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Results of the Echo Integration-Trawl Survey of Walleye Pollock (*Theragra chalcogramma*) on the U.S. and Russian Bering Sea Shelf in June and July 2008

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ABSTRACT

Eastern Bering Sea shelf walleye pollock (*Theragra chalcogramma*) abundance and distribution in midwater were assessed between 2 June and 31 July 2008 using echo integration-trawl techniques aboard the NOAA ship *Oscar Dyson*. The survey also assessed walleye pollock in the Cape Navarin area of Russia. Results showed that ocean conditions were cold in 2008, as in 2006 and 2007, compared to the previous 5 years. Fewer pollock were observed east of 170°W than in 2007 and a larger percentage of those observed were inside the Steller sea lion Conservation Area (SCA). The majority of the pollock biomass in the U.S. Exclusive Economic Zone (EEZ) was located to the west and southwest of St. Matthew Island between the 100 m and 200 m isobaths. Estimated pollock abundance in midwater (between 16 m from the surface and 3 m off bottom) in the U.S. EEZ portion of the Bering Sea shelf was 4.70 billion fish weighing 0.997 million metric tons (t); in the Russian EEZ, there were 58.6 million fish weighing 0.03 million t (3% of the total midwater biomass). East of 170°W (11% of total biomass) the predominant length mode was 55 cm inside the SCA and 51 cm outside the SCA. In the U.S. west of 170°W (86% of total biomass) modal lengths were 23, 32 and 47 cm. In Russia, modal lengths were similar to those in the U.S. west of 170°W with proportionally more adults and fewer juveniles. Age results indicated that inside the U.S. EEZ, age-2 and -3 fish were dominant numerically (62% and 22%, respectively) and together represented 46% of the total biomass. Walleye pollock ages 4+ totaled 16% of the population numerically and made up 53% of the total biomass. Age-1 pollock accounted for only 1% of the total estimated numbers and less than 0.1% of the biomass. Analyses of walleye pollock vertical distribution indicated that 93% of adult biomass was within 40 m of the seafloor. Juveniles were found both near the seafloor and higher in the water column; 21% of juvenile biomass was within 60 m of the surface.

CONTENTS

INTRODUCTION

Since 1979, scientists from the Midwater Assessment and Conservation Engineering (MACE) Program of the Alaska Fisheries Science Center (AFSC) have conducted summer surveys to estimate the abundance and distribution of walleye pollock (*Theragra chalcogramma*) along the eastern Bering Sea (EBS) shelf. Surveys have been conducted either annually or biennially since 1994. The 2008 echo integration-trawl (EIT) survey was carried out between 2 June and 31 July on the U.S. and Russian Bering Sea shelf aboard the NOAA ship *Oscar Dyson*. The survey's primary objective was to collect echo integration and trawl information to estimate midwater walleye pollock abundance and distribution. Additional survey sampling included conductivity-temperature-depth (CTD) and expendable bathythermograph (XBT) casts to characterize the Bering Sea shelf environment, and supplemental trawls to improve species identification using multiple frequency techniques. Macrozooplankton and micronekton layers (principally euphausiids) were sampled and target-strength measurements were made as part of the multi-disciplinary Bering Sea Integrated Ecosystem Research Program (BSIERP) study. A number of new, specialized sampling devices were tested, including light level sensors, Simrad ME70 multibeam sonar, and a lowered echosounding system. Seabird and marine mammal species abundances were recorded. After the stock assessment portion of the 2008 survey was completed, a paired codend experiment was conducted to examine effects of codend liner mesh size on catch composition, and a vessel comparison survey was completed with the NOAA ship *Miller Freeman*.

This report summarizes 2008 walleye pollock distribution and abundance estimates by size and age, as well as acoustic system calibration and physical oceanographic results. Walleye pollock vertical distribution, near-bottom pollock biomass trends, and spatial distribution patterns of backscatter at 38 kHz for pollock and non-pollock are shown. The results of the codend liner mesh size comparison are reported. Results from other secondary projects will be presented elsewhere.

METHODS

MACE scientists conducted the EIT survey (cruise DY2008-09) aboard the NOAA ship *Oscar Dyson*, a 64-m stern trawler equipped for fisheries and oceanographic research. The vessel itinerary and scientific personnel list are listed in Appendices I and II.

<u>Acoustic Equipment, Calibration, and Data Collection</u>

Acoustic measurements were collected with Simrad ER60 scientific echo sounding system (Simrad 2004, Bodholt and Solli 1992). Five split-beam transducers (18, 38, 70, 120, and 200 kHz) were mounted on the bottom of the vessel's retractable centerboard, which extended 9 m below the water surface. System electronics were housed inside the vessel in a permanent laboratory space dedicated to acoustics.

Standard sphere acoustic system calibrations were conducted to measure acoustic system performance. During calibrations, the *Oscar Dyson* was anchored at the bow and stern. A tungsten carbide sphere (38.1 mm diameter) and a copper sphere (64 mm diameter) were suspended below the centerboard-mounted transducers. The tungsten carbide sphere was used to calibrate the 38, 70, 120 and 200 kHz systems and the copper sphere was used to calibrate the 18 kHz system. After each sphere was centered on the acoustic axis, split-beam target strength and echo integration measurements were collected to estimate transducer gains following methods of Foote et al. (1987). Transducer beam characteristics were modeled by moving each sphere through a grid of angular coordinates and collecting target-strength data using EKLOBES software (Simrad 2004).

Acoustic telegram data were logged at all five frequencies using Myriax EchoLog 500 (v. 4.40) and ER60 software (v. 2.1.2). Raw acoustic data were also collected. Results presented in this report, including calibration, are based on 38 kHz echo integration telegram data with a post processing S_v threshold of -70dB. Acoustic measurements were collected from 16 m below the surface to within 0.5 m of the bottom and were analyzed using Myriax Echoview post-processing software (Version 4.40). Acoustic data collection was limited to 500 m depth.

Trawl Gear and Oceanographic Equipment

Midwater and near-bottom acoustic backscatter was sampled using an Aleutian Wing 30/26 Trawl (AWT). This trawl was constructed with full-mesh nylon wings, and polyethylene mesh in the codend and aft section of the body. The headrope and footrope each measured 81.7 m (268 ft). Mesh sizes tapered from 325.1 cm (128 in) in the forward section of the net to 8.9 cm (3.5 in) in the codend, where it was fitted with a single 12 mm (0.5 in) codend liner. Near-bottom backscatter was sampled with an 83-112 Eastern bottom trawl without roller gear, which was fitted with a 32 mm (1.25 in) codend liner. The AWT and bottom trawl were fished with 5 m^2 Fishbuster trawl doors each weighing 1,089 kg. Vertical net openings and depths were monitored with either a Simrad FS70 third-wire netsonde or a Furuno acoustic-link netsonde attached to the headrope. For AWT hauls, vertical net opening ranged from 18 to 36 m and averaged 27 m. For bottom trawl hauls, vertical net opening ranged from 2 to 3 m. Detailed trawl gear specifications are described in Honkalehto et al. (2002).

A Methot trawl was used to target midwater macro-zooplankton, age-0 walleye pollock, and other larval fishes. The Methot trawl had a rigid square frame measuring 2.3 m on each side, which formed the mouth of the net. Mesh sizes were 2 by 3 mm in the body of the net and 1 mm in the codend. A 1.8 m dihedral depressor was used to generate additional downward force. A calibrated General Oceanics flow meter was attached to the mouth of the trawl to determine the volume of water filtered during hauling. The trawl was attached to a single cable fed through a stern-mounted A-frame. Real-time trawl depths were monitored using a Simrad ITI acoustic link netsonde attached to the bottom of the Methot frame. All fishing operations were conducted as specified in NOAA protocols for fisheries acoustics surveys and related sampling[1].

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[1] National Marine Fisheries Service (NMFS) 2004. NOAA protocols for fisheries acoustics surveys and related sampling (Alaska Fisheries Science Center), NOAA Policy Directive 04-105-05, 24 p. Prepared by Midwater Assessment and Conservation Engineering Program, Alaska Fish. Sci. Center, Natl. Mar. Fish. Serv., NOAA. Available online http://reefshark.nmfs.noaa.gov/f/pds/publicsite/documents/supplements/04-105-05-01-AKC.pdf

Physical oceanographic measurements were made throughout the cruise. Temperature-depth profiles were obtained at trawl sites with a Sea-Bird Electronics temperature-depth probe (SBE-39) attached to the trawl headrope. CTD and fluorometer measurements were made with a Sea-Bird SBE 9/11 plus CTD throughout the survey and at calibration sites. Additional temperature-depth measurements were taken with Sippican Deep Blue XBTs at various locations along the survey route. Temperature profile data were subsequently binned by 1-m vertical depth intervals and averaged by shelf region (e.g., U.S. EEZ east and west of 170°W, and Russia) and bathymetry (e.g., ≤ 100 m isobath and > 100 m isobath). Sea surface temperature and salinity were measured continuously using the vessel's Sea-Bird Electronics SBE-45 external probe located mid-ship, approximately 5 m below the water line. Surface temperature data sampled along survey transects were subsequently averaged at 10 nautical mile (nmi) resolution. These and other environmental information were recorded using the ship's Scientific Computing System (SCS). Ambient atmospheric light levels were measured with a sensor attached to the vessel's flying bridge and water column light levels along the trawl path were measured with a sensor attached to the trawl headrope.

Survey Design

The survey design consisted of 31 north-south transects spaced 20 nmi apart over the Bering Sea shelf from Port Moller, Alaska, across the U.S.-Russia Convention Line to the area around Cape Navarin, Russia, (hereafter "Russia") (Fig. 1). Echo integration and trawl information were collected during daylight hours (typically between 0600 and 2400 local time). Nighttime activities included collection of additional physical oceanographic data and trawl hauls for species classification, and work with other specialized sampling devices (e.g., a lowered echosounding system, a free drifting acoustic buoy to measure potential fish avoidance behavior to the vessel, and performance tests of a Simrad ME-70 multibeam sonar). Macro-zooplankton and micronekton layers (principally euphausiids) were also sampled with a Methot trawl as part of the BSIERP study.

For trawls targeting walleye pollock, a portion of the catch was sampled to determine sexual maturity, and the size (fork length (FL)), and weight (kg) at age, by sex. If large numbers of juveniles mixed with adults were encountered in a haul, the predominant size groups were often sub-sampled separately. Approximately 50 to 500 individuals were randomly sampled for sex and length measurements, and about 10 to 60 were sampled for body weight, maturity, and age. Fork lengths were measured to the nearest millimeter. Small fish such as eulachon were measured to the nearest millimeter standard length. An electronic motion-compensating scale (Marel M60) was used to weigh individual walleye pollock specimens to the nearest 2 g. Maturity was determined by visual inspection and fish were categorized as immature, developing, pre-spawning, spawning, or post-spawning[2]. Walleye pollock otoliths were collected and stored in individually marked vials containing a 50% ethanol-water solution. After the survey the otoliths were read by scientists in the AFSC's Age and Growth Program to determine individual fish ages. Trawl station and biological measurements were digitally recorded using a Fisheries Scientific Computer System (FSCS) designed and developed by NOAA's Office of Marine and Aviation Operations for NOAA research vessels.

Data Analysis

Walleye pollock abundance was estimated by combining echo integration and trawl information. Acoustic backscatter that was identified as walleye pollock, non-pollock fishes, and an undifferentiated mixture (primarily jellyfish and other macro-zooplankton, possibly including some fish) was binned at 0.5 nmi horizontal by 10 m vertical resolution. Walleye pollock length compositions from 58 hauls were combined into 23 regional length strata based on geographic proximity, similarity of length composition, and backscatter characteristics. Results were stratified east and west of 170°W as historically walleye pollock have been observed to grow at different rates and to have different length and age compositions in these areas (Traynor and Nelson 1985, Honkalehto et al. 2002). Two separate weight-at-length and length-at-age

[2] ADP Code Book. 2008. Unpublished document. Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle WA 98115.

relationships (keys) were used to compute biomass for walleye pollock east of 170°W and west of 170°W including Russia. Mean fish weight-at-length for each length interval (cm) was estimated from the trawl information when there were six or more fish for that length interval in a haul; otherwise weight at a given length interval was estimated from a linear regression of the natural logs of the length and weight data for all the 2008 summer EBS hauls within a common length-weight key (De Robertis and Williams 2008).

Numbers and biomass for each regional length stratum were estimated as in Honkalehto et al. (2008). Population numbers and biomass were estimated by summing the regional stratum estimates. Walleye pollock distribution and abundance were then summarized into three areas: the U.S. EEZ east of 170°W and west of 170°W, and Russia. EIT survey results on the U.S. EBS shelf are generally presented for the water column down to 3 m off bottom, as the AFSC bottom trawl survey estimates the component of pollock between 3 m and 0.5 m off bottom (Honkalehto et al. 2008, Ianelli et al. 2008). In 2008, when comparing abundances in Russia to those in the two U.S. EEZ regions, all results are estimated to 3 m off bottom. When comparing abundance estimates within Russia across multiple years, results are estimated to 0.5 m off bottom, as no U.S. bottom trawl survey information is available for Russia. Results were also analyzed by depth.

Relative estimation errors associated with spatial structure observed in the acoustic data were derived using a one-dimensional (1D) geostatistical method (Petitgas 1993, Walline 2007, Williamson and Traynor 1996). Relative estimation error is defined as the ratio of the square root of the estimation variance to the estimate of biomass. Geostatistical methods are used for error computation because they account for the observed spatial structure. These errors quantify only transect sampling variability. Other sources of error (e.g., target strength, trawl sampling) are not evaluated.

RESULTS AND DISCUSSION

Calibration

Three acoustic system calibrations were conducted during the summer 2008 field season (Table 1). Excessive fish concentrations prevented completion of satisfactory sphere swings to estimate beam characteristics during the two July calibrations although on-axis measurements were adequate. A successful sphere swing was performed while drifting at sea in calm conditions at night on 16 July; however conditions were too rough to obtain additional on-axis information that night. No significant differences in gain parameters or transducer beam characteristics were observed for the Simrad ER 60 38 kHz system. Initial acoustic system settings for the survey were based on results from the 2 June acoustic system calibration. However, the average S_v gain from the summer 2008 calibrations was slightly less than that used during the survey. Therefore a scalar correction of 1.0583 was applied to echo integration backscatter values attributed to walleye pollock.

Physical Oceanographic Conditions

The summer EBS survey encompassed 2 months during which the Bering Sea was gradually stratifying and warming (Overland et al. 1999). Therefore, these temperature results reflected both geographic differences and temporal changes. The range of ocean surface temperatures observed in 2008 (Fig. 2a) was slightly less than that observed in 2007 and 2006 (Honkalehto et al. 2008, McKelvey et al. 2007). The coldest surface waters were on the inner shelf east of the Pribilof Islands (0.7 °C) and just south of St. Matthews Island (1.2 °C), and the warmest surface waters were in Russia over Navarin Canyon (8.3°C). Surface water temperatures observed in June averaged 4.0°C, but were higher in July, averaging 6.1°C. Temperatures were colder than in 2007 when they averaged 5.0°C in June and 8.9°C in July. The average temperature at the seafloor was 1.3°C overall and was coldest on the inner shelf north of St. Matthews Island to about 178°W, at -1.7°C (Fig. 2b). Seafloor temperatures were warmest on the outer shelf between Unimak Island and Pribilof Canyon (2.8°C to 4.0°C), and near Pervenets Canyon (4.9°C). Temperature-depth profiles for the three regions surveyed, from east to west, indicated that the water column to the east of 170°W appears to be more thoroughly mixed, and warmer throughout the water column, both on the middle shelf (≤ 100 m isobaths) and on the outer shelf (>100 m isobath) than west of 170°W and in Russia (Figs. 3 and 4).

Trawl Sampling

Biological data and specimens were collected from 133 trawl hauls (Table 2, Fig. 1). Ninety-three of these hauls targeted backscatter encountered during the survey for species identification: 54 with an AWT, 13 with an 83-112 bottom trawl, and 26 with a Methot trawl. Additionally, 22 AWT trawls were made for a codend liner mesh size selectivity comparison study, 2 AWT hauls were made in conjunction with the acoustic buoy and vessel comparison work, and 16 Methot trawls were made to collect live euphausiids for a target-strength study.

Catch composition in terms of total combined weight for the 93 species identification hauls indicated that walleye pollock was the most abundant, northern sea nettle jellyfish (*Chrysaora melanaster*) the second and arctic cod (*Boreogadus saida*) the third most abundant species in the AWT hauls (Table 3). Most arctic cod (99.8% of total weight) were captured in haul 56, which had the lowest AWT gear temperature (-1.7°C) of the survey and was in the vicinity of lowest seafloor temperatures. Walleye pollock was also the most abundant species in the bottom trawl hauls, followed by arrowtooth flounder (*Atheresthes stomias*) (Table 4). Euphausiids were the most abundant species group in the Methot hauls, followed by northern sea nettles (Table 5). No age-0 pollock were captured using the Methot trawl.

Summarizing walleye pollock samples from all 133 hauls made during the cruise indicated that 29,208 lengths were measured and 2,622 pairs of otoliths were collected (Table 6). Most fish were either in the developing or post-spawning maturity stage and less than 1% (n = 5 in the U.S. west of 170°W) of the females larger than 29 cm FL were actively spawning (Fig. 5). In walleye pollock mean weight at length curves plotted by area, error bars largely overlap (Fig. 6). However, fish ≥ 47 cm tend to be heaviest east of 170°W, even though they were measured up to one month earlier in the survey than those in the U.S. west of 170°W and Russia.

Distribution and Abundance

About one-third of the summed acoustic backscatter observed during the 2008 survey was attributed to adult or juvenile walleye pollock (Fig. 7). All other backscatter was attributed to an undifferentiated invertebrate-fish species mixture, or in a few isolated areas, to arctic cod, or unidentified fish. The proportion of walleye pollock found in the U.S. west of 170°W continued to increase as it has since 2002 (Table 7). Approximately three-quarters of the biomass east of 170°W was found north and west of Unimak Island inside the SCA, in contrast to previous EIT Bering Sea surveys in which less than half of the eastern biomass was found inside the SCA. This proportional change came from an 83% reduction in the 2008 biomass outside the SCA compared to that in 2007, while within the SCA biomass remained similar to 2007 estimates; although it too has declined in comparison to prior years. As in 2007, the majority of the 2008 biomass in the U.S. EEZ was located to the west and southwest of St. Matthew Island between the 100 and 200 m isobaths (Fig. 7). The largest adult aggregations were observed west of St. Matthew Island on the outer shelf north of 60°N between about 175°W and 179°W. Juvenile concentrations were high in this general area but also south of 60°N, on the shelf east of Pervenets Canyon.

Estimated walleye pollock abundance in midwater (between 16 m from the surface and 3 m off the bottom) along the U.S. Bering Sea shelf was 4.70 billion fish weighing 0.997 million t (Tables 7-9). Estimated midwater abundance in Russia was 58.6 million fish weighing 0.03 million tons (3% of total midwater biomass). East of 170°W (11% of total midwater biomass) the length composition ranged between 27 and 70 cm FL with larger fish inside the SCA (55 cm modal FL) than outside (51 cm modal FL); few juveniles (< 30 cm FL) were present east of 170°W (Fig. 8a). In the U.S. west of 170°W (86% of total midwater biomass; Fig. 8b), the length composition ranged from 11 to 79 cm FL with a major mode at 23 cm and lesser modes at 32 and 47-48 cm FL. The walleye pollock length composition in Russia (Fig. 8c) was similar to the U.S. west of 170°W, although proportionally more adults (≥ 30 cm FL) than juveniles were observed. Based on the 1D analysis, the relative estimation error of the U.S. EEZ walleye pollock biomass estimate was 0.076, higher than previous survey values dating back to 1994 when these analyses were first implemented (Table 7).

The 2008 vertical distribution of walleye pollock biomass in the U.S. was split into juvenile and adult length groups and analyzed to within 0.5 m of bottom by 10-m depth intervals referenced to the surface and the bottom (Fig. 9). Both east and west of 170°W, adults were mainly found deeper than 60 m from the surface and within 40 m of the bottom (Fig. 9a and c). The 40-m near-bottom region accounted for 93 % of the adult biomass in the water column. Only 5 % of the adult biomass was observed in the upper 60 m of the water column. Few juveniles were captured east of 170°W. West of 170°W, as has been observed in prior surveys (Honkalehto et al. 2008), juvenile aggregations were found both in midwater and near bottom (Fig. 9b and d). Twenty-one percent of the juvenile biomass was observed within 60 m of the surface and 69% in the near-bottom 40 m.

The estimated age composition of eastern Bering Sea pollock varied depending upon geographic area. Inside the U.S. EEZ (Table 10), ages 2 and 3 were dominant numerically (62% and 22%, respectively) and these two age groups represented 46% of the total biomass. Age-1 juveniles represented only 1% numerically and 0.1% of the total biomass. Pollock ages 4+ totaled 16% of the population numerically, and made up 53% of the total biomass. The pollock population east of 170°W was dominated by 6-9 year old adults, while in the U.S. west of 170°W, and in Russia, it was dominated by 2- and 3-year-old fish (Fig. 10).

The walleye pollock population tends to be supported by strong year classes. Acoustic-trawl survey numbers at age estimates between 1994 and 2008 show the progression of strong year classes through the midwater population (Fig. 11). In 2007, the 2006 year class was the most numerous age-1 group detected by the EIT survey since the large 1996 year class in 1997. Other strong recruiting year classes observed in acoustic-trawl surveys included the 1992 year class as 2-year-olds in 1994 and the 2000 year class as 2-year-olds in 2002.

Average length at age for pollock in the U.S. EEZ east and west of 170°W for 2008 was compared with the average length at age for these two strata between 1999 and 2007 to see if a longitudinal cline in growth existed, supporting the use of two separate age-length keys (Fig. 12). The 2008 average lengths were similar to historical values, although for older fish (8-12 years) in the east they tended to be higher than those from prior surveys. In general, length at age tended to be higher in the east than in the west, although it was usually measured up to one month earlier.

The EBS EIT survey provides estimates of pollock inhabiting midwater—from near the surface to 3 m off the bottom—for stock assessment (Ianelli et al. 2008). However, estimates of abundance to within 0.5 m of bottom are also produced (Honkalehto et al. 2008). The walleye pollock biomass estimated in the U.S. EEZ to 3 m off bottom, and from 3 m to 0.5 m off bottom, were compared east and west of 170°W and for the whole survey for the years 1999 to 2008 (Fig. 13). The percent of total biomass between 3 m and 0.5 m off bottom appeared to be relatively stable (~19%) between 1999 and 2006, increasing to 26% in 2007, and to 35% in 2008, in conjunction with a decline in the overall estimated biomass. The percent of biomass above 3 m averaged across years since 1999 was 70% east of 170°W and 80% west of 170°W. The higher percentage of pollock observed above 3 m west of 170°W is consistent with the greater abundance of juveniles usually observed in that area compared to the east, as juveniles tend to aggregate higher in the water column than the adults (Fig. 9).

Backscatter from the EIT survey time series (1994-2008) consisted of walleye pollock, and non-pollock species, primarily macro-zooplankton, jellyfish, and other fish species. Walleye pollock backscatter was relatively evenly distributed throughout the survey area between 1999 and 2004 but was lower and relatively more abundant west of 170°W during 2006-2008 (Fig. 14). Most non-pollock, non-fish backscatter (at 38 kHz) is typically observed in the upper part of the water column (Honkalehto et al. 2008). The 2008 distribution of non-pollock backscatter was similar to that observed in 2007 but extended farther to the west (Fig. 15). Non-pollock backscatter was roughly as prevalent as in 2007, and more prevalent than in 2006, but still less extensive than in prior survey years. In 2008, as in 2007, very little non-pollock backscatter was observed in Russian waters compared to the 2004 survey. This backscatter information should be interpreted with care because the exact biological composition of the scatterers is unknown (Honkalehto et al. 2008).

The AFSC has surveyed the Cape Navarin area of Russia during summers 1994, 2004, 2007, and 2008. In 2002, the U.S. EEZ survey took place at the same time the Russian research vessel *TINRO* was conducting an acoustic-trawl survey of the Russian EEZ near Cape Navarin. The results of these surveys indicate that the distribution of pollock backscatter in this region of Russia has varied between years (Fig. 16). The proportion of walleye pollock biomass estimated in Russia to within 0.5 m of the bottom has ranged from 2% (in 2002 and 2008) to 15% (in 1994) of the total U.S. and Russian Bering Sea shelf biomass for this portion of the water column (Table 11).

Codend Liner Mesh Size Comparison

Prior to 2008, a 3.2-cm (1.25 in) liner was used in the midwater-trawl codends during the Bering Sea summer EIT surveys. Surveys of walleye pollock in the Bogoslof Island and Shelikof Strait areas also use this configuration. Newer surveys such as the Chirikof Island shelf break, Shumagin Islands, and Sanak Trough used a 1.3-cm codend liner which allows for higher retention of smaller organisms such as juvenile walleye pollock and forage fishes.

To compare the retention rate of juvenile and older walleye pollock between the two codend liners, a series of hauls were conducted during the 2006 and 2008 Shelikof Strait surveys (Guttormsen and Yasenak 2006; Guttormsen et al. 2008), and during the Bering Sea survey in 2008. Trials consisted of pairs of hauls taken in succession using separate midwater trawls outfitted with the two respective codend liner sizes and targeting the same echosign. Preliminary results from the analysis of 6 trawl pairs taken in Shelikof Strait in 2006 show a roughly three-fold increase in the retention of age-1 walleye pollock in the smaller mesh liner but little difference in the catches of older fish (Fig. 17). Selection curves (not shown) were computed using the SELECT (Share Each Length's Catch Total) model (Millar 1992). Trials conducted in Shelikof Strait in 2008 were not incorporated in the analysis because of high numbers of eulachon (~59 %) in the catches. For the 2008 Bering Sea comparison trials, a scarcity of 1-year-old fish limited the study to larger fish, with 22 hauls (11 pairs) conducted in five different areas where ages 2 and 3+ walleye pollock occurred. Further analysis is in progress.

To estimate the potential impact of changing to a small-mesh liner for Bering Sea summer surveys, the 1996-2007 survey results were re-analyzed by correcting original walleye pollock length frequency estimates from catches using selection parameters from the Shelikof Strait 2006 trial. For all years, the selectivity-corrected total biomass varied <1% relative to original estimates; most of the variation occurred in estimates of age-1 fish (Table 12). This analysis suggests that in the Bering Sea the impact of switching to a small-mesh codend liner would be minimal, despite the large differences in the relative retention of juveniles seen in Shelikof Strait trial data. This apparent contradiction is primarily because the largest effects of trawl selectivity on acoustic-based abundance estimates are seen where juvenile and adult walleye pollock aggregations are mixed, which is not commonly observed in Bering Sea EIT surveys. Estimating EBS codend liner results based on Shelikof experiments is a conservative approach, as age-1 walleye pollock in Shelikof Strait in winter are much smaller than Bering Sea age-1s encountered nearly 4 months later in the year.

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Table 1. -- Simrad ER60 38 kHz acoustic system description and settings during the summer 2008 walleye pollock echo integration-trawl survey of the Bering Sea shelf, and results from standard sphere acoustic system calibrations conducted before, during, and after the survey using a 38.1 mm tungsten carbide sphere.

		Survey system settings	2-Jun Captain's Bay Alaska	11-Jul* Captain's Bay Alaska	16-Jul Zhemchug Canyon EBS Shelf	31-Jul* Nateekin Bay Alaska
Echosounder:		Simrad ER60	--	--	--	--
Transducer:		ES38B	--	--	--	--
Frequency (kHz):		38	--	--	--	--
Transducer depth (m):		9.15	--	--	--	--
Pulse length (ms):		1.024	--	--	--	--
Transmitted power (W):		2000	--	--	--	--
Angle sensitivity:	Along:	22.76	--	--	--	--
	Athwart:	21.37	--	--	--	--
2-way beam angle (dB):		-20.74	--	--	--	--
Gain (dB):		22.90	22.90	22.72	--	22.80
Sa correction (dB):		-0.60	-0.65	-0.61	--	-0.62
S_v gain (dB):		22.30	22.25	22.10	--	22.80
3 dB beamwidth (deg)	Along:	6.77	6.77	-	6.81	--
	Athwart:	7.25	7.25	-	7.29	--
Angle offset (deg):	Along:	-0.06	-0.06	-	-0.07	--
	Athwart:	-0.09	-0.09	-	-0.09	--
Sphere range from transducer (m):		--	20.60	24.50	23.0**	16.05
Absorption coefficient (dB/m):		0.0100	0.0100	0.0096	0.0096	0.0096
Sound velocity (m/s):		1470	1462.5	1467.9	1468.1	1472.3
Water temp at transducer (^{o}C):		2.0-10.9	4.2	5.9	5.8	6.4
Water temp at standard sphere (^{o}C):		--	3.5	4.0	2.3	6.0

* - Unfavorable conditions for calibration sphere swing
** - Average range during sphere swing
Note: Gain and Beam pattern terms are defined in the "Operator Manual for Simrad ER60 Scientific echo sounder application (2004)" available from Simrad AS, Strandpromenaden 50, Box 111, N-3191 Horten, Norway.

Table 2. -- Trawl stations and catch data summary from the summer 2008 Bering Sea shelf walleye pollock echo integration-trawl survey aboard the NOAA ship *Oscar Dyson* .

Haul	Gear[1]	Date	Time	Duration	Start position				Depth (m)		Temp. (°C)		Walleye pollock		Other
no.	type	(GMT)	(GMT)	(minutes)	Lat. (N)		Long. (W)		footrope	bottom	headrope	surface[2]	(kg)	number	(kg)
1	Methot	5-Jun	6:23	15	56	6.78	-162	9.67	29	76	-	4.8	-	-	19.6
2	Methot*	6-Jun	5:51	15	56	38.65	-163	19.72	57	77	0.5	2.4	-	-	-
3	Methot	6-Jun	6:45	15	56	38.63	-163	19.61	48	77	-	2.4	-	-	14.2
4	Methot	6-Jun	20:14	16	55	34.11	-163	20.96	52	70	2.5	3.6	-	-	20.9
5	AWT	6-Jun	22:39	42	55	29.73	-163	20.95	57	66	3.7	3.6	294.4	194	147.3
6	Methot*	7-Jun	11:18	5	55	46.14	-164	9.31	27	95	2.9	3.1	-	-	-
7	Methot	8-Jun	5:29	15	56	11	-164	32.01	63	91	0.8	3	-	-	7.8
8	Methot*	8-Jun	9:33	5	55	45.99	-164	36.52	23	97	3.9	4.6	-	-	-
9	AWT	8-Jun	19:22	30	55	20.7	-164	31.22	89	102	-	4.5	1,408.8	1,069	166.1
10	83-112	9-Jun	7:06	10	55	2.4	-165	6.23	106	112	3.9	4.9	-	-	-
11	AWT	9-Jun	8:40	25	55	2.33	-165	5.87	103	112	3.9	4.6	351.8	332	1.1
12	AWT	9-Jun	12:35	21	55	1.95	-165	5.86	107	111	3.8	4.6	295.3	258	15.1
13	Methot	9-Jun	20:18	15	55	58.76	-165	7.91	53	97	2.7	4.4	-	-	16.7
14	Methot	9-Jun	23:11	15	56	20.95	-165	8.38	74	87	0.2	3.1	-	-	26.6
15	AWT	11-Jun	5:39	30	54	39.07	-165	40.5	286	325	3.2	5.4	19.8	24	2.4
16	Methot	11-Jun	18:24	20	54	29.61	-165	43.24	142	370	4.1	4.6	-	-	8.1
17	Methot	12-Jun	1:26	15	54	39.86	-166	16.64	273	317	3.6	4.9	-	-	13.6
18	Methot	13-Jun	0:24	10	57	26.92	-166	23.48	60	69	0.5	0.9	-	-	7.8
19	Methot*	14-Jun	9:01	5	55	24.44	-167	31.11	13	142	4.9	5	-	-	1.7
20	Methot*	14-Jun	11:01	10	55	24.07	-167	29.94	19	142	4.8	5.1	-	-	-
21	83-112	14-Jun	21:56	10	56	39.01	-167	36.39	106	106	1.1	3.6	268.0	271	164.6
22	83-112	15-Jun	21:58	24	56	34.64	-168	13.08	111	111	2.3	4	557.5	749	151.0
23	Methot*	16-Jun	10:22	10	55	43.76	-168	23.88	11	139	5.2	5.5	-	-	-
24	AWT	16-Jun	20:59	38	56	30.14	-168	48.95	98	107	2.3	4.5	312.6	366	10.1
25	AWT	18-Jun	11:04	35	56	36.46	-170	9.85	95	105	1.9	4.3	398.1	525	5.0
26	AWT	18-Jun	20:39	60	56	43.42	-170	3.64	86	92	1.9	4.4	84.8	133	80.0
27	83-112	22-Jun	0:18	15	57	31.5	-170	11.29	70	70	1.1	4.6	902.7	774	376.8
28	Methot	23-Jun	7:59	10	56	11.23	-170	35.69	99	130	3.3	5.9	-	-	3.1
29	Methot*	23-Jun	8:54	5	56	15.56	-170	36.65	31	124	3	5.7	-	-	-
30	Methot	23-Jun	16:42	17	56	31.51	-171	15.54	72	131	2.9	5.4	-	-	7.3
31	AWT	23-Jun	20:58	60	57	1.69	-171	20.85	104	109	2	5.9	133.6	165	29.1
32	Methot	24-Jun	14:24	10	59	54.56	-171	53.95	61	72	-1.3	3.3	-	-	1.7
33	Methot	24-Jun	19:26	7	59	30.48	-172	28.48	63	88	-0.7	3.3	-	-	8.1
34	Methot*	25-Jun	8:46	5	57	6.48	-171	59.23	21	115	3.6	5.9	-	-	-
35	AWT	25-Jun	11:07	16	56	53.47	-171	56.33	118	119	3.1	5.5	68.5	70	-
36	83-112	26-Jun	4:59	12	57	46.57	-172	44.34	113	116	2	5.4	267.0	431	58.7

Table 2. -- Continued.

Haul	Gear[1]	Date	Time	Duration	Start position				Depth (m)		Temp. (°C)		Walleye pollock		Other
no.	type	(GMT)	(GMT)	(minutes)	Lat. (N)		Long. (W)		footrope	bottom	headrope	surface[2]	(kg)	number	(kg)
37	AWT	26-Jun	9:01	90	58	10.45	-172	49.23	102	108	1.5	5	215.5	272	0.7
38	AWT	26-Jun	17:25	20	58	28.92	-172	53.3	105	110	1.5	5.3	364.3	534	4.2
39	AWT	26-Jun	19:19	12	58	33.4	-172	54.33	57	111	2.5	4.1	202.1	2,092	11.5
40	83-112	26-Jun	23:14	5	58	52.2	-172	58.27	104	109	1.4	4.1	-	1	3.5
41	AWT	27-Jun	0:42	6	58	50.51	-172	58.12	83	109	1.4	4.5	516.7	14,892	8.4
42	Methot	27-Jun	5:41	10	59	38.18	-173	8.39	69	96	-0.4	3.5	-	-	10.8
43	Methot*	27-Jun	9:30	4	60	12.12	-173	16.23	30	65	1.5	2.8	-	-	-
44	AWT	28-Jun	5:35	30	59	0.49	-173	39.17	108	117	1.4	5.3	434.1	589	23.1
45	AWT	28-Jun	9:17	1	58	52.74	-173	37.36	56	121	3.5	5	2,863.5	26,666	29.5
46	AWT	28-Jun	12:20	24	58	37.4	-173	33.63	122	126	1.9	6	9.5	11	1.6
47	AWT	28-Jun	18:53	22	58	4.97	-173	26.03	109	112	1.8	6.2	282.6	388	-
48	Methot*	29-Jun	9:53	3	57	28.1	-173	55.32	24	152	5.5	6.4	-	-	-
49	AWT	29-Jun	10:47	7	57	28.92	-173	55.42	147	151	2.9	6.4	1.3	2	14.7
50	AWT	29-Jun	21:58	32	58	30.71	-174	11.03	132	135	2.3	6.6	13.6	16	-
51	AWT	30-Jun	2:42	37	58	55.95	-174	17.49	88	130	1.7	6	767.3	8,557	7.7
52	AWT	30-Jun	6:13	40	59	18.66	-174	23.64	100	121	-	4.9	738.3	1,056	21.7
53	AWT	30-Jun	13:22	60	59	38.32	-174	28.53	112	118	0.6	3.6	571.1	631	24.5
54	AWT	30-Jun	17:39	39	59	58.99	-174	34.7	102	109	0.1	5.3	1,255.7	1,010	90.2
55	Methot	1-Jul	1:10	10	61	4.01	-174	51.05	86	92	-1.7	5.4	-	-	0.9
56	AWT	1-Jul	3:38	20	61	14.56	-174	54.78	83	90	-1.7	5.1	-	-	285.7
57	Methot*	1-Jul	10:08	3	60	51.37	-175	28	29	107	-1.5	5.4	-	-	-
58	AWT	1-Jul	19:36	12	60	3.53	-175	15.5	109	116	0.6	4.4	1,359.7	1,808	74.3
59	AWT	2-Jul	0:19	40	59	43.86	-175	9.16	119	125	1	4.7	338.8	643	26.4
60	Methot	3-Jul	3:17	15	59	3.96	-175	36.29	111	136	1.7	5.9	-	-	2.0
61	AWT	3-Jul	6:14	60	59	18.37	-175	42.05	119	139	1.2	4.6	71.5	395	14.2
62	Methot*	3-Jul	9:34	5	59	25.31	-175	40.93	43	138	0.6	5.3	-	-	-
63	AWT	3-Jul	11:37	7	59	24.45	-175	43.64	59	138	1.3	4.8	289.2	1,854	2.1
64	AWT	3-Jul	13:55	1	59	22.8	-175	44.29	108	138	1.2	4.9	631.0	6,447	-
65	AWT	3-Jul	16:43	7	59	36.06	-175	47.66	128	139	1.4	5.4	663.3	4,057	0.7
66	AWT	3-Jul	23:23	9	59	58.35	-175	55.26	119	131	1	4.7	526.0	3,020	18.7
67	AWT	4-Jul	2:45	12	60	19.07	-176	0.94	114	123	0.2	5	715.0	1,226	31.1
68	AWT	4-Jul	6:22	20	60	40.11	-176	7.39	110	119	-0.3	5.2	719.4	964	10.0
69	AWT	4-Jul	9:16	15	60	51.51	-176	11.38	104	116	-	5.5	290.4	356	2.9
70	Methot*	4-Jul	10:34	5	60	51.9	-176	10.45	16	116	0.1	5.4	-	-	-
71	AWT	4-Jul	16:32	35	61	0.69	-176	54.25	113	122	0.5	5.4	1,019.9	3,648	4.1
72	AWT	4-Jul	20:17	11	60	43.71	-176	49.47	114	128	0.3	4.9	473.1	2,399	2.9
73	Methot	5-Jul	2:41	3	61	26.84	-176	22.58	94	108	-1.1	5.3	-	-	-
74	Methot	5-Jul	3:37	20	61	28.64	-176	23.27	99	108	-1	5.5	-	-	0.6

Table 2. -- Continued.

Haul no.	Gear[1] type	Date (GMT)	Time (GMT)	Duration (minutes)	Start position Lat. (N)	Start position Long. (W)	Depth (m) footrope	Depth (m) bottom	Temp. (°C) headrope	Temp. (°C) surface[2]	Walleye pollock (kg)	Walleye pollock number	Other (kg)
75	Methot	5-Jul	6:01	31	61 31.57	-176 24.09	92	107	-0.9	5.6	-	-	1.0
76	Methot*	5-Jul	9:18	4	61 54.17	-176 30.77	38	104	-1.7	5.6	-	-	-
77	Methot	5-Jul	16:57	13	62 16.5	-177 22.16	74	104	-1.4	5.5	-	-	1.5
78	Methot	5-Jul	19:10	5	61 59.83	-177 16.02	96	113	-0.1	5.6	-	-	0.7
79	AWT	5-Jul	23:32	30	61 29.28	-177 5.39	106	117	0	6	1,296.0	1,468	-
80	AWT	6-Jul	9:46	6	59 56.85	-176 33.06	135	142	0.9	5.8	337.0	2,734	0.8
81	Methot*	6-Jul	11:51	5	59 56.81	-176 34.05	40	142	-1.2	5.6	-	-	-
82	AWT	6-Jul	16:02	13	60 16.61	-176 40.15	122	139	0.8	5.5	669.0	3,040	8.4
83	83-112	6-Jul	21:26	14	59 32.14	-176 25.31	135	135	1.2	6.6	180.4	361	29.7
84	AWT	6-Jul	23:53	0	59 21.65	-176 21.8	101	136	1.1	7.1	366.0	2,285	4.7
85	83-112	7-Jul	3:40	4	58 57.72	-176 13.92	131	133	1.5	7.4	175.5	289	81.7
86	AWT	7-Jul	5:48	19	58 49.44	-176 11.44	92	129	1.5	6.9	959.6	8,109	-
87	83-112	8-Jul	2:59	2	57 30.15	-173 56.08	147	147	2.9	7.3	-	-	106.1
88	83-112	8-Jul	7:37	8	57 45.41	-174 9.67	86	104	2.9	7.3	-	-	-
89	Methot*	8-Jul	8:37	5	57 45.75	-174 9.06	31	119	4.4	7.1	-	-	-
90	Methot	12-Jul	23:27	25	58 42.51	-176 46.52	79	131	1.9	7	-	-	7.4
91	AWT	13-Jul	5:21	3	59 16.81	-176 57.12	131	147	1.7	6.6	4,000.0	26,985	-
92	AWT	13-Jul	19:35	31	59 56.96	-177 13.8	120	136	-	6	529.5	1,934	2.4
93	AWT	14-Jul	0:53	25	60 28.78	-177 24.82	141	154	0.7	5.9	494.5	6,029	2.5
94	AWT	14-Jul	6:13	2	61 4.81	-177 38.53	125	139	0.7	5.4	1,045.8	4,263	1.4
95	Methot	14-Jul	18:08	30	61 47.11	-177 54.7	114	132	0.3	5.5	-	-	9.1
96	83-112	15-Jul	0:54	19	62 18.47	-178 50.15	110	110	0.3	5.8	72.1	78	46.6
97	AWT	15-Jul	7:59	44	61 26.7	-178 29	169	180	0.7	6.3	167.0	256	-
98	AWT	15-Jul	19:12	32	60 46.6	-178 12.94	152	164	1.2	6	674.6	1,081	-
99	83-112	15-Jul	23:12	8	60 28.99	-178 6.11	158	158	1.6	6.7	117.9	160	67.7
100	AWT	16-Jul	4:40	27	59 57.92	-177 54.37	133	143	1.1	6.5	129.2	210	-
101	AWT	16-Jul	8:40	11	59 39.44	-177 47.16	217	248	2.3	7.1	446.5	734	-
102	Methot	16-Jul	19:24	21	59 0.89	-177 32.35	108	136	2.2	7.1	-	-	4.2
103	83-112	17-Jul	9:51	5	60 9.83	-178 39.48	227	235	-	7.2	57.8	44	122.3
104	Methot	17-Jul	21:23	30	61 11.66	-179 5.28	198	230	2	6.9	-	-	2.6
105	AWT	18-Jul	1:19	45	61 32.42	-179 14.61	134	140	0.4	6.7	97.6	228	2.1
106	Methot	18-Jul	4:53	20	61 51.29	-179 22.03	112	131	0.4	7	-	-	3.0
107	AWT	18-Jul	15:18	3	62 15.9	179 57.48	69	141	0.7	6.6	1,723.2	14,449	0.8
108	AWT	18-Jul	23:56	21	61 10.44	-179 46.57	153	159	0.8	8.1	407.2	681	5.3
109	AWT	19-Jul	8:57	39	61 6.51	179 33.02	139	158	-	8.5	829.9	3,120	1.5
110	AWT+	21-Jul	0:42	9	60 12.16	-177 41.07	135	142	0.8	6.9	127.3	380	2.3
111	AWT+	21-Jul	2:56	9	60 12.29	-177 41.09	135	142	0.8	7	187.6	597	-

Table 2. -- Continued.

Haul	Gear[1]	Date	Time	Duration	Start position				Depth (m)		Temp. (°C)		Walleye pollock		Other
no.	type	(GMT)	(GMT)	(minutes)	Lat. (N)		Long. (W)		footrope	bottom	headrope	surface[2]	(kg)	number	(kg)
112	AWT+	21-Jul	4:45	4	60	12.49	-177	40.72	131	143	0.8	7	575.2	2,247	-
113	AWT+	21-Jul	6:25	4	60	12.48	-177	41.02	137	143	0.8	7	1,451.6	5,973	1.4
114	AWT+	21-Jul	8:57	15	60	22.98	-177	31.89	136	148	0.8	6.9	404.0	1,101	0.3
115	AWT+	21-Jul	10:43	15	60	23.16	-177	32.5	139	148	0.8	7.1	160.0	460	2.6
116	AWT+	21-Jul	12:51	5	60	21.46	-177	30.59	135	146	0.9	6.9	426.9	1,459	0.6
117	AWT+	21-Jul	14:18	5	60	21.6	-177	30.65	140	146	0.9	6.9	356.1	1,129	-
118	AWT+	21-Jul	17:50	8	60	26.35	-177	33.01	144	154	0.9	6.9	1,008.0	2,611	2.0
119	AWT+	21-Jul	19:20	8	60	26.49	-177	33.24	144	154	0.9	7	1,270.0	2,667	-
120	AWT+	21-Jul	23:39	15	60	39.73	-177	42.06	145	155	0.8	6.9	351.9	962	10.4
121	AWT+	22-Jul	1:05	15	60	40.16	-177	43.06	147	155	0.8	6.9	357.7	977	1.8
122	AWT+	22-Jul	7:50	20	60	12.86	-176	38.89	96	139	0.3	6.1	138.1	1,228	3.2
123	AWT+	22-Jul	9:25	27	60	12.69	-176	38.66	100	139	-	6.2	230.4	2,151	-
124	AWT+	22-Jul	12:28	5	60	12.73	-176	38.88	112	139	0.9	6.4	482.7	4,890	-
125	AWT+	22-Jul	13:45	4	60	12.76	-176	39.47	106	139	0.9	6.4	384.4	4,485	0.7
126	AWT+	22-Jul	18:18	3	60	12.54	-176	40.03	130	139	0.9	6.3	342.7	2,388	1.6
127	AWT+	22-Jul	19:45	5	60	12.75	-176	40.2	131	139	0.9	6.3	226.0	1,306	7.1
128	AWT+	22-Jul	23:32	33	60	1.72	-176	0.36	92	131	0.1	7	382.3	2,482	19.6
129	AWT+	23-Jul	1:44	32	60	1.92	-176	0.61	104	131	0.4	7.5	535.9	4,903	19.6
130	AWT	23-Jul	8:06	12	59	32.5	-175	50.9	126	138	1.4	7.3	570.8	4,062	0.6
131	AWT+	23-Jul	20:19	4	59	29.2	-175	54.23	130	138	1.5	6.6	871.0	2,186	0.5
132	AWT+	23-Jul	21:37	10	59	29.53	-175	53.41	130	138	1.5	6.6	321.0	1,004	9.9
133	AWT	28-Jul	16:52	13	59	53.72	-177	7.46	125	136	1.1	7.6	661.9	5,966	-

[1]AWT = Aleutian wing trawl, 83-112 = bottom trawl, Methot = Methot trawl

[2]shipboard sensor at 1.4m depth.

* - Tow for live euphausiids, catch not quantified.

+ - Codend comparison tows

Table 3. -- Catch by species from 54 of the 77 Aleutian Wing trawl hauls conducted during the summer 2008 walleye pollock echo integration-trawl survey of the Bering Sea shelf. Catches from codend comparison, acoustic buoy and vessel comparison trawls are not included.

Common name	Scientific name	Weight (kg)	Weight (%)	Number
walleye pollock	*Theragra chalcogramma*	32,873.5	96.5	164,275
northern sea nettle	*Chrysaora melanaster*	787.1	2.3	1,197
Arctic cod	*Boreogadus saida*	285.7	0.8	8,370
Pacific cod	*Gadus macrocephalus*	38.3	0.1	5
flathead sole	*Hippoglossoides elassodon*	18.9	0.1	68
Pacific ocean perch	*Sebastes alutus*	13.7	<0.1	24
yellowfin sole	*Limanda aspera*	11.2	<0.1	24
smooth lumpsucker	*Aptocyclus ventricosus*	10.8	<0.1	8
Pacific herring	*Clupea pallasi*	7.7	<0.1	80
rock sole sp.	*Lepidopsetta* sp.	5.1	<0.1	8
Greenland turbot	*Reinhardtius hippoglossoides*	3.9	<0.1	2
Northern rock sole	*Lepidopsetta polyxystra*	3.0	<0.1	5
squid unident.	Cephalopoda (class)	1.9	<0.1	143
eulachon	*Thaleichthys pacificus*	1.8	<0.1	22
Bering flounder	*Hippoglossoides robustus*	1.4	<0.1	1
great sculpin	*Myoxocephalus polyacanthocephalus*	1.2	<0.1	1
Kamchatka flounder	*Atheresthes evermanni*	0.9	<0.1	1
yellow Irish lord	*Hemilepidotus jordani*	0.9	<0.1	1
arrowtooth flounder	*Atheresthes stomias*	0.9	<0.1	11
Alaska plaice	*Pleuronectes quadrituberculatus*	0.8	<0.1	1
sturgeon poacher	*Podothecus acipenserinus*	0.6	<0.1	12
capelin	*Mallotus villosus*	0.5	<0.1	39
jellyfish unident.	Scyphozoa (class)	0.4	<0.1	59
Pacific sandfish	*Trichodon trichodon*	0.3	<0.1	2
sea anemone unident.	Actiniaria (order)	0.2	<0.1	1
northern shrimp	*Pandalus borealis*	0.2	<0.1	84
sawback poacher	*Leptagonus frenatus*	0.1	<0.1	5
sea mouse	Aphrodita negligens	0.1	<0.1	1
salps unident.	Thaliacea (class)	0.1	<0.0	29
lanternfish unident.	Myctophidae (family)	0.1	<0.1	4
northern smoothtongue	*Leuroglossus schmidti*	0.1	<0.1	5
snake prickleback	*Lumpenus sagitta*	<0.1	<0.1	2
pandalid shrimp unident.	Pandalidae (family)	<0.1	<0.1	2
Tanner crab	*Chionoecetes bairdi*	<0.1	<0.1	1
isopod unident.	Isopoda (order)	<0.1	<0.1	2
shrimp unident.	Decapoda (order)	<0.1	<0.1	2
Totals		34,071.4		174,497

Table 4. -- Catch by species from 13 bottom trawl hauls (83-112) conducted during the summer 2008 echo integration-trawl survey on the Bering Sea shelf.

Common name	Scientific name	Weight (kg)	Weight (%)	Number
walleye pollock	*Theragra chalcogramma*	2,598.9	68.3	3,158
arrowtooth flounder	*Atheresthes stomias*	214.3	5.6	517
Pacific ocean perch	*Sebastes alutus*	107.1	2.8	173
Pacific cod	*Gadus macrocephalus*	98.0	2.6	47
flathead sole	*Hippoglossoides elassodon*	97.8	2.6	439
empty gastropod shells	Gastropoda (class)	90.1	2.4	116
northern sea nettle	*Chrysaora melanaster*	82.2	2.2	207
rock sole sp.	*Lepidopsetta* sp.	60.4	1.6	169
sea anemone unident.	Actiniaria (order)	52.5	1.4	218
hermit crab unident.	Paguridae (family)	45.8	1.2	354
snail unident.	Gastropoda (class)	38.6	1.0	345
compound ascidian unident.	Ascidiacea (class)	33.8	0.9	-
Kamchatka flounder	*Atheresthes evermanni*	29.9	0.8	39
basketstar	*Gorgonocephalus eucnemis* (prev *G. caryi*)	27.0	0.7	202
Alaska skate	*Bathyraja parmifera*	25.2	0.7	11
yellow Irish lord	*Hemilepidotus jordani*	22.0	0.6	25
snow crab	*Chionoecetes opilio*	21.2	0.6	209
great sculpin	*Myoxocephalus polyacanthocephalus*	24.5	0.6	8
purple-orange sea star	*Asterias amurensis*	19.9	0.5	153
bigmouth sculpin	*Hemitripterus bolini*	14.0	0.4	3
Tanner crab	*Chionoecetes bairdi*	12.9	0.3	88
northern sea star	*Dipsacaster borealis*	10.4	0.3	904
yellowfin sole	*Limanda aspera*	8.6	0.2	24
Greenland turbot	*Reinhardtius hippoglossoides*	8.3	0.2	7
Alaska plaice	*Pleuronectes quadrituberculatus*	7.8	0.2	8
Pacific halibut	*Hippoglossus stenolepis*	6.0	0.2	2
northern rockfish	*Sebastes polyspinis*	5.0	0.1	7
sponge unident.	Porifera (phylum)	4.9	0.1	1
starfish unident.	Asteroidea (class)	4.4	0.1	17
sturgeon poacher	*Podothecus acipenserinus*	3.3	0.1	41
northern rock sole	*Lepidopsetta polyxystra*	2.9	0.1	4
rex sole	*Glyptocephalus zachirus*	2.8	0.1	6
sea mouse	*Aphrodita negligens*	2.5	0.1	62
blackspined sea star	*Lethasterias nanimensis*	2.4	0.1	2
common mud star	*Ctenodiscus crispatus*	2.0	0.1	206
skate egg case	Rajiformes (order) egg case	1.9	0.1	-
Oregon triton	*Fusitriton oregonensis*	1.4	<0.1	22
Pacific lyre crab	*Hyas lyratus*	1.4	<0.1	29
Welk unident.	*Neptunea* sp.	1.3	<0.1	24

Table 4. -- Continued.

Common name	Scientific name	Weight (kg)	Weight (%)	Number
searcher	*Bathymaster signatus*	1.3	<0.1	6
pandalid shrimp unident.	Pandalidae (family)	1.0	<0.1	284
smooth lumpsucker	*Aptocyclus ventricosus*	1.0	<0.1	1
tentacle-shedding anemone	*Liponema brevicornis*	1.0	<0.1	1
Leptasterias polaris	*Leptasterias polaris*	0.9	<0.1	2
empty bivalve shells	Bivalvia (class)	0.6	<0.1	22
jellyfish unident.	Scyphozoa (class)	0.6	<0.1	2
snail eggs	Gastropoda (class)	0.6	<0.1	3
bivalve unident.	Bivalvia (class)	0.6	<0.1	6
red king crab	*Paralithodes camtschaticus*	0.6	<0.1	-
cushion sea star	*Pteraster temnochiton*	0.5	<0.1	4
Arctic cod	*Boreogadus saida*	0.5	<0.1	16
spectacled sculpin	*Triglops scepticus*	0.4	<0.1	17
eelpout unident.	Zoarcidae (family)	0.4	<0.1	3
lamprey unident.	Petromyzontidae (family)	0.4	<0.1	3
sawback poacher	*Leptagonus frenatus*	0.4	<0.1	7
obscure sea star	*Pteraster obscurus*	0.4	<0.1	7
green sea urchin	*Strongylocentrotus droebachiensis*	0.3	<0.1	2
sea urchin unident.	Echinoidia (class)	0.2	<0.1	2
dragon poacher	*Percis japonicus*	0.2	<0.1	1
sea whip unident.	Octocorallia (subclass)	0.2	<0.1	9
northern shrimp	*Pandalus borealis*	0.2	<0.1	31
spinyhead sculpin	*Dasycottus setiger*	0.2	<0.1	2
shortfin eelpout	*Lycodes brevipes*	0.2	<0.1	4
crangonid shrimp unident.	Crangonidae (family)	0.2	<0.1	58
Japatella diaphana	*Japatella diaphana*	0.2	<0.1	1
snailfish unident.	Liparidiae (family)	0.2	<0.1	1
Aurelia labiata	*Aurelia labiata*	0.1	<0.1	22
Volutopsius snail	*Volutopsius* sp.	0.1	<0.1	1
brittlestar unident.	Ophiuroidea (class)	0.1	<0.1	14
northern smoothtongue	*Leuroglossus schmidti*	0.1	<0.1	21
Beringius stimpsoni	*Beringius stimpsoni*	0.1	<0.1	1
Bering skate	*Bathyraja interrupta*	0.1	<0.1	1
frond-aeolis	*Dendronotus frondosus*	0.1	<0.1	13
spatulate sculpin	*Icelus spatula*	0.1	<0.1	5
shrimp unident.	Decapoda (order)	0.1	<0.1	18
Arctic welk	*Plicifusus (Colus) kroyeri*	<0.1	<0.1	1
salmon snailfish	*Careproctus rastrinus*	<0.1	<0.1	1
keeled aforia	*Aforia circinata*	<0.1	<0.1	3

Table 4. -- Continued.

Common name	Scientific name	Weight (kg)	Weight (%)	Number
polychaete worm unident.	Polychaeta (class)	<0.1	<0.1	1
capelin	*Mallotus villosus*	<0.1	<0.1	1
snake prickleback	*Lumpenus sagitta*	<0.1	<0.1	1
hydrocoral unident.	Anthoathecatae (order)	<0.1	<0.1	2
striped sea leech	*Carcinobdella cyclostomum*	<0.1	<0.1	3
tunicate unident.	Ascidiacea (class)	<0.1	<0.1	5
Totals		3,807.4		8,456

Table 5. -- Catch by species from 26 of 42 Methot trawl hauls conducted during the summer 2008 walleye pollock echo integration-trawl survey on the Bering Sea shelf. Catches from trawls for live euphausids are not included.

Common name	Scientific name	Weight (kg)	Weight (%)	Number
euphausiid unident.	Euphausiidae (family)	87.6	43.6	1,066,631
northern sea nettle	*Chrysaora melanaster*	81.8	40.7	267
fried egg jellyfish	*Phacellophora camtchatica*	25.7	12.8	51
smooth lumpsucker	*Aptocyclus ventricosus*	3.1	1.6	1
Pacific lamprey	*Lampetra tridentata*	1.2	0.6	6
Aurelia labiata	*Aurelia labiata*	1.2	0.6	65
jellyfish unident.	Scyphozoa (class)	0.1	<0.1	3
notched brittlestar	*Ophiura sarsi*	0.1	<0.1	135
salps unident.	Thaliacea (class)	<0.1	<0.1	13
humpy shrimp	*Pandalus goniurus*	<0.1	<0.1	23
hairy cockle	*Clinocardium ciliatum*	<0.1	<0.1	3
amphipod unident.	amphipoda (order)	<0.1	<0.1	31
common mud star	*Ctenodiscus crispatus*	<0.1	<0.1	18
Crangon shrimp unident	*Crangon sp.*	<0.1	<0.1	6
tube worm unident.	Canalipalpata (order)	<0.1	<0.1	12
snail unident.	Gastropoda (class)	<0.1	<0.1	7
fish larvae unident.	Actinopterygii (class)	<0.1	<0.1	2
northern smoothtongue	*Leuroglossus schmidti*	<0.1	<0.1	2
Totals		200.9		1,067,276

Table 6.-- Numbers of fish measured and biological samples collected during the summer 2008 echo integration-trawl survey of walleye pollock on the Bering Sea shelf.

Haul	Pollock				*Chrysaora melanaster*	TINRO
No.	Length	Weight	Maturity	Otoliths	bell diameter	collection*
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	-	-	-	-	-	-
4	-	-	-	-	-	-
5	193	36	36	36	-	50
6	-	-	-	-	-	-
7	-	-	-	-	-	-
8	-	-	-	-	-	-
9	393	47	47	47	-	50
10	-	-	-	-	-	-
11	242	50	50	50	-	50
12	241	-	-	-	-	-
13	-	-	-	-	-	-
14	-	-	-	-	51	-
15	24	24	24	24	-	-
16	-	-	-	-	-	-
17	-	-	-	-	-	-
18	-	-	-	-	-	-
19	-	-	-	-	-	-
20	-	-	-	-	-	-
21	271	70	70	70	-	50
22	664	88	59	88	-	50
23	-	-	-	-	-	-
24	366	55	55	55	-	50
25	525	58	58	58	-	50
26	133	50	50	50	-	-
27	401	52	52	52	-	-
28	-	-	-	-	-	-
29	-	-	-	-	-	-
30	-	-	-	-	-	-
31	165	53	53	53	-	-
32	-	-	-	-	-	-
33	-	-	-	-	-	-
34	-	-	-	-	-	-
35	70	-	-	-	-	-
36	330	48	48	48	-	-
37	209	30	30	30	-	50
38	420	70	35	70	-	-
39	253	67	54	67	-	50
40	1	-	-	-	-	-
41	428	47	40	47	-	-
42	-	-	-	-	-	-
43	-	-	-	-	-	-
44	262	31	31	31	-	-
45	585	51	30	51	-	-
46	11	-	-	-	-	-
47	329	45	35	45	-	50
48	-	-	-	-	-	-
49	2	2	-	2	-	-
50	16	16	-	16	-	-
51	329	45	30	43	-	50
52	303	30	30	30	-	-
53	398	79	53	79	-	-

Table 6. -- Continued.

Haul No.	Pollock Length	Weight	Maturity	Otoliths	*Chrysaora melanaster* bell diameter	TINRO collection*
54	186	61	35	61	29	-
55	-	-	-	-	-	-
56	-	-	-	-	-	-
57	-	-	-	-	-	-
58	337	67	35	67	27	-
59	406	53	53	53	-	50
60	-	-	-	-	-	-
61	119	19	19	19	-	-
62	-	-	-	-	-	-
63	495	48	48	48	-	-
64	382	96	55	96	-	50
65	541	72	50	72	-	-
66	452	39	39	39	-	-
67	293	35	35	35	-	-
68	291	37	37	37	-	-
69	151	-	-	-	-	-
70	-	-	-	-	-	-
71	447	54	54	54	-	50
72	515	100	50	100	-	-
73	-	-	-	-	-	-
74	-	-	-	-	-	-
75	-	-	-	-	-	-
76	-	-	-	-	-	-
77	-	-	-	-	-	-
78	-	-	-	-	-	-
79	322	29	29	29	-	-
80	220	25	25	25	-	-
81	-	-	-	-	-	-
82	531	55	55	55	-	50
83	361	35	35	35	-	-
84	232	23	23	23	-	-
85	289	26	26	26	-	-
86	96	21	21	21	1	-
87	-	-	-	-	-	-
88	-	-	-	-	-	-
89	-	-	-	-	-	-
90	-	-	-	-	-	-
91	525	93	50	93	-	-
92	432	52	52	52	-	50
93	644	47	45	47	-	-
94	352	59	52	59	-	-
95	-	-	-	-	-	-
96	78	48	48	48	-	-
97	236	20	19	19	-	50
98	384	36	36	36	-	-
99	160	43	43	43	-	-
100	210	25	25	25	-	-
101	299	22	22	22	-	-
102	-	-	-	-	-	-
103	44	20	20	20	-	-
104	-	-	-	-	-	-
105	228	25	20	20	-	-
106	-	-	-	-	-	-
107	475	33	33	33	-	50

Table 6. -- Continued.

Haul	Pollock				*Chrysaora melanaster*	TINRO
No.	Length	Weight	Maturity	Otoliths	bell diameter	collection*
108	346	33	33	33	-	50
109	391	34	24	34	-	-
110	380	-	-	-	-	50
111	382	-	-	-	-	-
112	429	-	-	-	-	-
113	379	-	-	-	-	-
114	295	-	-	-	-	-
115	460	-	-	-	-	-
116	471	-	-	-	-	-
117	343	-	-	-	-	-
118	440	-	-	-	-	-
119	296	-	-	-	-	-
120	368	-	-	-	-	-
121	363	-	-	-	-	-
122	512	-	-	-	-	-
123	576	-	-	-	-	-
124	484	-	-	-	-	-
125	447	-	-	-	-	-
126	370	-	-	-	-	-
127	367	-	-	-	-	-
128	461	-	-	-	-	-
129	466	-	-	-	-	-
130	533	1	1	1	-	-
131	398	-	-	-	-	-
132	486	-	-	-	-	-
133	468	-	-	-	-	-
Totals	29,208	2,630	2,217	2,622	108	1,000

*TINRO center biological sampling included pollock length, scale sample, sex, maturity, stomach fullness, and visual predominant food determination.

Table 7. -- Walleye pollock biomass from summer echo integration-trawl surveys on the U.S. EEZ portion of the Bering Sea shelf, 1994-2008. Data for the Steller sea lion Conservation Area (SCA), east of 170°W minus the SCA (E170-SCA), and the U.S. west of 170°W (W170) are estimated pollock biomass between near surface and 3 m off bottom. Relative estimation error for the biomass is indicated.

Date		**Area** (nmi)^2	**Biomass, million metric tons (top) and percent of total (bottom)** **SCA**	**E170-SCA**	**W170**	**Total biomass (million metric tons)**	**Relative estimation error**
1994	9 Jul-19 Aug	78,251	0.312	0.399	2.176	2.886	0.047
			10.8	13.8	75.4		
1996	20 Jul-30 Aug	93,810	0.215	0.269	1.826	2.311	0.039
			9.3	11.7	79.0		
1997	17 Jul-4 Sept	102,770	0.246	0.527	1.818	2.591	0.037
			9.5	20.3	70.2		
1999	7 Jun-5 Aug	103,670	0.299	0.579	2.408	3.290	0.055
			9.1	17.6	73.2		
2000	7 Jun-2 Aug	106,140	0.393	0.498	2.158	3.049	0.032
			12.9	16.3	70.8		
2002	4 Jun -30 Jul	99,526	0.647	0.797	2.178	3.622	0.031
			17.9	22.0	60.1		
2004	4 Jun -29 Jul	99,659	0.498	0.516	2.293	3.307	0.037
			15.1	15.6	69.3		
2006	3 Jun -25 Jul	89,550	0.131	0.254	1.175	1.560	0.039
			8.4	16.3	75.3		
2007	2 Jun -30 Jul	92,944	0.084	0.168	1.517	1.769	0.045
			4.7	9.5	85.8		
2008	2 Jun -31 Jul	95,374	0.085	0.029	0.883	0.997	0.076
			8.5	2.9	88.6		

Table 8. -- Numbers-at-length estimates (millions) of walleye pollock between near surface and 3 m off bottom from echo integration-trawl surveys in the U.S. EEZ, 1994-2008.

Length cm	**1994**	**1996**	**1997**	**1999**	**2000**	**2002**	**2004**	**2006**	**2007**	**2008**
0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0.03	0	0	0	0	0
9	0	0	0	0.01	0.03	0	0	0	0	0
10	0	0	2.04	0.12	0.76	0.01	0.24	0	30.12	0
11	0.40	0	0.19	4.78	2.30	0.77	0.20	5.29	259.94	0.74
12	5.44	0.47	30.13	14.43	5.50	4.70	2.56	59.83	662.11	2.82
13	44.79	5.44	238.10	22.71	19.26	21.36	2.38	144.42	1329.40	6.70
14	94.23	38.20	1416.21	22.35	36.70	100.48	4.08	117.62	1497.71	9.47
15	179.82	131.29	2949.25	16.20	56.69	194.98	1.84	84.56	803.75	6.13
16	166.05	227.77	3364.00	5.20	79.57	178.72	1.80	27.81	563.45	4.38
17	105.16	317.31	2207.83	5.20	50.81	99.74	1.76	10.15	304.30	7.78
18	129.71	215.26	1309.13	12.92	22.39	33.47	1.12	2.90	114.54	49.99
19	212.54	115.39	569.51	44.60	30.27	40.07	4.34	4.73	134.02	128.23
20	381.96	64.79	181.06	152.57	47.16	61.90	8.40	10.85	118.15	264.22
21	589.69	37.20	74.90	251.49	92.37	162.63	23.15	17.43	145.72	402.13
22	794.28	64.41	81.07	314.31	136.41	289.69	34.90	31.71	147.44	440.61
23	788.35	60.24	150.80	288.90	185.76	485.72	47.06	37.50	129.61	568.91
24	772.58	70.32	255.93	220.31	186.04	734.73	48.21	33.77	143.00	447.11
25	581.45	47.68	408.07	164.37	207.95	859.82	39.35	30.25	91.89	357.46
26	372.26	38.32	458.83	188.58	186.91	832.36	32.49	24.95	65.22	241.72
27	198.97	33.63	519.67	256.04	187.68	718.04	25.99	21.77	49.91	115.47
28	122.07	60.16	422.68	302.47	168.93	516.42	29.43	25.52	33.06	79.93
29	135.90	85.07	296.50	419.16	164.76	491.26	69.82	29.78	21.87	104.00
30	138.25	122.81	175.36	435.28	167.17	507.57	90.09	35.24	18.48	129.13
31	178.83	183.98	115.83	417.13	169.72	592.86	148.82	42.19	16.52	119.63
32	234.80	240.98	79.12	410.19	167.23	539.68	151.19	45.36	35.54	135.96
33	239.39	341.56	69.15	372.65	188.70	533.40	180.25	51.47	47.43	117.44
34	291.50	408.41	68.83	393.58	221.59	421.17	185.43	68.74	62.30	112.26
35	296.57	458.38	89.48	415.94	332.90	291.90	237.90	82.66	76.83	82.94
36	326.66	477.95	146.28	433.11	360.41	239.36	302.68	111.93	66.27	40.17
37	343.99	400.98	220.62	393.54	414.22	218.57	430.24	118.70	83.30	28.85
38	305.79	333.42	321.35	403.47	369.24	222.31	476.40	124.99	79.97	23.58
39	294.82	253.70	397.12	359.07	344.63	218.51	539.43	118.56	86.07	32.67
40	311.31	214.24	397.83	304.48	297.14	209.21	499.73	126.41	111.65	23.19

Table 8. -- Continued.

Length cm	1994	1996	1997	1999	2000	2002	2004	2006	2007	2008
41	271.09	168.18	350.37	243.06	331.55	200.43	511.11	140.54	120.23	24.95
42	289.53	154.99	292.97	240.38	316.41	179.46	475.59	154.29	153.14	26.81
43	273.09	149.27	222.05	265.33	331.24	186.32	453.93	163.58	207.58	38.14
44	243.93	133.46	172.49	321.32	302.44	185.26	388.07	178.01	210.12	39.27
45	256.58	117.96	125.08	328.57	290.08	197.15	339.54	170.87	233.42	44.81
46	216.09	103.48	93.20	304.97	249.82	183.59	247.30	158.64	235.18	50.85
47	177.93	98.39	74.75	238.84	235.52	182.87	196.13	146.34	204.08	54.78
48	148.15	94.29	59.37	182.91	176.81	168.36	150.84	130.84	163.92	54.71
49	73.11	83.67	45.51	122.90	143.24	154.43	113.57	105.90	140.07	47.05
50	66.74	79.87	40.23	88.16	106.27	133.48	78.29	88.25	107.33	41.79
51	33.15	72.52	33.10	60.42	78.54	117.74	64.53	73.93	75.97	39.74
52	30.35	60.21	31.72	42.15	48.15	91.92	56.33	62.45	53.78	29.92
53	18.15	50.89	29.59	33.02	35.75	88.43	41.08	45.82	41.44	23.84
54	15.68	38.44	23.91	26.90	22.09	62.98	30.20	35.31	32.67	21.89
55	18.57	25.63	19.77	16.14	16.58	44.34	19.12	23.01	23.66	16.11
56	11.05	14.07	14.58	9.26	12.58	40.16	14.43	19.33	16.43	12.38
57	9.52	7.65	10.61	9.40	8.92	24.16	8.83	14.93	13.42	10.47
58	4.85	7.68	8.60	5.68	6.41	18.77	5.83	10.63	7.51	9.21
59	2.96	3.02	5.98	3.24	5.13	11.26	6.16	8.11	4.76	8.31
60	3.47	4.71	3.45	3.04	1.87	10.58	4.00	5.39	3.72	7.39
61	6.63	2.88	4.58	2.40	2.30	7.11	2.89	4.60	1.86	4.09
62	1.39	1.79	1.55	2.12	1.72	3.92	1.95	2.07	1.13	4.94
63	0.71	0.28	2.01	0.62	1.57	2.18	2.07	1.17	1.09	2.62
64	0.49	0.59	0.47	0.57	0.98	1.74	0.08	1.98	1.06	2.12
65	1.86	0.85	0.81	0.93	0.64	1.74	0.30	0.73	0.48	1.48
66	0.77	0.35	0.32	1.42	0.70	1.16	0.55	0.85	0.60	0.67
67	0.97	0.66	1.27	0.48	0.03	0.27	0.35	0.27	0.35	0.58
68	1.46	0	0.19	0.30	0.27	0.17	0.19	0.02	0.21	0.51
69	0	0	0.59	0.29	0.59	0	0	0	0.02	0.12
70	1.93	0	0.10	0	0	0.43	0	0.02	0.30	0.21
71	0.49	0.11	0	<0.01	0	0.01	0	0.14	0.21	0.06
72	0.97	0	0	0.11	0.15	0	0	0.46	0	0.42
73	0.49	0	0.05	0.16	0	0	0	0.02	0	0.04
74	0	0	0	0	0.14	0	0	0	0.06	0.05
75	0	0	0	0.04	0	0	0	0	0	0.03
76	0	0	0	0	0	0	0	0	0	0
77	0	0	0	0	0	0	0	0	0	0
78	0.49	0	0	0	0	0	0	0	0	0
79	0	0	0	0.39	0	0	0	0.08	0	0.06
80	0	0	0	0	0	0	0	0	0	0
Total	10,821	6,525	18,686	9,601	7,630	12,122	6,835	3,396	9,385	4,704

Table 9. -- Biomass-at-length estimates (metric tons) of walleye pollock between near surface and 3 m off bottom on the Bering Sea shelf from echo integration-trawl surveys in the U.S. EEZ, 1994-2008.

Length cm	**1994**	**1996**	**1997**	**1999**	**2000**	**2002**	**2004**	**2006**	**2007**	**2008**
0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	<1	0	0	0	0	0
9	0	0	0	<1	<1	0	0	0	0	0
10	0	0	14	1	8	0	2	0	200	0
11	4	0	2	59	30	9	2	54	2,469	7
12	71	6	394	227	88	75	30	762	7,313	34
13	744	92	4,148	445	370	428	36	2,366	19,068	104
14	1,937	804	31,282	538	859	2,488	81	2,176	25,781	168
15	4,520	3,384	81,544	472	1,613	5,841	48	1,997	17,771	145
16	5,040	7,098	111,182	181	2,713	6,393	57	815	14,870	125
17	3,817	11,818	84,460	214	2,055	4,231	67	365	9,873	254
18	5,553	9,485	58,223	623	1,064	1,664	50	123	4,401	1,923
19	10,655	5,960	28,768	2,499	1,677	2,284	210	235	6,200	5,880
20	22,244	3,892	10,677	9,852	3,017	4,072	498	626	6,392	14,049
21	39,601	2,579	4,900	18,587	6,782	12,242	1,595	1,133	9,810	24,584
22	61,100	5,121	6,101	26,421	11,419	24,828	2,730	2,413	11,643	31,976
23	69,048	5,458	12,962	27,464	17,629	47,351	4,265	3,277	11,513	48,149
24	76,622	7,221	24,999	23,562	19,911	81,309	4,887	3,259	14,551	42,932
25	64,967	5,520	45,081	19,681	24,970	107,760	4,475	3,176	10,266	38,541
26	46,652	4,979	56,998	25,168	25,070	117,666	4,347	3,107	8,010	29,360
27	27,847	4,884	72,339	37,933	28,002	113,478	3,876	2,946	6,844	15,725
28	19,028	9,721	65,700	49,557	27,927	89,827	4,813	3,917	5,073	12,102
29	23,550	15,240	51,328	75,679	30,072	92,941	12,745	5,050	3,697	17,423
30	26,437	24,307	33,691	86,321	33,574	104,158	17,942	6,561	3,462	23,802
31	37,756	40,104	24,685	90,579	37,396	132,640	32,663	9,236	3,428	24,696
32	54,180	57,669	18,522	97,251	40,301	131,538	36,257	10,767	8,606	30,634
33	60,378	89,480	17,709	96,204	49,614	141,718	48,265	13,252	12,233	29,302
34	80,001	116,812	19,201	110,357	63,403	122,045	53,459	19,248	17,643	29,881
35	88,546	142,771	27,148	126,368	103,387	92,414	74,135	25,252	23,484	24,798
36	105,903	161,724	48,272	142,256	121,237	82,291	103,401	36,989	21,662	13,229
37	120,806	147,067	79,075	139,441	150,552	81,503	156,813	41,377	29,517	10,234
38	116,110	132,264	124,841	153,908	144,826	88,680	188,084	47,836	30,240	9,163
39	121,143	108,629	166,999	147,178	145,465	93,405	229,225	49,056	35,953	13,611
40	137,651	98,825	180,668	133,859	135,080	95,675	230,733	55,427	48,709	10,622

Table 9. -- Continued.

Length cm	1994	1996	1997	1999	2000	2002	2004	2006	2007	2008
41	129,335	83,422	171,750	114,415	161,884	98,165	252,339	65,790	54,826	11,866
42	149,294	82,523	154,670	120,957	165,982	94,168	253,443	78,528	72,602	13,379
43	152,526	85,177	125,886	142,492	185,961	104,975	261,967	87,505	105,904	20,806
44	147,017	81,478	104,750	183,897	181,482	110,994	239,860	102,839	111,390	22,429
45	166,444	76,937	81,320	200,114	185,345	125,772	222,131	103,984	131,381	27,203
46	149,720	71,999	64,736	197,389	169,854	124,740	171,216	102,312	143,460	32,686
47	131,130	72,930	55,323	164,067	170,024	132,267	142,845	100,258	131,598	37,569
48	115,921	74,352	46,750	133,183	135,575	129,623	115,709	94,693	112,575	38,443
49	60,566	70,102	38,100	94,742	116,332	126,481	92,215	81,175	101,538	36,199
50	58,531	71,016	35,728	71,872	91,389	115,778	67,512	73,481	85,481	34,038
51	30,462	68,346	31,145	52,026	71,352	108,641	58,478	63,585	64,652	33,569
52	29,789	60,080	31,560	38,303	46,186	89,753	53,394	56,209	49,596	26,625
53	18,463	53,710	31,087	31,630	36,163	91,552	41,489	44,479	39,922	23,325
54	16,856	42,859	26,500	27,130	23,496	68,832	31,998	36,086	34,719	22,249
55	21,296	30,163	23,075	17,129	18,562	51,122	21,285	25,029	26,503	17,789
56	13,207	17,456	17,914	10,327	14,788	48,961	17,136	21,089	19,415	15,024
57	11,943	9,998	13,712	11,013	11,004	30,986	11,453	17,519	16,742	13,074
58	6,368	10,573	11,671	6,984	8,300	25,335	7,517	13,507	9,953	12,444
59	4,167	4,365	8,530	4,174	6,962	15,953	8,825	10,892	6,815	11,544
60	5,001	7,163	5,155	4,104	2,656	15,550	6,038	7,784	5,687	11,354
61	10,199	4,591	7,172	3,394	3,421	11,003	4,574	6,869	2,990	6,534
62	2,285	2,998	2,550	3,135	2,679	6,415	3,214	3,241	1,874	8,250
63	1,196	498	3,448	953	2,551	3,683	3,585	1,937	1,934	4,528
64	844	1,084	843	925	1,660	3,109	139	3,360	1,958	3,835
65	3,382	1,637	1,531	1,562	1,122	3,223	562	1,314	928	2,717
66	1,467	704	617	2,497	1,296	2,202	1,097	1,587	1,212	1,303
67	1,929	1,386	2,622	876	52	505	717	519	734	1,201
68	3,021	0	413	567	551	352	406	46	464	1,072
69	0	0	1,351	585	1,244	0	0	0	45	273
70	4,349	0	230	0	0	945	0	51	720	493
71	1,142	267	0	3	0	33	0	322	538	132
72	2,380	0	0	238	351	0	0	1,084	0	1,016
73	1,239	0	126	362	0	0	0	57	0	112
74	0	0	0	0	362	0	0	0	181	135
75	1,340	0	0	90	0	0	0	0	0	90
76	0	0	0	0	0	0	0	0	0	0
77	0	0	0	0	0	0	0	0	0	0
78	1,503	0	0	0	0	0	0	0	0	0
79	0	0	0	1,118	0	0	0	245	0	181
80	0	0	0	0	0	0	0	0	0	0
Total	2,886,223	2,310,728	2,592,178	3,285,138	3,048,697	3,622,072	3,306,935	1,560,174	1,769,019	996,939

Table 10. -- Estimated numbers-at-age (millions, top panel) and biomass-at-age (thousand metric tons, bottom panel) for walleye pollock observed between near surface and 3 m off bottom in the U.S. EEZ from summer Bering Sea shelf echo integration-trawl surveys 1994-2008.

Age	1994	1996	1997	1999	2000	2002	2004	2006	2007	2008
1	610.2	972.3	12,360.0	111.9	257.9	634.8	15.8	455.6	5588.5	36.5
2	4,781.1	446.4	2,745.2	1,587.6	1,272.3	4,850.4	275.1	208.6	1026.2	2,905.3
3	1,336.0	520.4	386.2	3,597.0	1,184.9	3,295.1	1,189.3	282.0	319.7	1,031.6
4	1,655.7	2,686.5	490.9	1,683.6	2,480.0	1,155.0	2,933.9	610.1	430.1	144.4
5	1,898.1	820.7	1,921.5	582.6	899.7	507.2	1,442.1	695.3	669.2	106.9
6	296.1	509.3	384.4	273.9	243.9	756.8	416.6	551.8	588.8	170.2
7	71.2	434.4	205.2	1,169.1	234.0	436.7	199.2	319.7	305.7	132.4
8	65.2	84.9	142.5	400.2	725.1	91.4	194.0	110.1	166.2	70.7
9	31.9	16.7	32.7	104.6	190.4	110.3	68.3	53.0	60.2	58.2
10	23.2	6.3	3.9	66.9	84.7	205.4	33.5	40.3	18.8	15.0
11	8.5	5.7	4.9	14.5	35.6	52.1	24.8	23.3	20.2	15.1
12	19.3	12.1	2.0	6.5	18.1	17.9	19.8	16.2	5.7	6.9
13	4.8	1.3	2.2	1.7	1.2	3.1	12.1	8.6	1.7	4.5
14	5.7	4.8	2.3	0.0	1.4	5.9	5.8	9.9	2.1	1.9
15	1.2	2.4	2.0	0.1	0.1	0.0	4.3	5.0	1.8	0.9
16	7.9	0.5	0.0	0.1	0.3	0.0	0.0	3.8	0.2	2.0
17	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.6
18	0.0	0.5	0.0	0.4	0.1	0.0	0.0	0.1	0.0	0.6
19	0.7	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.6	0.4
20	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	-
21+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0
Total	10,821	6,525	18,686	9,601	7,630	12,122	6,834	3,396	9,207	4,704.0

Age	1994	1996	1997	1999	2000	2002	2004	2006	2007	2008
1	17.1	36.7	417.8	3.3	8.1	21.2	0.4	8.8	103.4	0.8
2	425.3	35.3	369.9	156.6	144.0	645.1	31.6	21.2	89.5	242.7
3	312.4	118.7	99.5	847.4	284.6	843.7	329.3	68.8	89.3	220.7
4	641.3	888.8	188.6	640.2	974.4	458.2	1349.4	230.7	188.0	58.7
5	1,067.2	396.0	921.0	271.7	488.6	286.0	820.9	366.4	389.8	61.5
6	187.2	341.8	235.0	164.3	156.0	514.5	288.7	359.8	404.3	117.3
7	50.1	359.9	161.3	751.5	166.6	351.6	153.0	244.1	240.9	106.6
8	55.3	72.5	139.5	278.9	540.8	85.6	166.3	93.2	144.8	69.4
9	30.9	16.3	34.2	84.6	149.0	111.0	62.4	49.5	58.4	56.4
10	26.4	6.6	4.4	62.5	76.3	212.5	33.1	39.2	20.7	18.9
11	10.5	6.9	6.1	14.2	39.0	59.6	25.3	23.3	22.3	18.9
12	27.9	17.1	3.4	7.2	16.7	19.7	21.9	18.7	7.1	8.6
13	6.7	1.5	4.5	1.5	1.3	4.6	12.7	10.4	2.1	6.2
14	7.7	7.0	3.8	0.0	2.6	8.5	6.2	12.7	3.7	3.2
15	2.1	3.8	2.9	0.2	0.1	0.0	5.7	5.9	2.2	1.1
16	12.5	0.9	0.0	0.2	0.3	0.0	0.0	4.3	0.3	3.3
17	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.9
18	0.0	0.9	0.0	0.7	0.3	0.0	0.0	0.3	0.0	1.1
19	0.8	0.0	0.0	0.0	0.0	0.0	0.0	2.5	1.0	0.5
20	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	-
21+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.1
Total	2,886	2,311	2,592	3,285	3,049	3,622	3,307	1,560	1,769	996.9

Table 11. -- Estimated numbers and biomass of walleye pollock observed between near the surface and 0.5 m off bottom from Bering Sea echo integration-trawl surveys in the U.S. and in the Cape Navarin area of Russia.

Year	Bering Sea EEZ region	Numbers (billions)	Biomass (million metric tons)	% Biomass	Survey nation	Area (nmi^2)
1994	US	12.60	3.72	85	US	78,250
	Russia	2.77	0.65	15	US	18,460
	Total	15.37	4.37			
2002	US	13.81	4.53	98	US	99,526
	Russia	0.75	0.08	2	Russia	32,270
	Total	14.56	4.61			
2004	US	7.95	4.03	91	US	99,659
	Russia	1.55	0.40	9	US	7,870
	Total	9.51	4.43			
2007	US	10.24	2.40	96	US	92,944
	Russia	1.09	0.11	4	US	12,460
	Total	11.33	2.51			
2008	US	5.47	1.54	98	US	95,374
	Russia	0.07	0.03	2	US	12,073
	Total	5.54	1.58			

Table 12. -- Expected relative changes in walleye pollock biomass by age class after implementing a selectivity correction for eastern Bering Sea shelf surveys to correct for escapement from the 3.2 cm codend liner. The selectivity parameters were based on paired tows with 3.2 and 1.3 cm codend liners conducted in Shelikof Strait in winter 2006.

Year		1996	1997	1999	2000	2002	2004	2006	2007
Difference	age1	4.6%	0.1%	44.4%	18.2%	10.1%	29.0%	32.8%	10.2%
	age2	-0.8%	-0.8%	-1.3%	-0.6%	-0.3%	0.1%	-3.8%	-8.6%
	age3+	-0.2%	-0.3%	-0.2%	-0.1%	-0.1%	-0.0%	-0.4%	-0.8%
Total		-0.1%	-0.3%	-0.2%	-0.1%	-0.1%	-0.0%	-0.2%	-0.4%

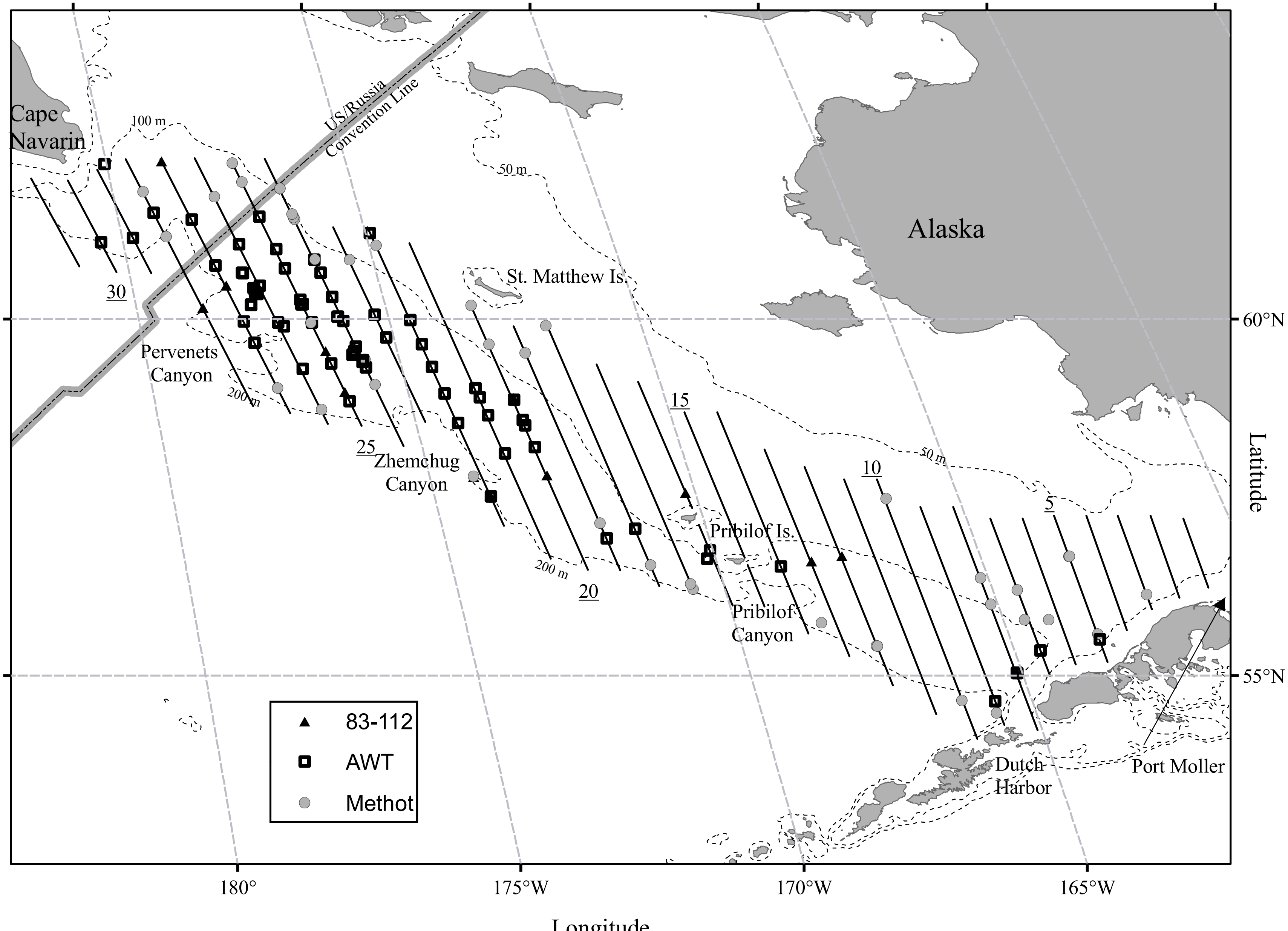


Figure 1. -- Transect lines with locations of midwater (Aleutian wing trawl (AWT), Methot trawl) and bottom trawls (83-112) during the summer 2008 echo integration-trawl survey of walleye pollock on the Bering Sea shelf. Transect numbers are underlined.

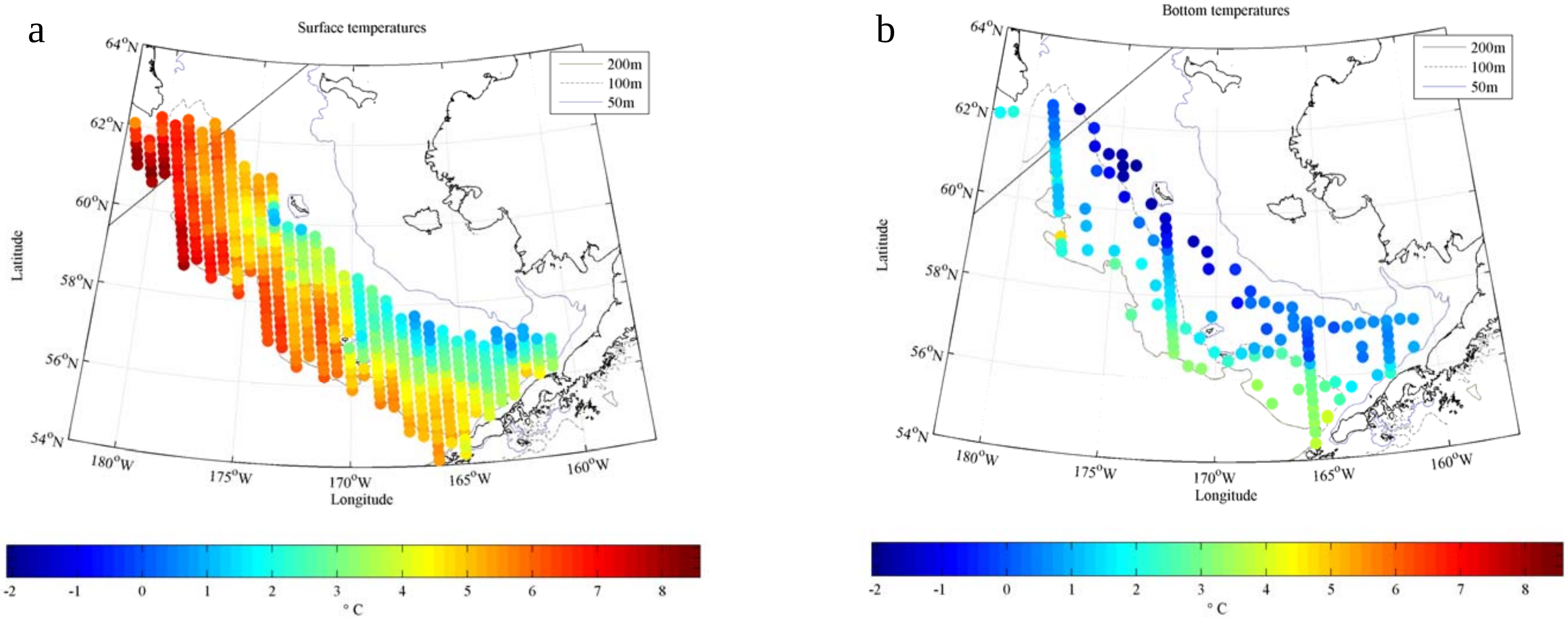
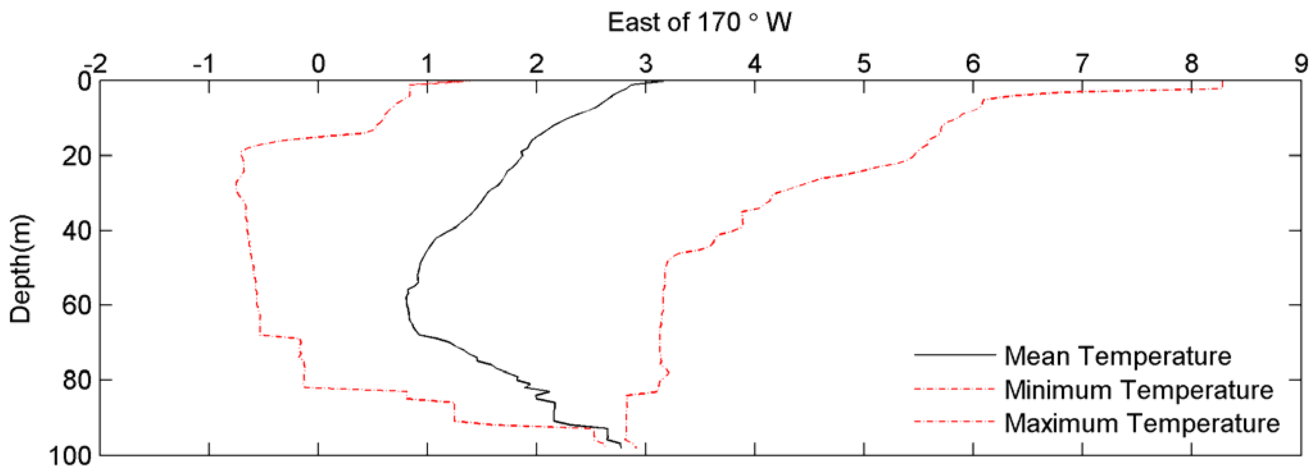


Figure 2. -- Temperature (°C) measured at the sea surface using shipboard surface temperature sensors along survey transects and averaged at 10-nmi resolution (a), and at the bottom using SBE-39s at trawl locations, conductivity-temperature-depth profilers (CTDs), and expendable bathy-thermographs (XBTs) (b) during the summer 2008 echo integration-trawl survey of the Bering Sea shelf.



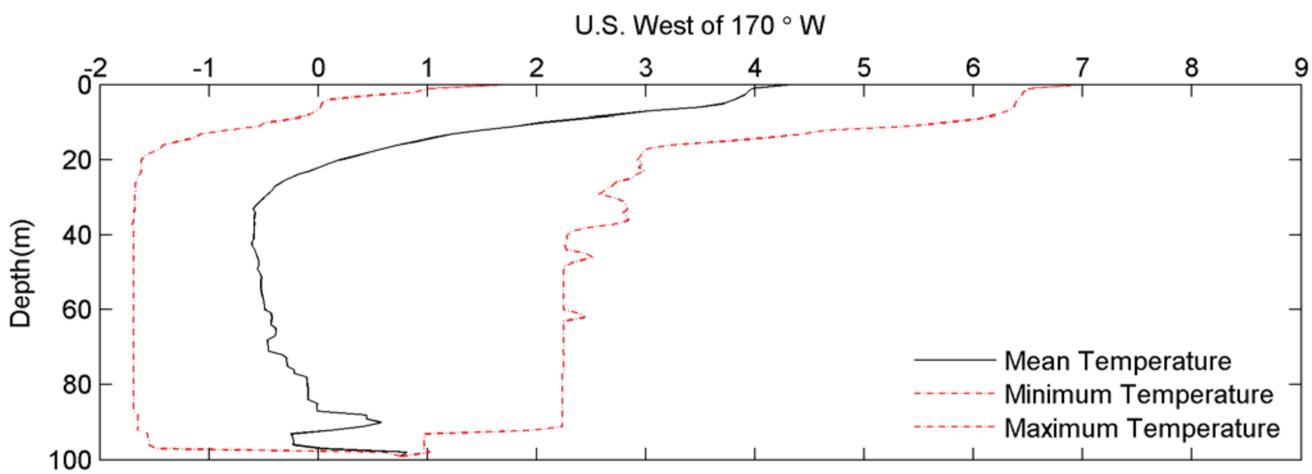


Figure 3. -- Average temperatures (°C, solid black line) by 1-m depth intervals observed over bottom depths ≤ 100-m isobath during the summer 2008 echo integration-trawl survey of walleye pollock in geographic regions of the eastern Bering Sea Shelf. Dashed lines represent minimum and maximum values. No data were collected in bathymetric regions shallower than 100 m in Russia.

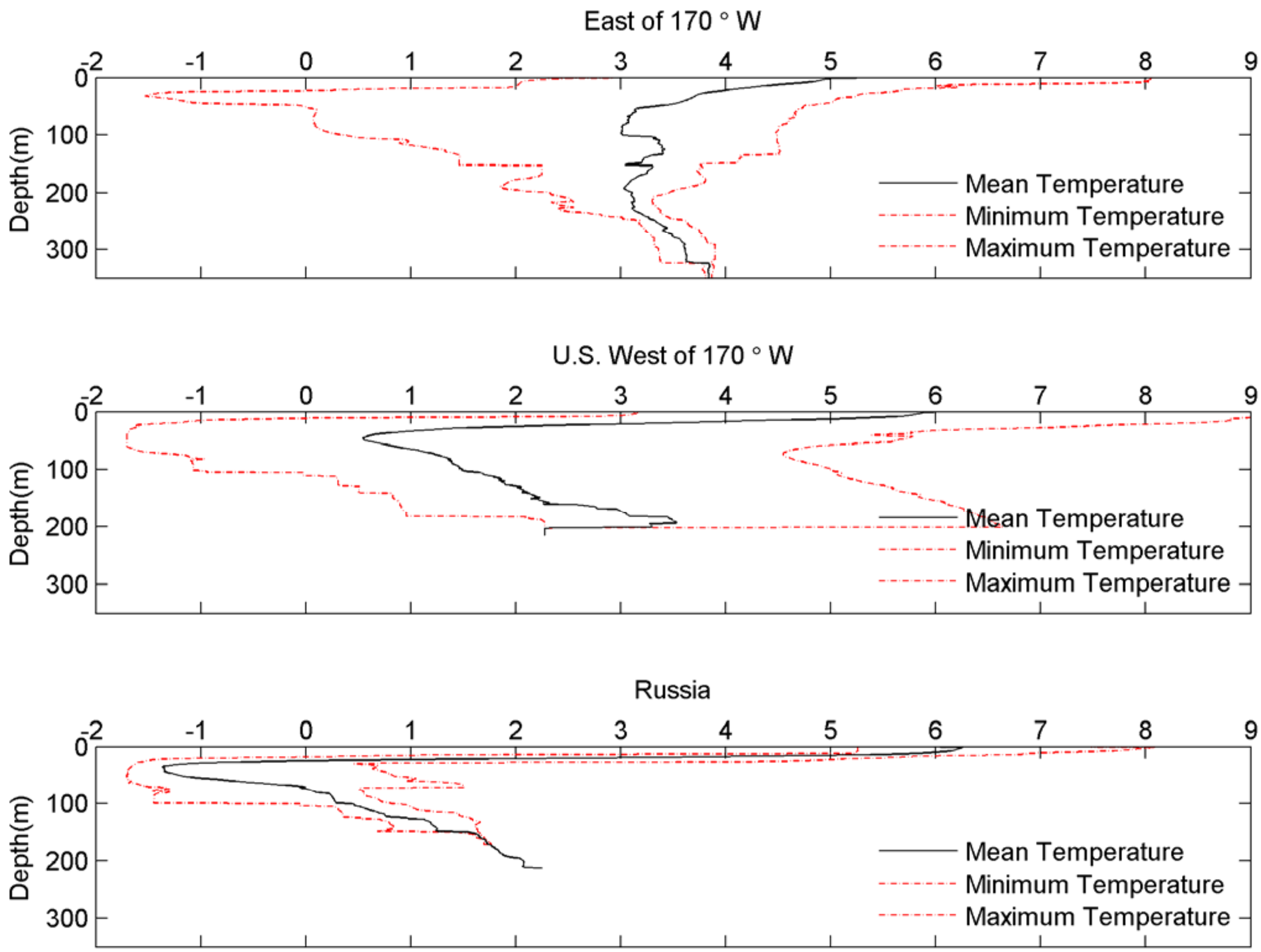


Figure 4. -- Average temperatures (°C, solid black line) by 1-m depth intervals observed over bottom depths > 100-m isobath during the summer 2008 echo integration-trawl survey of walleye pollock in geographic regions of the eastern Bering Sea Shelf. Dashed lines represent minimum and maximum values.

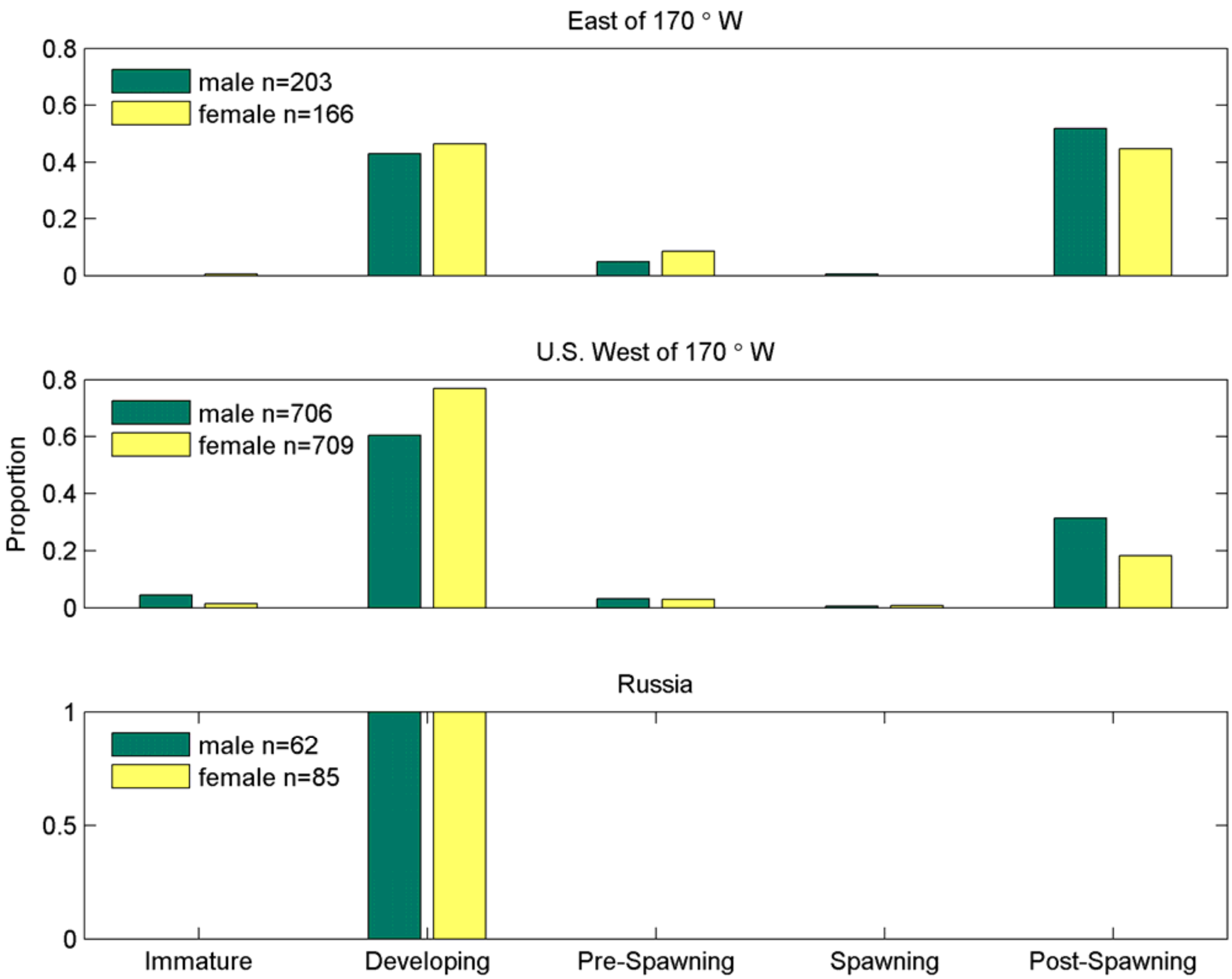


Figure 5. -- Maturity stages by sex for walleye pollock greater than 29 cm observed during the summer 2008 Bering Sea shelf echo integration-trawl survey east of 170°W, in the U.S. west of 170°W, and in Russia.

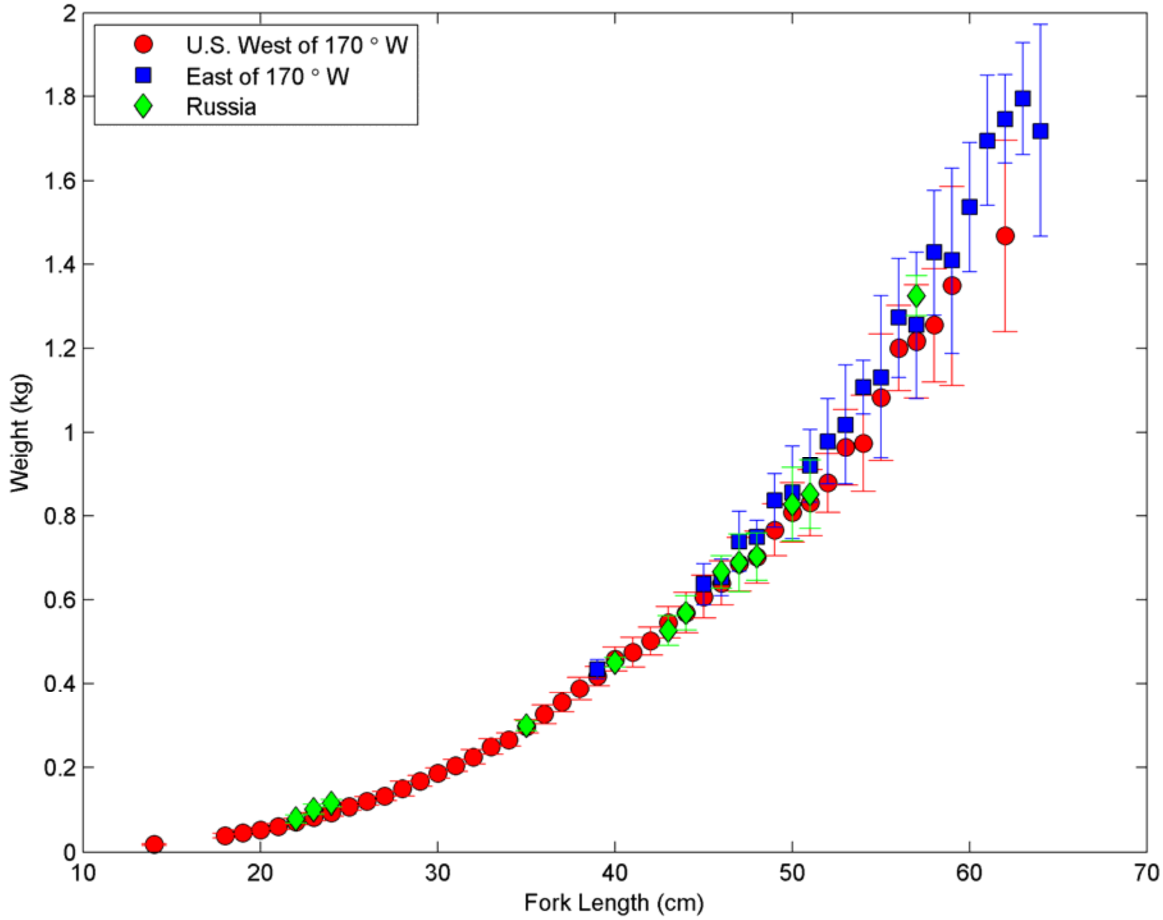


Figure 6. -- Mean weight-at-length for walleye pollock measured in the U.S. east and west of 170°W, and in Russia during the summer 2008 Bering Sea shelf echo integration-trawl survey. Average weights (kg) were computed when > 5 fish were measured at any given length (cm). Error bars represent ±1 standard deviation.

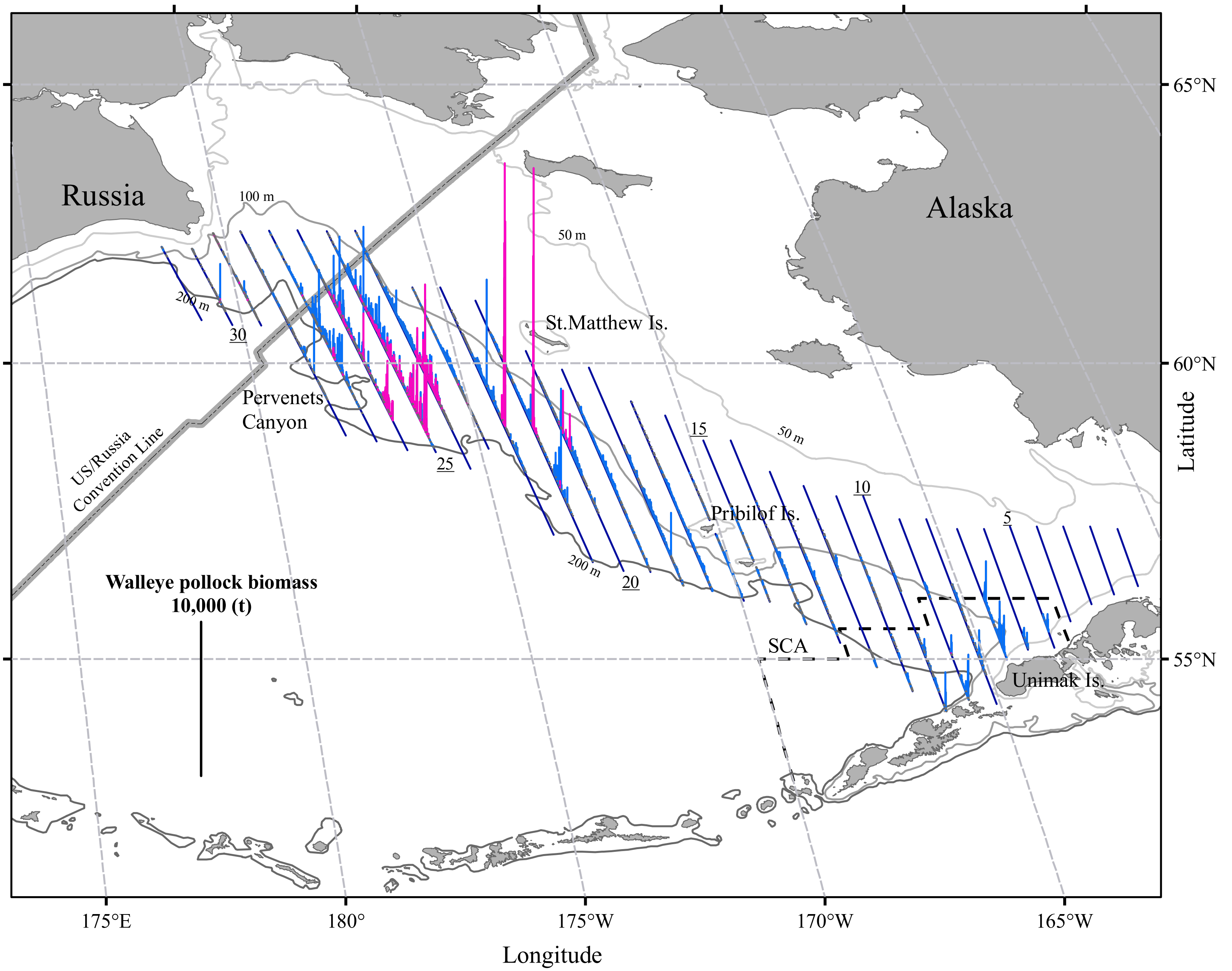


Figure 7 -- Estimated adult (≥30 cm, blue) and juvenile (< 30 cm, pink) walleye pollock biomass (t) by 0.5 nmi interval for the summer 2008 echo integration-trawl survey of the Bering Sea shelf between 3 m off bottom and 16 m from the surface. Transect numbers are underlined, and the Steller sea lion Conservation Area (SCA) is outlined (dashed line). Biomass points ≤ 0.1 t are excluded.

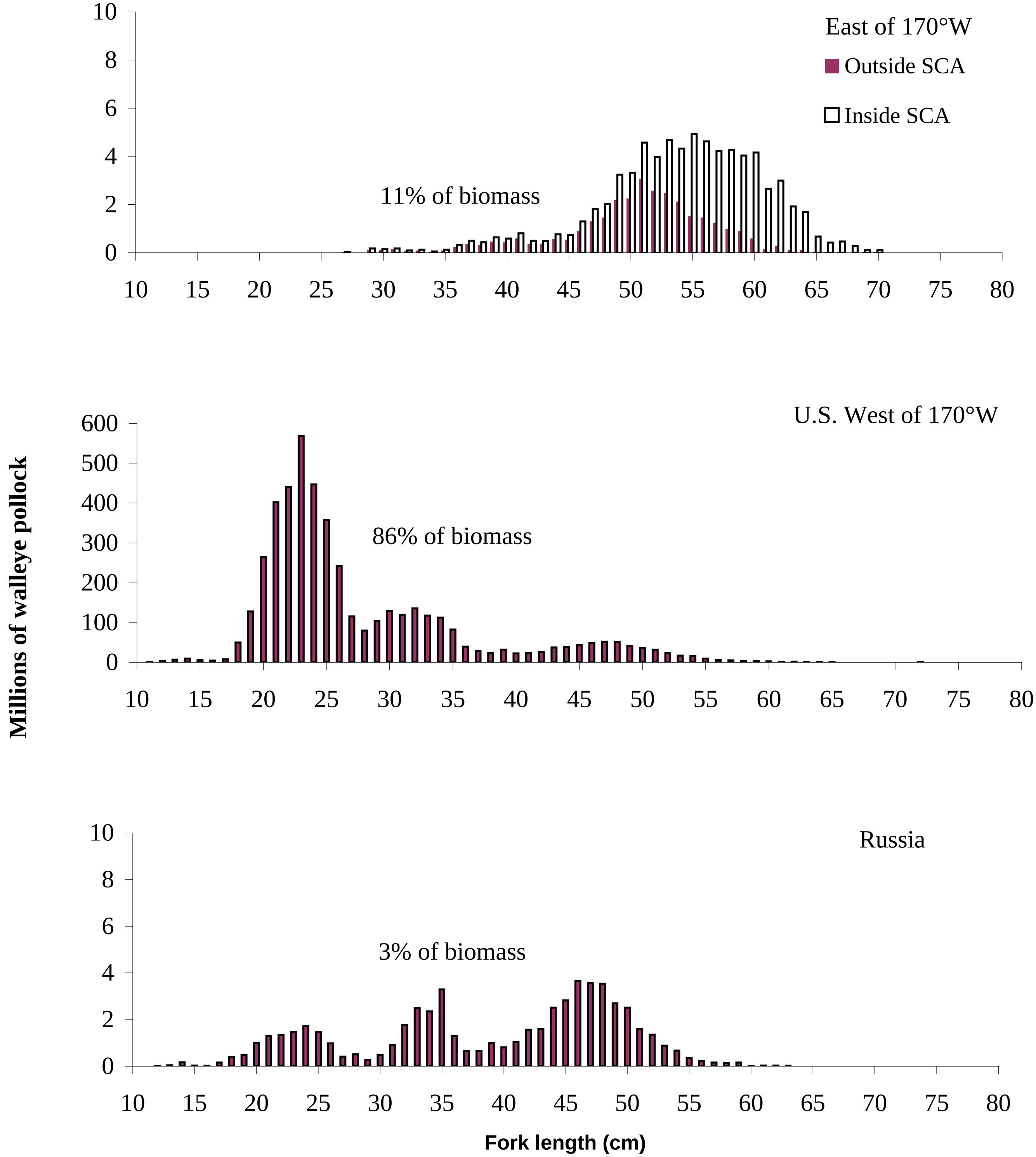


Figure 8. -- Population numbers at length estimated for walleye pollock between 16 m from the surface and 3 m off bottom from the summer Bering Sea shelf acoustic-trawl survey in three geographic regions. Note Y-axes differ.

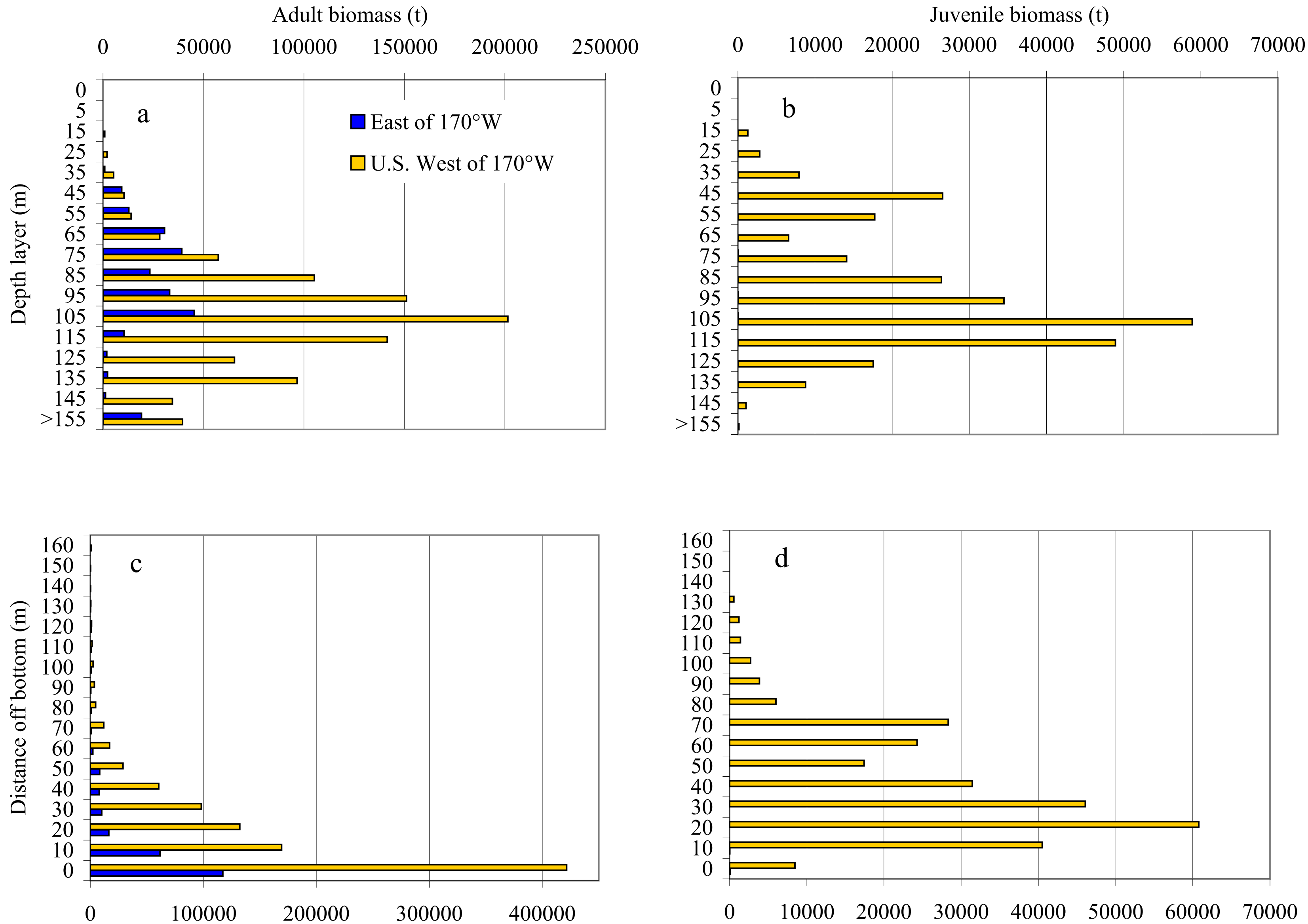


Figure 9. -- Depth distribution of adult (≥ 30 cm FL) and juvenile (< 30 cm FL) walleye pollock biomass (t) observed east and west of 170°W longitude in the U.S. EEZ of the Bering Sea shelf during the summer 2008 echo integration-trawl survey. Depth is referenced to the surface (a,b) and to the bottom (c,d). Note: So few juveniles were observed east of 170°W that they do not show on graph.Y-axes differ.

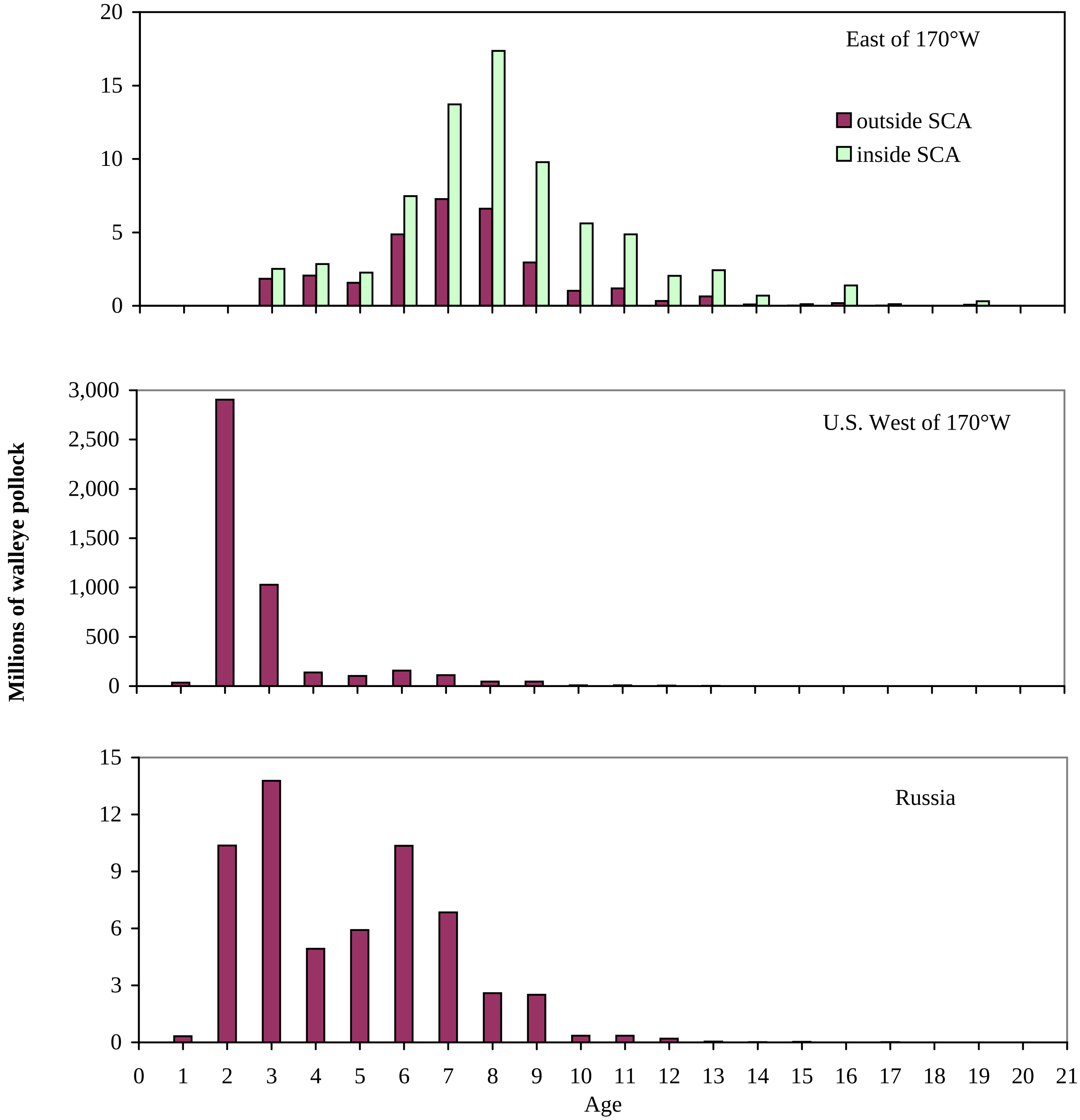


Figure 10. -- Population numbers at age estimated for walleye pollock between 16 m from surface and 3 m off bottom for three different geographic regions during the summer eastern Bering Sea shelf acoustic-trawl survey. Note: Y-axes differ.

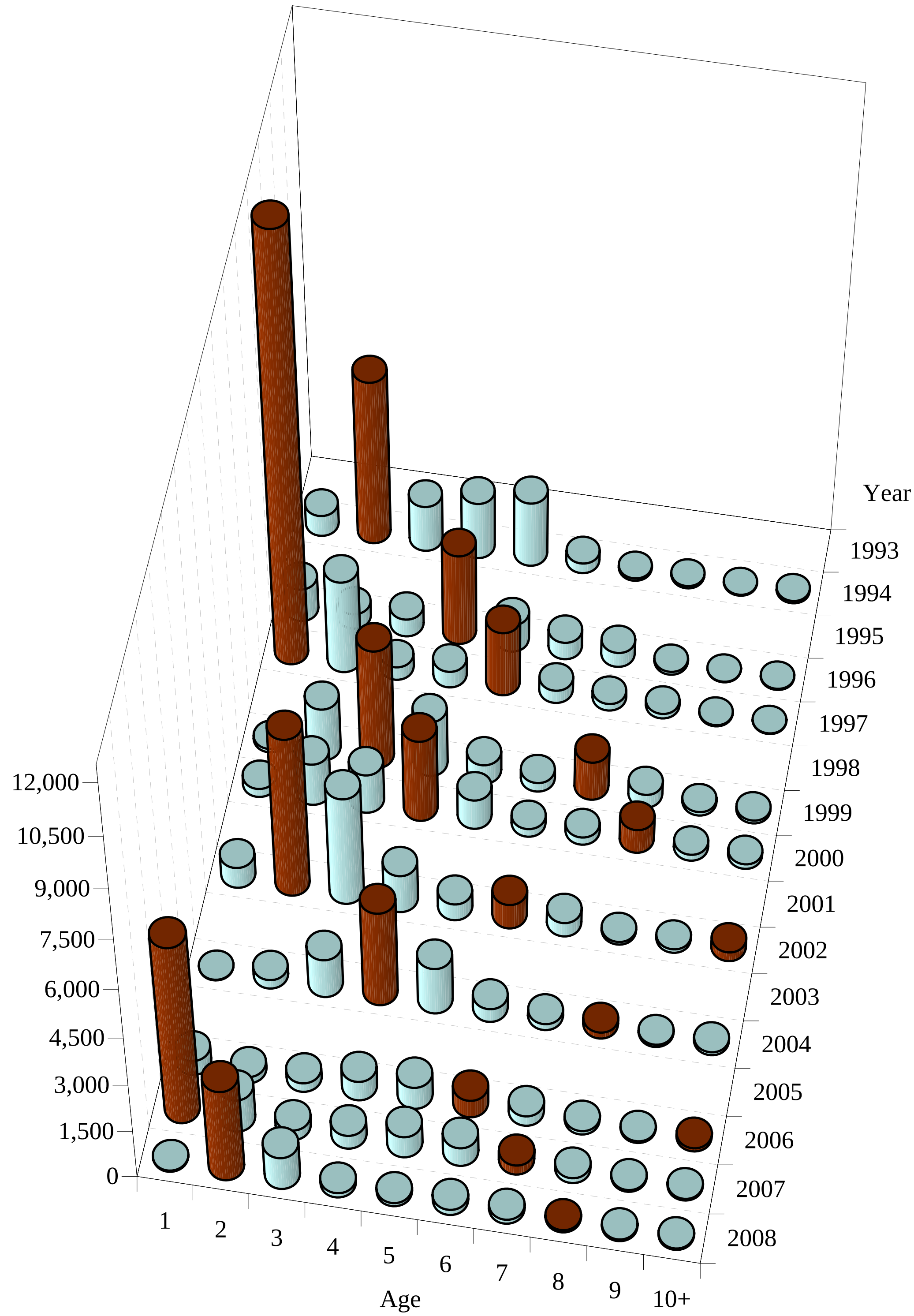


Figure 11. -- Historical numbers at age of walleye pollock between near the surface and 3 m off bottom in the U.S. EEZ for the summer eastern Bering Sea shelf acoustic-trawl surveys between 1994 and 2008. Strong year classes are indicated with dark shading.

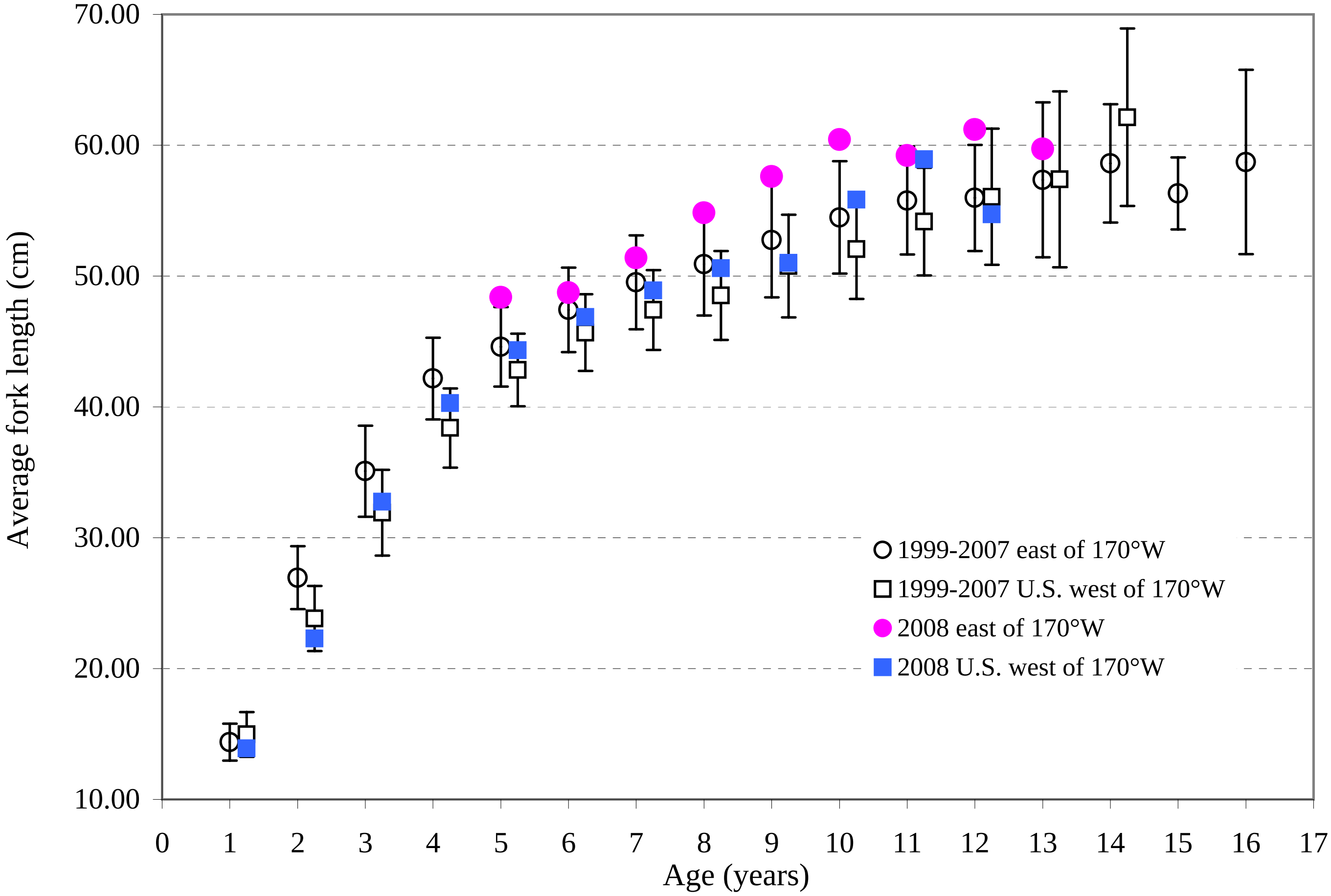
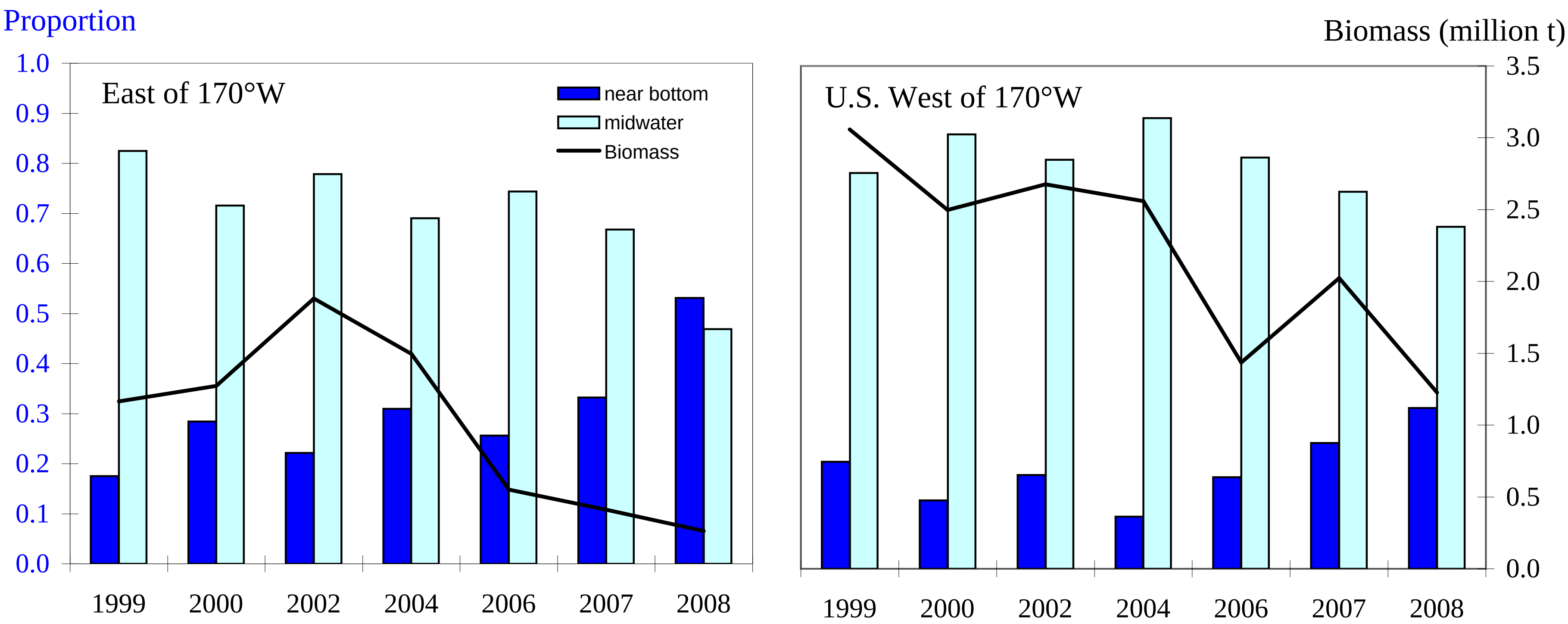


Figure 12. -- Walleye pollock average length at age from summer eastern Bering Sea echo integration-trawl surveys (1999, 2000, 2002, 2004, 2006 and 2007) compared with walleye pollock average length at age for summer 2008. Results are for midwater tows where at least five fish were measured in the U.S. EEZ. Bars show +/- 1 standard deviation for the 1999-2007 series.



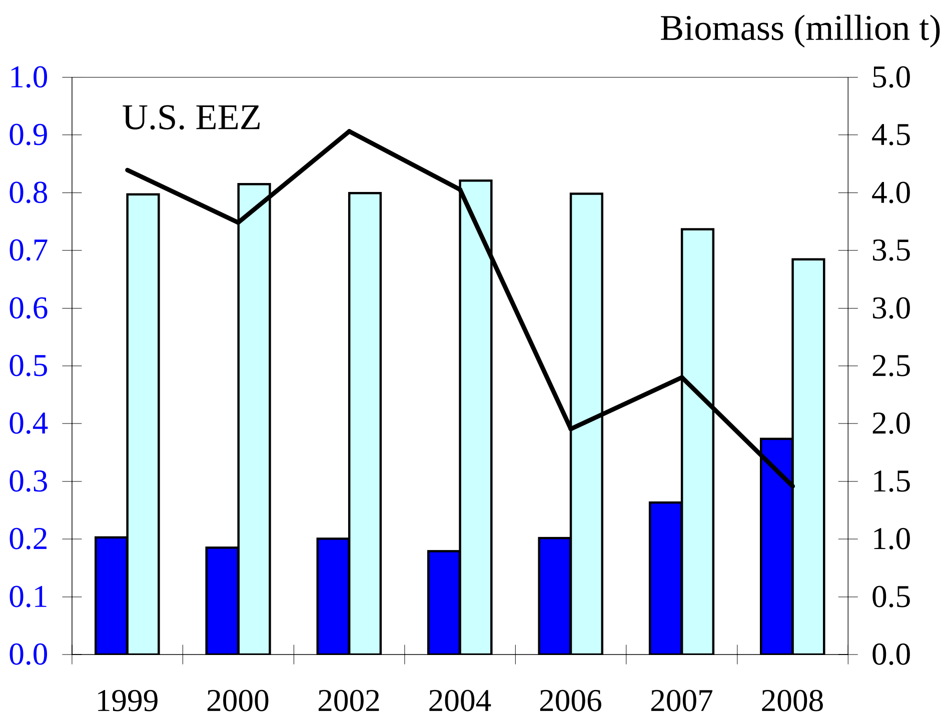
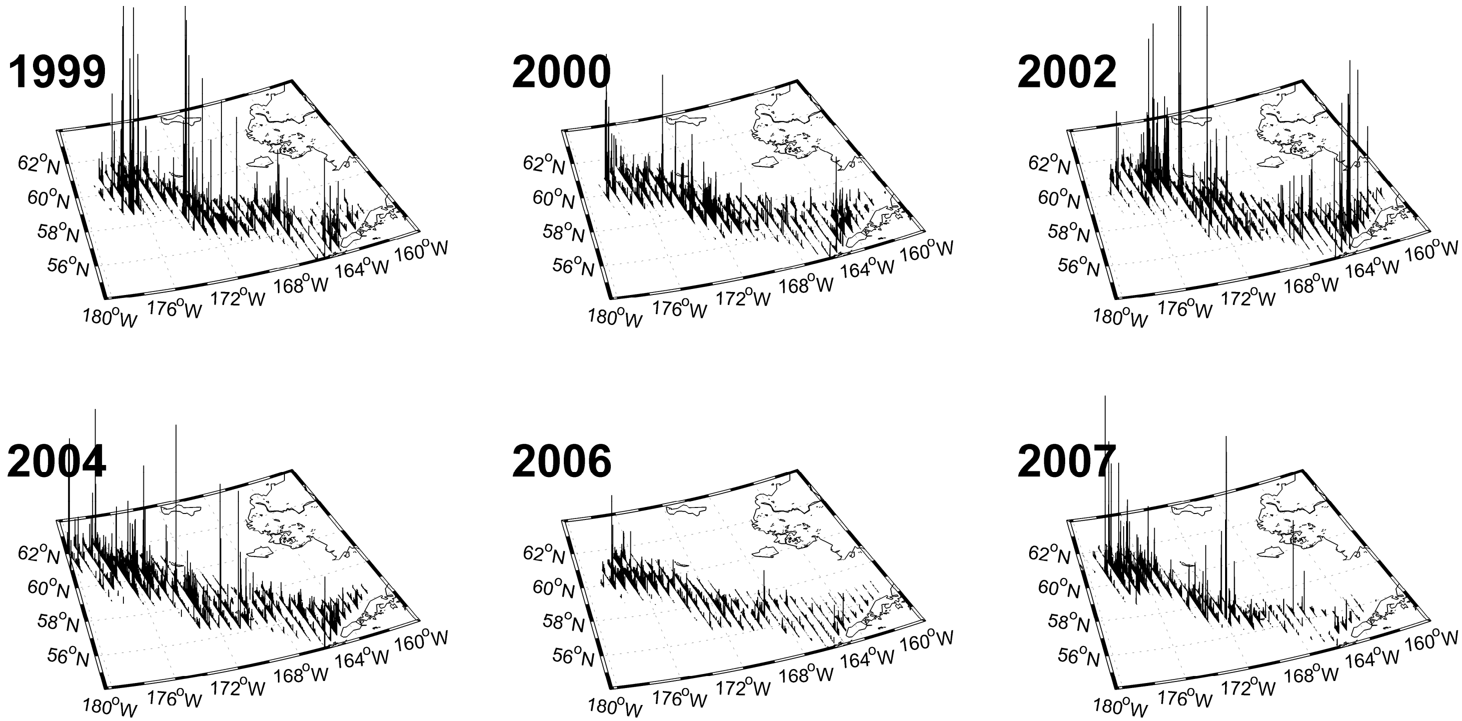


Figure 13. -- Proportion of walleye pollock biomass in midwater (surface to 3 m off the bottom), and near bottom (3 m to 0.5 m off bottom), east and west of 170°W, and in the U.S. EEZ during the 1999-2008 echo integration-trawl surveys. Total (midwater + near bottom) biomass is plotted on right Y-axes (black lines).



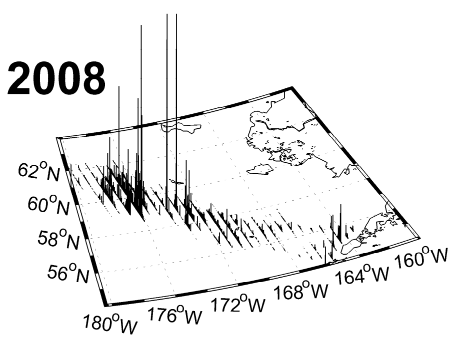


Figure 14. -- Walleye pollock backscatter (s_A) at 38 kHz observed along tracklines during the summer eastern Bering Sea echo integration-trawl surveys conducted between 1999 and 2008.

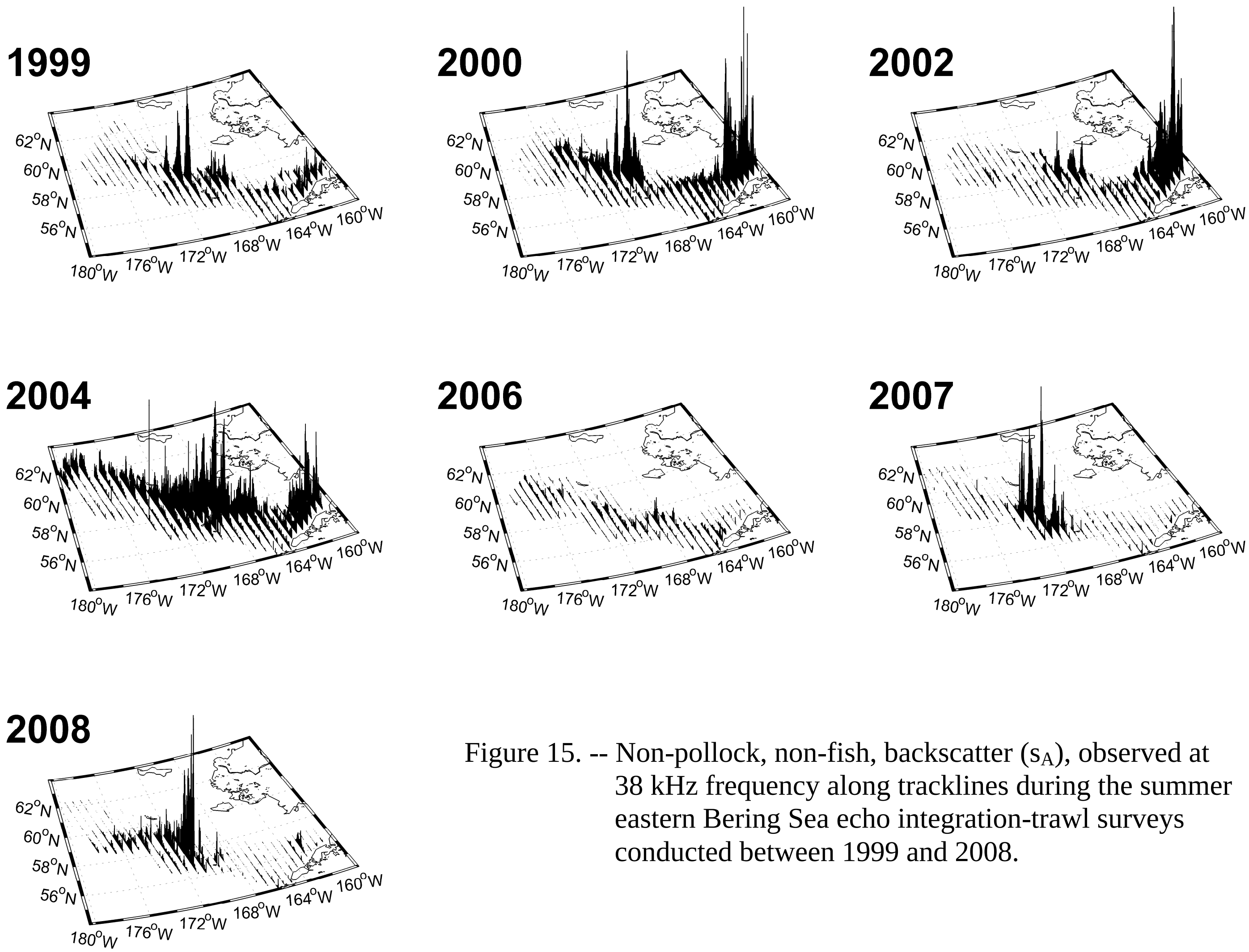


Figure 15. -- Non-pollock, non-fish, backscatter (s_A), observed at 38 kHz frequency along tracklines during the summer eastern Bering Sea echo integration-trawl surveys conducted between 1999 and 2008.

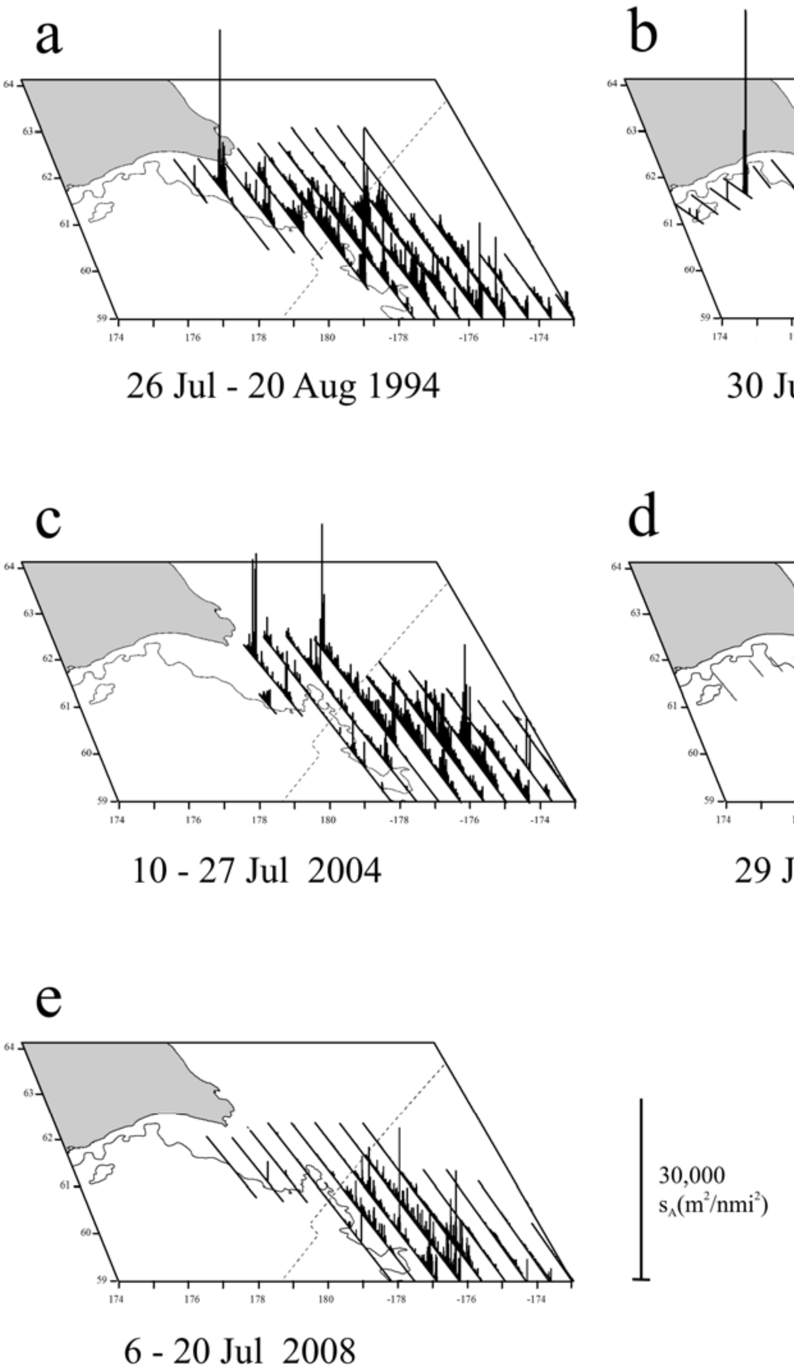


Figure 16. -- Walleye pollock acoustic backscatter (s_A) along tracklines between near surface and 0.5 m off bottom from echo integration-trawl surveys in the Cape Navarin area of Russia. U.S. conducted surveys in 1994 (a), 2004 (c), 2007 (d), and 2008 (e). Russia conducted survey in 2002 (b).

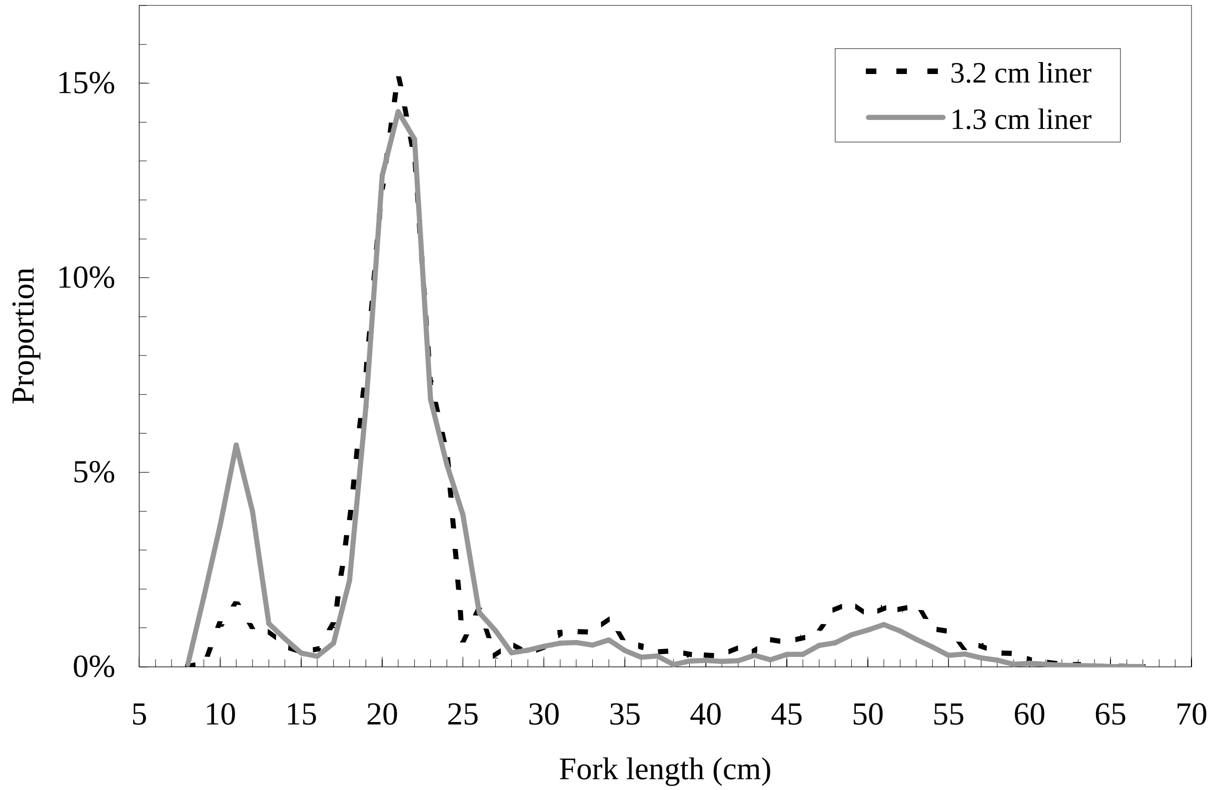


Figure 17. -- Mean length distribution by codend liner mesh size for six pairs of tows conducted following the 2006 echo integration-trawl survey of the Shelikof Strait area.

Appendix I. Itinerary

<u>Leg 1</u>

2 June	Acoustic sphere calibration in Captains Bay, Unalaska Island, AK
2-3 June	Depart Dutch Harbor, AK. Dutch standard transect. Transit to Bering Sea
3-18 June	Echo integration-trawl survey of the Bering Sea shelf through start of transect 16. Transit to Dutch Harbor
19 June	In port Dutch Harbor

<u>Leg 2</u>

21-22 June	Transit to transect 16 waypoint
22 June-8 July	Echo integration-trawl survey of the Bering Sea shelf (transects 16-25).
8 July	Transit to Unalaska Island, AK
9-10 July	In port Dutch Harbor, AK

<u>Leg 3</u>

11-12 July	Acoustic sphere calibration in Captains Bay, Unalaska Island, AK. Transit to transect 26 waypoint
12-19 July	Echo integration-trawl survey of the Bering Sea shelf (transects 26-31)
20-28 July	Paired trawl codend mesh size comparison experiments, and intervessel comparison between *Oscar Dyson* and *Miller Freeman*
28-31 July	Transit to Unalaska Island. Acoustic sphere calibration in Nateekin Bay, Unalaska Island, AK. End of cruise.

Appendix II. Scientific Personnel

Leg 1 (2-19 June)

Name	Position	Organization	Nation
Neal Williamson	Chief Scientist	AFSC	USA
Sarah Stienessen	Fishery Biologist	AFSC	USA
Scott Furnish	Info. Tech. Specialist	AFSC	USA
Abigail McCarthy	Fishery Biologist	AFSC	USA
Darin Jones	Fishery Biologist	AFSC	USA
William Floering	Fishery Biologist	AFSC	USA
Mikhail Stepanenko	Fishery Biologist	TINRO	Russia
Susan Yin	Whale Observer	NMML	USA
Patti Haase	Whale Observer	NMML	USA
Bridget Watts	Whale Observer	NMML	USA
Marty Reedy	Seabird Observer	USFWS	USA
Nathan Jones	Seabird Observer	USFWS	USA
	Leg 2 (21 June-9 July)		
Paul Walline	Chief Scientist	AFSC	USA
Michael Guttormsen	Fishery Biologist	AFSC	USA
Scott Furnish	Info. Tech. Specialist	AFSC	USA
Denise McKelvey	Fishery Biologist	AFSC	USA
Abigail McCarthy	Fishery Biologist	AFSC	USA
Mikhail Stepanenko	Fishery Biologist	TINRO	Russia
Susan Yin	Whale Observer	NMML	USA
Patti Haase	Whale Observer	NMML	USA
Kim Valentine	Whale Observer	NMML	USA
Joe Warren	Assistant Professor	Stony Brook Univ.	USA
Joy Smith	Graduate Student	Stony Brook Univ.	USA
Marty Reedy	Seabird Observer	USFWS	USA
Neal Dawson	Seabird Observer	USFWS	USA
	Leg 3 (11 -31 July)		
Alex DeRobertis	Chief Scientist	AFSC	USA
Chris Wilson	Fishery Biologist	AFSC	USA
Rick Towler	Info. Tech. Specialist	AFSC	USA
Taina Honkalehto	Fishery Biologist	AFSC	USA
Darin Jones	Fishery Biologist	AFSC	USA
Liz Conners	Fishery Biologist	AFSC	USA
Mikhail Stepanenko	Fishery Biologist	TINRO	Russia
Laura Morse	Whale Observer	NMML	USA
Patti Haase	Whale Observer	NMML	USA
Desray Reeb	Whale Observer	NMML	USA
Marty Reedy	Seabird Observer	USFWS	USA
Vivian Mendenhall	Seabird Observer	USFWS	USA

AFSC	Alaska Fisheries Science Center, Seattle WA
NMML	National Marine Mammal Laboratory, AFSC, Seattle, WA
USFWS	United States Fish and Wildlife Service, Juneau, AK
TINRO	Pacific Research Institute of Fisheries and Oceanography Vladivostok, Russia

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