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Resource Assessment and Conservation Engineering Division

Results of the Acoustic-Trawl Survey of Walleye Pollock (*Gadus chalcogrammus*) in the Shelikof Strait March 2022 (DY2022-04)

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Results of the Acoustic-Trawl Survey of Walleye Pollock (*Gadus chalcogrammus*) in the Shelikof Strait, March 2022 (DY2022-04)

by

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ABSTRACT

Scientists from the Alaska Fisheries Science Center conducted an acoustic-trawl survey in the Gulf of Alaska from March 9 to March 16 to estimate the distribution and abundance of walleye pollock (*Gadus chalcogrammus*; hereafter pollock) at their primary spawning grounds. This pre-spawning pollock survey (202204) covered the Shelikof Strait area, which has been surveyed annually in winter since 1981 (except in 1982, 1989, and 2011).

The amount of pollock estimated in the Shelikof Strait area in 2022 was 667 million fish weighing 365,409 t. Pollock between 45 and 64 cm fork length (FL) were primarily composed of the 10-year-old 2012 year class (27% of total biomass). Pollock between 35 and 44 cm FL consisted primarily of 4- and 5-year-old fish from the 2018 and 2017 year classes (20 and 19% of the biomass, respectively). The 17 to 25 cm FL age-2 fish from the 2020 year class were numerically the most abundant (29% of total abundance), but contributed less than 3% to the total biomass. Very few age-1 pollock (< 16 cm FL) from the 2021 year class were observed (< 2% of total abundance).

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).

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. 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. Marmot Bay and the continental shelf break near Chirikof Island have frequently been included as part of the Shelikof survey since 2002, while the Shumagin Islands, Sanak Trough, Morzhovoi Bay, and Pavlof Bay have historically been surveyed in a separate winter survey since 1994. Due to the continuation of the global COVID-19 pandemic in 2022 as well as vessel mechanical issues, only Shelikof Strait was surveyed. This report presents the AT survey results from the survey of Shelikof Strait from 9 March to 16 March 2022.

METHODS

All activities were conducted aboard the NOAA ship *Oscar Dyson*, a 64-m stern trawler equipped for fisheries and oceanographic research. The survey followed established AT methods as specified in NOAA protocols for fisheries acoustics surveys and related sampling[1]. The acoustic units used here are defined in MacLennan et al. (2002). Survey itineraries are listed in Appendix I and scientific personnel in Appendix II.

Shelikof Strait was surveyed a few days earlier in 2022 (and in 2021, 2020) than in most other years because of the relatively high percentages of spawning and spent female pollock observed in the 2017, 2018, and 2019 winter Shelikof Strait surveys. An earlier start date was intended to increase the chances of surveying when most 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.

Ltd).

Acoustic Equipment, Calibration, and Data Collection

Acoustic measurements were collected with a Simrad EK80 scientific echosounder (Bodholt and Solli 1992, Simrad 2018). 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 was extended 9.15 m below the water surface.

Standard sphere acoustic system calibrations were conducted to measure acoustic system performance (Table 1). The vessel's dynamic positioning system was used to maintain the vessel location during calibration. 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 2.0.1) 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 (version 12.1.27, Echoview Software Pty Ltd).

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 trawl 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. Near-bottom backscatter was sampled with a poly Nor'eastern (PNE) bottom trawl, which is a 4-panel high-opening trawl equipped with roller gear and constructed with mesh sizes that range from 13 cm (5 in.) in the forward portion of the net to 8.9 cm (3.5 in.) in the codend. The PNE codend was also fitted with a heavy delta nylon 12.7 mm (1/2 in.) mesh, 6.4 mm (1/4 in.) square opening codend liner. Detailed specifications are described in Guttormsen et al. (2010).

The LFS1421 trawl was fished with four, 45.7 m (150 ft) bridles (1.9 cm (0.75 in.) dia.), 5 m^2 Fishbuster trawl doors (1,247 kg (2,750 lb) each), and 227 kg (500 lb) tom weights attached to each wingtip. Average trawling speed was 1.7 m s^{-1} (3.3 knots). LFS1421 trawl 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 trawl ranged from 16.0 to 34.5 m (52.5 to 113.2 ft) and averaged 19.9 m (65.2 ft) while fishing. Average trawling speed for the bottom trawl was 1.9 m s^{-1} (3.8 knots). Bottom trawl vertical net openings and seafloor contact were monitored with a Furuno CN-24 netsounder system mounted on the headrope. The vertical net opening of the bottom trawl averaged 8.0 m (26.2 ft).

A stereo camera system (Camtrawl; Williams et al. 2010) was attached to the starboard panel forward of the codend on the LFS1421 trawl. 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

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

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).

Physical oceanographic data collected during the cruise included temperature profiles obtained with a temperature-depth probe (SBE 39, Sea-Bird Scientific) attached to the trawl headrope. Additional temperature-depth measurements were taken from conductivity-temperature-depth (CTD) casts with a Sea-Bird CTD (SBE 911plus) system at the calibration site. Sea surface temperature data are measured using the ship's sea surface temperature system (SBE 38, Sea-Bird Scientific, 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 are 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 99.8% of the time in the Shelikof Strait survey. These 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. The planned transect start and end locations matched those from 2021, encompassing the largest area that has been historically sampled within Shelikof Strait in winter. The survey was conducted 24 hours per 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). Fork length (FL), body weight, sex (FL > 20 cm), 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.

Additional biological samples were collected for special projects. Pollock ovaries were collected from pre-spawning pollock to investigate interannual variation in fecundity of mature females (Sandi Neidetcher, Sandi.Neidetcher@noaa.gov), and from female pollock of all maturity stages for a histological study. Fin clips were taken from pollock to investigate the genetic population structure within spawning stocks (Ingrid Spies, Ingrid.Spies@noaa.gov), and gill tissues from pollock and Pacific cod (*Gadus microcephalus*) were collected for an evolutionary marker analysis (Einar Arnason, einararn@hi.is). Blood and tissue samples were also taken from pollock and cod to investigate the prevalence of antifreeze proteins (Chi-Hing Christina Cheng, c-cheng@illinois.edu).

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 associated 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 recapture nets; Williams et al. 2011). Third, backscatter was converted to estimates of abundance using the nearest-haul catch association (step 1) with sample corrections (step 2) and the expected backscatter from each organism given species

[3] 2023 Groundfish Survey and Species Codes. 2023. RACE Division, AFSC, NMFS, NOAA; 7600 Sand Point Way NE, Seattle, WA 98115. DOI: https://doi.org/10.25923/e95d-q341

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

Associating Size and Species Composition with Acoustic Backscatter

Acoustic backscatter was assigned to strata based on the appearance and vertical distribution of the aggregations in the echogram. Strata containing backscatter not considered to be from pollock (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 the 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.

Accounting for Catch from Non-Targeted Scattering Layers

As noted above, each trawl was associated with an acoustic stratum. However, trawls may capture animals while passing through non-targeted strata during the trawling process. For example, a trawl targeting a deep stratum may capture acoustically-relevant animals while passing through a shallower stratum during set and retrieval. Because trawls aggregate catch from all the strata sampled, animals from the shallow stratum could then be associated incorrectly with the deeper stratum during analysis. These animals should not be included in the catch that is applied to the deeper stratum.

To avoid incorrectly applying catch from different strata, Camtrawl images collected during LFS1421 trawls were used to identify catch depth and location in the water column. Camtrawl images were captured at a rate of approximately 1 s^{-1} and each image was tagged with collection time and depth. Analysts visually identified and counted animals present in every 100^{th} image (approximately one image per 1.5 minute of trawl time) using SEBASTES Stereo Image Analysis software (Williams et al. 2016). For every examined image, the analyst identified all visible fish to the lowest taxonomic level possible, and identified invertebrates to broad taxonomic group (i.e., 'jellyfish', 'squid', 'shrimp'). Images were then examined using custom Python applications to identify cases where the trawl retained catch from non-targeted layers. In rare, exceptional cases where it was evident that the trawl catch contained acoustically-relevant species and/or size classes from outside of the target stratum, these species and/or size class records were excluded during the analysis process from the trawl catch associated with the target stratum (see figs. 3 and 4 in Levine et al. *In prep*. for a summary of the review process).

Selectivity Correction

Previous research has found that smaller pollock are less likely to be retained in large midwater trawls than larger pollock (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. Net selectivity corrections to trawl species and size composition estimates have been incrementally implemented to winter Shelikof Strait AT surveys conducted since 2008 based on the survey vessel, how backscatter was allocated to species, and the type of midwater net used in the survey (Honkalehto et al. *In prep*., Lauffenburger et al. 2019, Stienessen et al. 2019, McCarthy et al. 2022). Trawl selectivity in the 2022 survey was estimated for all species observed in the codend using correction functions developed from catch data collected by recapture nets mounted on the LFS1421 trawl during the 2020 and 2021 winter Shelikof Strait AT surveys (see appendix IV in Honkalehto et al. *In prep*.). No selectivity correction has been estimated for the bottom trawl. The counts and weights of fish and other taxa 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. The probability of retention was calculated using either species-specific trawl selectivity correction functions for the most abundant species or more generic selectivity functions for less abundant species that were pooled together (De Robertis et al. 2017b, Honkalehto et al. *In prep*.). Thus, the 2022 survey estimates reflect adjustments to the trawl-derived estimates of species and size composition which incorporate the estimated escapement of all organisms from the catch (e.g., De Robertis et al. 2017a).

Abundance Calculations

A series of target strength (TS, dB re 1 m^2; the expected backscatter from each organism) to length relationships from the literature (Table 3) were used along with size and species distributions from selectivity-corrected trawl catches to estimate the proportion of the observed acoustic scattering attributable to each of the species captured in the trawls (Appendix III). For species for which the TS-length relationship was derived using a different length measurement type than the one used for measuring the trawl catch specimens, an appropriate length conversion was applied (e.g., total length to fork length). Species-specific TS-length relationships from the literature were used for pollock, Pacific capelin, eulachon, Pacific herring, and for any species whose contribution to the total backscatter used in survey estimates was > 5%. Otherwise, species were assigned one of five group TS-length relationships: fishes with swim bladders, fishes without swim bladders, jellyfish, squid, and pelagic crustaceans (Table 3).

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 (Appendix III). When < 5 pollock occurred within a 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 (Appendix III; Miller 1984, De Robertis and Williams 2008).

An age-length key and a proportion-at-age matrix were applied to the population numbers-at-length and biomass-at-length to estimate numbers and biomass at age (Appendix III; Jones et al. 2019). 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 the approximate 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 abundance A_h by the average abundance per haul $\overline{A}$:

$$W_h = \frac{A_h}{\overline{A}} \ , \qquad \text{Eqn. 1}$$

where

$$\overline{A} = \frac{\sum_h A_h}{H} \ , \qquad \text{Eqn. 2}$$

and H is the total number of hauls.

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

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

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

For each haul, the number of female pollock considered mature (pre-spawning, spawning, or spent) and immature (immature or developing) were determined for each cm length bin. The length at 50% maturity ($L50$) was estimated for female pollock as a logistic regression using a weighted generalized linear model following Williams (2007) with the inclusion of the haul weights, W_h, into the model (function glm, R Core Team 2021).

The gonadosomatic index, GSI_h, (GSI: ovary weight/total 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:

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

Relative Estimation Error

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):

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

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):

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

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 across-transect sampling variability of the acoustic data (Rivoirard et al. 2000). Other sources of error (e.g., target strength, trawl sampling) were not evaluated.

Spatial Patterns Analysis

To examine pollock horizontal distribution relative to prior surveys, geostatistical measures of the mean location (center of gravity, COG) and dispersion of the distribution around its COG (inertia) were calculated for each survey from 2008 to 2022 (Woillez et al. 2007). To account for interannual changes in survey coverage, COG and inertia were estimated using acoustic samples located within a standardized area of Shelikof Strait based on a minimum convex polygon that encompasses 95% of all samples collected between 2008 and 2022. The minimum convex polygon was estimated using the smoothed cross-validation bandwidth selector and kernel density estimator functions in the 'KS' R package (Duong 2022). COG and inertia were calculated using the 'RGeostats' R package (MINES ParisTech / ARMINES 2021).

Additional Analyses

A 'no-selectivity' 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 no-selectivity analysis was the same as the primary analysis described above, except that it did not include a selectivity correction (i.e., trawl selectivity S_l for each cm length class l of all species or species group was set to 1 (see Eqn. x, appendix IV in Jones et al. 2022).

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:

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

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 in a similar fashion:

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

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 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

Acoustic System Calibration

Pre-survey calibration measurements of the 38 kHz echosounder showed no notable differences in gain parameters or beam pattern characteristics for either the swing or the on-axis results compared to previous calibrations conducted during the 2022 gear trials (30 January in Port Madison, WA) and winter 2021 in Kalsin Bay, AK (Honkalehto et al. *In prep*.), therefore the acoustic system was assumed to have performed as expected throughout the survey (Table 1). The on-axis results are used to calculate gain, while the swing are used to verify that the beam pattern matches expectations. At 38 kHz the integration gain differed by < 0.14 dB across the measurements collected during the winter 2021 and 2022 calibrations. On-axis acoustic system gain and s_A correction values, and EK80 calibration utility 3 dB beamwidths and offset angles measured during the winter 2022 calibration were used with the nominal sound speed and absorption values appropriate for the survey areas in the final 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

Survey Timing and Extent

The 2022 winter AT survey of pre-spawning pollock in Shelikof Strait was conducted between 9 March and 16 March. The entire survey area encompassed 21,427 km^2 (6,247 nmi^2). Acoustic backscatter was measured along 1,525.8 km (823.9 nmi) of transects spaced mainly 13.9 km (7.5 nmi) apart, with spacing varying from 11.3 to 15.6 km (6.1 to 8.4 nmi) in the survey area (Fig. 1). Bottom depths in the survey area ranged from 43 to 326 m.

Trawl Catch Summary

Biological data and specimens were collected in Shelikof Strait from 19 LFS1421 and 1 PNE hauls (Tables 4, 5, 6; Fig. 1) targeted on backscatter attributed to pollock. The lengths of an average of 338 randomly selected pollock were measured from each haul, with an average of 38 individuals more extensively sampled for at least one of the following: body weight, maturity, and age (Table 7). A total of 762 otoliths used to estimate pollock ages were collected in the Shelikof Strait region (Table 7).

Pollock and eulachon were the most abundant species in the LFS1421 hauls, contributing 91.5% and 5.8% of the total catch by weight and 57.5% and 23% of the total catch by numbers, respectively (Table 5). Pollock and eulachon were also the most abundant species in the PNE haul, contributing 95.8% and 3.7% of the total catch by weight and 44.7% and 35.8% of the total catch by numbers, respectively (Table 6).

Pollock Maturity

Most female pollock in Shelikof Strait were in the pre-spawning stage of maturity and substantially fewer were spawning or spent, which suggests that the timing of the 2022 Shelikof Strait survey relative to the spawning period was appropriate. The maturity composition of females > 40 cm FL (n = 377) was 1% immature, 13% developing, 80% pre-spawning, 6% spawning, and 0% spent, while the maturity composition of males > 40 cm FL (n = 315) was 1% immature, 7% developing, 35% pre-spawning, 56% spawning, and 1% spent (Fig. 2a). The length at which 50% of female pollock > 20 cm FL were determined to be reproductively mature (i.e., pre-spawning, spawning, or spent) is 40.6 cm FL (Fig. 2b). The average GSI from 143 pre-spawning females was 0.15 ± 0.03 (Fig. 2c, mean ± standard deviation), which was within 1 standard deviation of the 2021 estimate (0.14 ± 0.02) and the historical mean (0.13 ± 0.03).

Distribution and Abundance

Adult pollock (defined as > 30 cm FL) were detected throughout the Strait, with the largest aggregations concentrated in the center of the sea valley south of Cape Igvak (Fig. 3). Compared to previous years adult pollock were notably less abundant along the Alaska Peninsula side of the Strait between Cape Nukshak and Cape Kekurnoi where large numbers of pre-spawning fish have been observed during most previous Shelikof surveys. Juvenile pollock (≤ 30 cm FL and largely comprised of age-2 fish from 2020 year class) that are typically found in large midwater aggregations shallower than but in proximity to adult aggregations in the middle portion of the Strait in prior surveys were observed near the ends of transects in the southern portion of the Strait distinctly separated from adult aggregations. The center of gravity for pollock biomass shifted 10 km to the west and 11.2 km to the south from the 2021 distribution, continuing a more pronounced shift of 45.7 km to the west and 41 km to the south from the historical mean center of gravity between 2008 and 2021 (Fig. 4). While similar southwestward shifts have occurred since 2008, such a pronounced contraction of the distribution's mean location, as indicated by the reduced inertia axes, is atypical for the past 15-year period (Fig. 4).

The mean weighted depth of most adult pollock (comprising 97.2% of total biomass) were detected between depths of 215–275 m below the surface (Fig. 5a). Most juvenile pollock (comprising 30.7% of total abundance) were between depths of 95–175 m (Fig. 5b). Height above bottom distributions indicated that adult pollock were primarily observed within 35 m of the seafloor with most juveniles found within 85 m and ranging up to 105 m (includes 95% of the biomass) off the seafloor (Fig. 5c, d). Adult pollock vertical distributions in 2022 were deeper than those in 2021 and deeper than in the prior 4 years (Fig. 5a, c), with about 38% of the biomass observed within 10 m of the seafloor, and 93% percent of biomass within 50 m of the seafloor (Fig. 5c).

A total of 666.6 million pollock weighing 365,408.7 t were estimated to be in Shelikof Strait at the time of the survey (Tables 8, 9, 10). The 2022 biomass decreased 30.7% from that observed in 2021 (526,973.8 t) and was 51.6% of the historical mean of 708.8 thousand tons (Table 8, Fig. 8). The 2022 survey biomass estimate is the lowest since 2012 (Fig. 8), while the relative estimation error of the 2022 biomass estimate based on the 1-D geostatistical analysis was 10.3%, which is the highest reported in the Shelikof Strait time series (Table 8).

Adult pollock with modal lengths of ~42 and 48 cm were most abundant by weight (Table 10, Fig. 6), and primarily composed of age-4, -5, and -10 fish from the 2018, 2017, and 2012 year classes that accounted for 19.9%, 18.7%, and 26.8% of total biomass, respectively (Table 12, Fig. 7). Age-2 pollock (modal length ~20 cm FL, 2020 year class) dominated in terms of numbers (29%) but only accounted for 2.7% of the biomass (Tables 11, 12; Figs. 6, 7). This is a notable decline in numbers and biomass of the 2020 year class from the 2021 survey when they were particularly numerous (99% of the catch by numbers) as age-1s (Table 11, Figs. 10, 11). In addition, very few age-1 pollock (< 17 cm FL, 2021 year class) were observed in 2022, accounting for only 1.7% of the numbers and ≤ 0.03% of the biomass of all pollock observed in Shelikof Strait (Figs. 6, 7). Compared to the same age groups from previous surveys (2008–2021), pollock length- and weight-at-age were similar to historical measurements for most age classes 9 years and younger (Fig. 9). Age-5 and -10 pollock were slightly shorter and lighter, while age-3 pollock were slightly longer, but all were within one standard deviation of previous measurements (Fig. 9). Age-7 pollock were lighter and age-11+ pollock shorter and lighter by more than one standard deviation, but these age classes were not abundant (Fig. 7).

Effects of Net Selectivity Corrections and Estimated Strength of 2021 Year Class

The results presented here account for escapement of organisms from the net based on the prior LFS1421 selectivity values obtained from catches in the codend and recapture nets from the 2020 and 2021 winter Shelikof Strait surveys. These results also reflect adjustments to the backscatter allotted to the target species by removing backscatter that would be attributable to other species based on the catch composition of the nearest haul and their estimated scattering properties. While this reflects analysis procedures in the winter Shelikof Strait survey time series since 2019, analyses in previous years have not fully taken these factors into account. Thus, an alternate analysis was conducted that would more closely approximate analyses in prior years for comparison, and resulting abundances are presented (Fig. 12). Specifically, an alternate analysis was conducted that did not include the effect of net selectivity (referred to as the ‘no-selectivity’ analysis below). This is similar to the comparison performed in 2021 to evaluate the effects of net selectivity corrections (Honkalehto et al. *In prep*.).

The no-selectivity analysis for 2022 generated an overall decrease of 0.8% by numbers (to 661 million) and an increase of 0.2% by weight (to 366,253 t) for pollock in the Shelikof

Strait area compared to the primary analysis (i.e., "selectivity corrected", Fig. 12). The negligible effect of net selectivity corrections on the 2022 primary analysis estimates is expected given the spatial separation between juvenile (≤ 30 cm FL) and adult (> 30 cm FL) pollock (Fig. 3), which resulted in relatively low mixing of juveniles (i.e., low retention in codend) with adults (i.e., high retention) in trawl catches (see Appendix IV in Honkalehto et al. *In prep*.).

Historic population trends in Shelikof Strait as observed by winter pre-spawning AT surveys track the strong year classes well through time starting from relatively small sizes and young ages (Figs. 10, 11). McKelvey (1996) showed that there was a strong relationship between the estimated number of age-1 pollock from the winter Shelikof Strait 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, therefore, the 2022 non-selectivity based estimate (Analysis 2) was used to classify the strength of the 2021 year class (age-1 pollock observed in 2022) in the context of the McKelvey index. This estimate was 6.1 million age-1 pollock, which is considered a low or weak year class based on the McKelvey index.

Environmental Conditions

Sea surface temperatures (SST) measured in Shelikof Strait in March 2022 indicate relatively average thermal conditions during the survey. SST ranged from 1.9°C to 4.8°C as measured by the ship's flow-through instrumentation along acoustic transects and averaged 4.1°C (Fig. 13). The along-transect mean SST was the same as observed during 2021 and 0.4°C warmer than the 2006–2021 historical mean (3.7°C). The average SST measured by the SBE 39 at all haul locations was 4°C (Table 4), which was 0.5°C warmer than the haul-based mean SST in 2021, 0.5°C warmer than the 2006–2021 historical mean, and 0.3°C warmer than the long-term 1980–2021 historical mean. Mean SST anomalies from both sources in 2022 were less than ± 0.5, indicating average conditions relative to the 2006–2021 period (Fig. 14).

The observed spatial separation between adult (> 30 cm FL) and juvenile (≤ 30 cm FL) pollock distributions was unexpected based on historical distribution patterns (Fig. 3), and coincided with a pronounced difference in water temperature profiles between hauls in which catches were mostly comprised of either adult or juvenile pollock (Table 4; Fig. 15). Mean temperature between the surface and deepest trawl (i.e., headrope) depth at all haul locations varied by approximately 1°C. While mean surface temperatures at haul locations in which catches were dominated by either adult and juvenile pollock were similar (< 0.1°C difference), headrope temperatures were cooler at the locations of hauls where juvenile pollock dominated catches (4 ± 0.1°C, mean temperature ± 1 SD for events 13, 15, 17, and 21; Table 4) compared to headrope temperatures for hauls dominated by adult pollock (5.2 ± 0.1°C; Fig. 15). The difference in temperature at fishing depth is not due to adult pollock being distributed in deeper waters within Shelikof Strait (Table 4); water temperatures between 100 and 150 m within Shelikof Strait where adults occurred were approximately 1°C warmer than waters in that depth range near the ends of transects where juvenile pollock were concentrated (Fig. 3).

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Table 1. -- Simrad EK80 38 kHz acoustic system description and settings used during the 2022 winter Shelikof Strait acoustic-trawl survey. These include environmental parameters and results from the standard sphere acoustic system calibration conducted in association with the survey and final values used to calculate biomass and abundance data. The collection settings column contains 8 March EK80 calibration utility results. Other columns are a combination of on-axis and EK80 calibration utility results (see Methods and Results and Discussion sections of text for details).

		Survey collection settings	8 March Kalsin Bay Kodiak	Final analysis settings
Echosounder		Simrad EK80	--	Simrad EK80
Transducer		ES38-7 s/n 324	--	ES38-7 s/n 324
Frequency (kHz)		38.00	--	38.00
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
	Athwart	18.00	--	18.00
2-way beam angle (dB re 1 steradian)		-20.70	-20.70	-20.52
Gain (dB)		27.14	27.05	27.05
s_A correction (dB)		-0.04	-0.04	-0.04
Integration gain (dB)		27.10	27.01	27.01
3 dB beamwidth	Along	6.42	6.42	6.42
	Athwart	6.48	6.48	6.48
Angle offset	Along	-0.03	-0.03	-0.03
	Athwart	0.04	0.04	0.04
Post-processing S_v threshold (dB re 1 m^{-1})		-70.00	--	-70.00
Measured standard sphere TS (dB re 1 m^2)		--	-42.15	--
Sphere range from transducer (m)		--	20.72	--
Absorption coefficient (dB/m)			0.009826	0.009861
Sound velocity (m/s)			1463.9	1466.0
Water temperature at transducer (°C)		--	4.25	--

Note: Gain and beam pattern terms are defined in the Operator Manual for Simrad EL80 Scientific echosounder application, which is available from Simrad Strandpromenaden 50, Box 111, N-3191 Horten, Norway.
-- symbol indicates the same values for the system settings and final analysis are also applicable for the various calibrations.

Table 2. -- Selectivity curve estimates of length at 50% retention (LR50) and selection range (SR) from either the generalized linear mixed effects model (GLMM) or cumulative generalized linear model (cum. GLM) for species and groups of species. Surveys used in estimating the selectivity are listed. All values are in centimeters.

Selectivity group	Survey data used	Model used	Length at 50% retention (*LR*50)	*LR*50 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
Pacific capelin	DY2001, DY2003	cum. 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	cum. GLM	13.06	-74.74 – 55.08	6.78	-89.99 – 47.08	4 - 9
Gelatinous zooplankton	DY1906	cum. GLM	15.2	10.28 - 18.65	11.34	5.01 - 16.31	1 - 62
Generic fish	DY2001, DY2002, DY2003	cum. GLM	11.51	9.65 –15.11	3.79	2.53 – 7.48	2 - 67
Pacific herring	DY2001, DY2003	cum. 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	cum. GLM	6.69	5.46 – 9.27	2.26	1.60 – 3.34	1 - 32

Table 3. -- 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 cm 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
Pollock	$TS = 20 \log_{10} L - 66$	L = fork length	*Gadus chalcogrammus*	Foote and Traynor (1988), Traynor (1996)
Pacific capelin	$TS = 20 \log_{10} L - 70.3$	L = total length	*Mallotus catervarius*	Guttormsen and Wilson (2009)
Pacific herring[1]	$TS = 20 \log_{10} L - 2.3 \log_{10}(1 + depth/10) - 65.4$	L = fork length	*Clupea harengus*	Ona (2003)
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 and Horne (2004)
Jellyfish	$TS = 10 \log_{10}(\pi r^2) - 86.8$	r = bell radius	*Chrysaora melanaster*	De Robertis and 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 and Horne (2004)
Pelagic crustaceans[2]	$TS = A * (\log_{10}(BkL)/(BkL))^c + D((kL)^6) + E((kL)^5) + F((kL)^4) + G((kL)^3) + H((kL)^2) + I(kL) + J + 20 \log_{10}(L/L_0)$	L = total length	*Euphausia superba*	Demer and Conti (2005)

[1] *depth* (m) is fixed at 75 m

[2] A = -930.429983; B = 3.21027896; C = 1.74003785; D = 1.36133896 x 10^{-8}; E = -2.26958555 x 10^{-6}
F= 1.50291244 x 10^{-4}; G = -4.86306872 x 10^{-3}; H = 0.0738748423; I = -0.408004891; J = -73.9078690; and L_0 = 0.03835
If L < 15 m, TS = -105 dB; and if L > 65 m, TS = -73 dB.
k = 2πfc, where f = 38,000 (frequency in Hz) and c = 1470 (sound speed in m/s).

Table 4. -- Trawl stations and catch data summary from the winter 2022 acoustic-trawl survey of pollock in the Shelikof Strait regions.

Haul	Area	Gear	Date	Time	Duration	Start Position		Depth (m)		Temp (°C)		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	9-Mar	19:37	21.6	58.3267	-153.1601	190	223	5.2	4.5	225.7	495	31.9
2	Shelikof Strait	LFS1421	10-Mar	08:14	24.2	58.0464	-153.6767	184	226	5.2	4.3	639.0	1,165	237.1
3	Shelikof Strait	LFS1421	10-Mar	14:53	12.0	57.9900	-154.3858	256	298	5.1	3.3	199.8	376	80.4
4	Shelikof Strait	LFS1421	10-Mar	21:14	8.4	57.7969	-154.1827	201	227	5.2	4.2	434.3	794	96.5
5	Shelikof Strait	LFS1421	11-Mar	06:25	4.2	57.7715	-154.5698	186	219	5.2	4.4	497.2	844	145.7
6	Shelikof Strait	LFS1421	11-Mar	11:09	11.2	57.7822	-155.0010	247	313	5.0	3.2	566.3	668	7.4
7	Shelikof Strait	LFS1421	11-Mar	17:48	7.4	57.5573	-154.8060	199	253	5.2	4.4	392.1	758	59.6
8	Shelikof Strait	LFS1421	11-Mar	22:58	6.8	57.6192	-155.3614	246	320	5.0	3.5	997.3	1,026	5.3
9	Shelikof Strait	LFS1421	12-Mar	07:18	7.4	57.3033	-155.2432	211	243	5.4	4.1	296.1	423	93.4
10	Shelikof Strait	LFS1421	12-Mar	11:24	10.3	57.3767	-155.6222	241	289	5.3	4.3	1,117.2	1,391	39.9
11	Shelikof Strait	PNE	12-Mar	21:39	5.3	57.1181	-155.6471	253	275	5.4	4.1	293.4	396	13.0
12	Shelikof Strait	LFS1421	13-Mar	03:33	6.7	57.0024	-155.7568	255	288	5.3	4.3	1,423.2	1,628	219.0
13	Shelikof Strait	LFS1421	13-Mar	07:57	3.2	56.8712	-155.1094	96	130	3.9	4.1	313.7	4,890	5.9
14	Shelikof Strait	LFS1421	13-Mar	13:21	4.6	56.8883	-155.8449	269	306	5.4	3.7	1,716.4	1,978	52.6
15	Shelikof Strait	LFS1421	13-Mar	18:49	9.0	56.8567	-156.3461	102	186	4.0	3.7	1,858.8	35,416	1.2
16	Shelikof Strait	LFS1421	14-Mar	18:04	3.0	56.6556	-156.0261	266	299	5.4	4.1	1,186.3	1,178	18.4
17	Shelikof Strait	LFS1421	15-Mar	05:01	10.8	56.5112	-156.6103	146	178	4.1	4.1	161.7	3,040	3.8
18	Shelikof Strait	LFS1421	15-Mar	12:18	45.1	56.2537	-156.0287	201	235	5.4	3.9	540.6	1,035	50.3
19	Shelikof Strait	LFS1421	15-Mar	21:28	30.5	56.0147	-156.1398	173	201	5.3	4.1	59.8	128	32.2
21	Shelikof Strait	LFS1421	16-Mar	06:25	3.1	55.8766	-156.7865	142	176	4.1	4.0	83.1	1,492	2.7

[a]LFS1421 = LFS1421 midwater trawl, PNE = poly Nor'eastern bottom 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 5. -- Catch by species and numbers of length and weight measurements taken from 19 LFS1421 hauls during the 2022 acoustic-trawl survey of pollock in Shelikof Strait.

		Catch				Measurements	
Species name	Scientific name	Weight (kg)	%	Number	%	Length	Weight
pollock	*Gadus chalcogrammus*	12,708.4	91.5	58,725	57.5	6,378	1,226
eulachon	*Thaleichthys pacificus*	805.9	5.8	23,479	23.0	611	176
magistrate armhook squid	*Berryteuthis magister*	196.6	1.4	393	0.4	212	127
chinook salmon	*Oncorhynchus tshawytscha*	56.0	0.4	57	<0.1	57	48
northern smoothtongue	*Leuroglossus schmidti*	44.6	0.3	4,833	4.7	421	127
squid unid.	Cephalopoda (class)	31.9	0.2	4,989	4.9	259	139
longnose skate	*Raja rhina*	12.2	<0.1	1	<0.1	1	1
Pacific cod	*Gadus macrocephalus*	6.4	<0.1	2	<0.1	2	2
big skate	*Beringraja binoculata*	5.5	<0.1	1	<0.1	1	1
lumpsucker unid.	Cyclopteridae (family)	4.3	<0.1	3	<0.1	3	3
arrowtooth flounder	*Atheresthes stomias*	3.7	<0.1	4	<0.1	3	3
flathead sole	*Hippoglossoides elassodon*	3.0	<0.1	16	<0.1	16	16
spiny dogfish	*Squalus suckleyi*	2.8	<0.1	1	<0.1	1	1
Stenobrachius sp.	*Stenobrachius* sp.	2.1	<0.1	562	0.6	137	56
Pacific ocean perch	*Sebastes alutus*	1.9	<0.1	2	<0.1	2	2
Pacific glass shrimp	*Pasiphaea pacifica*	1.2	<0.1	984	1.0	24	24
chum salmon	*Oncorhynchus keta*	1.2	<0.1	1	<0.1	1	1
smooth lumpsucker	*Aptocyclus ventricosus*	1.1	<0.1	1	<0.1	1	1
Pacific herring	*Clupea pallasii*	0.7	<0.1	10	<0.1	10	10
Alaskan pink shrimp	*Pandalus eous*	0.7	<0.1	222	0.2	69	20
euphausiid unid.	Euphausiacea (order)	0.6	<0.1	7,463	7.3	-	-
Pacific capelin	*Mallotus catervarius*	0.5	<0.1	105	0.1	55	25
Pacific lamprey	*Lampetra tridentata*	0.2	<0.1	5	<0.1	2	2
shrimp unid.	Malacostraca (class)	0.1	<0.1	130	0.1	-	-
northern sea nettle	*Chrysaora melanaster*	0.1	<0.1	1	<0.1	1	1
salp unid.	Thaliacea (class)	<0.1	<0.1	1	<0.1	-	-
isopod unid.	Isopoda (order)	<0.1	<0.1	40	<0.1	-	-
eelpout unid.	Zoarcidae (family)	<0.1	<0.1	4	<0.1	2	2
smelt unid.	Osmeridae (family)	<0.1	<0.1	27	<0.1	27	3
fish larvae unid.	Actinopterygii (class)	<0.1	<0.1	50	<0.1	14	1
flatfish unid.	Pleuronectiformes (order)	<0.1	<0.1	1	<0.1	1	1
poacher unid.	Agonidae (family)	<0.1	<0.1	1	<0.1	1	1
prickleback unid.	Stichaeidae (family)	<0.1	<0.1	1	<0.1	1	1
Total		13,891.9		102,115		8,313	2,021

Table 6. -- Catch by species and numbers of length and weight measurements taken from 1 PNE haul during the 2022 acoustic-trawl survey of pollock in Shelikof Strait.

		Catch				Measurements	
Species name	Scientific name	Weight (kg)	%	Number	%	Length	Weight
pollock	*Gadus chalcogrammus*	293.4	95.8	396	44.7	374	61
eulachon	*Thaleichthys pacificus*	11.2	3.7	317	35.8	37	10
magistrate armhook squid	*Berryteuthis magister*	0.9	0.3	3	0.3	3	3
northern smoothtongue	*Leuroglossus schmidti*	0.8	0.3	104	11.7	42	10
Pacific glass shrimp	*Pasiphaea pacifica*	<0.1	<0.1	53	6.0	-	-
Pacific lamprey	*Lampetra tridentata*	<0.1	<0.1	1	0.1	1	1
squid unid.	Cephalopoda (class)	<0.1	<0.1	4	0.5	4	-
Stenobrachius sp.	*Stenobrachius* sp.	<0.1	<0.1	4	0.5	4	4
isopod unid.	Isopoda (order)	<0.1	<0.1	2	0.2	-	-
fish larvae unid.	Actinopterygii (class)	<0.1	<0.1	2	0.2	2	-
Total		306.4		886		467	89

Table 7. -- Numbers of pollock measured and biological samples collected during the winter 2022 acoustic-trawl survey of Shelikof Strait.

Haul no.	Region name	Catch lengths	Weights	Maturities	Otoliths	Ovary weights	Ovaries collected
1	Shelikof Strait	399	62	61	37	3	3
2	Shelikof Strait	440	69	58	38	9	3
3	Shelikof Strait	277	66	58	45	9	11
4	Shelikof Strait	390	55	54	35	4	4
5	Shelikof Strait	440	63	55	42	21	5
6	Shelikof Strait	343	53	50	34	14	10
7	Shelikof Strait	362	59	59	38	3	4
8	Shelikof Strait	376	94	92	47	20	1
9	Shelikof Strait	387	51	50	31	9	-
10	Shelikof Strait	402	65	58	35	3	3
11	Shelikof Strait	374	61	56	41	6	3
12	Shelikof Strait	362	51	50	31	22	-
13	Shelikof Strait	292	100	81	55	7	-
14	Shelikof Strait	312	62	61	36	7	3
15	Shelikof Strait	209	50	25	30	-	-
16	Shelikof Strait	359	51	51	31	10	3
17	Shelikof Strait	262	53	31	28	-	1
18	Shelikof Strait	412	64	59	43	3	3
19	Shelikof Strait	128	70	69	50	2	2
21	Shelikof Strait	226	88	42	35	-	1
Total		6,752	1,287	1,120	762	152	60

Table 8. -- Estimates of pollock biomass (thousands of metric tons) and relative estimation error for the Shelikof Strait area, Chirikof shelf break, and Marmot Bay regions. Estimates for 2008–2022 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 Shelfbreak		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	197.5	5.6%	21.9	9.6%		
2009	257.1	5.9%	0.4	32.3%	20.2	
2010	421.4	2.6%	9.4	15.0%	5.6	
2011						
2012	327.6	7.9%	21.2	16.4%		
2013	796.4	5.3%	63.2	31.4%	19.9	4.1%
2014	829.0	4.7%			14.5	9.4%
2015	859.0	4.3%	11.7	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	1,321.2	3.9%			13.5	7.5%[1]
2019	1,281.1	6.6%	9.9	17.7%	6.3	7.9%
2020	459.4	2.9%				
2021	527.0	2.9%			7.4	5.8%
2022	365.4	10.3%				

[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 9. -- Numbers-at-length estimates (millions of fish) from acoustic-trawl surveys of pollock in the Shelikof Strait area. Numbers from 2008 to 2022 reflect selectivity corrections for escapement of juveniles.

Length	2008	2009	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
5	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
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	4.5	0	0	15.4	<1	0	0	0	14.9	0	11.0	3.1
9	8.4	7.6	10.4	<1	454.9	44.6	0	0	1.3	77.1	115.7	0	246.1	<1
10	26.6	76.6	51.3	10.3	750.9	275.7	7.6	0	57.4	556.5	1799.9	<1	1386.2	<1
11	175.0	242.3	70.8	36.4	3789.1	433.0	5.5	0	134.1	756.8	3103.3	<1	2737.9	<1
12	417.0	317.0	75.9	71.8	3096.5	382.4	4.7	0	308.5	375.4	1906.8	2.8	2135.8	2.4
13	451.1	129.3	43.5	78.1	834.6	190.2	4.5	0	185.9	40.7	341.1	4.7	931.7	2.0
14	281.7	45.1	11.4	35.8	255.7	44.4	2.6	0	40.2	9.4	78.6	5.2	215.3	1.1
15	94.7	2.1	1.6	12.6	70.9	10.7	<1	0	16.8	2.4	0	2.0	59.5	<1
16	9.7	1.1	<1	3.3	22.1	5.0	<1	0	<1	1.2	<1	1.2	6.7	<1
17	1.7	0	<1	0	6.9	40.5	<1	0	0	0	5.8	<1	0	4.3
18	<1	4.9	<1	0	<1	104.7	<1	0	0	<1	37.4	<1	0	11.8
19	2.5	6.2	9.2	9.4	<1	461.0	<1	0	0	3.6	172.2	<1	0	41.7
20	3.3	70.4	15.4	54.4	1.4	995.0	1.6	0	<1	5.6	432.7	9.2	<1	56.9
21	11.0	165.4	34.4	151.3	3.0	942.7	8.6	0	0	16.3	437.5	19.8	<1	41.8
22	20.6	322.2	62.4	189.6	9.1	501.0	16.2	<1	0	26.3	291.5	24.0	<1	22.5
23	56.8	272.7	86.1	195.8	8.1	308.6	14.8	0	<1	27.9	166.1	17.0	<1	8.0
24	96.6	168.0	49.5	132.7	11.8	115.5	18.3	<1	<1	23.2	76.1	11.7	1.6	3.1
25	53.2	75.2	26.7	65.8	15.3	46.3	15.5	<1	<1	19.0	40.5	19.0	3.5	2.2
26	27.6	19.1	16.3	33.2	21.4	16.1	33.8	<1	0	7.8	14.8	23.3	2.7	<1
27	25.7	10.8	7.8	10.8	9.3	4.2	86.0	<1	0	7.9	4.2	44.4	1.8	<1
28	22.8	12.5	9.2	6.3	9.4	3.7	172.0	<1	<1	4.1	6.2	53.4	2.9	<1
29	16.8	5.4	28.6	<1	7.5	<1	274.3	<1	0	0	16.0	77.4	4.4	<1
30	7.0	6.7	56.6	4.4	22.2	<1	296.4	1.9	0	1.2	19.9	53.3	7.2	<1
31	32.0	8.5	91.5	<1	33.9	<1	244.2	3.2	0	<1	24.5	43.5	10.5	<1
32	46.2	12.0	109.6	4.8	39.3	2.0	193.6	10.7	0	<1	31.8	23.1	15.4	<1
33	49.2	24.6	91.4	3.2	66.6	3.6	128.9	22.0	<1	<1	17.9	16.7	17.3	1.1
34	24.8	23.6	66.8	3.0	74.9	2.3	68.3	50.7	1.1	0	14.1	16.8	21.0	2.0
35	40.2	18.8	32.2	4.3	112.3	3.0	50.0	91.1	<1	0	6.7	9.5	21.1	2.5
36	18.6	15.2	25.8	4.4	102.8	3.8	26.6	139.3	4.8	0	2.1	14.2	27.9	6.4
37	32.3	8.2	14.0	2.9	103.1	5.1	19.3	209.6	9.0	1.2	5.1	10.2	31.2	12.5
38	4.0	11.2	10.6	2.5	56.5	7.6	13.4	274.3	56.3	1.8	2.1	5.6	28.0	22.2
39	2.4	14.4	7.7	2.2	39.8	13.2	10.9	271.5	130.6	10.2	1.6	4.4	23.5	24.0
40	14.9	8.8	8.5	4.0	21.5	24.4	8.0	204.9	352.4	45.3	1.5	3.3	19.8	32.6
41	5.9	12.9	8.5	5.5	13.7	37.5	5.0	138.2	530.2	101.3	5.0	2.3	14.9	30.9

Length	2008	2009	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
42	4.3	15.1	9.8	9.0	10.3	51.8	5.8	76.3	578.5	202.3	34.3	7.8	15.1	28.7
43	5.0	13.9	10.2	15.8	8.2	55.8	9.5	40.2	544.0	305.4	102.9	15.1	12.0	22.4
44	3.1	13.6	10.9	13.6	9.9	52.1	13.0	22.2	326.5	371.2	177.4	34.3	9.4	21.3
45	3.4	11.6	14.1	17.6	4.4	37.2	20.2	13.0	169.8	351.5	245.3	67.1	16.7	19.6
46	3.0	8.6	13.2	20.0	5.7	25.2	30.6	10.1	80.9	258.9	244.9	78.3	31.9	18.6
47	1.4	5.1	11.2	20.0	8.7	14.8	33.1	7.0	46.4	191.2	221.6	74.7	29.5	25.2
48	<1	4.5	11.3	22.0	12.3	13.0	38.8	7.4	24.0	117.6	169.1	62.0	43.0	27.7
49	<1	2.8	10.5	19.6	14.2	11.6	33.8	8.8	8.9	62.6	122.9	40.9	45.6	29.4
50	<1	2.9	12.0	19.6	13.9	15.3	26.5	6.4	6.8	30.7	68.2	33.0	38.0	26.6
51	<1	2.6	10.5	16.5	23.0	16.2	25.6	4.3	3.5	29.3	35.2	20.4	29.0	21.6
52	<1	3.5	9.1	12.2	18.1	31.5	21.2	5.4	2.6	9.8	25.3	13.2	28.2	18.8
53	1.3	2.3	6.0	10.6	21.2	28.3	24.1	2.7	<1	9.5	10.4	5.6	24.1	15.7
54	1.8	2.4	7.2	9.7	28.6	33.4	23.0	2.8	2.8	3.7	5.3	4.9	16.9	15.4
55	2.0	1.7	7.9	7.4	21.6	28.7	28.4	2.3	4.5	6.8	4.7	2.9	14.1	13.4
56	1.2	2.2	5.9	6.8	26.9	36.0	25.5	2.7	4.5	1.8	<1	1.4	8.6	8.9
57	<1	1.6	4.9	6.9	18.9	24.7	23.2	2.7	<1	<1	<1	<1	5.7	5.9
58	1.4	1.2	6.2	5.2	17.2	19.3	20.2	1.2	2.0	0	<1	<1	4.3	2.2
59	1.5	1.2	5.6	3.1	16.5	12.5	15.4	<1	<1	0	<1	<1	3.1	2.5
60	1.3	1.2	3.3	3.5	18.6	9.6	14.3	1.3	<1	<1	<1	<1	<1	<1
61	2.6	1.2	5.2	1.5	7.9	9.0	8.3	<1	<1	0	<1	<1	<1	<1
62	<1	1.1	3.8	<1	8.8	6.8	6.9	<1	<1	<1	0	<1	<1	<1
63	<1	1.0	3.3	1.2	11.1	1.2	3.8	<1	<1	0	0	<1	0	<1
64	<1	<1	3.8	<1	2.7	2.9	1.6	0	0	0	0	0	<1	<1
65	<1	<1	3.3	<1	1.7	1.2	2.1	0	0	0	0	0	<1	0
66	<1	<1	2.5	<1	2.5	1.0	<1	0	0	0	0	0	0	0
67	<1	<1	2.4	<1	<1	<1	<1	0	0	0	0	0	0	0
68	<1	<1	1.3	<1	<1	<1	<1	0	0	0	0	0	0	0
69	<1	<1	<1	0	0	0	<1	0	0	0	0	0	0	0
70	0	<1	<1	<1	<1	<1	0	0	0	0	0	0	0	0
71	0	<1	<1	0	<1	0	0	0	0	0	0	0	0	0
72	0	0	<1	0	0	0	0	0	0	0	0	0	0	0
73	0	0	0	0	<1	0	0	0	0	0	0	0	0	0
74	0	0	0	0	<1	<1	0	0	0	0	0	0	0	0
75	0	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	0
Total	2120.4	2223.8	1338.7	1385.4	10401.5	5584.3	2188.2	1636.9	3638.7	4076.3	10664.6	985.0	8364.7	666.6

Table 10. -- Biomass-at-length estimates (thousands of metric tons) from acoustic-trawl surveys of pollock in the Shelikof Strait area. Biomass from 2008 to 2022 reflects selectivity corrections for escapement of juveniles.

Length	2008	2009	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
5	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
7	0	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	<1
9	<1	<1	<1	<1	1.7	<1	0	0	<1	<1	<1	0	1.2	<1
10	<1	<1	<1	<1	4.6	1.7	<1	0	<1	3.6	11.5	<1	8.8	<1
11	1.7	2.1	<1	<1	29.5	4.3	<1	0	1.0	6.2	25.5	<1	22.1	<1
12	4.6	3.4	<1	<1	29.4	4.0	<1	0	3.0	3.9	18.9	<1	21.1	<1
13	6.8	1.7	<1	1.1	10.1	2.5	<1	0	2.3	<1	4.3	<1	11.4	<1
14	4.9	<1	<1	<1	3.8	<1	<1	0	<1	<1	1.1	<1	3.3	<1
15	2.1	<1	<1	<1	1.3	<1	<1	0	<1	<1	0	<1	1.1	<1
16	<1	<1	<1	<1	<1	<1	<1	0	<1	<1	<1	<1	<1	<1
17	<1	0	<1	0	<1	1.3	<1	0	0	0	<1	<1	0	<1
18	<1	<1	<1	0	<1	3.9	<1	0	0	<1	1.4	<1	0	<1
19	<1	<1	<1	<1	<1	20.3	<1	0	0	<1	7.5	<1	0	1.8
20	<1	3.8	<1	3.1	<1	49.4	<1	0	<1	<1	22.0	<1	<1	2.7
21	<1	10.4	2.1	9.4	<1	54.5	<1	0	0	1.1	25.3	1.2	<1	2.3
22	1.6	22.9	4.3	13.5	<1	34.2	1.1	<1	0	1.9	19.1	1.7	<1	1.4
23	4.7	21.7	6.8	16.0	<1	23.3	1.2	0	<1	2.3	12.7	1.3	<1	<1
24	9.2	15.2	4.6	12.0	1.1	10.1	1.6	<1	<1	2.1	6.7	1.1	<1	<1
25	5.9	7.5	2.7	6.5	1.5	4.6	1.7	<1	<1	2.0	4.1	1.9	<1	<1
26	3.6	2.4	1.9	3.9	2.5	1.9	4.0	<1	0	<1	1.7	2.7	<1	<1
27	3.6	1.5	1.1	1.5	1.2	<1	11.3	<1	0	1.1	<1	5.8	<1	<1
28	3.7	2.0	1.4	<1	1.4	<1	25.4	<1	<1	<1	<1	7.8	<1	<1
29	3.1	<1	4.9	<1	1.3	<1	44.2	<1	0	0	2.5	12.6	<1	<1
30	1.4	1.3	10.8	<1	4.3	<1	53.6	<1	0	<1	3.8	9.7	1.4	<1
31	7.3	1.8	19.1	<1	7.3	<1	49.3	<1	0	<1	4.7	8.7	2.2	<1
32	11.8	2.7	25.0	1.1	9.3	<1	43.2	2.3	0	<1	7.2	5.1	3.6	<1
33	14.1	6.1	23.0	<1	17.6	<1	32.4	5.3	<1	<1	4.5	4.2	4.3	<1
34	7.8	6.5	18.4	<1	21.8	<1	18.5	13.4	<1	0	4.0	4.6	6.0	<1
35	13.8	5.7	9.7	1.3	36.4	<1	14.9	26.5	<1	0	2.2	2.9	6.6	<1
36	6.9	5.0	8.8	1.5	35.4	1.3	8.9	44.2	1.5	0	<1	4.7	9.6	2.0
37	13.2	3.1	5.2	1.1	40.1	1.9	7.0	72.4	3.1	<1	2.1	3.7	11.9	4.5
38	1.8	4.6	4.3	<1	24.0	3.0	5.5	102.8	20.6	<1	<1	2.2	11.4	8.7
39	1.2	6.5	3.6	<1	17.8	5.7	4.8	108.5	51.3	4.1	<1	1.9	10.3	9.9
40	8.1	4.3	4.2	1.9	13.0	11.6	4.0	88.3	150.1	20.0	<1	1.6	9.6	14.5
41	3.5	7.0	4.7	2.9	7.5	19.2	2.7	64.0	243.8	47.6	2.5	1.1	8.0	14.9

Length	2008	2009	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
42	2.6	8.7	5.8	5.0	6.0	28.6	3.3	37.5	283.7	99.7	18.8	4.2	8.7	15.2
43	3.4	8.7	6.5	9.6	5.1	33.0	5.7	21.6	280.7	164.4	59.6	8.9	7.4	12.6
44	2.2	9.4	7.5	8.7	6.7	33.3	8.4	12.7	181.0	215.3	108.3	21.8	6.4	13.0
45	2.7	8.6	10.8	12.4	3.2	25.6	14.5	7.8	100.0	214.3	159.7	44.8	12.2	12.9
46	2.5	6.7	10.9	15.1	4.5	18.4	23.6	6.5	52.3	168.7	170.0	54.3	25.3	13.6
47	1.2	4.5	9.7	16.0	7.4	11.6	27.2	4.7	32.2	132.0	165.7	58.4	24.6	19.8
48	<1	4.2	10.5	18.4	11.1	11.0	33.9	5.6	18.0	89.1	136.1	51.8	36.9	22.9
49	<1	2.9	10.7	18.5	13.8	10.5	31.6	7.2	7.7	49.8	108.4	37.5	41.2	26.6
50	<1	3.3	12.7	20.0	15.1	14.8	27.0	5.4	6.2	24.8	63.8	31.2	37.3	25.1
51	<1	3.0	12.2	17.8	25.8	17.4	27.4	3.7	3.1	28.4	35.7	21.4	30.9	22.9
52	<1	4.6	11.3	14.1	22.1	36.6	23.9	5.1	2.6	9.4	25.9	14.3	32.2	21.3
53	1.8	3.3	8.0	12.5	27.7	35.9	29.3	2.8	<1	9.7	12.3	6.9	29.2	19.7
54	2.5	3.6	9.9	12.2	39.7	42.9	29.5	3.0	3.0	4.0	6.2	6.2	21.2	19.6
55	3.2	2.8	11.7	10.2	30.0	39.5	37.6	2.5	5.2	7.7	6.3	4.2	19.0	18.9
56	2.0	3.7	9.3	10.1	41.2	52.3	36.6	2.9	5.4	2.2	<1	2.0	11.4	13.6
57	<1	2.7	8.6	10.1	30.2	38.0	34.6	3.0	<1	<1	1.3	1.1	8.8	8.9
58	2.6	2.2	11.0	9.1	29.8	31.2	32.3	1.5	2.7	0	<1	<1	7.1	3.4
59	2.8	2.6	10.3	5.4	29.5	20.6	25.2	1.1	1.1	0	<1	<1	5.7	4.1
60	2.7	2.6	6.4	6.3	35.7	18.4	25.0	1.6	<1	<1	<1	<1	1.6	1.3
61	5.5	2.5	10.5	2.8	15.8	16.2	15.4	<1	<1	0	<1	1.4	1.5	1.7
62	1.6	2.4	7.9	1.6	18.6	13.6	13.2	1.0	<1	<1	0	<1	1.4	1.1
63	2.2	2.3	7.4	2.5	24.6	2.5	7.2	<1	<1	0	0	<1	0	<1
64	1.4	1.7	8.8	2.0	6.4	6.2	3.4	0	0	0	0	0	<1	<1
65	2.2	<1	8.4	1.3	4.2	2.8	4.7	0	0	0	0	0	<1	0
66	<1	2.7	6.4	<1	6.5	2.4	1.9	0	0	0	0	0	0	0
67	<1	1.5	6.7	<1	<1	<1	<1	0	0	0	0	0	0	0
68	<1	1.3	3.7	<1	1.5	<1	<1	0	0	0	0	0	0	0
69	<1	<1	1.5	0	0	0	<1	0	0	0	0	0	0	0
70	0	<1	2.9	<1	1.7	<1	0	0	0	0	0	0	0	0
71	0	<1	1.8	0	3.1	0	0	0	0	0	0	0	0	0
72	0	0	1.6	0	0	0	0	0	0	0	0	0	0	0
73	0	0	0	0	1.3	0	0	0	0	0	0	0	0	0
74	0	0	0	0	<1	<1	0	0	0	0	0	0	0	0
75	0	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	0
Total	197.5	257.1	421.4	327.6	796.4	829.0	859.0	666.8	1465.1	1321.2	1281.1	459.4	527.0	365.4

Table 11. -- Numbers-at-age estimates (millions of fish) from acoustic-trawl surveys of pollock in the Shelikof Strait area. Numbers from 2008 to 2022 reflect selectivity corrections for escapement of juveniles.

Age	2008	2009	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
1	1465.9	821.1	270.5	248.3	9282.1	1397.8	25.6	0	745.0	1819.4	7361.3	17.6	7730.1	11.1
2	289.0	1120.4	299.1	848.7	116.7	3544.0	97.7	1.9	0	142.6	1671.7	81.4	36.7	193.3
3	272.8	106.3	538.7	28.5	659.3	15.8	1565.2	78.2	9.2	1.6	155.5	345.3	94.2	27.9
4	63.4	93.8	82.9	79.8	50.0	269.5	71.4	1451.8	126.4	9.9	6.1	72.2	150.7	132.7
5	11.4	56.9	76.3	107.1	62.6	81.2	172.4	43.4	2576.4	165.9	6.6	15.5	55.4	111.9
6	1.2	9.7	27.7	42.1	102.5	61.0	71.6	33.5	126.0	1804.6	261.7	27.0	7.3	26.9
7	2.5	2.8	11.2	25.0	58.0	106.6	60.7	15.5	32.0	85.7	1127.5	68.5	12.5	2.4
8	8.0	<1	5.1	3.7	42.7	54.6	70.9	3.6	8.9	46.7	53.9	192.8	64.0	13.5
9	4.6	4.8	5.0	<1	10.4	26.0	30.2	7.4	<1	0	11.1	116.8	133.9	30.7
10	1.3	5.8	10.3	<1	4.8	16.7	10.5	1.7	<1	0	9.0	37.2	63.4	86.6
11	<1	1.3	8.8	<1	4.6	7.7	5.4	0	0	0	<1	8.0	14.3	26.3
12	0	<1	3.2	<1	<1	<1	3.4	0	0	0	<1	2.7	2.2	1.9
13	0	0	0	0	1.4	2.1	<1	0	0	0	0	0	0	1.5
14	0	0	0	0	4.0	0	<1	0	0	0	0	0	0	0
15	0	0	0	0	2.0	<1	1.3	0	0	0	0	0	0	0
16	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2120.4	2223.8	1338.7	1384.6	10401.5	5584.3	2188.2	1636.9	3624.5	4076.3	10664.6	985.0	8364.7	666.6

Table 12. -- Biomass-at-age estimates (thousands of metric tons) from acoustic-trawl surveys of pollock in the Shelikof Strait area. Numbers from 2008 to 2022 reflect selectivity corrections for escapement of juveniles.

Age	2008	2009	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
1	20.6	8.5	2.4	3.0	81.3	14.2	<1	0	7.7	14.8	61.9	<1	69.3	<1
2	29.5	87.7	23.6	67.3	14.9	204.3	9.3	<1	0	12.6	102.1	5.9	7.0	9.9
3	75.3	27.6	129.0	7.9	229.0	4.8	310.4	23.6	3.3	<1	34.3	59.3	30.2	10.3
4	30.2	48.9	55.4	53.5	31.6	161.4	40.4	565.8	57.2	5.1	3.0	22.4	74.4	72.8
5	8.8	42.0	83.2	98.6	72.6	58.5	152.6	24.2	1287.5	89.4	4.2	7.5	37.8	68.4
6	1.6	10.4	35.5	53.5	140.7	78.3	75.2	25.2	70.4	1099.2	183.5	19.2	6.3	23.3
7	4.7	4.7	20.5	35.6	92.8	141.5	84.4	13.3	29.7	58.1	830.3	55.4	11.0	2.0
8	14.7	1.6	10.6	5.5	75.5	81.2	103.9	4.1	8.4	41.7	42.5	155.4	65.2	15.9
9	8.8	10.3	11.5	1.5	19.2	39.9	46.6	8.3	<1	0	9.7	93.5	141.2	32.1
10	2.7	12.3	20.9	<1	10.3	26.2	16.4	2.0	<1	0	9.3	29.9	66.3	98.1
11	<1	2.8	20.4	<1	9.9	11.7	8.3	0	0	0	<1	6.5	16.3	28.9
12	0	<1	8.2	<1	1.5	1.5	5.9	0	0	0	<1	4.3	2.0	2.3
13	0	0	0	0	3.4	4.1	1.5	0	0	0	0	0	0	1.4
14	0	0	0	0	8.7	0	<1	0	0	0	0	0	0	0
15	0	0	0	0	5.0	1.4	1.8	0	0	0	0	0	0	0
16	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	197.5	257.1	421.4	327.6	796.4	829.0	859.0	666.8	1465.1	1321.2	1281.1	459.4	527.0	365.4

Table 13. -- Numbers-at-length estimates (millions of fish) from acoustic-trawl surveys of pollock in the Shelikof Strait area from 1981 to 2007. Numbers reflect values that have not been corrected for escapement of juveniles.

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

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
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
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 14. -- Biomass-at-length estimates (thousands of metric tons) from acoustic-trawl surveys of pollock in the Shelikof Strait area from 1981 to 2007. Numbers reflect values that have not been corrected for escapement of juveniles.

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

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
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
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 15. -- Numbers-at-age estimates (millions of fish) from acoustic-trawl surveys of pollock in the Shelikof Strait area from 1981 to 2007. Numbers reflect values that have not been corrected for escapement of juveniles.

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 16. -- Biomass-at-age estimates (thousands of metric tons) from acoustic-trawl surveys of pollock in the Shelikof Strait area from 1981 to 2007. Numbers reflect values that have not been corrected for escapement of juveniles.

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

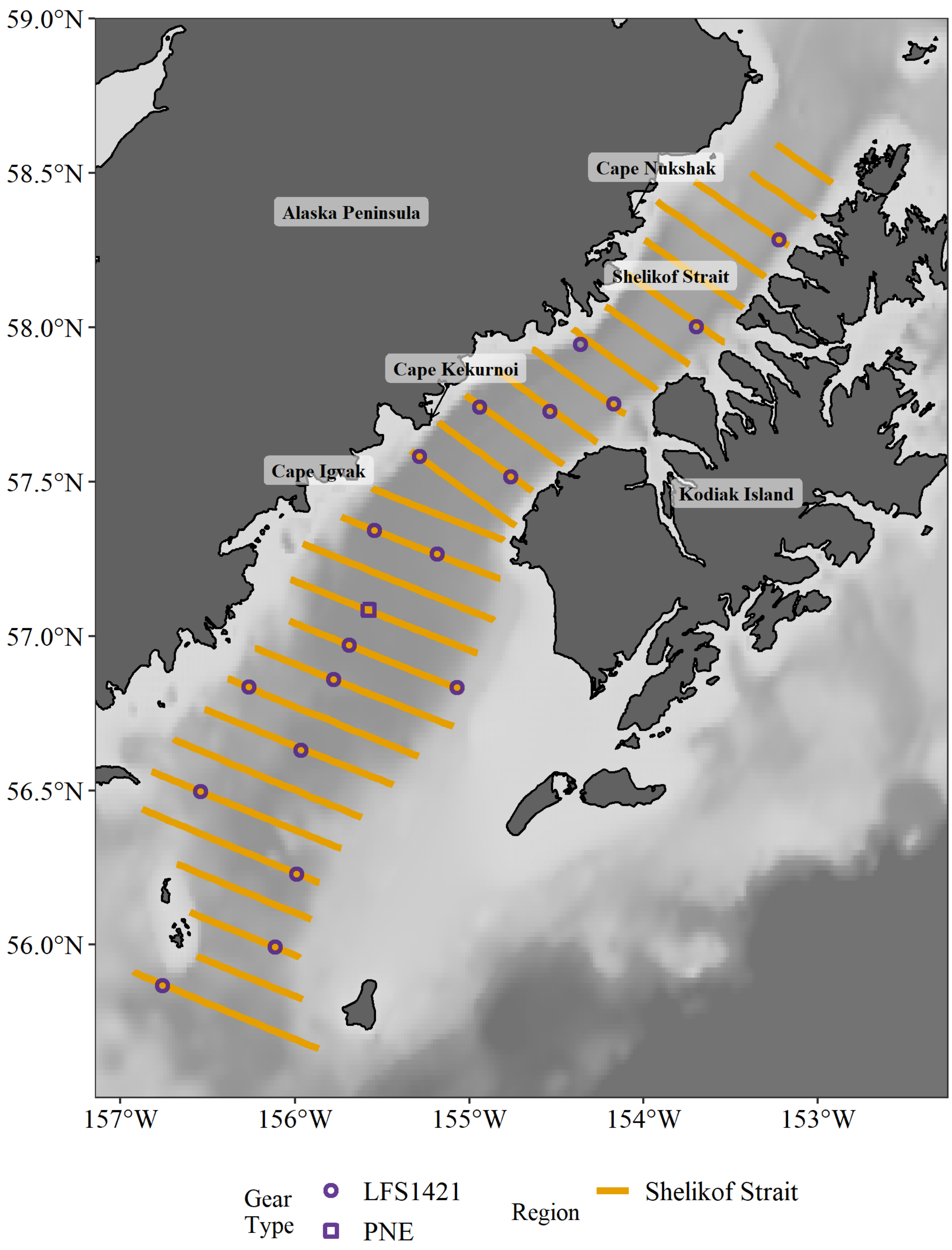

Figure 1. -- Transect lines and locations of trawl hauls during the winter 2022 acoustic-trawl survey of pollock in the Shelikof Strait regions. Labels refer to areas referenced in text.

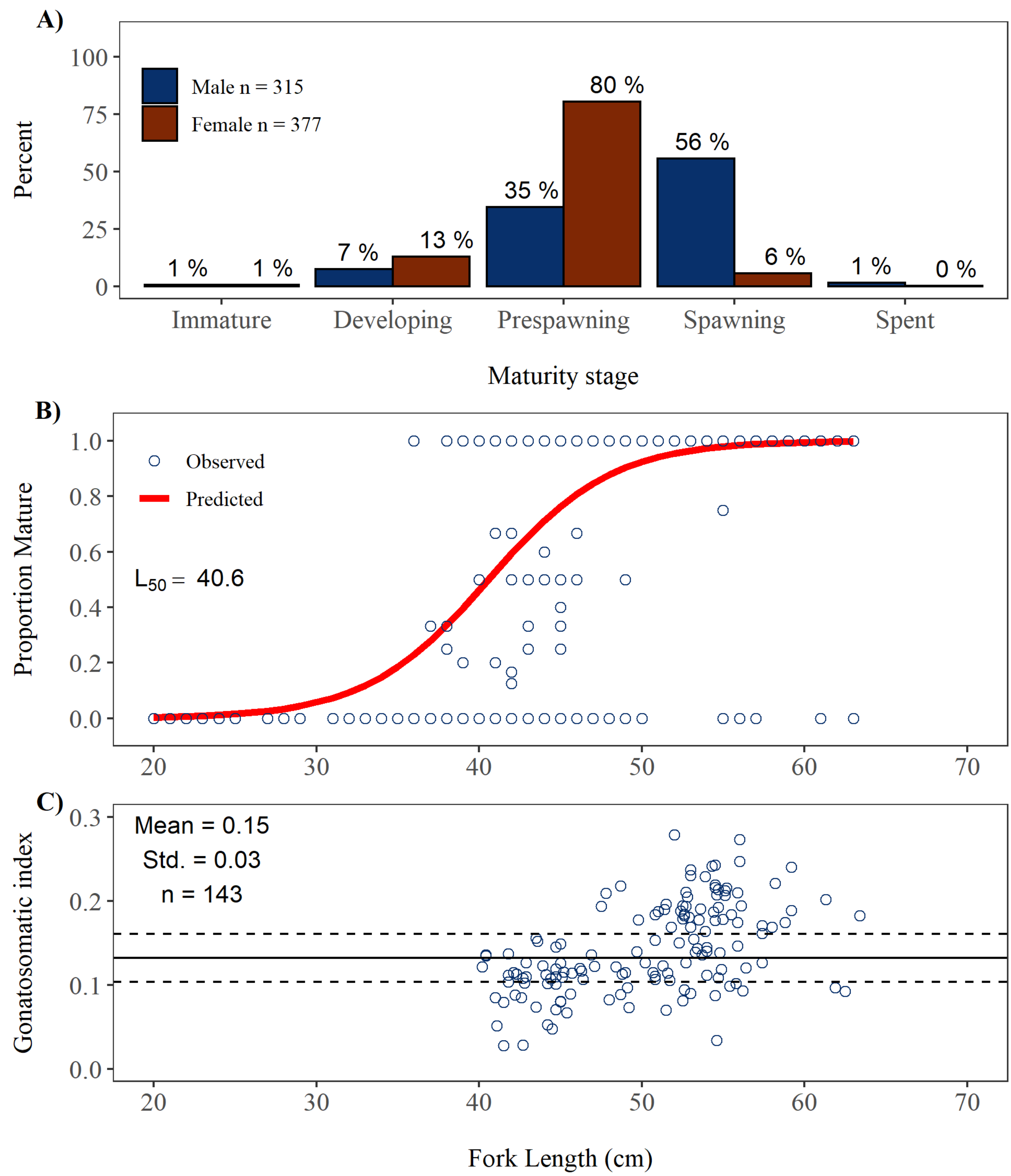

Figure 2. -- Pollock maturity in Shelikof Strait. A) Maturity composition for male and female pollock > 40 cm fork length (FL) within each stage; B) proportion mature (i.e., pre-spawning, spawning, or spent) by 1-cm size group for female pollock; C) gonadosomatic index for females > 40 cm FL (with historic survey mean ± 1 std. dev.). All maturity quantities are weighted by local pollock abundance.

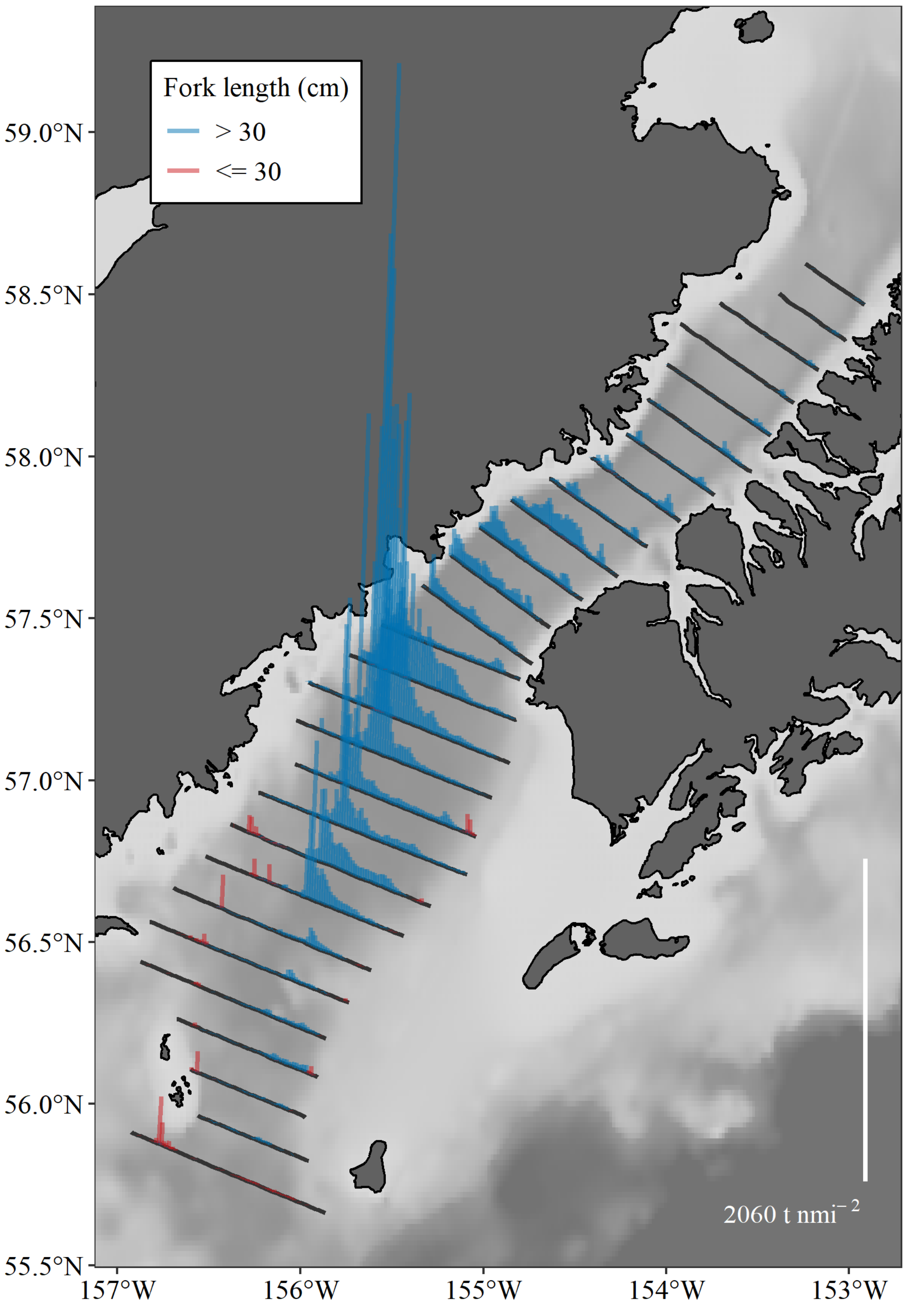

Figure 3. -- Density (t/nmi^2) attributed to pollock (vertical lines) along tracklines surveyed during the winter 2022 acoustic-trawl survey of Shelikof Strait. Biomass densities are categorized based on haul catches comprised of mostly adult (> 30 cm FL, blue) or juvenile (≤ 30 cm FL, red) pollock. The tallest bar value is 4120 t/nmi^2.

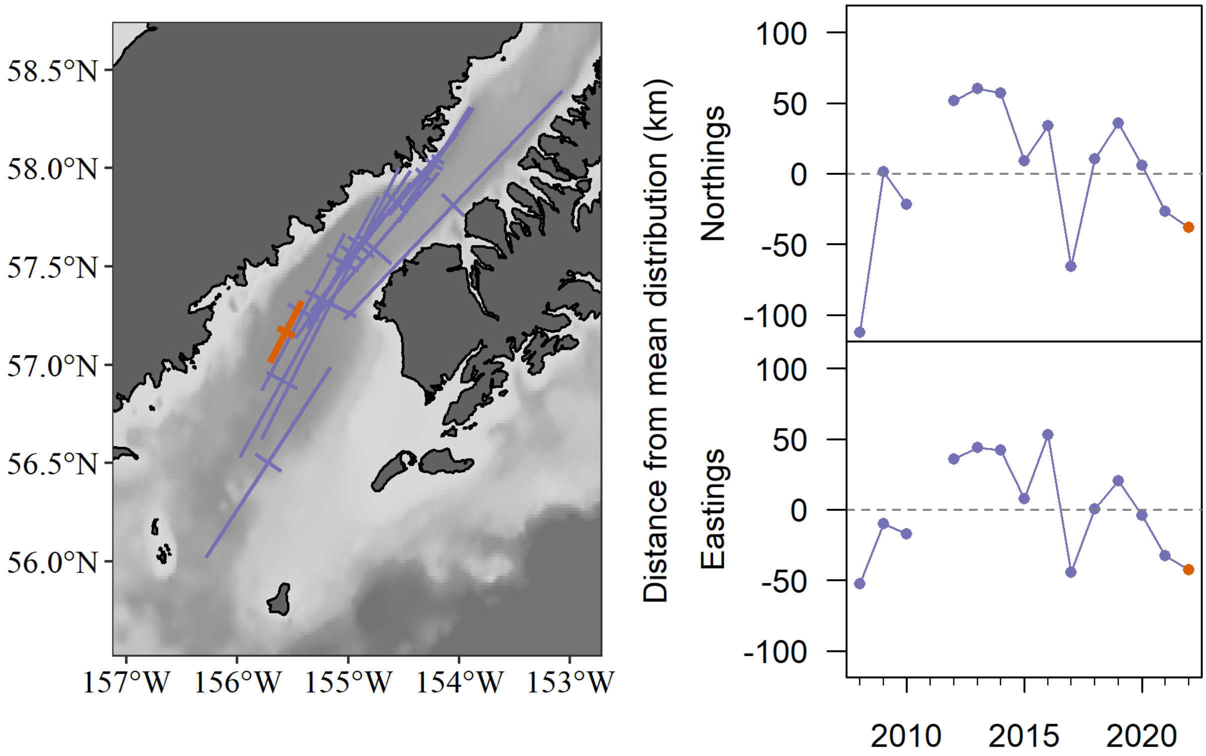

Figure 4. -- Geostatistical characterizations of pollock biomass distributions from 2008 to 2022. Center of gravity (COG, line intersection) and inertia (line length) estimates (left map) indicate the mean location and dispersion of the distribution around its COG during the 2022 survey (orange) and each of the other survey years (magenta). Time series of COG estimates (right plots) centered by the 15-year mean are shown along latitudinal ('Northings') and longitudinal ('Eastings') axes.

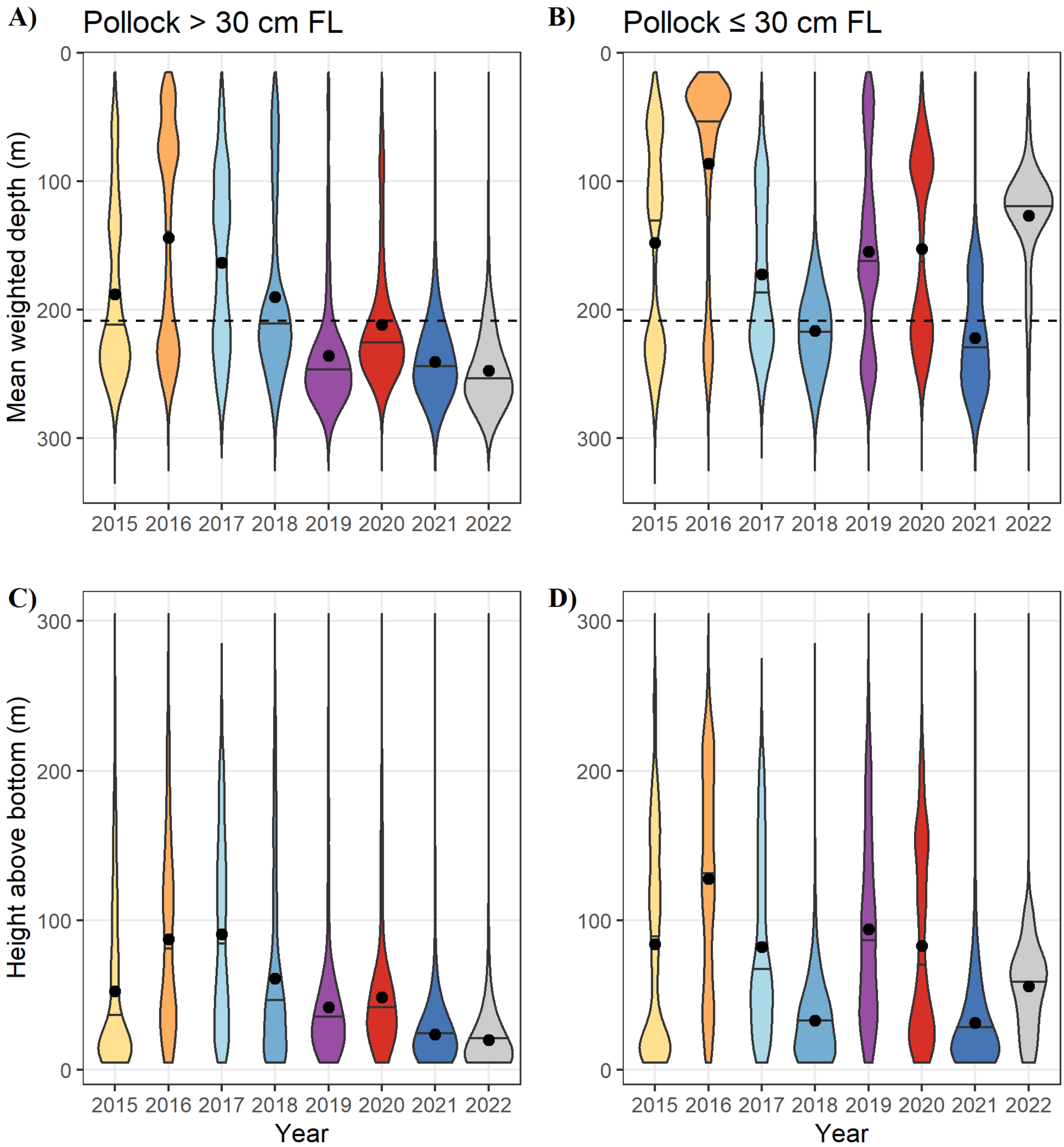

Figure 5. -- Estimated biomass distributions of adult (> 30 cm FL) and juvenile (≤ 30 cm FL) pollock A,B) mean weighted depth and C,D) height above bottom in the Shelikof Strait 2022 acoustic-trawl survey. Results for the winter 2015-2021 acoustic-trawl surveys are included for comparison. Mean weighted depth is referenced to the surface and height above bottom is referenced to the seafloor. Data were averaged in 10 m depth bins. Mean bottom depth for 2022 is shown in panels A,B) (dashed line). Plots show the probability density of pollock vertical distribution by year, including the median (black horizontal lines) and mean (black points) depth/height values indicated for each year.

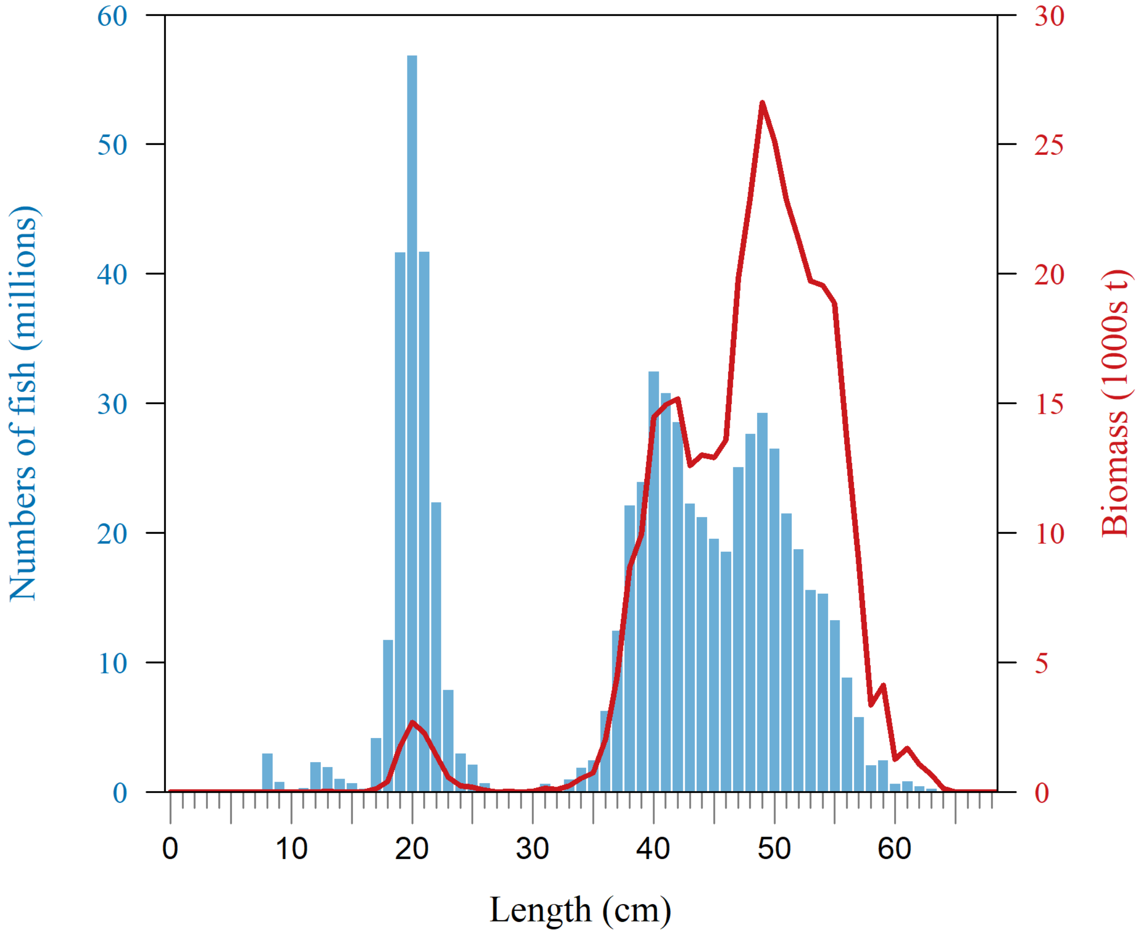

Figure 6. -- Numbers- (millions of fish, blue bars) and biomass- (1000s t, red line) at-length estimates of pollock for the 2022 acoustic-trawl survey of Shelikof Strait.

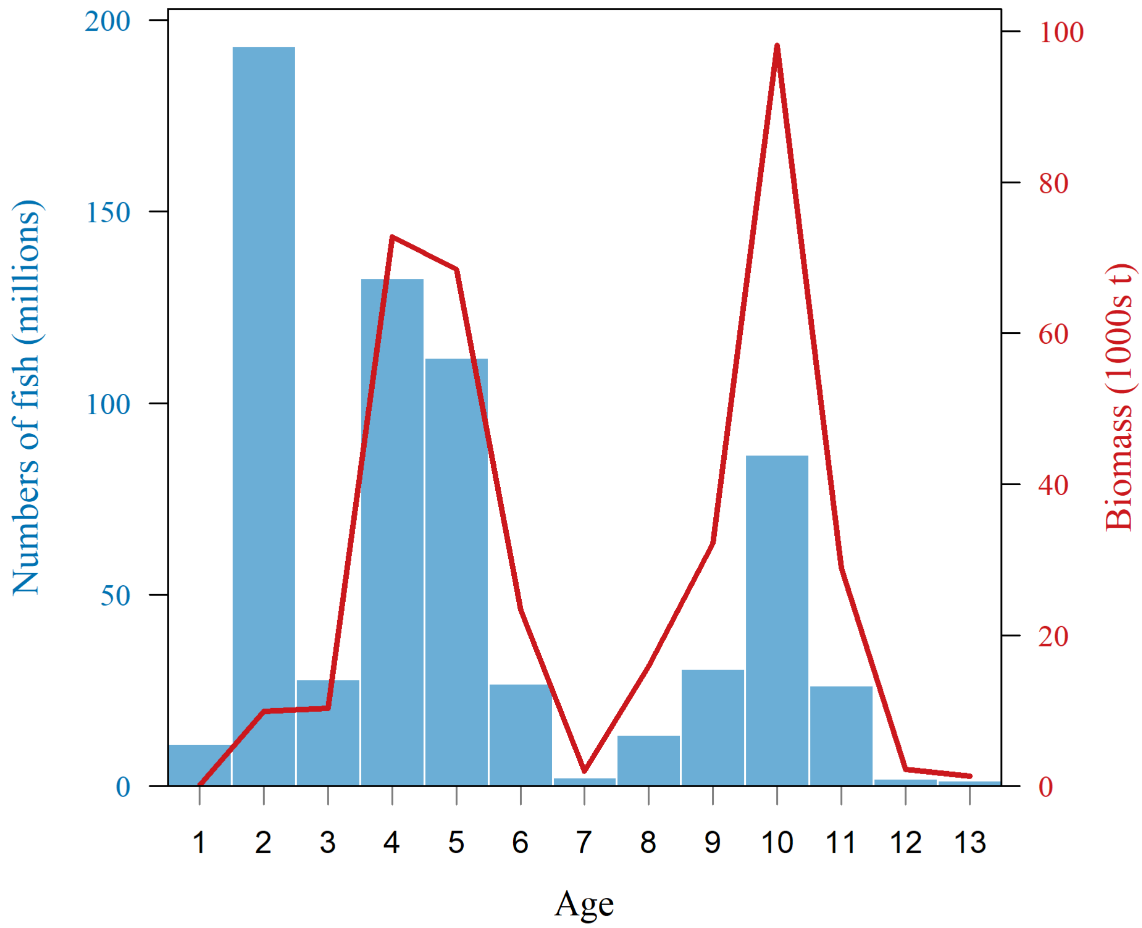

Figure 7. -- Numbers- (millions of fish, blue bars) and biomass- (1,000s t, red line) at-age estimates of pollock for the 2022 acoustic-trawl survey of Shelikof Strait.

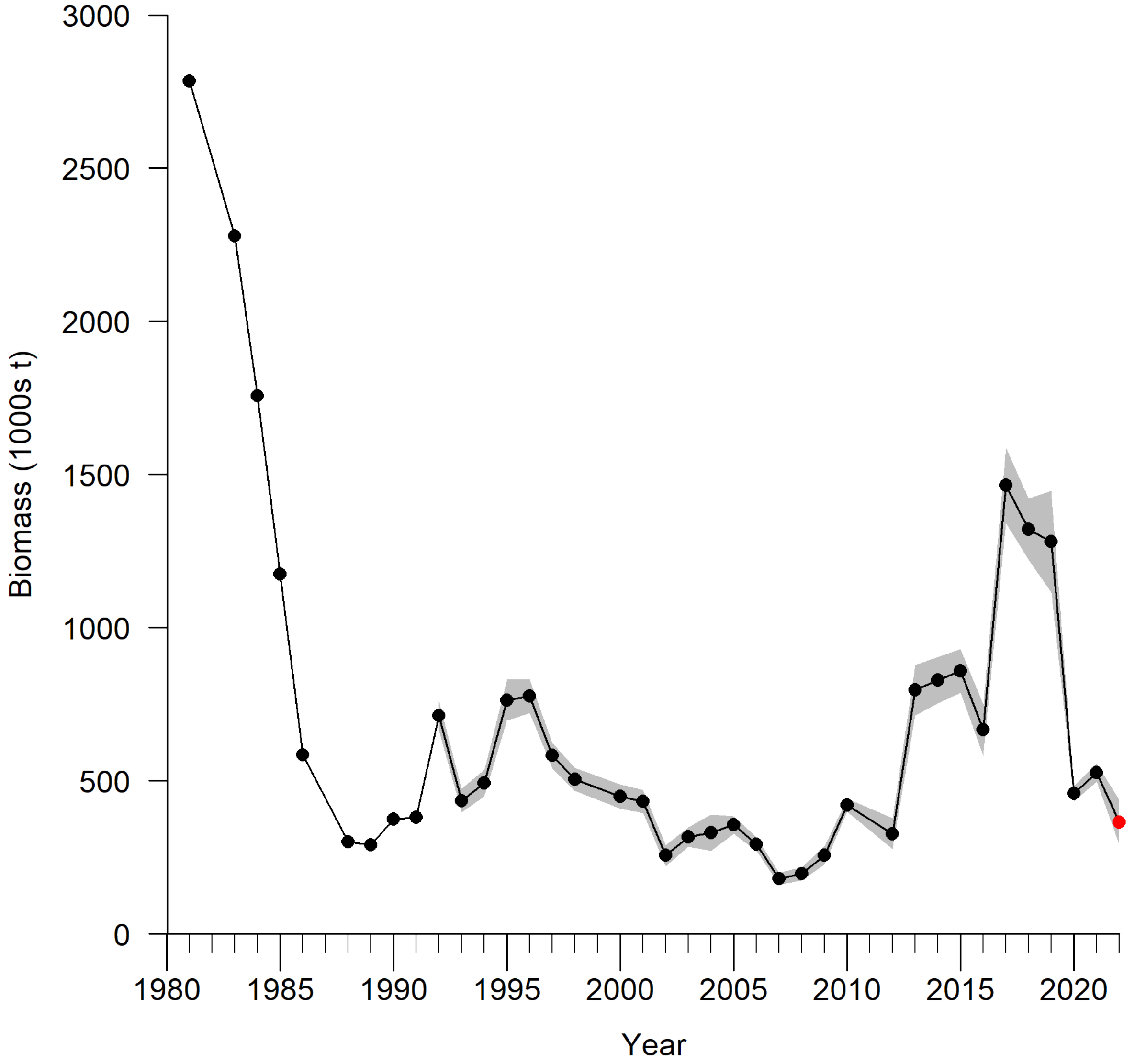

Figure 8. -- Summary of age-1+ pollock biomass estimates (thousands of metric tons) for Shelikof Strait based on acoustic-trawl surveys from 1981 to 2022 (except 1982, 1987, 1999, and 2011). Estimates for 2008–2022 include selectivity corrections for juvenile escapement (see text for explanation). Current survey estimate in red, and shaded area indicates 1-D geostatistical 95% confidence intervals (twice the relative estimation error; Walline 2007) from 1992 to 2022.

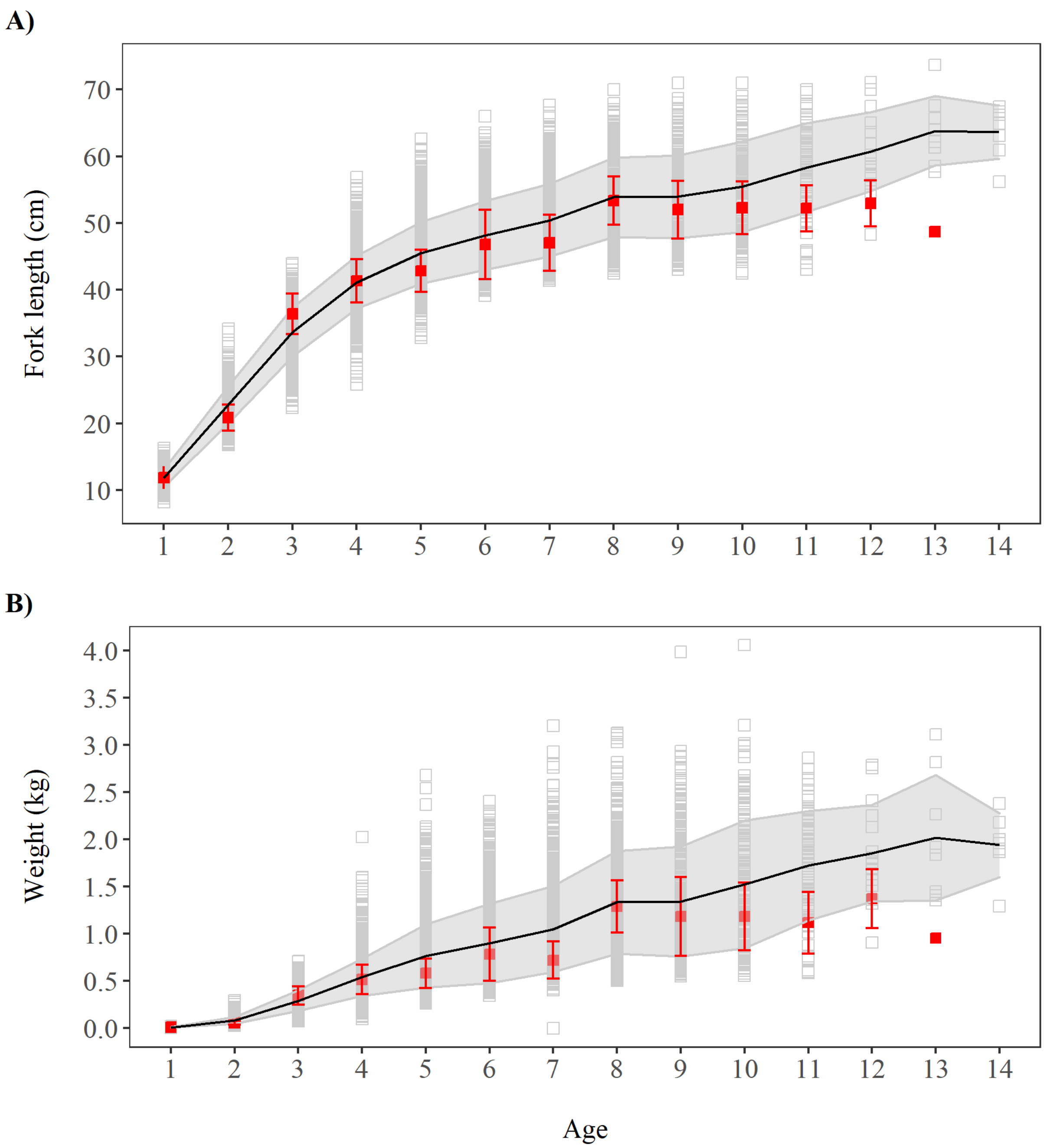

Figure 9. -- Pollock A) length- and B) weight-at-age for Shelikof Strait. The 2022 survey is highlighted in red (mean ± 1 s.d.). Gray squares indicate the range of observations in previous surveys (2008–2021), and the black line and gray ribbon indicate mean length- or weight- at age in previous surveys ± 1 s.d.

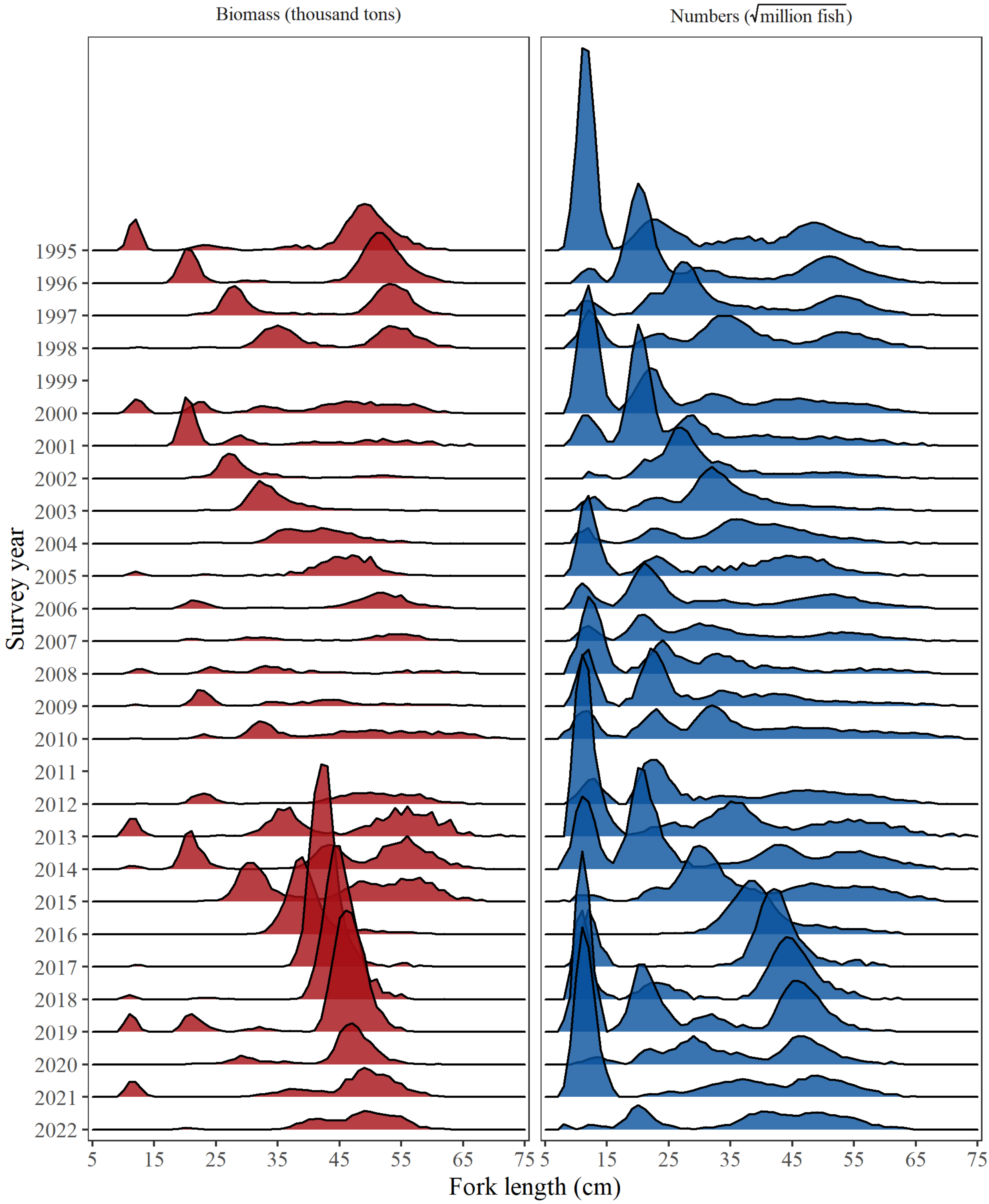

Figure 10. -- Time series of pollock population length composition by weight (left panel, thousand tons) and numbers (right panel, million fish) from acoustic-trawl surveys of Shelikof Strait area for 1981–2022. Estimates for 2008–2022 include selectivity corrections for juvenile escapement (see text for explanation).

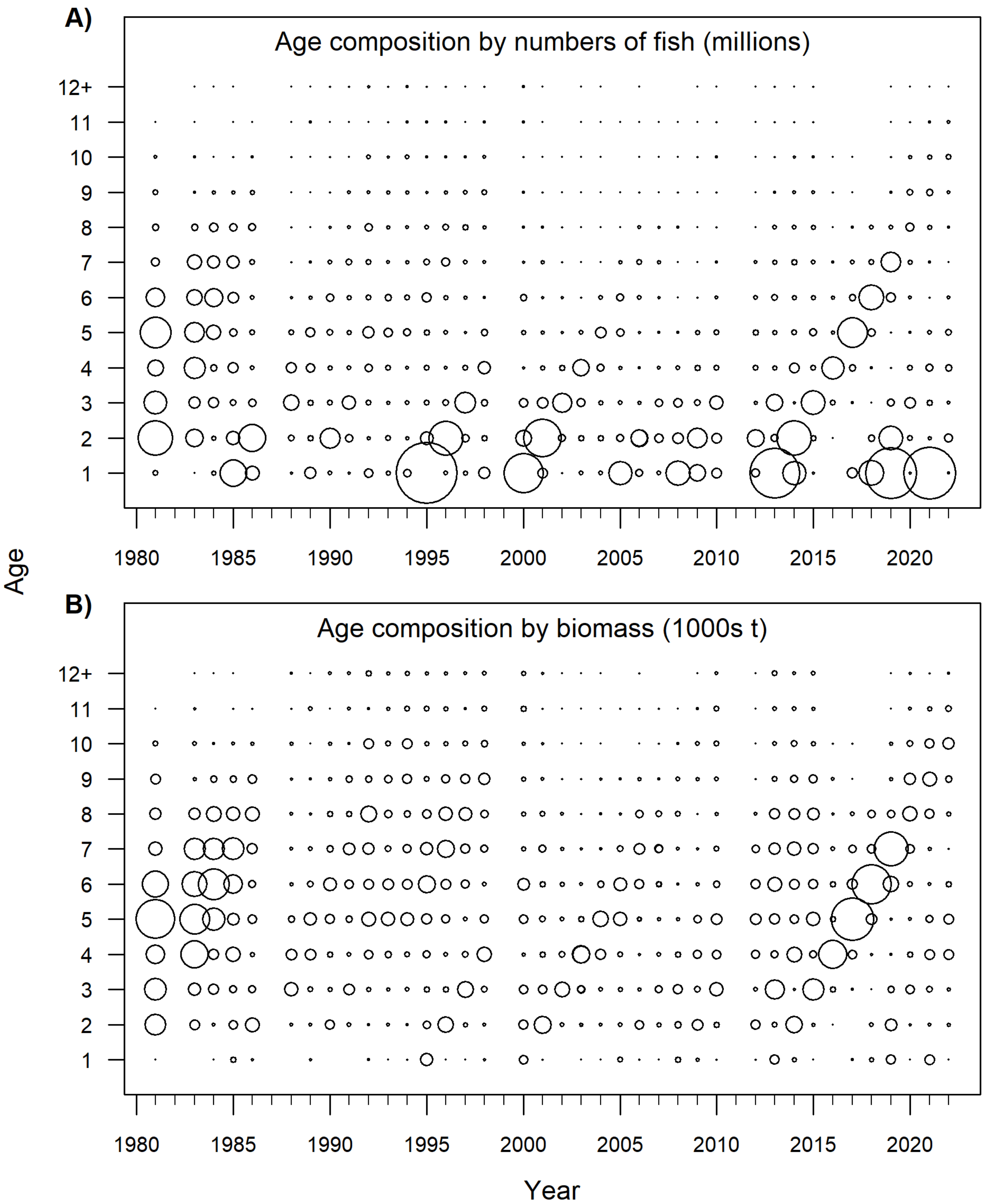

Figure 11. --Time series of pollock population age composition by A) numbers (millions of fish) and B) biomass (1,000s t) from acoustic-trawl surveys of Shelikof Strait area for 1981–2022. Estimates for 2008–2022 include selectivity corrections for juvenile escapement (see text for explanation). Bubble size is scaled based on square root transform of numbers/biomass estimate by age.

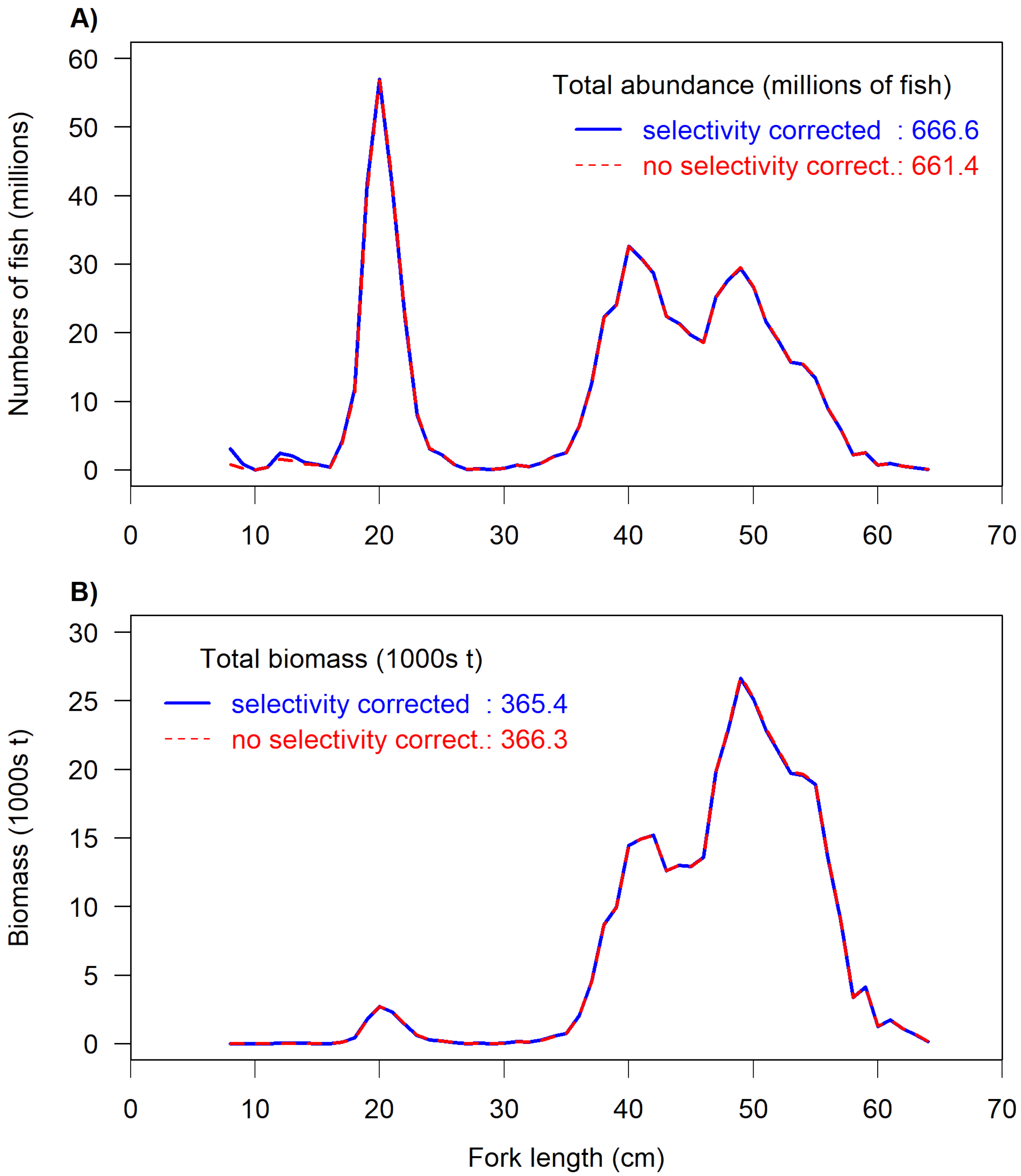

Figure 12. -- A) Numbers- and B) biomass-at-length estimates for the primary analysis corrected for net selectivity ('selectivity corrected') compared with estimates for the 'no-selectivity' analysis that do not include the effect of net selectivity ('no selectivity correct.'). The total numbers of fish (millions) and biomass (1,000s t) are also presented for each analysis.

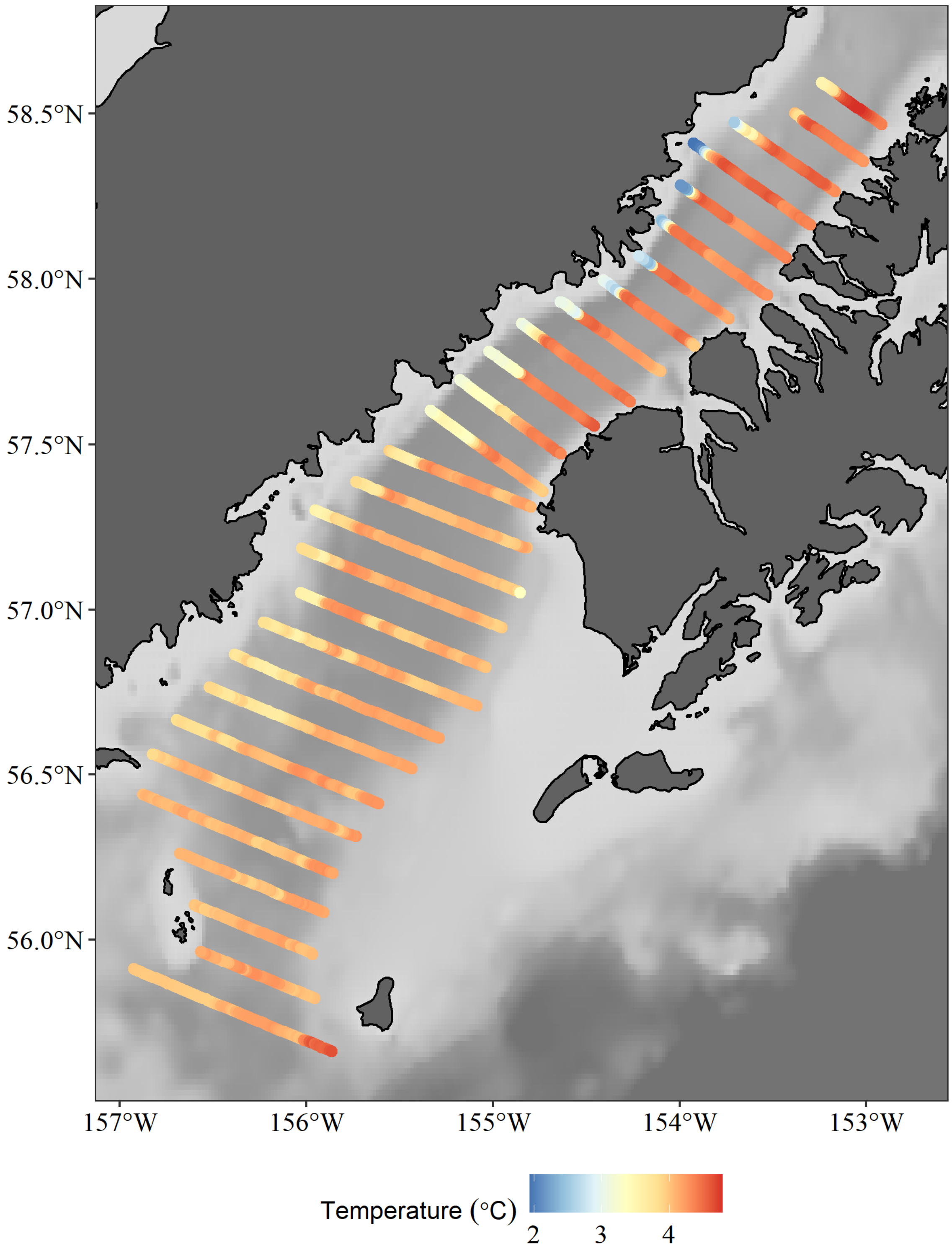

Figure 13. -- Surface water temperatures (°C) recorded at 5-second intervals during the winter 2022 acoustic-trawl survey of the Shelikof Strait regions.

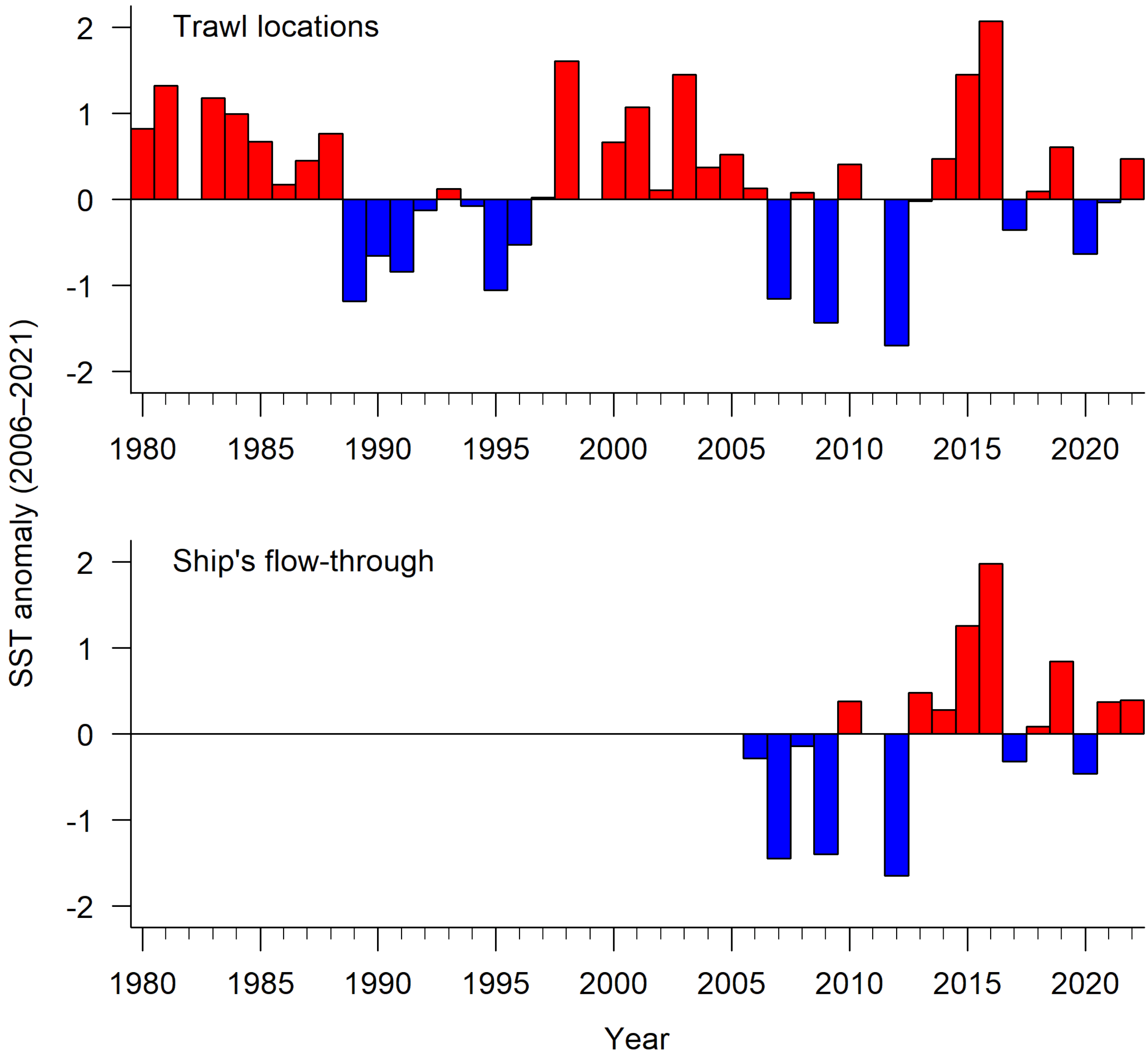

Figure 14. -- Sea surface temperature (SST, °C) anomalies recorded at trawl locations (upper panel) and from the ship's flow-through system for each 0.5 nmi interval (lower panel). SST anomalies for each temperature source are centered and scaled by their respective mean temperature and standard deviation from 2006 to 2021. Positive and negative anomalies are indicated by red and blue bars, respectively.

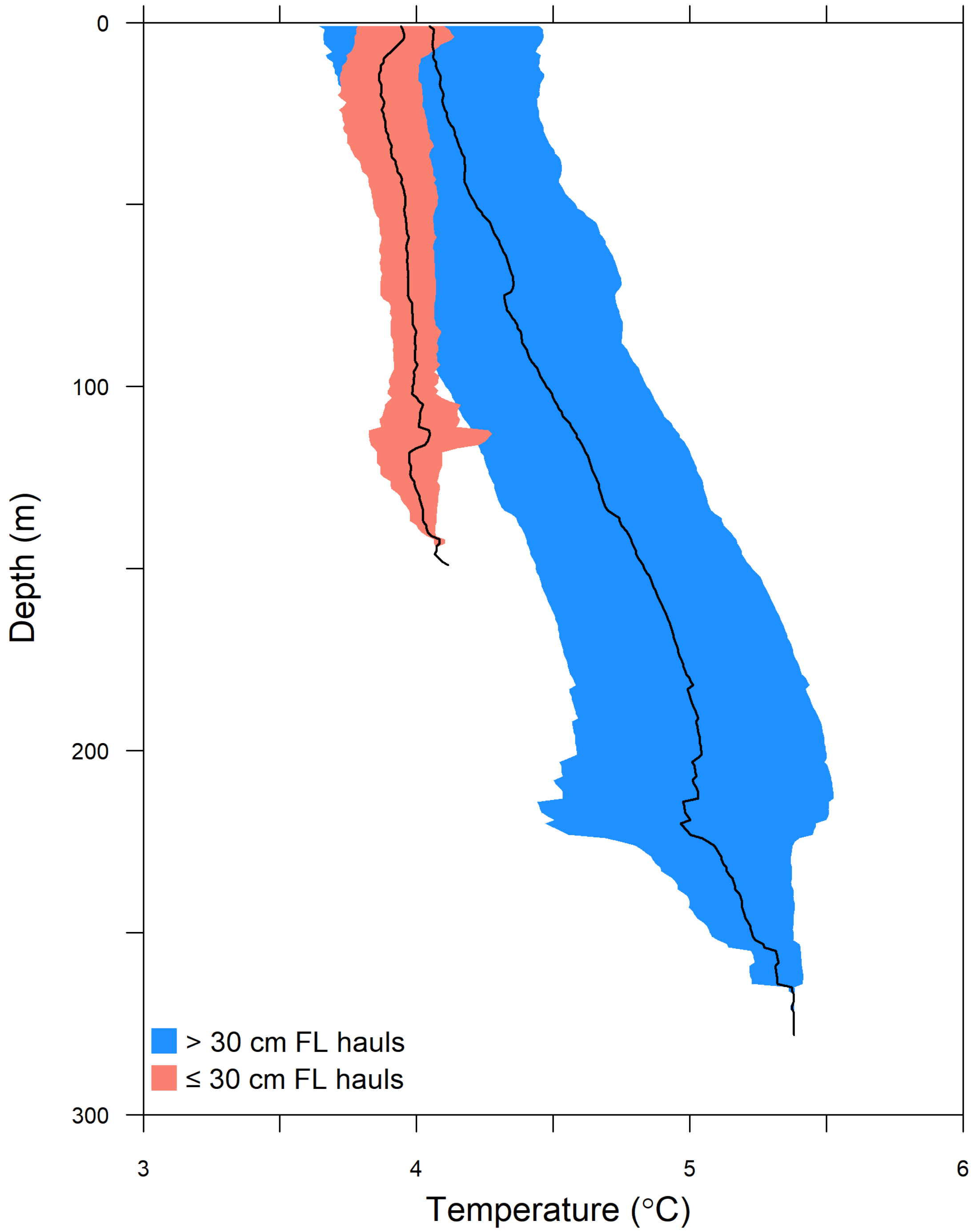

Figure 15. -- Mean water temperature profiles (°C; solid line) by 1-m depth intervals measured at trawl locations associated with catches dominated by adult (> 30 cm fork length, FL) or juvenile (≤ 30 cm FL) pollock during the 2022 acoustic-trawl survey of pollock in the Shelikof Strait area. Shaded areas represent one standard deviation.

APPENDIX I. ITINERARY

Shelikof Strait

8 March	Depart Kodiak, AK
8 March	Acoustic sphere calibration in Kalsin Bay, Kodiak Island
8 March	Transit to survey start area
9 March-16 March	Acoustic-trawl survey of the Shelikof Strait
16 March-17 March	Transit to Kodiak
17 March	In port Kodiak

APPENDIX II. SCIENTIFIC PERSONNEL

Shelikof Strait

Name	Position	Organization
Darin Jones	Chief Scientist	AFSC
Taina Honkalehto	Fishery Biologist	AFSC
Dave McGowan	Fishery Biologist	AFSC
Mike Levine	Fishery Biologist	AFSC
Scott Furnish	Computer Spec.	AFSC
Cecilia O'Leary	Fishery Biologist	AFSC
Ryan Byrne	Fishery Biologist	AIS

[1]AFSC = Alaska Fisheries Science Center, National Marine Fisheries Service, Seattle, WA; 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. 2017b 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 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):

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

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 ($P_{s.l,h}$):

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

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

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

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

where TS is the target strength (dB re m^2) of species *s* at size *l* (Table 3).

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:

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

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

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

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 the 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:

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

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

where $W_{s,l}$ is the mean weight-at-length 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:

$$\text{Numbers at age } j\text{: } N_{s,j} = \sum_i \left(Q_{s,l,j} \times N_{s,l} \right) \qquad \text{Eqn. } viii$$

$$\text{Biomass at age } j\text{: } B_{s,j} = \sum_i \left(Q_{s,l,j} \times B_{s,l} \right) \qquad \text{Eqn. } i$$

U.S. Secretary of Commerce
Gina M. Raimondo

Under Secretary of Commerce for
Oceans and Atmosphere
Dr. Richard W. Spinrad

Assistant Administrator,
National Marine Fisheries Service.
Janet Coit

April 2024

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