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Acoustic Vessel-of-Opportunity (AVO) index for midwater Bering Sea walleye pollock, 2024-2025

N. Lauffenburger, T. Honkalehto, and D. Stevenson

November 2026

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Acoustic Vessel-of-Opportunity (AVO) index for midwater Bering Sea walleye pollock, 2024-2025

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Abstract

An Acoustic Vessel-of-Opportunity (AVO) index for midwater walleye pollock (*Gadus chalcogrammus*) in the eastern Bering Sea has been estimated using backscatter information collected during annual Alaska Fisheries Science Center summer bottom trawl surveys since 2009. The AVO index is estimated using systematic subsampling of acoustic data throughout the EBS shelf; filtering of data based on acoustic ping attenuation, spatial location, time of day and speed of the vessel; and finally, manual classification of pollock versus non-pollock backscatter. New AVO pollock index estimates for the summer 2024 and 2025 are presented here in the context of the AVO time series. The 2024 AVO index was 19% less than the 2023 index value and 31% less than the 2022 index value. The 2025 AVO index was 24% greater than 2024, was very close to the 2023 estimate (1% less than 2023), and was 14% less than the 2022 AVO index value. Most pollock backscatter was distributed broadly across the shelf between the 50 and 200 m isobaths in 2024, and 67% was west of 170ºW. Pollock backscatter was more concentrated in the eastern portion of the EBS in 2025, with only 61% found west of 170ºW. The correlation between the biennial Alaska Fisheries Science Center summer acoustic-trawl survey pollock biomass estimates and the AVO index was still very strong with the inclusion of the 2024 index value ($r^2 = 0.90$).

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Introduction

Walleye pollock (*Gadus chalcogrammus*, hereafter pollock) is a commercially important gadid that is the target of a major trawl fishery on the eastern Bering Sea (EBS) shelf. The fishery-independent time series used to manage this valuable stock includes data from two summer surveys conducted by the Alaska Fisheries Science Center: a bottom trawl (BT) and an acoustic-trawl (AT) survey. The EBS BT survey is conducted annually by the Groundfish Assessment Program (GAP) and Shellfish Assessment Program (SAP) to assess commercially important crab and groundfish including demersal pollock (Markowitz et al. 2026). The EBS AT survey is currently conducted biennially (intervals ranged from 1 to 3 years in the past) by the Midwater Assessment and Conservation Engineering (MACE) Program to assess midwater pollock (Stienessen et al. 2025). An Acoustic Vessel-of-Opportunity (AVO) annual index was created for midwater pollock abundance utilizing acoustic backscatter collected by the BT survey. The methods to compute the AVO index, originally described in Honkalehto et al. (2011) and updated in Lauffenburger et al. (2025), use BT acoustic backscatter identified as pollock from near-surface to 3.0 m off bottom. Total AVO pollock backscatter for the EBS has been estimated annually since 2009 using systematic subsampling (following Levine and De Robertis 2019) across the entire footprint of the AT survey area to achieve a spatially comparable estimate to the AT survey. The AVO index is an important component of the eastern Bering Sea walleye pollock stock assessment because it provides information on midwater pollock in years when the AT survey is not conducted (Ianelli et al. 2022). This report presents results from 2024 and 2025 in the context of the AVO time series.

Methods

Data Collection for 2024 and 2025

Both the AT and BT surveys were conducted in summer 2024. The AT survey was conducted aboard NOAA Ship *Oscar Dyson* using standard AT survey methods and 38 kHz backscatter data collection as detailed in Stienessen et al. (2025).

In 2024, the EBS BT survey was conducted aboard the chartered commercial fishing vessels FV *Northwest Explorer* and FV *Alaska Knight* (Markowitz et al. 2026). Both BT vessels collected 38 kHz acoustic backscatter data using Simrad ES38B split beam transducers and ES60 echosounder systems at a rate of 2 pings s^{-1}. Backscatter data were also collected at 120 kHz on the FV *Alaska Knight*; however, these data were used only for qualitative classification of acoustic backscatter and not directly in the AVO index. Standard sphere calibrations were conducted for both 38 and 120 kHz acoustic systems immediately before (late-May) and halfway through (early-July) the BT survey. First, split-beam target strength (TS) and echo integration measurements of a tungsten carbide (38.1 mm diameter) sphere were made for each frequency once the sphere was centered on the respective beam axis (Demer et al. 2015). Next, on-axis sensitivity and beam characteristics, such as along and athwart beam angles and angle offsets, were estimated using post-processing software bundled with Simrad EK80 echosounders using data collected from the sphere as it moved throughout the four quadrants of each beam (Demer et al. 2015).

The BT survey, but not the AT survey, was conducted during summer 2025. The BT survey was conducted aboard the chartered commercial fishing vessels FV *Northwest Explorer* and FV *Alaska Knight*. Like in 2024, FV *Northwest Explorer* collected 38 kHz acoustic backscatter data and FV *Alaska Knight* collected 38 and 120 kHz data with Simrad ES38B split beam transducers. Both vessels collected acoustic data using Simrad ES80 echosounder software in 2025. The calibrations were conducted and processed before (late-May) and halfway through (mid-July) the BT survey as described for 2024. In the beginning of July (end of leg 2), the ping rate on the FV *Alaska Knight* was unintentionally changed from the typical 2 ping s^{-1} to 1 ping s^{-1} for the rest of the survey.

Data Pre-processing: Filtering and Subsampling

Acoustic backscatter data from BT survey chartered fishing vessels were pre-processed to ensure data quality and to expedite manual backscatter classification. For each data set (data collected on one BT vessel from one year), raw acoustic files were processed with MACE's pyEcholab2, a customized acoustic data processing suite, using Python 3.7.7 (Python Software Foundation, https://www.python.org). Acoustic files were processed in 6-hour groups. A Simrad hardware-related systematic ping-indexed bias in ES60/80 raw data (triangle wave noise) was removed as described in Honkalehto et al. (2011).

Systematic subsampling, outlined in Levine and De Robertis (2019), was used to reduce the amount of data to be manually processed to 10%. Two subsamples, each comprising 5% of the data in 50 ping intervals (interval specifies one contiguous chunk of pings), were selected and saved separately to compare and later combine into a full 10% subset. Multiple filters were applied to the data to address the impact of attenuated pings, diel vertical migration of pollock, a range of vessel speeds and data collected outside the EBS AT survey area. These filters occasionally reduced the number of pings in an interval to less than 50.

Pings were matched to the other frequencies, if available (120 kHz for FV *Alaska Knight*), and the selected pings, based on subsampling of the 38 kHz data and filtering, were kept.

Data Classification

Following the pre-processing, all remaining data in each subsample were reviewed and classified in 1-day datasets by trained analysts using Echoview software (Echoview Software Pty Ltd, Hobart, Australia), version 14.0 (2024) and 15.0 (2025). Trained analysts classified all backscatter from 12 m below the surface to within 0.5 m of the bottom into approximately six taxonomic categories. Previous work has shown that backscatter in the midwater on the EBS shelf in summer is predominantly pollock (De Robertis et al. 2010, Honkalehto et al. 2011) and can be separated from other taxonomic categories using backscatter characteristics, such as depth distribution, appearance, and acoustic frequency response. Generally, a line was drawn in Echoview below a near-surface layer attributed to a variable mixture of plankton and unidentified fishes. Nearly all midwater fish aggregations between that line and a line 0.5 m above the bottom were attributed to age-1+ pollock, but backscatter attributed to jellyfish, other fish, age-0 pollock, or dense euphausiid layers were also excluded.

Computing the Index

38 kHz acoustic data were exported from Echoview for each ping interval (typically 43-50 pings, but could be fewer) in 10 m vertical bins for most vessels and years. All data were stored in an Oracle database flagged by the subsample identifier (1 or 11). Before computing the index, a final filter was implemented to ensure that there were enough data to average. Only intervals with > 10 pings were included in the analysis.

Pollock backscatter (s_A, m^2 nmi^{-2}) in each interval was vertically integrated from 12.0 m from the surface to 3.0 m above the seafloor. The intervals for each subsample were averaged into 37 × 37 km (20 nmi × 20 nmi) grid cells surrounding BT survey bottom trawl stations. Only data < 197 m (i.e., 3.0 m above 200 m) depth were included in the vertical integration, following previous methods (Honkalehto et al. 2011). Grid cells that had < 3 intervals were removed from consideration, since there were not enough data to reliably average. Each interval was weighted by distance to compensate for slightly different vessel speeds (ranged from 4 knots to > 10 knots) and numbers of pings in each interval (10 to 50). The mean s_A in each grid cell was computed by multiplying the interval s_A by the ratio of the distance covered in each interval and the total distance sampled in the grid cell. The weighted mean s_A was multiplied by grid cell area and summed to compute the total acoustic backscattering cross section (m^2), hereafter referred to as total backscatter:

$$T_{ss,y} = \sum_i {s_{A,ss,i}}/{4\pi} \cdot A_{ss,i}$$

where *ss* is the subsample, *i* represents each individual grid cell, $s_{A,i}$ is the mean vertically integrated s_A for each grid cell, and A_i is the area of each grid cell (nmi^2). Each year and subsample may have a slightly different number of grid cells included in the total backscatter. To account for this, the AVO index for each subsample was computed by scaling to the ratio of the AT survey footprint of the EBS ($A_{ebs} = 2.5 \cdot 10^5$ km^2) by the sampled total area:

$$I_{ss,y} = T_{ss,y} \cdot {A_{ebs}}/{\sum_i A_{ss,i}}$$

The final AVO index by year, I_y, was computed in the same manner, but all data from both subsamples were included (10% of the total data) in the grid cell averages ($s_{A,i}$).

Relative Estimation Error and Spatial Distribution

The 1-D geostatistical relative estimation errors (Petitgas 1993) and approximate 95% confidence intervals describing sampling variability were calculated following methods described by Honkalehto et al. (2011). Maps of acoustic backscatter and center of gravity estimates (Bez et al. 1997, Woillez et al. 2007, 2009) were used to compare pollock distribution patterns from the AVO index and the AT survey.

Results

Calibrations

The integration (i.e., S_v) gain values used for 2024 and 2025 38 kHz backscatter data from the FV *Northwest Explorer* and FV *Alaska Knight* were based on the means of the May and July calibrations. The S_v gains were stable for both vessels both within and between 2024 and 2025 (Table 1).

AVO Index Time Series

The 2024 AVO pollock index estimate of 2.01 million m^2 decreased 19% from the 2023 index value and 31% from the 2022 index value (Table 2, Fig. 1a). The 2025 index of 2.50 million m^2 increased 24% from 2024, was very close to the 2023 estimate (0.6% less than 2023), and was down 14% from the 2022 AVO index value (Table 2, Fig.1a). The 2024 AVO index was similar to the 2018 estimate (4% less than 2018) and was the lowest it has been since 2012. The 2025 index value was similar to those in 2021 and 2023. The average for the time series (2.37 million m^2) is between the 2024 and 2025 estimates.

Comparing the two 5% subsamples suggested a 0.8% difference in 2024, and a 10% difference in 2025. The 2025 difference in subsample estimates (10%) is close to the mean absolute value from the time series (8%). Both the subsampling differences indicate that the combined 10% subsample is likely representative of the backscatter in the full data set.

The AVO index has had a similar interannual pattern as the AT survey biomass results throughout the time series (Table 2, Fig. 1). The 2024 AT survey biomass was 25% higher than the 2022 biomass, and the AVO index increased 30% between those years, suggesting a continued tracking of interannual patterns (Table 2, Fig.1). The comparison of the AVO index and AT survey biomass continues to suggest a strong correlation with the inclusion of 2024 (r^2 = 0.90, Fig. 2).

Spatial Distribution

The strongest pollock backscatter during 2024 was observed along the southern portion of the EBS shelf, mostly as semi-dense aggregations in midwater (Fig. 3). The strongest pollock backscatter in 2025 was observed to the east of 167ºW on the EBS shelf (Fig. 3), comprised of very dense schools in the upper water column (40-70 m depth), historically indicative of age 2-3 pollock. Sixty-seven percent of midwater pollock backscatter was observed to the west of the Pribilof islands in 2024, a decrease from 74% in 2023 (Fig. 4). Sixty-one percent of pollock backscatter was observed west of the Pribilof Islands in 2025, which was the second lowest in the time series, only higher than 59% in 2015 (Fig.4). The center of gravity estimate for the 2024 AVO index was similar to that of the AVO 2022 and 2023 indices, whereas the center of gravity for the 2024 AT survey was shifted southeast compared to the AT 2022 survey, and was more similar to the AVO 2022-2024 center of gravity (Fig. 5). The center of gravity of pollock backscatter for the 2025 AVO index was shifted to the east compared to recent years (2016 – 2024) and was much closer to the center of gravity estimates from 2014 and 2015 (Fig. 5).

Midwater pollock backscatter from the AVO index and AT survey exhibited similar spatial patterns across the eastern Bering Sea (EBS) shelf in 2024 (Fig. 3). Most pollock backscatter appeared to be distributed evenly throughout the AT and AVO survey areas between the 50 and 200 m isobaths. This even distribution is reflected in the lower relative estimation error for 2024, similar to the distribution and low relative estimation errors for 2014-2019, 2022, and 2023 (Table 2). The relative estimation error for the AVO index in 2025 was higher than the estimation errors since 2012, likely due to the patchy, dense backscatter concentrated in the east.

Discussion

The midwater pollock AVO estimate in 2024 was the lowest value since 2012, but the index increased above the time series average in 2025. The low amount of pollock observed in 2024 could be due to older pollock decreasing and the 2025 increase could be attributed to a new pollock year class (possibly 2022 or 2023).

The difference in the subsamples for 2024 (< 1%) alongside the relatively low and consistent 1-D geostatistical variance estimates suggests that using a 10% systematic subsample across the survey area has acceptable precision. The relatively higher difference in 5% subsample estimates in 2025 (8%) could mostly be attributed to the patchiness of the dense pollock schools observed east of 167ºW, since these schools were inconsistent but still contributed substantially to the index estimate for that year. The change in data collection rate from 1 ping s^{-1} to 2 ping s^{-1} for the second half of the FV *Alaska Knight* survey did not impact the spatial coverage of the sampling or the total percent of pings subsampled, even though there were effectively fewer pings in the estimate for this period.

The overall trends in the AVO time series and the AT survey time series continue to align well (Fig. 1) and have a strong correlation with the 2024 AT and AVO surveys included (Fig. 2, r^2 = 0.90).

Acknowledgements

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Table 1. Acoustic system descriptions, environmental conditions, and settings for sphere calibrations ('May,' 'July') and for processing acoustic data ('Final') for summer 2024 and 2025 AVO results.

Year	2024						2025					
Vessel	*Alaska Knight*			*Northwest Explorer*			*Alaska Knight*			*Northwest Explorer*		
	May	July	Final	May	July	Final	May	July	Final	May	July	Final
Simrad software	--	--	ES60	--	--	ES60	--	--	ES80	--	--	ES80
Transducer depth (m)	--	--	3 m	--	--	5 m	--	--	3 m	--	--	5 m
Pulse length (ms)	--	--	1.024	--	--	1.024	--	--	1.024	--	--	1.024
Transmitted power (W)	--	--	2000	--	--	2000	--	--	2000	--	--	2000
2-Way beam angle (dB re 1 steradian)	--	--	-20.69	--	--	-20.55	--	--	-20.69	--	--	-20.55
Gain (dB)	24.47	23.92	24.20	25.01	24.89	24.95	24.97	24.93	24.95	24.88	24.72	24.80
s_A correction (dB)	-0.65	-0.49	-0.57	-0.48	-0.44	-0.46	-0.54	-0.53	-0.54	-0.50	-0.42	-0.46
Integration gain (dB)	23.82	23.43	23.63	24.53	24.45	24.49	24.43	24.39	24.41	24.38	24.30	24.34
Absorption coefficient (dB m^{-1})	0.00971	0.00981	0.00998	0.00972	0.00979	0.00998	0.01001	0.00971	0.00998	0.01002	0.00978	0.00998
Sound velocity (m s^{-1})	1475.4	1475.4	1470.0	1475.5	14.75.7	1470.0	1469.8	1475.9	1470.0	1470.2	1473.9	1470.0

-- symbol indicates the same values for the final analysis are also applicable for the various calibrations for each vessel

Table 2. Acoustic Vessel-of-Opportunity (AVO) index values and acoustic-trawl (AT) survey biomass within the U.S. Exclusive Economic Zone since 2009. Relative estimation errors are one-dimensional geostatistical estimates of sampling variability. "No estimate" label for AVO indicates that the index was not recomputed for the updated time series in these years.

	AT survey time series		AVO index		
	AT survey biomass (million metric tons)	95% CI	AVO index (million m^2)	95% CI	Relative estimation error (CV_{AVO})
2009	1.325	0.178	0.695	0.166	0.122
2010	2.642	0.277	1.922	0.247	0.066
2011	No Survey	No Survey	No Estimate	No Estimate	No Estimate
2012	2.296	0.153	1.521	0.159	0.053
2013	No Survey	No Survey	No Estimate	No Estimate	No Estimate
2014	4.730	0.319	3.077	0.248	0.041
2015	No Survey	No Survey	3.593	0.173	0.025
2016	4.829	0.177	2.832	0.162	0.029
2017	No Survey	No Survey	2.263	0.135	0.031
2018	2.499	0.193	2.084	0.109	0.027
2019	No Survey	No Survey	2.829	0.271	0.049
2020	3.620	0.681	No Survey	No Survey	No Survey
2021	No Survey	No Survey	2.410	0.226	0.048
2022	3.834	0.515	2.903	0.194	0.034
2023	No Survey	No Survey	2.481	0.143	0.029
2024	2.871	0.314	2.007	0.107	0.027
2025	No Survey	No Survey	2.495	0.257	0.053

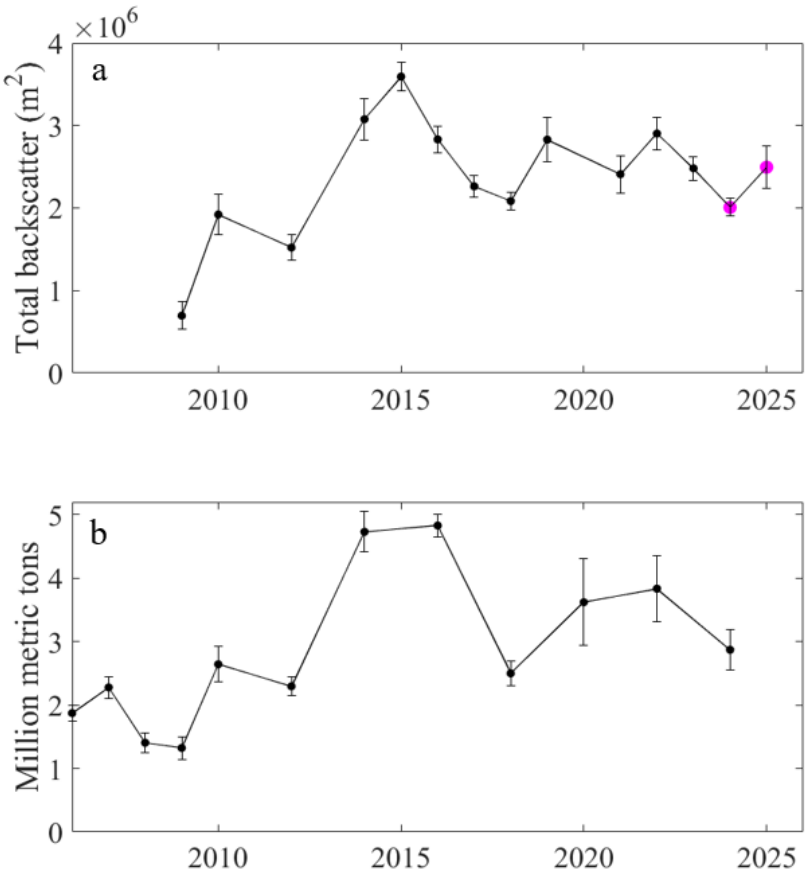


Figure 1. (a) Acoustic Vessel-of-Opportunity (AVO) index estimates for 2009-2025 (to 3.0 m off bottom) from the bottom-trawl (BT) survey and (b) acoustic-trawl (AT) survey biomass estimates for 2006-2024 (to 0.5 m off bottom) in the U.S. Exclusive Economic Zone (EEZ). Pink points in the top panel highlight the new estimates reported for 2024 and 2025. Error bars are 95% confidence intervals based on 1-D geostatistical estimates of sampling variability.

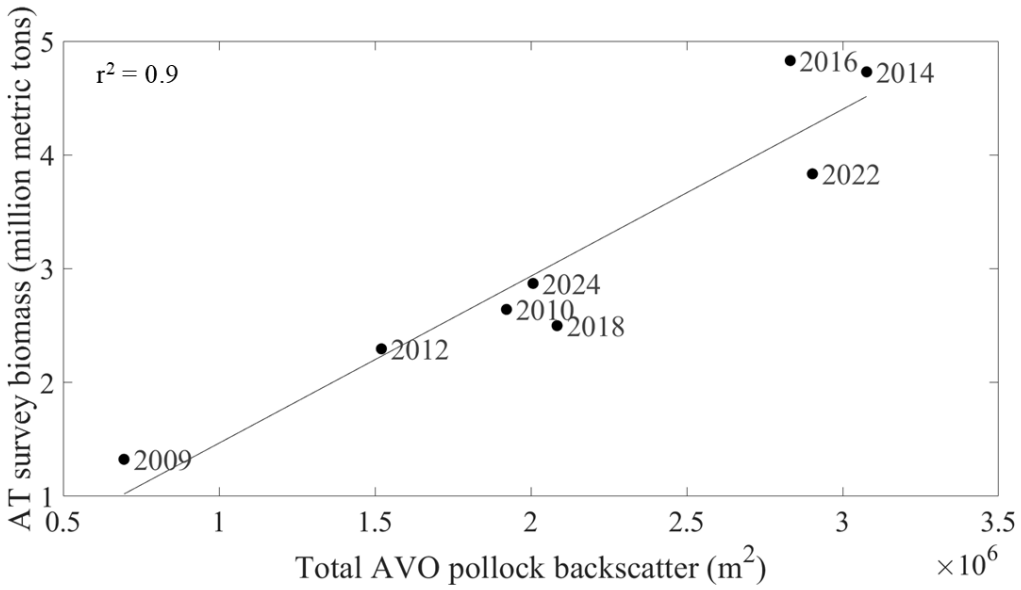


Figure 2. Regression of the acoustic-trawl (AT) survey biomass (million metric tons) on the Acoustic Vessel-of-Opportunity (AVO) index value, 2009-2024, with the y-intercept fixed at 0.

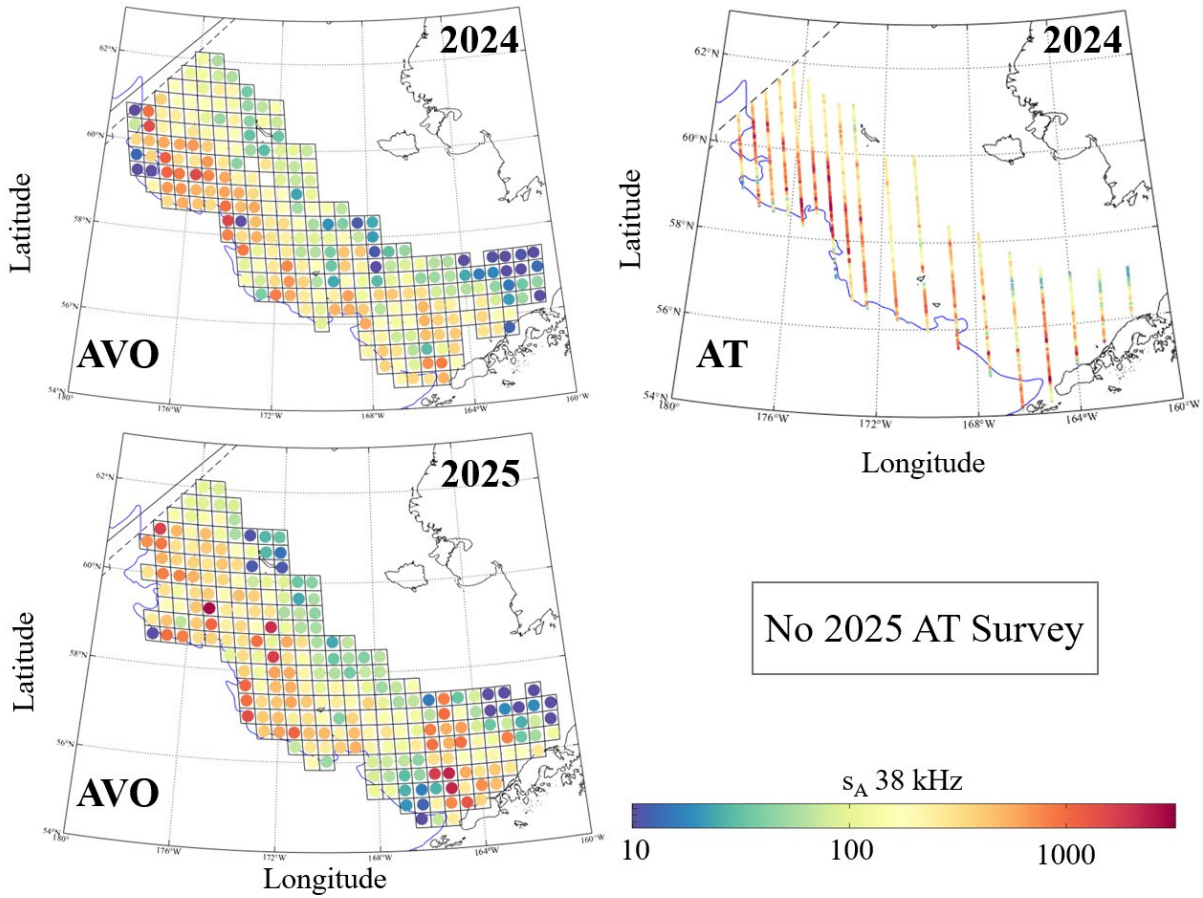


Figure 3. Average grid cell pollock s_A (m^2 nmi^{-2}) in new Acoustic Vessel-of-Opportunity (AVO) index (left column) and acoustic-trawl (AT) survey (right column) for 2024 and 2025. The bottom trawl (BT) survey grid cells used for the AVO index are shown in the left column. There was no AT survey in 2025. 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 color scale is logarithmic.

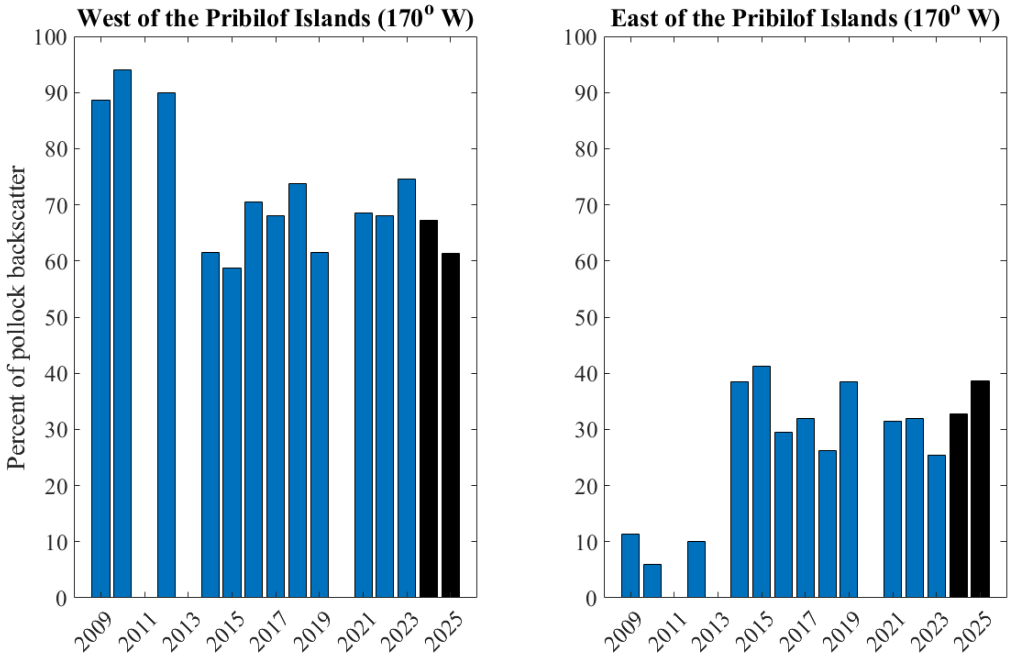


Figure 4. Relative pollock backscatter trends separated into the east and west sides of the U.S. Exclusive Economic Zone boundary (i.e., the approximate longitude of St. Paul Island, ca. 170ºW) for 2009-2025. The values were computed by summing pollock s_A (m^2 nmi^{-2}) along north-south columns of AFSC bottom trawl survey grid cells. Black bars highlight the two new estimates reported for 2024 and 2025.

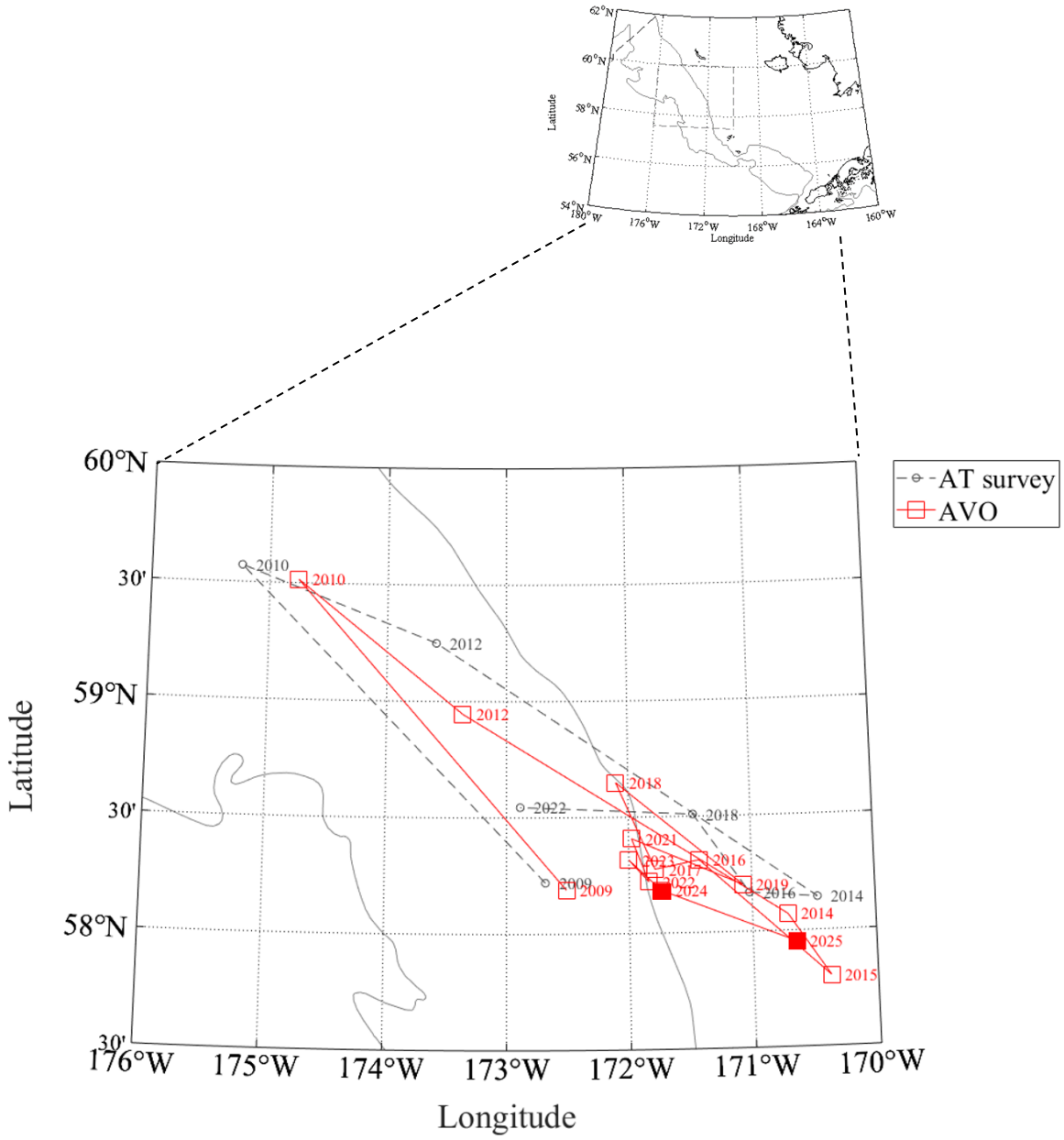


Figure 5. Geographic center of gravity estimates derived from pollock s_A (m^2 nmi^{-2}) from acoustic-trawl (AT) survey (gray circles) and the Acoustic Vessel-of-Opportunity index (red squares). The red highlighted squares are the new 2024 and 2025 estimates. The 100 and 200 m bathymetric contours are indicated in gray. The 2018 AT survey did not complete the last 3 transects (i.e., the western-most transects) due to vessel mechanical problems, and this omission of s_A from this area likely biases the 2018 AT data point to the southeast.