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Papers from
" Pollock Stock Structure and Identification Workshop"

Yokohama, Japan
7-9 September, 1999

Edited by
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Introduction

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This book contains papers presented at the "Pollock Stock Structure and Identification Workshop", Yokohama, September 7-9, 1999. This workshop was proposed at the annual meeting of the Convention for the Conservation of Pollock resources in the Central Bering Sea, and was coordinated by Dr. R. Marasco of Alaska Fisheries Science Center (AFSC), and Dr. T. Kobayashi of Hokkaido National Fisheries Research Institute (HNF).

The workshop was held at National Research Institute of Fisheries Science (NRIFS) in Yokohama. Over 50 representatives from Korea, Poland, Russia, United States, and Japan took part in the workshop to review and discuss about stock structure of walleye pollock and other marine species in the North Pacific region. The workshop was opened by Dr. Hatanaka (Director of NRIFS), and Dr. Low (AFSC) presented a keynote address on the general information about walleye pollock stock in the North Pacific region. Overall, 15 oral presentations contributed to this workshop. All contributors were invited to submit papers for the HNF Technical Report.

All of the papers were submitted by the summer 2000. However, publication of this book was delayed than our initial expectation for some confusion in the editorial work. In some papers, information may become older. But it is not the author's responsibility, and it should be attributed to the delay of editorial work.

As editor, I would like to thank all those who contributed to the proceeding of this workshop, and I appreciate their patience. And I believe that this book involve precious information for our future stock study of walleye Pollock and other marine species. I hope this book will contribute to the future stock identification study, and will lead to the future international cooperative research activities.

The Workshop and this publication were supported financially by the Fisheries Agency of Japan.

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Pollock Stock Structure and Identification Workshop

September 7-9, 1999
National Research Institute of Fisheries Science
Yokohama, Japan

Agenda

September 7

Opening remarks:	H. Hatanaka. (NRIFS)
Keynote Address:	Loh-Lee Low(NMFS)
	Joint paper by U.S. Japan, Russia, China, Korea, and Poland

Review of Pollock Stock Studies

Japan:	A. Nishimura & T. Yanagimoto (HNF)
Korea:	S. Kim (NFRDI)
Poland:	J. Janusz (SFI)
Russia:	A. Glubokov (VNIRO)
United States:	S. Grant (NMFS)

September 8

Stock Identification Technology

Morphology:	J. Ianelli (NMFS)
Otolith Chemistry:	K. Severin (UAF)
Otolith Chemistry:	S. Thorrold (ODU)
Biochemical Genetics:	J. Seeb (ADFG)
Biochemical Genetics:	S. Chow (NRIFSF)
Biochemical Genetics:	M. Sekino (NFRFE)
Mitochondrial DNA:	O. Katugin (TINRO)
Microsatellite Analysis:	P. O'Reilly & M. Canino (UW)
Microsatellite Analysis:	H. Abe & M. Goto (ICR)

September 9

Workshop to Develop Research Action Plan

(Co-charis: Marasco and Kobayashi)

- Data needs/ Field Sampling/ Sample Processing
- Training and Cooperative Research Opportunities
- Action Plan Development
- Concluding remarks
- Closing remarks

Pollock Stock Structure and Identification Workshop Rapporteur's Report

September 7-9, 1999
National Research Institute of Fisheries Science
Yokohama, Japan

Dr. H. Hatanaka (NRIFS) opened the conference with comments on the need for developing active research programs for stock structure problems facing Bering Sea pollock.

Dr. L. Low (AFSC) presented a review of pollock resources and issues for Bering Sea pollock fisheries management. This was followed by a review of studies occurring in each of the participating countries.

REVIEW OF POLLOCK STOCK STRUCTURE STUDIES

Chair Doug Eggers

In this session, each national section provided a review of pollock stock structure studies.

Japanese studies

Akira Nishimura provided the review of stock structure studies based on phenotypic characteristics. These studies found differences in morphology and in otolith characteristics between areas (western Bering Sea, Eastern Bering Sea, Aleutian Basin, and Northern Japan Sea). Recent studies have focused on otolith characteristics of pollock in northern eastern Bering Sea, southern eastern Bering Sea, and Chukchi Sea and suggest a strong relation between Aleutian Basin and southern eastern Bering Sea. However, biological characteristics have changed over time with declining abundance and increasing growth rates. Takashi Yanagimoto provided the review of genetic studies PCR-RFLP, RAPD-PCR, and AFLP. Early studies of pollock using the allozyme marker SOD suggest some isolation of eastern and western Bering Pollock and suggest these populations are isolated. In future studies, it is important to collect significant numbers of adult pollock from various spawning grounds.

Korean Studies

Soon-Song Kim provided the review of studies based on morphology and genetics. Meristic counts of pollock population through the western north Pacific and Bering Sea were examined. Significant differences were found due mostly to differences between two most southern populations (eastern Korea and Pacific side of Hokkaido) from the more northerly populations. Genetic characteristics of the populations were also examined.

Polish studies

Jerzy Janusz reviewed the age and length characteristics of fishery catches in the northern Bering Sea area, 1995 -1998. Age and length frequency distribution, as well as von Bertalanffy growth curves were presented.

Russian Studies

Alexander Glubokov reviewed the current status of walleye pollock in the northwestern Bering Sea. These populations were monitored using fishery catches and number of surveys. In the northwestern Bering Sea area, the 1990's were marked by decreasing abundance of pollock. Areas of pollock concentration clearly delineated. Stock characteristics of populations in the eastern Koryak shelf, western Koryak shelf and Navarin area were examined using morphological, physiological, and genetic indicators. Differences in physiological morphological indicators were found between the areas.

United States studies

Stewart Grant provided a review of genetic methods for defining stocks of marine fishes. Population segments may be defined with phenetic variability that reflects demographic or life-history responses to spatial or temporal changes. Population segments can also be distinguished by molecular genetics that measure inherited differences among populations as a result of geographic isolation. The phenetic and genetic methods reflect population changes that occur on vastly different time scales and may or may not coincide. There are limits to the molecular genetic methods in populations, such as walleye pollock, with high gene flow between population segments. The rigorous analysis of rapidly evolving genes, such as microsatellite loci and elemental analysis may hold the best promise for identifying population units on spatial and temporal used by managers. Other genetic and non-genetic methods should also play a role in stock identification.

STOCK IDENTIFICATION TECHNOLOGY, PART I.

Chair A. Nishimura

J. Ianelli (AFSC) presented problems in stock structure study using morphometric methods. Length-age data from catches suggested significant differences of pollock growth, and the possibility of the existence of multiple stocks was suggested in the EBS. He then presented alternative hypotheses based on size-related movement and showed that the same differences can occur even from a single stock. The distribution of length-frequency data by area over time showed patterns favoring a single stock. This was due to following the geographic changes in the abundance of strong year-classes.

K. Severin (Univ. of Alaska Fairbanks) and S. Thorrold (Old Dominion Univ.) made presentations about methods used for analyses of otolith chemistry. Technical and/or methodological discussions were made, and a pilot study of juvenile pollock was presented. EPMA is thought to be a useful method for stock identification study for the Bering Sea pollock. Thorrold introduced new method of otolith chemistry with using LA-ICP-MS. Otolith elemental information is thought to be useful for the natural tag of the stocks. The factors affecting otolith elemental characteristics were discussed with specially considering environmental and natal homing mechanism of the fish.

J. Seeb (Alaska Dept. Fish. and Game) introduced his genetic study conducted for the area from Gulf of Alaska to Bogoslof area in the Bering Sea. In his presentation, SOD analysis was suggested to be the useful method for the pollock stock study in the Alaskan waters. S. Chow (NRIFSF) introduced his genetic study for the tuna and swordfish in the global ocean scale. His genetic technique is thought to be fundamental to identify stock structure for those fish group.

STOCK IDENTIFICATION TECHNOLOGY, PART II.

Chair V.I. Radchenko

Four presentations were made during this session. Key points are presented below.

1. M. Sekino. Molecular cloning of microsatellite DNA from marine organisms.

(a) A new technique for microsatellite DNA cloning using sonication has been worked out. It resulted in construction of highly enriched genomic library.
(b) This method has been used to construct enriched libraries for Japanese rockfish and bastard halibut.
(c) This method could have some potential applications to walleye pollock stock structure studies, though it seems to be applicable primarily for isolating microsatellites with low frequency in genomes.

2. O. Katugin. Biochemical genetic variation and population structure study in walleye pollock (*Theragra chalcogramma*) from the Bering Sea.

(a) There exists an overall subdivision of the Bering Sea pollock gene pool into two parts: eastern and western, which had been confirmed by other studies with application of different techniques.
(b) Polymorphic genetic markers, which were used in this study, had not been applied to walleye pollock by other researchers. Nevertheless, the results appeared to be consistent with those derived from other sources of information, including proteins and mtDNA.

3. P. O'Reilly. High-resolution analysis of walleye pollock stock structure using microsatellite DNA markers.

(a) Highly polymorphic microsatellite loci were first used in the analysis of stock differentiation in walleye pollock.
(b) Applicability of the technique has been tested on a large geographic scale from Japan to Puget Sound. Although levels of population structuring were low, there was rather clear differentiation of geographically separated population units.
(c) It was shown that temporal stability of intra-specific differences even at a single locus could indicate existence of stock structure in a migratory fish species.

4. H. Abe. The application of microsatellite DNA for determining population structure of Minke whales.

(a) Population genetic analysis has been successfully applied to Minke whales which have several biologically units.
(b) Several genetic methods, including microsatellites and mtDNA, refined existing knowledge of Minke whale stock differentiation between the Sea of Japan and the western North Pacific.
(c) It was shown that samples for stock structure analysis of highly migratory species should be collected from the breeding areas.

General conclusions

Most presentations made at the afternoon session focused on stock structure analyses techniques and approaches rather than directed pollock research. Applicability of these techniques to the problem of stock structure analysis of pollock will take time, and the power of each method should be tested.

There is a need to optimize pollock stock structure analysis and stock identification methodologies. Calibration is needed between different methods. This implies that initially tests should be performed to determine if available methods can—and to what extent—discriminate between different populations or stocks.

DEVELOPMENT OF AN ACTION PLAN

Co-chairs: R. Marasco and T. Kobayashi

Dr. Marasco suggested that the following questions be used as guideposts in the development of an action plan:

- What methods should be used for stock structure studies?
- What data are required for these methods?
- How should samples be collected?
- How should they be analyzed?

The co-chairs opened discussions on these topics and the development of a summary statement for consideration by the S and T at its November meeting.

Stock ID methods

The following four methods were proposed as the core methodologies for stock ID work. These do not preclude developing and/or using other methods.

Genetic techniques

- Sequence analyses of mtDNA
- Allozymes
- Microsatellite loci analysis

Phenetic methods

- Otolith chemistry

Other methods were identified as follows

- Chromosomal DNA (rapids)
- Meristics and morphometrics
- Parasite fauna
- Tag-recapture programs
- Gonad-somatic studies
- Organ/tissue studies
- Analysis of non-coding DNA (Intron)
- MHC
- Sine

The necessity was discussed of having a central source for lab processing of collected samples. It was agreed that there should be sharing of raw data and coordination of data analyses.

Sampling locations

The following areas were identified for sampling locations:

- Bering Sea
  - Bogoslof Island
  - Eastern Bering Sea NW & SE of Pribilofs
  - Aleutian-Commander Islands
  - Donut hole area
  - Northern Bering sea
  - W. Bering Sea (Karaginski area)
- Other N. Pacific areas (for comparison)
  - Sea of Okhotsk, Peter the Great Bay, Sakhalin Coast, Hokkaido coast, Shelikof, Prince William Sound, and Korean Peninsula.

Timing of sampling

The sampling efforts should be collected over multiple years on spawning grounds for evaluating stationarity in stock ID methods. Samples also should be collected over different periods of the spawning events.

It was recognized that the cooperation of respective neighboring countries is necessary to help in sample collections.

Sample collect

It was recognized that consideration of sample size is extremely important for stock structure studies. It was concluded that sampling protocols be developed within each lab. Drs. Seeb & Grant agreed to develop and circulate draft protocols in time for the November S&T meeting. The information will be made available on the Internet.

Comments on sampling materials were as follows

- Tissue samples from spawning pollock
  - Heart, muscles & gonads
  - By size groups?
- Otolith samples of adults and juveniles

For otoliths, scales, & other hard structures

- Preservation in alcohol?
- Dry in envelopes?
- Single versus multiple samples?

For Tissue Samples

- Frozen —what temp and handling procedures?
- Tissue samples dissolved or preserved in preservative solutions?

Coordinate of data and samples collection

- From ships of opportunity?
- From special sampling schemes by research vessels?
- During spawning conditions only?
- Collection by Russia & U.S. in respective EEZs
- Help from fishing nations
- Designate coordinators by country

Pollock Stocks in the North Pacific and Importance of Stock Structure and Identification Research

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WON-SEOK YANG[4], JERZY JANUSZ[5], AND TANG QISHENG[6]

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2 Russian Federal Research Institute of Fisheries and Oceanography, Moscow, Russia
3 Hokkaido National Fisheries Research Institute, Kushiro, Japan
4 National Fisheries Research and Development Institute, Pusan, Korea
5 Sea Fisheries Institute, Gdynia, Poland
6 Yellow Sea Fisheries Research Institute, Qindao, China

ABSTRACT: The walleye pollock (*Theragra chalcogramma*) resource is presently the largest single species resource in the North Pacific Ocean. Its distribution stretches across the wide expanse of the Pacific Ocean from the western shores of Canada, up through the Gulf of Alaska, into the entire Bering Sea, across the Aleutian Basin to the shores of Siberia, down and across the Kamchatka Peninsula, into the Sea of Okhotsk, the waters of northen Japan, and along the Korean Peninsula. The resource is important to the region from two important aspects—to the ecology of the marine ecosystem and to support a fishing industry. The pollock stocks have a combined biomass of 15 to 30 million metric tons (mmt). They support a massive fishing industry that takes 3-7 million metric tons of fish per year for the past 30 years. Pollock occupies significant roles throughout its life stages in the food web of the ocean and sustains life for all tropic levels of the ecosystem. The paper will review the importance of pollock stock structure and identification for the Bering Sea to the Convention for the Conservation of Pollock resources in the Central Bering Sea. The pollock resource in the Bering Sea is composed of at least 5 major stocks which are transboundary and inter-mixes at various stages of their life history. Knowledge on stock structure, migration, and identification have generally been poor and has not been improved for almost 20 years. New research must be planned to advance their knowledge.

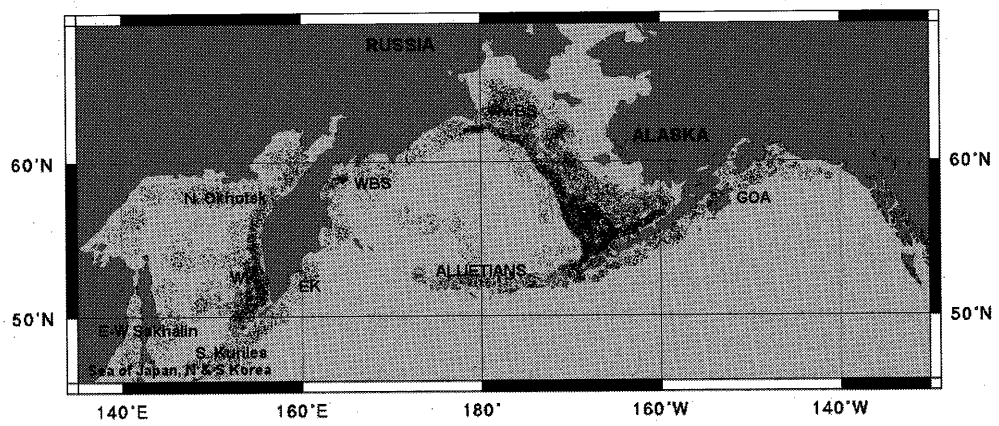

Fig. 1. General distribution of pollock in the North Pacific.

INTRODUCTION

The walleye pollock (*Theragra chalcogramma*) resource is presently the largest single species fisheries resource in the North Pacific Ocean. Its distribution stretches across the wide expanse of the Pacific Ocean from the western shores of Canada, up through the Gulf of Alaska, into the entire Bering Sea, across the Aleutian Basin to the shores of Siberia, down and across the Kamchatka Peninsula, into the Sea of Okhotsk, the waters of northen Japan, and along the Korean Peninsula (Fig. 1). The resource is important to the North Pacific Ocean and its adjacent seas from two important aspects -- to the ecology of the marine ecosystem and to support a fishing industry.

The pollock stocks from the various regions have a combined biomass of 15 - 30 mmt. They support a massive fishing industry that takes 3-7 mmt of fish per year for the past 30 years. Even though pollock fisheries are harvested locally in certain Asian areas in historic times, they are essentially modern day fisheries developed some 30 years ago after the Japanese fishing industry pioneered large-scale at-sea fishing and surimi-processing capabilities. The resource now supports important fishing industries from the Gulf of Alaska to the Korean Peninsula.

The individual fish itself is not particularly special. Its marketable size generally ranges from 25-60 cm in length and weighs 0.3 - 1.4 kg. As a group, however, the species plays an especially significant role in the fisheries and ecology of the North Pacific Ocean. It is the most abundant species in most parts of the region. It occupies significant roles throughout its life stages in the food web of the ocean and sustains life for all trophic levels in the ecosystem. This paper will review the importance of the pollock resource to countries that border the North Pacific Ocean and its adjacent seas and to other nations that have historically fished pollock. It will touch on the importance of pollock stock structure and their identification to the Convention for the Conservation of Pollock resources in the Central Bering Sea. This Convention has only been in force since 1995 to conserve and manage pollock stocks in the Central Bering Sea for the Parties of the Convention—The People's Republic of China, Japan, Republic of Korea, the Republic of Poland, the Russian Federation, and the United States.

MAJOR FISHING AREAS

The major fishing areas may be identified from historical catch statistics (Fig. 2) as:

(1) the Gulf of Alaska, including Shelikof Straits,
(2) the eastern Bering Sea — virtually all areas from the shelf to the continental slope regions,
(3) the Navarin Basin of the northern Bering Sea,
(4) the Olyotorski area of the western Bering Sea,
(5) the Aleutian Islands region,
(6) the central Bering Sea outside of the U.S. and Russian 200-mile exclusive economic zones, otherwise known as the "Donut Hole area",
(7) waters off Kamchatka and the island chain between northern Japan and the southern tip of Kamchatka,
(8) the Sea of Okhotsk,
(9) northern Japan, and
(10) the Korean Peninsula.

The two main centers of abundance are the Sea of Okhotsk and the eastern Bering Sea.

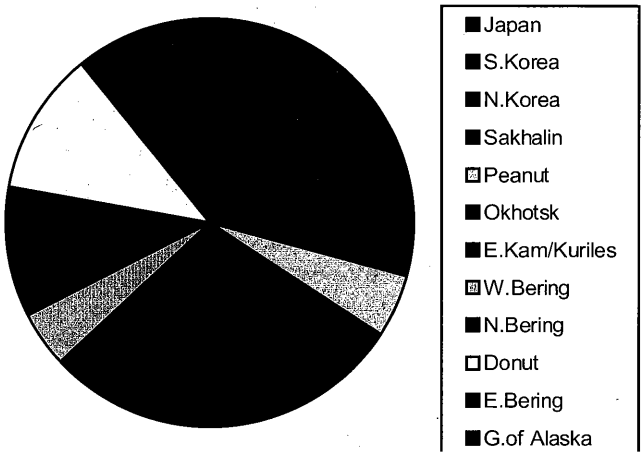

Fig. 2. Percentage distribution of average (1981-1995) catch of pollock by twelve North Pacific areas.

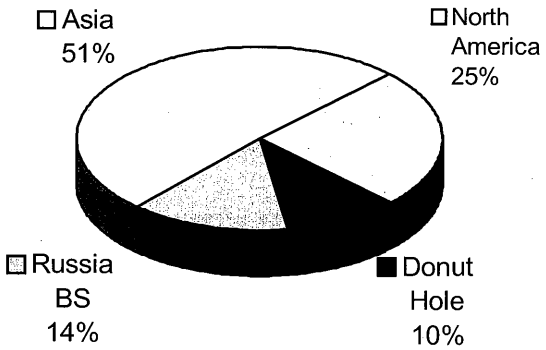

Fig. 3. Percentage distribution of average (1981-95) catch of pollock by four major North Pacific areas.

CATCH HISTORY AND ECONOMIC SIGNIFICANCE

The 15-year average catch for 1981-1995 was 2.9 mmt from the Asia region and 2.8 mmt from the North American region (that includes Russian catches from the Bering Sea) (Table 1, Fig. 3). At $500/t of product value (Joe Terry, personal communications), the recent average annual catch of 5.7 mmt would be worth $2.85 billion. With a simple assumed 2-times multiplier effect for processing, post-processing, transhipment, and marketing, the pollock fisheries would easily account for almost $6 billion worth of economic activity for the region.

Table 1. Walleye pollock catch (in metric tons) in the North Pacific Region

Year	Gulf of Alaska	Eastern Bering Sea	Bogoslof	Donut Hole	Western Bering Sea (a)	Navarin Basin (b)	Eastern North Pacific	Asiatic North Pacific ©	Total
1981	139,200	973,500			279,000	900,000		3,799,800	6,091,500
1982	168,700	956,000			356,000	804,000		3,259,700	5,544,400
1983	215,600	981,500			353,000	722,000		2,817,200	5,089,300
1984	306,700	1,092,100		181,200	376,000	503,000		3,617,400	6,076,400
1985	284,900	1,139,700		363,400	278,000	488,000		3,396,200	5,950,200
1986	93,600	1,142,000		1,039,800	271,000	570,000		3,393,100	6,509,500
1987	69,500	859,400	377,000	1,326,300	300,000	463,000		3,083,700	6,478,900
1988	65,600	1,228,700	87,800	1,396,700	324,000	852,000		2,778,200	6,733,000
1989	78,200	1,229,600	36,100	1,447,600	309,000	684,000		2,692,000	6,476,500
1990	90,500	1,455,200	151,700	917,400	383,000	232,000		2,720,500	5,950,300
1991	107,500	1,217,300	264,800	293,400	309,000	178,000		2,757,100	5,127,100
1992	93,900	1,164,400	200	10,700	281,000	316,000		2,860,100	4,726,300
1993	108,200	1,326,600	900	1,200	363,000	389,000		2,053,000	4,241,900
1994	111,200	1,363,500	600	0	210,000	178,000		1,861,900	3,725,200
1995	67,000	1,262,800	300	0	86,000	320,000		2,072,000	3,808,100
Average	133,353	1,159,487	102,156	581,475	298,533	506,600	2,781,604	2,877,460	5,659,064

(a) Russian EEZ, west of 176 degrees E Longitude
(b) Russian EEZ, east of 176 degrees E Longitude
© Catch data from the Asiatic North Pacific was compiled by Vidar Wespestad as part of the records of the Science Group meetings of the Convention for the Conservation of Pollock Resources in the Central Bering Sea.

In social terms, however, pollock fisheries employ, nurture, and sustain the livelihood of untold numbers of people and their communities. Pollock products provide food to supplement the nutrition of millions of people. The true importance of pollock to the people of our countries cannot be overstated.

The region of particular attention of this Workshop is, however, the Bering Sea region, since it encompasses the "Donut Hole area" of the Convention (Fig 4). The 15-year (1981-95) Bering Sea average catch totaled 2.6 mmt (Table 1, Fig. 5) and were distributed as follows: Eastern Bering Sea/Aleutians (44%), Bogoslof Island area (4%), western Bering Sea (11%), Navarin Basin (19%), and the Donut Hole area (22%). An average of 750,000 t of pollock were taken during the 9-year period (1985-93) when the Donut pollock fisheries were actively fishing (Fig. 6). Since 1993, however, the Donut Hole pollock fishery has been closed as a result of agreements made by the Parties to the Donut Convention. It is the hope of the Parties that the Donut Hole pollock stock would recover soon to support a sizeable fishery into the near future.

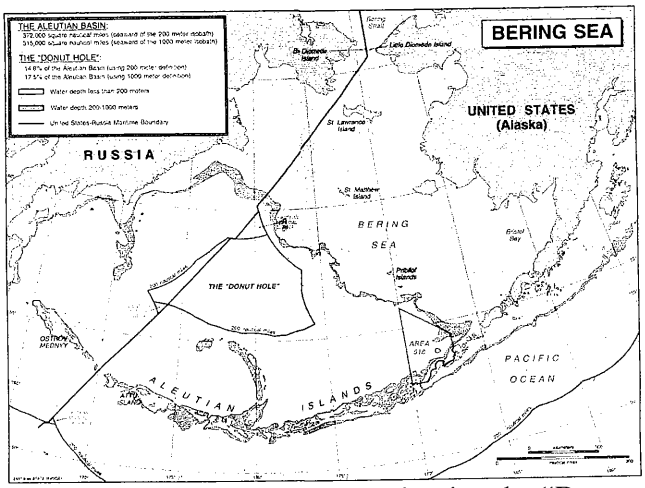

Fig. 4. Map of the Bering Sea showing the "Donut Hole" area.