APPENDIX D

Echo Integration-Trawl Survey Results for Walleye Pollock in the Gulf of Alaska during 2000

by
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INTRODUCTION

Since 1980, scientists from the Midwater Assessment and Conservation Engineering group at the Alaska Fisheries Science Center (AFSC), Seattle, WA, have conducted annual echo integration-trawl (EIT) surveys (except in 1982 and 1999) in the Gulf of Alaska to assess the distribution and abundance of walleye pollock (*Theragra chalcogramma*), hereafter referred to as pollock. The surveys focused primarily on pre-spawning pollock in the Shelikof Strait area. Results from surveys outside of Shelikof Strait generally did not indicate large amounts of pollock, although these efforts were quite restrictive both temporally and spatially (Williamson 1989, Karp 1990, and references therein). The only substantial pre-spawning aggregations of pollock found outside of Shelikof Strait were detected in 1994-96 during surveys of the Shumagin Islands (Wilson 1994, Wilson et al. 1995, Wilson et al. 1996). Only the Shelikof Strait area has been surveyed since 1997. The primary objectives of the most recent survey were to determine abundance estimates as well as various biological characteristics of pollock. This survey (AFSC cruise number is MF2000-04) was conducted during late winter/early spring 2000.

MATERIALS AND METHODS

Sampling Equipment

The survey was conducted using the NOAA ship *Miller Freeman*, a 66-m stern trawler equipped for fisheries and oceanographic research. Acoustic data were collected with a Simrad[1] EK500 quantitative echo-sounding system (Bodholt et al. 1989). Simrad 38 and 120 kHz split-beam transducers were mounted on the bottom of the vessel's retractable centerboard, which was fully extended during all scientific operations. This positioned the transducers 9 m below the ocean surface. All results presented here are based on data collected with the 38 kHz transducer. Acoustic backscatter data from the Simrad EK500 echo sounder/receiver were processed using Simrad BI500 echo integration and target strength data analysis software (Foote et al. 1991) on a SUN workstation.

Because only one of the *Miller Freeman*'s two net reels was operational during the survey, all echo sign sampling was conducted using an Aleutian Wing 30/26 trawl (AWT), which is a full mesh wing trawl constructed of nylon except for polyethylene towards the aft section of the body and the codend. The headrope and footrope lengths were 81.7 m. Mesh sizes tapered from 3.25 m in the forward section of the net to 8.9 cm in the codend. The codend was fitted with a 3.2 cm mesh liner. The AWT was fished with 82.4 m of 1.9 cm diameter 8 by 19 non-rotational dandylines, 340 kg tom weights on each side, and 5 m^2 “Fishbuster” doors (1,250 kg; NET Systems, Inc., Bainbridge Island, Washington).

Temperature profile data were collected by attaching a Seabird SBE39 micro bathythermograph to the trawl headrope. Vertical profile measurements of water temperature and salinity were collected at the calibration

[1]Reference to trade names or commercial firms does not constitute U.S. government endorsement.

sites using a Seabird conductivity/temperature/depth system. An acoustic Doppler current profiler was slaved to the EK500 to avoid interference, and it operated continuously throughout the cruise in the water profiling mode.

Survey Methods

Two survey passes were conducted in the Shelikof Strait area. The Shelikof Strait area refers to Shelikof Strait proper and the area between Middle Cape and Chirikof Island (Fig. 1). The first pass surveyed the entire Shelikof Strait area (Fig. 1). The second pass surveyed the area on the west side of the Strait (Fig. 2), where the greatest densities of pollock have historically been observed during surveys conducted in March (Williamson 1989, Karp 1990, Guttormsen and Wilson 1998), although Nunnallee and Williamson (1988) reported the greatest densities along the east side of the Strait in 1988. For the first pass, parallel transects were spaced 13.9 km apart except on the western side of Shelikof Strait, where transect spacing was reduced to 6.9 km. All transects were spaced 6.9 km apart for the second pass. Transects generally did not extend into waters less than about 50 m in depth.

Survey operations were conducted 24 hours a day. The acoustic system was used to collect echo integration and *in situ* target-strength data. Typical vessel speed was between 5.7-6.2 m/s while conducting transects. Trawl hauls were made at selected locations to identify echo sign and provide biological samples. Average trawling speed was about 1.5 m/s. The vertical net opening averaged about 25 m (range 19-29 m).

Standard catch sorting and biological sampling procedures were used to provide weight and number by species for each haul. Pollock were further sampled to determine sex, fork length (FL), age, maturity stage, and body and ovary weights. A Marel M60 motion-dampening electronic scale was used to determine weights of individual pollock to the nearest 2 g. Fish lengths were usually taken with a polycorder measuring device (a combination of a bar code reader and a hand-held computer; Sigler 1994). Fecundity samples were removed from selected mature females and preserved in 10% formalin. Tissue and otolith samples were collected from individual pollock for a Fisheries Oceanography Coordinated Investigations Program, AFSC, and Alaska Department of Fish and Game genetic research project. Adult pollock were successfully spawned, and the fertilized eggs were transported to Seattle, Washington, and Newport, Oregon, where various studies utilizing pollock eggs and larvae were conducted.

Four standard sphere calibrations were carried out in conjunction with the MACE late winter/early spring surveys (Table 1). The vessel was anchored fore and aft during the calibrations. The acoustic system was calibrated by suspending copper spheres with known backscattering characteristics below the transducer and measuring the acoustic returns following the procedure outlined by Foote et al. (1987). Sphere diameters were 60 and 23 mm for the 38 kHz and 120 kHz transducers, respectively. Split-beam target strength and echo-integration data from the copper spheres were collected to describe acoustic gain parameters and transducer beam pattern characteristics. No significant differences in the 38 kHz system parameters were observed between the four calibrations.

Data Analysis

Estimates of pollock absolute abundance were derived from the echo-integration and trawl data in the following manner. The pollock echo-integration data were initially partitioned into 6 sample strata based on the distributional patterns in the echo-integration data and size- composition catch data to stratify pollock aggregations of similar fish length distributions. The mean area backscattering estimate within each stratum was scaled to length-specific biomass and numbers using pollock size compositions, a length-weight relationship, and a previously derived relationship between target strength (TS) and fish length (TS = 20 log FL - 66, Traynor 1996). Estimates of length-specific biomass and numbers were then summed across strata to produce the total estimates. Age-specific estimates of biomass and numbers will be generated after the otolith samples are aged.

The relatively large numbers of eulachon (*Thaleichthys pacificus*) which primarily occurred in the southern portion of the Shelikof Strait area (see Results) contaminated the acoustic returns from pollock. Thus it was necessary to apportion the acoustic sign between these two species. This was accomplished by using the catch weight of the two species from hauls within the area in a manner similar to that done for the 1992-1998 Shelikof Strait surveys (Hollowed et al. 1992, Guttormsen and Wilson 1998). Because the amount of eulachon that occurred in hauls during the present EIT survey was relatively greater than that observed during many of the earlier surveys, plans are underway to determine the feasibility of conducting field studies to determine the TS to FL relationship for eulachon. Determination of this relationship would enable the proportion of the total acoustic backscattering (and thus abundance) attributable to eulachon to be more appropriately assessed.

Although annual EIT abundance estimates have been generated for the Shelikof Strait area since 1981, comparisons of these estimates are confounded because of a change in echo sounders that occurred in 1992. The newer sounder is considered more accurate than the earlier sounder primarily due to improved detectability (lower noise, higher signal-to-noise ratio), and ability to analyze acoustic data closer to the bottom. Thus, the ability to compare earlier estimates from the older sounder to recent estimates with the newer system is limited because pollock spatial distribution patterns likely vary from year to year. Nevertheless, comparison of acoustic data collected with both sounders in 1991 showed that similar biomass estimates were obtained when the volume backscattering (S_V) threshold of the newer system was adjusted to -58.5 dB (Hollowed et al. 1992). Because of the lower noise level, an S_V threshold of -69 dB has been used to generate abundance estimates since 1992. Based on data collected with the new sounder in 1992 and 1993, estimates based on an S_V threshold of -58.5 dB are about 21% less than those based on a threshold of -69 dB (Hollowed et al. 1994).

RESULTS AND DISCUSSION

Distribution

Acoustic data were collected along about 2,100 km of transect tracklines between March 17-25 in the Shelikof Strait area (Figs. 1-2). Pass 1 occurred from March 17-23 and Pass 2 occurred from March 24-25. Acoustic backscattering was assigned to 2 categories of echo sign: well-defined midwater layers of primarily age-1[2] pollock about 150-200 m below the surface or near-bottom layers of primarily adult and subadult pollock. A distributional plot of the acoustic backscattering attributed primarily to subadult and adult pollock during pass 1 indicated that the densest aggregations were distributed off of Cape Kerkurnoi and Cape Nukshak on the west side of the Strait (Fig. 3). Echo sign was less dense but more broadly distributed along transect lines from Chirikof Island to Cape Kekurnoi. Backscattering during pass 2 was similarly distributed, although relatively greater scattering was detected off Katmai Bay (Fig. 4). The highest densities of acoustic backscattering attributed primarily to pollock from the 1999 year class was observed on the eastern ends of the southernmost transects, and, to a lesser degree, between Cape Kerkurnoi and Katmai Bay (Fig. 5). The densest backscattering attributed to age-1 pollock during pass 2 was located just south of Cape Kerkernoi (Fig. 6).

Biological data were collected at 31 AWT midwater trawl locations (Tables 2-3, Fig. 1). Five of these hauls were conducted during Pass 2. The size composition of pollock varied over the survey area (Fig. 7). The numbers of age-1 pollock (modal FL 12 cm) exceeded the catch of older pollock in tows that targeted the age-1 mid-water layer. Near-bottom tows conducted in the southern Strait area caught mostly age-1 (modal FL 12 cm) and age-2 pollock (modal FL 22 cm), with lesser amounts of age-3 (modal FL 33 cm) and adult pollock (modal FL 43 cm). Tows made in the mouth of the Strait also caught a mixture of juvenile and adult pollock, although the relative contribution of age 3+ fish in this area increased compared to what was observed in the southern Strait area. Tows made between Capes Kekurnoi and Kuliak on the western side of the Strait caught mostly adult pollock (modal FL 47 cm).

Pollock was the dominant species captured, comprising 88.0% by weight and 66.2% by numbers of the total catch (Table 4). Eulachon was the next most common species caught (7.9% by weight, 32.7% by number) and were primarily associated with tows outside of the western side of the Strait.

Maturity Composition

A total of 2,776 pollock were sampled for maturity. All females less than 32 cm FL or males less than 27 cm FL were classified as immature or developing (Fig. 8). The unweighted maturity composition for males longer than 40 cm FL was <1% immature, 4% developing, 85% mature pre-spawning, 6% spawning, and 4% spent. The female maturity composition of fish longer than 40 cm FL was 1% immature, 23% developing, 73% mature pre-spawning, 1% spawning, and 2% spent. The dominance of pre-spawning fish suggests that the survey timing was appropriate. The mean GSI of 0.14 obtained from pre-spawning females (Fig. 9) was lower than the mean GSI of 0.18 , 0.19, and 0.17 obtained during the 1996-98 surveys, respectively (Wilson et al. 1996; Guttormsen and Wilson 1997; Guttormsen and Wilson 1998), but similar to other recent (1992-95) Shelikof Strait EIT surveys (0.14-0.16). A logistic model provided a reasonable fit to the female maturity at length data and predicted that 50% of females were mature at a length of 44 cm FL (Fig. 10). This estimate was similar to recent survey estimates but was markedly larger than estimates from the early 1980s (Guttormsen and Wilson 1998).

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[2]Because age data are not yet available for the current survey, length ranges were used as a proxy for age based on length at age from previous surveys. For this report, pollock between 9-16 cm FL are considered age 1, between 17-26 cm FL are considered age 2, most of the pollock from 27-40 cm FL are considered age 3, and most pollock exceeding 40 cm FL are considered adults.

Abundance

Abundance estimates for the Shelikof Strait area are 5.32 x 10^9 pollock weighing 389,300 t using an S_v threshold of -69 dB. The estimates include adjustments for backscattering attributed by eulachon, which reduced the total pollock biomass estimate by about 13%. Surveys prior to 1992 did not account for the eulachon contribution in the acoustic returns.

Based on results from the EIT surveys, the abundance of pollock within Shelikof Strait has shown a dramatic decline since 1981 (Fig. 11). Since 1988, estimates have remained relatively low and stable compared to earlier years. Results from the present survey, although lower than the 1995-98 estimates, continue this trend.

The numbers and biomass of pollock by length for 2000 are consistent with results from earlier surveys (Fig. 12). The temporal progression of the relatively strong 1988 year class through the population can be clearly seen since it appeared at a modal length of about 12 cm FL in 1989. Although age data are not yet available for 2000, it is likely that this cohort is represented in the mode centered around 53 cm FL. The 1994 year class, which represented the largest estimates of 1-, 2-, and 3-year-old fish in the history of the Shelikof Strait area EIT surveys, is represented by fish in the mode centered around 46 cm FL.

Although EIT surveys may underestimate age-1 pollock abundance relative to older fish due to factors such as availability and net selectivity, survey results are an indicator of future abundance. McKelvey (1996), for example, explained 61% of the variability in the year-class strength when regressing Gulf-wide population estimates of 3-year-old pollock (Hollowed et al. 1994) against the Shelikof Strait EIT estimates of age-1 pollock for the 1980-1990 year classes. Based on Table 2 in her paper, the 2000 EIT estimate of 4.28 x 10^9 age-1 fish suggests that the strength of the 1999 year class is strong. When modeling age-1 EIT estimates and age-3 Gulf-wide estimates provided by Hollowed et al (1997) for 1980-1997 year classes using the Beverton-Holt stock-recruitment curve (Beverton and Holt 1957)

$$Gulf\text{-}wide\ \ age\ \ 3\ \ estimates = \frac{a * acoustic\ \ age\, 1}{b + acoustic\ \ age\ \ 1}$$

where *a* is the asymptotic number of age-3 pollock and *b* is the number of age-1 pollock where the function has reached half of its asymptotic value, 46% of the variability is explained (Fig. 13).

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