Alaska
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U.S DEPARTMENT OF COMMERCE

AFSC PROCESSED REPORT 2012-04

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March 2012

This document should be cited as follows:

Ressler, P. H., T. Honkalehto, R. H. Towler, S. C. Stienessen, D. R. McKelvey, and A. L. McCarthy. 2012. Acoustic Vessel-of-Opportunity (AVO) index for midwater Bering Sea walleye pollock. AFSC Processed Rep. 2012-04, 13 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.

Acoustic Vessel-of-Opportunity (AVO) Index for

Midwater Bering Sea Walleye Pollock, 2010-2011

by

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March 2012

ABSTRACT

Surveys of the semi-demersal gadoid walleye pollock (*Theragra chalcogramma*) are conducted in summer on the eastern Bering Sea shelf by the Alaska Fisheries Science Center. The demersal portion of the stock is surveyed annually as part of a multispecies bottom trawl (BT) survey of groundfish and crab, while the midwater portion of the stock is surveyed biennially using acoustics and midwater trawling. Recently, an acoustic acoustic vessel-of-opportunity (AVO) index of midwater pollock biomass was developed with acoustic data collected by BT survey vessels for use during years in which AT survey data were not available. The AVO index was used in the Bering Sea walleye pollock stock assessment for the first time in 2010 and was fully incorporated in 2011. This document reports and discusses AVO index results for summers 2010 and 2011. Comparison of 2010 AVO and AT survey results provided additional confirmation that the AVO index is a good proxy for the abundance and distribution of midwater walleye pollock. Both AT and AVO time series suggested a rough doubling of midwater pollock biomass in the U.S. EEZ from summer 2009 to 2010, and a small decline in biomass from summer 2010 to 2011. Most of the change from 2010 to 2011 occurred on the shelf north and west of the Pribilof Islands, where the great majority of midwater pollock biomass was located in both years.

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INTRODUCTION

Surveys of the semi-demersal gadoid walleye pollock (*Theragra chalcogramma*) are conducted in summer on the eastern Bering Sea shelf by the Alaska Fisheries Science Center. The demersal portion of the stock is surveyed annually as part of a multispecies bottom trawl (BT) survey of groundfish and crab (Lauth 2011) while the midwater portion of the stock is surveyed biennially using acoustics and midwater trawling (AT survey; Honkalehto et al. 2010). Recently, Honkalehto et al. (2011) reported that acoustic data collected using BT survey vessels could provide an index of midwater pollock biomass during years in which AT survey data were not available. This acoustic vessel-of-opportunity (AVO) index of midwater pollock biomass for 2006-2009 was used in the Bering Sea walleye pollock stock assessment for the first time in 2010 (Ianelli et al. 2010) and was fully incorporated in 2011 (Ianelli et al. 2011). This document reports and discusses AVO index results for summers 2010 and 2011.

METHODS

Methods for generating the AVO index are described in Honkalehto et al. (2011) and will only be briefly presented, except for some newer developments in response to data collection issues in 2010 and 2011. Honkalehto et al. (2011) used results of AT surveys conducted between 1999 and 2004 to define an index area of the shelf where acoustic backscatter (38 kHz) attributed to midwater pollock was consistently detected. Pollock backscatter from this index area was classified through 1) visual examination of some data by trained analysts and 2) semi-automated processing of other data in which all backscatter within a specified depth range in the water column was assumed to be pollock. Integrated 38 kHz backscatter in the index area that was classified using this approach was well correlated with AT survey biomass in the U.S. Exclusive Economic Zone (EEZ). Since 2006, commercial fishing vessels chartered for the BT survey have collected 38 kHz backscatter in the AVO index area, and AVO indices calculated from these data have compared well with midwater pollock biomass and spatial distribution estimated by AT surveys in the same year (2006-2009). AVO index results from two subsequent years (2010 and 2011) are presented here.

2010

Both AT and BT surveys were conducted in summer 2010. Honkalehto et al. (2012) describe details of the 2010 AT survey conducted aboard the NOAA ship *Oscar Dyson*. The BT survey was conducted aboard the FV *Aldebaran* and FV *Alaska Knight* (Lauth 2011). The FV *Aldebaran* collected 38 kHz acoustic backscatter data (s_A, m^2 nmi^{-2}; MacLennan et al., 2002) with a Simrad ES60 echosounder and an ES38B split-beam transducer. The FV *Alaska Knight* was equipped with a Simrad ES60 echosounder and a 38-22-F single-beam transducer. Data from this older, wide angle, single-beam transducer had a lower signal-to-noise ratio (SNR) than the newer split-beam ES38B, so noise was estimated and removed in post-processing of visually examined data from the *Alaska Knight* following De Robertis and Higginbottom (2007). Calibrations with a standard sphere were conducted immediately before and after the survey.

2011

Only the BT survey was conducted in summer 2011. Again, the survey vessels used were the FV *Aldebaran* and FV *Alaska Knight.* The vessels were equipped as in 2010 except the *Alaska Knight's* 38-22-F transducer was replaced with a new ES38B split-beam transducer. Noise was estimated and removed during post-processing of visually examined data from both vessels. Calibrations with a standard sphere were conducted before and after the survey.

Following Honkalehto et al. (2011), AVO indices, 1-D geostatistical relative estimation errors (Petitgas 1993), and approximate 95% confidence intervals estimating sampling variability were calculated for

2010 and 2011. Both the trend in biomass indices and patterns in the spatial distribution of midwater pollock were described.

RESULTS

Biomass

Honkalehto et al. (2011) showed the AVO index was highly correlated with AT survey biomass in the U.S. EEZ; this remained true with the addition of data from 2010, when both AT and BT surveys were conducted (r^2 = 0.91, 2006-2010; Fig. 1, Table 1). The AVO index more than doubled in 2010, closely following the change in AT survey biomass, and then decreased by about 20% in 2011.

Spatial Distribution

The large-scale pattern in AT survey pollock s_A was captured by AVO index backscatter data in 2010 (Figs. 2, 3), and the index area continued to include a large fraction of the pollock biomass estimated by the AT survey (77%). Both AVO and AT surveys detected most pollock backscatter northwest of the Pribilof Islands (St. Paul Island, approximately 170° W), which has been true for the last several years. AVO pollock s_A appeared weaker and somewhat more evenly distributed in 2011 than in 2010. In particular, pollock s_A was 24% lower west of the Pribilofs in 2011 than 2010, while east of the Pribilofs, it was about 9% higher (Fig. 3). A plot of the centers of gravity of these data indicates a relative shift to the southeast in 2011 (Fig. 4).

Additional Uncertainty in 2010 Data

The fact that the BT survey vessel *Alaska Knight* was equipped with an older, wide angle, single-beam transducer during summer 2010 probably affected the accuracy and precision of the 2010 AVO index estimate in the following two ways:

Calibration

The accuracy and precision of a single-beam transducer calibration is likely to be lower than for a split-beam transducer calibration due to the difficulty in properly positioning the target sphere. The positive bias and greater uncertainty due to this effect is not easily quantified, but the existing data can provide some indication of the potential impact on 2010 AVO estimates. In terms of precision, results of the two calibrations of the *Alaska Knight* conducted in 2010 differed by 5.5%, which is within the range of differences between successive calibrations of split-beam systems on fishing vessels reported by Honkalehto et al. (2011). In terms of accuracy, agreement between AT survey and AVO estimates in 2010 appeared no different than for prior years when split-beam systems were used. In summary, the available data do not show evidence of a large change in precision or accuracy of the AVO estimate due to the single-beam calibrations.

Signal-to-Noise Ratio

Data from the 38-22-F transducer had a lower SNR than data from the other BT survey vessel in 2010. We estimated and removed noise in post-processing of visually examined data, but it was not possible to do so for the data that were processed in a semi-automated manner. Statistics computed on the visually examined data suggest that without noise estimation and removal, pollock s_A obtained from semi-automated processing would be biased high by about 31%. Given that approximately 50% of the data used in the AVO estimate were subjected to semi-automated processing, and 66% of those data were collected by *Alaska Knight* in 2010, we estimate that the 2010 AVO estimate could be biased high by about 10% (0.31 * 0.50 * 0.66 = 0.10) due to unremoved noise.

Thus, we suspect that the precision of the 2010 AVO estimate is somewhat lower than the confidence intervals shown in Figure 1 (which only include sampling variability) suggest, and that there could be an approximately 10% positive bias in the 2010 estimate, as well.

DISCUSSION

Comparison of 2010 AVO and AT survey results provided additional confirmation that the AVO index is a good proxy for the abundance and distribution of midwater walleye pollock. Both AT and AVO time series suggested a rough doubling of midwater pollock biomass in the U.S. EEZ from summer 2009 to 2010. The AVO index suggested a small decline in biomass in 2011, with most of the change occurring on the shelf north and west of the Pribilof Islands where the great majority of midwater biomass was located in both years.

While we carefully considered the potentially lower precision and positive bias of the 2010 AVO estimate, the continued good agreement between the AT survey and AVO index in 2010 suggests that the index continued to provide valuable information regarding the interannual and spatial trends for midwater pollock. Since the *Alaska Knight* transducer was upgraded prior to the 2011 BT survey, we have no reservations about the 2011 AVO index results.

The stock assessment for eastern Bering Sea walleye pollock relies on an age-structured model that estimates the number of fish by age-class; the preferred input currency for abundance information is number of fish at age or length. The AVO index provides a biomass index only, as no additional size or age information is collected for midwater pollock by the BT survey. Currently, efforts are being made to evaluate the AVO index using length composition information within the model (e.g., BT survey, fishery, model estimates; cf. Ianelli et al. 2011). Independent information on length composition of midwater pollock (particularly age-1 fish) in years when the AT survey is not conducted would improve interpretation of the AVO index for stock assessment purposes.

ACKNOWLEDGMENTS

This work would not have been possible without the assistance of survey scientists from the Groundfish Assessment and Midwater Assessment Programs of the Alaska Fisheries Science Center. In particular, Lyle Britt, Robert Lauth, Stan Kotwicki, Dan Nichol, Duane Stevenson, and Ken Weinberg of the Groundfish Assessment Program are thanked for their help in conducting calibrations and ensuring proper data collection aboard the chartered fishing vessels. We also thank the skippers and crews of NOAA ship *Oscar Dyson*, FV *Aldebaran*, FV *Alaska Knight*, and vessel managers and port engineers from Trident Seafoods and United States Seafoods.

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Table 1. -- Acoustic vessel-of-opportunity (AVO) index values and acoustic-trawl (AT) survey biomass within the U.S. Exclusive Economic Zone since 2006. Relative estimation errors are one-dimensional geostatistical estimates of sampling variability.

	AT survey biomass (million t)	AT survey biomass*	Relative estimation error	AVO index*	Relative estimation error
2006	1.560	0.471	0.039	0.555	0.051
2007	1.769	0.534	0.045	0.638	0.087
2008	0.997	0.301	0.076	0.316	0.064
2009	0.924	0.279	0.088	0.285	0.120
2010	2.323	0.701	0.060	0.679	0.086
2011	NO SURVEY	NO SURVEY	NO SURVEY	0.543	0.057

*Scaled to average value 1999-2004 (cf. Honkalehto et al. 2011)

Figure 1. -- Acoustic-trawl (AT) survey biomass in the U.S. Exclusive Economic Zone and acoustic vessel-of-opportunity (AVO) index 2006-2011 with 95% confidence intervals based on 1-D geostatistical estimates of sampling variability. Each time series has been scaled to its mean value for the period 1999-2004 (not shown).

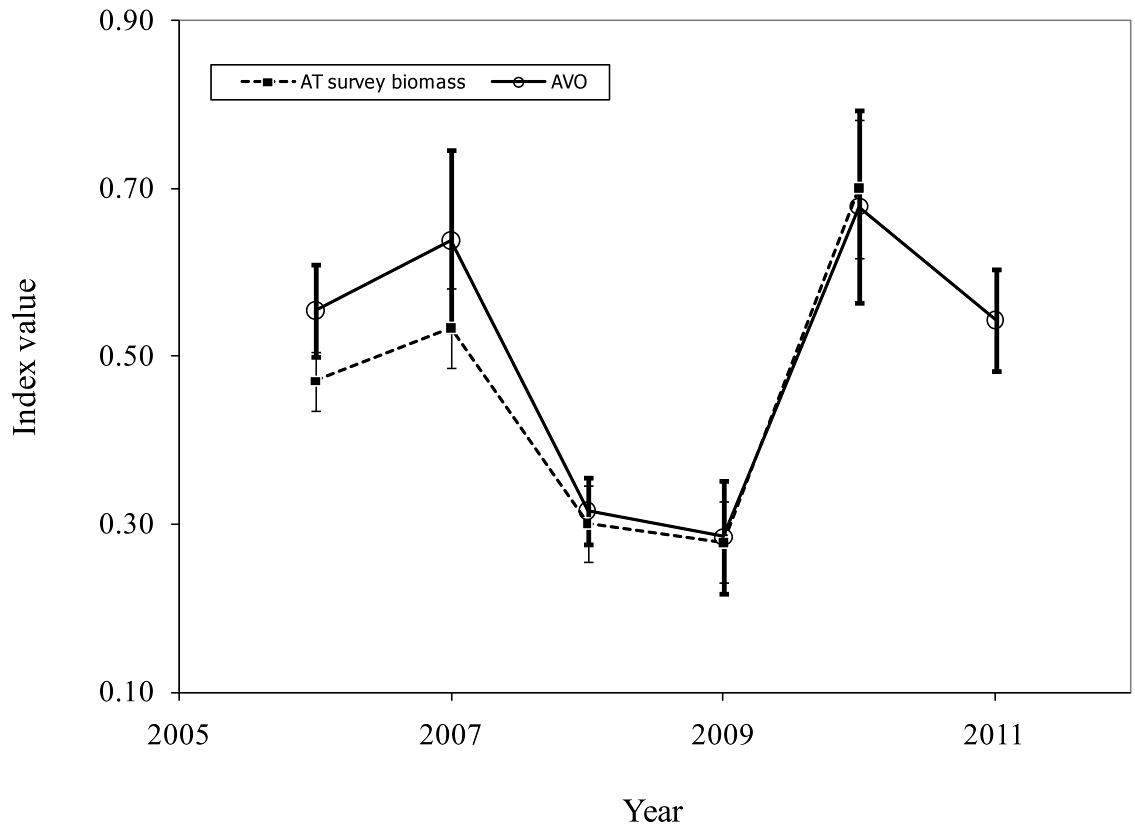

Figure 2. -- Pollock s_A (m^2 nmi^{-2}) in acoustic vessel-of-opportunity (AVO) index (left column) and acoustic-trawl (AT) survey (right column) data sets, 2010-2011. The bottom trawl (BT) survey grid cells used for the AVO index are shown in the left column. There was no AT survey in 2011. The 200 m bathymetric contour is indicated in blue, and the boundary between the U.S. and Russian Exclusive Economic Zones is denoted by a black line across the upper left corner of the plot. Note that the color scale is logarithmic.

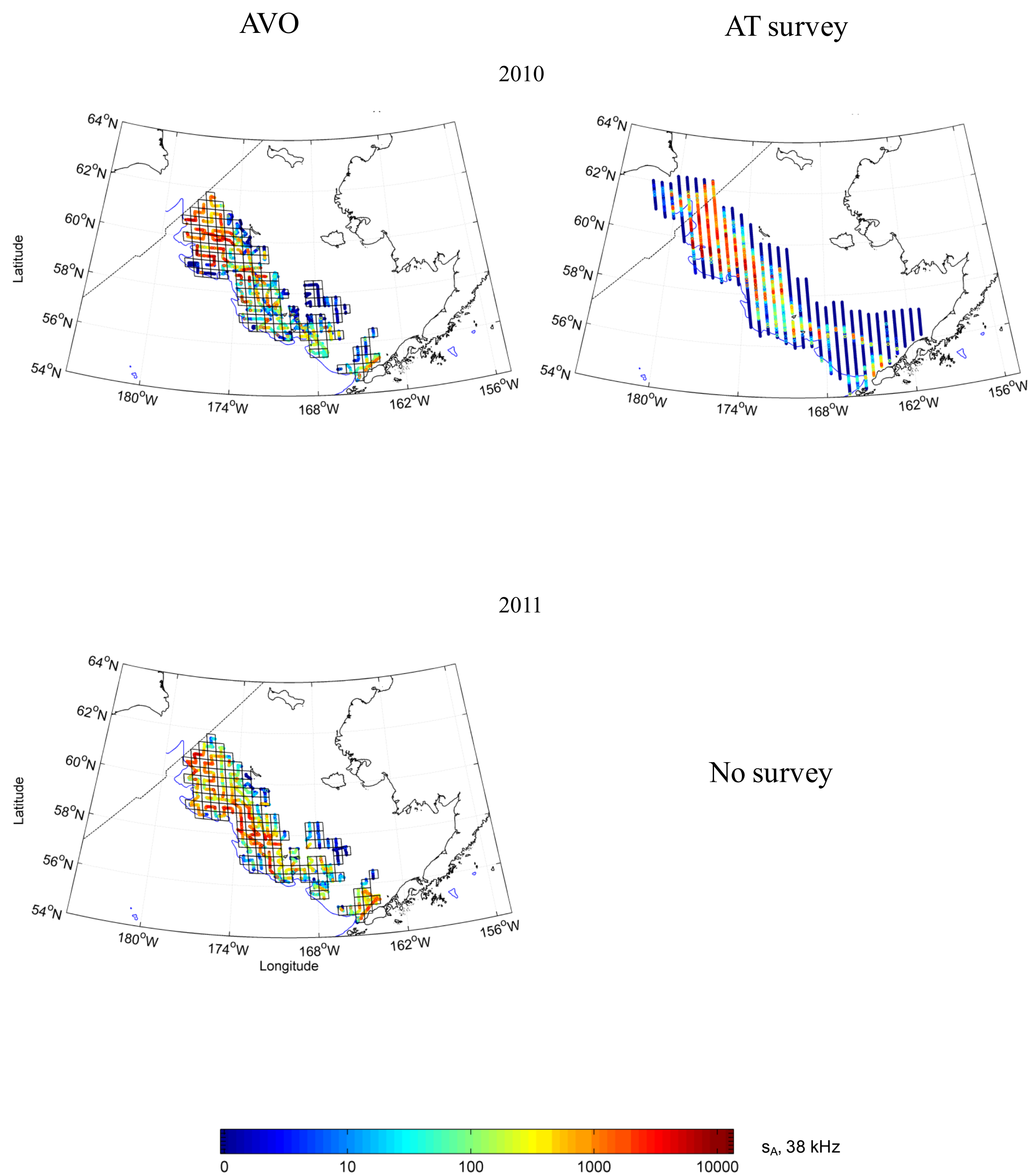

Figure 3. -- Relative pollock backscatter in 2010 and 2011, computed by multiplying pollock s_A (m^2 nmi^{-2}) in each acoustic vessel-of-opportunity (AVO) index grid cell (see Fig. 2) by grid cell area (400 nmi^2), summing along north-south columns of grid cells, and expressing the result as a proportion of all pollock backscatter in each year. For orientation, the location of the east and west boundaries of the U.S. Exclusive Economic Zone and the approximate longitude of St. Paul Island are indicated by text at the top of the plot.

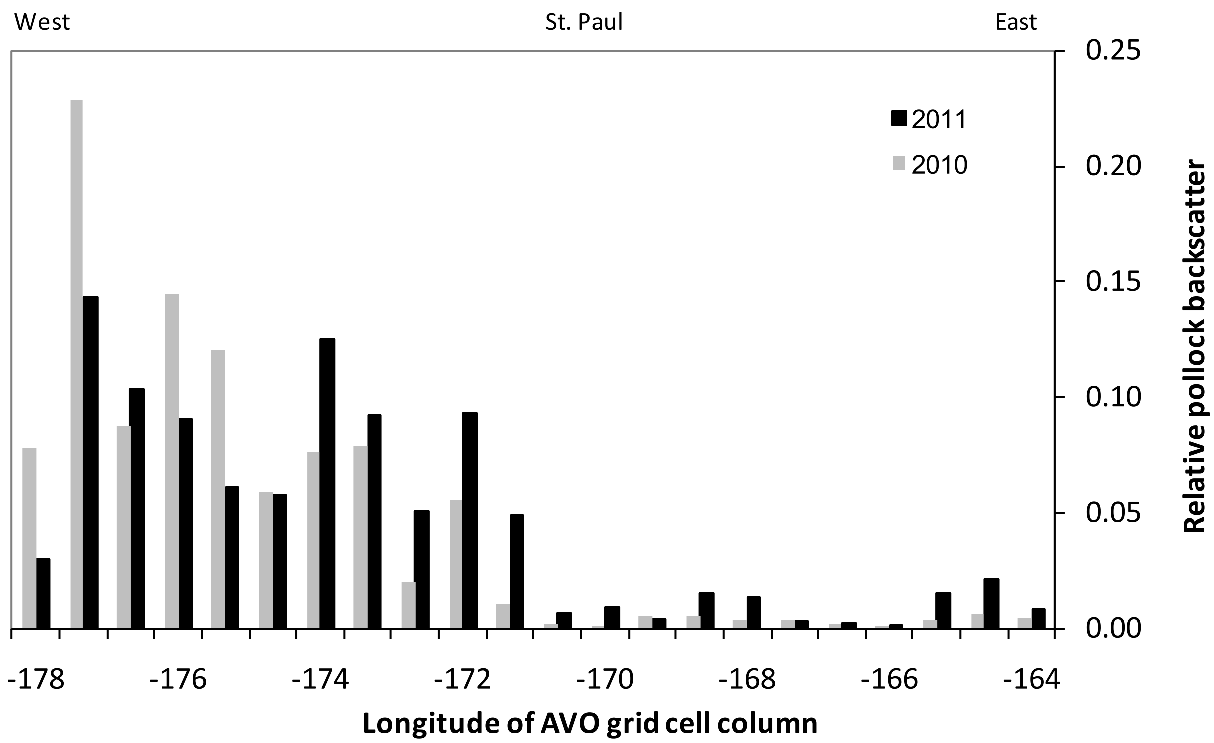

Figure 4. -- Spatial centers of gravity of acoustic-trawl (AT) survey biomass in the U.S. Exclusive Economic Zone and acoustic vessel-of-opportunity (AVO) index pollock s_A data sets. The 100 m and 200 m bathymetric contours are indicated in gray.