Chapter 1b: Assessment of pollock (*Theragra chalcogramma*) from the Bogoslof Island Region

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Executive Summary

In 1987 pollock catch peaked in the Bogoslof region (INPFC area 518) with over 370,000 tons reported. During the period from 1985 to 1991, a total of 932,996 t of pollock were caught in this region. NMFS subsequently closed this area to directed pollock fishing (1992-2005) due in part to agreements under the Convention on the Conservation and Management of the Pollock Resources in the Central Bering Sea. Under this convention, the Bogoslof spawning aggregations are linked to the abundance of pollock found in international waters of the Aleutian Basin. As part of the monitoring program for the Convention, 17 annual Echo Integration Trawl (EIT) surveys of Bogoslof pollock abundance have been undertaken since 1988.

In 2005 an age-structured stock assessment was developed and presented to the Council for consideration. In 2006 this analysis was refined based on advice of the SSC by considering alternative assumptions about Donut Hole catches during the 1980s. The analysis showed sensitivity to these assumptions and since they seem equally plausible, acceptance of a model was considered premature until the exchange of pollock between the Bogoslof and Central BS regions stock could be more clearly understood. Since information to help resolve these issues is still lacking, any improvements to be made on the assessment model would be of limited value. Therefore, this assessment provides maximum permissible ABC estimates based on Tier 5. Additionally, an adjusted ABC is provided identical to the method that the Council has selected in past years.

Changes in the assessment data, methodology, and results
In the winter of 2007 an echo-integration trawl (EIT) survey was conducted and provides the biomass estimate used for this assessment. Maximum permissible ABC and OFL estimates for 2008 and 2009 under Tier 5 were used in place of an age-structured stock assessment model. This method relies exclusively on the NMFS survey biomass estimate. The 2007 survey biomass estimate of 292,000 t represents a 22% increase over the 2006 estimate. This results in a Tier 5 maximum permissible ABC value of 43,800 t (assuming $M = 0.2$). Using an alternative to this value (which includes a target stock size) gives 8,000 t.

Response to SSC comments
In their December 2006 minutes, the SSC commented:

> *"This year the authors explored the effect of Donut Hole catches in the 1980s on the stock assessment results. They assumed that 75% of the Donut Hole catches came from the Bogoslof stock, which is in accord with past practices of international pollock workshops (which used a range from 60 to 80%). The authors and Plan Team have remaining concerns about this assumption and also about the degree of interchange between Bogoslof fish and central BS fish. The SSC encourages further work in this regard by exploring the sensitivity of the assessment to this percentage. Consequently, the SSC agrees with the Plan Team to postpone acceptance of the model until this research is done."*

Additional research on evaluating the proportion of Donut Hole pollock catches to assign to the Bogoslof stock awaits additional data and resources to conduct analyses. It is likely that additional information, if it exists, would fail to reduce the uncertainty appreciably. Given this, the authors feel that any improvements over the age-structured model presented last year would be of limited value. Therefore the

age-structured modeling effort for this stock has been set aside and the 2007 assessment is based on the Tier 5 methods presented prior to 2005.

Perhaps enhanced funding levels due to NPRB studies could be invoked to provide clearer hypotheses on possible movement rates between these regions. However, how the present ecosystem functions relative to the state of the population 20 years ago under a different oceanographic regime, will remain an open question.

Introduction

Alaska pollock (*Theragra chalcogramma*) 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 called for independent management. The Bogoslof region pollock has also been connected with the historical abundance of pollock found in the central Bering Sea (Donut Hole) due to concentrations of pollock successively moving toward this region prior to spawning (Smith 1981, Shuntov et al. 1993). Collectively, pollock found in the Donut Hole and in the Bogoslof region are considered a single stock, 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 also is 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. There are some characteristics that 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 EIT survey since 1988 is 18%; in the EBS region (from model estimates), the average from this period is only 2%.

The information available for pollock in the Aleutian Basin and the Bogoslof Island area indicates that these fish may belong to the same “stock”. The pollock found in winter surveys are generally older than age 4 and are considered distinct from eastern Bering Sea pollock. Although data on the age structure of Bogoslof pollock show that a majority of pollock originated from year classes that were also strong on the shelf, 1972, 1978, 1982, 1984, 1989, 1992, 1996, and 2000 (Fig. 1b.1), there has been some indication

that there are strong year classes appearing on the shelf that have not been as strong (in a relative sense) in the Bogoslof region (Ianelli et al., 2004). Strong year classes of pollock in Bogoslof may be functionally related to abundance on the shelf.

Fishery

Prior to 1977, few pollock were caught in the Donut Hole or Bogoslof region (Low and Akada 1978). Japanese scientists first reported significant quantities of pollock in the Aleutian Basin in the mid-to-late 1970's, but large scale fisheries did not occur until the mid-1980's in the Donut Hole. By 1987 significant components of these catches were attributed to the Bogoslof Island region (Table 1b.1), although the actual locations are poorly documented. The Bogoslof fishery primarily targeted winter spawning-aggregations. Since 1992, the Bogoslof management district has been 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 (recall that the Bogoslof management district was not yet established). However, after March 23, 1991 the EBS region was closed to fishing and some effort was re-directed to the Aleutian Islands region but adjacent to 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). Pollock retention levels are variable and have increased as bycatch levels from other fisheries in this area have increased (Table 1b.2).

Echo-integration trawl (EIT) surveys

The National Marine Fisheries Service has conducted echo-integration-trawl (EIT) surveys for Aleutian Basin pollock spawning in the Bogoslof Island area annually since 1988, except that the survey was not conducted in 1990 or 2004, and in 1999, the survey was conducted by the Fisheries Agency of Japan. Survey reports have appeared in various publications (see list in Ianelli et al., 2005).

Survey abundance declined between 1988 and 1994, was stable and variable, then dropped again to the level it has maintained since 2000 (Fig 1b.2; Table 1b.3). The 1989 year class recruited to the Bogoslof Island area and was partly responsible for the 1995 increase, but the abundance of all ages increased between 1994 and 1995. The decrease between 1995 and 1996 was followed by a continued decline in 1997, suggesting that the 1995 estimate may be high, or that conditions in that year affected the apparent abundance of pollock. The 1996 year class has appeared to some degree in the 2005 survey, while the 1999 and 2000 year classes appear to be strong. Pollock concentrations observed in the 2007 survey is similar to that of recent years (Fig. 1b.3).

ABC Recommendation

Since 1999 the North Pacific Fishery Management Council (NPFMC) has generally been presented with a number of alternative methods for computing ABC values for the Bogoslof region. These have included:

1. Using a biomass-adjusted harvest rate rule (with 2,000,000 ton estimate as a target stock size) with an estimate of a F_{ABC} based on growth, natural mortality, and maturation rate.
2. Using a harvest rate as a simple fraction of natural mortality rate (e.g., F_{ABC} =0.75M).
3. An age-structured model.

In 2005 and 2006 the SSC considered the third approach to be inappropriate and thus it will not be considered further in this document. The approaches 1 and 2 above are provided below (along with alternative assumptions about F_{ABC} level for 1). Using method 1 above and given the 2007 survey estimate of exploitable biomass of 0.292 million t (Honkalehto et al. in press?) and M = 0.2 and considering of a target stock size of 2 million tons (from the SSC), the F_{ABC} level is computed as:

$$F_{abc} \le F_{40\%} \bullet \left(\frac{B_{2007}}{B_{T\arg et}} - 0.05 \right) \Big/ (1 - 0.05) \; .$$

Assuming that $F_{40\%}$ = 0.27 (as in past assessments), this gives a fishing mortality rate of 0.0217 that translates to an exploitation rate of 0.0215. This value multiplied by the most recent survey estimate (292,000 t), gives a 2008 ABC of 7,967 t for the Bogoslof region. The value assumed for $F_{40\%}$ that is critical for this calculation was based on uncertain assumptions about selectivity, natural mortality, growth, and maturation. Some of these assumptions were reevaluated here using a simple knife-edged selectivity at age 4 and age 5. Female pollock were specified to be 50% mature by age 5 and immature for younger pollock and 100% mature for older pollock with a natural morality of 0.3. This results in an $F_{40\%}$ level of 0.22 for the age-4 knife edge assumption and $F_{40\%}$ = 0.33 for the age-5 knife-edge assumption. These two scenarios provide ABCs for 2008 that would be 6,492 t or 9,737 t for the age-4 and age-5 knife edge assumptions, respectively. Clearly, these rules are sensitive to assumptions about expected selectivity, assumed growth, natural mortality, and maturation rates.

The approach for computing ABC levels under 2) above (a Tier 5 computation) simply uses the most recent survey biomass estimate applied to an adjusted natural mortality. Given a value of $M=0.3$ then the ABC level would be (2007 survey biomass $\times M \times$ 0.75) of 65,700 t at a biomass of 292,000 t. With M = *0.2*, the ABC would be 43,800 t.

Ecosystem considerations

In general, a number of key issues for ecosystem conservation and management can be highlighted. These include:

- Preventing overfishing;
- Avoiding habitat degradation;
- Minimizing incidental bycatch (via multi-species analyses of technical interactions);
- Controlling the level of discards; and
- Considering multi-species trophic interactions relative to harvest policies.

For the case of pollock, the NPFMC and NMFS continue to manage the fishery on the basis of these issues in addition to the single-species harvest approach. The prevention of overfishing is clearly set out as a main guideline for management. Habitat degradation has been minimized in the pollock fishery by converting the industry to pelagic-gear only. Bycatch in the pollock fleet is closely monitored by the NMFS observer program, and individual species caught incidentally are managed on that basis. Discarding rates have been greatly reduced in this fishery and multi-species interactions is an ongoing research project within NMFS with extensive food-habit studies and simulation analyses to evaluate a number of "what if" scenarios with multi-species interactions.

As reported in Loughlin and Miller (1989) pups of Northern fur seals, *Callorhinus ursinus*, were first observed on Bogoslof Island in 1980. By 1988 the population had grown at a rate of 57% per year to over 400 individuals, including 80+ pups, 159 adult females, 22 territorial males, and 188 sub-adult males. They noted that the rookery is in the same location where solitary male fur seals were seen in 1976 and 1979 and is adjacent to a large northern sea lion rookery. On July 22, 2005 NMFS surveys resulted in counts of 1,123 adult males, a substantial increase over this time period (L. Fritz, AFSC, pers. comm.). This suggests that conditions in the ecosystem have changed and appear to favor Northern fur seals. The extent that this is due to environmental conditions is unknown. However, pollock abundance may play only a small role since during peak abundance levels, the Northern fur seal abundance was at very low levels. Also, pollock are most concentrated in this region during winter months when Northern fur seals have migrated to more southern areas.

Summary

2008 and 2009 ABC and OFL (**recommended**)

Maximum permissible ABC:	***Harvest Rule ($F_{40\%}$ = 0.27)***	**yield = 7,967 mt**
	Tier 5 (M = 0.2)	yield = 43,800 mt
	Tier 5 (M=0.3)	yield = 65,700 mt
Overfishing (OFL):	***Tier 5 (M = 0.2)***	**yield = 58,400 mt**
	Tier 5 (M=0.3)	yield = 87,600 mt

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Tables

Table 1b.1 Catch in tons from the Donut Hole, the Bogoslof Island area, and the Bogoslof region assuming 60% of the Donut Hole catch was part of the stock corresponding to the Bogoslof region, 1977-2007.

Year	Donut Hole (t)	Bogoslof Island (t)	Total (t)	Bogoslof Island + 60% of Donut Hole catch
1977		11,500	11,500	11,500
1978		9,600	9,600	9,600
1979		16,100	16,100	16,100
1980		13,100	13,100	13,100
1981		22,600	22,600	22,600
1982		14,700	14,700	14,700
1983		21,500	21,500	21,500
1984	181,200	22,900	204,100	131,620
1985	363,400	13,700	377,100	231,740
1986	1,039,800	34,600	1,074,400	658,480
1987	1,326,300	377,436	1,703,736	1,173,216
1988	1,395,900	87,813	1,483,713	925,353
1989	1,447,600	36,073	1,483,673	904,633
1990	917,400	151,672	1,069,072	702,112
1991	293,400	316,038	609,438	492,078
1992	10,000	241	10,241	6,241
1993	1,957	886	2,843	2,060
1994		556	556	556
1995		334	334	334
1996		499	499	499
1997		163	163	163
1998		136	136	136
1999		29	29	29
2000		29	29	29
2001		258	258	258
2002		1,042	1,042	1,042
2003		24	24	24
2004			0	0
2005			0	0
2006			0	0
2007			0	0

Table 1b.2. Estimated retained, discarded, and percent discarded of total pollock catch (t) from the Bogoslof region. Source: NMFS Regional office Blend database and catch accounting system.

Year	Discard	Retained	Total	Percent Discard
1991	20,327	295,711	316,038	6%
1992	240	1	241	100%
1993	308	578	886	35%
1994	11	545	556	2%
1995	267	66	334	80%
1996	7	492	499	1%
1997	13	150	163	8%
1998	3	133	136	2%
1999	11	18	29	39%
2000	20	10	29	67%
2001	28	231	258	11%
2002	12	1,031	1,042	1%
2003	19	5	24	79%
2004	0.01	0	0.01	-
2005	0.016	0.002	0.018	-
2006	0.002	0.006	0.008	-

Table 1b.3. Biomass (tons) of pollock as surveyed in the Bogoslof region, 1988-2007. Note that in 1999 the Fishery Agency of Japan conducted the survey. These estimates are based on the biomass from the entire vicinity surveyed in each year rather than the specified "convention area" (see Ianelli et al. (2006) for a list of references documenting these surveys). "Relative Error" is the coefficient of variation assumed for these years. Note that for 1988, 1989, and 1999 values were unavailable, hence they were set to the maximum value found from the other years. Source: Honkalehto et al. (In press).

Year	Survey biomass estimates (t)	Survey area (nmi2)	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	1,104,124	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	301,402	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	240,000	1,803	12%
2007	292,000	1,870	12%

Figures

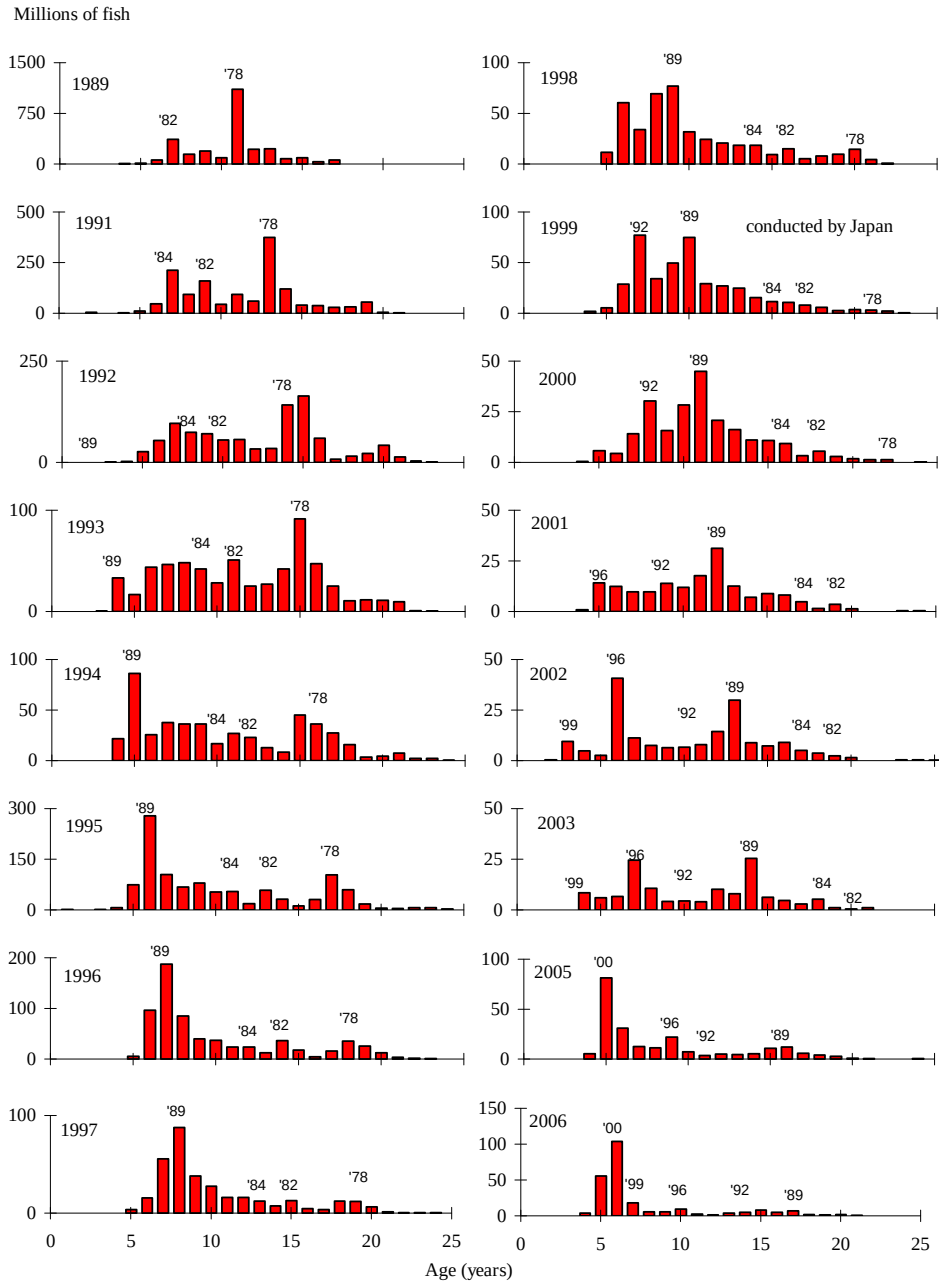

Figure 1b.1. Pollock catch at age from the winter 1989 - 2006 echo integration-trawl survey of walleye pollock in the Bogoslof Island area.

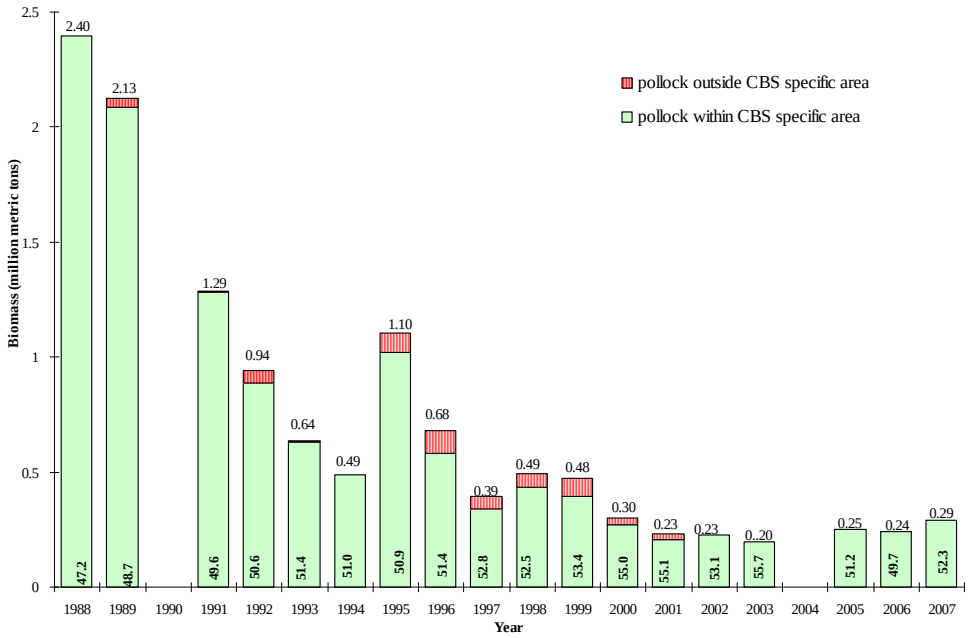

Figure 1b.2. Pollock biomass estimates from the 1988-2007 Bogoslof Area EIT surveys in millions of tons. There were no surveys in 1990 and in 2004.

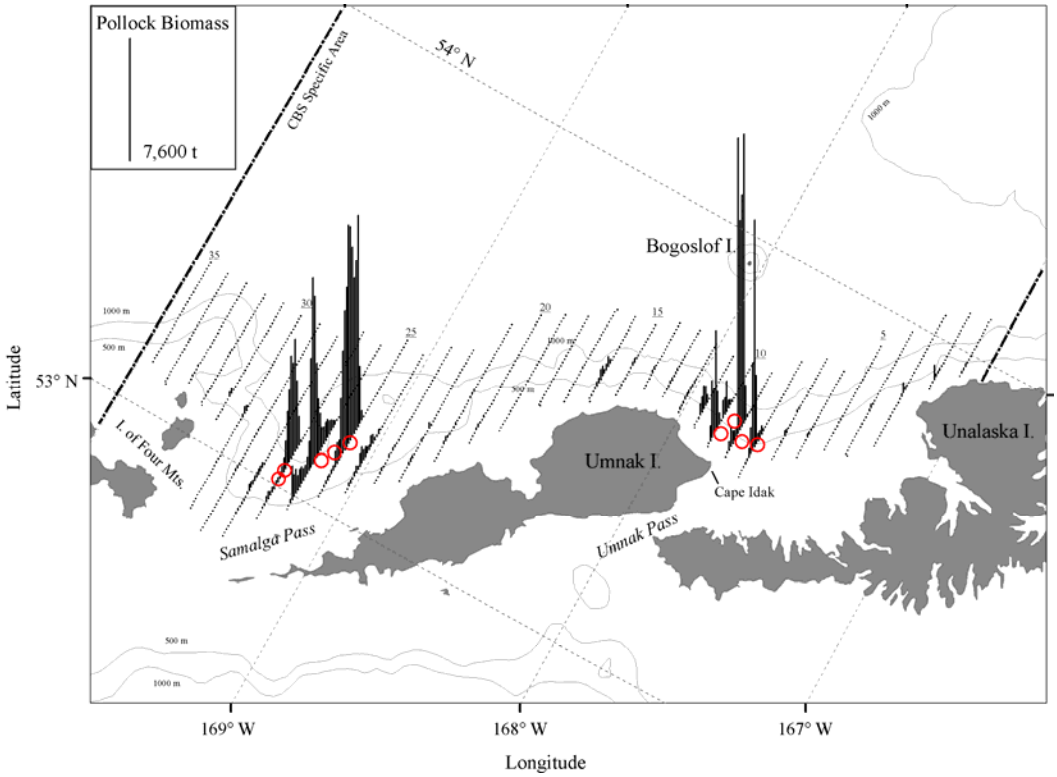

Figure 1b.3. Pollock biomass in metric tons (t) (vertical lines) and trawl hauls (circles) along tracklines from the winter 2007 echo integration-trawl survey of walleye pollock in the Bogoslof Island area. The Central Bering Sea Convention area is indicated by a dash-dotted line.

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