1.B. Assessment of walleye pollock in the Bogoslof Island Region

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Can be cited as:

Ianelli, J., N. Lauffenburger, I. Ortiz, and D. McKelvey. 2024. Assessment of the pollock in the Bogoslof Island region. North Pacific Fishery Management Council, Anchorage, AK. Available here.

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Executive Summary

Summary of changes in the assessment

The 2024 acoustic-trawl survey biomass estimates were added and Tier 5 calculations based on a random-effects model applied to the available time series of data.

Summary of results

The ABC and OFL levels using Tier 5 values and applying the random-effects model:

Quantity	As estimated or specified last year for:		As estimated or recommended this year for:	
	2024	2025	2025	2026
M (natural mortality rate)	0.313	0.313	0.313	0.313
Tier	5	5	5	5
Biomass (t)	367,880	367,880	247,137	247,137
F_{OFL}	0.313	0.313	0.313	0.313
$maxF_{ABC}$	0.23475	0.23475	0.23475	0.23475
F_{ABC}	0.23475	0.23475	0.23475	0.23475
OFL (t)	115,146	115,146	77,354	77,354
maxABC (t)	86,360	86,360	58,015	58,015
ABC (t)	86,360	86,360	58,015	58,015
Status	As determined *this* year for:		As determined *this* year for:	
	2022	2023	2023	2024
Overfishing	No	n/a	No	n/a

Response to SSC and Plan Team comments

General and specific comments:

There were no comments pertaining to this Tier 5 assessment

Introduction

Alaska pollock (*Gadus chalcogrammus*) are broadly distributed throughout the North Pacific with largest concentrations found in the Eastern Bering Sea. The Bogoslof region is noted for having distinct spawning aggregations that appear to be independent from pollock spawning in nearby regions. The Bogoslof management district (INPFC area 518) was established in 1992 in response to fisheries and surveys conducted during the late 1980s, which consistently found a discrete aggregation of spawning pollock in this area during the winter. The degree to which this aggregation represents a unique, self-recruiting stock is unknown but the persistence of this aggregation suggests some spawning site fidelity that calls for independent management. The Bogoslof region pollock has also been connected with the historical abundance of pollock found in the central Bering Sea (i.e., the Donut Hole) due to concentrations of pollock that appeared to be moving toward this region prior to spawning (Smith 1981). For the purpose of management within the US zone, pollock from this region are managed separately.

Collectively, pollock found in the Donut Hole and in the Bogoslof region are, by convention, considered to be part of the Aleutian Basin stock. Currently, based on an agreement from a Central Bering Sea convention meeting, it is assumed that 60% of the Aleutian Basin pollock population spawns in the Bogoslof region. The actual distribution of Aleutian Basin pollock is unknown and likely varies depending on environmental conditions and the age-structure of the stock. The Bogoslof component of the Aleutian Basin stock is one of three management stocks of pollock recognized in the BSAI region. The other stocks include pollock found in the large area of the Eastern Bering Sea shelf region and those in the Aleutian Islands near-shore region (i.e., less than 1000m depth; Barbeaux et al. 2004). The Aleutian Islands, Eastern Bering Sea and Aleutian Basin stocks probably intermingle, but the exchange rate and magnitude are unknown. The degree to which the Bogoslof spawning component contributes to subsequent recruitment to the Aleutian Basin stock is also unknown. From an early life-history perspective, the opportunities for survival of eggs and larvae from the Bogoslof region seem smaller than for other areas (e.g., north of Unimak Island on the shelf). There is a high degree of synchronicity among strong year-classes from these three areas, which suggests either that the spawning source contributing to recruitment is shared or that conditions favorable for survival are shared. From a biological perspective, the degree to which these management units are reasonable definitions depends on the active exchange among these stocks. If they are biologically distinct and have different levels of productivity, then management should be adjusted accordingly. Bailey et al. (1999) present a thorough review of population structure of pollock throughout the north Pacific region. They note that adjacent stocks were not genetically distinct but that differentiation between samples collected on either side of the N. Pacific was evident.

Some characteristics distinguish Bogoslof region pollock from other areas. Growth rates appear different (based on mean-lengths at age) and pollock sampled in the Bogoslof Island survey tend to be much older. For example, the average percentage (by numbers of fish older than age 6) of age 15 and older pollock observed from the Bogoslof AT surveys (1988-2012) was 18% but since then (2014-2020) this proportion only average 1%. Interestingly this pattern more closely aligns with pollock age distributions from the EBS.

Fishery and fishery management

Prior to 1977, few pollock were caught in the Donut Hole or Bogoslof region (Low and Ikeda 1978). Japanese scientists first reported significant quantities of pollock in the Aleutian Basin in the mid-to-late 1970's, but large-scale fisheries in the Donut Hole only began in the mid-1980's. By 1987 significant components of these catches were attributed to the Bogoslof Island region (Table 1B.1); however, the actual locations were poorly documented. The Bogoslof fishery primarily targeted winter spawning-aggregations, but in 1992 this area was closed to directed pollock fishing.

In 1991, the only year with extensive observer data, the fishery timing coincided with the open seasons for the EBS and Aleutian Islands pollock fisheries (the Bogoslof management district was established in

1992 by FMP amendment 17). However, after March 23, 1991 the EBS region was closed to fishing and some effort was re-directed to the Aleutian Islands region near the Bogoslof district. In subsequent years, seasons for the Aleutian Islands pollock fishery were managed separately. Bycatch and discard levels were relatively low from these areas when there was a directed fishery (e.g., 1991). Updated estimates of pollock bycatch levels from other fisheries has varied, with a high of over 1,000 t in 2016 (Table 1B.2). The majority of pollock bycatch in the Bogoslof region continues to be occurring in the non-pelagic trawl arrowtooth flounder target fishery. Catches have been low, with a recent peak of 256 t in 2022. The history of management measures since 1992 is provided in Table 1B.3.

Data

Survey

NMFS acoustic-trawl (AT) survey biomass estimates are the primary data source used in this assessment and are conducted in February and March time frames (Lauffenburger, et al. *In progress*, McKelvey and Levine, 2023). Since 2000, the values have varied between a low 67,000 t to a high of over 600 kt estimated in 2018. The 2024 AT survey estimate was 245 kt, a 31% decrease from the 2020 estimate (Table 1B.4). The area covered by surveys 2018, 2020, and 2024 including tow locations, and relative pollock densities are depicted in Fig. 1B.1. The time series of age composition data from this survey is provided in Table 1B.5 and in Fig. 1B.2. Note that ages from 2024 were unavailable in time for this assessment.

Analytical approach

Model Structure

Survey biomass averaging

The model for harvest recommendations is based on using a Tier-5 approach, which requires survey estimates of biomass (B_t). In Ianelli et al. (2015), the SSC accepted application of a random effects model of the form:

$$B_t = B_{t-1}e^{\varepsilon_t} \qquad \varepsilon_t \sim N\left(0,\sigma_{\varepsilon}^2\right)$$

with process errors ε_t estimated as random effects and σ_{ε}^2 also estimated with the observations and errors from Table 1B.3 included in the likelihood. The model was fit using REMA (Sullivan et al. 2022) and the script is provided in Appendix 1 below. This model provides an alternative estimate of survey biomass in 2024 that weights the relative influence of past survey estimates between estimated process error and specified observation errors.

Results

The random-effects model resulted in a 2025 biomass estimate of 247,137 t (Fig. 1B.3; Tables 1B.6 and 1.B7).

Harvest recommendations

Maximum permissible ABC and OFL estimates for 2025 and 2026 under Tier 5 relies exclusively on the NMFS biennial acoustic trawl survey biomass estimate. The biomass estimate based on the random-effects model gives:

Description	M	Biomass	ABC	OFL
Status quo, estimated M	0.313	247,137	58,015	77,354

A table of biomass estimates and uncertainties is provided in Table 1B.3

Risk table summary

Assessment considerations
The Bogoslof pollock assessment has been managed under Tier 5 of the FMP and is based on survey trends. In addition, a Tier-3 type age-structured model had been applied to track spawning biomass trends and consider survey age composition data to estimate natural mortality since fishing mortality has been near zero since 1992 due to directed fishing closures in this region. Genetic studies are underway which may require reconsidering the stock structure assumptions; however, we consider this assessment adequate given the limited fishing (level 1).

Population dynamics considerations
As with the assessment considerations, there are questions about the stock structure for this region. However, it appears that the spawning characteristics in this area continue to be consistent and until more details on the interactions with other areas are understood, we consider issues related to uncertainty in the population dynamics to be risk averse given there is no directed fishing in this region (level 1).

Environmental/Ecosystem considerations
Environment: In the Southern Bering Sea, pollock have been found in temperatures ranging from 2.9 7.3°C. The average bottom temperature from the 2024 Aleutian Islands bottom trawl survey (AIBTS, (165°W – 170°W) in the Southern Bering Sea was ~4.3°C, cooler than 2022 and cooler than the highest observed in 2016 but still above the 1991-2012 mean (Howard and Laman 2024). Satellite sea surface temperatures show a step increase in 2014 with higher temperatures both in summer and winter (Xiao and Ren, 2023). Sea surface temperatures in 2024 were above the mean through winter across all subregions. Over the eastern Aleutian Islands, there were few days of the marine heatwave (MHW) status relative to the mean over the last decade, which was also the case in 2021 and 2022. At times during late summer over 75% of the western Aleutians were in MHW status, however only a small percentage of AI pollock biomass is in this area. While there were also warm anomalies and MHWs over 25% of the central and eastern Aleutians in summer, these were not sufficient to register in the spatial mean (Lemagie and Callahan, 2024). The mean 1985-2014 peak summer temperature was ~ 10.4°C in August.

In 2024, the mean March SST in the eastern Aleutians was 3.6°C (compared to the 1985-2014 mean of 3.5°C) and the mean June SST was 6.4°C (close to the 6.6 °C mean for June during 1985-2014). Pollock spawn March through June and their larvae stay in surface waters (top 40 m) before they shift to deeper waters (Smart et al., 2013). This timing means the eggs are vulnerable to MHW penetrating the top of the water column; however, this was not the case for 2024.

Prey: The biennial cycle and cascading effects of pink salmon predation on copepods has been documented before by Springer and van Vliet (2014), Batten et al. (2018), and Matta et al. (2020). Based on these effects, we infer that copepods experienced lower predation pressure given the lower abundance of Kamchatka pink salmon during 2024. Time-series of the abundance of either only young or all pollock do not show alternating years of high numbers of pollock. Other inferences we can make about zooplankton prey availability are based on the average reproductive success of Leach's storm petrels at Aiktak. These feed on zooplankton as well as invertebrates, and the-above-the mean reproductive success of fork tailed storm petrels and Ancient murrelets in 2024 suggesting favorable abundances of prey items. Piscivorous puffins and murres also had above-the-mean reproductive success, suggesting that both zooplankton and forage fish were sufficiently abundant during recent years to support successful production of chicks and possibly indicative of abundant zooplankton and forage fish prey in that area. Data from the Continuous Plankton Recorders (CPR) in 2023 show the copepod community size anomaly has been negative in each season sampled since summer 2014 (apart from 2019 and in 2021), which suggests a real increase in the relative abundance of smaller species, potentially because of warmer than normal conditions. The CPR data also show that 2023 was the first time since 2016 that mesozooplankton biomass was above the long-term mean.

Recent fish condition indices for adult pollock taken during surveys have been lower than the long-term survey mean in the Southern Bering Sea since 2012. In contrast, the condition for small pollock in 2024 was two standard deviations above the long-term mean, the highest recorded. Cooler surface temperatures this year –similar to the 1991-2012 mean– may have favored the improved condition in small pollock as well as the availability of zooplankton prey.

Competitors and predators: The trends in fish condition and seabird reproductive success would seem to support the assumption that sufficient prey is available, so other factors may be limiting adult pollock from improving its condition further. Both Pacific ocean perch (particularly juvenile POP <20 cm), Kamchatka pink salmon, and Atka mackerel are primary consumers of copepods, with the first two showing biennial signals in their abundance. The increased consumption of copepods by the increasing POP population and high abundance years of Kamchatka pink salmon might be limiting the availability of prey for adult pollock through competitive pressure. Some fishery-related evidence of increased competitive overlap may be the increased bycatch of pollock in rockfish fisheries.

Walleye pollock are a key prey for northern fur seals, which are increasing in Bogoslof. Pollock in this area is also consumed by Steller sea lions (increasing in the eastern Aleutians, Rookery Cluster Area 6, Sweeney and Gelatt 2024) and Pacific cod (increasing, Ortiz 2024). Offsetting this potential increase in predation, arrowtooth flounder decreased compared to 2022 as have harbor seals in past years (London 2021). Overall, these trends suggest no large changes in predation pressure on AI pollock in the Bogoslof area. The increase of pollock in tufted puffin chick diets, along with the increased condition of small pollock might also signal an increased recruitment in Bogoslof pollock in 2024. The sustained high biomass of POP, which may be outcompeting pollock in other areas, may signal a return to conditions before POP was heavily fished by the foreign fleet during the 1960s and 70s.

Taken together, these indicators suggest that the current level of concern is level 1—no apparent environmental/ecosystem concerns.

Status determination

For Tier 5 stocks, status determinations on if overfished are unavailable. However, the stock is caught at levels well below overfishing rates (F_{limit} of 0.313).

Ecosystem Considerations

Effects on the Ecosystem and ecosystem effects on the fishery

There are no directed fisheries for this species. For a discussion of the contribution to discards and offal production or to bycatch of prohibited species, forage fish, HAPC biota, marine mammals, seabirds, sensitive species or non-target species from these fisheries, the reader should refer to the EBS pollock, Pacific cod, and rockfish assessments.

Data Gaps and Research Priorities

Genetic work should be developed further to distinguish this spawning aggregation from other studies. In particular, samples from the spawning grounds should be compared with nearby areas in other periods.

Other

Acknowledgments

We acknowledge the observer program and the NMFS regional office for collecting and compiling the bycatch data on pollock from this region. Also, we thank the crew for diligence in conducting the survey effort.

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Tables

Table 1B.1 Catch in tons from the Donut Hole and the Bogoslof Island area, 1977-2024.

Year	Donut Hole (t)	Bogoslof Island (t)	Total (t)
1977		11,500	11,500
1978		9,600	9,600
1979		16,100	16,100
1980		13,100	13,100
1981		22,600	22,600
1982		14,700	14,700
1983		21,500	21,500
1984	181,200	22,900	204,100
1985	363,400	13,700	377,100
1986	1,039,800	34,600	1,074,400
1987	1,326,300	377,436	1,703,736
1988	1,395,900	87,813	1,483,713
1989	1,447,600	36,073	1,483,673
1990	917,400	151,672	1,069,072
1991	293,400	316,038	609,438
1992	10,000	241	10,241
1993	1,957	886	2,843
1994		556	556
1995		334	334
1996		499	499
1997		163	163
1998		8	8
1999		29	29
2000		29	29
2001		258	258
2002		1,042	1,042
2003		24	24
2004		<1	<1
2005		<1	<1
2006		<1	<1
2007		<1	<1
2008		9	9
2009		73	73
2010		176	176
2011		173	173
2012		79	79
2013		57	57
2014		428	428
2015		733	733
2016		1,005	1,005
2017		186	186
2018		133	133
2019		8	8
2020		8	8
2021		9	9
2022		259	259
2023		125	125
2024		22	22

Table 1B.2. Estimated retained, discarded, and total pollock catch (t) from the Bogoslof region. Source: NMFS Regional office Blend database and Catch Accounting System.

Year	Discarded	Retained	Total
1991	20,327	295,711	316,038
1992	240	1	241
1993	308	578	886
1994	11	545	556
1995	267	67	334
1996	7	492	499
1997	13	150	163
1998	3	5	8
1999	11	18	29
2000	20	10	29
2001	28	231	259
2002	12	1,031	1,043
2003	19	5	24
2004	< 1		< 1
2005	< 1	< 1	< 1
2006	< 1	< 1	< 1
2007	< 1	< 1	< 1
2008	< 1	9	9
2009	6	67	73
2010	53	124	177
2011	23	150	173
2012	0	71	71
2013	0	56	57
2014	54	373	427
2015	138	595	733
2016	7	997	1,004
2017	1	184	185
2018	2	11	14
2019	0	8	8
2020	2	7	9
2021	4	4	8
2022	26	232	259
2023	5	120	125
2024	0	21	22

Table 1B.3. ABC, OFL, and TAC by year for Bogoslof region pollock, 1992—2024.

Year	ABC	OFL	TAC	Catch
1992	25,000	25,000	1,000	241
1993	42,000	42,000	1,000	886
1994	31,750	31,750	1,000	556
1995	22,100	22,100	1,000	334
1996	121,000	121,000	1,000	499
1997	32,100	43,800	1,000	163
1998	6,410	8,750	1,000	8
1999	15,300	21,000	1,000	29
2000	22,300	30,400	1,000	29
2001	8,470	60,200	1,000	258
2002	4,310	46,400	100	1,042
2003	4,070	45,300	50	24
2004	2,570	39,600	50	0
2005	2,570	39,600	10	0
2006	5,500	50,600	10	0
2007	5,220	48,000	10	0
2008	7,970	58,400	10	9
2009	7,970	58,400	50	73
2010	156	22,000	50	176
2011	156	22,000	150	173
2012	16,500	22,000	500	71
2013	10,100	13,400	100	57
2014	10,059	13,413	75	427
2015	15,900	21,200	100	733
2016	23,850	31,906	500	1,005
2017	60,800	130,428	500	185
2018	60,800	130,428	450	14
2019	137,310	183,080	75	8
2020	137,310	183,080	75	8
2021	85,109	113,479	250	9
2022	85,109	113,479	250	259
2023	86,360	115,146	300	125
2024	86,360	115,146	250	22

Table 1B.4. Biomass (tons) of pollock as surveyed in the Bogoslof region, 1988-2024. For additional details see Lauffenburger et al. (In progress) and McKelvey and Levine (2023).

Year	Survey biomass estimates (t)	Survey area (nmi^2)	Relative error
1988	2,395,737	NA	22%
1989	2,125,851	NA	22%
1990		No survey	
1991	1,289,006	8,411	12%
1992	940,198	8,794	20%
1993	635,405	7,743	9%
1994	490,077	6,412	12%
1995	1,104,118	7,781	11%
1996	682,277	7,898	20%
1997	392,402	8,321	14%
1998	492,396	8,796	19%
1999	475,311	NA	22%
2000	301,390	7,863	14%
2001	232,170	5,573	10%
2002	225,712	2,903	12%
2003	197,851	2,993	22%
2004		No survey	
2005	253,459	3,112	17%
2006	240,059	1,803	12%
2007	291,580	1,871	12%
2008		No survey	
2009	110,191	1,803	19%
2010		No survey	
2011		No survey	
2012	67,063	3,656	10%
2013		No survey	
2014	112,070	1,150	12%
2015		No survey	
2016	508,051	1,400	11%
2017		No survey	
2018	663,070	1,500	43%
2019		No survey	
2020	353,069	1,455	16%
2021		No survey	
2022		No survey	
2023		No survey	
2024	244,800	1,271	13%

Table 1B.5. Estimated survey numbers at age (millions) from the acoustic-trawl surveys used in the age-structured model for Bogoslof pollock (from McKelvey and Levine 2023). *Note, age data from the 2024 survey were unavailable at this time.*

	Age											
Year	4	5	6	7	8	9	10	11	12	13	14	15
1988	-	27.94	326.71	246.84	163.68	350.07	1,200.88	287.82	287.33	201.95	89.24	53.89
1989	6.00	15.00	58.00	363.00	147.00	194.00	91.00	1,105.00	222.00	223.00	82.00	180.00
1991	2.00	12.00	46.00	213.00	93.00	160.00	44.00	92.00	60.00	373.00	119.00	202.00
1992	2.00	27.00	54.00	97.00	74.00	71.00	55.00	57.00	33.00	34.00	142.00	327.00
1993	33.00	17.00	44.00	46.00	48.00	42.00	28.00	51.00	25.00	27.00	42.00	209.00
1994	21.00	86.00	26.00	38.00	36.00	36.00	17.00	27.00	23.00	13.00	9.00	146.00
1995	6.00	75.00	278.00	105.00	68.00	80.00	53.00	54.00	19.00	59.00	32.00	248.00
1996	0.50	6.00	96.00	187.00	85.00	40.00	37.00	24.00	24.00	12.00	36.00	117.00
1997	0.50	4.00	16.00	55.00	88.00	38.00	28.00	16.00	16.00	13.00	7.00	57.00
1998	0.50	11.00	61.00	34.00	70.00	77.00	32.00	25.00	21.00	19.00	18.00	67.00
1999	2.00	5.00	29.00	77.00	34.00	50.00	75.00	29.00	27.00	25.00	16.00	48.00
2000	1.00	6.00	4.00	14.00	30.00	16.00	28.00	45.00	21.00	16.00	11.00	36.00
2001	1.00	14.00	12.00	10.00	10.00	14.00	12.00	18.00	31.00	13.00	7.00	27.00
2002	5.00	3.00	41.00	11.00	8.00	6.00	7.00	8.00	14.00	30.00	9.00	29.00
2003	8.00	6.00	7.00	25.00	11.00	4.00	5.00	4.00	10.00	8.00	26.00	21.00
2005	5.00	81.00	31.00	13.00	11.00	22.00	7.00	3.00	5.00	4.00	5.00	37.00
2006	4.00	55.00	104.00	18.00	6.00	6.00	9.00	3.00	2.00	4.00	5.00	25.00
2007	1.00	8.00	92.00	70.00	17.00	3.00	3.00	8.00	4.00	1.00	5.00	24.00
2009	-	1.00	1.00	7.00	23.00	26.00	8.00	1.00	1.00	1.00	0.44	4.78
2012	0.14	1.38	14.96	9.65	2.24	0.89	2.36	6.74	7.85	1.12	0.20	1.06
2014	1.00	34.00	31.00	11.00	14.00	7.00	3.00	0.50	1.00	5.00	4.00	2.5
2016	170.25	40.69	161.41	366.88	98.69	16.84	9.30	1.03	0.00	0.00	0.00	0.00
2018	0.00	58.93	152.37	80.74	381.08	247.39	27.42	13.77	2.67	0.00	0.00	0.00
2020	3.31	0.39	4.04	14.29	27.19	56.40	107.44	88.56	21.00	4.60	0.39	0.00

Table 1B.6. Estimated survey biomass and uncertainties based on the random-effects model for Bogoslof pollock.

Year	Survey	Survey LCI	Survey UCI
1988	2,395,737	1,564,527	3,668,556
1989	2,125,851	1,388,279	3,255,283
1991	1,289,006	1,019,708	1,629,425
1992	940,198	637,743	1,386,095
1993	635,405	532,840	757,712
1994	490,077	387,690	619,503
1995	1,104,118	890,563	1,368,883
1996	682,277	462,793	1,005,853
1997	392,402	298,635	515,610
1998	492,396	340,422	712,215
1999	475,311	310,400	727,837
2000	301,390	229,371	396,022
2001	232,170	190,940	282,302
2002	225,712	178,556	285,321
2003	197,851	129,206	302,966
2005	253,459	182,068	352,844
2006	240,059	189,906	303,457
2007	291,580	230,663	368,584
2009	110,191	76,182	159,383
2012	67,063	55,154	81,544
2014	112,070	88,656	141,667
2016	508,051	409,785	629,880
2018	663,070	295,769	1,486,504
2020	353,068	258,539	482,160
2024	244,800	189,941	315,504

Table 1B.7. Estimated survey biomass and uncertainties based on the random-effects model for Bogoslof pollock.

Year	Survey	Survey LCI	Survey UCI
1988	2,314,812	1,575,451	3,401,156
1989	2,054,876	1,425,634	2,961,852
1990	1,621,575	887,638	2,962,364
1991	1,279,642	1,024,581	1,598,199
1992	928,872	672,852	1,282,307
1993	640,967	541,304	758,980
1994	527,945	423,506	658,140
1995	1,020,368	829,907	1,254,540
1996	673,369	487,244	930,593
1997	420,637	327,068	540,973
1998	472,352	344,464	647,721
1999	437,766	308,727	620,741
2000	305,033	237,928	391,063
2001	235,228	195,373	283,215
2002	225,016	180,880	279,923
2003	207,765	144,866	297,975
2004	227,267	123,322	418,828
2005	248,600	184,663	334,675
2006	243,292	195,626	302,571
2007	277,538	222,065	346,869
2008	179,841	98,848	327,196
2009	116,534	82,799	164,014
2010	97,795	49,027	195,075
2011	82,069	41,957	160,529
2012	68,872	56,854	83,430
2013	89,591	50,110	160,178
2014	116,543	92,953	146,119
2015	237,401	132,611	424,999
2016	483,593	391,641	597,135
2017	503,034	263,805	959,207
2018	523,257	293,193	933,845
2019	433,028	224,425	835,527
2020	358,357	266,059	482,675
2021	326,567	158,049	674,766
2022	297,596	131,393	674,035
2023	271,196	132,431	555,362
2024	247,137	192,331	317,561
2025	247,137	107,548	567,904
2026	247,137	78,283	780,207

Figures

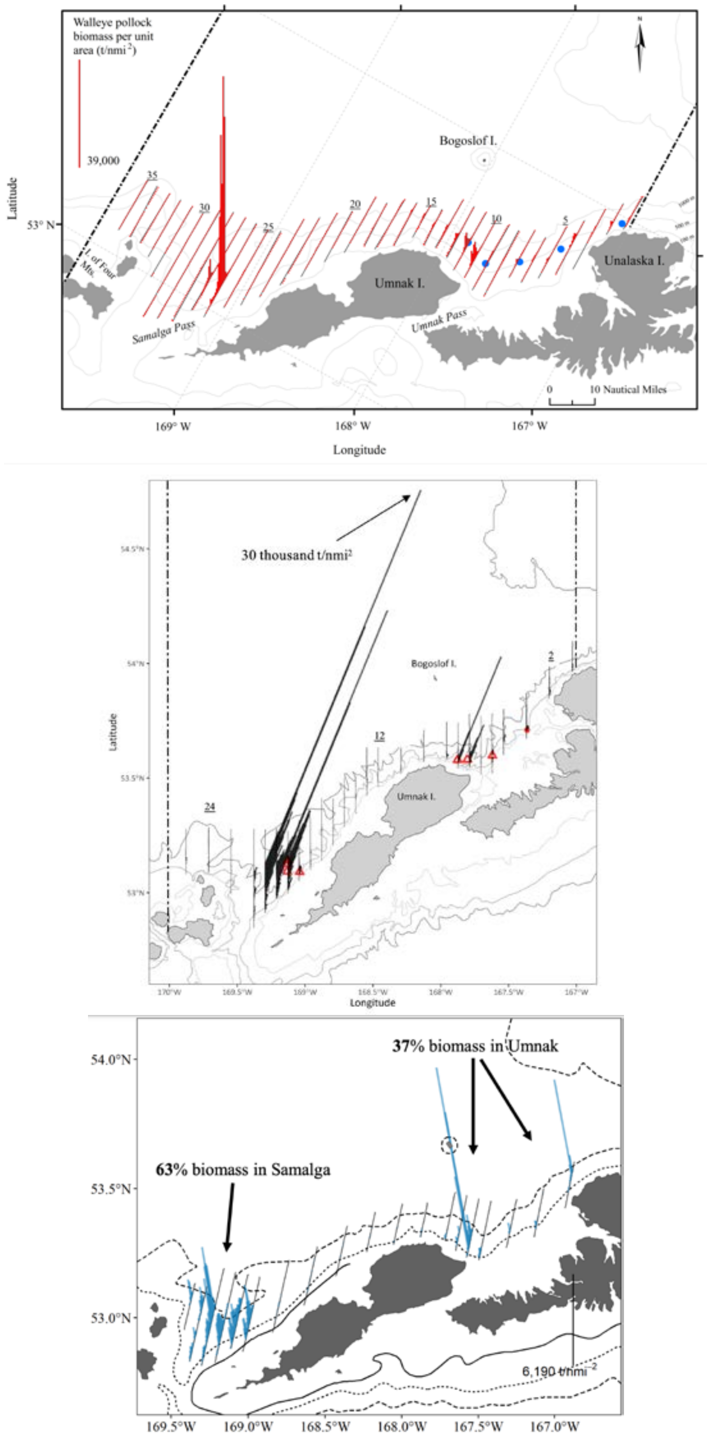

Figure 1B.1. Distribution of pollock biomass (t/nmi^2) observed along transects during the winter 2018 (top), 2020 (middle), and 2024 (bottom) acoustic-trawl survey. Transect numbers are underlined; trawl haul locations are indicated by circles or triangles.

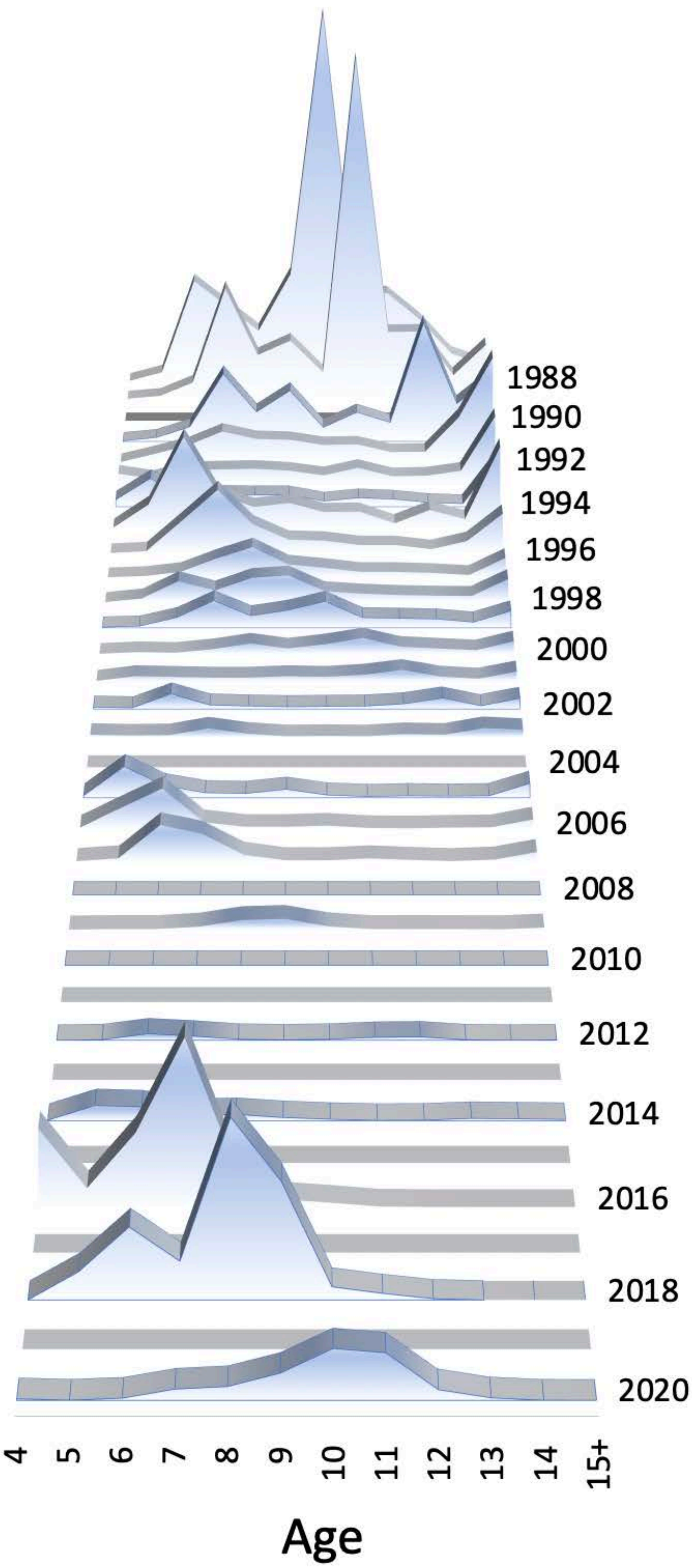

Figure 1B.2. Age composition estimates (numbers) during the winter surveys for Bogoslof region pollock, 1988-2020. *Note, age data from the 2024 survey were unavailable at this time.*

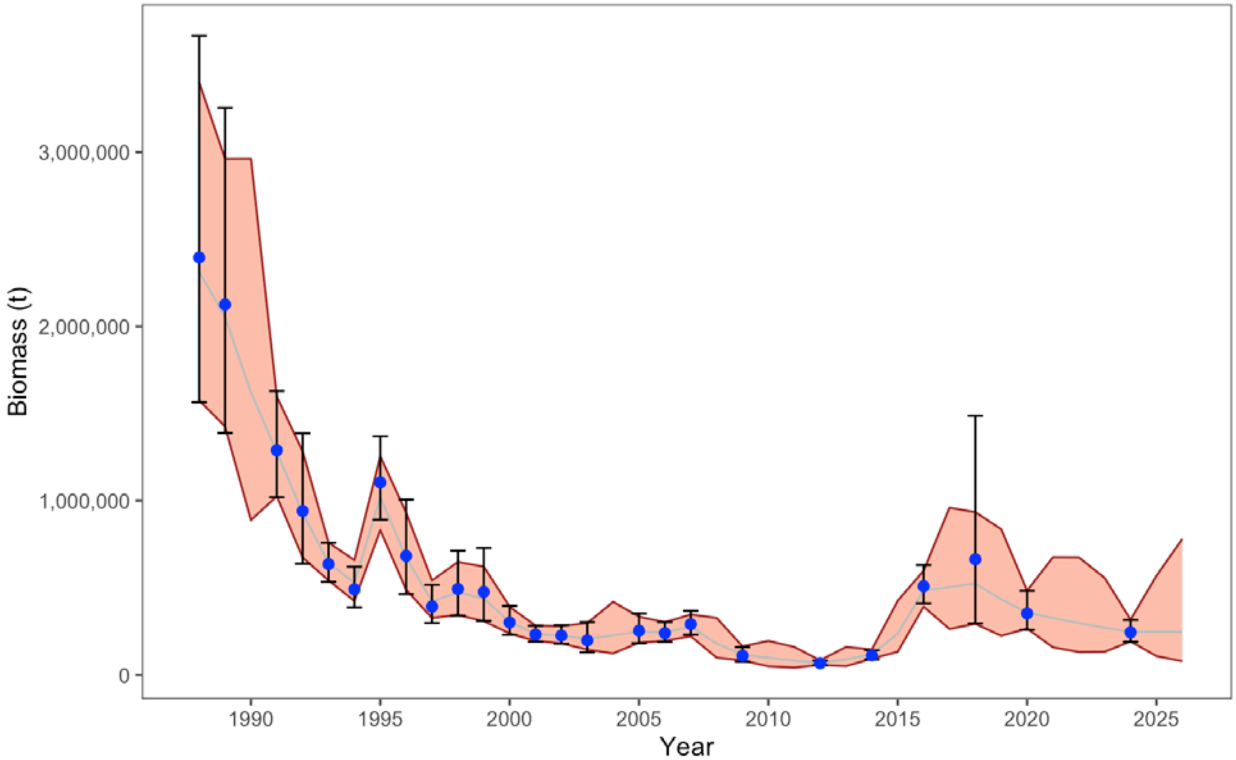

Figure 1B.3. Bogoslof Island pollock survey estimates fit to a process error model for averaging biomass. The shade represents the approximate 90% confidence interval from the model. Error bars and dots represent the data and estimated observation errors, grey line are model predictions.

Appendix 1. REMA script

The script and data below was used to accomplish the survey-trend model fit.

```
library(tidyverse)
library(scales)
library(patchwork)
library(rema)

bog<-prepare_rema_input(
  model_name = "Bogoslof",
  biomass_dat = read_csv("bog.csv"),
  end_year = 2026,
)
m <- fit_rema(bog)
(bog$data$biomass_obs)
names(bog$data)
names(bog$data$biomass_obs)

mo <- tidy_rema(rema_model = m)
names(mo$total_predicted_biomass)
names(mo)
obdf<-mo$biomass_by_strata[c(4,10,14:15)] |> filter(!is.na(obs))
obdf
predf <- mo$total_predicted_biomass
glimpse(predf)
glimpse(obdf)
p1<- ggplot( data=predf, aes(x=year,y=pred,ymin=pred_lci,ymax=pred_uci)) +
  geom_ribbon(  fill="coral",color="brown",alpha=.5 ) + geom_line(color="grey") +
  geom_errorbar(data=obdf,
                aes(x=year, y=obs, ymin = obs_lci, ymax = obs_uci),
                width=.6) +
  geom_point(data=obdf,
                aes(x=year, y=obs, ymin = obs_lci, ymax = obs_uci),
             size=2, color="blue")+
  ggthemes::theme_few() + scale_x_continuous(breaks = seq(1990, 2026, by = 5)) +
  scale_y_continuous(labels = scales::comma) + labs(x="Year",y="Biomass (t)")

write_csv(p1$data,"bog_out.csv")
write_csv(obdf,"Bog_in.csv"
```

File contents of “bog.csv”:

```
strata  year    biomass cv
"Bogoslof"     1988    2395737 0.22
"Bogoslof"     1989    2125851 0.22
"Bogoslof"     1991    1289006 0.12
"Bogoslof"     1992    940198  0.2
"Bogoslof"     1993    635405  0.09
"Bogoslof"     1994    490077  0.12
"Bogoslof"     1995    1104118 0.11
"Bogoslof"     1996    682277  0.2
"Bogoslof"     1997    392402  0.14
"Bogoslof"     1998    492396  0.19
"Bogoslof"     1999    475311  0.22
"Bogoslof"     2000    301390  0.14
"Bogoslof"     2001    232170  0.1
"Bogoslof"     2002    225712  0.12
"Bogoslof"     2003    197851  0.22
"Bogoslof"     2005    253459  0.17
"Bogoslof"     2006    240059  0.12
"Bogoslof"     2007    291580  0.12
"Bogoslof"     2009    110191  0.19
"Bogoslof"     2012    67063   0.1
"Bogoslof"     2014    112070  0.12
"Bogoslof"     2016    508051  0.11
"Bogoslof"     2018    663070  0.43
"Bogoslof"     2020    353068.4588    0.16
"Bogoslof"     2024    244800  0.13
```