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Results of the Acoustic-Trawl Surveys of Walleye Pollock (*Gadus chalcogrammus*) in the Gulf of Alaska, March 2019 (SH2019-04)

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Results of the Acoustic-Trawl Surveys of Walleye Pollock (*Gadus chalcogrammus*) in the Gulf of Alaska, March 2019 (SH2019-04)

by

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ABSTRACT

Scientists from the Alaska Fisheries Science Center conducted acoustic-trawl surveys in the Gulf of Alaska during late winter and early spring 2019 to estimate the distribution and abundance of walleye pollock (*Gadus chalcogrammus*) at several of their main spawning grounds. These pre-spawning pollock surveys covered Shelikof Strait, the shelf break near Chirikof Island and Marmot Bay (DY2019-04; 06-21 March). The Shelikof Strait area has been surveyed annually in winter since 1981 (except in 1982, 1999, and 2011), and since 1989 this survey has often included the shelf break near the Chirikof Island and Marmot Bay.

The estimated amounts of walleye pollock for the winter 2019 Shelikof Strait survey were 10,664 million fish weighing 1,281,083 metric tons (t), with an additional 12 million fish weighing 9,907 t in the Chirikof region and 138 million fish weighing 6,275 t in Marmot Bay. Walleye pollock between 40 and 55 cm fork length (FL), dominated by the 2012 year class, and contributed the majority of the biomass in all areas. These estimates were based on an analysis that allowed backscatter to be attributed to walleye pollock and other species using the biological data from the nearest haul locations to assign length-frequency distributions of various species to the backscatter. It also included a correction for escapement of smaller walleye pollock (primarily age-1 fish) from the survey trawl (as has been applied from 2008 to present) and a similar correction for eulachon for the first time applied to 2019 data.

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INTRODUCTION

The Midwater Assessment and Conservation Engineering (MACE) Program of the Alaska Fisheries Science Center's (AFSC) Resource Assessment and Conservation Engineering (RACE) Division conducts annual acoustic-trawl (AT) surveys in the Gulf of Alaska (GOA) during late winter and early spring. The goal of these surveys is to estimate the distribution and abundance of pre-spawning walleye pollock (*Gadus chalcogrammus*; hereafter pollock) at several of their main spawning grounds (i.e., pre-spawning surveys), which includes the Shelikof Strait, the continental shelf break near Chirikof Island, and Marmot Bay. Shelikof Strait has been surveyed annually since 1981 except in 1982, 1999, and 2011. Prior to 2019, Marmot Bay was surveyed in the winter 12 times (1989, 1990, 1992, 2007, 2009, 2010, 2013, and 2014-2018). The GOA continental shelf break east of Chirikof Island to Barnabas Trough has been surveyed annually since 2002 except in 2011, 2014, 2016, and 2018. This report presents the results from AT surveys conducted in the aforementioned areas of the GOA during March 2019.

METHODS

Three GOA pollock spawning areas including Shelikof Strait (7-16 March), Chirikof shelf break (16-18 March) and Marmot Bay (19-20 March) were surveyed using acoustic-trawl methods. Shelikof Strait was surveyed earlier this year compared to other years back to 1986. The Strait proper (northern part of the survey area) was surveyed almost 2 weeks earlier than 2018. The earlier start date was designed to better align the survey with the relatively earlier spawning inferred from the higher than average proportion of spawning and spent pollock during the 2018 survey. A recent historical analysis also indicates that estimated spawn time has become earlier concurrent with warmer temperatures and a change in the age distribution of the Shelikof pollock spawning population (Rogers and Dougherty 2019). Additionally, the survey was conducted from north to south (the opposite of 2018 survey direction). The cruise was conducted with the NOAA ship *Bell Shimada*, a 64-m stern trawler equipped for fisheries and oceanographic research, as the NOAA ship *Oscar Dyson*, the vessel traditionally used for these surveys, was under repair. The NOAA ship *Bell Shimada* is a sister ship to the NOAA ship *Oscar Dyson* and it is thus a very similar vessel in many respects (e.g., it is an acoustically-quieted fisheries research vessel and is equipped with an identical scientific echosounder system as the *Dyson*). Survey procedure followed established AT methods as specified in NOAA protocols for fisheries acoustics surveys and related sampling.[1] The acoustic units used here are defined in MacLennan et al. (2002). Survey itineraries are listed in Appendix I and scientific personnel in Appendix II.

Acoustic Equipment, Calibration, and Data Collection

Acoustic measurements were collected with a Simrad EK60 scientific echosounder (Simrad 2008, Bodholt and Solli 1992). System electronics were housed inside the vessel in a permanent laboratory space dedicated to acoustics. Five split-beam transducers (18-, 38-, 70-, 120-, and 200-kHz) were mounted on the bottom of the vessel's retractable centerboard, which extended 9 m below the water surface.

Two standard sphere acoustic system calibrations were conducted to measure acoustic system performance during the winter cruises (Table 1). The vessel's dynamic positioning system was used to maintain the vessel location during calibrations. A tungsten carbide sphere (38.1 mm diameter) suspended below the centerboard-mounted transducers was used to calibrate the 38-, 70-, 120-, and 200-kHz systems. The tungsten carbide sphere was then replaced with a 64 mm diameter copper sphere to calibrate the 18-kHz system. A two-stage calibration approach was followed for each frequency. On-axis sensitivity (i.e., transducer gain and s_A correction) was estimated from measurements with the sphere placed in the center of the beam following the procedure described in Foote et al. (1987). Transducer beam characteristics (i.e., beam angles and angle offsets) were estimated by moving the sphere in a horizontal plane through the beam and fitting these data to a second order polynomial model of the beam pattern using the EK60's calibration utility (Simrad, 2008, Jech et al. 2005). The equivalent beam angle (for characterizing the volume sampled by the beam) cannot be estimated from the calibration approach used because knowledge is required of the absolute position of the sphere (see Demer et al. 2015).

[1] National Marine Fisheries Service (NMFS) 2013. NOAA protocols for fisheries acoustics surveys and related sampling (Alaska Fisheries Science Center), 23 p. Prepared by Midwater Assessment and Conservation Engineering Program, Alaska Fish. Sci. Center, Natl. Mar. Fish. Serv., NOAA. Available online: http://www.afsc.noaa.gov/RACE/midwater/AFSC%20AT%20Survey%20Protocols_Feb%202013.pdf .

Thus, the transducer-specific equivalent beam angle measured by the echosounder manufacturer, corrected for the local sound speed (Bodholt 2002), was used in data processing.

Raw acoustic data were recorded at five split-beam frequencies using ER60 software (version 2.4.3). Processed telegram data were logged with Echoview EchoLog 500 (version 5.22) software as a backup. Acoustic measurements were collected from 16 m below the sea surface to within 0.5 m of the sounder-detected bottom. The raw acoustic data were analyzed using Echoview post-processing software (version 8.0.91.31697).

Trawl Gear and Oceanographic Equipment

General trawl gear specifications for sampling acoustic backscattering are described below. Midwater sound scatterers were sampled with an Aleutian wing 30/26 trawl (AWT). This trawl is constructed with full-mesh nylon wings and polyethylene mesh in the codend and aft section of the body. The headrope and footrope each measure 81.7 m (268 ft). Mesh sizes taper from 325.1 cm (128 in) in the forward section of the net to 8.9 cm (3.5 in) in the codend, which was fitted with a single 12 mm (0.5 in) codend liner. The AWT was fished with four 82.3 m (270 ft) non-rotational wire rope bridles (1.9 cm (0.75 in) dia.), 113.4 kg (250 lb) or 340.2 kg (500 lb) tom weights on each wingtip, and 5 m^2 Fishbuster trawl doors [1,247 kg (2,750 lb) each]. To gauge escapement of smaller fishes from the net, eight small-mesh (12 mm) recapture (also referred to as pocket) nets were placed at various locations of the middle and aft sections of the AWT (Williams et al. 2011). Additionally, a small-mesh (12 mm) recapture net was permanently attached to the bottom panel of the AWT approximately 26 m (85 ft) forward of the codend but was not used in the computing the escapement.

Near-bottom and extremely dense midwater acoustic scatterers were also sampled with a poly Nor'eastern (PNE) bottom trawl. The trawl is a 4-panel high-opening net equipped with roller gear and constructed with stretch mesh sizes that range from 13 cm (5 in) in the forward portion of the net to 8.9 cm (3.5 in) in the codend. The PNE codend was fitted with a single 12 mm (0.5 in) codend liner and was fished with the same 5 m^2 Fishbuster trawl doors.

The depth of both trawls and the vertical mouth opening of the AWT were monitored during fishing. The AWT was monitored using a Simrad FS70 third-wire trawl sonar attached to the trawl headrope. The AWT vertical opening ranged from 16 to 22 m (52-72 ft) and averaged 19 m (62 ft) while fishing. It was fished at an approximate speed of 1.7 m/sec (3.3 knots). No sensors were placed on the PNE trawl to measure the vertical opening, but experience on other surveys indicates that the vertical opening is ~ 7 m.

Oceanographic data were collected during the cruises. Temperature profiles were obtained with a Sea-Bird Electronics temperature-depth probe (SBE-39) attached to the trawl headrope and conductivity-temperature-depth (CTD) observations were collected with a Sea-Bird CTD (SBE 911 plus) system at calibration sites. Near-surface temperature was measured using the ship's Sea-Bird Electronics sea surface temperature system (SBE 38, accuracy ± 0.002 °C) located near the ship's bow, approximately 1.4 m below the surface. These and other environmental data were recorded using the ship's Scientific Computing Systems (SCS). Surface water temperatures were plotted as 0.5 nautical mile (nmi) averages along the vessel's cruise track.

Survey Design

The survey consisted of a series of predetermined parallel transects in each survey area, except in areas where it was necessary to reorient transects to maintain a perpendicular alignment to the isobaths or navigate around landmasses. Spatial coverage and transect spacing were chosen to be consistent with previous surveys in each area. Transect start and end locations matched those from 2018 in Shelikof Strait and Marmot Bay, and those from 2017 at the Chirikof shelf break. The surveys were conducted 24 hours/day.

Trawl hauls were conducted to identify the species and size composition of acoustically observed fish aggregations and to determine biological characteristics of pollock and other specimens. Catches were sorted to species and weighed. When large numbers of juvenile and adult pollock were encountered, the predominant size groups in the catch were sampled separately (e.g., age-1 vs. larger sizes). Sex, length, body weight, maturity, ages (otoliths) and gonad measurements were taken from a random subset of walleye pollock within each size group. Pollock and other fishes were measured to the nearest 1 mm fork length (FL), or standard length (SL) for small specimens, with an electronic measuring board (Towler and Williams 2010). All lengths are reported as FLs in this report. Lengths were converted to FL using SL to FL regressions if necessary. Gonad maturity was determined by visual inspection and categorized as immature, developing, mature (hereafter, “pre-spawning”), spawning, or spent[2]. The ovary weight was determined for pre-spawning females. An electronic motion-compensating scale (Marel M60) was used to weigh individual walleye pollock and selected ovaries to the nearest 2 g. Ototliths collected were stored in 50% glycerol/thymol/water solution and read by AFSC Age and Growth Program researchers to determine ages. Trawl station information and biological measurements were electronically recorded using the MACE Program’s custom Catch Logger for Acoustic Midwater Surveys (CLAMS) software. Each pocket net catch was logged separately, in a manner similar to, the codend catch.

Data Analysis

Processing of acoustic data

Although acoustic data were recorded at five frequencies, the results of this report and the survey time series are based on the 38 kHz data. The sounder-detected bottom was calculated by averaging the bottom detections for all five frequencies (Jones et al. 2011) and then carefully examined to remove bottom integrations. A minimum S_v threshold of –70 dB re 1 m^{-1} was applied to the 38 kHz acoustic data, which were then echo-integrated from 16 m below the surface to 0.5 m above the sounder-detected bottom. Data were averaged at 0.5 nmi horizontal by 10 m vertical resolution intervals and exported to a database.

Associating size and species composition with acoustic backscatter

Walleye pollock abundance was estimated by combining acoustic and trawl information. The analysis method employed here had three principal steps. First, backscatter was attributed to scatterers of a given species and size in trawl catches from nearest geographic haul locations within a stratum. Second, a correction was made for escapement of juvenile pollock and eulachon from the midwater net (based on data collected by the 8 removable pocket nets;

[2] Groundfish Survey Codes. 2016. RACE Division, AFSC, NMFS, NOAA; 7600 Sand Point Way NE, Seattle, WA 98115. Available online: https://www.afsc.noaa.gov/RACE/groundfish/Groundfish_Survey_Codes.pdf .

Williams et al. 2011). Third, backscatter was converted to estimates of abundance from the nearest-haul catch association (step 1) and sample corrections (step 2).

More specifically, acoustic backscatter was assigned to strata based on the appearance and vertical distribution of the aggregations. Strata containing backscatter not considered to be from pollock (e.g. the near-surface mixture of unidentifiable backscatter) were excluded from further analyses. Each trawl was associated with a stratum, and the backscatter at a given location was associated with the species and size composition of the geographically nearest haul within that stratum (see De Robertis et al. 2017 for details). For example, juvenile pollock were consistently found at shallow depths in many areas and adult pollock layers were consistently found at deeper depths in that same area. Thus, the backscatter dominated by aggregations of juveniles would be assigned to a shallow stratum (A) and the backscatter dominated by adult layers would be assigned to a deep stratum (B). Hauls that sampled the juvenile aggregations would be assigned to stratum A, and hauls that sampled the adult layer would be assigned to stratum B. Backscatter would be converted to abundance by species and size within a stratum using the catch composition from the geographically nearest trawl in that stratum as described below (see Appendix III for detailed description of this method).

<u>Selectivity Correction</u>

Previous research has found that juvenile pollock are less likely to be retained by the AWT than adults (Williams et al. 2011). To correct for this difference in retention, trawl selectivity was estimated using recapture nets mounted on the AWT trawl (Appendix IV). Eulachon catches were also corrected for selectivity using an equivalent method as used for pollock. The 2019 estimates reflect adjustments to juvenile pollock and eulachon in all areas, which was the first year eulachon selectivity corrections have been applied in the analysis.

In this report, estimates for 2008-2018 surveys reflect selectivity corrections for juvenile pollock escapement in all areas. For 2008-2017, a mean selectivity correction was applied using those years when recapture net data were collected (2008, 2013, and 2018). In 2018, corrections were applied based on recapture net data from the 2018 survey itself.

Abundance Calculations

Fish abundance was calculated by combining species and size compositions from the hauls with acoustic backscatter data following the approach described in De Robertis et al. (2017) and in Appendix III. A series of target strength (TS) to length relationships from the literature were used along with size and species distributions from trawl catches to estimate the proportion of the observed acoustic scattering attributable to each of the species captured in the trawls. For abundant species (e.g., contributing > 5% of the numbers or weight of the total catch in SH2019-04), the most appropriate TS to length relationship available in the literature was used for that species. Other, less abundant taxa, were assigned to one of five generic categories: fishes with swim bladders, fishes without swim bladders, jellyfish, squid, and pelagic crustaceans (Table 2).

Pollock, eulachon, and Pacific ocean perch (POP, *Sebastes alutus*) contributed more than 5% of the catch in SH2019-04 by weight or numbers. Therefore, a more specific TS relationship was used for pollock and eulachon in the analysis (Table 2). However, a more specific TS relationship is not available for Pacific ocean perch, so the relationship for generic fish with swim bladders, which has been used in other studies of rockfishes (e.g. Jones et al. 2012, Stanley et al. 2000) was used (Table 2).

Processing of maturity data

Maturity data by haul were weighted by the local abundance of adult pollock (number of individuals > 30 cm FL) to compensate for variation in maturity state due to differences in density. The 30 cm size criterion was selected as it represents the minimum size at which 5% of pollock are mature. The sum of the local abundance, A_h, assigned to the geographically nearest haul was computed. A weight, W_h, was then assigned to each haul by dividing the local haul abundance A_h by the average abundance per haul $\bar{A}$,

$$W_h = {}^{A_h}/_{\bar{A}} \qquad \text{(Eqn. 1)}$$

where

$$\bar{A} = {}^{\sum_h A_h}/_{N_h}, \qquad \text{(Eqn. 2)}$$

and N_h is the total number of hauls.

The percent of pollock, $PP_{sex,mat}$ greater than 40 cm by sex and maturity stage (immature, developing, pre-spawning, spawning, or spent) was computed for each haul and combined by survey area using a weighted average with W_h,

$$PP_{sex,mat} = \sum_h (N_{sex,mat,h} \cdot W_h) \Big/ \sum_h W_h, \qquad \text{(Eqn. 3)}$$

where $N_{sex,mat,h}$ is the number of pollock greater than 40 cm by sex and maturity for each haul.

For each haul, the number of female pollock considered mature (pre-spawning, spawning, or spent) and immature (immature or developing) were determined for each cm length bin. The length at 50% maturity (L50) was estimated for female pollock as a logistic regression using a weighted generalized linear model following Williams 2007 with the inclusion of the haul weights, W_h, into the model (function glm, R Core Team, 2019).

The gonadosomatic index, GSI_h, [GSI: ovary weight/(ovary weight + body weight)] was calculated for pre-spawning females in each haul and then a weighted average was computed for each survey area with W_h,

$$GSI = \sum_h (GSI_h \cdot W_h) \Big/ \sum_h W_h. \qquad \text{(Eqn. 4)}$$

<u>Relative estimation error</u>

In all areas, transects were parallel and relative estimation errors for the acoustic-based estimates were derived using a one-dimensional (1-D) geostatistical method (Petitgas 1993, Williamson and Traynor 1996, Walline 2007). "Relative estimation error" is defined as the ratio of the square root of the 1-D estimation variance ($variance_{sum}$) to the biomass estimate (i.e., the sum of biomass over all transects, $biomass_{sum}$, kg):

$$\textit{Relative estimation error}_{1\text{-}D} = \frac{\sqrt{variance_{sum}}}{biomass_{sum}} \,. \qquad \text{(Eqn. 5)}$$

Because sampling resolution affects the variance estimate, and the 1-D method assumes equal transect spacing, estimation variance was determined separately in each area with unique transect spacing. Relative estimation error for an entire survey area (among *n* survey areas with different transect spacings) was computed by summing the estimation variance for each area *j*, taking the square root, and then dividing by the sum of the biomass over all areas, assuming independence among estimation errors for each survey area (Rivoirard et al. 2000):

$$Relative\ estimation\ error_{1\text{-}D\ survey} = \frac{\sqrt{\sum_{j=1}^{n} variance_{sum\ j}}}{\sum_{j=1}^{n} biomass_{sum_j}} \quad . \qquad \text{(Eqn. 6)}$$

Geostatistical methods were used to compute estimation error as a means to account for estimation uncertainty arising from the observed spatial structure in the fish distribution. These errors, however, quantify only transect sampling variability of the acoustic data (Rivoirard et al. 2000). Other sources of error (e.g., target strength, trawl sampling) were not evaluated.

Additional Analyses

Two alternative analyses were conducted to estimate numbers and biomass of walleye pollock. The primary analysis described above relies on the fewest assumptions to generate abundance estimates and is thus considered the most appropriate approach. A secondary analysis (no-selectivity) was conducted to evaluate the impact of incorporating the trawl escapement correction on pollock estimates and to more closely align with the McKelvey index (McKelvey 1996). The no-selectivity analysis was the same as the primary analysis except that it did not include a correction for juvenile pollock or eulachon escapement. That is, the selectivity ($S_{s,l}$) was set to 1 (see Eqn. viii, Appendix IV) for all species and size classes.

To examine pollock vertical distribution in terms of distance above the seafloor, a bottom-referenced analysis was conducted, where all data were exported using Echoview in 10 m bins referenced to a scrutinized line 0.5 m above the sounder-detected seafloor echo. The bottom-referenced analysis was generated for previous years (2015-2018) to allow for inter-annual comparison of vertical distribution. All other parts of this analysis are the same as the primary analysis.

RESULTS and DISCUSSION

Calibration

Pre- and post-survey calibration measurements of the 38-kHz echosounder showed no significant differences in gain parameters or beam pattern characteristics, confirming that the acoustic system was stable throughout the survey (Table 1). At 38 kHz the echo integration gain differed by < 0.1 dB across the two measurements, and the average of all results (averages calculated in the linear domain for dB quantities) were used in the final analysis (Table 1).

Shelikof Strait

Acoustic backscatter was measured along 1,654 km (893 nmi) of transects spaced 13.9 km (7.5 nmi) apart with slightly different average spacing (7.4 and 7.6 nmi) in the center of the Strait accounting for curvature of the survey area (Fig. 1). Bottom depths in the survey area ranged from 40 to 325 m.

Water Temperature

Surface water temperatures in Shelikof Strait averaged 4.5 °C overall (Fig. 2), and ranged from 2.6 °C to 5.6 °C. This was 0.7 degrees warmer than the average of 3.8 °C observed during 2018 and 0.9 °C higher than the historic mean of the prior 36 surveys conducted in this area since 1981 (3.6 °C). Mean estimates at haul locations varied by around 2 °C between the surface and deepest trawl depth across all hauls (Fig. 3). The mean water temperature at fishing depths was 6.0 °C (Table 3).

Trawl Samples

Biological data and specimens were collected in the Shelikof Strait area from 19 AWT hauls and 7 PNE hauls (Tables 3 and 4, Fig. 1) targeted on backscatter attributed to pollock (Fig. 4). The lengths of an average of 291 randomly selected walleye pollock were measured on each haul in

Shelikof, with an average of 89 individuals more extensively sampled for at least one of the following: body weight, maturity, and age (Table 4). A total of 902 otoliths used to estimate walleye pollock ages were collected from Shelikof Strait (Table 4).

Walleye pollock and eulachon were the most abundant species by weight and numbers in the AWT hauls, contributing 95.6% and 4.1% of the catch by weight, and 78.7% and 19.3% by numbers, respectively (Table 5). Compared to the years when eulachon were most abundant, the contribution of eulachon to total catch by weight in 2019 was small (e.g., eulachon contributed 47% of the total catch by weight in 2018). Walleye pollock was the most abundant species in the PNE hauls conducted in the Shelikof Strait this year, accounting for 93.1% of the total weight and 57.5% of the total numbers. Arrowtooth flounder (*Atheresthes stomias*) and eulachon were the two next most abundant species by weight, contributing 2.8% and 2.0% to the total catch, respectively (Table 6). Shrimp (class Malacostraca) and eulachon were the two next most abundant species by number, contributing 22.3% and 15.8%, respectively (Table 6).

Pollock observed in Shelikof Strait were generally in pre-spawning (females) or spawning (males) maturity stages. The maturity composition in the Shelikof Strait area of males > 40 cm FL (n = 503) was 0% immature, 0% developing, 9% pre-spawning, 87% spawning, and 4% spent (Fig. 5, top panel). The maturity composition of females > 40 cm FL (n = 592) was 0% immature, 3% developing, 77% pre-spawning, 11% spawning, and 10% spent (Fig. 5, top panel). Fifty percent of female pollock > 15 cm FL were predicted to be reproductively mature (i.e., pre-spawning, spawning, or spent) at 38.5 cm FL (Fig. 5, middle panel). The average GSI from 462 pre-spawning females was 0.16 $\pm$ 0.02 (Fig. 5, bottom panel, mean $\pm$ standard deviation), which was virtually identical to the 2018 estimate and the historical mean (0.14 $\pm$ 0.04). Most females were in the pre-spawning stage of maturity and substantially fewer were spawning or spent, which suggests that the timing of the 2019 Shelikof survey relative to the spawning period was similar to most other survey years. This was in contrast to the 2018 survey (16-21 Mar.), which was relatively late (or more accurately, the spawning period was relatively early) based on the large percent of spawning/spent females that year (68%).

Distribution and Abundance

Walleye pollock were observed throughout the surveyed area and were most abundant in the central part of the surveyed area (Fig. 6). Adult pollock were detected throughout the Strait, with most distributed along the west side from Cape Nukshak to Cape Kekurnoi and in the center of the sea valley south of Cape Kekurnoi (Fig. 6), as is typical for most previous Shelikof surveys. Juveniles (< 30 cm FL) along with relatively few older fish were detected as a multiple midwater layers throughout the water column (Fig. 7). Dense aggregations of adult pollock (≥ 30 cm FL) were encountered deeper in the water column, generally 180-300 m and were observed mostly within 100 m of the bottom (Fig. 8), computed from bottom-referenced analysis. Adult pollock aggregations were observed to be deeper than the past 4 years. Only about 10% of biomass was observed within 3 m of the seafloor, and 80% percent of biomass was within about 60 m of the seafloor (Figs. 7 and 8).

Walleye pollock with lengths 9-14 cm FL, indicative of age-1 pollock, accounted for 69% of the numbers but only 4.8% of the biomass of all pollock observed in Shelikof Strait (Figs. 9 and 10). Pollock 16-29 cm FL, indicative of age-2s, accounted for 15.7% by numbers and 7.9% by biomass. Larger pollock 30-61 cm FL accounted for 15.2% and 87.3% of the numbers and biomass, respectively. Pollock of most ages were smaller when compared to the same age group from previous winter acoustic-trawl surveys (Fig. 11).

A total of 10.7 billion pollock weighing 1,281,083 t were estimated to be in the Shelikof Strait at the time of the survey. The 2019 biomass was 97% of that observed in 2017 (1,320,867 t) and almost twice the historic mean of 704,627 t (Table 7; Fig. 12). Survey biomass estimates in 2017, 2018, and 2019 are the largest since the mid-1980s (Table 7; Figs. 12 and 13). The relative estimation error of the 2019 biomass estimate based on the 1-D geostatistical analysis was 6.6%.

The continued strength of the 2012 year class was clearly visible in the population size composition time series by both numbers and biomass of pollock in the survey area beginning in 2013 (Fig. 12). Although there were more pollock (by numbers) in the 9-29 cm FL range compared to larger pollock (Tables 8 and 10), the larger pollock (ca. 40 cm FL to 55 cm FL, mostly age-6) accounted for most of the biomass (84.5%, Tables 9 and 11). Age-1 pollock

(9-14 cm FL) were particularly numerous in 2019 compared to previous years. Their numbers were greater than any other year class, when assessed as 1-year-olds, since the 2012 year class.

McKelvey (1996) showed that there was a strong relationship between the estimated number of age-1 pollock from the Shelikof Strait AT survey and year-class strength for GOA pollock. The McKelvey index is based on data that did not include a correction for escapement of age-1 pollock. Thus, the 2019 non-selectivity based estimate was used to classify the strength of the 2018 year class (age-1 pollock observed in 2019) in the context of the McKelvey index. This estimate was 4 billion age-1 pollock, which is considered a high or strong year class based on the McKelvey index. The non-selectivity correction analysis for 2019 generated an overall decrease of 26.5% by numbers (to 7,841 million) and an increase of 5% by biomass (to 1,344,548 t) for pollock in the Shelikof Strait area compared to the primary analysis. Specifically, the non-selectivity analysis decreased the number of small pollock and increased the number of adults relative to the primary analysis.

Chirikof Shelf Break

Acoustic backscatter was measured along 307 km (166 nmi) of transects spaced 11.1 km (6 nmi) apart along the Chirikof shelf break (Fig. 1). Bottom depths ranged from 50 to 500 m.

Water Temperature

Surface water temperatures averaged 5.6 °C throughout the Chirikof shelf break survey area (Fig. 2), which was 1.0 degree warmer than the mean of 4.6 °C measured in 2017. Mean water temperature ranged 0.9 °C between the surface and deepest trawl depth across all hauls, and the average temperature at the fishing depths was 5.6 °C (Fig. 14, Table 3).

Trawl Samples

Biological data and specimens were collected along the Chirikof shelf break from three AWT hauls (Tables 3 and 4, Fig. 1). An average of 146 randomly selected walleye pollock were collected for length measurements from each trawl catch, with an average of 44 individuals more extensively sampled for at least one of the following: body weight, maturity, and age (Table 4). Fifty-six walleye pollock otoliths were collected from Chirikof shelf break to estimate ages

(Table 4). POP and walleye pollock were the most abundant species by weight in AWT hauls, contributing 83.6% and 16.0% of the total catch, respectively (Table 12). POP and shrimp were the most abundant species (excluding euphausiids) by numbers in AWT hauls, contributing 50.8% and 9.4% of the total numbers, respectively (Table 12). Historically, more pollock by weight have been caught in this area (e.g., pollock were 75% by weight in 2015). Walleye pollock ranged in length from 27 to 66 cm FL (Fig. 9), which was a wider range than in 2017 (38-57 cm).

Pollock observed in Chirikof were mostly in pre-spawning (females) or spawning (males) maturity stages. The maturity composition for Chirikof males > 40 cm FL (n = 17) was 0% immature, 0% developing, 19% pre-spawning, 58% spawning, and 23% spent (Fig. 14, top panel). The maturity composition for females > 40 cm FL (n = 69) was 0% immature, 2% developing, 89% pre-spawning, 0% spawning, and 8% spent (Fig. 15, top panel). Fifty percent of female pollock > 15 cm FL were mature (i.e., pre-spawning, spawning, or spent) at 30.9 cm FL (Fig. 15, middle panel). The average GSI from 60 pre-spawning females was 0.13 ± 0.01 (Fig. 15, bottom panel**,** mean ± standard deviation), which was slightly higher than the 2017 (0.09 + 0.03) estimate but slightly lower the historical mean (0.16 ± 0.04). The relatively low proportion of females in the spawning and spent stages of maturity was similar to other survey years for this area, and suggested that survey timing relative to the spawning season was consistent with most other years in the time series.

Distribution and Abundance

The majority of pollock biomass in the Chirikof region was comprised of low-density aggregations distributed along the shelf break (Fig. 6). The pollock aggregations were indistinguishable from POP aggregations on the echosounder records, based on the catches being a mixture of both species. The pollock aggregations were mainly in midwater about 200-300 m and relatively evenly distributed 0-300 m height off the bottom, which contrasted with 2015 when pollock were very close to the bottom (Fig. 16). The estimated amounts of walleye pollock in Chirikof were 11.9 million fish weighing 9,907 t. The biomass estimate was almost four times the 2017 estimate (2,485 t) but much less than the historic mean for this survey (35,184 t; Table 7, Fig. 13). The relative estimation error of the biomass based on the 1-D geostatistical analysis was 17.7 %.

Marmot Bay

Acoustic backscatter was measured along 133.3 km (72 nmi) of transects spaced 1.75 km (1.0 nmi) apart in the inner Marmot Bay, and 184.4 km (99.6 nmi) of transects spaced 3.5 km (2.0 nmi) apart in outer Marmot Bay (Fig. 17). Bottom depths ranged from 68 to 275 m in inner Marmot Bay and from 108 to 190 m in the outer Marmot Bay.

<u>Water Temperature</u>

Surface water temperatures averaged 5.6 °C throughout the Marmot Bay survey area (Fig. 18), 1.4 degrees warmer than last year's mean of 4.2 °C. Mean water temperature ranged 0.2 °C between the surface and deepest trawl depth across all hauls (Fig. 19) and averaged 5.7 °C at fishing depths (Table 3).

<u>Trawl Samples</u>

Biological data and specimens were collected in Marmot Bay from five AWT hauls throughout the survey area (Tables 3 and 4, Figs. 1 and 17). The lengths of an average of 174 randomly selected walleye pollock were measured in Marmot, with an average of 65 individuals more extensively sampled for at least one of the following: body weight, maturity, and age (Table 4). A total of 162 walleye pollock otoliths were collected from Marmot Bay to estimate pollock ages (Table 4). Walleye pollock and eulachon were the most abundant species by weight in AWT hauls, contributing 99.4% and 0.4% by weight, and 93.4% and 2.5% by numbers, respectively (Table 13). Unidentified shrimp were the second most abundant species, contributing 2.6% by numbers (Table 13). Historically, eulachon are more numerous in the catch than pollock in the Marmot area.

In general, pollock observed in Marmot Bay were in pre-spawning (females) or spawning (males) maturity stages. The maturity composition in Marmot Bay of males > 40 cm FL (n = 62) was 0% immature, 0% developing, 11% pre-spawning, 84% spawning, and 6% spent (Fig. 20, top panel). The maturity composition of females > 40 cm FL (n = 133) was 1% immature, 3% developing, 81% pre-spawning, 9% spawning, and 7% spent (Fig. 20, top panel). The relatively low proportion of females in the spawning and spent stages of maturity was similar to other survey years for this area, and suggested that survey timing relative to the spawning season was comparable. Fifty percent of female pollock > 15 cm FL were reproductively mature (i.e., pre-spawning, spawning, or spent) at 38.3 cm FL (Fig. 20, middle panel). The average GSI for pre-spawning females was 0.16 + 0.01 (Fig. 20, bottom panel, mean ± standard deviation), which was very close to 2018 (0.15 + 0.05) and slightly higher than the historical mean (0.13 + 0.04).

Distribution and Abundance

A diffuse scattering layer near the seafloor in the inner Bay was attributed to a mix of age-1 and adult pollock (Fig. 21). Age-1 pollock were observed in the outer part of the Bay while pollock with lengths 15-30 cm FL, indicative of age-2 and age-3s, were present as a strong near-surface layer in the inner Bay (Fig. 21). Most juvenile pollock (< 30 cm FL) were observed between the surface and 100 m, similar but slightly higher off-bottom than 2015 juveniles (Fig. 22). Adult pollock (≥ 30 cm FL) were primarily detected in the Spruce Gully (inner portion of the outer Bay, Fig. 21) in dense schools around 130 m deep and between 70 and 150 m above the seafloor, which contrasted from the previous 4 years when pollock were distributed much closer to the bottom (Fig. 23).

Walleye pollock with lengths 9-14 cm FL, indicative of age-1 pollock, accounted for 83% of the numbers but only 13.8% of the biomass of all pollock observed in this area (Figs. 9 and 10). Pollock with lengths 15-30 cm FL, indicative of age-2s and age-3s, accounted for 12.6% by numbers and 25.7% by biomass. Walleye pollock ranging from 28 to 64 cm FL with a mode centered at 48 cm accounted for 60.4% of the biomass. There were no pollock > 64 cm caught in Marmot Bay in 2019 (Fig. 9).

The estimated amounts of pollock for Marmot Bay were 138 million pollock weighing 6,275 t (Table 7; Fig. 24). The 2019 biomass was about half the 2018 estimate of 13,521 t and the historic mean of 14,203 t. Sixteen percent of the total Marmot biomass was observed in inner Marmot, and 84% of the total Marmot biomass was observed in outer Marmot. The relative estimation error of the biomass in Marmot Bay, determined by combining the results of the inner and outer 1-D estimates (following Eqn. 5), was 7.9%.

Special Projects

Several collections of specimens were made to support studies by other investigators. Ovaries were collected from pre-spawning walleye pollock to investigate interannual variation in fecundity of mature females (contact Sandi Neidetcher for more information: Sandi.Neidetcher@noaa.gov). Ovaries were also collected from female walleye pollock of all maturity stages for a histological study (contact Sandi Neidetcher for more information: Sandi.Neidetcher@noaa.gov). Pollock (and less frequently other species) stomachs were collected to determine predation of the large 2019 year class of walleye pollock in the Gulf of Alaska (contact Troy Buckley: Troy.Buckley@noaa.gov). Presumed age-1 juvenile pollock were collected and frozen to characterize the optimal thermal overwintering habitat of the Gulf of Alaska (contact Ben Laurel: ben.laurel@noaa.gov). The results of these special projects will be reported elsewhere.

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CITATIONS

Bodholt, H., 2002. The effect of water temperature and salinity on echo sounder measurements. ICES Symposium on Acoustics in Fisheries, Montpellier 10–14 June 2002.

Bodholt, H., and H. Solli. 1992. Split beam techniques used in Simrad EK500 to measure target strength, p. 16-31. *In* World Fisheries Congress, May 1992, Athens, Greece.

Demer, D. A., Berger, L., Bernasconi, M., Bethke, E., Boswell, K., Chu, D., Domokos, R., et al. 2015. Calibration of acoustic instruments. ICES Coop. Res. Rep. 326, 133 p.

Demer, D. A., and S. G. Conti. 2005. New target-strength model indicates more krill in the Southern Ocean. ICES J. Mar. Sci. 62: 25-32.

De Robertis, A., R. Levine, and C. D. Wilson. 2018. Can a bottom-moored echo sounder array provide a survey-comparable index of abundance? Can. J. Fish. Aquat. Sci. 75: 629-640. dx.doi.org/10.1139/cjfas-2017-0013.

De Robertis, A., D. R. McKelvey, and P. H. Ressler. 2010. Development and application of an empirical multifrequency method for backscatter classification. Can. J. Fish. Aquat. Sci. 67:1459-1474.

De Robertis, A., and K. Taylor. 2014. *In situ* target strength measurements of the scyphomedusa *Chrysaora melanaster*. Fish. Res. 153:18-23.

De Robertis, A., K. Taylor, C.D. Wilson, and E. V. Farley. 2017. Abundance and distribution of Arctic cod (*Boreogadus saida*) and other pelagic fishes over the U.S. continental shelf of the northern Bering and Chukchi seas. Deep-sea Res. II. 135: 51-65.3

De Robertis, A., and K. Williams. 2008. Weight-length relationships in fisheries studies: the Standard allometric model should be applied with caution. Trans. Am. Fish. Soc. 137: 707-719.

Foote, K.G. 1987. Fish target strengths for use in echo integration surveys. J. Acoust. Soc. Am. 82: 981-987.

Foote, K. G., and J. Traynor. 1988. Comparison of walleye pollock target-strength estimates determined from *in situ* measurements and calculations based on swimbladder form. J. Acoust. Soc. Am. 83: 9-17.

Foote, K. G., H. P. Knudsen, G. Vestnes, and E. J. Simmonds. 1987. Calibration of acoustic instruments for fish density estimation: a Practical guide. ICES Coop. Res. Rep. 144, 69 p.

Gauthier, S., and J. K. Horne. 2004. Acoustic characteristics of forage fish species in the Gulf of Alaska and Bering Sea. Can. J. Fish. Aquat. Sci. 61: 1839-1850.

Guttormsen, M. A., and C. D. Wilson. 2009. *In situ* measurements of capelin (*Mallotus villosus*) target strength in the North Pacific Ocean. ICES J. Mar. Sci. 66: 258-263.

Honkalehto, T., N. Williamson, D. Jones, A. McCarthy, and D. McKelvey. 2008. Results of the echo integration-trawl survey of walleye pollock (*Theragra chalcogramma*) on the U.S. and Russian Bering Sea Shelf in June and July 2007. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-190, 53 p.

Jech, J. M., K. G. Foote, D. Chu, and L. C. Hufnagle. 2005. Comparing two 38-kHz scientific echosounders. ICES J. Mar. Sci. 62: 1168-1179.

Jones, D. T., A. De Robertis, and N. J. Williamson. 2011. Statistical combination of multifrequency sounder-detected bottom lines reduces bottom integrations. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-219, 13 p.

Jones, D., C. D. Wilson, A. De Robertis, T. C. Weber, and J. L. Butler. 2012. Evaluation of rockfish abundance in untrawlable habitat: combining acoustics with alternate sampling tools. Fish. Bull., U.S. 110: 332-343.

Kang, D., T. Mukai, K. Iida, D. Hwang, and J.-G. Myoung. 2005. The influence of tilt angle on the acoustic target strength of the Japanese common squid (*Todarodes pacificus*). ICES J. Mar. Sci. 62: 779-789.

MacLennan, D. N., P. G. Fernandes, and J. Dalen. 2002. A consistent approach to definitions and symbols in fisheries acoustics. ICES J. Mar. Sci. 59: 365-369.

McCarthy, A. L., S. Stienessen, and D. Jones. 2018. Results of the acoustic-trawl surveys of walleye pollock (*Gadus chalcogrammus*) in the Gulf of Alaska, February-March 2017 (DY2017-01, DY2017-02, and DY2017-03). AFSC Processed Rep. 2018-04, 126 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.

McKelvey, D. R. 1996. Juvenile walleye pollock, *Theragra chalcogramma*, distribution and abundance in Shelikof Strait—what can we learn from acoustic surveys, p. 25-34. *In* Ecology of juvenile walleye pollock, *Theragra chalcogramma*, U.S. Dep. Commer., NOAA Tech. Rep. NMFS-126.

Petitgas, P. 1993. Geostatistics for fish stock assessments: a Review and an acoustic application. ICES J. Mar. Sci. 50: 285-298.

R Core Team. 2019. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Rivoirard, J., J. Simmonds, K. G. Foote, P. Fernandez, and N. Bez. 2000. Geostatistics for estimating fish abundance. Blackwell Science Ltd., Osney Mead, Oxford OX2 0EL, England. 206 p.

Rogers, L.A. and A.B. Dougherty. 2019. Effects of climate and demography on reproductive phenology of a harvested marine fish population. Global Change Biol. 25(2): 708-720. https://doi.org/10.1111/gcb.14483.

Simrad. 2008. ER60 scientific echo sounder software reference manual. 221 p. Simrad AS, Strandpromenenaden 50, Box 111, N-3191 Horten, Norway.

Stanley, R. D., R. Kiesser, K. Cooke, A. M. Surry, and B. Mose, 2000. Estimation of a widow rockfish (*Sebastes entomelas*) shoal off British Columbia, Canada as a joint exercise between stock assessment staff and the fishing industry. ICES J. Mar. Sci. 57:1035-1049.

Towler, R., and K. Williams. 2010. An inexpensive millimeter-accuracy electronic length measuring board. Fish. Res. 106:107-111.

Traynor J. 1996. Target-strength measurements of walleye pollock *(Theragra chalcogramma*) and Pacific whiting *(Merluccius productus*). ICES J. Mar. Sci. 53:253-258.

Walline, P. D. 2007. Geostatistical simulations of eastern Bering Sea walleye pollock spatial distributions, to estimate sampling precision. ICES J. Mar. Sci. 64:559-569.

Williams, K., A. E. Punt, C. D. Wilson, and J. K. Horne. 2011. Length-selective retention of walleye pollock, *Theragra chalcogramma*, by midwater trawls. ICES J. Mar. Sci. 68: 119-129.

Williams, K. 2007. Evaluation of the macroscopic staging method for determining maturity of female walleye pollock *Theragra chalcogramma* in Shelikof Strait, Alaska. Alaska Fish. Res. Bul., 12: 252-263.

Williamson, N. J., and J. J. Traynor. 1996. Application of a one-dimensional geostatistical procedure to fisheries acoustic surveys of Alaskan pollock. ICES J. Mar. Sci. 53: 423-428.

Wilson, C. D. 1994. Echo integration-trawl survey of pollock in Shelikof Strait Alaska in 1994, p. 1-39. *In* Stock Assessment and Fishery Evaluation Report for the 1994 Gulf of Alaska Groundfish Fishery, November 1994, Supplement. Prepared by the Gulf of Alaska Groundfish Plan Team, North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

TABLES AND FIGURES

Table 1. -- Simrad ER60 38 kHz acoustic system description and settings used during the winter 2019 Gulf of Alaska acoustic-trawl surveys of walleye pollock. Presented are results from standard sphere acoustic system calibrations conducted in association with the survey and final values used to calculate biomass & abundance data.

	Winter 2018 system settings	7 Mar Kalsin Bay Alaska	20 Mar Kalsin Bay Alaska	Final analysis parameters
Echosounder	Simrad ER60	--	--	Simrad ER60
Transducer	ES38B	--	--	ES38B
Frequency (kHz)	38	--	--	38
Transducer depth (m)	9.15	--	--	9.15
Pulse length (ms)	1.024	--	--	1.024
Transmitted power (W)	2000	--	--	2000
Angle sensitivity along	23.00	--	--	23.00
Angle sensitivity athwart	23.00	--	--	23.00
2-way beam angle (dB re 1 steradian)	-21.01	--	--	-21.01
Gain (dB)	26.26	26.26	26.23	26.25
s_A correction (dB)	-0.59	-0.59	-0.53	-0.56
Integration gain (dB)	25.67	25.67	25.70	25.69
3 dB beamwidth along	6.63	6.63	6.62	6.63
3 dB beamwidth athwart	6.64	6.64	6.63	6.64
Angle offset along	-0.05	-0.02	-0.04	-0.03
Angle offset athwart	0.01	0.01	0.00	0.01
Post-processing S_v threshold (dB re 1 m^{-1})	-70	NA	NA	-70
Standard sphere TS (dB re 1 m^2)	NA	-42.19	-42.19	NA
Sphere range from transducer (m)	NA	20.50	20.76	NA
Absorption coefficient (dB/m)	0.0099	0.0099	0.0098	0.0099
Sound velocity (m/s)	1466	1468.0	1467.8	1466
Water temp at transducer (°C)	NA	5.1	5.0	NA

Note: Gain and beam pattern terms are defined in the Operator Manual for Simrad ER60 Scientific echosounder application, which is available from Simrad Strandpromenaden 50, Box 111, N-3191 Horten, Norway. -- symbol indicates the same values for the system settings and final analysis are also applicable for the various calibrations

Table 2.-- Target strength (TS) to size relationships from the literature used to allocate 38 kHz acoustic backscatter for all species in this report. The symbols in the equations are as follows: *r* is the bell radius in cm and *L* is length in cm for all groups except pelagic crustaceans, in which case L is in m. The species for which the TS was derived is given.

Group	**TS** (dB re a m^2)	**Length type**	**TS derived for which species**	**Reference**
Walleye pollock	$TS = 20 \log_{10} L - 66$	L = fork length	*Gadus chalcogrammus*	Foote & Traynor 1988, Traynor 1996
Eulachon	$TS = 20 \log_{10} L - 84.5$	L = total length	*Thaleichthys pacificus*	Gauthier & Horne 2004
Fish with swim bladders	$TS = 20 \log_{10} L - 67.5$	L = total length	Physoclist fishes	Foote 1987
Fish without swim bladders	$TS = 20\log_{10} L -83.2$	L = total length	*Pleurogrammus monopterygius*	Gauthier & Horne 2004
Jellyfish	$TS = 10\log_{10}(\pi r^2)-86.8$	R = bell radius	*Chrysaora melanaster*	De Robertis & Taylor 2014
Squid	$TS = 20\log_{10} L -75.4$	L = mantle length	*Todarodes pacificus*	Kang et al. 2005
Pelagic crustaceans*,+,#	$TS= A*(\log10(BkL)/(BkL))^C + D((kL)^6) + E((kL)^5) +F((kL)^4) + G((kL)^3) + H((kL)^2) + I(kL) + J +20\log_{10}(L/Lo)$	L = total length	*Euphausia superba*	Demer & Conti 2005

*A = -930.429983; B = 3.21027896; C = 1.74003785; D = 1.36133896 x 10^{-8}; E = -2.26958555 x 10^{-6}; F=1.50291244 x 10^{-4}; G = -4.86306872 x 10^{-3}; H = 0.0738748423; I = -0.408004891; J=-73.9078690; and Lo=0.03835.

+If L < 15 mm, TS = -105 dB; and if L > 65 mm, TS = -73 dB.

#k = 2πfc, where f = 38,000 (frequency in Hz) and c = 1470 (sound speed in m/s).

Table 3.-- Trawl station and catch data summary from the winter 2019 acoustic-trawl survey of walleye pollock in Shelikof Strait, Chirikof shelf break and Marmot Bay.

Haul No.	Area	Gear type[a]	Date (GMT)	Time (GMT)	Duration (minutes)	Start position Latitude (N)	Start position Longitude (W)	Depth (m) Footrope[b]	Depth (m) Bottom	Water temp. (°C) Headrope	Water temp. (°C) Surface[c]	Catch Pollock (kg)	Catch Pollock Number	Catch Eulachon (kg)	Catch Other (kg)
1	Shelikof Strait	AWT	7-Mar	18:25:16	5.53	58.5467	-152.893	-	197.63	6.35	4.98	89.3	5035.1	55.2	1.1
2	Shelikof Strait	AWT	8-Mar	1:45:20	6.35	58.3341	-153.1959	179.22	205.98	6.48	5.64	225.2	1727.4	1.0	1.6
3	Shelikof Strait	AWT	8-Mar	7:58:14	3.37	58.3904	-153.738	215.36	229.17	5.86	5.16	94.0	5584.6	292.5	2.5
4	Shelikof Strait	AWT	8-Mar	14:03:51	7.22	58.1525	-153.4933	187.24	203.31	6.26	3.65	78.4	1272.6	10.2	2.0
5	Shelikof Strait	PNE	8-Mar	18:21:16	3.2	58.291	-153.9271	232	256.67	5.78	4.67	430.6	723.0	3.6	1.1
6	Shelikof Strait	PNE	8-Mar	22:52:40	9.83	58.0552	-153.6595	214.18	216	5.85	3.6	98.9	2662.0	133.1	362.8
7	Shelikof Strait	AWT	9-Mar	3:01:58	9.57	58.032	-154.0227	158.56	202.96	6.48	2.99	107.4	2163.6	3.2	1.0
8	Shelikof Strait	AWT	9-Mar	6:18:19	2.83	58.0853	-154.1809	216.21	280.19	5.95	3.19	2896.4	6552.5	101.7	1.0
9	Shelikof Strait	AWT	9-Mar	12:12:51	15.82	57.8702	-153.9971	160.11	217.98	6.35	3.6	118.1	1312.0	6.5	2.1
10	Shelikof Strait	PNE	9-Mar	17:23:44	2.87	57.9269	-154.5657	234.45	267.91	5.84	3.49	59.9	383.1	0.6	0.2
11	Shelikof Strait	AWT	9-Mar	23:50:49	6.73	57.7023	-154.3583	168.04	190.83	6.26	4.57	114.6	6665.5	1.1	1.5
12	Shelikof Strait	PNE	10-Mar	5:43:18	4.4	58.0715	-154.1904	227.82	279.54	5.83	3.38	4281.7	6173.1	4.3	0.0
13	Shelikof Strait	PNE	10-Mar	9:58:08	2.7	57.8551	-154.7656	238.39	273.58	5.82	3.88	743.1	1101.4	1.3	-
14	Shelikof Strait	PNE	11-Mar	22:23:48	1.23	57.6923	-155.1472	256.51	284.86	5.84	4.47	671.3	1136.0	2.7	0.6
15	Shelikof Strait	AWT	12-Mar	1:03:47	18.57	57.698	-155.1657	142.23	292.93	6.35	4.38	2915.0	3652.4	-	11.0
16	Shelikof Strait	AWT	12-Mar	8:14:36	16	57.5355	-155.1124	190.42	239.33	6.31	4	320.4	5736.9	6.3	0.5
17	Shelikof Strait	PNE	12-Mar	13:34:00	2.73	57.4831	-155.4544	256.33	295.38	5.72	4.77	666.5	1171.8	4.8	0.2
18	Shelikof Strait	AWT	12-Mar	19:44:58	5.18	57.2609	-155.0587	158.57	225.04	6.27	4.77	312.0	8252.3	-	-
19	Shelikof Strait	AWT	13-Mar	3:00:58	14.62	57.25	-155.6547	-	275.16	5.98	4.6	260.0	5382.4	-	-
20	Shelikof Strait	AWT	13-Mar	12:14:59	2.52	57.1221	-155.6692	246.32	276.71	5.92	4.77	840.2	3999.7	23.1	4.7
21	Shelikof Strait	AWT	13-Mar	22:13:37	1.97	56.8264	-155.6063	245.5	271.11	5.66	5.16	1323.9	4282.4	109.6	2.7
22	Shelikof Strait	AWT	14-Mar	6:29:12	5.75	56.7769	-155.9293	255.18	305.96	5.71	5.06	2461.1	6093.1	10.3	0.6
23	Shelikof Strait	AWT	14-Mar	13:53:34	12.52	56.6381	-155.9494	174.88	284.71	6.14	5.06	277.7	5696.1	2.3	0.4
24	Shelikof Strait	AWT	14-Mar	22:09:28	3.23	56.5247	-156.0779	259.02	275.09	5.64	4.97	1600.6	5274.3	31.2	1.1
25	Shelikof Strait	AWT	15-Mar	9:34:19	6.1	56.3058	-156.2557	249.49	270.78	5.87	5.22	1463.3	7206.3	10.4	6.6
26	Shelikof Strait	AWT	16-Mar	13:49:46	10.18	56.0125	-156.176	187.06	205.43	6.01	5.16	178.3	3816.8	6.3	9.3
27	Chirikof shelf break	AWT	17-Mar	7:27:15	18.78	55.9411	-154.3059	274.36	445.64	5.4	1.93	35.0	37.0	-	52.3
28	Chirikof shelf break	AWT	17-Mar	19:58:36	7.1	55.9511	-153.9027	263.28	355.33	5.64	5.88	275.9	362.7	-	1584.1
29	Chirikof shelf break	AWT	18-Mar	15:47:41	1.25	56.3443	-152.5188	249.98	782.7	5.61	6.13	-	-	-	0.5
30	Marmot Bay	AWT	19-Mar	8:56:22	28.32	58.01	-151.8448	61.97	149.67	5.55	6.22	84.7	5358.4	-	0.1
31	Marmot Bay	AWT	19-Mar	15:34:24	7.48	57.9398	-151.9686	177.62	202.99	5.66	5.91	43.1	2761.2	3.3	2.2
32	Marmot Bay	AWT	19-Mar	22:38:39	9.78	57.9852	-152.3104	178.43	250.7	5.67	5.35*	3166.6	3757.4	4.0	4.4
33	Marmot Bay	AWT	20-Mar	5:45:41	40.6	58.0341	-152.5337	58.73	175.17	5.68	5.64	1562.7	15376.2	1.8	0.6
34	Marmot Bay	AWT	20-Mar	13:47:04	25.57	58.0267	-152.5165	156.35	200.99	5.77	5.74	108.1	1173.0	9.1	4.7

[a] Gear type: AWT = Aleutian wing trawl, PNE = poly Nor'eastern bottom trawl

[b] Footrope depths not collected for some AWT trawls and estimated for all PNE (assuming 7 m vertical opening, from previous surveys)

[c] Average temperature measured from an SBE shipboard temperature logger

* Average surface temperature in haul 32 measured from SBE attached to trawl average value between 1-5 m depth

Table 4.-- Numbers of walleye pollock measured and biological samples collected during the winter 2019 acoustic-trawl surveys of Shelikof Strait (hauls 1-26), Chirikof shelf break (hauls 27-29) and Marmot Bay (hauls 30-34).

	Walleye pollock						
Haul no.	Catch Lengths	Weights	Maturities	Otoliths	Ovary weights	Ovaries collected	Stomachs collected
1	108	44	28	15	-	5	10
2	255	113	91	45	27	12	14
3	75	57	43	32	10	7	10
4	147	84	65	40	35	7	10
5	426	95	72	40	12	11	10
6	172	94	67	45	24	-	-
7	223	77	57	45	19	-	4
8	401	97	82	45	1	-	-
9	267	95	77	40	16	6	10
10	149	88	76	40	19	4	10
11	209	86	70	38	14	4	5
12	302	108	108	33	17	-	5
13	361	113	93	40	43	-	-
14	416	87	72	40	4	1	5
15	308	52	52	25	29	4	5
16	330	97	78	41	21	2	3
17	380	96	80	40	24	3	10
18	208	99	79	29	10	8	11
19	228	89	68	30	24	6	5
20	481	95	80	30	18	3	8
21	424	95	80	29	10	3	5
22	410	90	74	30	14	-	5
23	263	94	80	30	9	4	10
24	444	92	77	30	19	1	5
25	351	97	82	30	24	4	-
26	257	96	80	20	14	4	10
27	37	37	37	30	22	6	4
28	254	51	51	26	38	4	10
30	144	69	54	31	13	-	10
31	82	41	26	31	8	4	11
32	312	76	60	35	32	-	15
33	114	48	44	26	6	1	18
34	220	92	76	39	32	1	10
Totals	8,758	2,744	2,259	1,120	608	115	248

Table 5.-- Catch by species and numbers of length and weight measurements taken from individuals found in the codend, during the 19 Aleutian Wing midwater trawl hauls during the winter 2019 acoustic-trawl survey of walleye pollock in Shelikof Strait. Recapture net catch data are not included.

		Catch				Individual measurements	
Species name	Scientific name	Weight (kg)	%	Number	%	Length	Weight
walleye pollock	*Gadus chalcogrammus*	15,675.9	95.6	89,706	78.7	5389	1649
eulachon	*Thaleichthys pacificus*	670.9	4.1	22,007	19.3	507	170
chinook salmon	*Oncorhynchus tshawytscha*	23.4	0.1	16	< 0.1	15	12
arrowtooth flounder	*Atheresthes stomias*	4.8	< 0.1	9	< 0.1	9	9
lanternfish unid.	Myctophidae (family)	4.3	< 0.1	576	0.5	63	35
smooth lumpsucker	*Aptocyclus ventricosus*	4.1	< 0.1	3	< 0.1	1	1
shrimp unid.	Malacostraca (class)	2.9	< 0.1	782	0.7	61	20
northern smoothtongue	*Leuroglossus schmidti*	2.9	< 0.1	443	0.4	44	24
squid	Cephalopoda (class)	2.1	< 0.1	102	0.1	16	10
Pacific herring	*Clupea pallasii*	1.1	< 0.1	7	< 0.1	7	7
northern sea nettle	*Chrysaora melanaster*	1.0	< 0.1	1	< 0.1	1	-
salmon	Salmonidae (family)	0.9	< 0.1	4	< 0.1	4	4
Pacific lamprey	*Lampetra tridentata*	0.7	< 0.1	7	< 0.1	2	2
capelin	*Mallotus villosus*	0.6	< 0.1	96	0.1	16	14
Aurelia	*Aurelia*	0.3	< 0.1	1	< 0.1	1	1
jellyfish	Scyphozoa (class)	0.2	< 0.1	8	< 0.1	1	-
smelt	Osmeridae (family)	0.2	< 0.1	201	0.2	13	-
flathead sole	*Hippoglossoides elassodon*	0.2	< 0.1	1	< 0.1	1	1
Total		16,396.5		113,970		6,151	1959

Table 6.-- Catch by species, and numbers of length and weight measurements taken from individuals found in the codend of the 7 poly Nor'eastern bottom trawl hauls during the winter 2019 acoustic-trawl survey of walleye pollock in Shelikof Strait. Recapture net catch data are not included.

		Catch				Individual measurements	
Species name	Scientific name	Weight (kg)	%	Number	%	Length	Weight
walleye pollock	*Gadus chalcogrammus*	6,952.0	93.1	13,350	57.5	2206	681
arrowtooth flounder	*Atheresthes stomias*	211.5	2.8	467	2.0	35	10
eulachon	*Thaleichthys pacificus*	150.5	2.0	3,664	15.8	210	67
flathead sole	*Hippoglossoides elassodon*	83.7	1.1	220	0.9	20	10
shrimp	Malacostraca (class)	23.6	0.3	5,174	22.3	19	9
big skate	*Beringraja binoculata*	22.9	0.3	3	< 0.1	3	3
longnose skate	*Raja rhina*	9.7	0.1	1	< 0.1	1	1
rex sole	*Glyptocephalus zachirus*	3.9	0.1	22	0.1	2	2
Baird's top shell	*Bathybembix bairdii*	3.1	< 0.1	11	< 0.1	1	1
sablefish	*Anoplopoma fimbria*	1.4	< 0.1	3	< 0.1	3	3
giant wrymouth	*Cryptacanthodes giganteus*	1.0	< 0.1	1	< 0.1	-	-
rougheye rockfish	*Sebastes aleutianus*	0.9	< 0.1	2	< 0.1	2	2
northern smoothtongue	*Leuroglossus schmidti*	0.9	< 0.1	200	0.9	56	41
smooth lumpsucker	*Aptocyclus ventricosus*	0.7	< 0.1	1	< 0.1	1	1
jellyfish	Scyphozoa (class)	0.7	< 0.1	3	< 0.1	2	2
sea star	Asteroidea (class)	0.6	< 0.1	66	0.3	-	-
prickleback	Stichaeidae (family)	0.1	< 0.1	11	< 0.1	1	1
lanternfish	Myctophidae (family)	0.1	< 0.1	9	< 0.1	4	3
squid	Cephalopoda (class)	0.1	< 0.1	1	< 0.1	1	1
isopod	Isopoda (order)	0.0	< 0.1	1	< 0.1	-	-
Total		7,467.3		23,211		2,567	838

Table 7. -- Estimates of walleye pollock biomass (in metric tons) and relative estimation error for the Shelikof Strait area, Chirikof shelf break, and Marmot Bay regions. Estimates for 2008-2019 selectivity corrections for escapement of juveniles are reflected in estimates for all areas.

Year	Shelikof Strait		Chirikof shelfbreak		Marmot Bay	
	Biomass	Est. error	Biomass	Est. error	Biomass	Est. error
1981	2,785,800					
1982	no survey					
1983	2,278,200					
1984	1,757,200					
1985	1,175,300					
1986	585,800					
1987	no estimate	[1]				
1988	301,700					
1989	290,500				2,400	no estimate
1990	374,700				no estimate	--
1991	380,300				no survey	--
1992	713,400	3.6%			no estimate	--
1993	435,800	4.6%			no survey	--
1994	492,600	4.5%			no survey	--
1995	763,600	4.5%			no survey	--
1996	777,200	3.7%			no survey	--
1997	583,000	3.7%			no survey	--
1998	504,800	3.8%			no survey	--
1999	no survey	--			no survey	--
2000	448,600	4.6%			no survey	--
2001	432,800	4.5%			no survey	--
2002	256,700	6.9%	82,100	12.2%	no survey	--
2003	316,500	5.2%	30,900	20.7%	no survey	--
2004	326,800	9.2%	30,400	20.4%	no survey	--
2005	356,100	4.1%	77,000	20.7%	no survey	--
2006	293,600	4.0%	69,000	11.0%	no survey	--
2007	180,900	5.8%	36,600	6.7%	3,600	5.0%
2008	197,722	5.6%	22,000	9.6%	no survey	--
2009	257,221	5.9%	400	32.3%	19,900	no estimate
2010	421,374	2.6%	9,400	15.0%	5,600	no estimate
2011	no survey	--	no survey	--	no survey	--
2012	333,859	7.9%	21,200	16.4%	no survey	--
2013	807,636	5.3%	63,200	31.4%	22,100	4.1%
2014	827,136	4.7%	no survey	--	14,426	9.4%
2015	847,768	4.3%	12,705	14.2%	22,489	3.1%
2016	666,801	6.5%	no survey	--	24,859	8.8%[2]
2017	1,465,027	4.3%	2,485	24.0%	13,131	7.9%
2018	1,320,867	3.9%	no survey	--	13,521	7.5%[2]
2019	**1,281,083**	**6.6%**	**9,907**	**17.7%**	**6,275**	**7.9%**

[1]Shelikof Strait surveyed in 1987, but no estimate was made due to mechanical problems.

[2]During these years, outer Marmot was surveyed in a zig-zag pattern, rather than parallel transects. Inner Marmot was surveyed with parallel transects. Relative estimation error was determined by combining estimation of error for biomass within the inner bay (1-D) and outer bay (2-D) following Equation 2.

Table 8. -- Numbers-at-length estimates (millions) from acoustic-trawl surveys of walleye pollock in the Shelikof Strait area. No surveys were conducted in 1982, 1999, or 2011, and no estimate was produced for 1987 due to mechanical problems. Selectivity corrections for escapement of juveniles are reflected in estimates from 2008 - 2019.

Length	1992	1993	1994	1995	1996	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2012	2013	2014	2015	2016	2017	2018	2019
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	2.0	0.0	0.0	0.0	<1	0.0	0.0	0.0	<1	0.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0	13.5	<1	0.0	0.0	0.0	14.9
9	<1	<1	4.0	163.0	0.0	3.0	4.0	29.0	4.0	0.0	0.0	<1	6.0	3.5	<1	26.2	9.3	10.4	1.9	330.0	48.8	0.0	0.0	1.3	77.1	115.7
10	4.0	3.0	32.0	1120.0	3.0	3.0	16.0	372.0	33.0	0.0	1.0	10.0	106.0	36.3	3.7	69.3	80.4	51.3	7.9	2001.2	314.0	4.3	0.0	57.7	560.1	1799.9
11	27.0	16.0	51.0	3906.0	12.0	20.0	70.0	1162.0	87.0	0.0	8.0	15.0	476.0	61.5	14.0	304.7	239.8	70.8	26.7	3150.3	505.2	3.6	0.0	133.8	754.5	3103.2
12	74.0	26.0	60.0	3779.0	20.0	21.0	140.0	1565.0	87.0	5.0	14.0	24.0	621.0	39.1	20.5	570.8	310.0	75.9	54.5	2641.0	432.8	4.4	0.0	308.4	374.2	1906.8
13	79.0	13.0	33.0	1538.0	18.0	15.0	104.0	999.0	52.0	2.0	20.0	3.0	296.0	12.8	10.5	461.6	128.6	43.5	63.5	719.2	218.5	4.1	0.0	185.9	40.7	341.1
14	36.0	3.0	6.0	157.0	4.0	7.0	49.0	320.0	24.0	1.0	8.0	1.0	98.0	5.3	3.8	262.2	42.8	11.4	27.3	240.8	45.7	2.3	0.0	40.2	9.4	78.6
15	6.0	1.0	<1	25.0	<1	1.0	10.0	30.0	2.0	1.0	1.0	<1	19.0	2.3	0.7	72.4	2.1	1.6	11.3	68.0	11.4	<1	0.0	16.8	2.4	0.0
16	1.0	0.0	<1	1.0	5.0	<1	2.0	7.0	2.0	0.0	<1	<1	4.0	0.9	0.1	9.2	1.2	1.0	2.6	21.2	3.5	<1	0.0	<1	1.2	1.0
17	0.0	0.0	0.0	1.0	51.0	<1	<1	1.0	20.0	0.0	<1	<1	<1	6.5	1.6	1.8	0.0	<1	0.0	6.1	36.4	0.0	0.0	0.0	0.0	5.8
18	0.0	<1	1.0	4.0	249.0	1.0	<1	10.0	185.0	<1	0.0	<1	1.0	23.4	7.6	<1	5.2	<1	0.0	<1	109.7	<1	0.0	0.0	<1	37.4
19	<1	<1	<1	16.0	634.0	1.0	1.0	32.0	808.0	3.0	1.0	1.0	2.0	75.4	24.3	4.4	6.6	9.2	11.0	<1	471.2	<1	0.0	0.0	3.6	172.2
20	1.0	4.0	2.0	39.0	945.0	8.0	3.0	81.0	1407.0	15.0	3.0	4.0	8.0	140.6	54.5	3.6	70.7	15.4	55.2	1.4	979.4	1.3	0.0	<1	5.6	432.7
21	2.0	8.0	5.0	68.0	772.0	23.0	10.0	147.0	1043.0	36.0	11.0	10.0	20.0	203.1	60.2	18.0	165.6	34.4	156.6	2.9	930.7	9.2	0.0	0.0	16.3	437.5
22	5.0	17.0	7.0	92.0	441.0	50.0	16.0	196.0	460.0	29.0	15.0	20.0	29.0	161.3	41.6	34.6	322.4	62.4	183.0	8.3	466.3	16.6	0.0	0.0	26.3	291.5
23	8.0	20.0	6.0	93.0	131.0	48.0	20.0	176.0	107.0	43.0	17.0	23.0	38.0	107.4	19.6	76.8	275.2	86.1	186.7	8.1	308.2	20.9	0.0	0.0	27.9	166.1
24	10.0	14.0	5.0	73.0	54.0	48.0	21.0	68.0	20.0	56.0	16.0	18.0	30.0	66.2	9.0	108.2	173.4	49.5	139.0	12.0	98.4	17.2	<1	<1	23.2	76.1
25	6.0	7.0	4.0	53.0	18.0	89.0	10.0	30.0	22.0	128.0	11.0	12.0	16.0	27.4	6.1	69.9	75.0	26.7	62.8	16.0	52.1	16.7	<1	0.0	19.0	40.5
26	5.0	5.0	2.0	36.0	9.0	208.0	8.0	11.0	31.0	239.0	8.0	9.0	7.0	13.7	7.4	32.7	18.7	16.3	32.3	20.3	25.6	38.9	<1	0.0	7.8	14.8
27	3.0	1.0	3.0	27.0	9.0	275.0	6.0	6.0	60.0	250.0	9.0	4.0	2.0	6.2	10.9	27.7	9.2	7.8	8.4	10.0	4.8	84.6	<1	0.0	7.9	4.2
28	3.0	1.0	1.0	17.0	11.0	268.0	5.0	10.0	85.0	210.0	23.0	2.0	3.0	3.1	15.1	18.0	12.5	9.2	9.6	10.0	6.1	167.7	<1	<1	4.1	6.2
29	8.0	1.0	1.0	5.0	22.0	205.0	10.0	13.0	91.0	124.0	52.0	3.0	1.0	5.4	23.1	12.4	5.0	28.6	1.5	8.0	<1	280.8	<1	0.0	0.0	16.0
30	19.0	1.0	3.0	2.0	23.0	104.0	25.0	18.0	50.0	74.0	107.0	4.0	8.0	5.6	29.5	9.6	6.2	56.6	5.6	21.6	<1	300.2	1.9	0.0	1.2	19.9
31	25.0	2.0	6.0	6.0	15.0	59.0	42.0	32.0	37.0	42.0	153.0	7.0	8.0	5.6	23.2	25.1	8.5	91.5	1.9	31.3	<1	270.9	3.2	0.0	<1	24.5
32	37.0	3.0	7.0	4.0	15.0	31.0	78.0	37.0	15.0	25.0	185.0	16.0	2.0	5.6	23.1	35.2	12.2	109.6	4.8	40.2	2.1	209.1	10.7	0.0	<1	31.8
33	48.0	5.0	11.0	8.0	13.0	21.0	102.0	34.0	14.0	29.0	145.0	25.0	10.0	6.5	18.7	39.1	23.7	91.4	6.1	71.0	3.6	142.6	22.0	<1	<1	17.9
34	67.0	6.0	6.0	6.0	6.0	16.0	99.0	28.0	7.0	20.0	122.0	41.0	3.0	8.0	15.6	29.1	23.0	66.8	6.2	80.3	2.9	66.2	50.7	<1	0.0	14.1
35	85.0	10.0	7.0	11.0	4.0	11.0	103.0	22.0	6.0	17.0	77.0	56.0	10.0	4.8	12.4	28.9	19.1	32.2	5.7	120.3	3.7	49.0	91.1	<1	0.0	6.7
36	83.0	9.0	6.0	15.0	4.0	10.0	84.0	13.0	8.0	7.0	57.0	59.0	4.0	3.8	7.7	15.3	16.2	25.8	5.5	108.1	3.8	28.2	139.3	4.5	0.0	2.1
37	84.0	17.0	3.0	14.0	3.0	10.0	66.0	9.0	9.0	5.0	38.0	54.0	18.0	2.7	4.8	17.2	8.4	14.0	4.6	106.2	5.4	23.8	209.6	9.0	1.2	5.1
38	65.0	26.0	3.0	20.0	2.0	9.0	45.0	8.0	9.0	6.0	28.0	47.0	10.0	2.3	4.3	6.7	11.5	10.6	3.8	60.7	7.8	15.8	274.3	56.3	1.7	2.1
39	36.0	40.0	2.0	9.0	2.0	5.0	26.0	7.0	11.0	6.0	23.0	39.0	11.0	1.3	3.5	3.0	15.2	7.7	3.3	41.1	14.3	15.5	271.5	131.1	10.2	1.6

Table 8. -- Continued.

Length	1992	1993	1994	1995	1996	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2012	2013	2014	2015	2016	2017	2018	2019
40	30.0	53.0	3.0	15.0	2.0	8.0	15.0	11.0	9.0	2.0	14.0	35.0	23.0	2.2	3.7	7.6	9.3	8.5	4.5	20.8	26.0	7.0	204.9	352.4	45.3	1.5
41	22.0	57.0	5.0	5.0	2.0	4.0	16.0	13.0	12.0	2.0	13.0	35.0	22.0	2.1	3.0	6.7	13.4	8.5	6.1	14.8	39.7	7.1	138.2	529.9	102.5	5.0
42	15.0	57.0	9.0	7.0	2.0	5.0	6.0	19.0	8.0	3.0	7.0	38.0	32.0	2.5	2.4	3.9	15.6	9.8	9.2	10.1	55.7	7.4	76.3	578.5	202.3	34.3
43	14.0	48.0	16.0	17.0	4.0	4.0	7.0	19.0	7.0	2.0	6.0	32.0	33.0	3.8	2.6	3.6	14.2	10.2	12.5	7.8	56.7	8.7	40.2	543.7	305.4	102.9
44	14.0	37.0	23.0	18.0	6.0	5.0	5.0	18.0	7.0	2.0	5.0	27.0	41.0	5.3	2.3	2.9	13.9	10.9	12.9	9.7	53.3	13.4	22.2	327.1	370.0	177.4
45	17.0	33.0	36.0	35.0	7.0	3.0	2.0	19.0	8.0	3.0	3.0	24.0	39.0	7.1	2.9	3.9	11.6	14.1	16.6	4.7	39.3	18.2	13.0	169.3	351.5	245.3
46	22.0	23.0	39.0	53.0	13.0	4.0	2.0	22.0	5.0	2.0	3.0	18.0	33.0	9.1	2.1	2.4	8.6	13.2	16.5	6.2	25.7	23.6	10.1	80.9	262.4	244.9
47	21.0	19.0	46.0	62.0	25.0	4.0	3.0	19.0	5.0	3.0	3.0	17.0	37.0	10.9	2.9	1.3	5.3	11.2	18.5	9.3	15.7	26.4	7.0	46.4	188.9	221.6
48	32.0	17.0	37.0	74.0	37.0	6.0	4.0	17.0	6.0	4.0	2.0	11.0	33.0	13.6	2.9	<1	4.5	11.3	17.7	13.2	12.0	32.7	7.4	24.0	116.4	169.1
49	38.0	16.0	33.0	73.0	53.0	13.0	6.0	13.0	9.0	3.0	2.0	8.0	22.0	15.4	4.3	1.2	2.6	10.5	15.6	14.8	10.5	30.2	8.8	8.9	62.6	122.9
50	46.0	17.0	29.0	66.0	64.0	20.0	13.0	16.0	8.0	3.0	2.0	7.0	28.0	17.6	6.1	0.4	2.8	12.0	16.3	14.0	13.7	25.0	6.4	6.8	30.7	68.2
51	40.0	15.0	24.0	51.0	69.0	30.0	18.0	10.0	5.0	4.0	2.0	5.0	14.0	19.5	7.7	<1	2.5	10.5	13.1	23.0	15.0	23.0	4.3	3.4	29.3	35.2
52	38.0	14.0	21.0	40.0	64.0	36.0	24.0	11.0	9.0	4.0	2.0	4.0	7.0	19.0	5.9	1.2	3.4	9.1	13.1	18.2	27.0	19.2	5.4	2.6	9.8	25.3
53	35.0	14.0	24.0	30.0	53.0	37.0	26.0	10.0	6.0	3.0	2.0	2.0	6.0	15.6	8.9	1.0	2.0	6.0	10.8	21.4	26.7	20.4	2.7	<1	9.5	10.4
54	35.0	13.0	18.0	22.0	39.0	34.0	23.0	9.0	4.0	3.0	1.0	3.0	4.0	11.7	7.4	1.8	2.3	7.2	8.9	29.1	27.9	18.9	2.8	2.8	3.7	5.3
55	30.0	11.0	18.0	16.0	29.0	28.0	20.0	9.0	5.0	2.0	1.0	3.0	3.0	12.8	7.9	1.6	1.6	7.9	10.3	21.7	27.4	24.9	2.3	4.5	6.8	4.7
56	15.0	9.0	18.0	14.0	19.0	24.0	19.0	8.0	5.0	1.0	<1	2.0	2.0	6.5	5.8	3.4	2.4	5.9	8.0	27.8	32.0	21.4	2.7	4.5	1.8	<1
57	18.0	7.0	13.0	7.0	13.0	12.0	12.0	9.0	3.0	1.0	<1	1.0	1.0	4.5	4.9	1.0	1.6	4.9	8.1	19.2	23.2	20.9	2.7	<1	<1	<1
58	14.0	7.0	11.0	6.0	10.0	8.0	9.0	6.0	2.0	1.0	<1	1.0	1.0	3.1	4.4	2.1	1.2	6.2	8.4	17.6	18.6	21.4	1.2	2.0	0.0	<1
59	4.0	4.0	9.0	3.0	6.0	5.0	8.0	5.0	3.0	1.0	1.0	1.0	1.0	3.1	2.7	2.5	1.2	5.6	4.9	16.8	14.4	16.0	<1	<1	0.0	<1
60	2.0	3.0	7.0	2.0	5.0	3.0	4.0	2.0	3.0	<1	1.0	<1	1.0	1.8	1.9	1.6	1.2	3.3	4.6	18.0	12.9	15.4	1.3	<1	<1	<1
61	2.0	2.0	5.0	1.0	3.0	2.0	2.0	1.0	1.0	<1	1.0	<1	<1	1.6	1.6	2.4	1.2	5.2	2.4	7.9	9.1	9.1	<1	0.0	0.0	<1
62	3.0	1.0	2.0	2.0	2.0	1.0	2.0	2.0	<1	<1	<1	<1	0.0	1.0	1.0	1.0	1.0	3.8	1.4	9.0	6.6	8.2	<1	0.0	<1	0.0
63	1.0	1.0	1.0	<1	1.0	1.0	2.0	1.0	1.0	<1	<1	<1	1.0	0.9	0.9	1.2	1.0	3.3	1.5	10.7	3.0	4.5	<1	<1	0.0	0.0
64	<1	<1	1.0	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.3	<1	3.8	1.0	2.7	4.0	1.8	0.0	0.0	0.0	0.0
65	0.0	<1	1.0	<1	<1	<1	<1	<1	<1	<1	0.0	<1	<1	<1	<1	<1	<1	3.3	<1	1.7	1.6	2.8	0.0	0.0	0.0	0.0
66	<1	<1	<1	0.0	<1	<1	<1	<1	1.0	0.0	0.0	0.0	<1	<1	<1	<1	<1	2.5	<1	2.6	1.6	2.6	0.0	0.0	0.0	0.0
67	<1	<1	<1	0.0	<1	<1	0.0	<1	0.0	<1	<1	0.0	0.0	<1	<1	<1	<1	2.4	<1	<1	<1	<1	0.0	0.0	0.0	0.0
68	0.0	<1	0.0	0.0	<1	<1	<1	0.0	<1	<1	0.0	<1	0.0	<1	<1	0.0	<1	1.3	<1	<1	<1	1.2	0.0	0.0	0.0	0.0
69	0.0	<1	<1	0.0	<1	<1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<1	0.0	<1	<1	0.0	0.0	0.0	<1	0.0	0.0	0.0	0.0
70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<1	<1	0.0	<1	<1	0.0	0.0	0.0	0.0	0.0
71	0.0	0.0	<1	0.0	0.0	0.0	0.0	0.0	0.0	<1	0.0	0.0	0.0	0.0	<1	0.0	<1	<1	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0
72	0.0	0.0	0.0	0.0	<1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
73	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<1	0.0	0.0	0.0	0.0	0.0	0.0
74	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<1	<1	0.0	0.0	0.0	0.0	0.0
75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
76	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	1339.0	740.0	729.0	11931.0	4024.0	1866.0	1425.0	5742.0	4931.0	1424.0	1224.0	780.0	2252.0	1239.6	575.0	2451.89	2225.452	1338.726	1333.981	10332.59	5728.907	2227.763	1636.922	3638	4076.5	10664.36

Table 9. -- Biomass-at-length estimates (thousands of metric tons) from acoustic-trawl surveys of walleye pollock in the Shelikof Strait area. No surveys were conducted in 1982, 1999, or 2011, and no estimate was produced for 1987 due to mechanical problems. Selectivity corrections for escapement of juveniles are reflected in estimates from 2008 - 2019.

Length	1992	1993	1994	1995	1996	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2012	2013	2014	2015	2016	2017	2018	2019
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	< 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	< 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	< 1	< 1	< 1	1.0	0.0	< 1	< 1	< 1	< 1	0.0	0.0	< 1	< 1	< 1	< 1	< 1	0.0	0.0	0.0	1.2	< 1	0.0	0.0	0.0	< 1	< 1
10	< 1	< 1	< 1	7.0	< 1	< 1	< 1	3.0	< 1	0.0	< 1	< 1	1.0	< 1	< 1	< 1	< 1	< 1	0.0	11.6	2.0	0.0	0.0	< 1	3.6	11.5
11	< 1	< 1	< 1	35.0	< 1	< 1	1.0	11.0	1.0	0.0	< 1	< 1	4.0	< 1	< 1	2.9	2.0	< 1	< 1	24.4	5.0	0.0	0.0	1.0	6.1	25.5
12	1.0	< 1	1.0	44.0	< 1	< 1	1.0	20.0	1.0	< 1	< 1	< 1	7.0	< 1	< 1	6.3	3.3	< 1	< 1	25.1	4.6	0.0	0.0	3.0	3.8	18.9
13	1.0	< 1	< 1	23.0	< 1	< 1	1.0	16.0	1.0	< 1	< 1	< 1	4.0	< 1	< 1	7.0	1.7	< 1	< 1	8.7	2.9	< 1	0.0	2.3	< 1	4.3
14	1.0	< 1	< 1	3.0	< 1	< 1	1.0	7.0	< 1	< 1	< 1	< 1	2.0	< 1	< 1	4.6	< 1	< 1	< 1	3.6	< 1	0.0	0.0	< 1	< 1	1.1
15	< 1	< 1	< 1	1.0	< 1	< 1	< 1	1.0	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.6	0.0	0.0	< 1	1.3	< 1	0.0	0.0	< 1	< 1	0.0
16	< 1	0.0	< 1	< 1	< 1	< 1	< 1	< 1	< 1	0.0	< 1	< 1	< 1	< 1	< 1	< 1	0.0	0.0	< 1	< 1	< 1	0.0	0.0	0.0	<1	0.0
17	0.0	0.0	0.0	< 1	2.0	< 1	< 1	< 1	1.0	0.0	< 1	< 1	< 1	< 1	< 1	< 1	0.0	0.0	0.0	< 1	1.1	0.0	0.0	0.0	0.0	< 1
18	0.0	< 1	< 1	< 1	9.0	< 1	< 1	< 1	6.0	< 1	0.0	< 1	< 1	< 1	< 1	0.0	< 1	0.0	0.0	0.0	4.1	0.0	0.0	0.0	<1	1.4
19	< 1	< 1	< 1	1.0	27.0	< 1	< 1	2.0	33.0	< 1	< 1	< 1	< 1	3.3	1.1	< 1	< 1	< 1	< 1	0.0	20.7	0.0	0.0	0.0	< 1	7.5
20	< 1	< 1	< 1	2.0	48.0	< 1	< 1	5.0	68.0	1.0	< 1	< 1	< 1	7.1	2.8	< 1	3.8	< 1	3.1	< 1	48.6	< 1	0.0	0.0	< 1	22.0
21	< 1	< 1	< 1	4.0	46.0	1.0	1.0	10.0	59.0	2.0	1.0	1.0	1.0	12.0	3.6	1.2	10.4	2.1	9.7	< 1	53.8	< 1	0.0	0.0	1.1	25.3
22	< 1	1.0	1.0	7.0	30.0	4.0	1.0	16.0	31.0	2.0	1.0	1.0	2.0	10.8	2.8	2.7	22.9	4.3	13.0	< 1	31.8	1.1	0.0	0.0	1.9	19.1
23	1.0	2.0	1.0	8.0	10.0	4.0	2.0	17.0	8.0	4.0	1.0	2.0	3.0	8.4	1.6	6.3	21.9	6.8	15.3	< 1	23.3	1.6	0.0	0.0	2.3	12.7
24	1.0	1.0	1.0	7.0	5.0	5.0	2.0	7.0	2.0	5.0	2.0	2.0	3.0	5.9	0.9	10.3	15.7	4.6	12.6	1.1	8.6	1.5	0.0	0.0	2.1	6.7
25	1.0	1.0	< 1	6.0	2.0	10.0	1.0	4.0	2.0	14.0	1.0	1.0	2.0	3.0	0.6	7.7	7.5	2.7	6.3	1.6	5.1	1.8	0.0	0.0	2.0	4.1
26	1.0	1.0	< 1	5.0	1.0	25.0	1.0	1.0	4.0	29.0	1.0	1.0	1.0	1.7	0.9	4.2	2.3	1.9	3.8	2.4	3.1	4.6	0.0	0.0	< 1	1.7
27	< 1	< 1	< 1	4.0	1.0	38.0	1.0	1.0	8.0	35.0	1.0	< 1	< 1	< 1	1.5	3.8	1.3	1.1	1.2	1.3	< 1	11.1	0.0	0.0	1.1	< 1
28	< 1	< 1	< 1	3.0	2.0	42.0	1.0	2.0	13.0	33.0	3.0	< 1	< 1	< 1	2.3	2.9	2.0	1.4	1.5	1.5	< 1	24.7	< 1	0.0	< 1	< 1
29	1.0	< 1	< 1	1.0	4.0	36.0	2.0	2.0	15.0	22.0	9.0	1.0	< 1	< 1	3.9	2.3	< 1	4.9	0.3	1.4	< 1	45.2	0.0	0.0	0.0	2.5
30	4.0	< 1	1.0	< 1	4.0	20.0	5.0	4.0	9.0	15.0	20.0	1.0	2.0	1.1	5.5	1.9	1.2	10.8	1.1	4.2	< 1	54.3	< 1	0.0	< 1	3.8
31	5.0	< 1	1.0	1.0	3.0	13.0	9.0	8.0	8.0	9.0	32.0	1.0	2.0	1.2	4.8	5.8	1.8	19.1	< 1	6.7	< 1	54.7	< 1	0.0	< 1	4.7
32	9.0	1.0	2.0	1.0	3.0	7.0	19.0	10.0	3.0	6.0	43.0	4.0	1.0	1.3	5.4	9.0	2.8	25.0	1.1	9.5	< 1	46.6	2.3	0.0	< 1	7.2
33	12.0	1.0	3.0	2.0	3.0	5.0	26.0	10.0	4.0	8.0	37.0	7.0	3.0	1.7	4.9	11.2	5.9	23.0	1.6	18.7	< 1	35.9	5.3	< 1	< 1	4.5
34	19.0	2.0	2.0	2.0	2.0	5.0	28.0	9.0	2.0	6.0	34.0	12.0	1.0	2.4	4.5	9.1	6.3	18.4	1.7	23.3	< 1	18.0	13.4	< 1	0.0	4.0
35	27.0	3.0	2.0	4.0	1.0	4.0	33.0	8.0	2.0	6.0	24.0	18.0	3.0	1.5	3.9	9.9	5.8	9.7	1.8	39.1	1.1	14.6	26.5	< 1	0.0	2.2
36	29.0	3.0	2.0	5.0	1.0	3.0	29.0	5.0	3.0	2.0	19.0	20.0	1.0	1.3	2.7	5.6	5.4	8.8	1.9	37.2	1.3	9.4	44.2	1.4	0.0	< 1
37	32.0	6.0	1.0	5.0	1.0	4.0	25.0	4.0	3.0	2.0	14.0	21.0	7.0	1.0	1.8	7.0	3.2	5.2	1.7	41.3	2.0	8.6	72.4	3.1	< 1	2.1
38	26.0	11.0	1.0	8.0	1.0	4.0	19.0	4.0	4.0	2.0	11.0	20.0	4.0	< 1	1.8	3.0	4.7	4.3	1.5	25.8	3.1	6.5	102.8	20.6	< 1	< 1
39	16.0	18.0	1.0	4.0	1.0	2.0	12.0	3.0	5.0	3.0	10.0	18.0	5.0	< 1	1.6	1.5	6.9	3.6	1.4	18.4	6.2	6.8	108.5	51.5	4.1	< 1

Table 9. -- Continued.

Length	1992	1993	1994	1995	1996	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2012	2013	2014	2015	2016	2017	2018	2019
40	15.0	26.0	2.0	7.0	1.0	4.0	7.0	6.0	4.0	1.0	7.0	17.0	12.0	1.2	1.9	4.1	4.5	4.2	2.1	12.6	12.3	3.5	88.3	150.1	20.0	< 1
41	11.0	30.0	3.0	3.0	1.0	2.0	8.0	7.0	6.0	1.0	7.0	19.0	13.0	1.2	1.7	4.0	7.3	4.7	3.2	8.1	20.3	3.7	64.0	243.7	48.1	2.5
42	9.0	32.0	5.0	4.0	1.0	3.0	3.0	11.0	5.0	2.0	4.0	22.0	19.0	1.5	1.4	2.4	8.9	5.8	5.0	5.9	30.8	4.2	37.5	283.7	99.7	18.8
43	9.0	29.0	10.0	10.0	2.0	2.0	4.0	13.0	5.0	1.0	4.0	20.0	21.0	2.5	1.6	2.5	8.8	6.5	7.6	4.9	33.6	5.2	21.6	280.6	164.4	59.6
44	9.0	24.0	16.0	12.0	4.0	3.0	3.0	13.0	5.0	1.0	3.0	19.0	27.0	3.7	1.6	2.1	9.6	7.5	8.3	6.6	34.1	8.7	12.7	181.3	214.6	108.3
45	12.0	23.0	26.0	24.0	5.0	2.0	2.0	15.0	6.0	2.0	2.0	17.0	27.0	5.2	2.3	3.0	8.6	10.8	11.6	3.5	27.0	13.1	7.8	99.6	214.3	159.7
46	17.0	18.0	31.0	39.0	10.0	3.0	1.0	17.0	4.0	2.0	3.0	15.0	24.0	7.3	1.6	2.1	6.7	10.9	12.4	4.9	18.9	18.2	6.5	52.3	171.0	170.0
47	17.0	16.0	39.0	49.0	20.0	3.0	3.0	16.0	4.0	2.0	3.0	14.0	29.0	9.7	2.6	1.2	4.6	9.7	14.8	7.9	12.2	21.6	4.7	32.2	130.4	165.7
48	29.0	15.0	34.0	63.0	32.0	6.0	4.0	15.0	6.0	3.0	2.0	10.0	28.0	12.2	2.7	< 1	4.2	10.5	14.8	11.9	10.2	28.6	5.6	18.0	88.2	136.1
49	36.0	15.0	32.0	66.0	48.0	13.0	6.0	13.0	8.0	3.0	2.0	8.0	19.0	15.2	4.2	1.2	2.7	10.7	14.7	14.4	9.6	28.3	7.2	7.7	49.8	108.4
50	47.0	17.0	30.0	63.0	62.0	20.0	13.0	16.0	8.0	3.0	2.0	8.0	28.0	18.4	6.3	< 1	3.1	12.7	16.6	15.2	13.4	25.5	5.4	6.2	24.8	63.8
51	43.0	16.0	26.0	52.0	71.0	32.0	20.0	12.0	6.0	4.0	2.0	5.0	14.0	21.9	8.6	< 1	2.8	12.2	14.1	25.9	16.1	24.7	3.7	3.1	28.4	35.7
52	44.0	15.0	24.0	43.0	70.0	41.0	27.0	13.0	10.0	5.0	2.0	5.0	8.0	23.0	7.1	1.5	4.5	11.3	15.2	22.3	31.4	21.5	5.1	2.6	9.4	25.9
53	43.0	17.0	29.0	34.0	62.0	45.0	32.0	12.0	8.0	4.0	2.0	3.0	7.0	20.2	11.3	1.4	3.0	8.0	12.7	27.8	33.8	24.8	2.8	0.4	9.7	12.3
54	45.0	17.0	23.0	26.0	48.0	44.0	30.0	13.0	6.0	4.0	1.0	4.0	5.0	16.3	9.9	2.5	3.5	9.9	11.1	40.4	35.8	24.2	3.0	3.0	4.0	6.2
55	41.0	15.0	24.0	20.0	38.0	38.0	27.0	12.0	7.0	3.0	2.0	4.0	4.0	19.2	11.5	2.6	2.6	11.7	14.2	30.3	37.7	32.9	2.5	5.2	7.7	6.3
56	22.0	13.0	27.0	19.0	27.0	35.0	28.0	12.0	8.0	2.0	< 1	3.0	3.0	10.4	8.8	5.5	4.0	9.3	12.0	42.6	46.5	30.7	2.9	5.4	2.2	< 1
57	28.0	11.0	21.0	10.0	20.0	19.0	18.0	13.0	5.0	2.0	< 1	1.0	1.0	7.7	8.5	1.7	2.8	8.6	11.8	30.6	35.8	31.1	3.0	< 1	< 1	1.3
58	24.0	12.0	19.0	10.0	15.0	13.0	15.0	11.0	4.0	2.0	1.0	2.0	2.0	5.5	7.7	3.8	2.3	11.0	14.5	30.3	30.1	34.2	1.5	2.7	0.0	< 1
59	8.0	7.0	16.0	4.0	11.0	8.0	13.0	8.0	6.0	2.0	2.0	1.0	1.0	5.8	4.8	4.6	2.5	10.3	8.5	30.0	23.9	26.2	1.1	1.1	0.0	< 1
60	4.0	5.0	13.0	3.0	9.0	5.0	8.0	4.0	6.0	1.0	1.0	< 1	1.0	3.8	3.6	3.2	2.7	6.4	8.2	34.4	24.6	27.0	1.6	< 1	< 1	< 1
61	4.0	3.0	9.0	3.0	5.0	4.0	4.0	2.0	3.0	1.0	1.0	< 1	< 1	3.6	3.2	5.1	2.5	10.5	4.4	15.8	16.4	16.9	< 1	0.0	0.0	< 1
62	5.0	2.0	4.0	3.0	3.0	2.0	3.0	3.0	1.0	1.0	< 1	< 1	0.0	2.2	2.2	2.4	2.3	7.9	2.8	19.0	13.2	15.8	1.0	0.0	< 1	0.0
63	3.0	1.0	3.0	< 1	2.0	2.0	4.0	1.0	3.0	< 1	< 1	1.0	1.0	2.2	2.2	2.8	2.1	7.4	3.1	23.8	6.1	8.6	< 1	< 1	0.0	0.0
64	1.0	< 1	2.0	1.0	1.0	< 1	1.0	1.0	1.0	< 1	1.0	< 1	< 1	1.0	1.0	3.2	1.6	8.8	2.2	6.3	8.6	3.9	0.0	0.0	0.0	0.0
65	0.0	< 1	2.0	< 1	1.0	< 1	1.0	< 1	< 1	< 1	0.0	< 1	< 1	< 1	0.8	1.2	< 1	8.4	2.2	4.2	3.7	6.3	0.0	0.0	0.0	0.0
66	1.0	< 1	< 1	0.0	< 1	< 1	1.0	< 1	3.0	0.0	0.0	0.0	1.0	< 1	< 1	1.7	2.4	6.4	< 1	6.9	3.8	5.6	0.0	0.0	0.0	0.0
67	1.0	< 1	1.0	0.0	< 1	< 1	0.0	< 1	0.0	< 1	< 1	0.0	0.0	< 1	< 1	1.2	1.3	6.7	1.0	1.0	1.4	1.6	0.0	0.0	0.0	0.0
68	0.0	< 1	0.0	0.0	< 1	1.0	< 1	0.0	1.0	< 1	0.0	< 1	0.0	< 1	< 1	< 1	1.2	3.7	< 1	1.3	1.4	3.0	0.0	0.0	0.0	0.0
69	0.0	< 1	< 1	0.0	< 1	< 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	< 1	< 1	< 1	1.5	0.0	0.0	0.0	< 1	0.0	0.0	0.0	0.0
70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	< 1	2.9	< 1	1.6	< 1	0.0	0.0	0.0	0.0	0.0
71	0.0	0.0	< 1	0.0	0.0	0.0	0.0	0.0	0.0	< 1	0.0	0.0	0.0	0.0	< 1	0.0	< 1	1.8	0.0	3.5	0.0	0.0	0.0	0.0	0.0	0.0
72	0.0	0.0	0.0	0.0	< 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
73	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0
74	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	< 1	< 1	0.0	0.0	0.0	0.0	0.0
75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	< 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
76	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	713.0	436.0	493.0	764.0	777.0	583.0	505.0	449.0	433.0	257.0	317.0	331.0	356.0	294.0	181.0	197.7	257.2	421.4	333.9	807.6	827.1	847.8	666.8	1465.0	1320.8	1281.1

Table 10. -- Numbers-at-age estimates (millions) from acoustic-trawl surveys of walleye pollock in the Shelikof Strait area. since 1992 . No surveys were conducted in 1982, 1999, or 2011, and no estimate was produced for 1987 due to mechanical problems. Selectivity corrections for escapement of juveniles are reflected

Age	1992	1993	1994	1995	1996	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2012	2013	2014	2015	2016	2017	2018	2019	Mean
1	228.0	63.0	186.0	10,690.0	56.0	70.0	395.0	4,484.0	289.0	8.0	48.0	53.0	1,626.1	161.7	53.5	1778.2	814.1	270.5	193.8	9178.4	1590.8	19.8	0.0	744.7	1,819.6	7,361.2	1,622.4
2	34.0	76.0	36.0	510.0	3,307.0	183.0	89.0	755.0	4,104.0	163.0	94.0	94.0	157.5	836.0	231.7	359.2	1127.2	299.1	842.3	117.1	3492.9	103.9	1.8	0.0	142.6	1,671.7	724.2
3	74.0	37.0	49.0	79.0	119.0	1,247.0	126.0	217.0	352.0	1,107.0	205.0	58.0	55.5	40.7	174.9	230.2	105.8	538.7	43.3	688.0	17.4	1637.3	78.2	9.4	1.6	155.5	286.4
4	188.0	72.0	32.0	78.0	25.0	80.0	474.0	16.0	61.0	97.0	800.0	159.0	34.6	11.5	29.7	49.0	95.8	82.9	76.6	51.3	279.9	72.4	1451.8	126.4	9.9	6.1	171.5
5	368.0	233.0	155.0	103.0	54.0	18.0	136.0	67.0	42.0	16.0	56.0	357.0	172.7	17.4	10.1	11.2	57.8	76.3	94.7	64.4	82.8	152.8	43.4	2576.2	166.3	6.6	197.6
6	84.0	126.0	84.0	245.0	71.0	44.0	14.0	132.0	23.0	16.0	8.0	48.0	162.4	56.0	17.3	2.0	9.5	27.7	45.9	104.0	57.7	62.4	33.5	126.0	1,804.0	261.7	141.0
7	85.0	27.0	42.0	122.0	201.0	52.0	32.0	17.0	35.0	8.0	4.0	3.0	36.0	75.0	34.4	3.7	2.7	11.2	28.9	58.7	98.5	56.7	15.5	31.1	85.9	1,127.5	88.2
8	171.0	36.0	27.0	54.0	119.0	98.0	36.0	13.0	13.0	7.0	2.0	3.0	3.6	32.2	20.9	9.8	0.8	5.1	4.4	42.8	54.6	68.1	3.6	9.3	46.7	53.9	36.0
9	33.0	39.0	44.0	17.0	40.0	53.0	74.0	10.0	6.0	1.0	1.0	3.0	2.4	6.9	1.5	6.2	4.7	5.0	1.1	10.5	25.6	30.0	7.4	0.3	0.0	11.1	16.7
10	56.0	16.0	48.0	11.0	13.0	14.0	26.0	8.0	3.0	1.0	< 1	< 1	0.0	< 1	1.0	1.9	5.6	10.3	0.3	4.9	17.6	11.0	1.7	< 1	0.0	9.0	11.8
11	2.0	8.0	15.0	15.0	11.0	2.0	14.0	14.0	1.0	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.3	8.8	< 1	4.5	7.3	5.6	0.0	0.0	0.0	< 1	6.4
12	15.0	3.0	7.0	6.0	5.0	3.0	7.0	7.0	2.0	< 1	0.0	0.0	0.0	< 1	0.0	0.0	< 1	3.2	< 1	< 1	< 1	3.7	0.0	0.0	0.0	< 1	3.3
13	1.0	2.0	1.0	2.0	3.0	1.0	< 1	2.0	1.0	< 1	< 1	< 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	2.3	< 1	0.0	0.0	0.0	0.0	0.8
14	< 1	< 1	2.0	< 1	< 1	< 1	1.0	1.0	< 1	< 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	< 1	0.0	0.0	0.0	0.0	0.4
15	0.0	1.0	< 1	0.0	0.0	0.0	1.0	0.0	< 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	< 1	1.5	0.0	0.0	0.0	0.0	0.2
16	0.0	1.0	0.0	0.0	< 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	< 1	0.0	0.0	0.0	0.0	0.0
17	0.0	< 1	< 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	1,339.0	740.0	728.0	11,932.0	4,024.0	1,865.0	1,425.0	5,743.0	4,932.0	1,424.0	1,220.0	777.0	2,251.7	1,240.0	576.0	2,451.9	2,225.5	1,338.7	1,332.0	10,332.6	5,728.9	2,227.8	1,636.9	3,624.2	4,076.5	10,664.4	3,302.2

Table 11. -- Biomass-at-age estimates (thousands of metric tons) from acoustic-trawl surveys of walleye pollock in the Shelikof Strait area, since 1992. No surveys were conducted in 1999 or 2011 due to mechanical problems with the survey vessel. Selectivity corrections for escapement of juveniles are reflected in estimates from 2008 - 2019.

Age	1992	1993	1994	1995	1996	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2012	2013	2014	2015	2016	2017	2018	2019	Mean
1	3.0	1.0	2.0	114.0	1.0	1.0	4.0	57.0	2.0	< 1	< 1	< 1	18.1	1.5	< 1	23.2	8.4	2.4	2.4	76.6	16.2	0.2	0.0	7.7	14.8	61.9	19.0
2	3.0	6.0	3.0	46.0	180.0	15.0	8.0	63.0	214.0	13.0	8.0	8.0	13.2	54.9	14.6	35.4	88.1	23.6	66.6	15.0	201.6	9.8	0.3	0.0	12.6	102.1	46.3
3	16.0	11.0	14.0	23.0	24.0	195.0	28.0	60.0	60.0	164.0	42.0	14.0	17.0	10.7	38.9	61.5	27.7	129.0	11.8	238.9	5.3	327.1	23.6	3.3	0.3	34.3	60.8
4	60.0	34.0	20.0	41.0	12.0	28.0	153.0	9.0	25.0	29.0	222.0	77.0	19.0	5.0	13.2	23.7	49.8	55.4	50.0	32.3	166.4	39.2	565.8	57.2	5.1	3.0	69.1
5	144.0	136.0	127.0	83.0	50.0	13.0	53.0	54.0	27.0	12.0	25.0	179.0	132.5	14.4	8.5	8.9	42.3	83.2	87.9	74.4	59.1	134.4	24.2	1287.3	89.6	4.2	113.6
6	68.0	90.0	75.0	220.0	73.0	53.0	12.0	107.0	24.0	16.0	7.0	35.0	119.2	62.9	21.6	2.8	10.1	35.5	61.3	142.5	74.8	65.8	25.2	70.5	1,098.5	183.5	105.9
7	92.0	28.0	48.0	116.0	212.0	61.0	39.0	17.0	40.0	9.0	5.0	4.0	28.8	87.2	47.4	7.1	4.5	20.5	43.0	93.9	131.7	81.2	13.3	28.9	58.2	830.3	82.6
8	194.0	43.0	34.0	55.0	132.0	120.0	47.0	17.0	18.0	8.0	2.0	3.0	4.2	42.8	30.0	18.5	1.7	10.6	6.9	75.6	83.8	102.0	4.1	8.7	41.7	42.5	44.1
9	36.0	46.0	64.0	19.0	48.0	67.0	95.0	15.0	8.0	2.0	2.0	4.0	2.9	10.3	2.8	11.7	10.0	11.5	2.2	19.3	40.4	47.9	8.3	< 1	0.0	9.7	23.3
10	71.0	21.0	68.0	15.0	17.0	20.0	33.0	11.0	5.0	1.0	1.0	< 1	0.0	1.0	1.9	3.9	11.7	20.9	< 1	10.6	29.0	17.6	2.0	< 1	0.0	9.3	16.1
11	3.0	10.0	21.0	20.0	16.0	3.0	21.0	22.0	2.0	1.0	< 1	< 1	1.4	1.6	1.4	< 1	2.7	20.4	0.2	9.7	11.3	9.0	0.0	0.0	0.0	< 1	8.0
12	21.0	4.0	10.0	7.0	7.0	5.0	10.0	11.0	3.0	1.0	0.0	0.0	0.0	1.3	0.0	0.0	< 1	8.2	< 1	1.6	1.4	6.5	0.0	0.0	0.0	< 1	4.3
13	1.0	3.0	2.0	3.0	4.0	1.0	< 1	4.0	1.0	< 1	< 1	< 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	4.8	1.5	0.0	0.0	0.0	0.0	1.3
14	1.0	1.0	4.0	1.0	< 1	1.0	1.0	2.0	1.0	< 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8	0.0	1.4	0.0	0.0	0.0	0.0	0.9
15	0.0	1.0	< 1	0.0	0.0	0.0	1.0	0.0	< 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	1.3	2.5	0.0	0.0	0.0	0.0	0.5
16	0.0	1.0	0.0	0.0	< 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.1
17	0.0	< 1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	713.0	436.0	493.0	764.0	777.0	583.0	505.0	449.0	433.0	257.0	316.0	327.0	356.1	293.6	180.9	197.7	257.2	421.4	333.9	807.6	827.1	847.8	666.8	1465.0	1,320.9	1,281.1	561.2

Table 12.-- Catch by species, and numbers of length and weight measurements taken from individuals found in the codend, during the three Aleutian Wing midwater trawl hauls during the winter 2019 acoustic-trawl survey of walleye pollock in Chirikof shelf break region. Recapture net catch data are not included.

		Catch				Individual measurements	
Species name	Scientific name	Weight (kg)	%	Number	%	Length	Weight
Pacific ocean perch	*Sebastes alutus*	1,629.2	83.6	2,347	50.8	211	64
walleye pollock	*Gadus chalcogrammus*	310.9	16.0	400	8.7	291	88
chinook salmon	*Oncorhynchus tshawytscha*	2.5	0.1	1	< 0.1	1	-
dusky rockfish	*Sebastes variabilis*	2.0	0.1	1	< 0.1	1	1
arrowtooth flounder	*Atheresthes stomias*	1.4	0.1	2	< 0.1	2	2
shrimp	Malacostraca (class)	0.8	< 0.1	432	9.4	11	-
northern sea nettle	*Chrysaora melanaster*	0.3	< 0.1	1	< 0.1	1	1
euphausiid	Euphausiacea (order)	0.3	< 0.1	1,363	29.5	10	-
lanternfish	Myctophidae (family)	0.3	< 0.1	42	0.9	39	11
northern smoothtongue	*Leuroglossus schmidti*	0.2	< 0.1	10	0.2	4	4
jellyfish	Scyphozoa (class)	0.1	< 0.1	8	0.2	5	5
squid	Cephalopoda (class)	0.0	< 0.1	3	0.1	-	-
Pacific viperfish	*Chauliodus macouni*	0.0	< 0.1	7	0.2	6	6
Total		1,947.8		4,616		528	156

Table 13.-- Catch by species, and numbers of length and weight measurements taken from individuals found in the codend, during the five Aleutian Wing midwater trawl hauls during the winter 2019 acoustic-trawl survey of walleye pollock in Marmot Bay. Recapture net catch data are not included.

		Catch				Individual measurements	
Species name	Scientific name	Weight (kg)	%	Number	%	Length	Weight
walleye pollock	*Gadus chalcogrammus*	4,965.2	99.4	28,426	93.4	872	326
eulachon	*Thaleichthys pacificus*	18.2	0.4	756	2.5	107	31
starry flounder	*Platichthys stellatus*	4.4	0.1	2	< 0.1	1	1
shrimp unid.	Malacostraca (class)	3.3	0.1	798	2.6	20	11
flathead sole	*Hippoglossoides elassodon*	1.5	< 0.1	3	< 0.1	3	3
capelin	*Mallotus villosus*	1.0	< 0.1	166	0.5	27	17
northern sea nettle	*Chrysaora melanaster*	0.6	< 0.1	3	< 0.1	1	1
arrowtooth flounder	*Atheresthes stomias*	0.5	< 0.1	6	< 0.1	6	6
Pacific herring	*Clupea pallasii*	0.4	< 0.1	4	< 0.1	4	4
smelt	Osmeridae (family)	0.4	< 0.1	276	0.9	-	-
Total		4,995.4		30,440		1,037	396

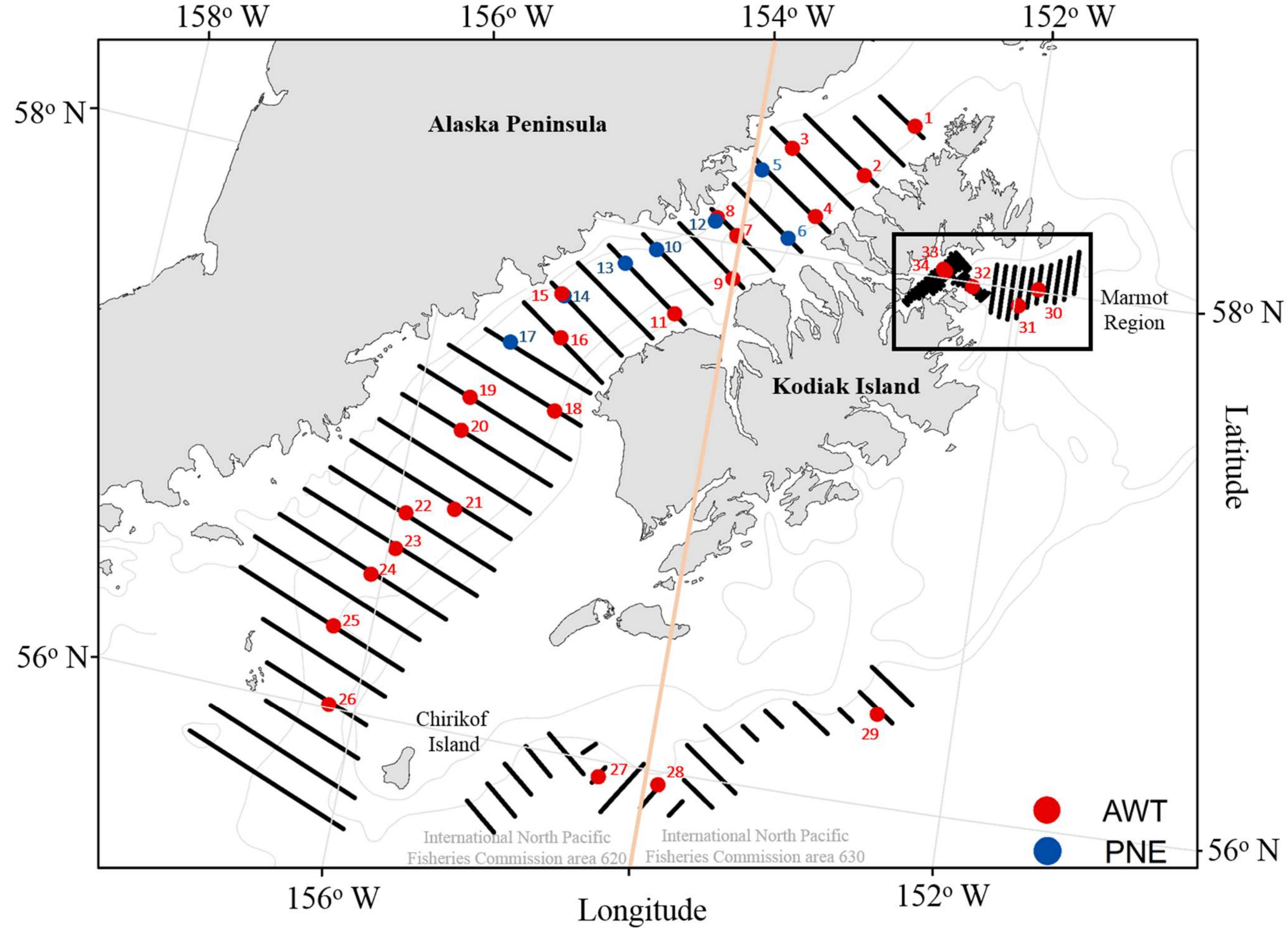


Figure 1. -- Transect lines and locations of midwater Aleutian-wing trawl (AWT; red circle) and poly Nor'eastern bottom trawl (PNE; blue circle) hauls during the winter 2019 acoustic-trawl survey of walleye pollock in Shelikof Strait, Marmot Bay, and the Chirikof shelf break. The international North Pacific Fisheries Commission areas 620 and 630 are shown on map separated by the orange line at 154° W. The box indicates enlarged area displayed in Figure 17.

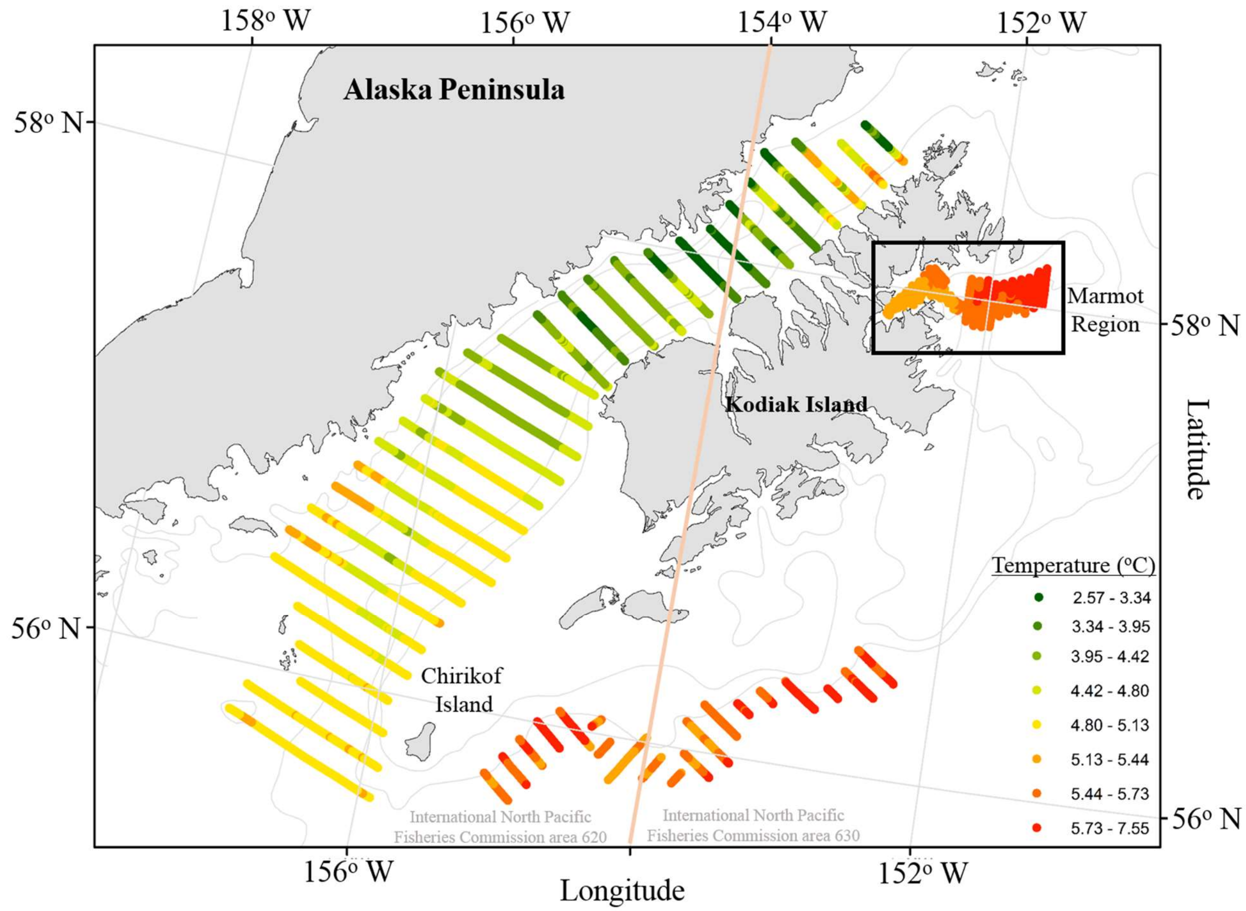


Figure 2. -- Surface water temperatures (°C) recorded at 5-second intervals during the 2019 acoustic-trawl survey of Shelikof Strait, Chirikof shelf break and Marmot Bay. The box indicates enlarged area displayed in Figure 18.

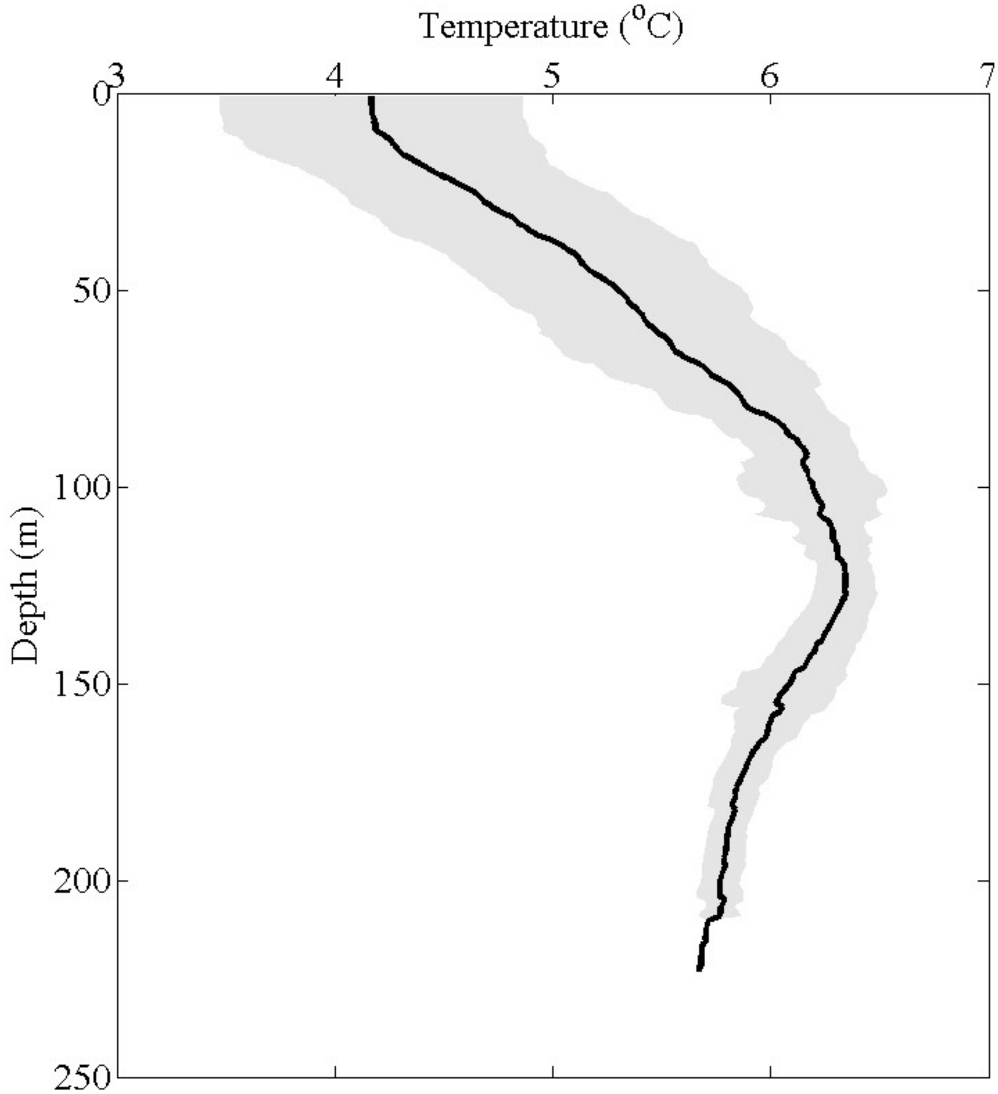


Figure 3. -- Mean water temperature (°C; solid line) by 1-m depth intervals measured at the 26 trawl haul locations during the winter 2019 acoustic-trawl survey of walleye pollock in Shelikof Strait. The shaded area represents one standard deviation.

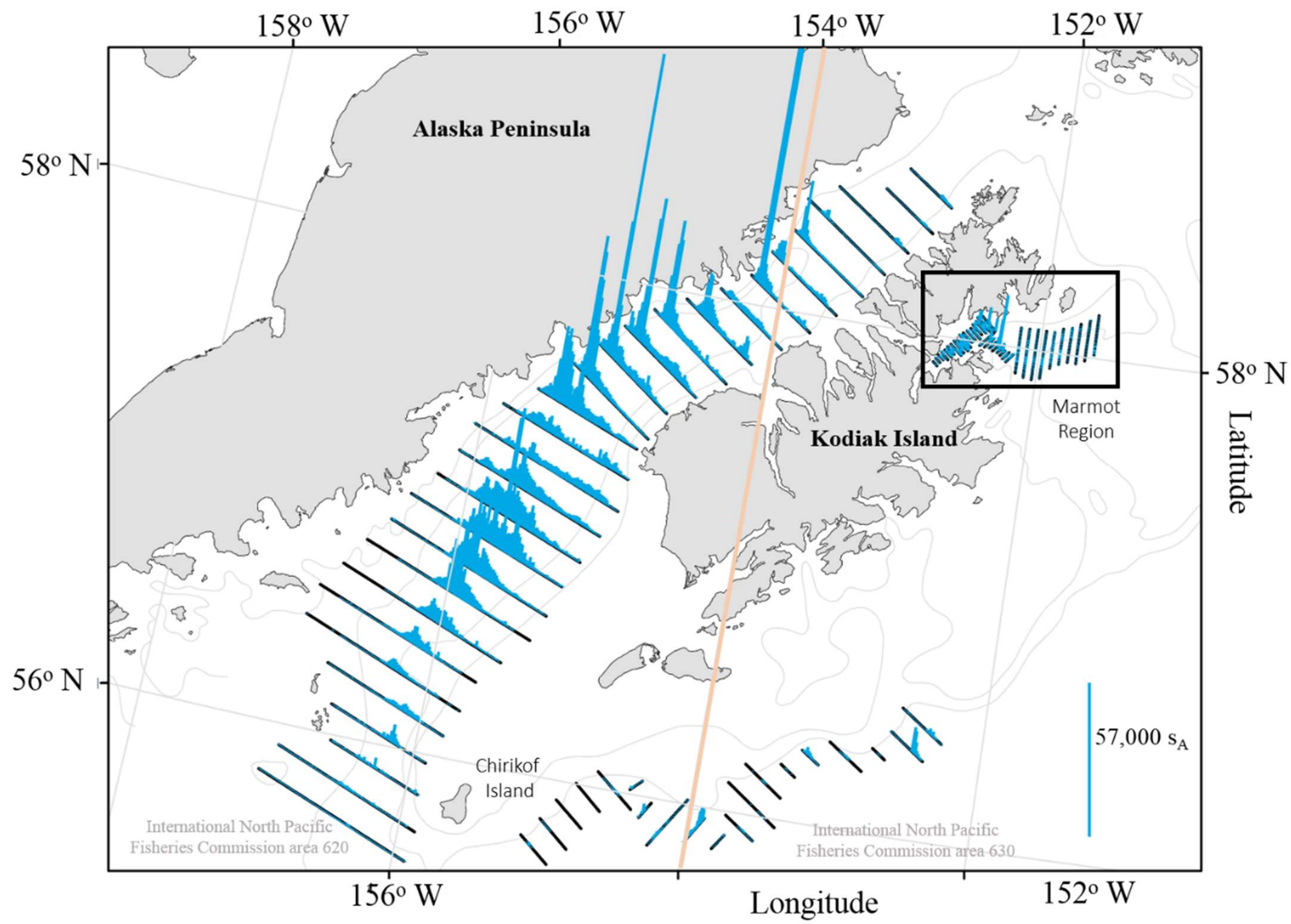


Figure 4. -- Backscatter (s_A, m^2/nmi^2) attributed to walleye pollock (vertical lines) along tracklines surveyed during the winter 2019 acoustic-trawl survey of the Shelikof Strait, Marmot Bay and the Chirikof shelf break. Two bars with backscatter values 143,332 and 170,392 m^2/nmi^2 were truncated for illustrative purposes.

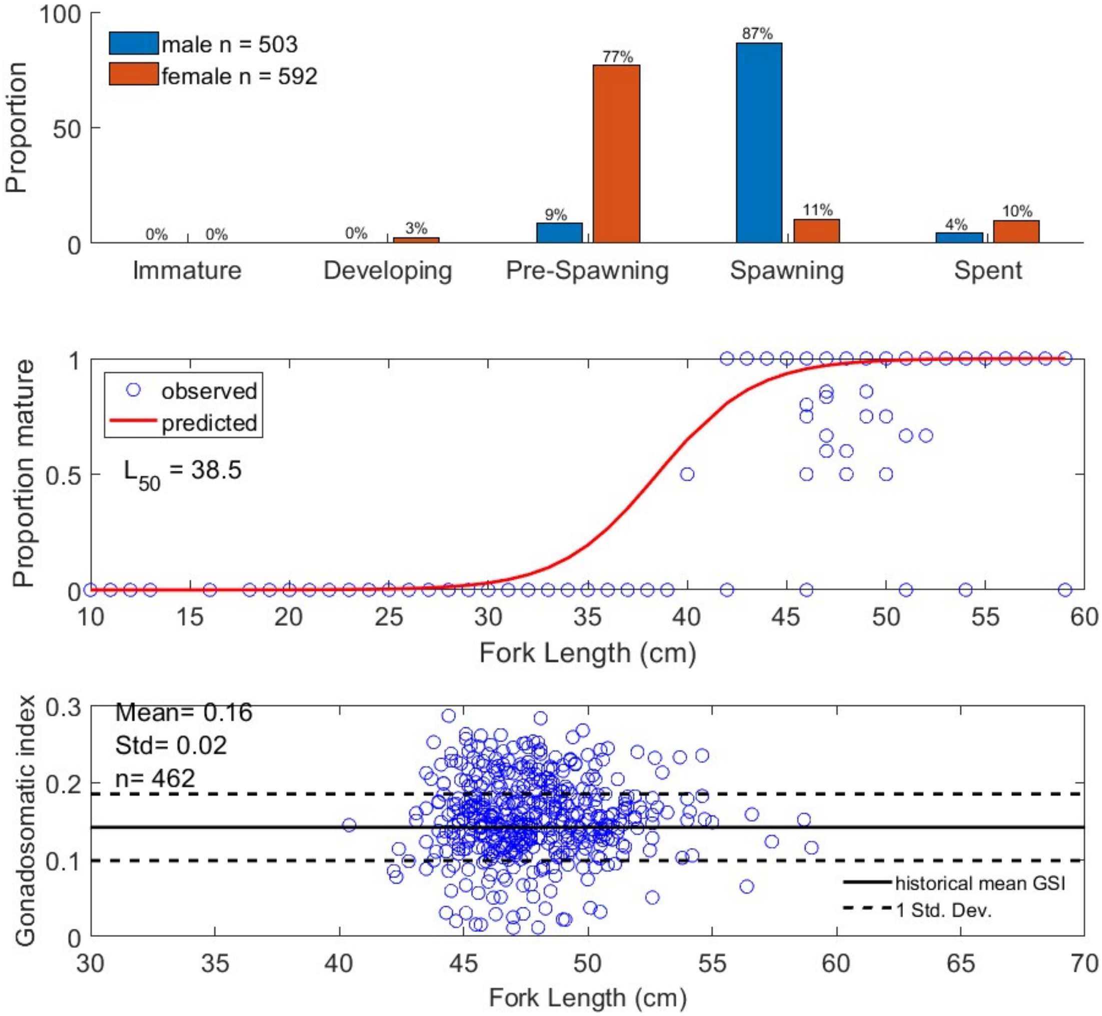


Figure 5. -- During the 2019 acoustic-trawl survey of Shelikof Strait, maturity composition for male and female walleye pollock greater than 40 cm FL within each stage (top panel); proportion mature (i.e., pre-spawning, spawning, or spent) by 1-cm size group for female walleye pollock (middle panel); gonadosomatic index greater than 40 cm FL (with historic survey mean ± 1 std. dev., bottom panel). All maturity quantities are weighted by local pollock abundance.

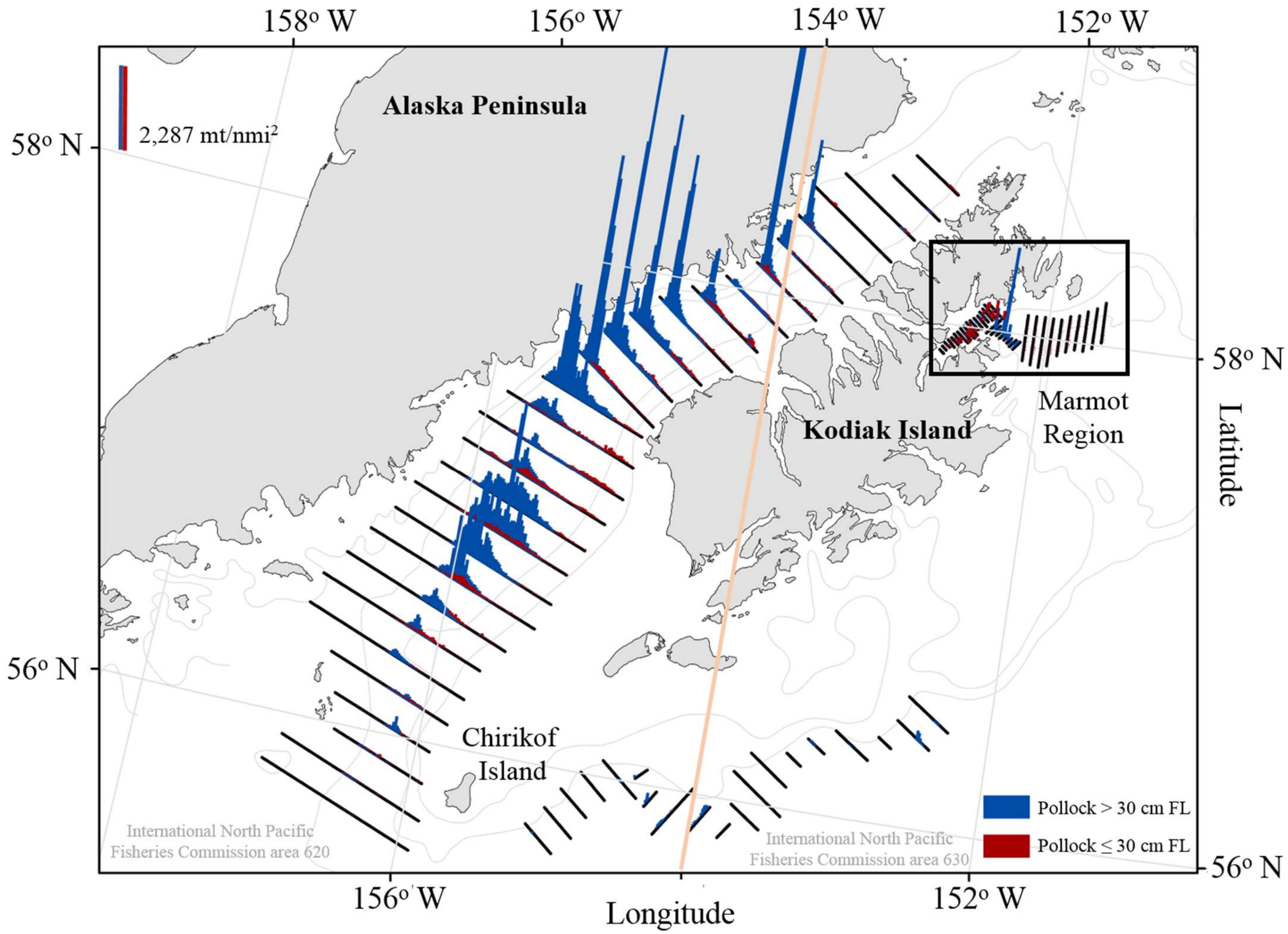


Figure 6. -- Biomass (t/nmi^2) attributed to walleye pollock (vertical lines) along tracklines surveyed during the winter 2019 acoustic-trawl survey of Shelikof Strait and Marmot Bay. Two sets of bars were truncated for illustrative purposes. Southwest bar value is 11,986 t/nmi^2 and NE bars extend from 8,711 to 27,528 t/nmi^2. The box indicated enlarged area displayed in Figure 20.

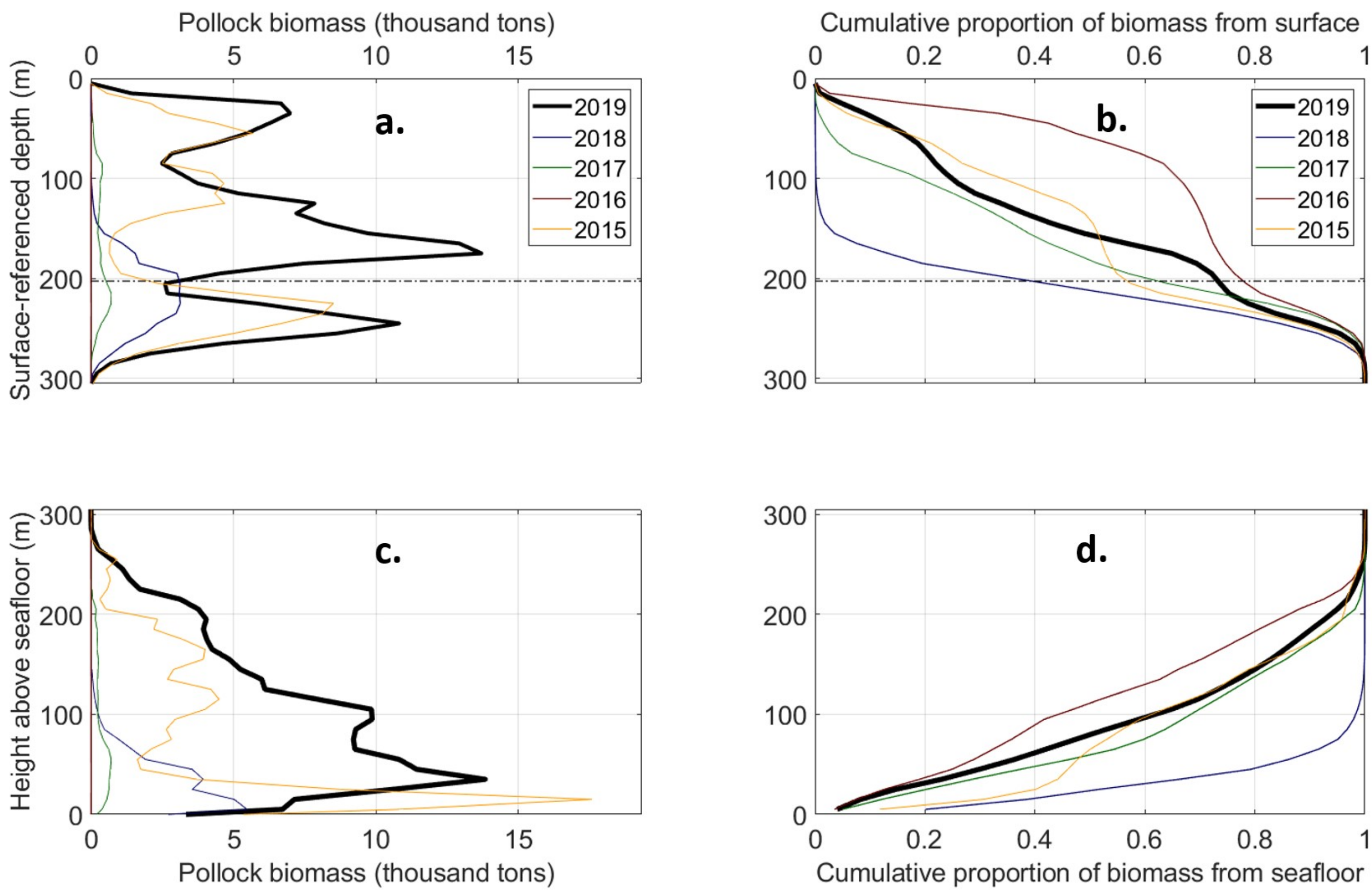


Figure 7. -- Estimated biomass distributions of juvenile pollock (< 30 cm FL) depth (a.) and height (c.) above the seafloor in Shelikof Strait during the winter 2019 acoustic-trawl survey. Cumulative percentage of pollock referenced to the surface (b.) and to the seafloor (d.) are also shown. Results for the winter 2015-2018 acoustic-trawl surveys are included. Depth is referenced to the surface and height is referenced to the bottom. Data were averaged in 10 m depth bins. Mean bottom depth for 2019 is shown in a. and b. (dashed line).

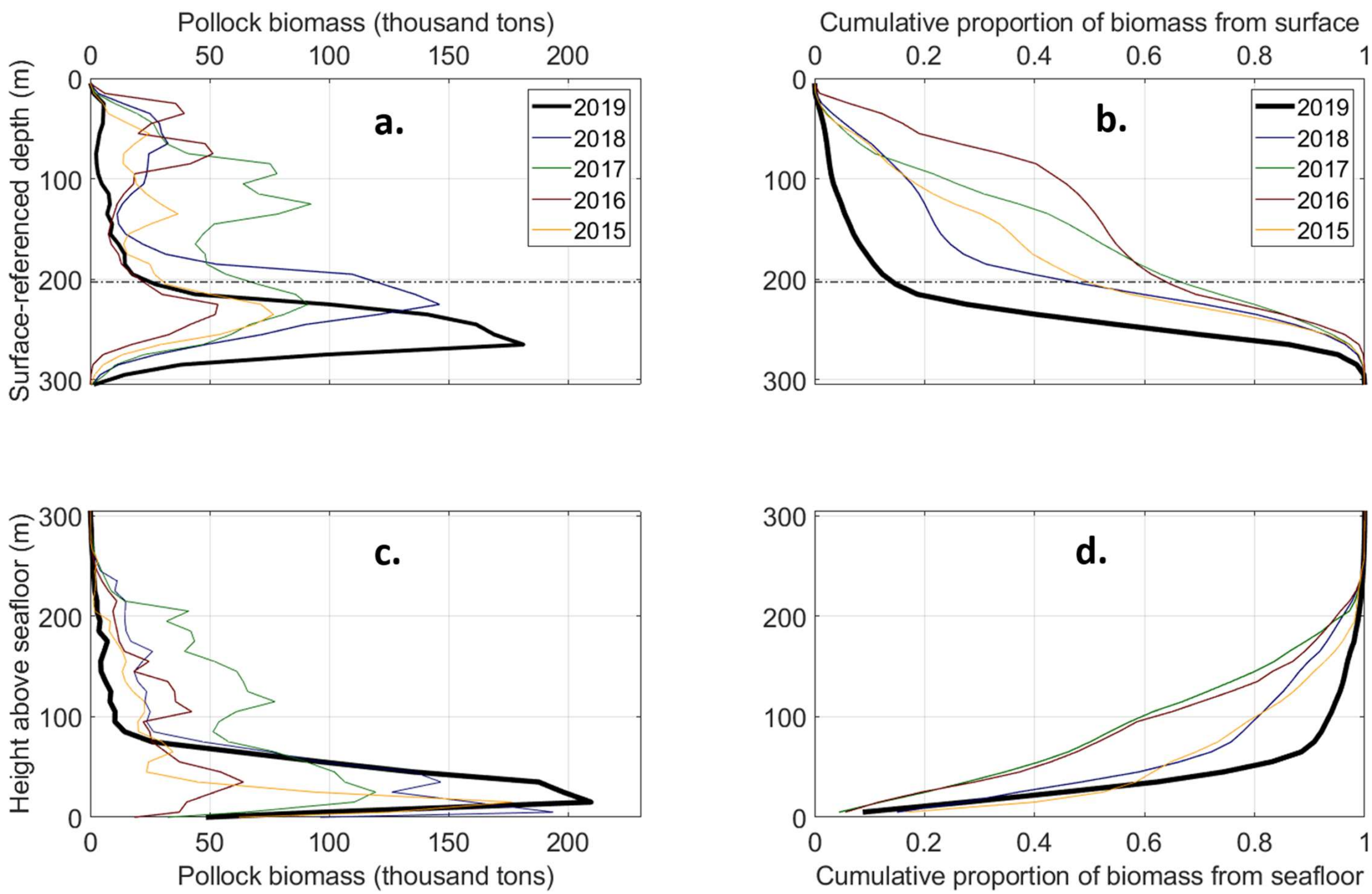


Figure 8. -- Estimated biomass distributions of adult pollock (≥ 30 cm FL) depth (a.) and height (c.) above the seafloor in Shelikof Strait during the winter 2019 acoustic-trawl survey. Cumulative percentage of pollock referenced to the surface (b.) and to the seafloor (d.) are also shown. Results for the winter 2015-2018 acoustic-trawl surveys are included. Depth is referenced to the surface and height is referenced to the bottom. Data were averaged in 10 m depth bins. Mean bottom depth for 2019 is shown in a. and b. (dashed line).

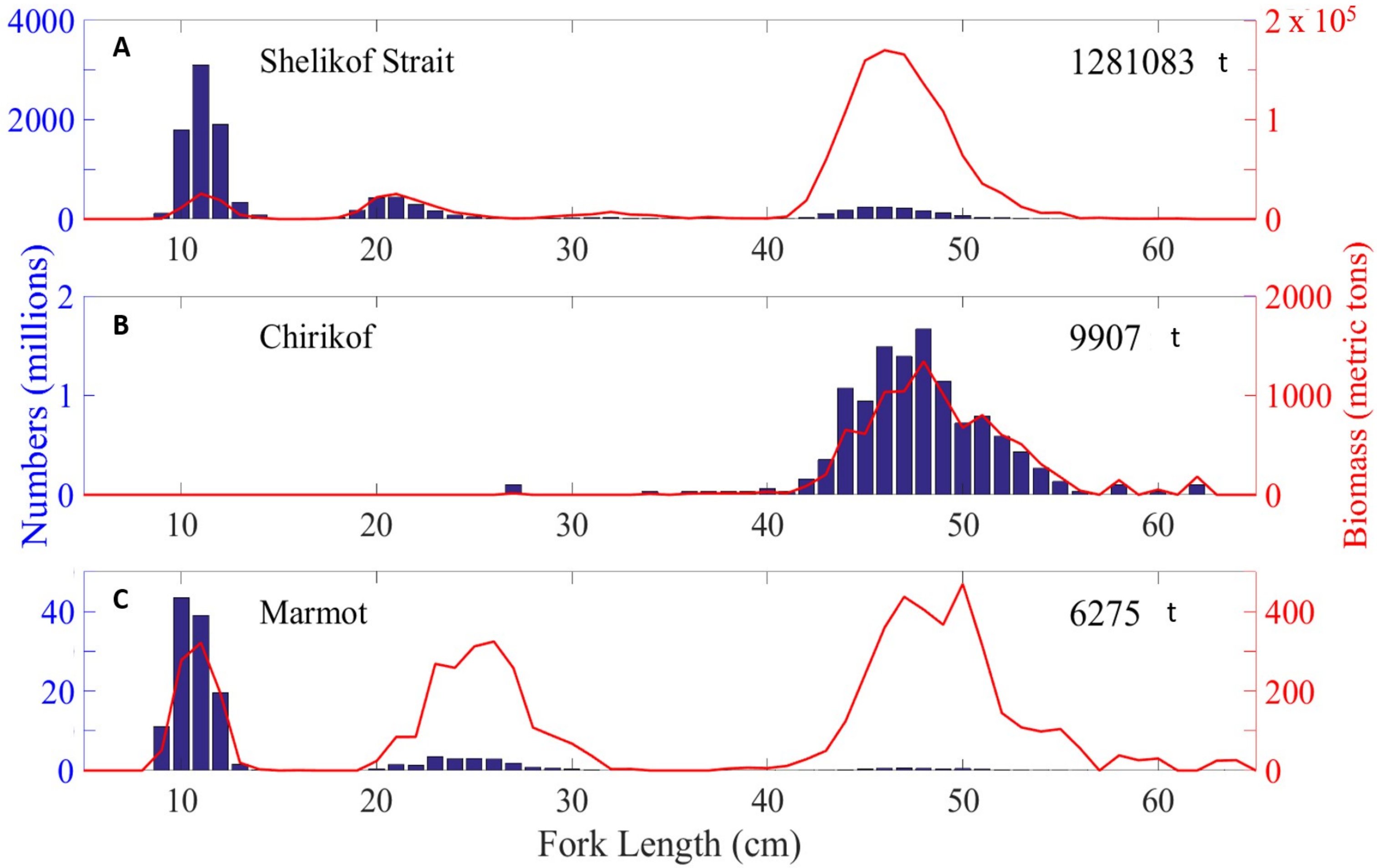


Figure 9. -- Length distribution of numbers of walleye pollock shown with blue bars (numbers) and biomass estimates in red line (metric tons, t) for the 2019 acoustic-trawl survey of the Shelikof Strait (A), Chirikof shelf break (B) and Marmot Bay (C).

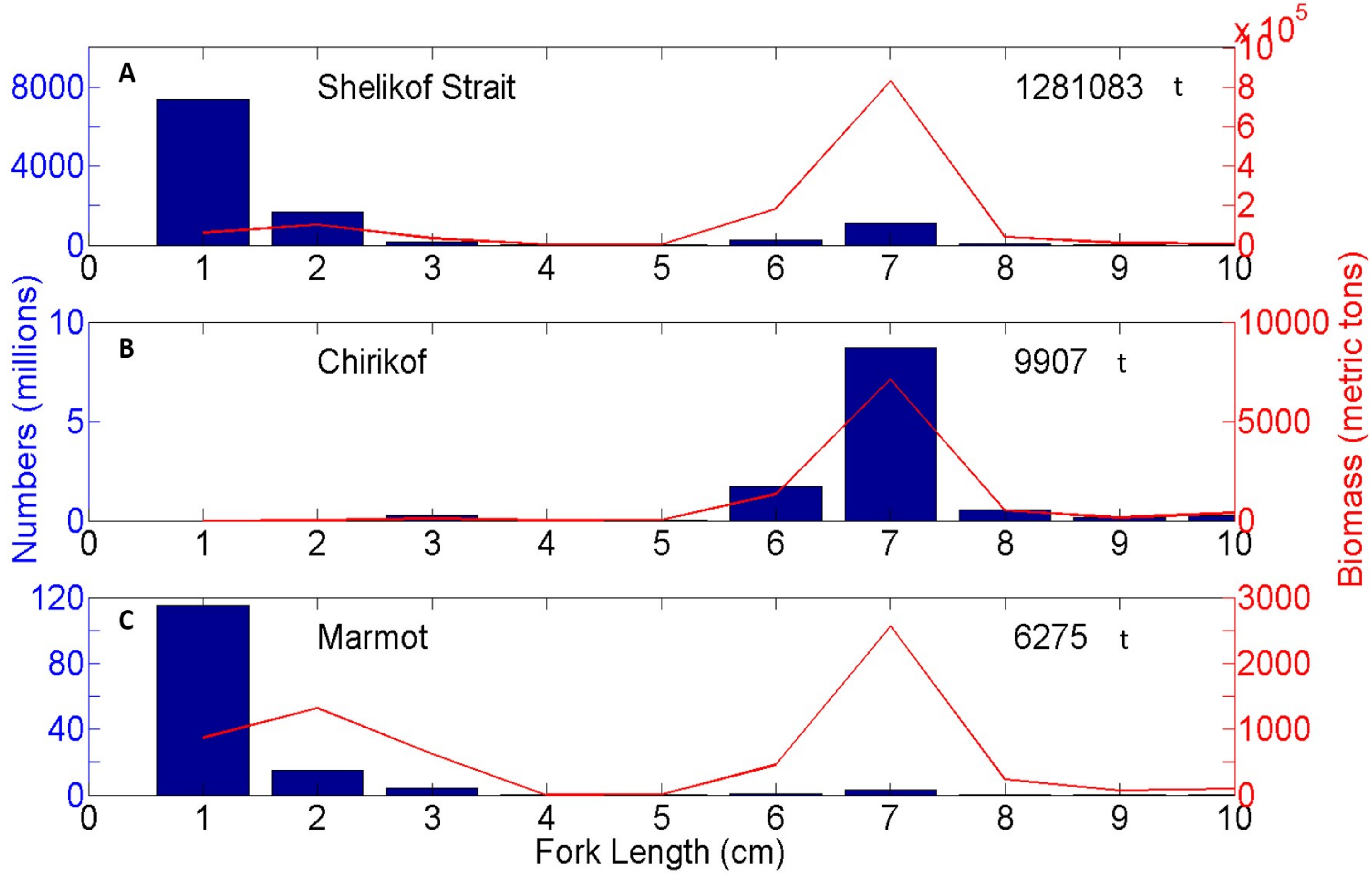


Figure 10. -- Age distribution of walleye pollock shown with blue bars (numbers) and biomass estimate in red line (metric tons, t) for the 2019 acoustic-trawl survey of the Shelikof Strait (A), Chirikof shelf break (B) and Marmot Bay (C).

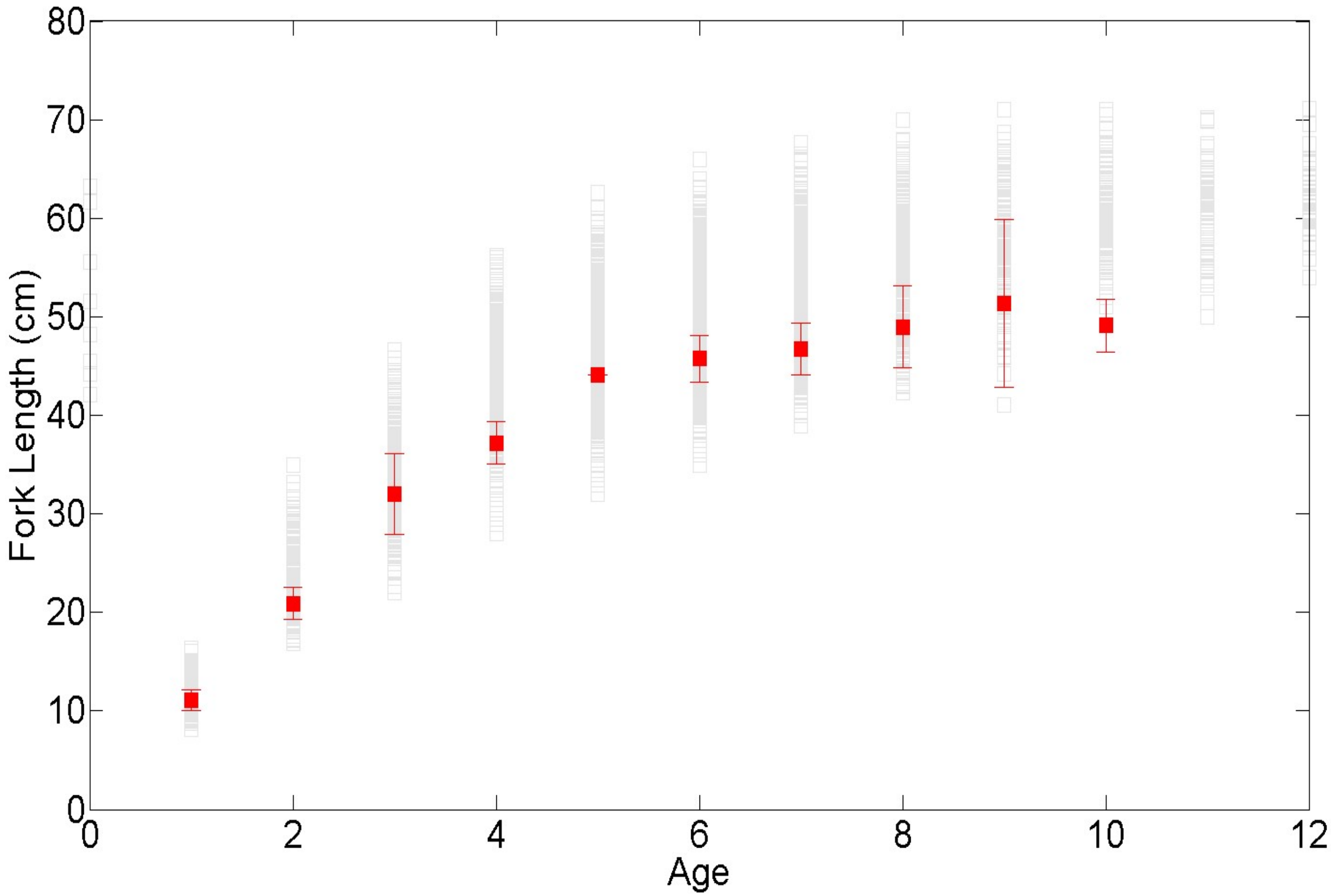


Figure 11. -- Walleye pollock average length at age from historic winter Shelikof, Chirikof and Marmot acoustic-trawl surveys (2002-present), gray squares, compared with walleye pollock average length at age for winter 2019, red squares with confidence intervals. Bars show +/- 1 standard deviation for the historic data.

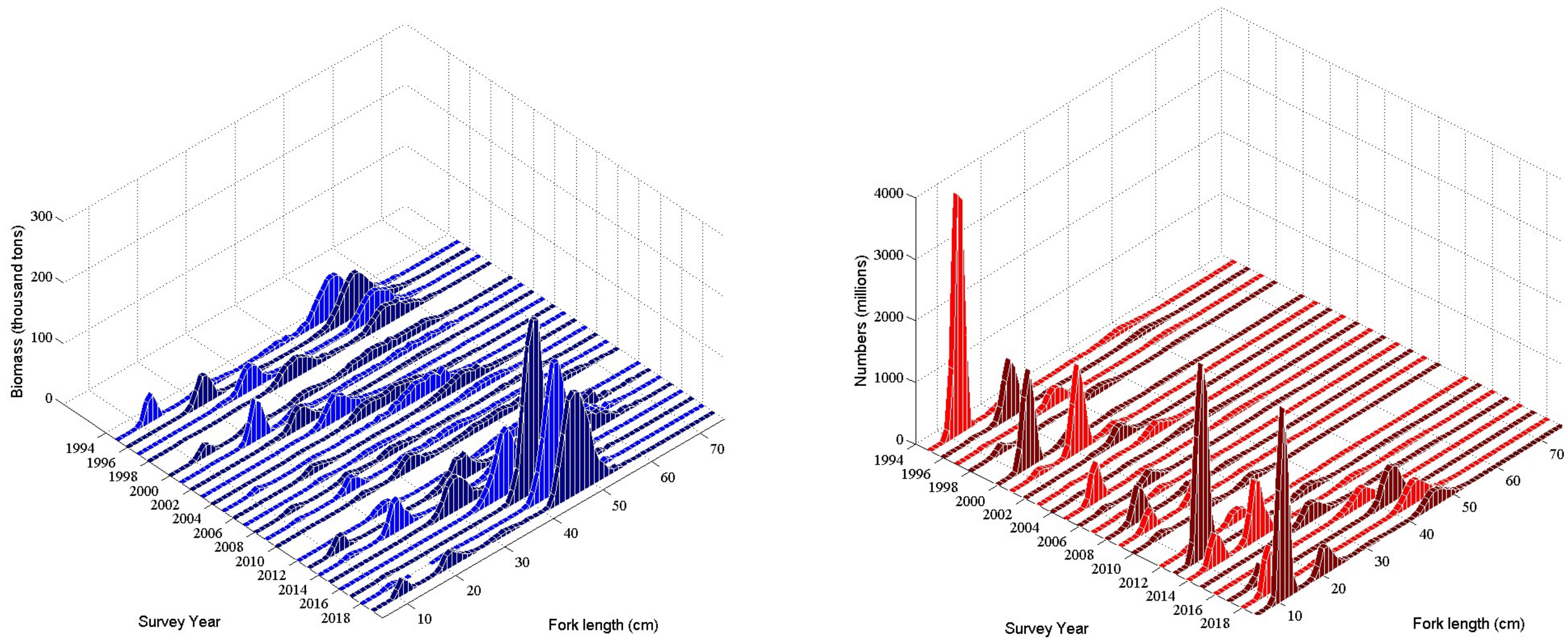


Figure 12. -- Time series of walleye pollock population size composition by weight (left panel) and numbers (right panel) from acoustic-trawl surveys of Shelikof Strait area since 1994. No surveys were conducted in 1998 or 2011. Estimates for 2008-2019 include selectivity corrections for juvenile escapement (see text for explanation).

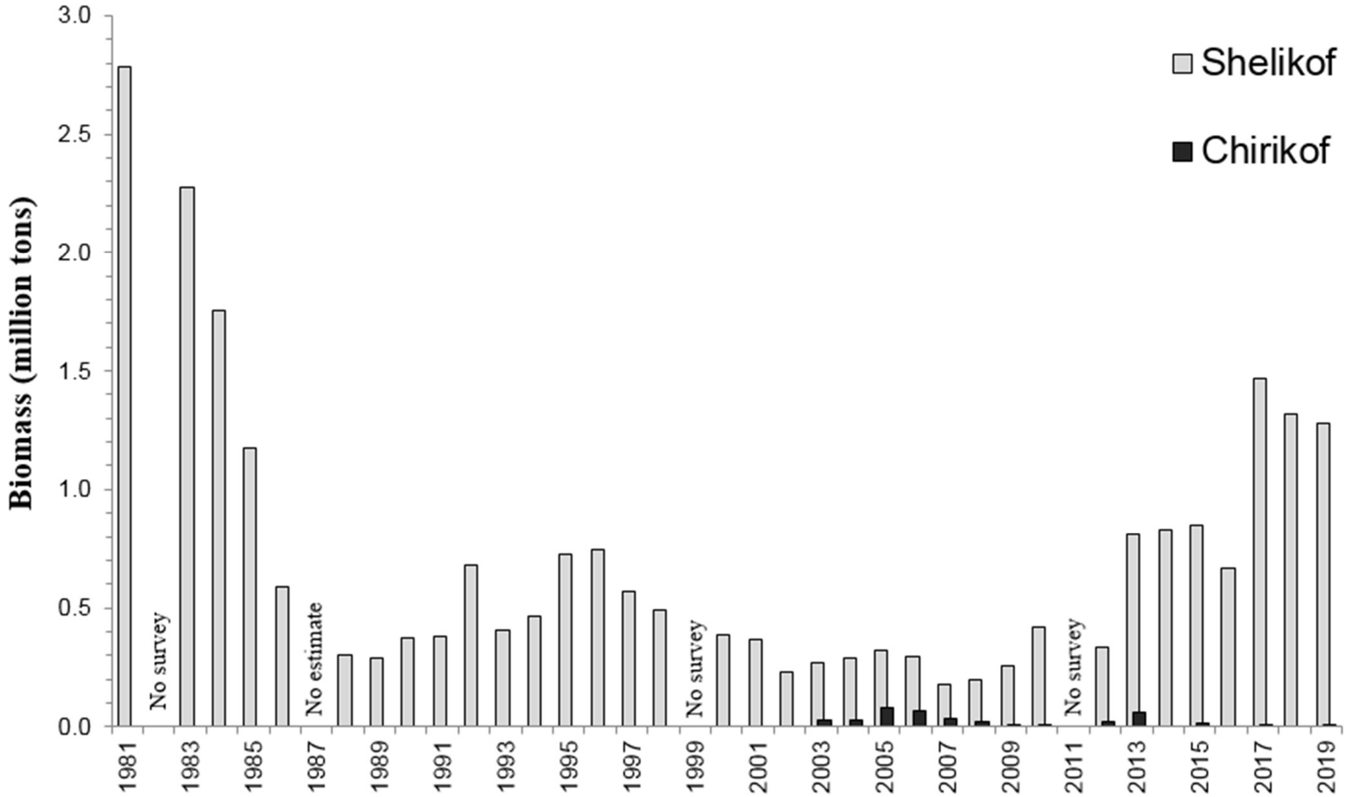


Figure 13. -- Summary of walleye pollock biomass estimates (million metric tons) for Shelikof Strait and Chirikof Island shelf break based on acoustic-trawl surveys. Estimates for 2008-2019 include selectivity corrections for juvenile escapement (see text for explanation).

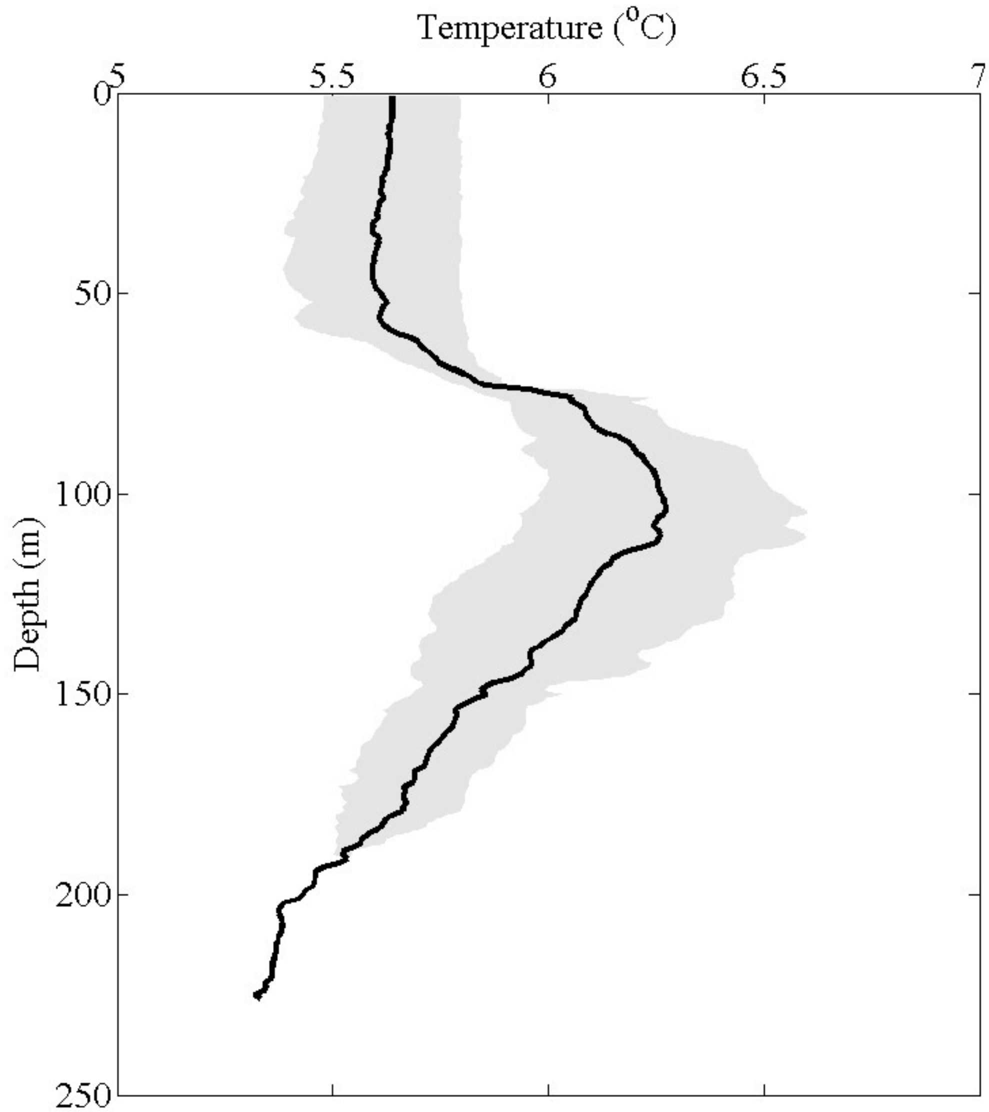


Figure 14. -- Mean water temperature (°C; solid line) by 1-m depth intervals measured at 3 trawl haul locations during the winter 2019 acoustic-trawl survey of walleye pollock in the Chirikof shelf break region. The shaded area represents one standard deviation.

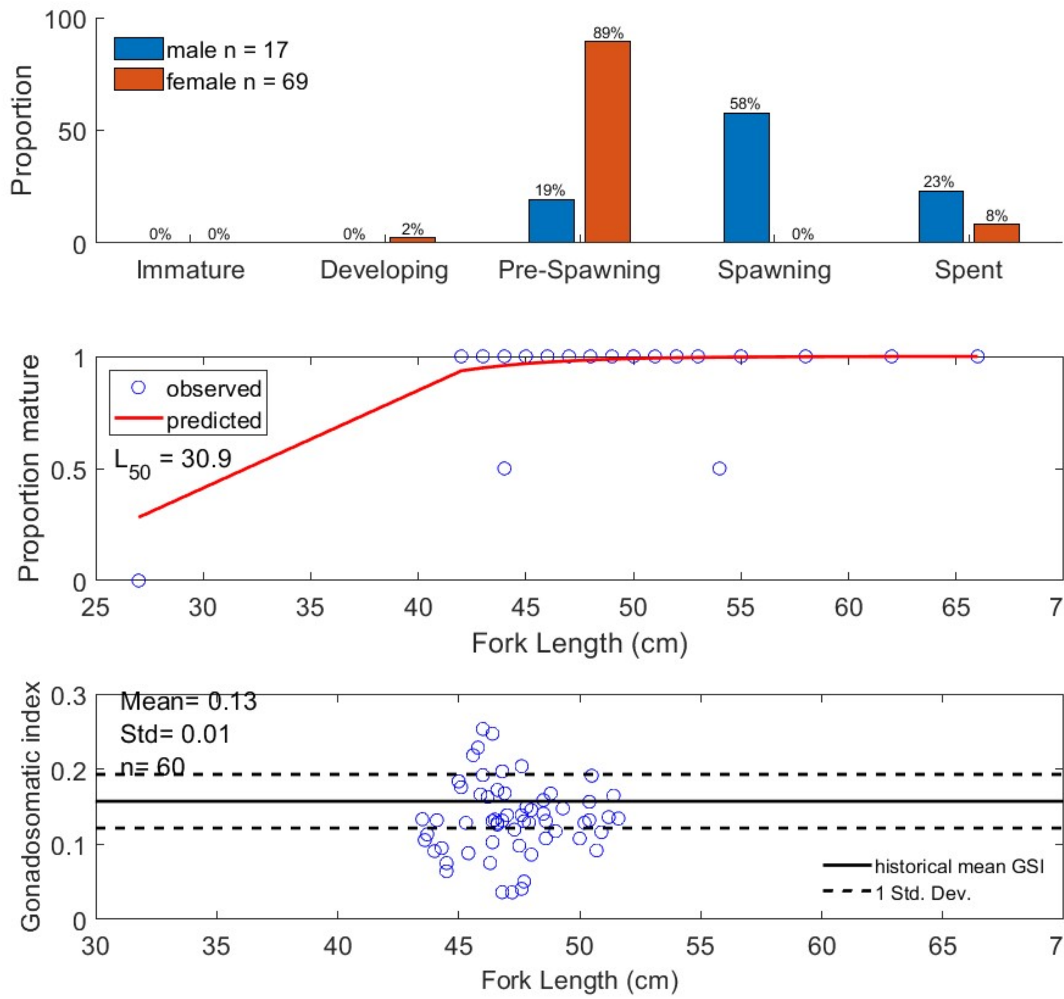


Figure 15. -- During the 2019 acoustic-trawl survey of Chirikof shelf break, maturity composition for male and female walleye pollock greater than 40 cm FL within each stage (top panel); proportion mature (i.e., pre-spawning, spawning, or spent) by 1-cm size group for female walleye pollock (middle panel); gonadosomatic index greater than 40 cm FL (with historic survey mean ± 1 std. dev., bottom panel). All maturity quantities are weighted by local pollock abundance.

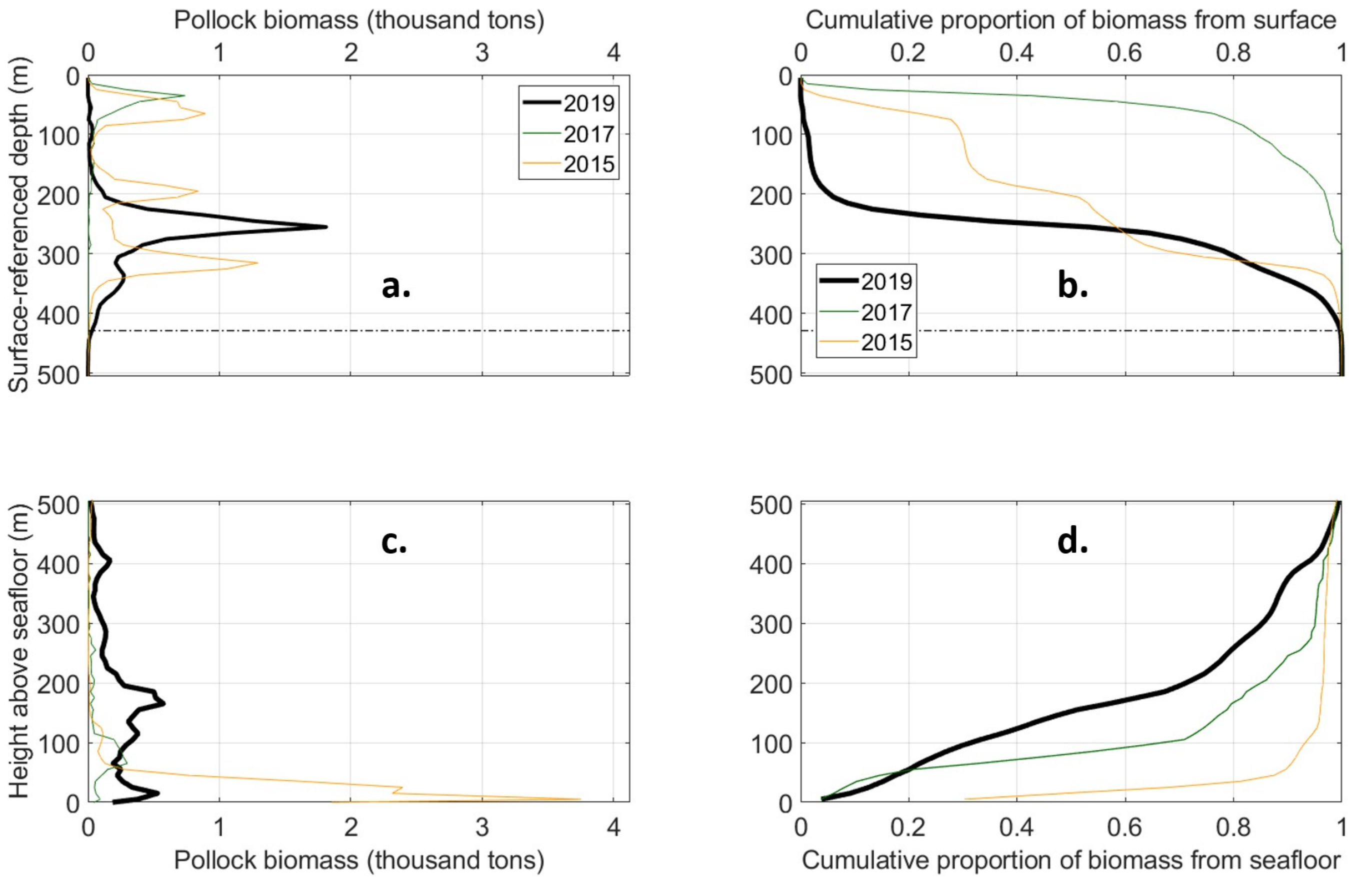


Figure 16. -- Estimated biomass distributions of pollock depth (a.) and height (c.) above the seafloor in Chirikof shelf break during the winter 2019 acoustic-trawl survey. Cumulative percentage of pollock referenced to the surface (b.) and to the seafloor (d.) are also shown. Results for the winter 2015 and 2017 acoustic-trawl surveys are included. Depth is referenced to the surface and height is referenced to the bottom. Data were averaged in 10 m depth bins. Mean bottom depth for 2019 is shown in a. and b. (dashed line).

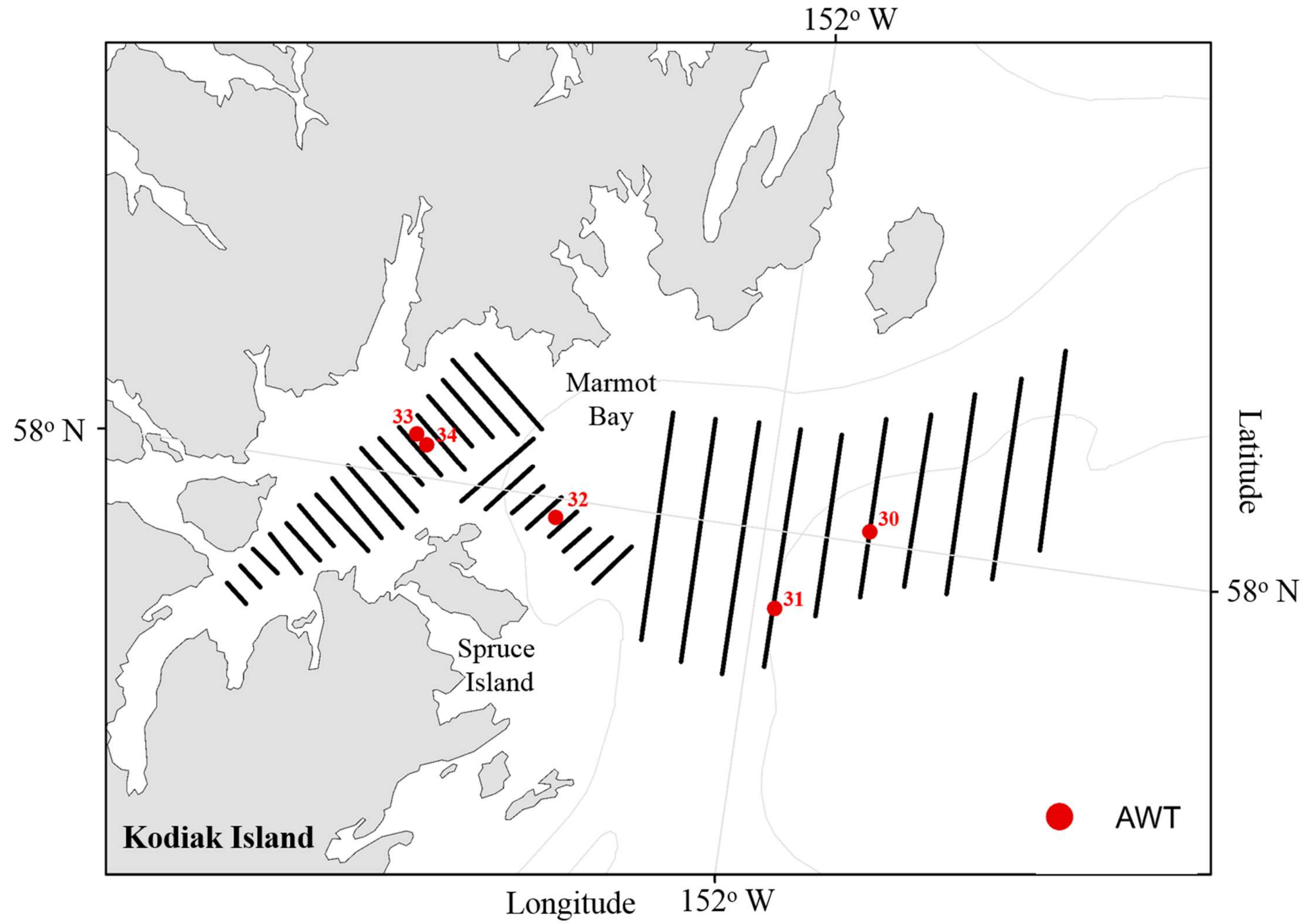


Figure 17. -- Transect lines and locations of five Aleutian-wing trawl (AWT) hauls during the winter 2019 acoustic-trawl survey of walleye pollock in Marmot Bay. Figure represents area enlarged from Figure 1.

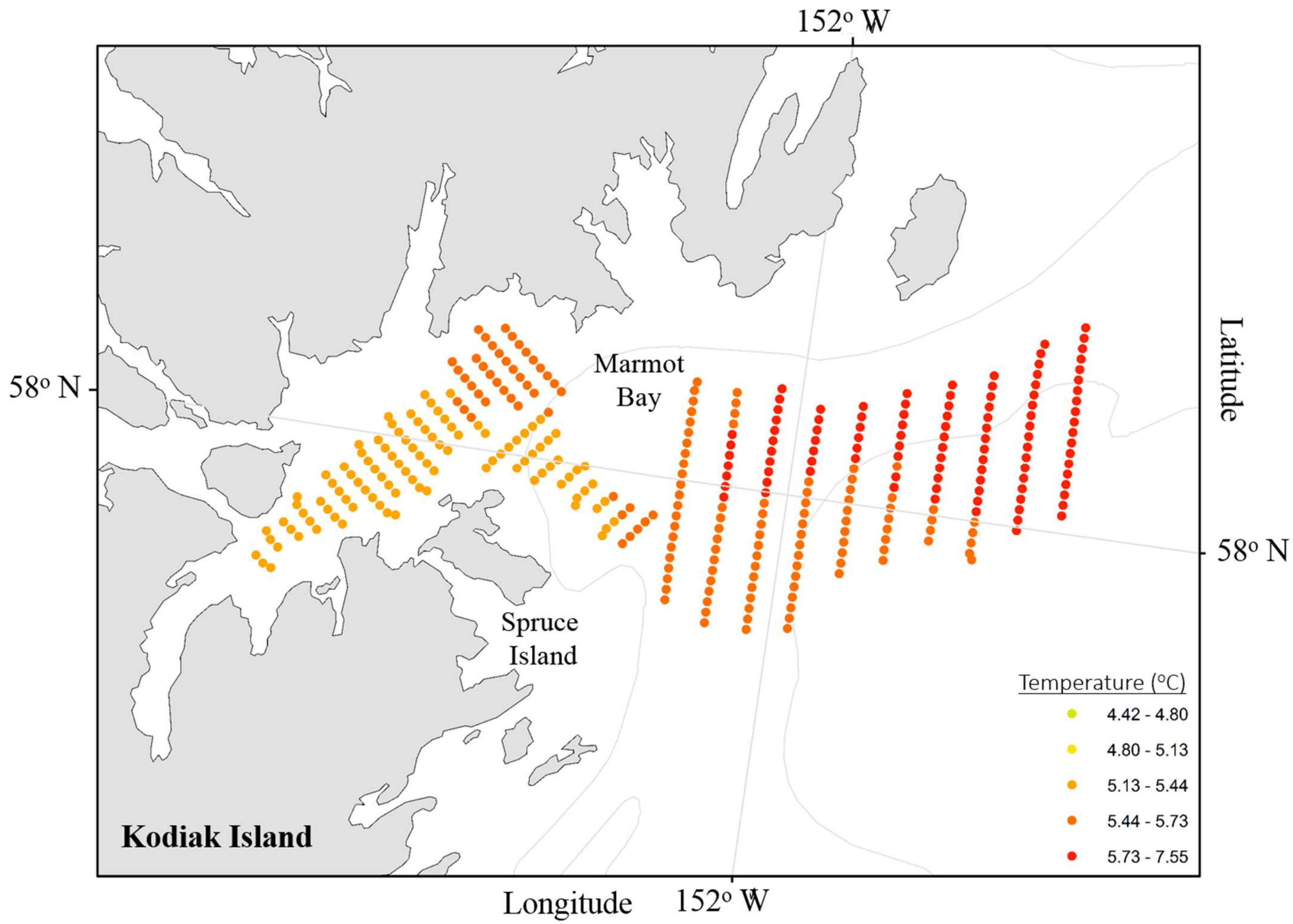


Figure 18. -- Surface water temperatures (°C) recorded at 5-second intervals during the 2019 acoustic-trawl survey of Marmot Bay. Figure represents area enlarged from Figure 2.

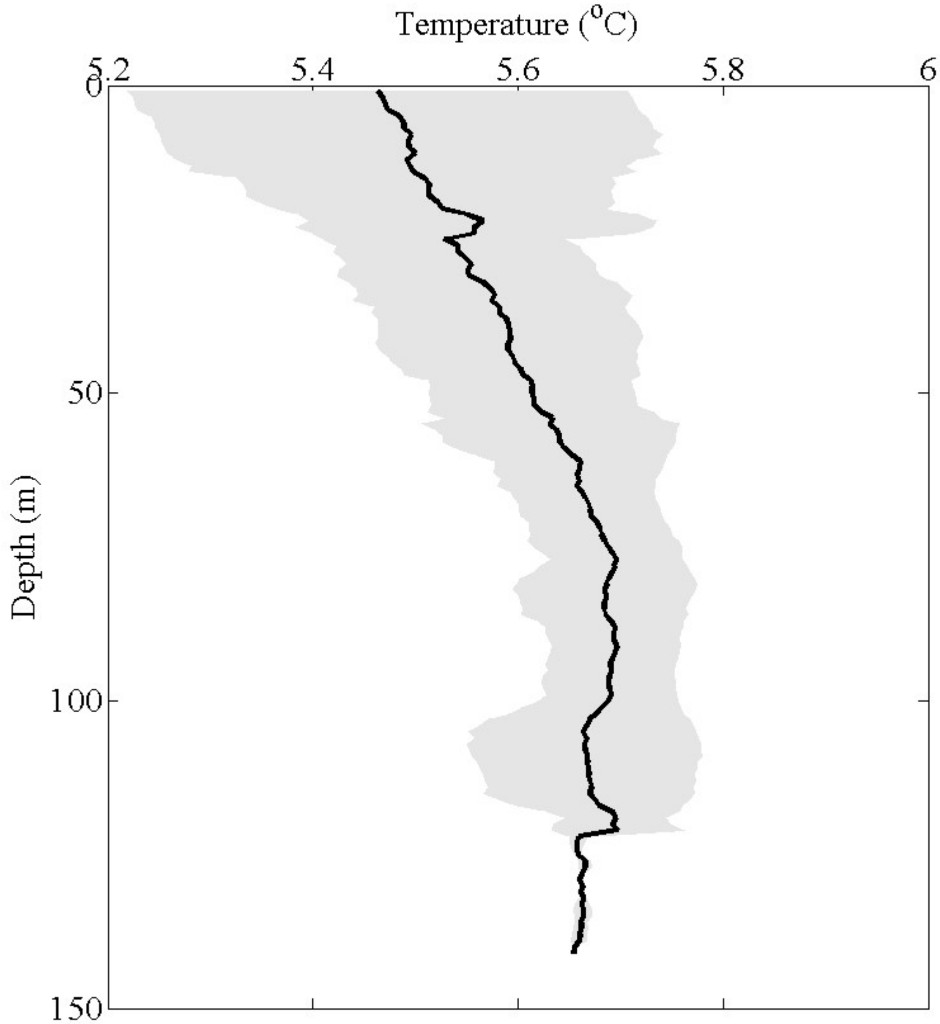


Figure 19. -- Mean water temperature (°C; solid line) by 1-m depth intervals for the five trawl haul locations observed during the winter 2019 acoustic-trawl survey of walleye pollock in Marmot Bay. Shaded area represents one standard deviation.

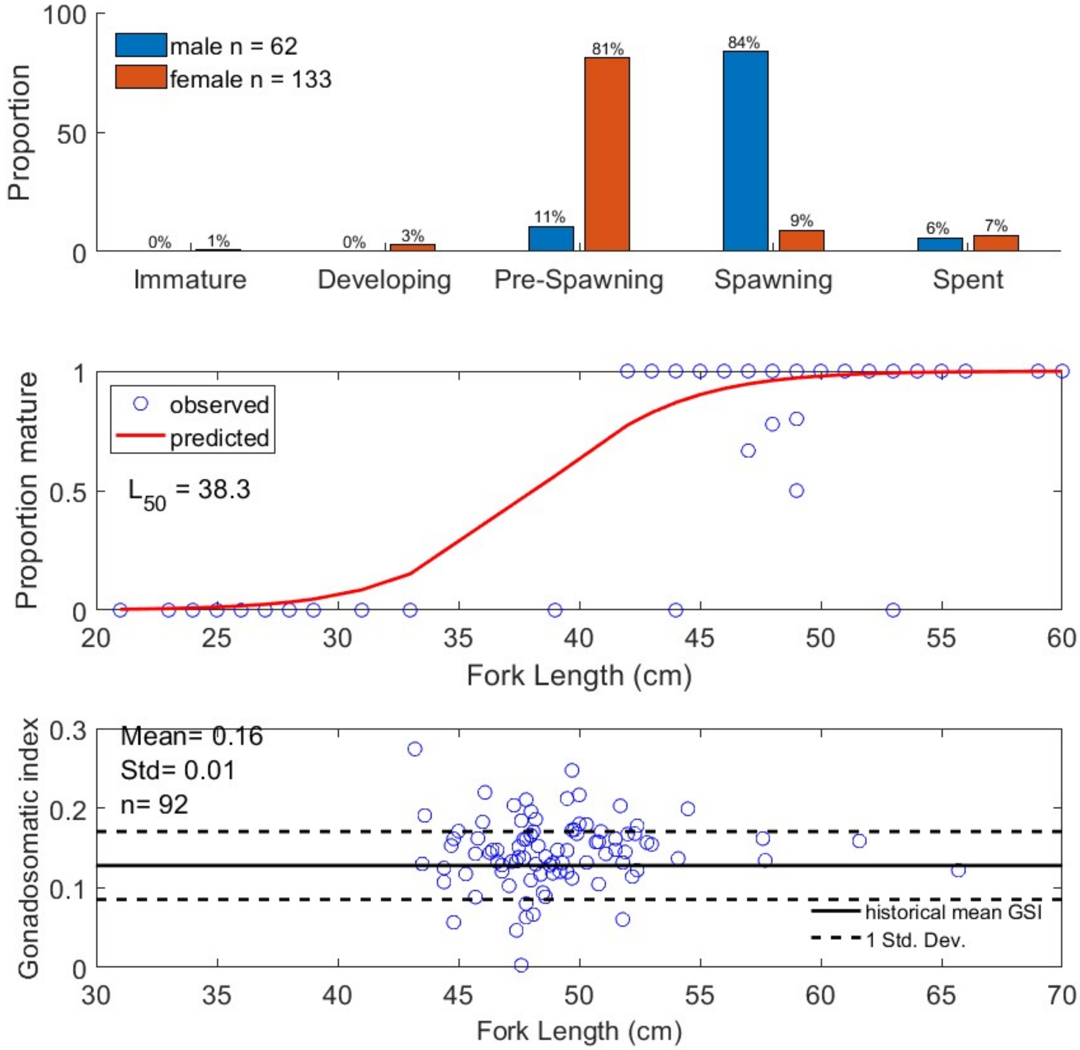


Figure 20. -- During the 2019 acoustic-trawl survey of Marmot Bay, maturity composition for male and female walleye pollock greater than 40 cm FL within each stage (top panel); proportion mature (i.e. pre-spawning, spawning, or spent) by 1-cm size group for female walleye pollock (middle panel); gonadosomatic index greater than 40 cm FL (with historic survey mean ± 1 std. dev., bottom panel). All maturity quantities are weighted by local pollock abundance.

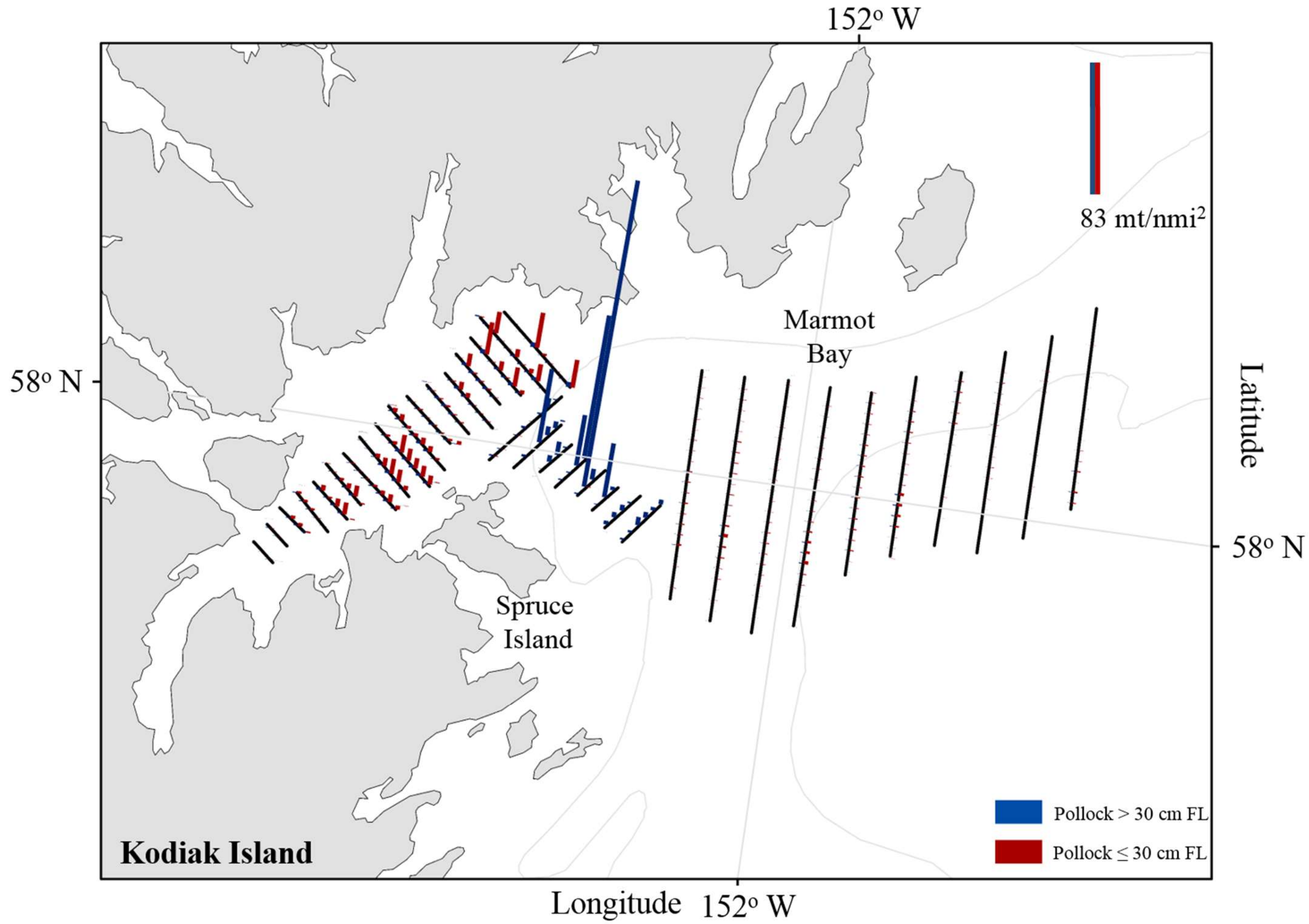


Figure 21. -- Biomass (t/nmi^2) attributed to walleye pollock (vertical lines) along track lines surveyed during the winter 2019 acoustic-trawl survey of Marmot Bay.

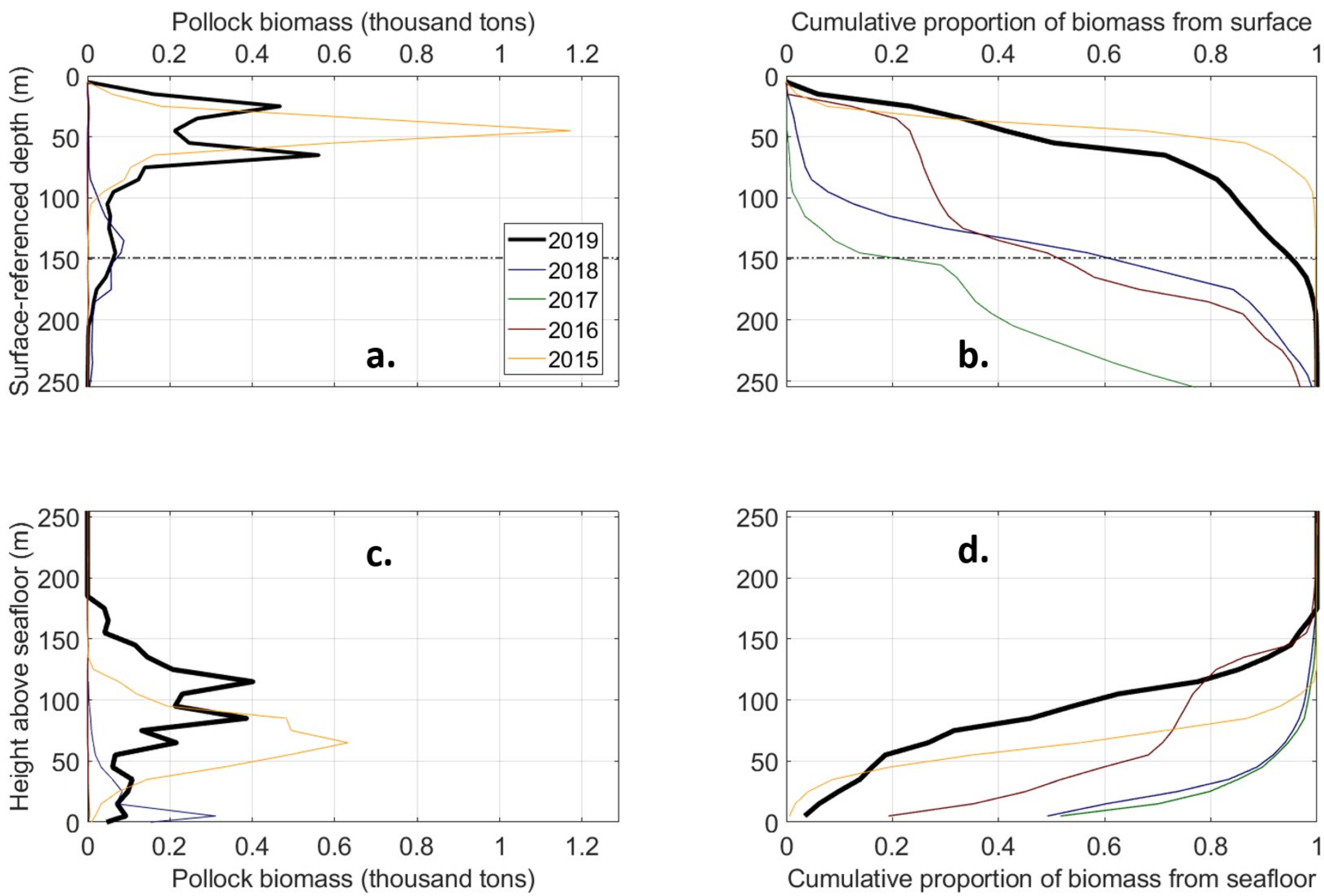


Figure 22. -- Estimated biomass distributions of juvenile pollock (< 30 cm FL) depth (a.) and height (c.) above the seafloor in Marmot Bay during the winter 2019 acoustic-trawl survey. Cumulative percentage of pollock referenced to the surface (b.) and to the seafloor (d.) are also shown. Results for the winter 2015-2018 acoustic-trawl surveys are included. Depth is referenced to the surface and height is referenced to the bottom. Data were averaged in 10 m depth bins. Mean bottom depth for 2019 is shown in a. and b. (dashed line).

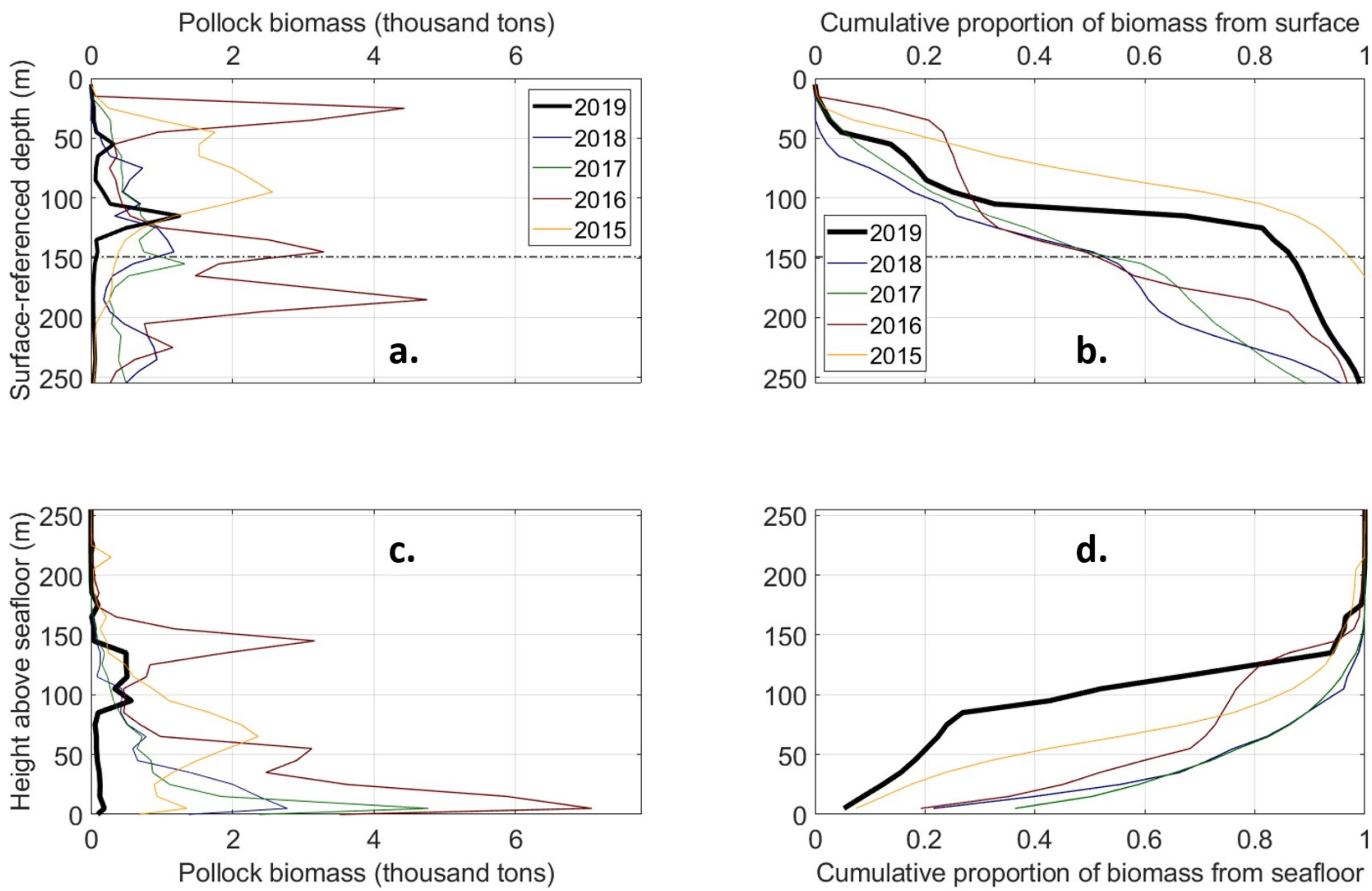


Figure 23. -- Estimated biomass distributions of adult pollock (≥ 28 cm FL) depth (a.) and height (c.) above the seafloor in Marmot Bay during the winter 2019 acoustic-trawl survey. Cumulative percentage of pollock referenced to the surface (b.) and to the seafloor (d.) are also shown. Results for the winter 2015-2018 acoustic-trawl surveys are included. Depth is referenced to the surface and height is referenced to the bottom. Data were averaged in 10 m depth bins. Mean bottom depth for 2019 is shown in a. and b. (dashed line).

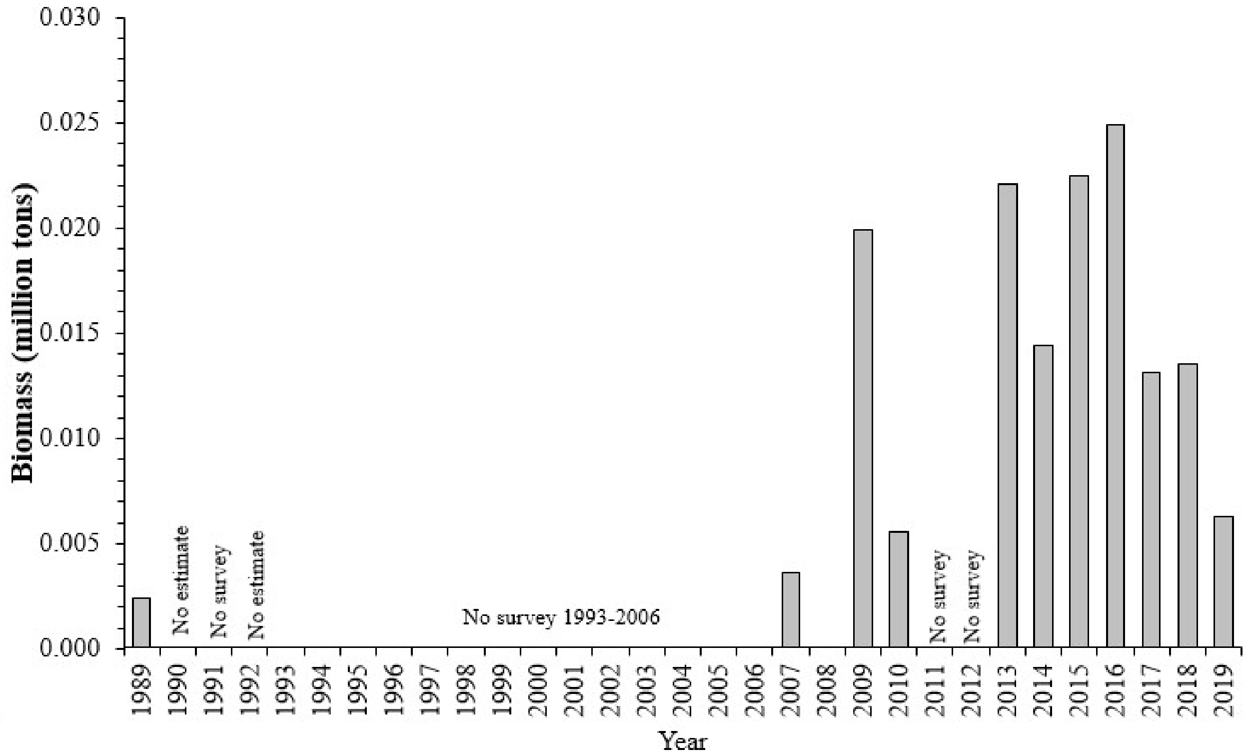


Figure 24. -- Summary of walleye pollock biomass estimates (million metric tons) based on acoustic-trawl surveys of the Marmot Bay area. Selectivity corrections for escapement of juveniles are reflected in estimates from 2008 to 2019.

APPENDIX I. ITINERARY

SH2019-04

Shelikof Strait\Chirikof\Marmot Bay

6 Mar.	Depart Kodiak, AK.
7 Mar.	Acoustic sphere calibration in Kalsin Bay, AK.
7-16 Mar.	Acoustic-trawl survey of Shelikof Strait.
16-18 Mar.	Acoustic-trawl survey of Chirikof shelf break.
19-20 Mar.	Acoustic-trawl survey of Marmot Bay.
20-21 Mar.	Acoustic sphere calibration in Kalsin Bay, AK.
21 Mar.	Arrive Kodiak, AK. End cruise.

APPENDIX II. SCIENTIFIC PERSONNEL

SH2019-04

Shelikof Strait\Chirikof\Marmot Bay

Name	Position	Organization
Darin Jones	Chief Scientist	AFSC-RACE
Nathan Lauffenburger	Fishery Biologist	AFSC-RACE
Scott Furnish	IT Spec.	AFSC-RACE
Matthew Phillips	Fishery Biologist	AIS
Mike Levine	Fishery Biologist	AFSC-RACE
Kresimir Williams	Fishery Biologist	AFSC-RACE
Sarah Stienessen	Fishery Biologist	AFSC-RACE
Kevin McCarty	Fishery Biologist	AFSC-RACE
Heather Kenney	Fishery Biologist	AFSC-RACE

AFSC- Alaska Fisheries Science Center, National Marine Fisheries Service, Seattle, WA

RACE- Resource Assessment and Conservation Engineering Division

AIS- AIS Scientific and Environmental Services, Inc.

APPENDIX III. ABUNDANCE CALCULATIONS

The abundance of target species was calculated by combining the echosounder measurements with size and species distributions from trawl catches and target strength (TS) to length relationships from the literature (see De Robertis et al. 2017 for details). The echosounder measures volume backscattering strength, which is integrated vertically to produce the nautical area scattering coefficient, s_A (units of m^2 nmi^{-2}; MacLennan et al. 2002). The backscatter from an individual fish of species *s* and at length *l* is referred to as its backscattering cross-section, $\sigma_{bs,s.l}$ (m^2), or in logarithmic terms as its target strength, $TS_{s,l}$ (dB re 1 m^2), where,

$$TS_{s,l} = 10 \log_{10} \sigma_{bs,s,l}. \qquad \text{Eqn (i)}$$

The numbers of individuals of species *s* and at length *l* ($N_{s,l}$) captured in each haul *h* were used to compute the proportion of acoustic backscatter associated with each species and length. First, the number of individuals in the catch were converted to a proportion ($P_{s.l,h}$)

$$P_{s,l,h} = \frac{N_{s.l,h}}{\sum_{s,l} N_{s.l,h}} \text{, where } \sum_{s,l} P_{s,l,h} = 1. \qquad \text{Eqn (ii)}$$

In analyses where trawl selectivity was considered, the selectivity-corrected numbers $N_{s\_corr,l,h}$ were used in place of $N_{s,l,h}$ in Eqn ii . This corrects the catch for trawl escapement. The corrected catch is that expected for an unselective sampling device. Refer to the main text for a description of the selectivity corrections applied.

The mean backscattering cross section (an areal measure of acoustic scattering in m^2 – MacLennan et al. 2002) of species *s* of length class *l* is

$$\sigma_{bs_{s,l}} = 10^{(0.1 \cdot TS_{s,l})} , \qquad \text{Eqn (iii)}$$

where TS is the target strength (dB re m^2) of species *s* at size *l*.

The proportion of backscatter from species s of length class l in haul h ($PB_{s,l,h}$) is computed from the proportion of individuals of species s and length class l estimated from haul h ($P_{s,l,h}$) and their backscattering cross section,

$$PB_{s,l,h} = \frac{P_{s,l,h} \cdot \sigma_{bs_{s,l}}}{\sum_{s,l}(P_{s,l,h} \cdot \sigma_{bs_{s,l}})}. \qquad \text{Eqn (iv)}$$

The measured nautical area backscattering coefficient (s_A) at interval i was allocated to species and length as follows:

$$s_{A_{s,l,i}} = s_{A_i} \cdot PB_{s,l,h}, \qquad \text{Eqn (v)}$$

where haul h is the nearest haul within a stratum assigned to represent the species composition in a given 0.5 nmi along-track interval i . The nearest geographic haul was determined by using great-circle distance to find the nearest trawl location (defined as the location where the net is at depth and begins to catch fish) out of the pool of hauls assigned to the same stratum (see above for details) closest to the start of interval i.

The abundance of species of length l in interval i was estimated from the area represented by that interval (A_i, nmi^2), the mean areal backscatter attributed to species s in given length/size class l ($s_{A_{s,l,i}}$, m^2 nmi^{-2}), and mean backscattering cross-section of species s at that size ($\sigma_{bs_{s,l}}$ m^2).

$$\text{Numbers at length } l\text{: } N_{s,l} = \sum_i \left(\frac{s_{A,s,l,i}}{4\pi\sigma_{bs_{s,l,i}}} \cdot A_i \right) \qquad \text{Eqn (vi)}$$

$$\text{Biomass at length } l\text{: } B_{s,l} = \Sigma_i \left(W_{s,l} \times N_{s,l,i} \right), \qquad \text{Eqn (vii)}$$

where $W_{s,l}$ is the mean weight-at-length in for species s in each 1 cm length l. In the case of pollock, when five or more individuals were measured within a length interval, the mean weight at length was used. Otherwise (i.e. for length classes of pollock with <5 weight measurements, or other species), weight-at-length was estimated using a linear regression of the natural log-transformed length-weight data (De Robertis and Williams 2008).

APPENDIX IV. SELECTIVITY CORRECTION

Previous research has found that juvenile pollock (fork length < 20 cm) are less likely to be retained by the survey trawl than adults (Williams et al. 2011). To account for this bias, the pollock length composition was adjusted to that which would be expected from an unselective sampler. Trawl selectivity S_l for each cm pollock length class (l) was estimated by analyzing the catch of the codend and that of eight small recapture nets permanently mounted on the outside of the AWT trawl during the current survey using methods similar to those presented in Williams et al. 2011. A generalized linear mixed effects model was fitted with a logistic link function and binomial error where variation between tows (26 trawls, Appendix Fig. 1) in selectivity was modeled with random effects. S_l was then computed as

$$S_l = \left(1 + e^{2\log 3(LR_{50}-l)/SR}\right)^{-1} , \qquad \text{Eqn. (viii)}$$

where LR_{50} is the length at which 50% of individuals we be retained and SR = selection range (i.e., range in length between 25% and 75% retention values).

These trawl selectivity estimates were then applied to the pollock codend catch composition to correct the sample for trawl escapement from the trawl as

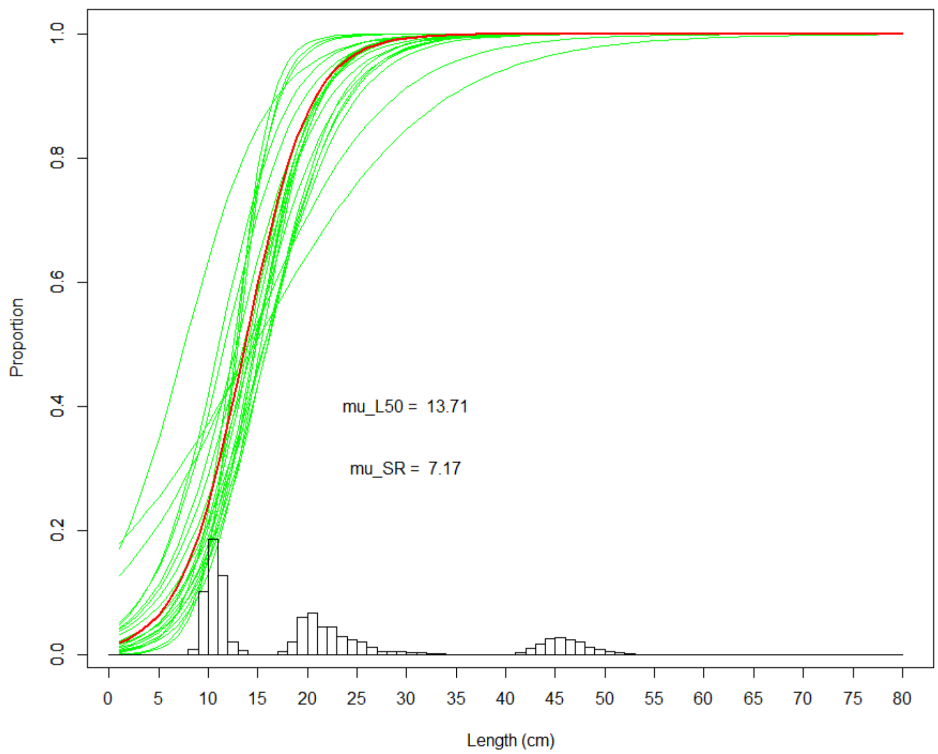
$$N_{pk\_corr,l} = \frac{N_{pk,l}}{S_l} , \qquad \text{Eqn. (ix)}$$

where $N_{pk\_corr,l}$ is the number of pollock that would be captured in an unselective sampler in the sampled population and $N_{pk,l}$ is the number of pollock in the 1 cm length class l in the trawl catch. In analyses with a selectivity correction applied, $N_{pk\_corr,l}$ was used in place of $N_{pk,l}$ in the abundance calculations (see Eqn. ii).

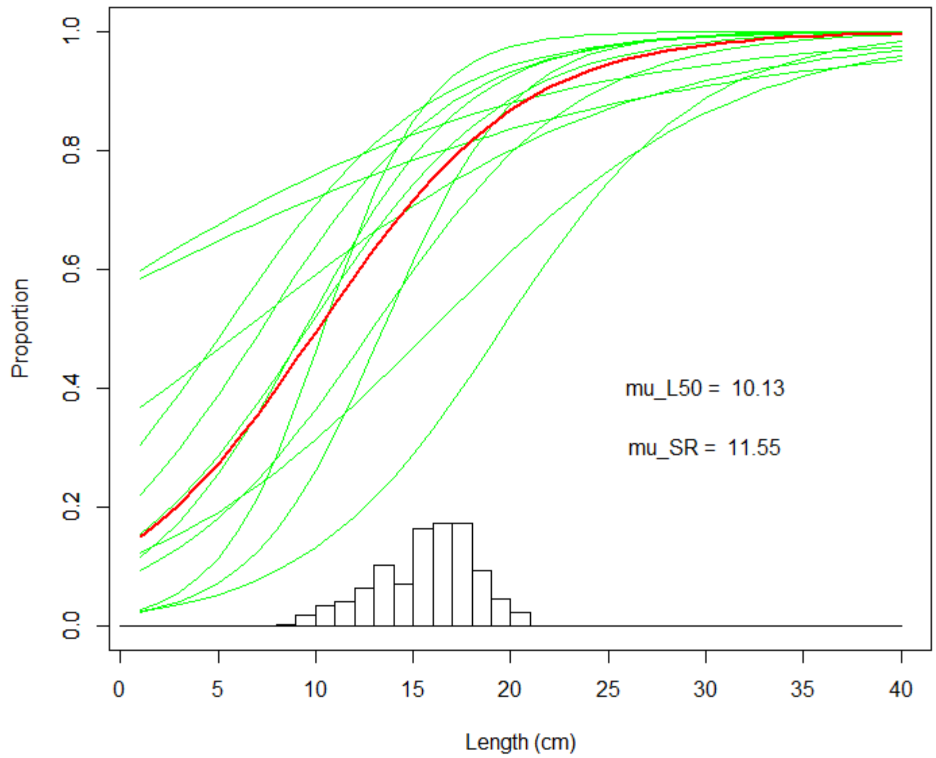
The selectivity model was fitted to data from 27 AWT hauls conducted during SH2019-04, which contained juvenile pollock in the resample nets and in the codend. Analysis of these AWT hauls resulted in estimates of LR_{50} of 13.71 cm and SR of 7.17. The LR_{50} value increased by

2.19 cm from that used in 2018, most likely due to increased numbers of age-2 (15-25 cm), which provided a greater range of lengths for the model to fit.

Additionally, trawl selectivity was estimated for eulachon (*Thaleichthys pacificus)* using the same methods, since it was predominant in many of the catches. Eulachon catch data were fitted to the selectivity curve model from the 12 AWT hauls containing eulachon in both the resample nets and in the codend (Appendix Fig. 2). Analysis of these hauls resulted in estimates of LR_{50} of 10.13 cm and SR of 11.55 for eulachon. The selection estimates were applied to the eulachon codend catch composition in an equivalent manner to the method used for pollock. This was the first year eulachon selectivity corrections have been applied in the analysis. No selectivity correction was applied for any other species (i.e., S_l was assumed to be 1).



Appendix Figure 1. -- Selectivity curves as proportion retained versus length for walleye pollock in all areas computed from codend and recapture net catch lengths during winter 2019 AWT hauls (solid green lines), including the fitted mean curve used for correction (solid red line). Length-frequency histogram of all sizes for the model fit including all codend and recapture nets catch data are shown as bars.



Appendix Figure 2. -- Selectivity curves as proportion retained versus length for eulachon in all areas computed from codend and recapture net catch lengths during winter 2019 AWT hauls (solid green lines), including the fitted mean curve used for correction (solid red line). Length-frequency histogram of all sizes for the model fit including all codend and recapture nets catch data are shown as bars.

U.S. Secretary of Commerce
Wilbur L. Ross, Jr.

Acting Under Secretary of Commerce
for Oceans and Atmosphere
Dr. Neil Jacobs

Assistant Administrator for Fisheries
Chris Oliver

December 2019

www.fisheries.noaa.gov

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