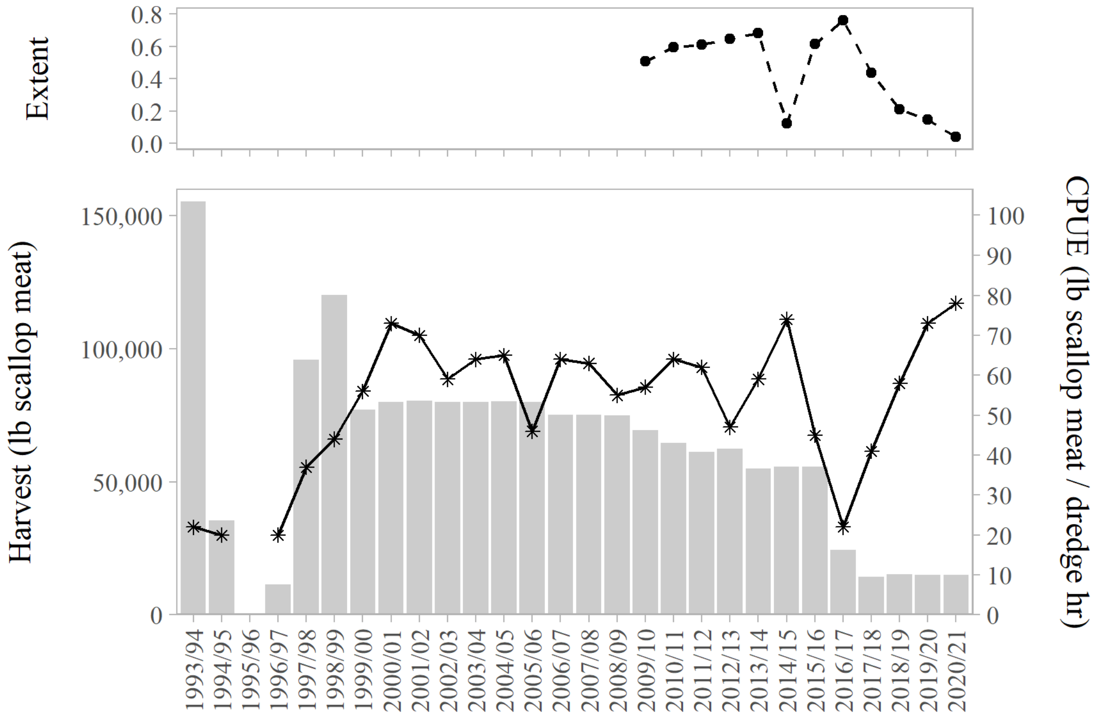

Figure 4.9 **Kodiak Northeast seasonal scallop harvest (gray bars) and CPUE (points) (Bottom). Index of spatial extent of the catch, for seasons in which dredge location data are available (Top).**

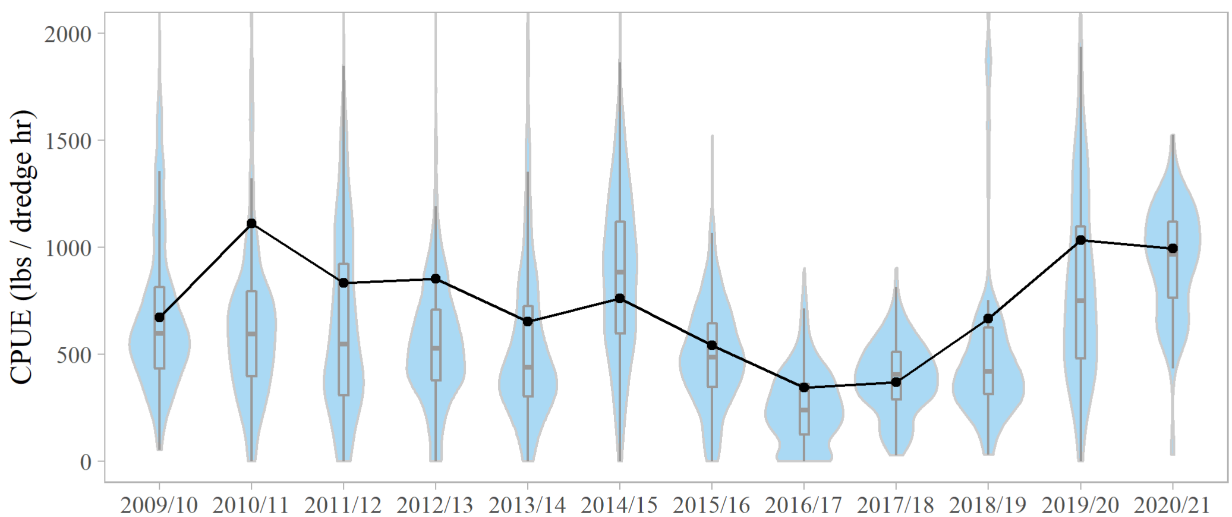

Figure 4.10 **Violin plots of nominal CPUE (round lb / dredge hr) overlaid with standardized CPUE (round lb / dredge hr) by season (black line) in the Kodiak Northeast district.**

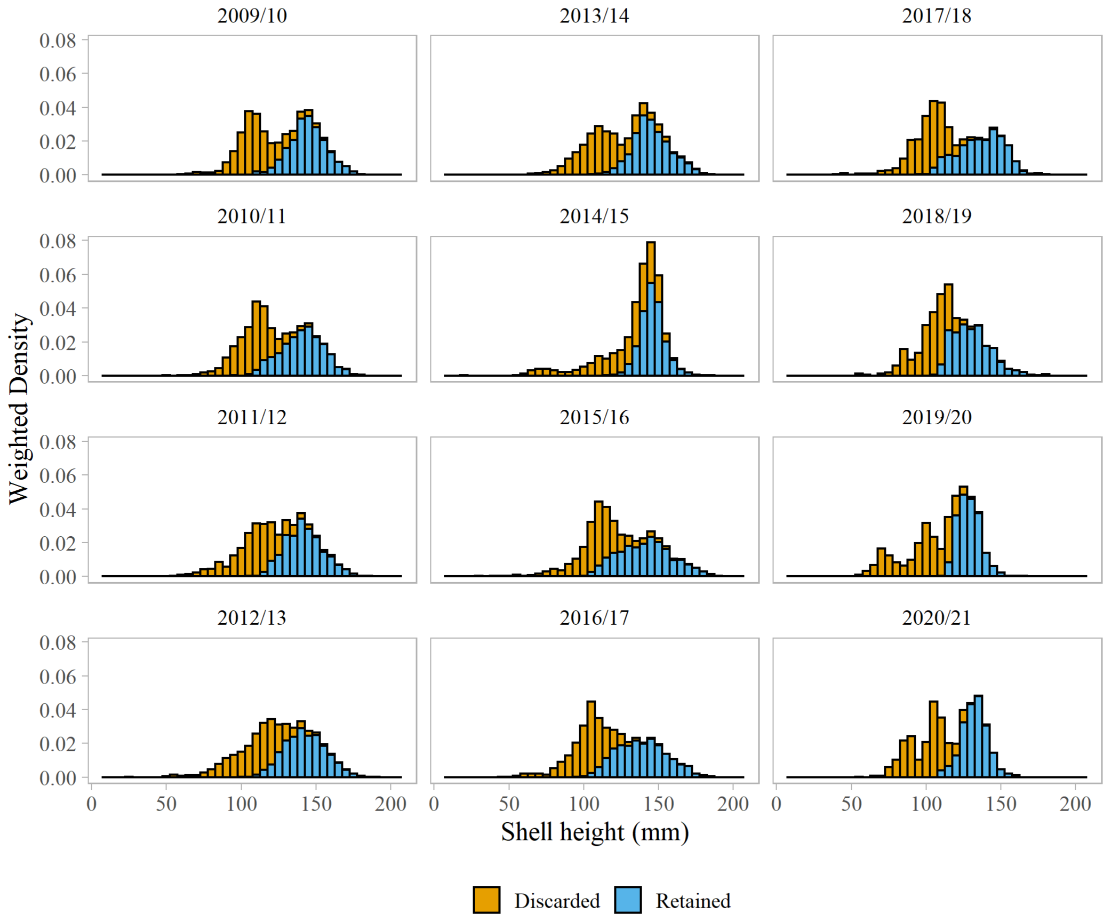

Figure 4.11 Kodiak Northeast District retained and discarded shell height distribution for the 2009/10-2020/21 seasons.

Kodiak Shelikof District

Beginning in the 2019/20 season, only scallop beds along the north shore of the Shelikof Strait have been managed as part of the Kodiak Shelikof District. GHLs prior to the 2018/19 season do not reflect the omission of beds adjacent to the Karluk River (Southwest Kodiak Island), but all other fishery statistics have been adjusted to reflect current management practices for season in which observer data are available (2009/10 – present).

The 2020/21 Kodiak Shelikof District scallop fishery opened on July 1, 2020 with a GHL of 40,000 lbs of scallop meats. One vessel participated in the fishery harvesting 40,060 lbs scallop meat with a nominal CPUE of 92.6 lbs meat/dredge hour. Total round weight of retained scallops was 408,723 lbs with a nominal CPUE of 944 lbs/dredge hour (Figure 4.8). Fishing effort was the most spatially concentrated it has been since the 2009/10 season, and nominal CPUE was the highest in the entire timeseries (since the 1993/94 season) (Figure 4.8, Figure 4.12). Both nominal and standardized indices of round weight CPUE support the increasing trend in fishery performance (Figure 4.13). Estimated scallop discard mortality meat weight sharply decreased from the previous two seasons. The shell height composition of the 2020/21 fishery included 3-4 cohorts, including one large cohort greater than 120 mm shell height that was retained and 2-3 less numerous cohorts less than 120 mm shell height that were mostly discarded (Table 4.8).

Crab bycatch estimates calculated from 2020/21 Kodiak Shelikof observer samples were 1,308 Tanner crab, no red king crab, and 694 Dungeness crab (Table 3.4). Tanner crab sampled by observers were as large as approximately 120 mm carapace width, though the majority were less than 60 mm carapace width (Figure 3.1).

The 2021/22 Kodiak Shelikof District fishery opened with a GHL of 80,000 lb of scallop meats. Preliminary retained catch was 80,215 lb shucked meats by two vessels, averaging a meat CPUE of 107 lb meat per dredge hour.

Table 4.8 Kodiak Shelikof District scallop fishery summary statistics, 2000/01- 2021/22.

Season	Number vessels	GHL (lb meat)	Retained catch (lb meat)	(lb round)	Dredge hours[a]	Meat weight CPUE[a]	Round weight CPUE[b]	Discard mortality (lb meat)[c]
2000/01	5	180,000	180,087	1,768,376	2,905	62	609	2,570
2001/02	4	180,000	177,112	1,830,265	3,398	53	539	4,784
2002/03	3	180,000	180,580	1,857,466	3,799	47	489	9,922
2003/04	2	180,000	180,011	1,724,498	3,258	64	529	8,048
2004/05	2	180,000	174,622	1,641,608	3,467	50	474	8,709
2005/06	2	160,000	159,941	1,453,656	2,278	70	638	4,674
2006/07	3	160,000	162,537	1,404,134	2,181	74	644	4,695
2007/08	3	170,000	169,968	1,695,563	2,937	58	577	7,534
2008/09	2	150,000	13,761	2,053,912	3,286	46	625	645
2009/10	3	170,000	170,021	1,667,958	3,496	49	477	6,358
2010/11	4	170,000	167,293	1,839,480	3,407	49	540	6,923
2011/12	4	135,000	136,435	1,437,093	2,437	56	590	2,314
2012/13	4	105,000	106,040	992,665	2,001	53	496	2,296
2013/14	4	105,000	104,725	899,261	2,449	43	367	1,443
2014/15	3	105,000	62,556	609,092	1,548	40	393	734
2015/16	3	75,000	35,626	431,843	1,188	30	364	1,011
2016/17	2	25,000	20,606	264,153	719	29	367	873
2017/18	1	25,000	20,870	211,277	481	43	439	740
2018/19	1	25,000	21,701	239,700	416	52	577	2,973
2019/20	2	20,000	20,125	249,287	380	53	657	2,296
2020/21	1	40,000	40,060	408,723	433	93	944	848
2021/22[d]	2	80,000	80,215		751	107		

[a] *lb scallop meat / dredge hour*
[b] *lb scallop round / dredge hour*
[c] *Calculated from round weight discard estimates assuming 20% mortality for discarded scallops and meat recovery of 10 %.*
[d] *PRELIMINARY data subject to change.*
[e]*GHLs in prior to 2019/20 were based on the inclusion of scallop beds adjacent to the Karluk River*
[f]*2008/09 inseason closure at due to Tanner crab bycatch*
[g]*2014/15, 2015/16 inseason closure due to poor fishing performance*

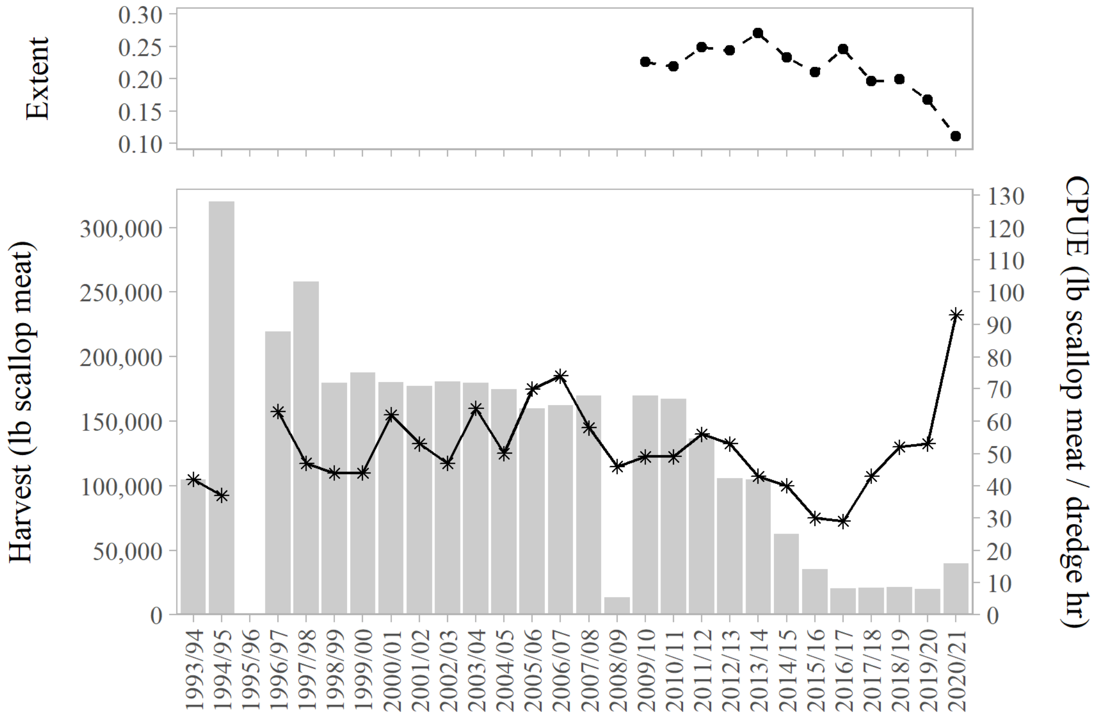

Figure 4.12 Kodiak Shelikof District seasonal scallop harvest (gray bars) and CPUE (points) (Bottom). Index of spatial extent of the catch, for seasons in which dredge location data are available (Top).

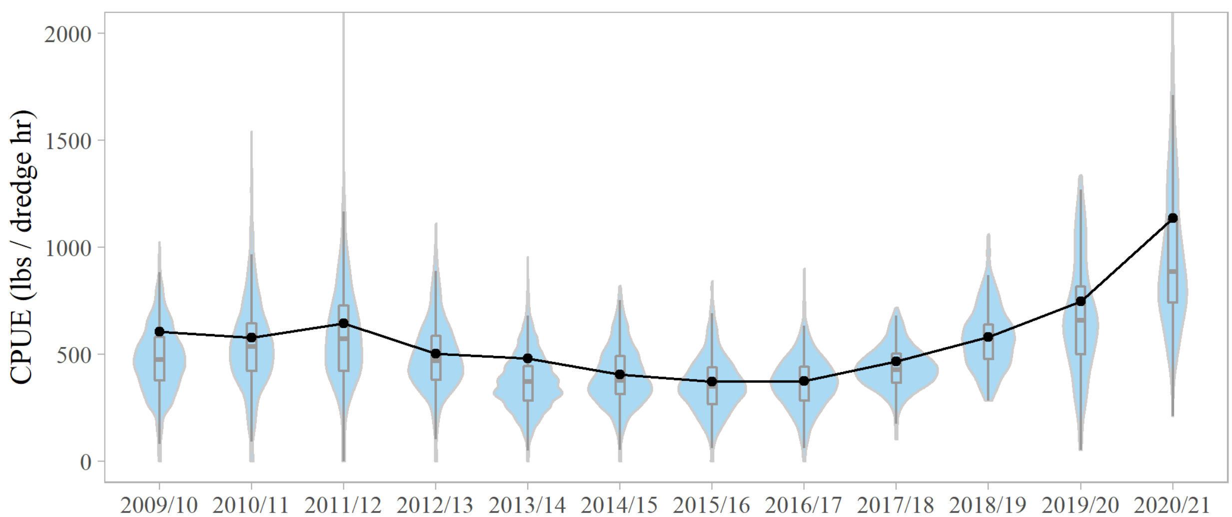

Figure 4.13 Violin plots of nominal CPUE (round lb / dredge hr) overlaid with standardized CPUE (round lb / dredge hr) by season (black line) in the Kodiak Shelikof District.

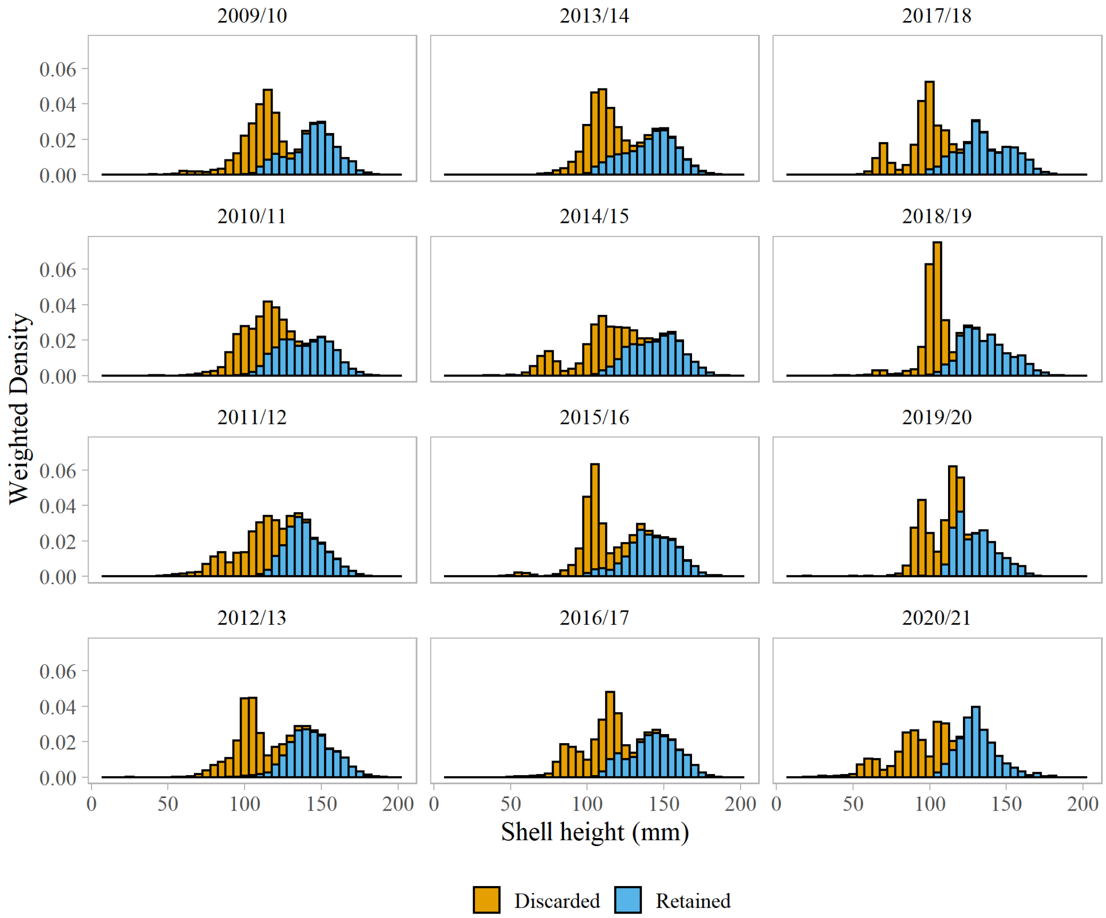

Figure 4.14 Kodiak Shelikof District retained and discarded shell height distribution for the 2009/10-2020/21 seasons.

Kodiak Southwest District

Beginning in the 2019/20 season, scallop beds located with the Kodiak Shelikof District, but located offshore of Kodiak Island directly adjacent to the Karluk River have been managed as part of the Kodiak Southwest District. GHLs prior to the 2018/19 season do not reflect the inclusion of these beds, but all other fishery statistics have been adjusted to reflect current management practices.

The 2020/21 Kodiak Southwest District scallop fishery opened on July 1, 2020 with a GHL of 35,000 lbs of scallop meats. One vessel participated in the fishery harvesting 25,950 lbs scallop meat with a nominal CPUE of 44.0 lbs meat/dredge hour. Total round weight of retained scallops was 360,788 lbs with a nominal CPUE of 612 lbs/dredge hour (Table 4.9). Fishing effort occurred over a smaller spatial area than in the 2019/20 season, though the spatial extent of the resulting catch was greater (Figure 4.15). Standardized round weight CPUE suggests fishing performance within the district was similar to the 2019/20 season (Figure 4.16). Estimated scallop discard mortality meat weight decreased by nearly 75% from the previous season and was the lowest since the 2015/16 season. The shell height composition of the 2020/21 fishery included at least three cohorts, including one large cohort less than 120 mm shell height that was discarded and two less numerous cohorts greater than 120 mm shell height that were retained (Figure 4.17).

Crab bycatch included 6,750 Tanner crab, 67 red king crab, and 1,496 Dungeness crab (Table 3.4). While Tanner and Dungeness crab bycatch underwent large decreases from the previous season, red king crab bycatch was the greatest in the timeseries and exceeded the red king crab bycatch limit (25 crab; Table 3.4) early in the season. The fishing vessel reallocated effort away from grounds where red king crab where caught, so the fishery was not closed prior to the season end date. Tanner crab sampled by observers were as large as approximately 150 mm carapace width, though the majority were less than 30 mm carapace width (Figure 3.1).

The 2021/22 Kodiak Southwest District fishery opened with a GHL of 35,000 lb of scallop meats. Preliminary retained catch was 35,080 lb shucked meats by two vessels, averaging a meat CPUE of 57 lb meat per dredge hour.

Table 4.9 Kodiak Southwest District scallop fishery summary statistics, 2009/10 – 2021/22.

Season	Number vessels	GHL (lb meat)	Retained catch (lb meat)	Retained catch (lb round)	Dredge hours[a]	Meat weight CPUE[a]	Round weight CPUE[b]	Discard mortality (lb meat)[c]
2009/10	1	25,000	3,480	62,241	159	22	392	75
2010/11	1	25,000	3,783	49,485	100	38	493	493
2011/12	1	25,000	25,110	348,142	455	55	766	335
2012/13	2	25,000	25,014	261,318	671	37	389	312
2013/14	3	25,000	21,715	241,692	549	40	440	371
2014/15	3	25,000	28,555	352,196	636	45	554	253
2015/16	2	25,000	15,614	208,140	417	37	499	132
2016/17	1	25,000	29,624	503,046	558	53	901	561
2017/18	1	25,000	29,200	384,891	441	66	872	1,756
2018/19	1	30,000	33,319	398,928	510	65	782	1,991
2019/20	2	35,000	35,010	450,977	636	55	709	1,740
2020/21	1	35,000	25,950	360,788	589	44	612	455
2021/22[d]	1	35,000	35,080		618	57		

[a] *lb scallop meat / dredge hour*
[b] *lb scallop round / dredge hour*
[c] *Calculated from round weight discard estimates assuming 20% mortality for discarded scallops and meat recovery of 10%.*
[d] *PRELIMINARY data subject to change.*
[e] *GHLs in prior to 2019/20 were based on the inclusion of scallop beds adjacent to the Karluk River*

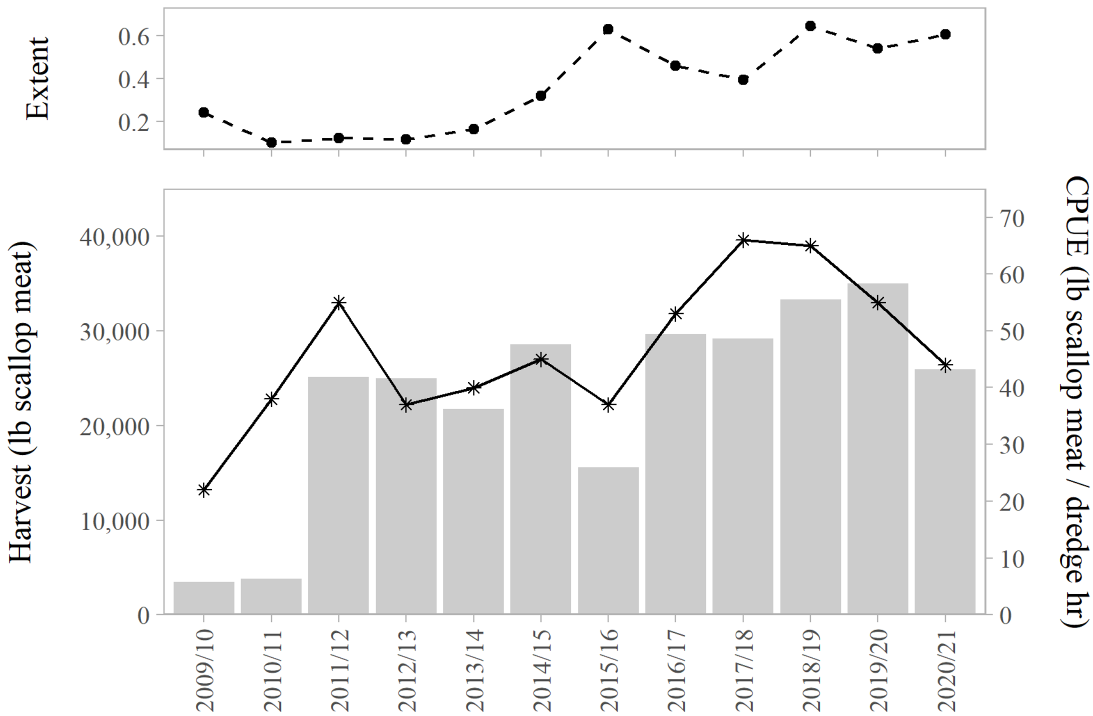

Figure 4.15 Kodiak Southwest District seasonal scallop harvest (gray bars) and CPUE (points) (Bottom). Index of spatial extent of the catch (Top).

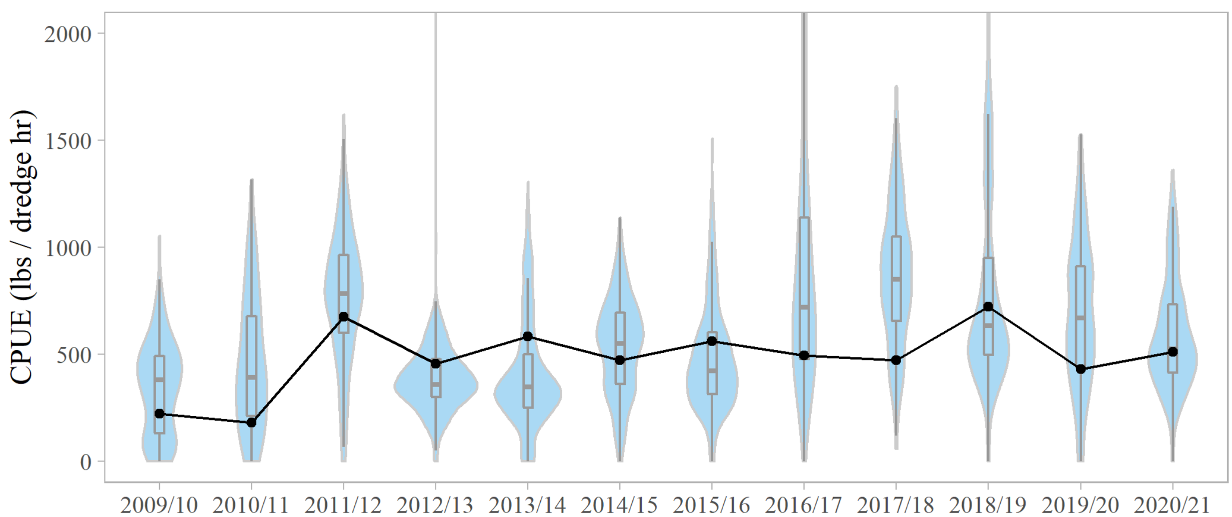

Figure 4.16 Violin plots of nominal CPUE (round lb / dredge hr) overlaid with standardized CPUE (round lb / dredge hr) by season (black line) in the Kodiak Southwest District.

Figure 4.17 Kodiak Southwest District retained and discarded shell height distribution for the 2009/10-2020/21 seasons.

Kodiak Southeast District

The 2020/21 Kodiak Southeast District scallop fishery opened on July 1, 2020 with a GHL of 15,000 lbs of scallop meats. No vessels participated in the fishery. The only recorded harvest in the Kodiak Southeast District occurred during the 2018/19 season under a GHL of 15,000 lb. Only 470 lb scallop meats were retained with a low CPUE (8 lb / dredge hr), which equated to 3,348 lb round weight retained (CPUE = 56 lb / dredge hr) (Table 4.10). Information on discards and shell height distributions are limited to one year with small sample sizes. Shell heights ranged from 75 to 175 mm and the bulk of retained scallops were 100–150 mm (Figure 4.18).

The 2021/22 Kodiak Southeast District fishery opened with a GHL of 15,000 lb of scallop meats, but no vessels participated in the fishery.

Table 4.10 Kodiak Southeast District scallop fishery summary statistics, 2018/19 – 2021/22.

Season	Number vessels	GHL (lb meat)	Retained catch (lb meat)	(lb round)	Dredge hours[a]	Meat weight CPUE[a]	Round weight CPUE[b]	Discard mortality (lb meat)[c]
2018/19	1	15,000	470	3,348	60	8	56	2
2019/20	0	15,000	0	0	0			0
2020/21	0	15,000	0	0	0			0
2021/22	0	15,000	0	0	0			0

a lb scallop meat / dredge hour
b lb scallop round / dredge hour
c Calculated from round weight discard estimates assuming 20% mortality for discarded scallops and meat recovery of 10%.

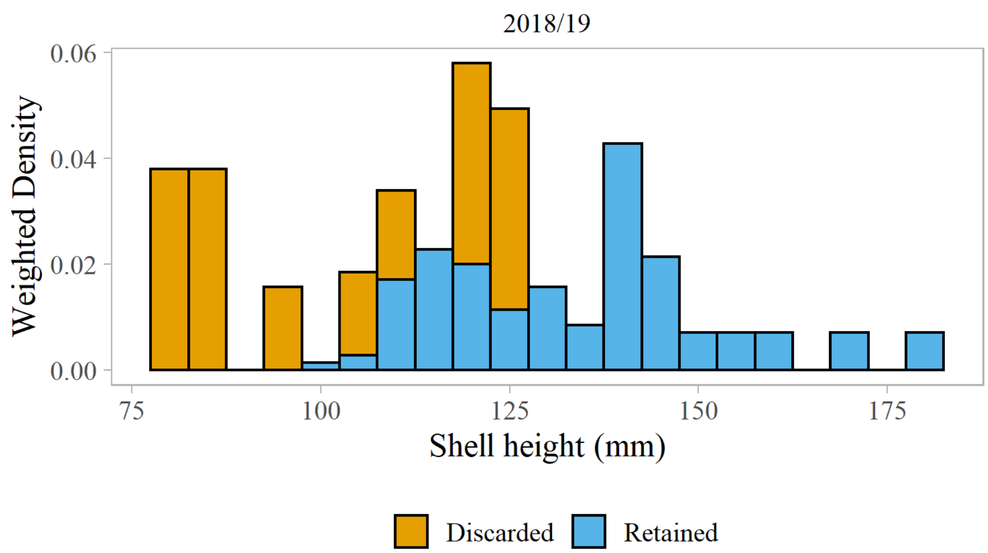

Figure 4.18 Kodiak Southeast District retained and discarded shell height distribution for the 2018/19 season.

Kodiak Semidi District

The Kodiak Semidi District has been open for exploratory fishing since the 2000 season, but no vessels fished within the district during 2020/21. The only recent fishing effort within the district occurred during the 2013/14 season, in which 11 hauls were made and less than 5 lb round weight of scallops were caught and discarded.

4.6 Alaska Peninsula Registration Area (M)

The Alaska Peninsula Registration Area (M) consists of the Unimak Bight, West Chignik, and Central Districts. GHLs for the 2020/21 season were set for the UB district (7,500 lbs) and waters between 160° W - 161°W longitude (7,500 lbs), which is within the C district. No vessels participated in the 2020/21 fishery (Table 4.11; Figure 4.19,Figure 4.20,Figure 4.21). Fisheries statistics presented in this document are for all districts combined.

The 2021/22 Alaska Peninsula Registration Area fishery opened with a combined GHL of 15,000 lb of scallop meats. No vessels participated in the fishery.

Table 4.11 Alaska Peninsula Registration Area scallop fishery summary statistics, 2000/01- 2021/22.

Season	Number vessels	GHL (lb meat)	Retained catch (lb meat)	(lb round)	Dredge hours[a]	Meat weight CPUE[a]	Round weight CPUE[b]	Discard mortality (lb meat)[c]
2000/01	3	33,000	7,660	92,874	320	24	290	24
2001/02		closed						
2002/03		closed						
2003/04		closed						
2004/05		closed						
2005/06	0	10,000	0	0	0			0
2006/07	2	25,000	155	2,936	64	2	99	2
2007/08	0	10,000	0	0	0			0
2008/09	1	10,000	2,460	31,870	154	16	207	16
2009/10		closed						
2010/11		closed						
2011/12		closed						
2012/13	1	15,000[e]	15,040	217,607	255	59	853	59
2013/14	1	15,000[e]	15,155	193,106	247	61	781	61
2014/15	2	15,000[e]	15,000	227,369	288	52	789	52
2015/16	1	15,000[e]	15,000	207,991	302	50	689	50
2016/17	1	15,000[e]	15,013	202,806	340	44	597	44
2017/18	1	15,000[e]	15,250	181,646	328	47	555	47
2018/19	1	15,000[e]	8,905	119,458	260	34	459	34
2019/20	1	7,500[e]	5,740	63,937	118	49	542	49
2020/21	0	7,500[e]	0	0	0			0
2021/22[d]	0	7,500[e]	0	0	0			0

a lb scallop meat / dredge hour
b lb scallop round / dredge hour
c Calculated from round weight discard estimates assuming 20% mortality for discarded scallops and meat recovery of 10%.
d PRELIMINARY data subject to change.
e Exploratory Unimak Bight District fishery opened by Commissioner's Permit

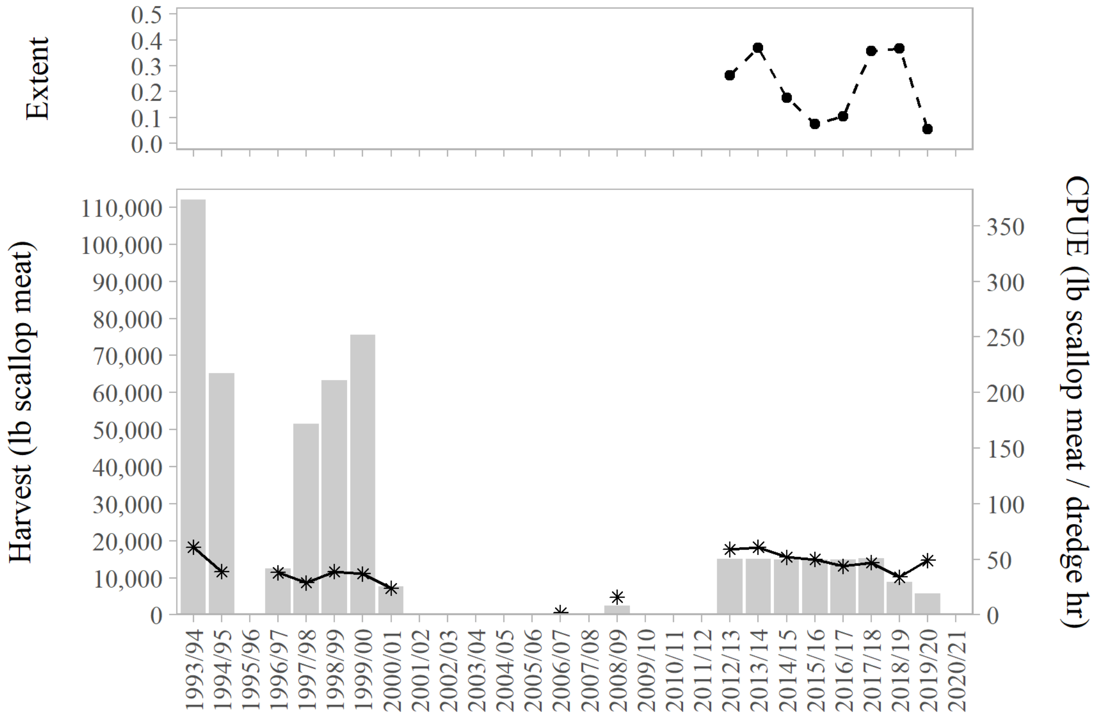

Figure 4.19 Alaska Peninsula Registration Area seasonal scallop harvest (gray bars) and CPUE (points) (Bottom). Index of spatial extent of the catch (Top).

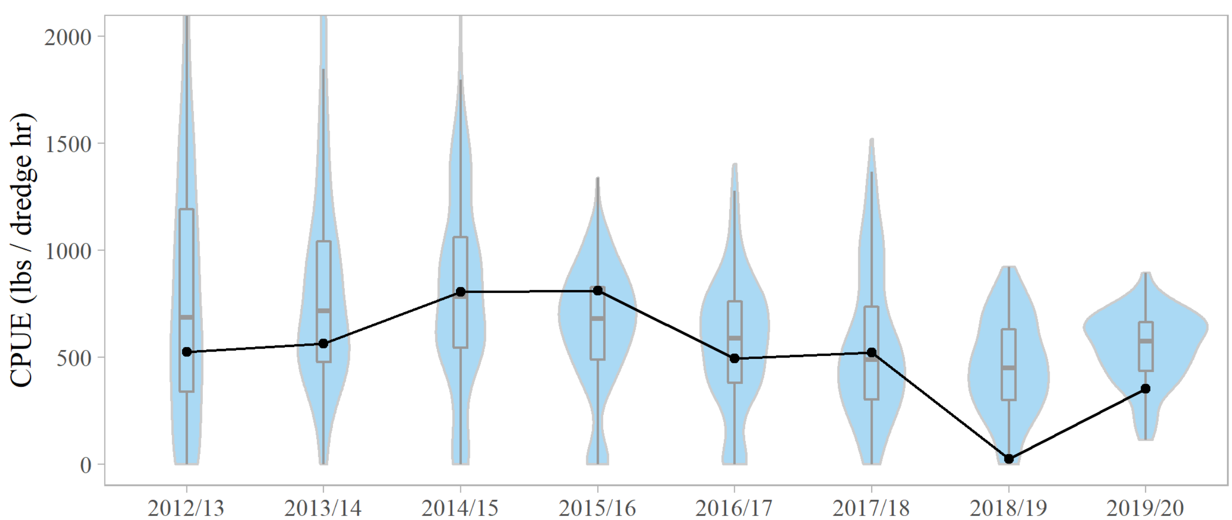

Figure 4.20 Violin plots of nominal CPUE (round lb / dredge hr) overlaid with standardized CPUE (round lb / dredge hr) by season (black line) in the Alaska Peninsula Registration Area.

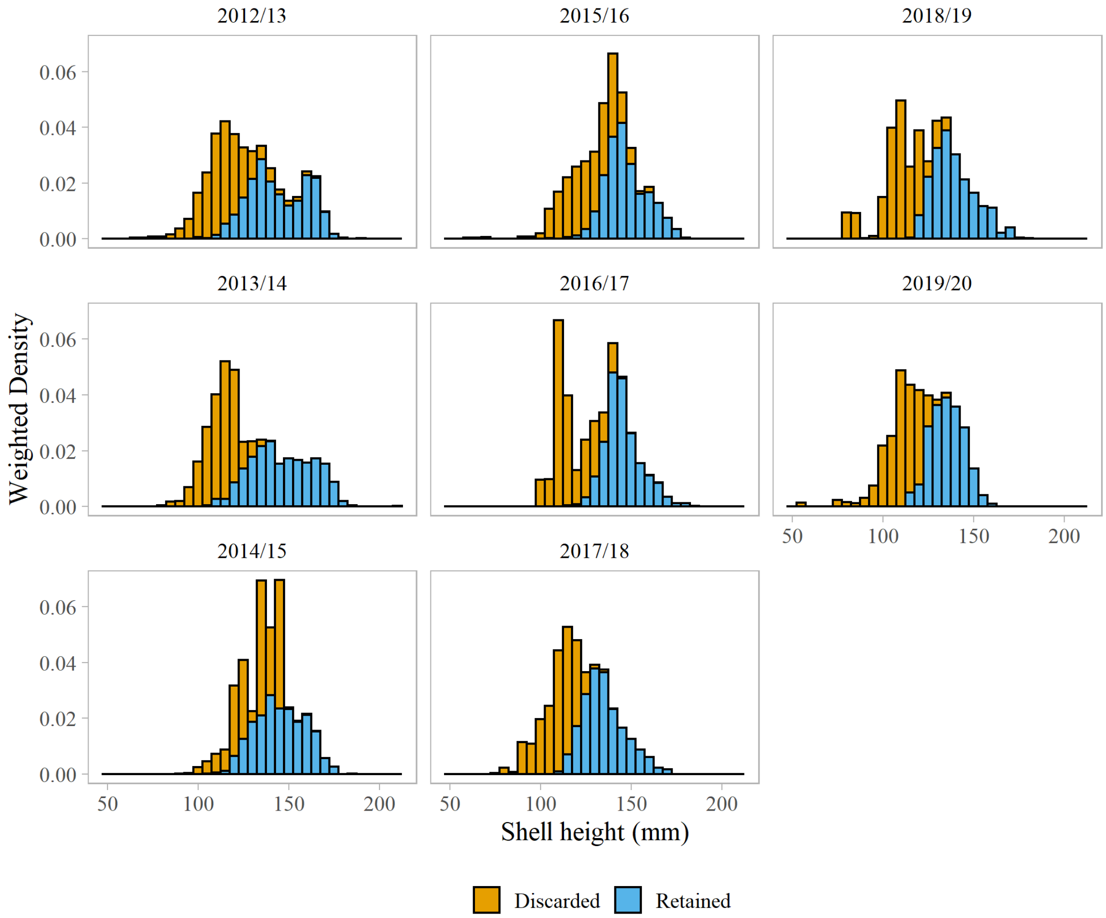

Figure 4.21 Alaska Peninsula Registration Area retained and discarded shell height distribution for the 2012/13 – 2019/20 seasons.

4.7 Dutch Harbor Registration Area (O)

Dutch Harbor registration area (O) consists of a single district, but is managed based on beds, one on the Bering Sea side and one on the Pacific Ocean side of Unalaska Island. During the 2020/21 season, the Pacific Ocean side was closed and the Bering Sea side was fished within a monitoring GHL of 5,000 lbs. No vessel participated in the fishery (Table 4.12; Figure 4.20, Figure 4.21, Figure 4.22). Fisheries statistics presented here represent both beds combined.

The 2021/22 Dutch Harbor Registration Area fishery opened with a GHL of 10,000 lb of scallop meats. No vessels participated in the fishery.

Table 4.12 Dutch Harbor Registration Area scallop fishery summary statistics, 2000/01 – 2021/22.

Season	Number vessels	GHL (lb meat)	Retained catch (lb meat)	(lb round)	Dredge hours[a]	Meat weight CPUE[a]	Round weight CPUE[b]	Discard mortality (lb meat)[c]
2000/01		closed						
2001/02		closed						
2002/03	1	10,000	6,000	59,066	177	33	333	87
2003/04		closed						
2004/05		closed						
2005/06		closed						
2006/07		closed						
2007/08		closed						
2008/09	1	10,000	10,040	93,077	191	53	488	654
2009/10	1	10,000	6,080	54,882	104	59	528	42
2010/11	1	10,000	5,640	42,177	83	68	506	65
2011/12	1	10,000	5,570	45,513	77	73	593	51
2012/13	1	5,000	5,100	37,730	64	79	588	54
2013/14	1	5,000	5,225	44,572	56	94	798	89
2014/15	1	5,000	5,160	41,323	73	70	563	78
2015/16	1	10,000	5,040	45,215	157	32	288	69
2016/17	1	10,000	5,050	39,181	104	48	376	26
2017/18	1	10,000	285	2,250	24	12	93	1
2018/19	1	5,000	325	3,571	24	14	152	1
2019/20	1	5,000	2,625	24,739	131	20	189	64
2020/21	0	5,000	0	0	0			0
2021/22[d]	0	10,000	0	0	0			0

a lb scallop meat / dredge hour
b lb scallop round / dredge hour
c Calculated from round weight discard estimates assuming 20% mortality for discarded scallops and meat recovery of 10%.
d PRELIMINARY data subject to change.

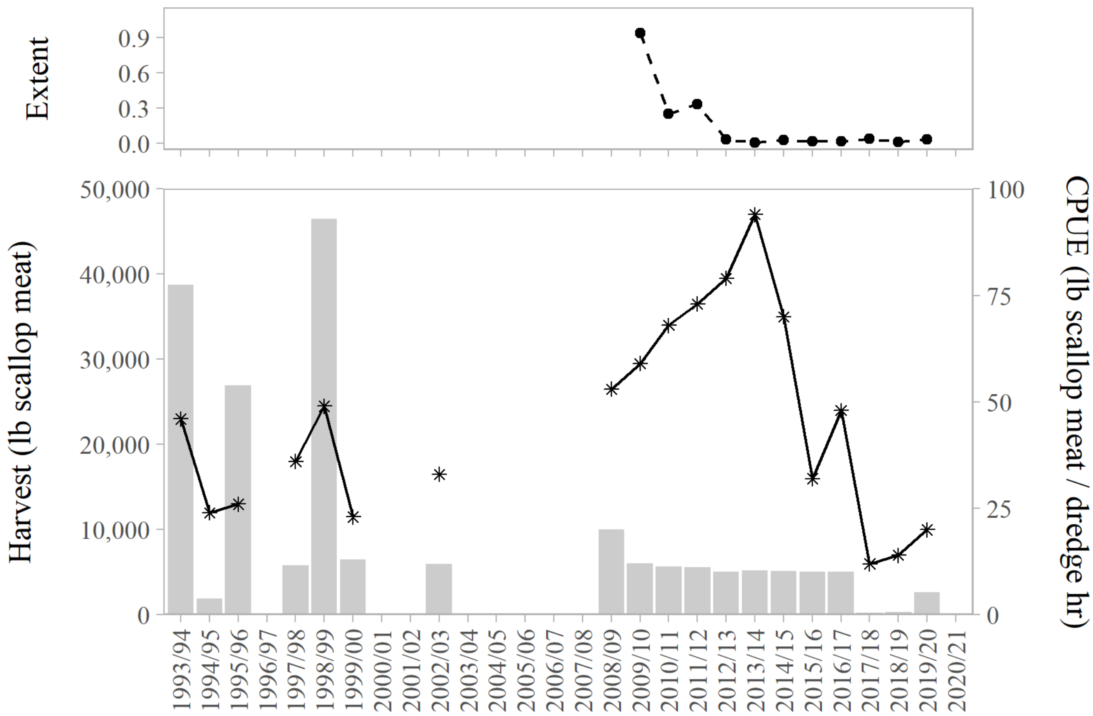

Figure 4.22 **Dutch Harbor Registration Area seasonal scallop harvest (gray bars) and CPUE (points) (Bottom). Index of spatial extent of the catch (Top).**

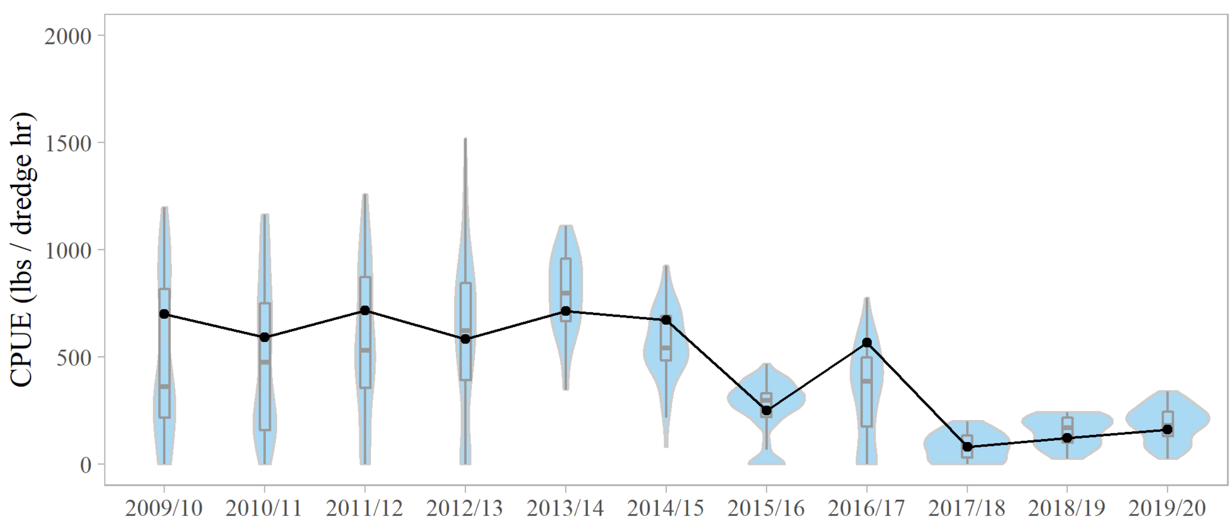

Figure 4.23 **Violin plots of nominal CPUE (round lb / dredge hr) overlaid with standardized CPUE (round lb / dredge hr) by season (black line) in the Dutch Harbor Registration Area.**

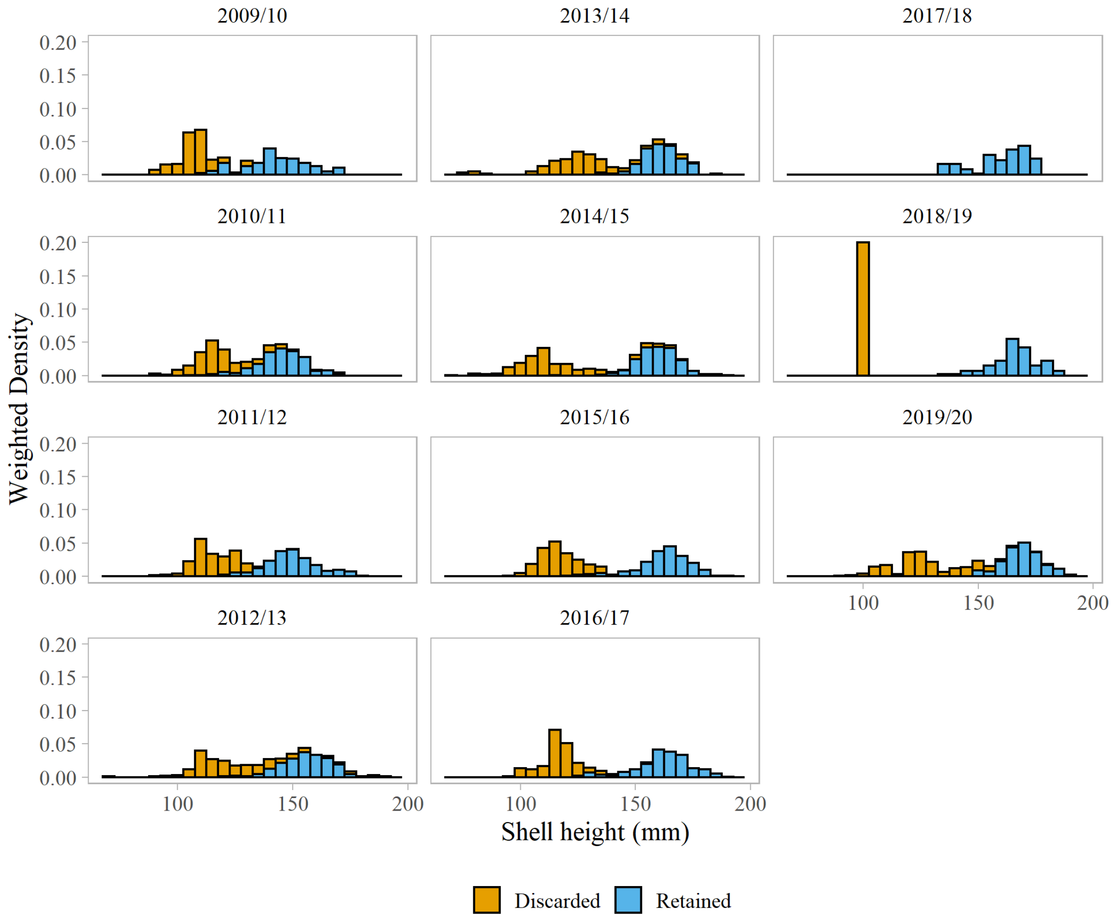

Figure 4.24 Dutch Harbor Registration Area retained and discarded shell height distribution for the 2009/10 – 2019/20 seasons.

4.8 Bering Sea Registration Area (Q)

The Bering Sea Registration Area consists of a single district, with fishing effort predominately occurring north of Unimak Island. The Bering Sea used to contribute a substantial proportion of the statewide harvest until the 2014/15 season, when scallop meat quality began suffering from weak meats. Since then, minimal GHLs have been used to maintain availability of fishery data. The GHL for the 2020/21 season was 7,500 lb., but no vessels participated in the fishery (Table 4.13; Figure 4.23,Figure 4.24,Figure 4.25).

The 2021/22 Bering Sea Registration Area fishery opened with a GHL of 7,500 lb. of scallop meats. No vessels participated in the fishery.

Table 4.13 Bering Sea Registration Area scallop fishery summary statistics, 2000/01 – 2021/22.

Season	Number vessels	GHL (lb meat)	Retained catch (lb meat)	Retained catch (lb round)	Dredge hours[a]	Meat weight CPUE[a]	Round weight CPUE[b]	Discard mortality (lb meat)[c]
2000/01	3	200,000	205,520	2,376,601	3,355	61	710	1,966
2001/02	3	200,000	140,871	1,700,500	3,072	46	559	1,531
2002/03	2	105,000	92,240	951,938	2,038	44	468	1,108
2003/04	2	105,000	42,590	537,552	1,020	41	527	689
2004/05	1	50,000	10,050	128,128	275	37	475	113
2005/06	1	50,000	23,220	231,700	602	39	386	349
2006/07	1	50,000	48,246	529,590	1,138	43	466	1,093
2007/08	2	50,000	49,995	697,288	1,084	46	647	990
2008/09	1	50,000	49,995	502,450	960	52	525	1,173
2009/10	1	50,000	48,921	595,602	1,275	38	467	1,078
2010/11	2	50,000	50,100	547,302	972	52	563	1,434
2011/12	2	50,000	50,275	529,235	984	51	538	619
2012/13	1	50,000	50,045	564,787	943	53	599	758
2013/14	2	50,000	49,989	561,033	1,086	46	517	422
2014/15	2	50,000	12,445	227,196	525	24	432	159
2015/16	1	7,500	7,500	107,337	307	24	350	93
2016/17	1	7,500	7,575	108,191	275	28	393	133
2017/18	1	7,500	7,535	105,668	316	24	334	78
2018/19	1	7,500	7,540	125,978	357	21	353	75
2019/20	1	7,500	7,130	106,177	365	20	291	123
2020/21	0	7,500	0	0	0			0
2021/22[d]	0	7,500	0	0	0			0

a lb scallop meat / dredge hour
b lb scallop round / dredge hour
c Calculated from round weight discard estimates assuming 20% mortality for discarded scallops and meat recovery of 10%.
d PRELIMINARY data subject to change.

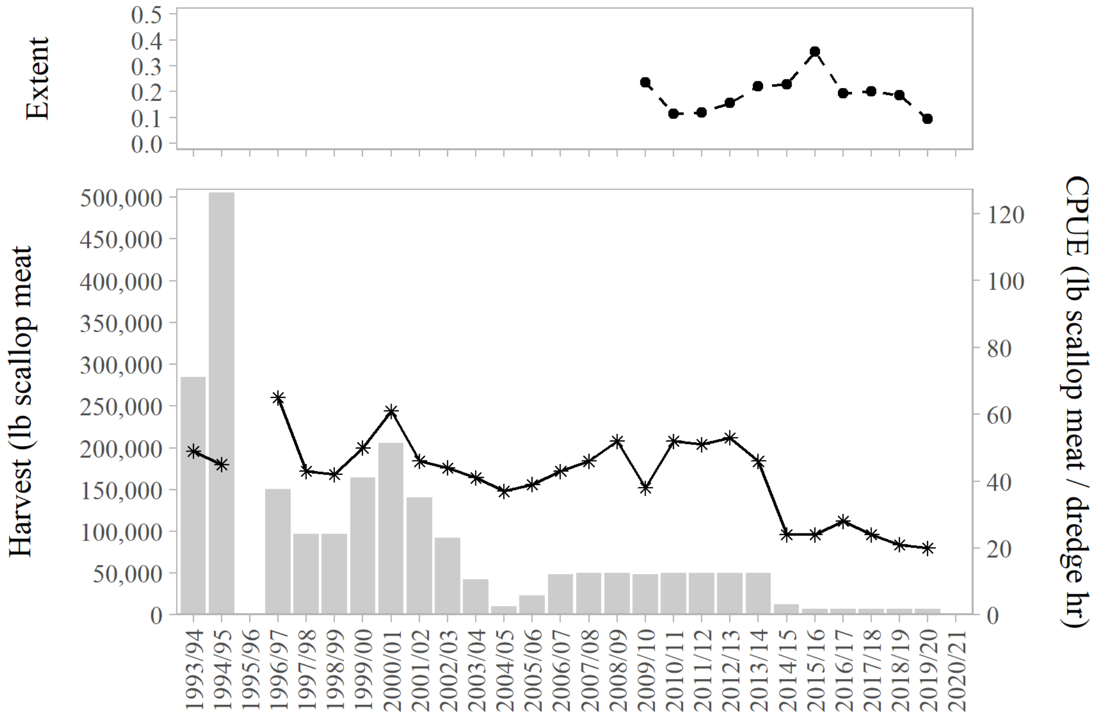

Figure 4.25 **Bering Sea Registration Area seasonal scallop harvest (gray bars) and CPUE (points) (Bottom). Index of spatial extent of the catch (Top).**

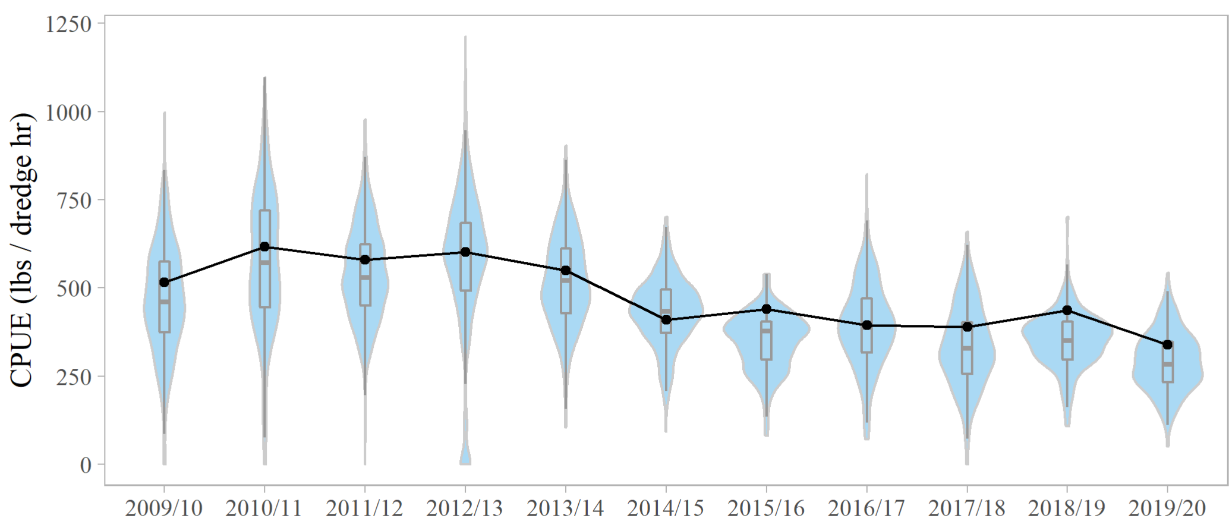

Figure 4.26 **Violin plots of nominal CPUE (round lb / dredge hr) overlaid with standardized CPUE (round lb / dredge hr) by season (black line) in the Bering Sea Registration Area.**

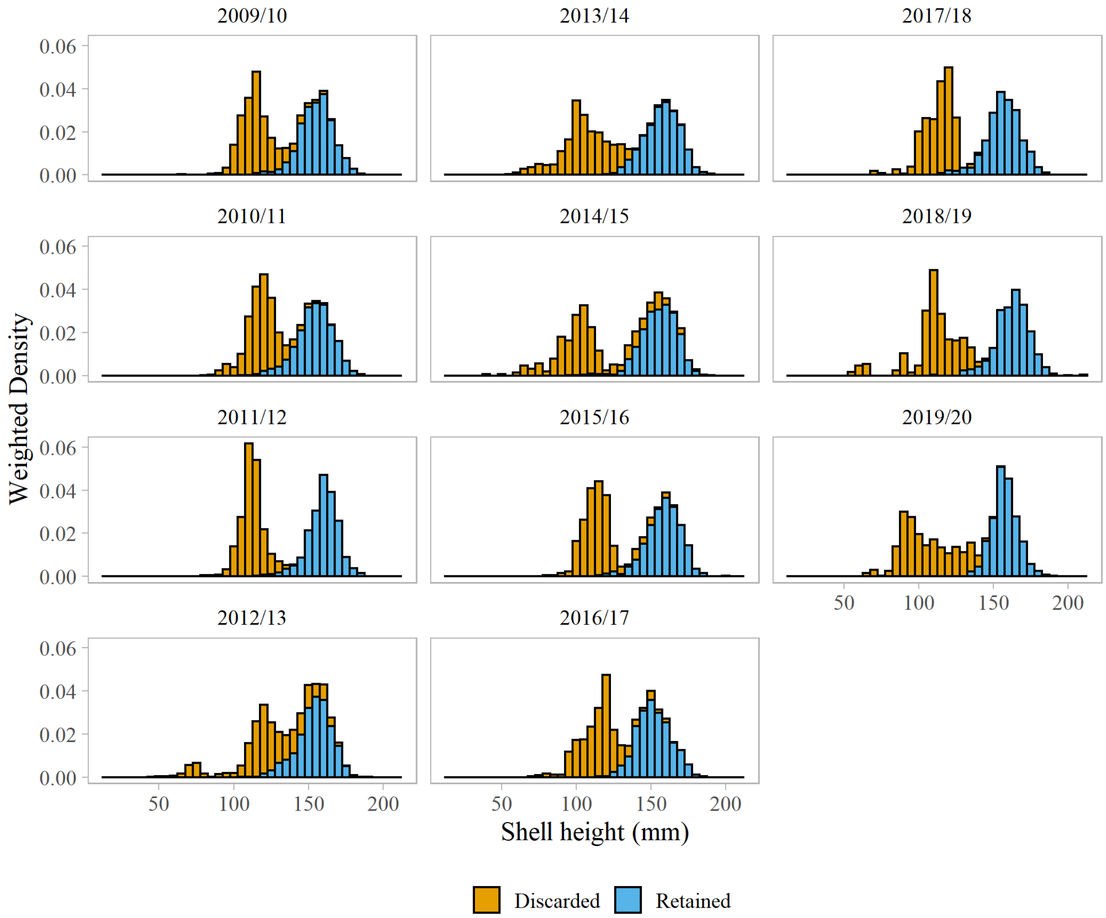

Figure 4.27 Bering Sea Registration Area retained and discarded shell height distribution for the 2009/10 – 2019/20 seasons.

4.9 Adak Registration Area (R)

Scallops were first harvested from the Adak Registration Area in 1979 with subsequent fishing periods in 1992 and 1995. Bathymetry of the Aleutian Islands, along with a narrow continental shelf edge, provides limited scallop habitat; however, a scallop bed was known to occur on Petrel Bank, an area of important red king crab habitat. To protect red king crab habitat on Petrel Bank, and reduce red king crab bycatch mortality, the waters were closed to commercial scallop fishing in 1991.

5 Ecosystem Considerations

The Ecosystem Considerations section was added to the SAFE in 2006, and the SPT hopes to continue improving the section. A wealth of information of climate effects on ecosystems and ecosystem trends contained in the GOA Groundfish Plan Team Ecosystems Considerations document is equally relevant to the scallop fishery and may be accessed at: https://www.afsc.noaa.gov/REFM/Docs/2017/ecosysGOA.pdf.

Commercial concentrations of weathervane scallops occur along the Alaska coast in elongated beds oriented in the same direction as prevailing currents. Image data from ADF&G CamSled tows show that benthic habitats where scallop fishing occurs in the Bering Sea, eastern GOA, and Shelikof Strait, consist predominately of fine sediments (silt, mud, and sand), with heavy sediment clouds regularly suspended by tidal currents. Areas of harder bottom and larger sediments are found inshore where scallop fishing occurs.

5.1 Ecosystem Components

In Amendment 13 to the Scallop FMP, a new category was created within the FMP for the 'Ecosystem Component" (EC). The non-target scallop stocks (pink, rock and spiny scallops) were moved into this EC under the FMP. Stocks contained under this category of the FMP are stocks which are not the subject of a directed fishery. For these stocks ACLs are not required to be annually specified.

No commercial harvests have been documented for scallop species other than weathervane scallops in waters off Alaska since at least 1992, but there are currently low-level personal use/subsistence fisheries for some of these species. Should a target fishery become desirable for any of these species, either as a whole complex or by individual stock grouping, an FMP amendment would need to be initiated by the Council to move the stock 'into the fishery' under the FMP and ACLs annually specified. Major fishery development is not anticipated for non-weathervane scallops, but market potential does exist for both pink (Chlamys spp.) and rock scallops (*Crassadoma gigantea*). The spatial distribution of non-weathervane scallop species is not well defined, although these species currently compose a relatively minor component of catches in both NMFS and ADF&G surveys (Table 5.1).

Table 5.1 Catch per unit effort (CPUE) (kg / km²) of *Chlamys* scallops in ADF&G trawl surveys in the Westward and Central Regions, by registration area.

	Area K		Area M		Area O		Area H		Area E	
Year	CPUE	CV	CPUE	CV	CPUE	CV	CPUE	CV	CPUE	CV
1988	2.85	5.45	0.00		0.00					
1989	0.95	10.46	38.23	2.98	0.00					
1990	3.68	4.37	38.15	5.57	17.69	2.48				
1991	23.77	3.30	0.00		0.00					
1992	99.72	3.33	2.07	5.19	0.00					
1993	0.21	9.86	0.41	9.89	0.00					
1994	0.55	13.29	4.28	4.26	27.93	2.38				
1995	1.60	6.34	0.00		14.10	4.11				
1996	0.42	12.74	5.06	6.60	0.00					
1997	0.40	9.54	36.43	3.95	0.00					
1998	0.66	16.40	24.01	3.83	0.00					
1999	0.20	16.03	3.65	3.68	22.26	2.68				
2000	0.86	6.52	16.03	3.82	15.63	2.72	13.77	0.50		
2001	0.37	7.02	8.37	5.90	0.00		10.01	0.64	0.00	
2002	0.06	13.38	7.81	3.70	0.00		1.61	0.42		
2003	0.17	9.19	2.06	5.46	5.94	3.29	2.49	0.70	0.00	
2004	0.18	23.34	0.40	7.28	6.49	3.89	16.52	0.75		
2005	0.15	8.54	0.15	10.69	2.33	2.45	2.97	0.50	0.11	1.00
2006	0.44	7.14	0.79	6.23	10.62	3.88	5.52	0.53		
2007	0.22	8.79	0.19	7.81	11.82	2.30	1.70	0.50	0.00	
2008	0.00		0.44	6.02	6.77	2.95	0.00			
2009	0.50	8.46	5.65	5.08	9.58	2.78	0.00		0.00	
2010	0.03	20.06	9.74	6.93	12.54	1.57	4.37	0.41		
2011	0.19	7.93	1.94	6.50	34.11	2.24	0.22	0.70	0.00	
2012	0.88	6.59	44.17	7.71	23.77	2.22	2.99	0.52		
2013	0.12	8.38	2.95	5.66	9.34	1.89	0.20	1.00	0.00	
2014	0.30	7.09	0.00		15.52	2.84			0.14	1.00
2015	0.59	6.40	0.07	6.56	4.10	3.17			0.00	
2016	0.16	13.98	0.65	5.50	2.42	4.50				
2017	0.39	7.26	2.18	4.64	0.57	3.45	0.00		0.00	
2018	0.51	8.53	6.11	4.41	13.38	2.27	0.40	1.00	0.00	
2019	0.41	6.32	5.78	5.76	29.39	3.50	0.12	1.00	0.00	
2020	0.43	7.50	5.50	6.61	0.00					
2021	0.20	10.85	5.52	7.20	7.24	2.10				

Table 5.2 Catch per unit effort (CPUE) (kg / km^2) of *Chlamys* scallops in the NOAA RACE Eastern Bering Sea Shelf Bottom Trawl Survey in the Bering Sea Registration Area (Q).

Year	CPUE	CV	Year	CPUE	CV
1982	0.02	0.53	2002	0.41	0.84
1983	0.04	0.73	2003	0.04	0.59
1984	0.23	0.56	2004	0.02	0.87
1985	0.01	1.00	2005	0.00	1.00
1986	0.00	0.98	2006	0.02	1.00
1987	1.58	0.97	2007	0.05	1.00
1988	0.25	0.55	2008	0.00	
1989	1.47	0.71	2009	0.11	0.99
1990	0.21	1.00	2010	0.65	0.79
1991	0.68	0.77	2011	0.00	1.00
1992	0.71	0.63	2012	0.05	1.00
1993	0.35	0.72	2013	0.05	1.00
1994	0.21	0.49	2014	0.17	1.00
1995	0.18	0.59	2015	0.00	
1996	0.03	0.73	2016	0.00	
1997	0.11	0.61	2017	0.02	0.99
1998	0.45	0.53	2018	0.00	
1999	0.68	0.98	2019	0.00	
2000	0.01	1.00	2020	0.00	
2001	0.53	0.61	2021	0.00	

Table 5.3 Catch per unit effort (CPUE) (kg / km^2) of *Chlamys* scallops in the NOAA RACE Gulf of Alaska Bottom Trawl Survey by registration area.

	Area O		Area M		Area K	
Year	CPUE	CV	CPUE	CV	CPUE	CV
1984	0.00		0.62	0.31	0.05	0.52
1987	2.75	0.89	0.13	0.31	0.83	0.78
1990	0.09	0.94	0.21	0.70	3.11	0.44
1993	0.08	0.48	0.23	0.58	0.51	0.38
1996	0.71	0.65	1.73	0.52	0.60	0.32
1999	0.57	0.41	1.06	0.32	1.49	0.27
2001	0.88	0.55	1.44	0.35	0.99	0.42
2003	0.41	0.50	0.58	0.24	2.92	0.25
2005	3.84	0.63	3.42	0.49	2.34	0.27
2007	1.49	0.45	1.47	0.45	1.68	0.56
2009	0.00		1.00	0.40	3.23	0.22
2011	0.60	0.99	0.56	0.51	2.58	0.65
2013	0.00		0.00		0.00	
2015	0.13	0.70	0.00		0.00	
2017	0.00		0.00		0.02	1.00
2019	0.00		0.00		0.00	
2021	0.60	0.59	0.74	0.45	0.09	0.47

	Area H		Area E		Area D		Area A	
Year	CPUE	CV	CPUE	CV	CPUE	CV	CPUE	CV
1984	0.17	0.83	0.02	0.97	0.05	0.67	0.00	
1987	0.53	0.83	0.02	1.00	0.00		0.00	
1990	1.37	0.92	0.00		0.00		0.00	
1993	0.06	0.73	0.00		0.00		0.00	
1996	0.00		0.14	0.99	0.00		0.04	0.89
1999	0.52	0.90	1.54	0.76	0.00		0.00	
2001	0.02	1.00	0.00					
2003	0.00		0.11	0.58	0.00		0.16	0.58
2005	0.03	1.00	0.00		0.00		0.00	
2007	0.00		0.00		0.00		0.00	
2009	1.21	0.68	0.82	0.81	0.00		0.00	
2011	0.00		0.00		0.00		0.15	0.71
2013	0.00		0.00		0.00		0.00	
2015	0.00		0.00		0.00		0.00	
2017	0.00		0.00		0.00		0.00	
2019	0.00		0.00		0.00		0.00	
2021	0.00		0.00		0.00		0.00	

5.2 Ecosystem Effects on the Stock

Weathervane scallops are distributed in dynamic relationship to other benthic marine organisms as well as the non-living components of the marine ecosystem off Alaska. Spatiotemporal ecosystem dynamics, therefore, influence the abundance and distribution of scallops and other benthic community organisms. A recent study by Glass and Kruse (2017) provides analyses of continental shelf benthic communities off Alaska in areas historically and currently targeted by the commercial Weathervane scallop fishery. Based on observer records of bycatch from 1996–2012 the researchers found significant changes in community composition associated with a temperature regime shift in 1998. Differences in community structure in the Kodiak Northeast and Yakutat management districts were correlated with abiotic ecosystem features such as depth and sediment size.

Species distribution models (SDM) were developed for most managed groundfish and crab species in Alaska as part of the Essential Fish Habitat (EFH) 5-year review (Simpson et al 2017). Scallops, however, were not included in this modeling effort due to a lack of data for SDMs. Glass and Kruse (2017) advance potentially useful information to defining EFH for scallops by characterizing the composition of biotic habitat in weathervane scallop EFH areas. According to the authors, further improvements in understanding scallop EFH could be achieved through bed-specific sampling of environmental variables.

5.3 Fishery Effects on Ecosystem

The Alaska weathervane scallop fishery occurs in continental shelf waters at depths 40–150 m in three main areas: the eastern Gulf of Alaska between Prince William Sound and Cape Spencer; around Kodiak Island; and in the eastern Bering Sea (Figure 1.1). There is strong evidence that scallop dredging reduces diversity, at least in the near term, however, the level of impact and the recovery rate tend to vary among habitat types (Collie et al. 2000; Kaiser et al. 2006). Past studies on the effects of scallop dredging in the Gulf of Alaska have found differences in community abundance and diversity for areas either open or closed to dredging (Stone et al. 2005). More recently, Glass and Kruse (2017) found evidence of recovery from disturbance by fishing gear in the Bering Sea scallop bed through increases in sessile benthic organisms during a period of decreased fishing activity. Although Glass and Kruse (2017) also found contrasting impacts in the Kodiak Shelikof district, the authors suggest that reductions in bycatch through self-regulatory fishing practices, extensive closure areas, and the small size of the fishery combine to constrain impacts, overall. It is proposed, however, that controlled fishing experiments that apply a before–after, control–impact (BACI) approach could be used to better characterize the effects of scallop dredging on benthic communities off Alaska.

A Fishing Effects (FE) model was developed to assess the effects of fishing on managed species as part of the 2017 EFH 5-year review (Simpson et al 2017). However, catch data for scallops was not available. For the 2022 EFH 5-year review, model authors will seek to include scallop fishery data into the FE model to estimate habitat reduction across modeled scallop habitat.

Effects on Predators: Little is known about scallop predators. Plankton feeders probably eat a large amount of floating larvae. Small weathervane scallops have been found in the stomachs of flounders, crabs, and sea stars. Sunflower sea stars and giant pacific octopus are known predators of weathervane scallops.

Bycatch: Scallop fishery bycatch is closely monitored by the onboard observer program. Bycatch in the scallop fishery includes prohibited species such as red king crab, Tanner crab, snow crab, and Pacific halibut, other commercially important species of fish and invertebrates, miscellaneous non-commercial species, and natural and man-made debris. Crab bycatch in the scallop fishery is highest in the Bering Sea, although this accounts for a small proportion of total Bering Sea crab bycatch.

Although a variety of marine vertebrates, invertebrates, and debris are caught incidentally in scallop dredges, weathervane scallops predominate catches. For example, during the 2009/10-2019/20 seasons, the most frequently caught species or items in the statewide scallop fishery by weight were weathervane scallops and scallop shells (94%), natural debris (kelp, wood, etc., 1.9%), sea stars (1%), several species of skates (0.8%), and brittle and basket stars (0.7%) (Figure 5.1).

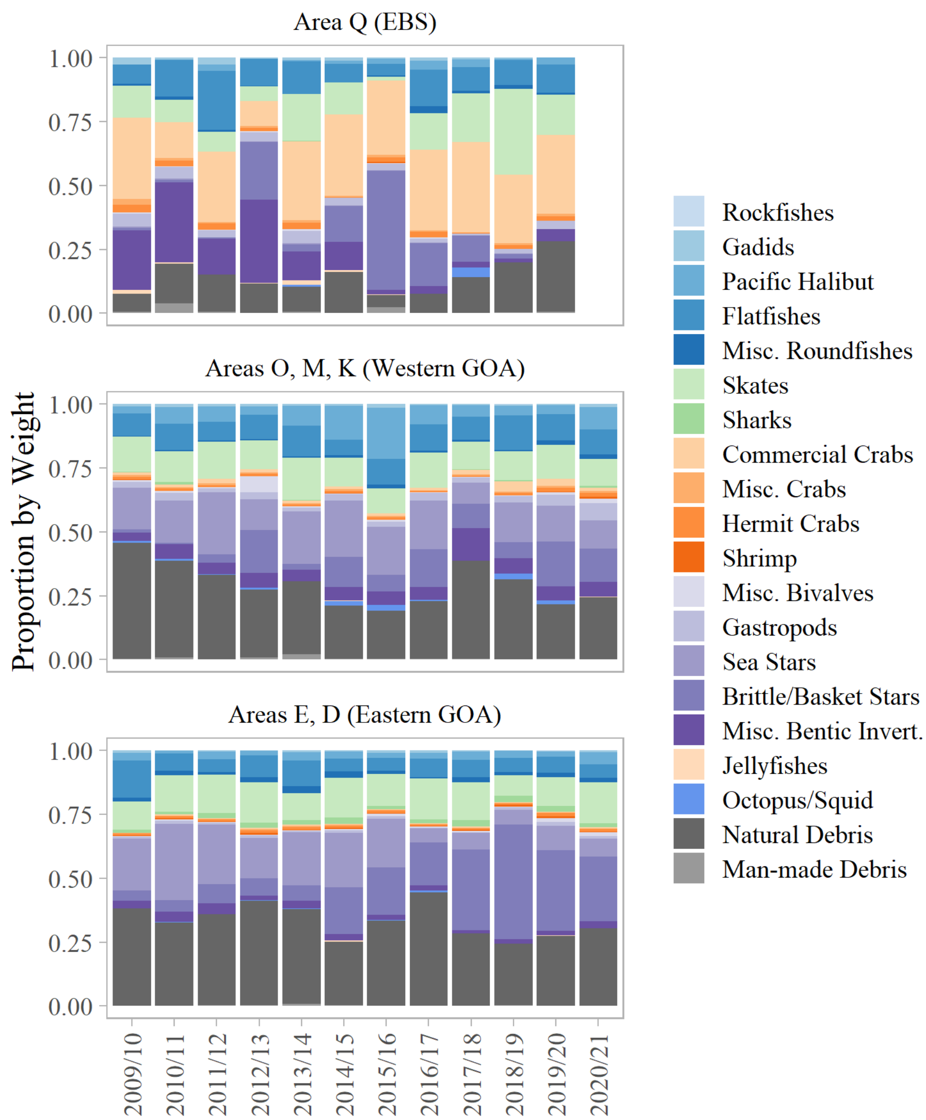

Figure 5.1 Bycatch composition by weight (excluding directed catch of weathervane scallops) from 2009/10 to present by groups of registration areas.

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Appendix 1: Response to SSC Comments

A1.1 Comments from April 2021

Comment: The SSC recommends that the Executive Summary should be as abbreviated as possible, and offers the following specific recommendations for content:

- **highlight important changes in ownership, community engagement, and general performance of the fishery relative to the GHL;**
- **highlight any social, economic, and biological issues that are of concern;**
  - **include a figure showing the time series of survey abundance and biomass indices, with associated uncertainty, by scallop bed. This should be included in addition to Table 2.**

Response: The SSC's recommendation on the executive summary is noted and will be addressed in the 2023 SAFE.

Comment: The SPT response did not include responses to the SSC comments from April 2018, April 2019, and June 2020 on outstanding social and economic issues. Scott Miller noted these comments will be addressed in the 2022 full SAFE and the SSC looks forward to responses to its comments.

Response: These responses are provided under subheadings below.

Comment: The SSC recommends the authors provide a detailed overview of the hierarchical sample design for the dredge survey and the new two-stage estimation methodology described in the response to comments.

Response: Notation for all dredge survey computations are found in Section 2.3.2 of this SAFE, but will not be included in future versions of the full SAFE because it is fully documented in Burt et al. (2021). Gear efficiency (q) is included in abundance and biomass computations via Equation (4).

Comment: The SSC recommends the authors check the Executive Summary SAFE document to ensure units of meat weight versus round weight are consistently applied in the report and clearly defined.

Response: The SPT has taken care to clarify reported statistics as either 'meat biomass' or 'round biomass', likewise, 'meat CPUE' or 'round CPUE', wherever present.

Comment: The SSC encourages continued research on scallop stock structure to improve the understanding of the scallop metapopulation and its relationship to Alaska-wide specifications (i.e., MSST, OFL and ABC) and bed-specific GHL management. Consideration should be given to the fraction of the area or the population that is being exploited relative to the total area/population available. The SPT response to comments indicated that a fishery extent index has been developed that evaluates the spatial extent of the fishery. The SSC looks forward to seeing details and results in the upcoming SAFE, and is interested in whether this method could be adapted to quantify the area exploited versus the total population area.

Response: The fishery extent index has been included in the SAFE as part of the Regional Fishery Performance section (4). The last paragraph of Section 2.2 details its meaning and computation. This method wouldn't specifically quantify the area exploited versus the total population area as is. It is currently considered by managers to add context to CPUE trends, for instance, managers might suspect hyperstability if CPUE shows an increasing trend, but extent of catch decreases over the same time period. Interpretation of the index is limited, as the nature of fishing effort is affected by multiple factors including the size of the GHL.

Comment: The SSC supports additional research to evaluate the current survey sample design and whether oceanographic and other environmental features are associated with scallop abundance, growth, and reproductive potential. The SPT report indicated that ADF&G is collecting in-situ environmental data at the scale of the survey. The SSC notes several existing data sources that may also be of use: the Gulf of Alaska Regional Ocean Modeling System (ROMS, contact Al Hermann, University of Washington), GOA Integrated Ecosystem Program and GOA biennial surveys, satellite derived oceanographic information (available via the NOAA ERRDAP serverhttps:// coastwatch.pfeg.noaa.gov/erddap/index.html), and 50 m resolution bathymetry GIS (contact Steve Lewis, NOAA-AKRO). The SSC notes that the ROMS output may provide information on oceanographic conditions that influence larval dispersal relative to scallop bed location and physical oceanographic processes. The SSC requests future progress reports on this research as it becomes available.

Response: ADF&G will continue to collect various data from CTD casts annually during the dredge survey, and bottom temperature data will continue to be collected by the ADF&G Westward Region Large-mesh Trawl Survey.

ADF&G was unable to make progress on obtaining ROMS data during this cycle, but will report to the SPT as progress is made on this objective.

Comment: The SSC recommends inclusion of these [ADF&G Westward Region Large-mesh Trawl Survey] data in the SAFE if available.

Response: 2021 ADF&G Westward Region Large-mesh Trawl Survey results are detailed in Section 2.4.

Comment: Investigations of recent trends in meat weight using both fishery and survey data are underway, and the SSC looks forward to seeing that work in the future. The SSC discussed whether trends in meat weight could be driven by environmental factors, such as temperature, versus the timing of the survey. The SSC recommends the authors consider including appropriate environmental, seasonal, and survey-timing variables in their analysis.

Response: This work is in progress and is following recommendations by the SPT and SSC, but no results were available for presentation and review during the 2022 plan team meeting. In the interim, it is not expected that fluctuation in meat weight at size will directly influence management as growth parameters are not used in determination of management quantities.

Comment: The SSC looks forward to a report on this [shell height conversion] research, wherein the authors compare the measurements under the new and old definitions and historical data used in the assessment.

Response: An ADF&G dredge survey special project was conducted to address this issue and results were presented to the SPT in 2022. Results will be documented in the 2022 SPT report and in a standalone ADF&G report after similar data is collected by observers during the fishery.

A1.2 Socioeconomic Comments from the April 2020

Comment: Additional work is needed to document the current limits of knowledge about crew share changes over time.

Response: We have included an estimate of potential crew shares over time since formation of the License Limitation Program. The estimate is based on several assumptions and one data point providing crew share cost percentages for two vessels that are now owned by cooperative members. That data is quite old. Further, data points on crew shares have been requested from industry but that data has not been provided (personal communication, Jim Stone, Alaska Scallop Cooperative, February 2018 Scallop Plan Team). Discussion of crew data collection efforts from a previous version of this chapter has also been added to the document.

There is no crew data collection program in the Alaska scallop fishery, nor has such a program ever existed. There is also no Economic Data Reporting program, as the fishery is not a catch shares program and would not be subject to cost recovery or MSA required program reporting.

There is anecdotal evidence described in the Regulatory Impact Review for Amendment 4 to the Scallop FMP (established the LLP program) that many crew in the early days of the fishery, and possibly into the 1990's, travelled from the U.S east coast to participate. Three LLPs are presently owned by east coast based entities, thus, one could speculate that if those entities acquire vessels they could bring crew in from the east coast Atlantic sea scallop fishery.

Several LLPs that are co-owned by cooperative members have corporate bases in the Seattle Tacoma area, and another is based in Kodiak. It is likely that crew are sourced from these areas.

Comment: Additional work is needed to better document changes in patterns of landings associated with cold storage availability and access to shipping routes.

Response: Available landings data from the recent past, including numbers of landing made each year, and ports that received landings is provided. However, some past landings data, included in previous versions of the economics chapter of the scallop SAFE report, misidentify some landings of products that were processed into frozen forms at sea, making that data erroneous. Correcting this issue would require obtaining raw data from the State's fish ticket system, building a new database, assigning staff to go through the landings data to correct it, and having staff potentially go through historic fish tickets to gain historic landings data. With other high priority issues to attend to, and the severe limitations we may face in displaying landings to shore based processors, as discussed below, this data correction effort begun but has not been completed.

Reporting landings in ports of fresh non-frozen scallop meats would, in most cases, involve deliveries to a single processor, raising confidentiality concerns. While it is true that Amendment 4 included provisions for confidentiality waivers by LLP holders, those waivers do not apply to shore based processors, as they were not directly regulated by the Amendment 4 action. Also, there is no equipment in regulation for scallop product transfer reports to be completed.

Comment: Additional work is needed to provide information on which taxes are applied to different types of landings or offloads/transfers

Response: Scallop harvests are taxed in different ways depending on where they are caught and on where they are landed. Scallops caught in State of Alaska waters are subject to the Fishery Business Tax, while scallops caught in Federal waters of the Exclusive Economic Zone are subject to the Resource Landings Tax. The Alaska Department of Revenue requires scallop fishing entities to record both where scallops were harvested as well as where they were landed. Additionally, there are local taxes, such as Kodiak's Natural Resources Severance tax for fish products harvested with in the Kodiak borough. These local taxes vary by community. Tax data for this fishery is not available due to confidentiality, just as a statewide scallop price is no longer provided by ADOR due to confidentiality concerns.

With regard to cold storage availability, this fishery is presently producing frozen at sea product that can be transferred to shore based freezers in any major fishing port, or to frozen shipping containers for barge transport. The cooperative vessels have utilized frozen storage capabilities primarily in Kodiak and the Seattle area and have periodically made landings for shipping in Yakutat, Juneau, and Sitka.

Fresh product can be sold locally, direct marketed, or sold to a processor for freezing. Since creation of the LLP program, it has been anecdotally reported that road side sales were occurring in the Homer area, and the fresh product was being delivered to Homer and Kodiak for processing. Shore based scallop processing would involve washing, grading, sizing, packaging, and freezing in a plate freezer. Some specialized equipment may be needed; however, most fish processing plants and possibly even custom processors could process scallops. Thus processing capacity and freezer capacity do not appear to be limiting factors.

Comment: Additional work is needed to clarify what product forms are currently being landed and how the forms have varied over time

Response: Historically, as this fishery was populated with several east coast vessels, the product would likely have been shucked meats delivered fresh for either fresh sales or for freezing. Processing capability has evolved over time and currently the Alaska Scallop Cooperative member vessels process the vast majority of their product into frozen at sea blocks. In recent years, the Kilkenny (independent of the cooperative) delivered shucked meats to a processor in Kodiak and one in Homer. There was also recently a change to Alaska law that allows live scallops to be landed from the Cook Inlet area; however, with nearby beds closed that product form has not been utilized.

Comment: Additional work is needed to elucidate changes in the frequency of landings over time by community

Response: The limitation of reporting such data are discussed above. The document does discuss the management history and trend in consolidation starting with the LLP program, permit transfers, cooperative formation, and present break even estimates, in the context of community involvement.

Comment: The SSC recommends that the analysts explore ways to use qualitative information, potentially in combination with indices of relative change, to portray the sustained participation (or lack thereof) of fishing communities in the fishery.

Response: The analysis does discuss the history of this fishery, both in terms of management structure and in terms of fishery performance. LLP ownership and fleet consolidation are extensively discussed as are the changes in vessel ownership over time. It is not clear what is meant by indices of relative change. The fishery has existed with 9 LLP since program inception in 2000. Six LLPs are members of a cooperative that has consolidated operations to two vessels to remain profitable and deliver to ports adjacent to the beds that they fish. Three LLPs are now owned by east coast interests that have not fished in recent years.

Comment: The SSC recommends that appropriately-sourced information on historical crew share levels and vessel haulout/repair locations provided in the presentation would also be useful additions to Appendix 2.

Response: Information on historical crew shares is largely unavailable. There is a highly caveated estimate of potential crew share per crew position contained in the documents. Currently active vessels are utilizing haul out facilities in Kodiak and all are home ported in Kodiak. We have no information on where vessels previously involved in the fishery did maintenance and haulout/repair.

Comment: The SSC recommends that appendix 4, which provides a brief history of the fishery, should be merged with Appendix 2, as there is substantial redundancy between the two.

Response: This has been completed.

Comment: References cited in both appendices should also be embedded within the final text.

Response: It is unclear whether this suggests embedding the references in the text of the appendix or in the references section of the main document. All references used in the appendix have been updated.

A1.3 Socioeconomic Comments from the April 2019

Comment: The SSC recommends that the analysts explore ways to use qualitative information, potentially in combination with indices of relative change, to illustrate the changes that have resulted in this fishery that involved 13 communities (according to the FMP) from the 1990s through the early 2000s, but is now apparently concentrated in a single community.

This represents an important case study of the sustained participation (or lack thereof) of fishing communities in a federally managed fishery, per National Standard 8. The

analysts intended to include social and economic data in the main SAFE, but because of the furlough, were unable to complete that task this year. The SSC recommends these data be integrated in the next full SAFE report.

Response: See responses to SSC comments from 2020. We have provided what we are able to and have an ongoing project to attempt to address issues with landings data for product processed at sea that would allow us to identify all landings by community since inception of the LLP in 2000.

A1.4 Socioeconomic Comments from the April 2018

Comment: The Scallop SAFE would benefit from a series of tables tracking a time series of annual quantitative indicators of sustained community participation, per National Standard 8. These could include:

- **LLPs by community of ownership address**
- **Active vessels by community of ownership address**
- **Active vessels by homeport (both as determined from vessel data and other sources)**
- **Active vessel diversity (fishing portfolio)**
- **Number of offloads by port**
- **Number of unique vessels making offloads by port**
- **Number of processors receiving deliveries by port**

Response: The 2017 Scallop SAFE appendix contained an extensive coverage of many of these items in Table 3 and in some textual discussions. That information has been updated. Of note, is that LLP ownership by community address is not included in public facing scallop LLP registration files provided on the NMFS website. Such information is required to be publicly disclosed for certain other permits but apparently not for scallop LLPs. An information request was directed to NMFS staff in the Restricted Access Management Division; however, staff indicated that the information is not in the database and would require retrieval of paper records going back 22 years to document original issuance addresses, all transfer applications, and annual LLP issuance. It is also not clear that such a data mining exercise would yield meaningful results, as all but one LLP are presently owned by Limited Liability Corporations with multiple owners and may utilize their Alaska Corporate agent addresses. The analysis does identify corporate homestate, and provides an analysis of individuals' corporate ownership percentages. This information has been in the Economics Considerations Appendix for several years and is presently the best information available.

Offloads by port and landings data are problematic and discussed in the responses to comments from 2020, above.

Comment: Additionally, brief narrative text qualitatively describing the major patterns of change tracked in these indicators (and, where possible, the drivers of those changes) would inform the nature, direction, and order of magnitude of community engagement in and dependency on the scallop fishery.

Response: This discussion is included in the section regarding fleet consolidation and it has been updated.

Comment: Further, some of the information provided in the economic analysis in the 2017 SAFE (pgs. 59-60) that was not carried forward would be beneficial to incorporate in future SAFE documents, including:

- **Crew size pre-co-op formation**
- **Attempted crew wage data collection effort in 2012/2013**
- **Vessel maintenance and repair work done in Kodiak**

Response: The 2017 Scallop SAFE appendix contained an extensive coverage of many of these items in Table 3 and in some textual discussions. That information has been updated. Of note, is that LLP ownership by community address is not included in public facing scallop LLP registration files provided on the NMFS website. Such information is required to be publicly disclosed for certain other permits but apparently not for scallop LLPs. An information request was directed to NMFS staff in the Restricted Access Management Division; however, staff indicated that the information is not in the database and would require retrieval of paper records going back 22 years to document original issuance addresses, all transfer applications, and annual LLP issuance. It is also not clear that such a data mining exercise would yield meaningful results, as all but one LLP are presently owned by Limited Liability Corporations with multiple owners and may utilize their Alaska Corporate agent addresses. The analysis does identify corporate homestate, and provides an analysis of individuals' corporate ownership percentages. This information has been in the Economics Considerations Appendix for several years and is presently the best information available.

Offloads by port and landings data are problematic and discussed in the responses to comments from 2020, above.

Comment: For example,

- **the Scallop FMP (February 2014) provides data on the number of offloads by specific port, but only for the years 1990-2003 (Table 5).**
- **The FMP is supplemented with community profiles (FMP Appendix F) for those communities that had landings of scallops in 1990-2003.**
- **However, while they were "intended to give an overview of the community, demographics, and involvement in North Pacific fisheries with particular emphasis placed on harvesting and processing of scallops,"**
- **data on engagement was limited to the year 2000 alone and 10 of the 13 community profiles contain no mention of scallops (Cordova, Ketchikan, Pelican, Petersburg, Sand Point, Seattle, Seldovia, Seward, Sitka, and Yakutat).**

Information on the scallop fishery presented for the other three communities was limited to the following:

- **Homer, 1 permit;**
- **Kodiak, 1 permit, 2 vessels delivered scallops, and scallop processing occurred;**
- **and Unalaska/Dutch Harbor, 1 vessel delivered scallops.**

Response: The FMP update of February 2014 addresses Amendment 15, revisions to EFH, and although the executive summary indicates that updates to catch date were made, landings data were not updated. As discussed in the response to 2020 comments, above, data by port in the LLP fishery is problematic for several reasons and this revision occurred around the time that the problems with frozen at sea product being misidentified as to port of landing was discovered.

The community profiles project utilized a community based survey that had varying success with survey response. Since scallop are landed primarily as a frozen product, respondents may not have fully understood that there was scallop offloading activity in their port, as there are no requirements for product transfer reporting in the scallop fishery. Homer, Kodiak, Yakutat and Unalaska/Dutch harbor have been consistent scallop fishery ports since formation of the LLP, for both cooperative affiliated vessels and independent vessels. Landings of frozen product have also occurred in Juneau, Sitka, and Seattle. At present, landings are occurring primarily in Kodiak. This information has been updated with port of landing data for the most recent three years and the appendix details a project that is now underway to determine whether historic landings by port since inception of the LLP program can be recovered.

At the time the most recent community profile work was being done the effect of the LLP creation had resulted in consolidation in the fishery. The cooperative had formed. Two east coast vessels had left the fishery but remained members in the cooperative for several years until their LLPs were purchased by the other cooperative members. An AFA affiliated vessel owner is a member of the cooperative but is subject to a restrictive AFA sideboard. A Homer based vessel had been repurposed, and another vessel that normally fished Cook Inlet had been sold with the associated LLP sold to an east coast entity. The three remaining cooperative affiliated vessels were the most active in the fishery. The remaining independent vessel continued to fish, and deliver fresh shucked meats to processors in Kodiak and Homer. Thus, the information provided regarding vessels is not incorrect. The information regarding permits seems to miss permit ownership of multiple permits in and around the Tacoma Washington metropolitan area. That ownership information is provided in the appendix.

Comment: This lack of basic information on the human dimensions of the fishery highlights the need to incorporate updated time series for community engagement indicator tracking in annual SAFE documents going forward.

Response: We will continue to report on catch, participation, revenue, ownership of LLPs and vessels, and any developments in the State of Alaska waters with new entry. We will also provide a market update.

Landings data are problematic, as has been discussed in response to comments from 2020, and progress on addressing that issue will depend on competing priorities and resources, with the understanding that much of the port delivery data for fresh product may be confidential.

We do not have any data on crew other than potential numbers of crew positions under the assumption that each participating vessel will carry the maximum allowed 12 crewmembers. However, the North Pacific Fisheries Management Council recently tasked staff to work with the Alaska Fish Information Network to develop a plan to collect some basic data, such as crew level data, across multiple fisheries. It is not likely that such a program will occur in the very near term, and it is not known whether the scallop fishery, as a primarily State managed fishery, will be included. Also, there is not, nor has there ever been, a Council mandated economic data collection program applied to the scallop fishery.

Appendix 2: Socioeconomic Considerations in the Scallop Fishery Off Alaska

Scott Miller
National Marine Fisheries Service

A2.1 Introduction

This chapter provides an update of available economic information in an attempt to identify factors that have contributed to major changes in the Alaska scallop fishery over time. Thus, the analyst is limited to landings, price, value, ownership, and basic marketing data and does not have access to current vessel operational costs, crew shares, or other economic information. Nonetheless, every effort has been made to utilize data submissions from industry for past analyses to highlight likely current conditions in the fishery.

The following overview of the management history of the fishery is largely excerpted from information presented in Appendix A of the current Scallop Fishery Management Plan (NPFMC, 2009) and incorporates that discussion and information sources identified in that discussion here by reference.

A2.2 History of the Alaska Weathervane Scallop Fishery

Fishery Management History

Alaska weathervane scallop *Patinopecten caurinus* populations were first evaluated for commercial potential in the early 1950s by government and private sector investigators. Interest in the Alaska fishery increased in the late 1960s as catches from U.S. and Canadian sea scallop *Placopecten magellanicus* fisheries on Georges Bank declined.

From the inception of the fishery in 1967 through mid-May 1993, the scallop fishery was passively managed with minimal management measures. Closed waters and seasons were established to protect crabs and crab habitat. When catches declined in one bed, vessels moved to new areas. This management strategy may have been acceptable for a sporadic and low intensity fishery; increased participation inevitably led to boom and bust cycles.

In the early 1990s, the Alaska weathervane scallop fishery expanded rapidly with an influx of boats from the East Coast of the United States. Concerns about overharvest of scallops and bycatch of other commercially important species such as crabs prompted the ADF&G Commissioner to designate the weathervane scallop fishery a high-impact emerging fishery on May 21, 1993. This action required ADF&G to close the fishery and implement an interim management plan prior to reopening. The interim management plan contained provisions for king and Tanner crab bycatch limits (CBLs) for most areas within the Westward Region. Since then, crab bycatch limits have been established for the Kamishak District of the Cook Inlet Registration Area and for the Prince William Sound Registration Area. The commissioner adopted the regulations and opened the fishery on June 17, 1993, consistent with the measures identified in the interim management plan. The interim management plan included a provision for 100% onboard observer coverage to monitor crab bycatch and to collect biological and fishery data. In March 1994, the Alaska Board of Fisheries (BOF) adopted the interim regulations identified as the Alaska Scallop Fishery Management Plan, 5 AAC 38.076.

From 1967 until early 1995, all vessels participating in the Alaska scallop fishery were registered under the laws of the State of Alaska. Scallop fishing in both state and federal waters was managed under state jurisdiction. In January 1995, the captain of a scallop fishing vessel returned his 1995 scallop interim use permit card to the State of Alaska Commercial Fisheries Entry Commission in Juneau and proceeded to fish scallops in the EEZ with total disregard to harvest limits, observer coverage, and other management measures and regulations. In response to this unanticipated event, federal waters in the EEZ were closed to scallop fishing by emergency rule on February 23, 1995.

The initial emergency rule was in effect through May 30, 1995, and was extended for an additional 90 days through August 28, 1995. The intent of the emergency rule was to control the unregulated scallop fishery in federal waters until an FMP could be implemented to close the fishery. Prior to August 28, NPFMC submitted a proposed FMP which closed scallop fishing in the EEZ for a maximum of one year with an expiration date of August 28, 1996. The final rule implementing Amendment 1 to the FMP was filed July 18, 1996 and published in the Federal Register on July 23, 1996. It became effective August 1, 1996, allowing the weathervane scallop fishery to reopen in the EEZ. Scallop fishing in state waters of the Westward Region was delayed until August 1, 1996 to coincide with the opening of the EEZ. The state continued as the active manager of the fishery with in-season actions duplicated by the federal system.

In March 1997, NPFMC approved Amendment 2, a vessel moratorium under which 18 vessels qualified for federal moratorium permits to fish weathervane scallops in federal waters off Alaska. By February 1999, the Council recommended replacing the federal moratorium program with a Federal License Limitation Program (LLP), which became Amendment 4 to the FMP (NPFMC 1999). The Council's goal was to reduce capacity to approach a sustainable fishery with maximum net benefits to the Nation, as required by the Magnuson-Stevens Act. These changes ushered in a new era in the scallop fishery off Alaska. The successes of the early exploratory years had now necessitated stock and effort management measures and capacity reduction.

NPFMC's preferred alternative for Amendment 4 created a total of nine licenses with no area endorsements; each vessel is permitted to fish statewide. However, vessels that fished exclusively in the Cook Inlet Registration Area where a single 6-foot dredge was the legal gear type during the qualifying period were also limited to fishing a single 6-foot dredge in federal waters outside Cook Inlet. The NPFMC later modified the gear restriction in Amendment 10 to allow these vessels to fish 2 dredges with a combined maximum width of 20 feet (NPFMC 2005).

Amendment 10 was approved on June 22, 2005. NMFS published final regulations on July 11, 2005, which were effective August 10, 2005. NMFS implemented Amendment 10 by reissuing the two LLP licenses with the larger gear restriction.

In 1997, the Alaska legislature approved legislation (AS 16.43.906) establishing a scallop vessel moratorium in state waters. In 2001, the legislature authorized a 3-year extension of the moratorium set to expire July 1, 2004. During the 2002 legislative session, passage of CSHB206 resulted in significant changes to the state's limited entry statutes. The changes authorized use of a vessel-based limited entry program in the weathervane scallop and hair crab fisheries. However, the program had a sunset provision. Under AS 16.43.450-520, the vessel permit system was set to expire on December 30, 2008 unless statutory authority was extended. Introduced in the 25th Alaska Legislature in January 2007, House Bill 16 would have extended the existing vessel permit system until December 30, 2013. House Bill 16 became locked in committee. It was offered up under Senate Bill 254, where it passed through the legislative process and was signed into law on June 5, 2008. The State's vessel-based limited entry program for weathervane scallops did expire on December 30, 2013.

In January 2014, the Board of Fisheries implemented a new State-Waters Weathervane Scallop Management Plan (5 AAC 38.078) that delineates additional tools needed to manage open-access weathervane scallop fisheries in waters of Alaska. The management plan applies to the Yakutat, Prince William Sound, Kodiak, and Dutch Harbor scallop registration areas, which all have scallop beds that span both state and federal waters. The new management plan is in addition to the existing Alaska Scallop Fishery Management Plan (5 AAC 38.076) that establishes registration, reporting, gear, and observer coverage requirements.

The state-waters management plan allows the department to manage scallop beds in waters of Alaska separately from beds in adjacent federal waters if effort increases in the open-access state-waters fishery. The plan defines the scallop vessel registration year (April 1 – March 31) and establishes an annual preseason registration deadline of April 1. It also requires a registered scallop vessel to have onboard an activated vessel monitoring system, permits the department to establish trip limits, and allows for separate registrations for state and federal-waters fishing. The additional management measures are necessary to prevent overharvest of the weathervane scallop resource during an open-access fishery.

In 2014, eight vessels acquired state open-access permits. None of these vessels fished for scallops, however. Information provided at the 2015 Scallop Plan Team meeting indicated that these vessels may not have fished due to the cost of carrying observers and/or a lack of needed scallop harvesting gear. In the years since, several vessel owners have obtained scallop permits but to date, none have participated in the fishery.

Historic Fishery Participation, Catch, and Revenue Pre License Limitation Program

Commercial fishing effort first took place in Alaska during 1967 when two vessels harvested weathervane scallops from fishing grounds east of Kodiak Island and made six landings totaling less than 1,000 pounds of shucked meats. By the following year, 19 vessels including New England scallopers, converted Alaskan crab boats, salmon seiners, halibut longliners, and shrimp trawlers, entered the fishery.

As shown in, Table 8-1 an additional 17 vessels entered the fishery in 1968 and the 19 vessels that participated made 125 landings totaling 1,677,268 pounds of shucked meats. In 1969, 19 vessels continued harvesting scallops and made 157 landings totaling 1,849,947 pounds of shucked meats. The 1969 fishery had the largest number of landings and the largest pound total in the history of the fishery. first wholesale value of the 1969 catch was just over $1.5 million (inflation adjusted value would exceed $6.6 million[1]). However, this level of harvest and effort was not to be sustained.

[1] Note that previous versions of this document provided inflation-adjusted values for the historic time series; however, at the urging of the SSC the inflation adjustment that has been provided in the economic section of the Scallop SAFE utilizes the Frozen and Processed Seafood Producer Price Index and that index is presently re-based to the year 1996, and not available for the historic time series of harvests shown here. The intent here is to show the changing scale of harvest and participation in this fishery and inflation-adjusted wholesale value from 1993/94 to the present is available in Table 8-1 below.

Table A2.1 Historic Statewide Commercial Weathervane Scallop Statistics, 1967-2019/20.

Year	Vessels	Landings[a]	Catch (lb meats)[b]	Average Price/lb	Wholesale Value	Real Wholesale Value
1967	2	6	778[c]	$0.70	$545	
1968	19	125	1,677,268	$0.85	$1,425,678	
1969	19	157	1,849,947	$0.85	$1,572,455	
1970	7	137	1,440,338	$1.00	$1,440,338	
1971	5	60	931,151	$1.05	$977,709	
1972	5	65	1,167,034	$1.15	$1,342,089	
1973	5	45	1,109,405	$1.20	$1,331,286	
1974	3	29	504,438	$1.30	$655,769	
1975	4	56	435,672	$1.40	$609,941	
1976	7	21	264,788	$1.59	$421,013	
1977-79			No Fishery			
1980	8	56	616,717[c]	$3.60	$2,220,181	
1981	18	101	924,441	$4.00	$3,697,764	
1982	13	120	913,996	$3.25	$2,970,487	
1983	5	30	192,310	$5.00	$961,550	
1984	6	52	383,512	$4.00	$1,534,048	
1985	7	47	615,564	$4.00	$2,462,256	
1986	8	74	667,258	$4.25	$2,835,847	
1987	4	54	599,947[d]	$3.45	$2,069,817	
1988	4	47	341,070	$3.68	$1,255,138	
1989	7	55	534,763	$3.87	$2,069,533	
1990	9	144	1,481,136	$3.43	$5,080,296	
1991	6	136	1,136,649	$3.82	$4,341,999	
1992	8	136	1,785,673	$3.96	$7,071,265	
1993[e]	7	51	568,077	$5.15	$2,925,597	
1993/94	15	111	984,583	$5.15	$5,070,602	$7,491,342
1994/95	15	104	1,240,775	$5.79	$7,184,087	$10,520,805
1995/96	10	29	410,743d	$6.05	$2,484,995	$3,737,433
1996/97	9	30	732,424	$6.30	$4,614,271	$6,419,856
1997/98	9	31	818,913	$6.50	$5,322,935	$7,028,704
1998/99	8	35	822,096	$6.40	$5,261,414	$5,945,280
1999/00	10	22	837,971	$6.25	$5,237,319	$5,297,194
2000/01	8	20	750,617	$5.50	$4,128,394	$4,779,911
2001/02	6	26	572,838	$5.25	$3,007,400	$3,495,463
2002/03	6	28	509,455	$5.25	$2,674,639	$3,059,055
2003/04	4	32	500,379	$5.25	$2,626,990	$2,707,200
2004/05	5	22	431,594	$5.50	$2,373,767	$2,674,427
2005/06	3	35	532,741	$8.02[f]	$4,272,583	$5,525,127
2006/07	3	21	486,564	$7.78[f]	$3,785,468	$4,916,922
2007/08	4	21	458,313	$5.94	$2,722,379	$3,499,537
2008/09	4	20	342,434	$6.34	$2,171,032	$3,009,430
2009/10	3	31	488,059	$6.48	$3,162,622	$3,807,175
2010/11	3	37	459,759	$8.35	$3,838,988	$4,269,364
2011/12	4	26	456,058	$10.39	$4,738,443	$5,678,577
2012/13	4	24	417,551	$10.63	$4,438,567	$4,488,507
2013/14	4	20	399,134	$12.25	$4,889,392	$4,988,904
2014/15	4	24	308,888	$12.39	$3,827,122	$4,050,401
2015/16	3	20	264,316	$12.22	$3,229,942	$3,152,920
2016/17	2	17	233,003	$12.53	$2,919,528	$3,017,693
2017/18	2	8	238,710	$11.54	$2,754,713	$2,782,610
2018/19	2	13	238,973	$11.26	$2,690,836	$2,690,836
2019/20	2	17	229,955	$11.26	$2,589,293	$2,589,293
2020/21	2	8	227,270	$10.43	$2,370,426	$2,370,426
2021/22	2	10	298,755	$11.06	$3,304,230	$3,304,230
10 year average	3	15	285,809	$11.56	$3,334,725	$3,770,910

(notes continued next page)

(Continued from Table 1 previous page)
Sources: ADF&G fish ticket data, and Alaska Department of Revenue annual fish prices through 2016, Industry provided prices, 2017-2021, preliminary estimated price for 2021/22.
[a] *Prior to and including 1995, number of landings equals number of fish tickets. After 1995, the number of landings equals number of deliveries (off-loads). A delivery typically includes multiple tickets, normally one per week.*
[b] *Pounds of shucked scallop meats.*
[c] *Unshucked scallop deliveries were converted to shucked meats using a 10 percent conversion factor.*
[d] *Includes illegal harvest.*
[e] *January 1 through June 30*
[f] *estimated by fresh product ex-vessel price and limited first wholesale product value data.*

Data from 1970 suggest that there may have been relatively few vessels landing most of the scallops during 1968 and 1969. This appears so because only 7 vessels remained in the fishery in 1970 despite an 18 percent increase in the average nominal price per pound. These 7 vessels made 137 landings totaling 1,440,338 pounds of shucked meats, which was 78 percent of the harvest taken by 19 vessels the previous year. The first wholesale value of the 1970 catch was about $1.4 million, or an average of more than $205,000 per vessel. While this revenue picture appears rosy, there is no data available on operating costs or effort levels in the early days of this fishery, and the trend during the rest of the 1970's suggests that the fishery was not as lucrative as the 1970 revenue numbers suggest.

In 1971, effort fell to 5 vessels and remained at 5 vessels for several years before falling to 3 vessels in 1974. During those years, landings fell from 137 in 1970 to 29 in 1974. However, shucked meat totals stayed near or above 1 million pounds through 1973 before falling by more than 50 percent to approximately a half million pounds in 1974. Prices continued to rise over this time frame, however, the declining catch forced revenue to decline to just over $421,000 in 1976 when 264,788 pounds, just 14 percent of the 1969 peak harvest, of shucked meats were caught. In 1977 and 1978, no effort was expended in the weathervane scallop fishery off Alaska.

The period of 1967 to 1976 demonstrates what can happen in an emerging fishery with passive management. There were no effort controls, limits, or guideline harvest levels in place. The fishery expanded rapidly as scallop beds were located and exploited, experienced substantial effort consolidation as marginal vessels departed, and eventually overexploited the known beds to the point that the fishery was not economically viable by 1977 and 1978. This could have been the end of the weathervane scallop fishery off Alaska, except for the fact that scallops are somewhat resilient and discoveries of new beds had yet to be made.

In 1979, following two years with no harvest, a single vessel made 4 landings totaling less than 25,000 pounds. of shucked meats. Three years of zero or minimal effort had likely allowed the scallop resource to regenerate somewhat. That likelihood, combined with a price increase to $3.80 per pound contributed to 8 vessels making 56 landings totaling about 617,000 pounds in 1980.

Given fishing success in 1980 and significant price increases to $3.60 per pound, it is not surprising to see that 1981 participation increased to 18 vessels that made 101 landings totaling 924,441 pounds of shucked meats. The 1980 first wholesale value was approximately $2.2 million and rose to nearly $3.7 million in 1981. However, data for the next several years show a similar cycle as occurred between 1969 and 1974. By 1983, five vessels made 30 landings totaling less than 200,000 pounds of shucked meats. However, 1983 was the year of record high nominal prices of $5 per pound so first wholesale value was nearly $1 million.

Over the next several years, participation increased slightly as did landings and catch but repeated the cyclical pattern by trending back downwards before another cyclic increase in landings and catch began in 1989. Beginning in 1990, an influx of East Coast scallop vessels began to occur; once again this was because of unfavorable economic conditions in East Coast scallop fisheries. The upward trend continued into 1992, when the second highest historic catch of 1,785,673 pounds was taken by 8 vessels making 136 landings. The first wholesale value of over $7 million recorded in 1992 is the second highest nominal first wholesale value ever recorded in the fishery and if inflation adjusted is the historic high value in the history of this fishery.

This period of this fishery has been characterized as a “gold rush atmosphere” (Barnhart, 2006). It is also important to note that by this time, scallop beds had been located in several areas around Kodiak Island, in Shelikof Strait, near Yakutat, in the Northern Gulf of Alaska near Kayak Island, in Cook Inlet, as well as in the Aleutians and Bering Sea.

Catch statistics shown in table 1 for the 1993-94[2] season indicate participation by 15 vessels making 111 landings of a total of 984,583 pounds of shucked meats. Total first wholesale value was just over $5 million in 1993-94. The 1994-95 season also had participation by 15 vessels making 104 landings totaling 1,240,775 pounds. Total first wholesale value in 1994-95 was nearly $7.2 million, the highest nominal value in history.

A2.3 Economic Performance in the LLP Fishery

An overview of Alaska weathervane scallop harvest and wholesale revenue and real wholesale value is presented in Table 1. Vessel participation in this fishery has declined since the late 1990s due to the Federal LLP and formation of a voluntary marketing association which will both be discussed in detail below. The Federal LLP limits the participation to 9 permit holders. In the early 2000s as many as 8 vessels have participated; however, since 2014 no more than 4 vessels have participated. In each of the past four years two vessels have participated, as the harvest levels have fallen to historically low levels.

Table 1 provides estimated statewide commercial Weathervane scallop landings and value from 1993/94 to present. Total real gross first wholesale revenue is calculated by multiplying landed pounds of meats by the adjusted price. Adjusted price converts the landed prices by year-to-year 2019 values to allow for comparisons in current dollar values, after accounting for inflation. The statewide scallop price used here is calculated by the Alaska Department of Revenue (ADOR), Division of Taxation, and is an average of all the reported annual State fish tax revenue collected from all participants in the scallop fishery as reported on Commercial Operators Annual Report submissions.

The majority of the scallop meats that are landed have been processed (shucked) and frozen at sea and their value represents gross revenue at the first wholesale level. However, in some past years some shucked meats were delivered fresh to dockside processors (pers. comm, Bill Harrington, February 2013). There have also been some anecdotal reports of scallop meats landed and sold in a roadside stand outside of Homer in the distant past. In 2018, the Alaska Board of Fisheries approved a proposal to allow delivery of live scallops; however, none of the current Scallop LLP holders have delivered live scallops to port to date. Thus, although landed price is often referred to as an ex-vessel price, it is actually primarily a first wholesale price in that the landed product is a primary processed product. As a result, gross revenue is identified as first wholesale gross revenue here.

Nominal Alaska scallop prices have shown considerable variability over time and have increased dramatically since the mid-2000s. After trending downward to $5.25 per pound in the early to mid-2000s, nominal scallop prices increased to $7.86 by the 2006/07 season. However, in the 2007/08 season the nominal scallop price declined significantly to $5.94 per pound of shucked meats. Since the 2007/08 season, nominal Alaska Weathervane scallop price has trended upward and reached $12.53 per pound of shucked meats in 2016/17 but fell to $11.54 in 2017/18 and $11.26 in 2018/19 and 2019/20. Prices declined in the first of the Covid-19 pandemic to $10.43 in 2020/21, but have rebounded to an estimated $11.06 in 2021/22. The historical variability in Alaska scallop prices are likely due to market factors that are driven by the much larger U.S. east coast sea scallop fishery, as well as by import markets. However, in recent years, the

[2] The seasons established in the management plan extend into the first three months of the following year.

Alaska Scallop Association has made considerable progress in its marketing efforts and has been able to maintain relatively high prices it receives for the scallops landed by the three vessels that are associated with the cooperative. However, the strength in Alaska scallop prices have faced market pressure in the in recent years as indicated by declines in U.S. commercial sea scallop average price per pound from $12.52 per pound in 2014 to $12.00 per pound in 2016 and below $10 per pound as supply expanded in 2017 but has risen to $12.18 in 2018, declined to $9.39 in 2019 and rebounded to $10.53 by 2021. The average price per pound of imported scallop products declined from $7.11 to $6.40 between 2015 and 2017 and continued declines to $5.24 and 5.93 in 2018 and 2019 respectively, and to $5.35 in 2020 before rebounding to $5.86 in 2021. Please see section 8.4 for further discussion of competing scallop markets.

First wholesale revenue in this fishery has varied considerably over the period as both price and landings have varied. The peak value in the fishery, occurred in 1994/95 season when inflation adjusted $10.5 million was earned. Since that time, real total first wholesale revenue in the fishery has fluctuated with prices, and the reduction in landed pounds. Overall, the total value has trended downward as landings have fallen from more than 1.2 million pounds down to a preliminary low in 2019/20 of 229,955 pounds. The total real first wholesale revenue of less than $2.4 million in 2020/21 is lowest revenue total historically. The 2021/22 fishery earned $3.3 million as catch and prices both increased. It is difficult to predict what market forces will materialize post pandemic.

Port of Landing and Impacts on Communities

At the present time all Alaska scallop harvests are landed in ports within Alaska. However, during the 2020-21 fishery one scallop vessel transited from Seattle to the fishing grounds and back to offload at Fishermen's Terminal in Seattle due to Covid 19 quarantine (pers. Comm, Jim Stone, via e-mail February 25, 2022). The vessels that fish within the Alaska Scallop Association make landings of frozen product in several ports including, but not limited to, Dutch Harbor, Kodiak, Yakutat, Juneau, and Sitka (pers. comm, Jim Stone, February 2013). Given that these landings are often made by a single vessel in a port, these landings would normally be confidential; however, Amendment 4 included provisions for confidentiality waivers for LLP holders. In addition to the cooperative vessels, one vessel has made landings of fresh product in Homer and Kodiak in the past decade. However these landings are made to too few processors for the quantity and value to be released due to confidentiality restrictions, as shore based processors do not provide confidentiality waivers. Thus, it is not possible to release landings by port on fresh product that is then processed or sold directly. Furthermore, there is no economic data collection program in place to collect vessel expenditure data while vessels, and crew, are in port. Unfortunately, the limits of confidentiality and limited expenditure data make it difficult to establish the potential importance of this fishery to dependent communities.

The ADF&G office in Kodiak has reviewed fish ticket data and is able to provide the total number of scallop landings in the most recent three seasons, as well as the number of scallop landings by port. Table 8-2 shows that ten or fewer total landings have occurred in each year, and they have occurred in Dutch Harbor, Homer, Kodiak, Yakutat, and recently Seattle due to Covid 19 quarantine protocols. Kodiak is presently receive a majority of the landings.

Table A2.2 Scallop Landings by port, 2019-2022.

Port	Season 2019/20	2020/21	2021/22
Dutch Harbor	1		
Homer	1		
Kodiak	5	5	8
Yakutat	3	2	2
Seattle		1	
Total	**10**	**8**	**10**

Source: ADF&G Kodiak Scallop Program Office, 2022

The ADF&G office in Kodiak (Ryan Burt) has researched difficulties with reporting landing by port of frozen at sea product since formation of the LLP program. In that process, several historic landings spreadsheets were located and fish ticket data was preliminarily reviewed to provide the landing by port for the past three seasons. ADF&G staff have begun to develop a plan to try to recover the landings data and will use the following process to recover the data as time permits:

- Create a dedicated Access database for this project
- Download select columns of scallop fish ticket data from the State's fish ticket system and import into Access database
- Import spreadsheets of historic fish ticket data from the Kodiak office file server and import into Access database
- Using the unique fish ticket numbers, create data queries to compare these data sets against each other to determine what data is useful from the fish ticket and/or spreadsheet data
- If port of landing cannot be recovered from the fish ticket and/or spreadsheet data, a request (listing unique fish ticket numbers) may need to be submitted to Information Services in Juneau so staff there can physically retrieve select archived fish tickets
- Assign Kodiak staff to go through these retrieved fish tickets to recover port of landing data
- Create queries to summarize the data as needed for incorporation into analysis

There have been several developments in this fishery with regard to the permanent location of vessels and with maintenance and repair of these vessels. All three cooperative associated vessels, that are presently fishing, are now permanently home ported in Kodiak. In addition, the one non-cooperative vessel presently fishing is also permanently home ported in Kodiak.

With the installation of a new 600 ton Marine Travelift, virtually all maintenance and repair work is now done in Kodiak (Stone, Jim, public testimony at the 2018 Scallop Plan Team meeting February 2018). Thus, at present, all landings of Alaska scallops are made in Alaska ports, all vessels presently operating in the fishery are home ported in Kodiak, Alaska, and the Port of Kodiak is able to provide the necessary facilities for haul out, repair, and annual maintenance that these vessels require.

A2.4 License Limitation Program Permit Ownership, Consolidation, and Current Participation

A review of fish ticket data suggest that, in the early days of this fishery, much of the harvest was made by catcher vessels (CVs) making single day trips and delivering to shoreside processors. The shoreside processors then processed the meats (e.g. trim, freezing, and packaging) and moved the product to market, whether in fresh or frozen form. That method appears to have continued into the mid 1990's. At that time, single day trips had begun to be replaced by multiday trips and freezing at sea by catcher processors (CPs). This change was likely the result of some vessels earning marginal returns due to the cost of daily transit to and from port as well as the 10 day maximum that shucked meats can be held on ice by a CV (Kandianis 2006) The further vessels operated from port the more severe this inefficiency became. As new beds were found in distant areas some vessels likely found their participation was not economically sustainable. This fact was likely exacerbated by the fact that harvesters had little or no market power.

Under these conditions, vessel operators are constrained by the inefficiency of the day trip and external market forces dictating the value of their catch. Thus, operators would look to reduce inefficiencies, reduce operating costs, and attempt to capture processing value added that was being captured by the shoreside processing sector. Operators might even attempt to improve value by increasing quality. It can be argued that fresh frozen (at sea) product may be superior to product that is iced for a period of time before being consumed and/or frozen. The result of these forces appears to be the entrance of catcher processors (CPs) into the scallop fishery. That this began to happen should be no surprise. It was around this time that the CP fleet began to expand in several of the Bering Sea fisheries for many of the same reasons. This practice expanded over the next several seasons. By the time the vessel moratorium was imposed in 1997 there were 18 vessels included under the moratorium.

Further consolidation of the fleet was deemed necessary by the North Pacific Fisheries Management Council. In 1999 the Council adopted Amendment 4 to the Scallop FMP, which established the Federal License Limitation Program (LLP) (NPFMC 1999). The LLP recognized 9 participants and granted them statewide access with maximum vessel length overall (MLOA) limits (equal to the length of the vessel they were using during the qualifying period) and with gear restrictions for two vessels that primarily fished inside the Cook Inlet registration area. All of the remaining 7 participants in the statewide fishery outside the Cook Inlet registration area were using vessels categorized as CPs. Thus, at the time of the LLP, virtually all effort in the statewide fishery outside the Cook Inlet registration area was from CPs. Thus, the transition away from the inefficiency of day trips, the capture of shoreside processing value added by offshore processing, and any potential improvement in quality brought about by at-sea freezing appeared to be complete by the time of LLP implementation in 2000. However, further fleet consolidation was predictable, and had already begun.

The Regulatory Impact Review (RIR) analysis supporting the action to create the LLP (NPFMC 1999) develops a breakeven analysis for the scallop fishery in the statewide fishery outside the Cook Inlet registration area. This analysis estimates the number of vessels that could breakeven in the fishery under a series of price and landings scenarios. The analysis is based on operating cost and revenue data provided voluntarily by fishery participants. Table 3 presents the analysis.

Table A2.3 Number of Vessels that Could Breakeven Under Various Price and Landings Scenarios (recreated from Regulatory Impact Review for Amendment 4 to the North Pacific Scallop FMP).

Price	Landing (pounds)			
	600,000	800,000	1,000,000	1,200,000
$5.00	3.6	4.9	6.1	7.3
$5.50	4.0	5.3	6.7	8.0
$6.00	4.4	5.8	7.3	8.7
$6.50	4.7	6.3	7.9	9.5
$7.00	5.1	6.8	8.5	10.2
$7.50	5.5	7.3	9.1	10.9
$8.00	5.8	7.8	9.7	11.6

In the 1999/00 season 10 vessels, including two inside the Cook Inlet registration area, landed 837,971 pounds of scallops with an average price of $6.25. The analysis recreated in Table 8-3 indicates that approximately 6 vessels could breakeven fishing in the statewide fishery outside the Cook Inlet registration area under this price and landings scenario. Thus, participation in the statewide fishery outside the Cook Inlet registration area exceeded the breakeven number of vessel by two.

In 2000/01 8 vessels, including two operating inside the Cook Inlet registration area, landed 750,617 pounds of scallops with an average price of $5.50 per pound. The breakeven analysis suggests that this price and landings combination could probably support 5 vessels in the statewide fishery outside the Cook Inlet registration area; however, 6 were fishing in that season.

In 2001/02 6 vessels, likely four in the statewide fishery outside the Cook Inlet registration area, landed 572,838 pounds of scallops with an average price of $5.25 per pound. The breakeven analysis suggests that this landings and price scenario could support fewer than four vessels at breakeven levels and this appears to be the case in 2002/03 as well.

In 2000 a group of six of the LLP holders, who traditionally have fished in the statewide fishery outside the Cook Inlet registration area, formed a voluntary marketing cooperative (NPFMC 2005). The cooperative members agreed to reduce harvesting capacity and entered into revenue sharing agreements with members who agreed to not use their vessel(s). That the cooperative chose to do this is not surprising given the effect of declining landings and price on breakeven numbers in this fishery between 2000/01 and 2002/03.

In 2001, the cooperative reduced vessel participation by 50 percent, however, one vessel continued to operate independently in the statewide fishery outside the Cook Inlet registration area. Two vessels continued to fish independent of the cooperative inside the Cook Inlet registration area. Thus, capacity reduction efforts made by the cooperative had reduced overall capacity but not to the level suggested by the breakeven analysis presented above.

A point worth considering is that several of the LLP holders who had joined the cooperative had, at one time, been involved in the East Coast Atlantic sea scallop fishery. This was true of the LLP associated with the vessels Carolina Girl and Carolina Boy and the vessel Pursuit. The Pursuit was operating out of Kodiak when the LLP was implemented and the Carolina Boy and Carolina Girl were operating out of Seward (Barnhart, 2006). Each of these operations, however, was East Coast based and likely had to bear costs of travel to and from the east coast, or vessel caretaking costs during the off-season, and idle vessel time. These factors likely contributed to these three vessels not fishing under the cooperative and limiting participation.

Another consideration is that the Kamishak beds traditionally fished by the two primarily cook inlet vessels have been closed for some time. The south bed has been closed since the 2008/09 season, while the north bed was last open for fishing during the 2017/18 season. During the 2017/18 season, the GHL was 10,000 lb shucked meats, and no vessels participated in the fishery. The Kamishak District remained closed for the 2021/22 season. Further, the outside waters adjacent to the Kenai peninsula and outside of Prince William Sound are fished via a Commissioner's permits, as the area have very limited scallop beds, necessitating enhanced management of harvests. These restrictions, combined with the gear restrictions (maximum of 20 foot total dredges) may have significantly contributed to the elimination of active participation in the scallop fishery by LLP holders that previously had operated out of Homer and Seward, and likely caused reductions in deliveries to historic scallop ports of Homer, Seward, and Cordova. All vessels that historically fished these areas have been sold or lengthened and repurposed.

Instead of fishing, the owners of the LLP that originally used the east coast vessels received some form of revenue and/or ownership sharing while the other cooperative members continued to fish. Evidence of this was presented in Appendix A to the Environmental Assessment conducted for Amendment 10 to the FMP (NPFMC 2005). Provider Inc. and Ocean Fisheries LLC provided operating cost data for their scallop fishing enterprise in 2003. This data shows that these two operators paid $244,516 in "scallop leases" in 2003.

The fees paid by Ocean Hunter and Provider Inc. could only be afforded if the operations gained considerably more revenue and/or if they are able to decrease operating costs under the cooperative. The breakeven analysis presented in the RIR for Amendment 4 (LLP establishment) to the FMP determined that the average fixed and variable non-labor costs of the fleet at the time (pre LLP, pre coop) was approximately 59 percent (NPFMC 2005, Appendix B).

The data provided by Provider Inc. and Ocean Hunter/ Ocean Fisheries LLC in 2003 indicate a non-labor cost ratios of 59 percent and 57 percent for Provider and Ocean Hunter respectively. However, these non-labor cost ratios include fees of $157,493 paid by Provider Inc. and $87,097 in fees paid by Ocean Hunter. Thus, these two cooperative vessels were able to maintain the same, or slightly lower, cost ratio inclusive of leases paid to other cooperative members totaling $244,516. Overall revenue for the remaining vessels increased with fewer vessels fishing, and it is likely that payments to labor, including owner shares, increased with greater overall revenue and similar non-labor cost ratios.

While the cooperative initially limited effort by using revenue sharing to compensate owners of unused vessels, a more permanent effort reduction began to take place in 2002. It is important to understand that Federal Alaska Scallop LLP permits are not directly associated with a specific vessel. The only vessel requirement on the LLP permit is that it cannot be used on any vessel larger than the MLOA assigned to the LLP. Further restrictions are that no more than two LLPs may be held by one individual.

In contrast, the Alaska Commercial Fisheries Entry Commission (CFEC) Limited Entry Scallop permit, which was allowed to sunset in 2014 and no longer exists, was specifically attached to a vessel. Thus, through 2013, to fish in both Federal and State waters, one had to have a Federal LLP and would need to use the actual vessel assigned the CFEC Limited Entry permit if also fishing in State waters. However, if one wanted to fish only in Federal waters they could use any vessel so long as it was under the MLOA of that LLP and was not an American Fisheries Act (AFA) vessel (sideboarded by State statue). Alternatively, if an individual or entity were to purchase a Federal LLP, they would not be required to actually fish the LLP, nor would they then have need of a CFEC Limited Entry licensed vessel.

Starting in 2002, the members of the cooperative wishing to remain in the fishery formed several Alaska corporations with shared ownership, purchased the interest of those who no longer wished to remain in the fishery, and consolidated operations on three vessels. There was one additional original cooperative member, Forum Star Inc. The vessel Forum Star was an AFA eligible vessel and has been permitted as such since 2000. Under Amendment 8 to the FMP authority was delegated to the State of Alaska to set an AFA sideboard in the scallop fishery. The State set a limit of approximately 35,000 pounds (Barnhart, 2006) at present stock levels, on that vessel making its active participation in scalloping likely not profitable.

In 2005, Forum Star Inc. and its Scallop LLP were purchased by American Seafoods LLC, also an AFA entity. If the LLP held by American Seafoods LLC remains in the control of an AFA entity, it will continue to be restricted by the AFA sideboard. It is, however, important to note that the LLP itself is not AFA endorsed. This means that it could presumably be sold to a non-AFA entity. As long as a vessel no longer than 97' (the MLOA allowed under Federal Scallop LLP #002) with no AFA endorsement is used with LLP #002, the AFA sideboard restriction would not apply. Thus, an existing scallop operation could buy this LLP and use it on a 97 foot non-AFA vessel under current federal regulations (50 CFR 679.4, 50 CFR 679.7). Alternatively, an existing entity would not have to use it at all as just holding the second permit means more scallop harvest for the remaining vessels.

Table 4 provides a summary of LLP holdings and changes in those holdings over time separately for independent operators and for cooperative members. The three LLPs not associated with cooperative members have also gone through several permit transfers and organizational changes. LLP #003, and the vessel Kilkenny that has most recently been used to fish that LLP, is presently identified in State permit records as owned by Atlantic Cape Fisheries Inc. of New Jersey. Atlantic Capes has not fished that LLP since it was purchased.

LLP #004 was originally registered to Max G. Hulse, and was transferred to Scott Hulse in 2018. The vessels historically utilized by the Hulse family have been lengthened and re-purposed and would no longer be eligible to fish the LLP. As of 2022, Scott Hulse has transferred the LLP to Ty Babb of Maine. Mr. Babb did not participate in the Scallop Plan Team meeting in February of 2022 and his intentions for fishing scallops in Alaska are unknown. He is also a registered Bristol Bay salmon permit holder.

Finally, LLP #006 was most recently transferred to EWT LLC, which was an Alaska LLC with ownership by U.S. East coast scallop interests. However, EWT LLC was involuntarily dissolved by the State of Alaska either due to non-filing of renewal and/or nonpayment of fees. EWT LLC is, however, registered in New Bedford, Massachusetts. The vessel historically used to fish this LLP has been sold by the original LLP holder and is not owned by EWT LLC interests. Thus, none of these three original LLPs are currently directly associated with vessel ownership but could be used on any vessel that meets the MLOA restrictions and gear restrictions for the LLPs.

Also shown in Table 4 are the present owners of LLPs associated with the Alaska Scallop Cooperative. The information provided includes corporate and individual ownership percentages which will be discussed further below. At present, there are effectively two cooperative associated vessels fishing in the statewide fishery outside the Cook Inlet registration area: Ocean Hunter, and Provider. However, Arctic Hunter LLC recently replaced the Arctic Hunter with the Polar Sea, thus, the cooperative has three vessels, all homeported in Kodiak, that are prepared to fish scallops and these are the only known vessels owned by entities that also own LLPs.

Table 4 provides the ownership percentages of Alaska Weathervane Scallop LLPs, by Alaska Corporation. Alaska corporate records available online include the ownership percentages of each identified owner and they are presented in Table 4 as well(ADOC, 2022). Several of the identified owners of LLPs that are associated with the Alaska Scallop Cooperative are Washington based corporate entities. Table 6 provides available information from Washington corporate records online regarding the individuals who own these Washington corporations, (State of Washington, 2022). Unfortunately, Washington State does not publicly identify ownership percentages. For this analysis, it is assumed that a single identified governor of a Washington corporation holds 100 percent ownership, and when two governors are identified it is assumed they each hold equal 50% shares. Table 5 identifies these individuals and the assumptions regarding their ownership shares.

Utilizing the Alaska corporate LLP ownership percentages and the ownership percentages of individual owners of the Washington corporations identified in Alaska corporate records it is possible to assign ownership shares of each LLP to the individual owners and to tabulate cumulative ownership shares of Alaska Weathervane scallop LLPs attributable to Alaska Scallop Cooperative members. This ownership attribution is provided in Table 6 for each cooperative member, individually, and shows that the highest level of cumulative ownership shares, under the assumptions described above, is 110%, or the equivalent of 1.1 LLP. LLP ownership limitations enacted when the LLP was established allow up to two LLP to be owned by one individual.

Table A2.4 Federal Scallop LLP Holder History and Current Activity.

LLP	Original Holder	MLOA	Current Holder	Restrictions	Corporate Ownership and Homestate	Vessel Historically Used	Fished in 2015-2022
Independent Operators							
003	Hogan, Thomas C.	75	Atlantic Capes Fisheries LLC	2 dredges with 20' max. combined width	Atlantic Capes Fisheries Inc: Daniel Cohen (100%) in good standing, Cape May NJ	**Kilkenny**: Owned by Atlantic Cape Fisheries Inc,	no
004	Hulse, Max G. et al.	79	Ty W. Babb	2 dredges with 20' max. combined width	Transferred to Scott D. Hulse in 2018, transferred to Ty W. Babb in 2021, corporate status unknown.	**La Brisa / Wayward Wind**: Vessels rebuilt (lengthened) and re-purposed	no
006	Oceanic Research Services	70	EWT LLC	none	EWT LLC: Eric Orman (66.67%) Warren Alexander (33.33%) New Bedford, MA	**Artic Storm**: sold	no
Alaska Scallop Association Members							
002	Forum Star Inc.	97	American Seafoods Co., LLC	State Imposed AFA Sideboard	American Seafoods Group, LLC (100%), in turn owned by ASG Parent LLC (100%) Delaware, Operations Seattle WA	**Forum Star** (owned by Forum Star LLC, which is 100% owned by American Seafoods Company LLC)	no
005	Ocean Fisheries LLC	102	Arctic Hunter LLC	none	Egil Mikkelsen, Glenn Mikkelsen, James Stone, John Lemar, Stein Nyhammer (20% each), Lakewood, WA	Artic Hunter, Replaced by **Polar Sea** (owned by Arctic Hunter LLC)	yes
007	Pursuit, Inc.	101	Ocean Fisheries LLC	none	Festus Fisheries Inc (WA). (20%) Mikkelsen Fisheries Inc (WA). (40%) Stein Enterprises Inc. (WA) (20%), Stone Maritime Inc (WA). (20%), Tacoma, WA	**Pursuit** (no longer documented)	no
008	Provider, Inc.	124	Provider Fisheries LLC	none	Egil Mikkelsen (20%), Glenn Mikkelsen (20%), James Stone (25%), John Lemar (25%), Tom Minio (10%) Lakewood, WA	**Provider** (owned by Provider Fisheries LLC)	yes
009	Carolina Boy, Inc.	95	Ocean Fisheries, LLC	none	Festus Fisheries Inc(WA). (20%) Mikkelsen Fisheries Inc(WA). (40%) Stein Enterprises inc. (WA) (20%), Stone Maritime Inc(WA) (20%), Lakewood, WA	**Ocean Hunter** (owned by Ocean Fisheries LLC)	yes
010	Carolina Girl, Inc.	96	Alaska Scallop Fisheries , LLC	none	Egil Mikkelsen (20%), Glenn Mikkelsen (20%), James Stone (25%), John Lemar (25%), Tom Minio (10% each), Kodiak, AK	**Carolina Girl** (no longer documented)	no

Source: https://alaskafisheries.noaa.gov /and https://myalaska.state.ak.us/business/sosb

Table A2.5 Ownership Interest of Washington Corporations.

Washington Corporation	Governors	Ownership
Festus Fisheries, Inc.	John Lemar, Curtis Lemar	Assumed equal 50% shares
Mikkelsen Fisheries Inc.	Egil Mikkelsen, Glenn Mikkelsen	Assumed equal 50% shares
Stein Enterprises	Stein Nyhammer	100%
Stone Maritime	James Stone	100%

Source: Washington Corporate Records Search: https://www.sos.wa.gov/corps/

Table A2.6 Cooperative Member LLP Ownership Attribution.

Owner	LLP Number						Cumulative Ownership
	002	005	007	008	009	010	
American Seafoods	100%						100%
John Lemar		20%	10%	25%	10%	25%	90%
Curtis Lemar			10%		10%		20%
Egil Mikkelsen		20%	20%	20%	20%	20%	100%
Glenn Mikkelsen		20%	20%	20%	20%	20%	100%
Tom Minio				10%		10%	20%
Stein Nyhammer		20%	20%		20%		60%
James Stone		20%	20%	25%	20%	25%	110%

Effects of Fleet Consolidation

The story of fleet consolidation in the Alaska Weathervane scallop fishery is not unlike that of any other fishery that has had overexploitation under open access, inefficiency caused by the race for fish, and marginally profitable operations due to overcapacity. Fleet consolidation likely results in access to a greater proportion of available harvest for each remaining participant, and reductions in cost are likely due to reduced crowding on available grounds and elimination of the inefficiencies of the race for fish that occurs in an overcapitalized fishery. However, consolidation has also likely occurred as the harvest levels have trended downwards to historically low levels in the most recent years.

Fleet consolidation undoubtedly has a direct effect on the number of crew and operator positions in the fishery. At the time of the vessel moratorium, 18 vessels qualified and likely employed at least 216 crew members (12, including operator, cooks, mechanics, etc. per vessel). However, crew earnings and data linking crew members to vessels do not exist. It is impossible to say, using presently available data, exactly how many crew were employed or the amount of their crew shares. Similarly, it is impossible to determine how many crew were locally (Alaska Residents) acquired or available. In any event, the Federal LLP effectively reduced the number of crew positions, including operators etc., to 108. The fleet consolidation that has occurred under the cooperative, and due to declining guideline harvest levels, has further reduced crew positions to no more than 24. It is possible; however, that the crew shares earned by these crew members are higher than what was earned in the past.

Fishery participants were asked to voluntarily submit information on the percent of total revenue paid to crew during the 2012/13 season. However, three quarters of the present participants declined to provide crew payment data due to the information being highly proprietary to each fishing business. One operator did provide an estimate of crew wages paid; however, this information is unique to that fishing operation and not necessarily indicative of crew wage percentage for the entire fishery. Further, were that information divulged here, it would allow a straightforward back calculation of total revenue earned by that operation, which could then be used to calculate landed pounds. Since that operation delivers product to two processors in two ports, divulging information that could then be used to calculate landed pounds delivered to fewer than three processors would violate confidentiality restrictions. Thus, it is not possible to address current crew compensation, or changes in crew compensation, with existing sources of data.

The formation of the scallop cooperative, and its further development into what is now the Alaska Scallop Association, along with declining CPUE in several areas, reduced harvest levels, and high participation costs have had some impacts on crew positions. Some participants have reported that they will vary the number of crew they carry depending on their expectations of fishing conditions. Essentially, if they feel that the pace of fishing will slow, on any given trip, they may carry anywhere between 8 and 12 crew. The one non-cooperative vessel in the fleet, the Kilkenny, most recently fished the Kamishak Bay beds, when open, and areas near Kodiak Island. They delivered fresh-shucked meats to buyers in Homer and Kodiak and indicate that, since they are not freezing their product at sea, they can fish with as few as 3 crew but usually take 4 or more (pers. comm, Bill Harrington, February 2013).

Crew wages in the present fishery are undoubtedly less, in the aggregate, than they would have been as a share of total revenue in the past. What is not clear; however, is whether individual crew shares have increased for those who continue to work in the scallop fishery. Improved efficiency and reduced numbers of crew on a vessel create the opportunity to have increased crew shares; however, there is no economic data collection program in the scallop fishery that could be used to confirm this possibility. The figure below is an example of the potential crew shares within the cooperative over time. This example assumes 42 percent of revenue goes to crew shares (based on industry provided data from two cooperative vessels) and that each vessel participating utilizes the maximum of 12 crew (position numbers shown on left axis). This example does not account for differentiation in crew compensation based on position (Captain vs. deck and plant crew) or experience. What this example does illustrate is that potential crew shares within the cooperative have fluctuated with landings, price, and the number of positions. However, with the cooperative's ability to reduce overcapitalization by utilizing two of its three associated vessels it appears that potential crew compensation has stabilized and possibly increased with the 2021/22 increase in GHL and wholesale prices. The ability of the cooperative to manage capacity may also be influenced by the fact that one associated boat only participates in the scallop fishery, while owners of the other two boats and associated scallop LLPs are known to be participants in the BSAI crab rationalization program fisheries.

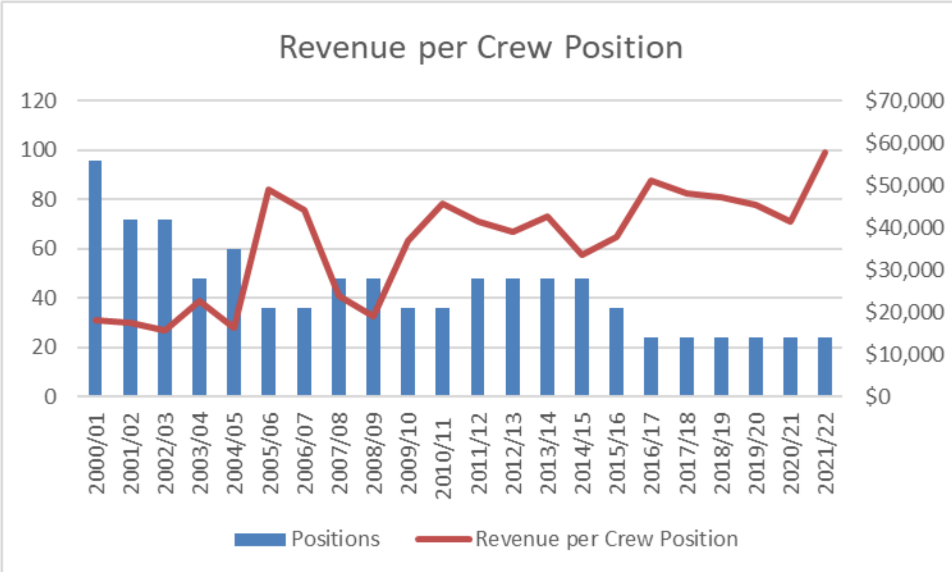

Figure A2.1 Potential Cooperative Revenue per Crew Position, 2000-2021.

As has been discussed above, the Alaska Scallop Association has entered into a revenue sharing system that resulted in payments to members who agreed to not use their LLPs so that the vessels that do fish can remain economically viable. At present, all three active vessels associated with the Alaska Scallop Association members are homeported in Kodiak (personal communication, Jim Stone, February 2018) as is the one identified non-cooperative vessel that has recently fished.

Fleet consolidation has also affected deliveries to several Alaska ports. Information on scallop deliveries to ports from 1990-2017 (ADF&G 2018) show that, since formation of the cooperative and associated fleet consolidation, scallop landing have occurred in several ports and the location of landings has varied over the years. Cordova, Dutch Harbor, Homer, Kodiak, Sitka and Yakutat have all had landings in between 2012 and 2017; however occasional past landings in Alaska ports of Juneau, Ketchikan, Pelican, Petersburg, Sand Point, Seldovia, Seward and Whittier are not presently occurring. Also of note is that past landings made outside of Alaska to ports in Bellingham, and Seattle had not occurred since 2008 and not by any of the present members of the Alaska Scallop Association, except for a single Covid-19 related delivery to Seattle in 2021.

Scallop harvests are taxed in different ways depending on where they are caught and on where they are landed. Scallops caught in State of Alaska waters are subject to the Fishery Business Tax, while scallops caught in Federal waters of the Exclusive Economic Zone are subject to the Resource Landings Tax. The Alaska Department of Revenue requires scallop-fishing entities to record both where scallops were harvested as well as where they were landed. Additionally, there are local taxes, such as Kodiak's Natural Resources Severance tax for fish products harvested with in the Kodiak borough. These local taxes vary by community. Tax data for this fishery is not available due to confidentiality.

All of the vessels that participate in this fishery, at present, are homeported in Alaska ports and, as discussed above, pay both Alaska Business taxes and Resource Landings taxes and any applicable local taxes in landing ports and their home port (e.g. sales tax). From 2017-2019 the two vessels fishing made between 8 and 17 landings per year in ports of Yakutat, Homer, Kodiak and Dutch Harbor. While all of the effects of consolidation mentioned above have negative consequences for some fishery participants and fishing communities, it is likely that the overall effect of fleet reduction is improved profitability for the remaining participants given that the harvest level is at historic lows.

A fundamental question is whether another vessel could fish in the Alaska Scallop Fishery profitably. Table 7 decomposes the breakeven analysis from the Amendment 4 Regulatory Impact Review and re-specifies those breakeven levels using present harvest and price ranges. Doing so imposes the same fixed cost ratios as were used in the Amendment 4 analysis and data from vessels that, with the exception of the Provider, do not currently participate in the fishery. With that limitation duly noted, application of present price of $11.00 to $11.50 and just over 200,000 pounds of harvest roughly 1.2 vessels would breakeven under present fishery and market conditions assuming cost ratios are similar to the past. It is likely that the members of the Alaska Scallop Cooperative have achieved some cost efficiencies since this breakeven analysis was conducted as evidenced by their two vessels currently operating.

In addition, Appendix B to the analysis of Amendment 10 to the Scallop FMP (NPFMC 2005) contains cost and breakeven data from 2003 for the Provider and Ocean Hunter, both of which are presently active in the fishery. That data, though limited to an average of two vessels shows that breakeven levels of income from 2003, inflation adjusted to 2019 values using the U.S. Gross Domestic Product Implicit Price Deflator, also suggests that fewer than two vessels would breakeven under current price and landings values.

Table A2.7 Number of Vessels that Could Breakeven Under Current Price and Landings Scenarios (recreated from Regulatory Impact Review for Amendment 4-10 to the North Pacific Scallop FMP).

Price	Landing (pounds)			
	200,000	400,000	600,000	800,000
$10.00	1.1	2.1	3.2	4.3
$10.50	1.1	2.2	3.4	4.5
$11.00	1.2	2.3	3.5	4.7
$11.50	1.2	2.4	3.7	4.9
$12.00	1.3	2.6	3.8	5.1
$12.50	1.3	2.7	4.0	5.3
$13.00	1.4	2.8	4.2	5.5

Purchase of LLPs from other cooperative members has likely reduced revenue sharing obligations for active participants, albeit with the potential cost of debt finance for these transactions. Overall, it is likely that fleet consolidation has resulted in a more efficient fleet with lower operating costs, potentially greater average crew wages, and improved returns to owned capital. However, the historically low harvest levels in the Alaska Weathervane scallop fishery, even with historically high prices are limiting the economic performance of the fishery and likely also preventing new entrants to the State waters fishery.

A2.5 Scallop Market Conditions

In the domestic U.S. market, Alaska weathervane scallops are similar to Atlantic sea scallops; however, they tend to be smaller and sweeter to the palate. Table 8 compares total landings and value of Alaska weathervane scallops with Atlantic sea scallops from 1990 through 2020/21 and with imports of all scallop products from 1990 through December of 2021. These data show that Atlantic sea scallop harvest is consistently orders of magnitude larger than weathervane scallop harvests off Alaska.

There are some intuitive conclusions that can be made from the data presented in Table 8 and from the price trends displayed in Figure 2. First, domestic markets are dominated by Atlantic sea scallop production and scallop imports. For example, in 2021, an estimated 40 million pounds of Atlantic Sea Scallops were landed in the United States, down from a decade high of nearly 61 million pounds in 2019. Additionally, 55.4 million pounds of scallop products were imported into the United States, which is a considerable increase over the 36.5 million pounds imported the previous year. This compares to just under 300,000 pounds of Alaska Weathervane scallop landings in 2021/22. Even in the highest production year of 1994, the 1.2 million pounds of Alaska Weathervane scallop landings made in that year compare to 16.8 million pounds of Atlantic Sea scallop landings and 56.8 million pounds of imported scallop products.

Second, prices of weathervane scallops track closely to those of Atlantic sea scallops. Thus, it is highly likely that domestic market price is dominated by the relationship between quantity supplied in the Atlantic sea scallop fishery and domestic market demand as well as by substitution of imported scallop product. 2 provides a very clear picture of the relationship between Sea scallop prices and Alaska Weathervane scallop prices. These data appear to show that Alaska Weathervane scallop price declines tend to lag U.S. Sea scallop price declines and, at least since formation of the Alaska Scallop Association, have tended to slightly lead market price increases.

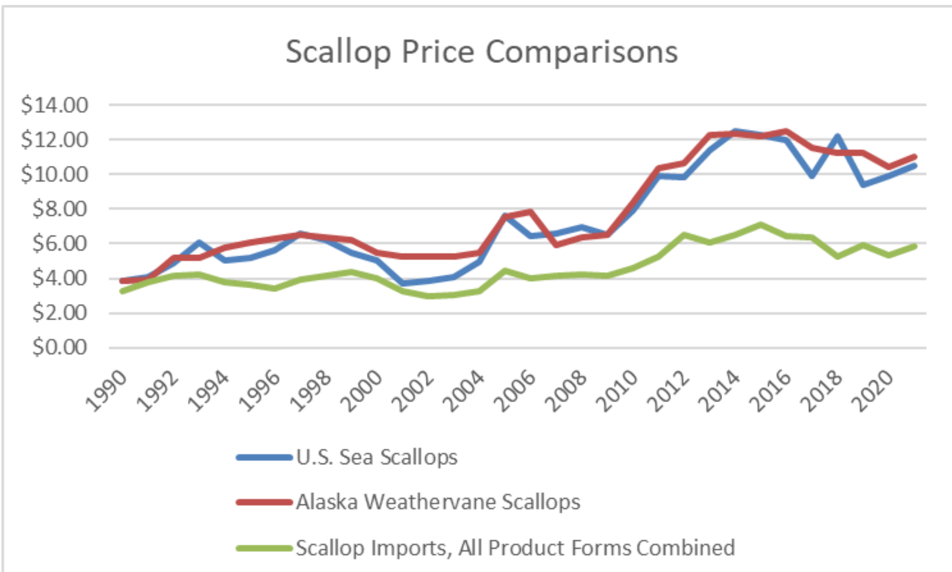

Figure A2.2 Scallop Price Comparisons, 1990-2021.

One might argue that the appearance may be driven by data collection differences. Sea Scallop prices are tabulated somewhat continuously through the season and landings and value are available on a monthly basis. In contrast, Alaska Weathervane scallops are primarily processed at sea and a value is not established at the time of landing but rather via the annual tax filings of harvesting entities with the Alaska Department of Revenue. The Alaska Weathervane scallop price determination for the previous year is usually published in May or June of the following year. However, for this analysis, average prices are tabulated for each year and, thus, are from a comparable time frame leading one to wonder as to the price dynamics at work behind the apparent time lag in declines and slight lead in increases that Alaska Weathervane scallops seem to exhibit.

Unfortunately, while Sea Scallop landings and value data are incredibly rich, Alaska Weathervane scallop pricing data is represented by a single data point per year with occasional fish ticket values when fresh product has been landed. These imbalanced data sets largely prevent meaningful econometric analysis of the demand for each product, including the extent to which Alaska Weathervane scallop prices may be driven by the Sea Scallop market.

Another important factor in scallop market is imports of scallop products. Unfortunately, available import data commingles imports of several small scallop species (e.g. pink, calico, bay etc.) with larger scallop varieties such as sea scallops and weathervane scallops. However, as these products are substitutes for one another, although not perfectly, the imports of these other species may influence domestic market prices.

The conclusion that can be drawn from the data presented in Table 8 is that the wholesale price of weathervane scallops is likely heavily influenced by domestic supply and import supply. This suggests that North Pacific harvesters have little market power to negotiate prices, except based on quality and taste preferences, and are likely price takers in the wholesale market.

Table A2.8 US Scallop Landings and Value versus Scallop Imports and Value, 1990-2017.

Year	U.S. Sea Scallops			Alaska Weathervane Scallops*			Scallop Imports, All Product Forms Combined		
	Millions of Pounds	Value ($ millions)	Av. $/lb	Millions of Pounds	Value ($ millions)	Av. $/lb	Millions of Pounds	Value ($ millions)	Av. $/lb
1990	38.6	$149.1	$3.87	1.1	$4.3	$3.82	40.0	$131.6	$3.29
1991	37.9	$153.7	$4.05	1.8	$7.1	$3.96	29.7	$111.4	$3.76
1992	31.3	$153.4	$4.90	0.6	$2.9	$5.15	38.8	$160.2	$4.13
1993	16.1	$97.1	$6.04	1.0	$5.1	$5.15	52.1	$219.2	$4.21
1994	16.8	$84.1	$5.01	1.2	$7.2	$5.79	56.8	$216.9	$3.82
1995	17.4	$89.8	$5.16	0.4	$2.5	$6.05	48.4	$174.8	$3.61
1996	17.5	$98.8	$5.64	0.7	$4.6	$6.30	58.8	$198.8	$3.38
1997	13.6	$89.5	$6.56	0.8	$5.3	$6.50	60.3	$238.1	$3.95
1998	12.1	$75.1	$6.19	0.8	$5.3	$6.40	53.2	$221.1	$4.16
1999	22.0	$121.0	$5.49	0.8	$5.2	$6.25	44.6	$194.7	$4.37
2000	32.2	$160.9	$5.00	0.8	$4.1	$5.50	54.1	$214.8	$3.97
2001	46.4	$172.6	$3.72	0.6	$3.0	$5.25	40.0	$130.0	$3.25
2002	52.7	$202.1	$3.84	0.5	$2.7	$5.25	49.0	$146.7	$3.00
2003	56.0	$229.1	$4.09	0.5	$2.6	$5.25	52.9	$161.9	$3.06
2004	64.1	$320.0	$4.99	0.4	$2.3	$5.50	45.3	$149.4	$3.29
2005	56.6	$432.5	$7.64	0.5	$4.0	$7.58	51.4	$229.8	$4.47
2006	60.1	$386.3	$6.43	0.5	$3.8	$7.86	60.8	$243.3	$4.00
2007	58.5	$386.0	$6.60	0.5	$2.7	$5.94	56.6	$236.8	$4.18
2008	53.4	$370.1	$6.93	0.3	$2.2	$6.34	57.8	$244.8	$4.24
2009	57.9	$375.6	$6.48	0.5	$3.2	$6.48	56.3	$233.0	$4.14
2010	57.5	$455.7	$7.92	0.5	$3.8	$8.35	51.9	$238.5	$4.60
2011	59.2	$585.1	$9.89	0.5	$4.7	$10.39	56.8	$300.4	$5.29
2012	56.9	$559.0	$9.82	0.4	$4.4	$10.63	34.5	$224.7	$6.52
2013	41.0	$466.8	$11.39	0.4	$4.9	$12.25	60.9	$371.9	$6.11
2014	33.8	$423.7	$12.52	0.3	$3.8	$12.39	60.7	$394.4	$6.50
2015	35.7	$439.7	$12.32	0.3	$3.2	$12.22	49.3	$350.2	$7.11
2016	40.5	$486.0	$12.00	0.2	$2.9	$12.53	51.0	$328.5	$6.43
2017	53.8	$532.9	$9.90	0.2	$2.8	$11.54	41.3	$264.5	$6.40
2018	60.1	$732.0	$12.18	0.2	$2.8	$11.26	46.5	$243.6	$5.24
2019	60.7	$570.1	$9.39	0.2	$2.7	$11.26	35.3	$208.9	$5.92
2020	48.9	$486.2	$9.94	0.2	$2.4	$10.43	36.5	$195.4	$5.35
2021	40.0	$421.4	$10.53	0.3	$3.3	$11.06	55.4	$324.4	$5.86

*Sources: NMFS Data at https://www.fisheries.noaa.gov and ADF&G Fish Ticket data. * Seasonal data is displayed as annual data for comparison with annual sea scallop landings. n/a= data for 2019/20 Atlantic US Sea scallop fishery is not yet available.*

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Appendix 3: Size and Age Structured Modelling of Weathervane Scallops Using Stock Synthesis

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A3.1 Background

Development of a model-based assessment for Alaska's weathervane scallop stock has long been a goal of ADF&G and the Scallop Plan Team (SPT). Bechtol (2000) used fishery and ADF&G dredge survey data to develop an age-structured assessment model of the Kamishak Bay portion of the stock from 1983 – 1997, similar to modelling framework of Deriso et al. (1985). Zhang later updated the work by Bechtol (2000) to include data collected from 1985 – 2012 and presented results to the SPT in 2015. Although aging of scallop shells appears to be reliable (Barnhart and Carpenter 2000), methods for shell aging were not standardized state-wide prior to 2017 (Siddon et al. 2017) and size (i.e., shell height) composition data are more ubiquitous. Models that combine both size and age structure would leverage the suite of available fishery and survey data, and likely improve model estimation.

Zheng (2018, ADF&G, unpublished) used Stock Synthesis v3.24 (Methot and Wetzel 2013) assess Kamishak Bay scallop abundance from 1983 – 2015 and presented results to the SPT in 2018. Zheng evaluated eight model scenarios. The base model included fishery catch and catch per unit effort (CPUE) data, dredge survey biomass estimates, and both size and age compositions from both the fishery and the dredge survey. Four alternative model scenarios evaluated the base model with varying natural mortality, ranging from 0.14 – 0.24, and another alternative scenario included data from the survey's first year, which was not complete. The remaining two model scenarios evaluated the base model using harmonic mean to adjust effective sample size for composition data, while the other evaluated the base model without any survey data. All model scenarios resulted in the same relative trend in spawning biomass, though at slightly different scales, while varied natural morality appeared to strongly influence total biomass.

Here, we advanced the previous work by Zheng by updating the Kamishak dredge survey data to include the most recent survey of the area in 2018, though only carrying forward model scenarios that varied natural mortality. In addition, we applied the same modeling framework to the Kodiak Shelikof District which has a short timeseries of dredge survey data and a lengthy timeseries of bottom trawl survey data.

A3.2 Objectives

The objective of this analysis is to

- Update previous draft Stock Synthesis assessment of Kamishak Bay weathervane scallops (Zheng 2018) from SSv3.24 to SSv3.30 with dredge survey data.
- Evaluate framework used in assessment of Kamishak Bay for weathervane scallops in the Kodiak Shelikof District.

A3.3 Data

Fishery

Fishery data was accessed from the ADF&G Shellfish Observer Program and Central Region fishery managers. Annual landings were estimated in units of round (i.e. whole animal) biomass (t). Fishery catch per unit effort (CPUE; round t / dredge hr) was used in both Kamishak and Kodiak Shelikof models (Tables 9-1 – 9-2). Nominal values were used for Kamishak and pre-2009 season Kodiak Shelikof CPUE as data required for standardization were not available. Kodiak Shelikof CPUE estimates from 2009 to 2020 were standardized using the general additive model structure specified in section 2.2 and specified as a separate fleet than pre-2009 season data. Discard data was not used in either Kamishak or Kodiak Shelikof models.

Shell height compositions were estimated from observer sampled dredges. Scallop ages were estimated from observer collected shells and read by ADF&G research staff (1985 – 2015) or ADF&G Age Determination Unit staff (2016 – 2020). Shell height and age compositions were expanded using relative catch biomass of sampled dredges.

Dredge Survey

Kamishak dredge survey data were accessed from ADF&G Central region staff for surveys from 1996 – 2015 and from the ADF&G Shellfish Observer Program for 2018. Kodiak Shelikof dredge survey data (2016 – 2018, 2020) was accessed from the ADF&G Shellfish Observer Program. Survey sampling and estimation methods are described by Burt et al. (2021). Survey biomass was estimated in units of round tons (Table 9-3). Shell height compositions and age compositions were expanded using relative catch per tow. Scallop ages were read by ADF&G research staff (1996 – 2015) or ADF&G Age Determination Unit staff (2016 – 2020).

Trawl Survey

ADF&G Westward Region large-mesh trawl survey (Knutson and Spalinger 2021) data were accessed via the ADF&G Kodiak intranet database. Since survey stations are not comprised entirely of suitable scallop habitat, CPUE (kg / km towed) estimated from a subset of index stations was used instead of total biomass estimates (Table 9-4). Estimation methods are described in the SAFE, section 2.4.2. Shell height compositions were expanded using relative catch per tow. No shells are collected for aging during the trawl survey.

A3.4 Model Descriptions

Stock Synthesis (Methot 1989, 1990; Methot and Wetzel 2013) is a generalized age and size structured population dynamics model implemented in ADMB (Fournier et al. 2012). It contains a population sub-model to model growth, maturity, fecundity, recruitment, movement, and mortality, an observation sub-model to estimate expected values, a statistical sub-model to evaluate goodness of fit, and a forecast sub-model to project management quantities (Methot et al. 2020). Technical details of the modelling framework can be found in Methot (2000) and Methot and Wetzel (2013).

Assumptions specific to base models of Kamishak and Kodiak Shelikof districts include:

a) Males and females are combined in all model processes, and the sex ratio was assumed to be 50:50.
b) The base natural mortality rate (*M*) is 0.19 yr^{-1}, except for alternative scenarios in which *M* varied from 0.14 yr^{-1} – 0.24 yr^{-1}. Natural mortality is kept constant across all sizes and modelled years.
c) Shell height at age is estimated using the Schnute (1981) parametrization of von Bertalanffy growth. The minimum age for von Bertalanffy growth is age-0 and the age at maximum shell height is age-18.
d) Round weight at shell height is allometric and estimated outside of the model.
e) Maturity is a logistic function of shell height and estimated outside of the model using survey gonad condition data.
f) Egg production (i.e. fecundity) is assumed to be equal to spawning biomass.
g) Annual recruitment is estimated using with unconstrained annual recruitment deviations distributed $N(0, 2)$.

h) Catchability (*Q*) was estimated as a simple proportional scalar for fishery and trawl CPUE, and is constant across years.
i) Fishery and survey selectivities are both estimated as a logistic function of shell height, and are constant across years. All models assumed full selectivity across ages.

None of the models for either district included discards or non-directed bycatch. These data are available for the Kodiak Shelikof District from 2009/20 to present, but were not available for the Kamishak District at the time of this analysis. Kamishak models were run from 1983 – 2018 and Kodiak Shelikof models were run from 1992 – 2020. Size and age structure consisted of 33 shell height bins ranging from 2.1 cm to 18.1+ cm and 18 age bins (ages 1-18) for all model scenarios evaluated.

Kamishak District model scenarios included:

- KAM 22.0: Base model which includes fishery catch from 1983 – 2016, fishery CPUE from 1983 – 2016, and dredge survey biomass from 1996 – 2018.
  - KAM 22.0a: Base model + $M = 0.14$ yr^{-1}
  - KAM 22.0b: Base model + $M = 0.17$ yr^{-1}
  - KAM 22.0c: Base model + $M = 0.21$ yr^{-1}
  - KAM 22.0d: Base model + $M = 0.24$ yr^{-1}

Kodiak Shelikof District model scenarios include:

- KSH 22.0: Base model which includes fishery catch from 1993 – 2020, fishery CPUE from 2009– 2020, and dredge survey biomass from 2016 - 2020.
- KSH 22.1: Base model with fishery CPUE data 1993 – 2008
  - KSH 22.1a: KSH 22.1 + $M = 0.14$ yr^{-1}
  - KSH 22.1b: KSH 22.1 + $M = 0.24$ yr^{-1}
- KSH 22.2: 22.1 with trawl survey CPUE from 1992 - 2020 and shell height composition from 1999 - 2020

A3.5 Results

Kamishak District

KAM 22.0 and alternative scenarios with varying *M* (KAM 22.0a – d) all successfully converged and fit population dynamics reasonably well. Fits to dredge survey biomass were coherent among model scenarios after 2009, while predicted dredge survey biomass was greater with higher *M* values between 1996 – 2008 (Figure 1). Fits to fishery CPUE were similar among all model scenarios, and varied slightly after 2005 (Figure 2). As expected, larger values of *M* led to improved overall model fits (Table 6) and considerably larger spawning biomass and recruitment (Table 8; Figure 3 –5). Improved fit at large *M* was consistent among likelihood components, but most notably fishery catch, dredge survey biomass, and fishery CPUE (Table 6).

Varying *M* had less effect on fits to size and age compositions (Figures 6 – 9; 11 – 16). Models captured modes of composition data adequately in nearly all years of fishery and dredge survey data, though models often had trouble scaling to the observed proportion of dominant modes, particularly in fishery shell heights from 1998 – 2010. Dredge survey size selectivities were low, and decrease substantially as *M* increased. A similar but much less drastic pattern was observed for fishery size selectivity, though selectivity was lowest at $M = 0.14$ (Figure 10).

The base model has a strong retrospective pattern throughout much of the timeseries. Models that included data more recent than 2015 typically resulted in larger spawning biomass and recruitment, except for those that only included data up to 2009 (Figures 17 – 18).

Kodiak Shelikof District

All Kodiak Shelikof District models successfully converged. The addition of trawl survey data (KSH 22.2) led to a poorer fit overall and among all likelihood components (Table 9-10) and a marginally larger spawning biomass than KSH 22.0 and KSH 22.1 throughout much of the timeseries (Figure 22). Table 9-11 lists parameter estimates by model scenario. The addition of fishery CPUE index prior to the 2009/10 season led to slightly improved model fit, and resulted in lower spawning biomass before 1996. Varying natural mortality (KSH 22.1a, KSH 22.1b) had the same effect as Kamishak model scenarios, that is, higher *M* led to better overall fit, greater spawning biomass (Table 12; Figure 22) and recruitment (Table 12; Figures 23 – 24), while there was minor differences in fits to biomass indices (i.e., dredge survey biomass and fishery CPUE) (Figures 19 –20) or composition data.

Models were able to capture the dominant modes of fishery shell height composition data in most years, but failed to fit to multimodal shell height distributions whenever present (Figures 25 – 30). Fits to dredge survey shell height also suggested smoother distributions than were observed (Figure 26 and 30). Models performed better in fitting to age composition data from both the fishery and the dredge survey (Figures 32-35). Differences in *M* did not result in any meaningful changes in estimated size selectivities (Figure 31).

A strong retrospective pattern occurs for model KSH 22.1. Spawning biomass was greatly overestimated in the terminal year, particularly since 2017. The retrospective pattern in recruitment was variable (Figures 38 – 39). Strong retrospective patterns imply that there may be some model misspecifications that warrant further investigation.

A3.6 Conclusions

Overall, Stock Synthesis appears to be a useful modeling framework for assessing weathervane scallop populations in Alaska. Both Kamishak and Kodiak Shelikof District base models were able to fit to observed data reasonably well. Fishery CPUE and the ADF&G dredge survey appear to be the most useful biomass indices. The ADF&G Westward Region Large-mesh Trawl Survey is specifically designed for commercial crab species and does not necessarily overlap with scallop beds. In addition, bottom trawl gear efficiency for catching scallops is unknown and likely poor. In its current state, it is possible that trawl survey data do not accurately reflect population dynamics of scallops. Addition of the trawl survey data did not improve Kodiak Shelikof model fit, suggesting data should be further investigated before it is re-incorporated into stock assessment models.

Natural mortality strongly influences and predicted spawning biomass in both Kamishak and Kodiak Shelikof District models. For both districts, greater natural mortality rates lead to larger estimates of spawning biomass, though the scale of biomass differences was much greater in Kamishak. Similar to previous work by Zheng (2018 presentation to SPT), greater natural mortality led to improved overall model fit (Tables 6, 10). The best overall fit was found using $M = 0.24$ for both Kamishak and Kodiak Shelikof District Models. Longevity based methods of estimating natural mortality rate evaluated by Then et al. (2015) suggest that an appropriate value of *M* ranges from 0.18 – 0.22, assuming maximum age is 29 years (ADF&G *unpublished data*). Future model development should refine the estimate of natural mortality rate used, and potentially explore age specific rates. Both Kamishak and Kodiak Shelikof District models have very strong retrospective patterns. Further work is needed to investigate these retrospective patterns and identify model misspecifications to reduce them.

The Stock Synthesis framework makes full use of the available data, though how best to extend model development efforts to the remaining population remains somewhat unclear due to data limitations. Kamishak and Kodiak Shelikof Districts are currently the most data rich subunits of the stock in terms of the dredge survey timeseries. The only other districts having had at least partial coverage during previous dredge surveys include Kodiak Northeast (2017, 2020), Yakutat (2017, 2019, 2021), and Kayak Island (East – 2016, 2018, 2021; West – 2016, 2019, 2021). Other districts would rely exclusively on observer CPUE data, some of which have only short timeseries or lack fishery participation (e.g., Kodiak Southeast). For all districts, extensive effort is required to make available observer data prior to the 2009/10 season and data quality concerns may yet limit usage of historical data (Ryan Burt, ADF&G Shellfish Observer Program, pers. communication). Moreover, better knowledge of larval connectivity among beds and districts would be necessary to re-define scallop stocks and combine beds or districts into a single stock (e.g., modelling population dynamics of Kamishak and Kodiak Shelikof together), which would be an eventual necessary step in assessment development.

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A3.8 Tables and Figures

Table A3.1: Retained round weight of catch and catch per unit effort index from 1983 – 2018 for the Kamishak District.

Year	Retained Catch (t)	CPUE Index	Year (cont.)	Retained Catch (t) (cont.)	CPUE Index (cont.)
1983	13.302	0.125	2002	34.275	0.147
1984	35.749	0.142	2003	closed	
1985	66.962	0.227	2004	25.622	0.130
1986	87.112	0.204	2005	41.833	0.113
1987	8.437	0.085	2006	0.283	0.028
1988	closed		2007	no effort	
1989	closed		2008	no effort	
1990	closed		2009	no effort	
1991	closed		2010	53.637	0.147
1992	closed		2011	56.557	0.176
1993	114.05	0.215	2012	66.559	0.113
1994	115.842	0.255	2013	closed	
1995	closed		2014	closed	
1996	160.05	0.301	2015	53.779	0.119
1997	115.303	0.295	2016	22.578	0.085
1998	97.783	0.249	2017	no effort	
1999	115.184	0.357	2018	closed	
2000	116.324	0.425			
2001	113.948	0.352			

Table A3.2: Retained round weight of catch and catch per unit effort index from 1993 – 2020 for the Kodiak Shelikof District.

Year	Retained Catch (t)	CPUE Index	Year (cont.)	Retained Catch (t) (cont.)	CPUE Index (cont.)
1993	531	0.25	2007	769	0.26
1994	1,566	0.26	2008	932	0.28
1995	closed		2009	757	0.26
1996	852	0.25	2010	834	0.28
1997	1,405	0.26	2011	652	0.29
1998	965	0.24	2012	450	0.23
1999	863	0.2	2013	408	0.22
2000	802	0.28	2014	276	0.18
2001	830	0.24	2015	196	0.17
2002	843	0.22	2016	120	0.17
2003	782	0.24	2017	96	0.21
2004	745	0.22	2018	109	0.26
2005	659	0.29	2019	113	0.34
2006	637	0.29	2020	185	0.52

Table A3.3: ADF&G Dredge Survey round biomass estimates and associated log standard error.

	Kamishak District		Kodiak Shelikof District	
Year	Round Biomass (t)	ln σ	Round Biomass (t)	ln σ
1996	2,409	0.17		
1999	4,247	0.17		
2001	3,591	0.18		
2003	1,253	0.16		
2005	1,329	0.16		
2007	1,749	0.14		
2009	1,360	0.14		
2011	1,197	0.14		
2013	839	0.13		
2015	1,061	0.13		
2016			1,282	0.43
2017			1,209	0.4
2018	901	0.16	2,332	0.72
2020			4,872	1.12

Table A3.4: ADF&G Westward Region Large-mesh Trawl Survey CPUE estimates and associated observed log standard error. A log standard error of 0.45 was used in model fitting.

Year	CPUE (t / km)	ln σ	Year (cont.)	CPUE (t / km) (cont.)	ln σ
1992	2.49	0.01	2007	14.18	1.46
1993	2.31	0.01	2008	9.78	1.1
1994	0.28	0.01	2009	17.32	2.15
1995	6.87	0.7	2010	6.81	0.67
1996	4.09	0.08	2011	6.28	0.69
1997	7.47	0.72	2012	5.58	0.58
1998	12.71	1.48	2013	6.85	0.83
1999	2.75	0.01	2014	4.67	0.38
2000	7.4	0.9	2015	1.61	0.01
2001	5.59	0.46	2016	9.14	1.03
2002	8.13	0.89	2017	4.65	0.43
2003	21.41	2.19	2018	5.16	0.49
2004	7.61	0.86	2019	3.57	0.07
2005	6.67	0.69	2020	9.81	1.3
2006	10.07	1.09			

Table A3.5: Number of free parameters by model process for each Kamishak District model.

	Number of Parameters
Total	65
Growth	5
Virgin Recruitment	1
Recruitment Deviations	54
Catchability	1
Size Selectivity	4

Table A3.6: Negative log likelihood components for Kamishak District models.

	Models				
Likelihood Component	KAM 22.0	KAM 22.0a	KAM 22.0b	KAM 22.0c	KAM 22.0d
Total	615.43	668.783	633.694	600.764	584.912
Fishery Catch	3.64E-12	1.52E-11	7.05E-12	1.47E-12	6.285E-14
Dredge Survey Biomass	9.724	20.532	12.718	8.060	7.347
Fishery CPUE	6.229	11.445	8.123	4.653	2.874
Fishery SH Comp	169.549	175.768	172.110	166.904	162.891
Dredge Survey SH Comp	118.183	119.690	118.647	117.987	118.353
Fishery Age Comp	157.045	170.969	161.914	152.941	148.04
Dredge Survey Age Comp	111.625	119.004	114.337	109.223	106.201
Fishery Size-at-Age	-9.973	-8.826	-9.628	-10.155	-10.125
Dredge Survey Size-at-Age	42.691	47.850	44.586	41.116	39.517
Parameter Priors	1.137	1.210	1.166	1.108	1.066

Table A3.7: Parameter estimates for each Kamishak District model.

	Models					
	KAM 22.0	KAM 22.0a	KAM 22.0b	KAM 22.0c	KAM 22.0d	Bounds
Natural Mortality*	0.19	0.14	0.17	0.21	0.24	
Weight-at-SH α*	1.43E-04	1.43E-04	1.43E-04	1.43E-04	1.43E-04	
Weight-at-SH β*	2.873	2.873	2.873	2.873	2.873	
Size at 50% maturity*	9	9	9	9	9	
Maturity slope*	-1.5	-1.5	-1.5	-1.5	-1.5	
Log Virgin Rec	7.70524	6.48612	7.17604	8.3598	10.256	(1, 25)
SD Log Rec*	2	2	2	2	2	
LvB Growth Min SH	1.988	1.901	1.952	2.026	2.086	(-1, 8)
LvB Growth Max SH	17.059	17.034	17.051	17.065	17.070	(15, 20)
LvB *k*	0.253	0.260	0.256	0.250	0.245	(0.05, 0.35)
CV growth < min SH	0.121	0.118	0.119	0.122	0.124	(0.05, 0.25)
CV growth > max SH	0.036	0.038	0.037	0.035	0.034	(0.01, 0.25)
Fishery ln Q	-9.687	-9.032	-9.377	-10.125	-11.693	(-20, 5)
Fishery Size Sel p1	13.029	12.684	12.882	13.188	13.448	(2, 20)
Fishery Size Sel p2	2.961	2.874	2.923	3.000	3.063	(0.01, 8)
Dredge Size Sel p1	17.636	13.240	15.681	20.104	27.476	(0.01, 45)
Dredge Size Sel p2	11.819	11.168	11.599	11.978	12.081	(0.01, 20)

Table A3.8: Unfished recruitment and spawning biomass for Kamishak District models.

	Models				
	KAM 22.0	KAM 22.0a	KAM 22.0b	KAM 22.0c	KAM 22.0d
Unfished *R* (millions)	2.220	0.656	1.308	4.272	28.453
Unfished SSB (1,000 t)	1.99	1.036	1.453	3.126	15.646

Table A3.9: Number of free parameters by model process for each Kodiak Shelikof District model.

	Models				
	KSH 22.0	KSH 22.1	KSH 22.1a	KSH 22.1b	KSH 22.2
Total	58	59	59	59	62
Growth	5	5	5	5	5
Virgin Recruitment	1	1	1	1	1
Recruitment Deviations	47	47	47	47	47
Catchability	1	2	2	2	3
Size Selectivity	4	4	4	4	6

Table A3.10: Negative log likelihood components for Kodiak Shelikof District models.

	Models				
Likelihood Component	KSH 22.0	KSH 22.1	KSH 22.1a	KSH 22.1b	KSH 22.2
Total	314.274	304.553	314.602	295.704	541.505
Fishery Catch	4.56E-08	4.24E-06	4.51E-06	1.14E-06	1.14E-05
Dredge Survey Biomass	-0.598	-0.635	-0.093	-1.098	-1.848
Fishery CPUE (≤ 2008/09)		-11.263	-10.861	-11.425	-6.668
Fishery CPUE (≥ 2009/10)	-17.913	-18.021	-17.023	-18.692	-24.292
Trawl CPUE					11.006
Fishery SH Comp	147.045	147.227	149.697	144.916	120.734
Dredge Survey SH Comp	97.964	98.041	99.809	96.364	59.852
Trawl SH Comp					250.233
Fishery Age Comp	38.635	38.296	38.688	37.864	44.552
Dredge Survey Age Comp	29.126	29.067	28.792	29.365	29.611
Fishery Size-at-Age	10.871	11.083	12.948	9.214	40.641
Dredge Survey Size-at-Age	1.817	1.790	2.810	0.693	4.191
Parameter Priors	0.944	1.658	1.662	1.654	2.445

Table A3.11: Parameter estimates for each Kodiak Shelikof District model.

	Models					
	KSH_22.0	KSH_22.1	KSH_22.1a	KSH_22.1b	KSH_22.2	Bounds
Natural Mortality*	0.19	0.19	0.14	0.24	0.19	
Weight-at-SH α*	1.48E-04	1.48E-04	1.48E-04	1.48E-04	1.48E-04	
Weight-at-SH β*	2.786	2.786	2.786	2.786	2.786	
Size at 50% maturity*	7.3	7.3	7.3	7.3	7.3	
Maturity slope*	-1.5	-1.5	-1.5	-1.5	-1.5	
Log Virgin Rec	9.291	9.076	8.492	9.627	8.561	(1, 25)
SD Log Rec*	2	2	2	2	2	
LvB Growth Min SH	2.293	2.291	2.283	2.300	2.166	(-1, 8)
LvB Growth Max SH	17.080	17.079	17.067	17.086	16.831	(15, 20)
LvB k	0.136	0.137	0.144	0.129	0.190	(0.05, 0.35)
CV growth < min SH	0.298	0.297	0.289	0.306	0.197	(0.05, 0.5)
CV growth > max SH	0.083	0.083	0.082	0.085	0.078	(0.01, 0.25)
Fishery (≤ 2008/09) ln Q		-8.826	-8.809	-8.871	-9.022	(-12, 5)
Fishery (≥ 2009/10) ln Q	-8.342	-8.350	-8.270	-8.436	-8.730	(-12, 5)
Trawl Survey ln Q					-5.378	(-12, 5)
Fishery Size Sel p1	13.113	13.103	12.969	13.233	12.845	(2, 20)
Fishery Size Sel p2	3.312	3.314	3.385	3.241	3.363	(0.01, 8)
Dredge Survey Size Sel p1	13.137	13.125	12.798	13.405	12.355	(0.01, 45)
Dredge Survey Size Sel p2	6.976	7.001	7.477	6.568	8.417	(0.01, 20)
Trawl Survey Size Sel p1					13.378	(2, 20)
Trawl Survey Size Sel p2					4.276	(0.01, 8)

**Fixed parameter*

Table A3.12. Unfished recruitment and spawning biomass for Kodiak Shelikof District models.

	Models				
	KSH 22.0	KSH 22.1	KSH 22.1a	KSH 22.1b	KSH 22.2
Unfished *R* (millions)	10.844	8.746	4.876	15.169	5.225
Unfished SSB (1,000 t)	5.932	4.792	5.031	4.813	3.281

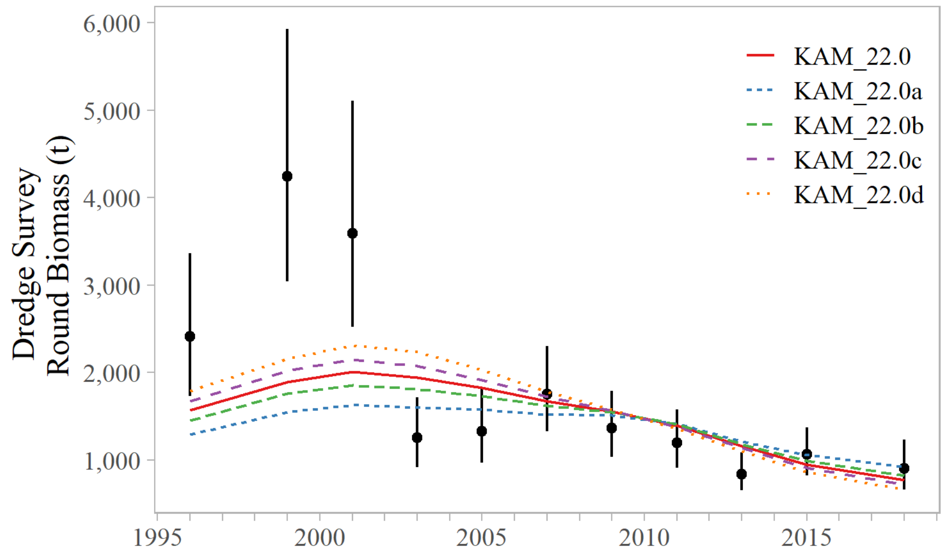

Figure A3.1: Fit to Kamishak District ADF&G dredge survey total round biomass (t) by model scenario. Error bars indicate 95% lognormal confidence intervals.

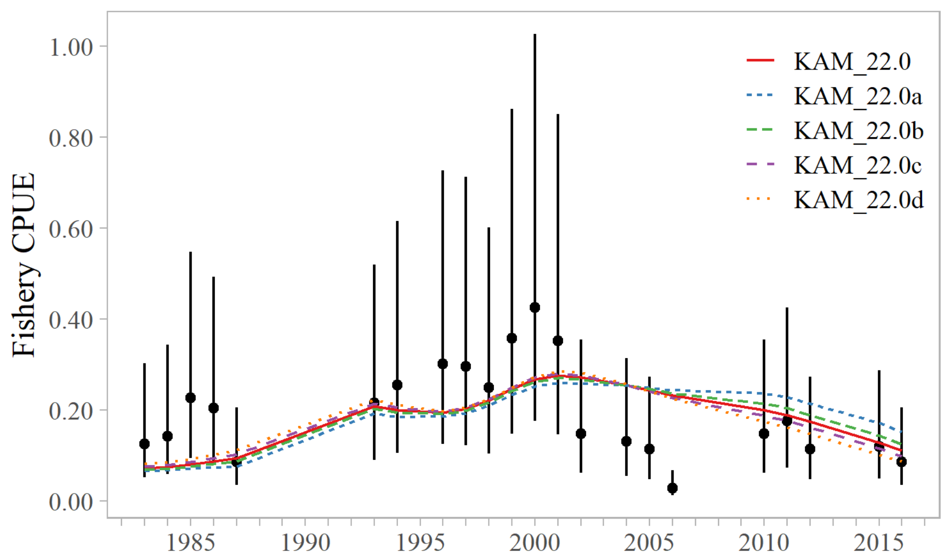

Figure A3.2: Fit to Kamishak District fishery catch per unit effort (CPUE) index by model scenario. Error bars indicate 95% lognormal confidence intervals.

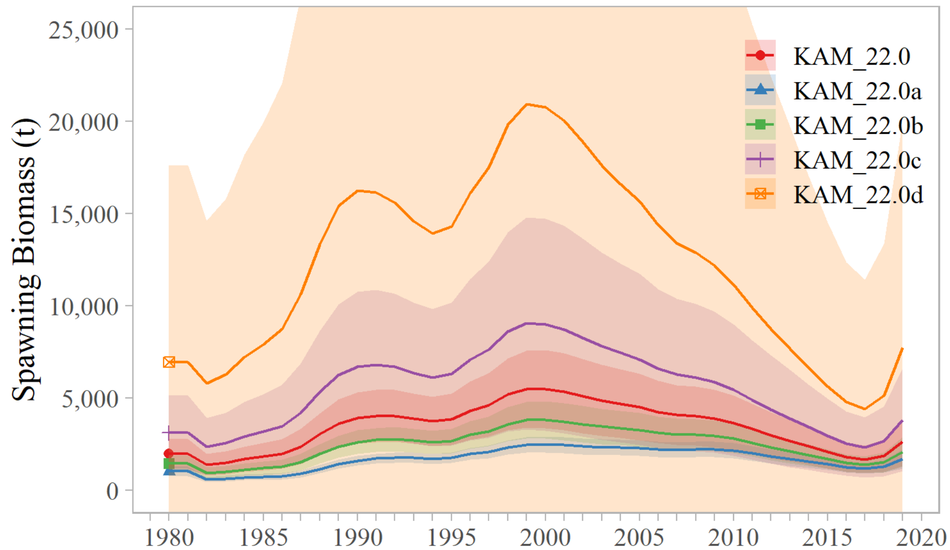

Figure A3.3: Kamishak District predicted total spawning biomass (t) by model scenario.

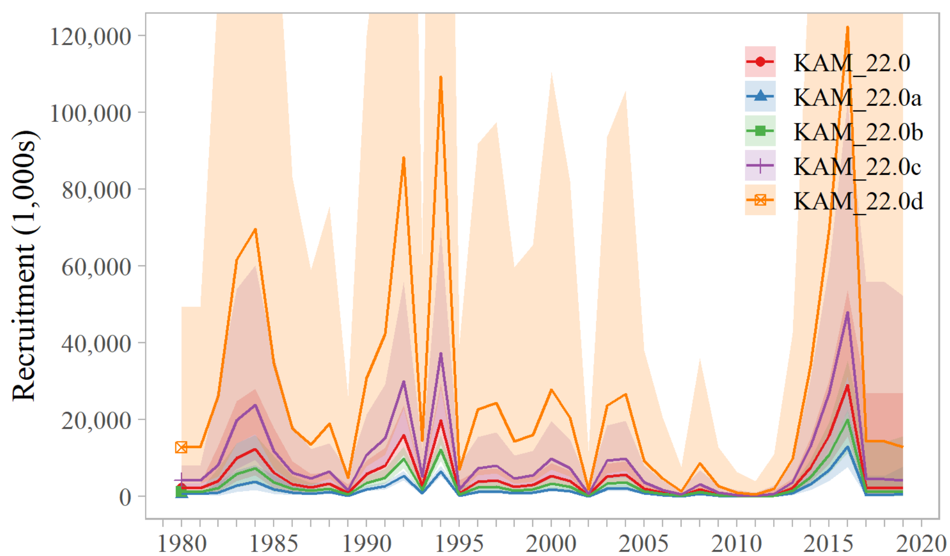

Figure A3.4: Kamishak District predicted annual recruitment (millions) by model scenario.

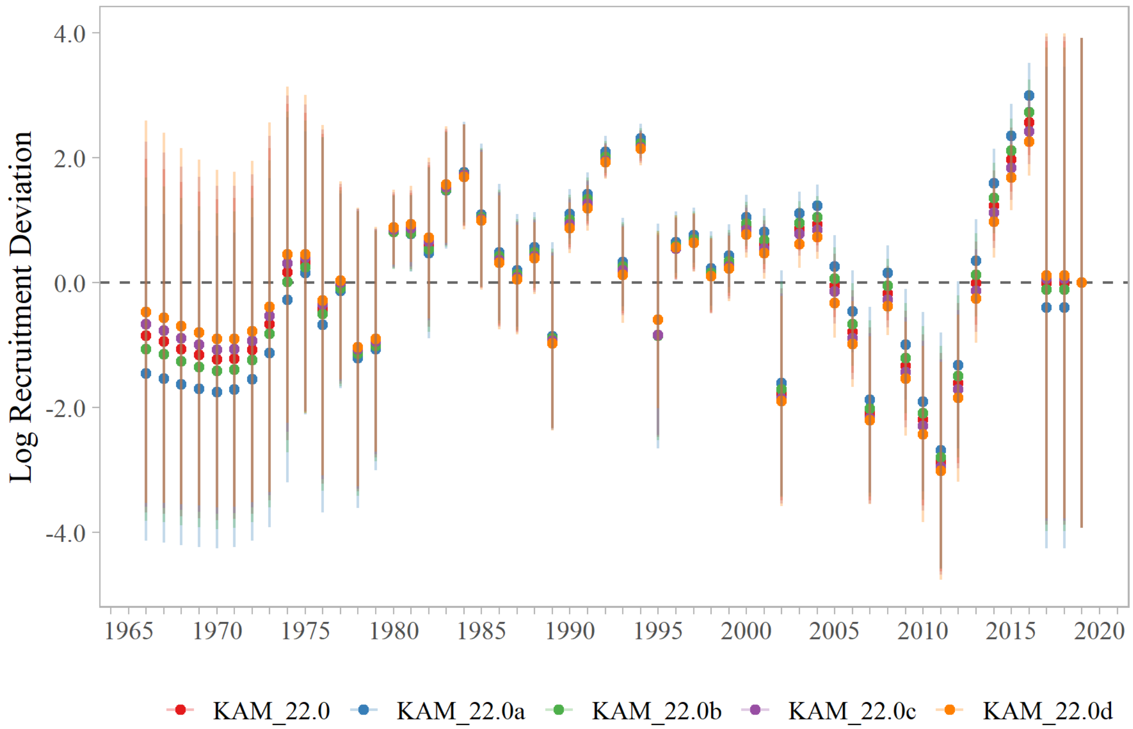

Figure A3.5: Kamishak District recruitment deviation and associated 95% confidence intervals.

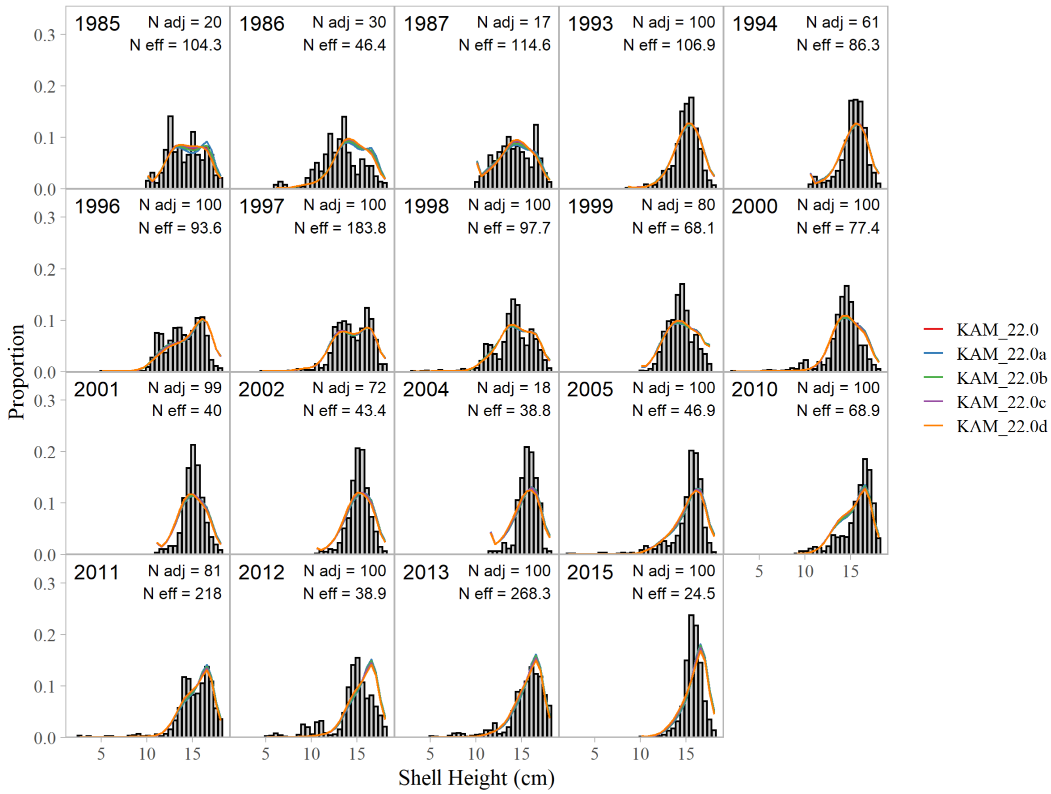

Figure A3.6: Fits to Kamishak District fishery shell height composition data by year and model scenario.

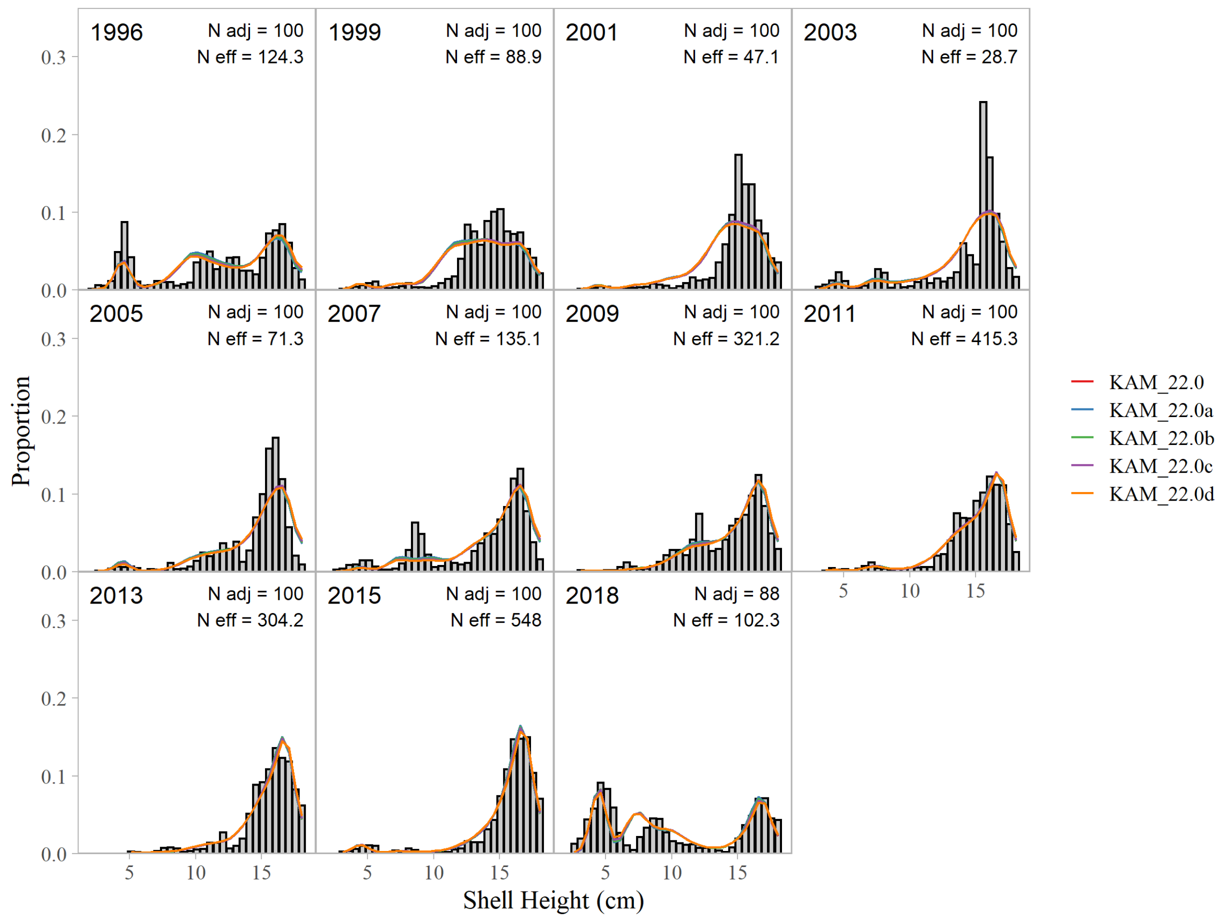

Figure A3.7: Fits to Kamishak District ADF&G dredge survey shell height composition data by year and model scenario.

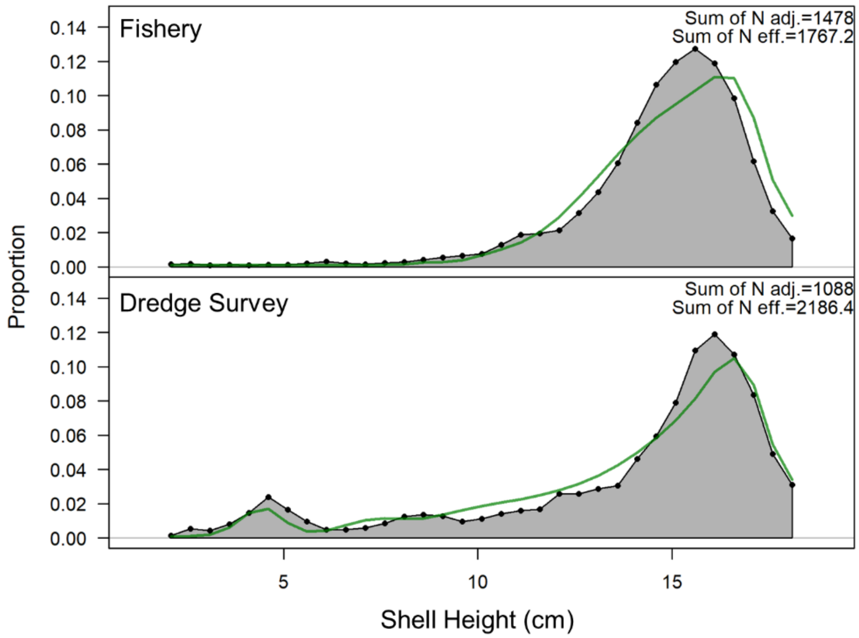

Figure A3.8: Base model fits to Kamishak District shell height composition data aggregated across years by data source.

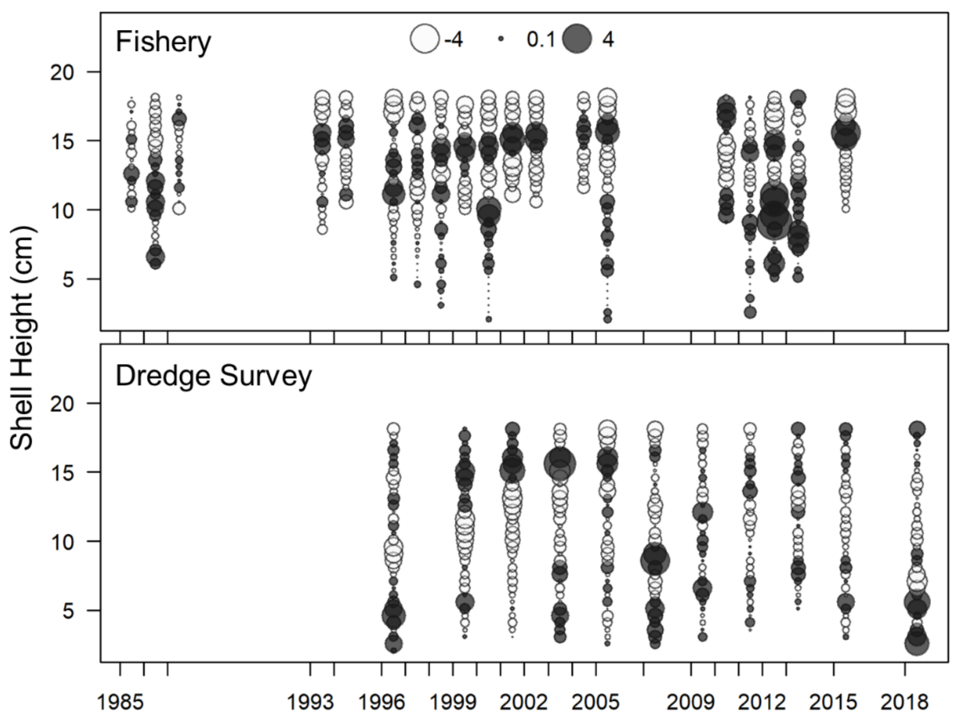

Figure A3.9: Pearson residuals of base model fits to Kamishak District shell height composition data by year and data source.

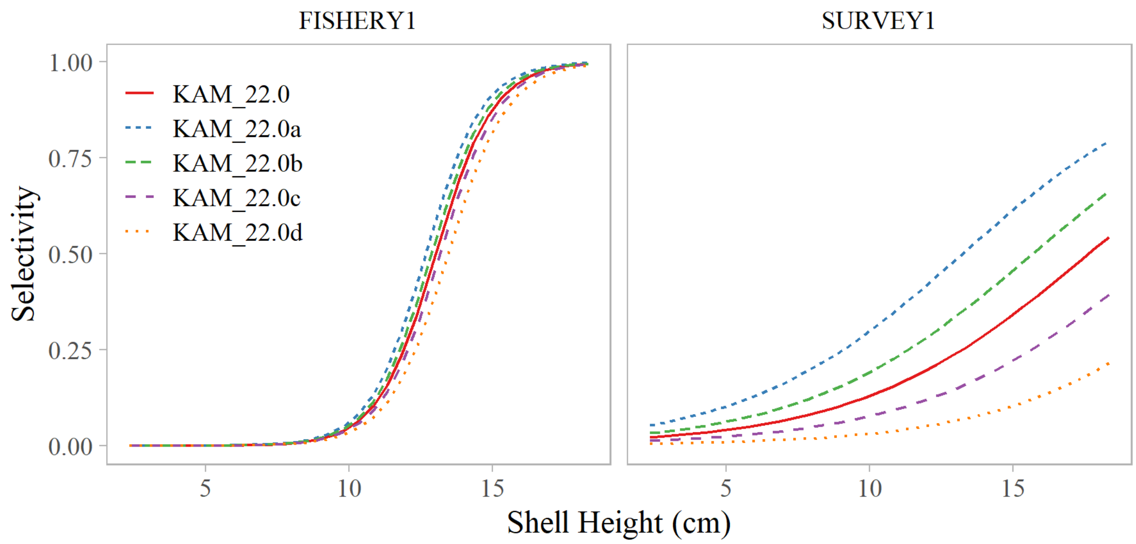

Figure A3.10: **Size (i.e., shell height) selectivity for the Kamishak District fishery and ADF&G dredge survey by model scenario.**

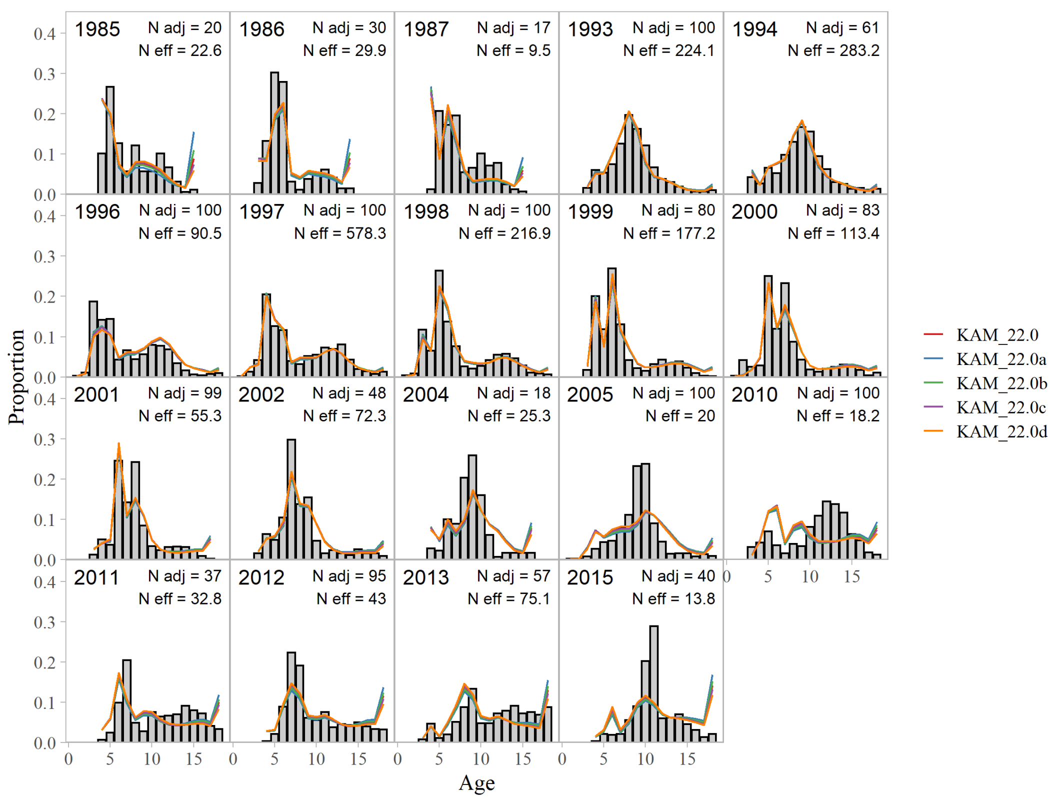

Figure A3.11: **Fits to Kamishak District fishery age composition data by year and model scenario.**

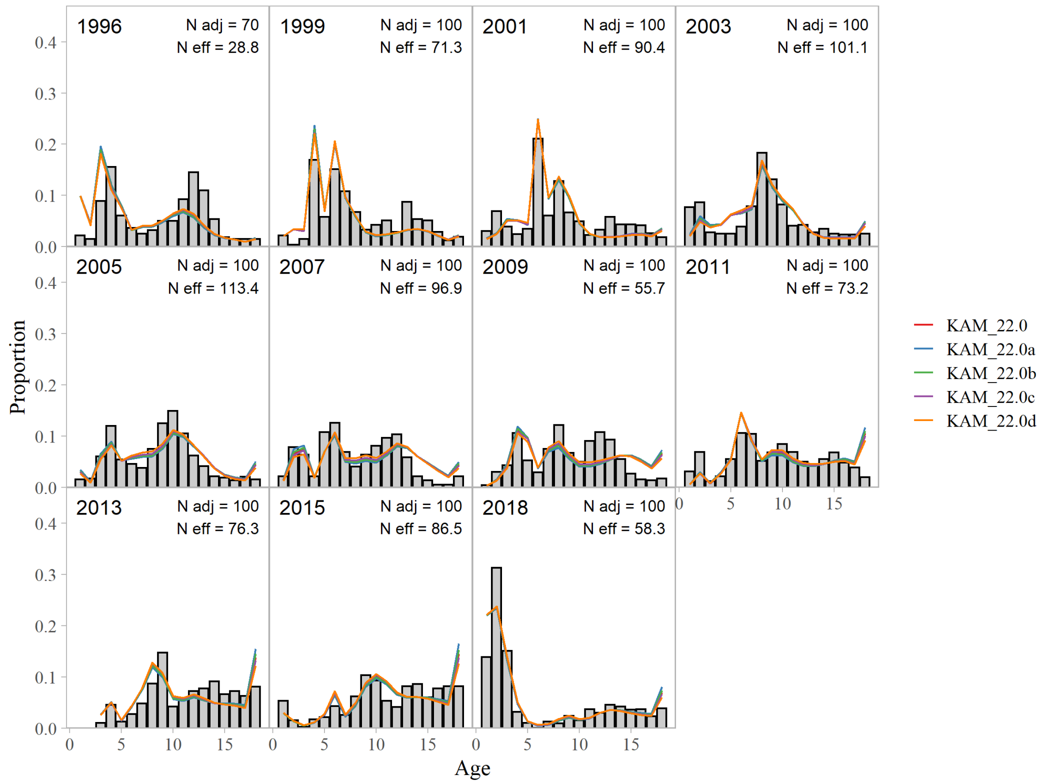

Figure A3.12: Fits to Kamishak District ADF&G dredge survey age composition data by year and model scenario.

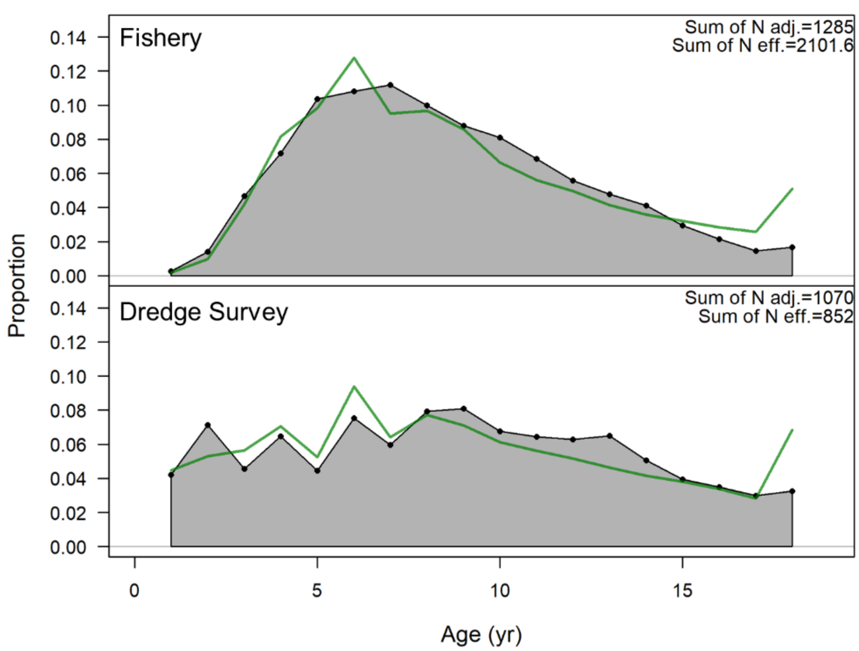

Figure A3.13: Base model fits to Kamishak District age composition data aggregated across years by data source.

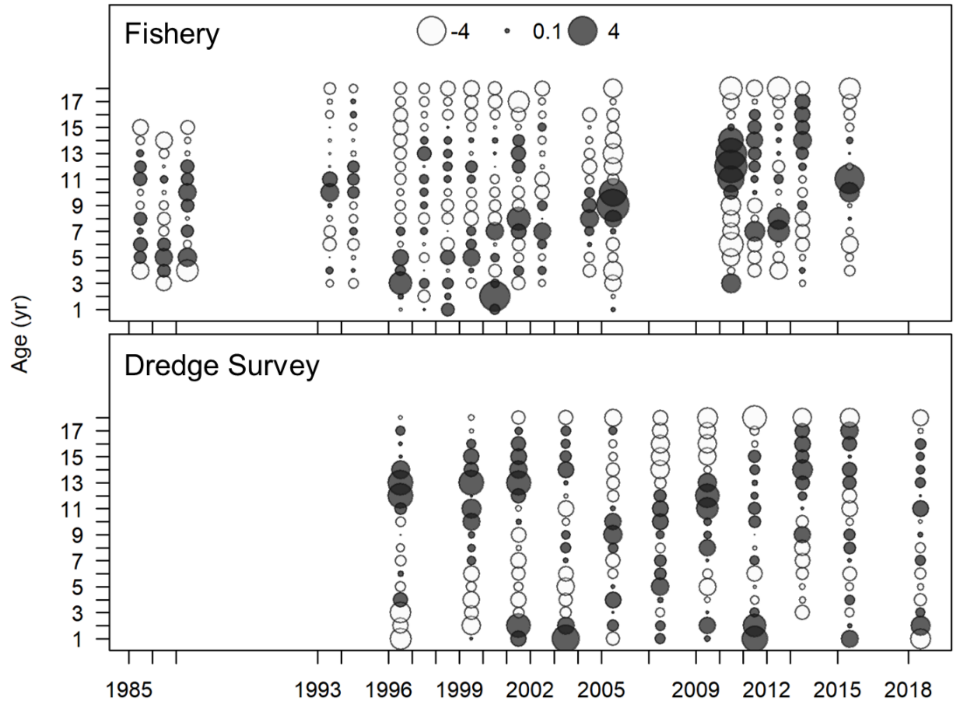

Figure A3.14: **Pearson residuals of base model fits to Kamishak District age composition data by year and data source.**

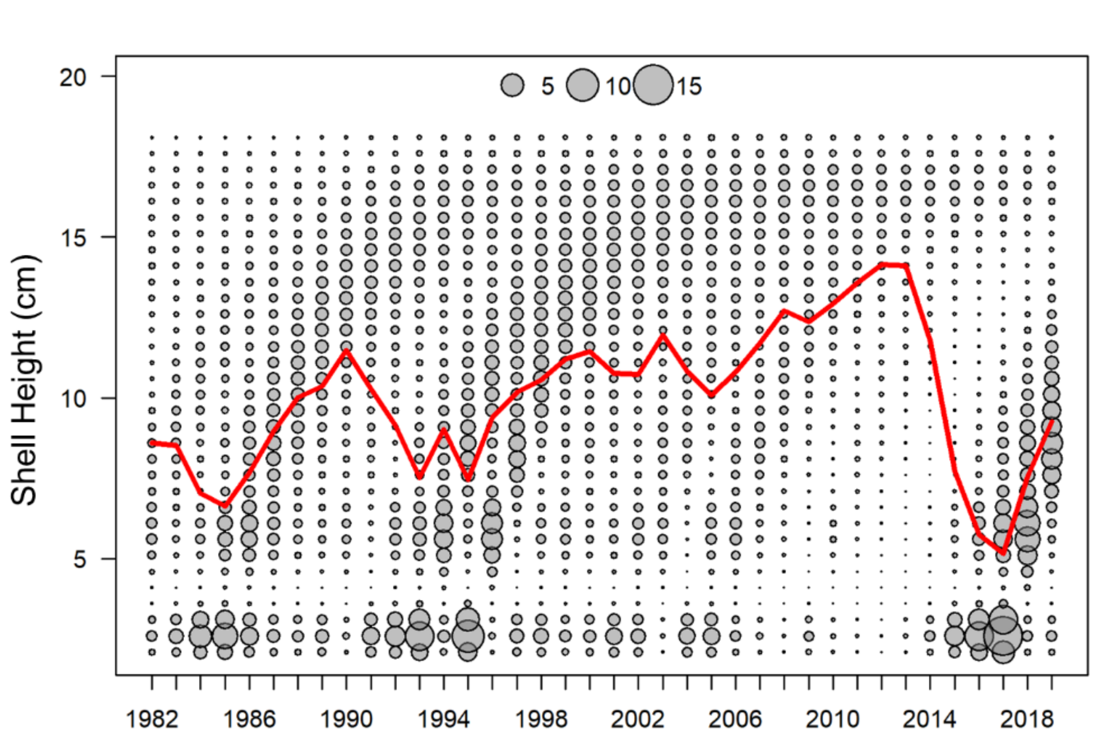

Figure A3.15: **Kamishak District base model mid-year numbers (millions) at shell height (cm). Red line indicates annual mean shell height.**

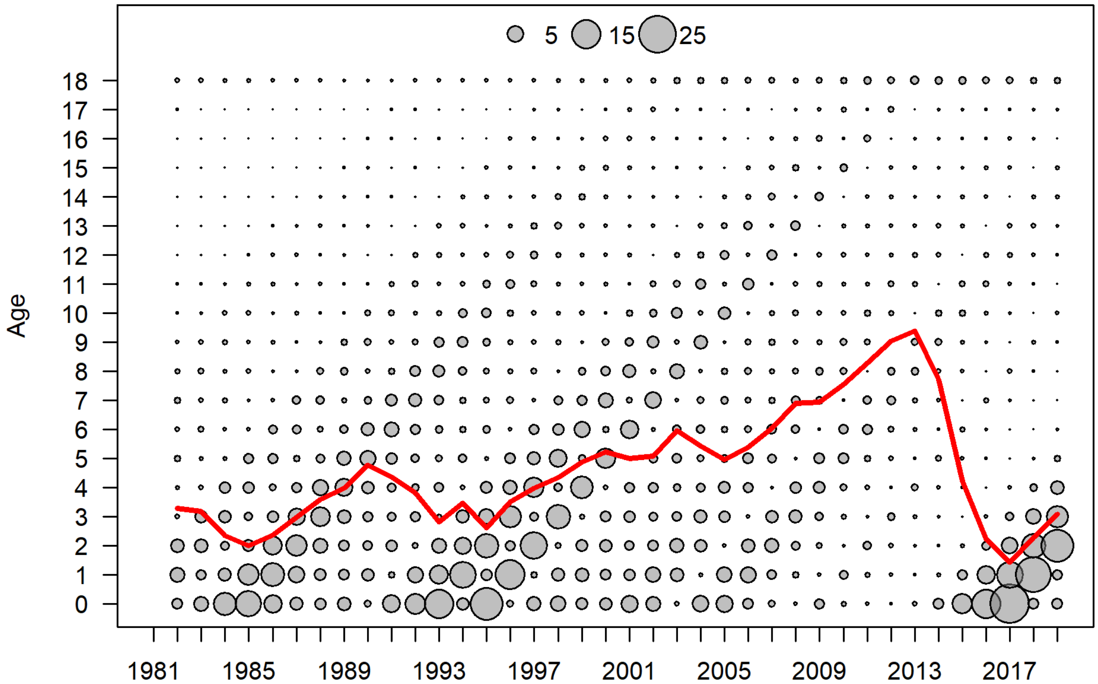

Figure A3.16: **Kamishak District base model mid-year numbers (millions) at age. Red line indicates annual mean age.**

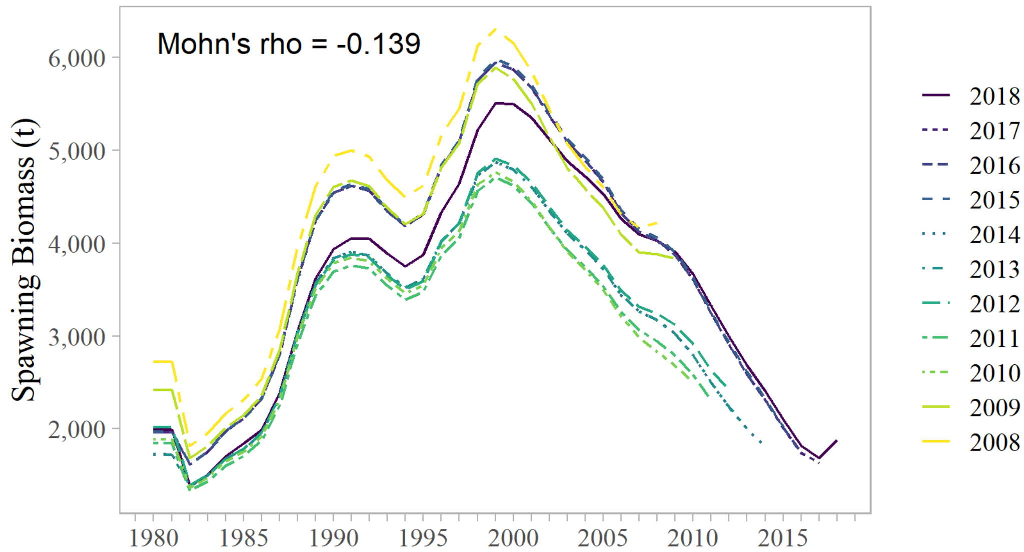

Figure A3.17: Kamishak District spawning biomass (t) from hindcast retrospective analysis of the base model (*M* = 0.19).

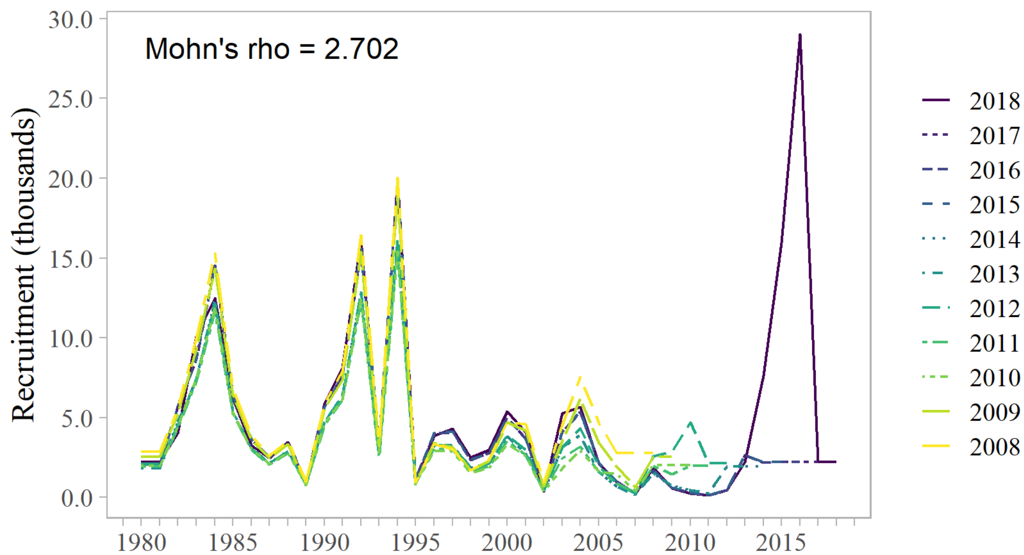

Figure A3.18: Kamishak District recruitment (millions) from hindcast retrospective analysis of the base model (*M* = 0.19).

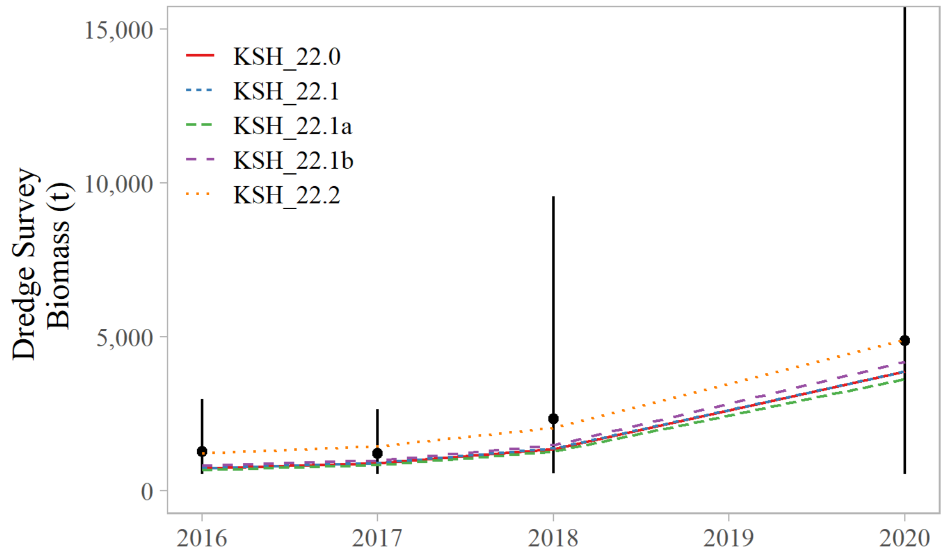

Figure A3.19: **Fit to Kodiak Shelikof District ADF&G dredge survey total round biomass (t) by model scenario. Error bars indicate 95% lognormal confidence intervals.**

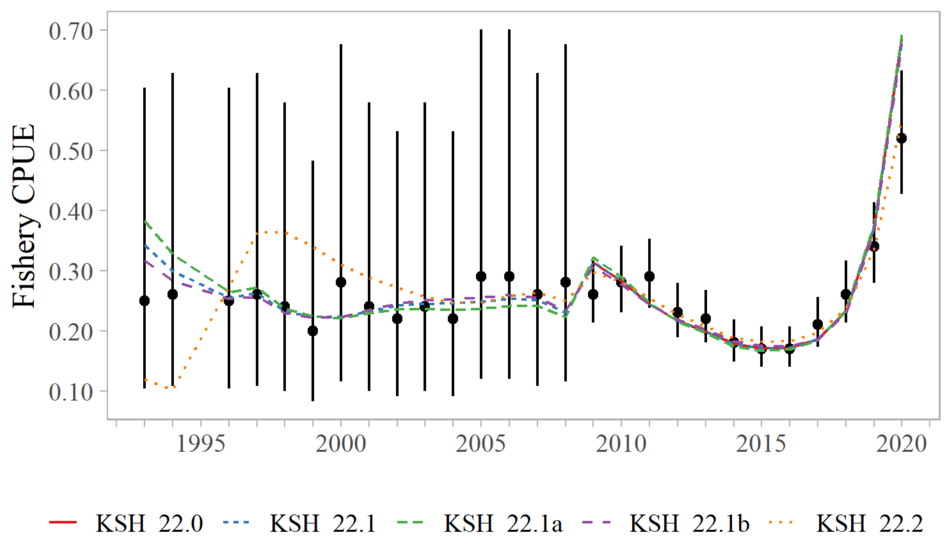

Figure A3.20: **Fit to Kodiak Shelikof District fishery catch per unit effort (CPUE) index by model scenario. Error bars indicate 95% lognormal confidence intervals.**

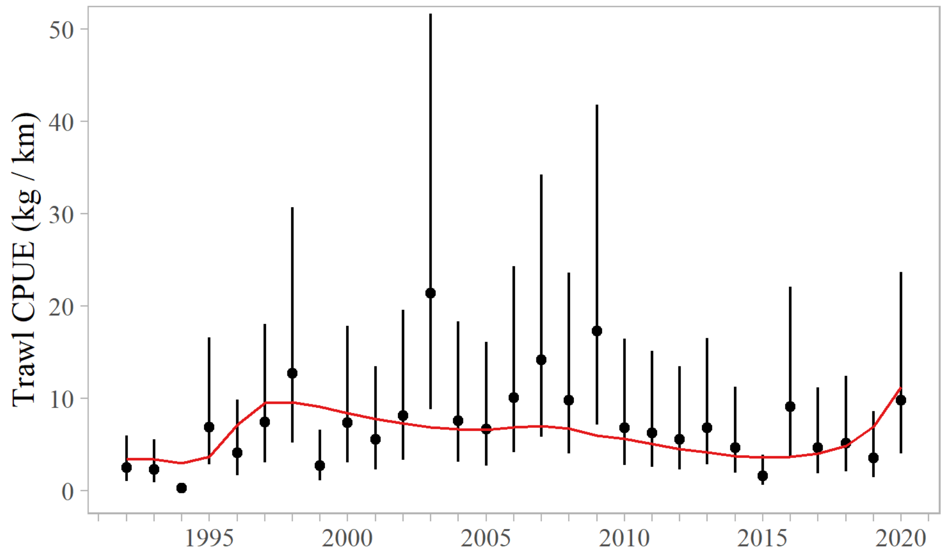

Figure A3.21: Fit to Kodiak Shelikof District ADF&G trawl survey catch per unit effort (CPUE) (t / km) by model scenario. Error bars indicate 95% lognormal confidence intervals.

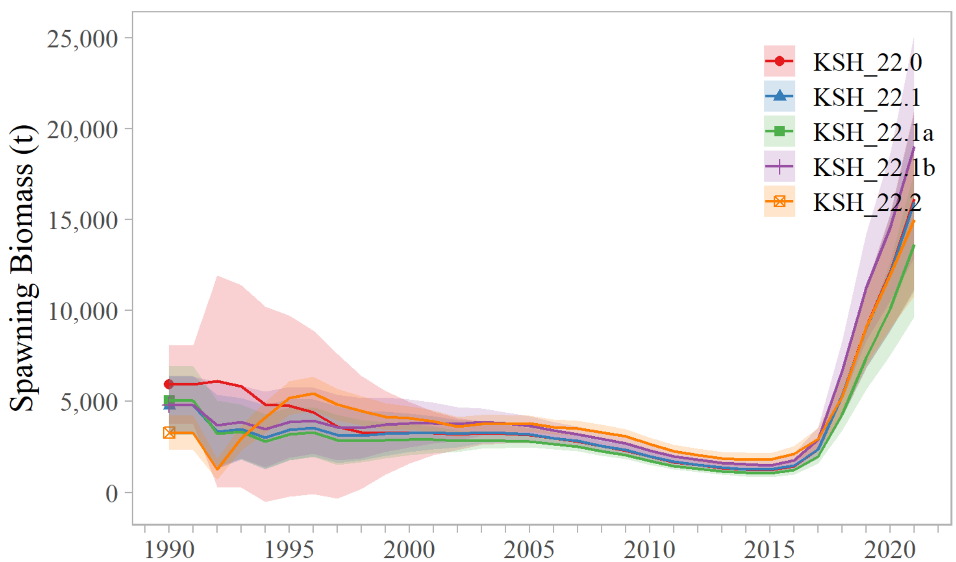

Figure A3.22: Kodiak Shelikof District predicted total spawning biomass (t) by model scenario.

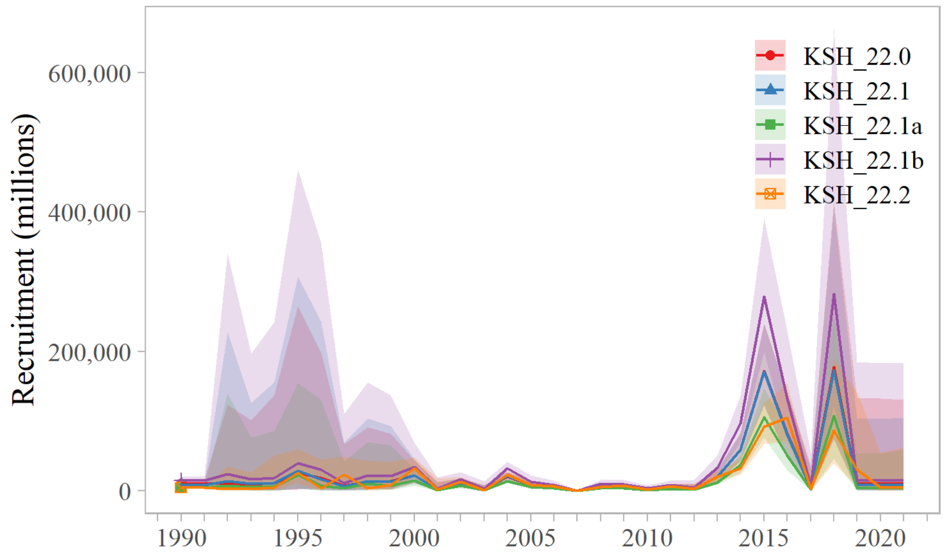

Figure A3.23: **Kodiak Shelikof District predicted annual recruitment (millions) by model scenario.**

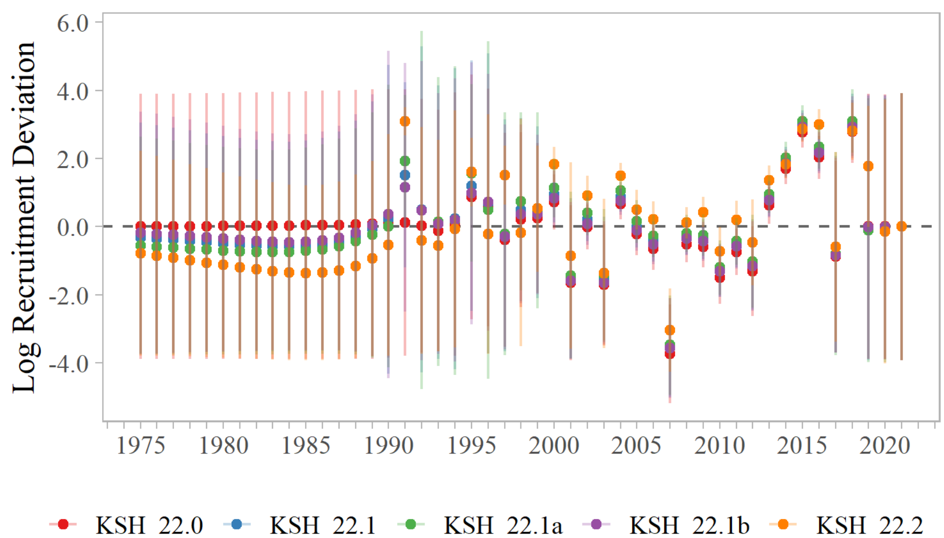

Figure A3.24: **Kodiak Shelikof District recruitment deviation and associated 95% confidence intervals.**

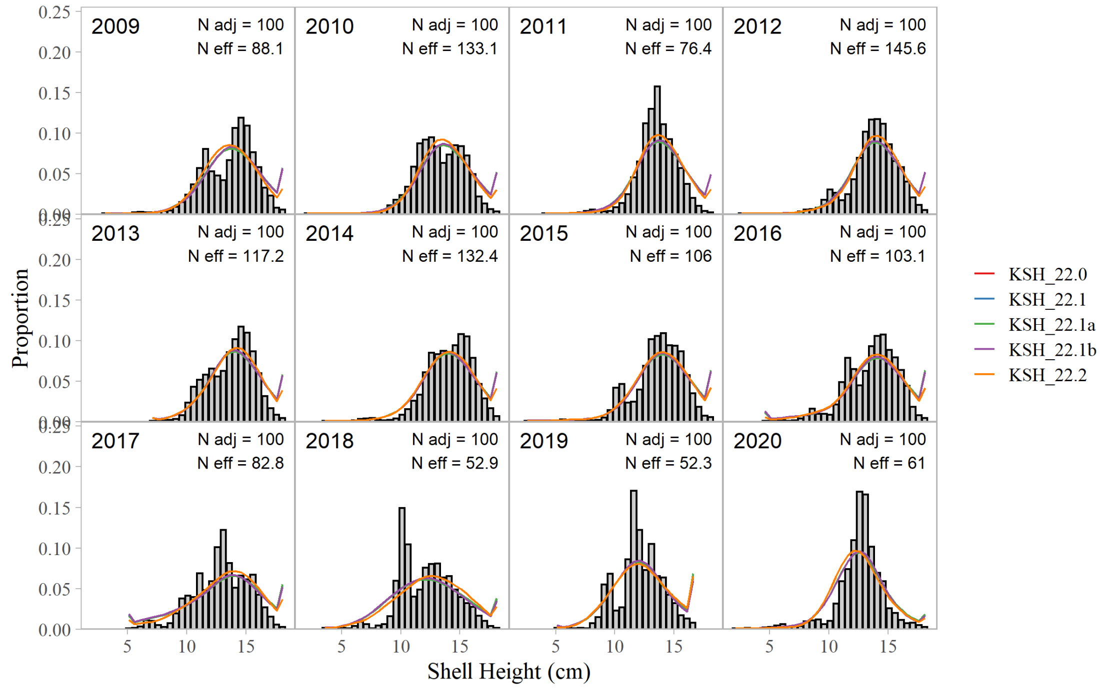

Figure A3.25: Fits to Kodiak Shelikof District fishery shell height composition data by year and model scenario.

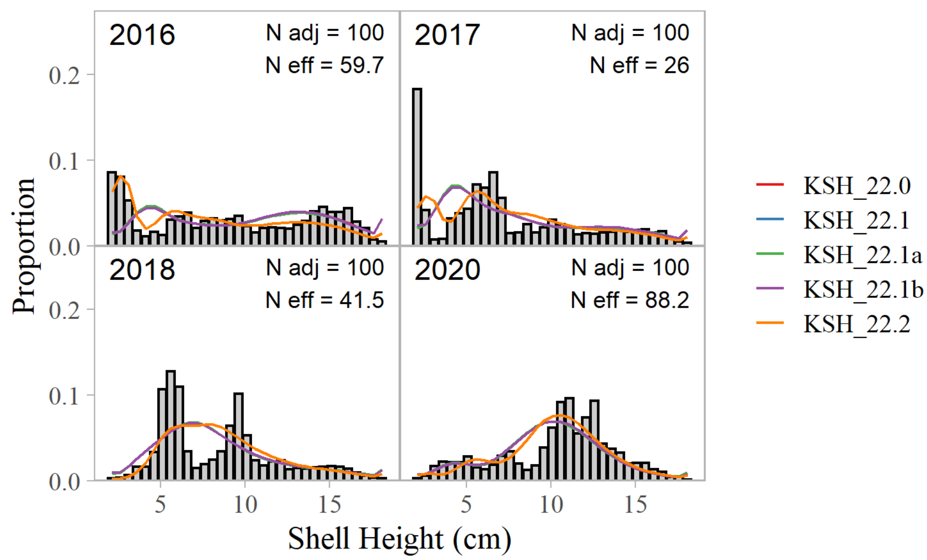

Figure A3.26: Fits to Kodiak Shelikof District ADF&G dredge survey shell height composition data by year and model scenario.

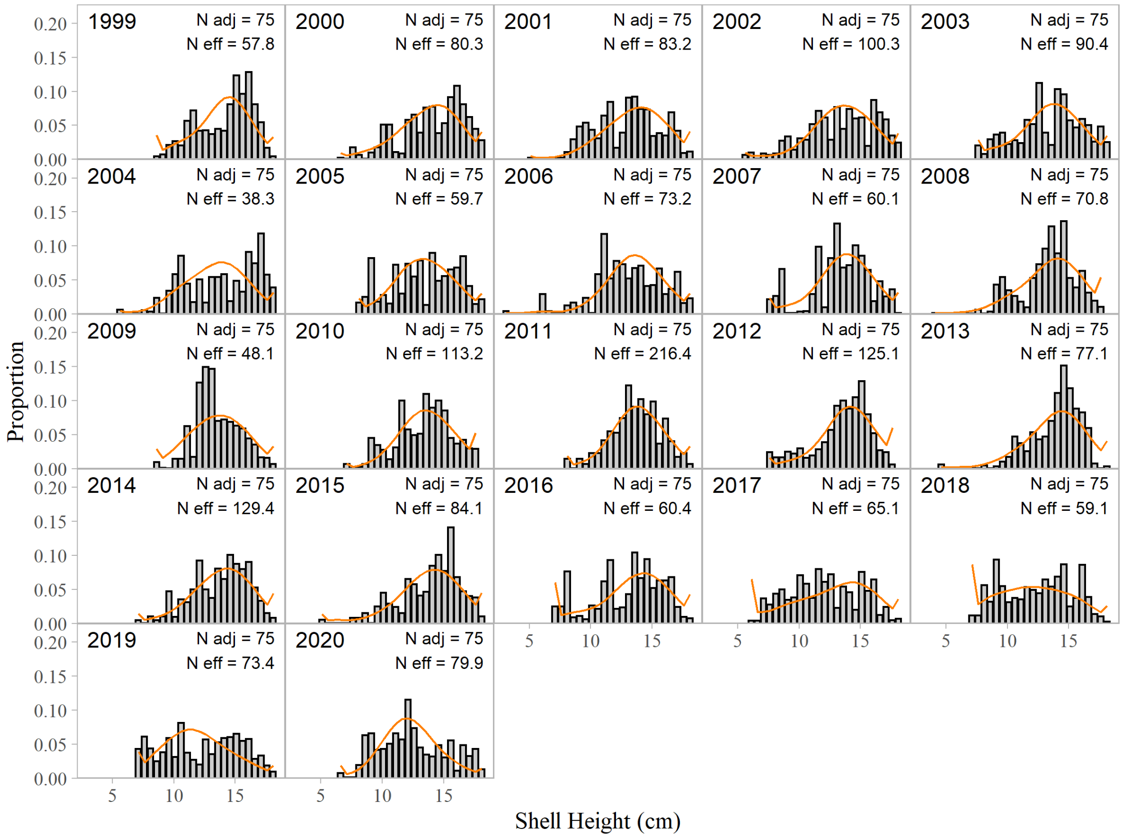

Figure A3.27: Fits to Kodiak Shelikof District ADF&G trawl survey shell height composition data by year and model scenario.

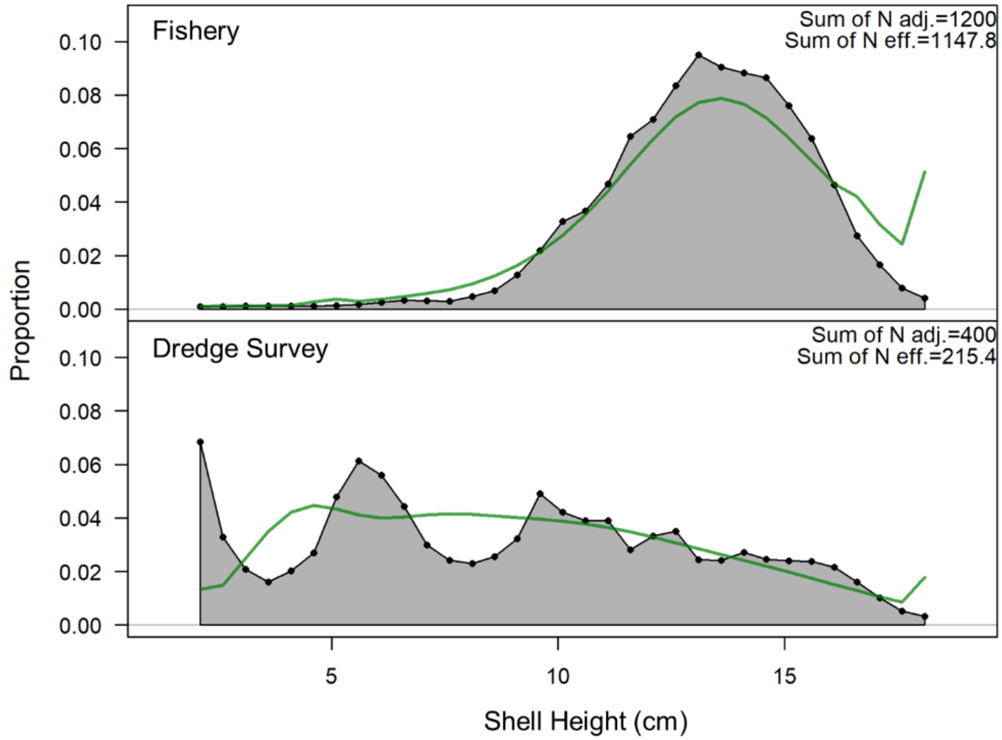

Figure A3.28: Fits (model KSH 22.1) to Kodiak Shelikof District shell height composition data aggregated across years by data source.

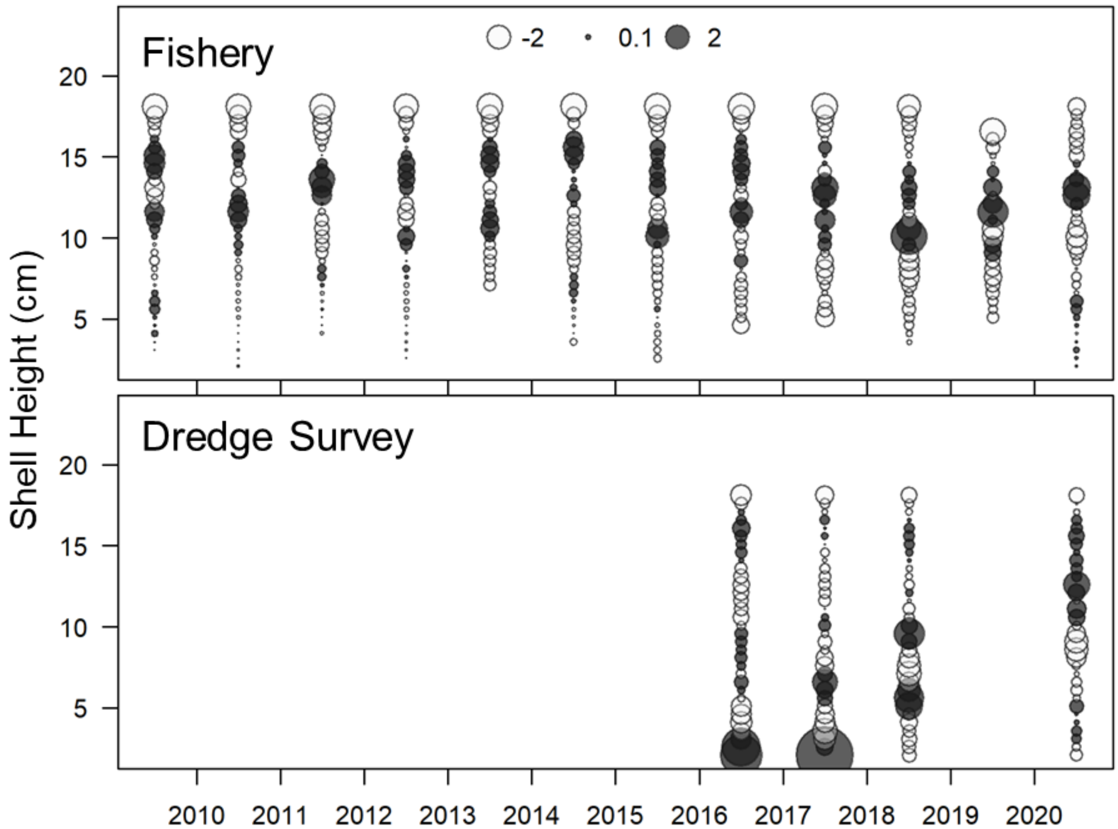

Figure A3.29: Pearson residuals for fits (model KSH 22.1) to Kodiak Shelikof District shell height composition data by year and data source.

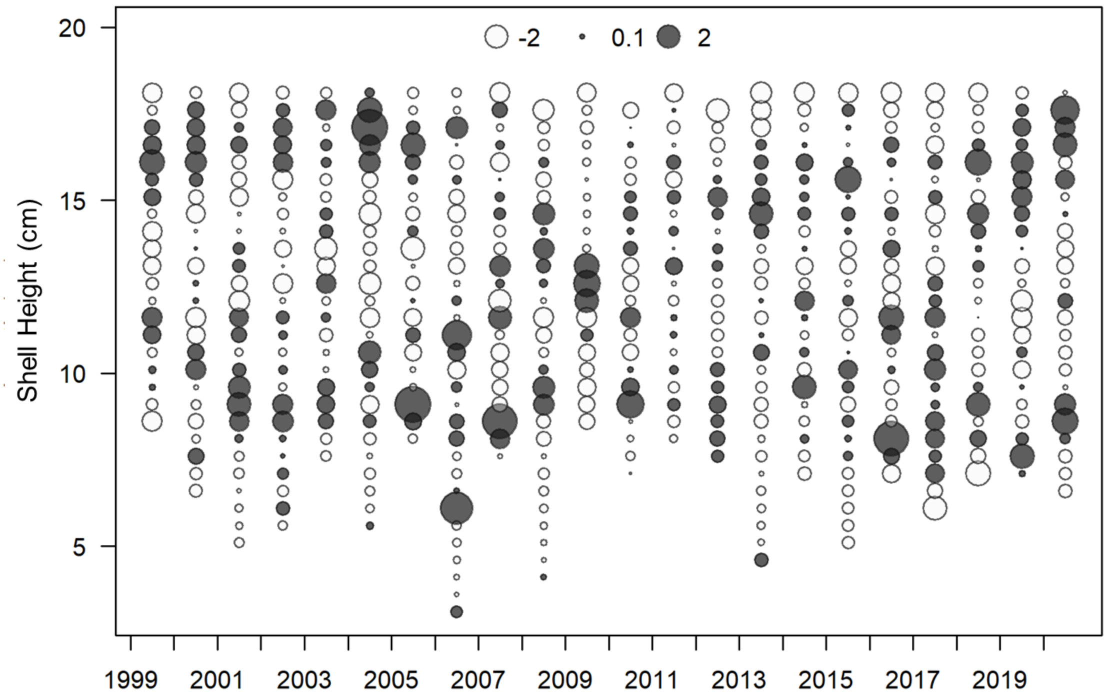

Figure A3.30: **Pearson residuals for fits (model KSH 22.2) to Kodiak Shelikof District trawl survey shell height composition data by year.**

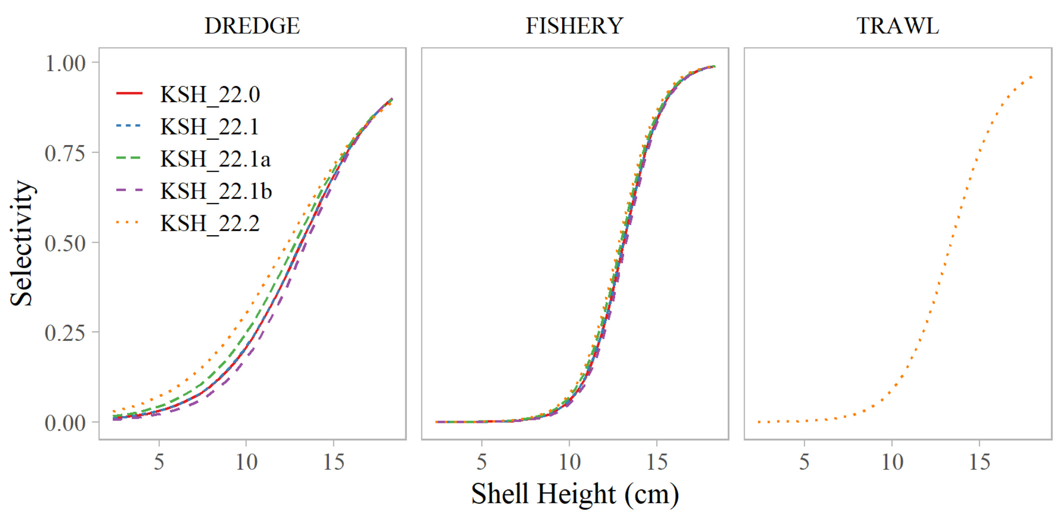

Figure A3.31: **Size (i.e., shell height) selectivity for the Kodiak Shelikof District fishery, ADF&G dredge survey, and trawl survey by model scenario.**

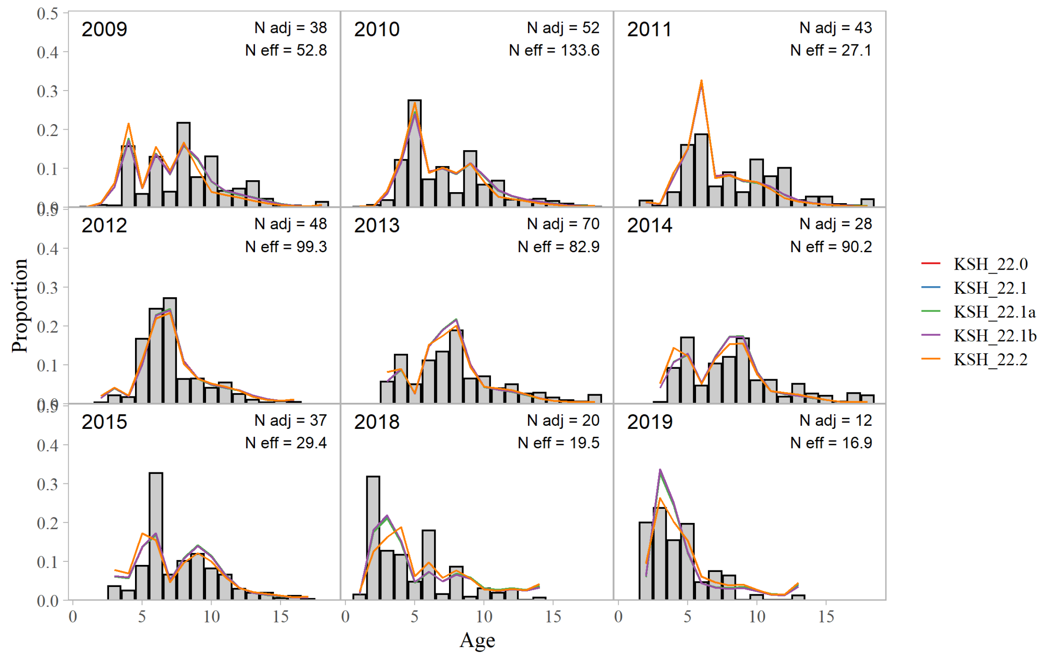

Figure A3.32: Fits to Kodiak Shelikof District fishery age composition data by year and model scenario.

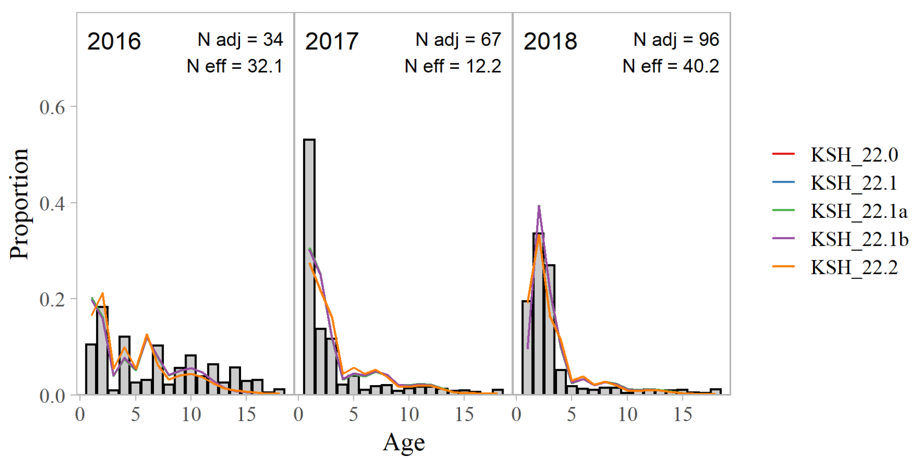

Figure A3.33: Fits to Kodiak Shelikof District ADF&G dredge survey age composition data by year and model scenario.

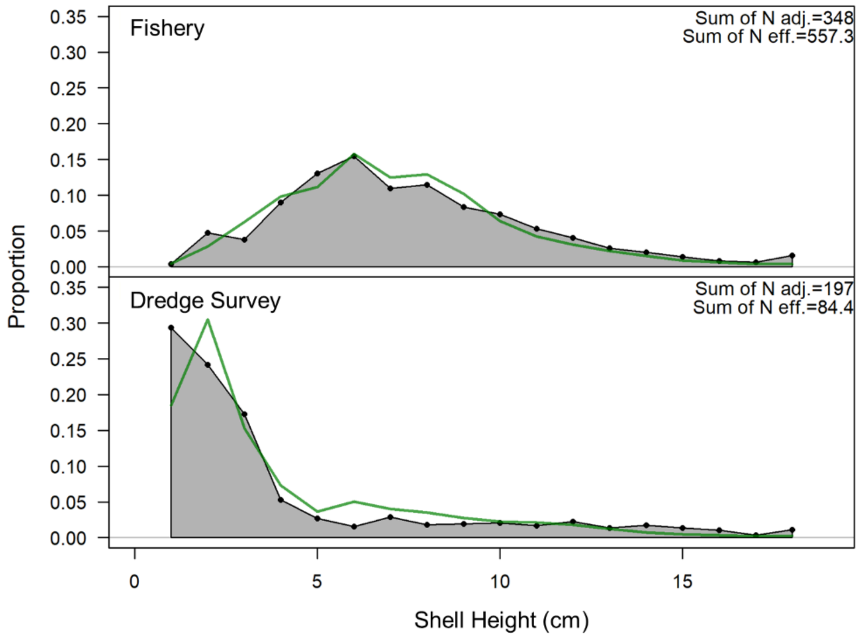

Figure A3.34: **Fits (model KSH 22.1) to Kodiak Shelikof District age composition data aggregated across years by data source.**

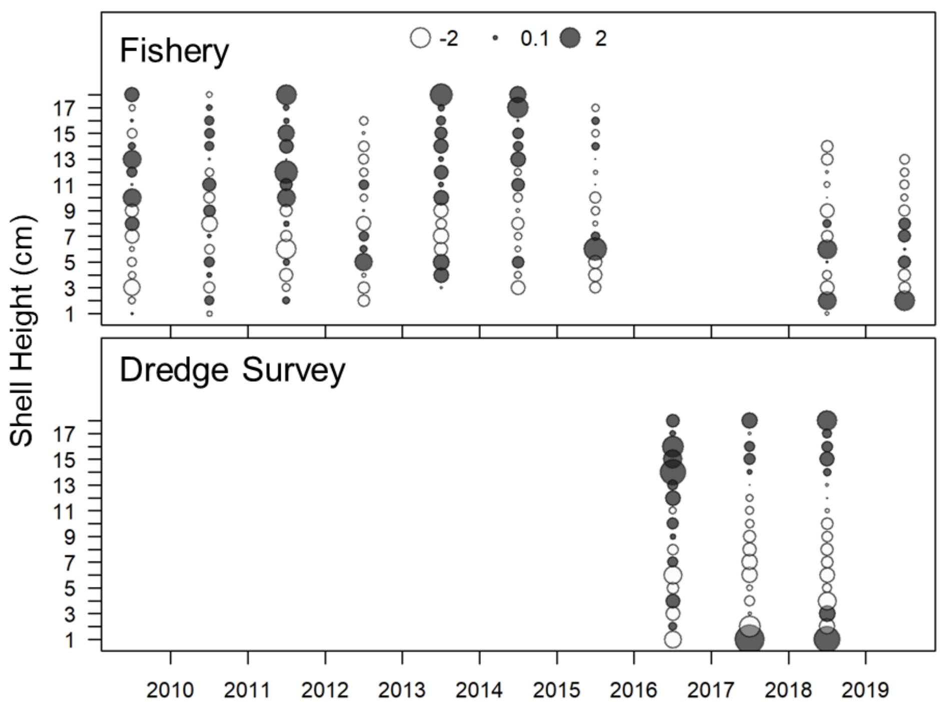

Figure A3.35: **Pearson residuals for fits (model KSH 22.1) to Kodiak Shelikof District age composition data by year and data source.**

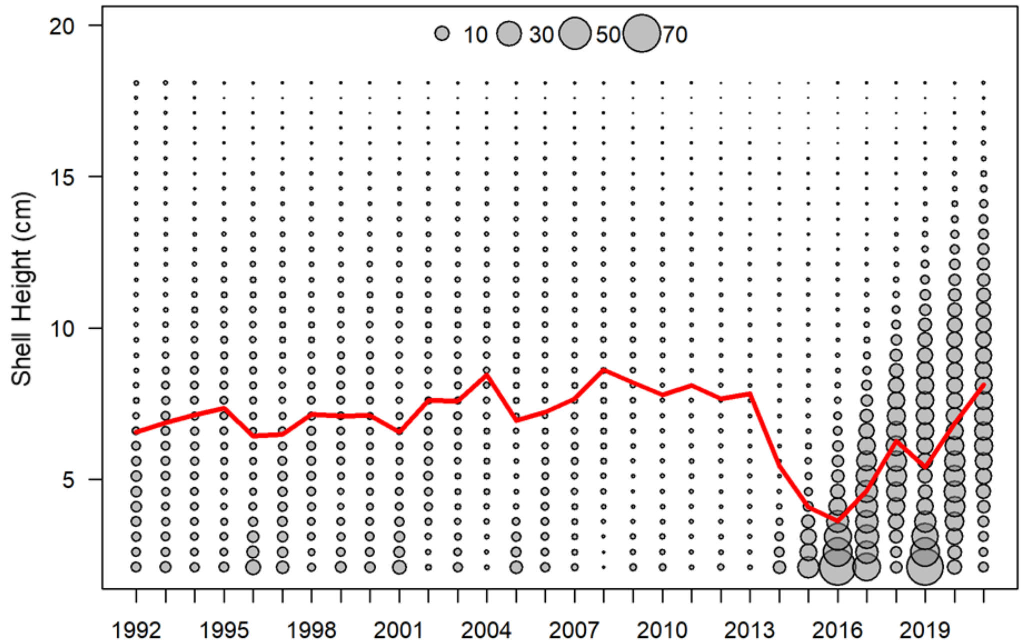

Figure A3.36: **Kodiak Shelikof District model KSH 22.1 mid-year numbers (millions) at shell height (cm). Red line indicates annual mean shell height.**

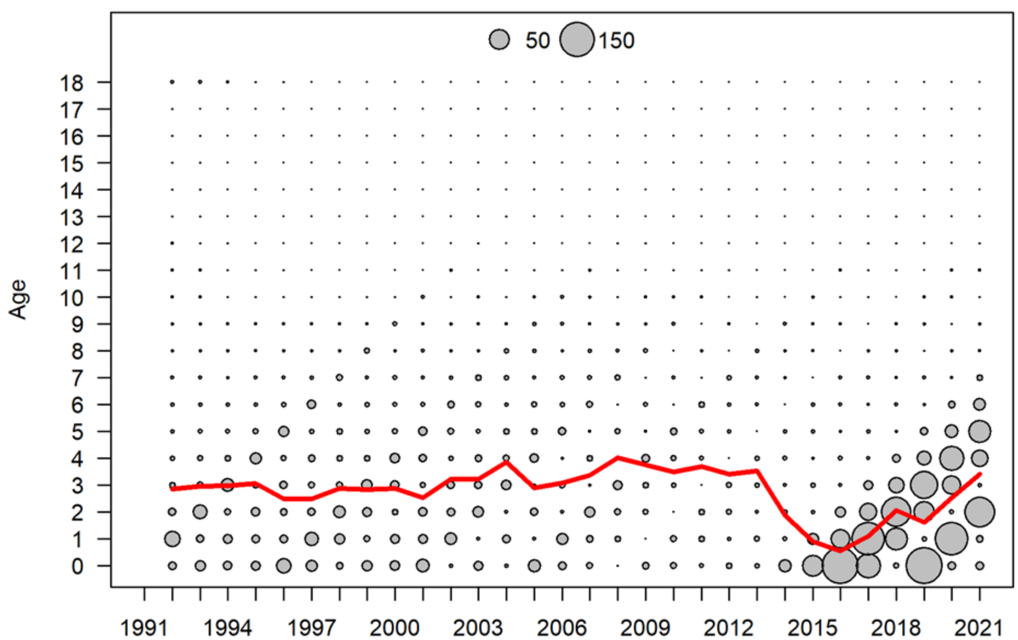

Figure A3.37: **Kodiak Shelikof District model KSH 22.1 mid-year numbers (millions) at age. Red line indicates annual mean age.**

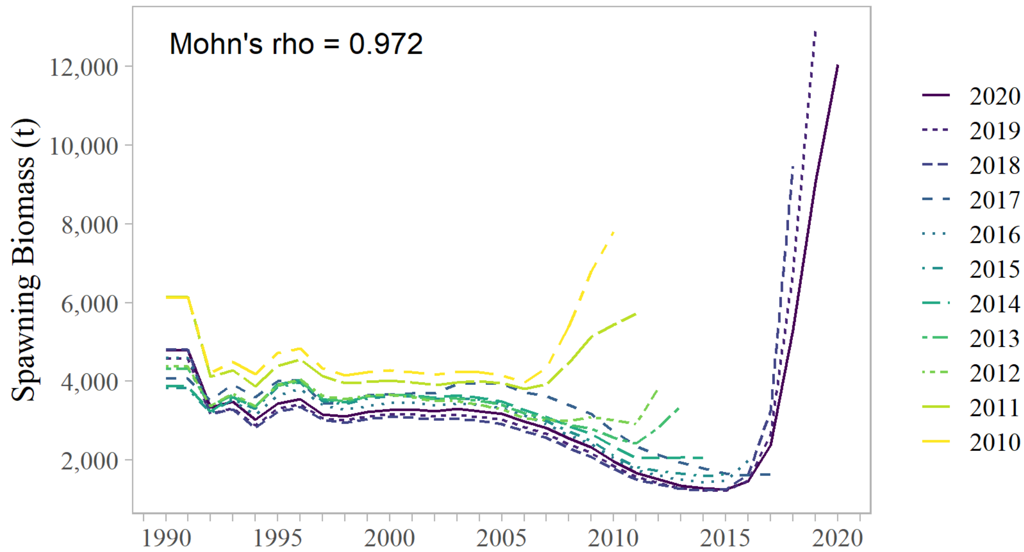

Figure A3.38: Kodiak Shelikof District spawning biomass (t) from hindcast retrospective analysis of model KSH 22.1.

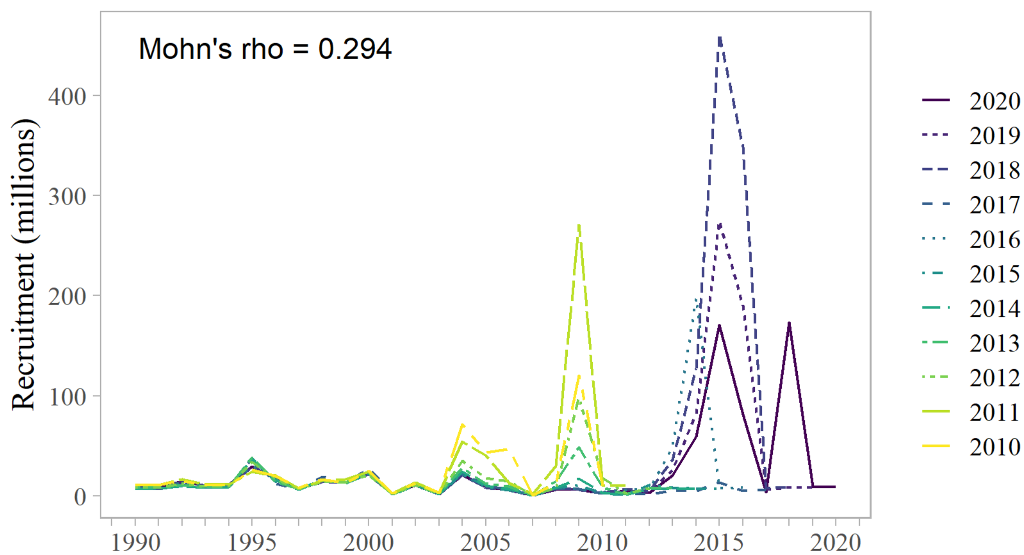

Figure A3.39: Kodiak Shelikof District recruitment (millions) from hindcast retrospective analysis of model KSH 22.