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Results of the Acoustic-Trawl Survey of Walleye Pollock (*Gadus chalcogrammus*) in Shelikof Strait and Marmot Bay, March 2021 (DY2021-02)

by

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ABSTRACT

Scientists from the Alaska Fisheries Science Center conducted an acoustic-trawl survey in the Gulf of Alaska during March 2021 to estimate the distribution and abundance of walleye pollock (*Gadus chalcogrammus*) in two of their main spawning grounds. This pre-spawning pollock survey covered the Shelikof Strait and Marmot Bay regions (2021-02; 2 to 15 March). The Shelikof Strait area has been surveyed annually in winter since 1981 (except in 1982, 1999, and 2011). Marmot Bay has been surveyed periodically since 1989 and was last surveyed in 2019.

The amount of walleye pollock for the winter 2021 Shelikof Strait survey was 8,365 million fish weighing 526,974 metric tons (t). This was 14.7% higher than the total biomass observed in 2020 (459,399 t). Walleye pollock between 44 and 65 cm fork length (FL), were primarily composed of the 9-year-old 2012 year class (27% of the biomass) with additional biomass contributed by the surrounding year classes. Pollock between 24 and 43 cm FL consisted primarily of the 4-year-old 2017 year class (14% of the biomass) and to a lesser extent, the 2016 and 2018 year classes (7% and 6% of the biomass, respectively). The 8 to 16 cm FL age-1 fish dominated the population numerically (92%) and contributed 13% of the biomass.

A total of 180 million pollock weighing 7,401 t were estimated to be in Marmot Bay at the time of the survey. The 2021 biomass increased 17.9% over that observed in 2019 (6,275 t) the last time Marmot Bay was surveyed.

These estimates were based on an analysis where length-frequency distributions of all species were assigned to observed backscatter using biological data and species compositions of the hauls nearest that backscatter. It also included a correction for escapement of fishes and other catch from the survey trawl (i.e., net selectivity). These results were compared with an analysis not incorporating net selectivity (‘no-selectivity analysis’). The no-selectivity analysis estimated slightly more biomass (14.2% higher in Shelikof) compared to the primary analysis.

CONTENTS

INTRODUCTION

The Midwater Assessment and Conservation Engineering (MACE) Program of the Alaska Fisheries Science Center (AFSC) 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 their main spawning grounds (i.e., pre-spawning surveys). Shelikof Strait has been surveyed annually since 1981 except in 1982, 1999, and 2011. Historical surveys have also frequently included the Shumagin Islands, Sanak Trough, Morzhovoi Bay, and Pavlof Bay since 2002 as part of the Shumagins survey, and the continental shelf break near Chirikof Island, and Marmot Bay as part of the Shelikof survey. Due to the continuation of the global COVID-19 pandemic in 2021, general lack of a vaccine and concomitant long time periods required for science and ship staff to isolate before joining the survey, the prior plans to survey the Shumagins, the Chirikof shelf break, and Kenai/Prince William Sound were abandoned. This report presents the results of the AT survey of Shelikof Strait and Marmot Bay conducted from 2 to 15 March.

METHODS

The survey was conducted aboard the NOAA ship *Oscar Dyson*, a 64-m stern trawler equipped for fisheries and oceanographic research. It followed established AT survey 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.

Shelikof Strait was surveyed a few days earlier in 2021 than in most other years (as in 2020) because of the relatively high percentages of spawning and spent female pollock observed in the 2017, 2018, and 2019 Shelikof Strait surveys. An earlier start date was intended to increase the chances of surveying when more pollock were in the mature (or pre-spawning) stage, a timing consistent with most prior surveys.

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[1] National Marine Fisheries Service (NMFS) 2014. NOAA protocols for fisheries acoustics surveys and related sampling (Alaska Fisheries Science Center), 26 p. Prepared by Midwater Assessment and Conservation Engineering Program, Alaska Fish. Sci. Center, Natl. Mar. Fish. Serv., NOAA 7600 Sand Point Way NE Seattle WA 98115.

Acoustic Equipment, Calibration, and Data Collection

Acoustic measurements were collected with a Simrad EK80 scientific echosounder (Simrad 2018, Bodholt and Solli 1992). Data were collected with five split-beam transducers (18, 38, 70, 120, and 200 kHz) mounted on the bottom of the vessel's retractable centerboard, which extended 9.15 m below the water surface.

Two standard sphere acoustic system calibrations were conducted to measure acoustic system performance during the cruise (Table 1). The vessel’s dynamic positioning system was used to maintain the vessel location during calibrations. Local water temperature and salinity were measured and used to estimate absorption and sound speed. 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 using the EK80’s calibration utility (Jech et al. 2005, Simrad 2018). The equivalent beam angle (for characterizing the volume sampled by the beam) and angle sensitivities (for conversion of electrical to mechanical angles) cannot be estimated from the calibration approach used because that requires knowledge of the absolute position of the sphere (see Demer et al. 2015). Therefore, the factory default values for equivalent beam angle and angle sensitivities for each transducer were used during calibration.

Raw acoustic data were recorded using EK80 software (version 2.0.0) at a nominal ping interval of 1.2 seconds, and analyzed from 16 m below the sea surface to within 0.5 m of the sounder-detected bottom to a maximum depth of 500 m. Data shallower than 16 m were excluded to account for the acoustic near-field range of all transducers (Simmonds and MacLennan 2005). Data within 0.5 m of the seafloor were also excluded to account for the bottom-associated acoustic dead zone (Ona and Mitson 1996). The raw acoustic data were analyzed using Echoview post-processing software (v. 11.1.49).

Trawl Gear and Oceanographic Equipment

Midwater and near-bottom acoustic backscatter was sampled using an LFS1421 trawl[2]. The headrope and footrope of the LFS1421 each measure 76.8 m (252 ft), with meshes tapering from 650 cm (256 in.) in the forward sections to 3.8 cm (1.5 in.) in the section immediately preceding the codend (mesh sizes are stretched measurements unless otherwise noted). To increase retention of small organisms, the LFS1421 codend is fitted with a knotless nylon 7.9 mm (5/16 in) mesh, 3.2 mm (1/8 in) square opening codend liner. The LFS1421 trawl was fished with four 45.7 m (150 ft) bridles (1.9 cm (0.75 in) dia.) and 5 m^2 Fishbuster trawl doors (1,247 kg (2,750 lb) each), with 227 kg (500 lb) tom weights attached to each wingtip. Average trawling speed was approximately 1.8 m/sec (3.5 knots). Vertical net openings and headrope depths were monitored with a Simrad FS70, third-wire netsonde attached to the headrope. The vertical net opening of the LFS1421 ranged from 13.3 to 23.0 m (43.7 to 75.5 ft) and averaged 16.7 m (54.8 ft) while fishing.

To gauge escapement of smaller fishes from the net, recapture (or pocket) nets were placed at several locations along the LFS1421 net (Williams et al. 2011). The LFS1421 trawl was fitted with a total of nine recapture nets placed on forward (813 mm stretch mesh), mid (102 mm stretch mesh), and aft (102 mm stretch mesh) sections of the trawl, one recapture net on the top, bottom, and port panel of each section. The recapture nets were constructed from knotless nylon 7.9 mm (5/16 in) stretched mesh, 3.2 mm (1/8 in) square opening mesh material (matching the codend liner). These data are being used in ongoing work to estimate the trawl selectivity of the nets and to gauge escapement of juvenile pollock and other small fishes (see Appendix IV).

A stereo camera system (Camtrawl; Williams et al. 2010) was attached to the starboard panel forward of the codend on the LFS1421. The Camtrawl is used to capture stereo images for species identification and length measurement of individual fish and other taxa as they pass through the net toward the codend. The Camtrawl data are useful for determining the depth and size distribution of fish and other taxa when distinct and separate backscatter layers are sampled by a trawl haul but cannot be differentiated in the codend catch. Images are viewed and annotated using procedures described in Williams et al. (2010).

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[2] LFS1421 trawl (LFS Marine, NOAA, 1421 Research Trawl, designed and built in 2018/2019 to MACE specifications; hereafter LFS1421).

Physical oceanographic data were collected during the cruise at trawl locations, calibration sites, and continuously along transects. Water temperature profiles were obtained at trawl locations with a temperature-depth probe (Sea-Bird Electronics SBE 39) attached to the LFS1421 headrope. Additional temperature-depth profile measurements were taken from conductivity-temperature-depth (CTD) casts collected with a Sea-Bird (SBE 911plus) system at calibration sites. Sea surface temperature data were measured along transects using the ship's sea surface temperature flow through system (Sea-Bird Electronics SBE 38, accuracy ± 0.002°C) located near the ship's bow, approximately 1.4 m below the surface. At times when the SBE 38 was not operating, sea surface temperatures were taken from the Furuno T-2000 temperature probe (accuracy ± 0.2°C) located amidships 1.4 m below the surface. The SBE 38 was used 98% of the time. Sea surface temperature and other environmental data were recorded using the ship's Scientific Computing Systems (SCS).

Survey Design

The survey consisted of a series of parallel transects 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 predetermined transect location and spacing were chosen to be consistent with previous surveys. Transect start and end locations matched those from 2020 in Shelikof Strait and 2019 in Marmot Bay. The survey was 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 (for fork length (FL) > 20 cm), length, body weight, maturity, age (otoliths) and gonad measurements were collected for a random subset of pollock within each size group. Pollock and other fishes were measured to the nearest 1 mm FL, or standard length (SL) for small specimens, with an electronic measuring board (Towler and Williams 2010). All lengths measured as SL were converted to FL using an SL to FL regression obtained from historic survey data when necessary. Other invertebrate organisms (e.g., jellyfish, squid) were measured to the nearest 1 mm length using accepted measurements for their class (e.g., jellyfish bell diameter, squid mantle length). Gonad maturity was determined by visual inspection and categorized as immature, developing, mature (hereafter, "pre-spawning"), spawning, or spent[3]. The ovary weight was determined for pre-spawning females. An electronic motion-compensating scale (Marel M60) was used to weigh individual pollock and selected ovaries to the nearest 2 g. Otoliths that were collected were stored in 50% glycerin/thymol/water solution and interpreted by AFSC Age and Growth Program researchers to determine fish 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

Pollock abundance was estimated by combining acoustic and trawl catch information. The analysis method employed here had three principal steps. First, backscatter was attributed with the trawl catches from the nearest geographic haul locations within a stratum. Second, a correction was made for net selectivity (escapement from the midwater net, based on relationships derived from the recapture nets; Williams et al. 2011). Third, backscatter was converted to estimates of abundance using the nearest-haul catch association (step 1) and sample corrections (step 2) and the expected backscatter from each organism given species and size. Biomass was computed from abundance using the mean weight-at-length from all pollock specimens measured in the survey.

Processing of Acoustic Data

Although acoustic data were recorded at multiple 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 the five frequencies from 18 kHz-200 kHz (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.

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[3] 2023 Groundfish Survey Data Codes and Forms, Alaska Fisheries Science Center (U.S.). Resource Assessment and Conservation Engineering Division, https://doi.org/10.25923/58c2-w627

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Associating Size and Species Composition with Acoustic Backscatter

Acoustic backscatter was assigned to strata based on the appearance and vertical distribution of the aggregations in the echogram. Strata containing backscatter not adequately sampled by trawls (e.g. the near-surface mixture of unidentifiable backscatter, backscatter with frequency response indicative of euphausiids or myctophids [De Robertis et al. 2010], or near-bottom backscatter "haystack" morphology indicative of some rockfishes that could not be sampled) 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. 2017b for details). For example, juvenile pollock can be found in shallow, dense schools with a diffuse layer of adult pollock at deeper depths in that same area. In this case, 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 shallow layer would be assigned to stratum A, and hauls that sampled the deeper layer would be assigned to stratum B. Backscatter was apportioned by species and size within a stratum using the selectivity-corrected catch composition from the geographically nearest trawl in that stratum and converted to abundance.

Selectivity Correction

Previous research has found that smaller fish are less likely to be retained in large midwater trawls than larger fish (Williams et al. 2011). To correct for species- and size-related differences in retention, trawl catch compositions were adjusted to that which would be expected from an unselective net. Trawl selectivity was estimated using correction functions developed from catch data collected by recapture nets mounted on the midwater trawl (Appendix IV). The counts and weights of animals caught in the recapture nets were expanded to provide an estimate of escapement from the entire trawl. The catch of all species was corrected for the estimated probability of escapement by dividing the abundance of a given species and size class by the estimated probability of retention of that species and size class. To generate trawl selectivity correction functions for all organisms in the catch, the species and size selectivity of the survey trawl was accounted for in the acoustic-trawl abundance estimate (e.g., De Robertis et al. 2017a, De Robertis 2021). Species-specific selectivity functions were estimated for the most abundant species. More generic selectivity functions obtained by pooling species were applied to less abundant species (Appendix IV, see also De Robertis et al. 2017b).

In this report, estimates for 2008-2018 surveys reflect selectivity corrections for juvenile pollock escapement (but not for escapement of other species) in all areas. The 2019 estimates reflect corrections for both pollock and eulachon escapement in all areas. The 2020 survey was the first winter survey in which explicit selectivity corrections were applied to all species (including pollock and eulachon) in the analysis. For 2008-2017, selectivity was estimated using recapture net data collected in 2008, 2013, and 2018. In surveys 2018-2019, corrections were applied based on recapture net data from each year's survey only. In 2020, the selectivity curves in Appendix IV of McCarthy et al. (2022) were used. In 2021, a very large juvenile year class was present prompting collection of additional net selectivity data for pollock. Thus in 2021, the same Appendix IV McCarthy et al. 2022 curves were applied to all species groups other than pollock, and a new pollock selectivity curve was estimated and applied based on data from the recapture nets attached to the LFS net in this survey (summarized in Appendix IV, this report).

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. (2017b) and in Appendix III. A series of target strength (TS) to length relationships from the literature (Table 2) 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 species for which the TS relationship was derived using a different length measurement type than the one used for measuring the trawl catch specimens, an appropriate length-length conversion was applied. For abundant species (e.g., contributing > 5% of the numbers or weight of the total catch), 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 and eulachon contributed more than 5% of the catch in 2021 by weight or numbers. Therefore, a more specific TS relationship was used for pollock, and eulachon in the analysis.

Biomass was computed from abundance using the mean weight-at-length from all pollock specimens included in the length-weight key, which in winter is typically all specimens lengthed and weighed in the survey trawl catches (see Appendix III for detailed description of this method). When fewer than 5 pollock occurred per 1-cm length interval, weight at a given length interval was estimated from a linear regression of the natural logs of the length and weight data and corrected for a small bias due to back-transformation (Miller 1984, De Robertis and Williams 2008; this report, Appendix III).

An age-length key, and a subsequent proportion-at-age matrix was applied to the population numbers-at-length and biomass-at-length to estimate numbers and biomass at age (Jones et al. 2019; this report Appendix III). For population estimates at lengths where no otolith specimens were collected, the proportion-at-age was estimated using a Gaussian-model approach based on historical age-at-length data (2000-2014).

Processing of Maturity Data

Maturity data by haul were weighted by the local acoustically-estimated abundance of adult pollock (number of individuals > 30 cm FL). 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

$$\bar{A} = {\sum_h A_h}/{H}, \qquad \text{Eqn. 2}$$

and H is the total number of hauls.

The percent of pollock, $PP_{sex,mat}$ greater than 40 cm FL 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,

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

where $N_{sex,mat,h}$ is the number of pollock greater than 40 cm by sex and maturity for each haul. The > 40 cm cutoff is used for consistency with reporting from past surveys (Wilson 1994).

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 (L_{50m}) 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):

$$Relative\ estimation\ error_{1\text{-}D} = \frac{\sqrt{variance_{sum}}}{biomass_{sum}} . \qquad \text{Eqn. 5}$$

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):

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

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

A ‘non-selectivity corrected’ analysis was conducted to estimate the effect of the selectivity corrections used in the ‘primary analysis’ on the numbers and biomass of pollock and other target species. The non-selectivity corrected analysis was the same as the primary analysis except that it did not include a selectivity correction. The selectivity (S_l) was set to 1 (see Eqn. x, Appendix IV) for all species and size classes.

Pollock vertical distribution patterns were examined using two metrics: 1) mean weighted depth (MWD) of pollock from the surface-referenced primary analysis, and 2) height above bottom (HAB) calculated from a ‘bottom-referenced’ analysis in which pollock vertical position was measured in terms of distance above the seafloor. The MWD in each along-track interval i is computed as:

$$MWD_i = \sum_j \left(\left(\frac{B_{i,j}}{\sum_j B_{i,j}} \right) d_{i,j} \right) \quad , \qquad \text{Eqn. 7}$$

where $B_{i,j}$ is observed biomass in 0.5 nmi along-track interval i and 10 m depth bin j, and d is the depth in meters of bin i from the sea surface. In contrast to the surface-referenced primary analysis, the bottom-referenced analysis data were exported using Echoview in 10 m vertical bins referenced to the scrutinized line 0.5 m above the sounder-detected bottom. The HAB is computed from the bottom-referenced data in a similar fashion:

$$HAB_i = \sum_j \left(\left(\frac{B_{i,j}}{\sum_j B_{i,j}} \right) h_{i,j} \right) \quad , \qquad \text{Eqn. 8}$$

where the terms are as described above and h is the height in meters of bin i above the sounder-detected bottom. MWD and HAB were summarized for a given survey area by first summing biomass over all intervals i in the area and then computing the MWD and HAB using the equations above. The bottom-referenced analysis was generated for previous years (2015-2019) 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 of the 38 kHz echosounder on-axis measurements showed minor differences in gain parameters, and measurements using the EK80 calibration utility showed only minor differences in beam pattern characteristics, confirming that the acoustic system was stable throughout the survey (Table 1). The on-axis integration gain differed by < 0.15 dB across the two measurements. On-axis acoustic system gain and s_A correction values, and EK80 calibration utility 3 dB beamwidths and offset angles measured during the first and second calibrations were averaged (averages calculated in the linear domain for dB quantities). These averaged values were used with nominal sound speed and absorption values appropriate for the survey areas in the final calibration parameter set for survey data analysis. The measured equivalent beam angle recorded on the 38 kHz transducer's specification sheet was adjusted (Bodholt 2002) using the sound speed assumed during survey conditions for data analysis (Table 1).

Shelikof Strait

Acoustic backscatter was measured along 1735.2 km (937 nmi) of transects spaced mainly 13.9 km (7.5 nmi) apart with spacing varying from 11.3 km to 15.6 km (6.1 to 8.4 nmi) in the survey area (Fig. 1). Bottom depths in the survey area ranged from 44 m to 326 m.

Surface water temperatures in Shelikof Strait averaged 4.1 °C overall (Fig. 2), and ranged from 1.3 °C to 4.9 °C as measured by the ship's flow-through instrumentation. Surface water temperatures at haul locations averaged 3.5 °C (Table 3). This was 0.7 °C warmer than the average of 2.8 °C observed during 2020 and 0.2 °C cooler than the historic mean of the prior 37 surveys conducted in this area since 1981 (3.7 °C). Mean temperature between the surface and deepest trawl depth at haul locations varied by around 2.2 °C (Fig. 3). The mean water temperature at fishing depths was 5.7°C (Table 3).

<u>Trawl Samples</u>

Biological data and specimens were collected in Shelikof Strait from 24 LFS1421 hauls (Tables 3, 4a, 5; Fig. 1) targeted on backscatter attributed to pollock. The lengths of an average of 367 randomly selected walleye pollock were measured from each haul, with an average of 40 individuals more extensively sampled for at least one of the following: body weight, maturity, and age (Table 5). A total of 603 otoliths used to estimate walleye pollock ages were collected in the Shelikof Strait region.

Pollock and eulachon were the most abundant species by weight in the hauls, contributing 68.3% and 24.7% of the catch by weight, respectively (Table 4a). Pollock and eulachon were the most abundant species by numbers with 52.1% and 40.9% of total catch numbers, respectively.

Pollock observed in the Shelikof Strait were generally in pre-spawning (females) or spawning (males) maturity stages (Fig. 4). The maturity composition in the Shelikof Strait of males > 40 cm FL (n = 189) was 7% immature, 2% developing, 21% pre-spawning, 70% spawning, and 1% spent (Fig. 4a). The maturity composition of females > 40 cm FL (n = 219) was 1% immature, 8% developing, 88% pre-spawning, 2% spawning, and 0% spent. The L_{50m} of female pollock > 22 cm FL is 41.4 cm FL (Fig. 4b). The average GSI from 181 pre-spawning females was 0.14 ± 0.02 (Fig. 4c, mean ± standard deviation), which was virtually identical to the 2020 estimate and the historical mean (0.13 ± 0.03). Most females were in the pre-spawning stage of maturity, substantially fewer were spawning and none was spent, which suggests that the timing of the 2021 Shelikof Strait survey relative to the spawning period was appropriate.

Distribution and Abundance

Pollock were detected throughout the main body of Shelikof Strait from roughly the Semidi Islands to north of Cape Nukshak (Fig. 5). Most of the fish were distributed along the west side between Cape Nukshak and Cape Kekurnoi, and in the center of the sea valley south of Cape Kekurnoi, as is typical for previous winter Shelikof surveys. Most adult pollock (defined for describing depth distribution as 75% of the biomass) were detected in a thick, uniform layer in water column depths between 205 and 275 m (Fig. 6a). Most juveniles ≤ 30 cm FL (largely comprising 8-16 cm FL age-1 pollock) were between depths of 165-265 m (Fig. 6b). They were often observed in relatively shallow layers in the middle and eastern portion of the Strait, and would typically disperse at night. Most adult pollock were observed within 45 m of the bottom, while most juveniles were within 65 m and ranged up to 85 m (95% of juveniles) above bottom (Fig. 6c, d). The overall adult pollock MWD was deeper than in 2020 and the prior 4 years with about 24% of the biomass observed within 10 m of the seafloor, and 92% percent of biomass within 50 m of the seafloor.

A total of 8,364.7 million pollock weighing 526,974 t were estimated to be in the Shelikof Strait at the time of the survey (Figs. 7, 8). The 2021 biomass was 14.7% higher than that observed in 2020 (459,399 t) and 27.1% lower than the historic mean of 715,570 t (Table 6, Fig. 9). The relative estimation error of the 2021 biomass estimate based on the 1-D geostatistical analysis was 2.9%.

Walleye pollock between 44 and 65 cm FL were primarily composed of the 9-year-old 2012 year class (2% of numbers, 27% of the biomass) with additional biomass contributed by the surrounding year classes (Tables 7, 8, 9, 10; Figs. 7, 8). Pollock between 24 and 43 cm FL consisted primarily of the 4-year-old 2017 year class (2% of numbers, 14% of the biomass) and to a lesser extent, the 2016 and 2018 year classes (7% and 6% of the biomass, respectively). The 8 to 16 cm FL age-1 fish dominated the Shelikof Strait population numerically (92%) and contributed 13% of the biomass. Pollock ages 4-5, and ages 7 and older were somewhat shorter and lighter when compared to the same age groups from previous winter acoustic-trawl surveys, though most of this year's observations were within a standard deviation of the long-term means (Fig. 10).

Historic population trends in Shelikof Strait as observed by the winter pre-spawning AT surveys track the strong year classes well through time starting from relatively small sizes and young ages (Figs. 11, 12). 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 2021 non-selectivity corrected estimate was used to classify the strength of the 2020 year class (age-1 pollock observed in 2021) in the context of the McKelvey index. This estimate was 5,752.8 million age-1 pollock, which is considered a high or strong year class based on the McKelvey index.

The non-selectivity corrected analysis for the estimated Shelikof pollock population in 2021 generated an overall decrease of 22% by numbers (to 6,531 million) and an increase of 14% by weight (to 602,516 t) compared to the primary analysis (Fig. 13). The non-selectivity corrected analysis decreased the number of small pollock and increased the number of adults relative to the primary analysis, and as there were a substantial number of age-1 pollock in 2021, the overall impact of this change was noticeable.

Marmot Bay

Acoustic backscatter was measured along 312.1 km (168.5 nmi) of transects spaced mainly 1.9 km (1 nmi) apart with spacing varying from 1.9 km to 3.7 km (1 to 2 nmi) in the survey area (Fig. 1). Bottom depths in the survey area ranged from 69 m to 276 m.

Surface water temperatures in the Marmot Region averaged 4.2 °C overall (Fig. 2), and ranged from 3.6 °C to 4.7 °C as measured by the ship's flow-through instrumentation. Surface water temperatures at haul locations averaged 4 °C (Table 3). This was 1.5 °C cooler than the average of 5.5 °C observed during the 2019 survey, and the same as the historic mean of the prior 14 surveys conducted in this area since 1989. Mean temperature between the surface and deepest trawl depth at haul locations varied by around 0.2 °C (Fig. 14). The mean water temperature at fishing depths was 4.3°C (Table 3).

<u>Trawl Samples</u>

Biological data and specimens were collected in the Marmot Region from 6 LFS1421 hauls (Tables 3, 4b and 5; Fig. 1) targeted on backscatter attributed to pollock. The lengths of an average of 261 randomly selected walleye pollock were measured from each haul, with an average of 32 individuals more extensively sampled for at least one of the following: body weight, maturity, and age (Table 5). A total of 143 otoliths used to estimate walleye pollock ages were collected in the Marmot Region.

Pollock and eulachon were the most abundant species by weight in the LFS1421 hauls, contributing 98.1% and 1.2% of the catch by weight, respectively (Table 4b). Pollock and eulachon were the most abundant species by numbers with 83.9% and 10.8% of total catch numbers, respectively.

Pollock observed in the Marmot Region were generally in developing (females) or spawning (males) maturity stages. The maturity composition in the Marmot Region of males > 40 cm FL (n = 17) was 31% immature, 5% developing, 0% pre-spawning, 63% spawning, and 0% spent (Fig. 15a). The maturity composition of females > 40 cm FL (n = 19) was 30% immature, 44% developing, 25% pre-spawning, 0% spawning, and 1% spent. The L_{50m} of female pollock > 22 cm FL is 50.7 cm FL (Fig. 15b). The average GSI from the few pre-spawning females sampled (n=5) was 0.10 ± 0.02 (Fig. 15c, mean ± standard deviation). As most females were in the developing stage of maturity and substantially fewer were spawning or spent, the timing of the 2021 Marmot Region survey relative to the spawning period was likely to have been appropriate. However, since only 19 female pollock > 40 cm FL were sampled in Marmot Bay, all of these maturity results must be interpreted with caution.

Distribution and Abundance

Adult pollock were detected throughout Marmot Region but were primarily found in Spruce Gully (Fig. 5). Most adult pollock (75% of the biomass) were detected between depths of 135 and 265 m (Fig. 16a). Most juvenile pollock were detected between depths of 85 and 165 m (Fig. 16b). Most adult pollock were observed within 55 m of the bottom, with most juveniles found within 75 m and ranging up to 115 m (includes 95% of the biomass) off the bottom (Fig. 16c and d). Adult pollock MWD distributions in 2021 were deeper than those in 2019 and the prior 4 years (Fig. 16a and c). The HAB analysis showed that 34% of the pollock biomass was within 10 m of the seafloor, and 83% of biomass was within 50 m of the seafloor.

A total of 180.5 million pollock weighing 7,400.9 t were estimated to be in the Marmot Region at the time of the survey. The 2021 biomass was 17.9% higher than was observed in 2019 (6,275 t; Table 6). The relative estimation error of the 2021 biomass estimate based on the 1-D geostatistical analysis was 5.8%.

In contrast to Shelikof Strait, the age-4, 2017 year class made up the highest percentage of pollock biomass (2% of numbers, 28% of biomass) in the Marmot area, whereas the age-9, 2012 year class pollock were relatively less abundant (< 1% of numbers, 11% of the biomass). Age-1 pollock (9-16 cm FL) accounted for 92.4 % of the numbers and 17.2% of the pollock biomass observed in Marmot Bay. Age 3 pollock (the 2018 year class) accounted for 2% of the numbers and 16% of the biomass. Age-2 pollock on average were longer than the same age group from previous winter acoustic-trawl surveys, leading to an overlap in length among age 2- and 3-year-old pollock (Fig. 17).

Comparing the non-selectivity corrected analysis for the Marmot Bay area to the primary analysis which corrects the LFS trawl catch for net selectivity indicated that numbers and biomass both increased slightly when selectivity was not included (Fig. 13). This was because among the six hauls, the relative proportion of other species decreased slightly when selectivity effects were removed, increasing the relative proportion of pollock applied to the backscatter and thus slightly increasing both numbers and biomass of pollock.

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TABLES and FIGURES

Table 1. -- Simrad EK80 38 kHz acoustic system description and settings used during the collection and analysis of winter 2021 Shelikof Strait acoustic-trawl survey of walleye pollock. These include environmental parameters and results from standard sphere acoustic system calibrations conducted during the survey and final values used to calculate biomass and abundance data. The system settings column contains the 2 March EK80 calibration utility results. The other three columns are a combination of on-axis (Gain and S_a correction values) and EK80 calibration utility results (see Methods, Results, and Discussion sections of text for details).

	Winter 2021 system settings	2 Mar Kalsin Bay Alaska	15 Mar Kalsin Bay Alaska	Final analysis parameters
Echosounder	Simrad EK80	--	--	Simrad EK80
Transducer	ES38-7 s/n 324	--	--	ES38-7 s/n 324
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	18.00	--	--	18.00
Angle sensitivity athwart	18.00	--	--	18.00
2-way beam angle (dB re 1 steradian)	-20.70	--	--	-20.52
Gain (dB)	27.25	27.18	27.08	27.13
S_a correction (dB)	-0.05	-0.03	-0.05	-0.04
Integration gain (dB)	27.20	27.15	27.02	27.09
3 dB beamwidth along	6.40	6.40	6.41	6.41
3 dB beamwidth athwart	6.43	6.43	6.50	6.47
Angle offset along	-0.04	-0.04	-0.02	-0.03
Angle offset athwart	0.05	0.05	0.07	0.06
Post-processing S_v threshold (dB re 1 m^{-1})	-70	NA	NA	-70
Standard sphere TS (dB re 1 m^2)	NA	-42.09	-42.47	NA
Sphere range from transducer (m)	NA	20.69	20.60	NA
Absorption coefficient (dB/m)	0.0099	0.0099	0.0099	0.0099
Sound velocity (m/s)	1466	1462.6	1460.2	1466
Water temp at transducer (°C)	NA	3.9	3.3	NA

Note: Gain and beam pattern terms are defined in the Operator Manual for Simrad EK80 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. NA indicates ‘not applicable’.

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

Group	TS (dB re 1 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
Fish with swim bladders	$TS = 20 \log_{10} L - 67.4$	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
Eulachon	$TS = 20 \log_{10} L - 84.5$	L = total length	*Thaleichthys pacificus*	Gauthier & Horne 2004
Pelagic crustaceans[1]	$TS = A * (\log_{10}(BkL)/(BkL))^c + D((kL)^6) + E((kL)^5) + F((kL)^4) + G((kL)^3) + H((kL)^2) + I(kL) + J + 20 \log_{10}(L/L_0)$	L = total length	*Euphausia superba*	Demer & Conti 2005

[1] A = -930.429983; B = 3.21027896; C = 1.74003785; D = 1.36133896 × 10^{-8}; E = -2.26958555 × 10^{-6}; F=1.50291244 × 10^{-4}; G = -4.86306872 × 10^{-3}; H = 0.0738748423.
If L < 0.015 m, TS = -105 dB; and if L > 0.065 m, TS = -73 dB.
k = 2*pi*fc, where f = 38,000 (frequency in Hz) and c = 1470 (sound speed in m/s).

Table 3. --Trawl stations and catch data summary from the winter 2021 acoustic-trawl survey of walleye pollock in the Shelikof Strait and Marmot Region.

Haul	Area	Gear	Date	Time	Duration	Start Position		Depth (m)		Temp (°C)		walleye pollock		Other
No.		Type[a]	(GMT)	(GMT)	(mins)	Lat. (N)	Long. (W)	Headrope[b]	Bottom	Headrope	Surface[c]	(kg)	Number	(kg)
1	Shelikof Strait	LFS1421	3-Mar	22:27	25.1	58.4195	-152.9739	-	198	-	4.7	204.2	18,431	40.9
2	Shelikof Strait	LFS1421	4-Mar	08:44	12.8	58.1659	-153.5502	165	191	5.8	4.2	158.8	6,536	195.6
3	Shelikof Strait	LFS1421	4-Mar	14:43	2.8	58.1936	-154.0360	246	279	5.7	2.3	249.2	13,158	88.4
4	Shelikof Strait	LFS1421	4-Mar	19:50	16.0	57.9629	-153.8278	198	227	5.8	3.2	582.2	5,296	194.1
5	Shelikof Strait	LFS1421	5-Mar	01:29	22.3	57.9811	-154.2934	215	241	5.8	3.7	1,481.9	13,080	252.0
6	Shelikof Strait	LFS1421	5-Mar	09:44	10.6	57.8563	-154.7822	248	276	5.6	2.5	797.1	10,330	720.2
7	Shelikof Strait	LFS1421	5-Mar	19:26	4.8	57.6906	-155.1585	242	289	5.6	3.8	571.1	5,846	346.1
8	Shelikof Strait	LFS1421	5-Mar	23:51	12.3	57.5509	-154.7720	161	232	5.8	3.8	831.0	12,727	1,515.8
9	Shelikof Strait	LFS1421	6-Mar	04:31	5.0	57.4504	-154.9064	137	225	5.6	4.0	83.8	6,207	32.9
10	Shelikof Strait	LFS1421	6-Mar	08:43	5.7	57.5990	-155.3099	253	306	5.6	3.8	1,286.7	11,455	222.3
11	Shelikof Strait	LFS1421	6-Mar	17:46	3.3	57.3491	-155.5017	250	277	5.6	4.1	750.1	4,587	138.5
12	Shelikof Strait	LFS1421	7-Mar	00:44	4.6	57.1201	-155.0282	165	203	5.8	3.7	108.2	11,747	15.5
13	Shelikof Strait	LFS1421	7-Mar	10:14	28.3	56.9602	-155.5644	232	278	5.6	3.8	1,386.6	1,544	14.8
14	Shelikof Strait	LFS1421	7-Mar	16:03	15.4	56.8142	-155.4957	224	258	5.8	4.0	1,036.7	4,628	133.0
15	Shelikof Strait	LFS1421	7-Mar	23:39	2.1	56.7813	-155.9907	239	286	5.6	4.4	1,684.9	2,966	14.2
16	Shelikof Strait	LFS1421	9-Mar	05:31	12.0	56.7018	-156.1427	196	245	5.7	4.3	580.5	8,138	70.7
17	Shelikof Strait	LFS1421	9-Mar	12:46	1.4	56.5504	-156.1510	224	282	5.6	4.4	513.4	2,954	24.1
18	Shelikof Strait	LFS1421	9-Mar	23:39	2.4	56.2999	-156.2945	219	276	5.8	4.3	142.3	4,317	7.8
19	Shelikof Strait	LFS1421	11-Mar	03:15	12.2	55.5211	-156.3608	194	225	5.5	4.4	2.7	7	1,082.9
20	Shelikof Strait	LFS1421	12-Mar	17:53	17.1	57.8188	-154.2686	162	203	5.7	1.8	156.4	13,810	31.3
21	Shelikof Strait	LFS1421	12-Mar	21:18	9.6	57.9098	-154.5046	202	259	5.7	2.1	569.7	6,064	206.4
22	Shelikof Strait	LFS1421	13-Mar	00:42	9.1	57.9056	-154.4788	199	247	5.7	1.6	418.7	5,596	646.0
23	Shelikof Strait	LFS1421	13-Mar	04:32	10.4	57.9538	-154.2194	164	211	5.8	2.2	199.3	6,093	255.5
24	Shelikof Strait	LFS1421	13-Mar	15:23	4.0	57.9653	-154.2811	188	223	5.7	2.1	198.7	7,702	249.2
25	Marmot Region	LFS1421	14-Mar	04:25	7.9	58.0240	-152.5336	-	202	-	4.0	386.6	1,648	6.6
26	Marmot Region	LFS1421	14-Mar	06:26	20.9	58.0218	-152.5424	168	203	4.3	4.0	1,258.5	4,700	8.7
27	Marmot Region	LFS1421	14-Mar	09:53	6.5	57.9950	-152.5175	103	176	4.1	3.7	97.1	10,804	10.4
28	Marmot Region	LFS1421	14-Mar	14:30	11.3	58.0644	-152.4289	92	220	4.2	4.1	22.5	2,828	3.8
29	Marmot Region	LFS1421	14-Mar	18:29	3.8	57.9981	-152.3410	230	340	4.5	4.1	1,574.4	2,790	13.6
30	Marmot Region	LFS1421	15-Mar	05:45	3.5	58.0435	-151.8419	120	162	4.2	4.2	66.6	8,621	23.2

[a] LFS1421 = LFS1421 midwater trawl

[b] Headrope depth obtained from SBE temperature logger. In hauls without SBE temperature logger records, footrope depth was obtained from scientist notes when possible.

[c] Average temperature measured from an SBE temperature logger

Table 4a. -- Catch by species and numbers of length and weight measurements taken from 24 LFS1421 hauls during the 2021 acoustic-trawl survey of walleye pollock in Shelikof Strait.

		Catch				Measurements	
Species name	Scientific name	Weight (kg)	%	Number	%	Length	Weight
walleye pollock	*Gadus chalcogrammus*	13,994.3	68.3	183,219	52.1	8,814	1,688
eulachon	*Thaleichthys pacificus*	5,065.9	24.7	143,863	40.9	820	225
Pacific ocean perch	*Sebastes alutus*	1,082.1	5.3	1,553	0.4	237	45
northern smoothtongue	*Leuroglossus schmidti*	126.1	0.6	8,638	2.5	263	106
Chinook salmon	*Oncorhynchus tshawytscha*	83.4	0.4	70	<0.1	70	70
Pacific herring	*Clupea pallasii*	33.2	0.2	1,996	0.6	67	42
squid unid.	Cephalopoda (class)	16.0	<0.1	3,106	0.9	120	58
longnose skate	*Raja rhina*	14.4	<0.1	1	<0.1	-	-
magistrate armhook squid	*Berryteuthis magister*	11.4	<0.1	17	<0.1	12	12
smooth lumpsucker	*Aptocyclus ventricosus*	11.2	<0.1	11	<0.1	9	9
spiny dogfish	*Squalus suckleyi*	7.9	<0.1	3	<0.1	1	1
Stenobrachius sp.	*Stenobrachius sp.*	7.4	<0.1	1,947	0.6	176	79
shrimp unid.	Malacostraca (class)	7.3	<0.1	4,492	1.3	44	-
big skate	*Beringraja binoculata*	6.5	<0.1	1	<0.1	1	1
northern sea nettle	*Chrysaora melanaster*	4.2	<0.1	19	<0.1	19	19
arrowtooth flounder	*Atheresthes stomias*	4.0	<0.1	11	<0.1	9	9
Pacific cod	*Gadus macrocephalus*	3.6	<0.1	1	<0.1	1	1
egg yolk jelly	*Phacellophora camtschatica*	3.1	<0.1	8	<0.1	8	8
Pacific glass shrimp	*Pasiphaea pacifica*	2.7	<0.1	1,296	0.4	30	-
flathead sole	*Hippoglossoides elassodon*	2.2	<0.1	6	<0.1	6	6
rougheye rockfish	*Sebastes aleutianus*	1.1	<0.1	1	<0.1	1	1
medusafish	*Icichthys lockingtoni*	0.9	<0.1	24	<0.1	1	1
Pacific capelin	*Mallotus villosus*	0.9	<0.1	131	<0.1	38	30
jellyfish unid.	Scyphozoa (class)	0.7	<0.1	2	<0.1	2	2
fish larvae unid.	Actinopterygii (class)	0.5	<0.1	409	0.1	28	1
smelt unid.	Osmeridae (family)	0.4	<0.1	315	<0.1	8	1
Pandalus sp.	*Pandalus sp.*	0.4	<0.1	282	<0.1	6	-
Pacific lamprey	*Lampetra tridentata*	0.2	<0.1	5	<0.1	5	4
sablefish	*Anoplopoma fimbria*	0.2	<0.1	1	<0.1	1	1
Alaskan pink shrimp	*Pandalus eous*	0.2	<0.1	89	<0.1	1	1
eelpout unid.	Zoarcidae (family)	<0.1	<0.1	2	<0.1	2	2
isopod unid.	Isopoda (order)	<0.1	<0.1	6	<0.1	-	-
Hydromedusa (unid.)	Hydromedusa (unid.)	<0.1	<0.1	1	<0.1	1	-
Total		20,492.4		351,526		10,801	2,423

Table 4b. -- Catch by species and numbers of length and weight measurements taken from 6 LFS1421 hauls during the 2021 acoustic-trawl survey of walleye pollock in the Marmot Region.

		Catch				Measurements	
Species name	Scientific name	Weight (kg)	%	Number	%	Length	Weight
walleye pollock	*Gadus chalcogrammus*	3,405.8	98.1	31,391	83.9	1,564	319
eulachon	*Thaleichthys pacificus*	41.0	1.2	4,043	10.8	208	60
smooth lumpsucker	*Aptocyclus ventricosus*	5.2	0.1	4	<0.1	3	3
arrowtooth flounder	*Atheresthes stomias*	4.4	0.1	3	<0.1	2	2
Pacfic capelin	*Mallotus villosus*	3.4	<0.1	738	2.0	43	15
black rockfish	*Sebastes melanops*	2.8	<0.1	1	<0.1	1	1
flathead sole	*Hippoglossoides elassodon*	2.6	<0.1	11	<0.1	11	11
Pandalus sp.	*Pandalus sp.*	2.2	<0.1	474	1.3	20	-
rougheye rockfish	*Sebastes aleutianus*	0.9	<0.1	1	<0.1	1	1
northern rock sole	*Lepidopsetta polyxystra*	0.9	<0.1	1	<0.1	1	1
fish larvae unid.	Actinopterygii (class)	0.7	<0.1	509	1.4	12	-
Pacific herring	*Clupea pallasii*	0.7	<0.1	31	<0.1	10	10
northern sea nettle	*Chrysaora melanaster*	0.6	<0.1	2	<0.1	2	2
magistrate armhook squid	*Berryteuthis magister*	0.6	<0.1	2	<0.1	1	1
Alaskan pink shrimp	*Pandalus eous*	0.2	<0.1	138	0.4	20	-
shrimp unid.	Malacostraca (class)	0.1	<0.1	46	0.1	10	-
sturgeon poacher	*Podothecus accipenserinus*	<0.1	<0.1	1	<0.1	1	1
Pacific sandfish	*Trichodon trichodon*	<0.1	<0.1	1	<0.1	1	1
smelt unid.	Osmeridae (family)	<0.1	<0.1	12	<0.1	4	-
squid unid.	Cephalopoda (class)	<0.1	<0.1	2	<0.1	1	1
Total		3,472.0		37,411		1,916	429

Table 5. -- Numbers of walleye pollock measured and biological samples collected during the winter 2021 acoustic-trawl survey of Shelikof Strait and Marmot Region.

Haul no.	Region name	Catch lengths	Weights	Maturities	Otoliths	Ovary weights	Ovaries collected
1	Shelikof Strait	217	49	30	15	-	-
2	Shelikof Strait	406	80	60	40	9	-
3	Shelikof Strait	382	70	50	35	10	-
4	Shelikof Strait	333	70	50	35	7	-
5	Shelikof Strait	532	85	65	35	9	-
6	Shelikof Strait	368	76	53	35	18	-
7	Shelikof Strait	358	70	50	35	4	-
8	Shelikof Strait	679	87	67	35	-	-
9	Shelikof Strait	126	83	63	35	8	-
10	Shelikof Strait	469	89	69	35	23	-
11	Shelikof Strait	367	70	50	35	13	-
12	Shelikof Strait	76	27	7	12	-	-
13	Shelikof Strait	504	89	69	35	29	-
14	Shelikof Strait	460	71	51	35	6	-
15	Shelikof Strait	426	70	50	35	30	-
16	Shelikof Strait	534	79	59	35	7	-
17	Shelikof Strait	396	69	49	34	12	-
18	Shelikof Strait	246	70	50	35	14	-
19	Shelikof Strait	7	7	4	4	1	-
20	Shelikof Strait	154	81	61	-	3	-
21	Shelikof Strait	450	70	50	-	12	-
22	Shelikof Strait	528	85	70	2	8	-
23	Shelikof Strait	465	68	53	1	5	-
24	Shelikof Strait	331	73	53	5	10	-
25	Marmot Region	468	85	65	30	-	-
26	Marmot Region	479	66	51	30	1	-
27	Marmot Region	83	43	23	28	1	-
28	Marmot Region	64	20	-	5	-	-
29	Marmot Region	395	70	50	30	3	-
30	Marmot Region	75	35	15	20	1	-
Total		10,378	2,007	1,437	746	244	0

Table 6. -- Estimates of walleye pollock biomass (thousands of metric tons) and relative estimation error for the Shelikof Strait area, Chirikof shelf break, and Marmot Bay regions. Estimates for 2008-2021 reflect selectivity corrections for escapement of juveniles. Blank values indicate no survey or estimation error was completed within a given region and year.

Year	Shelikof Strait		Chirikof Shelf break		Marmot Region	
	Biomass	Est. error	Biomass	Est. error	Biomass	Est. error
1981	2,785.7					
1982						
1983	2,278.1					
1984	1,757.1					
1985	1,175.2					
1986	585.7					
1987						
1988	301.7					
1989	290.5				2.4	
1990	374.7					
1991	380.3					
1992	713.4	3.6%				
1993	435.8	4.6%				
1994	492.6	4.5%				
1995	763.6	4.5%				
1996	777.2	3.7%				
1997	583.0	3.7%				
1998	504.8	3.8%				
1999						
2000	448.6	4.6%				
2001	432.7	4.5%				
2002	256.7	6.9%	82.1	12.2%		
2003	317.3	5.2%	31.0	20.7%		
2004	330.8	9.2%	30.0	20.4%		
2005	356.1	4.1%	77.0	20.7%		
2006	293.6	4.0%	69.0	11.0%		
2007	180.9	5.8%	37.0	6.7%	3.6	5.0%
2008	197.7	5.6%	22.0	9.6%		
2009	257.2	5.9%	0.4	32.3%	19.9	
2010	421.4	2.6%	9.4	15.0%	5.6	
2011						
2012	333.9	7.9%	21.2	16.4%		
2013	866.0	5.3%	63.2	31.4%	19.9	4.1%
2014	827.1	4.7%			14.4	9.4%
2015	847.8	4.3%	12.7	14.2%	22.5	3.1%
2016	666.8	6.5%			24.9	8.8%[1]
2017	1,465.1	4.3%	2.5	24.0%	13.1	7.9%
2018	1,320.9	2.9%			13.5	7.5%[1]
2019	1,281.1	6.6%	9.9	17.7%	6.3	7.9%
2020	459.4	4.9%				
2021	527.0	2.9%			7.4	5.8%

[1]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).

Table 7. -- Numbers-at-length estimates (millions of fish) from acoustic-trawl surveys of walleye pollock in the Shelikof Strait area. Numbers from 2008 to 2021 reflect selectivity corrections for escapement of juveniles. Non-selectivity corrected estimates (prior to 2008) are presented in Appendix V, Table 11.

Length	2008	2009	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
5	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
7	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	4.5	0	0	13.5	<1	0	0	0	14.9	0	11.0
9	26.2	9.3	10.4	1.9	142.1	48.8	0	0	1.3	77.1	115.7	0	246.1
10	69.3	80.4	51.3	7.9	1142.6	314.0	4.3	0	57.4	560.1	1799.9	<1	1386.2
11	304.7	239.8	70.8	26.7	2478.3	505.2	3.6	0	134.1	754.5	3103.2	<1	2737.9
12	570.8	310.0	75.9	54.5	2374.1	432.8	4.4	0	308.5	374.2	1906.8	2.8	2135.8
13	461.6	128.6	43.5	63.5	699.5	218.5	4.1	0	185.9	40.7	341.1	4.7	931.7
14	262.2	42.8	11.4	27.3	243.4	45.7	2.3	0	40.2	9.4	78.6	5.2	215.3
15	72.4	2.1	1.6	11.3	70.7	11.4	<1	0	16.8	2.4	0	2.0	59.5
16	9.2	1.2	<1	2.6	23.2	3.5	<1	0	<1	1.2	<1	1.2	6.7
17	1.8	0	<1	0	8.4	36.4	<1	0	0	0	5.8	<1	0
18	<1	5.2	<1	0	<1	109.7	<1	0	0	<1	37.4	<1	0
19	4.4	6.6	9.2	11.0	<1	471.2	<1	0	0	3.6	172.2	<1	0
20	3.6	70.7	15.4	55.2	1.6	979.4	1.3	0	<1	5.6	432.7	9.2	<1
21	18.0	165.6	34.4	156.6	3.8	930.7	9.2	0	0	16.3	437.5	19.8	<1
22	34.6	322.4	62.4	183.0	12.4	466.3	16.6	<1	0	26.3	291.5	24.0	<1
23	76.8	275.2	86.1	186.7	10.1	308.2	20.9	0	<1	27.9	166.1	17.0	<1
24	108.2	173.4	49.5	139.0	14.5	98.4	17.2	<1	<1	23.2	76.1	11.7	1.6
25	69.9	75.0	26.7	62.8	18.3	52.1	16.7	<1	<1	19.0	40.5	19.0	3.5
26	32.7	18.7	16.3	32.3	28.5	25.6	38.9	<1	0	7.8	14.8	23.3	2.7
27	27.7	9.2	7.8	8.4	10.7	4.8	84.6	<1	0	7.9	4.2	44.4	1.8
28	18.0	12.5	9.2	9.6	11.0	6.1	167.7	<1	<1	4.1	6.2	53.4	2.9
29	12.4	5.0	28.6	1.5	9.0	<1	280.8	<1	0	0	16.0	77.4	4.4
30	9.6	6.2	56.6	5.6	28.8	<1	300.2	1.9	0	1.2	19.9	53.3	7.2
31	25.1	8.5	91.5	1.9	46.0	<1	270.9	3.2	0	<1	24.5	43.5	10.5
32	35.2	12.2	109.6	4.8	48.6	2.1	209.1	10.7	0	<1	31.8	23.1	15.4
33	39.1	23.7	91.4	6.1	79.0	3.6	142.6	22.0	<1	<1	17.9	16.7	17.3
34	29.1	23.0	66.8	6.2	88.4	2.9	66.2	50.7	1.1	0	14.1	16.8	21.0
35	28.9	19.1	32.2	5.7	132.3	3.7	49.0	91.1	<1	0	6.7	9.5	21.1
36	15.3	16.2	25.8	5.5	123.1	3.8	28.2	139.3	4.8	0	2.1	14.2	27.9
37	17.2	8.4	14.0	4.6	126.5	5.4	23.8	209.6	9.0	1.2	5.1	10.2	31.2
38	6.7	11.5	10.6	3.8	66.1	7.8	15.8	274.3	56.3	1.8	2.1	5.6	28.0
39	3.0	15.2	7.7	3.3	48.5	14.3	15.5	271.5	130.6	10.2	1.6	4.4	23.5
40	7.6	9.3	8.5	4.5	27.4	26.0	7.0	204.9	352.4	45.3	1.5	3.3	19.8
41	6.7	13.4	8.5	6.1	15.8	39.7	7.1	138.2	530.2	102.5	5.0	2.3	14.9
42	3.9	15.6	9.8	9.2	13.1	55.7	7.4	76.3	578.5	202.3	34.3	7.8	15.1
43	3.6	14.2	10.2	12.5	10.6	56.7	8.7	40.2	544.0	305.4	102.9	15.1	12.0
44	2.9	13.9	10.9	12.9	12.5	53.3	13.4	22.2	326.5	370.0	177.4	34.3	9.4
45	3.9	11.6	14.1	16.6	4.7	39.3	18.2	13.0	169.8	351.5	245.3	67.1	16.7
46	2.4	8.6	13.2	16.5	6.2	25.7	23.6	10.1	80.9	262.4	244.9	78.3	31.9

Length	2008	2009	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
47	1.3	5.3	11.2	18.5	9.4	15.7	26.4	7.0	46.4	188.9	221.6	74.7	29.5
48	<1	4.5	11.3	17.7	13.3	12.0	32.7	7.4	24.0	116.4	169.1	62.0	43.0
49	1.2	2.6	10.5	15.6	15.0	10.5	30.2	8.8	8.9	62.6	122.9	40.9	45.6
50	<1	2.8	12.0	16.3	14.3	13.7	25.0	6.4	6.8	30.7	68.2	33.0	38.0
51	<1	2.5	10.5	13.1	25.8	15.0	23.0	4.3	3.5	29.3	35.2	20.4	29.0
52	1.2	3.4	9.1	13.1	18.4	27.0	19.2	5.4	2.6	9.8	25.3	13.2	28.2
53	1.0	2.0	6.0	10.8	21.6	26.7	20.4	2.7	<1	9.5	10.4	5.6	24.1
54	1.8	2.3	7.2	8.9	29.6	27.9	18.9	2.8	2.8	3.7	5.3	4.9	16.9
55	1.6	1.6	7.9	10.3	22.2	27.4	24.9	2.3	4.5	6.8	4.7	2.9	14.1
56	3.4	2.4	5.9	8.0	28.4	32.0	21.4	2.7	4.5	1.8	<1	1.4	8.6
57	<1	1.6	4.9	8.1	20.2	23.2	20.9	2.7	<1	<1	<1	<1	5.7
58	2.1	1.2	6.2	8.4	18.3	18.6	21.4	1.2	2.0	0	<1	<1	4.3
59	2.5	1.2	5.6	4.9	17.6	14.4	16.0	<1	<1	0	<1	<1	3.1
60	1.6	1.2	3.3	4.6	21.5	12.9	15.4	1.3	<1	<1	<1	<1	<1
61	2.4	1.2	5.2	2.4	8.2	9.1	9.1	<1	<1	0	<1	<1	<1
62	1.0	1.0	3.8	1.4	9.2	6.6	8.2	<1	<1	<1	0	<1	<1
63	1.2	<1	3.3	1.5	13.5	3.0	4.5	<1	<1	0	0	<1	0
64	1.3	<1	3.8	1.0	2.9	4.0	1.8	0	0	0	0	0	<1
65	<1	<1	3.3	<1	1.7	1.6	2.8	0	0	0	0	0	<1
66	<1	<1	2.5	<1	2.7	1.6	2.6	0	0	0	0	0	0
67	<1	<1	2.4	<1	<1	<1	<1	0	0	0	0	0	0
68	<1	<1	1.3	<1	<1	<1	1.2	0	0	0	0	0	0
69	<1	<1	<1	0	0	0	<1	0	0	0	0	0	0
70	0	<1	<1	<1	<1	<1	0	0	0	0	0	0	0
71	0	<1	<1	0	1.1	0	0	0	0	0	0	0	0
72	0	0	<1	0	0	0	0	0	0	0	0	0	0
73	0	0	0	0	<1	0	0	0	0	0	0	0	0
74	0	0	0	0	<1	<1	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	0	0	0	0	0	0
76	0	<1	0	0	0	0	0	0	0	0	0	0	0
Total	2451.9	2225.5	1338.7	1334.0	8498.0	5728.9	2227.8	1636.9	3638.7	4076.5	10664.4	985.0	8364.7

Table 8. -- Biomass-at-length estimates (thousands of metric tons) from acoustic-trawl surveys of walleye pollock in the Shelikof Strait area. Biomass from 2008 to 2021 reflects selectivity corrections for escapement of juveniles. Non-selectivity corrected estimates (prior to 2008) are presented in Appendix V, Table 12.

Length	2008	2009	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
5	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
7	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	<1	0	0	<1	<1	0	0	0	<1	0	<1
9	<1	<1	<1	<1	<1	<1	0	0	<1	<1	<1	0	1.2
10	<1	<1	<1	<1	6.8	2.0	<1	0	<1	3.6	11.5	<1	8.8
11	2.9	2.0	<1	<1	18.9	5.0	<1	0	1.0	6.1	25.5	<1	22.1
12	6.3	3.3	<1	<1	22.6	4.6	<1	0	3.0	3.8	18.9	<1	21.1
13	7.0	1.7	<1	<1	8.5	2.9	<1	0	2.3	<1	4.3	<1	11.4
14	4.6	<1	<1	<1	3.6	<1	<1	0	<1	<1	1.1	<1	3.3
15	1.6	<1	<1	<1	1.3	<1	<1	0	<1	<1	0	<1	1.1
16	<1	<1	<1	<1	<1	<1	<1	0	<1	<1	<1	<1	<1
17	<1	0	<1	0	<1	1.1	<1	0	0	0	<1	<1	0
18	<1	<1	<1	0	<1	4.1	<1	0	0	<1	1.4	<1	0
19	<1	<1	<1	<1	<1	20.7	<1	0	0	<1	7.5	<1	0
20	<1	3.8	<1	3.1	<1	48.6	<1	0	<1	<1	22.0	<1	<1
21	1.2	10.4	2.1	9.7	<1	53.8	<1	0	0	1.1	25.3	1.2	<1
22	2.7	22.9	4.3	13.0	<1	31.8	1.1	<1	0	1.9	19.1	1.7	<1
23	6.3	21.9	6.8	15.3	<1	23.3	1.6	0	<1	2.3	12.7	1.3	<1
24	10.3	15.7	4.6	12.6	1.3	8.6	1.5	<1	<1	2.1	6.7	1.1	<1
25	7.7	7.5	2.7	6.3	1.8	5.1	1.8	<1	<1	2.0	4.1	1.9	<1
26	4.2	2.3	1.9	3.8	3.3	3.1	4.6	<1	0	<1	1.7	2.7	<1
27	3.8	1.3	1.1	1.2	1.4	<1	11.1	<1	0	1.1	<1	5.8	<1
28	2.9	2.0	1.4	1.5	1.7	<1	24.7	<1	<1	<1	<1	7.8	<1
29	2.3	<1	4.9	<1	1.6	<1	45.2	<1	0	0	2.5	12.6	<1
30	1.9	1.2	10.8	1.1	5.6	<1	54.3	<1	0	<1	3.8	9.7	1.4
31	5.8	1.8	19.1	<1	9.9	<1	54.7	<1	0	<1	4.7	8.7	2.2
32	9.0	2.8	25.0	1.1	11.6	<1	46.6	2.3	0	<1	7.2	5.1	3.6
33	11.2	5.9	23.0	1.6	20.8	<1	35.9	5.3	<1	<1	4.5	4.2	4.3
34	9.1	6.3	18.4	1.7	25.7	<1	18.0	13.4	<1	0	4.0	4.6	6.0
35	9.9	5.8	9.7	1.8	43.0	1.1	14.6	26.5	<1	0	2.2	2.9	6.6
36	5.6	5.4	8.8	1.9	42.4	1.3	9.4	44.2	1.5	0	<1	4.7	9.6
37	7.0	3.2	5.2	1.7	49.2	2.0	8.6	72.4	3.1	<1	2.1	3.7	11.9
38	3.0	4.7	4.3	1.5	28.1	3.1	6.5	102.8	20.6	<1	<1	2.2	11.4
39	1.5	6.9	3.6	1.4	21.7	6.2	6.8	108.5	51.3	4.1	<1	1.9	10.3
40	4.1	4.5	4.2	2.1	16.6	12.3	3.5	88.3	150.1	20.0	<1	1.6	9.6
41	4.0	7.3	4.7	3.2	8.7	20.3	3.7	64.0	243.8	48.1	2.5	1.1	8.0
42	2.4	8.9	5.8	5.0	7.6	30.8	4.2	37.5	283.7	99.7	18.8	4.2	8.7
43	2.5	8.8	6.5	7.6	6.7	33.6	5.2	21.6	280.7	164.4	59.6	8.9	7.4
44	2.1	9.6	7.5	8.3	8.5	34.1	8.7	12.7	181.0	214.6	108.3	21.8	6.4
45	3.0	8.6	10.8	11.6	3.5	27.0	13.1	7.8	100.0	214.3	159.7	44.8	12.2
46	2.1	6.7	10.9	12.4	4.9	18.9	18.2	6.5	52.3	171.0	170.0	54.3	25.3

Length	2008	2009	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
47	1.2	4.6	9.7	14.8	7.9	12.2	21.6	4.7	32.2	130.4	165.7	58.4	24.6
48	<1	4.2	10.5	14.8	12.1	10.2	28.6	5.6	18.0	88.2	136.1	51.8	36.9
49	1.2	2.7	10.7	14.7	14.6	9.6	28.3	7.2	7.7	49.8	108.4	37.5	41.2
50	<1	3.1	12.7	16.6	15.5	13.4	25.5	5.4	6.2	24.8	63.8	31.2	37.3
51	<1	2.8	12.2	14.1	28.9	16.1	24.7	3.7	3.1	28.4	35.7	21.4	30.9
52	1.5	4.5	11.3	15.2	22.5	31.4	21.5	5.1	2.6	9.4	25.9	14.3	32.2
53	1.4	3.0	8.0	12.7	28.1	33.8	24.8	2.8	<1	9.7	12.3	6.9	29.2
54	2.5	3.5	9.9	11.1	41.2	35.8	24.2	3.0	3.0	4.0	6.2	6.2	21.2
55	2.6	2.6	11.7	14.2	30.9	37.7	32.9	2.5	5.2	7.7	6.3	4.2	19.0
56	5.5	4.0	9.3	12.0	43.3	46.5	30.7	2.9	5.4	2.2	<1	2.0	11.4
57	1.7	2.8	8.6	11.8	32.2	35.8	31.1	3.0	<1	<1	1.3	1.1	8.8
58	3.8	2.3	11.0	14.5	31.6	30.1	34.2	1.5	2.7	0	<1	<1	7.1
59	4.6	2.5	10.3	8.5	31.3	23.9	26.2	1.1	1.1	0	<1	<1	5.7
60	3.2	2.7	6.4	8.2	41.1	24.6	27.0	1.6	<1	<1	<1	<1	1.6
61	5.1	2.5	10.5	4.4	16.5	16.4	16.9	<1	<1	0	<1	1.4	1.5
62	2.4	2.3	7.9	2.8	19.4	13.2	15.8	1.0	<1	<1	0	<1	1.4
63	2.8	2.1	7.4	3.1	29.9	6.1	8.6	<1	<1	0	0	<1	0
64	3.2	1.6	8.8	2.2	6.7	8.6	3.9	0	0	0	0	0	<1
65	1.2	<1	8.4	2.2	4.2	3.7	6.3	0	0	0	0	0	<1
66	1.7	2.4	6.4	<1	7.0	3.8	5.6	0	0	0	0	0	0
67	1.2	1.3	6.7	1.0	<1	1.4	1.6	0	0	0	0	0	0
68	<1	1.2	3.7	<1	1.8	1.4	3.0	0	0	0	0	0	0
69	<1	<1	1.5	0	0	0	<1	0	0	0	0	0	0
70	0	<1	2.9	<1	2.0	<1	0	0	0	0	0	0	0
71	0	<1	1.8	0	3.5	0	0	0	0	0	0	0	0
72	0	0	1.6	0	0	0	0	0	0	0	0	0	0
73	0	0	0	0	1.4	0	0	0	0	0	0	0	0
74	0	0	0	0	<1	<1	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	0	0	0	0	0	0
76	0	<1	0	0	0	0	0	0	0	0	0	0	0
Total	197.7	257.2	421.4	333.9	866.0	827.1	847.8	666.8	1465.1	1320.9	1281.1	459.4	527.0

Table 9. -- Numbers-at-age estimates (millions of fish) from acoustic-trawl surveys of walleye pollock in the Shelikof Strait area. Numbers from 2008 to 2021 reflect selectivity corrections for escapement of juveniles. Non-selectivity corrected estimates (prior to 2008) are presented in Appendix V, Table 13.

Age	2008	2009	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1	1778.2	814.1	270.5	193.8	7182.9	1590.8	19.8	0	745.0	1819.6	7361.2	17.6	7730.1
2	359.2	1127.2	299.1	842.3	145.3	3492.9	103.9	1.8	0	142.6	1671.7	81.4	36.7
3	230.2	105.8	538.7	43.3	797.2	17.4	1637.3	78.2	9.2	1.6	155.5	345.3	94.2
4	49.0	95.8	82.9	76.6	59.6	279.9	72.4	1451.8	126.4	9.9	6.1	72.2	150.7
5	11.2	57.8	76.3	94.7	66.1	82.8	152.8	43.4	2576.4	166.3	6.6	15.5	55.4
6	2.0	9.5	27.7	45.9	108.8	57.7	62.4	33.5	126.0	1804.0	261.7	27.0	7.3
7	3.7	2.7	11.2	28.9	61.4	98.5	56.7	15.5	32.0	85.9	1127.5	68.5	12.5
8	9.8	<1	5.1	4.4	46.0	54.6	68.1	3.6	8.9	46.7	53.9	192.8	64.0
9	6.2	4.7	5.0	1.1	11.2	25.6	30.0	7.4	<1	0	11.1	116.8	133.9
10	1.9	5.6	10.3	<1	5.3	17.6	11.0	1.7	<1	0	9.0	37.2	63.4
11	<1	1.3	8.8	<1	5.3	7.3	5.6	0	0	0	<1	8.0	14.3
12	0	<1	3.2	<1	<1	<1	3.7	0	0	0	<1	2.7	2.2
13	0	0	0	0	1.5	2.3	<1	0	0	0	0	0	0
14	0	0	0	0	4.4	0	<1	0	0	0	0	0	0
15	0	0	0	0	2.5	<1	1.5	0	0	0	0	0	0
16	0	0	0	0	0	0	<1	0	0	0	0	0	0
17	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
Total	2451.9	2225.5	1338.7	1332.0	8498.0	5728.9	2227.8	1636.9	3624.5	4076.5	10664.4	985.0	8364.7

Table 10. -- Biomass-at-age estimates (thousands of metric tons) from acoustic-trawl surveys of walleye pollock in the Shelikof Strait area. Numbers from 2008 to 2021 reflect selectivity corrections for escapement of juveniles. Non-selectivity corrected estimates (prior to 2008) are presented in Appendix V, Table 14.

Age	2008	2009	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1	23.2	8.4	2.4	2.4	63.1	16.2	<1	0	7.7	14.8	61.9	<1	69.3
2	35.4	88.1	23.6	66.6	18.5	201.6	9.8	<1	0	12.6	102.1	5.9	7.0
3	61.5	27.7	129.0	11.8	276.7	5.3	327.1	23.6	3.3	<1	34.3	59.3	30.2
4	23.7	49.8	55.4	50.0	37.2	166.4	39.2	565.8	57.2	5.1	3.0	22.4	74.4
5	8.9	42.3	83.2	87.9	76.4	59.1	134.4	24.2	1287.5	89.6	4.2	7.5	37.8
6	2.8	10.1	35.5	61.3	149.2	74.8	65.8	25.2	70.4	1098.5	183.5	19.2	6.3
7	7.1	4.5	20.5	43.0	98.5	131.7	81.2	13.3	29.7	58.2	830.3	55.4	11.0
8	18.5	1.7	10.6	6.9	81.5	83.8	102.0	4.1	8.4	41.7	42.5	155.4	65.2
9	11.7	10.0	11.5	2.2	20.8	40.4	47.9	8.3	<1	0	9.7	93.5	141.2
10	3.9	11.7	20.9	<1	11.3	29.0	17.6	2.0	<1	0	9.3	29.9	66.3
11	<1	2.7	20.4	<1	11.6	11.3	9.0	0	0	0	<1	6.5	16.3
12	0	<1	8.2	<1	1.7	1.4	6.5	0	0	0	<1	4.3	2.0
13	0	0	0	0	3.8	4.8	1.5	0	0	0	0	0	0
14	0	0	0	0	9.7	0	1.4	0	0	0	0	0	0
15	0	0	0	0	6.0	1.3	2.5	0	0	0	0	0	0
16	0	0	0	0	0	0	1.6	0	0	0	0	0	0
17	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
Total	197.7	257.2	421.4	333.9	866.0	827.1	847.8	666.8	1465.1	1320.9	1281.1	459.4	527.0

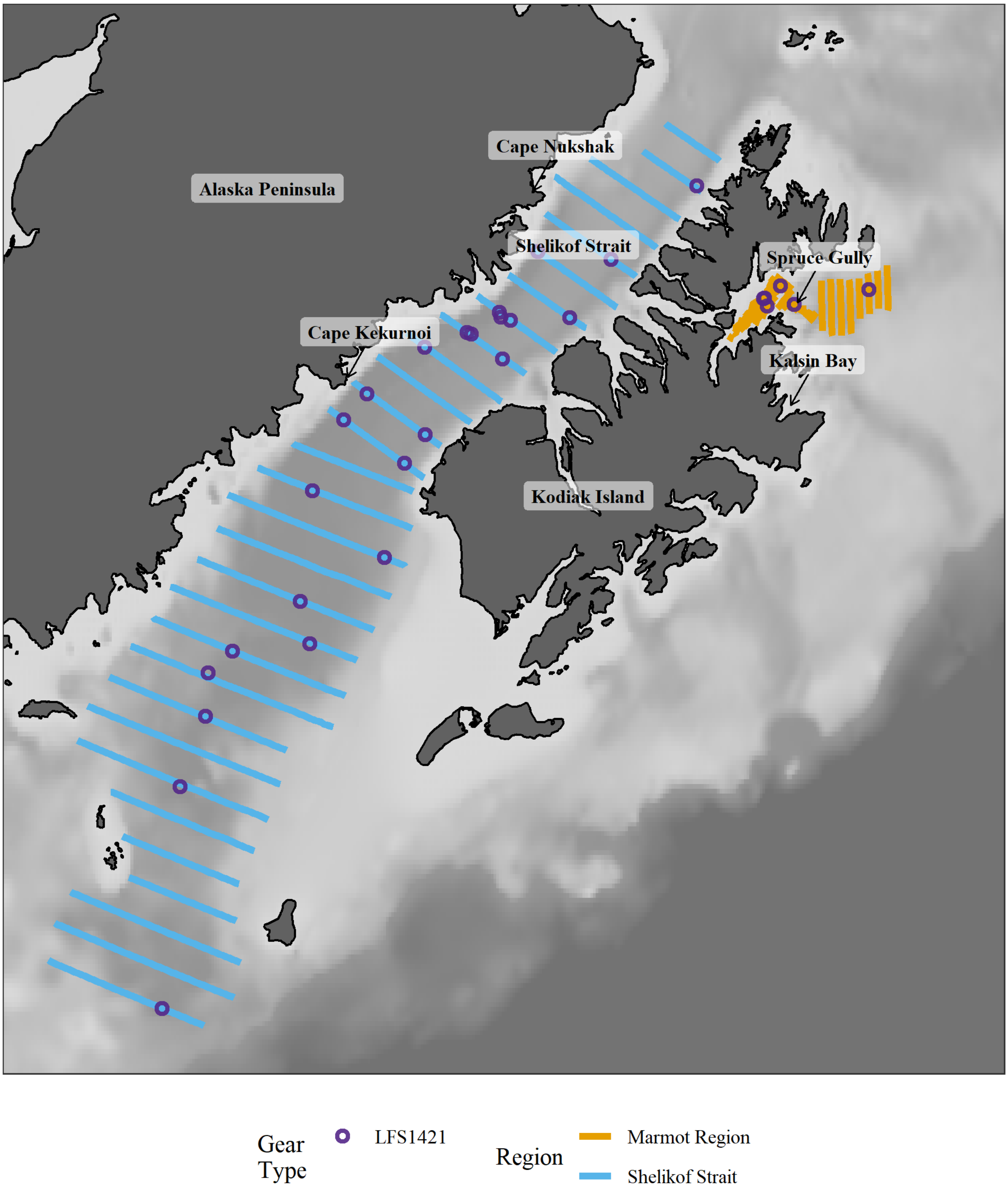


Figure 1. -- Transect lines and locations of trawl hauls during the winter 2021 acoustic-trawl survey of walleye pollock in the Shelikof Strait and Marmot Bay regions. Labels refer to areas referenced in text.

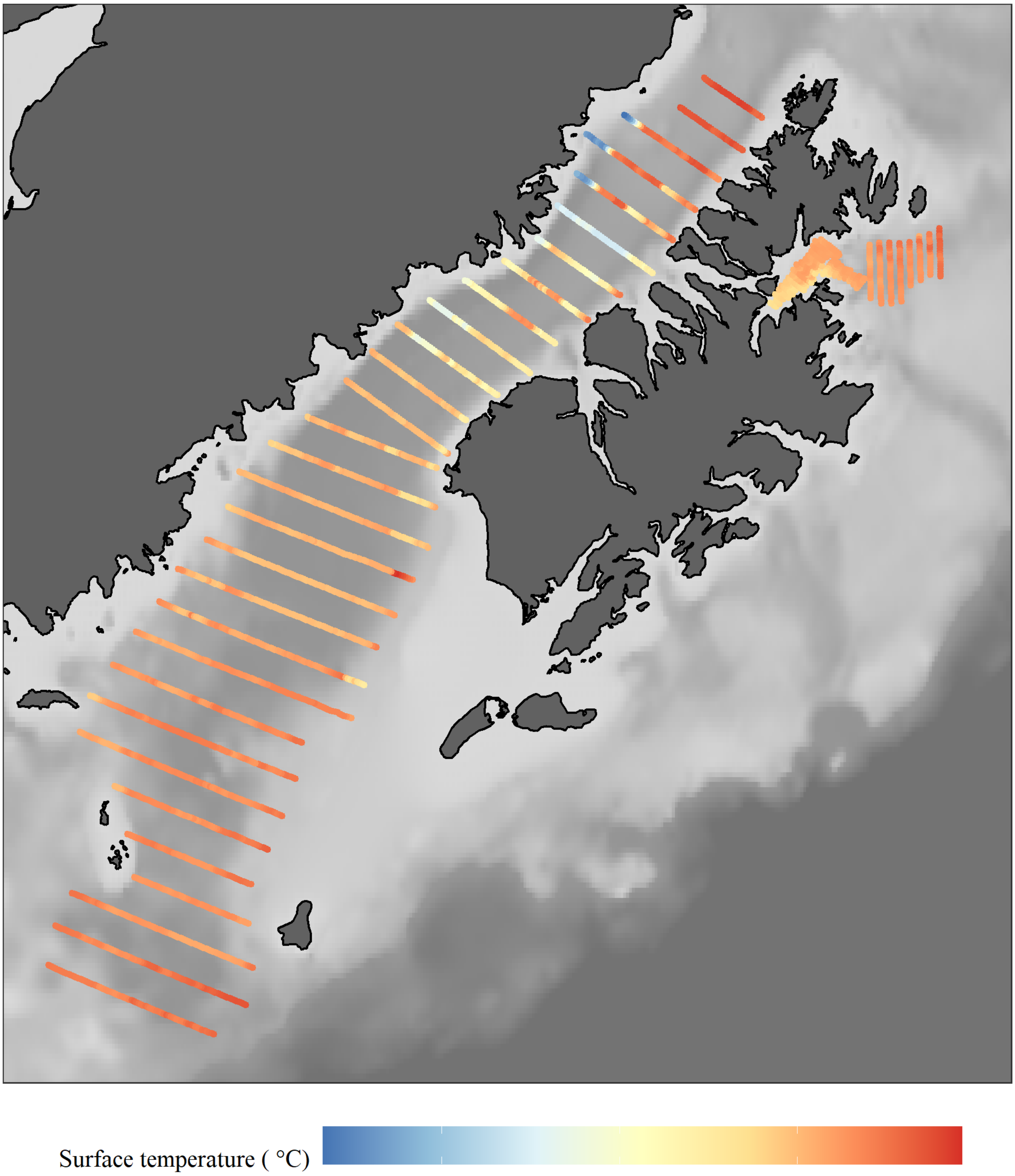


Figure 2. -- Surface water temperatures (°C) recorded at 5-second intervals during the winter 2021 acoustic-trawl survey of the Shelikof Strait and Marmot Region regions.

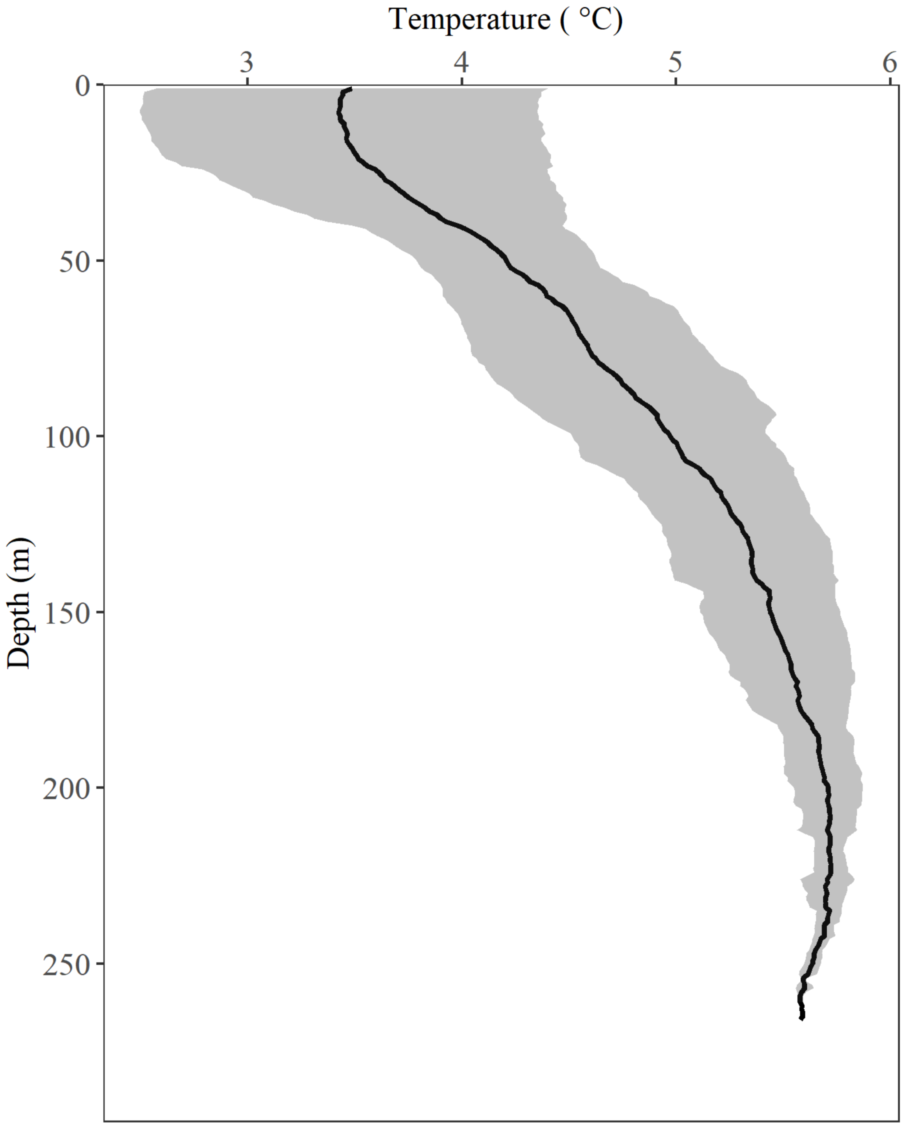


Figure 3. -- Mean water temperature (°C ; solid line) by 1-m depth intervals measured at 23 trawl haul locations during the 2021 acoustic-trawl survey of walleye pollock in the Shelikof Strait area. The shaded area represents one standard deviation.

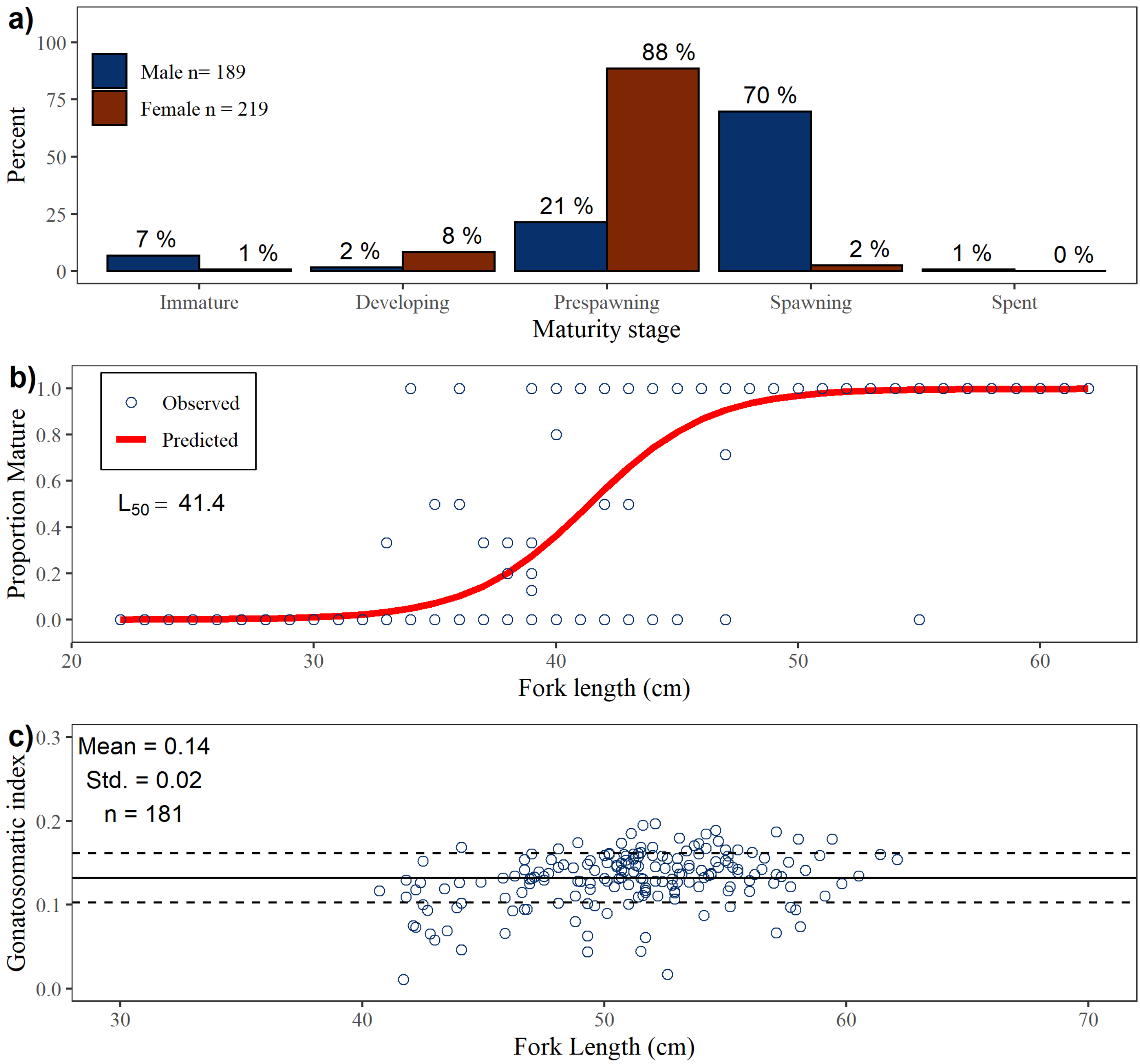


Figure 4. -- Walleye pollock maturity in the Shelikof Strait. a) Maturity composition for male and female walleye pollock greater than 40 cm FL within each stage; b) proportion mature (i.e., pre-spawning, spawning, or spent) by 1-cm size group for female walleye pollock; c) gonadosomatic index for females greater than 40 cm FL (with historic survey mean ± 1 std. dev.). All maturity quantities are weighted by local pollock abundance.

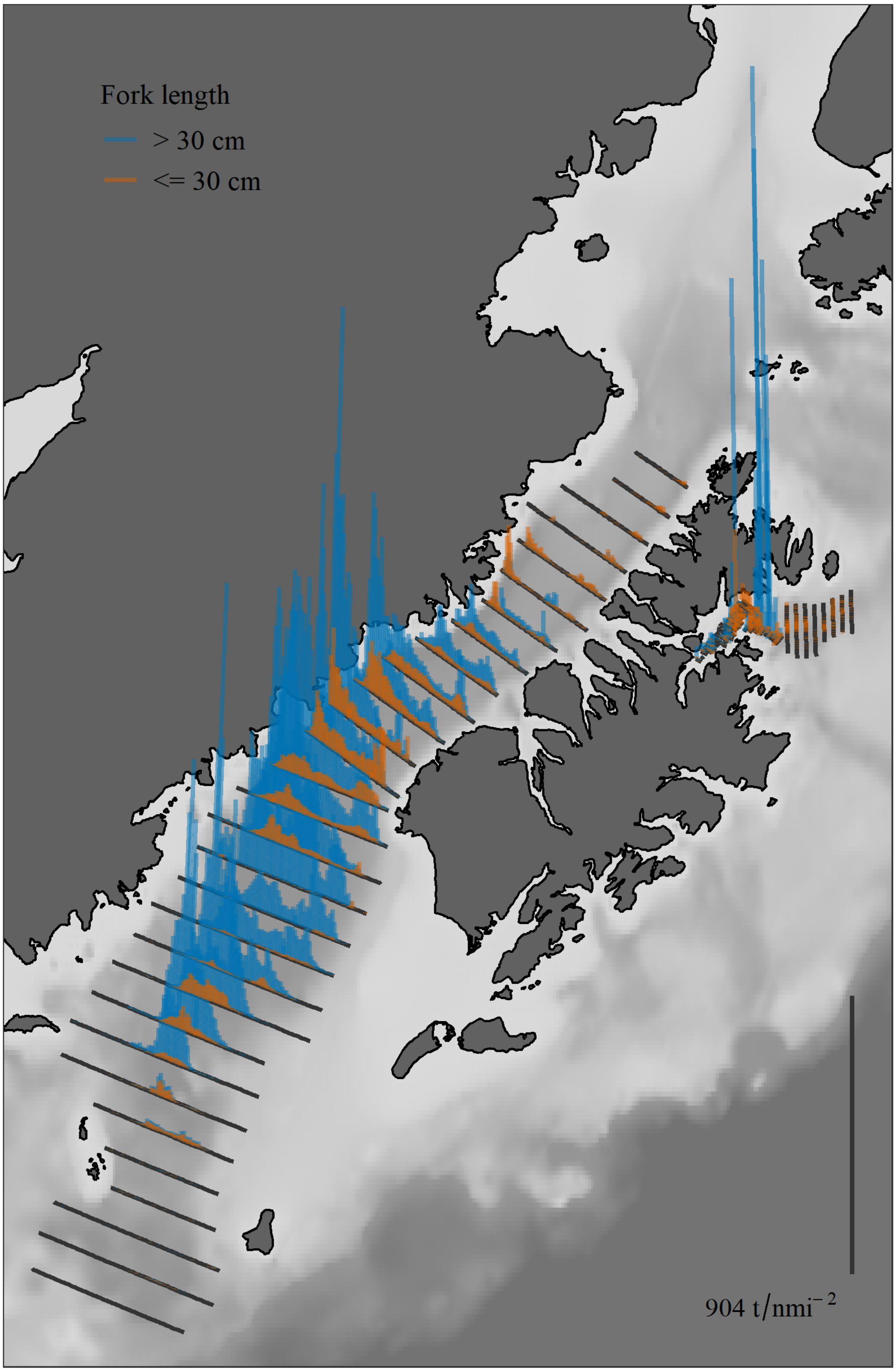


Figure 5. -- Density (t/nmi^2) attributed to walleye pollock (vertical lines) along tracklines surveyed during the winter 2021 acoustic-trawl survey of the Shelikof Strait and Marmot Region regions. The tallest bar value is 1,809 t/nmi^2.

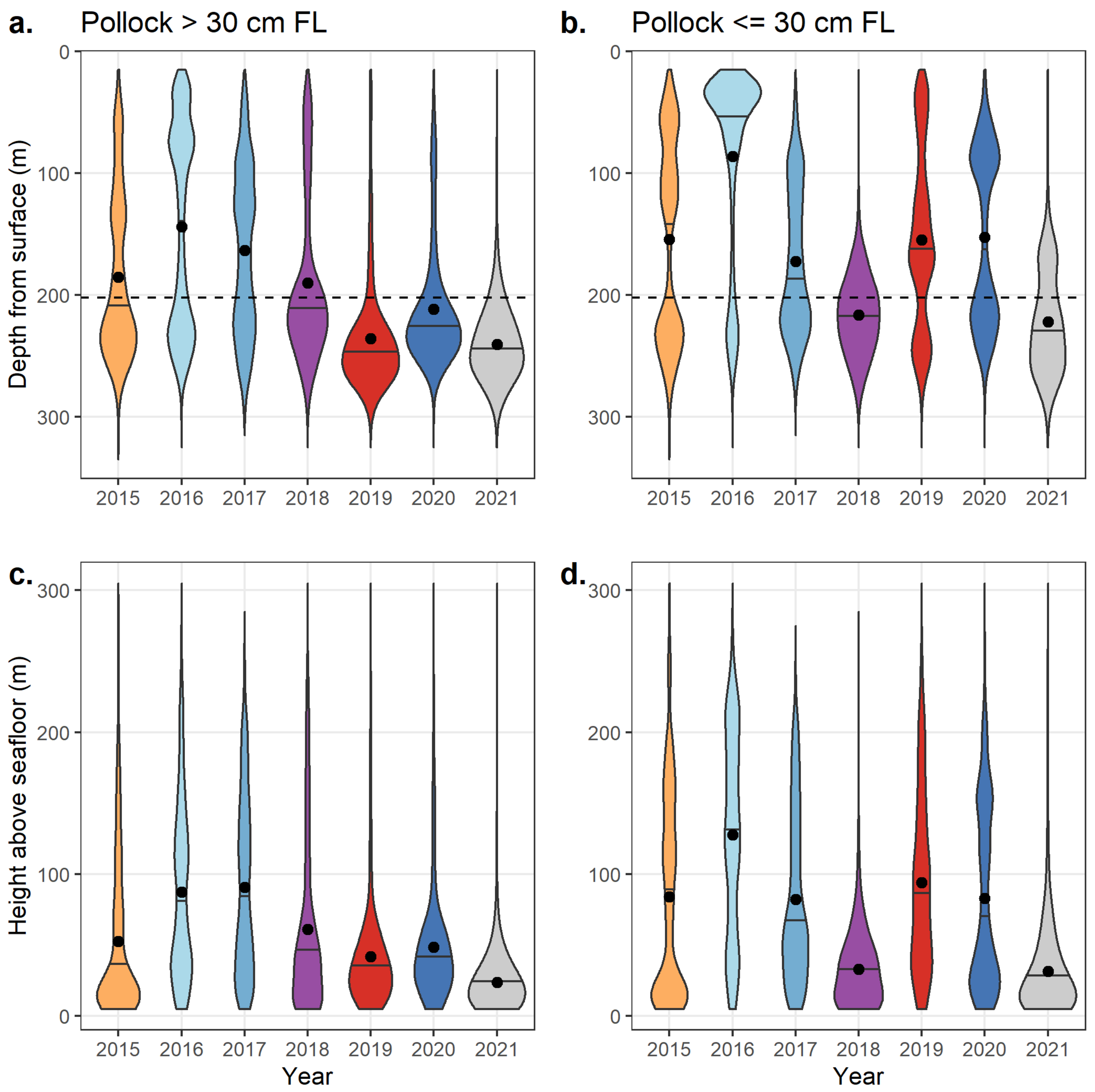
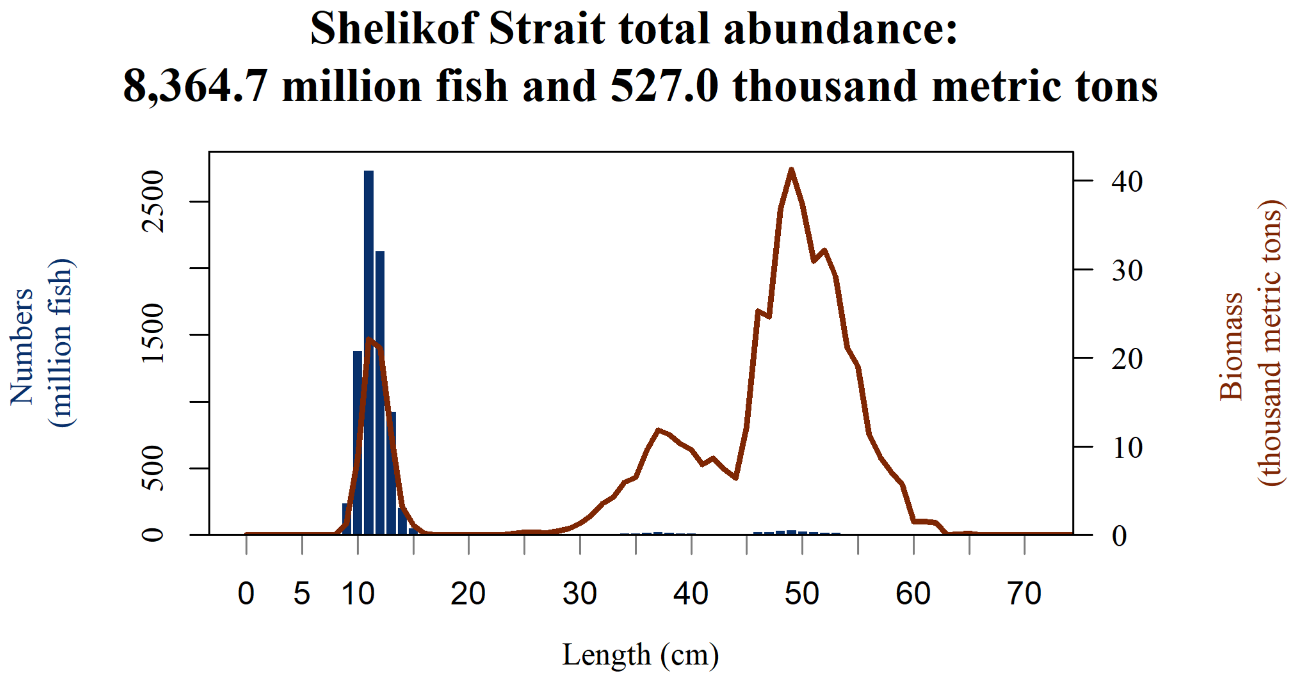


Figure 6. -- Estimated biomass distributions of adult pollock (> 30 cm FL) and juvenile pollock (≤ 30 cm FL) depth (a. and b.) and height (c. and d.) above the seafloor in the Shelikof Strait 2021 acoustic-trawl survey. Results for the winter 2015 to 2020 acoustic-trawl surveys are included for comparison. 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 2021 is shown in a. and b. (dashed line). Plots show the probability density of pollock distribution, with median pollock depth noted by black horizontal lines, and the mean weighted pollock depth indicated by black points (MWD, in panels a) and b), and height above bottom (HAB), in panels c) and d)).



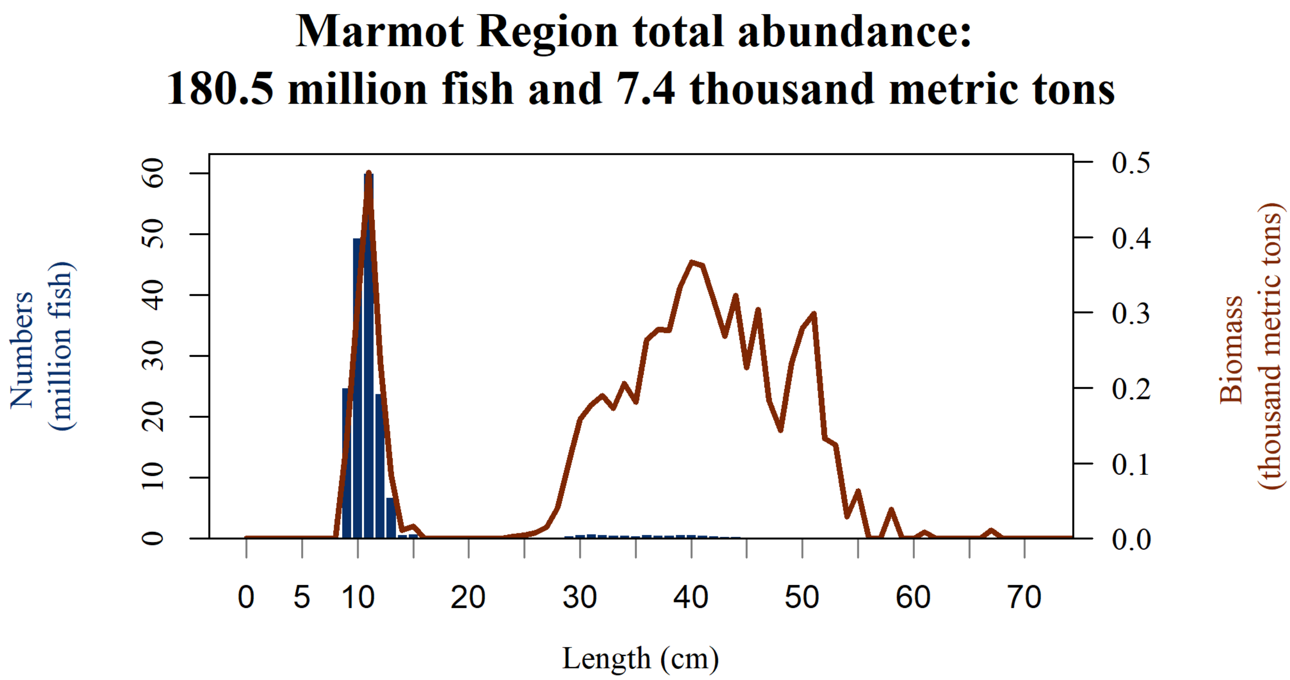
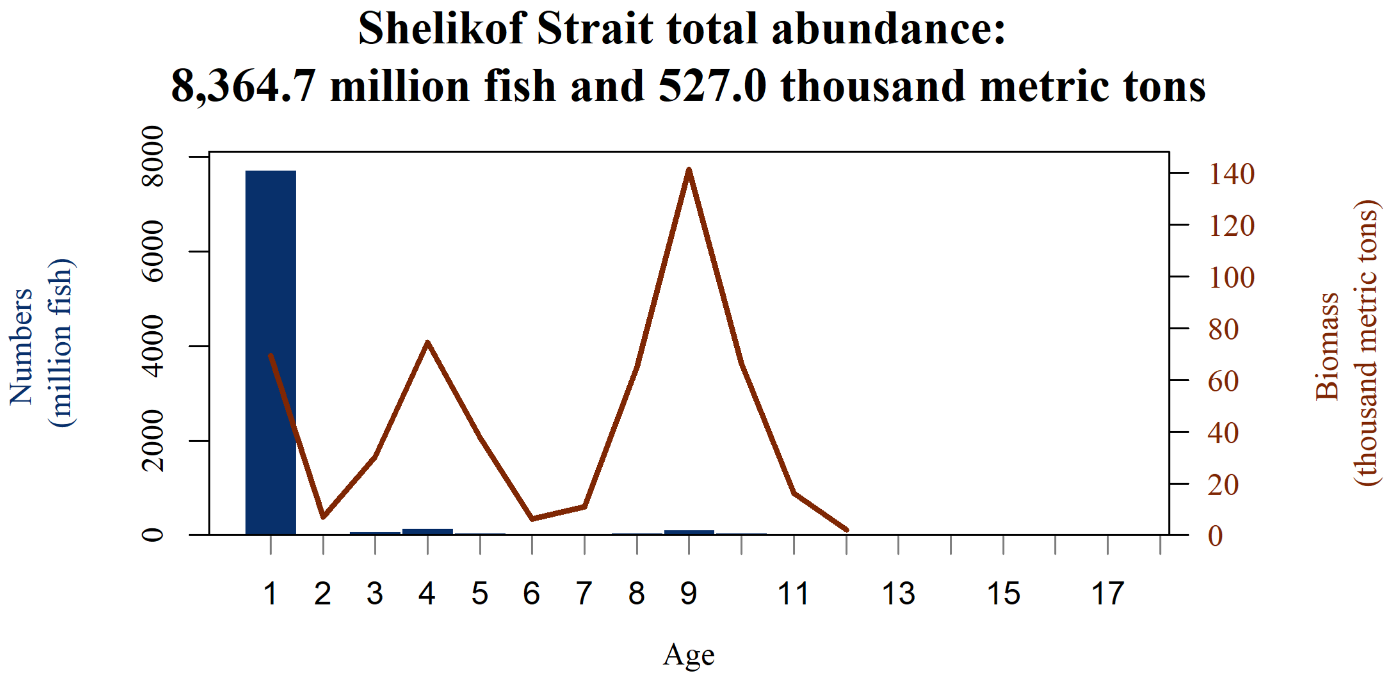


Figure 7. -- Numbers- and biomass- estimates of walleye pollock at length, shown with blue bars (million fish) and biomass estimates in red line (thousand metric tons) for the 2021 acoustic-trawl survey of Shelikof Strait and Marmot Region.



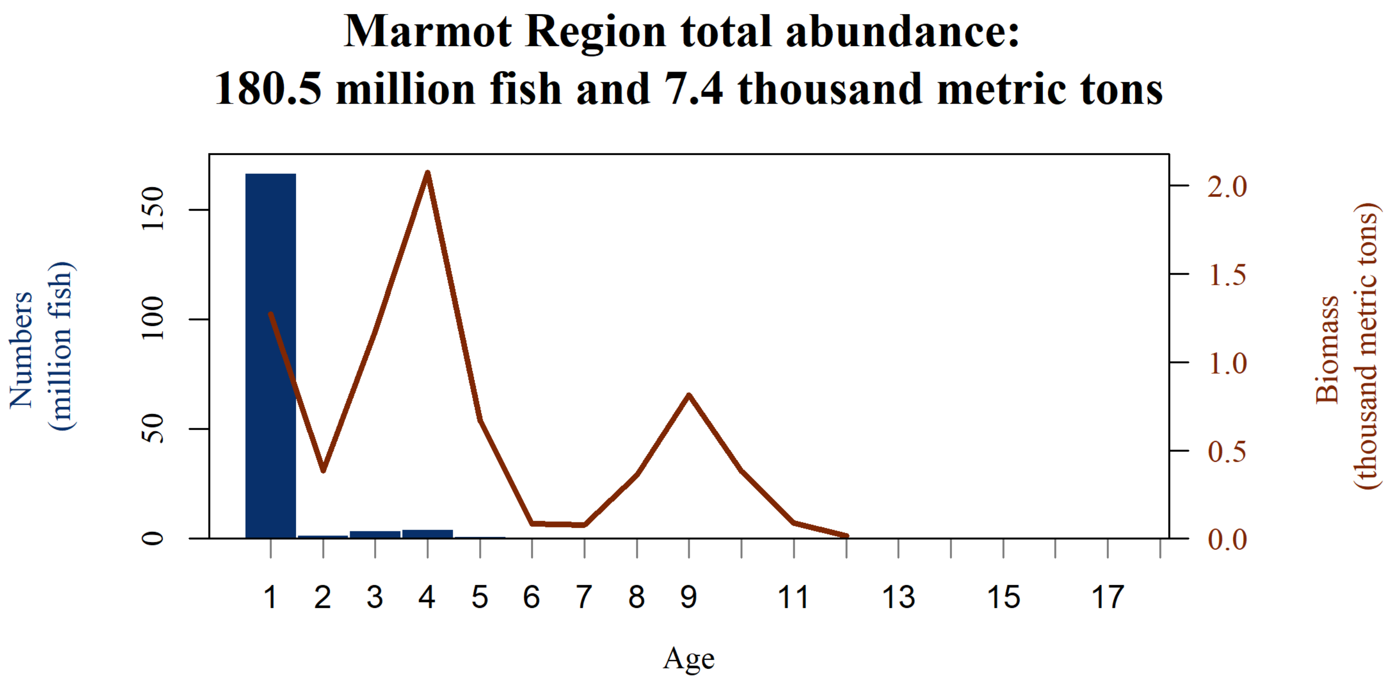


Figure 8. -- Numbers- and biomass- estimates of walleye pollock at age shown with blue bars (million fish) and biomass estimates in red line (thousand metric tons) for the 2021 acoustic-trawl survey of Shelikof Strait and Marmot Region.

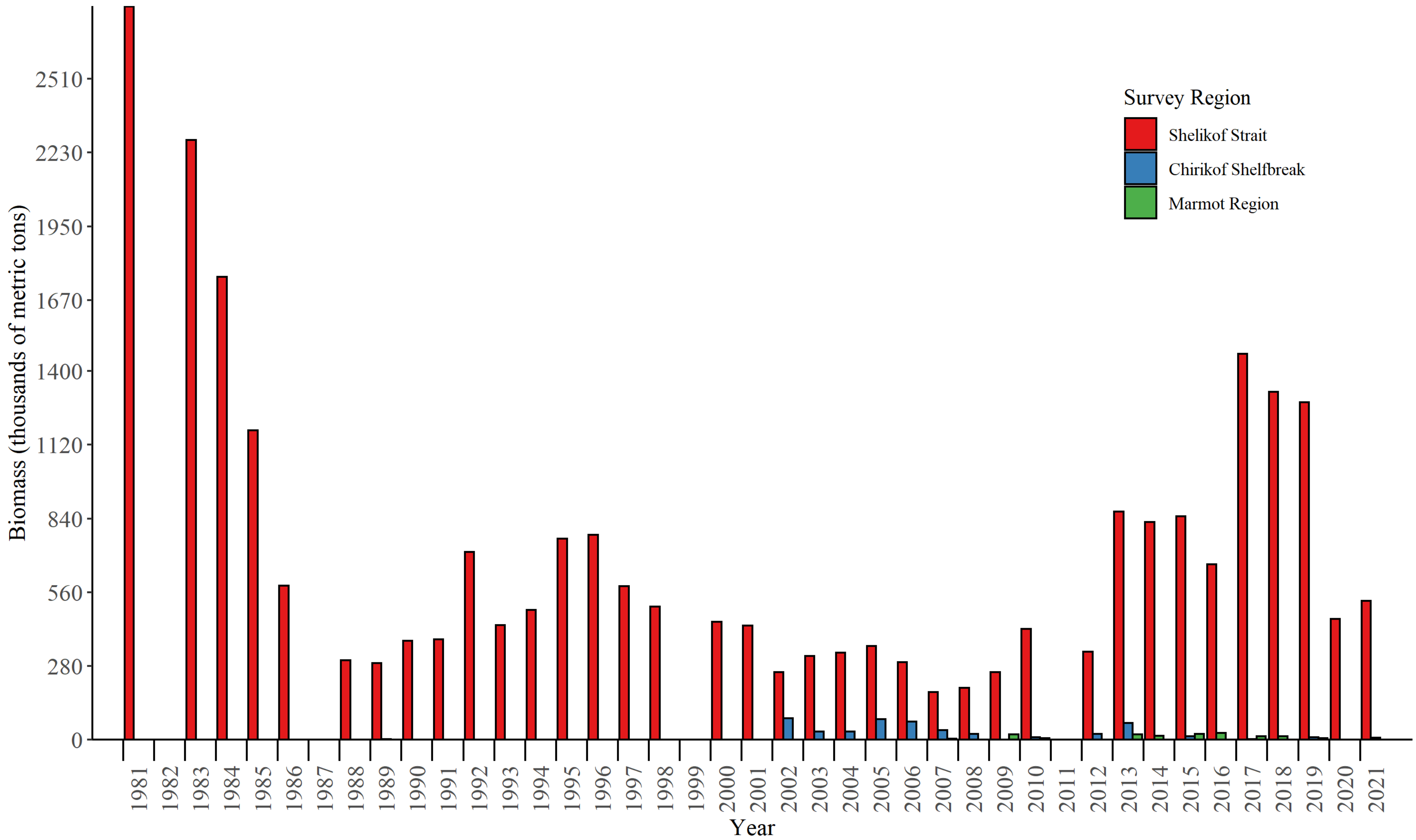


Figure 9. -- Summary of walleye pollock biomass estimates (thousands of metric tons) for the Shelikof Strait, Chirikof shelf break, and Marmot Bay areas based on acoustic-trawl surveys. Estimates for 2008 to 2021 include selectivity corrections for juvenile escapement (see text for explanation).

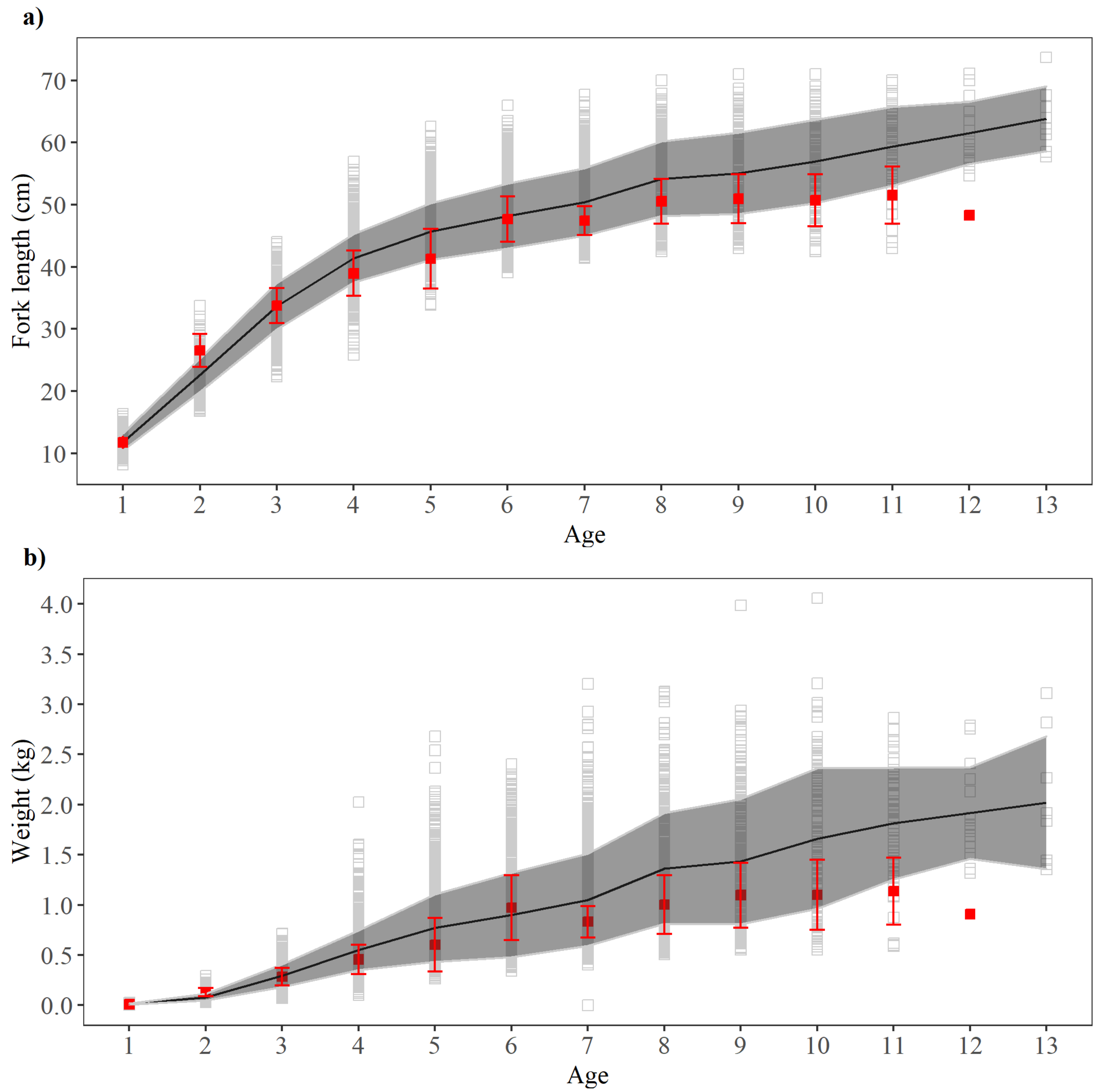


Figure 10. -- Walleye pollock a) length- and b) weight- at age for the Shelikof Strait. The 2021 survey is highlighted in red (mean ± 1 s.d). Gray squares indicate the range of observations in previous surveys, and the black line and gray ribbon indicate mean length- or weight- at age in previous surveys ± 1 s.d.

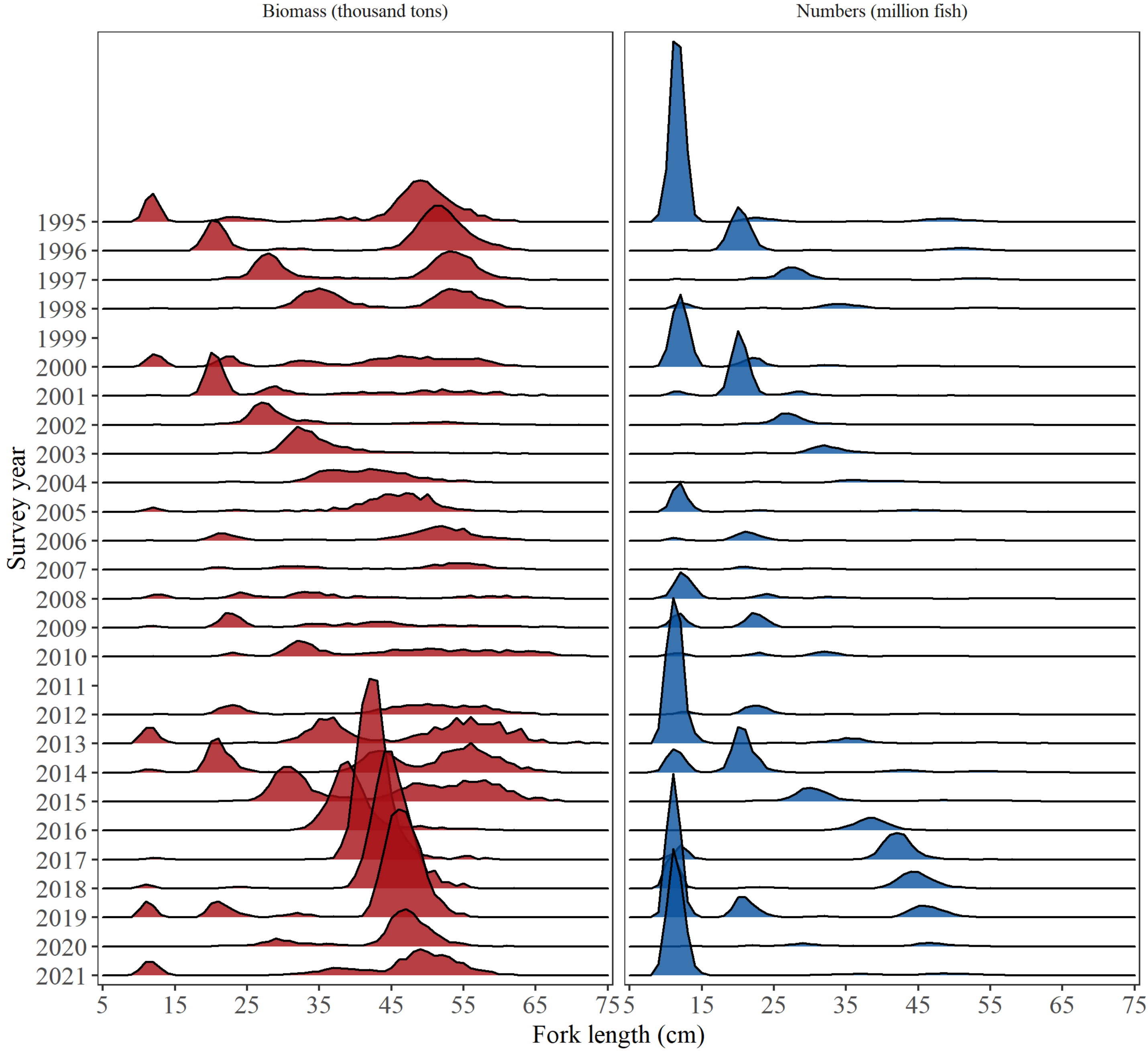


Figure 11. -- Time series of walleye pollock population length composition by weight (left panel, thousand tons) and numbers (right panel, million fish) from acoustic-trawl surveys of Shelikof Strait area since 1995. Estimates for 2008 to 2021 include selectivity corrections for juvenile escapement (see text for explanation).

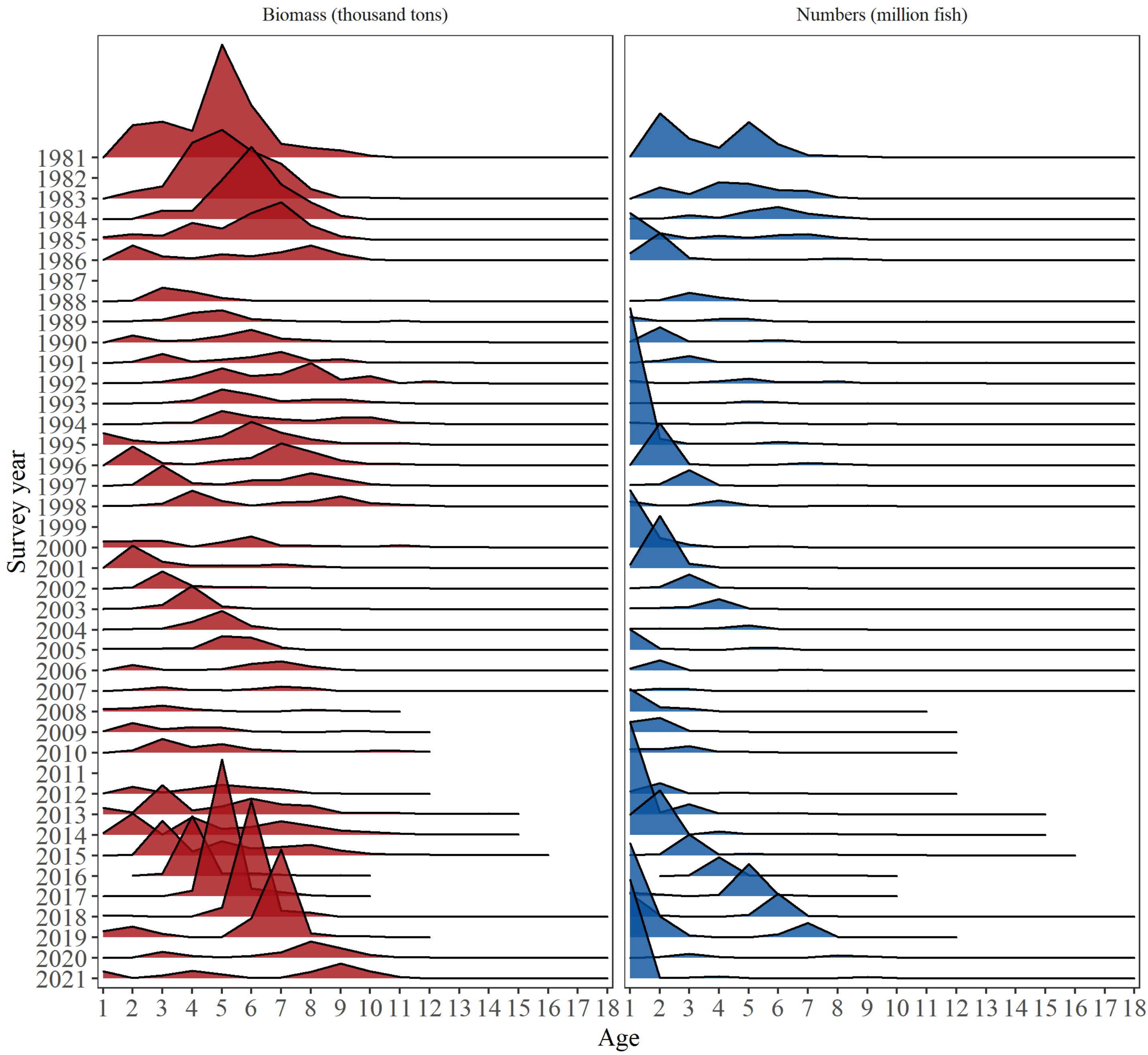


Figure 12. -- Time series of walleye pollock population age composition by weight (left panel, thousand tons) and numbers (right panel, million fish) from acoustic-trawl surveys of Shelikof Strait area since 1981. Estimates for 2008 to 2021 include selectivity corrections for juvenile escapement (see text for explanation).

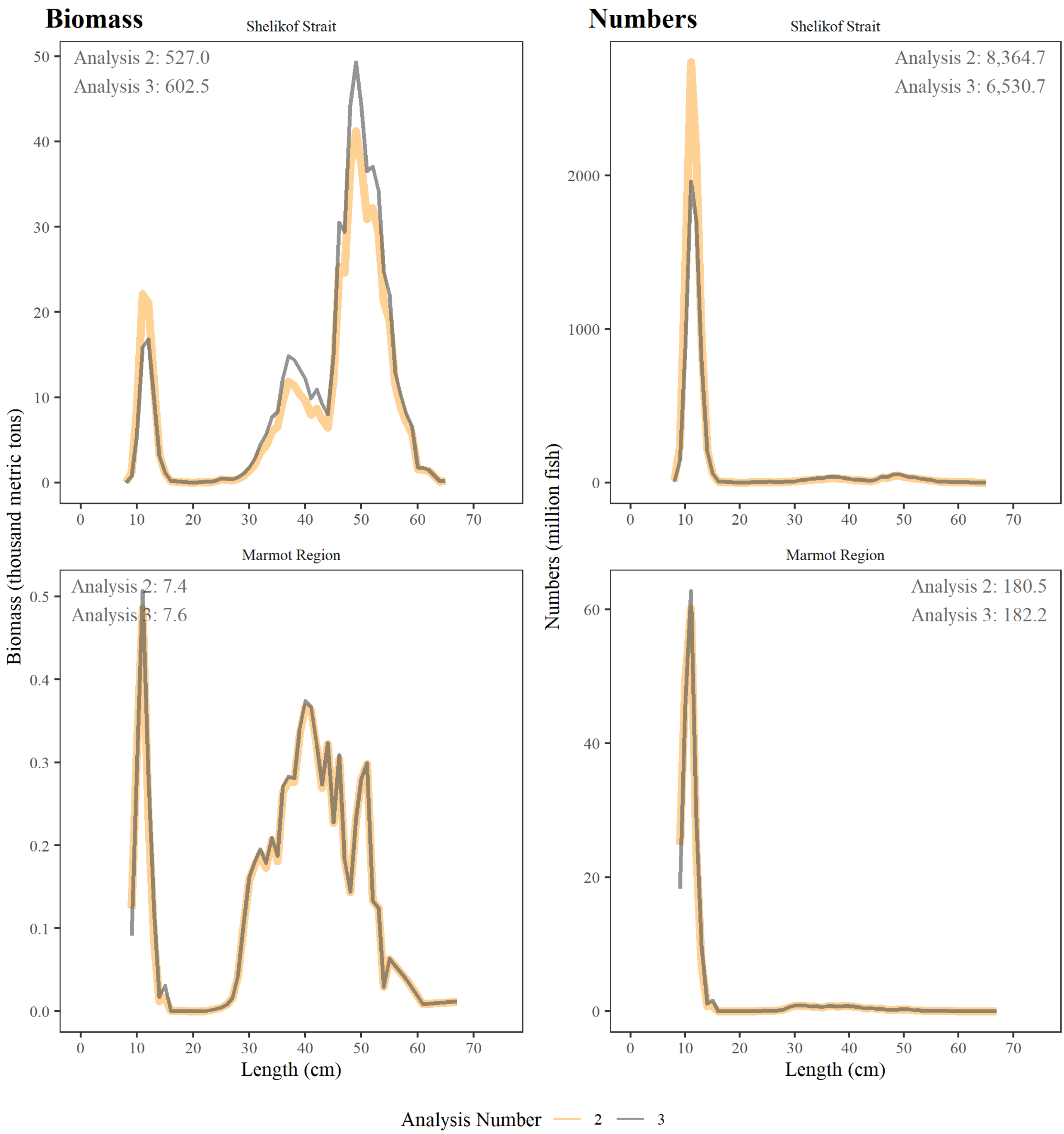


Figure 13. -- Numbers- and biomass- at length for the primary analysis (orange line, Analysis 2) compared with the non-selectivity corrected analysis (black line, Analysis 3) for the 2021 Shelikof survey. The total numbers (million fish) and biomass (thousand metric tons) are also presented for each analysis.

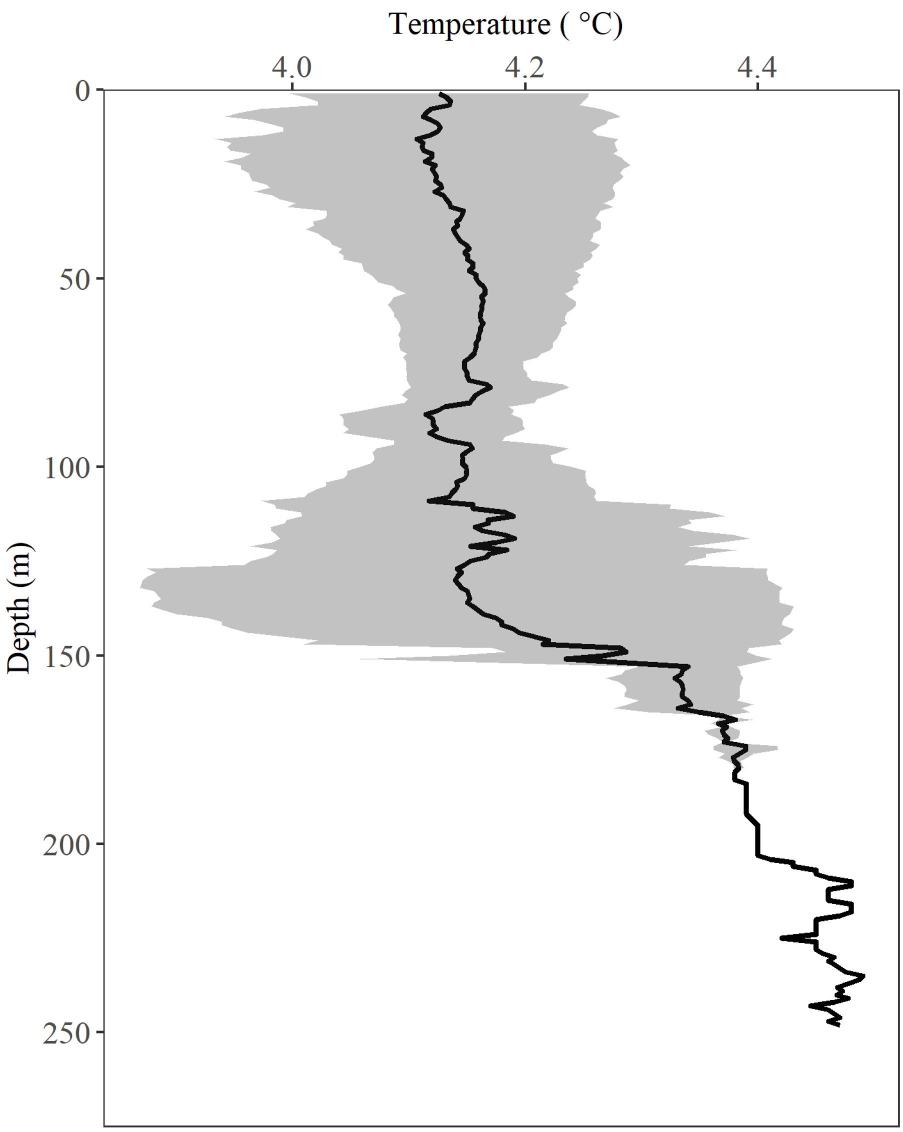


Figure 14. -- Mean water temperature (°C ; solid line) by 1-m depth intervals measured at five trawl haul locations during the 2021 acoustic-trawl survey of walleye pollock in the Marmot Bay area. The shaded area represents one standard deviation.

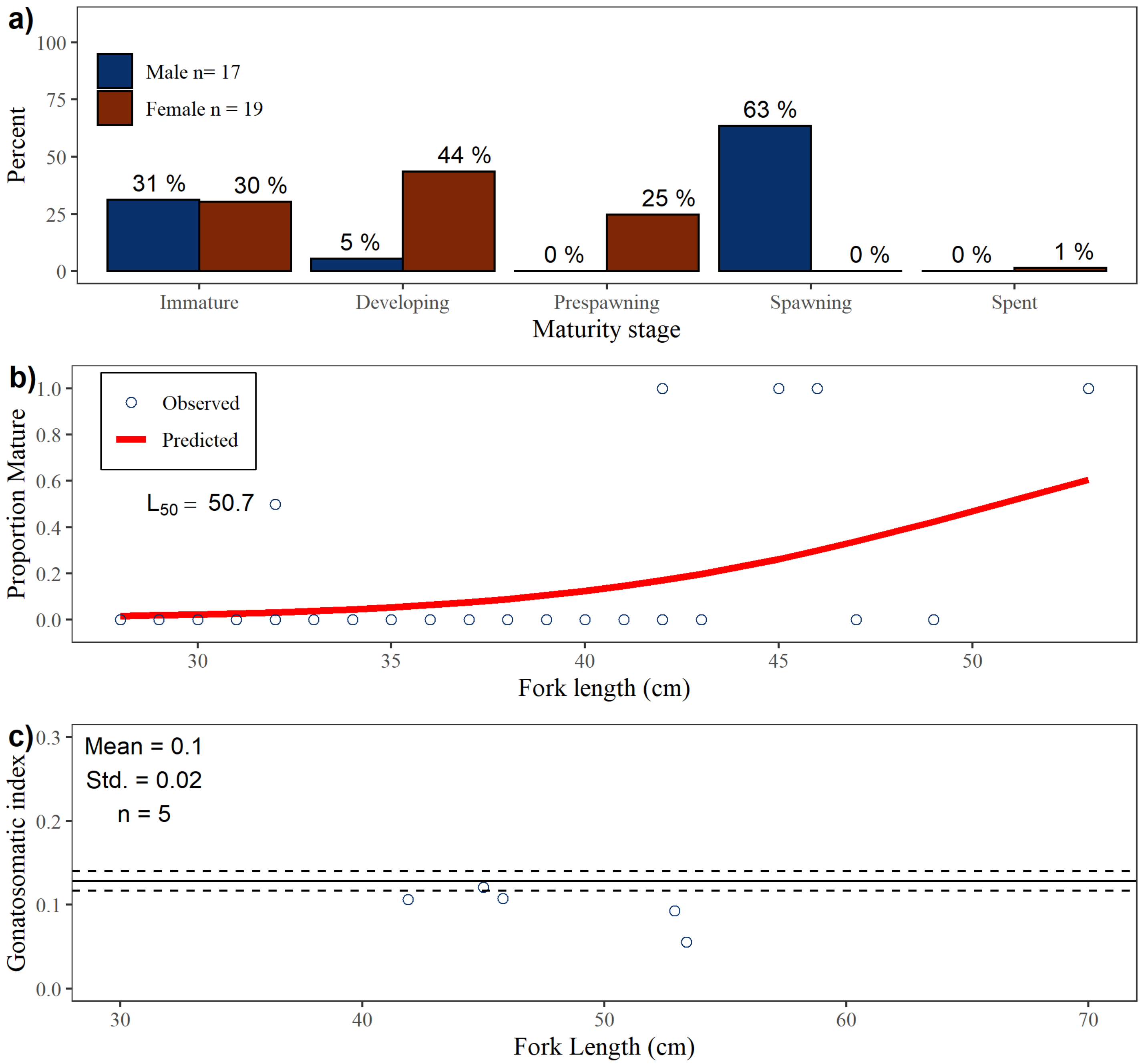


Figure 15. -- Walleye pollock maturity in the Marmot Region. a) Maturity composition for male and female walleye pollock greater than 40 cm FL within each stage; b) proportion mature (i.e., pre-spawning, spawning, or spent) by 1-cm size group for female walleye pollock; c) gonadosomatic index for females greater than 40 cm FL (with historic survey mean ± 1 std. dev.). All maturity quantities are weighted by local pollock abundance.

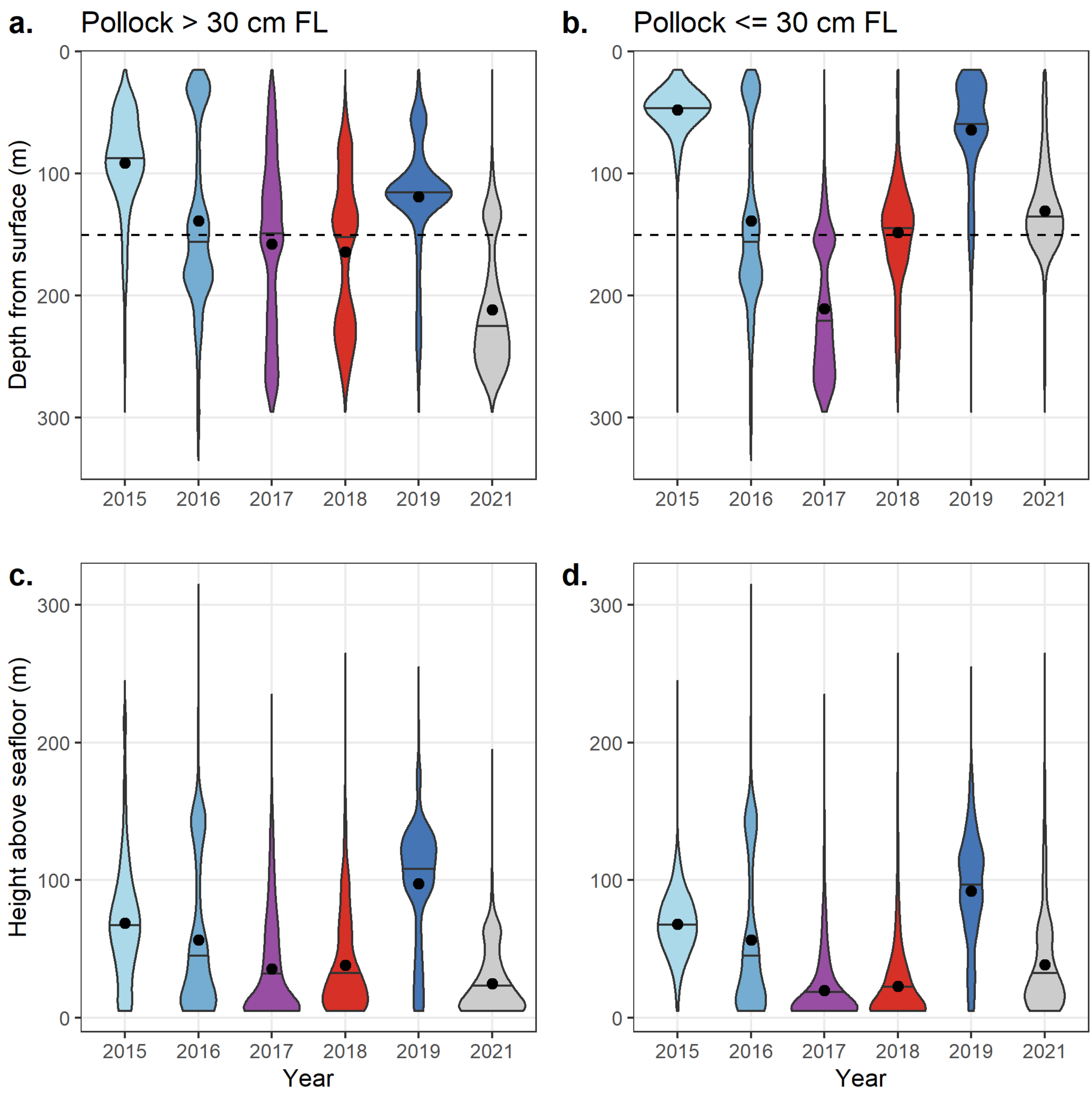


Figure 1616. -- Estimated biomass distributions of adult pollock (> 30 cm FL) and juvenile pollock (≤ 30 cm FL) depth (a. and b.) and height (c. and d.) above the seafloor in the Marmot Region 2021 acoustic-trawl survey. Results for the winter 2015 to 2020 acoustic-trawl surveys are included for comparison. 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 2021 is shown in a. and b. (dashed line). Plots show the probability density of pollock distribution, with median pollock depth noted by black horizontal lines, and the mean weighted pollock depth indicated by black points (MWD, in panels a) and b), and HAB, in panels c) and d)).

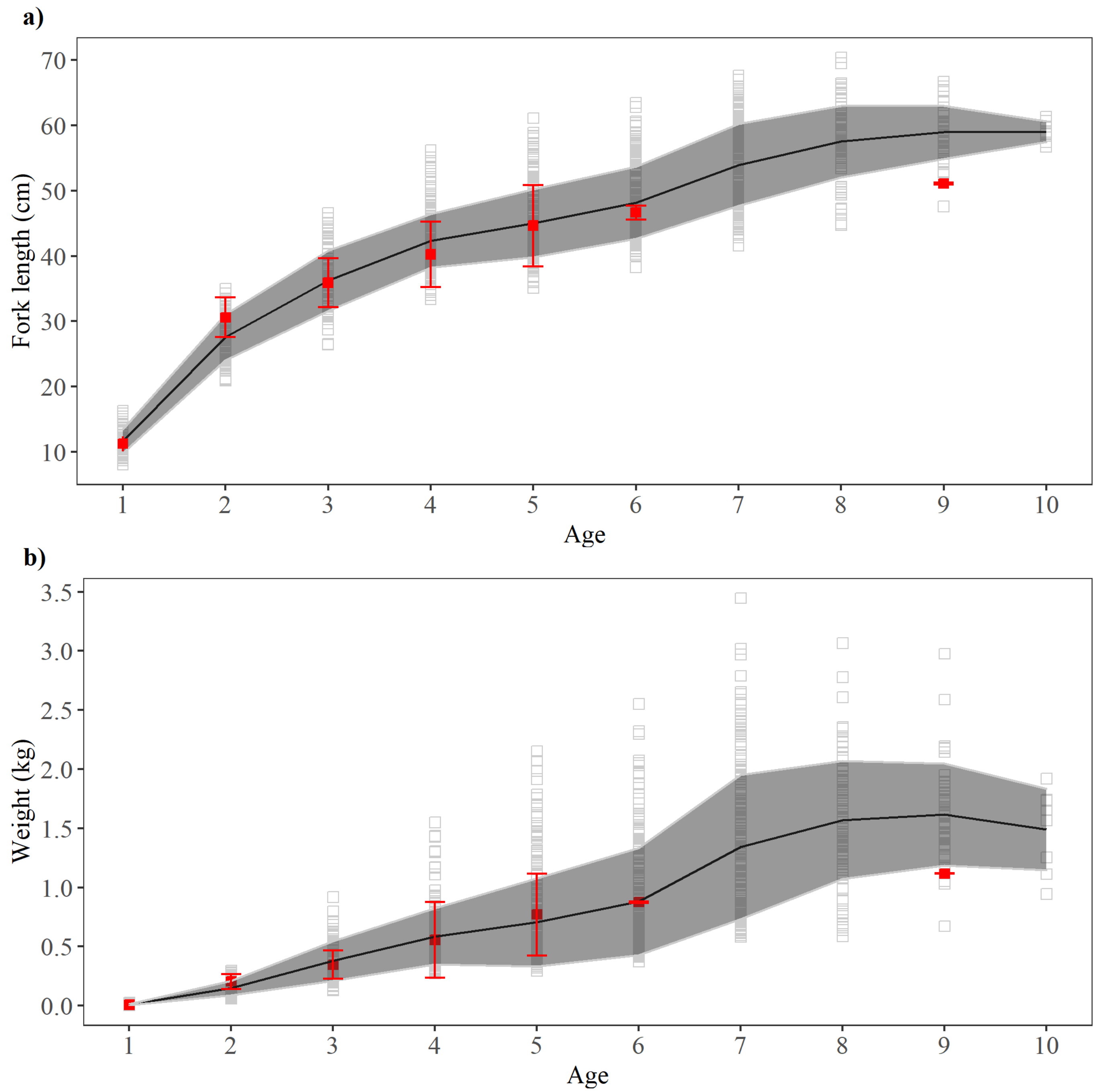


Figure 17. -- Walleye pollock a) length- and b) weight- at age for the Marmot Region. The 2021 survey is highlighted in red (mean ± 1 s.d). Grey squares indicate the range of observations in previous surveys, and the black line and grey ribbon indicate mean length- or weight- at age in previous surveys ± 1 s.d.

APPENDIX I. ITINERARY

Shelikof Strait and Marmot Bay

2-3 March	Depart Kodiak, AK. Calibration in Kalsin Bay, AK.
3-10 March	Acoustic-trawl survey of Shelikof Strait.
10-13 March	Return to northern transects in Shelikof Strait for selectivity data trawling.
13-15 March	Surveying in Marmot Bay.
15 March	Acoustic sphere calibration in Kalsin Bay, AK.
15 March	Arrive Kodiak, AK. End cruise.

APPENDIX II. SCIENTIFIC PERSONNEL

Name	Position	Organization
Darin Jones	Chief Scientist	AFSC-RACE
Scott Furnish	IT Spec.	AFSC-RACE
Matthew Phillips	Fishery Biologist	AIS
Ethan Beyer	Fishery Biologist	AIS
Denise McKelvey	Fishery Biologist	AFSC-RACE
Mike Levine	Fishery Biologist	AFSC-RACE
Allison Meyers	Fishery Biologist	AIS
Jacob Buck	Fishery Biologist	AIS

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,

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

The numbers of individuals of species *s* in length class *l* ($N_{s,l}$) captured in the nearest 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 ($P_{s.l,h}$)

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

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 Eq. ii. This correction accounts for escapement in the trawl catch. 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

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

where TS is the target strength (dB re m^2) of species *s* at size *l* (Table 1).

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,

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

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

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

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 an area encompassing a series of transect intervals *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) as follows:

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

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

where $W_{s,l}$ is the mean weight-at-length for species s in each 1 cm length *l* derived from length-weight regressions. 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).

The abundance at age was computed from $Q_{s,l,j}$, the proportion of j-aged individuals of species s in length class l, and the abundance of that species and age class in each surveyed interval follows

Numbers at age j: $N_{s,j} = \Sigma_i \, (Q_{s\ l,j} \times N_{s,l})$, Eqn. viii

Biomass at age j: $\mathrm{B}_{s,j} = \Sigma_i \, (Q_{s,l,j} \times B_{s,l})$. Eqn. ix

APPENDIX IV. SELECTIVITY CORRECTION

To account for the size and species dependent loss of organisms though the midwater survey trawl meshes ahead of the codend, or "mesh selection", length compositions were adjusted to that which would be expected from an unselective sampler. Species-specific selectivity relationships describing the probability of retaining a given sized individual were used for the most abundant species, and other species were pooled in broad taxonomic groups. Trawl selectivity S_l for each cm length class (l) of all species or species group caught was estimated by analyzing the catch of the codend and that of small recapture nets mounted on the outside of the trawl during the current survey using methods similar to those presented in Williams et al. (2011). A generalized linear mixed effects model (GLMM) was fitted with a logistic link function and binomial error where variation between tows in selectivity was modeled with random effects. S_l was then computed as

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

where L_{50r} is the length at which 50% of individuals were retained and *SR* is the selection range (i.e., range in length between 25% and 75% retention values).

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

$$N_{sp\_corr,l} = \frac{N_{sp,}}{S_l} \quad , \qquad \text{Eqn. xi}$$

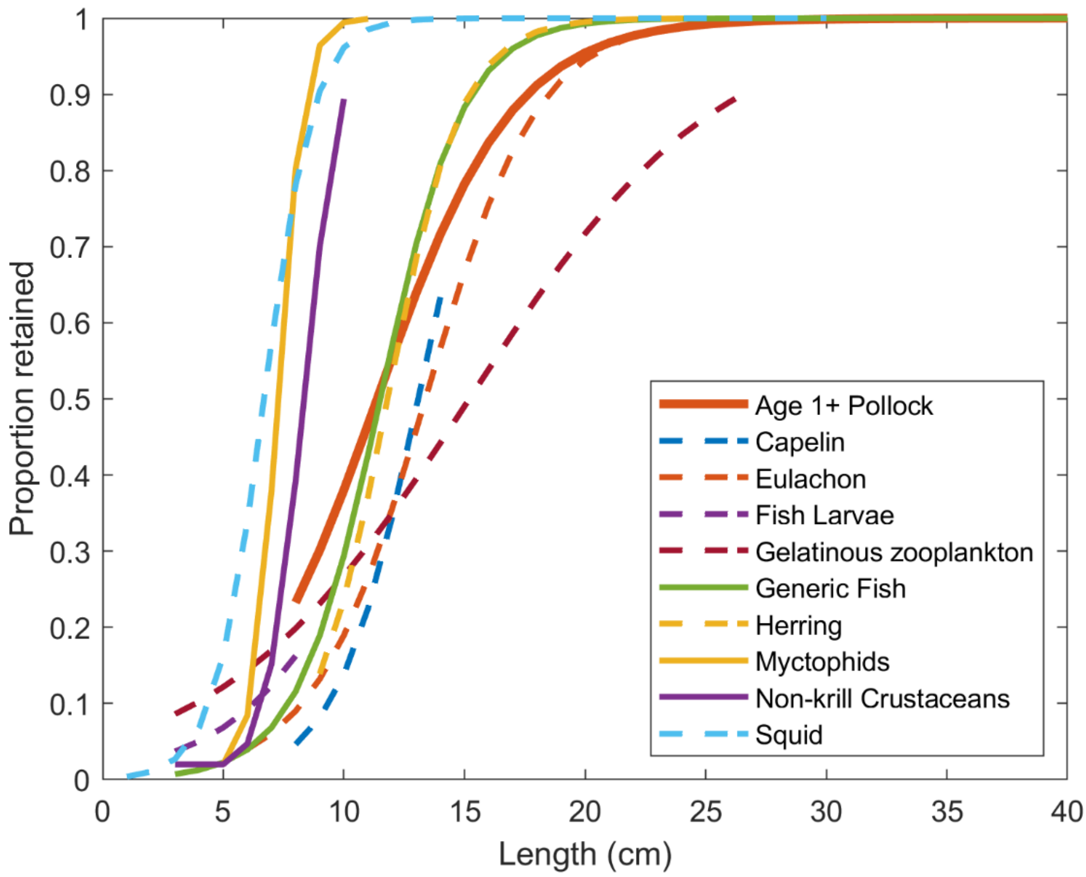
where $N_{sp\_corr,l}$ is the number of fish within a species that would be captured in an unselective sampler in the sampled population and $N_{sp,l}$ is the number of fish within that species in the 1 cm length class l in the trawl catch. In analyses with a selectivity correction applied, $N_{sp\_corr,l}$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

Selectivity curves for the most abundant taxa were estimated using the GLMM. Variance was estimated by multivariate normal resampling of selectivity parameters using the point estimates and variance-covariance matrix (n = 1,000). In the case of less abundant animals the catch data were too sparse for this approach. For less abundant groups, data were combined across all hauls and a model was fit to the cumulative GLM result. Variance for this approach was estimated by bootstrap (random sub-sampling with replacement) of the input data by haul (n = 1,000). The criteria for deciding which of these approaches was used was based on whether a selectivity group had at least ten hauls in which at least 20 individuals were encountered in the combined recapture nets. A simpler model estimating the ratio of biomass retained in the codend without length dependence was used for euphausiids because of their similar sizes, and reliable length estimates of retained individuals were not available, particularly from the codend where they were often damaged.

Selectivity curve estimates and their uncertainty are presented in Table A1 and Figure A1. For the GLMM some hauls with strong outlier estimates of selectivity were further excluded. For all curves, a minimum retention of 0.25% was enforced to prevent overlarge extrapolation errors with model values approaching 0%.

Appendix Table A1. -- Selectivity curve estimates of length at 50% retention (L_{50r}) and selection range (*SR*) from either the generalized linear mixed effects model (GLMM) or cumulative GLM for species and groups of species. Surveys used in estimating the selectivity are listed. All values are in cm. * indicates some values may be negative.

Selectivity group	Survey data used	Model used	Length at 50% retention (L_{50r})	L_{50r} 95% resample range*	Selection Range (*SR*)	*SR* 95% resample range*	Length range in haul and recapture nets
Age 1+ Pollock	DY2102	GLMM	11.38	10.44 – 11.98	6.22	4.26 – 11.21	11 - 60
Capelin	DY2001, DY2003	cumulative GLM	13.08	12.08 - 15.21	3.69	2.85 - 5.89	3 - 13
Eulachon	DY2001, DY2002, DY2003	GLMM	13.38	11.82 – 15.47	5.11	3.70 – 8.03	4 - 25
Fish Larvae	DY2003	cumulative GLM	13.06	-74.74 – 55.08	6.78	-89.99 – 47.08	4 - 9
Gelatinous zooplankton	DY1906	cumulative GLM	15.12	10.28 - 18.65	11.68	5.01 - 16.31	1 - 62
Generic Fish	DY2001, DY2002, DY2003	cumulative GLM	11.51	9.65 –15.11	3.79	2.53 – 7.48	2 - 67
Herring	DY2001, DY2003	cumulative GLM	11.81	11.20 – 16.33	3.38	1.83 – 11.78	7 - 23
Myctophids	DY1906, DY2002, DY2003	GLMM	7.26	6.46 – 10.54	1.16	0.56 – 6.47	5 - 21
Non-krill Crustaceans	DY1906, DY2002, DY2003	GLMM	8.34	-4.41 – 24.12	1.71	-7.29 – 14.55	5 - 11
Squid	DY1906, DY2001, DY2002, DY2003	cumulative GLM	6.69	5.46 – 9.27	2.26	1.60 – 3.34	1 - 32



Appendix Figure A1. -- Selectivity functions estimated for the DY2102 survey using recapture nets. Selection function values are only plotted for length ranges encountered for each selectivity group.

APPENDIX V. SHELIKOF HISTORICAL TIME SERIES WITH NO SELECTIVITY CORRECTION

Table 11. -- Numbers-at-length estimates (millions of fish) from acoustic-trawl surveys of walleye pollock in the Shelikof Strait area. Numbers from 1981 to 2007 have not been corrected for escapement of juveniles. Selectivity corrected estimates for surveys after 2007 are presented in Table 7.

Length	1981	1983	1984	1985	1986	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007
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
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
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
8	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	<1	0	0	0	<1	0	0	0
9	0	0	0	21	60	0	4	1	1	<1	<1	4	163	0	3	4	29	4	0	0	<1	6	4	<1
10	0	0	0	310	175	0	47	5	0	4	3	32	1120	3	3	16	372	33	0	1	10	106	36	4
11	2	0	1	581	206	4	133	16	4	27	16	51	3906	12	20	70	1162	87	0	8	15	476	61	14
12	10	1	60	810	102	8	153	16	9	74	26	60	3779	20	21	140	1565	87	5	14	24	621	39	20
13	26	1	0	278	32	4	50	9	4	79	13	33	1538	18	15	104	999	52	2	20	3	296	13	11
14	31	0	1	79	1	1	9	1	4	36	3	6	157	4	7	49	320	24	1	8	1	98	5	4
15	5	0	0	13	0	<1	3	<1	<1	6	1	<1	25	<1	1	10	30	2	1	1	<1	19	2	1
16	5	0	0	1	3	0	<1	0	<1	1	0	<1	1	5	<1	2	7	2	0	<1	<1	4	1	0
17	1	1	0	<1	7	0	0	4	<1	0	0	0	1	51	<1	<1	1	20	0	<1	<1	<1	7	2
18	5	1	0	1	41	1	<1	36	1	0	<1	1	4	249	1	<1	10	185	<1	0	<1	1	23	8
19	12	8	0	2	187	2	1	165	7	<1	<1	<1	16	634	1	1	32	808	3	1	1	2	75	24
20	70	70	0	6	444	8	2	341	12	1	4	2	39	945	8	3	81	1407	15	3	4	8	141	54
21	280	177	<1	20	535	26	7	362	33	2	8	5	68	772	23	10	147	1043	36	11	10	20	203	60
22	733	221	1	75	431	32	17	198	48	5	17	7	92	441	50	16	196	460	29	15	20	29	161	42
23	952	198	7	152	267	29	23	75	41	8	20	6	93	131	48	20	176	107	43	17	23	38	107	20
24	695	142	15	151	136	9	19	21	23	10	14	5	73	54	48	21	68	20	56	16	18	30	66	9
25	389	37	21	75	46	4	11	7	23	6	7	4	53	18	89	10	30	22	128	11	12	16	27	6
26	219	28	12	36	23	11	5	1	59	5	5	2	36	9	208	8	11	31	239	8	9	7	14	7
27	90	6	5	16	11	40	3	6	108	3	1	3	27	9	275	6	6	60	250	9	4	2	6	11
28	70	6	6	6	9	107	3	3	142	3	1	1	17	11	268	5	10	85	210	23	2	3	3	15
29	83	3	9	3	15	158	6	9	123	8	1	1	5	22	205	10	13	91	124	52	3	1	5	23
30	235	7	26	5	31	191	12	16	72	19	1	3	2	23	104	25	18	50	74	107	4	8	6	30
31	420	3	48	6	34	129	23	19	32	25	2	6	6	15	59	42	32	37	42	153	7	8	6	23
32	492	24	67	4	38	92	27	17	22	37	3	7	4	15	31	78	37	15	25	185	16	2	6	23
33	490	65	68	11	29	85	24	11	8	48	5	11	8	13	21	102	34	14	29	145	25	10	6	19
34	499	141	53	22	18	89	28	10	8	67	6	6	6	6	16	99	28	7	20	122	41	3	8	16
35	592	195	27	27	12	63	37	8	7	85	10	7	11	4	11	103	22	6	17	77	56	10	5	12
36	665	258	21	41	9	41	53	12	8	83	9	6	15	4	10	84	13	8	7	57	59	4	4	8
37	541	339	20	44	7	28	62	19	9	84	17	3	14	3	10	66	9	9	5	38	54	18	3	5
38	403	368	35	53	3	24	66	23	8	65	26	3	20	2	9	45	8	9	6	28	47	10	2	4
39	352	341	87	64	4	12	57	21	6	36	40	2	9	2	5	26	7	11	6	23	39	11	1	4
40	339	343	138	77	3	13	52	33	10	30	53	3	15	2	8	15	11	9	2	14	35	23	2	4
41	231	290	170	82	8	8	46	34	9	22	57	5	5	2	4	16	13	12	2	13	35	22	2	3
42	224	326	219	96	8	5	36	37	13	15	57	9	7	2	5	6	19	8	3	7	38	32	2	2
43	178	311	271	106	12	5	22	32	14	14	48	16	17	4	4	7	19	7	2	6	32	33	4	3
44	145	304	309	113	22	3	16	37	19	14	37	23	18	6	5	5	18	7	2	5	27	41	5	2
45	116	256	316	119	35	2	12	34	21	17	33	36	35	7	3	2	19	8	3	3	24	39	7	3
46	84	201	283	148	39	2	6	25	24	22	23	39	53	13	4	2	22	5	2	3	18	33	9	2

Length	1981	1983	1984	1985	1986	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007
47	113	171	213	140	50	2	6	23	22	21	19	46	62	25	4	3	19	5	3	3	17	37	11	3
48	62	116	158	139	57	2	4	20	26	32	17	37	74	37	6	4	17	6	4	2	11	33	14	3
49	75	91	104	117	52	3	5	16	20	38	16	33	73	53	13	6	13	9	3	2	8	22	15	4
50	58	52	68	83	51	4	5	15	19	46	17	29	66	64	20	13	16	8	3	2	7	28	18	6
51	50	49	40	52	42	4	4	8	20	40	15	24	51	69	30	18	10	5	4	2	5	14	19	8
52	25	23	25	28	21	3	4	8	14	38	14	21	40	64	36	24	11	9	4	2	4	7	19	6
53	12	17	13	23	18	3	5	7	13	35	14	24	30	53	37	26	10	6	3	2	2	6	16	9
54	9	7	4	9	6	2	4	5	9	35	13	18	22	39	34	23	9	4	3	1	3	4	12	7
55	15	9	3	4	11	2	2	7	10	30	11	18	16	29	28	20	9	5	2	1	3	3	13	8
56	5	2	2	2	2	2	1	2	6	15	9	18	14	19	24	19	8	5	1	<1	2	2	7	6
57	7	2	1	2	<1	1	1	2	3	18	7	13	7	13	12	12	9	3	1	<1	1	1	5	5
58	3	1	1	1	1	<1	1	1	5	14	7	11	6	10	8	9	6	2	1	<1	1	1	3	4
59	1	1	<1	1	<1	<1	1	1	2	4	4	9	3	6	5	8	5	3	1	1	1	1	3	3
60	0	1	<1	2	1	0	1	1	2	2	3	7	2	5	3	4	2	3	<1	1	<1	1	2	2
61	0	1	<1	<1	1	<1	<1	<1	1	2	2	5	1	3	2	2	1	1	<1	1	<1	<1	2	2
62	0	0	1	1	<1	<1	<1	<1	<1	3	1	2	2	2	1	2	2	<1	<1	<1	<1	0	1	1
63	0	0	1	1	<1	0	<1	<1	1	1	1	1	<1	1	1	2	1	1	<1	<1	<1	1	1	1
64	0	0	<1	0	<1	0	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
65	0	0	0	0	<1	0	0	<1	1	0	<1	1	<1	<1	<1	<1	<1	<1	<1	0	<1	<1	<1	<1
66	0	0	0	<1	<1	0	<1	<1	0	<1	<1	<1	0	<1	<1	<1	<1	1	0	0	0	<1	<1	<1
67	0	0	0	0	<1	<1	0	<1	<1	<1	<1	<1	0	<1	<1	0	<1	0	<1	<1	0	0	<1	<1
68	0	0	0	0	0	0	0	<1	0	0	<1	0	0	<1	<1	<1	0	<1	<1	0	<1	0	<1	<1
69	0	0	0	0	0	0	0	<1	1	0	<1	<1	0	<1	<1	0	0	0	0	0	0	0	0	<1
70	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
71	0	0	0	0	0	0	0	<1	0	0	0	<1	0	0	0	0	0	0	<1	0	0	0	0	<1
72	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	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
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
75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	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
Total	10121	5211	2928	4259	3352	1266	1119	1782	1109	1339	740	729	11931	4024	1866	1425	5742	4931	1424	1224	780	2252	1240	575

Table 12. -- Biomass-at-length estimates (thousands of metric tons) from acoustic-trawl surveys of walleye pollock in the Shelikof Strait area. Biomass from 1981 to 2007 have not been corrected for escapement of juveniles. Selectivity corrected estimates for surveys after 2007 are presented in Table 8.

Length	1981	1983	1984	1985	1986	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007
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
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
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
8	0	0	0	0	0	0	0	0	0	0	0	0	< 1	0	0	0	0	0	0	0	< 1	0	0	0
9	0	0	0	< 1	< 1	0	< 1	< 1	< 1	< 1	< 1	< 1	1	0	< 1	< 1	< 1	< 1	0	0	< 1	< 1	< 1	< 1
10	0	0	0	2	1	0	< 1	< 1	0	< 1	< 1	< 1	7	< 1	< 1	< 1	3	< 1	0	< 1	< 1	1	< 1	< 1
11	< 1	0	< 1	6	2	< 1	1	< 1	< 1	< 1	< 1	< 1	35	< 1	< 1	1	11	1	0	< 1	< 1	4	< 1	< 1
12	< 1	< 1	1	10	1	< 1	2	< 1	< 1	1	< 1	1	44	< 1	< 1	1	20	1	< 1	< 1	< 1	7	< 1	< 1
13	< 1	< 1	0	4	< 1	< 1	1	< 1	< 1	1	< 1	< 1	23	< 1	< 1	1	16	1	< 1	< 1	< 1	4	< 1	< 1
14	1	0	< 1	2	< 1	< 1	< 1	< 1	< 1	1	< 1	< 1	3	< 1	< 1	1	7	< 1	< 1	< 1	< 1	2	< 1	< 1
15	< 1	0	0	< 1	0	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1	< 1	< 1	< 1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
16	< 1	0	0	< 1	< 1	0	< 1	0	< 1	< 1	0	< 1	< 1	< 1	< 1	< 1	< 1	< 1	0	< 1	< 1	< 1	< 1	< 1
17	< 1	< 1	0	< 1	< 1	0	0	< 1	< 1	0	0	0	< 1	2	< 1	< 1	< 1	1	0	< 1	< 1	< 1	< 1	< 1
18	< 1	< 1	0	< 1	2	< 1	< 1	1	< 1	0	< 1	< 1	< 1	9	< 1	< 1	< 1	6	< 1	0	< 1	< 1	< 1	< 1
19	1	< 1	0	< 1	8	< 1	< 1	7	< 1	< 1	< 1	< 1	1	27	< 1	< 1	2	33	< 1	< 1	< 1	< 1	3	1
20	4	4	0	< 1	23	< 1	< 1	16	1	< 1	< 1	< 1	2	48	< 1	< 1	5	68	1	< 1	< 1	< 1	7	3
21	18	11	< 1	1	33	1	< 1	21	2	< 1	< 1	< 1	4	46	1	1	10	59	2	1	1	1	12	4
22	53	16	< 1	6	31	2	1	13	3	< 1	1	1	7	30	4	1	16	31	2	1	1	2	11	3
23	78	16	1	14	22	2	2	6	3	1	2	1	8	10	4	2	17	8	4	1	2	3	8	2
24	65	13	2	15	13	1	2	2	2	1	1	1	7	5	5	2	7	2	5	2	2	3	6	1
25	41	4	2	9	5	< 1	1	1	2	1	1	< 1	6	2	10	1	4	2	14	1	1	2	3	1
26	26	3	2	5	3	1	1	< 1	7	1	1	< 1	5	1	25	1	1	4	29	1	1	1	2	1
27	12	1	1	2	2	5	< 1	1	14	< 1	< 1	< 1	4	1	38	1	1	8	35	1	< 1	< 1	< 1	1
28	11	1	1	1	1	16	< 1	< 1	21	< 1	< 1	< 1	3	2	42	1	2	13	33	3	< 1	< 1	< 1	2
29	14	1	2	1	3	26	1	1	20	1	< 1	< 1	1	4	36	2	2	15	22	9	1	< 1	< 1	4
30	44	1	5	1	6	35	2	3	13	4	< 1	1	< 1	4	20	5	4	9	15	20	1	2	1	5
31	86	1	10	1	7	27	5	4	7	5	< 1	1	1	3	13	9	8	8	9	32	1	2	1	5
32	111	5	16	1	9	21	6	4	5	9	1	2	1	3	7	19	10	3	6	43	4	1	1	5
33	122	16	18	3	7	22	6	3	2	12	1	3	2	3	5	26	10	4	8	37	7	3	2	5
34	136	39	15	6	5	25	8	3	2	19	2	2	2	2	5	28	9	2	6	34	12	1	2	5
35	176	59	9	9	4	19	11	2	2	27	3	2	4	1	4	33	8	2	6	24	18	3	2	4
36	216	84	7	14	3	14	18	4	3	29	3	2	5	1	3	29	5	3	2	19	20	1	1	3
37	191	121	7	17	2	11	23	7	3	32	6	1	5	1	4	25	4	3	2	14	21	7	1	2
38	154	142	14	21	1	10	26	9	3	26	11	1	8	1	4	19	4	4	2	11	20	4	< 1	2
39	146	143	38	28	2	5	25	9	3	16	18	1	4	1	2	12	3	5	3	10	18	5	< 1	2
40	152	155	66	37	1	6	24	15	5	15	26	2	7	1	4	7	6	4	1	7	17	12	1	2
41	112	142	87	42	4	4	23	17	4	11	30	3	3	1	2	8	7	6	1	7	19	13	1	2
42	117	172	121	53	4	3	20	20	7	9	32	5	4	1	3	3	11	5	2	4	22	19	1	1
43	100	176	161	63	7	3	13	19	9	9	29	10	10	2	2	4	13	5	1	4	20	21	2	2
44	87	185	197	72	14	2	10	24	12	9	24	16	12	4	3	3	13	5	1	3	19	27	4	2
45	75	167	215	81	24	2	8	23	15	12	23	26	24	5	2	2	15	6	2	2	17	27	5	2
46	58	140	206	107	29	2	4	19	18	17	18	31	39	10	3	1	17	4	2	3	15	24	7	2
47	83	127	166	108	40	1	5	18	18	17	16	39	49	20	3	3	16	4	2	3	14	29	10	3
48	49	92	131	115	49	2	3	17	22	29	15	34	63	32	6	4	15	6	3	2	10	28	12	3
49	63	77	92	102	47	2	4	15	19	36	15	32	66	48	13	6	13	8	3	2	8	19	15	4
50	51	46	63	78	49	4	4	15	19	47	17	30	63	62	20	13	16	8	3	2	8	28	18	6
51	47	47	40	52	43	4	4	8	21	43	16	26	52	71	32	20	12	6	4	2	5	14	22	9
52	25	23	26	29	24	3	4	8	15	44	15	24	43	70	41	27	13	10	5	2	5	8	23	7

Length	1981	1983	1984	1985	1986	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007
53	13	19	15	26	21	4	5	8	15	43	17	29	34	62	45	32	12	8	4	2	3	7	20	11
54	11	8	5	10	7	3	5	6	12	45	17	23	26	48	44	30	13	6	4	1	4	5	16	10
55	18	11	4	5	14	3	2	9	14	41	15	24	20	38	38	27	12	7	3	2	4	4	19	11
56	6	2	2	3	3	2	2	3	9	22	13	27	19	27	35	28	12	8	2	< 1	3	3	10	9
57	10	3	2	3	< 1	1	2	4	5	28	11	21	10	20	19	18	13	5	2	< 1	1	1	8	8
58	4	1	1	1	2	1	1	2	7	24	12	19	10	15	13	15	11	4	2	1	2	2	6	8
59	1	1	< 1	2	1	1	1	2	3	8	7	16	4	11	8	13	8	6	2	2	1	1	6	5
60	0	1	< 1	3	1	0	1	2	4	4	5	13	3	9	5	8	4	6	1	1	< 1	1	4	4
61	0	1	1	< 1	1	< 1	1	1	1	4	3	9	3	5	4	4	2	3	1	1	< 1	< 1	4	3
62	0	0	2	1	1	1	< 1	< 1	1	5	2	4	3	3	2	3	3	1	1	< 1	< 1	0	2	2
63	0	0	2	2	< 1	0	< 1	< 1	1	3	1	3	< 1	2	2	4	1	3	< 1	< 1	1	1	2	2
64	0	0	1	0	< 1	0	< 1	< 1	< 1	1	< 1	2	1	1	< 1	1	1	1	< 1	1	< 1	< 1	1	1
65	0	0	0	0	< 1	0	0	< 1	3	0	< 1	2	< 1	1	< 1	1	< 1	< 1	< 1	0	< 1	< 1	< 1	1
66	0	0	0	< 1	1	0	< 1	< 1	0	1	< 1	< 1	0	< 1	< 1	1	< 1	3	0	0	0	1	< 1	< 1
67	0	0	0	0	1	1	0	< 1	< 1	1	< 1	1	0	< 1	< 1	0	< 1	0	< 1	< 1	0	0	< 1	< 1
68	0	0	0	0	0	0	0	< 1	0	0	< 1	0	0	< 1	1	< 1	0	1	< 1	0	< 1	0	< 1	< 1
69	0	0	0	0	0	0	0	< 1	2	0	< 1	< 1	0	< 1	< 1	0	0	0	0	0	0	0	0	< 1
70	0	0	0	0	0	< 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
71	0	0	0	0	0	0	0	< 1	0	0	0	< 1	0	0	0	0	0	0	< 1	0	0	0	0	< 1
72	0	0	0	0	0	0	0	0	0	0	0	0	0	< 1	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
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
75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	< 1	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
Total	2786	2278	1757	1175	586	302	290	375	380	713	436	493	764	777	583	505	449	433	257	317	331	356	294	181

Table 13. -- Numbers-at-age estimates (millions of fish) from acoustic-trawl surveys of walleye pollock in the Shelikof Strait area. Numbers from 1981 to 2007 have not been corrected for escapement of juveniles. Selectivity corrected estimates for surveys after 2007 are presented in Table 9.

Age	1981	1983	1984	1985	1986	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007
1	78	1	62	2092	575	17	399	49	22	228	63	186	10690	56	70	395	4484	289	8	48	53	1626	162	54
2	3481	902	58	544	2115	110	90	1210	174	34	76	36	510	3307	183	89	755	4104	163	94	94	157	836	232
3	1511	380	324	123	184	694	90	72	550	74	37	49	79	119	1247	126	217	352	1107	205	58	56	41	175
4	769	1297	142	315	46	322	216	63	48	188	72	32	78	25	80	474	16	61	97	800	159	35	12	30
5	2786	1171	635	181	75	78	249	116	65	368	233	155	103	54	18	136	67	42	16	56	357	173	17	10
6	1052	698	988	347	49	17	43	180	70	84	126	84	245	71	44	14	132	23	16	8	48	162	56	17
7	210	599	450	439	86	6	14	46	116	85	27	42	122	201	52	32	17	35	8	4	3	36	75	34
8	129	132	224	167	149	6	4	22	24	171	36	27	54	119	98	36	13	13	7	2	3	4	32	21
9	79	14	41	43	60	4	2	8	29	33	39	44	17	40	53	74	10	6	1	1	3	2	7	2
10	25	12	3	6	11	9	1	8	2	56	16	48	11	13	14	26	8	3	1	< 1	< 1	0	< 1	1
11	2	4	0	2	1	2	10	1	4	2	8	15	15	11	2	14	14	1	< 1	< 1	< 1	< 1	< 1	< 1
12	0	2	1	1	0	2	1	3	1	15	3	7	6	5	3	7	7	2	< 1	0	0	0	< 1	0
13	0	0	0	0	0	< 1	< 1	2	4	1	2	1	2	3	1	< 1	2	1	< 1	< 1	< 1	0	0	0
14	0	0	0	0	0	0	0	1	0	< 1	< 1	2	< 1	< 1	< 1	1	1	< 1	< 1	0	0	0	0	0
15	0	0	0	0	0	0	0	< 1	0	0	1	< 1	0	0	0	1	0	< 1	0	0	0	0	0	0
16	0	0	0	0	0	0	0	< 1	0	0	1	0	0	< 1	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	< 1	< 1	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	< 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	10122	5212	2928	4260	3351	1267	1119	1781	1109	1339	740	728	11932	4024	1865	1425	5743	4932	1424	1220	777	2252	1240	576

Table 14. -- Biomass-at-age estimates (thousands of metric tons) from acoustic-trawl surveys of walleye pollock in the Shelikof Strait area. Biomass from 1981 to 2007 have not been corrected for escapement of juveniles. Selectivity corrected estimates for surveys after 2007 are presented in Table 10.

Age	1981	1983	1984	1985	1986	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007
1	1	< 1	1	24	4	< 1	4	< 1	< 1	3	1	2	114	1	1	4	57	2	< 1	< 1	< 1	18	1	< 1
2	309	71	6	54	139	8	8	67	12	3	6	3	46	180	15	8	63	214	13	8	8	13	55	15
3	342	117	83	41	40	130	21	15	85	16	11	14	23	24	195	28	60	60	164	42	14	17	11	39
4	255	529	78	159	17	91	86	23	13	60	34	20	41	12	28	153	9	25	29	222	77	19	5	13
5	1068	650	373	109	56	31	111	61	33	144	136	127	83	50	13	53	54	27	12	25	179	132	14	9
6	496	455	684	253	41	9	27	120	54	68	90	75	220	73	53	12	107	24	16	7	35	119	63	22
7	133	332	331	353	76	6	12	36	106	92	28	48	116	212	61	39	17	40	9	5	4	29	87	47
8	92	94	161	138	140	6	4	24	23	194	43	34	55	132	120	47	17	18	8	2	3	4	43	30
9	68	11	36	35	58	5	3	9	36	36	46	64	19	48	67	95	15	8	2	2	4	3	10	3
10	19	12	3	6	11	11	1	11	3	71	21	68	15	17	20	33	11	5	1	1	< 1	0	1	2
11	1	5	0	2	2	2	12	1	6	3	10	21	20	16	3	21	22	2	1	< 1	< 1	1	2	1
12	0	1	1	1	0	3	1	4	1	21	4	10	7	7	5	10	11	3	1	0	0	0	1	0
13	0	0	0	0	0	< 1	< 1	2	7	1	3	2	3	4	1	< 1	4	1	< 1	< 1	< 1	0	0	0
14	0	0	0	0	0	0	0	1	0	1	1	4	1	< 1	1	1	2	1	< 1	0	0	0	0	0
15	0	0	0	0	0	0	0	< 1	0	0	1	< 1	0	0	0	1	0	< 1	0	0	0	0	0	0
16	0	0	0	0	0	0	0	< 1	0	0	1	0	0	< 1	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	< 1	1	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	< 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2786	2278	1757	1175	586	302	290	375	380	713	436	493	764	777	583	505	449	433	257	316	327	356	294	181

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