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Results of the Acoustic-Trawl Survey of Walleye Pollock (*Theragra chalcogramma*) on the U.S. and Russian Bering Sea Shelf in June - August 2009 (DY0909)

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Results of the Acoustic-Trawl Survey of Walleye Pollock (*Theragra chalcogramma*) on the U.S. and Russian Bering Sea Shelf in June - August 2009 (DY0909)

by

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ABSTRACT

Eastern Bering Sea shelf walleye pollock (*Theragra chalcogramma*) abundance and distribution in midwater were assessed between 9 June and 7 August 2009 using acoustic-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 2009, as in the previous 3 years, compared to 2001-2005. Fewer pollock were observed east of 170° W than in 2008, and a larger percentage of those were inside the Steller sea lion Conservation Area (SCA) than outside the SCA (79% in 2009, 70% in 2008). The majority of the pollock biomass in the U.S. Exclusive Economic Zone (EEZ) was located to the west and northwest of the Pribilof Islands 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 8.08 billion fish weighing 0.924 million metric tons (t); in the Russian EEZ, there were 9.67 million fish weighing 0.005 million t (0.6% of the total midwater biomass). East of 170° W, (9.6% of total biomass) the predominant length mode was 55 cm both inside and outside of the SCA. In the U.S. west of 170° W (89.8% of total biomass) dominant modal lengths were 13, 31, and 23 cm, respectively. In Russia, modal lengths were 43, 51, and 29 cm, with proportionally more adults and fewer juveniles than in the adjacent western U.S. EEZ. Age results indicated that inside the U.S. EEZ, juvenile walleye pollock (ages-1, -2, and -3) were dominant numerically (64%, 10%, and 21%, respectively) and represented 63% of the total biomass. Adult pollock (ages 4+) totaled 6% of the population numerically and 37% of the total biomass. Vertical distribution analyses 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; 17% of juvenile biomass was within 50 m of the surface. Three-dimensional size and shape patterns of the juveniles are described using data collected with a calibrated multibeam sonar, and variability in these patterns are explored as a function of ontogeny. Finally, a new euphausiid index of abundance computed from backscatter at four frequencies (18, 38, 120, and 200 kHz) is described.

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 2009 acoustic-trawl (AT) survey was carried out between 9 June and 7 August on the U.S. and Russian Bering Sea shelf aboard the NOAA ship *Oscar Dyson*. Its primary objective was to collect acoustic 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. In particular, multiple frequency identification techniques and supplemental trawling were used to estimate a new index of euphausiid abundance. A number of specialized sampling devices were used during or after the survey, including light level sensors, a Simrad ME70 multibeam sonar to image fish schools, a Tucker trawl to sample euphausiids layers near the surface and near the seafloor, a lowered echosounding system to measure target strength, and an underwater stereo camera (“peapod”) and dual-frequency identification sonar (DIDSON) acoustic imaging instrument mounted inside the trawl to study net selectivity. During daylight hours, while on transect, U.S. Fish and Wildlife observers recorded seabird species abundances. Results of their survey are reported elsewhere.

This report summarizes 2009 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. Brief summaries of the new euphausiids abundance index and ME70 research on the aggregation characteristics of juvenile pollock are presented. Additional results from secondary projects will be presented elsewhere.

METHODS

MACE scientists conducted the AT survey (cruise DY2009-09) 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.

Acoustic Equipment, Calibration, and Data Collection

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. A Simrad ME70 multibeam sonar (Simrad 2007, Trenkel et al. 2008) was mounted on the hull 10 m forward of the centerboard at 6 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). A 25 mm tungsten carbide sphere was used to calibrate each beam of the ME70 sonar.

Acoustic telegram data were logged at the five split-beam frequencies using Myriax EchoLog 500 (v. 4.40) and ER60 software (v. 2.2.0). Raw split-beam and multibeam acoustic data were 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 –70 dB. 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 4.60.49). 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 13 to 32 m and averaged 25 m. For bottom trawl hauls, vertical net opening ranged from 1.5 to 3 m and averaged 2.5 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 flowmeter was attached to the mouth of the trawl; the number of flowmeter revolutions and the total time the net was in the water was used 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 temperature–depth sensor 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].

A messenger-operated Tucker trawl (Hopkins et al., 1973) modified with runners so it could be towed along the seafloor (Brodeur and Terazaki, 1999) was used to sample zooplankton layers. The effective mouth area of this 'Tucker sled' when towed was 1 m^2. The mesh used was 0.505 mm in each of three nets and codends.

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. Sea surface temperature was measured continuously using both the vessel's Furuno T-2000 sea surface temperature system, approximately 1.4 m below the water line, and by a SeaBird SBE-45 thermo-salinograph. These and other environmental information were recorded using the ship's Scientific Computing System (SCS). Surface temperatures from the Furuno system sampled along survey transects were subsequently averaged at 10 nautical mile (nmi) resolution. Ambient atmospheric light levels were measured with a sensor attached to the vessel's flying bridge. Water column light levels were measured along the AWT or bottom trawl

[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, and https://reefshark.nmfs.noaa.gov/f/pds/publicsite/documents/procedures/04-105-05.pdf

path with a sensor attached to the trawl headrope on the first 15 trawls and subsequently to the trawl footrope.

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 to measure target strength, and the Simrad ME70 multibeam sonar to measure three-dimensional properties of fish schools).

Additional sampling in support of the Bering Sea Integrated Ecosystem Research Program (BSIERP) included CTD casts with fluorometer and oxygen samples, XBT casts, and underway water sample collections (salinity, chlorophyll fluorescence, oxygen, nutrients) to calibrate the shipboard seawater monitoring system. Also, daytime Methot and Tucker trawls were made to assess the proportion of Bering Sea euphausiids (number per m^2 of sea surface for whole water column) near the seafloor and near surface. Protocols were developed to measure lengths of euphausiid individuals at sea using a dissecting scope and a modified flatbed scanner.

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 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 capelin (*Mallotus villosus*) 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.

For Methot trawls, the catch from the net and codend was transferred to a large bucket. Large organisms such as jellyfish and small fish were removed, identified, weighed, and lengthed. Next the remainder of the catch was placed on a 1-mm mesh screen and weighed. A subsample of this zooplankton mixture was then weighed and sorted at sea into broad taxonomic groups, while a second subsample was weighed and preserved in 5% buffered formalin solution for more detailed enumeration at the Polish Sorting Center in Szczecin, Poland. These results will be reported elsewhere when they become available.

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 plankton mixture (primarily jellyfish and possibly including some fish) was binned at 0.5 nmi horizontal by 10 m vertical resolution. Walleye pollock length compositions from 33 hauls were combined into 11 regional length strata based on geographic proximity, similarity of length composition, and backscatter characteristics. Results were stratified east and west of 170° W as walleye pollock have been observed historically to grow at different rates and to have different length and age compositions in these areas (Traynor and Nelson 1985,

[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.

Honkalehto et al. 2002). Results east of 170° W were also examined inside and outside of the Steller sea lion Conservation Area (SCA). Two length-at-age 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 length-weight key; otherwise weight at a given length interval was estimated from a linear regression of the natural logs of the length and weight data from all the 2009 summer EBS hauls within a common length-weight key (De Robertis and Williams 2008). Three separate weight-at length keys were used; one for adult pollock east of 170° W, and one each for adults and juveniles west of 170° W, including Russia.

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. AT 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 within 3 m of the bottom (Honkalehto et al. 2008, Ianelli et al. 2009). When comparing abundance estimates between the Russian EEZ near Cape Navarin and the two U.S. EEZ regions (east and west of 170° W) estimates to 3 m off bottom were used. When comparing abundance estimates within Russia across multiple years, estimates to 0.5 m off bottom were used, 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 the acoustic sampling variability (Rivoirard et al. 2000). 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 2009 field season (Table 1). 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 10 June acoustic system calibration. However, the average S_v gain from the summer 2009 calibrations was slightly less than that used during the survey. Therefore a scalar correction of 1.0545 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 2009 (Fig. 2a) was similar to that observed in 2008, and colder than that observed in in 2007 (Honkalehto et al. 2009, Honkalehto et al. 2008). The coldest surface waters were on the inner shelf northeast of the Pribilof Islands (0.89° C), and the warmest surface waters were in Russia over Navarin Canyon (8.87° C). However, the average surface water temperatures observed in June and July (6.32° C and 6.37° C, respectively) were warmer than in 2008 when they were 4.0° C in June and 6.1° C in July. The average temperature at the seafloor was 2.01° C overall and was coldest on the inner shelf north of St. Matthews Island to about 178° W, at -1.64° C (Fig. 2b). Seafloor temperatures were warmest just north of Unimak Island (6.07° C). Temperature-depth (XBT) profiles along selected transects, plotted from east to west, indicated that the water column was vertically stratified throughout the EBS with a thermocline at 20-40 m from the surface (Fig. 3).

Trawl Sampling

Biological data and specimens were collected from 95 trawl hauls (Table 2, Fig. 1). Sixty-four of these hauls targeted backscatter encountered during the survey for species identification: 40 with an AWT, 9 with an 83-112 bottom trawl, and 15 with a Methot trawl. Twenty-three successful Tucker trawls were deployed for a separate euphausiid study as mentioned earlier; analyses are underway, and results will be presented elsewhere. After completion of the main survey, 7 AWT trawls and one Methot trawl were made for target strength data collection, in conjunction with ME70 data collection on fish schools or euphausiid layers, or in support of a net selectivity study.

Catch composition for the species identification hauls indicated that, by weight, walleye pollock was the most abundant at 95%, with northern sea nettle jellyfish (*Chrysaora melanaster*) and Pacific ocean perch (*Sebastes alutus*) the second and third most abundant species in the AWT hauls (Table 3). Walleye pollock was also the most abundant species in the bottom trawl hauls at 79% by weight, followed by Pacific ocean perch (Table 4). Most Pacific ocean perch were captured in haul 22 near Akutan Island and haul 37 on the east edge of Pribilof Canyon. Euphausiids were the most abundant group in Methot hauls, followed by northern sea nettles (Table 5).

Summarizing walleye pollock samples from all 95 hauls made during the cruise indicated that 13,982 lengths were measured and 1573 pairs of otoliths were collected (Table 6). Most fish were either in the developing or post-spawning maturity stage, and < 1% (n = 4 in the U.S. east of 170° W and n = 1 in Russia) of the females larger than 29 cm FL were actively spawning (Fig. 4). In walleye pollock mean weight at length curves plotted by area, error bars largely overlap (Fig. 5). However, fish larger than 40 cm FL ranged from < 1% to 18% heavier east of 170° W than west of 170° W or in Russia, even though they were measured earlier in the summer.

Distribution and Abundance

About two-thirds of the summed acoustic backscatter observed during the 2009 survey was attributed to adult or juvenile walleye pollock (Fig. 6), more than in 2008 when only one-third of the backscatter was pollock (Honkalehto et al. 2009). The remaining backscatter was attributed to an undifferentiated plankton-fish mixture, or in a few isolated areas, to Pacific ocean perch 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). More than three-quarters of the biomass east of 170° W was found north and west of Unimak Island inside the SCA, similar to what was observed in 2008, but in contrast to prior AT Bering Sea surveys in which less than half of the eastern biomass was found inside the SCA. The majority of the 2009 biomass in the U.S. EEZ spanned a region west of the Pribilof Islands to the eastern edge of Zhemchug Canyon between the 100 and 200 m isobaths (Fig. 6). The largest adult aggregations were observed north of the Aleutian Island chain between Unimak and Unalaska Islands, and throughout the region south and west of St. Matthew Island. Age-1 juveniles were observed in high concentrations along the 100-m isobath between the Pribilof Islands and St. Matthew Island, and age-3 pollock (with some age-2s) were most concentrated east of Zhemchug Canyon and on the outer shelf between Zhemchug and Pervenets Canyons.

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 8.08 billion fish weighing 0.924 million metric tons (t) (Tables 7-9). Estimated midwater abundance in Russia was 9.67 million fish weighing 0.005 million t (0.6% of total midwater biomass). East of 170° W (9.6% of total midwater biomass) the length composition ranged between 15 and 70 cm FL although very few juveniles (< 39 cm FL) were present (Fig. 7a). In the U.S. west of 170° W (89.8% of total midwater biomass; Fig. 7b), the length composition ranged from 9 to 75 cm FL with a major mode at 13 cm and lesser modes at 31 and 23 cm FL. Numerically, relatively few adult pollock ≥ 39 cm FL were observed west of 170° W. The walleye pollock length composition for the fish observed in Russia (Fig. 7c) ranged from 13 to 75 cm FL, but the majority of fish were between

20 and 60 cm FL. Based on the 1D analysis, the relative estimation error of the U.S. EEZ walleye pollock biomass estimate was 0.088, the highest observed since 1994 when these analyses were first implemented (Table 7).

The 2009 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. 8). Both east and west of 170° W, adults were mainly found deeper than 50 m from the surface and within 40 m of the bottom (Fig. 8a and c). The 40 m near-bottom region accounted for 93% of the adult biomass in the water column. Only 7% of the adult biomass was observed in the upper 50 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, 2009) juvenile aggregations were found both in midwater and near bottom (Fig. 8b and d). Subsequent analyses of backscatter data from juvenile aggregations with the ME70 multibeam sonar indicated that age-1 pollock formed the shallowest schools (see “Size and Shape Patterns of Juvenile Walleye Pollock Aggregations”). Seventeen percent of the juvenile biomass was observed within 50 m of the surface and 76% 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), juvenile pollock (ages 1, 2, and 3) were dominant numerically (accounting for 64%, 10%, and 21%, respectively). These three age groups represented 63% of the total biomass. Adult pollock (ages 4+) totaled 6% of the population numerically, and made up 37% of the total biomass. The pollock population east of 170° W was dominated by 8-year-old adults, while in the U.S. west of 170° W it was dominated by 1- and 3-year-old fish (Fig. 9). In Russia, a mix of age 2 and 3+ fish made up most of the small biomass.

The walleye pollock population tends to be supported by strong year classes. Acoustic-trawl survey numbers-at-age estimates between 1994 and 2009 show the progression of strong year classes through the midwater population (Fig. 10). In 2007, the 2006 year class was the most numerous age-1 group detected by the AT survey since the large 1996 year class in 1997 and it was moderately apparent as 3-year-olds in 2009 (Table 10). The 2008 year class appeared to be nearly as strong numerically in the 2009 AT survey as the 2006 year class was in the 2007 survey. 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 2009 was compared with the average length at age for these two strata between 1999 and 2008 to see if differences in growth existed that supported the use of two separate age-length keys (Fig. 11). The 2009 average lengths-at-age were similar to historical values, although older fish (6-12 years) in the east tended to be larger than those from prior surveys. In general, length at age tended to be greater in the east than in the west, although it was usually measured up to one month earlier.

In addition to providing midwater pollock abundance estimates (to 3 m off the bottom), the EBS AT survey can estimate abundance to within 0.5 m of bottom (Honkalehto et al. 2009). 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 between 1999 and 2009 (Fig. 12). The percentage of total biomass for the entire U.S. EEZ between 3 m and 0.5 m off bottom appeared to be relatively stable (~19%) between 1999 and 2006. It increased to 26% in 2007 and again to 35% in 2008 followed by a slight decrease to 30% in 2009. The percentage of biomass above 3 m averaged across years since 1999 was 66% 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 in the west compared to the east; juveniles tend to aggregate higher in the water column than the adults (Fig. 8). The near-bottom estimates should be treated with caution as 1) there is a higher possibility of species contamination of the backscatter in this stratum than in the midwater stratum, 2) the size composition of near-bottom pollock may not be as well represented by trawl hauls conducted during the AT survey as the size composition of the midwater component, and 3) the acoustic dead-zone is not accounted for. Improvements to the estimation of near-bottom pollock abundance from the AT survey backscatter are currently underway to increase their value to the walleye pollock stock assessment.

Backscatter from the AT survey time series (1994-2009) consisted of walleye pollock, and non-pollock species, primarily a mix of zooplankton and individual fish. 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 2006-2009 (Fig. 13). Most non-pollock backscatter (at 38 kHz) is typically observed in the upper part of the water column (Honkalehto et al. 2008). In 2009 relatively little non-pollock backscatter was observed, similar to observations in 2006 (Fig. 14). This backscatter information should be interpreted with care because the exact biological composition of the scatterers is unknown (Honkalehto et al. 2008, 2009).

The AFSC has surveyed the Cape Navarin area of Russia during summers 1994, 2004, 2007, 2008, and 2009. 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 (Fig. 15). The proportion of walleye pollock biomass estimated in Russia to within 0.5 m of the bottom has ranged from 1% (in 2009) to 15% (in 1994) of the total combined U.S. and Russian Bering Sea shelf biomass (Table 11).

Size and Shape Patterns of Juvenile Walleye Pollock Aggregations

Size and shape descriptors of juvenile walleye pollock aggregations were chosen based on previous work on fish school morphology (Diner 1998, Coetzee 2000, Wilson et al. 2003, Stienessen and Wilson 2008). The aggregation descriptors examined were depth, height, width, surface area, volume, and the ratio of surface area to volume (D). The multibeam backscatter data collected on juvenile pollock schools were analyzed by fish age, using fish lengths from trawl hauls as a proxy for ages (age-1s < 19 cm FL, age-2s 19–26 cm, and age-3s 27-38 cm) as age data were not yet available. Trawl samples indicated three prominent groups of juvenile pollock found in schools: age 1, ages 2,3 mix, and age 3.

Preliminary results suggest a variety of aggregation patterns for juvenile walleye pollock (Fig. 16). Age-1 pollock formed the shallower and smaller (i.e., smaller lengths, widths, surface areas, and volumes) schools compared to ages-2,-3 mix and age-3 fish. Age-1 pollock also formed more convoluted schools (i.e., larger D) compared to the older juveniles. The results presented here suggest that variation in walleye pollock school structure not only occurs between the adult and juvenile stage (Wilson et al. 2003) but within the juvenile stages as well.

An Acoustic Index of Euphausiid Abundance in the EBS

Euphausiids, principally *Thysanoessa inermis* and *T. raschii*, are among the most important prey items for walleye pollock in the Bering Sea (Livingston 1991, Lang et al. 2000, Brodeur et al. 2002, Ciannelli et al. 2004, Lang et al. 2005). A new analysis of MACE AT survey backscatter data from 2004-present was used to create an index of euphausiid abundance on the Bering Sea shelf. The analysis relies on a comparison of acoustic backscatter at four frequencies (18, 38, 120, and 200 kHz) and net sampling with a Methot trawl (De Robertis et al. in review, Ressler, unpublished data). Typically, 12-24 Methot trawls are targeted at euphausiids during an AT survey.

The 2004-2009 time series of Bering Sea summer euphausiid abundance (Fig. 18) shows that euphausiid backscatter has increased more than three-fold. Other data sets from the Bering Sea have also suggested an increase in large copepods since 2004 (Napp and Yamaguchi 2008). Over the same period of time, midwater pollock backscatter measured by the AT survey decreased by half, and walleye pollock age 3+ biomass estimated by the stock assessment model shows a similar decline. These opposing trends of euphausiid (prey) and pollock (predator) abundance may be related or they may be independent responses to changes in environmental conditions. These euphausiid backscatter data are spatially explicit (Fig. 19), so distribution, as well as abundance, can be tracked over time. This euphausiid index may help us better understand temporal and spatial variability in walleye pollock abundance.

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Table 1. -- Simrad ER60 38 kHz acoustic system description and settings during the summer 2009 walleye pollock acoustic-trawl survey of the Bering Sea shelf, and settings 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	10-Jun Three Saint's Bay Alaska	2-Jul Captain's Bay Alaska	6-Aug Anderson 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):		22.79	22.79	22.82	22.82
Sa correction (dB):		-0.46	-0.60	-0.59	-0.60
S_v gain (dB):		22.33	22.19	22.23	22.22
3 dB beamwidth (deg):	Along:	6.76	6.76	-	6.77
	Athwart:	7.15	7.14	-	7.20
Angle offset (deg):	Along:	-0.10	-0.10	-	-0.10
	Athwart:	-0.13	-0.13	-	-0.08
Sphere range from transducer (m):		--	18.2	16.9	17.4
Absorption coefficient (dB/m):		0.0100	0.0095	0.0100	0.0098
Sound velocity (m/s):		1470	1469.0	1467.8	1474.0
Water temp at transducer (°C):		2.0-10.9	6.9	6.1	7.0
Water temp at standard sphere (°C):		--	4.7	4.1	6.4

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 2009 Bering Sea shelf walleye pollock acoustic-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	Tucker Trawl	14-Jun	22:52	16	56	10.44	-161	38.73	23	59	4.2	6.14	-	-	13.6
2	Tucker Trawl	14-Jun	23:08	14	56	10.85	-161	38.37	58	59	2.5	6.14	-	-	4.5
3	Tucker Trawl	14-Jun	23:22	12	56	11.18	-161	38.04	38	59	3.1	5.94	-	-	10.2
4	Tucker Trawl	16-Jun	2:33	10	55	48.46	-162	51.7	63	75	1.4	6.82	-	-	-
5	Tucker Trawl	16-Jun	21:34	17	56	23.14	-163	26.85	44	84	3.3	6.82	-	-	2.6
6	Tucker Trawl	16-Jun	21:52	5	56	23.63	-163	26.55	82	84	1.0	6.84	-	-	1.8
7	Tucker Trawl	16-Jun	21:57	9	56	23.78	-163	26.45	41	84	2.7	6.84	-	-	-
8	AWT	17-Jun	15:57	29	55	19.65	-164	2.93	77	80	4.6	6.44	433.9	516	94.2
9	Tucker Trawl	17-Jun	21:31	13	56	9.16	-164	2.1	46	90	2.2	6.64	-	-	1.6
10	Tucker Trawl	17-Jun	21:44	6	56	9.56	-164	2.22	88	90	0.2	6.54	-	-	0.2
11	Tucker Trawl	17-Jun	21:51	10	56	9.73	-164	2.25	57	90	1.1	6.54	-	-	1.4
12	Tucker Trawl	18-Jun	17:10	13	56	16.94	-164	37.29	87	89	0.2	5.94	-	-	1.4
13	83-112	19-Jun	0:35	12	55	6.24	-164	37.55	76	76	4.4	7.14	244.4	174	71.5
14	83-112	19-Jun	16:44	10	54	46.77	-165	11.59	117	122	-	5.84	4.4	4	0.4
15	AWT	19-Jun	17:58	28	54	46.82	-165	11.69	115	121	-	5.84	828.5	981	28.9
16	Tucker Trawl	20-Jun	22:09	14	55	50.87	-165	49.38	50	116	4.8	6.54	-	-	1.0
17	Tucker Trawl	20-Jun	22:30	5	55	50.56	-165	49.28	115	116	3.3	6.54	-	-	0.2
18	Tucker Trawl	20-Jun	22:35	11	55	50.46	-165	49.23	62	116	4.3	6.54	-	-	0.6
19	AWT	21-Jun	8:34	40	54	35.34	-165	45.77	362	402	3.7	6.04	10.8	9	43.9
20	83-112	21-Jun	17:09	12	54	23.32	-165	44.96	192	210	4.0	5.94	31.7	21	1.2
21	AWT	21-Jun	20:22	24	54	23.32	-165	45.9	232	256	4.3	6.02	1.8	1	2.4
22	83-112	22-Jun	6:52	10	54	9.72	-166	19.43	163	170	4.3	6.04	8581.3	6806	1768.7
23	Tucker Trawl	22-Jun	21:28	18	55	27.47	-166	22.54	63	130	4.5	6.94	-	-	1.1
24	Tucker Trawl	22-Jun	21:43	9	55	27.33	-166	23.62	129	130	3.5	6.94	-	-	0.6
25	Tucker Trawl	22-Jun	21:54	13	55	27.22	-166	24.26	74	131	4.0	6.94	-	-	1.3
26	Methot	23-Jun	4:18	15	56	25.85	-166	25.61	58	101	1.0	6.14	-	-	25.4
27	Tucker Trawl	24-Jun	1:51	11	56	34.11	-167	3.97	72	103	1.3	6.14	-	-	0.2
28	Methot	24-Jun	2:47	11	56	34.16	-167	3.66	80	104	1.3	6.14	-	-	21.0
29	Tucker Trawl	25-Jun	3:31	21	55	36.48	-167	36.01	119	136	3.4	8.32	-	-	1.4
30	Methot	25-Jun	4:35	20	55	36.89	-167	36.04	123	136	3.4	8.34	-	-	3.4
31	83-112	25-Jun	16:04	30	56	37.07	-167	41.57	110	110	1.5	6.44	867.4	702	735.9
32	Tucker Trawl	25-Jun	22:18	12	57	28.54	-167	45.87	40	72	1.8	5.94	-	-	0.5
33	Tucker Trawl	25-Jun	22:31	7	57	28.17	-167	46.17	70	72	-0.7	5.94	-	-	0.8
34	Tucker Trawl	25-Jun	22:38	7	57	27.96	-167	46.31	33	72	1.7	5.94	-	-	0.5
35	83-112	26-Jun	11:29	8	55	37.34	-168	12.41	136	137	3.4	7.04	144.1	129	20.4
36	AWT	26-Jun	17:29	28	55	24.74	-168	11.7	355	390	3.7	7.34	4.8	4	314.0

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	22:21	31	55	44.17	-168	48.73	204	215	-	7.44	-	-	298.5
38	AWT	27-Jun	5:39	26	56	34.2	-168	54.66	93	103	2.2	7.44	16.8	31	14.7
39	Tucker Trawl	27-Jun	15:50	16	57	30.66	-168	59.99	63	71	-0.2	6.03	-	-	0.9
40	Methot	27-Jun	16:51	15	57	30.68	-169	0.18	68	71	-0.2	5.97	-	-	6.3
41	Methot	4-Jul	18:51	20	56	19.55	-170	5.54	95	110	3.1	6.03	-	-	7.5
42	Methot	5-Jul	2:39	20	56	36.97	-170	45.24	98	116	-	6.52	< 0.1	23	9.0
43	Methot	5-Jul	5:25	20	56	54.49	-170	48.33	86	104	2.9	6.24	< 0.1	2	10.7
44	AWT	5-Jul	10:15	60	57	14.65	-170	51.85	81	83	3.4	6.44	586	786	60.0
45	AWT	5-Jul	18:36	31	57	43.4	-170	56.59	79	86	2.6	5.24	359	26041	345.7
46	AWT	7-Jul	2:39	3	58	21.21	-171	40.54	90	97	-0.3	5.84	442.3	25059	48.8
47	AWT	7-Jul	11:44	5	57	34.92	-171	32.03	42	101	5.3	6.14	55.7	3416	84.7
48	AWT	8-Jul	2:04	47	56	29.46	-171	20.23	71	145	5.0	6.94	-	-	17.3
49	AWT	8-Jul	23:09	17	57	41.21	-172	11.33	103	108	1.8	6.44	755.6	41344	40.3
50	AWT	9-Jul	4:41	9	58	23.99	-172	19.74	89	103	1.8	6.84	242.6	10780	24.6
51	83-112	9-Jul	8:43	30	58	50.1	-172	25.1	94	102	0.9	6.34	-	-	32.7
52	AWT	9-Jul	14:47	42	58	49.44	-172	22.03	61	101	5.2	6.14	1048.6	54507	289.7
53	83-112	10-Jul	6:23	15	59	7.97	-173	7.96	105	105	0.8	6.43	1815.9	2069	363.4
54	AWT	10-Jul	14:24	20	58	50.54	-173	4.26	106	112	1.5	6.44	3.4	98	11.9
55	AWT	10-Jul	18:51	18	58	23.45	-172	58.86	109	111	2.2	6.44	494.2	13260	5.2
56	AWT	10-Jul	22:13	10	58	6.28	-172	55.5	103	108	2.2	6.85	2837.6	28584	-
57	AWT	11-Jul	2:10	10	57	46.32	-172	50.63	105	117	2.2	6.68	1375.5	40877	8.6
58	AWT	11-Jul	21:57	5	57	45.83	-173	28.04	124	145	3.1	6.94	2181	8714	-
59	AWT	12-Jul	2:10	2	58	3.94	-173	31.91	110	114	2.5	6.54	2290.4	8833	-
60	AWT	12-Jul	7:32	18	58	45.5	-173	41.37	114	127	2.5	6.64	606.7	15061	1.9
61	AWT	12-Jul	18:12	51	59	10.02	-173	48.78	108	114	1.4	6.64	28.5	32	21.5
62	AWT	12-Jul	23:00	32	59	38.25	-173	54.32	101	106	1.0	6.44	36.9	50	5.1
63	AWT	14-Jul	20:38	60	59	32.48	-175	11.26	125	133	1.9	6.64	77.6	317	6.6
64	AWT	15-Jul	22:05	31	59	39.25	-174	4.05	104	109	1.0	6.51	1533.3	4225	8.7
65	AWT	16-Jul	9:07	30	58	39.27	-172	32.79	87	105	1.3	6.64	122.8	2380	15.8
66	AWT	16-Jul	18:49	9	58	27	-172	53.05	101	110	2.1	6.74	3460.5	14705	10.5
67	Methot	24-Jul	7:31	21	58	40.83	-175	36.05	129	135	2.4	7.44	-	-	10.5
68	Methot	24-Jul	17:59	22	59	0.36	-175	42.11	116	135	1.1	7.54	-	-	6.2
69	AWT	24-Jul	20:36	41	59	8.3	-175	45.31	73	137	2.4	7.44	0.1	1	0.5
70	AWT	24-Jul	22:34	34	59	8.31	-175	45.11	129	137	1.1	7.44	6938	21843	-
71	AWT	25-Jul	3:26	30	59	33.83	-175	52.65	133	137	1.7	7.17	227.2	679	0.8
72	Methot	26-Jul	0:37	30	62	2.92	-176	42.03	76	102	-1.0	6.34	-	-	5.8
73	Methot	26-Jul	16:59	20	61	21.05	-177	9.67	103	121	0.6	6.94	-	-	8.1
74	AWT	27-Jul	1:21	6	60	16.12	-176	46.32	134	139	1.1	7.44	1098.9	4196	8.4

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)
75	AWT	27-Jul	4:39	3	59 54.95	-176 39.06	138	141	1.0	7.54	867.1	4571	-
76	Methot	27-Jul	13:11	20	59 47.46	-176 36.55	32	138	2.6	7.64	-	-	0.6
77	AWT	27-Jul	17:04	4	59 23.29	-176 28.41	133	137	0.9	7.84	402.9	1705	3.7
78	AWT	28-Jul	9:20	41	60 5.29	-177 22.82	118	138	1.1	7.54	304.5	1262	3.7
79	AWT	28-Jul	14:38	21	60 7.02	-177 22.8	46	138	5.2	7.44	139.4	675	3.0
80	AWT	28-Jul	20:02	12	60 40.81	-177 36.04	141	150	1.0	7.64	408	569	4.1
81	AWT	29-Jul	22:11	26	60 51.64	-178 21.7	162	168	1.1	7.54	532.2	1148	0.8
82	Methot	31-Jul	16:36	20	61 12.11	-179 10.77	176	212	1.4	7.44	-	-	10.2
83	Methot	1-Aug	6:42	10	61 16	-179 55.29	141	155	0.9	8.34	-	-	3.6
84	AWT	1-Aug	14:19	43	60 47.99	-179 43.56	232	246	1.4	8.38	0.6	1	0.5
85	AWT	2-Aug	1:17	47	61 2.03	179 28.36	165	172	1.1	8.57	1.4	3	-
86	83-112	2-Aug	3:48	53	61 1.26	179 29.11	182	186	1.2	8.44	251.2	364	245.9
87	Methot	2-Aug	21:12	20	62 3.48	178 16.25	78	81	1.9	-	-	-	34.2
88*	AWT	3-Aug	18:14	2	60 8.99	-177 24.63	119	138	-	8.60	908	3953	-
89*	AWT	3-Aug	21:07	2	60 6.51	-177 24.38	133	137	0.9	8.44	822.1	3069	-
90*	AWT	4-Aug	0:47	6	60 10.15	-177 9.51	126	141	1.0	8.44	1445.6	5794	7.4
91*	AWT	4-Aug	5:04	26	60 9.02	-177 10.28	125	141	0.9	8.54	322.3	966	0.1
92*	AWT	4-Aug	9:25	3	60 0.57	-176 50.62	108	142	1.1	8.64	413	1847	-
93*	AWT	4-Aug	18:27	14	59 29.67	-175 36.09	96	137	2.3	8.37	236.7	2767	6.6
94*	AWT	5-Aug	10:46	10	57 45.28	-172 49.55	43	118	7.5	8.84	157.1	4931	13.3
95*	Methot	5-Aug	23:31	18	56 38.69	-170 45.69	101	115	3.1	8.14	-	-	13.2

[1]AWT = Aleutian wing trawl, 83-112 = bottom trawl, Methot = Methot trawl, Tucker Trawl = Tucker multiple depth trawl.
[2]shipboard sensor at 1.4 m depth.
* Experimental gear trawl.

Table 3. -- Catch by species from 40 Aleutian Wing trawl hauls conducted during the summer 2009 walleye pollock acoustic-trawl survey of the Bering Sea shelf. Catches from experimental trawls are not included.

Common name	Scientific name	Weight (kg)	Weight (%)	Number
walleye pollock	*Theragra chalcogramma*	30,755.1	94.4	337,264
northern sea nettle	*Chrysaora melanaster*	1,078.0	3.3	994
Pacific ocean perch	*Sebastes alutus*	290.3	0.9	297
northern smoothtongue	*Leuroglossus schmidti*	145.2	0.4	24,100
Gonatopsis squid unident.	*Gonatopsis* sp.	135.1	0.4	6,237
magistrate armhook squid	*Berryteuthis magister*	52.2	0.2	371
flathead sole	*Hippoglossoides elassodon*	37.0	0.1	69
squid unident.	Cephalopoda (class)	25.2	<0.1	489
Pacific cod	*Gadus macrocephalus*	13.6	<0.1	4
smooth lumpsucker	*Aptocyclus ventricosus*	9.9	<0.1	11
yellow Irish lord	*Hemilepidotus jordani*	9.6	<0.1	5
arrowtooth flounder	*Atheresthes stomias*	5.2	<0.1	11
Alaska skate	*Bathyraja parmifera*	3.4	<0.1	11
chum salmon	*Oncorhynchus keta*	3.3	<0.1	1
chinook salmon	*Oncorhynchus tshawytscha*	3.2	<0.1	1
lamprey unident.	Petromyzontidae (family)	3.1	<0.1	6
rock sole sp.	*Lepidopsetta* sp.	2.9	<0.1	6
capelin	*Mallotus villosus*	2.8	<0.1	136
crystal jelly unident.	*Aequorea* sp.	2.3	<0.1	13
shrimp unident.	Decapoda (order)	2.0	<0.1	408
northern rock sole	*Lepidopsetta polyxystra*	1.4	<0.1	2
eulachon	*Thaleichthys pacificus*	1.4	<0.1	10
jellyfish unident.	Scyphozoa (class)	0.9	<0.1	70
lanternfish unident.	*Lampanyctus* sp.	0.3	<0.1	58
sturgeon poacher	*Podothecus acipenserinus*	0.3	<0.1	4
salps unident.	Thaliacea (class)	0.2	<0.1	4
lanternfish unident.	Myctophidae (family)	0.1	<0.1	34
shortfin eelpout	*Lycodes brevipes*	<0.1	<0.1	1
sidestripe shrimp	*Pandalopsis dispar*	<0.1	<0.1	2
Pacific spiny lumpsucker	*Eumicrotremus orbis*	<0.1	<0.1	1
Totals		32,584.2		370,620

Table 4. -- Catch by species from nine bottom trawl hauls (83-112) conducted during the summer 2009 acoustic-trawl survey on the Bering Sea shelf.

Common name	Scientific name	Weight (kg)	Weight (%)	Number
walleye pollock	*Theragra chalcogramma*	11,940.4	78.7	10,269
Pacific ocean perch	*Sebastes alutus*	1,138.4	7.5	1,303
arrowtooth flounder	*Atheresthes stomias*	425.9	2.8	773
Pacific cod	*Gadus macrocephalus*	276.6	1.8	220
Alaska skate	*Bathyraja parmifera*	195.1	1.3	10
snail unident.	Gastropoda (class)	184.1	1.2	1,990
flathead sole	*Hippoglossoides elassodon*	154.4	1.0	677
northern sea nettle	*Chrysaora melanaster*	126.9	0.8	167
skate unident.	Rajidae (family)	124.8	0.8	26
hermit crab unident.	Paguridae (family)	72.5	0.5	1,110
tentacle-shedding anemone	*Liponema brevicornis*	62.9	0.4	339
rock sole sp.	*Lepidopsetta* sp.	61.0	0.4	76
rex sole	*Glyptocephalus zachirus*	54.5	0.4	137
shortfin eelpout	*Lycodes brevipes*	43.9	0.3	678
Bering skate	*Bathyraja interrupta*	38.1	0.3	15
Tanner crab	*Chionoecetes bairdi*	37.0	0.2	242
empty gastropod shells	Gastropoda (class)	27.4	0.2	414
snow crab	*Chionoecetes opilio*	25.8	0.2	119
pandalid shrimp unident.	Pandalidae (family)	22.8	0.1	4,202
Kamchatka flounder	*Atheresthes evermanni*	22.4	0.1	42
red Irish lord	*Hemilepidotus hemilepidotus*	22.2	0.1	4
mollusk unident.	Mollusca (phylum)	21.8	0.1	107
sea anemone unident.	Actiniaria (order)	16.8	0.1	102
Pacific halibut	*Hippoglossus stenolepis*	11.7	0.1	3
basketstar	*Gorgonocephalus eucnemis*	11.5	0.1	28
octopus unident.	Octopodidae (family)	9.2	0.1	3
starfish unident.	Asteroidea (class)	6.7	<0.1	193
roughshoulder skate	*Raja badia*	5.7	<0.1	2
Aleutian skate	*Bathyraja aleutica*	5.6	<0.1	3
sea urchin unident.	Echinoidea (class)	5.4	<0.1	81
sea whip unident.	*Ellisella elongata*	4.4	<0.1	23
Pacific lyre crab	*Hyas lyratus*	4.2	<0.1	50
scallop unident.	Pectinidae (family)	4.1	<0.1	90
searcher	*Bathymaster signatus*	2.2	<0.1	16
northern rock sole	*Lepidopsetta polyxystra*	2.0	<0.1	4
spinyhead sculpin	*Dasycottus setiger*	1.8	<0.1	7
darkfin sculpin	*Malacocottus zonurus*	1.3	<0.1	5
redstripe rockfish	*Sebastes proriger*	1.0	<0.1	1
yellow Irish lord	*Hemilepidotus jordani*	1.0	<0.1	8

Table 4. -- Continued.

Common name	Scientific name	Weight (kg)	Weight (%)	Number
salmon snailfish	*Careproctus rastrinus*	0.9	<0.1	8
sea mouse	*Aphrodita negligens*	0.7	<0.1	24
crangonid shrimp unident.	Crangonidae (family)	0.7	<0.1	314
thorny sculpin	*Icelus spiniger*	0.5	<0.1	22
sawback poacher	*Leptagonus frenatus*	0.5	<0.1	12
spectacled sculpin	*Triglops scepticus*	0.5	<0.1	10
whiteblotched skate	*Bathyraja maculata*	0.4	<0.1	5
short-spined sea star	*Pisaster brevispinus*	0.4	<0.1	4
arrowtooth flounder	*Atheresthes stomias*	0.4	<0.1	1
Greenland turbot	*Reinhardtius hippoglossoides*	0.3	<0.1	1
sturgeon poacher	*Podothecus acipenserinus*	0.2	<0.1	4
lamprey unident.	*Lampetra tridentata*	0.2	<0.1	1
snail eggs	Gastropoda (class)	0.2	<0.1	2
capelin	*Mallotus villosus*	0.2	<0.1	7
empty bivalve shells	Bivalvia (class)	0.2	<0.1	5
flathead sole	*Hippoglossoides elassodon*	0.2	<0.1	1
nudibranch unident.	Nudibranchia (order)	0.1	<0.1	16
stout eelblenny	*Lumpenus medius*	<0.1	<0.1	2
scissortail sculpin	*Triglops forficata*	<0.1	<0.1	1
eelpout unident.	Zoarcidae (family)	<0.1	<0.1	2
pygmy poacher	*Odontopyxis trispinosa*	<0.1	<0.1	6
eulachon	*Thaleichthys pacificus*	<0.1	<0.1	1
rockfish unident.	*Sebastes* sp.	<0.1	<0.1	1
isopod unident.	Isopoda (order)	<0.1	<0.1	1
Totals		15,180.4		8,456

Table 5. -- Catch by species from 16 Methot trawl hauls conducted during the summer 2009 walleye pollock acoustic-trawl survey on the Bering Sea shelf.

Common name	Scientific name	Weight (kg)	Weight (%)	Number
euphausiid unident.	Euphausiidae (family)	104.6	60	1,174,796
northern sea nettle	*Chrysaora melanaster*	65.6	37	238
Aurelia jelly unident.	*Aurelia* sp.	1.7	1	59
jellyfish unident.	Scyphozoa (class)	1.6	1	74
copepod unident.	Copepoda (class)	1.2	1	23,014
crystal jelly unident.	*Aequorea* sp.	0.4	<0.1	3
amphipod unident.	Amphipoda (order)	0.3	<0.1	3,645
moon jelly	*Aurelia labiata*	0.1	<0.1	4
walleye pollock age 0	*Theragra chalcogramma*	<0.1	<0.1	50
squid unident.	Cephalopoda (class)	<0.1	<0.1	1
fish larvae unident.	Actinopterygii (class)	<0.1	<0.1	1
Totals		175.5		1,201,885

Table 6.-- Numbers of fish measured and biological samples collected during the summer 2009 acoustic-trawl survey of walleye pollock on the Bering Sea shelf.

Haul	Pollock				Other	*Chrysaora melanaster*	TINRO
No.	Length	Weight	Maturity	Otoliths	Length	bell diameter	collection*
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-
5	-	-	-	-	-	10	-
6	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-
8	264	40	40	40	-	17	50
9	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-
13	174	40	40	40	-	20	50
14	4	4	4	4	-	-	-
15	330	59	59	39	-	-	-
16	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-
19	9	9	9	9	-	-	-
20	21	21	21	20	-	-	-
21	1	1	1	1	-	-	-
22	339	46	46	40	-	-	50
23	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-
25	-	-	-	-	-	-	-
26	-	-	-	-	-	31	-
27	-	-	-	-	-	-	-
28	-	-	-	-	-	76	-
29	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-
31	270	51	49	40	-	-	50
32	-	-	-	-	-	-	-
33	-	-	-	-	-	-	-
34	-	-	-	-	-	-	-
35	129	42	40	40	-	-	-
36	4	4	4	4	93[$]	-	-
37	-	-	-	-	88[#]	-	-
38	31	31	31	31	-	28	-
39	-	-	-	-	-	-	-
40	-	-	-	-	59^	7	-
41	-	-	-	-	-	-	-
42	23	-	-	-	-	-	-
43	2	-	-	-	-	-	-
44	350	56	56	49	-	-	50
45	79	30	30	10	-	19	50
46	184	44	42	26	54**	12	-
47	79	28	28	11	-	42	-
48	-	-	-	-	-	15	-
49	185	34	34	34	19**	29	50
50	130	42	42	42	-	8	-
51	-	-	-	-	-	30	-

Table 6. -- Continued.

Haul	Pollock				Other	*Chrysaora melanaster*	TINRO
No.	Length	Weight	Maturity	Otoliths	Length	bell diameter	collection*
52	116	66	66	52	31**	72	-
53	372	77	77	56	3**	-	50
54	98	21	21	7	-	-	-
55	684	105	105	64	-	-	50
56	498	60	60	60	-	-	-
57	428	42	42	21	-	-	-
58	399	53	53	50	-	-	50
59	355	49	49	49	-	-	-
60	411	51	51	18	-	-	-
61	32	32	32	32	-	-	50
62	50	50	50	50	-	-	-
63	287	70	70	55	-	-	-
64	401	52	52	52	-	-	50
65	150	34	34	34	-	-	-
66	390	75	75	55	-	-	-
67	-	-	-	-	-	-	-
68	-	-	-	-	-	-	-
69	1	1	1	-	-	-	-
70	444	51	51	51	-	-	50
71	395	51	51	45	-	-	50
72	-	-	-	-	-	-	-
73	-	-	-	-	-	11	-
74	374	70	70	50	-	-	50
75	531	73	73	50	-	-	-
76	-	-	-	-	-	-	-
77	395	57	57	40	-	-	-
78	396	73	73	46	-	-	-
79	323	-	-	-	-	5	-
80	334	79	79	51	-	2	50
81	386	85	85	50	-	-	50
82	-	-	-	-	-	-	-
83	-	-	-	-	-	-	-
84	1	1	1	1	-	-	-
85	3	3	3	3	-	-	-
86	278	50	50	50	-	-	50
87	-	-	-	-	-	-	-
88	303	1	1	-	-	-	50
89	608	78	78	1	-	-	50
90	444	56	56	-	-	-	-
91	369	54	55	-	-	-	-
92	348	67	67	-	-	-	-
93	366	73	73	-	-	-	-
94	404	95	96	-	-	-	-
95	-	-	-	-	-	-	-
Totals	13982	2437	2433	1573	347	434	1000

** Capelin.
$ Northern smoothtongue.
# Pacific ocean perch.
^ Aurelia jellyfish bell diameter.
*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 acoustic-trawl surveys on the U.S. EEZ portion of the Bering Sea shelf, 1994-2009. 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)**			**Total biomass (million metric tons)**	**Relative estimation error**
			SCA	**E170-SCA**	**W170**		
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		
2009	9 Jun -7 Aug	91,414	0.070	0.018	0.835	0.924	0.088
			7.6	2.0	90.4		

Table 8. -- Numbers-at-length estimates (millions) of walleye pollock between near surface and 3 m off bottom from acoustic-trawl surveys in the U.S. EEZ, 1994-2009.

Length (cm)	**1994**	**1996**	**1997**	**1999**	**2000**	**2002**	**2004**	**2006**	**2007**	**2008**	**2009**
0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0.03	0	0	0	0	0	0
9	0	0	0	0.01	0.03	0	0	0	0	0	4.42
10	0	0	2.04	0.12	0.76	0.01	0.24	0	30.12	0	45.53
11	0.40	0	0.19	4.78	2.30	0.77	0.20	5.29	259.94	0.74	221.44
12	5.44	0.47	30.13	14.43	5.50	4.70	2.56	59.83	662.11	2.82	768.23
13	44.79	5.44	238.10	22.71	19.26	21.36	2.38	144.42	1329.33	6.70	1112.48
14	94.23	38.20	1416.21	22.35	36.70	100.48	4.08	117.62	1497.63	9.47	1087.89
15	179.82	131.29	2949.25	16.20	56.69	194.98	1.84	84.56	803.62	6.13	1046.86
16	166.05	227.77	3364.00	5.20	79.57	178.72	1.80	27.81	563.27	4.38	535.32
17	105.16	317.31	2207.83	5.20	50.81	99.74	1.76	10.15	304.17	7.78	266.25
18	129.71	215.26	1309.13	12.92	22.39	33.47	1.12	2.90	114.52	49.99	84.01
19	212.54	115.39	569.51	44.60	30.27	40.07	4.34	4.73	133.95	128.23	82.88
20	381.96	64.79	181.06	152.57	47.16	61.90	8.40	10.85	117.76	264.22	55.95
21	589.69	37.20	74.90	251.49	92.37	162.63	23.15	17.43	145.33	402.13	77.20
22	794.28	64.41	81.07	314.31	136.41	289.69	34.90	31.71	147.44	440.61	106.28
23	788.35	60.24	150.80	288.90	185.76	485.72	47.06	37.50	129.53	568.91	135.13
24	772.58	70.32	255.93	220.31	186.04	734.73	48.21	33.77	142.76	447.11	112.14
25	581.45	47.68	408.07	164.37	207.95	859.82	39.35	30.25	91.73	357.46	114.43
26	372.26	38.32	458.83	188.58	186.91	832.36	32.49	24.95	65.22	241.72	114.22
27	198.97	33.63	519.67	256.04	187.68	718.04	25.99	21.77	49.83	115.47	129.48
28	122.07	60.16	422.68	302.47	168.93	516.42	29.43	25.52	32.98	79.93	139.98
29	135.90	85.07	296.50	419.16	164.76	491.26	69.82	29.78	21.87	104.00	181.74
30	138.25	122.81	175.36	435.28	167.17	507.57	90.09	35.24	18.40	129.13	205.96
31	178.83	183.98	115.83	417.13	169.72	592.86	148.82	42.19	16.21	119.63	253.04
32	234.80	240.98	79.12	410.19	167.23	539.68	151.19	45.36	35.23	135.96	243.92
33	239.39	341.56	69.15	372.65	188.70	533.40	180.25	51.47	46.64	117.44	197.30
34	291.50	408.41	68.83	393.58	221.59	421.17	185.43	68.74	61.27	112.26	149.26
35	296.57	458.38	89.48	415.94	332.90	291.90	237.90	82.66	74.85	82.94	100.61
36	326.66	477.95	146.28	433.11	360.41	239.36	302.68	111.93	64.09	40.17	76.70
37	343.99	400.98	220.62	393.54	414.22	218.57	430.24	118.70	79.64	28.85	50.97
38	305.79	333.42	321.35	403.47	369.24	222.31	476.40	124.99	75.28	23.58	34.05
39	294.82	253.70	397.12	359.07	344.63	218.51	539.43	118.56	83.27	32.67	26.29
40	311.31	214.24	397.83	304.48	297.14	209.21	499.73	126.41	106.70	23.19	20.55

Table 8. -- Continued.

Length (cm)	**1994**	**1996**	**1997**	**1999**	**2000**	**2002**	**2004**	**2006**	**2007**	**2008**	**2009**
41	271.09	168.18	350.37	243.06	331.55	200.43	511.11	140.54	113.05	24.95	15.78
42	289.53	154.99	292.97	240.38	316.41	179.46	475.59	154.29	141.30	26.81	18.00
43	273.09	149.27	222.05	265.33	331.24	186.32	453.93	163.58	191.31	38.14	14.29
44	243.93	133.46	172.49	321.32	302.44	185.26	388.07	178.01	189.44	39.27	11.12
45	256.58	117.96	125.08	328.57	290.08	197.15	339.54	170.87	210.76	44.81	11.44
46	216.09	103.48	93.20	304.97	249.82	183.59	247.30	158.64	213.99	50.85	13.24
47	177.93	98.39	74.75	238.84	235.52	182.87	196.13	146.34	185.68	54.78	12.35
48	148.15	94.29	59.37	182.91	176.81	168.36	150.84	130.84	150.01	54.71	21.23
49	73.11	83.67	45.51	122.90	143.24	154.43	113.57	105.90	128.80	47.05	22.51
50	66.74	79.87	40.23	88.16	106.27	133.48	78.29	88.25	101.90	41.79	20.42
51	33.15	72.52	33.10	60.42	78.54	117.74	64.53	73.93	73.22	39.74	19.56
52	30.35	60.21	31.72	42.15	48.15	91.92	56.33	62.45	52.96	29.92	20.66
53	18.15	50.89	29.59	33.02	35.75	88.43	41.08	45.82	41.04	23.84	15.37
54	15.68	38.44	23.91	26.90	22.09	62.98	30.20	35.31	32.46	21.89	13.54
55	18.57	25.63	19.77	16.14	16.58	44.34	19.12	23.01	23.25	16.11	16.29
56	11.05	14.07	14.58	9.26	12.58	40.16	14.43	19.33	16.43	12.38	9.96
57	9.52	7.65	10.61	9.40	8.92	24.16	8.83	14.93	13.02	10.47	8.63
58	4.85	7.68	8.60	5.68	6.41	18.77	5.83	10.63	7.51	9.21	9.24
59	2.96	3.02	5.98	3.24	5.13	11.26	6.16	8.11	4.76	8.31	5.28
60	3.47	4.71	3.45	3.04	1.87	10.58	4.00	5.39	3.72	7.39	4.50
61	6.63	2.88	4.58	2.40	2.30	7.11	2.89	4.60	1.86	4.09	2.37
62	1.39	1.79	1.55	2.12	1.72	3.92	1.95	2.07	1.13	4.94	2.41
63	0.71	0.28	2.01	0.62	1.57	2.18	2.07	1.17	1.09	2.62	1.70
64	0.49	0.59	0.47	0.57	0.98	1.74	0.08	1.98	1.06	2.12	1.21
65	1.86	0.85	0.81	0.93	0.64	1.74	0.30	0.73	0.48	1.48	1.42
66	0.77	0.35	0.32	1.42	0.70	1.16	0.55	0.85	0.60	0.67	1.15
67	0.97	0.66	1.27	0.48	0.03	0.27	0.35	0.27	0.35	0.58	0.50
68	1.46	0	0.19	0.30	0.27	0.17	0.19	0.02	0.21	0.51	0.30
69	0	0	0.59	0.29	0.59	0	0	0	0.02	0.12	0.44
70	1.93	0	0.10	0	0	0.43	0	0.02	0.30	0.21	0.04
71	0.49	0.11	0	<0.01	0	0.01	0	0.14	0.21	0.06	0
72	0.97	0	0	0.11	0.15	0	0	0.46	0	0.42	0
73	0.49	0	0.05	0.16	0	0	0	0.02	0	0.04	0
74	0	0	0	0	0.14	0	0	0	0.06	0.05	0
75	0	0	0	0.04	0	0	0	0	0	0.03	0.03
76	0	0	0	0	0	0	0	0	0	0	0
77	0	0	0	0	0	0	0	0	0	0	0
78	0.49	0	0	0	0	0	0	0	0	0	0
79	0	0	0	0.39	0	0	0	0.08	0	0.06	0
80	0	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	9,207	4,704	8,075

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 acoustic-trawl surveys in the U.S. EEZ, 1994-2009.

Length (cm)	**1994**	**1996**	**1997**	**1999**	**2000**	**2002**	**2004**	**2006**	**2007**	**2008**	**2009**
0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	<1	0	0	0	0	0	0
9	0	0	0	<1	<1	0	0	0	0	0	24
10	0	0	14	1	8	0	2	0	200	0	336
11	4	0	2	59	30	9	2	54	2,469	7	2,003
12	71	6	394	227	88	75	30	762	7,313	34	9,219
13	744	92	4,148	445	370	428	36	2,366	19,068	104	17,136
14	1,937	804	31,282	538	859	2,488	81	2,176	25,781	168	21,613
15	4,520	3,384	81,544	472	1,613	5,841	48	1,997	17,771	145	25,658
16	5,040	7,098	111,182	181	2,713	6,393	57	815	14,870	125	16,147
17	3,817	11,818	84,460	214	2,055	4,231	67	365	9,873	254	10,147
18	5,553	9,485	58,223	623	1,064	1,664	50	123	4,401	1,923	3,671
19	10,655	5,960	28,768	2,499	1,677	2,284	210	235	6,200	5,880	4,185
20	22,244	3,892	10,677	9,852	3,017	4,072	498	626	6,392	14,049	3,204
21	39,601	2,579	4,900	18,587	6,782	12,242	1,595	1,133	9,810	24,584	5,259
22	61,100	5,121	6,101	26,421	11,419	24,828	2,730	2,413	11,643	31,976	8,715
23	69,048	5,458	12,962	27,464	17,629	47,351	4,265	3,277	11,513	48,149	12,534
24	76,622	7,221	24,999	23,562	19,911	81,309	4,887	3,259	14,551	42,932	11,518
25	64,967	5,520	45,081	19,681	24,970	107,760	4,475	3,176	10,266	38,541	14,070
26	46,652	4,979	56,998	25,168	25,070	117,666	4,347	3,107	8,010	29,360	15,332
27	27,847	4,884	72,339	37,933	28,002	113,478	3,876	2,946	6,844	15,725	20,391
28	19,028	9,721	65,700	49,557	27,927	89,827	4,813	3,917	5,073	12,102	23,816
29	23,550	15,240	51,328	75,679	30,072	92,941	12,745	5,050	3,697	17,423	35,978
30	26,437	24,307	33,691	86,321	33,574	104,158	17,942	6,561	3,462	23,802	44,259
31	37,756	40,104	24,685	90,579	37,396	132,640	32,663	9,236	3,428	24,696	60,686
32	54,180	57,669	18,522	97,251	40,301	131,538	36,257	10,767	8,606	30,634	63,679
33	60,378	89,480	17,709	96,204	49,614	141,718	48,265	13,252	12,233	29,302	56,444
34	80,001	116,812	19,201	110,357	63,403	122,045	53,459	19,248	17,643	29,881	46,340
35	88,546	142,771	27,148	126,368	103,387	92,414	74,135	25,252	23,484	24,798	33,904
36	105,903	161,724	48,272	142,256	121,237	82,291	103,401	36,989	21,662	13,229	27,902
37	120,806	147,067	79,075	139,441	150,552	81,503	156,813	41,377	29,517	10,234	19,593
38	116,110	132,264	124,841	153,908	144,826	88,680	188,084	47,836	30,240	9,163	14,455
39	121,143	108,629	166,999	147,178	145,465	93,405	229,225	49,056	35,953	13,611	11,726
40	137,651	98,825	180,668	133,859	135,080	95,675	230,733	55,427	48,709	10,622	9,876

Table 9. -- Continued.

Length (cm)	**1994**	**1996**	**1997**	**1999**	**2000**	**2002**	**2004**	**2006**	**2007**	**2008**	**2009**
41	129,335	83,422	171,750	114,415	161,884	98,165	252,339	65,790	54,826	11,866	8,172
42	149,294	82,523	154,670	120,957	165,982	94,168	253,443	78,528	72,602	13,379	9,940
43	152,526	85,177	125,886	142,492	185,961	104,975	261,967	87,505	105,904	20,806	8,596
44	147,017	81,478	104,750	183,897	181,482	110,994	239,860	102,839	111,390	22,429	6,934
45	166,444	76,937	81,320	200,114	185,345	125,772	222,131	103,984	131,381	27,203	7,500
46	149,720	71,999	64,736	197,389	169,854	124,740	171,216	102,312	143,460	32,686	9,387
47	131,130	72,930	55,323	164,067	170,024	132,267	142,845	100,258	131,598	37,569	9,438
48	115,921	74,352	46,750	133,183	135,575	129,623	115,709	94,693	112,575	38,443	16,576
49	60,566	70,102	38,100	94,742	116,332	126,481	92,215	81,175	101,538	36,199	18,743
50	58,531	71,016	35,728	71,872	91,389	115,778	67,512	73,481	85,481	34,038	18,222
51	30,462	68,346	31,145	52,026	71,352	108,641	58,478	63,585	64,652	33,569	18,440
52	29,789	60,080	31,560	38,303	46,186	89,753	53,394	56,209	49,596	26,625	20,583
53	18,463	53,710	31,087	31,630	36,163	91,552	41,489	44,479	39,922	23,325	15,872
54	16,856	42,859	26,500	27,130	23,496	68,832	31,998	36,086	34,719	22,249	14,241
55	21,296	30,163	23,075	17,129	18,562	51,122	21,285	25,029	26,503	17,789	17,943
56	13,207	17,456	17,914	10,327	14,788	48,961	17,136	21,089	19,415	15,024	12,046
57	11,943	9,998	13,712	11,013	11,004	30,986	11,453	17,519	16,742	13,074	11,371
58	6,368	10,573	11,671	6,984	8,300	25,335	7,517	13,507	9,953	12,444	11,563
59	4,167	4,365	8,530	4,174	6,962	15,953	8,825	10,892	6,815	11,544	8,251
60	5,001	7,163	5,155	4,104	2,656	15,550	6,038	7,784	5,687	11,354	7,402
61	10,199	4,591	7,172	3,394	3,421	11,003	4,574	6,869	2,990	6,534	4,100
62	2,285	2,998	2,550	3,135	2,679	6,415	3,214	3,241	1,874	8,250	4,373
63	1,196	498	3,448	953	2,551	3,683	3,585	1,937	1,934	4,528	3,241
64	844	1,084	843	925	1,660	3,109	139	3,360	1,958	3,835	2,423
65	3,382	1,637	1,531	1,562	1,122	3,223	562	1,314	928	2,717	2,978
66	1,467	704	617	2,497	1,296	2,202	1,097	1,587	1,212	1,303	2,525
67	1,929	1,386	2,622	876	52	505	717	519	734	1,201	1,150
68	3,021	0	413	567	551	352	406	46	464	1,072	729
69	0	0	1,351	585	1,244	0	0	0	45	273	1,096
70	4,349	0	230	0	0	945	0	51	720	493	101
71	1,142	267	0	3	0	33	0	322	538	132	0
72	2,380	0	0	238	351	0	0	1,084	0	1,016	0
73	1,239	0	126	362	0	0	0	57	0	112	0
74	0	0	0	0	362	0	0	0	181	135	0
75	1,340	0	0	90	0	0	0	0	0	90	86
76	0	0	0	0	0	0	0	0	0	0	0
77	0	0	0	0	0	0	0	0	0	0	0
78	1,503	0	0	0	0	0	0	0	0	0	0
79	0	0	0	1,118	0	0	0	245	0	181	0
80	0	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	923,843

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 acoustic-trawl surveys 1994-2009. Trace amounts are indicated as 'tr'.

Age	1994	1996	1997	1999	2000	2002	2004	2006	2007	2008	2009
1	610.2	972.3	12,360.0	111.9	257.9	634.8	15.8	455.6	5588.5	36.5	5127.9
2	4,781.1	446.4	2,745.2	1,587.6	1,272.3	4,850.4	275.1	208.6	1026.2	2905.3	797.5
3	1,336.0	520.4	386.2	3,597.0	1,184.9	3,295.1	1,189.3	282.0	319.7	1031.6	1675.9
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	202.8
5	1,898.1	820.7	1,921.5	582.6	899.7	507.2	1,442.1	695.3	669.2	106.9	40.1
6	296.1	509.3	384.4	273.9	243.9	756.8	416.6	551.8	588.8	170.2	44.0
7	71.2	434.4	205.2	1,169.1	234.0	436.7	199.2	319.7	305.7	132.4	62.0
8	65.2	84.9	142.5	400.2	725.1	91.4	194.0	110.1	166.2	70.7	55.5
9	31.9	16.7	32.7	104.6	190.4	110.3	68.3	53.0	60.2	58.2	32.6
10	23.2	6.3	3.9	66.9	84.7	205.4	33.5	40.3	18.8	15.0	21.2
11	8.5	5.7	4.9	14.5	35.6	52.1	24.8	23.3	20.2	15.1	8.2
12	19.3	12.1	2.0	6.5	18.1	17.9	19.8	16.2	5.7	6.9	3.8
13	4.8	1.3	2.2	1.7	1.2	3.1	12.1	8.6	1.7	4.5	2.0
14	5.7	4.8	2.3	0.0	1.4	5.9	5.8	9.9	2.1	1.9	1.2
15	1.2	2.4	2.0	0.1	0.1	0.0	4.3	5.0	1.8	0.9	0.1
16	7.9	0.5	0.0	0.1	0.3	0.0	0.0	3.8	0.2	2.0	0.0
17	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.6	0.0
18	0.0	0.5	0.0	0.4	0.1	0.0	0.0	0.1	0.0	0.6	tr
19	0.7	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.6	0.4	tr
20	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
21+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	tr	0.0
Total	10,821	6,525	18,686	9,601	7,630	12,122	6,834	3,396	9,207	4,704.0	8075.5

Age	1994	1996	1997	1999	2000	2002	2004	2006	2007	2008	2009
1	17.1	36.7	417.8	3.3	8.1	21.2	0.4	8.8	103.4	0.8	104.4
2	425.3	35.3	369.9	156.6	144.0	645.1	31.6	21.2	89.5	242.7	78.5
3	312.4	118.7	99.5	847.4	284.6	843.7	329.3	68.8	89.3	220.7	399.6
4	641.3	888.8	188.6	640.2	974.4	458.2	1349.4	230.7	188.0	58.7	84.1
5	1,067.2	396.0	921.0	271.7	488.6	286.0	820.9	366.4	389.8	61.5	23.4
6	187.2	341.8	235.0	164.3	156.0	514.5	288.7	359.8	404.3	117.3	35.7
7	50.1	359.9	161.3	751.5	166.6	351.6	153.0	244.1	240.9	106.6	56.0
8	55.3	72.5	139.5	278.9	540.8	85.6	166.3	93.2	144.8	69.4	57.0
9	30.9	16.3	34.2	84.6	149.0	111.0	62.4	49.5	58.4	56.4	36.8
10	26.4	6.6	4.4	62.5	76.3	212.5	33.1	39.2	20.7	18.9	25.1
11	10.5	6.9	6.1	14.2	39.0	59.6	25.3	23.3	22.3	18.9	10.7
12	27.9	17.1	3.4	7.2	16.7	19.7	21.9	18.7	7.1	8.6	5.5
13	6.7	1.5	4.5	1.5	1.3	4.6	12.7	10.4	2.1	6.2	3.4
14	7.7	7.0	3.8	0.0	2.6	8.5	6.2	12.7	3.7	3.2	2.5
15	2.1	3.8	2.9	0.2	0.1	0.0	5.7	5.9	2.2	1.1	0.3
16	12.5	0.9	0.0	0.2	0.3	0.0	0.0	4.3	0.3	3.3	0.0
17	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.9	0.0
18	0.0	0.9	0.0	0.7	0.3	0.0	0.0	0.3	0.0	1.1	tr
19	0.8	0.0	0.0	0.0	0.0	0.0	0.0	2.5	1.0	0.5	tr
20	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
21+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.1	0.0
Total	2,886	2,311	2,592	3,285	3,049	3,622	3,307	1,560	1,769	996.9	923.8

Table 11. -- Estimated numbers and biomass of walleye pollock observed between near the surface and 0.5 m off bottom from Bering Sea acoustic-trawl surveys in the United States 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			
2009	US	9.25	1.33	99	US	91,414
	Russia	0.02	0.01	1	US	11,714
	Total	9.27	1.34			

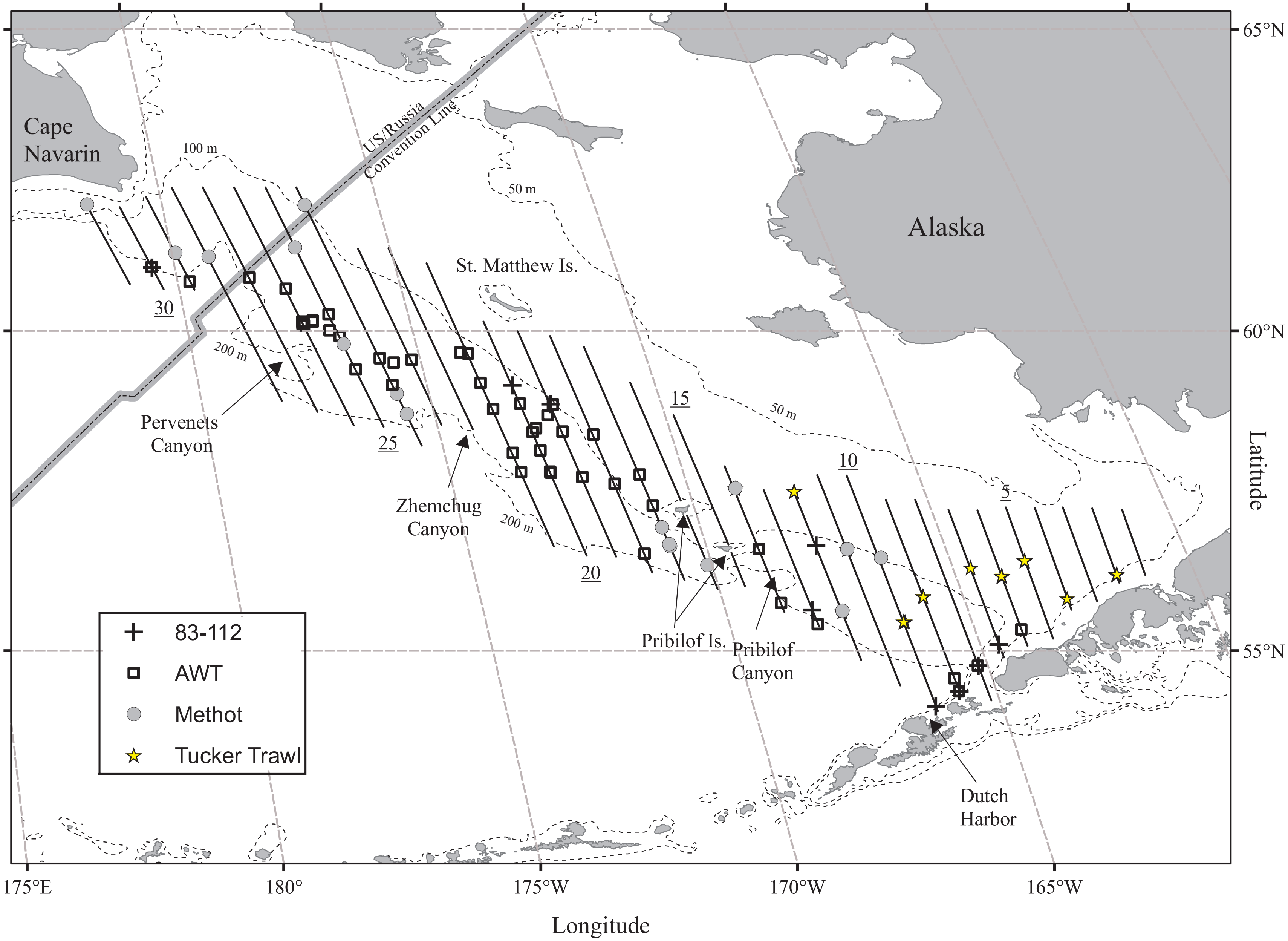


Figure 1.--Transect lines with locations of midwater (Aleutian wing trawl (AWT), and Methot trawls), bottom trawls (83-112), and Tucker trawls during the summer 2009 acoustic-trawl survey of walleye pollock on the Bering Sea shelf. Transect numbers are underlined.

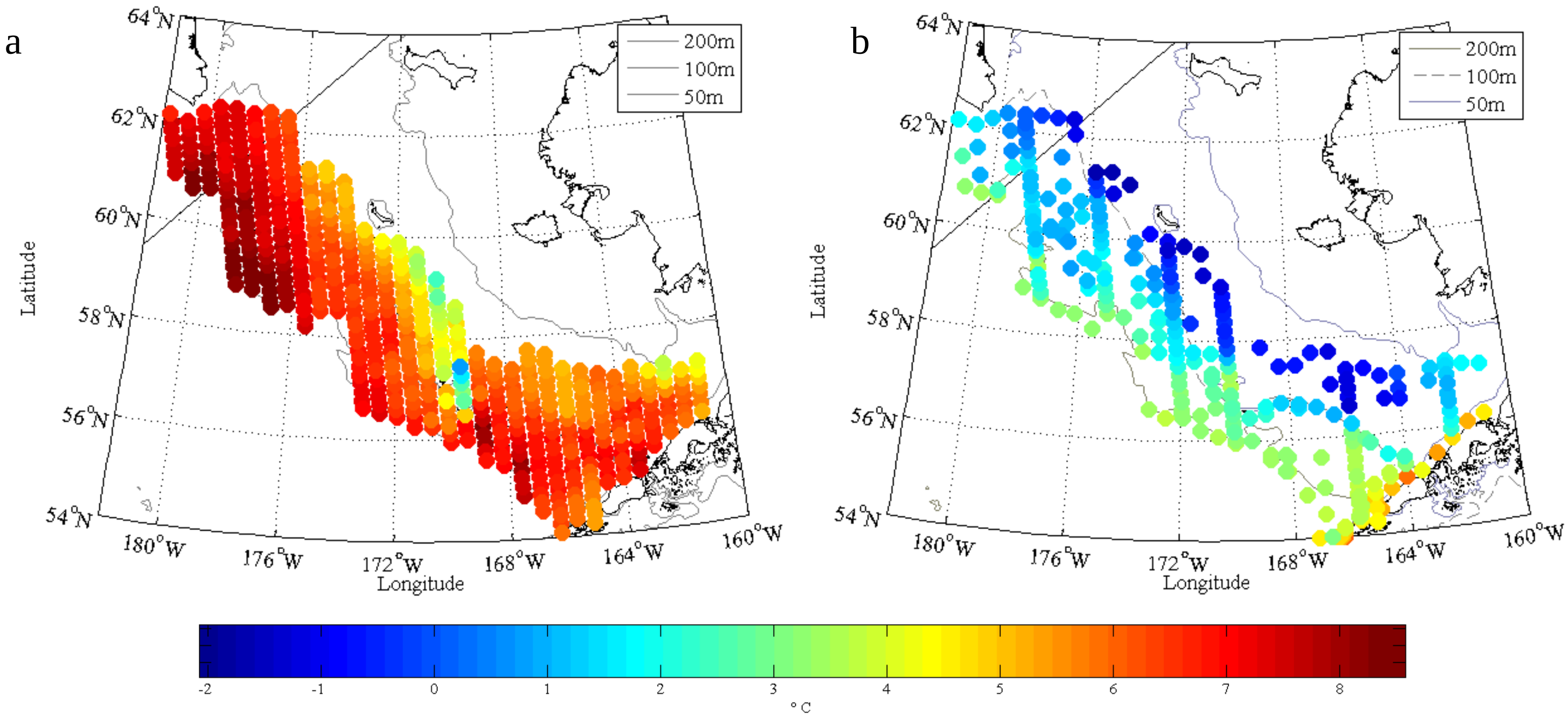


Figure 2. -- Temperature (°C) measured at the sea surface using shipboard surface temperature sensors along survey transects and averaged at 10-nmi resolution (a), and at the bottom using SBE-39s at trawl locations, conductivity-temperature-depth profilers (CTDs), and expendable bathythermographs (XBTs) (b) during the summer 2009 acoustic-trawl survey of the Bering Sea shelf.

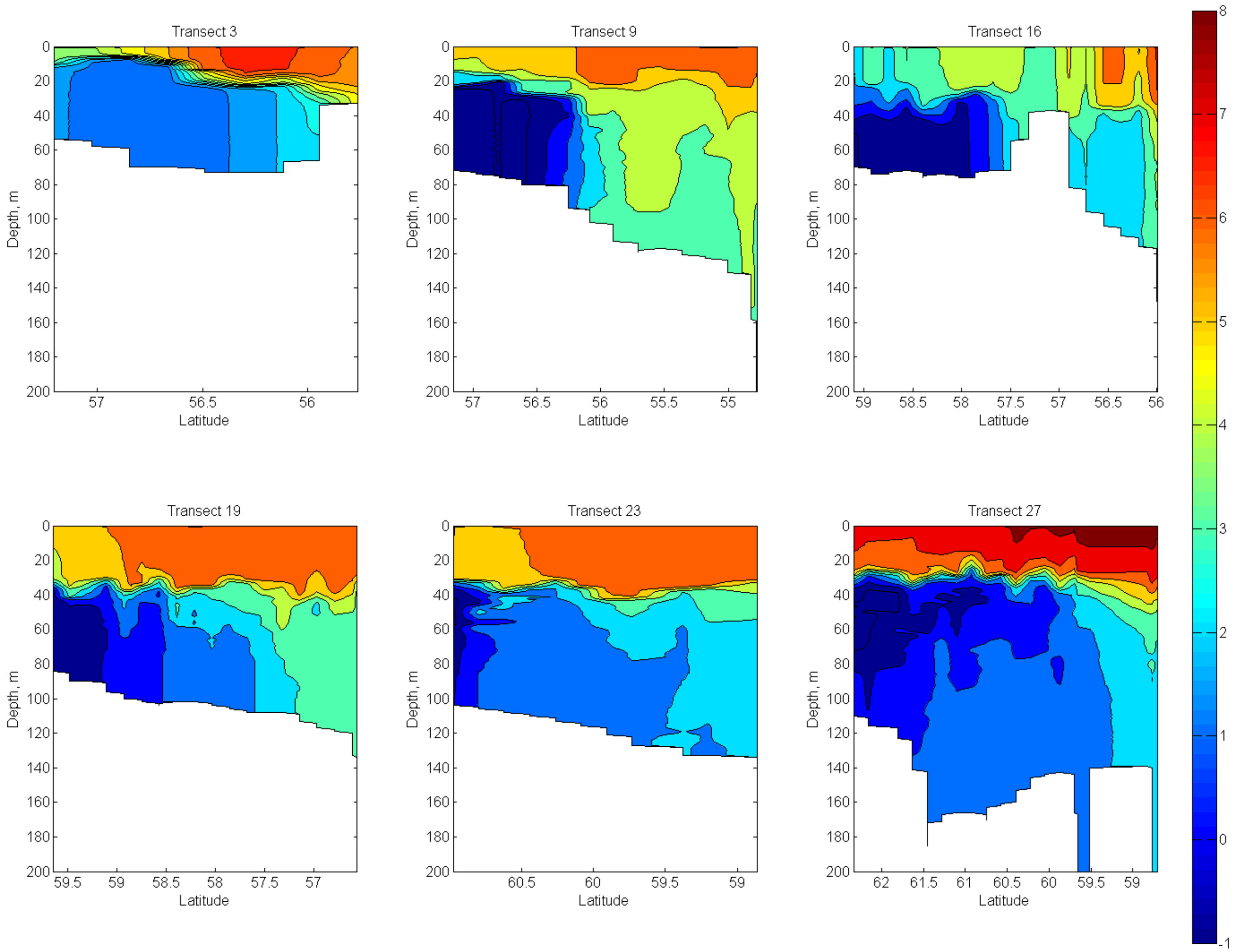


Figure 3. -- Temperature (°C) profiles measured using expendable bathythermographs (XBTs) dropped along survey transects during the summer 2009 acoustic-trawl survey of the Bering Sea shelf from June - August.

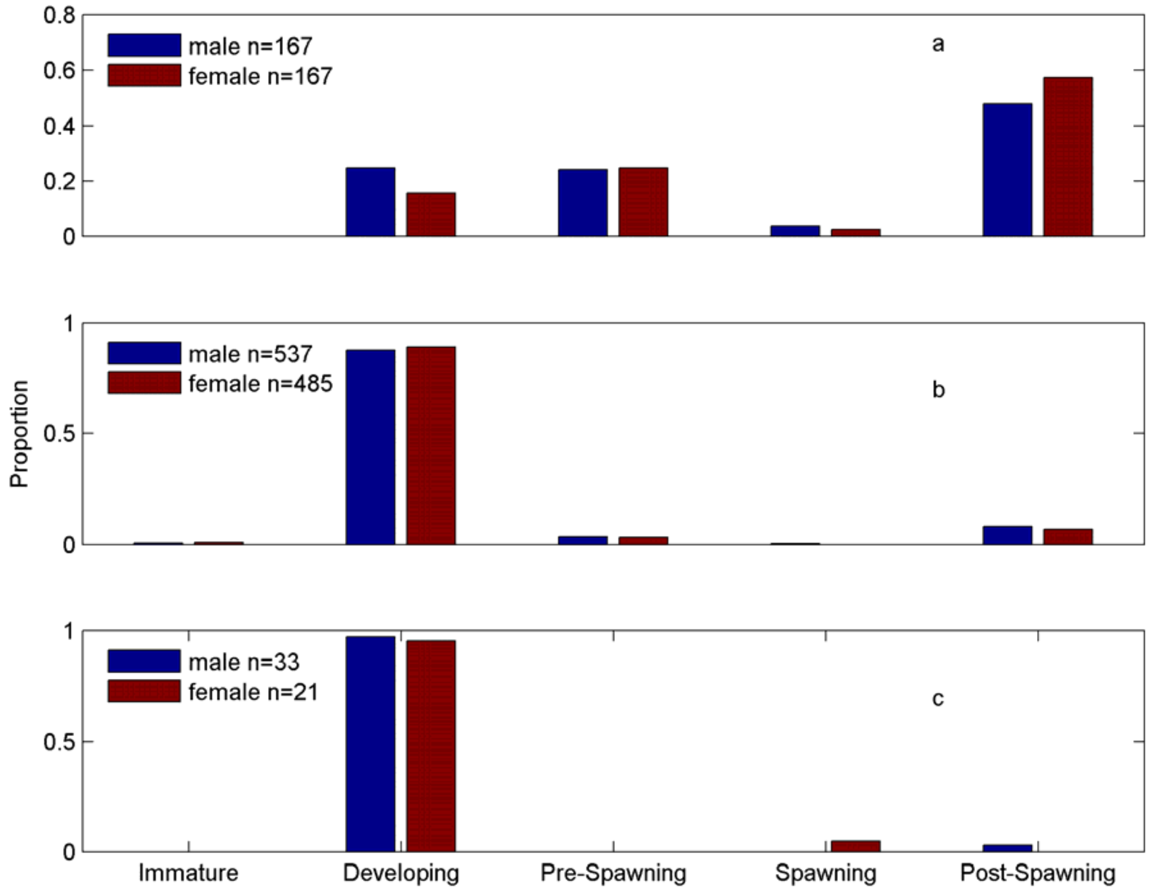


Figure 4. -- Maturity stages by sex for walleye pollock greater than 29 cm observed during the summer 2009 Bering Sea shelf acoustic-trawl survey a) east of 170° W, b) in U.S. waters west of 170° W, and c) in Russian waters.

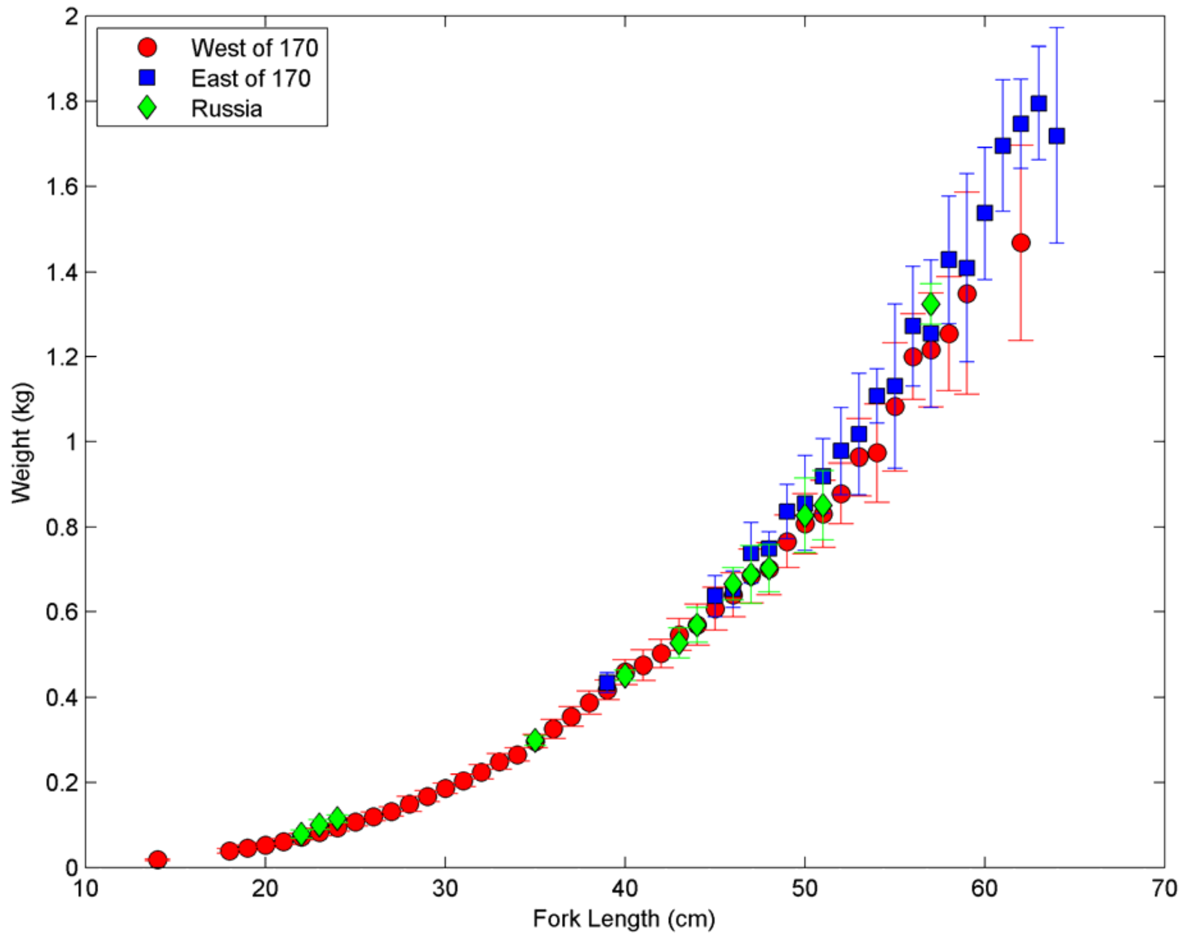


Figure 5. -- Mean weight-at-length for walleye pollock measured in the U.S. EEZ east and west of 170°W and in Russia during the summer 2009 Bering Sea shelf acoustic-trawl survey. Average weights (kg) were computed when > 5 fish were measured at any given length (cm). Error bars represent ± 1 standard deviation.

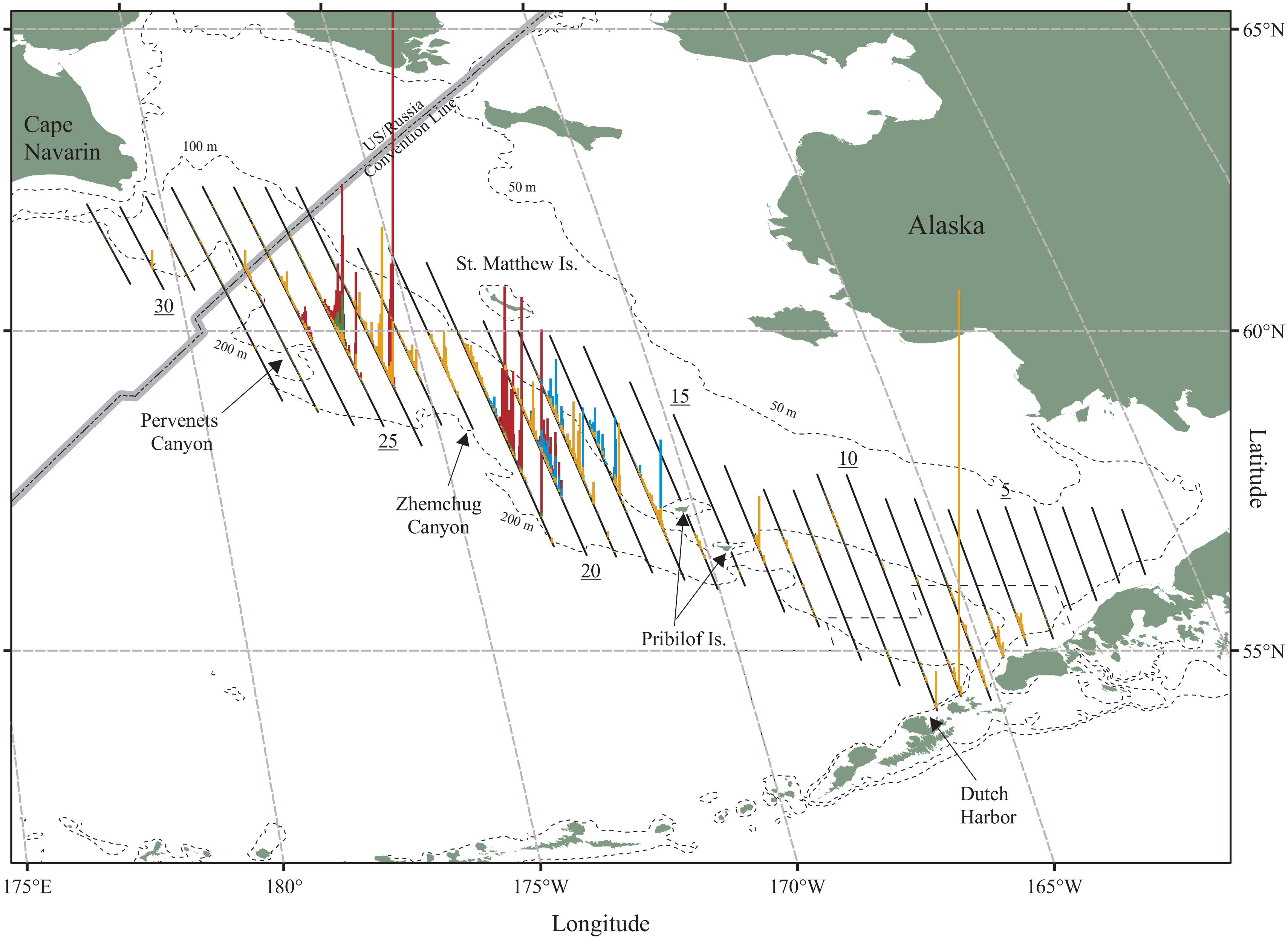


Figure 6.-- Estimated juvenile (< 19 cm, blue; 19-26 cm, green; 27-38 cm, dark orange) and adult (> 38 cm, light orange) walleye pollock biomass (t) by 0.5 nmi interval for the summer 2009 acoustic-trawl survey (16 m from the surface to 3 m off bottom). Transect numbers are underlined, and the Steller sea lion Conservation Area (SCA) is outlined (dashed line).

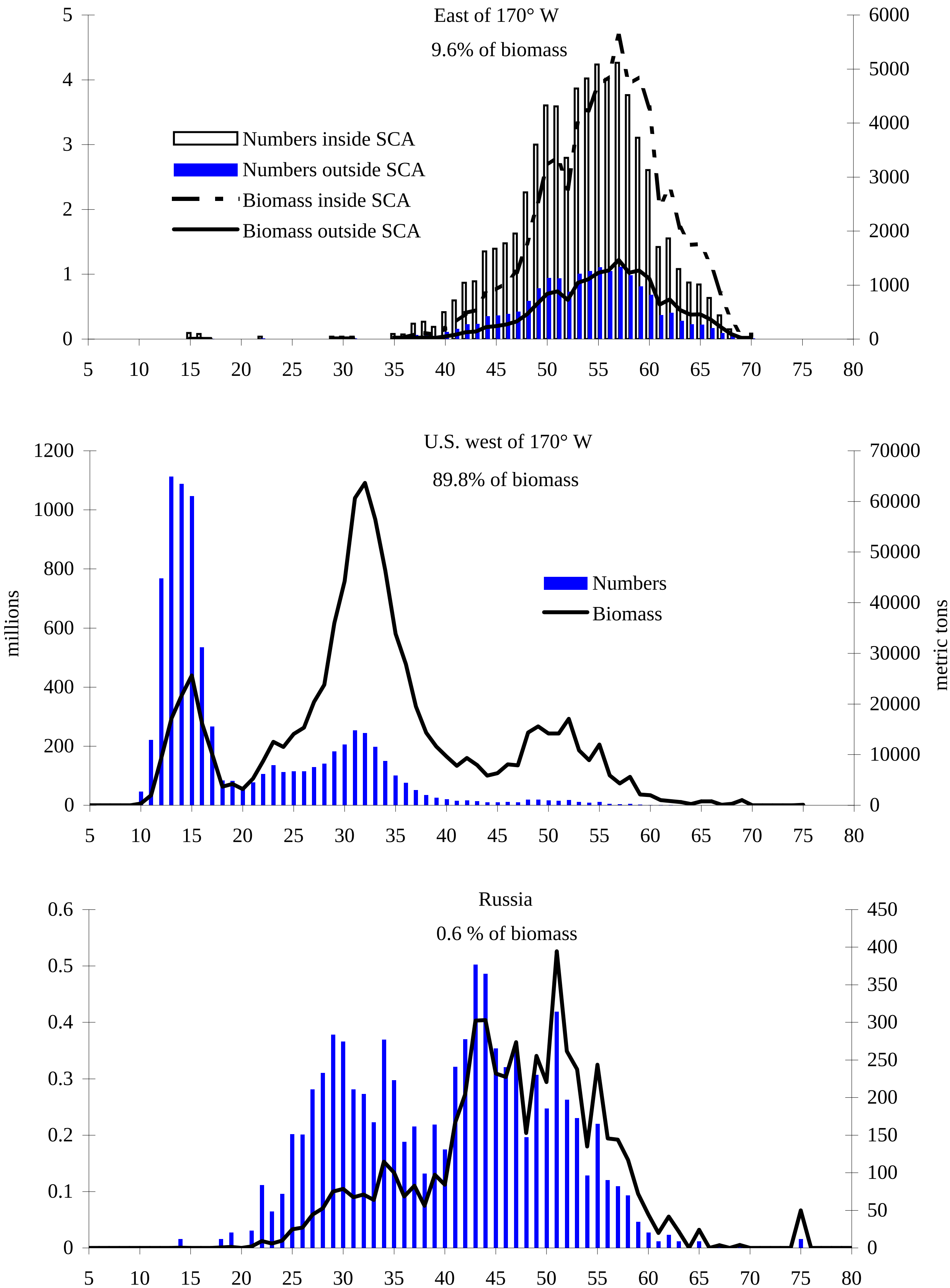


Figure 7. Population numbers and biomass at length estimated for walleye pollock between 16 m from the surface and 3 m off the bottom from the summer Bering Sea shelf acoustic-trawl survey in three geographic regions.

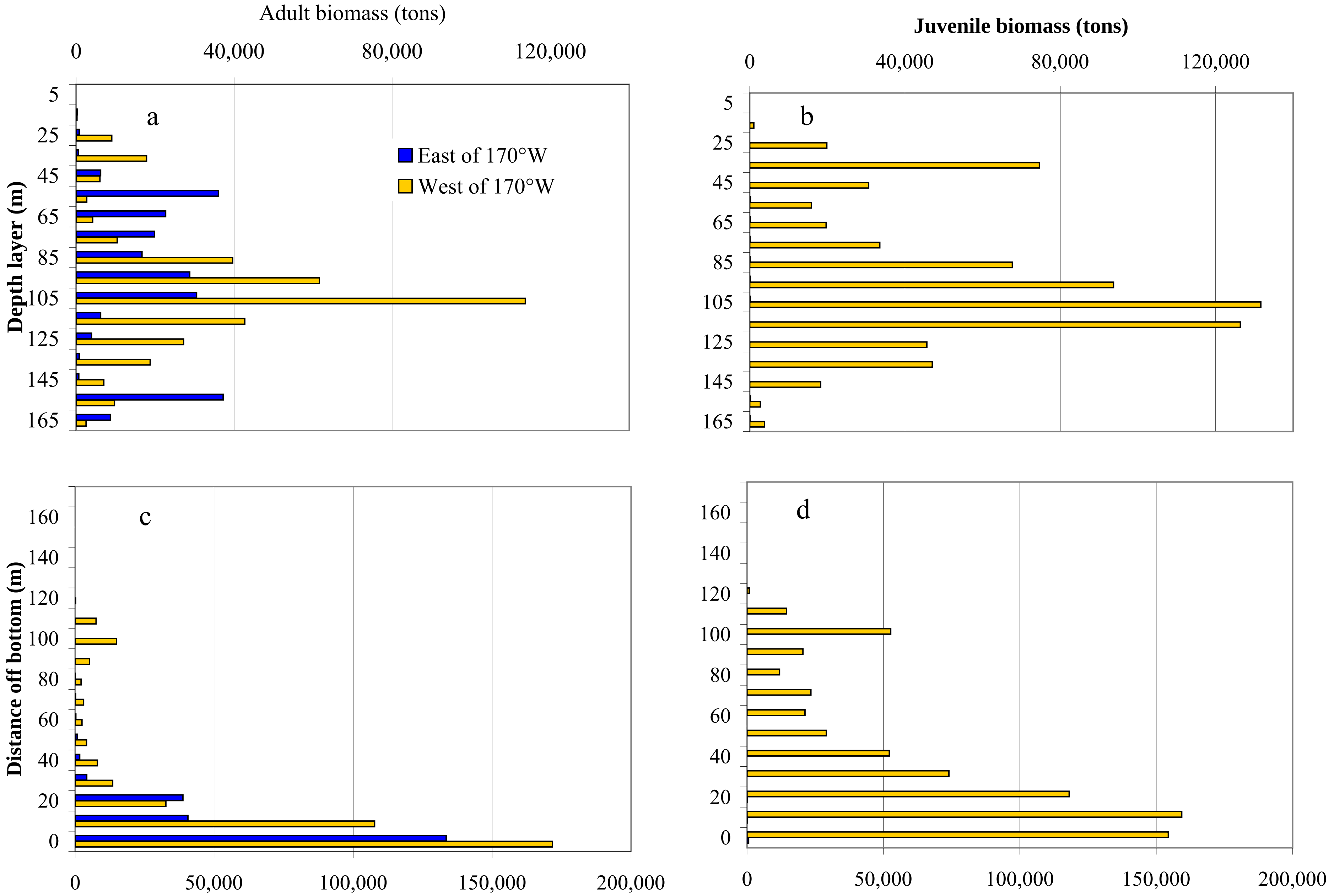


Figure 8.-- Depth distribution of adult (≤ 39 cm FL) or juvenile (< 39 cm FL) walleye pollock biomass in metric tons (t) observed east and west of 170°W longitude in the U.S. EEZ of the Bering Sea shelf during the summer 2009 acoustic-trawl survey. Depth is referenced to the surface (a,b) and to the bottom (c,d). Note: So few juveniles were observed east of 170°W that they do not show up on the graph. Y-axes differ.

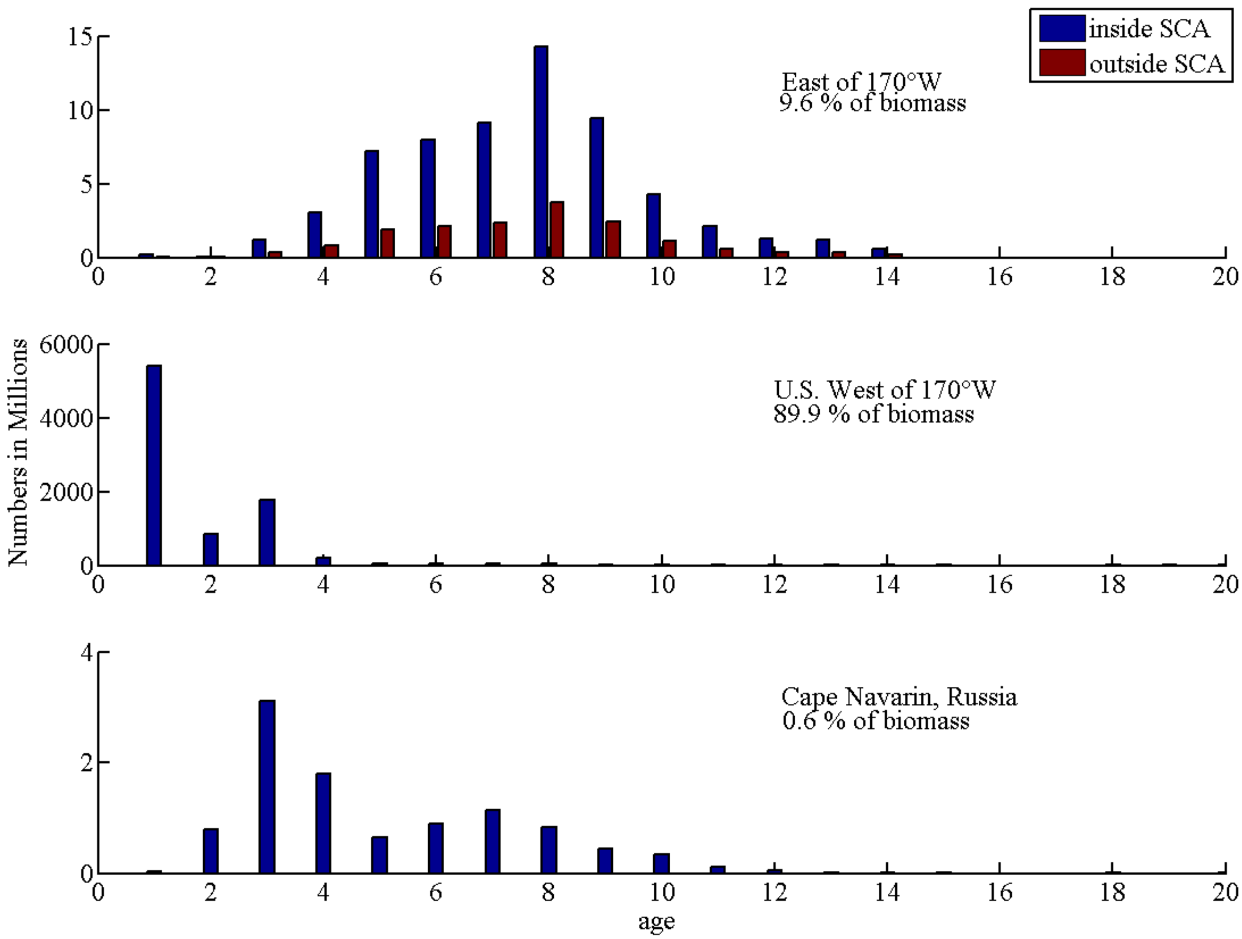


Figure 9. -- Population numbers at age estimated for walleye pollock between 16 m from surface and 3 m off bottom for three different geographic regions during the summer eastern Bering Sea shelf acoustic-trawl survey. Note: Y-axes differ.

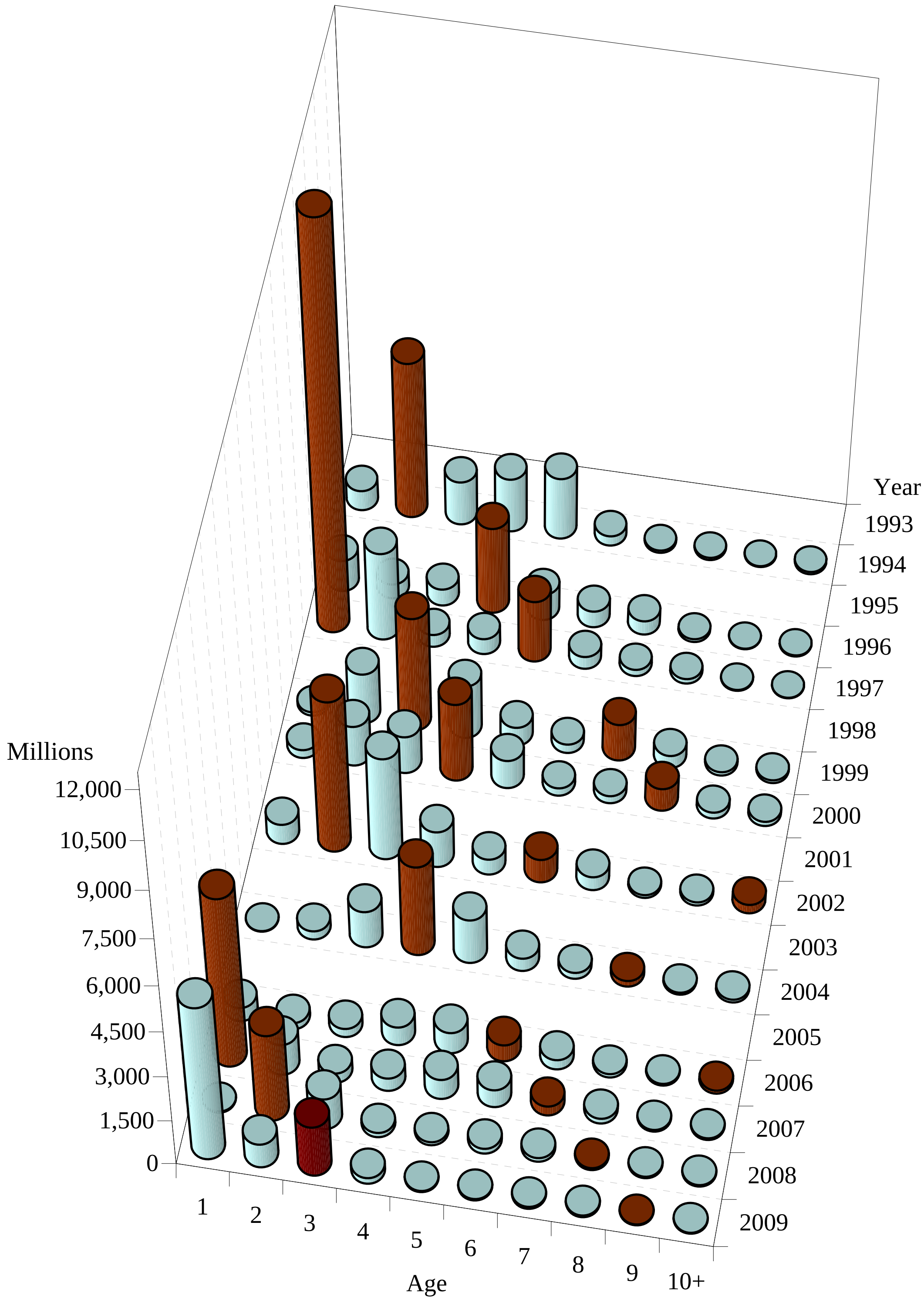


Figure 10. -- Historical numbers at age of walleye pollock between near the surface and 3 m off bottom in the U.S. EEZ for the summer eastern Bering Sea shelf acoustic-trawl surveys between 1994 and 2009. Strong year classes are indicated with dark shading.

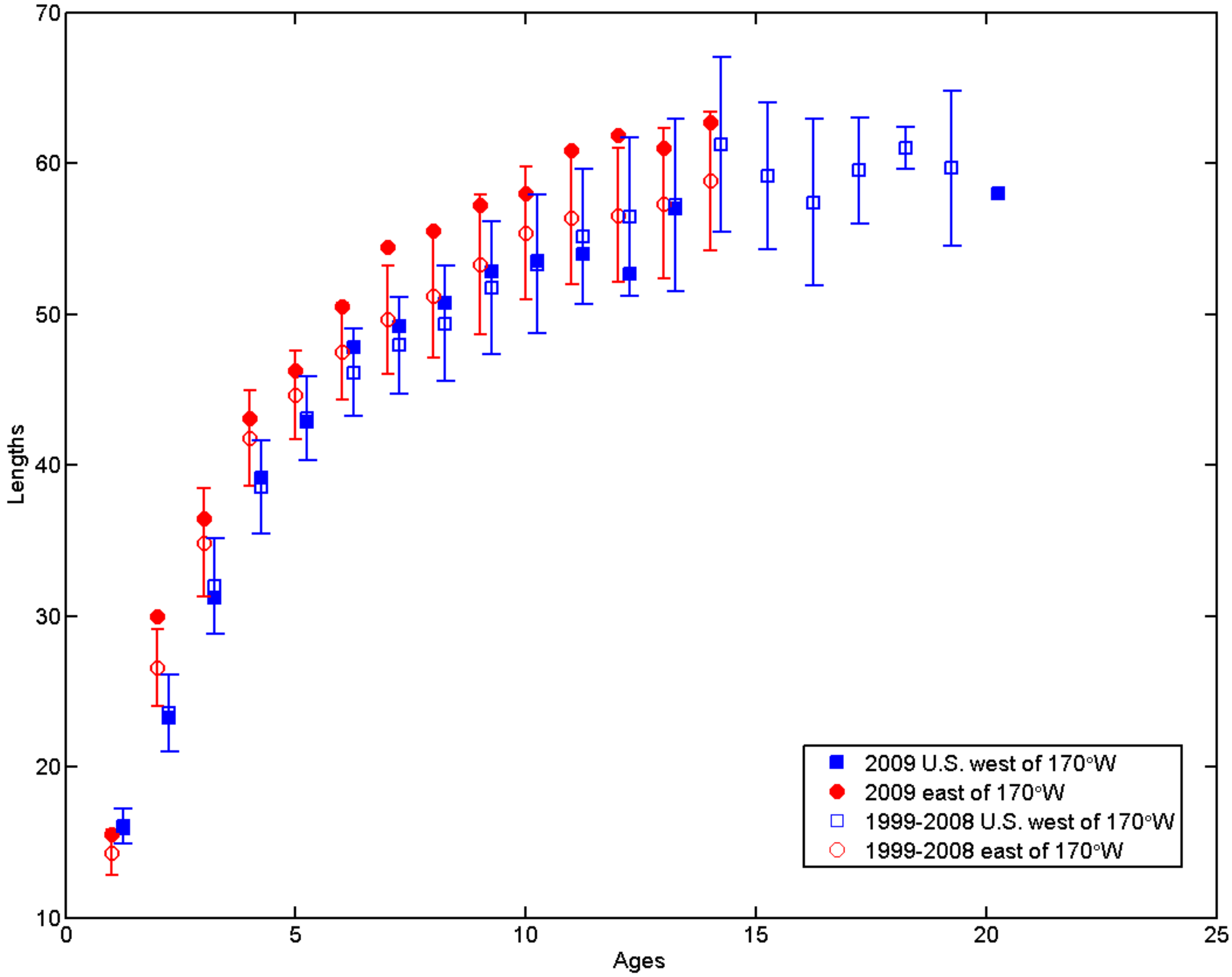
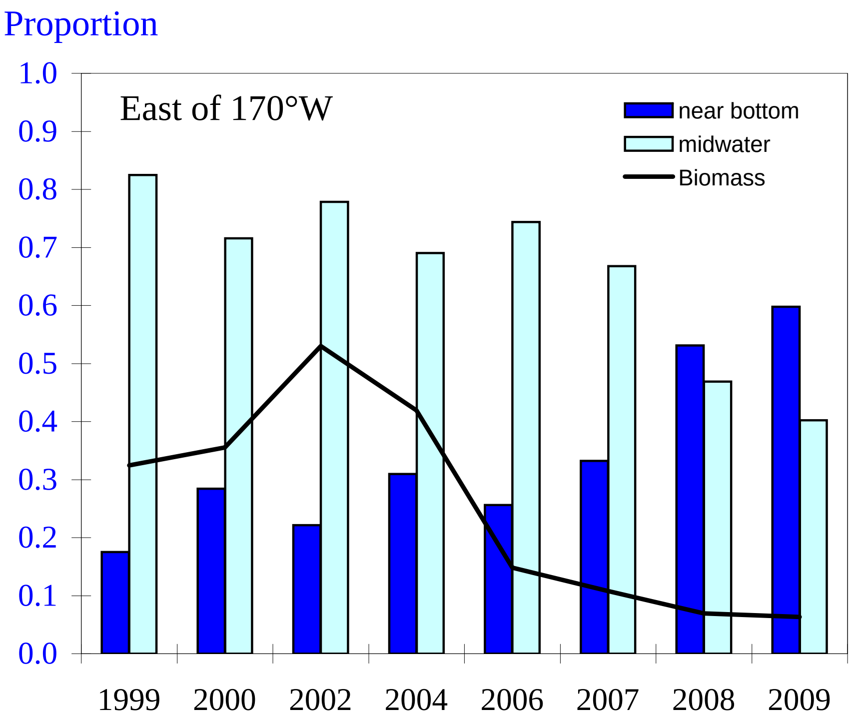
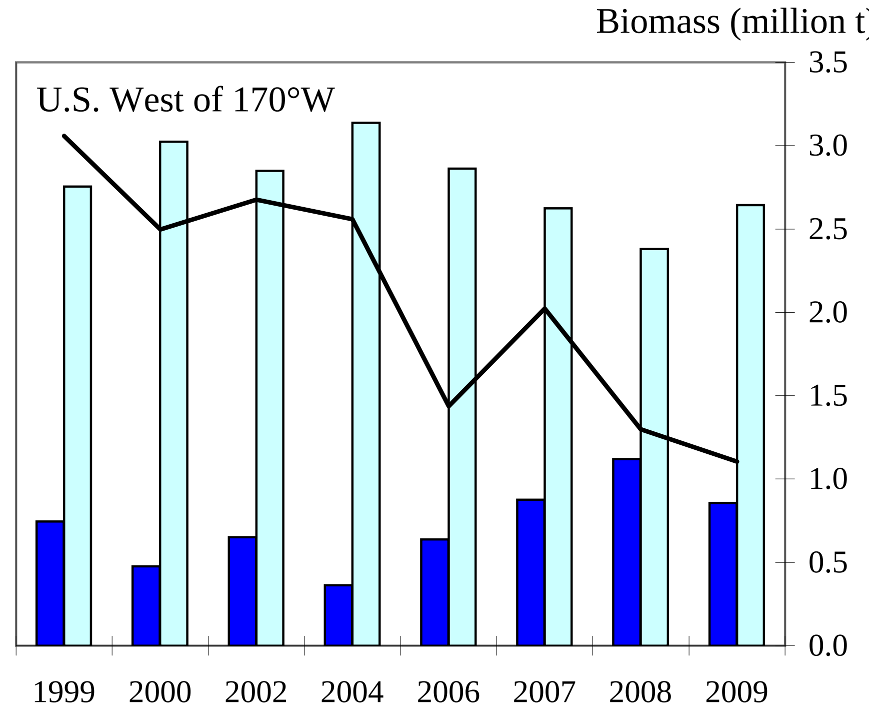


Figure 11. -- Walleye pollock average length at age from summer eastern Bering Sea acoustic-trawl surveys (1999, 2000, 2002, 2004, 2006, 2007, and 2008) compared with walleye pollock average length at age for summer 2009. Results are for midwater tows where at least five fish were measured in the U.S. EEZ. Bars show +/- 1 standard deviation for the 1999-2008 series.





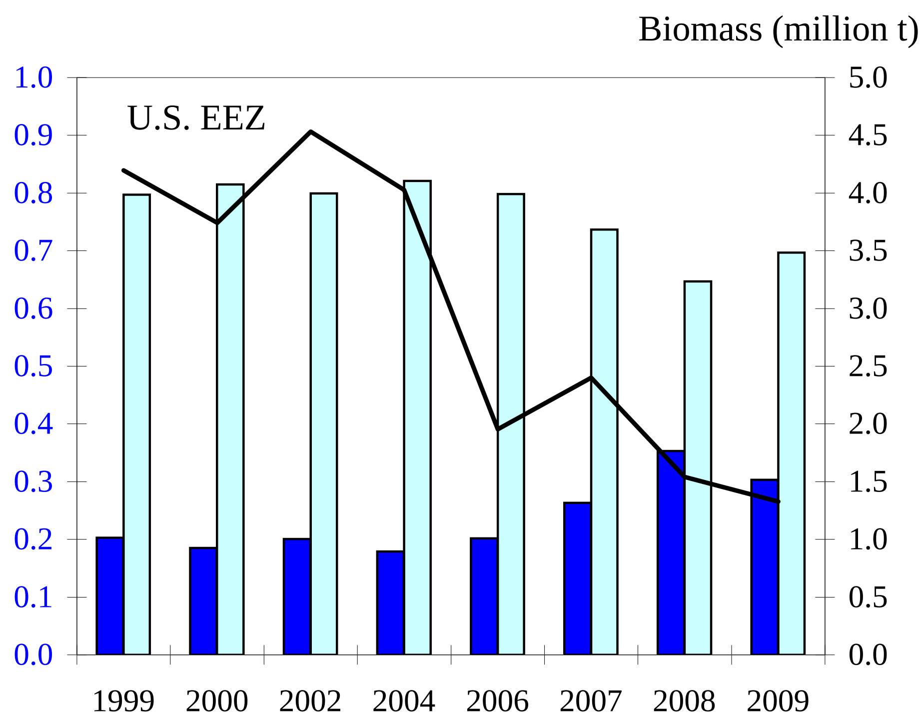


Figure 12. -- Proportion of walleye pollock biomass in midwater (surface to 3 m off the bottom), and near bottom (3 m to 0.5 m off bottom), east and west of 170°W, and in the U.S. EEZ during the 1999-2009 acoustic-trawl surveys. Total (midwater + near bottom) biomass (black lines) is plotted on right Y-axes.

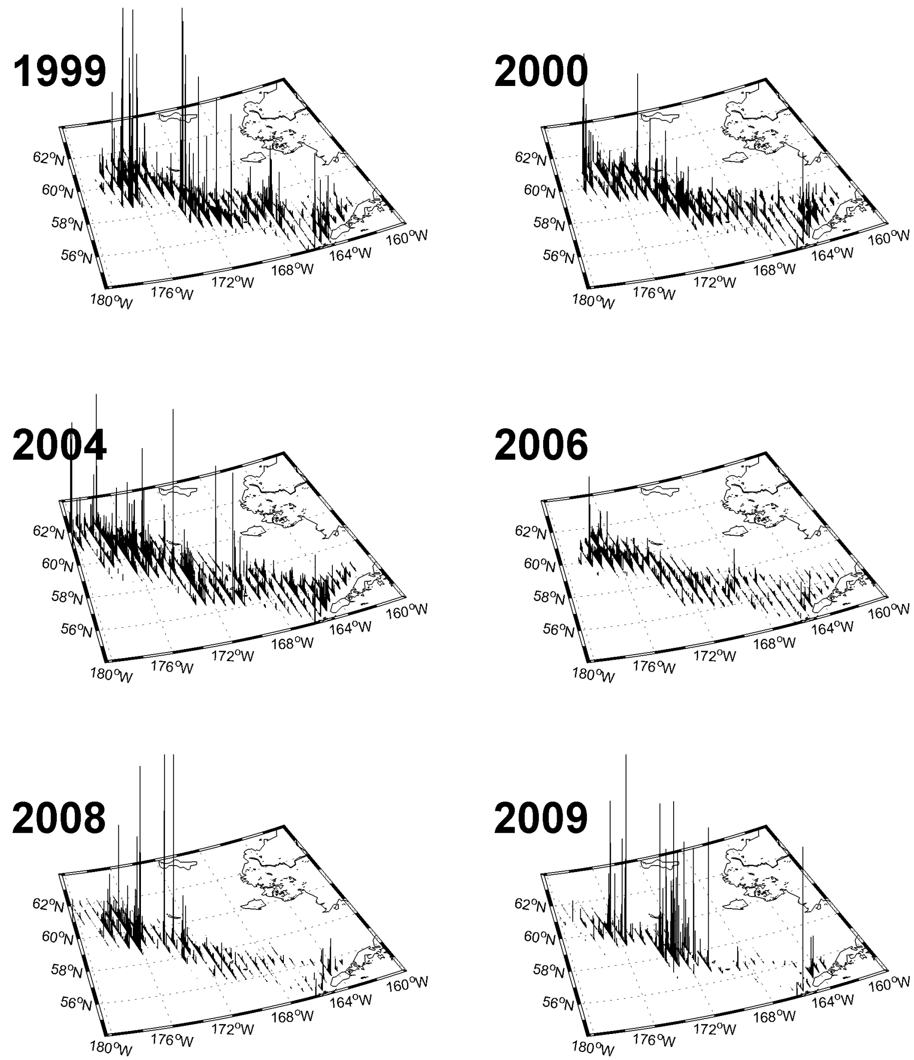


Figure 13. -- Walleye pollock backscatter (s_A) at 38 kHz observed along tracklines during the summer eastern Bering Sea acoustic-trawl surveys conducted between 1999 and 2009.

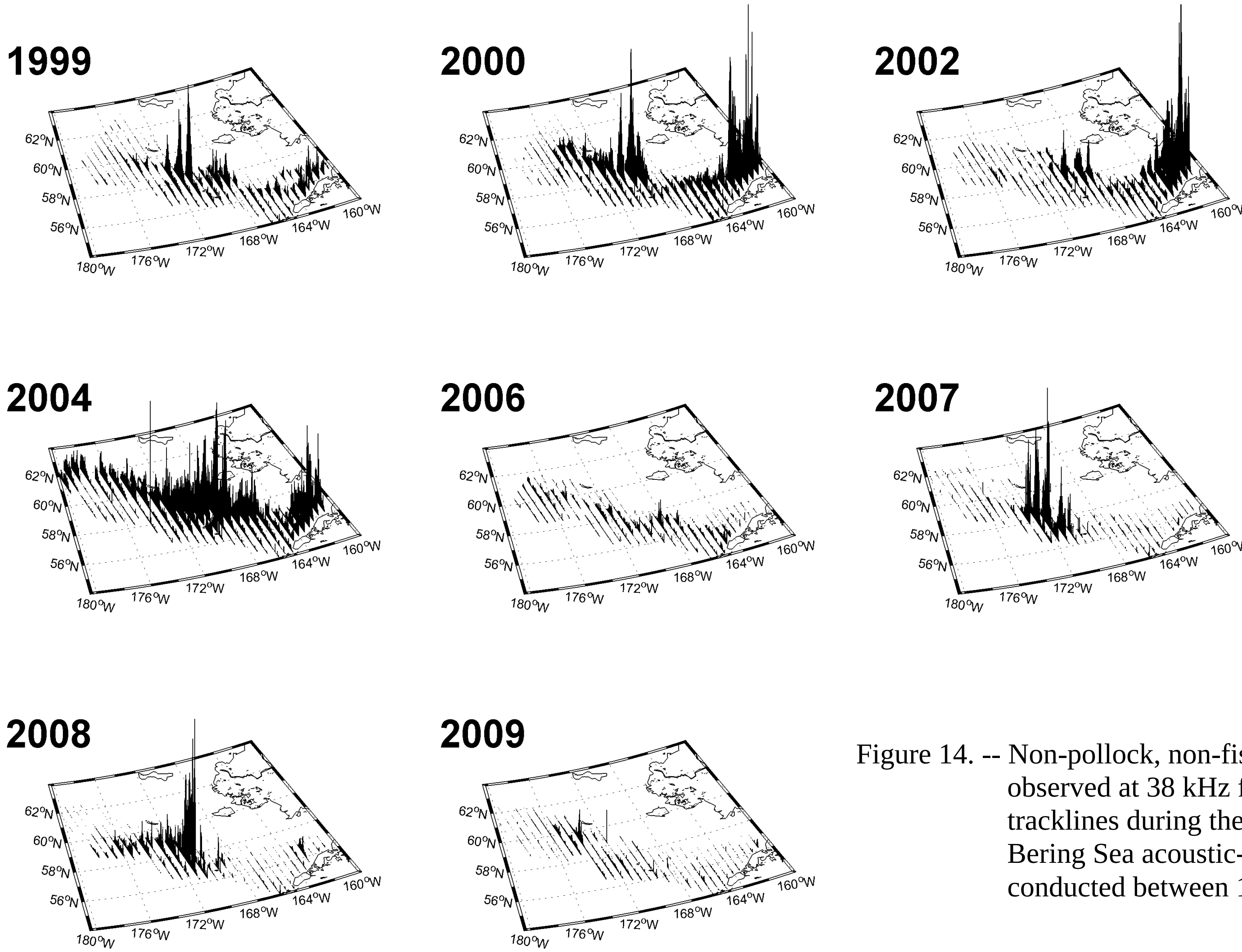


Figure 14. -- Non-pollock, non-fish, backscatter (s_A), observed at 38 kHz frequency along tracklines during the summer eastern Bering Sea acoustic-trawl surveys conducted between 1999 and 2009.

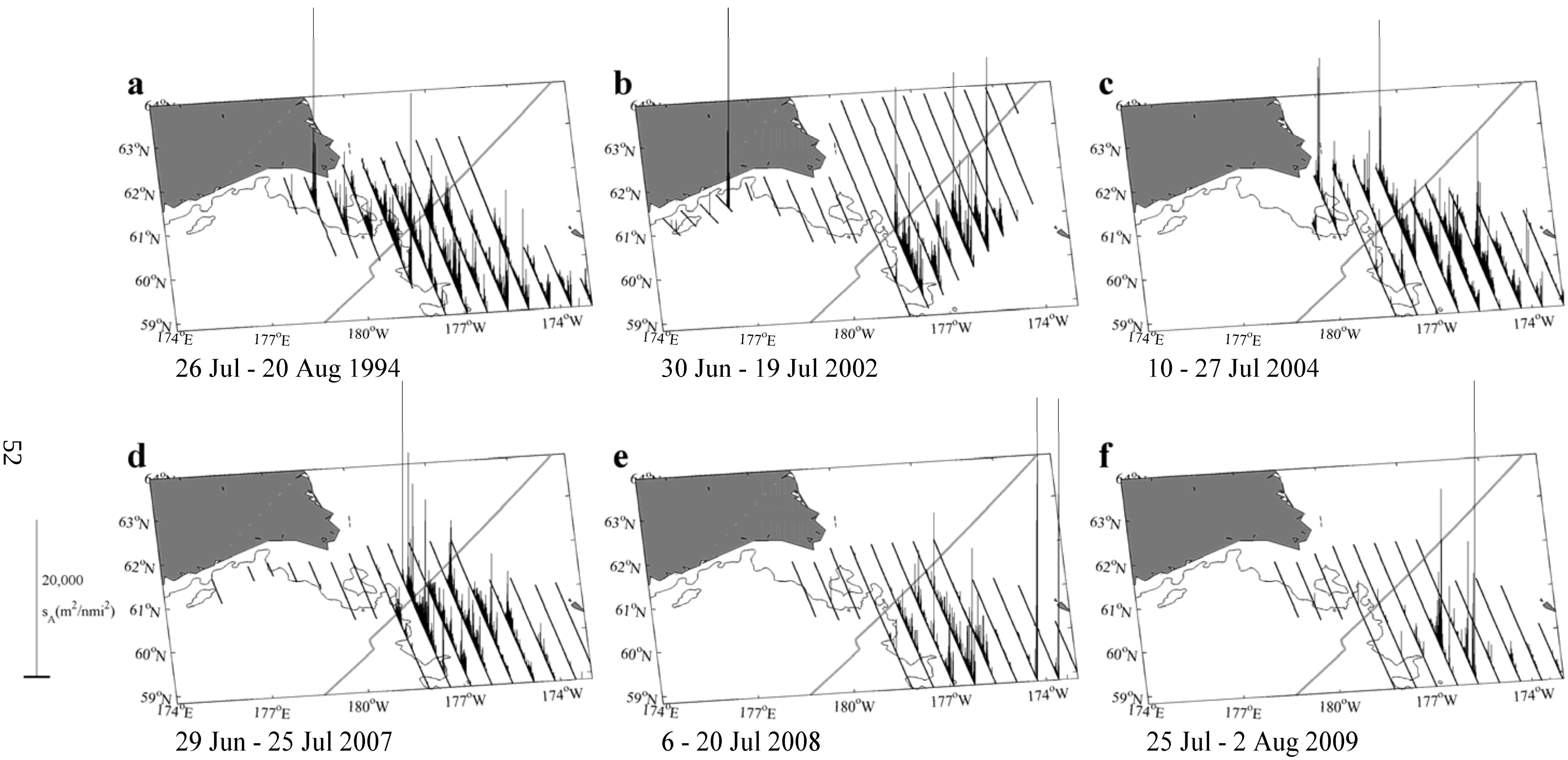


Figure 15. -- Walleye pollock acoustic backscatter (s_A) along tracklines between near surface and 0.5 m off bottom from acoustic-trawl surveys in the Cape Navarin area of Russia. The United States conducted surveys in 1994 (a), 2004 (c), 2007 (d), 2008 (e) and 2009 (f). Russia conducted survey in 2002 (b).

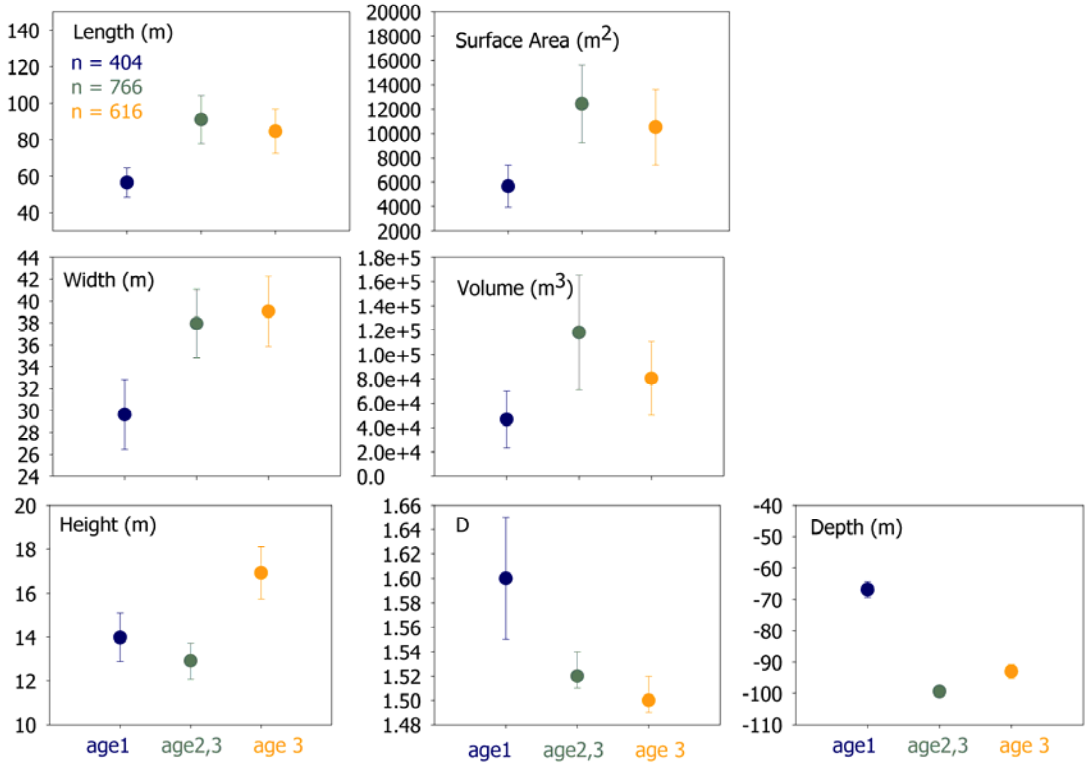


Figure 16. -- Aggregation descriptors and 95% confidence intervals for the various age groups of juvenile walleye pollock in the Bering Sea during summer 2009. "D" is the ratio of aggregation surface area to volume.

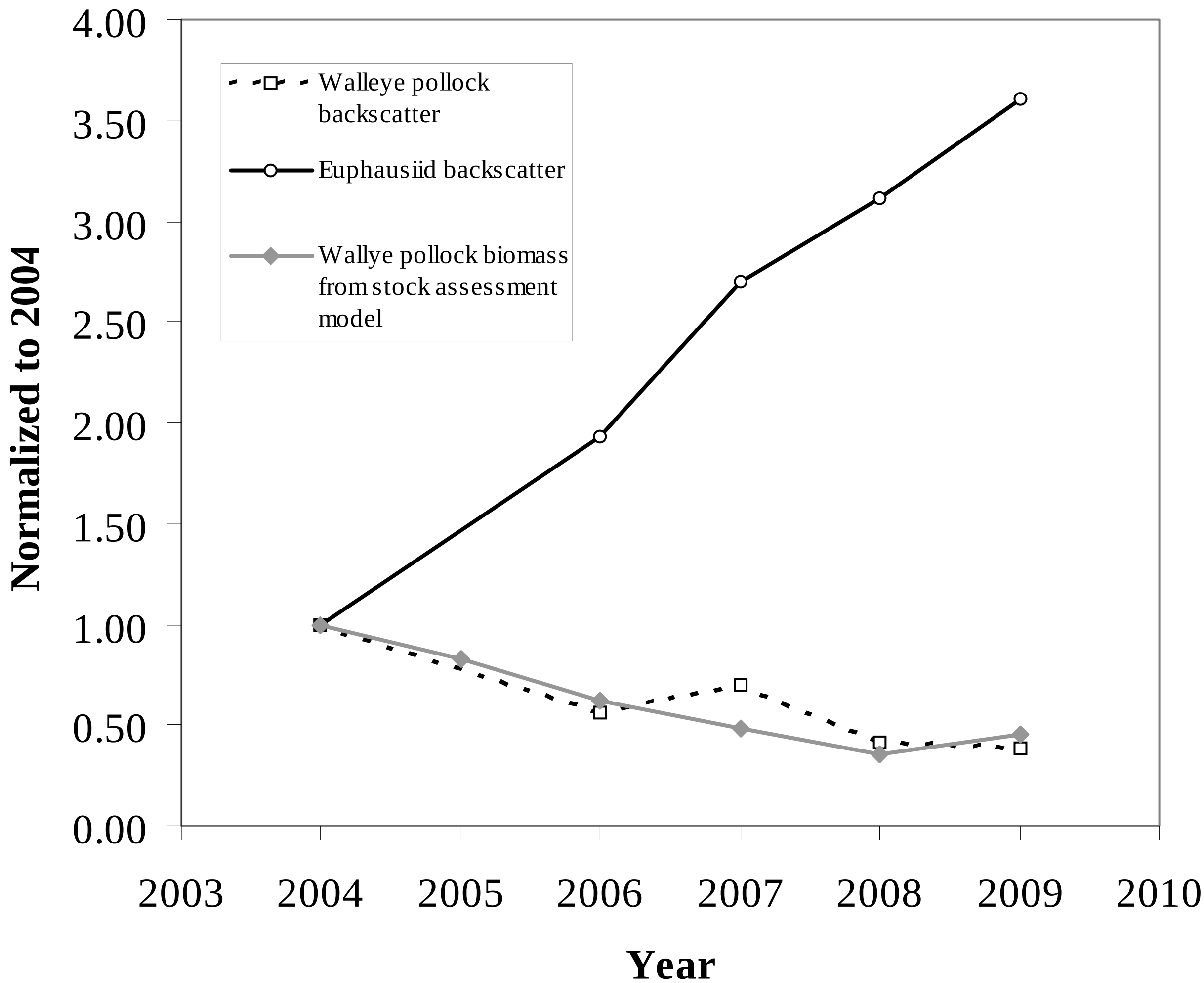
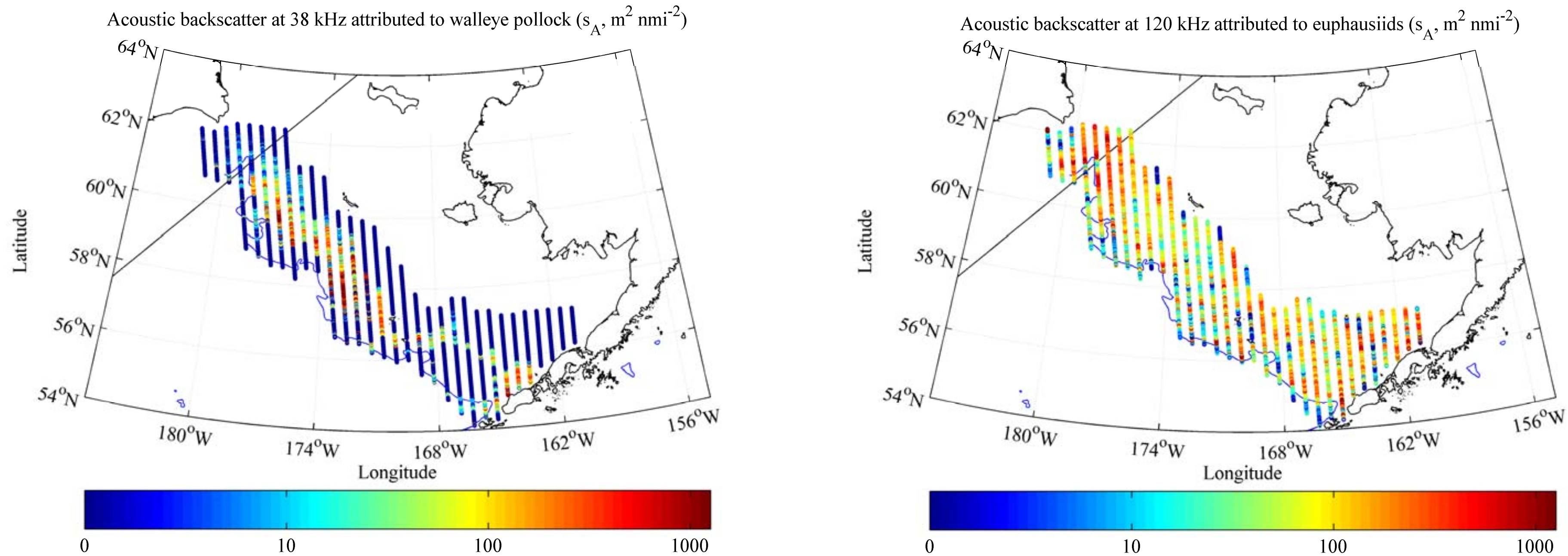


Figure 17. -- Bering Sea summer euphausiid backscatter at 120 kHz and walleye pollock backscatter at 38 kHz from the acoustic-survey, and age 3+ walleye pollock biomass estimated by the stock assessment model, 2004-2009 (Ianelli et al. 2009, Table 1.22). Each time series has been normalized to its value in 2004. The 2009 results are preliminary.



2009 (preliminary)

Figure 18. -- Pollock backscatter at 38 kHz (left panel) and euphausiid backscatter at 120 kHz (right panel) along tracklines from the summer 2009 acoustic-trawl survey of Bering Sea walleye pollock.

Appendix I. Itinerary

Leg 1

9 June	Depart Kodiak, AK
10-11 June	Acoustic sphere calibration in Three Saints Bay, Kodiak Island, AK
11-14 June	Transit to Bering Sea. Drop TS and ME70 data collection enroute
14-27 June	Acoustic-trawl survey of the Bering Sea shelf (through transect 14). Scientific personnel exchange in Dutch Harbor on June 21.
27 June	Transit to Dutch Harbor
28 June	In port Dutch Harbor

Leg 2

1 July	Acoustic sphere calibration in Captains Bay, Unalaska Island, AK. Transit to transect 15 waypoint
3-15 July	Acoustic-trawl survey of the Bering Sea shelf (transects 15 - 23)
16 July	ME70 and Drop TS data collection
17 July	Transit to Unalaska Island, AK
18 July	In port Dutch Harbor, AK

Leg 3

21 July	Transit to transect 24 waypoint
23 Jul.-2 Aug.	Acoustic-trawl survey of the Bering Sea shelf (transects 24 - 31)
3-5 Aug.	Experimental trawls, ME70 and Drop TS data collection. Transit to Unalaska Island
6-7 Aug.	Acoustic sphere calibration in Anderson Bay, Unalaska Island, AK. Transit to Dutch Harbor, AK. ME70 data collection along Dutch standard transects.
7 Aug.	End of cruise

Appendix II. Scientific Personnel

Leg 1 (9-28 June)

Name	Position	Organization	Nation
Patrick Ressler	Chief Scientist	AFSC	USA
Sarah Stienessen	Fishery Biologist	AFSC	USA
Scott Furnish	Info. Tech. Specialist	AFSC	USA
Chris Wilson	Fishery Biologist	AFSC	USA
Abigail McCarthy	Fishery Biologist	AFSC	USA
Darin Jones	Fishery Biologist	AFSC	USA
Amanda Guenther	Fishery Biologist	AFSC	USA
Mikhail Stepanenko	Fishery Biologist	TINRO	Russia
Alexander Nikolaev	Fishery Acoustician	TINRO	Russia
Tom Weber	Acoustician	UNH	USA
Marty Reedy	Seabird Observer	USFWS	USA
Brian Hoover	Seabird Observer	USFWS	USA

Leg 2 (1 July -18 July)

Name	Position	Organization	Nation
Neal Williamson	Chief Scientist	AFSC	USA
Paul Walline	Fishery Biologist	AFSC	USA
Scott Furnish	Info. Tech. Specialist	AFSC	USA
Darin Jones	Fishery Biologist	AFSC	USA
Denise McKelvey	Fishery Biologist	AFSC	USA
Mikhail Stepanenko	Fishery Biologist	TINRO	Russia
Alexander Nikolaev	Fishery Acoustician	TINRO	Russia
Megan Woodward	Teacher At Sea	NOAA	USA
Zachery Cress	Fishery Biologist	NOAA	USA
Marty Reedy	Seabird Observer	USFWS	USA
Scott Mills	Seabird Observer	USFWS	USA

Leg 3 (21 July -7 August)

Name	Position	Organization	Nation
Taina Honkalehto	Chief Scientist	AFSC	USA
Paul Walline	Fishery Biologist	AFSC	USA
Rick Towler	Info. Tech. Specialist	AFSC	USA
Darin Jones	Fishery Biologist	AFSC	USA
Abigail McCarthy	Fishery Biologist	AFSC	USA
William Floering	Fishery Biologist	AFSC	USA
Kathryn Lanouette	Teacher At Sea	NOAA	USA
Mikhail Stepanenko	Fishery Biologist	TINRO	Russia
Alexander Nikolaev	Fishery Acoustician	TINRO	Russia
Marty Reedy	Seabird Observer	USFWS	USA
Aaron Lang	Seabird Observer	USFWS	USA

AFSC	Alaska Fisheries Science Center, Seattle WA
USFWS	United States Fish and Wildlife Service, Juneau, AK
UNH	University of New Hampshire
PMEL	Pacific Marine Environmental Laboratory
TINRO	Pacific Research Institute of Fisheries and Oceanography Vladivostok, Russia
NOAA	National Oceanic and Atmospheric Administration