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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 2010 (DY1006)

by

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ABSTRACT

Eastern Bering Sea shelf walleye pollock (*Theragra chalcogramma*) abundance and distribution in midwater were assessed between 5 June and 7 August 2010 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 surface temperatures were warmer in 2010 than in recent years (1.8° – 12.3°C in 2010 vs. 0.7° – 8.3°C in 2008 and 0.9° – 8.9°C in 2009). The majority of the pollock biomass in the U.S. Exclusive Economic Zone (EEZ) was located to the south and west 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 high compared to recent surveys. The 2010 pollock biomass estimate in the U.S. EEZ was 2.323 million metric tons (t). The 2009 biomass was 0.924 million t and the estimated 2008 biomass was 0.997 million t. East of 170° W, the predominant length mode was 40 cm and most ages ranged between 3 and 6 years. In the U.S. west of 170° W (87.4% of total biomass), dominant modal lengths were 26, 16, and 39 cm, corresponding to pollock aged 2, 1, and 4, respectively. In Russia (5.3% of total biomass), modal lengths and ages were generally similar to those in the U.S. west of 170° W. Vertical distribution analyses indicated that 85% of adult biomass was within 40 m of the seafloor. Juveniles were found both near the seafloor and higher in the water column; 65% of juvenile biomass was within 40 m of the seafloor while 13% was within 45 m of the surface. Finally, the first field tests of a non-extractive stereo camera-trawl system (Cam-Trawl) were successfully completed during the 2010 survey, and the multifrequency euphausiid backscatter index of abundance was successfully computed, indicating a reduced abundance of euphausiids compared with that in summer 2009.

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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 2010 acoustic-trawl (AT) survey was carried out between 5 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 physical environment, and supplemental trawls to improve species identification and to obtain an index of euphausiid abundance using multiple frequency techniques. 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 euphausiid layers near the surface and near the seafloor; a lowered echosounding system to measure target strength; a sideways-looking 70 kHz transducer; and a trawl-mounted stereo camera (“Cam-Trawl”) designed to determine the species identification, density, and size of animals as they pass by the camera and out through the rear of the open trawl. During daylight hours, while on transect, U.S. Fish and Wildlife observers recorded seabird species abundances and National Marine Mammal Laboratory (NMML) scientists recorded marine mammal abundances. Results of their surveys are reported elsewhere.

This report summarizes 2010 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. A brief summary of the euphausiid abundance index is presented, as are preliminary results from the Cam-Trawl. Additional results from secondary projects will be presented elsewhere.

METHODS

MACE scientists conducted the AT survey (cruise DY2010-06) 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 presented in Appendices I and II.

Acoustic Equipment, Calibration, and Data Collection

Acoustic measurements were collected with a 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. An experimental sideways-looking 70 kHz transducer was installed on the *Oscar Dyson* centerboard to investigate vessel-avoidance behavior by pollock during the survey.

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 the 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 the five split-beam frequencies using Myriax EchoLog 500 (v. 4.70) 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 analyzed from 16 m below the surface to within 0.5 m of the bottom using Myriax Echoview post-processing software (Version 4.90.47). 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. The AWT was fished with 5 m^2 Fishbuster trawl doors each weighing 1,089 kg. Vertical net openings and depths were monitored with a Simrad FS70 third-wire netsounder attached to the headrope. The AWT vertical net opening ranged from 13 to 32 m and averaged 25 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 were 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].

[1] National Marine Fisheries Service (NMFS) 2009. NOAA protocols for fisheries acoustics surveys and related sampling (Alaska Fisheries Science Center), NOAA Policy Directive 04-105-05, 26 p. Prepared by Midwater Assessment and Conservation Engineering Program, Alaska Fish. Sci. Center, Natl. Mar. Fish. Serv., NOAA. Available online https://reefshark.nmfs.noaa.gov/f/pds/publicsite/documents/procedures/04-105-05.pdf

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.

Field tests of a non-extractive stereo camera-trawl (Cam-Trawl) system were successfully completed during the survey. The Cam-Trawl consists of a stereo camera system attached to the back of an AWT with no codend. The device is designed to determine the species identification, density, and size of animals as they pass by the camera and out through the rear of the open trawl.

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 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 path with a sensor attached 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, trawl hauls for species classification, and work with other specialized sampling devices (e.g., a lowered echosounding system to measure target strength, the Simrad ME70 multibeam sonar to measure bottom type and three-dimensional properties of fish aggregations, Cam-Trawl testing, and sideways looking 70-kHz data collection).

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 density of Bering Sea euphausiids (number per m^3) near the seafloor and surface.

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 400 individuals were randomly sampled for sex and length measurements, and about 10 to 60 were sampled for body weight, maturity, and age. When available in the catch, stomach samples were preserved in formalin for diet analysis from 20 of each of the following species: walleye pollock, Pacific herring, eulachon and capelin (contact: troy.buckley@noaa.gov). When present, age-1 specimens of pollock, Pacific cod, and arrowtooth flounder were frozen for energetics analysis (contact: ron.heintz@noaa.gov). 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 glycerol-thymol 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

[2] ADP Code Book. 2010. Unpublished document. Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle WA 98115.

Catch Logger for Acoustic Midwater Surveys (CLAMS) tool designed and developed by MACE scientists for MACE surveys.

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. 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 a 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. When present in the catch, 15 individual euphausiids were frozen for a special study examining their biomass-length relationship and the use of eye pigmentation as a method of aging. Also frozen when present were age-zero arrowtooth flounder, pollock, and Pacific cod for an energetics study.

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 64 hauls were combined into 24 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, 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 keys were used to apportion abundance-at-age 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 five 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 2010 summer EBS hauls (De Robertis and Williams 2008). One weight-at length key was used for the entire survey area.

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. 2010). 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 bin within the water column.

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

Two acoustic system calibrations – one at the start and one at the end – were conducted during the summer 2010 field season (Table 1). A mid-cruise calibration was scheduled but cancelled because of time lost to an unscheduled vessel repair (27-29 June). Initial acoustic system settings for the survey were based on results from the 5-6 June acoustic system calibration. The end-of cruise sphere calibration on 6-7 August revealed a 0.29 dB decrease in integration gain for the 38-kHz system. Assuming the correct integration gain to be the average of the pre- and post-cruise (linearized) gain values, a scalar correction of 1.0679 was applied to backscatter values collected in real time.

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. Temperature measurements indicated that while the maximum surface temperature in 2010 (12.3°C) was higher than the maximum in both 2009 (8.9°C) and 2008 (8.3°C), the overall mean surface temperature of 6.1 °C was similar to that in 2009 (6.4 °C) but much warmer than that in 2008 (4.8 °C) (Fig. 2, Honkalehto et al. 2009, 2010). This difference may be partly due to the later timing of the surveys in 2009 and 2010, both of which extended into August. Ocean surface temperatures observed in 2010 (1.8 – 12.3°C) also spanned a wider range of values than those in 2009 (0.9 – 8.9°C) and 2008 (0.7 – 8.3°C). Bottom temperatures in 2010 were coldest near St. Matthew Island (-1.6°C), similar to those in 2008 (-1.7°C) and 2009 (-1.6°C), cool along the shelf as far east as Unimak Island and warmest early in the survey off Unimak Island. Surface temperatures were warmest late in the survey off Cape Navarin. Temperature-depth profiles taken along selected transects, plotted from east to west, indicated that the water column was vertically stratified throughout the EBS with a thermocline at 20-30 m from the surface (Fig. 3).

Trawl Sampling

Biological data and specimens were collected from 114 trawl hauls (Table 2, Fig. 1). Eighty-eight of these hauls targeted backscatter for species identification: 71 with an AWT and 17 with a Methot trawl. Twenty-six successful Tucker trawls were deployed for a separate euphausiid study as mentioned earlier; analyses are underway, and preliminary results are presented at the end of this document. After completion of the main survey, 12 modified AWT trawls were made with the Cam-Trawl. No bottom tows were conducted this year. On Legs 1 and 2, significant echosign was easily sampled with the midwater AWT; on Leg 3, the bottom trawl on the second net reel was replaced with an AWT modified for Cam-Trawl work.

Catch composition for the species identification hauls indicated that, by weight, walleye pollock was the most abundant at 89%, with northern sea nettle jellyfish (*Chrysaora melanaster*) and Pacific herring (*Clupea pallasi*) the second and third most abundant species, respectively, in the AWT hauls (Table 3). Most Pacific herring were captured in haul 109 just off Cape Navarin in Russian waters. By weight, northern sea nettles were the most abundant group in Methot hauls, followed by euphausiids (Table 4). The demersal organisms (brittle stars, sand dollars, etc.) found in the Methot catch list were the result of a single haul where the Methot trawl unintentionally came into contact with the ocean floor. Tucker trawl catch composition (Table 5) is oversimplified because the high volume and wide variety of small zooplankters caught in these trawls necessitated that they be sent to Poland for sorting. Accordingly, the majority of the catch in most Tucker trawls was classified as “unsorted zooplankton”, and the actual composition of the catch from these hauls will be addressed in future publications.

A summary of walleye pollock samples from all 71 AWT hauls made during the cruise indicates that 26,708 lengths were measured and 2,904 pairs of otoliths were collected (Table 6). Most fish were either in the developing or post-spawning maturity stage, and < 1% (n = 2 in the U.S. west of 170° W) of the females larger than 30 cm FL were actively spawning (Fig. 4). In walleye pollock mean weight at length curves plotted by area, there was very little difference between the three areas for fish < 50 cm (Fig. 5). Sample sizes were insufficient to allow comparison for fish ≥ 50 cm.

Distribution and Abundance

Over 80% of the summed acoustic backscatter observed during the 2010 survey was attributed to adult or juvenile walleye pollock (Fig. 6), more than in 2009 when two-thirds of the backscatter was pollock (Honkalehto et al. 2010). The remaining backscatter was attributed to an undifferentiated plankton-fish mixture, or in a few isolated areas, to 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). In contrast to the patterns observed in 2008 and 2009, when the majority of the biomass east of 170° W was found inside the SCA, this year 63% of the biomass east of 170° W was outside the SCA. The majority of the 2010 biomass in the U.S. EEZ spanned a region south of St. Matthew Island and inshore of Zhemchug and Pervenets Canyons, northward to and slightly across the U.S./ Russia Convention Line between the 100 and 200 m isobaths (Fig. 6). Within this area, the highest concentration of adult biomass was to the northeast of Navarin Canyon, along the US/ Russia convention line. More larger fish (>50 cm length) were found east of 170° W than west, including Russian waters, and the majority of those were observed east of the Pribilof Islands and just north of Unimak Island (Fig 7). Juveniles ≤ 30 cm were observed in high concentrations between the 100- and 200-m isobaths south and west of St. Matthew Island to Pervenets Canyon and across the Convention Line into Russia.

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 12.55 billion fish weighing 2.323 million metric tons (t) (Tables 7-9). Estimated midwater abundance in Russia between 16 m from the surface and 3 m off the bottom was 1.00 billion fish weighing 0.131 million t (5.3% of total midwater biomass). East of 170° W (7.3% of total midwater biomass) the length composition ranged between 16 and 78 cm FL with a mode at 40 cm and very few juveniles present (Fig. 7). In the U.S. west of 170° W (87.4% of total midwater biomass; Fig. 7), the length composition ranged from 11 to 75 cm FL with modes at 16 and 26 cm and a lesser mode at 39 cm FL. Numerically, few adult pollock > 50 cm FL were observed west of 170° W. The walleye pollock length composition for the fish observed in Russia (Fig. 7) was similar to that west of 170º W and ranged from 12 to 73 cm FL, but the majority of fish were between 12 and 30 cm FL, in contrast with 2009 when the few fish present were somewhat larger. Based on the 1D analysis, the relative estimation error of the U.S. EEZ walleye pollock biomass estimate was 0.060 (Table 7).

The 2010 vertical distribution of walleye pollock biomass in the United States 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 80 m from the surface and within 40 m of the bottom (Figs. 8a and c). The 40 m near-bottom region accounted for 85% of the adult biomass in the water column. Only 5% of the adult biomass was observed in the upper 45 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. 2009, 2010) juvenile aggregations were found both in midwater and near bottom (Figs. 8b and d). Twelve percent of the juvenile biomass was observed within 45 m of the surface and 65% 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, juvenile pollock (ages 1 and 2) were dominant numerically (accounting for 20% and 51% of the population, respectively; Table 10). These two age groups represented 36% of the total biomass. Adult pollock (ages 4+) totaled 21% of the population numerically, and made up 55% of the total biomass, with much of that composed of age-4 fish. The midwater pollock population east of 170° W was dominated by 4-year-old fish in terms of both numbers and biomass. West of 170° W in the U.S. was numerically dominated by 1- and 2-year-old fish (35% of biomass) although 4-year-olds made up slightly more of the biomass (41%; Fig. 9). In Russia, a mix of age-1 and age-2 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 2010 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 apparent as 4-year-olds in 2010 (Table 10). In 2010, the 2008 year class was the most numerous age-2 group detected by the AT survey since prior to 1994. Other strong recruiting year classes observed in AT 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 2010 was compared with the average length-at-age for these two strata between 1999 and 2009 (Fig. 11). For the dominant age classes (i.e., ages 1-6, Fig. 10), the 2010 average lengths-at-age were similar to historical values. Older fish (> age 6) 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, even though it was usually measured up to one month earlier. This difference in growth rate supports the use of two separate age-length keys in scaling abundance-at-length to abundance-at-age. Comparing average weight-at-age for 2010 with average weight-at-age for 1999-2009 showed correspondingly higher weights-at-age east of 170° W than west of 170° W, especially among older fish (Fig. 12). The average weights-at-age for 2010 west of 170° W (where most pollock biomass was observed) tended to be slightly higher than the average weight for 1999-2009, although they remained within one standard deviation of the mean with the exception of age-7 pollock.

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. 2010). The walleye pollock biomasses 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 2010 (Fig. 13). The percentage of total biomass for the entire U.S. EEZ between 3 m and 0.5 m off bottom ranged from 19% to 35% in 1999-2009, but decreased steeply to 11% in 2010. East of 170° W, 44% of the pollock biomass was below 3 m off bottom, while west of 170° W, only 8% was below 3 m. The higher percentage of pollock observed above 3 m west of 170° W is consistent with the much greater abundance of juveniles in the west compared to the east; juveniles tend to aggregate higher in the water column than adults. The near-bottom estimates should be treated with caution as in previous years (Honkalehto et al. 2010). 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 (1994-2010) 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 overall and relatively more abundant west of 170° W during 2006-2010 (Fig. 14). Most non-pollock backscatter (at 38 kHz) is typically observed in the upper part of the water column (Honkalehto et al. 2008). In 2010 very little non-pollock backscatter was observed, similar to observations in 2006 and 2009 (Fig. 15). 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, 2009, and 2010. 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, with this year's geographic distribution and biomass being closest to that in 2007 (Fig. 16, Table 11). The proportion of walleye pollock biomass estimated in Russia to within 0.5 m of the bottom has ranged from a low of 1% in 2009 to a high of 15% in 1994 of the total combined U.S. and Russian Bering Sea shelf biomass (Table 11). The 2010 value was intermediate at 5%.

Cam-Trawl

The Cam-Trawl was deployed 12 times during the third leg of the EBS survey. The stereo-camera image pairs collected will be used to develop automated software for extracting pollock lengths and counts. One set was processed manually, showing the changes in fish lengths observed during the towing process (Fig. 17). Individual pollock aggregations seen in the echogram are composed of different pollock size distributions, suggesting that there is significant horizontal variability in pollock size even in adjacent fish schools.

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, Cianelli et al. 2004, Lang et al. 2005). MACE AT survey backscatter data from 2004-present were 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. 2010, Ressler et al. in press). This year, 17 Methot trawls were targeted at euphausiids during the AT survey.

The 2004-2010 time series of Bering Sea summer euphausiid abundance shows that euphausiid backscatter increased more than three-fold from 2004 to 2009 (Fig. 18), while midwater pollock biomass declined by about half over the same time period (Ianelli et al. 2010). In 2010, the euphausiid backscatter index decreased by 24% when midwater pollock biomass in the acoustic-trawl survey showed a 1.5-fold increase. These opposing trends are probably driven by pollock predation, although changing environmental conditions may also play a role (Ressler et al., in press). 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, as well as being a useful measure of the availability of prey for other planktivorous fish, marine mammals, and seabirds.

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TABLES AND FIGURES

Table 1. -- Simrad ER60 38 kHz acoustic system description and settings during the summer 2010 walleye pollock acoustic-trawl survey of the Bering Sea shelf, and results from standard sphere acoustic system calibrations conducted before and after the survey using a 38.1 mm tungsten carbide sphere.

		Survey system settings	5-6 June Three Saint's Bay Alaska	6-7 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):		22.93	22.93	22.72
Sa correction (dB):		-0.57	-0.57	-0.65
S_v gain (dB):		22.36	22.36	22.07
3 dB beamwidth (deg):	Along:	6.66	6.66	6.67
	Athwart:	7.22	7.22	7.11
Angle offset (deg):	Along:	-0.10	-0.10	-0.12
	Athwart:	-0.04	-0.04	-0.05
Sphere range from transducer (m):		--	17.52	22.06
Absorption coefficient (dB/m):		0.0100	0.0097	0.0098
Sound velocity (m/s):		1470	1474.1	1475.2
Water temp at transducer (°C):		1.8-12.3	7.9	8.2
Water temp at standard sphere (°C):		--	6.3	6.2

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 2010 Bering Sea shelf walleye pollock acoustic-trawl survey aboard the NOAA ship *Oscar Dyson*.

Haul	Gear[a]	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[b]	(kg)	number	(kg)
1	Tucker	10-Jun	21:14	12	56 31.54	161 13.41	35	69	-	4.6	-	-	9.3
2	Tucker	10-Jun	21:27	11	56 31.93	161 13.35	69	69	-	4.4	-	-	0.8
3	Tucker	10-Jun	21:39	11	56 32.27	161 13.32	35	69	-	4.3	-	-	10.1
4	Methot	11-Jun	16:59	12	56 39.95	162 25.25	50	71	-0.2	2.7	-	-	33.7
5	Tucker	11-Jun	21:58	20	55 55.94	162 26.05	38	71	2.4	4.2	-	-	1.3
6	Tucker	11-Jun	22:18	11	55 56.21	162 27.05	72	72	1.7	4.0	-	-	3.4
7	Tucker	11-Jun	22:30	10	55 56.27	162 27.65	42	73	2.2	3.9	-	-	0.6
8	Methot	12-Jun	3:31	15	55 43.43	163 02.02	63	74	1.5	4.6	-	-	26.0
9	Tucker	12-Jun	21:39	19	56 52.84	163 35.94	38	70	1.1	3.1	-	-	9.2
10	Tucker	12-Jun	21:59	9	56 52.48	163 37.62	69	70	-1.1	3.1	-	-	0.8
11	Tucker	12-Jun	22:10	10	56 52.29	163 38.46	35	70	0.8	3.2	-	-	0.8
12	AWT	13-Jun	9:37	39	55 25.43	163 38.52	69	75	2.2	5.2	137.5	78	35.9
13	AWT	13-Jun	16:02	30	55 12.88	164 13.55	67	71	3.9	5.0	277.4	204	651.2
14	Tucker	13-Jun	22:11	27	56 07.87	164 14.42	45	90	2.7	3.8	-	-	-
15	AWT	15-Jun	3:15	23	55 07.59	164 47.39	90	104	-	5.1	867.4	797	500.0
16	AWT	15-Jun	8:03	16	54 51.05	164 47.14	64	70	5	4.8	95.3	67	112.0
17	Tucker	15-Jun	21:49	11	55 34.24	165 24.52	20	113	5.2	5.0	-	-	0.4
18	AWT	16-Jun	2:14	41	56 06.23	165 25.74	91	96	2.5	3.3	17.5	31	312.2
19	Methot	17-Jun	17:45	15	54 55.68	165 56.22	125	140	4.1	4.9	-	-	1.3
20	Methot	18-Jun	20:04	15	55 01.93	166 32.35	129	146	3.9	5.1	-	-	1.0
21	Tucker	18-Jun	22:47	24	55 08.51	166 32.71	65	143	4.7	5.1	-	-	2.1
22	Tucker	18-Jun	23:12	11	55 07.42	166 33.27	142	143	4.1	5.1	-	-	1.3
23	Tucker	18-Jun	23:24	21	55 06.94	166 33.33	79	143	4.4	5.1	-	-	-
24	AWT	19-Jun	11:30	45	56 22.94	166 02.08	85	95	1.9	3.0	1,021.7	1,924	49.8
25	Methot	19-Jun	17:17	15	56 36.87	166 39.49	77	93	1.4	3.3	-	-	10.2
26	Tucker	19-Jun	21:13	17	57 16.21	166 42.11	31	73	1	1.3	-	-	0.3
27	Tucker	19-Jun	21:31	10	57 15.76	166 41.55	72	73	0.2	1.3	-	-	0.3
28	Tucker	19-Jun	21:42	8	57 15.49	166 41.07	30	73	0.9	1.3	-	-	0.3
29	Methot	20-Jun	7:02	15	56 55.28	167 17.17	68	79	-0.5	2.8	-	-	7.3
30	AWT	20-Jun	16:49	23	56 41.33	167 16.09	93	100	1.5	3.5	549.3	1,002	171.5
31	AWT	22-Jun	10:19	30	56 27.74	167 51.45	116	124	3.4	4.7	128.9	202	7.3
32	Tucker	22-Jun	22:39	18	57 32.35	168 36.64	30	72	1.8	3.1	-	-	0.3
33	Tucker	22-Jun	22:57	13	57 32.39	168 35.47	71	72	0.5	3.1	-	-	1.2
34	Tucker	22-Jun	23:11	10	57 32.44	168 34.52	34	73	0.7	3.1	-	-	-
35	AWT	23-Jun	6:07	35	56 38.15	168 28.65	108	112	2.5	4.6	366.2	631	68.6
36	Methot	23-Jun	8:21	15	56 38.31	168 29.06	102	112	2.5	4.6	-	-	5.9

Table 2. -- Continued.

Haul no.	Gear[a] type	Date (GMT)	Time (GMT)	Duration (minutes)	Start position Lat. (N)	Long. (W)	Depth (m) footrope	bottom	Temp. (°C) headrope	surface[b]	Walleye pollock (kg)	number	Other (kg)
37	AWT	23-Jun	16:29	31	56 25.01	168 26.79	126	130	3.8	4.9	386.6	701	9.0
38	Tucker	23-Jun	21:15	20	55 52.81	168 24.55	75	145	4.7	5.7	-	-	-
39	Tucker	23-Jun	21:35	11	55 52.69	168 23.25	145	145	3.8	5.7	-	-	-
40	Tucker	23-Jun	21:47	19	55 52.62	168 22.59	79	145	4.4	5.7	-	-	-
41	Tucker	23-Jun	22:33	22	55 52.59	168 24.49	75	146	4.8	5.7	-	-	0.9
42	Tucker	23-Jun	22:56	11	55 52.83	168 22.81	145	146	3.8	5.7	-	-	0.3
43	Tucker	23-Jun	23:07	15	55 53.00	168 21.99	73	146	4.6	5.7	-	-	0.7
44	Methot	30-Jun	13:06	23	56 00.62	168 57.85	31	1289	5.4	5.7	-	-	3.5
45	AWT	30-Jun	20:13	44	56 48.12	169 07.87	81	86	0.1	4.6	80.2	143	169.9
46	Methot	2-Jul	7:41	15	56 40.87	169 41.49	53	79	1.5	3.7	-	-	2.6
47	Methot	2-Jul	21:31	13	56 12.71	170 12.77	104	118	3.8	6.2	-	-	-
48	Methot	2-Jul	22:50	11	56 12.55	170 12.88	95	118	3.8	6.2	-	-	1.7
49	AWT	3-Jul	2:57	30	56 39.16	170 17.77	104	107	3.3	7.0	56.8	85	129.2
50	AWT	3-Jul	9:03	35	56 40.29	170 17.77	94	105	3.1	6.7	915.6	1,598	59.4
51	AWT	4-Jul	18:42	27	58 22.73	171 14.57	83	90	0.6	5.3	383.8	1,700	1359.2
52	AWT	6-Jul	0:45	2	58 08.82	171 49.16	81	101	1.4	5.7	260.6	1,135	140.0
53	Methot	6-Jul	16:17	21	59 39.55	172 49.71	84	87	-0.5	5.6	-	-	11.5
54	AWT	6-Jul	23:52	45	58 35.43	172 33.56	101	106	2.3	6.3	539.4	20,712	19.5
55	AWT	7-Jul	5:46	25	58 00.82	172 25.78	98	107	2.4	6.0	135.4	526	289.3
56	AWT	7-Jul	12:15	26	57 53.64	172 25.17	65	109	1.6	5.8	474.9	944	421.3
57	AWT	8-Jul	10:19	1	57 55.91	173 04.48	111	114	2.9	6.4	245.2	481	0.4
58	AWT	8-Jul	18:54	12	58 16.72	173 10.05	105	111	3	6.6	1,795.4	29,989	3.6
59	AWT	8-Jul	23:55	8	58 33.07	173 13.66	109	116	3.5	6.9	1,773.1	11,998	0.9
60	AWT	9-Jul	3:53	20	58 54.67	173 18.15	105	114	2.5	6.7	646.0	3,679	6.4
61	AWT	9-Jul	8:55	10	59 15.40	173 24.51	89	107	2.1	6.3	677.5	1,783	21.1
62	AWT	10-Jul	9:41	10	59 42.29	174 11.23	101	111	1.1	6.4	810.3	2,300	9.7
63	AWT	10-Jul	13:04	12	59 41.51	174 12.79	90	112	1	6.3	105.4	1,161	7.8
64	AWT	10-Jul	19:56	10	59 18.51	174 03.98	108	115	2.1	6.6	1,125.1	8,255	9.3
65	AWT	10-Jul	23:39	26	59 03.99	173 59.04	88	120	2.4	7.0	1,251.3	10,090	7.0
66	Methot	11-Jul	4:10	16	58 43.66	173 54.53	113	134	3.4	7.2	-	-	1.9
67	AWT	11-Jul	13:02	9	58 19.53	173 49.67	109	122	3.7	6.8	276.4	499	0.7
68	Methot	11-Jul	15:19	11	58 19.21	174 10.52	128	136	3.2	7.0	-	-	6.1
69	AWT	11-Jul	22:31	16	59 10.95	174 40.51	103	126	2.5	7.4	2,844.5	23,475	30.5
70	AWT	12-Jul	4:41	9	59 41.25	174 50.73	70	122	1.7	7.4	1,134.4	34,642	5.5
71	AWT	12-Jul	9:18	11	59 51.63	174 54.16	108	122	1.6	7.0	1,108.3	2,616	25.9
72	AWT	13-Jul	5:10	35	60 46.51	175 53.11	108	113	1.6	6.7	1,228.7	2,940	72.1
73	AWT	13-Jul	9:55	39	60 35.93	175 49.52	69	115	-0.7	7.0	-	-	35.0
74	AWT	13-Jul	13:25	23	60 33.93	175 50.21	107	116	1.6	6.9	1,172.7	3,026	11.3

Table 2. -- Continued.

Haul no.	Gear[a] 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[b]	Walleye pollock (kg)	Walleye pollock number	Other (kg)
75	AWT	13-Jul	17:52	26	60 13.06	175 41.39	52	119	1.1	7.1	489.2	1,450	443.3
76	AWT	13-Jul	22:21	21	59 51.57	175 33.69	120	127	1.7	7.1	1,323.1	8,664	37.9
77	AWT	14-Jul	2:49	24	59 30.90	175 26.42	129	136	1.9	7.4	409.9	3,291	14.3
78	Methot	14-Jul	16:09	19	58 25.80	174 26.11	147	152	3.1	7.3	-	-	3.3
79	AWT	15-Jul	7:25	34	56 44.77	173 21.94	294	382	3.6	7.7	3.1	1	56.3
80	AWT	22-Jul	19:28	6	58 55.96	175 54.38	116	130	2.6	8.5	3,176.0	20,775	-
81	AWT	23-Jul	2:32	1	59 35.24	176 10.72	131	139	2.5	8.7	835.8	15,549	-
82	Methot	23-Jul	6:36	15	59 49.87	176 12.26	94	140	2	8.6	-	-	1.0
83	AWT	23-Jul	9:56	20	59 59.32	176 17.59	124	139	2.1	8.3	193.3	4,681	2.0
84	AWT	23-Jul	16:53	8	60 12.16	176 22.04	57	133	1.6	8.3	554.1	5,335	41.3
85	AWT	23-Jul	20:26	16	60 31.02	176 29.19	116	128	1.9	8.6	1,328.7	7,579	14.3
86	AWT	24-Jul	0:59	22	60 59.14	176 39.64	111	119	1.7	8.2	874.1	2,928	38.1
87	AWT	24-Jul	5:27	15	61 24.75	176 49.50	105	115	1.2	8.1	1,172.4	3,760	103.6
88	AWT	24-Jul	17:29	20	61 59.70	177 05.35	102	110	0.9	8.0	656.4	3,288	70.1
89	AWT	24-Jul	22:14	26	62 13.90	177 09.35	47	104	-1	8.0	29.0	252	27.2
90	AWT	25-Jul	4:13	1	62 06.27	177 51.14	100	114	0.9	8.0	316.1	2,457	74.0
91	AWT	25-Jul	9:47	7	61 27.88	177 32.78	99	126	1.9	7.8	235.0	4,457	21.9
92	AWT	25-Jul	17:54	21	61 10.74	177 28.08	120	133	2	8.0	1,278.1	4,767	1.9
93	AWT	25-Jul	23:45	15	60 41.89	177 16.09	127	138	2.1	8.6	1,310.2	3,603	17.8
94	AWT	26-Jul	2:38	7	60 34.34	177 13.06	60	146	-0.7	8.7	730.1	6,570	5.8
95	AWT	26-Jul	7:28	11	60 04.75	177 00.48	124	142	2.1	9.1	900.4	5,991	-
96	AWT	26-Jul	9:34	1	60 03.94	176 58.72	45	142	1.3	9.1	14.8	103	30.1
97	AWT	26-Jul	18:07	1	59 42.85	176 52.18	74	142	2.4	9.0	500.1	4,476	3.6
98	AWT	26-Jul	20:43	8	59 31.57	176 47.36	120	148	2.7	9.0	1,388.0	12,473	-
99	AWT	27-Jul	16:55	1	59 23.88	177 24.22	69	172	2.6	9.2	465.8	11,603	-
100	AWT	27-Jul	19:50	6	59 34.53	177 28.73	139	157	2.8	9.2	1,643.0	12,531	-
101	AWT	28-Jul	1:13	20	60 14.91	177 45.78	133	146	2	9.6	936.2	4,324	-
102	AWT	28-Jul	5:34	3	60 44.94	177 58.25	133	157	2.1	9.0	2,195.0	6,698	-
103	AWT	28-Jul	18:01	0	61 21.07	178 15.08	120	154	2	8.8	439.0	2,521	8.4
104	AWT	29-Jul	9:34	8	61 08.44	178 51.67	206	219	2.4	9.3	1,034.7	1,387	17.3
105	AWT	29-Jul	18:41	5	60 38.42	178 37.33	117	193	2.6	9.2	936.6	6,320	1.2
106	AWT	29-Jul	23:04	3	60 19.46	178 28.76	195	210	2.6	9.6	1,190.6	2,491	2.4
107	AWT	30-Jul	4:27	11	59 45.49	178 13.79	126	148	2.6	9.5	2,123.0	25,276	-
108	AWT	31-Jul	10:04	27	61 17.76	179 36.98	144	156	2	8.9	412.2	2,945	33.8
109	AWT	31-Jul	21:02	0	62 03.52	179 58.95	141	166	2.2	10.5	2.2	14	827.0
110	AWT	1-Aug	8:09	13	61 03.62	179 47.94[#]	123	169	2.2	9.6	457.2	3,805	3.8

Table 2. -- Continued.

Haul no.	Gear[a] type	Date (GMT)	Time (GMT)	Duration (minutes)	Start position Lat. (N)	Long. (W)	Depth (m) footrope	bottom	Temp. (°C) headrope	surface[b]	Walleye pollock (kg)	number	Other (kg)
111	Methot	2-Aug	7:41	15	61 51.75	177 54.95[#]	77	114	2	10.7	-	-	1.8
112*	AWT	3-Aug	18:23	30	59 46.41	178 00.60	124	148	2.4	9.2	728.5	9,254	2.3
113*	AWT	4-Aug	21:44	45	58 21.34	175 17.13	286	298	3.2	9.5	-	-	9.7
114*	AWT	5-Aug	6:55	39	57 47.83	174 12.71	275	320	3.1	9.5	-	-	52.6

[a]AWT = Aleutian wing trawl, Methot = Methot trawl, Tucker = Tucker multiple depth trawl

[b]shipboard sensor at 1.4 m depth.

[#]East Longitude

* Experimental gear trawl.

Table 3. -- Catch by species from 68 Aleutian wing trawl hauls conducted during the summer 2010 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*	52,441.7	88.7	371,779
northern sea nettle	*Chrysaora melanaster*	5,629.5	9.5	6,593
Pacific herring	*Clupea pallasi*	830.2	1.4	3,707
northern shrimp	*Pandalus borealis*	39.1	0.1	7,338
Pacific ocean perch	*Sebastes alutus*	38.4	0.1	33
smooth lumpsucker	*Aptocyclus ventricosus*	27.8	<0.1	12
flathead sole	*Hippoglossoides elassodon*	18.7	<0.1	67
arrowtooth flounder	*Atheresthes stomias*	13.0	<0.1	40
chinook salmon	*Oncorhynchus tshawytscha*	11.9	<0.1	1
chum salmon	*Oncorhynchus keta*	10.2	<0.1	6
Pacific cod	*Gadus macrocephalus*	7.8	<0.1	4
jellyfish unident.	Scyphozoa (class)	5.4	<0.1	393
southern rock sole	*Lepidopsetta bilineata*	5.3	<0.1	4
eulachon	*Thaleichthys pacificus*	2.1	<0.1	32
rock sole sp.	*Lepidopsetta* sp.	2.0	<0.1	6
squid unident.	Cephalopoda (class)	1.9	<0.1	39
shrimp unident.	Decapoda (order)	1.4	<0.1	409
Kamchatka flounder	*Atheresthes evermanni*	1.1	<0.1	3
northern rock sole	*Lepidopsetta polyxystra*	0.8	<0.1	1
yellowfin sole	*Limanda aspera*	0.8	<0.1	2
sturgeon poacher	*Podothecus acipenserinus*	0.7	<0.1	13
Greenland turbot	*Reinhardtius hippoglossoides*	0.5	<0.1	2
prowfish	*Zaprora silenus*	0.4	<0.1	2
capelin	*Mallotus villosus*	0.4	<0.1	28
Pacific sandfish	*Trichodon trichodon*	0.2	<0.1	1
spiny lumpsuckers	*Eumicrotremus* sp.	0.1	<0.1	2
Arctic cod	*Boreogadus saida*	<0.1	<0.1	1
sculpin unident.	Cottidae (family)	<0.1	<0.1	1
Totals		59,091.4		390,519

Table 4. -- Catch by species from 17 Methot trawl hauls conducted during the summer 2010 walleye pollock acoustic-trawl survey on the Bering Sea shelf.

Common name	Scientific name	Weight (kg)	Weight (%)	Number
northern sea nettle	*Chrysaora melanaster*	73.0	61.5	149
euphausiid unident.	Euphausiidae (family)	37.4	31.5	425,017
jellyfish unident.	Scyphozoa (class)	2.8	2.3	2,326
amphipod unident.	Amphipoda (order)	2.1	1.8	18,948
moon jelly	*Aurelia labiata*	0.9	0.7	1,288
sand dollar unident.	*Clypeaster* sp.	0.7	0.6	57
brittle star unident.	*Ophiura* sp.	0.7	0.6	1,614
hermit crab unident.	Paguridae (family)	0.4	0.4	5
comb jelly unident.	*Beroe* sp.	0.2	0.2	1,004
cockle unident.	*Clinocardium* sp.	0.2	0.1	13
cockle unident.	*Serripes* sp.	0.1	0.1	3
Tanner crab	*Chionoecetes bairdi*	0.1	0.1	3
jellyfish unident.	*Cyanea* sp.	0.1	0.1	5
snail unident.	Gastropoda (class)	<0.1	<0.1	1
copepod unident.	Copepoda (class)	<0.1	<0.1	7,368
Aleutian moonsnail	*Cryptonatica aleutica*	<0.1	<0.1	2
isopod unident.	Isopoda (order)	<0.1	<0.1	46
squid unident.	Cephalopoda (class)	<0.1	<0.1	48
shrimp unident.	Decapoda (order)	<0.1	<0.1	46
Arctic moonsnail	*Cryptonatica affinis*	<0.1	<0.1	1
fish larvae unident.	Actinopterygii (class)	<0.1	<0.1	2
flatfish larvae	Pleuronectiformes (order)	<0.1	<0.1	2
sculpin unident.	Cottidae (family)	<0.1	<0.1	1
Totals		118.8		457,949

Table 5. -- Catch by species from 26 Tucker trawl hauls conducted during the summer 2010 walleye pollock acoustic-trawl survey on the Bering Sea shelf.

Common name	Scientific name	Weight (kg)	Weight (%)	Number
northern sea nettle	*Chrysaora melanaster*	24.1	54.5	42
unsorted small zooplankton*	unsorted small zooplankton	16.2	36.5	-
red king crab	*Paralithodes camtschaticus*	3.1	7.0	1
moon jelly	*Aurelia labiata*	0.5	1.2	27
pandalid shrimp unident.	Pandalidae (family)	0.2	0.4	52
sea anemone unident.	Actiniaria (order)	0.1	0.3	6
brittlestarfish unident.	*Ophiura* sp.	<0.1	0.1	6
Crangon shrimp unident.	Crangonidae (family)	<0.1	<0.1	38
walleye pollock (age 0)	*Theragra chalcogramma*	<0.1	<0.1	2
squid unident.	Cephalopoda (class)	<0.1	<0.1	1
salps unident.	Thaliacea (class)	<0.1	<0.1	1
fish larvae unident.	Actinopterygii (class)	<0.1	<0.1	3
flathead sole	*Hippoglossoides elassodon*	<0.1	<0.1	2
Tanner crab	*Chionoecetes bairdi*	<0.1	<0.1	1
Totals		44.3		182

Table 6. -- Number of fish measured and biological samples collected during the summer 2010 acoustic-trawl survey of walleye pollock on the Bering Sea shelf.

Haul	Pollock					Other	*Chrysaora melanaster*	TINRO	Energetics
no.	Length	Weight	Maturity	Stomachs	Otoliths	Length	bell diameter	collection*	study^
1	-	-	-	-	-	-	14	-	-
2	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	11	-	-
4	-	-	-	-	-	-	44	-	-
5	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	12	-	-
9	-	-	-	-	-	-	12	-	-
10	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-
12	78	78	78	20	78	2[a]	16	-	-
13	204	62	62	21	62	1[b]	22	-	-
14	-	-	-	-	-	-	-	-	-
15	309	75	75	20	61	22[c]	31	50	-
16	67	47	47	19	47	-	25	-	-
17	-	-	-	-	-	-	-	-	-
18	31	31	31	40	31	24[b]	86	-	-
19	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-		-	-
21	-	-	-	-	-	-		-	-
22	-	-	-	-	-	-		-	-
23	-	-	-	-	-	-		-	-
24	335	61	61	21	60	1[b]	46	50	-
25	-	-	-	-	-	-	28	-	-
26	-	-	-	-	-	-	-	-	-
27	-	-	-	-	-	-	-	-	-
28	-	-	-	-	-	-	3	-	-
29	-	-	-	-	-	-	14	-	-
30	346	84	84	20	71	-	41	50	-
31	202	62	62	24	62	4[b]	-	-	-
32	-	-	-	-	-	-	-	-	-
33	-	-	-	-	-	-	-	-	-
34	-	-	-	-	-	-	-	-	-
35	351	61	61	20	61	-	19	50	-
36	-	-	-	-	-	-	-	-	-
37	366	110	110	20	60	-	-	50	-
38	-	-	-	-	-	-	-	-	-
39	-	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-	-
41	-	-	-	-	-	-	-	-	-
42	-	-	-	-	-	-	-	-	-
43	-	-	-	-	-	-	-	-	-
44	-	-	-	-	-	-	-	-	-
45	143	69	69	20	60	-	-	-	-
46	-	-	-	-	-	-	-	-	-
47	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-
49	85	48	48	20	48	-	28	-	-
50	391	53	52	20	47	-	-	-	-

Table 6. -- Continued.

Haul	Pollock					Other	*Chrysaora melanaster*	TINRO	Energetics
No.	Length	Weight	Maturity	Stomachs	Otoliths	Length	bell diameter	collection*	study^
51	314	75	75	27	75	-	-	50	-
52	498	73	64	31	64	-	37	50	-
53	-	-	-	-	-	-	-	-	-
54	297	63	63	19	33	-	-	50	-
55	494	80	80	20	50	-	51	-	-
56	446	53	53	20	44	-	24	-	-
57	374	40	40	20	40	-	-	-	-
58	661	121	121	20	55	-	2	50	-
59	540	74	74	20	50	-	-	-	-
60	463	89	89	20	66	-	-	50	-
61	458	56	56	20	56	-	7	-	-
62	538	84	84	20	52	-	-	-	-
63	290	-	-	-	-	-	-	-	-
64	513	54	54	23	54	-	-	-	-
65	577	63	63	20	48	-	-	-	-
66	-	-	-	-	-	-	-	-	-
67	347	66	66	20	66	-	-	-	-
68	-	-	-	-	-	-	-	-	-
69	550	112	112	19	45	-	-	50	-
70	755	175	175	20	19	-	-	-	-
71	535	80	80	20	61	-	-	-	-
72	513	79	79	20	48	-	27	50	-
73	-	-	-	-	-	-	-	-	-
74	373	82	82	20	67	-	-	-	-
75	392	68	68	20	54	-	26	50	-
76	485	61	61	19	55	-	-	-	-
77	449	52	52	20	51	-	-	-	-
78	-	-	-	-	-	-	-	-	-
79	1	-	-	-	-	4[a], 33[e]	-	-	-
80	473	100	100	20	67	-	-	-	-
81	767	50	45	20	25	-	-	-	5
82	-	-	-	-	-	-	-	-	-
83	413	-	-	-	-	-	-	-	-
84	452	36	32	19	32	-	-	-	4
85	497	61	61	20	40	-	-	-	-
86	382	104	104	20	38	-	-	-	-
87	454	76	76	20	48	-	-	-	-
88	519	48	43	20	43	-	37	50	5
89	252	40	40	20	39	-	-	-	-
90	432	56	51	20	39	-	-	-	5
91	362	68	68	20	32	-	-	-	-
92	451	56	51	20	32	-	-	-	5
93	383	87	86	20	40	-	-	-	-
94	331	58	57	20	29	-	-	-	-
95	373	37	37	20	18	-	-	-	-
96	103	28	28	-	-	-	-	-	-
97	332	50	45	20	10	-	-	-	5
98	335	32	29	17	5	-	-	-	3
99	346	55	55	19	-	-	-	-	-
100	503	75	75	20	40	-	-	50	-

Table 6. -- Continued.

Haul No.	Pollock Length	Weight	Maturity	Stomachs	Otoliths	Other Length	*Chrysaora melanaster* bell diameter	TINRO collection*	Energetics study^
101	470	69	64	20	55	-	-	-	5
102	423	71	66	20	51	-	-	-	5
103	543	66	60	20	38	-	-	-	6
104	459	96	96	20	96	-	-	50	-
105	450	49	43	26	27	6[f]	-	-	7
106	342	55	55	20	55	-	-	-	-
107	646	47	42	20	10	-	-	-	5
108	509	86	80	21	40	1[g]	-	-	6
109	14	14	14	18	-	166[f #]	-	-	-
110	412	83	83	21	54	1[a]	-	-	-
111	-	-	-	-	-	-	-	-	-
112	501	-	-	-	-	-	-	-	-
113	-	-	-	-	-	-	-	-	-
114	8	-	-	-	-	-	-	-	-
Totals	26,708	4,294	4,217	1,304	2,904	-	663	800	66

Other species measured - [a] Pacific cod, [b] eulachon, [c] capelin, [d] chum salmon, [e] Pacific ocean perch, [f] Pacific herring, [g] arctic cod

[#] 45 Pacific herring weights recorded

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

^Energetics study (R. Heinz) included individual juvenile and adult pollock samples.

Table 7. -- Walleye pollock biomass from summer acoustic-trawl surveys on the U.S. EEZ portion of the Bering Sea shelf, 1994-2010. 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**	**Biomass, million metric tons (top) and percent of total (bottom)**			**Total biomass**	**Relative estimation**
		(nmi)^2	**SCA**	**E170-SCA**	**W170**	**(million metric tons)**	**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	2.592	0.037
			9.5	20.3	70.1		
1999	7 Jun-5 Aug	103,670	0.299	0.579	2.408	3.285	0.055
			9.1	17.6	73.3		
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		
2010	5 Jun -7 Aug	92,849	0.067	0.113	2.143	2.323	0.060
			2.9	4.8	92.3		

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, 1994-2010.

Length (cm)	**1994**	**1996**	**1997**	**1999**	**2000**	**2002**	**2004**	**2006**	**2007**	**2008**	**2009**	**2010**
0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0.03	0	0	0	0	0	0	0
9	0	0	0	0.01	0.03	0	0	0	0	0	4.42	0
10	0	0	2.04	0.12	0.76	0.01	0.24	0	30.12	0	45.53	0
11	0.40	0	0.19	4.78	2.30	0.77	0.20	5.29	259.94	0.74	221.44	0.92
12	5.44	0.47	30.13	14.43	5.50	4.70	2.56	59.83	662.11	2.82	768.23	8.56
13	44.79	5.44	238.10	22.71	19.26	21.36	2.38	144.42	1329.33	6.70	1112.48	65.31
14	94.23	38.20	1416.21	22.35	36.70	100.48	4.08	117.62	1497.63	9.47	1087.89	259.44
15	179.82	131.29	2949.25	16.20	56.69	194.98	1.84	84.56	803.62	6.13	1046.86	508.46
16	166.05	227.77	3364.00	5.20	79.57	178.72	1.80	27.81	563.27	4.38	535.32	799.69
17	105.16	317.31	2207.83	5.20	50.81	99.74	1.76	10.15	304.17	7.78	266.25	698.61
18	129.71	215.26	1309.13	12.92	22.39	33.47	1.12	2.90	114.52	49.99	84.01	304.04
19	212.54	115.39	569.51	44.60	30.27	40.07	4.34	4.73	133.95	128.23	82.88	155.46
20	381.96	64.79	181.06	152.57	47.16	61.90	8.40	10.85	117.76	264.22	55.95	175.31
21	589.69	37.20	74.90	251.49	92.37	162.63	23.15	17.43	145.33	402.13	77.20	228.58
22	794.28	64.41	81.07	314.31	136.41	289.69	34.90	31.71	147.44	440.61	106.28	374.84
23	788.35	60.24	150.80	288.90	185.76	485.72	47.06	37.50	129.53	568.91	135.13	629.53
24	772.58	70.32	255.93	220.31	186.04	734.73	48.21	33.77	142.76	447.11	112.14	938.65
25	581.45	47.68	408.07	164.37	207.95	859.82	39.35	30.25	91.73	357.46	114.43	1170.05
26	372.26	38.32	458.83	188.58	186.91	832.36	32.49	24.95	65.22	241.72	114.22	1174.04
27	198.97	33.63	519.67	256.04	187.68	718.04	25.99	21.77	49.83	115.47	129.48	931.46
28	122.07	60.16	422.68	302.47	168.93	516.42	29.43	25.52	32.98	79.93	139.98	578.26
29	135.90	85.07	296.50	419.16	164.76	491.26	69.82	29.78	21.87	104.00	181.74	273.70
30	138.25	122.81	175.36	435.28	167.17	507.57	90.09	35.24	18.40	129.13	205.96	131.43
31	178.83	183.98	115.83	417.13	169.72	592.86	148.82	42.19	16.21	119.63	253.04	89.40
32	234.80	240.98	79.12	410.19	167.23	539.68	151.19	45.36	35.23	135.96	243.92	103.67
33	239.39	341.56	69.15	372.65	188.70	533.40	180.25	51.47	46.64	117.44	197.30	114.41
34	291.50	408.41	68.83	393.58	221.59	421.17	185.43	68.74	61.27	112.26	149.26	129.05
35	296.57	458.38	89.48	415.94	332.90	291.90	237.90	82.66	74.85	82.94	100.61	162.44
36	326.66	477.95	146.28	433.11	360.41	239.36	302.68	111.93	64.09	40.17	76.70	233.18
37	343.99	400.98	220.62	393.54	414.22	218.57	430.24	118.70	79.64	28.85	50.97	288.73
38	305.79	333.42	321.35	403.47	369.24	222.31	476.40	124.99	75.28	23.58	34.05	382.43
39	294.82	253.70	397.12	359.07	344.63	218.51	539.43	118.56	83.27	32.67	26.29	400.38
40	311.31	214.24	397.83	304.48	297.14	209.21	499.73	126.41	106.70	23.19	20.55	359.88

Table 8. -- Continued.

Length (cm)	1994	1996	1997	1999	2000	2002	2004	2006	2007	2008	2009	2010
41	271.09	168.18	350.37	243.06	331.55	200.43	511.11	140.54	113.05	24.95	15.78	278.88
42	289.53	154.99	292.97	240.38	316.41	179.46	475.59	154.29	141.30	26.81	18.00	196.02
43	273.09	149.27	222.05	265.33	331.24	186.32	453.93	163.58	191.31	38.14	14.29	127.23
44	243.93	133.46	172.49	321.32	302.44	185.26	388.07	178.01	189.44	39.27	11.12	86.81
45	256.58	117.96	125.08	328.57	290.08	197.15	339.54	170.87	210.76	44.81	11.44	57.23
46	216.09	103.48	93.20	304.97	249.82	183.59	247.30	158.64	213.99	50.85	13.24	36.97
47	177.93	98.39	74.75	238.84	235.52	182.87	196.13	146.34	185.68	54.78	12.35	21.51
48	148.15	94.29	59.37	182.91	176.81	168.36	150.84	130.84	150.01	54.71	21.23	11.68
49	73.11	83.67	45.51	122.90	143.24	154.43	113.57	105.90	128.80	47.05	22.51	7.53
50	66.74	79.87	40.23	88.16	106.27	133.48	78.29	88.25	101.90	41.79	20.42	6.85
51	33.15	72.52	33.10	60.42	78.54	117.74	64.53	73.93	73.22	39.74	19.56	6.24
52	30.35	60.21	31.72	42.15	48.15	91.92	56.33	62.45	52.96	29.92	20.66	3.61
53	18.15	50.89	29.59	33.02	35.75	88.43	41.08	45.82	41.04	23.84	15.37	2.75
54	15.68	38.44	23.91	26.90	22.09	62.98	30.20	35.31	32.46	21.89	13.54	1.69
55	18.57	25.63	19.77	16.14	16.58	44.34	19.12	23.01	23.25	16.11	16.29	3.16
56	11.05	14.07	14.58	9.26	12.58	40.16	14.43	19.33	16.43	12.38	9.96	2.24
57	9.52	7.65	10.61	9.40	8.92	24.16	8.83	14.93	13.02	10.47	8.63	3.51
58	4.85	7.68	8.60	5.68	6.41	18.77	5.83	10.63	7.51	9.21	9.24	3.05
59	2.96	3.02	5.98	3.24	5.13	11.26	6.16	8.11	4.76	8.31	5.28	2.79
60	3.47	4.71	3.45	3.04	1.87	10.58	4.00	5.39	3.72	7.39	4.50	3.20
61	6.63	2.88	4.58	2.40	2.30	7.11	2.89	4.60	1.86	4.09	2.37	4.29
62	1.39	1.79	1.55	2.12	1.72	3.92	1.95	2.07	1.13	4.94	2.41	1.76
63	0.71	0.28	2.01	0.62	1.57	2.18	2.07	1.17	1.09	2.62	1.70	1.26
64	0.49	0.59	0.47	0.57	0.98	1.74	0.08	1.98	1.06	2.12	1.21	1.55
65	1.86	0.85	0.81	0.93	0.64	1.74	0.30	0.73	0.48	1.48	1.42	1.16
66	0.77	0.35	0.32	1.42	0.70	1.16	0.55	0.85	0.60	0.67	1.15	1.26
67	0.97	0.66	1.27	0.48	0.03	0.27	0.35	0.27	0.35	0.58	0.50	1.13
68	1.46	0	0.19	0.30	0.27	0.17	0.19	0.02	0.21	0.51	0.30	1.36
69	0	0	0.59	0.29	0.59	0	0	0	0.02	0.12	0.44	0.14
70	1.93	0	0.10	0	0	0.43	0	0.02	0.30	0.21	0.04	0.36
71	0.49	0.11	0	<0.01	0	0.01	0	0.14	0.21	0.06	0	0
72	0.97	0	0	0.11	0.15	0	0	0.46	0	0.42	0	0.17
73	0.49	0	0.05	0.16	0	0	0	0.02	0	0.04	0	0.83
74	0	0	0	0	0.14	0	0	0	0.06	0.05	0	0.17
75	0	0	0	0.04	0	0	0	0	0	0.03	0.03	0.00
76	0	0	0	0	0	0	0	0	0	0	0	0.14
77	0	0	0	0	0	0	0	0	0	0	0	0
78	0.49	0	0	0	0	0	0	0	0	0	0	0.14
79	0	0	0	0.39	0	0	0	0.08	0	0.06	0	0
80	0	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	12,549

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, 1994-2010.

Length (cm)	**1994**	**1996**	**1997**	**1999**	**2000**	**2002**	**2004**	**2006**	**2007**	**2008**	**2009**	**2010**
0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	<1	0	0	0	0	0	0	0
9	0	0	0	<1	<1	0	0	0	0	0	24	0
10	0	0	14	1	8	0	2	0	200	0	336	0
11	4	0	2	59	30	9	2	54	2,469	7	2,003	9
12	71	6	394	227	88	75	30	762	7,313	34	9,219	112
13	744	92	4,148	445	370	428	36	2,366	19,068	104	17,136	1,064
14	1,937	804	31,282	538	859	2,488	81	2,176	25,781	168	21,613	5,436
15	4,520	3,384	81,544	472	1,613	5,841	48	1,997	17,771	145	25,658	12,983
16	5,040	7,098	111,182	181	2,713	6,393	57	815	14,870	125	16,147	25,180
17	3,817	11,818	84,460	214	2,055	4,231	67	365	9,873	254	10,147	26,219
18	5,553	9,485	58,223	623	1,064	1,664	50	123	4,401	1,923	3,671	13,313
19	10,655	5,960	28,768	2,499	1,677	2,284	210	235	6,200	5,880	4,185	7,577
20	22,244	3,892	10,677	9,852	3,017	4,072	498	626	6,392	14,049	3,204	10,002
21	39,601	2,579	4,900	18,587	6,782	12,242	1,595	1,133	9,810	24,584	5,259	15,444
22	61,100	5,121	6,101	26,421	11,419	24,828	2,730	2,413	11,643	31,976	8,715	29,774
23	69,048	5,458	12,962	27,464	17,629	47,351	4,265	3,277	11,513	48,149	12,534	56,840
24	76,622	7,221	24,999	23,562	19,911	81,309	4,887	3,259	14,551	42,932	11,518	97,422
25	64,967	5,520	45,081	19,681	24,970	107,760	4,475	3,176	10,266	38,541	14,070	137,766
26	46,652	4,979	56,998	25,168	25,070	117,666	4,347	3,107	8,010	29,360	15,332	154,353
27	27,847	4,884	72,339	37,933	28,002	113,478	3,876	2,946	6,844	15,725	20,391	136,592
28	19,028	9,721	65,700	49,557	27,927	89,827	4,813	3,917	5,073	12,102	23,816	95,619
29	23,550	15,240	51,328	75,679	30,072	92,941	12,745	5,050	3,697	17,423	35,978	49,597
30	26,437	24,307	33,691	86,321	33,574	104,158	17,942	6,561	3,462	23,802	44,259	25,366
31	37,756	40,104	24,685	90,579	37,396	132,640	32,663	9,236	3,428	24,696	60,686	19,576
32	54,180	57,669	18,522	97,251	40,301	131,538	36,257	10,767	8,606	30,634	63,679	24,976
33	60,378	89,480	17,709	96,204	49,614	141,718	48,265	13,252	12,233	29,302	56,444	30,732
34	80,001	116,812	19,201	110,357	63,403	122,045	53,459	19,248	17,643	29,881	46,340	38,481
35	88,546	142,771	27,148	126,368	103,387	92,414	74,135	25,252	23,484	24,798	33,904	52,816
36	105,903	161,724	48,272	142,256	121,237	82,291	103,401	36,989	21,662	13,229	27,902	82,376
37	120,806	147,067	79,075	139,441	150,552	81,503	156,813	41,377	29,517	10,234	19,593	110,112
38	116,110	132,264	124,841	153,908	144,826	88,680	188,084	47,836	30,240	9,163	14,455	160,201
39	121,143	108,629	166,999	147,178	145,465	93,405	229,225	49,056	35,953	13,611	11,726	178,105
40	137,651	98,825	180,668	133,859	135,080	95,675	230,733	55,427	48,709	10,622	9,876	173,381

Table 9. -- Continued.

Length (cm)	1994	1996	1997	1999	2000	2002	2004	2006	2007	2008	2009	2010
41	129,335	83,422	171,750	114,415	161,884	98,165	252,339	65,790	54,826	11,866	8,172	143,345
42	149,294	82,523	154,670	120,957	165,982	94,168	253,443	78,528	72,602	13,379	9,940	107,271
43	152,526	85,177	125,886	142,492	185,961	104,975	261,967	87,505	105,904	20,806	8,596	73,519
44	147,017	81,478	104,750	183,897	181,482	110,994	239,860	102,839	111,390	22,429	6,934	53,494
45	166,444	76,937	81,320	200,114	185,345	125,772	222,131	103,984	131,381	27,203	7,500	37,336
46	149,720	71,999	64,736	197,389	169,854	124,740	171,216	102,312	143,460	32,686	9,387	26,169
47	131,130	72,930	55,323	164,067	170,024	132,267	142,845	100,258	131,598	37,569	9,438	15,750
48	115,921	74,352	46,750	133,183	135,575	129,623	115,709	94,693	112,575	38,443	16,576	9,524
49	60,566	70,102	38,100	94,742	116,332	126,481	92,215	81,175	101,538	36,199	18,743	6,433
50	58,531	71,016	35,728	71,872	91,389	115,778	67,512	73,481	85,481	34,038	18,222	6,199
51	30,462	68,346	31,145	52,026	71,352	108,641	58,478	63,585	64,652	33,569	18,440	6,300
52	29,789	60,080	31,560	38,303	46,186	89,753	53,394	56,209	49,596	26,625	20,583	3,889
53	18,463	53,710	31,087	31,630	36,163	91,552	41,489	44,479	39,922	23,325	15,872	2,942
54	16,856	42,859	26,500	27,130	23,496	68,832	31,998	36,086	34,719	22,249	14,241	1,945
55	21,296	30,163	23,075	17,129	18,562	51,122	21,285	25,029	26,503	17,789	17,943	3,908
56	13,207	17,456	17,914	10,327	14,788	48,961	17,136	21,089	19,415	15,024	12,046	3,032
57	11,943	9,998	13,712	11,013	11,004	30,986	11,453	17,519	16,742	13,074	11,371	4,615
58	6,368	10,573	11,671	6,984	8,300	25,335	7,517	13,507	9,953	12,444	11,563	4,159
59	4,167	4,365	8,530	4,174	6,962	15,953	8,825	10,892	6,815	11,544	8,251	4,250
60	5,001	7,163	5,155	4,104	2,656	15,550	6,038	7,784	5,687	11,354	7,402	5,271
61	10,199	4,591	7,172	3,394	3,421	11,003	4,574	6,869	2,990	6,534	4,100	7,381
62	2,285	2,998	2,550	3,135	2,679	6,415	3,214	3,241	1,874	8,250	4,373	2,936
63	1,196	498	3,448	953	2,551	3,683	3,585	1,937	1,934	4,528	3,241	2,241
64	844	1,084	843	925	1,660	3,109	139	3,360	1,958	3,835	2,423	2,844
65	3,382	1,637	1,531	1,562	1,122	3,223	562	1,314	928	2,717	2,978	2,325
66	1,467	704	617	2,497	1,296	2,202	1,097	1,587	1,212	1,303	2,525	2,802
67	1,929	1,386	2,622	876	52	505	717	519	734	1,201	1,150	2,522
68	3,021	0	413	567	551	352	406	46	464	1,072	729	3,292
69	0	0	1,351	585	1,244	0	0	0	45	273	1,096	343
70	4,349	0	230	0	0	945	0	51	720	493	101	911
71	1,142	267	0	3	0	33	0	322	538	132	0	0
72	2,380	0	0	238	351	0	0	1,084	0	1,016	0	453
73	1,239	0	126	362	0	0	0	57	0	112	0	2,365
74	0	0	0	0	362	0	0	0	181	135	0	492
75	1,340	0	0	90	0	0	0	0	0	90	86	11
76	0	0	0	0	0	0	0	0	0	0	0	457
77	0	0	0	0	0	0	0	0	0	0	0	0
78	1,503	0	0	0	0	0	0	0	0	0	0	494
79	0	0	0	1,118	0	0	0	245	0	181	0	0
80	0	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	2,322,643

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 1994-2010. Trace amounts are indicated as 'tr'.

Age	1994	1996	1997	1999	2000	2002	2004	2006	2007	2008	2009	2010
1	610.2	972.3	12,360.0	111.9	257.9	634.8	15.8	455.6	5588.5	36.5	5127.9	2525.5
2	4,781.1	446.4	2,745.2	1,587.6	1,272.3	4,850.4	275.1	208.6	1026.2	2905.3	797.5	6395.2
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	973.5
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	2183.5
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	383.6
6	296.1	509.3	384.4	273.9	243.9	756.8	416.6	551.8	588.8	170.2	44.0	46.3
7	71.2	434.4	205.2	1,169.1	234.0	436.7	199.2	319.7	305.7	132.4	62.0	6.2
8	65.2	84.9	142.5	400.2	725.1	91.4	194.0	110.1	166.2	70.7	55.5	7.4
9	31.9	16.7	32.7	104.6	190.4	110.3	68.3	53.0	60.2	58.2	32.6	6.8
10	23.2	6.3	3.9	66.9	84.7	205.4	33.5	40.3	18.8	15.0	21.2	6.5
11	8.5	5.7	4.9	14.5	35.6	52.1	24.8	23.3	20.2	15.1	8.2	6.0
12	19.3	12.1	2.0	6.5	18.1	17.9	19.8	16.2	5.7	6.9	3.8	2.6
13	4.8	1.3	2.2	1.7	1.2	3.1	12.1	8.6	1.7	4.5	2.0	1.9
14	5.7	4.8	2.3	0.0	1.4	5.9	5.8	9.9	2.1	1.9	1.2	1.3
15	1.2	2.4	2.0	0.1	0.1	0.0	4.3	5.0	1.8	0.9	0.1	1.1
16	7.9	0.5	0.0	0.1	0.3	0.0	0.0	3.8	0.2	2.0	0.0	0.3
17	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.6	0.0	0.3
18	0.0	0.5	0.0	0.4	0.1	0.0	0.0	0.1	0.0	0.6	tr	0.4
19	0.7	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.6	0.4	tr	0.1
20	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.1
21+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	tr	0.0	tr
Total	10,821	6,525	18,686	9,601	7,630	12,122	6,834	3,396	9,207	4,704.0	8075.5	12,549

Age	1994	1996	1997	1999	2000	2002	2004	2006	2007	2008	2009	2010
1	17.1	36.7	417.8	3.3	8.1	21.2	0.4	8.8	103.4	0.8	104.4	80.0
2	425.3	35.3	369.9	156.6	144.0	645.1	31.6	21.2	89.5	242.7	78.5	750.4
3	312.4	118.7	99.5	847.4	284.6	843.7	329.3	68.8	89.3	220.7	399.6	215.4
4	641.3	888.8	188.6	640.2	974.4	458.2	1349.4	230.7	188.0	58.7	84.1	963.2
5	1,067.2	396.0	921.0	271.7	488.6	286.0	820.9	366.4	389.8	61.5	23.4	216.8
6	187.2	341.8	235.0	164.3	156.0	514.5	288.7	359.8	404.3	117.3	35.7	33.4
7	50.1	359.9	161.3	751.5	166.6	351.6	153.0	244.1	240.9	106.6	56.0	5.8
8	55.3	72.5	139.5	278.9	540.8	85.6	166.3	93.2	144.8	69.4	57.0	9.9
9	30.9	16.3	34.2	84.6	149.0	111.0	62.4	49.5	58.4	56.4	36.8	10.7
10	26.4	6.6	4.4	62.5	76.3	212.5	33.1	39.2	20.7	18.9	25.1	10.5
11	10.5	6.9	6.1	14.2	39.0	59.6	25.3	23.3	22.3	18.9	10.7	10.1
12	27.9	17.1	3.4	7.2	16.7	19.7	21.9	18.7	7.1	8.6	5.5	4.9
13	6.7	1.5	4.5	1.5	1.3	4.6	12.7	10.4	2.1	6.2	3.4	3.7
14	7.7	7.0	3.8	0.0	2.6	8.5	6.2	12.7	3.7	3.2	2.5	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	2.1
16	12.5	0.9	0.0	0.2	0.3	0.0	0.0	4.3	0.3	3.3	0.0	0.7
17	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.9	0.0	0.6
18	0.0	0.9	0.0	0.7	0.3	0.0	0.0	0.3	0.0	1.1	tr	1.2
19	0.8	0.0	0.0	0.0	0.0	0.0	0.0	2.5	1.0	0.5	tr	0.2
20	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.2
21+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.1	0.0	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	2,323

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			
2010	US	13.50	2.62	95	US	92,849
	Russia	1.03	0.13	5	US	12,260
	Total	14.53	2.75			

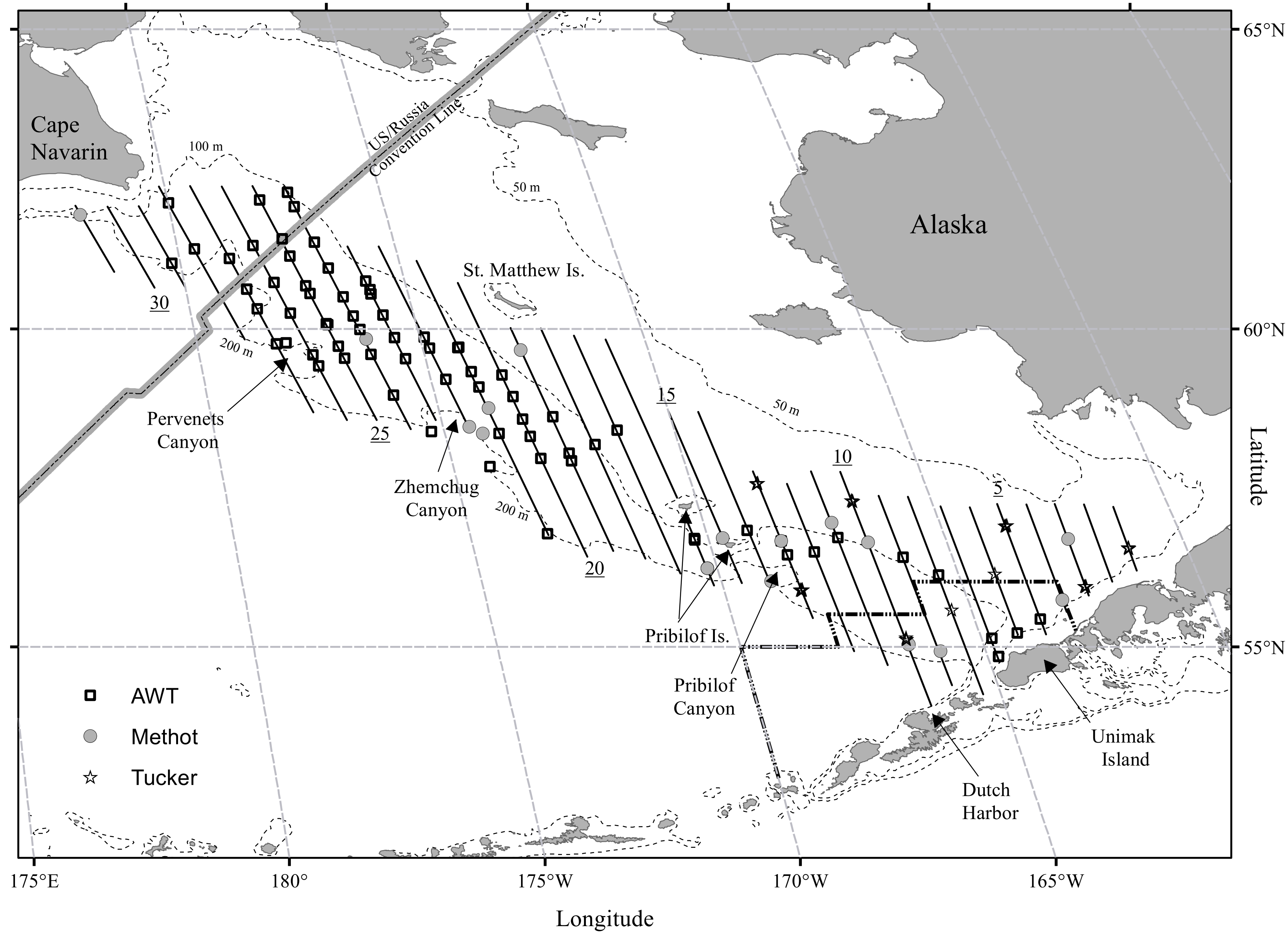


Figure 1. -- Transect lines with locations of Aleutian wing trawls (AWT), Methot trawls, and Tucker trawls during the summer 2010 acoustic-trawl survey of walleye pollock on the eastern Bering Sea shelf. Transect numbers are underlined and the Steller sea lion Conservation Area (SCA) is outlined (dashed line).

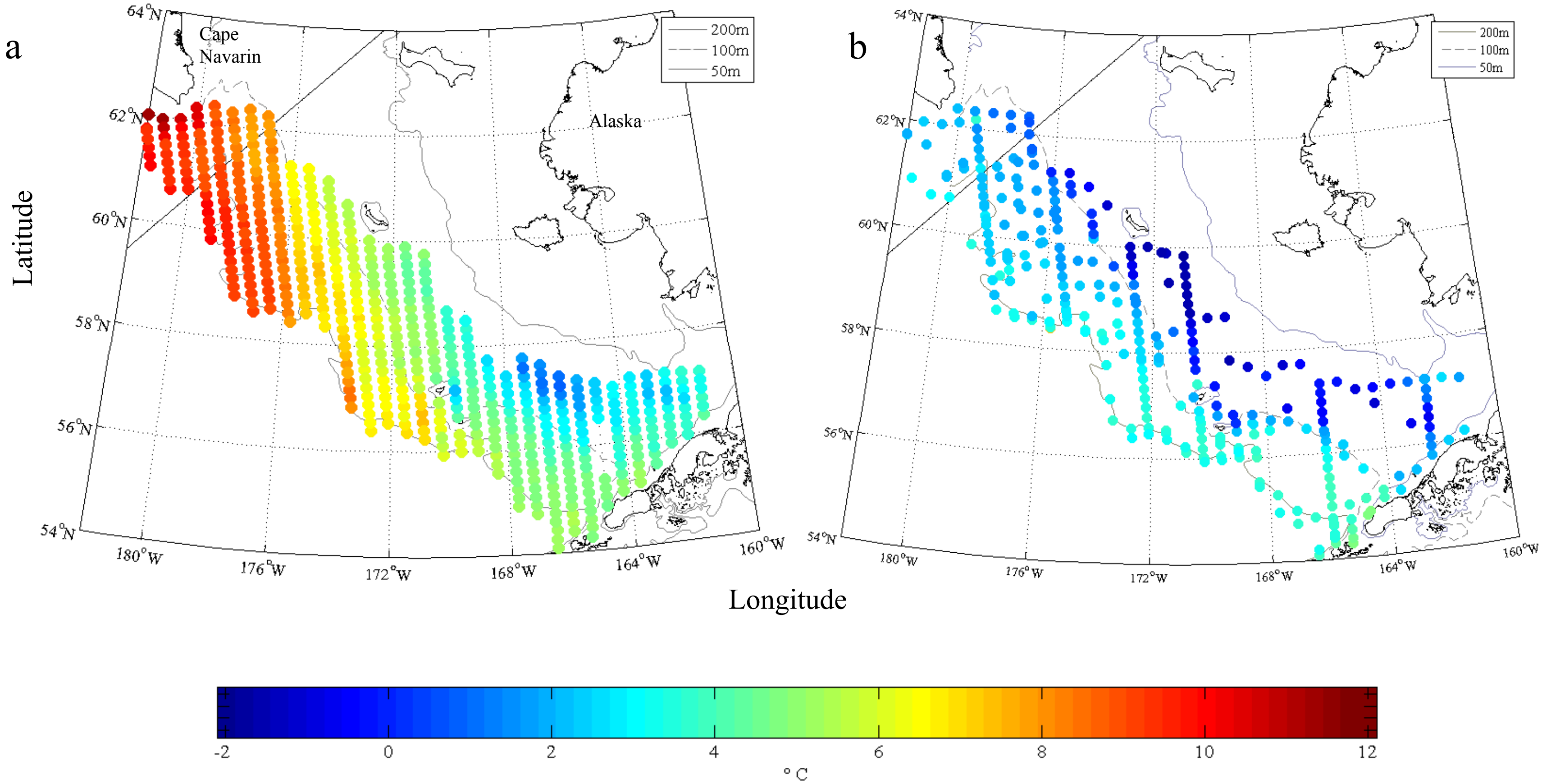


Figure 2. -- Temperature (°C) a) measured at the sea surface using shipboard surface temperature sensors along survey transects averaged at 10-nmi resolution, and b) at the bottom using SBE-39s at trawl locations, conductivity-temperature-depth profilers (CTDs), and expendable bathythermographs (XBTs) during the summer 2010 acoustic-trawl survey of the eastern Bering Sea shelf.

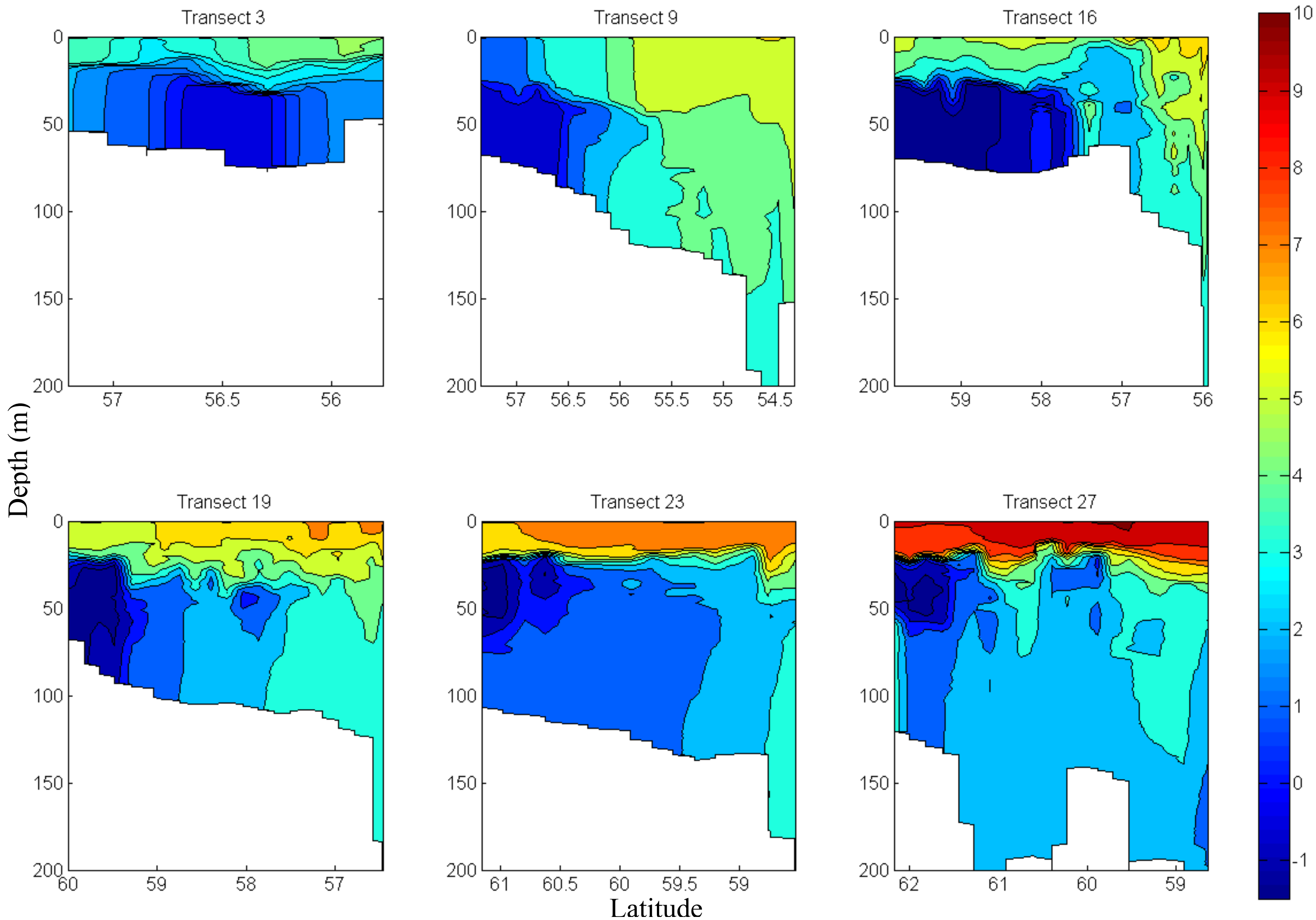


Figure 3. -- Temperature (°C) profiles measured using expendable bathythermographs (XBTs) dropped along survey transects during the summer 2010 acoustic-trawl survey of the eastern Bering Sea shelf from June - August.

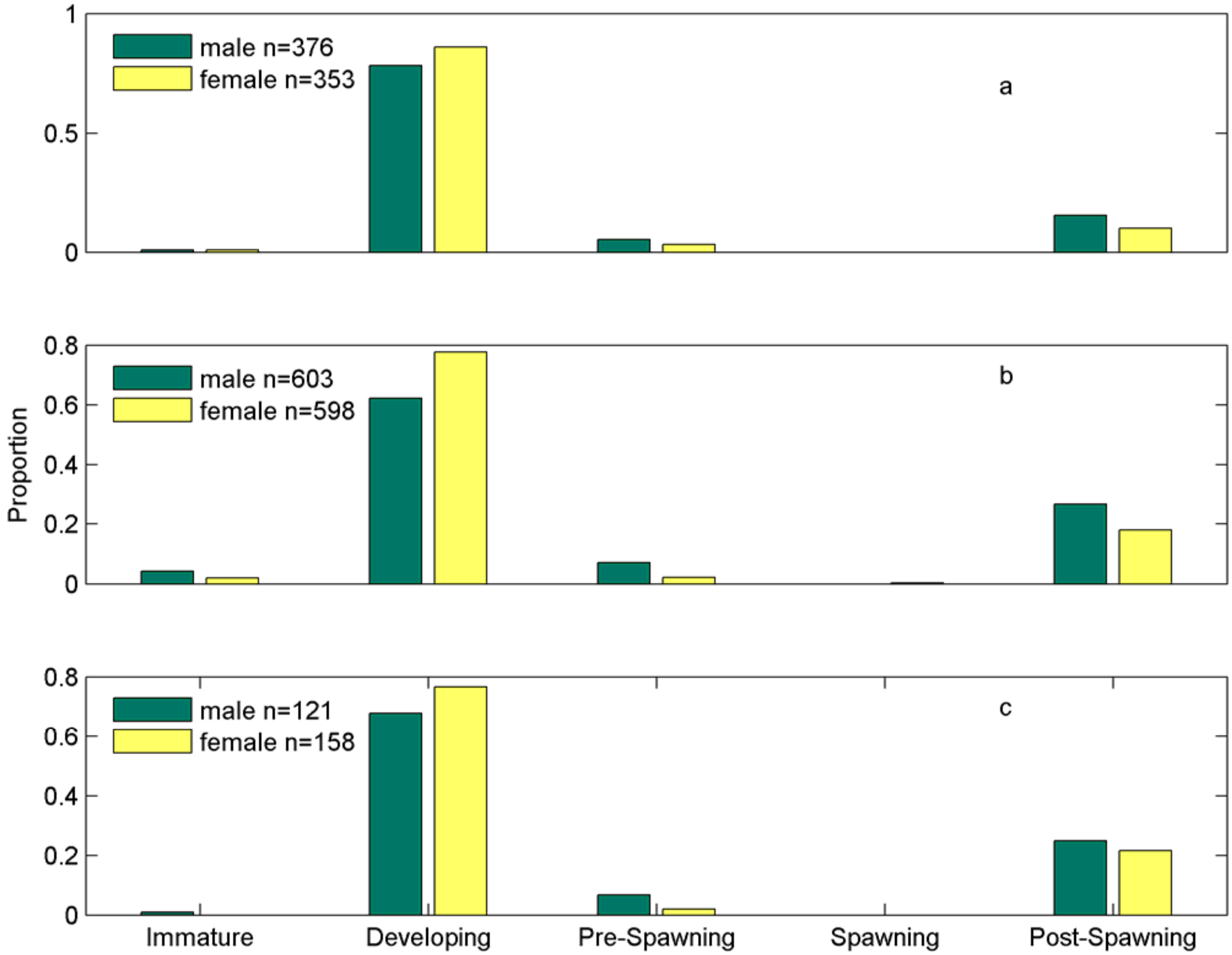


Figure 4. -- Maturity stages by sex for walleye pollock > 30 cm observed during the summer 2010 eastern Bering Sea shelf acoustic-trawl survey a) east of 170° W, b) in U.S. waters west of 170° W, and c) in Russian waters.

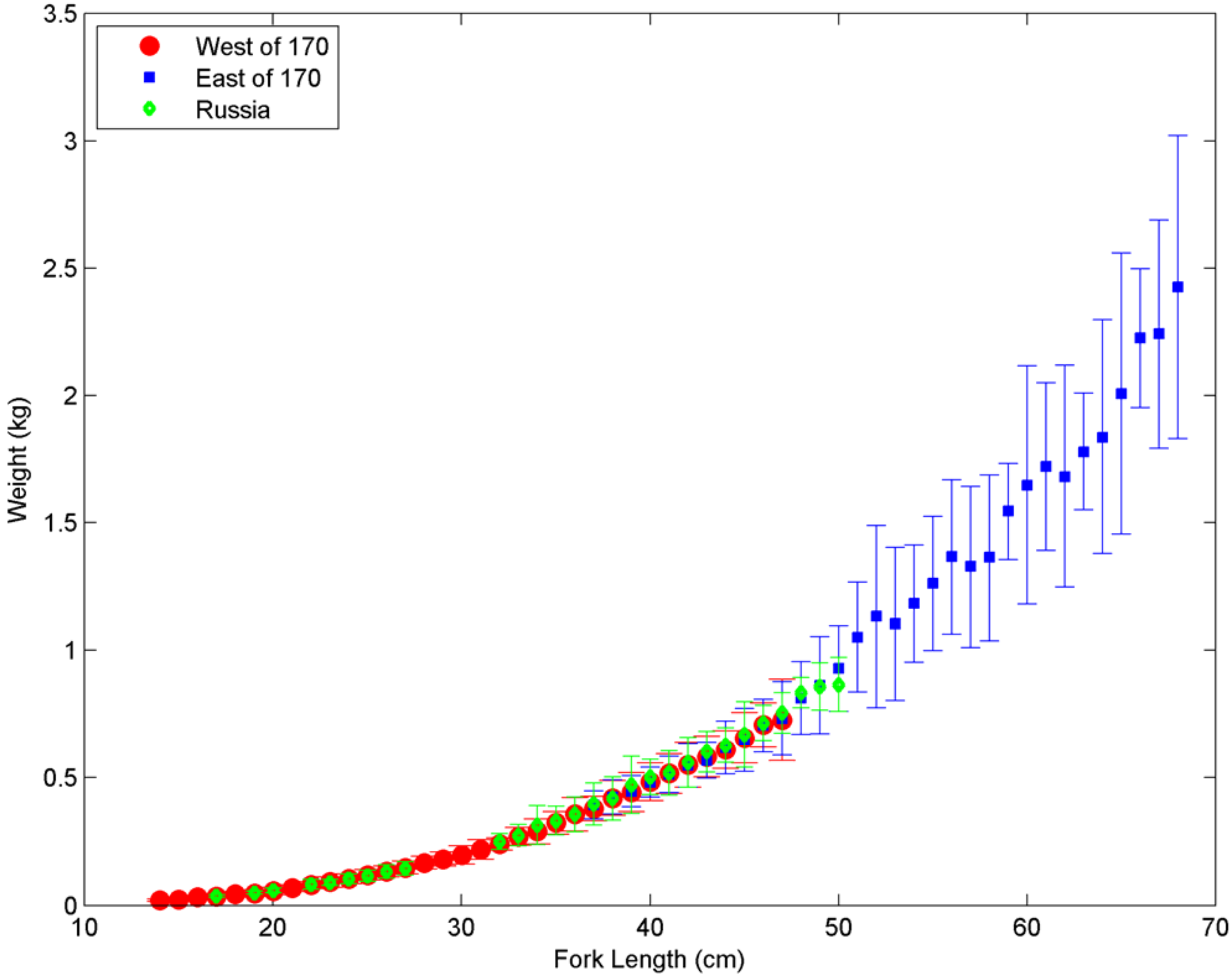


Figure 5. -- Mean weight-at-length for walleye pollock measured in the U.S. EEZ east and west of 170°W and in Russia during the summer 2010 eastern Bering Sea shelf acoustic-trawl survey. Average weights (kg) were computed when > 5 fish were measured at any given length (cm). Error bars represent ± 1 standard deviation.

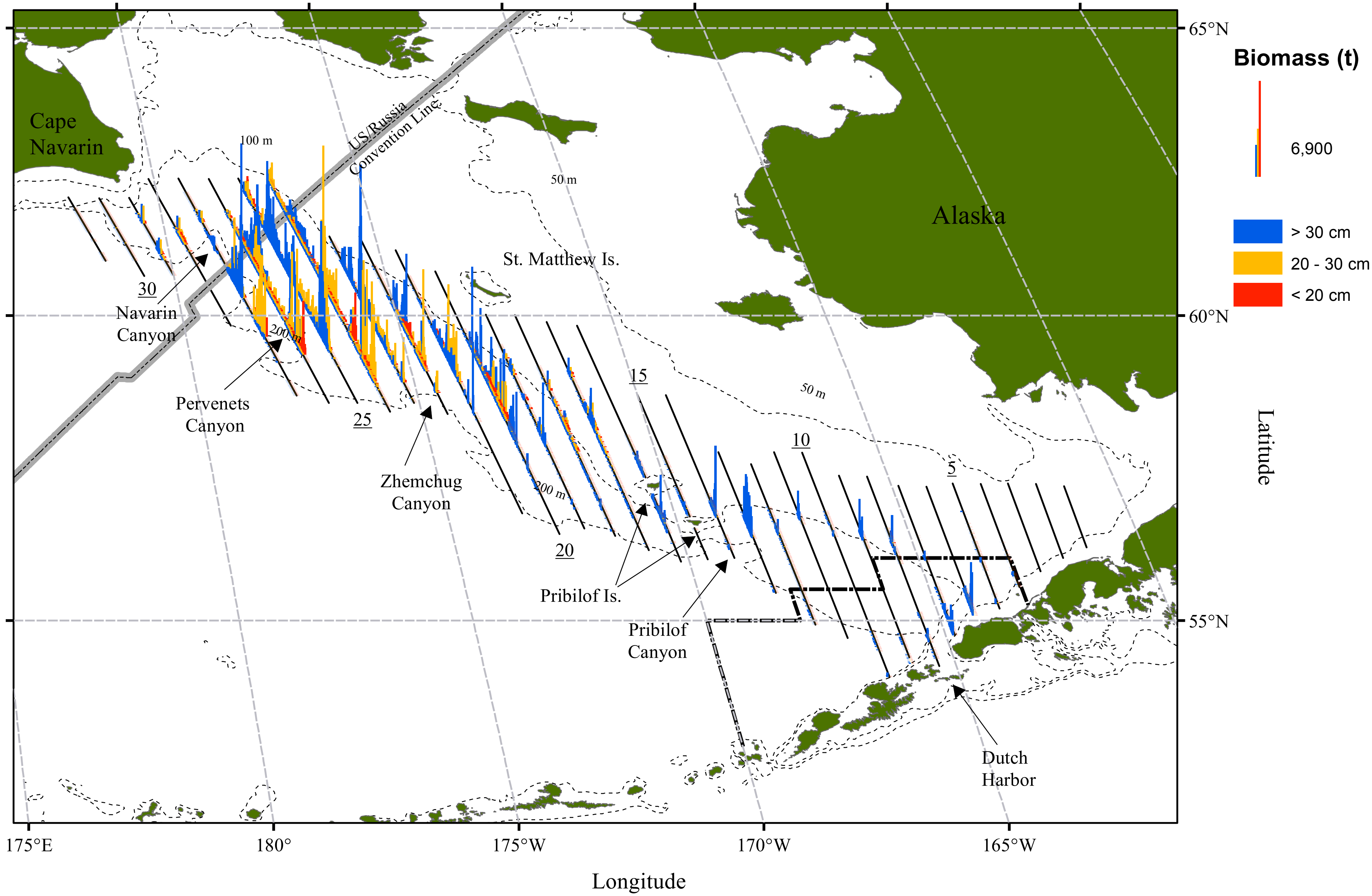


Figure 6.-- Estimated juvenile and adult (< 20 cm, red; 20 - 30 cm, yellow; > 30 cm, blue) walleye pollock biomass by 0.5 nmi intervals for the summer 2010 acoustic-trawl survey (16 m from the surface to 3 m off bottom). Transect numbers are underlined, and the Steller sea lion Conservation Area (SCA) is outlined (dashed line).

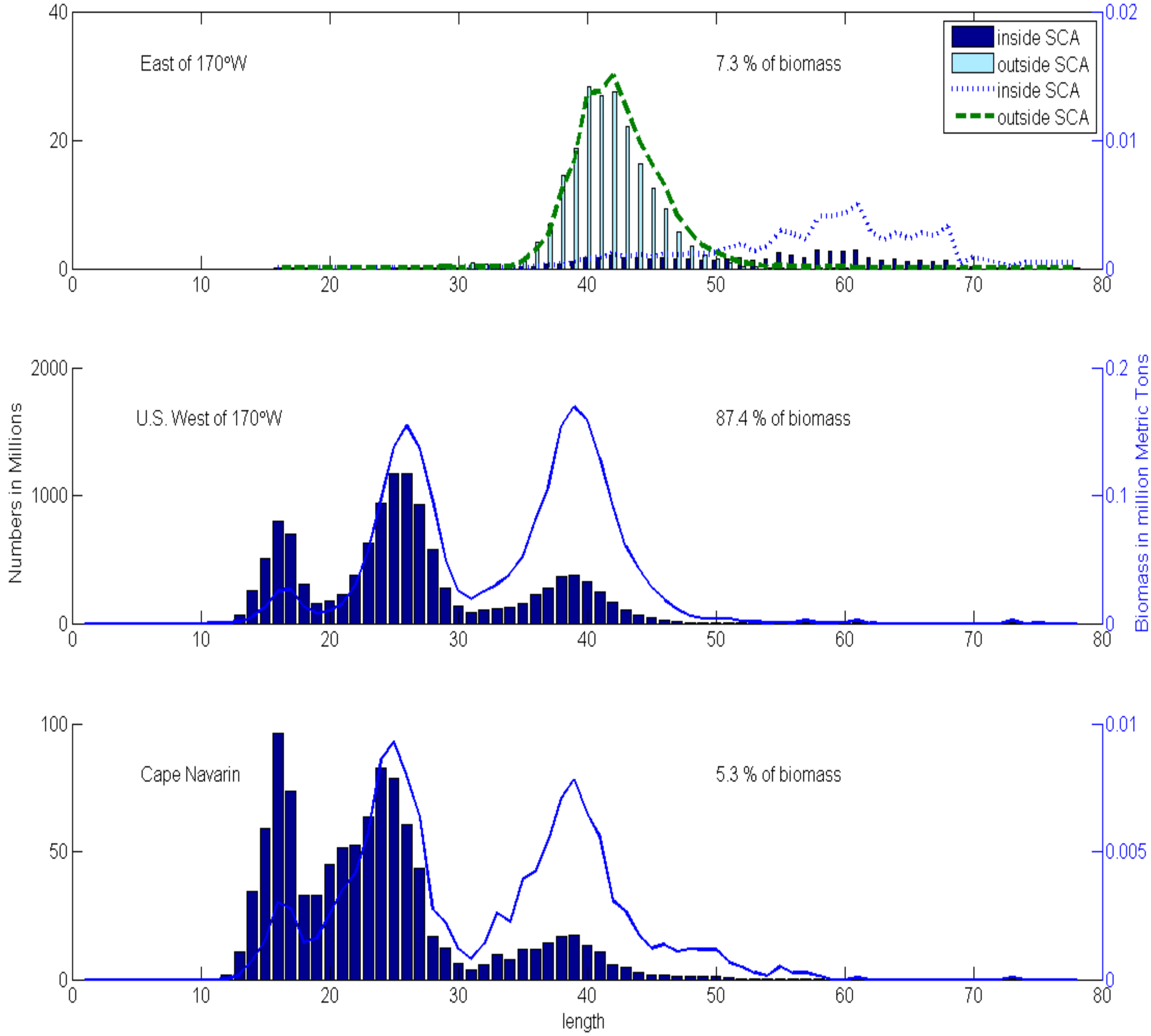


Figure 7. -- Population numbers (lines) and biomass (histogram bars) at length (cm) estimated for walleye pollock between 16 m from the surface and 3 m off the bottom from the summer 2010 eastern Bering Sea shelf acoustic-trawl survey in three geographic regions.

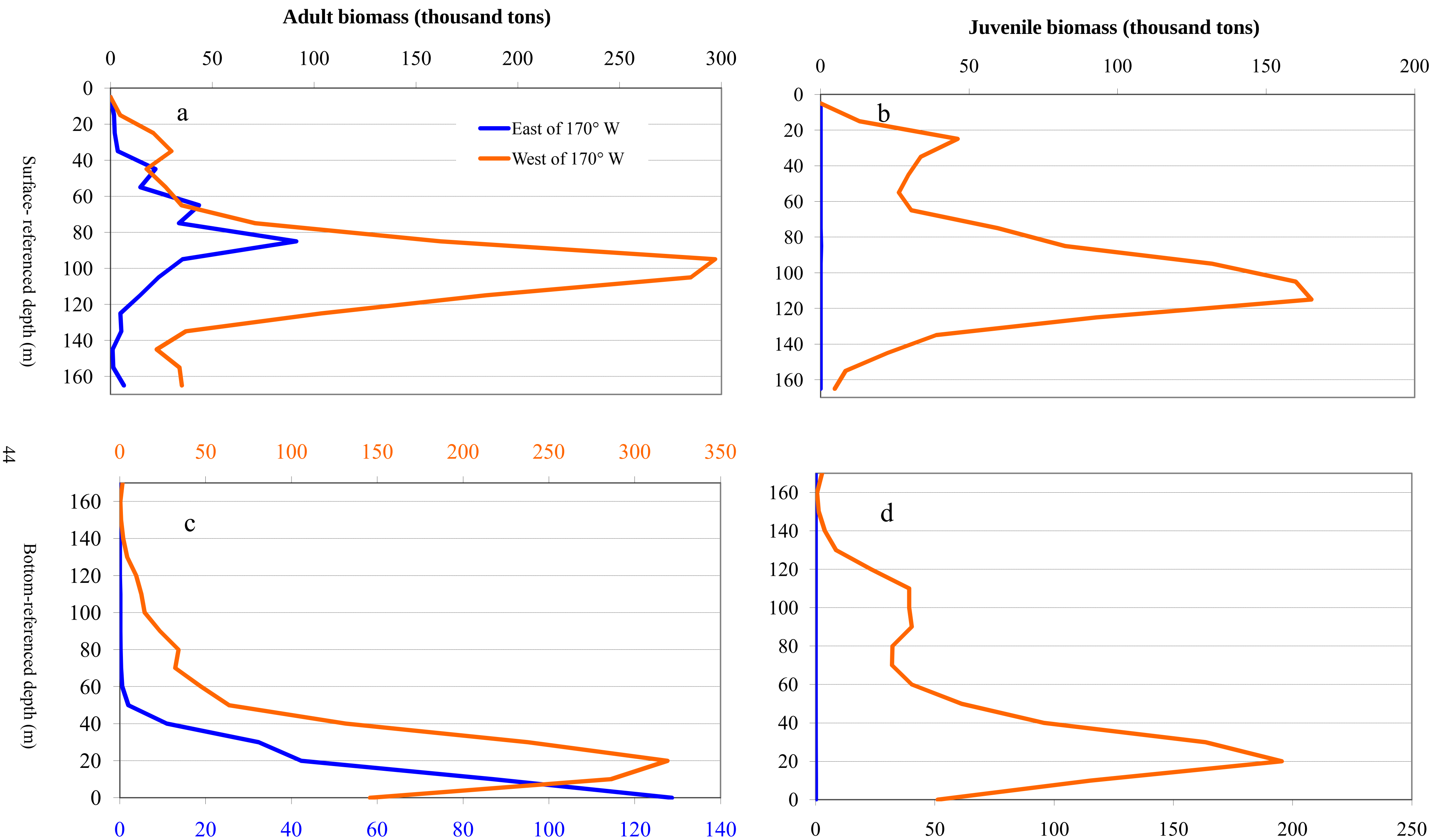


Figure 8.-- Depth distribution (m) of adult (> 30 cm FL) or juvenile (≤ 30 cm FL) walleye pollock biomass in metric tons (t) observed east and west of 170°W longitude in the U.S. EEZ of the Bering Sea shelf during the summer 2010 acoustic-trawl survey. Depth is referenced to the surface (a,b) and to the bottom (c,d) and is in 10m depth intervals. Note: So few juveniles were observed east of 170°W that they do not show up on the graph. Y-axes differ.

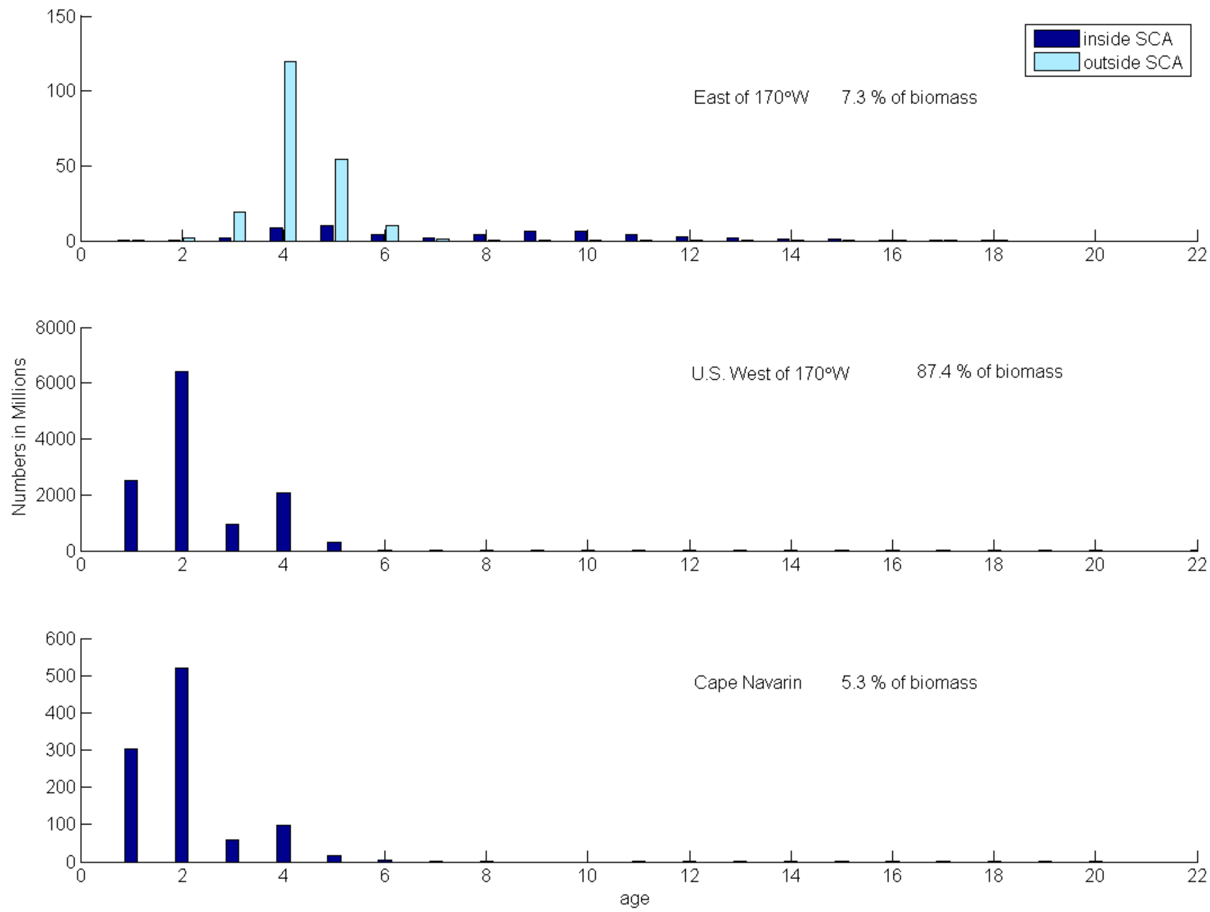


Figure 9. -- Population numbers at age estimated for walleye pollock between 16 m from surface and 3 m off bottom for three different geographic regions during the summer eastern Bering Sea shelf acoustic-trawl survey. Note: Y-axes differ.

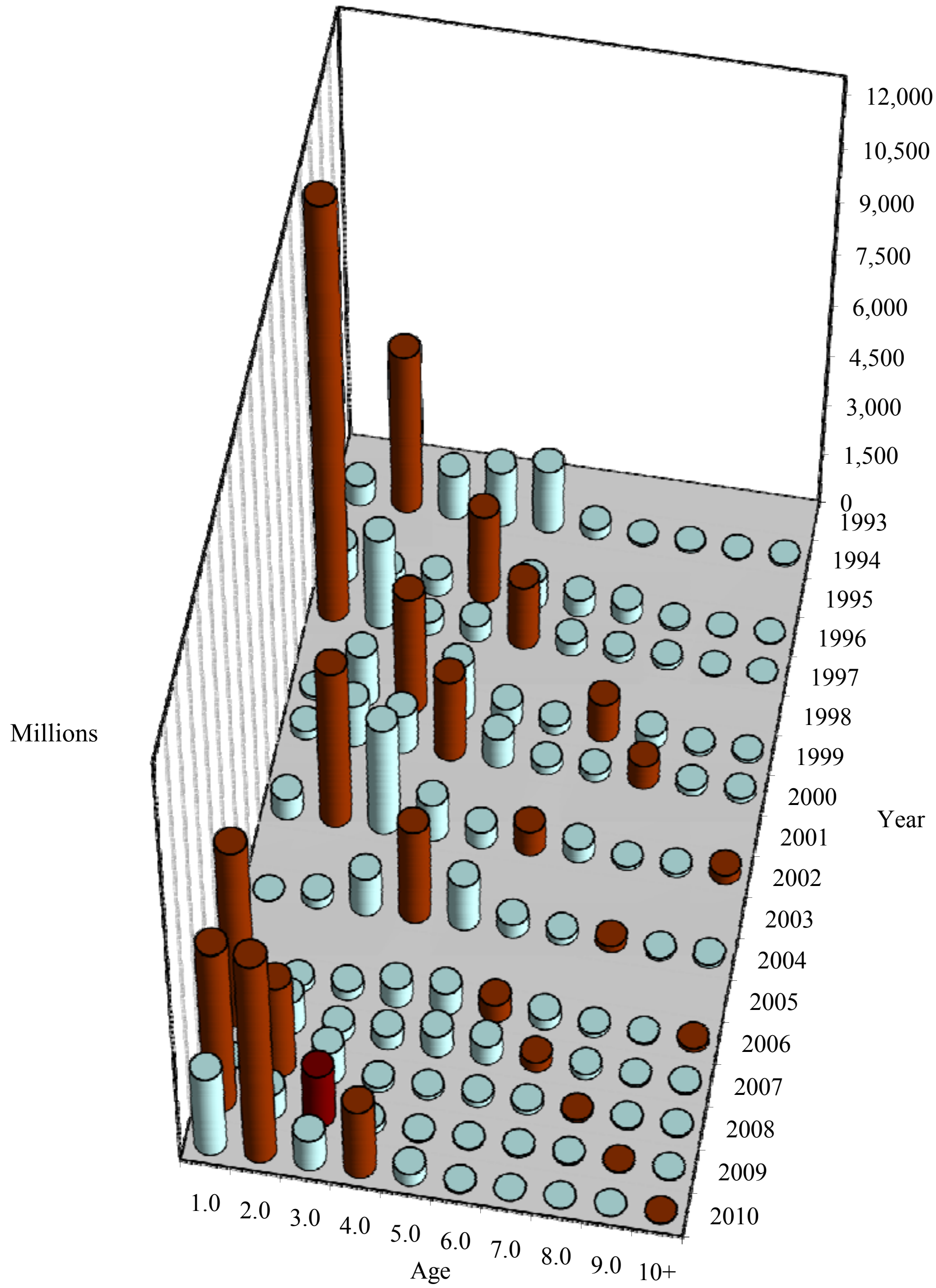


Figure 10. -- Historical numbers at age of walleye pollock between near the surface and 3 m off bottom in the U.S. EEZ for the summer eastern Bering Sea shelf acoustic-trawl surveys between 1994 and 2010. Strong year classes are indicated with dark shading.

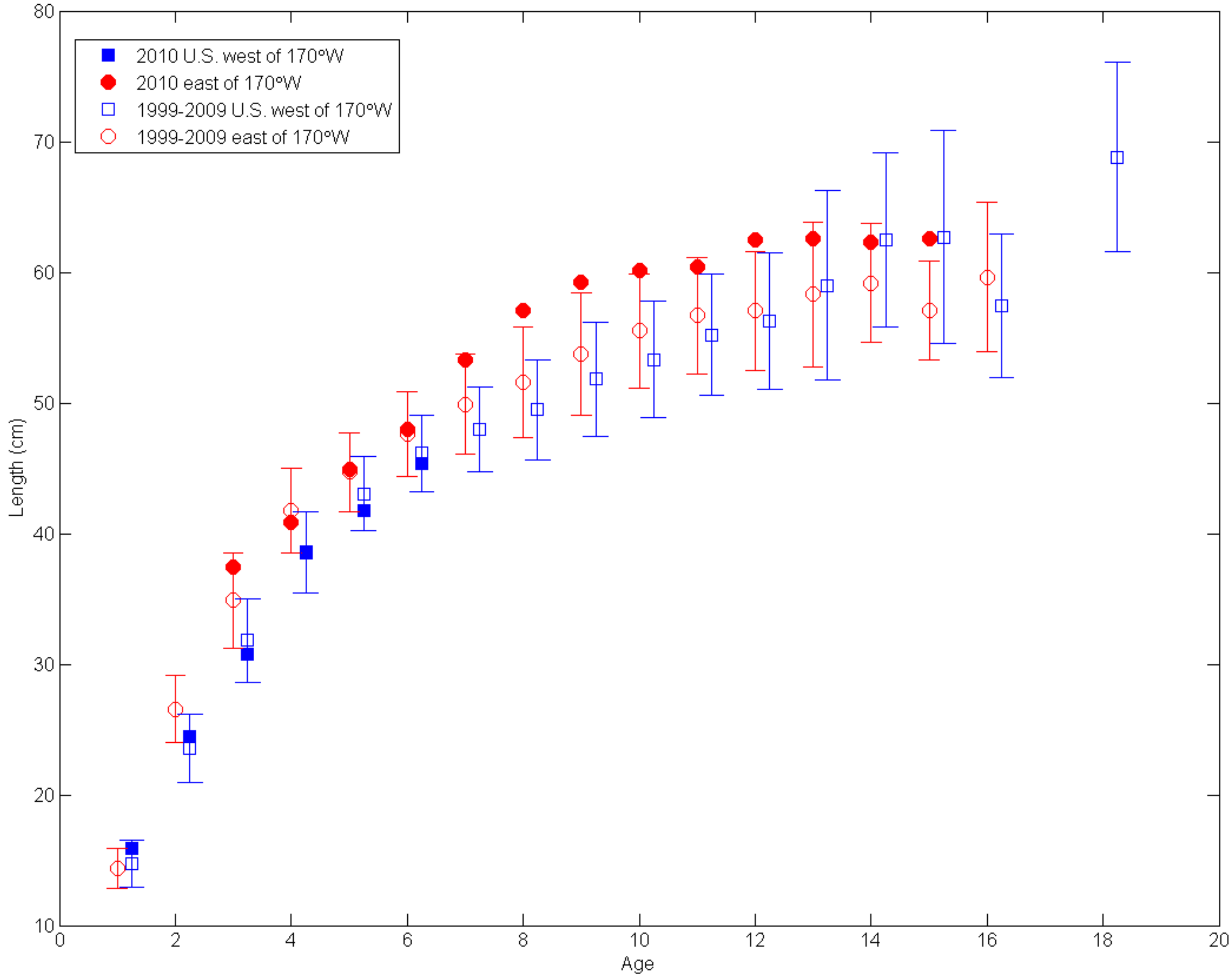


Figure 11. -- Walleye pollock average length at age from summer eastern Bering Sea acoustic-trawl surveys (1999, 2000, 2002, 2004, 2006, 2007, 2008 and 2009) compared with walleye pollock average length at age for summer 2010. Results are for midwater tows where at least five fish were measured in the U.S. EEZ. Bars show +/- 1 standard deviation for the 1999-2009 series.

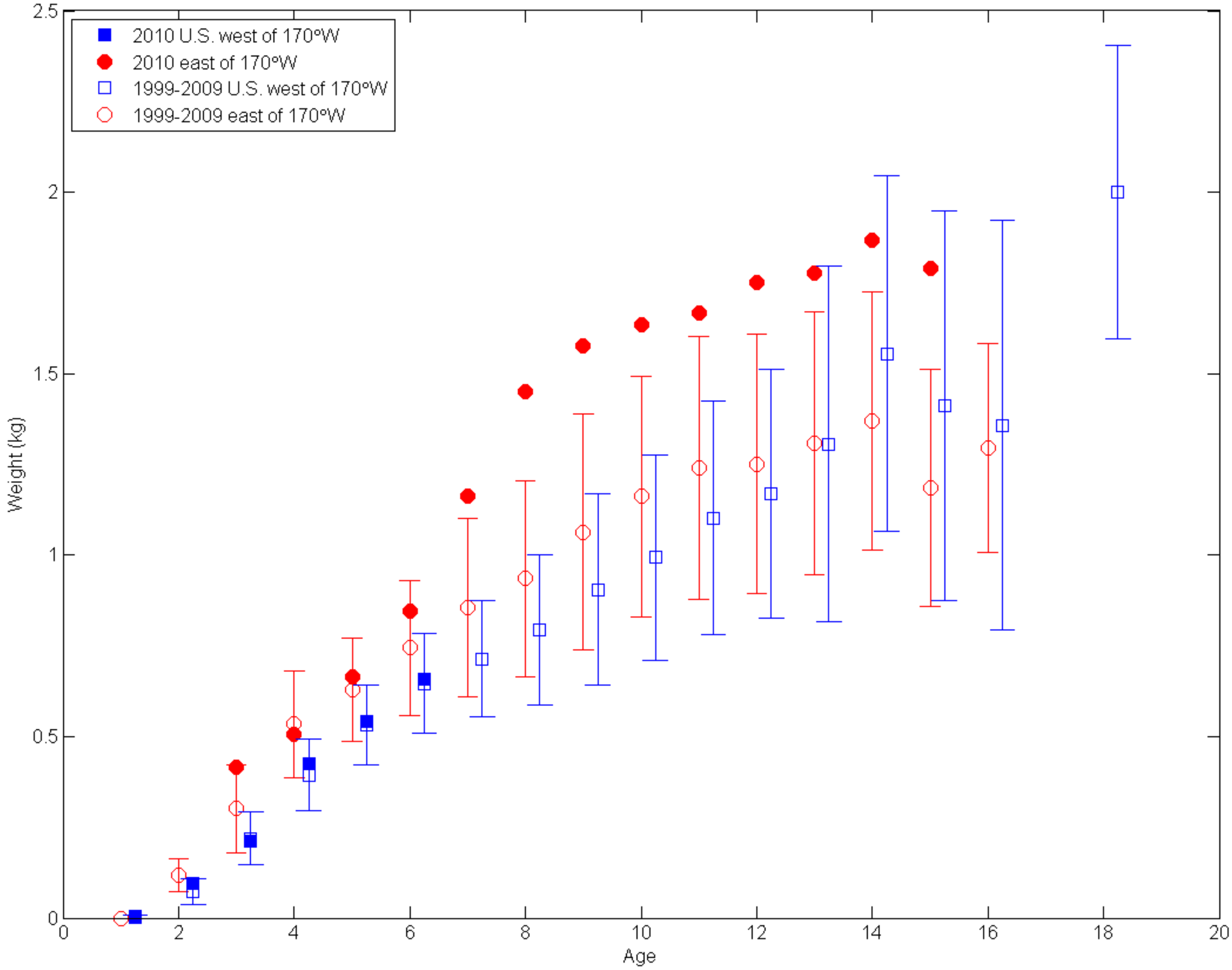
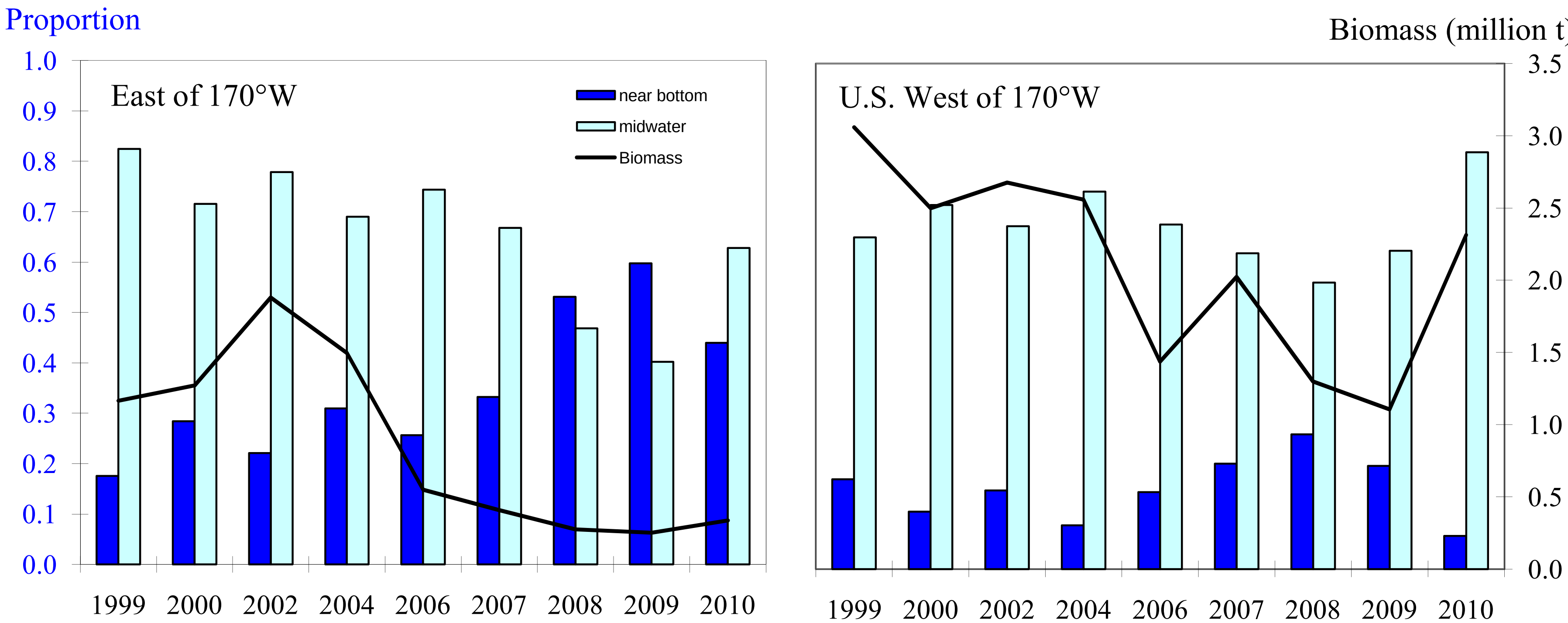


Figure 12. -- Walleye pollock average weight at age from summer eastern Bering Sea acoustic-trawl surveys (1999, 2000, 2002, 2004, 2006, 2007, 2008, 2009) compared with walleye pollock average weight at age for summer 2010 for the U.S. EEZ east and west of 170°W. Results are limited to age classes where at least five fish have been aged and weighed. Bars show +/- 1 standard deviation for the 2010 data.



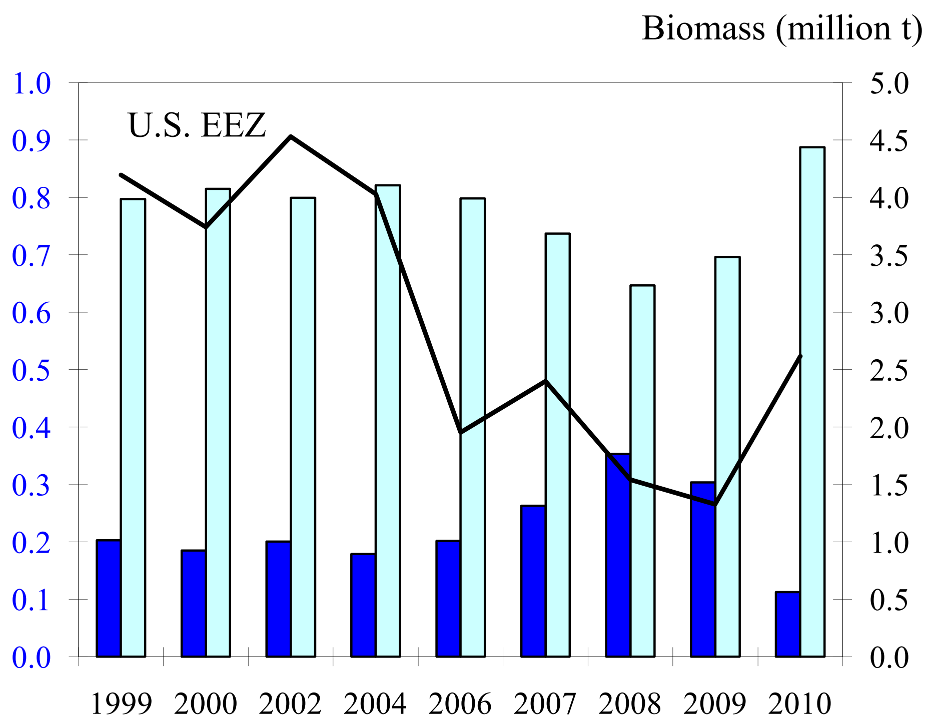


Figure 13. -- Proportion of walleye pollock biomass in the midwater (surface to 3 m off the bottom), and near bottom (3 m to 0.5 m off bottom), regions east and west of 170°W, and in the U.S. EEZ during the 1999-2010 acoustic-trawl surveys. Total (midwater + near bottom) biomass (black lines) is plotted on right Y-axes.

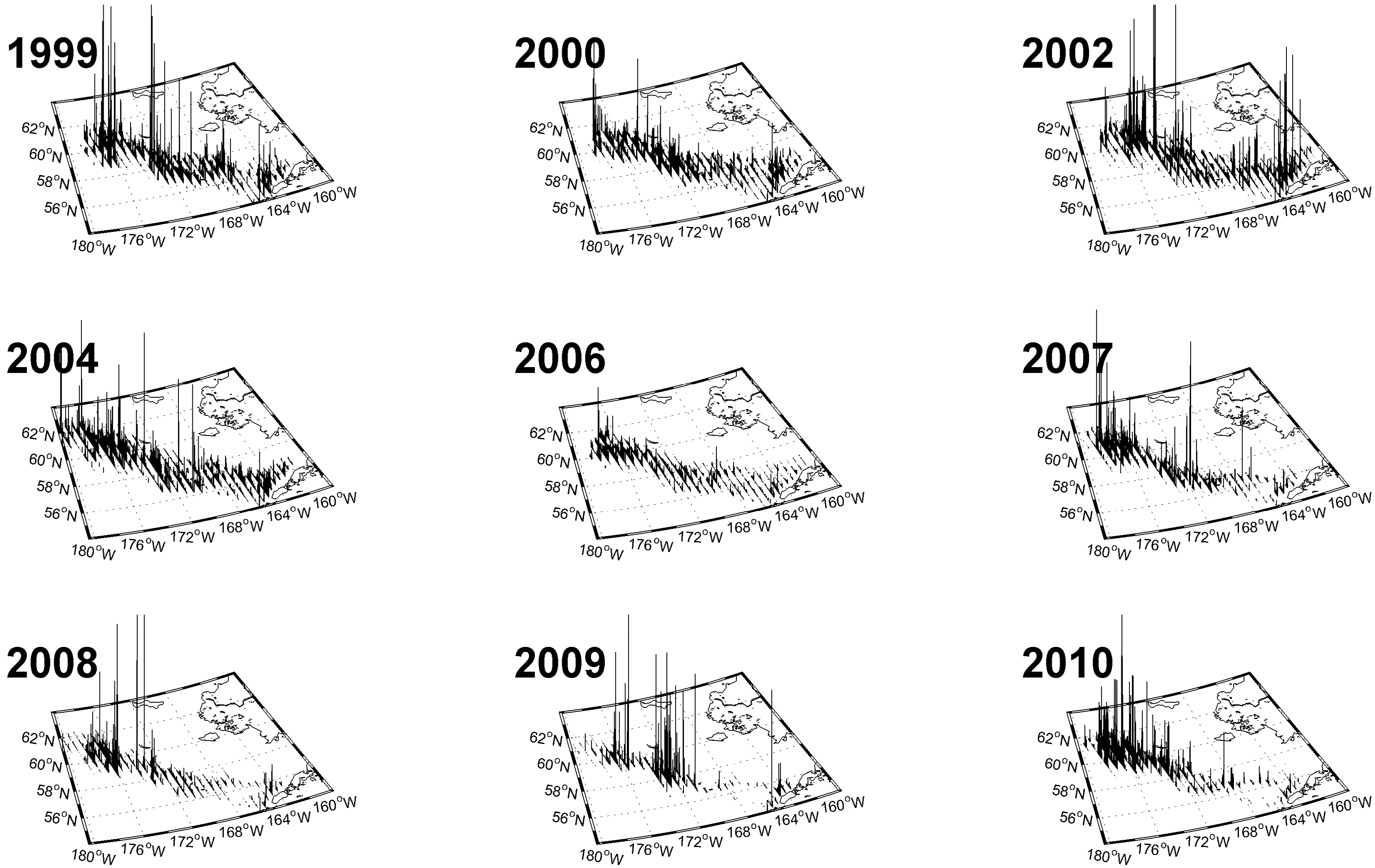


Figure 14. -- Walleye pollock backscatter (s_A) at 38 kHz observed along tracklines during the summer eastern Bering Sea acoustic-trawl surveys conducted between 1999 and 2010.

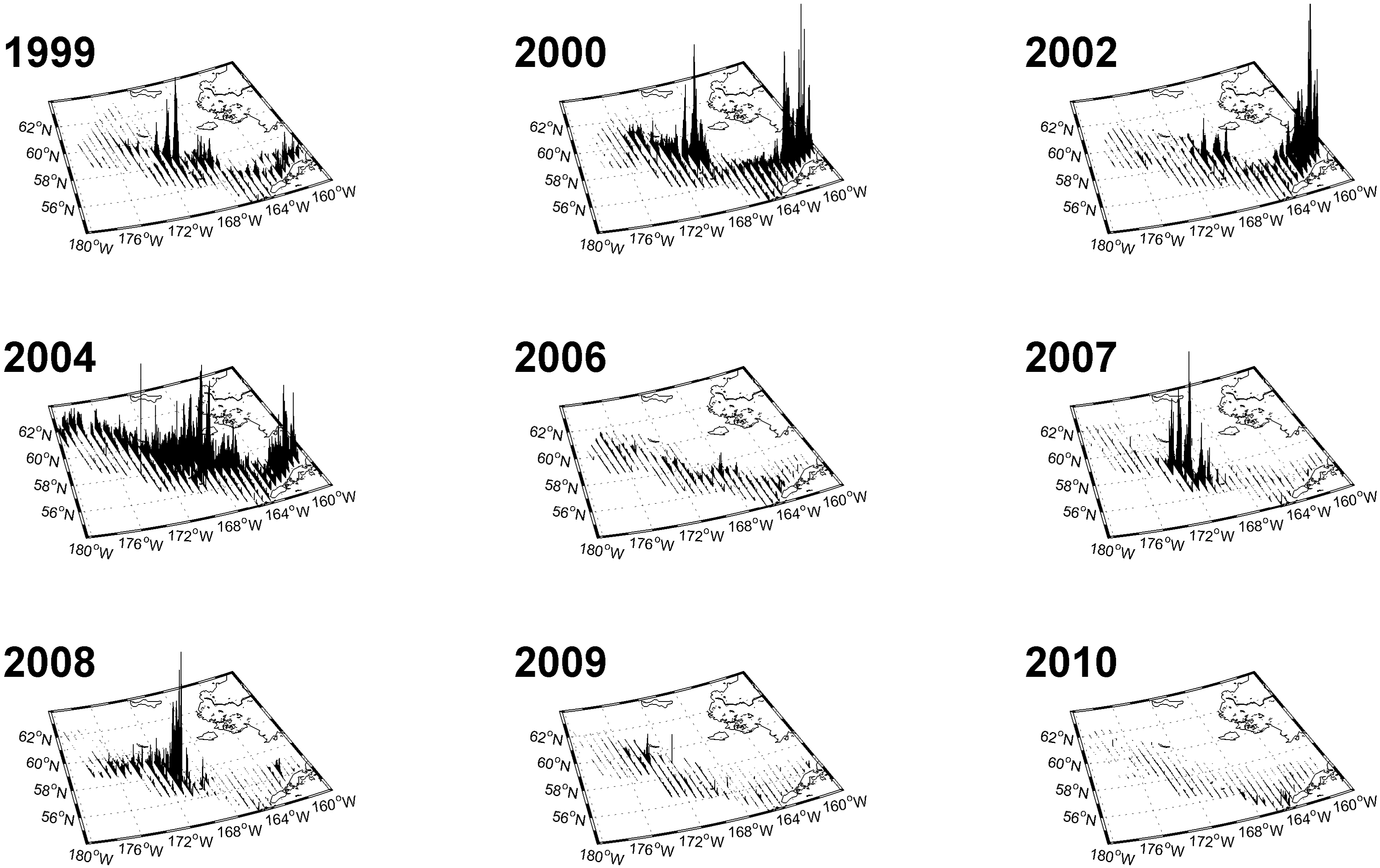


Figure 15. -- Non-pollock, non-fish, backscatter (s_A), observed at 38 kHz frequency along tracklines during the summer eastern Bering Sea acoustic-trawl surveys conducted between 1999 and 2010.

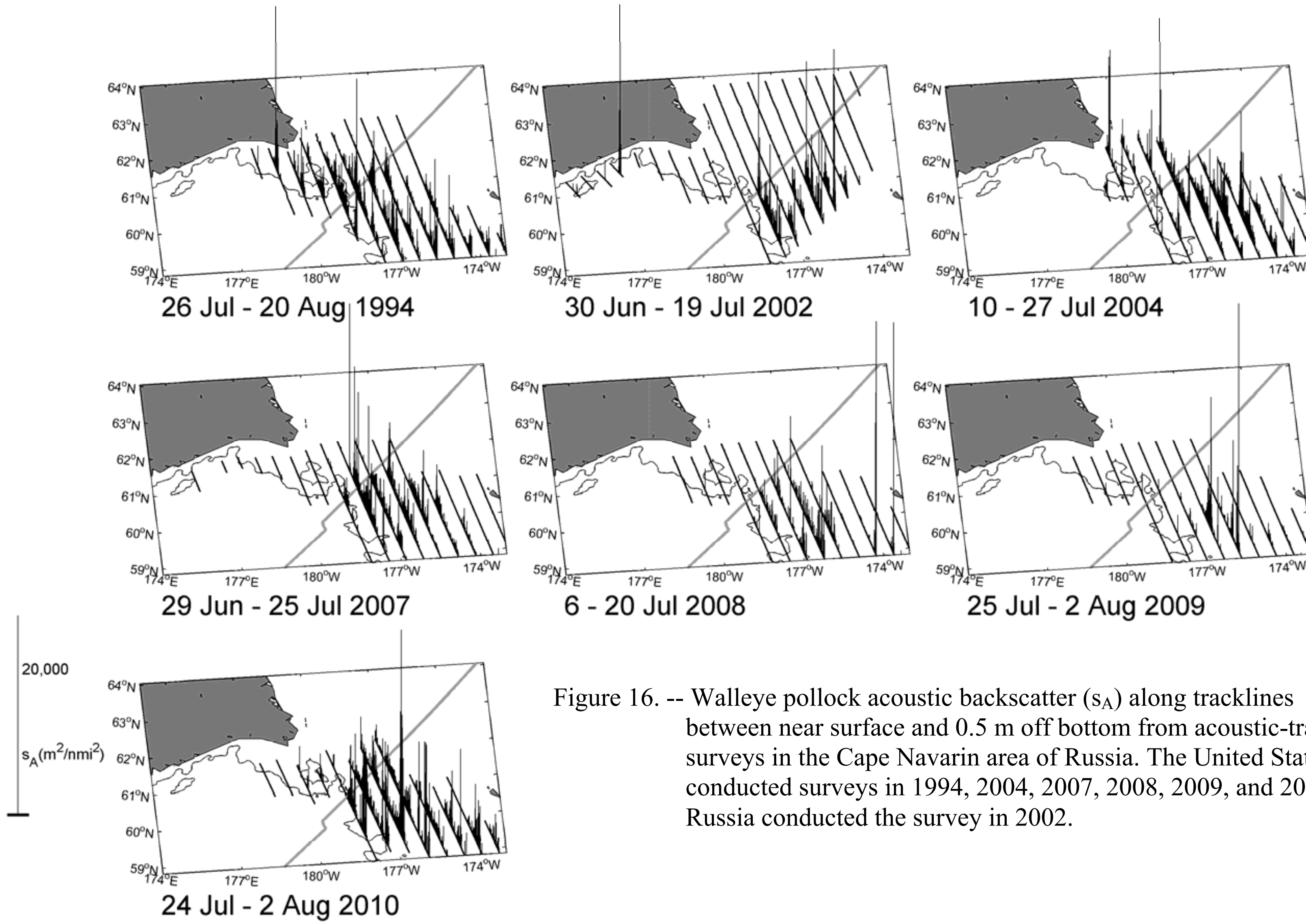


Figure 16. -- Walleye pollock acoustic backscatter (s_A) along tracklines between near surface and 0.5 m off bottom from acoustic-trawl surveys in the Cape Navarin area of Russia. The United States conducted surveys in 1994, 2004, 2007, 2008, 2009, and 2010. Russia conducted the survey in 2002.

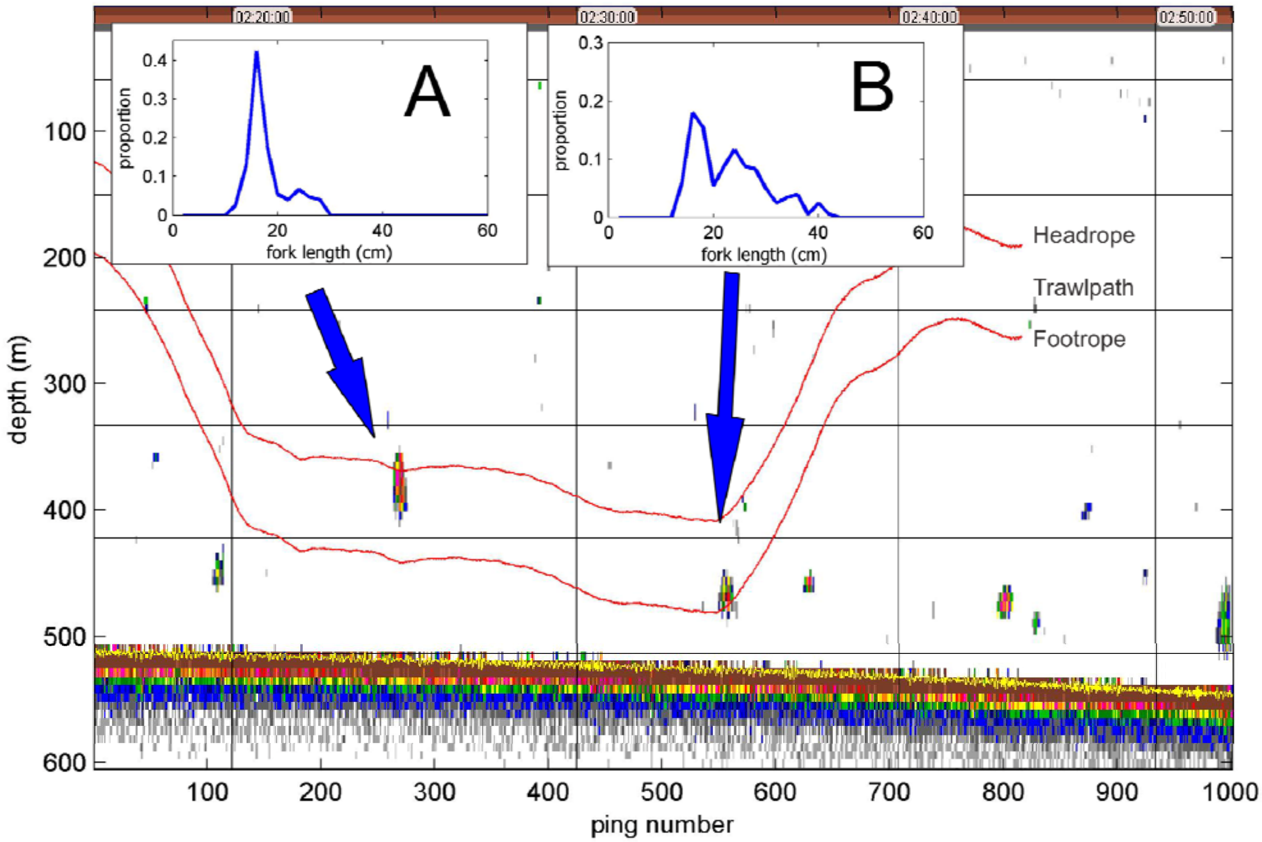


Figure 17. -- Length frequencies of distinct aggregations of walleye pollock from stereo camera images in two locations along the trawl path taken by the Cam-Trawl compared with the corresponding echogram during the summer 2010 eastern Bering Sea shelf acoustic-trawl survey. A) primarily age-1 juveniles and B) a mix of age-1, age-2, and older fish. Arrows indicate the schools associated with the length frequency samples from the camera images.

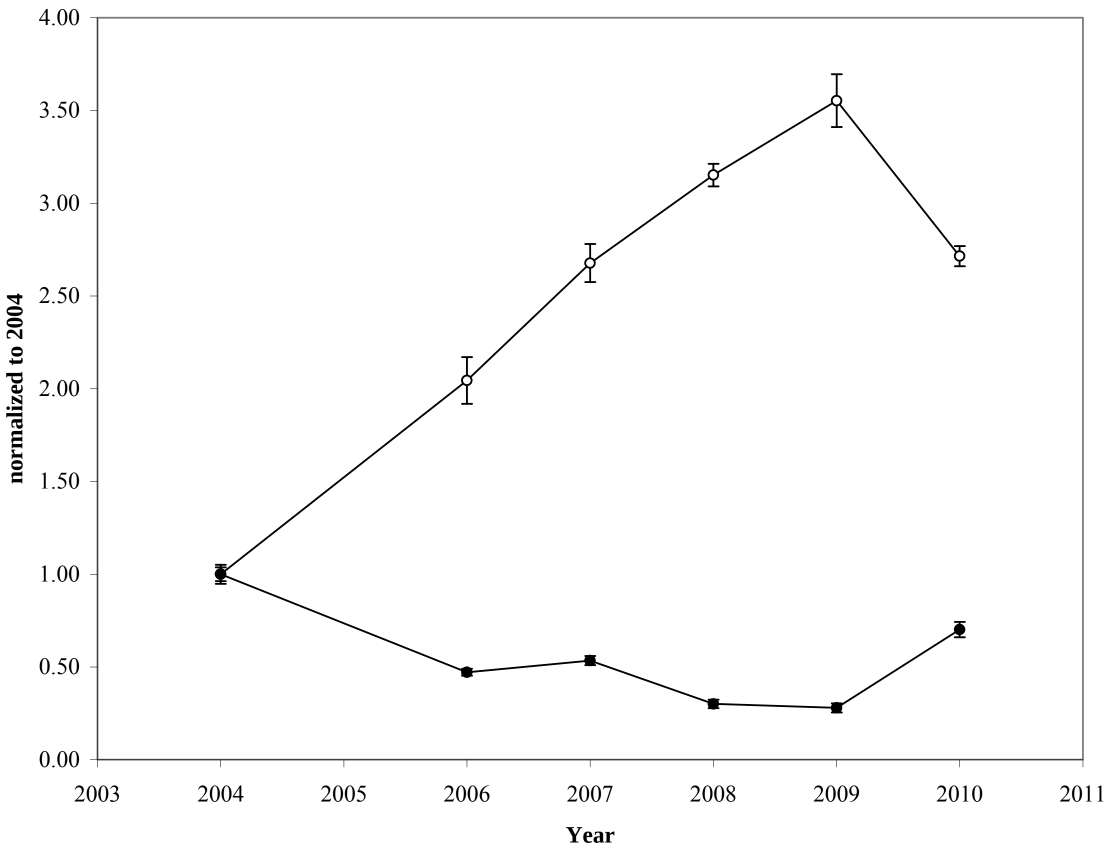


Figure 18.--Bering Sea summer euphausiid backscatter at 120 kHz (open circles) and walleye pollock biomass from the acoustic-trawl survey (closed circles). Each time series has been normalized to its value in 2004. Error bars indicate relative estimation error.

Appendix I. -- Itinerary

Leg 1

5 June	Depart Kodiak, AK
5-6 June	Conduct sphere calibration in Three Saints Bay, Kodiak Island
7-9 June	Conduct camera deployments and Drop TS data collections on Snakehead plateau south of Kodiak Island
9-10 June	Transit to survey start area in Bristol Bay, eastern Bering Sea
10-24 June	Acoustic-trawl survey of the Bering Sea shelf (through waypoint 13.1) Scientific personnel exchange in Dutch Harbor on 18 June
24 June	Transit to Dutch Harbor
25-29 June	In port Dutch Harbor (generator repair)

Leg 2

29 June	Transit to survey resume point
30 June-14 July	Acoustic-trawl survey of the Bering Sea shelf (transects 14 - 23)
15-16 July	Transit to Unalaska Island, AK
16-20 July	In port Dutch Harbor, AK

Leg 3

20-21 July	Transit to Zhemchug Canyon
21-22 July	Rockfish reconnaissance work
22 Jul.-2 Aug.	Acoustic-trawl survey of the Bering Sea shelf including Russian waters (transects 24 - 31)
3-5 Aug.	Experimental Cam-Trawls, rockfish study, 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.
7 Aug.	End of cruise.

Appendix II. -- Scientific Personnel

Name	Position	Organization	Nation
	Leg 1 (5-24 June)		
Paul Walline	Chief Scientist	AFSC	USA
Patrick Ressler	Fishery Biologist	AFSC	USA
Rick Towler	Info. Tech. Specialist	AFSC	USA
Darin Jones	Fishery Biologist	AFSC	USA
Mikhail Stepanenko	Fishery Biologist	TINRO	Russia
William Floering	Fishery Biologist	AFSC	USA
Mike Sigler	Fish Biologist (approx Jun 17- 24)	AFSC	USA
Liz Labunski	Seabird Observer	USFWS	USA
Patti Sullivan	Seabird Observer	USFWS	USA
Ernesto Vazquez	Whale Biologist	NMML	Mexico
Paula Olson	Whale Biologist	NMML	USA
Suzanne Yin	Whale Biologist	NMML	USA
Richard Chewning	Teacher At Sea	NOAA	USA
	Leg 2 (29 June- 16 July)		
Neal Williamson	Chief Scientist		
Paul Walline	Chief Scientist	AFSC	USA
Scott Furnish	Info. Tech. Specialist	AFSC	USA
Abigail McCarthy	Fishery Biologist	AFSC	USA
William Floering	Fishery Biologist	AFSC	USA
Mikhail Stepanenko	Fishery Biologist	TINRO	Russia
Elena Gritsay	Fishery Biologist	TINRO	Russia
Katie Wurtzell	Student Intern	Cornell University	USA
Rebecca Kimport	Teacher At Sea	NOAA	USA
Michele Brustolon	Teacher At Sea	NOAA	USA
Nate Jones	Seabird Observer	USFWS	USA
Martin Reedy	Seabird Observer	USFWS	USA
Ernesto Vazquez	Whale Biologist	NMML	Mexico
Paula Olson	Whale Biologist	NMML	USA
Suzanne Yin	Whale Biologist	NMML	USA
	Leg 3 (20 July -7 August)		
Taina Honkalehto	Chief Scientist	AFSC	USA
Chris Wilson	Fishery Biologist	AFSC	USA
Scott Furnish	Info. Tech. Specialist	AFSC	USA
Darin Jones	Fishery Biologist	AFSC	USA
Mikhail Stepanenko	Fishery Biologist	TINRO	Russia
Elena Gritsay	Fishery Biologist	TINRO	Russia
Kresimir Williams	Fishery Biologist	AFSC	USA
Liz Labunsky	Seabird Observer	USFWS	USA
Martin Reedy	Seabird Observer	USFWS	USA
Ernesto Vazquez	Whale Biologist	NMML	Mexico
Paula Olson	Whale Biologist	NMML	USA
Suzanne Yin	Whale Biologist	NMML	USA
Story Miller	Teacher At Sea	NOAA	USA
Obed Fulcar	Teacher At Sea	NOAA	USA

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