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Resource Assessment and Conservation Engineering Division
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Results of the Acoustic-Trawl Survey of Walleye Pollock (*Gadus chalcogrammus*) in the Gulf of Alaska, June-August 2023 (DY2023-08)

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Results of the Acoustic-Trawl Survey of Walleye Pollock (*Gadus chalcogrammus*) in the Gulf of Alaska, June-August 2023 (DY2023-08)

by

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ABSTRACT

Scientists from the Midwater Assessment and Conservation Engineering (MACE) Program of the Alaska Fisheries Science Center's (AFSC) Resource Assessment and Conservation Engineering (RACE) Division conducted an acoustic-trawl (AT) survey of the Gulf of Alaska (GOA) shelf to estimate the distribution and abundance of walleye pollock (*Gadus chalcogrammus*; hereafter, pollock) in summer 2023. Previous surveys of the GOA have also been conducted by the MACE Program during the summers of 2003, 2005, and every other year since 2011. The 2023 survey covered the shelf from the Islands of Four Mountains to Yakutat Trough as well as the Shumagin Islands, Shelikof Strait, Chiniak Trough, and Barnabas Trough regions. These regions have been consistently surveyed since 2013. Abundance estimates were based on an analysis where backscatter was attributed to all trawl-captured species and size classes using the biological length-frequency data from the nearest trawl locations. Abundance estimates also included a correction for escapement of fishes and other catch from the survey trawl (i.e., net selectivity). The estimated abundance of age-1+ pollock for the entire surveyed area was 1,774.2 million fish weighing 732,863 metric tons (t), a decrease of 58.8% by numbers and an increase of 70.0% by weight from the 2021 estimated abundance. The majority of the pollock biomass was observed in the GOA Shelf (84%) and Shelikof Strait (9%) regions. Age-3 pollock dominated by numbers (33% of total pollock numbers) and by weight (36% of total pollock biomass). Additionally, abundance estimates were calculated for Pacific ocean perch (*Sebastes alutus*; 190.7 million fish weighing 137,892 t) and Pacific capelin (*Mallotus catervarius*; 21,057.3 million fish weighing 71,712 t).

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INTRODUCTION

Scientists from the Midwater Assessment and Conservation Engineering (MACE) Program of the Alaska Fisheries Science Center's (AFSC) Resource Assessment and Conservation Engineering (RACE) Division conduct acoustic-trawl (AT) stock assessment surveys to estimate the abundance and distribution of walleye pollock (*Gadus chalcogrammus*; hereafter, pollock) in the Gulf of Alaska (GOA). Annual surveys of pre-spawning aggregations in the GOA are conducted during late winter and early spring. AT surveys were conducted in Chiniak and Barnabas Troughs east of Kodiak Island during the summers of 2000-2006 to explore species spatial distribution relative to environmental conditions (Hollowed et al. 2007, Logerwell et al. 2007) and the effect of commercial fishing on pollock abundance (Wilson et al. 2003, Walline et al. 2012). Expanded AT summer surveys to estimate pollock distribution and abundance across the GOA were carried out in summers of 2003, 2005, and biennially since summer 2011. Surveys were abbreviated due to budget restrictions in 2003, and ship mechanical issues in 2005 and 2011 (surveys from 2003-2011 are reviewed in Jones et al. 2014). Biennial summer surveys since 2013 (Jones et al. 2014, 2017, 2019, and Jones et al. 2022) have covered the shelf from the Islands of Four Mountains to Yakutat Trough (hereafter referred to as the GOA Shelf) as well as the Shelikof Strait, Shumagin Islands, Barnabas Trough, and Chiniak Trough regions (Fig. 1 presents the survey regions and all place names used within this report). In the 2013-2019 surveys, additional bays and troughs were surveyed. Estimates of the distribution and abundance of pollock, Pacific ocean perch (*Sebastes alutus*; hereafter, POP), and Pacific capelin (*Mallotus catervarius*, hereafter, capelin) have been made for the areas surveyed when they were sufficiently abundant to allow a reliable estimate. Since 2011, an estimate of the distribution and abundance of backscatter attributed to euphausiids (or 'krill,' primarily consisting of *Thysanoessa inermis*, *T. spinifera*, and *Euphausia pacifica*) has also been provided; work to produce this estimate in 2023 is ongoing, and these results are not presented in the current report.

This report presents the distribution and abundance estimates for pollock, POP, and capelin based on the summer GOA AT survey conducted between June and August 2023. Acoustic system calibration results and observations of water temperature are also presented.

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.

The survey (cruise DY2023-08) was conducted between 14 June and 17 August 2023 (all dates and times are reported in GMT unless noted otherwise) from the Islands of Four Mountains in the west to Yakutat Trough in the east (Fig. 1). The total number of survey days at sea was reduced from 66 to 46 days due to crew staffing issues on the NOAA Ship *Oscar Dyson*.

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.

Two 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. 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

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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.

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 21.15.2) at a nominal ping interval of 1.1 second at water depths < 275 m and 2.5 seconds or longer at water depths > 275 m, and analyzed from 16 m below the sea surface to within 0.5 m of the sounder-detected bottom to a maximum depth of 1,000 m. Data shallower than 16 m were excluded to account for the acoustic near-field range of the 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 13.0396, 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 Series-2000-V trawl doors with 4 in. shoes (918 kg (2,024 lb) each), and 227 kg (500 lb) tom

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

weights attached to each wingtip. Average trawling speed was 1.8 m s^{-1} (3.5 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 12.0 to 20.0 m (39.4 to 65.6 ft) and averaged 15.4 m (50.6 ft) while fishing. Average trawling speed for the bottom trawl was 1.3 m s^{-1} (2.5 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 ranged from 5.5 to 6.5 m (18.0 to 21.3 ft) and averaged 6.0 m (19.7 ft).

A Methot trawl (Methot 1986) was used to target midwater acoustic layers containing macro-zooplankton such as euphausiids, age-0 pollock, and other larval fishes. The Methot trawl had a rigid square frame measuring 2.3 m (7.5 ft) on each side, which formed the mouth of the net. The body of the net consisted of nylon 63.5 mm (2.5 in.) mesh material, lined with delta nylon 1/8 in. mesh material with 2 × 3 mm oval openings, and attached to a hard plastic codend bucket lined with 1 × 1 mm square opening mesh. A 1.8 m (5.9 ft) dihedral depressor was used to generate additional downward force. A calibrated General Oceanics flowmeter was attached to the mouth of the net; the number of flowmeter revolutions and the total time the net was in the water were used to determine the volume of water filtered during the haul. The Methot trawl was attached to a single cable fed through a stern-mounted A-frame. Real-time haul depths were monitored using a Simrad ITI acoustic link temperature-depth sensor attached to the bottom of the Methot frame. The Methot trawl was towed at an average speed of 1.6 m s^{-1} (3.1 knots).

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 are sampled by a trawl haul as they cannot be differentiated in the codend catch. Images are viewed and annotated using procedures described in Williams et al. (2010).

Physical oceanographic data were collected during the cruise at trawl locations, at calibration locations, and continuously along transects. Water temperature profiles were obtained at trawl locations 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 and throughout the survey to describe GOA Shelf temperature features associated with pollock. CTD casts were made at the closest point along a survey transect to seven predetermined stations located in the survey area, selected to provide a systematic, representative set of water column observations (P. Stabeno, PMEL, pers. comm.) to complement SBE profiles. A cast was also made wherever the ship stopped surveying after sunset for most nights if it was more than 20 nmi from another nighttime cast. This sampling strategy is repeatable each survey year with minimal impact on other survey operations. Salinity bottle samples (e.g., one bottle every other day, alternating at surface and bottom of cast) were collected from the casts to calibrate the CTD conductivity sensor. Sea surface temperature was measured using the ship's flow-through sea surface temperature system (SBE 38, Sea-Bird Scientific, accuracy $\pm$ 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 temperature was measured from the Furuno T-2000 temperature probe (accuracy $\pm$ 0.2°C) located amidships 1.4 m below the surface. The SBE 38 was used 95.4% of the time and the Furuno was used 4.6% of the time in this 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 predetermined 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 transect location and spacing were chosen to be consistent with previous surveys. Overall, the survey was comprised of a main GOA Shelf region (hereafter GOA Shelf) and four localized regions: Shumagin Islands (including Renshaw Point, Unga Strait, and West Nagai Strait), Shelikof Strait, Barnabas Trough, and Chiniak Trough (Fig. 1). GOA Shelf transects extend in a generally north-south direction covering bottom depths of approximately 50-1,000 m, roughly perpendicular to the depth contours over the continental shelf, and were spaced 55.5-74.1 km (30.0-40.0 nmi) apart. The four localized regions had finer transect spacing: 5.6-11.1 km (3.0-6.0 nmi) in the Shumagins, 37.0 km (20.0 nmi) in Shelikof, 11.1 km (6.0 nmi) in Barnabas, and 11.1 km (6.0 nmi) in Chiniak. Transects within each localized region were also oriented perpendicular to depth contours.

Traditionally, the GOA Shelf consists of parallel transects spaced 46.3 km (25.0 nmi) apart. The loss of a total of 20 survey days due to crew staffing issues (10 days lost from both Legs 1 and 3) required increasing spacing between transects on the GOA Shelf to 74.1 km (40.0 nmi) in NMFS Reporting Areas 610 and 640, and to 55.5 km (30.0 nmi) in Areas 620 and 630 (Figs. 1 and 2). In addition, the loss of survey days prevented sampling a number of smaller bays and troughs surveyed between 2013 and 2019, including Sanak Trough, Morzhovoi Bay, Pavlof Bay, Mitrofania, Nakchamik, Alitak Bay, Marmot Bay, Kenai Peninsula, Prince William Sound, and Hinchinbrook Canyon. The 2023 survey coverage was similar to the design of the 2021 summer GOA AT survey, in which the COVID-19 pandemic's effects on survey participation and logistics resulted in a similar reduction of 20 survey days in sampling effort (Levine et al. 2024). A prior analysis of historical surveys for the 2021 survey design indicated that this would have a minimal impact on the survey estimate as 92-98% of the survey biomass from 2013-2019 was observed within the regions surveyed in 2021 and 2023 (see appendix I in Levine et al. 2024). The 2023 survey was conducted during daylight hours.

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 a 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

[3] Groundfish Survey and Species Codes. 2019. RACE Division, AFSC, NMFS, NOAA; 7600 Sand Point Way NE, Seattle, WA 98115. https://doi.org/10.25923/kp5e-1g02.

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.

The catch from Methot trawl hauls was transferred to a large tote. Large organisms (such as jellyfish) and small fishes were removed, identified, weighed, and measured. The remainder of the plankton catch was placed on a 1 mm mesh screen to remove excess water and weighed. A subsample of the zooplankton mixture was then weighed and sorted into broad taxonomic groups for which a count and weight were determined. A second subsample was weighed and preserved in a 5% buffered formalin solution for more detailed enumeration at the Polish Sorting Center in Szczecin, Poland.

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 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.

During the 2023 summer GOA AT survey, an issue with radiated vessel noise was identified and required a minor change in the way the acoustic data were processed. The processing methods outlined above assume that noise is negligible. However, in this survey there was concern that this was no longer the case due to recent changes in vessel-radiated noise (sonar self-noise at 38 kHz at survey speed was ~10 dB or ten-fold higher than in 2022). The effects of this noise are depth- and density-dependent and are difficult to predict. Background noise and signal-to-noise ratio were estimated from the data (De Robertis and Higginbottom 2007), background noise was removed, and all areas with a signal-to-noise threshold of < 6 dB were removed from the pollock estimate. This revised processing resulted in total pollock biomass that was 0.2% less than for uncorrected data at the survey level, suggesting that noise had only a minor impact on the pollock estimate. Similarly, the biomass estimate for POP was reduced by only 0.5%, and there was no change in the capelin biomass estimate.

The minimal impact of vessel noise on survey estimates is attributed to actions immediately taken during the survey when vessel noise was first observed. Revolutions of the ship's propeller were reduced from ~105 to 90 RPMs, decreasing vessel speed from ~5.9 m s^{-1} (11.5 knots) to ~5.1 m s^{-1} (10 knots), to lower the observed noise floor below 250 m, the maximum water column depth where most backscatter associated with pollock, POP, and capelin was observed throughout the survey. Most backscatter data later removed as noise during data processing occurred at water column depths > 300 m.

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 horizontal 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 100th 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. 2024 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 MACE AT surveys conducted since 2008 based on the survey area and season (winter GOA, summer GOA, summer eastern Bering Sea, EBS), vessel, how backscatter was allocated to species, and the type of midwater net used in the survey (winter GOA: Stienessen et al. 2019, McCarthy et al. 2022, Honkalehto et al. 2024; summer GOA: Lauffenburger et al. 2019, Levine et al. 2024; summer EBS: McCarthy et al. 2020). Trawl selectivity in the 2023 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. 2024). 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. 2024). Thus, the 2023 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 (hereafter TS-length) relationships from the literature (Table 2) 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 FL). Species-specific TS-length relationships from the literature were used for pollock, capelin, eulachon, Pacific herring, and for any species whose contribution to the total backscatter used in survey estimates was > 5%. Otherwise, species were assigned to one of five group TS-length relationships: fishes with swim bladders, fishes without swim bladders, jellyfish, squid, and pelagic crustaceans (Table 2).

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 $\overline{A}$:

$$W_h = \frac{A_h}{\overline{A}} \quad , \qquad \text{(Eq. 1)}$$

where

$$\overline{A} = \frac{\sum_h \; A_h}{H} \quad , \qquad \text{(Eq. 2)}$$

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:

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

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) was 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:

$$GSI = \frac{\sum_h \left(GSI_h \cdot W_h\right)}{\sum_h W_h} \quad . \qquad \text{(Eq. 4)}$$

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):

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

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):

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

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 2013-2023 (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 each NMFS Reporting Area based on a polygon that encompasses all samples collected between 2013 and 2023 and was manually corrected to exclude land features. 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 eq. 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:

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

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:

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

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 were the same as the primary analysis.

Special Projects

In addition to standard survey operations, multiple special projects were conducted during the 2023 summer GOA AT survey. An additional six survey days at sea were added to the survey to test the Exail DriX uncrewed surface vehicle (USV). The primary goal of this project was to determine if the USV could be routinely deployed, recovered, and refueled from the ship to examine how well the USV could be integrated into future acoustic-survey operations. All DriX testing occurred interspersed throughout the 2nd survey leg (21 June - 22 July) (Alex De Robertis, alex.derobertis@noaa.gov). A miniature live-feed camera system (PelagiCam) was also tested, being lowered into shallow fish layers to determine species and length composition of acoustic observations (Kresimir Williams, kresimir.williams@noaa.gov). Two commercial fish finders were calibrated to determine viability for use in scientific applications (Robert Levine, robert.levine@noaa.gov). Mooring operations for the AFSC Marine Mammal Laboratory were also conducted at two sites within the survey area, at which a subsurface passive acoustic recorder mooring was recovered and a replacement mooring was deployed to track the distribution and seasonal occurrence of North Pacific right whales (*Eubalaena japonica*) in the shelf waters of the northern GOA (Catherine Berchok, catherine.berchok@noaa.gov).

Additional biological samples were also collected for special studies. Pollock ovaries were collected from pre-spawning pollock to investigate interannual variation in fecundity of mature females and from female pollock of all maturity stages for a histological study (Sandi Neidetcher, sandi.neidetcher@noaa.gov). Whole fish specimens of forage fish species were collected for the Alaska Maritime National Wildlife Refuge to obtain a reference collection of bones of seabird prey species at various sizes for use in identifying items in seabird diet samples (Lisa Spitler, lisa_spitler@fws.gov). Whole specimens for a variety of fish species were also collected for NOAA's Northwest Fisheries Science Center's Genetics and Evolution Program's Forensic Voucher Collection to collect, store, and genetically analyze East Pacific marine fishes for the purpose of identifying marine species using forensic molecular genetic techniques, and to build reference databases crucial to eDNA analysis (Krista Nichols, krista.nichols@noaa.gov).

RESULTS AND DISCUSSION

Acoustic System Calibration

Pre- and post-survey calibration measurements of the 38 kHz echosounder showed no significant differences in gain parameters or beam pattern characteristics for either the swing or the on-axis results, 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 results are used to verify that the beam pattern matches expectations. At 38 kHz the integration gain differed by 0.05 dB across the two measurements. Acoustic system gain and beam pattern parameters measured during the first and second calibrations were averaged (averages calculated in the linear domain for dB quantities), nominal sound speed and absorption values appropriate for the survey areas were used in the final parameter set for survey data analysis, and the equivalent beam angle initially measured by the manufacturer in a test tank was adjusted (Bodholt 2002) using the *in situ* sound speed during survey conditions (Table 1).

Survey Timing and Extent

The summer GOA AT survey was conducted between 10 June and 18 August. The entire survey area encompassed 198,234 km^2 (57,796 nmi^2). Acoustic backscatter was measured along 4,396 km (2,374 nmi) of trackline on 94 transects spaced from 3.4 km (1.9 nmi) to 74.1 km (40.0 nmi) apart, depending on the survey region (Fig. 2). In general, the summer GOA AT survey extended from inshore depths of approximately 50 m to approximately 1,000 m, averaging 209 m.

For in-depth summaries of the multiple regions that comprise the summer GOA AT survey (including the GOA Shelf, Shumagin Islands, Shelikof Strait, Barnabas Trough, and Chiniak Trough regions), see Appendix IV.

Accounting for Catch from Non-targeted Scattering Layers

There were very few trawls in which substantial amounts of acoustically-relevant species and/or size classes were captured outside of the targeted trawl stratum. CamTrawl review indicated four trawls in which multiple pollock size classes were captured in different vertical strata. In each case, the trawl was targeting a stratum in the lower water column, and passed through a stratum containing pollock < 20 cm in length (indicative of age-1 pollock). These small pollock were removed from the catch data that was assigned to the targeted lower stratum. In one trawl, POP were observed in an upper water column stratum but not in the targeted lower stratum and were removed from the catch assigned to the targeted lower stratum. In the remainder of the trawls that were applied to abundance calculation (n = 57), no adjustments were made.

Trawl Catch Summary

Biological data and specimens were collected from 63 LFS1421, 3 Methot, and 2 PNE hauls, of which 60 LFS1421 and 1 PNE hauls were used in fish abundance estimate calculations (Fig. 2, Table 3). In cases where hauls were excluded from fish abundance calculations, this was due to low catch and/or mechanical issues during the trawl. Pollock and POP were the most abundant species by weight in the LFS1421 trawls used to estimate fish abundance, contributing 68.1 and 15.7% of the catch by weight (Table 4). Capelin and pollock were the most abundant species by number in the LFS1421 trawls used to estimate fish abundance, contributing 37.8 and 19.5% of the catch by number (Table 4). Pollock and POP were the most abundant species by weight in the PNE trawls used to estimate fish abundance, contributing 88.8 and 4.1% of the catch by weight (Table 5). Pollock and POP were the most abundant species by number in the PNE trawls used to estimate fish abundance, contributing 89.6 and 4.2% of the catch by number (Table 5). Lions mane jellyfish (*Cyanea capillata*) and euphausiids (Euphausiacea) were the most abundant species by weight in the Methot trawls used to estimate fish abundance, contributing 41.7 and 21.4% of the catch by weight (Table 6). Euphausiids and *Aequorea sp.* were the most abundant species by number in the Methot trawls used to estimate fish abundance, contributing 99.3 and 0.3% of the catch by number (Table 6).

Pollock Weight, Length, Maturity, and Age

Both weight and length were measured from 2,733 pollock during the 2023 summer GOA AT survey, of which 2,732 were from hauls used to scale acoustic backscatter (Table 7). Weight-at-length was observed to be similar throughout the surveyed regions, and pollock were therefore grouped into a single weight-at-length key for the entire survey. Pollock weight-at-length during the 2023 summer GOA AT survey was heavier than that in previous surveys for fish ≤ 40 cm FL, and it was similar to that in previous surveys for fish > 40 cm FL (Fig. 3).

Almost all male and female pollock examined throughout the survey were in the developing or spent stages of maturity (92.6 and 89.8%, respectively; Fig. 4), with the remaining individuals primarily in the immature stages. There is some ambiguity as to exactly when the stage of maturity reverts from spent back to developing prior to active spawning again. No actively spawning individuals were identified.

Otoliths were collected from 1,542 pollock (Table 7), of which 1,532 were aged and used to scale acoustic backscatter. A single length-at-age key was used for the entire survey. All pollock age classes were within 10.0% of their historical average length, with the exception of age-1 fish that were longer by 13.8% and age-11 fish that were shorter by 10.2% (Fig. 5a). Age-1 and age-2 pollock were heavier by 54.5 and 24.3% than in previous years, age-3 to age-5 pollock were of similar weight, and age-6+ fish were all lighter than the historical average by more than 10%, with the exception of age-7 fish (Fig. 5b).

In the 42 trawls that captured age-0 pollock, the backscatter attributed to age-0 pollock averaged 6.4 ± 21.0% (± 1 standard deviation) of total backscatter in the haul (range: < 0.1 to 99.6% of backscatter attributed to age-0 pollock).

Pollock Distribution

Pollock were observed throughout the survey area. Locally dense pollock aggregations were observed over the GOA Shelf southwest of Kodiak Island, the southern Shelikof Strait (in the vicinity of Chirikof Island), Chiniak Trough, and over the GOA Shelf northeast of Kodiak Island (Fig. 6). Most of the pollock biomass was observed over the GOA Shelf, containing 83.9% of total biomass, and most pollock by number were also observed over the GOA Shelf, containing 79.0% of the total abundance (Table 8). Pollock biomass was concentrated on the GOA Shelf southwest of Kodiak Island and the GOA Shelf northeast of Kodiak Island (Fig. 7b). The pollock distribution in 2023 was broadly similar to previously observed distributions in 2013-2021 (Fig. 7a), indicating that pollock continue to occupy the standard survey area. Geostatistical measures of the mean location and dispersion of a population (COG and inertia, Woillez et al. 2007), were also used to compare patterns in pollock distribution over time. Compared to the 2013-2021 surveys, the COG in 2023 (Fig. 7c) was not closer to the shelf break in any NMFS Reporting Areas, indicating pollock biomass has not shifted farther offshore towards the outer shelf. While the distribution of pollock in NMFS Reporting Areas 610 and 640 was similar to prior surveys, there were notable shifts in COG to the southwest in Area 620 and northeastward in Area 630, indicating localized shifts in areas of high pollock biomass.

Pollock Abundance and Biomass

The total estimated abundance of age-1+ pollock for the 2023 summer GOA AT survey was 1,774.2 million fish weighing 732,862.6 t. This represents a 58.8% decrease in numbers of fish and a 70.0% increase in biomass from the 2021 summer GOA AT survey (Fig. 8). The 2023 abundance estimates are 61.7% below and 19.3% below the 2013-2021 mean abundance estimates of numbers and biomass, respectively, for the core survey regions that have been consistently sampled in all years since 2013. The relative estimation error of the overall biomass based on the 1-D geostatistical analysis was 7.4% (Table 8). Despite the increase in transect spacing from 25 nmi to 30-40 nmi over the GOA shelf, the estimation error remained similar to prior surveys.

Age-1+ pollock ranged in length from 14 to 67 cm FL with modes at 21, 40, and 46 cm FL (Fig. 9; Tables 9 and 10). Approximately 32.9% of total pollock numbers were attributed to age-3 fish from the 2020 year class, with age-1 and age-5 pollock from the 2022 and 2018 year classes contributing 31.7 and 14.3% of total abundance by numbers, respectively (Figs. 10 and 11a; Table 11). Age-3 (2020 year class), age-5 (2018), and age-6 fish (2017) fish contributed 36.4, 25.7, and 14.4% of total pollock biomass, respectively (Figs. 10 and 11b; Table 12). The presence of multiple dominant year classes has been a pattern since 2019, while the large 2012 year class accounted for most of the observed pollock numbers and biomass in the 2013-2017 surveys (Fig. 11).

The individual survey regions that comprise the summer GOA AT survey (Fig. 2) do not follow the boundaries of the NMFS Reporting Areas (Fig. 1). Some regions, such as the GOA Shelf and Shelikof Strait, extend across multiple NMFS Reporting Areas. Because pollock are managed by NMFS Reporting Area, survey results are also summarized by Area and corresponding survey region (Table 13). The majority of pollock biomass (62%) was distributed in Area 630. Less of the pollock biomass was distributed in Areas 610 (17%) and 620 (20%), and only 2% was observed in Area 640.

Pollock Vertical Distribution

Pollock mean weighted depth from the surface and height above bottom in 2023 were compared to the 2013-2021 summer GOA AT surveys (Fig. 12). This was done for pollock > 30 cm (presumed age-3+) as well as for pollock ≤ 30 cm (presumed age-1 and age-2). Based on pollock mean weighted depth, most (defined as 75% of the biomass) > 30 cm pollock were distributed between depths of 55-205 m, which is deeper than those in 2013, 2015, 2017, and 2019 (Fig. 12a). Most ≤ 30 cm pollock were distributed between depths of 65-135 m, deeper than those in 2015 and 2019 (Fig. 12b). Based on height above bottom, 19.5% of the > 30 cm biomass was observed within 10 m of the seafloor, and 59.2% of biomass within 50 m of the seafloor; this vertical distribution was farther from the seafloor than those in 2013, 2015, and 2017 (Fig. 12c). Approximately 11.0% of the ≤ 30 cm pollock biomass was observed within 10 m of the seafloor, and 43.1% of biomass was observed within 50 m of the seafloor; this was closer to the seafloor than in the previous five surveys (Fig. 12d).

Other Species Distribution and Abundance

The summer GOA AT survey design is designed to encompass the geographic distribution of the highest densities of midwater age-1+ pollock during summer. Other species are encountered, but the survey design may not provide adequate coverage for complete population assessment. Thus, the following distribution and abundance estimates for POP and capelin are not comprehensive, and they are likely underestimates due to incomplete coverage of the population's geographic extent. Abundances of these species are reported to establish a time series of relative abundances and distributions within the survey area.

Pacific Ocean Perch

POP were captured in 34 hauls across the summer GOA AT survey in 2023 (Fig. 13). POP were most often found intermixed with pollock in the midwater and were located predominately along the shelf break across all NMFS Reporting Areas, with high concentrations in the southern portion of Shelikof Strait (Fig. 14). POP were also more broadly distributed over the GOA Shelf between Kodiak and Middleton Island compared to other years (Fig. 14b, c), but they were not concentrated in high densities in NMFS Reporting Area 630 as observed in the 2021 survey (Fig. 14a). POP captured in trawl hauls ranged from 31 cm to 47 cm FL with a mode at 37 cm

(Fig. 15). The estimated abundance of POP for the 2023 summer GOA AT survey area was 190.7 million fish weighing 137,891.6 t, approximately 50.6% lower by numbers and 50.4% lower by biomass than the 2021 estimate (Fig. 16). The relative estimation error of the POP biomass based on the 1-D geostatistical analysis was 14.7%.

POP mean weighted depth from the surface and height above bottom in 2023 were compared to the 2013-2021 summer GOA AT surveys (Fig. 17). Based on mean weighted depth, most (defined as 75.0% of the biomass) POP were detected between depths of 105-275 m, which is a broader depth range compared to most other years, but the median depth of 187 m is within 25 m of the median depth of all other years (Fig. 17a). The broader vertical distribution from the surface in 2023 may reflect a shift in POP biomass farther offshore towards the shelf break, particularly in NMFS Reporting Area 630 where POP were less concentrated over Amatuli Trough while they were widely distributed over deeper waters along the shelf break (Fig. 14). Based on height above bottom, approximately 17.9% of POP biomass was observed within 10 m of the seafloor, and 47.7% of biomass within 50 m of the seafloor; this was similar to the more recent 2019-2021 surveys (Fig. 17b).

Pacific Capelin

Capelin were captured in 24 hauls across the summer GOA AT survey in 2023 (Fig. 18). Capelin were predominately concentrated in shallow waters (< 100 m bottom depth) over Portlock and Albatross Banks and along the edges of Barnabas and Chiniak Troughs in NMFS Reporting Area 630, and in the southwestern portion of Shelikof Strait in Area 620 (Fig. 19). Capelin captured in trawl hauls ranged from 3 cm to 15 cm SL with a mode at 8 cm (Fig. 20). The estimated abundance of capelin for the 2023 summer GOA AT survey area was 21,057.3 million fish weighing 71,712.3 t, which is a 1,246.7% increase in numbers and a 734.6% increase in total biomass from the 2021 estimates (Fig. 21). This was the highest abundance estimate for capelin since 2013, indicating a possible recovery of the population following its collapse during the 2014-2016 marine heatwave (Arimitsu et al. 2021). The relative estimation error of the capelin biomass based on the 1-D geostatistical analysis was 19.0%.

Capelin mean weighted depth from the surface and height above bottom in 2023 were compared to the 2013-2021 summer GOA AT surveys (Fig. 22). This was done for capelin > 10 cm (presumed age-2+) as well as for capelin ≤ 10 cm (presumed age-1). Based on mean weighted depth, most (defined as 75% of the biomass) > 10 cm capelin were detected between depths of 25-55 m, which is shallower than in previous years (Fig. 22a). Most ≤ 10 cm capelin were detected between depths of 25-75 m, which is also shallower than in previous years, except in 2013 when capelin were also detected between depths of 25-75 m (Fig. 22b). Based on height above bottom, approximately 27.8% of the > 10 cm biomass was observed within 10 m of the seafloor, and 98.0% of biomass within 50 m of the seafloor; this was similar to most other years, except in 2021 when capelin were distributed farther above the seafloor (Fig. 22c). Approximately 6.7% of the ≤ 10 cm capelin biomass was observed within 10 m of the seafloor, the lowest compared to all other years, indicating capelin were concentrated farther off bottom, and 55.0% of biomass was observed within 50 m of the seafloor, which is similar to other years (Fig. 22d).

Selectivity Correction

The results presented here account for escapement of organisms from the net (net selectivity) based on the 2019 LFS1421 selectivity values obtained from catches in the codend and recapture nets. Correcting catch data for net selectivity has been done in the summer GOA AT survey time series since 2013 (details in McGowan et al. In prep). Thus, an alternate analysis that did not include the effect of net selectivity (referred to as the 'no-selectivity' analysis below; Fig. 23) was conducted for pollock, POP, and capelin to evaluate the effect of the selectivity correction in the 2023 survey results and for comparison with results from previous surveys.

For pollock, this difference in methodology had a minimal effect on numerical abundance (Fig. 23a), with a 0.6% decrease in the primary, selectivity-corrected analysis as opposed to the no-selectivity analysis. This corresponded to a 1.2% decrease in the selectivity-corrected pollock biomass estimate. This is expected, as, in comparison to the selectivity-corrected analysis, the no-selectivity analysis underestimated the number of smaller pollock < 20 cm FL, which resulted in a larger proportion of the backscatter being attributed to larger pollock > 20 cm fork length. For POP, the selectivity-corrected analysis resulted in a 6.1% decrease in numbers, which corresponded to a 6.9% decrease in biomass (Fig. 23b). For capelin, the selectivity-corrected analysis resulted in a 19.2% increase in numbers; this corresponded to a 7.3% decrease in biomass (Fig. 23c). The more pronounced effect of selectivity corrections on capelin estimates is expected, as escapement is much higher for small pelagic fishes (e.g., De Robertis et al. 2017a).

Inter-annual Changes in Water Temperature

Since 2013, five survey regions have been consistently sampled during the summer GOA AT survey: GOA Shelf, Shumagin Islands, Shelikof Strait, Barnabas Trough, and Chiniak Trough (Fig. 2). Within the consistently sampled region, average surface water temperatures recorded from the hull mounted flow-through seawater system in previous surveys have ranged from 9.0°C (2021) to 12.0°C (2015). In 2023, the average surface temperature was 10.0°C, within the range of previous surveys. A similar pattern was seen with near-surface temperatures recorded at fishing locations in the consistently sampled regions (Fig. 24). Surface temperatures became progressively warmer from west to east; however, this trend is confounded with survey timing, as water temperatures increased to seasonal highs during the survey period (Fig. 25a). Similarly, differences in survey timing confound any inter-annual comparisons of surface temperature as survey regions were not always sampled at the same time within each survey year. The mean temperature at 100 m depth in the consistently sampled areas in 2023 was 5.5°C, within the range of previous surveys, which have ranged from 5.1°C (2013) to 6.5°C (2015; Fig. 24). The mean bottom temperature, as measured during 35 CTD deployments during 2023, was 5.3°C (Fig. 25b), within the range of previous surveys which have ranged from 5.0°C (2021) to 6.0°C (2019).

TABLES

Table 1. -- Simrad EK80 38 kHz acoustic system description and settings used during the summer 2023 acoustic-trawl survey of the Gulf of Alaska. These include environmental parameters and results from standard sphere acoustic system calibrations conducted in association with the survey and final values used to calculate biomass and abundance data. The collection settings column contains 11 June 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	11 June Uyak Bay Kodiak	12 August Nuka Bay Kenai	Final analysis settings
Echosounder	Simrad EK80	Simrad EK80	Simrad EK80	Simrad EK80
Transducer	ES38-7 s/n 324	ES38-7 s/n 324	ES38-7 s/n 324	ES38-7 s/n 324
Frequency (kHz)	38.00	38.00	38.00	38.00
Transducer depth (m)	9.15	9.15	9.15	9.15
Pulse length (ms)	0.512	0.512	0.512	0.512
Transmitted power (W)	2000	2000	2000	2000
Angle sensitivity along	18.00	18.00	18.00	18.00
Angle sensitivity athwart	18.00	18.00	18.00	18.00
2-way beam angle (dB re 1 steradian)	-20.70	-20.70	-20.70	-20.46
Gain (dB)	27.18	27.11	27.16	27.13
S_a correction (dB)	-0.12	-0.09	-0.12	-0.10
Integration gain (dB)	27.06	27.02	27.04	27.03
3 dB beamwidth along	6.71	6.71	6.47	6.59
3 dB beamwidth athwart	6.70	6.70	6.39	6.55
Angle offset along	-0.03	-0.03	-0.02	-0.03
Angle offset athwart	0.09	0.09	0.08	0.09
Post-processing S_v threshold (dB re 1 m^{-1})	-70.00	--	--	-70.00
Measured standard sphere TS (dB re 1 m^2)	--	-38.94	-42.25	--
Sphere range from transducer (m)	--	24.19	20.98	--
Absorption coefficient (dB m^{-1})	0.0096	0.0098	0.0086	0.0096
Sound velocity (m s^{-1})	1476.0	1470.7	1485.1	1476.0
Water temp at transducer (ºC)	--	5.91	12.16	--

Note: Gain and beam pattern terms are defined in the Operator Manual for Simrad EK80 Scientific echosounder application, which is available from Simrad Strandpromenaden 50, Box 111, N-3191 Horten, Norway.
-- symbol indicates the value is not applicable for the noted survey collection or calibration setting.

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

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)
eulachon	$TS = 20 \log_{10} L - 84.5$	L = total length	*Thaleichthys pacificus*	Gauthier and Horne (2004)
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)
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 = $1.36133896 \times 10^{-8}$; E = $-2.26958555 \times 10^{-6}$
F= $1.50291244 \times 10^{-4}$; G = $-4.86306872 \times 10^{-3}$; H = 0.0738748423; I = -0.408004891; J = -73.9078690; and L_0 = 0.03835
If L < 0.015 m, TS = -105 dB; and if L > 0.065 m, TS = -73 dB.
k = 2πfc, where f = 38,000 (frequency in Hz) and c = 1470 (sound speed in m s^{-1}).

Table 3. -- Trawl stations and catch data summary by survey region from the summer 2023 acoustic-trawl survey of the Gulf of Alaska.

Haul		Gear	Date	Time	Duration	Start position		Depth (m)		Temp (°C)		Pollock		Other
No.	Region name	Type[a]	(GMT)	(GMT)	(mins)	Lat. (N)	Long. (W)	Headrope[b]	Bottom	Headrope	Surface[c]	(kg)	Number	(kg)
1	GOA Shelf	LFS1421	15-Jun	05:11	28.9	53.0027	-168.2754	45	93	4.9	7.2	1,134.0	2,158	0.2
2	GOA Shelf	PNE	16-Jun	03:37	16.2	53.7210	-165.2430	182	188	5.3	7.6	337.6	466	42.6
3	GOA Shelf	LFS1421	16-Jun	17:19	16.4	53.7749	-164.0454	225	376	5.5	7.3	114.6	158	860.9
4	GOA Shelf	LFS1421	17-Jun	07:05	45.4	54.0322	-162.9955	81	100	4.7	7.1	-	-	0.0
5	GOA Shelf	PNE	18-Jun	04:22	26.7	54.3107	-160.7967	118	124	5.3	8.3	-	-	526.1
6	GOA Shelf	LFS1421	18-Jun	06:54	26.2	54.2769	-160.7696	215	270	5.6	8.5	24.1	35	28.9
7	Shumagin Islands	LFS1421	18-Jun	18:20	15.2	55.1100	-160.3442	131	186	4.3	7.2	794.2	2,231	2.5
8	Shumagin Islands	LFS1421	19-Jun	00:19	15.9	55.2335	-160.1694	70	220	4.6	6.7	211.7	3,688	4.3
10	Shumagin Islands	LFS1421	20-Jun	01:27	7.4	55.5560	-160.3339	119	160	4.2	7.4	88.6	1,861	17.7
12	Shumagin Islands	LFS1421	20-Jun	05:55	26.9	55.5744	-160.3207	138	191	4.2	7.3	218.6	2,544	57.9
13	Shumagin Islands	LFS1421	20-Jun	18:56	60.3	55.4705	-159.5039	135	159	4.3	7.3	467.3	1,318	19.4
14	Shumagin Islands	LFS1421	21-Jun	03:57	28.9	55.3033	-159.0702	153	192	4.6	8.5	280.6	7,700	35.3
15	Shelikof Strait	LFS1421	2-Jul	17:58	30.5	58.3086	-153.2154	193	226	5.4	9.1	105.9	122	2,734.6
16	Shelikof Strait	LFS1421	3-Jul	03:02	10.0	58.0913	-153.4504	158	181	5.4	9.6	301.8	378	366.7
18	Shelikof Strait	LFS1421	4-Jul	17:18	18.4	57.4854	-155.0343	192	230	5.4	8.8	238.2	242	51.0
20	Shelikof Strait	LFS1421	5-Jul	22:38	18.2	56.7564	-156.6020	65	166	7.2	9.0	1.0	1	21.1
21	Shelikof Strait	LFS1421	6-Jul	05:28	6.8	56.5341	-155.5356	46	80	5.4	8.4	1,761.8	1,933	8.2
22	Shelikof Strait	LFS1421	6-Jul	16:24	30.9	56.3417	-155.8767	135	154	5.2	8.5	35.5	39	70.1
23	Shelikof Strait	LFS1421	7-Jul	03:27	32.4	56.5063	-156.7127	92	167	6.0	8.5	0.7	1	29.7
24	Shelikof Strait	LFS1421	7-Jul	08:07	18.7	56.2632	-156.5998	38	175	6.6	8.3	1.4	1	38.3
25	Shelikof Strait	LFS1421	7-Jul	16:21	41.2	56.1590	-156.2967	194	223	5.3	8.5	14.2	12	539.9
26	Shelikof Strait	LFS1421	8-Jul	02:09	44.4	55.8606	-156.0715	66	183	5.8	8.8	192.3	241	55.7
27	Shelikof Strait	LFS1421	8-Jul	18:47	11.8	55.7837	-157.0026	46	92	6.3	8.4	1,748.5	2,126	20.7
28	Shelikof Strait	LFS1421	9-Jul	02:20	30.8	55.6170	-156.2251	170	251	5.6	9.0	409.5	600	880.2
29	GOA Shelf	LFS1421	9-Jul	17:52	13.9	54.3914	-159.6183	191	242	5.5	8.1	202.6	270	51.2
30	GOA Shelf	LFS1421	10-Jul	04:46	4.3	54.9003	-158.8148	41	85	5.8	8.2	2,568.8	5,012	1.2
31	GOA Shelf	LFS1421	10-Jul	22:23	28.9	55.2252	-158.1409	47	111	5.7	8.8	-	-	7.0
32	GOA Shelf	LFS1421	11-Jul	17:51	23.6	55.7532	-157.7320	84	132	4.6	9.0	305.5	327	6.9
33	GOA Shelf	LFS1421	12-Jul	02:24	13.7	55.1204	-156.9419	189	223	5.6	8.6	187.7	249	25.8
34	GOA Shelf	LFS1421	12-Jul	16:36	13.4	55.3685	-156.1785	161	200	5.4	9.3	122.0	164	858.9
35	GOA Shelf	LFS1421	13-Jul	22:11	14.4	56.2031	-153.9821	85	185	5.9	10.0	255.1	585	24.2

Haul		Gear	Date	Time	Duration	Start position		Depth (m)		Temp (°C)		Pollock		Other
No.	Region name	Type[a]	(GMT)	(GMT)	(mins)	Lat. (N)	Long. (W)	Headrope[b]	Bottom	Headrope	Surface[c]	(kg)	Number	(kg)
36	GOA Shelf	LFS1421	14-Jul	02:20	19.9	56.1162	-153.8553	186	213	5.4	11.2	195.3	262	59.0
37	GOA Shelf	LFS1421	15-Jul	03:02	14.3	56.2658	-152.9389	207	597	5.3	11.8	197.6	298	99.7
38	GOA Shelf	Methot	15-Jul	16:57	20.3	56.6684	-153.4521	123	142	-	11.3	-	-	17.4
39	Barnabas Trough	LFS1421	16-Jul	05:38	22.5	56.3348	-152.4552	186	328	5.1	11.2	8.7	10	99.8
40	Barnabas Trough	LFS1421	16-Jul	14:19	25.4	56.4247	-152.5340	232	260	5.2	11.3	59.2	72	56.2
41	Barnabas Trough	LFS1421	16-Jul	18:30	8.1	56.5391	-152.4556	133	283	5.7	11.0	1,498.8	2,867	51.6
42	Barnabas Trough	LFS1421	17-Jul	00:20	6.9	56.6594	-152.4304	90	159	6.0	11.2	513.2	5,572	31.9
43	Barnabas Trough	LFS1421	17-Jul	05:35	1.5	56.8687	-152.4286	73	163	5.5	11.5	332.1	4,308	25.8
44	Barnabas Trough	LFS1421	17-Jul	16:52	6.7	56.8753	-152.9362	32	73	6.8	11.2	-	-	301.3
45	Barnabas Trough	LFS1421	17-Jul	22:15	1.2	57.0917	-152.4249	96	153	5.7	11.8	203.6	370	41.4
46	Barnabas Trough	Methot	18-Jul	02:25	20.0	57.0037	-152.8474	113	136	-	11.7	-	-	6.1
47	Barnabas Trough	LFS1421	18-Jul	06:11	18.1	57.0323	-152.8054	128	165	5.8	11.3	579.1	463	40.6
48	Barnabas Trough	LFS1421	18-Jul	15:21	7.4	57.1253	-152.7595	100	146	5.7	11.5	140.9	903	56.6
49	Barnabas Trough	LFS1421	18-Jul	23:49	11.2	57.3731	-152.5361	64	89	7.2	8.8	163.9	2,531	68.1
50	GOA Shelf	LFS1421	19-Jul	06:00	12.7	57.1286	-151.8196	35	79	7.9	10.6	9.1	12	287.6
51	GOA Shelf	LFS1421	19-Jul	16:09	21.5	56.9094	-151.5220	203	296	5.4	10.7	128.7	172	73.0
52	Chiniak Trough	LFS1421	19-Jul	22:40	20.1	57.0894	-151.2368	186	326	5.6	11.1	396.2	625	164.5
53	Chiniak Trough	LFS1421	20-Jul	04:13	4.8	57.2107	-151.3165	63	159	6.2	9.5	167.2	420	27.8
54	Chiniak Trough	LFS1421	21-Jul	03:55	12.9	57.5542	-151.7085	113	138	6.2	10.8	394.9	1,607	31.9
55	Chiniak Trough	LFS1421	21-Jul	16:33	12.6	57.4859	-151.5822	106	141	6.3	10.3	30.9	40	58.6
56	GOA Shelf	LFS1421	8-Aug	22:30	4.1	58.4261	-151.4929	120	170	6.0	11.7	920.8	2,008	19.5
57	GOA Shelf	LFS1421	9-Aug	02:14	1.4	58.1878	-151.1666	77	158	6.9	11.9	224.1	2,080	20.5
60	GOA Shelf	LFS1421	9-Aug	16:42	5.5	57.7836	-150.6223	47	92	7.0	11.7	1.2	2	56.1
61	GOA Shelf	LFS1421	10-Aug	03:05	14.6	58.1501	-149.9503	129	171	5.7	14.0	480.3	804	35.6
62	GOA Shelf	LFS1421	10-Aug	06:02	16.9	58.3202	-150.1759	23	54	9.5	11.4	-	-	324.5
63	GOA Shelf	LFS1421	10-Aug	17:02	32.9	58.5498	-150.4822	120	169	5.9	12.7	2,626.7	16,695	62.5
64	GOA Shelf	LFS1421	11-Aug	03:35	17.9	58.1897	-148.8163	167	302	5.3	14.7	1,728.9	2,953	52.3
65	GOA Shelf	LFS1421	11-Aug	18:18	0.2	59.0119	-148.7698	-	229	-	14.3	-	-	-
66	GOA Shelf	LFS1421	11-Aug	21:44	28.6	59.1414	-148.8785	123	157	5.9	14.6	469.9	907	33.8
67	GOA Shelf	LFS1421	12-Aug	00:35	3.1	59.0358	-148.6993	112	204	5.8	14.5	531.5	1,035	15.8
68	GOA Shelf	LFS1421	14-Aug	20:08	28.4	59.2711	-147.8932	153	184	5.9	12.2	125.9	263	41.0
69	GOA Shelf	LFS1421	15-Aug	18:20	12.6	59.6487	-145.7820	80	103	5.9	13.5	0.4	1	400.6
72	GOA Shelf	LFS1421	16-Aug	05:48	22.6	59.5382	-144.4629	214	474	5.7	14.2	80.0	106	69.8

Haul		Gear	Date	Time	Duration	Start position		Depth (m)		Temp (°C)		Pollock		Other
No.	Region name	Type[a]	(GMT)	(GMT)	(mins)	Lat. (N)	Long. (W)	Headrope[b]	Bottom	Headrope	Surface[c]	(kg)	Number	(kg)
73	GOA Shelf	LFS1421	18-Aug	00:55	22.4	58.6796	-140.6237	232	345	5.7	14.7	9.9	12	2,041.7
75	GOA Shelf	LFS1421	18-Aug	23:52	15.3	59.3184	-147.0832	167	199	5.8	13.2	495.5	623	60.8
76	GOA Shelf	LFS1421	19-Aug	03:13	11.6	59.2094	-147.1088	254	424	5.3	13.0	0.8	1	273.6
77	GOA Shelf	Methot	19-Aug	20:46	36.4	58.2084	-148.8625	116	137	-	12.7	-	-	1.6

[a] LFS1421 = LFS1421 midwater trawl, PNE = poly Nor'eastern bottom trawl, Methot = Methot plankton net.
[b] Headrope depth obtained from temperature-depth probe. In hauls without temperature-depth probe records, depth was obtained from scientist notes when possible.
[c] Average temperature measured from a temperature-depth probe (SBE 39, Sea-Bird Scientific).

Table 4. -- Catch by species and numbers of length and weight measurements taken from 60 LFS1421 hauls for the summer 2023 acoustic trawl survey of the Gulf of Alaska.

		Catch				Measurements	
Species name	Scientific name	Weight (kg)	%	Number	%	Length	Weight
pollock	*Gadus chalcogrammus*	24,501.0	68.1	82,017	19.5	13,431	2,682
POP	*Sebastes alutus*	5,651.7	15.7	7,751	1.8	1,282	462
magistrate armhook squid	*Berryteuthis magister*	1,668.9	4.6	2,355	0.6	173	84
eulachon	*Thaleichthys pacificus*	1,579.2	4.4	65,393	15.6	379	150
Pacific capelin	*Mallotus catervarius*	818.0	2.3	158,697	37.8	933	227
northern sea nettle	*Chrysaora melanaster*	491.1	1.4	1,147	0.3	541	346
squids	Cephalopoda (class)	250.4	0.7	17,952	4.3	380	118
Pacific herring	*Clupea pallasii*	174.4	0.5	1,091	0.3	416	117
lions mane	*Cyanea capillata*	142.8	0.4	750	0.2	524	262
pink salmon	*Oncorhynchus gorbuscha*	110.5	0.3	101	<0.1	101	101
chum salmon	*Oncorhynchus keta*	95.6	0.3	57	<0.1	57	57
salmon shark	*Lamna ditropis*	73.3	0.2	1	<0.1	1	1
giant grenadier	*Coryphaenoides pectoralis*	66.8	0.2	25	<0.1	25	9
jellyfishes	Scyphozoa (class)	66.3	0.2	787	0.2	255	130
widow rockfish	*Sebastes entomelas*	46.2	0.1	32	<0.1	32	32
Chinook salmon	*Oncorhynchus tshawytscha*	39.8	0.1	34	<0.1	34	34
coho salmon	*Oncorhynchus kisutch*	37.4	0.1	11	<0.1	11	11
Pacific pomfret	*Brama japonica*	29.6	<0.1	41	<0.1	41	41
euphausiids	Euphausiacea (order)	28.6	<0.1	63,178	15.0	0	0
lanternfishes	Myctophidae (family)	21.3	<0.1	2,712	0.6	167	53
unsorted catch and debris		16.6	<0.1	<0.1	<0.1	0	0
Aequorea sp.	*Aequorea* sp.	14.2	<0.1	69	<0.1	21	21
dusky rockfish	*Sebastes variabilis*	12.4	<0.1	6	<0.1	6	6
salmon spp.	Oncorhynchus (genus)	11.8	<0.1	42	<0.1	42	42
arrowtooth flounder	*Atheresthes stomias*	10.5	<0.1	7	<0.1	5	4
pollock age-0	*Gadus chalcogrammus*	5.3	<0.1	12,234	2.9	874	0
whitecross jelly	*Staurostoma mertensii*	5.1	<0.1	1	<0.1	1	1
northern smoothtongue	*Leuroglossus schmidti*	4.9	<0.1	387	<0.1	8	7
sockeye salmon	*Oncorhynchus nerka*	4.8	<0.1	13	<0.1	13	13
Hydromedusas	Hydromedusa (unid.)	4.6	<0.1	807	0.2	219	87
egg yolk jelly	*Phacellophora camtschatica*	4.5	<0.1	17	<0.1	12	12
rougheye and blackspotted rockfish spp.	Sebastes (genus)	4.0	<0.1	3	<0.1	3	3
silvergray rockfish	*Sebastes brevispinis*	2.7	<0.1	1	<0.1	1	1
redstripe rockfish	*Sebastes proriger*	2.2	<0.1	4	<0.1	4	4
Atka mackerel	*Pleurogrammus monopterygius*	1.2	<0.1	3	<0.1	1	1
Aurelia sp.	*Aurelia* sp.	1.0	<0.1	42	<0.1	9	2
Pacific glass shrimp	*Pasiphaea pacifica*	0.9	<0.1	925	0.2	27	0
Staurophora mertensi	*Staurophora mertensi*	0.8	<0.1	<0.1	<0.1	0	0
prowfish	*Zaprora silenus*	0.6	<0.1	104	<0.1	104	54
isopods	Isopoda (order)	0.3	<0.1	322	<0.1	0	0
sablefish	*Anoplopoma fimbria*	0.3	<0.1	1	<0.1	1	1
Alaskan pink shrimp	*Pandalus eous*	0.3	<0.1	132	<0.1	21	0
fish larvae	Actinopterygii (class)	0.1	<0.1	505	0.1	91	8

Species name	Scientific name	Catch				Measurements	
		Weight (kg)	%	Number	%	Length	Weight
Pacific lamprey	*Lampetra tridentata*	<0.1	<0.1	2	<0.1	2	2
northern pearleye	*Benthalbella dentata*	<0.1	<0.1	1	<0.1	1	1
Pacific sandfish	*Trichodon trichodon*	<0.1	<0.1	2	<0.1	2	2
viperfishes	Stomiidae (family)	<0.1	<0.1	2	<0.1	2	2
flatfish larvae	*Pleuronectiform* larvae	<0.1	<0.1	126	<0.1	16	2
Ptychogena sp.	Ptychogena (Genus)	<0.1	<0.1	10	<0.1	10	8
sand lance spp.	Ammodytes (genus)	<0.1	<0.1	23	<0.1	23	12
sculpins	Cottidae (family)	<0.1	<0.1	3	<0.1	3	3
amphipods	Amphipoda (order)	<0.1	<0.1	8	<0.1	0	0
Periphylla sp.	*Periphylla* sp.	<0.1	<0.1	2	<0.1	2	0
Aurelia labiata	*Aurelia labiata*	<0.1	<0.1	1	<0.1	1	0
Protomyctophum sp.	*Protomyctophum* sp.	<0.1	<0.1	1	<0.1	1	1
shrimps	Malacostraca (class)	<0.1	<0.1	1	<0.1	1	1
Total		36,002.3		419,939		20,310	5,218

Table 5. -- Catch by species and numbers of length and weight measurements taken from 1 PNE haul for the summer 2023 acoustic trawl survey of the Gulf of Alaska.

		Catch				Measurements	
Species name	Scientific name	Weight (kg)	%	Number	%	Length	Weight
pollock	*Gadus chalcogrammus*	337.6	88.8	466	89.6	291	50
POP	*Sebastes alutus*	15.8	4.1	22	4.2	22	10
sablefish	*Anoplopoma fimbria*	15.6	4.1	12	2.3	12	12
rex sole	*Glyptocephalus zachirus*	3.9	1.0	12	2.3	12	12
Pacific cod	*Gadus macrocephalus*	3.1	0.8	1	0.2	1	1
Pacific halibut	*Hippoglossus stenolepis*	2.0	0.5	1	0.2	0	0
shortspine thornyhead	*Sebastolobus alascanus*	1.3	0.3	3	0.6	3	3
Dover sole	*Microstomus pacificus*	0.4	0.1	1	0.2	1	1
flathead sole	*Hippoglossoides elassodon*	0.3	<0.1	1	0.2	1	1
jellyfishes	Scyphozoa (class)	<0.1	<0.1	1	0.2	0	0
Total		380.2		520		343	90

Table 6. -- Catch by species and numbers of length and weight measurements taken from 3 Methot hauls for the summer 2023 acoustic trawl survey of the Gulf of Alaska.

		Catch				Measurements	
Species name	Scientific name	Weight (kg)	%	Number	%	Length	Weight
lions mane	*Cyanea capillata*	10.4	41.7	33	<0.1	17	17
euphausiids	Euphausiacea (order)	5.4	21.4	103,374	99.3	0	0
Aequorea sp.	*Aequorea* sp.	4.9	19.6	363	0.3	87	30
whitecross jelly	*Staurostoma mertensii*	2.6	10.4	33	<0.1	13	0
jellyfishes	Scyphozoa (class)	0.6	2.6	9	<0.1	9	9
northern sea nettle	*Chrysaora melanaster*	0.6	2.4	12	<0.1	12	12
Hydromedusas	Hydromedusa (unid.)	0.1	0.5	15	<0.1	15	15
copepods	Maxillopoda (class)	<0.1	0.3	128	0.1	0	0
unsorted catch and debris		<0.1	0.2	<0.1	<0.1	0	0
fish larvae	Actinopterygii (class)	<0.1	0.2	54	<0.1	5	0
flatfish larvae	*Pleuronectiform* larvae	<0.1	0.2	50	<0.1	1	0
squids	Cephalopoda (class)	<0.1	0.2	40	<0.1	2	0
Invert. unident. 1	Invert. unident. 1	<0.1	0.2	38	<0.1	0	0
Ptychogena sp.	Ptychogena (genus)	<0.1	<0.1	2	<0.1	2	0
isopods	Isopoda (order)	<0.1	<0.1	1	<0.1	0	0
pollock age-0	*Gadus chalcogrammus*	<0.1	<0.1	1	<0.1	1	0
Total		25.0		104,153		164	83

Table 7. -- Numbers of specimens measured and biological samples collected for the summer 2023 acoustic trawl survey of the Gulf of Alaska.

Haul no.	Region name	Pollock Lengths	Pollock Weights	Pollock maturities	Pollock Otoliths	Pollock Ovaries	Pacific capelin Weights	Pacific capelin Lengths	Pacific ocean perch Weights	Pacific ocean perch Lengths	Other Weights	Other Lengths
1	GOA Shelf	274	82	82	50	-	-	-	-	-	-	-
2	GOA Shelf	291	50	50	50	-	-	-	22	10	30	30
3	GOA Shelf	157	50	50	50	5	-	-	87	25	4	2
6	GOA Shelf	34	34	34	34	-	-	-	19	9	70	16
7	Shumagin Islands	417	75	50	55	-	11	11	1	1	42	8
8	Shumagin Islands	265	64	49	53	4	2	2	-	-	23	7
10	Shumagin Islands	255	78	63	58	4	6	3	-	-	51	15
12	Shumagin Islands	412	61	51	56	10	11	11	-	-	56	30
13	Shumagin Islands	443	73	50	55	8	8	8	1	1	124	48
14	Shumagin Islands	81	40	20	25	-	35	12	-	-	55	20
15	Shelikof Strait	40	40	40	25	4	-	-	-	-	120	39
16	Shelikof Strait	296	51	51	25	11	-	-	-	-	160	49
18	Shelikof Strait	242	50	50	25	4	3	3	-	-	152	42
20	Shelikof Strait	1	1	1	1	-	-	-	-	-	104	54
21	Shelikof Strait	269	55	55	35	13	-	-	-	-	5	5
22	Shelikof Strait	39	39	39	39	3	-	-	77	19	44	7
23	Shelikof Strait	1	1	1	1	-	35	-	-	-	144	30
24	Shelikof Strait	1	1	1	1	-	54	-	-	-	43	23
25	Shelikof Strait	12	12	12	12	4	21	1	100	25	100	28
26	Shelikof Strait	241	49	49	40	-	-	-	35	10	74	49
27	Shelikof Strait	315	50	50	50	3	-	-	2	2	11	11
28	Shelikof Strait	301	50	50	40	3	-	-	75	25	26	26
29	GOA Shelf	270	50	50	12	-	-	-	65	25	11	11
30	GOA Shelf	379	50	50	40	5	-	-	-	-	1	1
32	GOA Shelf	327	50	50	40	2	-	-	-	-	37	14
33	GOA Shelf	249	50	50	40	-	-	-	28	10	62	19
34	GOA Shelf	164	50	50	40	-	-	-	89	25	37	33
35	GOA Shelf	385	60	60	20	3	-	-	-	-	54	24
36	GOA Shelf	230	50	50	20	-	-	-	59	10	64	28
37	GOA Shelf	298	50	50	20	1	-	-	43	14	61	45
39	Barnabas Trough	10	10	10	10	-	-	-	94	25	73	46

Haul		Pollock					Pacific capelin		Pacific ocean perch		Other	
no.	Region name	Lengths	Weights	maturities	Otoliths	Ovaries	Weights	Lengths	Weights	Lengths	Weights	Lengths
40	Barnabas Trough	72	50	50	25	-	-	-	42	27	61	28
41	Barnabas Trough	305	50	50	24	3	-	-	19	19	73	19
42	Barnabas Trough	440	69	61	25	5	-	-	-	-	91	50
43	Barnabas Trough	186	70	65	25	4	-	-	-	-	128	31
45	Barnabas Trough	370	51	51	26	4	-	-	-	-	96	31
47	Barnabas Trough	326	70	69	26	1	-	-	2	2	230	37
48	Barnabas Trough	377	81	71	32	-	5	5	1	1	155	47
49	Barnabas Trough	89	28	19	10	1	40	10	-	-	138	53
50	GOA Shelf	12	12	12	10	1	196	10	-	-	270	91
51	GOA Shelf	172	39	39	10	-	1	1	88	23	137	43
52	Chiniak Trough	431	52	52	10	-	-	-	35	10	71	28
53	Chiniak Trough	377	50	50	10	-	-	-	2	2	90	41
54	Chiniak Trough	376	70	61	25	5	6	6	5	5	84	28
55	Chiniak Trough	40	40	40	20	-	4	4	4	4	109	49
56	GOA Shelf	387	51	51	21	7	3	3	-	-	68	28
57	GOA Shelf	412	86	74	25	6	-	-	-	-	50	27
60	GOA Shelf	2	2	1	2	1	124	51	-	-	55	18
61	GOA Shelf	298	50	50	20	-	-	-	5	5	60	45
63	GOA Shelf	619	61	61	30	6	-	-	42	10	81	32
64	GOA Shelf	300	50	50	20	9	-	-	29	29	19	19
66	GOA Shelf	406	50	50	20	7	-	-	6	6	84	48
67	GOA Shelf	331	50	50	20	10	-	-	-	-	18	15
68	GOA Shelf	263	54	53	24	11	-	-	5	5	79	35
72	GOA Shelf	106	57	54	26	-	-	-	42	28	85	56
73	GOA Shelf	12	12	12	12	6	-	-	88	25	132	84
75	GOA Shelf	313	50	50	20	9	-	-	10	10	49	26
76	GOA Shelf	1	1	1	1	-	-	-	82	25	108	41
Total		13,722	2,732	2,565	1,541	183	565	141	1,304	472	4,459	1,810

Table 8. -- Pollock number (millions of fish), biomass (1,000s t), and relative estimation error by survey region for the summer 2013, 2015, 2017, 2019, 2021, and 2023 acoustic trawl surveys of the Gulf of Alaska. Shelf area estimated error value is for all shelf region transects combined.

	2013			2015			2017			2019			2021			2023		
Region name	Number	Biomass	Error	Number	Biomass	Error	Number	Biomass	Error	Number	Biomass	Error	Number	Biomass	Error	Number	Biomass	Error
GOA Shelf (541)[a]	0.0	0.0	15%				34.1	23.7	7%	9.5	9.0	6%						
GOA Shelf (610)[b]	33.6	45.1	15%	882.8	392.1	9%	641.1	413.8	7%	137.5	95.5	6%	331.6	74.2	8%	163.9	111.7	8%
GOA Shelf (620)[c]	48.4	33.3	15%	478.8	206.8	9%	294.0	195.2	7%	665.1	113.9	6%	330.2	39.8	8%	133.5	88.4	8%
GOA Shelf (630)[d]	819.9	145.3	15%	892.7	384.2	9%	572.0	400.4	7%	1,388.2	154.6	6%	923.2	122.2	8%	1,089.2	403.3	8%
GOA Shelf (640)[e]	470.2	34.4	15%	134.9	54.5	9%	94.7	71.3	7%	416.9	43.5	6%	68.9	23.9	8%	15.8	11.6	8%
Sanak Trough	1.4	0.9	23%	10.0	3.1	11%	23.4	18.1	10%	27.0	1.3	16%						
Morzhovoi Bay	23.8	4.6	20%	11.6	4.5	28%	3.2	2.5	20%	31.3	1.6	15%						
Pavlof Bay	45.3	2.7	18%	8.6	2.6	17%	2.1	1.4	17%	2.8	1.9	12%						
Shumagin Islands	1,695.1	31.2	14%	32.2	15.0	8%	41.8	25.7	10%	31.9	19.2	14%	131.5	5.5	15%	96.2	11.0	12%
Mitrofania	134.2	2.5	24%	31.5	14.7	13%	36.2	23.4	13%	2.2	1.6	16%						
Nakchamik	6.9	8.9	13%	19.9	9.1	19%	0.6	0.4	16%									
Shelikof Strait	4,888.0	411.4	6%	873.6	289.9	6%	526.9	53.1	11%	1,646.2	106.8	14%	2,228.4	119.6	10%	78.2	65.4	14%
Alitak	16.4	14.9	26%	13.2	6.5	16%/ 6%[f]	4.2	3.5	36%[f]	10.2	1.9	43%[f]						
Barnabas Trough	342.4	56.9	6%	191.5	88.0	17%	73.1	49.5	12%	215.7	35.8	10%	174.7	36.0	7%	155.0	25.8	26%
Chiniak Trough	38.0	29.4	7%	83.9	34.6	6%	41.7	30.7	19%	26.0	4.9	8%	119.1	9.9	7%	42.3	15.6	6%
Marmot Bay	98.3	9.1	7%	107.4	44.8	14%/ 16%[f]	3.5	2.3	21%	41.5	2.9	13%						
Kenai Peninsula				20.5	6.8	14%				7.8	0.3	46%						
Prince William Sound	173.5	10.1	9%	21.0	12.2	8%				0.0	0.0	22%						
Kayak Island Trough	6.7	2.3	15%															
Yakutat Trough	95.1	5.6		4.8	4.8	18%												
Total[g]	8,937.4	848.7	8%	3,819.1	1,574.2	8%	2,392.5	1,315.0	6%	4,659.8	594.9	6%	4,307.6	431.1	7%	1,774.2	732.9	7%

[a] Aleutian District – NMFS Reporting Area 541 - 170°-177° W.
[b] Shumagin District – NMFS Reporting Area 610 - 159°-170° W.
[c] Chirikof District – NMFS Reporting Area 620 - 154°-159° W.
[d] Kodiak District – NMFS Reporting Area 630 - 147°-154° W.
[e] Eastern District – NMFS Reporting Area 640 - 140°-147° W.
[f] 2D variance estimation for zig-zag transects.
[g] Total number and biomass values differ from previously published values because they have been updated to address minor misspecifications in target strength relationships (2013-2019) and reallocation of some backscatter due to minor errors in strata assignment (2015).

Table 9. -- Pollock numbers-at-length estimates (millions of fish) by survey region for the summer 2023 acoustic trawl survey of the Gulf of Alaska.

Length	GOA Shelf	Shumagin Islands	Shelikof Strait	Barnabas Trough	Chiniak Trough	Total
14	-	0.26	-	-	-	0.26
15	-	12.51	-	-	-	12.51
16	0.28	24.46	-	0.37	0.99	26.09
17	2.54	22.92	-	0.72	1.69	27.86
18	10.27	11.81	-	4.65	2.36	29.10
19	51.30	2.27	-	14.36	1.85	69.78
20	63.94	0.40	-	44.17	2.27	110.78
21	89.89	-	-	38.64	1.80	130.32
22	78.75	0.02	-	15.46	1.11	95.34
23	35.79	-	-	6.18	1.99	43.95
24	19.65	<0.01	-	0.53	-	20.19
25	3.50	0.08	-	-	-	3.58
26	0.48	0.23	-	-	-	0.71
27	0.24	0.40	-	-	-	0.64
28	0.67	0.44	-	-	0.02	1.12
29	1.72	0.48	-	0.03	-	2.23
30	4.28	0.24	-	0.22	0.21	4.95
31	12.16	0.33	-	0.48	0.33	13.30
32	17.59	0.85	-	1.00	1.11	20.55
33	28.73	0.93	-	1.59	1.63	32.88
34	27.22	1.62	0.02	1.38	2.60	32.84
35	44.60	2.70	0.26	1.44	1.84	50.84
36	52.56	3.27	0.24	1.52	1.53	59.11
37	67.63	3.46	0.26	1.68	2.24	75.27
38	86.86	2.31	0.94	2.47	3.12	95.69
39	98.72	1.63	1.05	2.64	2.13	106.18
40	103.03	0.90	1.80	3.25	1.69	110.68
41	80.95	0.40	1.69	2.68	1.44	87.16
42	57.15	0.23	2.19	1.88	0.83	62.28
43	47.01	0.12	3.42	0.87	0.74	52.16
44	48.38	0.16	4.75	0.90	0.79	54.97
45	53.10	0.09	7.34	0.43	0.66	61.61
46	56.31	0.07	6.89	0.69	0.85	64.81
47	44.89	0.10	8.41	0.64	1.10	55.14
48	39.43	0.06	8.15	0.42	0.83	48.89
49	27.74	0.06	7.49	0.28	0.50	36.06
50	19.45	0.09	5.69	0.34	0.48	26.06
51	9.71	0.02	4.91	0.26	0.55	15.45
52	6.44	0.06	3.57	0.25	0.31	10.64
53	2.59	0.05	2.90	0.37	0.22	6.14
54	2.37	0.04	2.28	0.26	0.18	5.13
55	1.49	0.02	1.52	0.35	0.07	3.45
56	1.04	0.02	1.10	0.30	0.13	2.60
57	1.07	-	0.49	0.44	0.10	2.11
58	0.48	<0.01	0.40	0.16	0.03	1.08

Length	GOA Shelf	Shumagin Islands	Shelikof Strait	Barnabas Trough	Chiniak Trough	Total
59	0.07	0.02	0.24	0.15	-	0.47
60	0.14	-	0.12	0.22	-	0.48
61	0.26	<0.01	0.08	0.17	-	0.51
62	-	-	-	0.09	-	0.09
63	-	-	-	0.03	-	0.03
64	-	<0.01	-	0.04	-	0.05
65	-	-	0.02	<0.01	-	0.03
66	-	-	-	-	-	-
67	-	-	-	-	0.01	0.01
Total	1,402.45	96.18	78.24	154.99	42.33	1,774.18

Table 10. -- Pollock biomass-at-length estimates (1,000s t) by survey region for the summer 2023 acoustic-trawl survey of the Gulf of Alaska.

Length	GOA Shelf	Shumagin Islands	Shelikof Strait	Barnabas Trough	Chiniak Trough	Total
14	-	5.79	-	-	-	5.79
15	-	313.89	-	-	-	313.89
16	8.36	726.09	-	10.90	29.25	774.59
17	90.76	820.39	-	25.70	60.32	997.18
18	465.29	535.00	-	210.81	106.77	1,317.88
19	2,844.67	125.98	-	796.17	102.71	3,869.53
20	4,015.81	25.25	-	2,774.04	142.82	6,957.92
21	6,490.11	-	-	2,789.70	129.74	9,409.55
22	6,774.25	1.78	-	1,330.00	95.66	8,201.68
23	3,545.19	-	-	611.86	197.22	4,354.28
24	2,090.29	0.44	-	56.83	-	2,147.56
25	422.97	9.99	-	-	-	432.96
26	59.84	28.54	-	-	-	88.38
27	32.40	54.52	-	-	-	86.92
28	108.99	72.51	-	-	2.46	183.95
29	297.40	82.60	-	5.52	-	385.53
30	944.42	52.20	-	47.88	46.53	1,091.04
31	2,934.36	78.69	-	116.27	79.99	3,209.31
32	4,773.29	230.89	-	271.63	301.74	5,577.56
33	8,362.29	271.61	-	462.25	474.22	9,570.37
34	8,546.51	507.64	6.75	433.64	816.07	10,310.60
35	15,061.26	912.93	87.43	487.53	622.46	17,171.61
36	19,477.31	1,211.56	89.50	561.69	566.06	21,906.12
37	27,858.83	1,426.25	106.63	692.99	922.29	31,006.99
38	38,916.82	1,034.82	420.43	1,107.24	1,396.40	42,875.72
39	47,588.27	785.18	507.91	1,272.09	1,027.37	51,180.83
40	53,254.65	464.03	932.79	1,679.72	874.71	57,205.90
41	44,672.04	220.19	929.90	1,476.78	796.73	48,095.65
42	33,810.55	137.74	1,294.40	1,115.16	488.19	36,846.04
43	29,525.79	76.27	2,147.87	545.71	467.49	32,763.14
44	32,329.38	108.36	3,170.66	599.25	525.21	36,732.87
45	37,539.81	64.53	5,189.80	300.88	463.45	43,558.47
46	42,510.25	55.12	5,201.13	521.27	638.87	48,926.65
47	35,147.67	75.50	6,586.59	504.47	858.59	43,172.82
48	33,256.92	52.88	6,875.36	352.00	702.26	41,239.43
49	25,118.10	52.35	6,778.73	254.39	453.37	32,656.95
50	18,061.83	86.29	5,288.29	320.41	447.89	24,204.71
51	9,695.50	21.00	4,901.49	260.41	548.65	15,427.05
52	6,706.92	62.85	3,719.73	257.93	324.62	11,072.05
53	2,892.84	60.18	3,236.36	415.69	247.94	6,853.00
54	2,729.96	48.40	2,628.80	294.75	204.32	5,906.24
55	1,805.15	18.27	1,846.25	426.34	89.02	4,185.02
56	1,323.09	26.75	1,398.97	385.35	168.89	3,303.05
57	1,526.56	-	703.79	623.22	148.34	3,001.90
58	683.49	8.52	579.33	224.25	42.70	1,538.28

Length	GOA Shelf	Shumagin Islands	Shelikof Strait	Barnabas Trough	Chiniak Trough	Total
59	107.16	22.29	350.12	217.20	-	696.76
60	220.18	-	185.84	327.27	-	733.29
61	449.58	10.46	137.27	292.76	-	890.08
62	-	-	-	162.69	-	162.69
63	-	-	-	56.88	-	56.88
64	-	18.52	-	79.48	-	98.00
65	-	-	52.44	20.81	-	73.25
66	-	-	-	-	-	-
67	-	-	-	-	34.70	34.70
Total	615,077.13	11,005.06	65,354.58	25,779.85	15,646.02	732,862.63

Table 11. -- Pollock numbers-at-age estimates (millions of fish) by survey region for the summer 2023 acoustic-trawl survey of the Gulf of Alaska.

Age	GOA Shelf	Shumagin Islands	Shelikof Strait	Barnabas Trough	Chiniak Trough	Total
1	349.35	74.69	-	124.97	14.05	563.06
2	80.87	4.92	0.12	3.39	3.95	93.26
3	530.66	14.63	7.39	16.25	15.25	584.18
4	97.69	0.88	6.94	2.34	1.85	109.70
5	213.58	0.60	31.74	3.84	3.98	253.75
6	102.95	0.30	21.72	2.16	2.29	129.42
7	14.36	0.05	3.93	0.41	0.38	19.14
8	0.74	<0.01	0.36	0.08	0.03	1.22
9	1.80	0.01	0.93	0.20	0.10	3.04
10	4.86	0.04	2.18	0.60	0.18	7.87
11	4.90	0.04	2.53	0.71	0.22	8.39
12	0.69	<0.01	0.41	0.03	0.04	1.17
Total	1,402.45	96.18	78.24	154.99	42.33	1,774.18

Table 12. -- Pollock biomass-at-age estimates (1,000s t) by survey region for the summer 2023 acoustic-trawl survey of the Gulf of Alaska.

Age	GOA Shelf	Shumagin Islands	Shelikof Strait	Barnabas Trough	Chiniak Trough	Total
1	26,012.43	2,557.03	-	8,594.65	864.48	38,028.58
2	22,776.35	1,269.90	43.30	978.85	1,190.43	26,258.83
3	243,460.01	5,871.74	3,930.63	7,317.01	6,467.60	267,046.99
4	59,189.58	429.11	5,078.51	1,350.04	1,101.77	67,149.01
5	156,236.80	438.71	26,016.36	2,821.91	3,051.55	188,565.33
6	81,866.82	262.67	19,395.55	1,991.85	1,966.59	105,483.49
7	12,118.17	53.10	3,756.91	454.66	357.74	16,740.58
8	778.59	7.51	408.86	121.53	31.70	1,348.19
9	1,917.44	12.94	1,034.16	260.12	117.61	3,342.27
10	4,962.85	52.31	2,433.23	866.22	210.14	8,524.75
11	5,052.39	46.15	2,830.93	991.76	243.71	9,164.93
12	705.69	3.89	426.13	31.26	42.70	1,209.67
Total	615,077.13	11,005.06	65,354.58	25,779.85	15,646.02	732,862.63

Table 13. -- Pollock numbers (millions of fish) and biomass (t) by NMFS Reporting Area and survey region for the summer 2023 acoustic-trawl survey of the Gulf of Alaska.

Reporting Area	Survey region	Numbers (millions)	Biomass (t)
610	GOA Shelf	163.95	111,718.52
610	Shumagin Islands	62.41	9,825.61
610	Total	226.35	121,544.13
620	GOA Shelf	133.46	88,396.43
620	Shumagin Islands	33.77	1,179.45
620	Shelikof Strait	70.20	58,856.81
620	Total	237.43	148,432.69
630	GOA Shelf	1,089.24	403,349.15
630	Shelikof Strait	8.04	6,497.77
630	Barnabas Trough	154.99	25,779.85
630	Chiniak Trough	42.33	15,646.02
630	Total	1,294.61	451,272.78
640	GOA Shelf	15.80	11,613.03
640	Total	15.80	11,613.03
Survey total		1,774.18	732,862.63

FIGURES

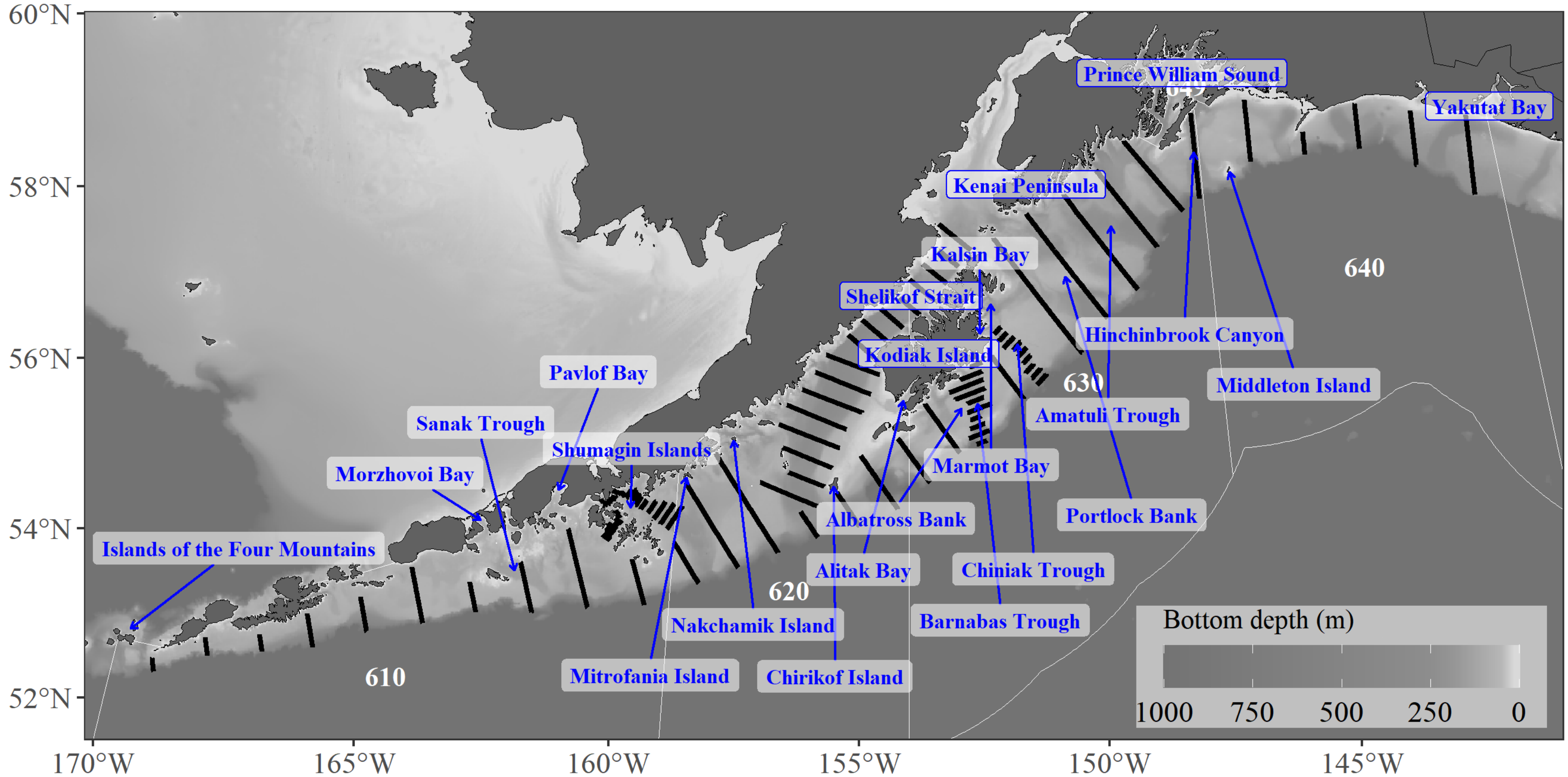

Figure 1. -- Overview of the summer 2023 acoustic-trawl survey of the Gulf of Alaska. Black lines indicate transect locations. Labels refer to areas referenced in text. NMFS Reporting Areas are noted in white text. Bottom depths are indicated in greyscale. Note that this scale is used in all maps throughout report.

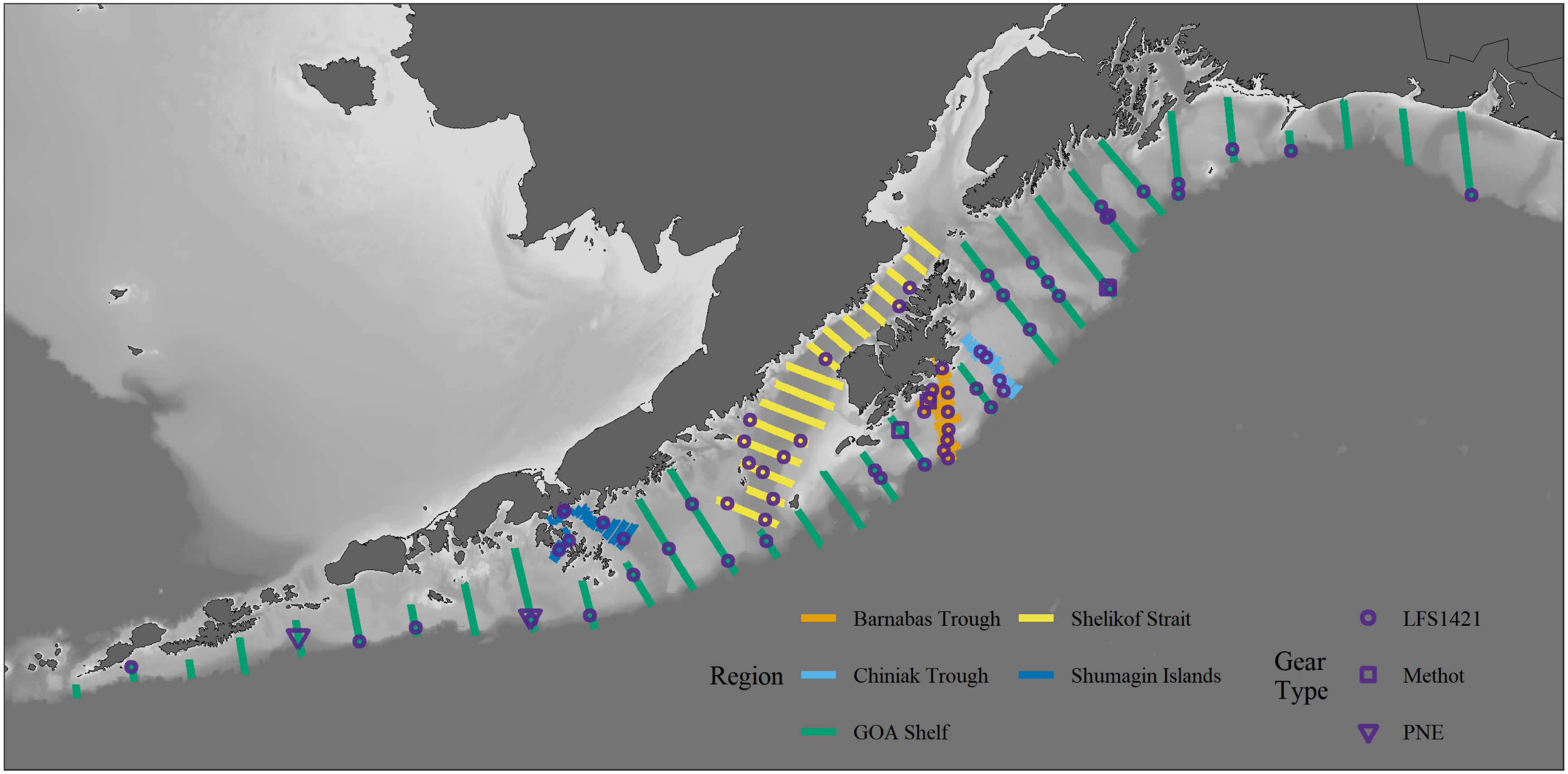

Figure 2. -- Transect lines and trawl haul locations during the summer 2023 acoustic-trawl survey of the Gulf of Alaska. The survey region associated with each transect is indicated by the transect color. The location of trawl events are indicated with purple markers.

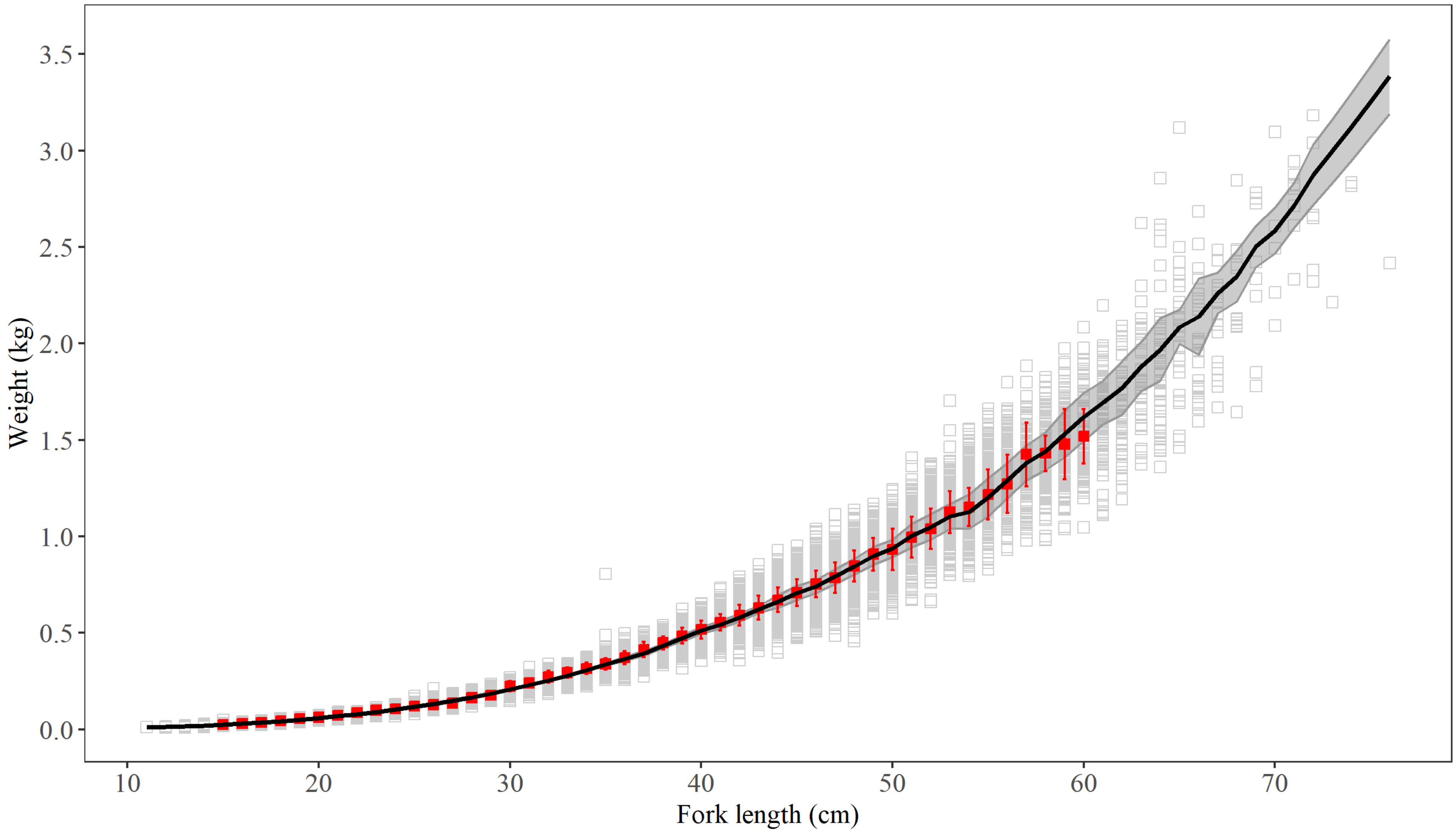

Figure 3. -- Pollock mean weight-at-length for all areas combined during summer acoustic-trawl surveys of the Gulf of Alaska. The 2023 survey is highlighted in red (mean ± 1 standard deviation). Only length classes containing at least five fish were plotted. Grey squares indicate the range of observations in previous surveys (2013-2021), and the black line and grey ribbon indicate mean weight-at-length in previous surveys ± 1 standard deviation.

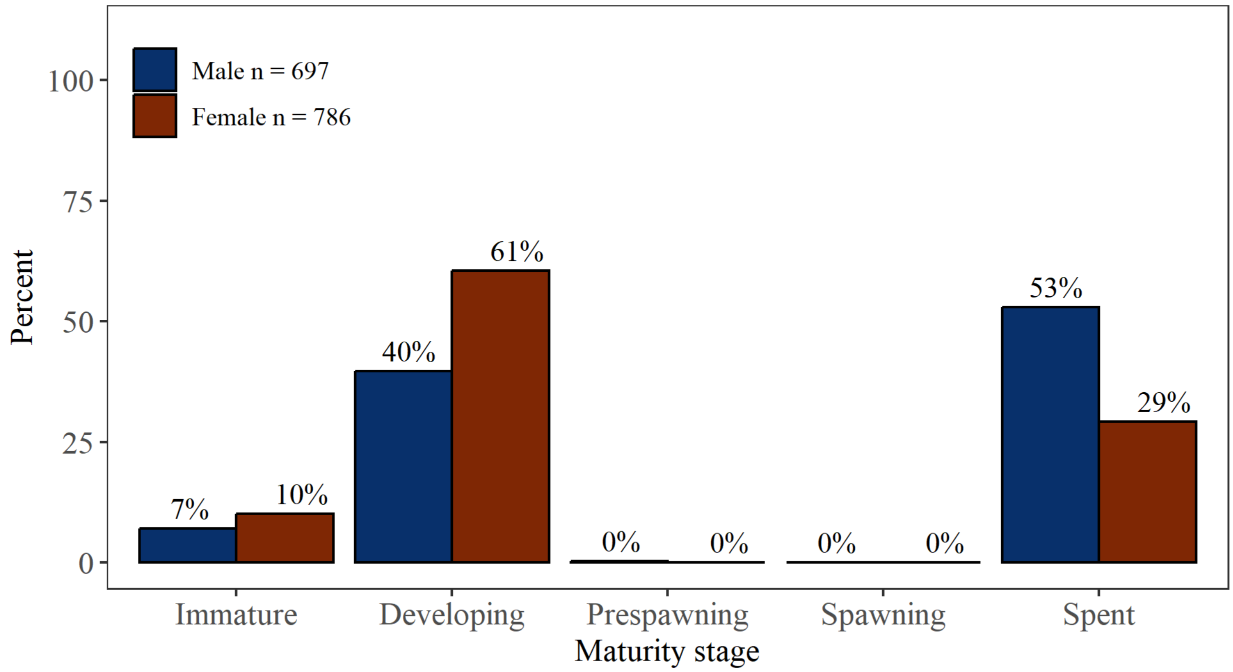

Figure 4. -- Maturity composition for male and female pollock > 40 cm FL within each stage in the summer 2023 acoustic-trawl survey of the Gulf of Alaska. Maturity quantities are weighted by local pollock abundance.

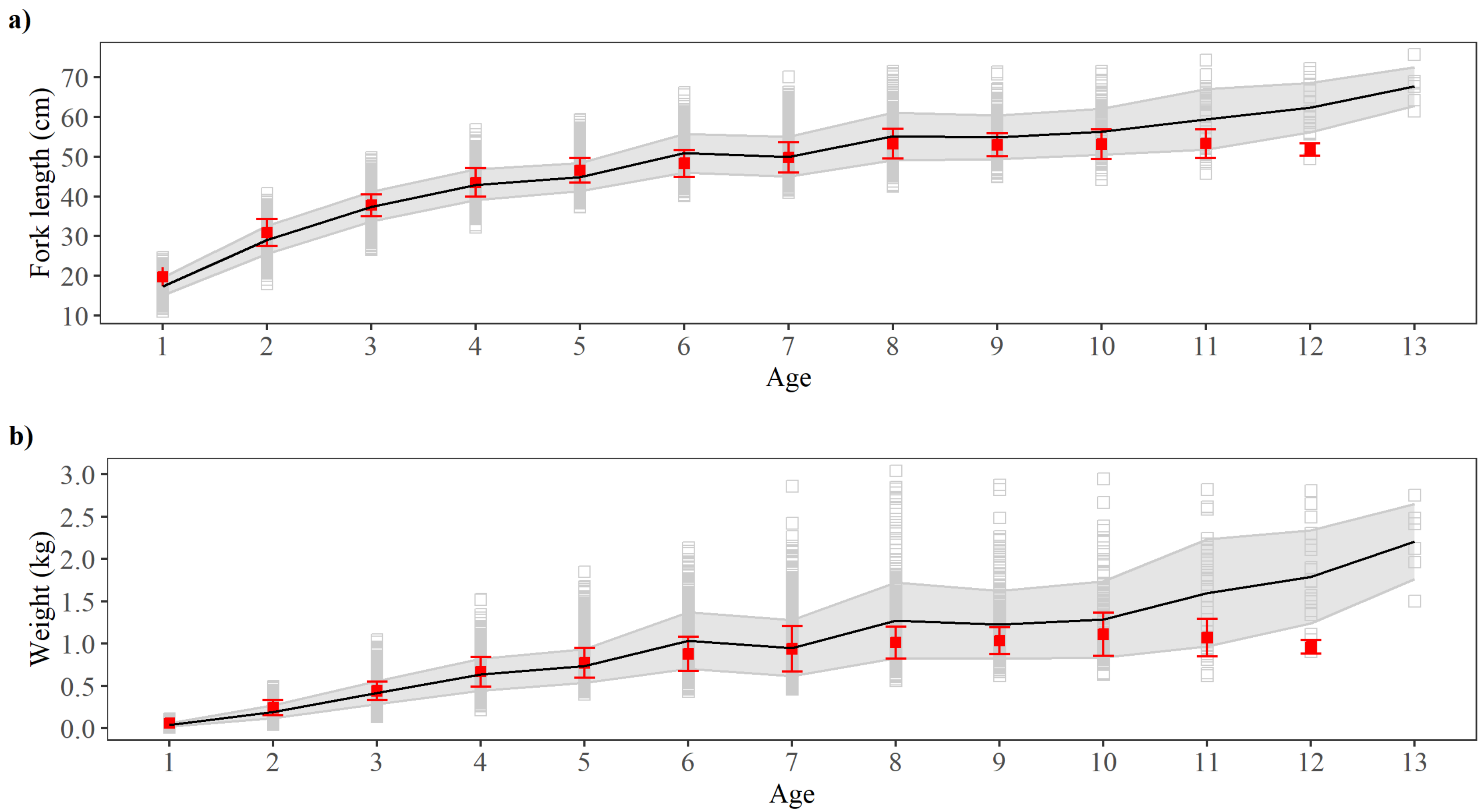

Figure 5. -- Pollock a) length- and b) weight-at-age for all areas combined during summer acoustic-trawl surveys of the Gulf of Alaska. The 2023 survey is highlighted in red (mean ± 1 standard deviation). Grey squares indicate the range of observations in previous surveys (2013-2021), and the black line and grey ribbon indicate mean length- or weight-at-length in previous surveys ± 1 standard deviation.

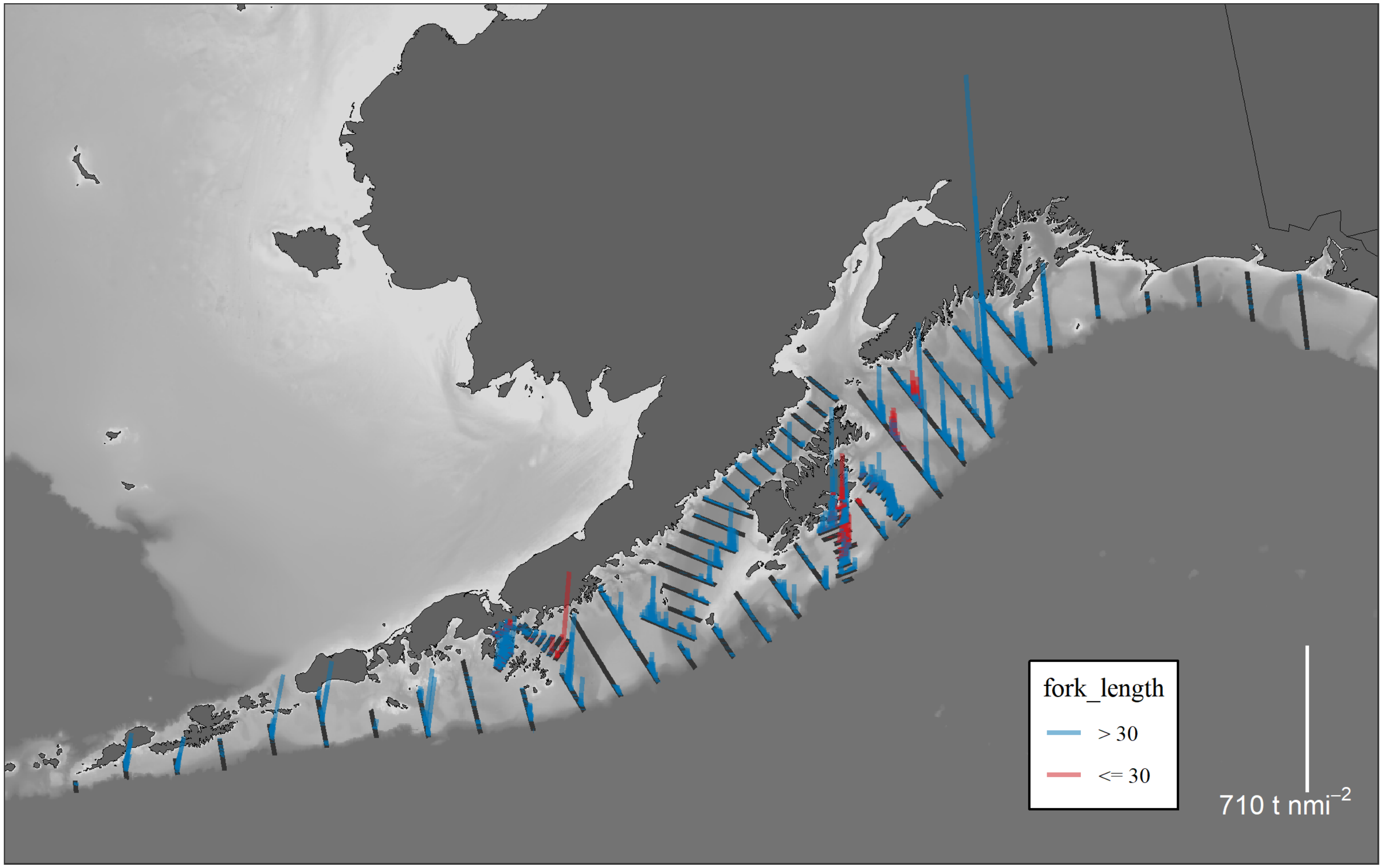

Figure 6. -- Density (t nmi^{-2}) attributed to pollock (vertical lines) for pollock > 30 cm fork length and ≤ 30 cm fork length along tracklines surveyed during the summer 2023 acoustic-trawl survey of the Gulf of Alaska.

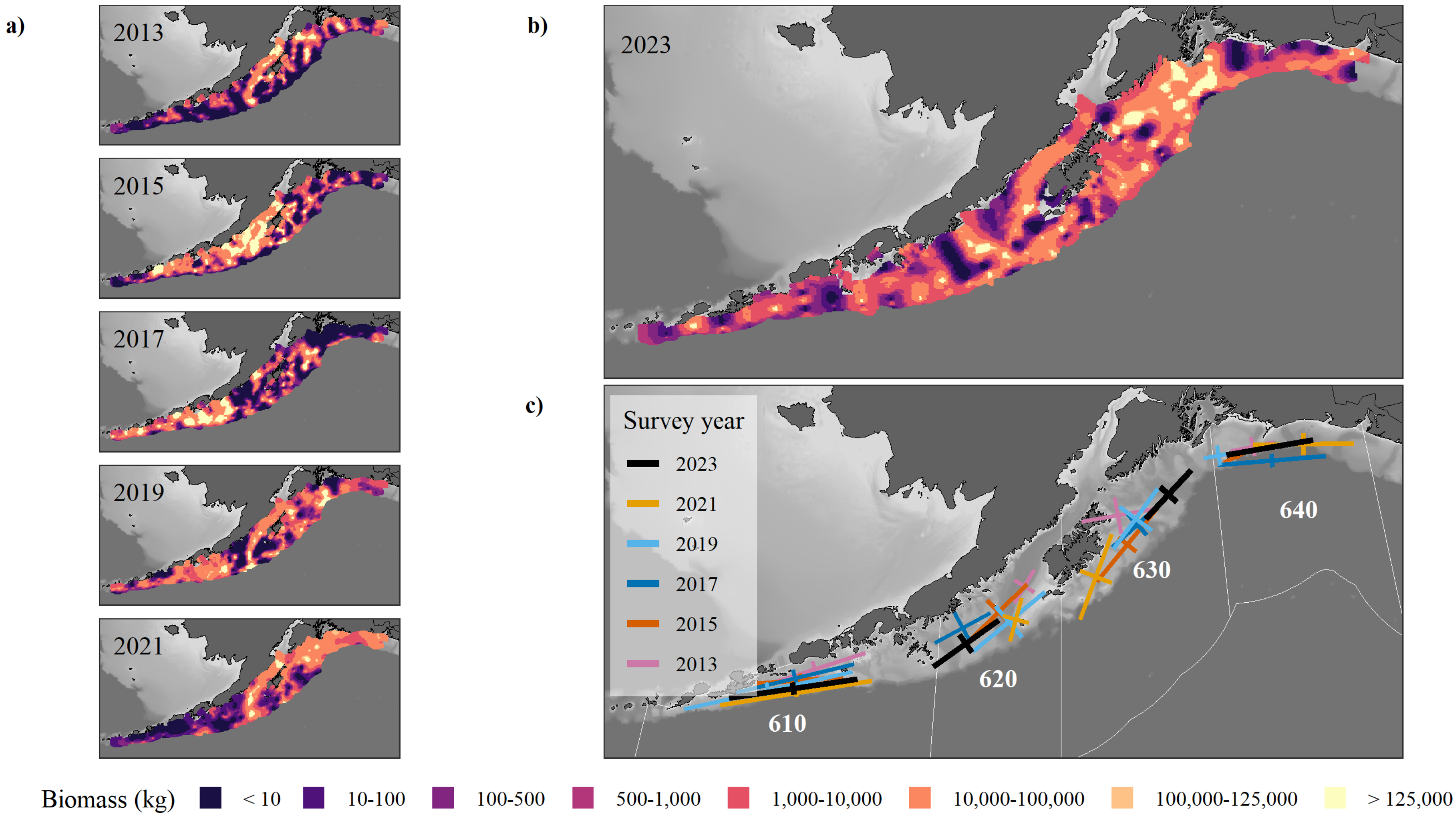

Figure 7. -- a) Historical time series of pollock biomass distributions for 2013-2021, and b) 2023 from summer acoustic-trawl surveys of the Gulf of Alaska. Note that the total amount of pollock biomass varies widely between surveys, but all surveys are plotted using a common color scale. Values have been interpolated within the survey area via universal kriging (Pebesma 2004) to make spatial patterns easier to visualize. c) Center of gravity and inertia (colored crosses; Woillez et al. 2007) indicating the mean location and dispersion of pollock within each NMFS Reporting Area by survey year.

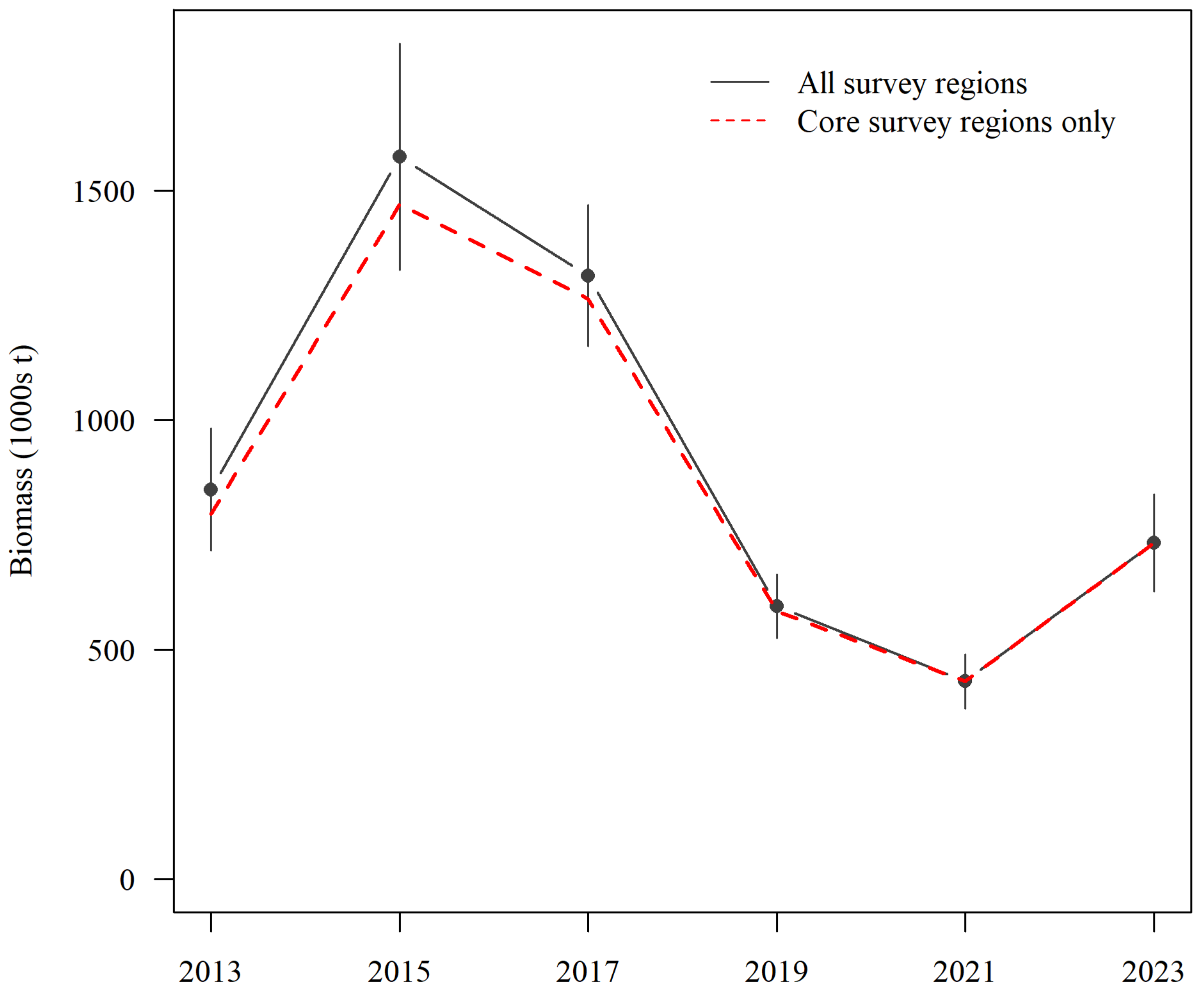

Figure 8. -- Index of pollock biomass (1,000s t) from summer acoustic-trawl surveys of the Gulf of Alaska for 2013-2023. Total biomass is shown for all survey regions (solid line, see details in Table 8) with 95% confidence intervals and for the core survey regions that have been consistently sampled in all years (dashed red line). Note only the core survey regions were sampled in 2021 and 2023.

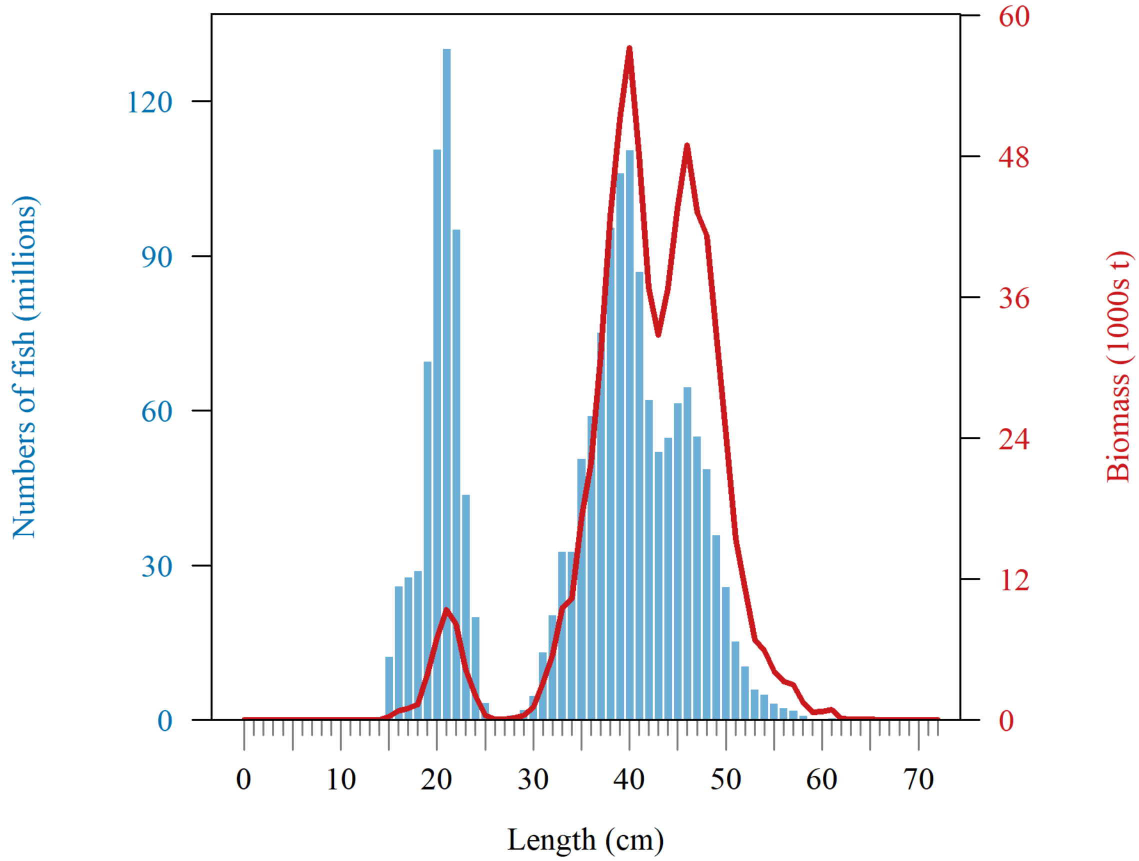

Figure 9. -- Pollock numbers- (blue bars) and biomass- (red line) at-length for the summer 2023 acoustic-trawl survey of the Gulf of Alaska.

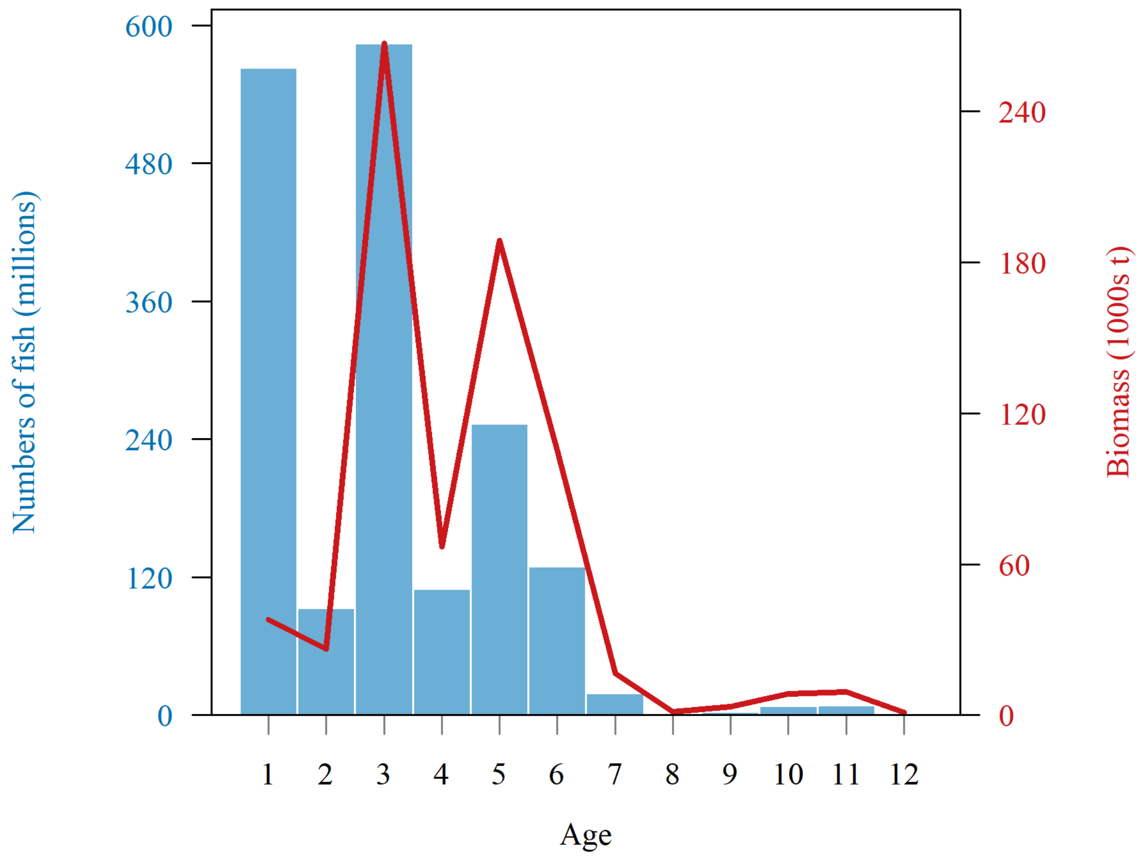

Figure 10. -- Pollock numbers- (blue bars) and biomass- (red line) at-age for the summer 2023 acoustic-trawl survey of the Gulf of Alaska.

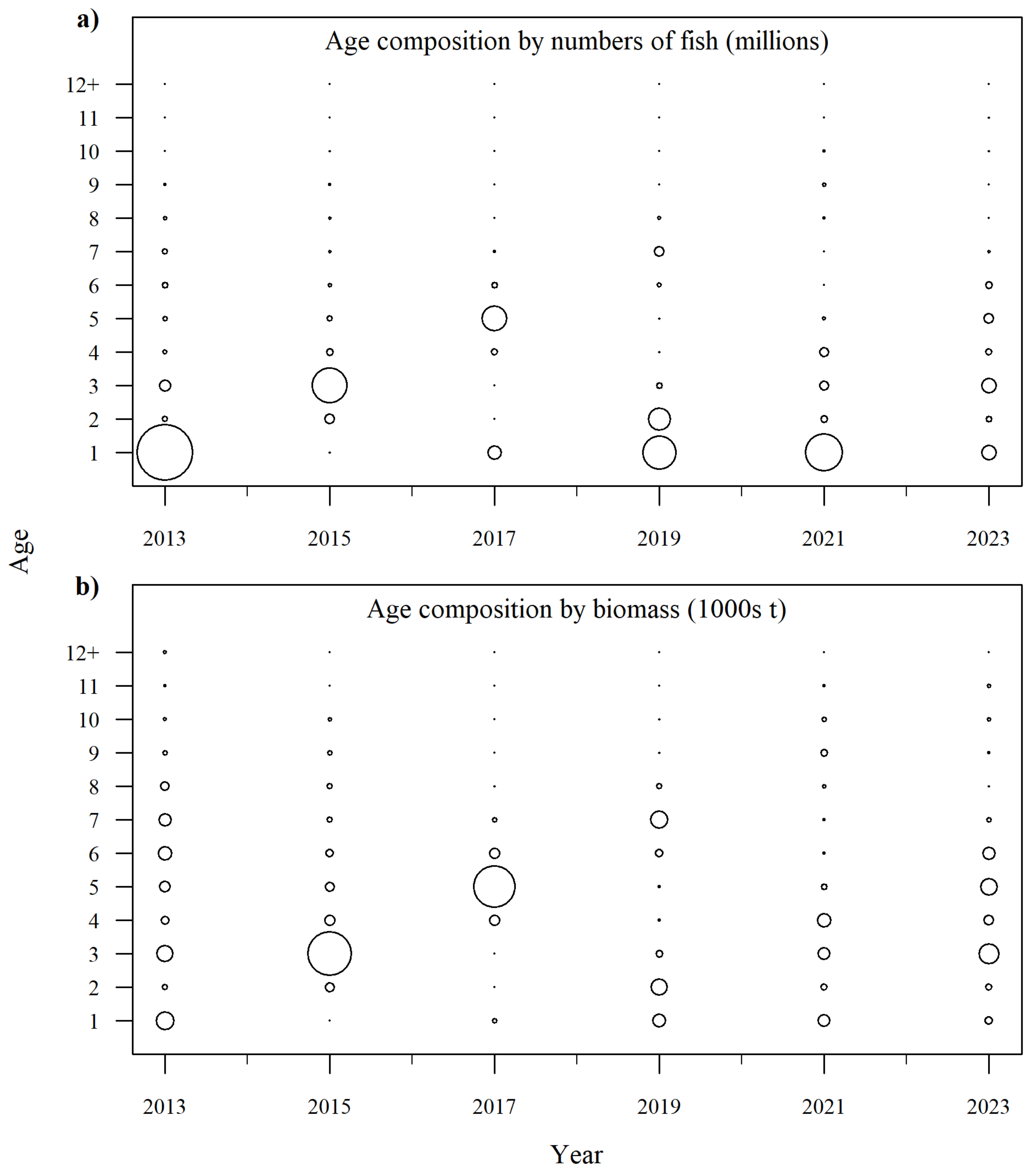

Figure 11. -- Time series of pollock population age composition by a) numbers and b) biomass from summer acoustic-trawl surveys of the Gulf of Alaska for 2013-2023. Bubble size is scaled based on square root transform of numbers/biomass estimate by age.

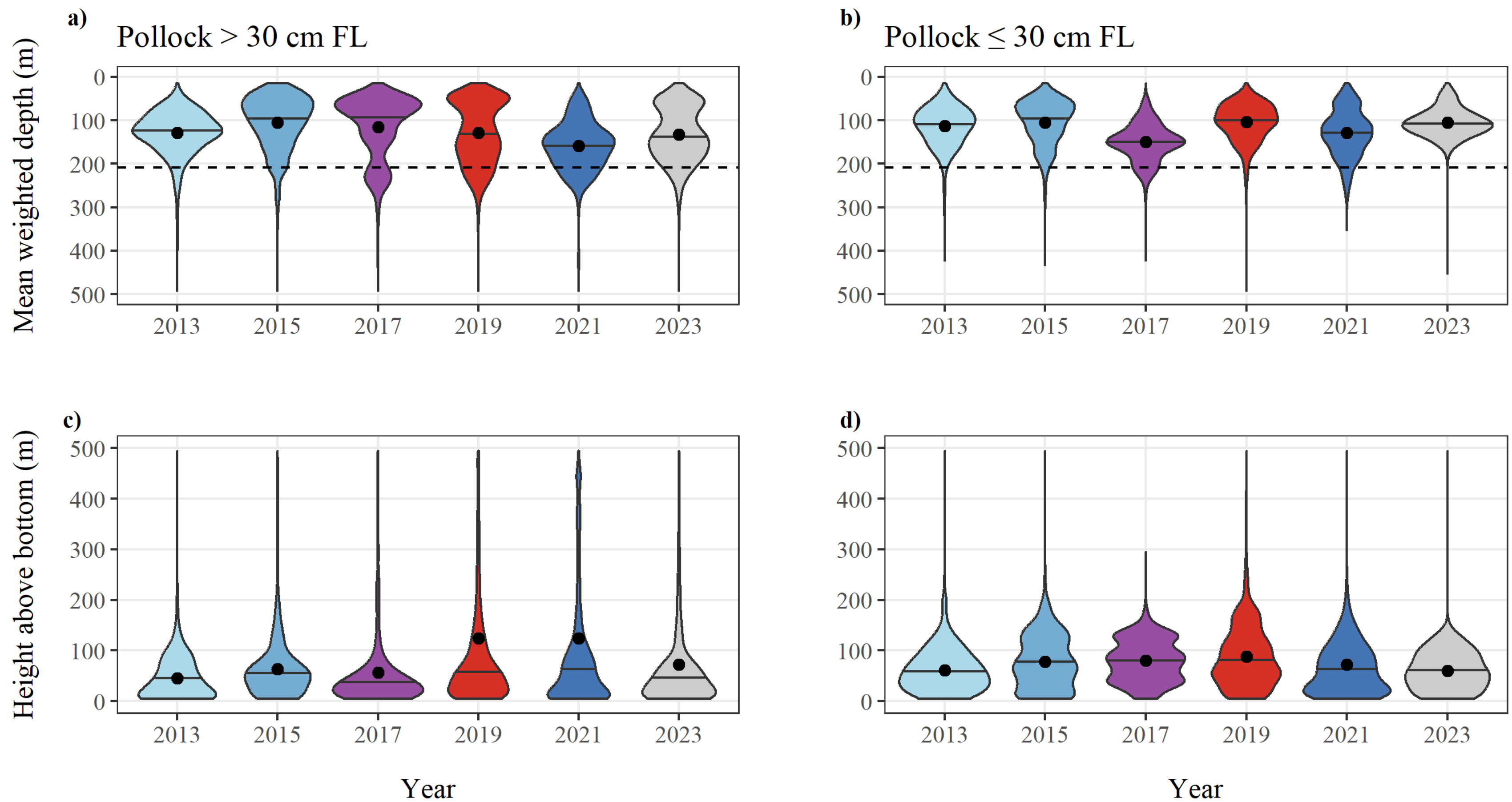

Figure 12. -- Estimated biomass distributions of adult pollock (> 30 cm FL) and juvenile pollock (≤ 30 cm FL) a, b) mean weighted depth and c, d) height above the bottom during summer acoustic-trawl surveys of the Gulf of Alaska. Mean weighted depth is referenced to the surface and height above bottom is referenced to the seafloor. Data were averaged in 10 m depth bins. Mean bottom depth for 2023 is shown in panels a and 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. Note that depths (or heights) > 500 m are omitted from plotting, but calculations include pollock at all surveyed depths.

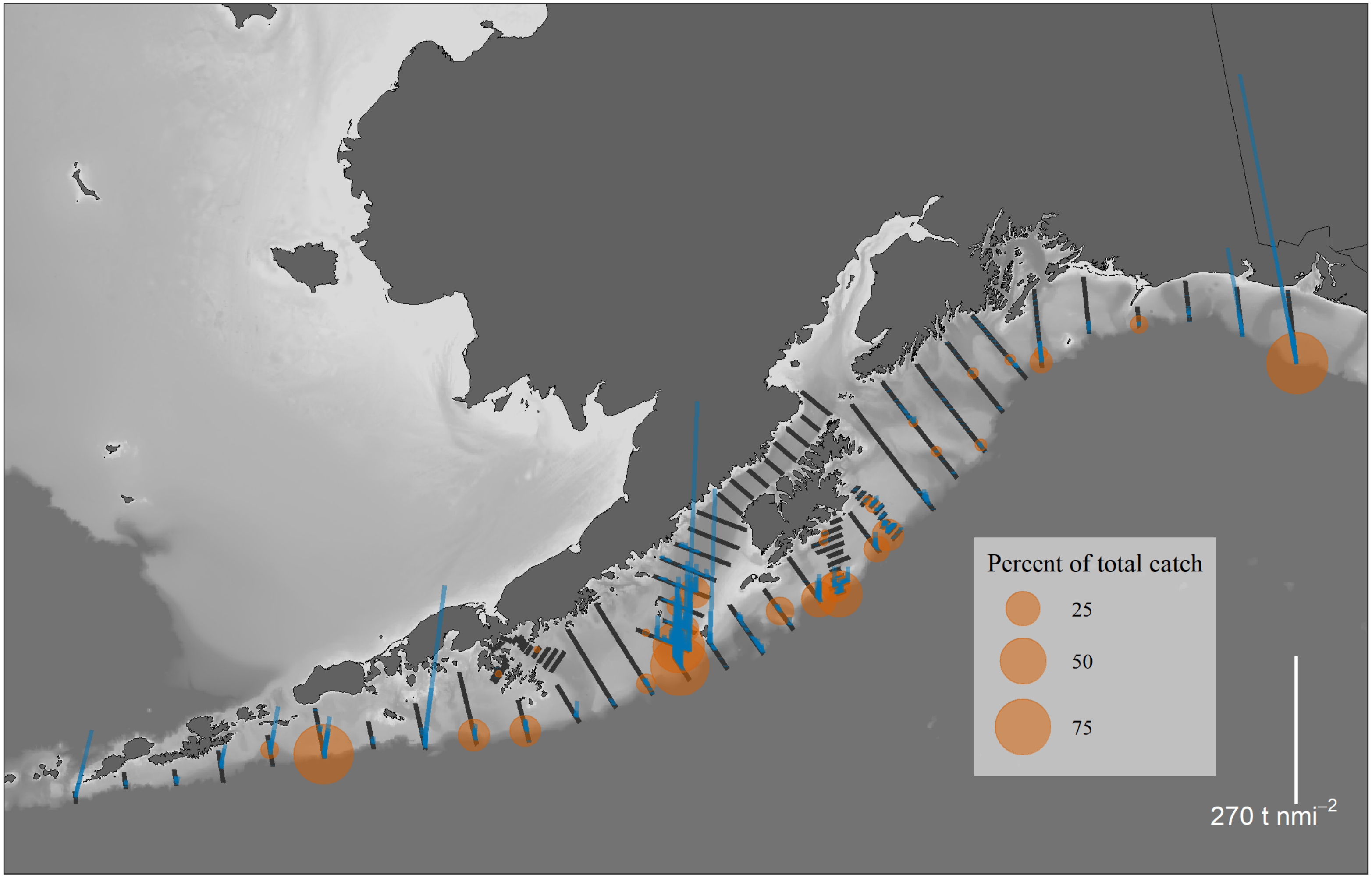

Figure 13. -- Density (t nmi^{-2}) attributed to Pacific ocean perch (POP, blue vertical lines) along tracklines surveyed during the summer 2023 acoustic-trawl survey of the Gulf of Alaska. Orange circles indicate the location of trawl hauls containing POP and are proportional to the percent of the total trawl catch (by numbers of individuals) that is comprised of this species within each haul.

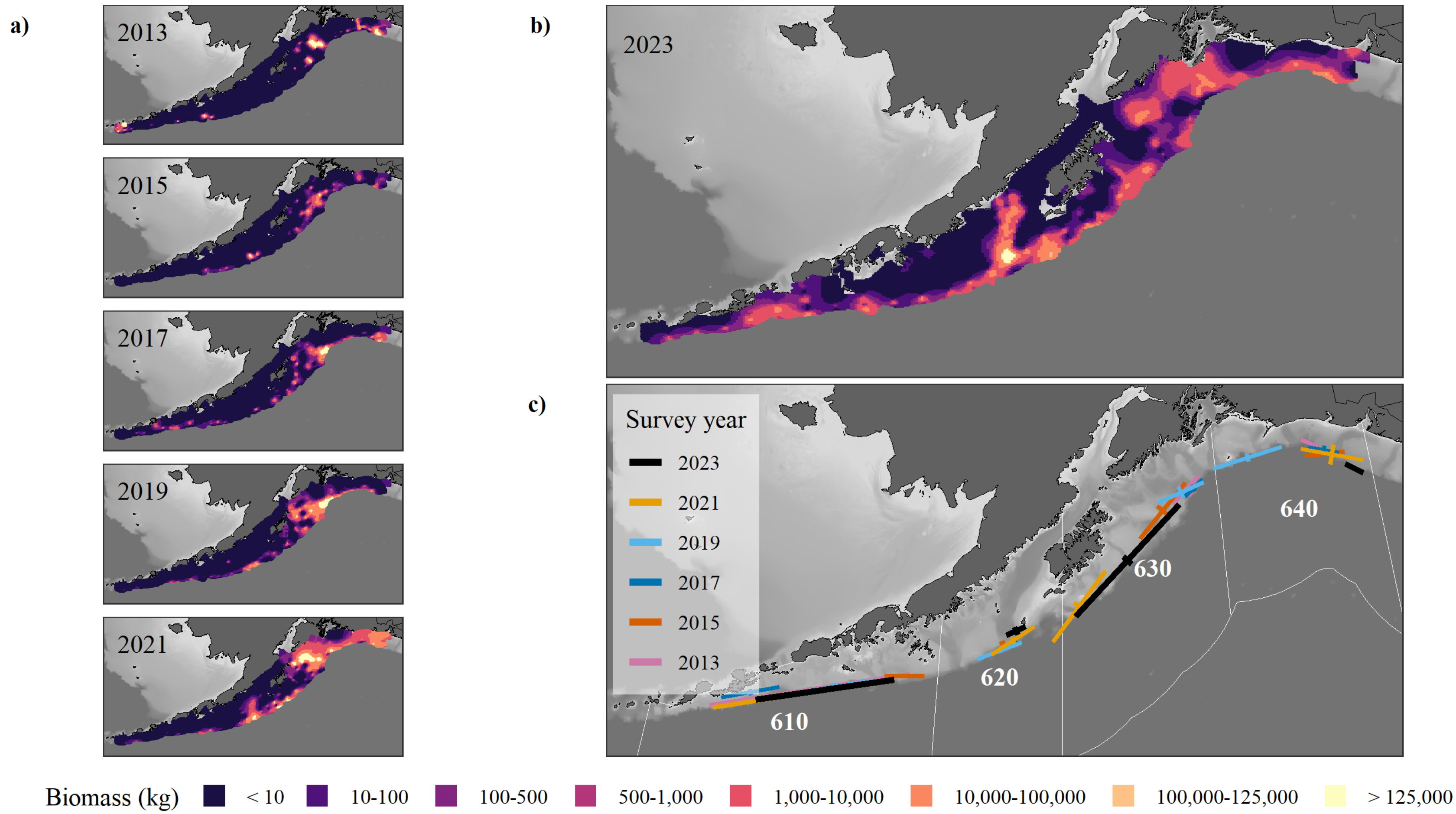

Figure 14. -- a) Historical time series of Pacific ocean perch (POP) biomass distributions for 2013-2021 and b) 2023 from summer acoustic-trawl surveys of the Gulf of Alaska. Note that the total amount of POP biomass varies widely between surveys, but all surveys are plotted using a common color scale. Values have been interpolated within the survey area via universal kriging (Pebesma 2004) to make spatial patterns easier to visualize. c) Center of gravity and inertia (colored crosses; Woillez et al. 2007) indicating the mean location and dispersion of POP within each NMFS Reporting Area by year.

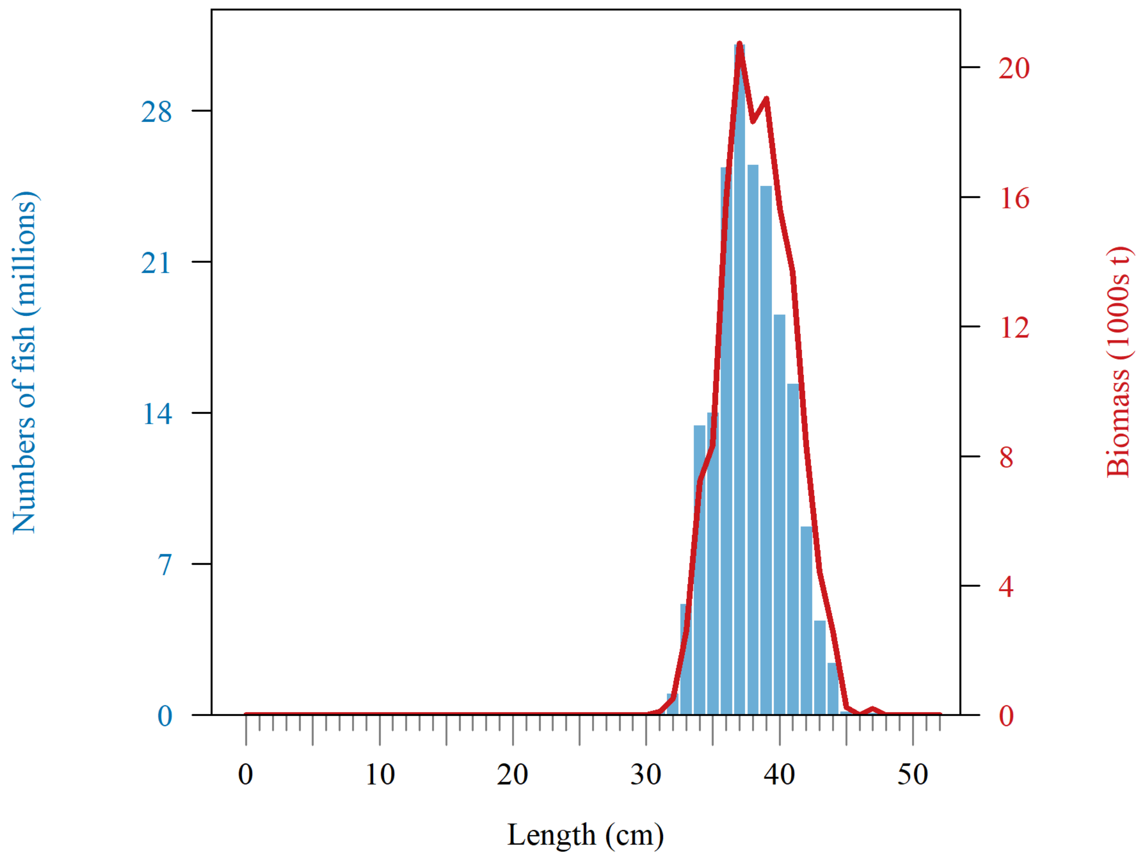

Figure 15. -- Pacific ocean perch numbers- (blue bars) and biomass- (red line) at-length for the summer 2023 acoustic-trawl survey of the Gulf of Alaska.

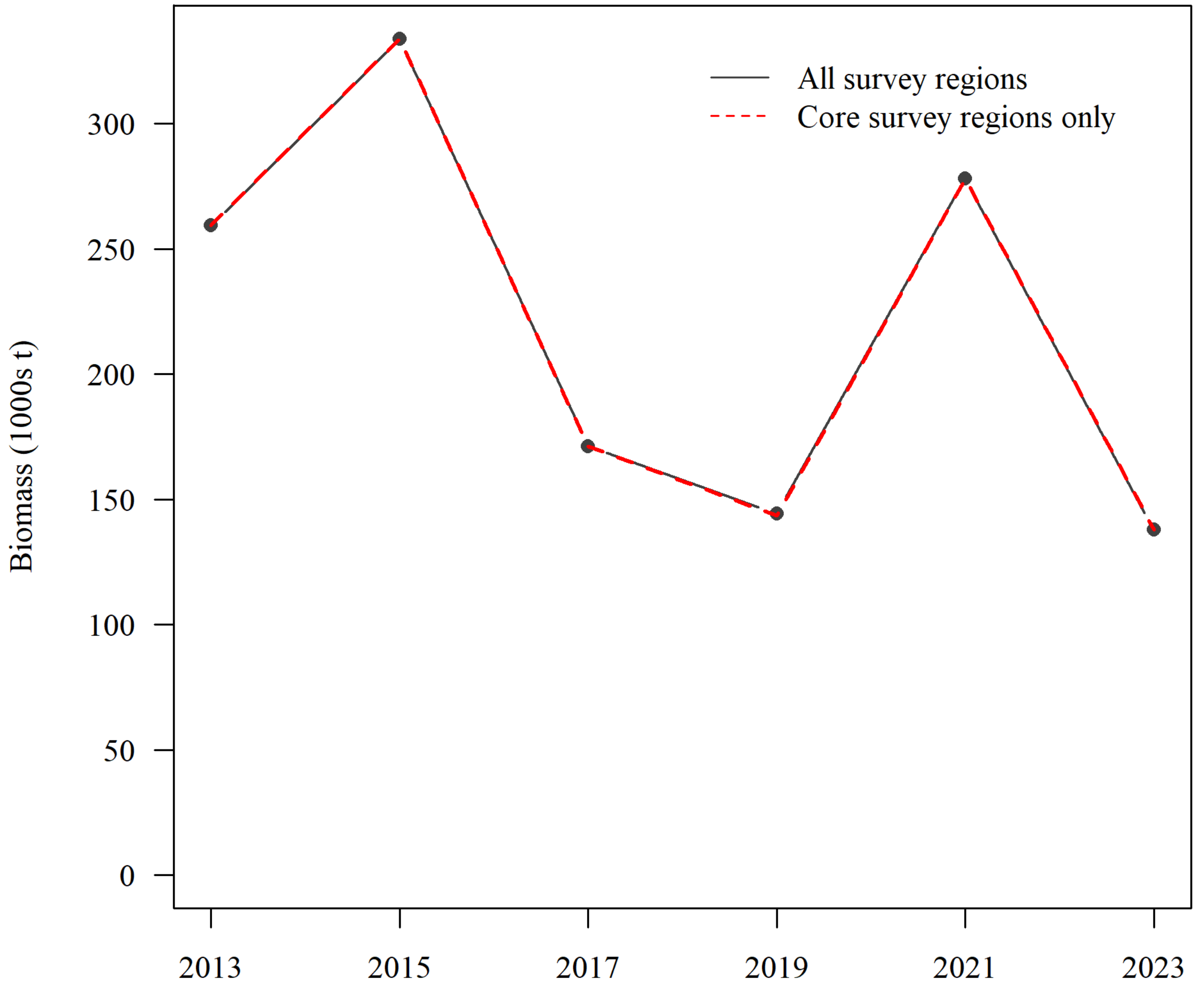

Figure 16. -- Index of Pacific ocean perch biomass (1,000s t) from summer acoustic-trawl surveys of the Gulf of Alaska for 2013-2023. Total biomass is shown for all survey regions (solid line) and for the core survey regions that have been consistently sampled in all years (dashed red line). Note only the core survey regions were sampled in 2021 and 2023.

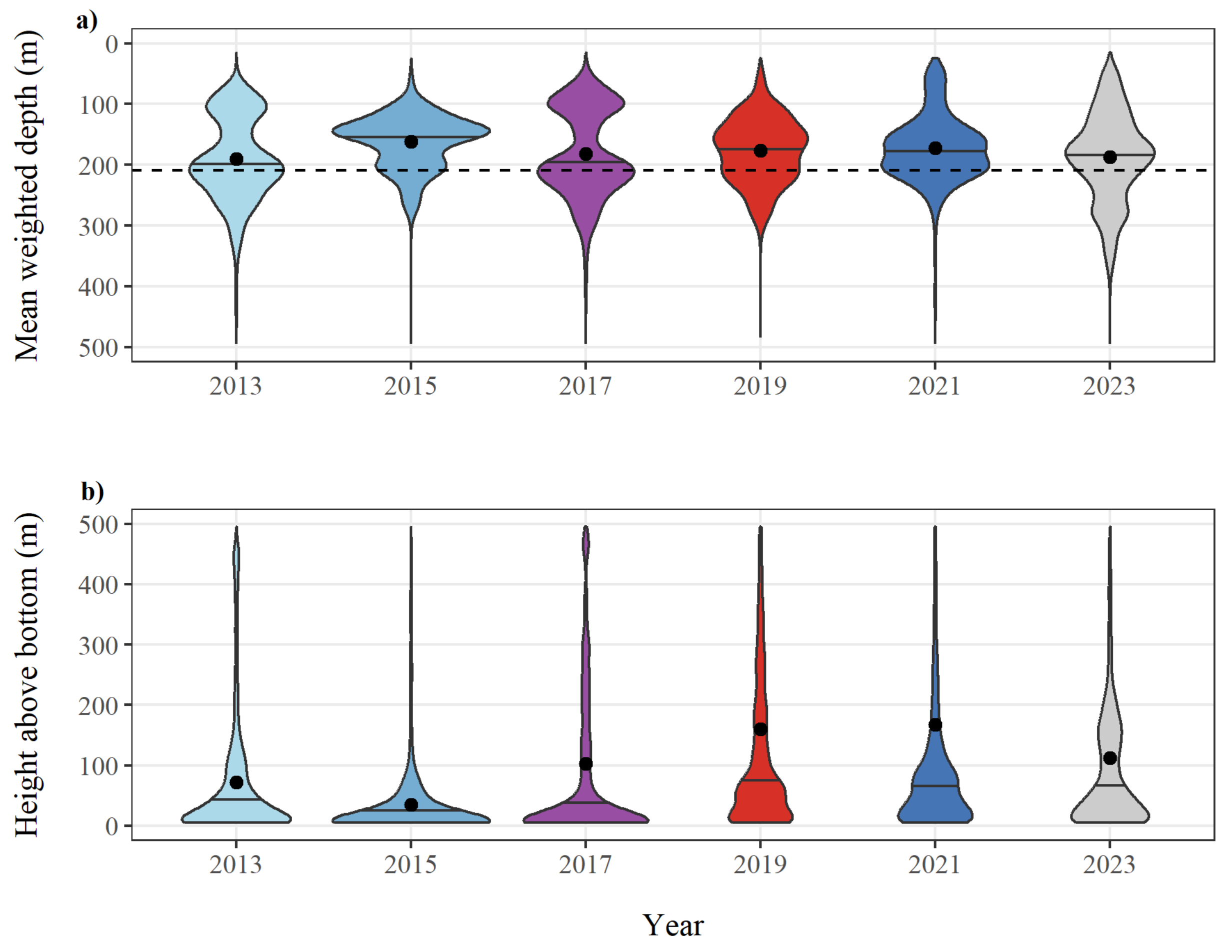

Figure 17. -- Estimated biomass distributions of Pacific ocean perch (POP) a) mean weighted depth and b) height above the bottom during summer acoustic-trawl surveys of the Gulf of Alaska. Mean weighted depth is referenced to the surface and height above bottom is referenced to the seafloor. Data were averaged in 10 m depth bins. Mean bottom depth for 2023 is shown in panel a (dashed line). Plots show the probability density of POP vertical distribution by year, including the median (black horizontal lines) and mean (black points) depth/height values indicated for each year. Note that depths (or heights) > 500 m are omitted from plotting, but calculations include POP at all surveyed depths.

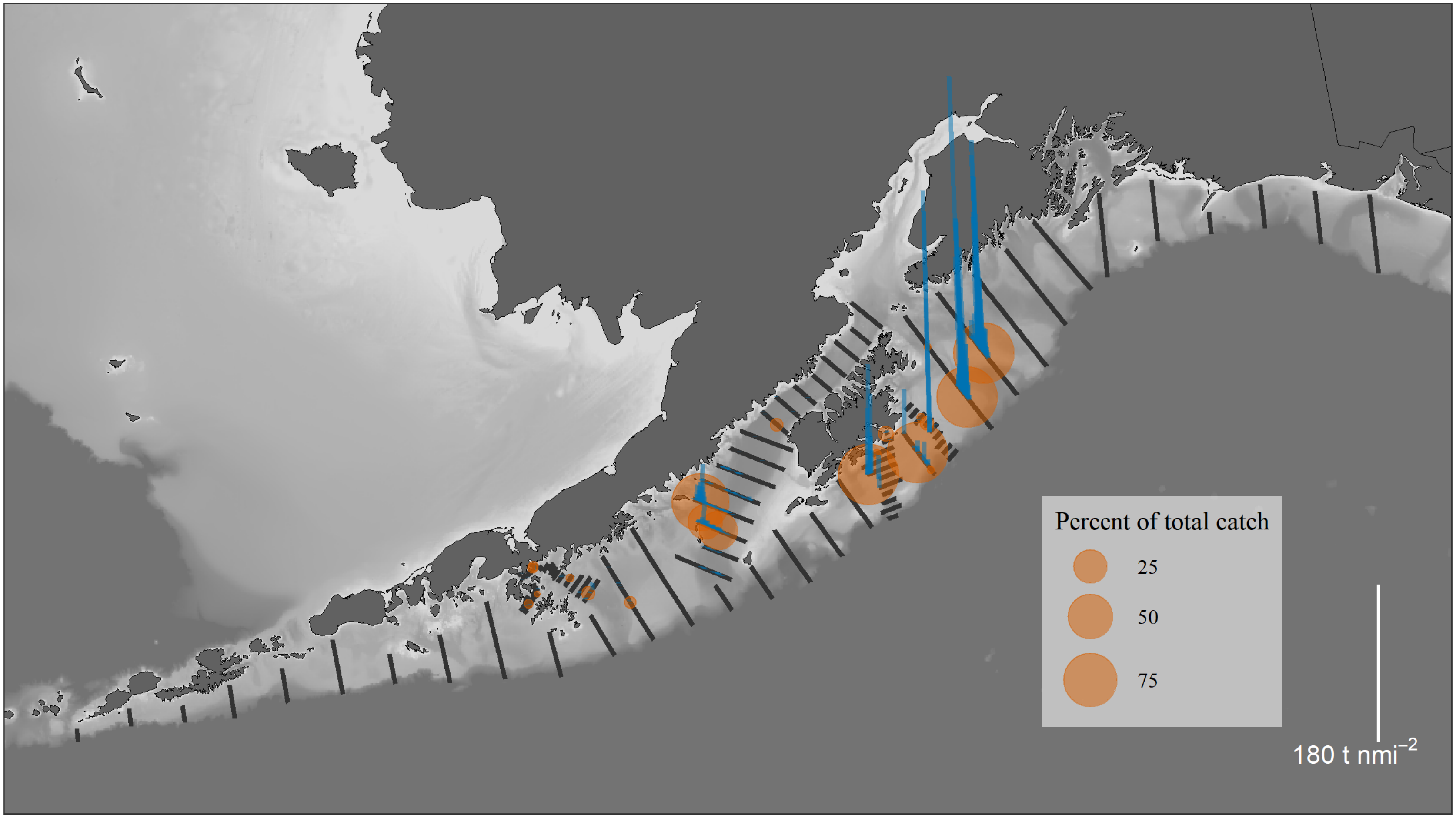

Figure 18. -- Density (t nmi^{-2}) attributed to capelin (blue vertical lines) along tracklines surveyed during the summer 2023 acoustic-trawl survey of the Gulf of Alaska. Orange circles indicate the location of trawl hauls containing capelin and are proportional to the percent of the total trawl catch (by numbers of individuals) that is comprised of this species within each haul.

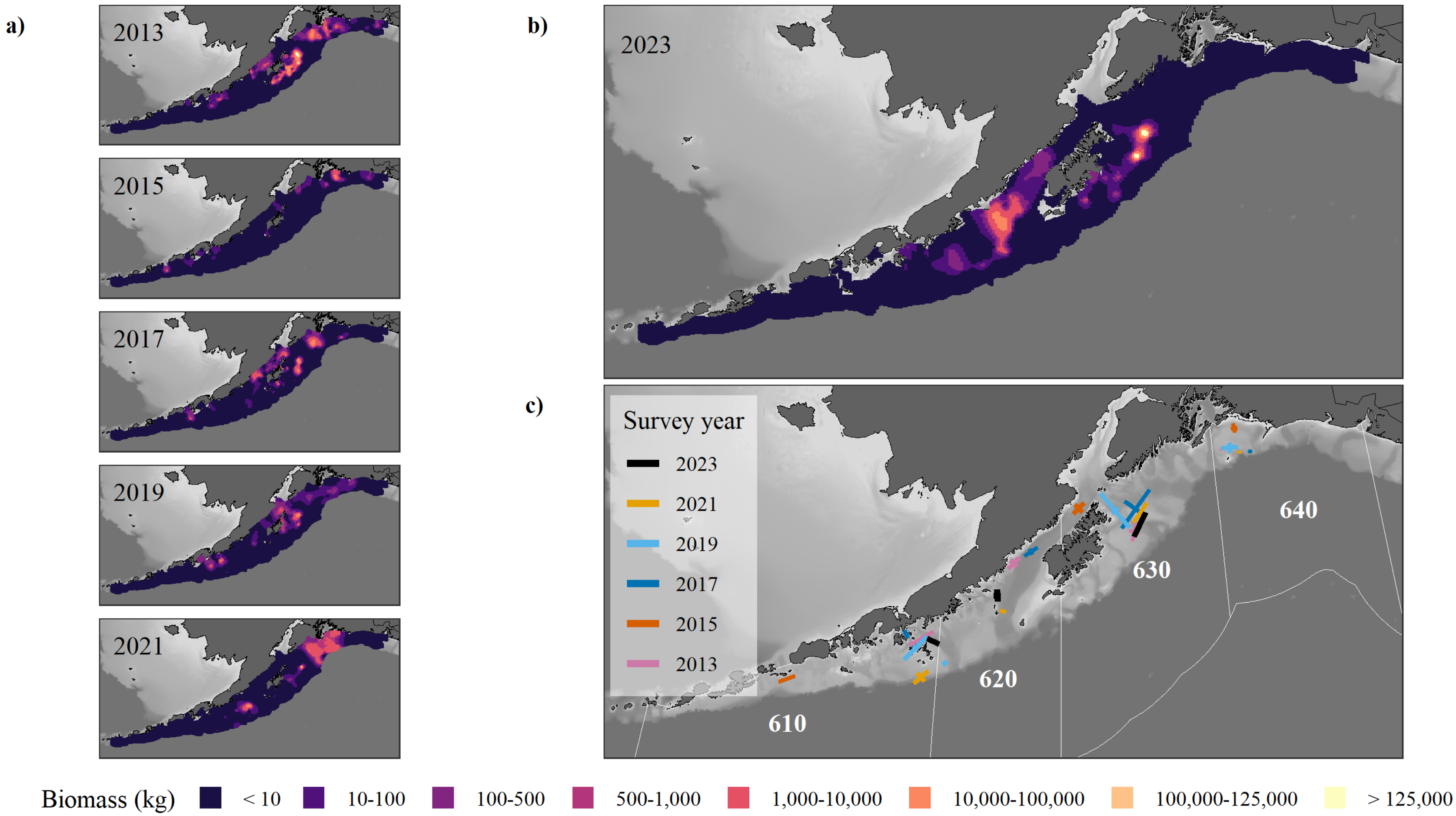

Figure 19. -- Capelin biomass distributions for a) 2013-2021 and b) 2023 from summer acoustic-trawl surveys of the Gulf of Alaska. Note that the total amount of capelin biomass varies widely between surveys, but all surveys are plotted using a common color scale. Values have been interpolated within the survey area via universal kriging (Pebesma 2004) to make spatial patterns easier to visualize. c) Center of gravity and inertia (colored crosses; Woillez et al. 2007) indicating the mean location and dispersion of capelin within each NMFS Reporting Area by year.

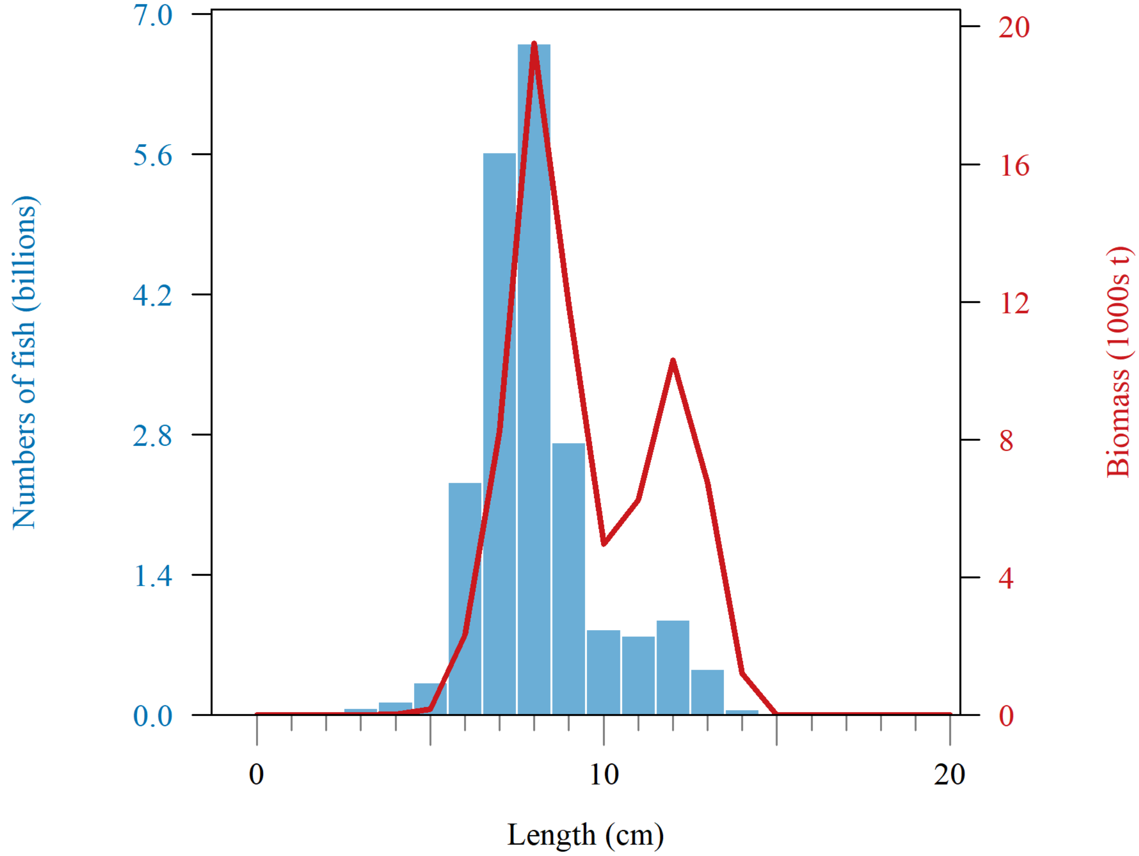

Figure 20. -- Capelin numbers- (blue bars) and biomass- (red line) at-length for the summer 2023 acoustic-trawl survey of the Gulf of Alaska.

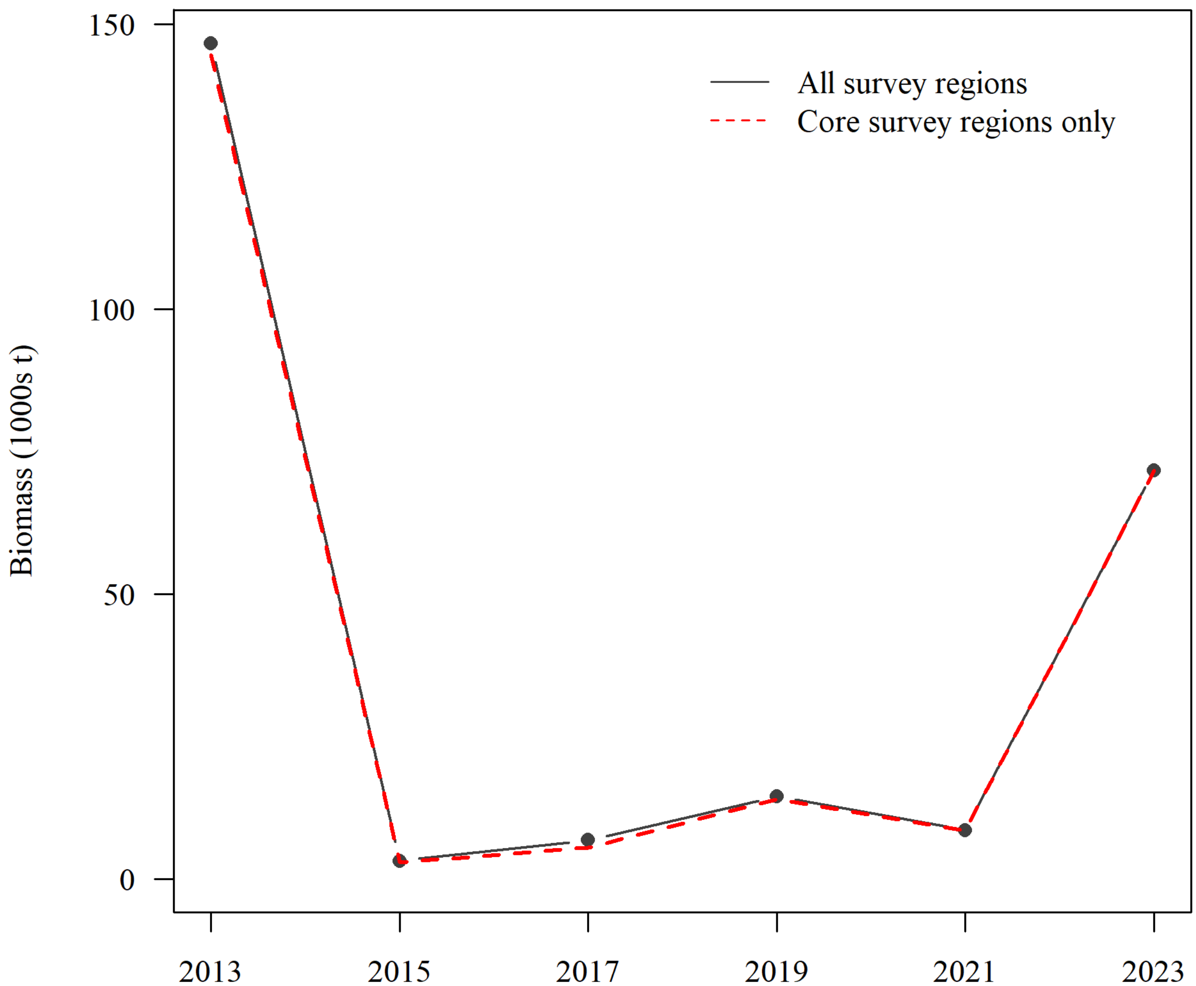

Figure 21. -- Index of capelin biomass (1,000s t) from summer acoustic-trawl surveys of the Gulf of Alaska for 2013-2023. Total biomass is shown for all survey regions (solid line) and for the core survey regions that have been consistently sampled in all years (dashed red line). Note only the core survey regions were sampled in 2021 and 2023.

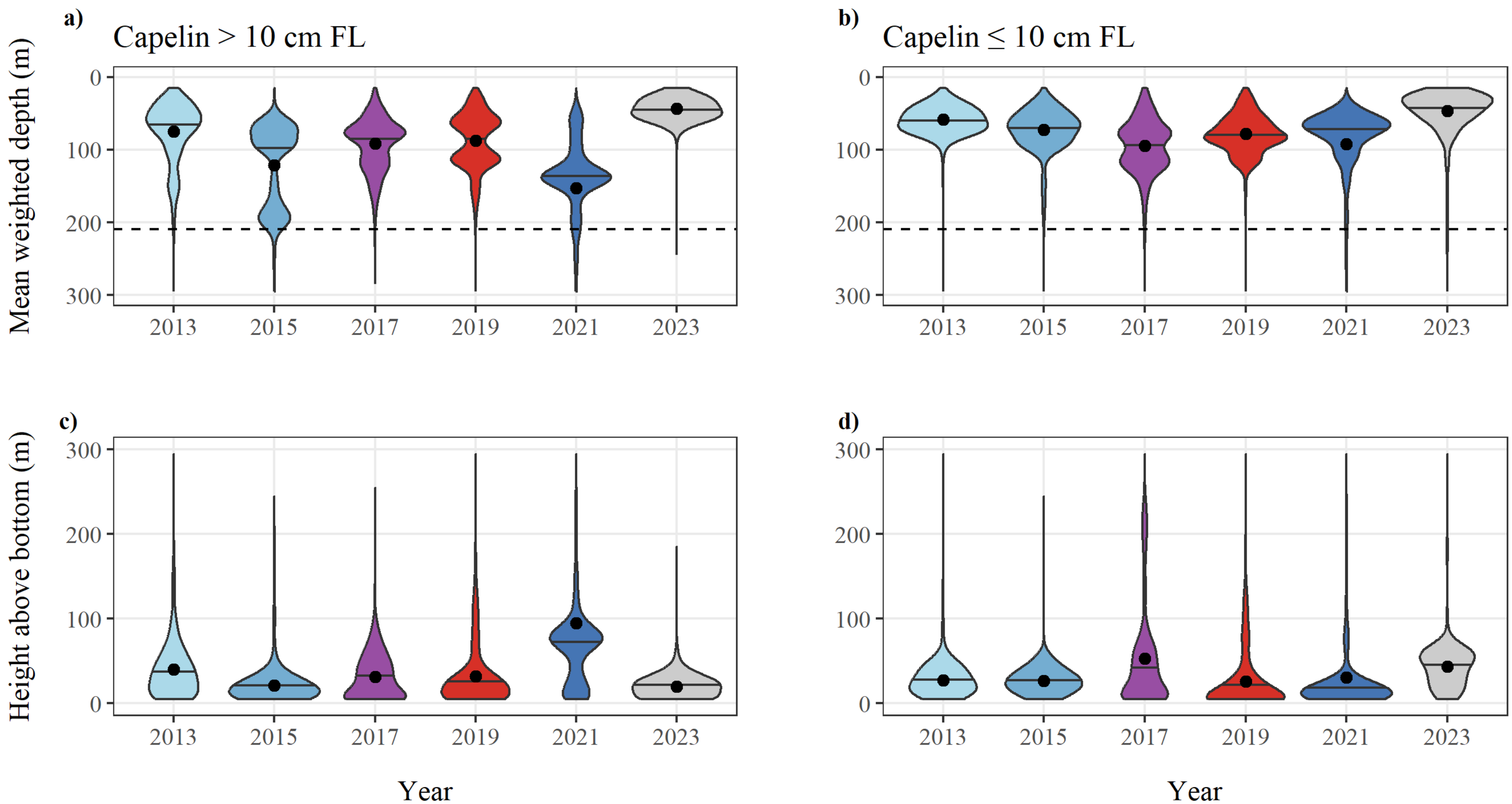

Figure 22. -- Estimated biomass distributions of capelin > 10 cm FL and ≤ 10 cm FL a, b) mean weighted depth and c, d) height above the bottom during summer acoustic-trawl surveys of the Gulf of Alaska. Mean weighted depth is referenced to the surface and height above bottom is referenced to the seafloor. Mean bottom depth for 2023 is shown in panels a and b (dashed line). Plots show the probability density of capelin vertical distribution by year, including the median (black horizontal lines) and mean (black points) depth/height values indicated for each year. Note that depths (or heights) > 300 m are omitted from plotting, but calculations include capelin at all surveyed depths.

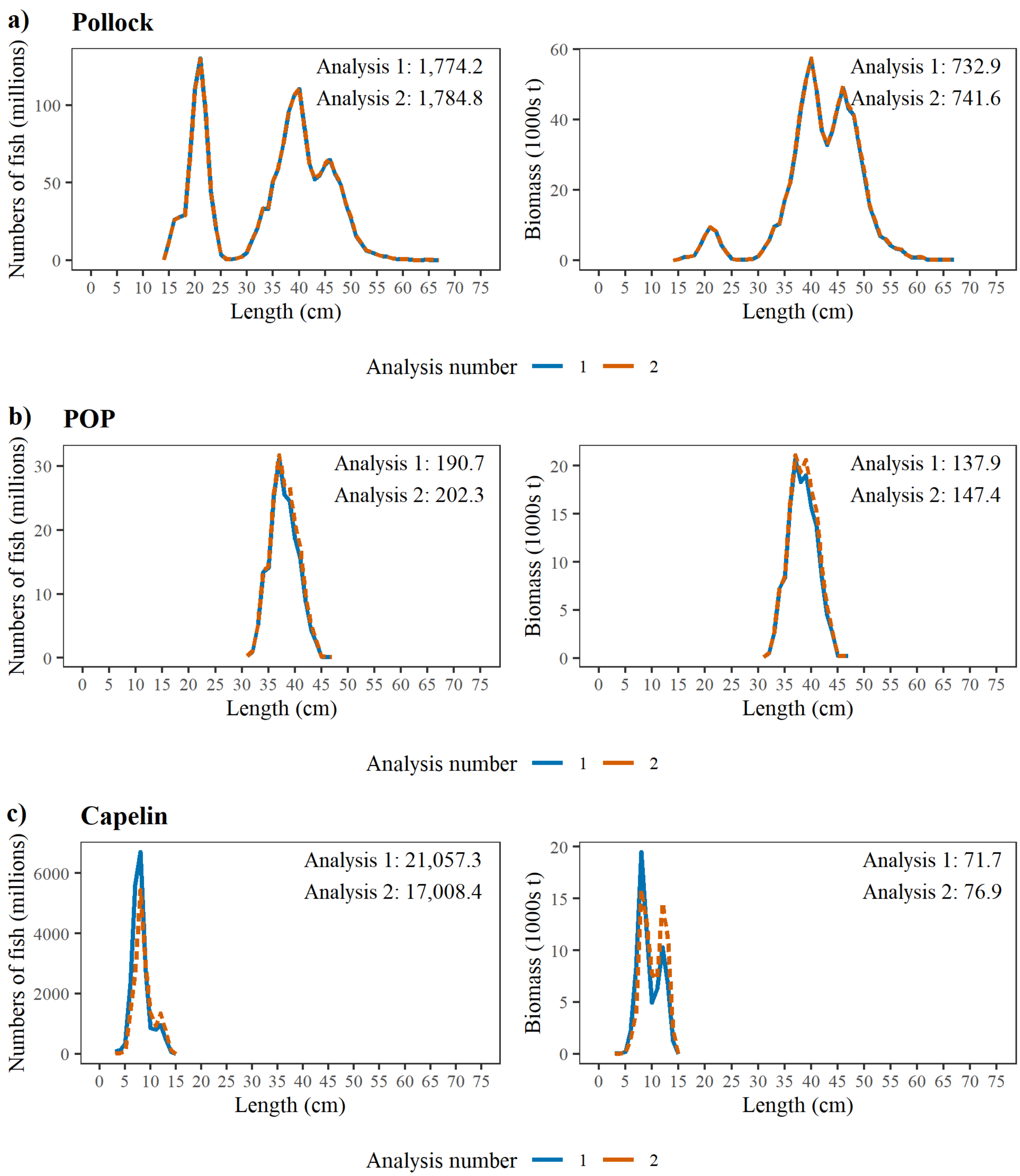

Figure 23. -- a) Pollock, b) Pacific ocean perch, and c) capelin numbers- and biomass-at-length for the primary analysis (blue, Analysis 1) compared with a non-selectivity analysis (orange, Analysis 2) from the summer 2023 acoustic-trawl survey of the Gulf of Alaska. The total numbers (million fish) and biomass (1,000s t) are presented for each analysis and species.

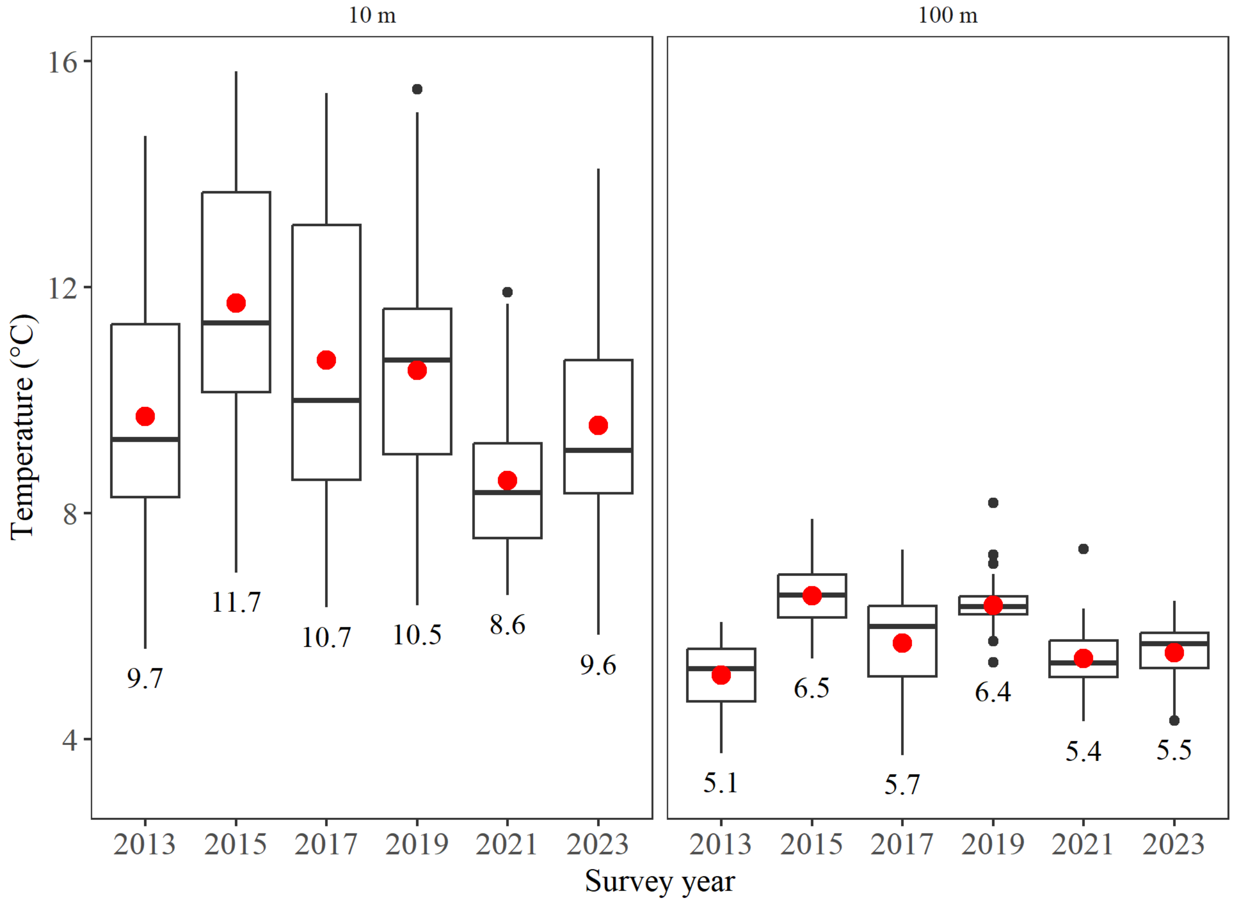

Figure 24. -- Water temperatures near the surface and at 100 m depth at fishing locations from SBE 39 probes placed on the headrope of fishing gear in core survey regions (GOA Shelf, Shumagin Islands, Shelikof Strait, Barnabas Trough, Chiniak Trough) during summer acoustic-trawl surveys of the Gulf of Alaska from 2013-2023. Boxes represent data within the 25th to 75th percentiles, whiskers bound the 9th to 91st percentile, black line represents the median, red dot represents the mean, and black dots represent outliers.

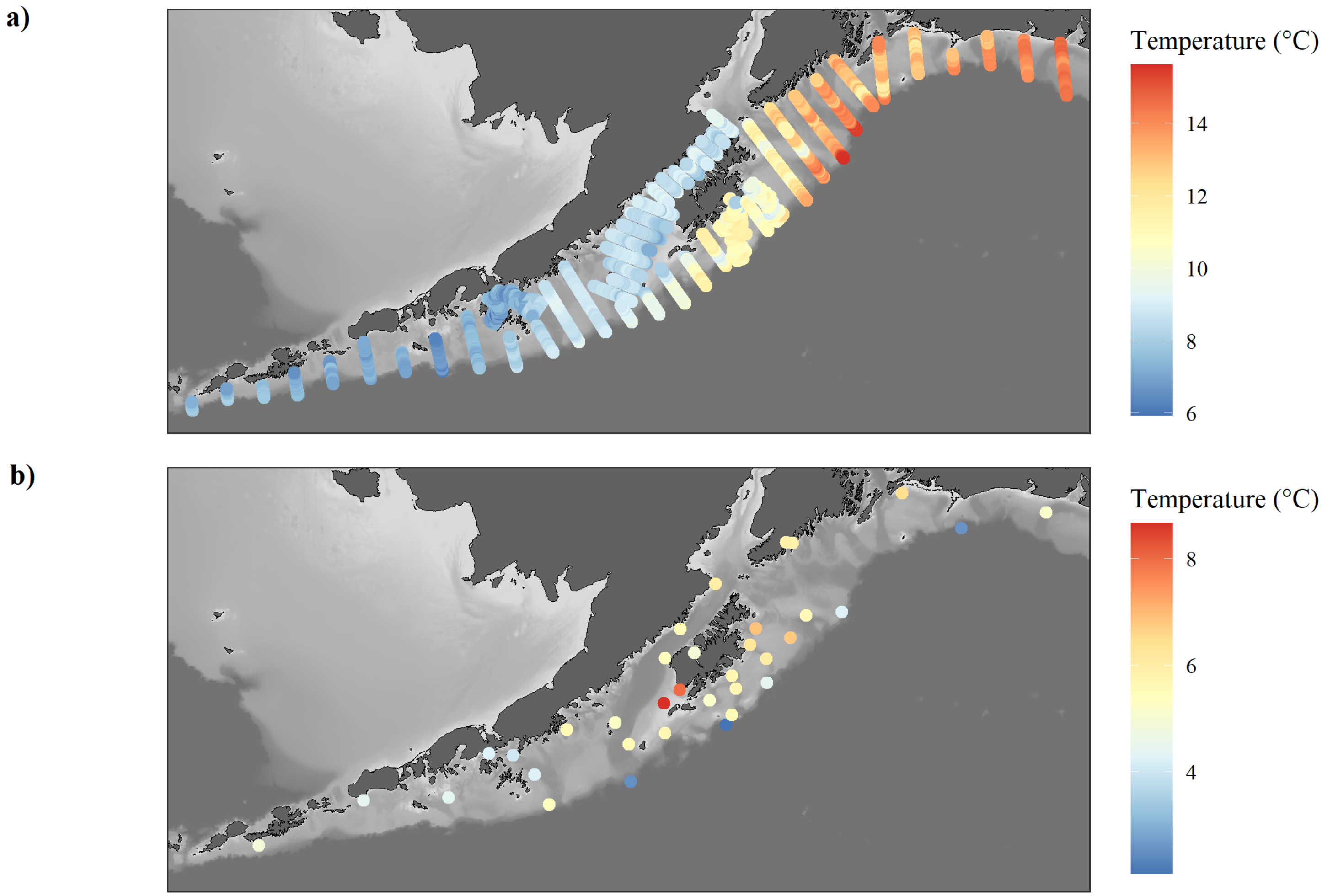

Figure 25. -- a) Sea surface water temperatures (°C) recorded at 5-second intervals from the hull-mounted flow-through seawater system and b) bottom water temperatures recorded during 35 CTD casts during the summer 2023 acoustic-trawl survey of the Gulf of Alaska. Note that temperature color scales differ between plots.

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APPENDIX I. ITINERARY

Leg 1	
10 June	Depart Kodiak, AK
10 June	Transit to calibration site
11 June-12 June	Acoustic sphere calibration in Uyak Bay, Kodiak Island
12 June-14 June	Transit to survey start area
14 June-18 June	Acoustic-trawl survey of the GOA Shelf (Transects 1-9)
18 June-21 June	Acoustic-trawl survey of Shumagin Islands area (Transects 251-275)
21 June	Transit to Kodiak
22 June-29 June	In port Kodiak
Leg 2	
29 June	Depart Kodiak, AK
29 June-30 June	Transit to Malina Bay for DriX ops
30 June-1 July	DriX ops in Maline Bay
1 July	Transit to survey start area
1 July-6 July	Acoustic-trawl survey of Shelikof Strait (Transects 401-413)
6 July-6 July	MML mooring ops near Sutwick Island
6 July-8 July	Acoustic-trawl survey of Shelikof Strait (Transects 414-416)
9 July-15 July	Acoustic-trawl survey of the GOA Shelf (Transects 10-18)
15 July-18 July	Acoustic-trawl survey of Barnabas Trough (Transects 501-512)
18 July-19 July	Acoustic-trawl survey of the GOA Shelf (Transects 19)
19 July-21 July	Acoustic-trawl survey of Chiniak Trough (Transects 551-557)
21 July	Transit to Kodiak
21 July-7 August	In port Kodiak
Leg 3	
7 August	Depart Kodiak, AK
7 August-8 August	Transit to MML mooring site
8 August-8 August	MML mooring ops near Stevenson Entrance
8 August	Transit to survey start area
8 August-11 August	Acoustic-trawl survey of the GOA Shelf (Transects 20-23)
11 August	Break from survey due to weather, transit to Nuka Bay
12 August-12 August	Acoustic sphere calibration in Nuka Bay, Kodiak Island
13 August	Transit to resume survey
13 August-18 August	Acoustic-trawl survey of the GOA Shelf (north end T21-22, T24-30)
18 August-20 August	Transit to Kodiak
20 August	In port Kodiak

* All dates are based on local time

APPENDIX II. SCIENTIFIC PERSONNEL

Leg 1

Name	Position	Organization
Stienessen, Sarah	Chief Scientist	AFSC
Towler, Rick	Computer Spec.	AFSC
Phillips, Matthew	Biologist	AFSC
Urmy, Sam	Biologist	AFSC
Williams, Kresimir	Biologist	AFSC
Wilson, Katherine	Biologist	AFSC
Agarwal, Karuna	NRC post-doc	AFSC
McLean, Robert	Biologist	PIFSC
Gossom, James	Biologist	AIS, Inc.
Guertin, Laura	Teacher-at-Sea	NOAA-TAS

Leg 2

Name	Position	Organization
Jones, Darin	Chief Scientist	AFSC
De Robertis, Alex	Biologist	AFSC
Furnish, Scott	Computer Spec.	AFSC
Lauffenburger, Nathan	Biologist	AFSC
McKelvey, Denise	Biologist	AFSC
Parker-Stetter, Sandra	Biologist	AFSC
Phillips, Matthew	Biologist	AFSC
Gossom, James	Biologist	AIS, Inc.
Gallagher, Mike	Research Platform Coordinator	OST
Gini, Marc	DriX Consultant	iXblue
Kerjean, Mathieu	DriX Consultant	iXblue

Leg 3

Name	Position	Organization
Honkalehto, Taina	Chief Scientist	AFSC
Levine, Mike	Computer Spec.	AFSC
Levine, Robert	Biologist	AFSC
McCarthy, Abigail	Biologist	AFSC
McGowan, David	Biologist	AFSC
Neidetcher, Sandi	Biologist	AFSC
Phillips, Matthew	Biologist	AFSC
Gossom, James	Biologist	AIS, Inc.
Thomas, Germaine	Teacher-at-Sea	NOAA-TAS

AFSC = Alaska Fisheries Science Center, National Marine Fisheries Service, Seattle, WA
AIS Scientific and Environmental Services, Inc.
OST = Office of Science and Technology, National Marine Fisheries Service, Seattle, WA
PIFSC = Pacific Islands Fisheries Science Center, National Marine Fisheries Service, Honolulu, WA

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 TS-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):

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

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

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

In analyses where trawl selectivity was considered, the selectivity-corrected numbers $N_{s_{corr},l,h}$ were used in place of $N_{s,l,h}$ in Eq. ii. This correction 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:

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

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

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:

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

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

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

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:

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

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

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:

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

$$\text{Biomass-at-age } j: B_{s,j} = \sum_{i} \left(Q_{s,l,j} \times B_{s,l}\right) \quad . \qquad \text{(Eq. } ix\text{)}$$

APPENDIX IV. REGIONAL SUMMARIES

GOA Shelf

The GOA Shelf region (Fig. 2; Fig. A4.1a) was surveyed between 14 June and 17 August. The survey region encompassed 162,376 km^2 (47,341 nmi^2). Acoustic backscatter was measured along 2,592 km (1,399 nmi) of trackline on 32 transects spaced at 55.6 km (30.0 nmi) apart in NMFS Reporting Areas 620 and 630 and 74.1 km (40.0 nmi) apart in NMFS areas 610 and 640 (Fig. 2; Fig. A4.1b). Bottom depths in the GOA Shelf region ranged from 26 to 1,217 m and averaged 231 m.

Surface water temperatures in the GOA Shelf region measured by the ship's flow-thru seawater system ranged from 6.1 to 15.6°C, and averaged 10.8°C (Fig. 25a, Fig. A4.1c). Average surface temperature in summer 2023 were 1.5°C warmer than during the last GOA Shelf summer survey (2021; 9.3°C), and within the range of surface water temperatures observed in previous summer surveys from 2013-2021 (9.3-12.2 °C). Temperatures at 100 m depth at fishing locations from SBE 39 probes on the fishing gear ranged from 4.7 to 6.2°C and averaged 5.6°C (n = 25 trawls; Fig. A4.1d). This was 0.3°C warmer than in summer 2021 (5.3°C), and within the range of average water temperatures at 100 m depth observed in previous summer surveys from 2013-2021 (5.3-6.6°C). Bottom temperatures from 18 CTD deployments averaged 4.8°C at an average sampling depth of 388 m, 0.0°C warmer than in summer 2021 (4.8°C; Fig. 25b, Fig. A4.1c), within the range of bottom water temperatures observed in this region from 2013-2021 (4.8-5.8°C).

Biological data and specimens were collected along the GOA Shelf from 28 LFS1421, 1 PNE, and 2 Methot hauls (Figs. 2 and A4.1b; Table A4.1, Table A4.2, Table A4.3). Pollock and POP were the most abundant species by weight in LFS1421 trawls, contributing 70.5 and 22.2% of the catch by weight, respectively (Table A4.1). Capelin and pollock were the most abundant species by number, contributing 62.2 and 26.4% of the catch by number, respectively (Table A4.1). Pollock and POP were the most abundant species by weight in PNE trawls, contributing 88.8 and 4.1% of the catch by weight, respectively (Table A4.2). Pollock and POP were the most abundant species by number, contributing 89.6 and 4.2% of the catch by number, respectively (Table A4.2). Lions mane jellyfish and *Aequorea* sp. were the most abundant species by weight in Methot trawls, contributing 51.4 and 20.4% of the catch by weight, respectively (Table A4.3). Euphausiids and *Aequorea* sp. were the most abundant species by number, contributing 99.2 and 0.4% of the catch by number, respectively (Table A4.3).

Age-1+ pollock observed on the GOA Shelf ranged in length from 16 to 61 cm FL with modes at 21 and 40 cm FL (Fig. A4.2a, Table 11). Pollock ranged from age-1 to age-12, with age-3 fish comprising the vast majority by number (37.8%) and biomass (39.6%; Fig. A4.2b, Table 12). The mean weighted depth of pollock in the GOA Shelf region was approximately 135 m from the surface and 76 m above the bottom.

The estimated abundance of age-1+ pollock for the GOA Shelf was 1,402.5 million fish weighing 615.1 thousand tons, approximately 83.9% of the total pollock biomass observed in this survey and 236.5% of the summer 2021 GOA Shelf biomass estimate (Table 8). The relative estimation error of the biomass resulting from the 1-D geostatistical analysis was 8.0% (Table 8).

Table A4.1. -- Catch by species and numbers of length and weight measurements taken from 28 LFS1421 hauls during the summer 2023 acoustic-trawl survey of the Gulf of Alaska for the GOA Shelf region.

		Catch				Measurements	
Species name	Scientific name	Weight (kg)	%	Number	%	Length	Weight
pollock	*Gadus chalcogrammus*	13,140.6	70.5	37,191	26.4	6,401	1,201
POP	*Sebastes alutus*	4,127.3	22.2	5,760	4.1	787	284
Pacific capelin	*Mallotus catervarius*	517.6	2.8	87,712	62.2	536	131
northern sea nettle	*Chrysaora melanaster*	305.2	1.6	555	0.4	308	196
salmon shark	*Lamna ditropis*	73.3	0.4	1	<0.1	1	1
giant grenadier	*Coryphaenoides pectoralis*	66.8	0.4	25	<0.1	25	9
pink salmon	*Oncorhynchus gorbuscha*	55.9	0.3	51	<0.1	51	51
widow rockfish	*Sebastes entomelas*	46.2	0.2	32	<0.1	32	32
coho salmon	*Oncorhynchus kisutch*	37.4	0.2	11	<0.1	11	11
Pacific herring	*Clupea pallasii*	34.9	0.2	219	0.2	156	47
Pacific pomfret	*Brama japonica*	29.6	0.2	41	<0.1	41	41
lions mane	*Cyanea capillata*	28.3	0.2	160	0.1	116	73
jellyfishes	Scyphozoa (class)	27.9	0.1	194	0.1	102	44
lanternfishes	Myctophidae (family)	20.9	0.1	2,554	1.8	156	50
eulachon	*Thaleichthys pacificus*	19.8	0.1	522	0.4	61	35
Chinook salmon	*Oncorhynchus tshawytscha*	17.7	<0.1	15	<0.1	15	15
dusky rockfish	*Sebastes variabilis*	12.4	<0.1	6	<0.1	6	6
magistrate armhook squid	*Berryteuthis magister*	11.5	<0.1	35	<0.1	35	35
euphausiids	Euphausiacea (order)	10.7	<0.1	33	<0.1	0	0
salmon spp.	Oncorhynchus (genus)	10.6	<0.1	38	<0.1	38	38
chum salmon	*Oncorhynchus keta*	10.4	<0.1	10	<0.1	10	10
squids	Cephalopoda (class)	5.7	<0.1	229	0.2	83	40
rougheye and blackspotted rockfish spp.	Sebastes (genus)	4.0	<0.1	3	<0.1	3	3
silvergray rockfish	*Sebastes brevispinis*	2.7	<0.1	1	<0.1	1	1
redstripe rockfish	*Sebastes proriger*	2.2	<0.1	4	<0.1	4	4
arrowtooth flounder	*Atheresthes stomias*	2.0	<0.1	1	<0.1	1	1
sockeye salmon	*Oncorhynchus nerka*	2.0	<0.1	12	<0.1	12	12
Aequorea sp.	*Aequorea* sp.	2.0	<0.1	46	<0.1	12	12
pollock age-0	*Gadus chalcogrammus*	1.7	<0.1	3,744	2.7	329	0
Atka mackerel	*Pleurogrammus monopterygius*	1.2	<0.1	3	<0.1	1	1
Hydromedusas	Hydromedusa (unid.)	1.0	<0.1	184	0.1	79	27
Pacific glass shrimp	*Pasiphaea pacifica*	0.9	<0.1	925	0.7	27	0
egg yolk jelly	*Phacellophora camtschatica*	0.7	<0.1	7	<0.1	6	6
northern smoothtongue	*Leuroglossus schmidti*	0.4	<0.1	33	<0.1	2	1
prowfish	*Zaprora silenus*	0.3	<0.1	45	<0.1	45	30
unsorted catch and debris		0.1	<0.1	0	<0.1	0	0
Pacific lamprey	*Lampetra tridentata*	<0.1	<0.1	2	<0.1	2	2
fish larvae	Actinopterygii (class)	<0.1	<0.1	420	0.3	69	0
northern pearleye	*Benthalbella dentata*	<0.1	<0.1	1	<0.1	1	1
isopods	Isopoda (order)	<0.1	<0.1	56	<0.1	0	0
viperfishes	Stomiidae (family)	<0.1	<0.1	2	<0.1	2	2
whitecross jelly	*Staurostoma mertensii*	<0.1	<0.1	1	<0.1	1	1
Ptychogena sp.	Ptychogena (genus)	<0.1	<0.1	8	<0.1	8	8

		Catch				Measurements	
Species name	Scientific name	Weight (kg)	%	Number	%	Length	Weight
flatfish larvae	*Pleuronectiform* larvae	<0.1	<0.1	108	<0.1	15	1
amphipods	Amphipoda (order)	<0.1	<0.1	8	<0.1	0	0
Aurelia labiata	*Aurelia labiata*	<0.1	<0.1	1	<0.1	1	0
sand lance spp.	Ammodytes (genus)	<0.1	<0.1	11	<0.1	11	0
shrimps	Malacostraca (class)	<0.1	<0.1	1	<0.1	1	1
Total		18,632.4		141,021		9,604	2,464

Table A4.2. -- Catch by species and numbers of length and weight measurements taken from 1 PNE haul during the summer 2023 acoustic-trawl survey of the Gulf of Alaska for the GOA Shelf region.

		Catch				Measurements	
Species name	Scientific name	Weight (kg)	%	Number	%	Length	Weight
pollock	*Gadus chalcogrammus*	337.6	88.8	466	89.6	291	50
POP	*Sebastes alutus*	15.8	4.1	22	4.2	22	10
sablefish	*Anoplopoma fimbria*	15.6	4.1	12	2.3	12	12
rex sole	*Glyptocephalus zachirus*	3.9	1.0	12	2.3	12	12
Pacific cod	*Gadus macrocephalus*	3.1	0.8	1	0.2	1	1
Pacific halibut	*Hippoglossus stenolepis*	2.0	0.5	1	0.2	0	0
shortspine thornyhead	*Sebastolobus alascanus*	1.3	0.3	3	0.6	3	3
Dover sole	*Microstomus pacificus*	0.4	0.1	1	0.2	1	1
flathead sole	*Hippoglossoides elassodon*	0.3	<0.1	1	0.2	1	1
jellyfishes	Scyphozoa (class)	<0.1	<0.1	1	0.2	0	0
Total		380.2		520		343	90

Table A4.3. -- Catch by species and numbers of length and weight measurements taken from 2 Methot hauls during the summer 2023 acoustic-trawl survey of the Gulf of Alaska for the GOA Shelf region.

		Catch				Measurements	
Species name	Scientific name	Weight (kg)	%	Number	%	Length	Weight
lions mane	*Cyanea capillata*	9.7	51.4	29	<0.1	13	13
Aequorea sp.	*Aequorea* sp.	3.9	20.4	255	0.4	11	11
euphausiids	Euphausiacea (order)	2.8	14.7	61,414	99.2	0	0
whitecross jelly	*Staurostoma mertensii*	1.8	9.4	18	<0.1	8	0
northern sea nettle	*Chrysaora melanaster*	0.4	2.3	11	<0.1	11	11
Hydromedusas	Hydromedusa (unid.)	0.1	0.6	12	<0.1	12	12
fish larvae	Actinopterygii (class)	<0.1	0.3	50	<0.1	1	0
flatfish larvae	*Pleuronectiform* larvae	<0.1	0.3	50	<0.1	1	0
jellyfishes	Scyphozoa (class)	<0.1	0.3	0	<0.1	0	0
Invert. unident. 1	Invert. unident. 1	<0.1	0.2	38	<0.1	0	0
squids	Cephalopoda (class)	<0.1	0.2	38	<0.1	0	0
Ptychogena sp.	Ptychogena (genus)	<0.1	<0.1	1	<0.1	1	0
isopods	Isopoda (order)	<0.1	<0.1	1	<0.1	0	0
pollock age-0	*Gadus chalcogrammus*	<0.1	<0.1	1	<0.1	1	0
Total		18.9		61,918		59	47

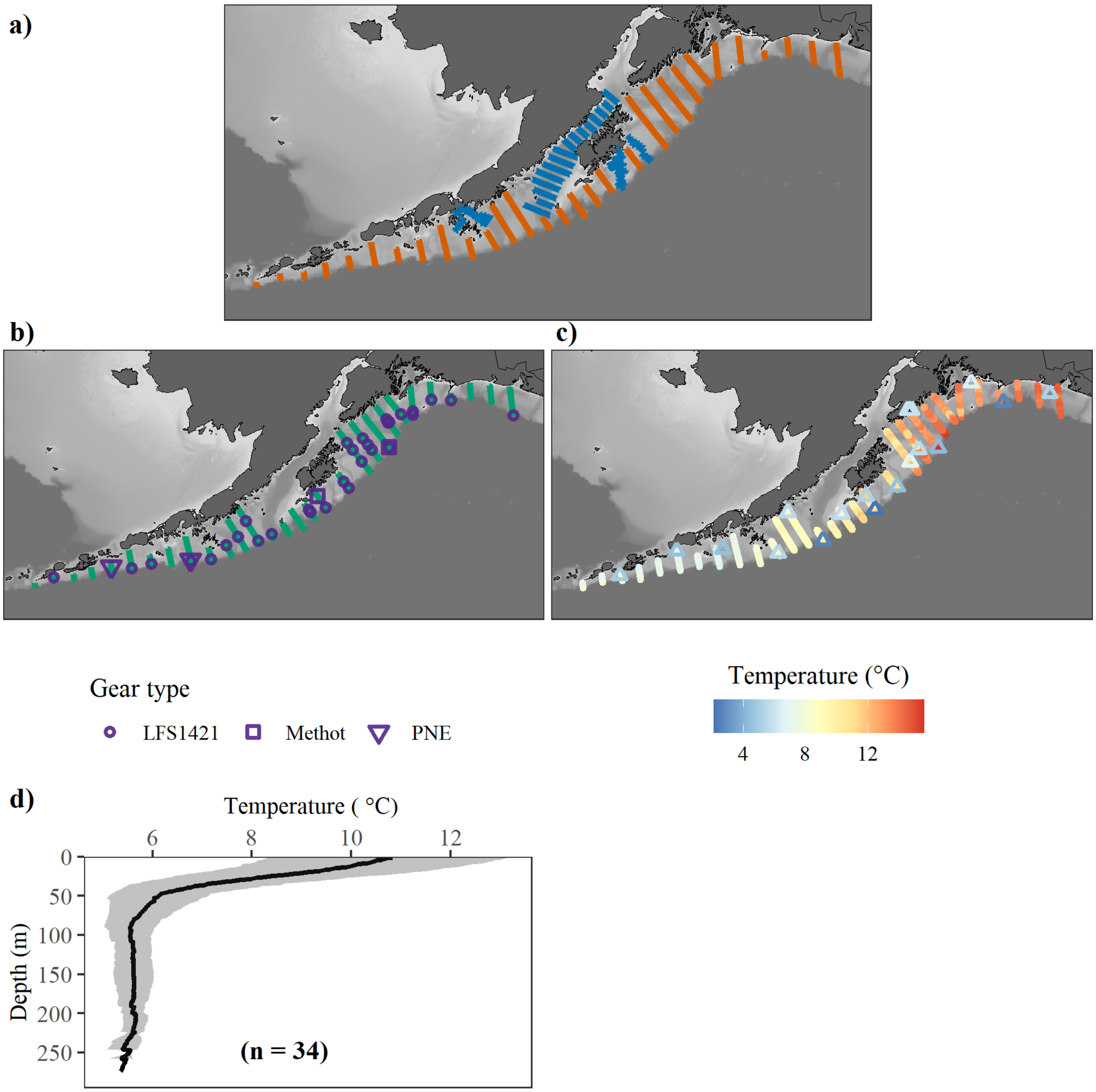


Figure A4.1. -- GOA Shelf sampling summary for the summer 2023 acoustic-trawl survey of the Gulf of Alaska. a) Region location (orange lines indicate the GOA Shelf transect locations and blue lines are transect locations outside of the GOA Shelf for survey-wide context), b) transect lines (green) and locations of trawl hauls (purple), c) surface water temperatures (°C) recorded at 5-second intervals from the ship's flow-through seawater system and bottom water temperatures (triangles) recorded during CTD deployments, and d) mean temperature (°C) at depth (m) from SBE 39 probes on the gear at sampling locations; the shaded area represents ± 1 standard deviation from the average temperature.

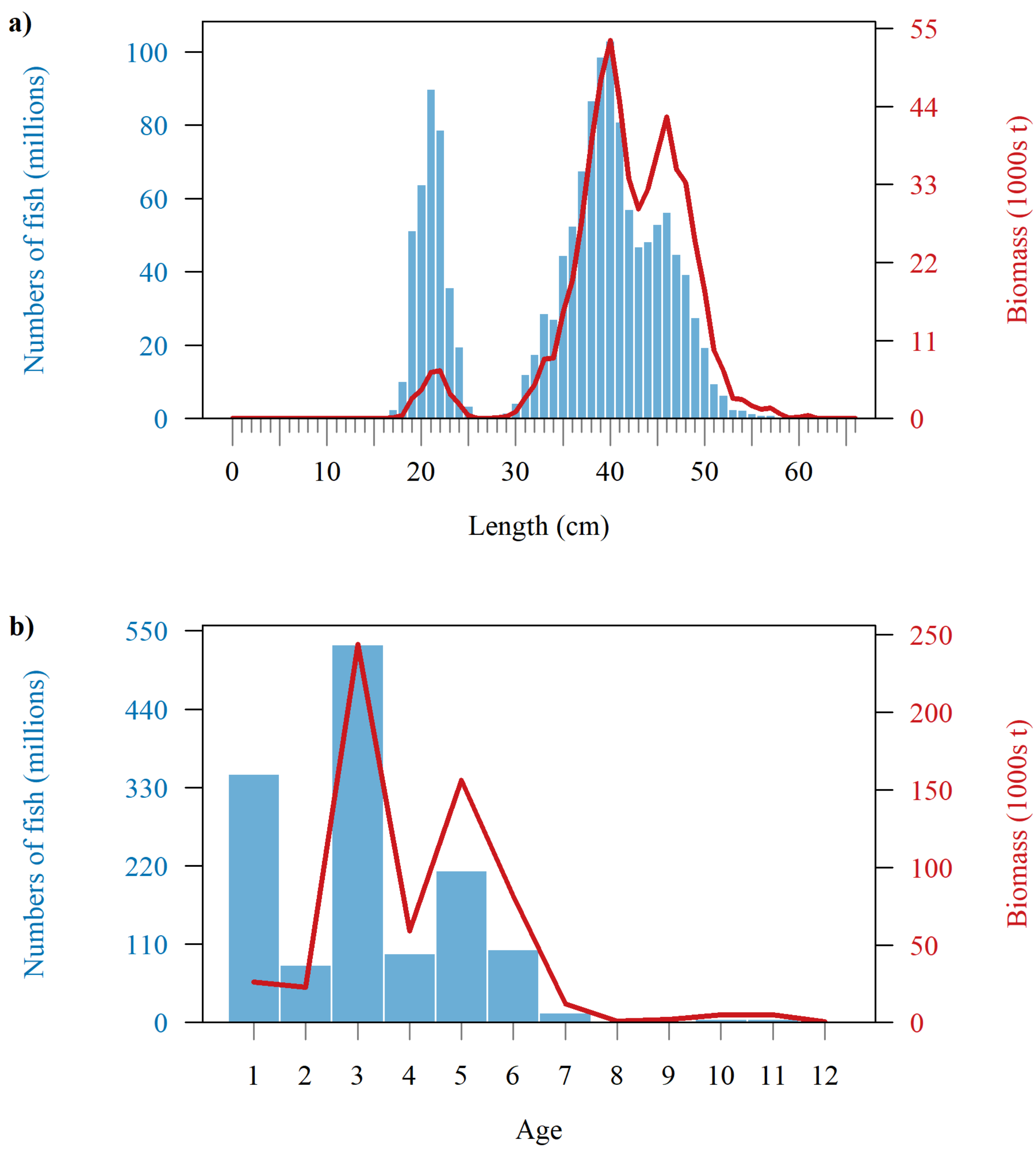


Figure A4.2. -- GOA Shelf region a) pollock numbers- (blue bars) and biomass- (red line) at-length and b) pollock numbers- and biomass-at-age for the summer 2023 acoustic-trawl survey of the Gulf of Alaska.

Shumagin Islands

The Shumagin Islands region (Fig. 2; Fig. A4.3a) was surveyed between 18 June and 21 June. The survey region encompassed 2,734 km^2 (797 nmi^2). Acoustic backscatter was measured along 352 km (190 nmi) of trackline on 25 transects spaced mainly 5.6 km (3.0 nmi) apart and ranging from 5.6 km (3.0 nmi) to 11.1 km (6.0 nmi) apart (Fig. 2; Fig. A4.3b). Bottom depths in the Shumagin Islands region ranged from 55 to 226 m and averaged 140 m.

Surface water temperatures in the Shumagin Islands region measured by the ship's flow-thru seawater system ranged from 5.9 to 8.6°C, and averaged 7.3°C (Fig. 25a, Fig. A4.3c). Average surface temperature in summer 2023 were 0.5°C cooler than during the last Shumagin Islands summer survey (2021; 7.8°C), and cooler than the average surface water temperature observed in previous summer surveys from 2013-2021 (7.8-10.5 °C). Temperatures at 100 m depth at fishing locations from SBE 39 probes on the fishing gear ranged from 4.3 to 4.4°C and averaged 4.4°C (n = 5 trawls; Fig. A4.3d). This was 0.3°C cooler than in summer 2021 (4.7°C), and within the range of average water temperatures at 100 m depth observed in previous summer surveys from 2013-2021 (4.3-6.0°C). Bottom temperatures from 3 CTD deployments averaged 4.2°C at an average sampling depth of 142 m, 0.5°C cooler than in summer 2021 (4.7°C; Fig. 25b, Fig. A4.3c), within the range of bottom water temperatures observed in this region from 2013-2021 (4.0-6.0°C).

Biological data and specimens were collected along the Shumagin Islands from 6 LFS1421 hauls (Figs. 2 and A4.3b; Table A4.4). Pollock and squids were the most abundant species by weight in LFS1421 trawls, contributing 93.8 and 3.3% of the catch by weight, respectively (Table A4.4). Pollock and euphausiids were the most abundant species by number, contributing 49.1 and 25.2% of the catch by number, respectively (Table A4.4).

Age-1+ pollock observed on the Shumagin Islands ranged in length from 14 to 64 cm FL with modes at 16 and 37 cm FL (Fig. A4.4a, Table 11). Pollock ranged from age-1 to age-12, with age-1 fish comprising the vast majority by number (77.7%) and age-3 fish comprising the majority of the biomass (53.4%; Fig. A4.4b, Table 12). The mean weighted depth of pollock in the Shumagin Islands region was approximately 125 m from the surface and 35 m above the bottom.

The estimated abundance of age-1+ pollock for the Shumagin Islands was 96.2 million fish weighing 11.0 thousand tons, approximately 1.5% of the total pollock biomass observed in this survey and 200.8% of the summer 2021 Shumagin Islands biomass estimate (Table 8). The relative estimation error of the biomass resulting from the 1-D geostatistical analysis was 12.2% (Table 8).

Table A4.4. -- Catch by species and numbers of length and weight measurements taken from 6 LFS1421 hauls during the summer 2023 acoustic-trawl survey of the Gulf of Alaska for the Shumagin Islands region.

		Catch				Measurements	
Species name	Scientific name	Weight (kg)	%	Number	%	Length	Weight
pollock	*Gadus chalcogrammus*	2,061.0	93.8	19,342	49.1	1,873	391
squids	Cephalopoda (class)	71.9	3.3	6,778	17.2	156	36
eulachon	*Thaleichthys pacificus*	48.9	2.2	2,974	7.5	167	74
jellyfishes	Scyphozoa (class)	4.1	0.2	10	<0.1	0	0
pink salmon	*Oncorhynchus gorbuscha*	2.7	0.1	3	<0.1	3	3
chum salmon	*Oncorhynchus keta*	2.3	0.1	1	<0.1	1	1
Chinook salmon	*Oncorhynchus tshawytscha*	1.9	<0.1	1	<0.1	1	1
Pacific capelin	*Mallotus catervarius*	1.6	<0.1	271	0.7	73	47
euphausiids	Euphausiacea (order)	1.4	<0.1	9,934	25.2	0	0
POP	*Sebastes alutus*	1.4	<0.1	2	<0.1	2	2
arrowtooth flounder	*Atheresthes stomias*	0.6	<0.1	1	<0.1	1	0
magistrate armhook squid	*Berryteuthis magister*	0.2	<0.1	7	<0.1	7	7
lions mane	*Cyanea capillata*	<0.1	<0.1	4	<0.1	3	1
isopods	Isopoda (order)	<0.1	<0.1	35	<0.1	0	0
sand lance spp.	Ammodytes (genus)	<0.1	<0.1	1	<0.1	1	1
fish larvae	Actinopterygii (class)	<0.1	<0.1	45	0.1	9	4
Alaskan pink shrimp	*Pandalus eous*	<0.1	<0.1	2	<0.1	2	0
Total		2,198.1		39,411		2,299	568

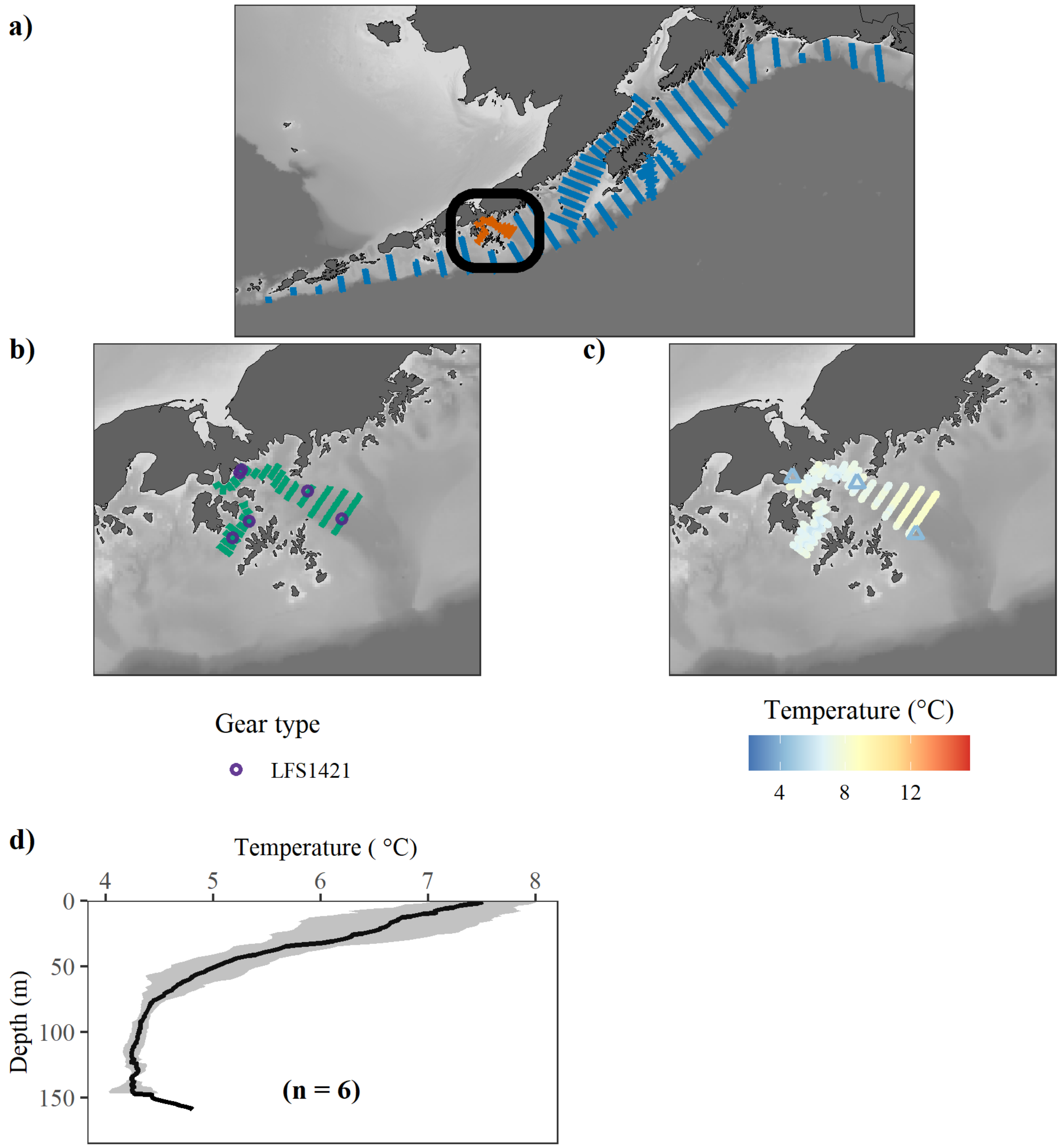


Figure A4.3. -- Shumagin Islands sampling summary for the summer 2023 acoustic-trawl survey of the Gulf of Alaska. a) Region location (orange lines indicate the Shumagin Islands transect locations and blue lines are transect locations outside of the Shumagin Islands for survey-wide context), b) transect lines (green) and locations of trawl hauls (purple), c) surface water temperatures (°C) recorded at 5-second intervals from the ship's flow-through seawater system and bottom water temperatures (triangles) recorded during CTD deployments, and d) mean temperature (°C) at depth (m) from SBE 39 probes on the gear at sampling locations; the shaded area represents ± 1 standard deviation from the average temperature.

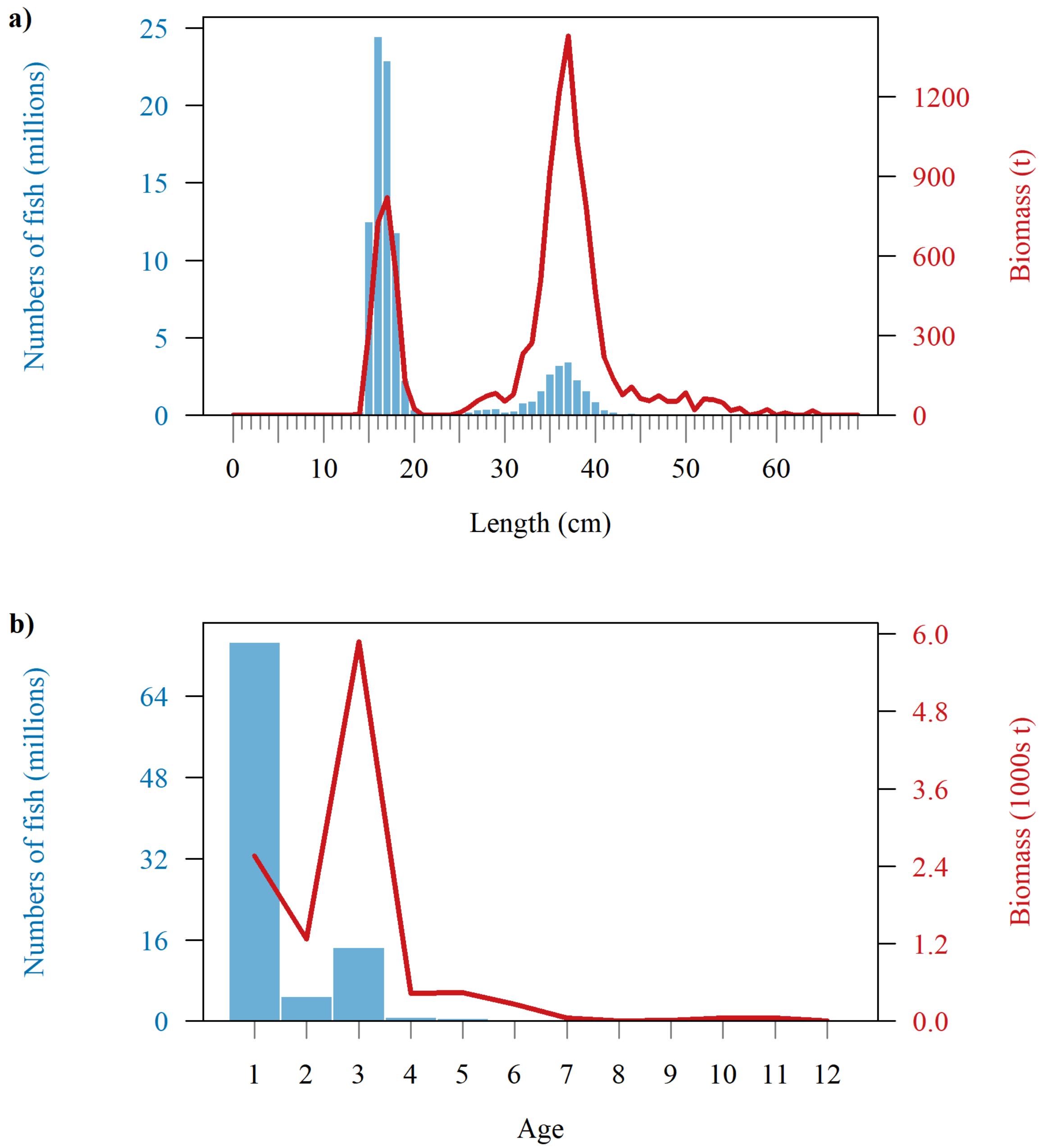


Figure A4.4. -- Shumagin Islands region a) pollock numbers- (blue bars) and biomass- (red line) at-length and b) pollock numbers- and biomass-at-age for the summer 2023 acoustic-trawl survey of the Gulf of Alaska.

Shelikof Strait

The Shelikof Strait region (Fig. 2; Fig. A4.5a) was surveyed between 2 July and 8 July. The survey region encompassed 27,825 km^2 (8,112 nmi^2). Acoustic backscatter was measured along 985 km (532 nmi) of trackline on 16 transects spaced 27.8 km (15.0 nmi) apart (Fig. 2; Fig. A4.5b). Bottom depths in Shelikof Strait ranged from 43 to 332 m and averaged 190 m.

Surface water temperatures in Shelikof Strait measured by the ship's flow-thru seawater system ranged from 6.9 to 9.8°C, and averaged 8.6°C (Fig. 25a, Fig. A4.5c). Average surface temperature in summer 2023 were 0.1°C warmer than during the last Shelikof Strait summer survey (2021; 8.5°C), and within the range of surface water temperatures observed in previous summer surveys from 2013-2021 (8.5-11.9 °C). Temperatures at 100 m depth at fishing locations from SBE 39 probes on the fishing gear ranged from 5.2 to 6.2°C and averaged 5.6°C (n = 8 trawls; Fig. A4.5d). This was 0.2°C cooler than in summer 2021 (5.9°C), and within the range of average water temperatures at 100 m depth observed in previous summer surveys from 2013-2021 (4.7-6.4°C). Bottom temperatures from 8 CTD deployments averaged 6.2°C at an average sampling depth of 160 m, 0.7°C warmer than in summer 2021 (5.5°C; Fig. 25b, Fig. A4.5c), within the range of bottom water temperatures observed in this region from 2013-2021 (4.7-6.4°C).

Biological data and specimens were collected in Shelikof Strait from 12 LFS1421 hauls (Figs. 2 and A4.5b; Table A4.5). Pollock and magistrate armhook squid were the most abundant species by weight in LFS1421 trawls, contributing 50.0 and 17.2% of the catch by weight, respectively (Table A4.5). Eulachon and euphausiids were the most abundant species by number, contributing 34.6 and 29.8% of the catch by number, respectively (Table A4.5).

Age-1+ pollock observed in Shelikof Strait ranged in length from 34 to 65 cm FL with a mode at 47 cm FL (Fig. A4.6a, Table 11). Pollock ranged from age-2 to age-12, with age-5 fish comprising the vast majority by number (40.6%) and age-5 fish comprising the majority of the biomass (39.8%; Fig. A4.6b, Table 12). The mean weighted depth of pollock in Shelikof Strait was approximately 106 m from the surface and 52 m above the bottom.

The estimated abundance of age-1+ pollock in Shelikof Strait was 78.2 million fish weighing 65.4 thousand tons, approximately 8.9% of the total pollock biomass observed in this survey and

54.6% of the summer 2021 Shelikof Strait biomass estimate (Table 8). The relative estimation error for biomass resulting from the 1-D geostatistical analysis was 14.1% (Table 8).

Table A4.5. -- Catch by species and numbers of length and weight measurements taken from 12 LFS1421 hauls during the summer 2023 acoustic-trawl survey of the Gulf of Alaska for the Shelikof Strait region.

		Catch				Measurements	
Species name	Scientific name	Weight (kg)	%	Number	%	Length	Weight
pollock	*Gadus chalcogrammus*	4,810.7	50.0	5,696	3.2	1,758	399
magistrate armhook squid	*Berryteuthis magister*	1,656.7	17.2	2,312	1.3	130	41
eulachon	*Thaleichthys pacificus*	1,510.5	15.7	61,896	34.6	150	40
POP	*Sebastes alutus*	1,250.4	13.0	1,589	0.9	289	81
squids	Cephalopoda (class)	172.7	1.8	10,929	6.1	125	36
Pacific capelin	*Mallotus catervarius*	37.9	0.4	33,152	18.6	113	4
Pacific herring	*Clupea pallasii*	28.7	0.3	256	0.1	38	12
pink salmon	*Oncorhynchus gorbuscha*	26.8	0.3	24	<0.1	24	24
northern sea nettle	*Chrysaora melanaster*	25.1	0.3	95	<0.1	54	34
chum salmon	*Oncorhynchus keta*	25.0	0.3	16	<0.1	16	16
Chinook salmon	*Oncorhynchus tshawytscha*	18.3	0.2	17	<0.1	17	17
lions mane	*Cyanea capillata*	16.1	0.2	125	<0.1	98	69
euphausiids	Euphausiacea (order)	15.7	0.2	53,211	29.8	0	0
jellyfishes	Scyphozoa (class)	6.5	<0.1	214	0.1	23	23
arrowtooth flounder	*Atheresthes stomias*	4.6	<0.1	3	<0.1	1	1
northern smoothtongue	*Leuroglossus schmidti*	4.6	<0.1	354	0.2	6	6
unsorted catch and debris		4.4	<0.1	0	<0.1	0	0
Aequorea sp.	*Aequorea sp.*	3.9	<0.1	0	<0.1	0	0
pollock age-0	*Gadus chalcogrammus*	3.0	<0.1	7,792	4.4	232	0
Hydromedusas	Hydromedusa (unid.)	2.8	<0.1	474	0.3	30	23
Aurelia sp.	*Aurelia* sp.	1.0	<0.1	42	<0.1	9	2
egg yolk jelly	*Phacellophora camtschatica*	0.6	<0.1	3	<0.1	2	2
salmon spp.	Oncorhynchus (genus)	0.3	<0.1	2	<0.1	2	2
lanternfishes	Myctophidae (family)	0.3	<0.1	129	<0.1	6	3
Alaskan pink shrimp	*Pandalus eous*	0.2	<0.1	112	<0.1	6	0
isopods	Isopoda (order)	<0.1	<0.1	139	<0.1	0	0
flatfish larvae	*Pleuronectiform* larvae	<0.1	<0.1	18	<0.1	1	1
fish larvae	Actinopterygii (class)	<0.1	<0.1	32	<0.1	5	3
prowfish	*Zaprora silenus*	<0.1	<0.1	5	<0.1	5	5
sculpins	Cottidae (family)	<0.1	<0.1	3	<0.1	3	3
Total		9,626.9		178,640		3,143	847

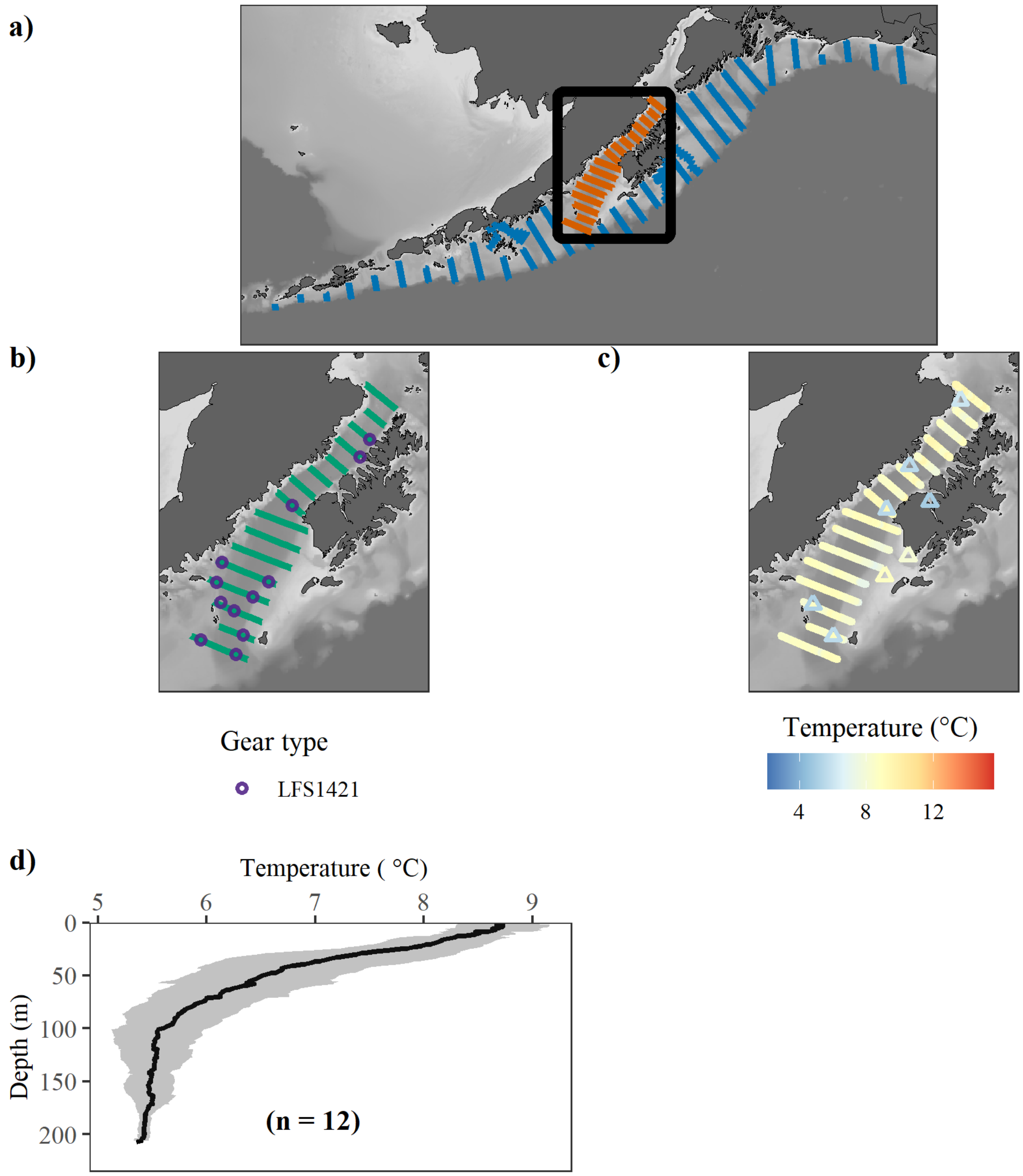


Figure A4.5. -- Shelikof Strait sampling summary for the summer 2023 acoustic-trawl survey of the Gulf of Alaska. a) Region location (orange lines indicate the Shelikof Strait transect locations and blue lines are transect locations outside of the Shelikof Strait for survey-wide context), b) transect lines (green) and locations of trawl hauls (purple), c) surface water temperatures (°C) recorded at 5-second intervals from the ship's flow-through seawater system and bottom water temperatures (triangles) recorded during CTD deployments, and d) mean temperature (°C) at depth (m) from SBE 39 probes on the gear at sampling locations; the shaded area represents ± 1 standard deviation from the average temperature.

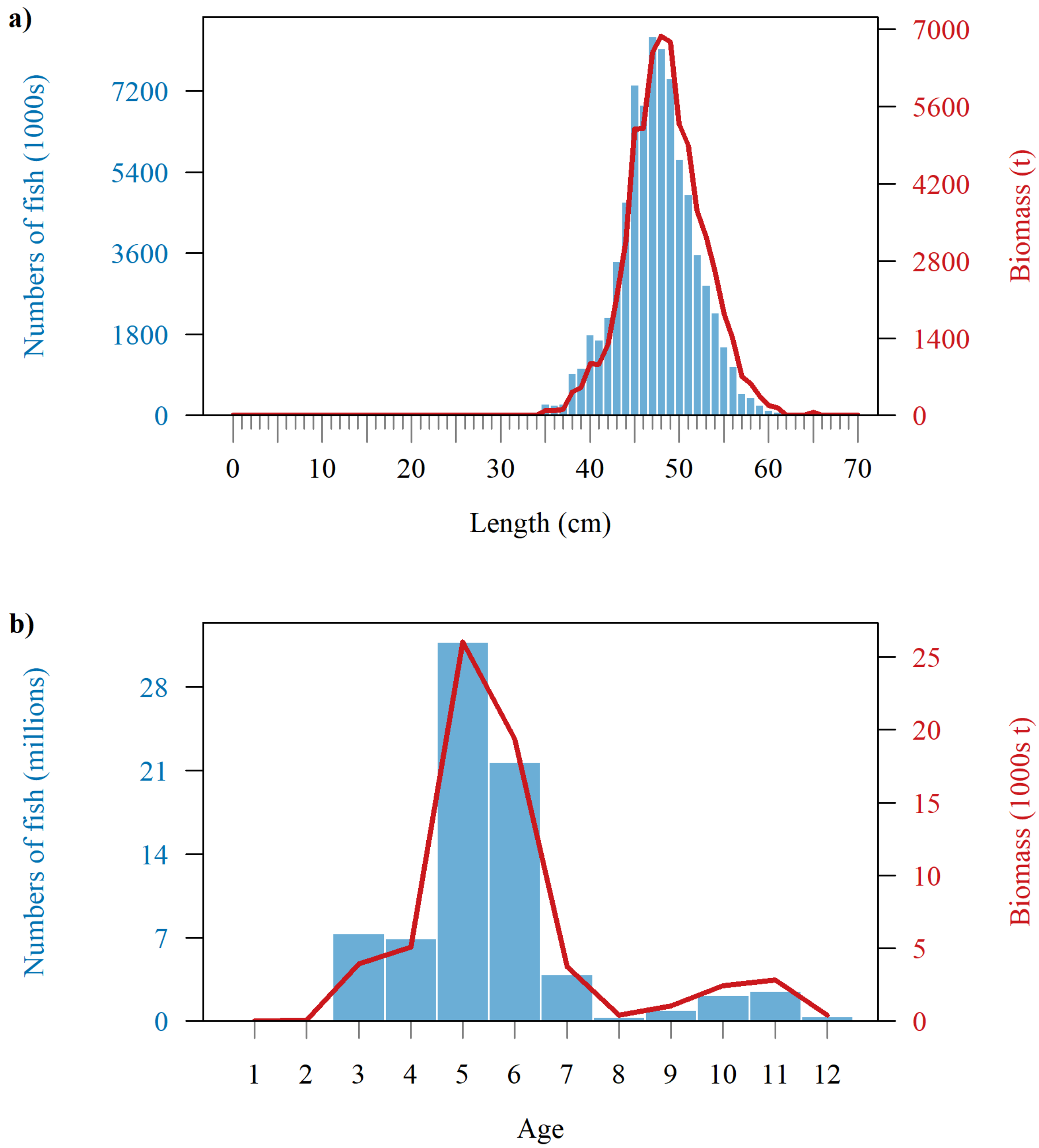


Figure A4.6. -- Shelikof Strait region a) pollock numbers- (blue bars) and biomass- (red line) at-length and b) pollock numbers- and biomass-at-age for the summer 2023 acoustic-trawl survey of the Gulf of Alaska.

Barnabas Trough

The Barnabas Trough region (Fig. 2; Fig. A4.7a) was surveyed between 15 July and 18 July. The survey region encompassed 3,468 km^2 (1,011 nmi^2). Acoustic backscatter was measured along 305 km (165 nmi) of trackline on 12 transects spaced 11.1 km (6.0 nmi) apart (Fig. 2; Fig. A4.7b). Bottom depths in the Barnabas Trough region ranged from 41 to 1,039 m and averaged 167 m.

Surface water temperatures in the Barnabas Trough region measured by the ship's flow-thru seawater system ranged from 8.0 to 11.9°C, and averaged 11.0°C (Fig. 25a, Fig. A4.7c). Average surface temperature in summer 2023 were 1.9°C warmer than during the last Barnabas Trough summer survey (2021; 9.2°C), and within the range of surface water temperatures observed in previous summer surveys from 2013-2021 (9.2-13.1 °C). Temperatures at 100 m depth at fishing locations from SBE 39 probes on the fishing gear ranged from 5.7 to 6.0°C and averaged 5.8°C (n = 7 trawls; Fig. A4.7d). This was 0.3°C warmer than in summer 2021 (5.5°C), and within the range of average water temperatures at 100 m depth observed in previous summer surveys from 2013-2021 (5.4-6.7°C). Bottom temperatures from 3 CTD deployments averaged 5.6°C at an average sampling depth of 153 m, 0.3°C warmer than in summer 2021 (5.3°C; Fig. 25b, Fig. A4.7c), within the range of bottom water temperatures observed in this region from 2013-2021 (5.3-6.8°C).

Biological data and specimens were collected along the Barnabas Trough from 10 LFS1421 and 1 Methot hauls (Figs. 2 and A4.7b; Table A4.6, Table A4.7). Pollock and capelin were the most abundant species by weight in LFS1421 trawls, contributing 81.9 and 6.1% of the catch by weight, respectively (Table A4.6). Capelin and pollock were the most abundant species by number, contributing 65.5 and 29.8% of the catch by number, respectively (Table A4.6). Euphausiids and *Aequorea* sp. were the most abundant species by weight in Methot trawls, contributing 42.2 and 17.3% of the catch by weight, respectively (Table A4.7). Euphausiids and copepods were the most abundant species by number, contributing 99.3 and 0.3% of the catch by number, respectively (Table A4.7).

Age-1+ pollock observed on the Barnabas Trough ranged in length from 16 to 65 cm FL with modes at 20, 21, 40, and 57 cm FL (Fig. A4.8a, Table 11). Pollock ranged from age-1 to age-12, with age-1 fish comprising the vast majority by number (80.6%) and age-1 fish comprising the majority of the biomass (33.3%; Fig. A4.8b, Table 12). The mean weighted depth of pollock in the Barnabas Trough region was approximately 112 m from the surface and 59 m above the bottom.

The estimated abundance of age-1+ pollock for the Barnabas Trough was 155.0 million fish weighing 25.8 thousand tons, approximately 3.5% of the total pollock biomass observed in this survey and 71.6% of the summer 2021 Barnabas Trough biomass estimate (Table 8). The relative estimation error of the biomass resulting from the 1-D geostatistical analysis was 25.7% (Table 8).

Table A4.6. -- Catch by species and numbers of length and weight measurements taken from 10 LFS1421 hauls during the summer 2023 acoustic-trawl survey of the Gulf of Alaska for the Barnabas Trough region.

		Catch				Measurements	
Species name	Scientific name	Weight (kg)	%	Number	%	Length	Weight
pollock	*Gadus chalcogrammus*	3,499.6	81.9	17,096	29.8	2,175	479
Pacific capelin	*Mallotus catervarius*	260.7	6.1	37,552	65.5	201	35
northern sea nettle	*Chrysaora melanaster*	143.0	3.3	425	0.7	160	97
POP	*Sebastes alutus*	120.6	2.8	183	0.3	158	74
Pacific herring	*Clupea pallasii*	89.0	2.1	516	0.9	170	34
lions mane	*Cyanea capillata*	65.5	1.5	261	0.5	201	79
pink salmon	*Oncorhynchus gorbuscha*	21.9	0.5	20	<0.1	20	20
chum salmon	*Oncorhynchus keta*	17.7	0.4	11	<0.1	11	11
jellyfishes	Scyphozoa (class)	14.5	0.3	315	0.5	123	56
unsorted catch and debris		12.1	0.3	0	<0.1	0	0
Aequorea sp.	*Aequorea* sp.	8.4	0.2	23	<0.1	9	9
whitecross jelly	*Staurostoma mertensii*	5.1	0.1	0	<0.1	0	0
egg yolk jelly	*Phacellophora camtschatica*	3.3	<0.1	7	<0.1	4	4
arrowtooth flounder	*Atheresthes stomias*	3.2	<0.1	2	<0.1	2	2
sockeye salmon	*Oncorhynchus nerka*	2.8	<0.1	1	<0.1	1	1
Chinook salmon	*Oncorhynchus tshawytscha*	1.9	<0.1	1	<0.1	1	1
Staurophora mertensi	*Staurophora mertensi*	0.8	<0.1	0	<0.1	0	0
magistrate armhook squid	*Berryteuthis magister*	0.6	<0.1	1	<0.1	1	1
pollock age-0	*Gadus chalcogrammus*	0.5	<0.1	569	1.0	228	0
Hydromedusas	Hydromedusa (unid.)	0.5	<0.1	104	0.2	65	9
salmon spp.	Oncorhynchus (genus)	0.4	<0.1	1	<0.1	1	1
prowfish	*Zaprora silenus*	0.3	<0.1	50	<0.1	50	16
sablefish	*Anoplopoma fimbria*	0.3	<0.1	1	<0.1	1	1
isopods	Isopoda (order)	0.1	<0.1	91	0.2	0	0
Pacific sandfish	*Trichodon trichodon*	<0.1	<0.1	2	<0.1	2	2
squids	Cephalopoda (class)	<0.1	<0.1	9	<0.1	9	5
Alaskan pink shrimp	*Pandalus eous*	<0.1	<0.1	18	<0.1	13	0
lanternfishes	Myctophidae (family)	<0.1	<0.1	29	<0.1	5	0
Periphylla sp.	*Periphylla* sp.	<0.1	<0.1	2	<0.1	2	0
Ptychogena sp.	Ptychogena (genus)	<0.1	<0.1	2	<0.1	2	0
sand lance spp.	Ammodytes (genus)	<0.1	<0.1	11	<0.1	11	11
Protomyctophum sp.	*Protomyctophum* sp.	<0.1	<0.1	1	<0.1	1	1
fish larvae	Actinopterygii (class)	<0.1	<0.1	3	<0.1	3	1
Total		4,272.9		57,307		3,630	950

Table A4.7. -- Catch by species and numbers of length and weight measurements taken from 1 Methot haul during the summer 2023 acoustic-trawl survey of the Gulf of Alaska for the Barnabas Trough region.

		Catch				Measurements	
Species name	Scientific name	Weight (kg)	%	Number	%	Length	Weight
euphausiids	Euphausiacea (order)	2.6	42.2	41,960	99.3	0	0
Aequorea sp.	*Aequorea* sp.	1.0	17.3	108	0.3	76	19
whitecross jelly	*Staurostoma mertensii*	0.8	13.7	15	<0.1	5	0
lions mane	*Cyanea capillata*	0.7	11.7	4	<0.1	4	4
jellyfishes	Scyphozoa (class)	0.6	9.9	9	<0.1	9	9
northern sea nettle	*Chrysaora melanaster*	0.2	2.6	1	<0.1	1	1
copepods	Maxillopoda (class)	<0.1	1.1	128	0.3	0	0
unsorted catch and debris		<0.1	1.0	0	<0.1	0	0
Hydromedusas	Hydromedusa (unid.)	<0.1	0.5	3	<0.1	3	3
Ptychogena sp.	Ptychogena (genus)	<0.1	<0.1	1	<0.1	1	0
squids	Cephalopoda (class)	<0.1	<0.1	2	<0.1	2	0
fish larvae	Actinopterygii (class)	<0.1	<0.1	4	<0.1	4	0
Total		6.1		42,235		105	36

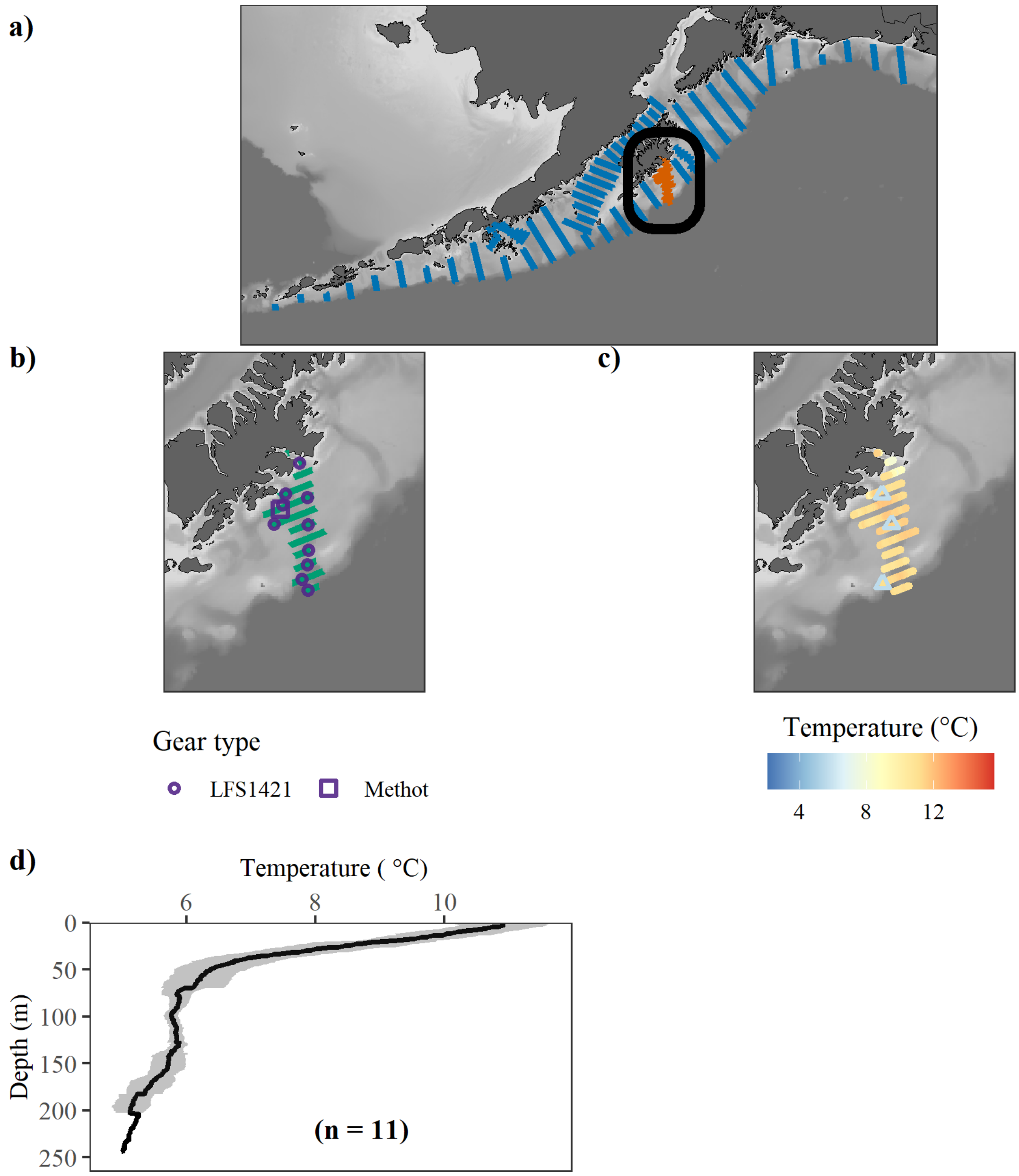


Figure A4.7. -- Barnabas Trough sampling summary for the summer 2023 acoustic-trawl survey of the Gulf of Alaska. a) Region location (orange lines indicate the Barnabas Trough transect locations and blue lines are transect locations outside of the Barnabas Trough for survey-wide context), b) transect lines (green) and locations of trawl hauls (purple), c) surface water temperatures (°C) recorded at 5-second intervals from the ship's flow-through seawater system and bottom water temperatures (triangles) recorded during CTD deployments, and d) mean temperature (°C) at depth (m) from SBE 39 probes on the gear at sampling locations; the shaded area represents ± 1 standard deviation from the average temperature.

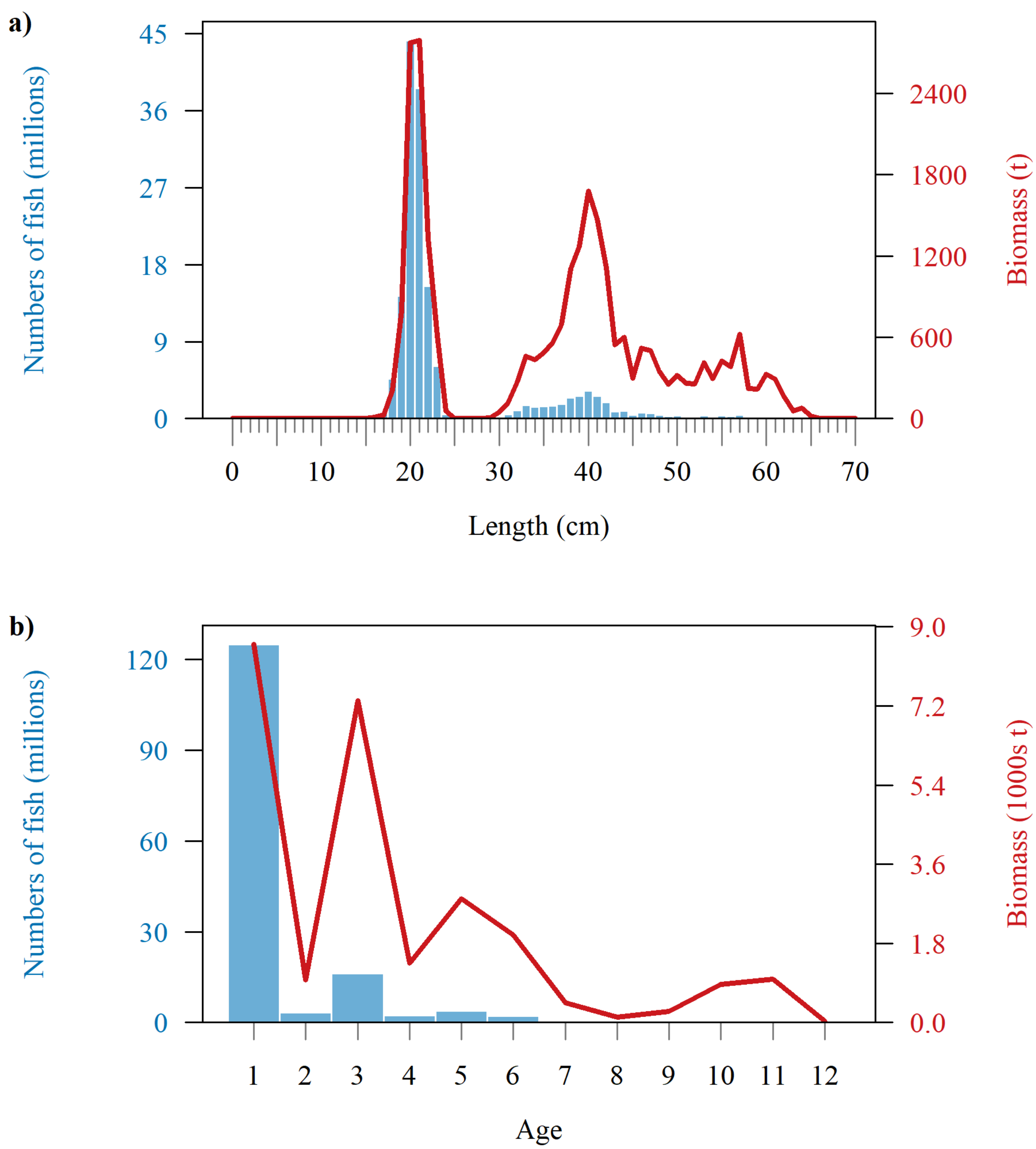


Figure A4.8. -- Barnabas Trough region a) pollock numbers- (blue bars) and biomass- (red line) at-length and b) pollock numbers- and biomass-at-age for the summer 2023 acoustic-trawl survey of the Gulf of Alaska.

Chiniak Trough

The Chiniak Trough region (Fig. 2; Fig. A4.9a) was surveyed between 19 July and 21 July. The survey region encompassed 1,832 km^2 (534 nmi^2). Acoustic backscatter was measured along 162 km (88 nmi) of trackline on 9 transects spaced 11.1 km (6.0 nmi) apart (Fig. 2; Fig. A4.9b). Bottom depths in the Chiniak Trough region ranged from 63 to 961 m and averaged 211 m.

Surface water temperatures in the Chiniak Trough region measured by the ship's flow-thru seawater system ranged from 8.4 to 12.4°C, and averaged 10.3°C (Fig. 25a, Fig. A4.9c). Average surface temperature in summer 2023 were 1.4°C warmer than during the last Chiniak Trough summer survey (2021; 8.9°C), and within the range of surface water temperatures observed in previous summer surveys from 2013-2021 (8.9-11.5 °C). Temperatures at 100 m depth at fishing locations from SBE 39 probes on the fishing gear ranged from 5.9 to 6.4°C and averaged 6.3°C (n = 3 trawls; Fig. A4.9d). This was 0.2°C warmer than in summer 2021 (6.0°C), and within the range of average water temperatures at 100 m depth observed in previous summer surveys from 2013-2021 (6.0-7.4°C). Bottom temperatures from 3 CTD deployments averaged 6.4°C at an average sampling depth of 151 m, 0.8°C warmer than in summer 2021 (5.6°C; Fig. 25b, Fig. A4.9c), within the range of bottom water temperatures observed in this region from 2013-2021 (5.6-7.2°C).

Biological data and specimens were collected along the Chiniak Trough from 4 LFS1421 hauls (Figs. 2 and A4.9b; Table A4.8). Pollock and POP were the most abundant species by weight in LFS1421 trawls, contributing 77.8 and 11.9% of the catch by weight, respectively (Table A4.8). Pollock and POP were the most abundant species by number, contributing 75.6 and 6.1% of the catch by number, respectively (Table A4.8).

Age-1+ pollock observed on the Chiniak Trough ranged in length from 16 to 67 cm FL with modes at 19, 21, 38, 47, and 67 cm FL (Fig. A4.10a, Table 11). Pollock ranged from age-1 to age-12, with age-3 fish comprising the vast majority by number (36.0%) and age-3 fish comprising the majority of the biomass (41.3%; Fig. A4.10b, Table 12). The mean weighted depth of pollock in the Chiniak Trough region was approximately 96 m from the surface and 68 m above the bottom.

The estimated abundance of age-1+ pollock for the Chiniak Trough was 42.3 million fish weighing 15.6 thousand tons, approximately 2.1% of the total pollock biomass observed in this survey and 157.8% of the summer 2021 Chiniak Trough biomass estimate (Table 8). The relative estimation error of the biomass resulting from the 1-D geostatistical analysis was 5.6% (Table 8).

Table A4.8. -- Catch by species and numbers of length and weight measurements taken from 4 LFS1421 hauls during the summer 2023 acoustic-trawl survey of the Gulf of Alaska for the Chiniak Trough region.

		Catch				Measurements	
Species name	Scientific name	Weight (kg)	%	Number	%	Length	Weight
pollock	*Gadus chalcogrammus*	989.1	77.8	2,692	75.6	1,224	212
POP	*Sebastes alutus*	151.9	11.9	217	6.1	46	21
chum salmon	*Oncorhynchus keta*	40.2	3.2	19	0.5	19	19
lions mane	*Cyanea capillata*	32.7	2.6	200	5.6	106	40
Pacific herring	*Clupea pallasii*	21.8	1.7	100	2.8	52	24
northern sea nettle	*Chrysaora melanaster*	17.9	1.4	72	2.0	19	19
jellyfishes	Scyphozoa (class)	13.2	1.0	54	1.5	7	7
pink salmon	*Oncorhynchus gorbuscha*	3.1	0.2	3	<0.1	3	3
euphausiids	Euphausiacea (order)	0.8	<0.1	0	<0.1	0	0
salmon spp.	Oncorhynchus (genus)	0.4	<0.1	1	<0.1	1	1
Hydromedusas	Hydromedusa (unid.)	0.3	<0.1	45	1.3	45	28
Pacific capelin	*Mallotus catervarius*	0.1	<0.1	10	0.3	10	10
pollock age-0	*Gadus chalcogrammus*	<0.1	<0.1	129	3.6	85	0
eulachon	*Thaleichthys pacificus*	<0.1	<0.1	1	<0.1	1	1
squids	Cephalopoda (class)	<0.1	<0.1	7	0.2	7	1
prowfish	*Zaprora silenus*	<0.1	<0.1	4	0.1	4	3
lanternfishes	Myctophidae (family)	<0.1	<0.1	0	<0.1	0	0
fish larvae	Actinopterygii (class)	<0.1	<0.1	5	0.1	5	0
isopods	Isopoda (order)	<0.1	<0.1	1	<0.1	0	0
Total		1,271.9		3,560		1,634	389

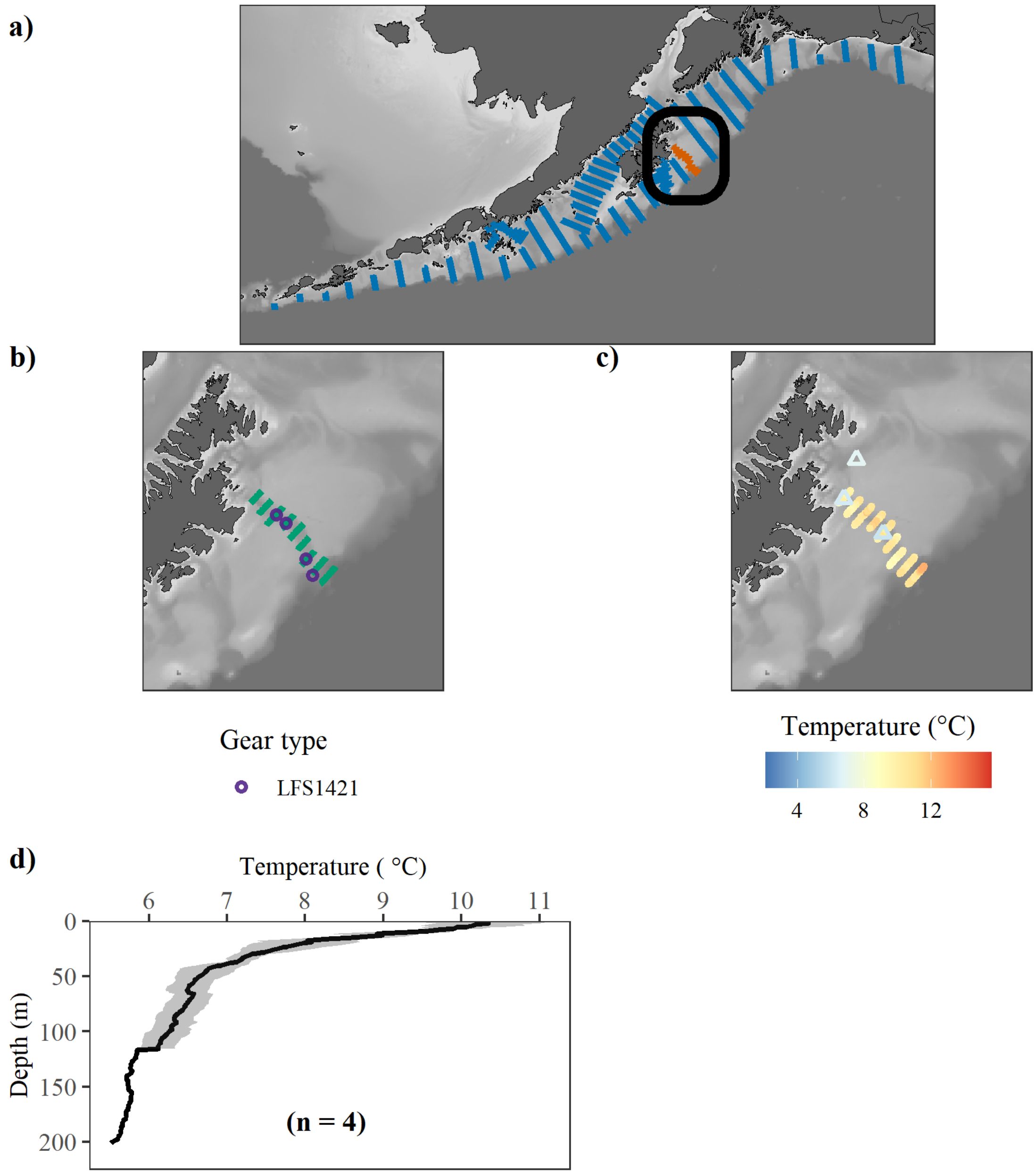
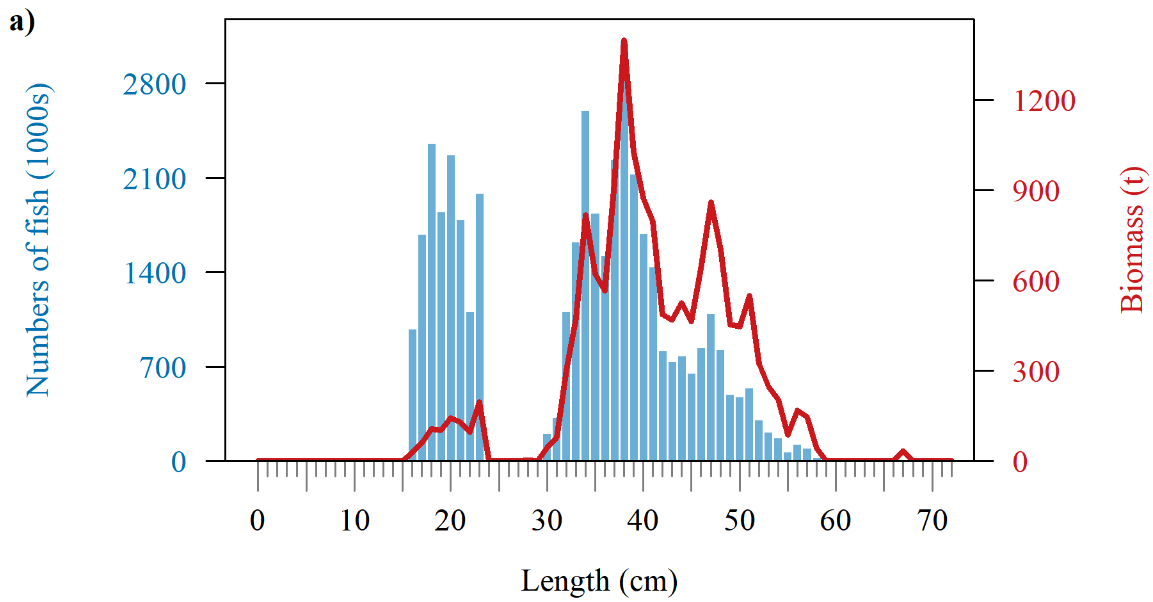


Figure A4.9. -- Chiniak Trough sampling summary for the summer 2023 acoustic-trawl survey of the Gulf of Alaska. a) Region location (orange lines indicate the Chiniak Trough transect locations and blue lines are transect locations outside of the Chiniak Trough for survey-wide context), b) transect lines (green) and locations of trawl hauls (purple), c) surface water temperatures (°C) recorded at 5-second intervals from the ship's flow-through seawater system and bottom water temperatures (triangles) recorded during CTD deployments, and d) mean temperature (°C) at depth (m) from SBE 39 probes on the gear at sampling locations; the shaded area represents ± 1 standard deviation from the average temperature.



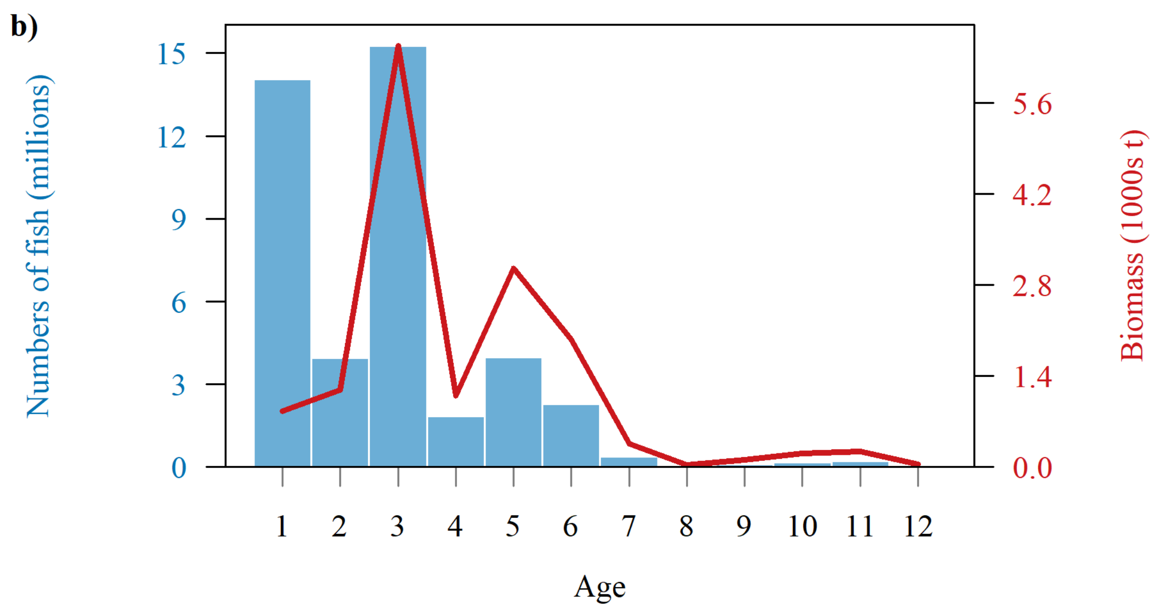


Figure A4.10. -- Chiniak Trough region a) pollock numbers- (blue bars) and biomass- (red line) at-length and b) pollock numbers- and biomass-at-age for the summer 2023 acoustic-trawl survey of the Gulf of Alaska.

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