Intersessional Meeting
of the
Scientific and Technical Committee
for the
Convention on the Conservation and Management
of Pollock Resources
in the Central Bering Sea

2-4 September 1998
Seattle, Washington

1. **Report of the Enforcement/Management Group**
2. **Report of the Science Group**

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ENFORCEMENT/MANAGEMENT GROUP INTERSESSIONAL

THE CONVENTION FOR THE CONSERVATION AND MANAGEMENT OF POLLOCK RESOURCES IN THE CENTRAL BERING SEA
SEATTLE, WASHINGTON, USA
02-04 SEPTEMBER 1998

Report

Delegations from the People's Republic of China, Japan, the Republic of Korea, the Republic of Poland, the Russian Federation, and the United States of America participated in an intersessional meeting of the Parties to the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea, Scientific and Technical Committee's Enforcement/Management Group (the Group). This meeting was held in Seattle, Washington, USA, September 02-04, 1998. Captain J.V. O'Shea, U.S. Coast Guard (USCG), was elected Chair. LCDR Dwight Mathers, USCG, was elected Rapporteur.

The Group continued to develop measures and programs for the management of pollock fishing in the Convention Area, when the Allowable Harvest Level (AHL) is other than zero.

The Group discussed the Trial Fishing Terms and Conditions for 1999. The Group agreed that each Party planning to conduct trial fishing in 1999 should be prepared to present Trial Fishing Proposals at the Third Annual Conference. It recommended that the Trial Fishing Terms and Conditions for 1999 (the "Terms") should be the same used for 1998, except several Parties sought clarification of the first sentence regarding two vessels; does this mean no more than any two vessels or two specifically identified vessels. Poland submitted a Cruise Plan for Trial Fishing in 1999.

The Group discussed the placement and number of observers required by Article XI. There was considerable discussion of Poland's proposal on this issue submitted at last year's S&T Committee Meeting, but the Group did not reach consensus on the issue. The Group agreed to study Poland's proposal for further discussions at the Third Annual Conference.

Next, the Group discussed how the catch weight on board vessels fishing in the Convention Area would be determined. The United States presented the results of a recent evaluation of three methods used in the United States and provided the Group with a report of the evaluation. The Group agreed that this was a very complicated issue and each Party had its own preferred methods. The United States and Russia indicated that the Parties needed to agree on the most accurate and cost effective method (or methods) to be used by fishing vessels of all the Parties to best conserve and manage the pollock stocks. The Group agreed that a workshop on this issue may be beneficial in the future, but prior to that, each Party agreed to prepare an issue paper describing the catch estimate methods it used and its preferred method. The United States prepared and distributed an outline of information (Attachment 3) that each Party should include in this paper, with the understanding that the Parties may submit any additional information. The United

States asked that the reports be submitted to the United States via official channels prior to the Third Annual Conference and indicated that it would circulate the reports to the other Parties.

The Group discussed Transparency and received a proposal from the Russian Delegation (Attachment 4). The Group agreed that the Transparency issue be referred to the Procedures Group. The Chair recommended that each Party submit the Russian proposal to its transparency experts, may transmit any comments or questions on the proposal through official channels, and be prepared to discuss the proposal at a Procedures Group Meeting during the Third Annual Conference.

The Group discussed several components of a Management System that would apply when fishing for pollock resumes in the Convention Area. Japan and Poland submitted written comments (Attachments 5 and 6) on the United States' proposal submitted last year and Japan submitted its own proposal (Attachment 7). Japan's proposal addressed an Individual National Quota (INQ) system and the United States' proposal addressed a non-INQ management system in accordance with the Convention. There was considerable discussion on establishing a fishing season. Some of the Parties favored a year round fishery and other Parties supported a specific time frame for fishing. It was agreed to continue work on the development of both the United States' and Japan's Management Plan proposals. The United States indicated that it would respond to Japan and Poland's written comments and that the Parties would use the time before the Third Annual Conference to respond to both proposals so they can be discussed at that meeting.

Finally, the Group discussed whether data from the fishing vessel master or the observer aboard the vessel should be used to manage the fishery. Some of the Parties felt that both sets of data should be used and if there were differences between the two data sets then the flag State should be required to investigate the discrepancies and provide an explanation to the S&T. The Group noted that this issue was closely related to the method used to estimate catch and did not reach consensus on which data set should be used.

Attachments:
1 – Meeting Agenda
2 – Meeting Participants
3 – U.S. Outline for Pollock Catch Weight Estimation Procedures
4 – Russian Transparency Proposal
5 – Japan's Comments on U.S. Management System Proposal
6 – Poland's Comments on U.S. Management System Proposal
7 - Japan's Management System Proposal

EG Attachment 1

MEETING OF THE ENFORCEMENT/MANAGEMENT GROUP OF THE SCIENCE AND TECHNICAL COMMITTEE

OF THE CONVENTION FOR THE CONSERVATION AND MANAGEMENT OF POLLOCK RESOURCES IN THE CENTRAL BERING SEA

SEATTLE, WASHINGTON, USA

02-04 SEPTEMBER 1998

Agenda

A. Election of the Chair and Rappateur

B. Enforcement Issues
   - B.1. Trial fishing terms and conditions for 1999
   - B.2. U.S. Presentation on Catch Estimation Methods
   - B.3. Placement of observers aboard flag-state and non flag-state vessels
   - B.4. Estimation of catch

C. Transparency Issues

D. Management Issues/System
   - D.1. INQ Fishery and Olympic Fishery
   - D.2. Fishing Season
   - D.3. Data to manage the fishery-vessel and/or observer data

ENFORCEMENT/MANAGEMENT GROUP
PARTIES TO THE CONVENTION FOR THE CONSERVATION AND MANAGEMENT OF POLLOCK RESOURCES IN THE CENTRAL BERING SEA

September 02-04, 1998 - Seattle, Washington, USA

DELEGATION OF JAPAN

Mr. Ichiro Kanto
Head of Delegation
Fisheries Policy Planning Department
Fisheries Agency of Japan

Mr. Shoichi Takayama
Far Seas Fisheries Division
Resource Managment Department, Fisheries Agency of Japan

Mr. Noriaki Takagi
Executive Secretary
Japan Deep Sea Trawlers Association

DELEGATION OF THE PEOPLE'S REPUBLIC OF CHINA

Mr. Liu Xiuabing
Head of Delegation
Assistant Consultant, Divisions of International Cooperation
Bureau of Fisheries, Ministry of Agriculture

Mr. Zhou Maoliang
Deputy Manager
Shanghai Deep Sea Fisheries Corporation

DELEGATION OF THE REPUBLIC OF KOREA

Mr. Shim Dong Hyun
Director
Ministry of Marine Affairs and Fisheries

Mr. Yang Won-Seok
National Fisheries Research and Development Institute

Mr. Kim Tae-Won
Deputy Director
Korea Deep Sea Fishing Association

DELEGATION OF THE REPUBLIC OF POLAND

Dr. Jerzy Kleniewski
Consul of Poland, Ministry of Transportation and Maritime Economic Affairs
Polish Consulate General, New York, NY

Ms. Anna Radomska
Ministry of Transportation and Maritime Economic Affairs
Warsaw

Mr. Stanislaw Kasperek
Advisor
"GRYF" Fishing Companay, Szczesin

Mr. Tadeusz Czerwinski
Advisor
"ODRA" Fishing Company, Swinoujscie

DELEGATION OF THE RUSSIAN FEDERATION

Dr. Vladimir Bourkanov
Head of Kamchatrybvod

DELEGATION OF THE UNITED STATES OF AMERICA

<u>U.S. Department of State</u>

Mr. Stetson Tinkham
Head of Delegation
Senior Pacific Fishery Officer
Office of Marine Conservation

<u>National Marine Fisheries Service</u>

Dr. William Karp
Alaska Fisheries Science Center
Seattle, Washington

Mr. David Flannagan
Officer of Enforcement, Juneau, Alaska

Mr. William Hines
Office of the Regional Director, Juneau, Alaska

Mr. Galen Tromble
Groundfish Manager, Alaska Region

Mr. Paul Niemeier
Sustainable Fisheries, Silver Spring, Maryland

National Oceanic and Atmospheric Administration

Mr. Jonathan Pollard
Associate General Counsel for Fisheries, Juneau, Alaska

United States Coast Guard

Captain J.V. O'Shea
Chief, Maritime Plans, Policy, and Operations
17th District, Juneau, Alaska

LCDR Dwight T. Mathers
Coast Guard Liaison Officer
Department of State, Washington D.C.

LT E.J. Marohn
Graduate Student
School of Marine Affairs, University of Washington

LT Lisa Ragone
Graduate Student
School of Marine Affairs, University of Washington

ADVISORS

Mr. Alvin R, Burch
Alaska Draggers Association

Ms. Francine Bennis
Alaska Marine Conservation Council

Mr. Paul MacGregor
At-Sea Processors Association

Mr. Dennis Austin
Washington State Department of Fisheries and Wildlife

Mr. Brent Paine
Executive Director
United Catcher Boats

OUTLINE FOR CATCH WEIGHT ESTIMATION PROCEDURES USED IN POLLOCK FISHERIES.
(Submit separate paper for each method used.)

Description of Method

How Does this method account for total catch of pollock and other species, including fish that are not retained or processed?

If method utilizes volumetric measurements:

1) Are actual measurements recorded or just the resulting weight calculation?

2) What pollock density factor (metric tons per cubic meter) is used?

3) How was this density factor determined? (for example.....scientific research or historic industry practice, etc.)

If method utilizes conversion to round weight from product weights and product recovery rates (IE. average weight of product obtained from a whole fish):

1) What product recovery rates are utilized for those conversions?

2) How are these product recovery rates determined?

3) How is the weight of fish not retained for processing determined?

Describe attributes of utilizing this method of catch weight determinations.

Describe drawbacks of utilizing this method of catch weight determinations.

If more than ~~two~~ one method~~s~~ of catch weight determinations are utilized by vessels of your nation, which is the preferred method of choice?

1) Could all vessels of the nation utilize the preferred method?

[Please attach the results of any scientific evaluation of this method conducted by your nation.]

Proposal of the Russian Federation to the Rules of Procedure of Annual Conference and of the Scientific and Technical Committee of the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea Regarding the Admission of Observers to its Meetings

1. Any non-Party shall be eligible to participate as observer in plenary meetings of the Annual Conference and meetings of the Scientific and Technical Committee on the basis of unanimous decision of the Parties.
2. Parties may take by consensus during the foregoing meeting of the Annual Conference the decision to invite a non-Party to attend the plenary meetings of the future Annual Conference and meetings of the Scientific and Technical Committee.
3. Any other non-Party wishing to participate as observer in plenary meetings of the Annual Conference and meetings of the Scientific and Technical Committee, shall notify the Party hosting the meeting of an Annual Conference of its request to participate at least 90 days in advance of the meeting.
4. The Party hosting the meeting of the Annual Conference shall notify the other Parties to the Convention of the request received from that non-Party at latest 20 days after the receipt of the notification
5. Any eligible non-Party expressing a desire to participate as observer may do so unless any Party to the Convention formally objects for cause in writing at least 30 days prior to the beginning of the meeting.
6. The Party hosting the meeting of the Annual Conference shall notify the non-Party of the decision of the Parties to the Convention.

7. Any intergovernmental organisation known for its activity in the sphere of conservation and management of the marine living resources shall be eligible to participate as observer in plenary meetings of the Annual Conference and meetings of the Scientific and Technical Committee on the basis of a unanimous decision of the Parties.
8. The intergovernmental organisation is granted the permission to attend the Annual Conference and meetings of the Scientific and Technical Committee according to the procedure described in para. 3 - 6.
9. Any non-governmental organisation, national or international, known for its activity in the sphere of conservation and management of the marine living resources shall be eligible to participate as observer in plenary meetings of the Annual Conference and meetings of the Scientific and Technical Committee on the basis of a unanimous decision of the Parties.
10. The non-governmental organisation is granted the permission to attend the Annual Conference and meetings of the Scientific and Technical Committee according to the procedure described in para. 3 - 6.
11. Any non-governmental organisation described in para.9 and participating as observer in plenary meetings of the Annual Conference and meetings of the Scientific and Technical Committee shall pay in the registration fee equivalent to ___ US dollars.
12. The meetings of other subsidiary bodies of the Convention shall not be open to the observers
13. Any observer admitted to a meeting may:

    a) attend the meetings, as set forth above, but may not vote;

    b) make oral statements during the meeting upon the invitation of the presiding officer;

c) distribute documents at meetings; and

d) engage in other activities, as appropriate and as approved by the presiding officer.

14. Upon the request of any Party to the Convention or the presiding officer the attendance to any plenary meeting of the Annual Conference and meetings of the Scientific and Technical Committee may be limited to Parties only.

15. All observers admitted to plenary meetings of the Annual Conference and meetings of the Scientific and Technical Committee shall be sent or otherwise receive the same documentation generally available to the Parties to the Convention and their representatives.

16. All observers admitted to plenary meetings of the Annual Conference and meetings of the Scientific and Technical Committee shall comply with these and all other rules and procedures applicable to other participants in the meeting.

Comments on Donut Hole Management from Shingo OTA

According to the "REPORT OF THE SECOND ANNUAL CONFERENCE OF THE PARTIES TO THE CONVENTION ON THE CONSERVATION AND MANAGEMENT OF POLLOCK RESOURCES IN THE CENTRAL BERING SEA, 5.8.", Japan submits the following written comments to the United States on the "United States Proposal for A MANAGEMENT SYSTEM IN THE CENTRAL BERING SEA", with the general comments on the management system provided in Part 2 of the Annex of the Convention :

I. General Comments on the management system

Japan understands that the United States Proposal was made for the purpose of establishing the management system provided for in Part 2 of the Annex of the Convention.

Japan insisted "olympic" fishery as the management system at the past conferences.

Taking into consideration of the total fishery resources and fishing capacity of the Parties , Japan found , however , that the implementation of " olympic "fishery would not provide sufficient fishing term for the parties and bring the result of depriving each Party of the flexibility in making its own fishery plan .

Japan also found that the implementation of " olympic "fishery would involve much technical and practical difficulties in the monitoring of fisheries and for the determination of the fishery closure date and ways of its anouncement .

From these points of view , Japan is now planning to propose a management system including INQ fishery , not " olympic " fishery , in the next meeting on compliance .

II. Comments on the U.S. proposal

1. Because the U.S. proposal was made for the purpose of establishing the management system provided for in Part 2 of the Annex of the Convention, a description of "THE MANAGEMENT SYSTEM provided in PART 2 OF THE ANNEX OF THE CONVENTION" should be added in the title of the U.S. proposal .

2. "II.1. Fishing Season"

Japan understands that, in order to avoid unnecessary financial burden ,long term fishing season should be established .

All the Parties should be reminded of the past experience of the operations of Japanese fishing vessels within the U.S. 200mile-waters that the fishing operations of all the year round have resulted in comparatively adequate utilizations and reproductions of the pollock resources.

Taking into consideration of such backgrounds, Japan considers that 1 February would be practical as the starting date of fisheries and 31 December would be the most suitable as the closure date of fisheries.

3. "II.2. Indivisual National Quota (INQ)"

Japan is ready to discuss on the introduction of a INQ fishery .

4. "II.3. "Olympic" fishery";

(a) As mentioned above , Japan is now planning to propose a management system including INQ fishery .not " Olympic " fishery .

Concerning the Central Managing Agency (CMA) and the Managing Agency (MA) mentioned in the U.S. proposal , Japan would like to examine carefully from various aspects including Japanese legal system .

(b) "Required Information"

1. We have already established the procedure of check-in report (at least 48 hours before) to the U.S. coast guard, so that the U.S. proposal may become the additional and/or duplicable to the exsisting procedure.

In order to simplify the procedures and prevent the mistakes of reporting by fishing vessels, the Parties should further discuss on the simplification of this report taking into consideration of the exsisting procedure.

2. With regard to the item of "daily harvesting and/or processing capacity" contained in a check-in report, Japan understands that this kind of information would not be changed frequently so that it is better to include this item in the list of fishing vessels, which should be submitted to the other Parties in advance in accordance with a Central Bering Sea Observer Program.

3. With regard to involvement of the items of amount of other species caught, all bycatch and discards in a check-in report , Japan would like to suggest that these items should be deleted from required items in a check-in report because fishermen are required too much burden .

4. With regard to the item of catch-per-unit-effort-of-pollock, Japan would like to suggest that this item should be reported by the manner of "metric tons per day" instead of the "metric tons per hour", as this manner would be enough to maintain the implementation of the management system.

5. With regard to the time basis of a check-in report, Japan would like to suggest to adopt the GMT basis instead of the ALT basis, as all Parties already agreeed the GMT basis in the manners for a filling of the fishing diary and, therefore, the adoption of the ALT basis may cause the unnecessary mistakes at report making.

The GMT basis would also become the most universal measure among all the Parties.

(c) "Fishery Monitoring Procedure"

1. With regard to the treatment of missing date of daily harvest amount, Japan understands the purport of the U.S. proposal . However, Japan would like to

discuss on this point in later stage , if necessary .

2. As mentioned above , the "A.I.t." should be replaced by the "G.M.T." .

5. " III.2 ENFORCEMENT

With regard to this item , the U.S. proposal may become the additional and /or duplicable to the existing procedure of the announcement .

For this reason , the U.S. proposal should be discussed on taking into the account of the simplification of announcement and prevention of the mistakes of reporting by fishing vessels .

Further ,concerning the other points mentioned in the III-2 of U.S. proposal , Japan considers that the necessity of these points should be discussed in later stage .

Polish remarks to the „United States Proposal for
A MANAGEMENT SYSTEM IN THE
CENTRAL BERING SEA"

Conservation and Management Measures

1. Fishing Season

In the Annex, Part 2 the Convention the definition „a starting date" exists and there is nothing about „a fishing season". Polish proposal is: „The starting day for the fishery on pollock in the Central Bering Sea shall start on_1-th of January each year and last to the time when the Annual Harvest Level (AHL) is exhausted".

Comments

Fishing seasons are usually established for protecting the spawning period, juvenile fish or for protecting the other species passing through the fishing grounds. There are no such reasons in the Central Bering Sea.

2. Individual National Quota (INQs)

Polish approach to distribution of AHL is based on two criteria: historical base (the catch level) and geographical approach. This_proposal can be presented at the meeting of Science and Technical Committee. If that proposal is rejected we will support US suggestion on equal division of the AHL among the six Parties.

3. „Olympic" fishery

Poland oppose to the „Olympic" system of fishery for pollock for the following reasons:

- The „Olympic" system does not serve the goal of rational utilisation of the fish stocks. This system commences a „race for fish" with increased investment in larger vessels and a shortening of the fishing season.
- The „Olympic" system has been subjected to the criticism of many states, international fishing_organisations, as well as individual fishermen.
- The „Olympic" system, in the case of the Bering Sea, would greatly favour coastal states.

The US proposal does not take into consideration the subparagraphs (b) and © Annex part 2 which obliged to „take into account the applicable fishing effort of each party, the harvesting and processing capacity of the fishing vessels that may be involved, and their relative efficiency; not_prejudge the opportunity for fishing vessels of all Parties to participate in the fishery".

JAPANESE PROPOSAL FOR A MANAGEMENT SYSTEM IN THE CENTRAL BERING SEA, WHICH SHOULD BE PROVIDED IN THE PART 2 OF THE ANNEX OF THE CONVENTION

1. Each Parties shall establish the next year's INQs on the basis of the next year's AHL, as follows:

(1) In case that AHL was determined at other than 0 and less than 190,000MT, equal division of AHL among Parties will be established as INQs for each Parties.

(2) In case that AHL was determined at more than 190,000MT, INQs shall be determined by consensus at the Annual Conference.

(3) In case that each Parties have experienced 3 years(times) the establishment of next year's INQs in accordance with the procedures of (1) above, the next years INQ's after 4th year(time) shall be established, in spite of the provision of (1) above, as follows:

(a) If the total catch amount of the latest 3 years attained more than 50% of its total amount of AHLs, 50% of AHL would be divided equally among Parties and the rest 50% of AHL would be divided in accordance with the ratio of the catch amount of the latest 3 years of each Parties.

(b) If the total catch amount of the latest 3 years did not attain 50% of its total amount of AHLs, equal division of AHL among Parties would be established as the next year's INQs for each Parties.

2. Starting date for the fisheries is 1 January .

3. A program for effective monitoring of catch and procedures of closing the fishery

(1) Each Parteies are responsible for establishment of monitoring catch, procedures of closing the fishery and implementations of them.

Therefore, each Parties shall establish the most effective and suitable program and procedures in accordance with their fisheries situations.

(2) Each Parties shall inform the monthly pollock-catch amount (MT:XX.X) to the representative Party,who is appointed from Parties in order, until 5th day of next month. If 5th day is holiday, it should be informed until the latest working day.

(3) The representative Party should prepare the list of monthly pollock-catch data and distribute it to other Parties immediately.

If the total catch amount of the Party was reached to INQ, the representative Party should notify the recomendation of immidiate close of fisheries to its Party.

(4) Each Parties should submit the final pollock-catch data of the last year and the provisional catch data of this year at the Annual Conference.

If any Parties closed fisheries, they should notify the closed date and provisional catch data to other Parties immediately.

(5) For making schedules of boarding observers, each Parties should notify the fishing plan to other Parties until the date of six weeks advance of the starting day of fishing operation within the Convention Area.

If the fishing plan was amended after notification, the Party should notify the amendment of its plan to other Parties.

These amendment should be notified at least six weeks advance of the starting day of fishing operation within the Convention Area, unless it was caused by weather, sea conditions or other unavoidable incident.

The fishing plan should include at least the specific informations of fishing vessels and of individual plans of each fishing trips.

4. This management system may be revised in any time, if necessary,by the consensus of Parties.

A CASE STUDY OF INQ ESTABLISHMENT BY MANAGEMENT SYSTEM OF JAPAN PROPOSED

YEAR	AHL	INQ	AMOUNT OF CATCH	NOTE
2000 (1st year)	60,000	A=10,000 D=10,000 B=10,000 E=10,000 C=10,000 F=10,000	A= 0 D= 0 B= 5,000 E=10,000 C=10,000 F=10,000	(1st year of begining 3years) INQs are established by equal division of AHL among 6 Parties.
2001 (-)	0	-	-	This year is not included in a year of begining 3years.
2002 (2nd year)	120,000	A=20,000 D=20,000 B=20,000 E=20,000 C=20,000 F=20,000	A=10,000 D=15,000 B=20,000 E=10,000 C=0 F=5,000	(2nd year of begining 3years) INQs are established by equal division of AHL among 6 Parties.
2003 (3rd year)	120,000	A=20,000 D=20,000 B=20,000 E=20,000 C=20,000 F=20,000	A=0 D=15,000 B=10,000 E=10,000 C=20,000 F=10,000	(last year of begining 3years) INQs are established by equal division of AHL among 6 Parties.
2004 (4th year)	120,000	A=10,000+3,750 =13,750 B=10,000+13,125 =23,125 C=10,000+11,250 =21,250 D=10,000+11,250 =21,250 E=10,000+11,250 =21,250 F=10,000+15,675 =25,675	A= ? B= ? C= ? D= ? E= ? F= ?	- As total catch of the latest 3years is 160,000 and more than 50% of total AHLs(300,000), 50% of AHL is divided equally and rest 50% is divided in accordance with the 3years catch ratio of Parties. - 3years catch ratio: A:10,000/160,000=6.25% B:35,000/160,000=21.875% C:30,000/160,000=18.75% D:30,000/160,000=18.75% E:30,000/160,000=18.75% F:25,000/160,000=15.625%

Report of the Meeting of the Science Group
of the Scientific and Technical Committee for the
Convention on the Conservation and Management of Pollock Resources
in the Central Bering Sea

2-4 September 1998
Seattle, Washington

Final 1300 4 September 1998

Delegations from the People's Republic of China, Japan, the Republic of Korea, the Republic of Poland, the Russian Federation, and the United States participated in a meeting of the Science Group during the intersessional meeting of the Scientific and Technical Committee held at the Alaska Fisheries Science Center in Seattle. The meeting agenda and a list of the participants are provided in Attachments 1 and 2, respectively.

A. Election of Chair and Rapporteur

The group elected Dr. Loh-Lee Low (USA) chairman of the meeting. Mr. Paul Niemeier (USA) was appointed rapporteur.

B. Pollock Stock Assessments

B.1. Update catch and effort statistics

The Bering Sea basin pollock fishery data manager, Dr. James Ianelli (USA), reported on the status of the pollock data base. He provided the participants with tables containing data on pollock catch and age composition for the Bering Sea (Attachment 3) and requested that they review the information and, where possible, provide updated or missing information. The tables will be updated at the next Annual Conference.

B.2. Present Results of Trial Fishing

Only Poland conducted trial fishing operations in the central Bering Sea since the last meeting of the Science Group. The Polish delegation presented the results of these operations, which were conducted by one Polish fishing vessel from 12-15 October 1997 (Attachment 4). Echosounding along the northeastern and southern boundaries of the Convention Area produced no indications of pollock. A total of three control hauls were made (all executed along the southern boundary), but no pollock were caught.

B.3. Review results of the 1997/1998 research cruises

Japan reported on the results of its mid-water trawl survey conducted in the central Bering Sea area from 4-13 January 1998 (Attachment 5). No significant echo sign of adult pollock was observed and no pollock were caught during the survey period.

Dr. Anne Hollowed (USA) reported on an interdisciplinary research project in progress to study the early life history of pollock in the eastern Bering Sea. One objective of the research is to develop a 3-dimensional physical model of the eastern Bering Sea which includes surface and subsurface flows. Dr. Hollowed said that model results should be available in 1999.

The U.S. delegation presented results from the NOAA research vessel *MILLER FREEMAN* echo integration-trawl survey of pollock in the southeastern Aleutian Basin near Bogoslof Island during March 1998 (Attachments 6 and 7). The Bogoslof Island spawning area was surveyed from 2-9 March 1998. Fourteen midwater hauls were taken over a 1,500 nautical-mile trackline. Most pollock were found to be in pre-spawning condition and aggregated in slope waters in Samalga Pass, between Umnak Island and the Islands of the Four Mountains in the Aleutian chain. The biomass estimate for the entire Bogoslof survey area was 492,000 t, with biomass acoustic error bounds of +/- 38%. The estimate for the Bogoslof Area specified in the Convention (the Specific Area) was 432,000 t. The United States noted that the total biomass in 1998 appears to be up slightly from 1997.

The United States delegation also distributed a stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands region (Attachment 8). The Russian delegation distributed pollock stock assessment documents for the western Bering Sea and Navarin area (Attachment 9).

B.4. Review and update status of the Aleutian Basin stock

B.4.i Relative and absolute abundance of pollock resources in the Aleutian Basin

Participants agreed that there is insufficient information to estimate the absolute biomass of the pollock resource in the Aleutian Basin directly (Table 1). Information from scientific surveys and trial fishing operations conducted by the Parties indicate that relative abundance of pollock in the Aleutian Basin remains low. Nevertheless, the results of the *MILLER FREEMAN* survey of pollock in the southeastern Aleutian Basin near Bogoslof Island during March 1998 suggest that pollock biomass may be increasing (from 392,000 t in 1997 to 492,000 t in 1998).

B.4.ii. Biomass of pollock in the area identified in Annex Part 1(b)

Only one estimate of absolute abundance of pollock in the Annex Part 1(b) Specific Area was made in 1998 (Table 2). This direct estimate was made from data collected during the echo integration-trawl survey in the Bogoslof Island area by the United States.

Table 1. Aleutian Basin pollock biomass estimates

Absolute Abundance estimates:	insufficient information to estimate biomass directly
Relative Abundance estimates:	Bogoslof survey series (U.S. in 1998) -- low abundance
	Donut Hole survey (Japan in 1998) -- low abundance
	Donut Hole trial fishing (Poland in 1997) -- low abundance

Table 2. Annex Part 1(b) Specific Area pollock biomass estimates

Country	Dates	Description	Estimate
United States	2-9 March 1998	pre-spawning	432,000 t

B.4.iii. The status of pollock stocks in the central Bering Sea and fishery prospects

Participants agreed that, based on the available information, the pollock stocks in the central Bering Sea are at a low level (Tables 1 and 2). It was the opinion of the U.S. and Russian delegations that, on a scientific basis, the Parties could discuss the prospects of a fishery in the central Bering Sea. The Japanese, Korean, and Polish delegations, however, expressed the opinion that any discussion of fishery prospects in 1999 would need to be deferred to the Third Annual Conference in Tokyo. Poland commented that a Polish vessel will begin trial fishing in the central Bering Sea for a period of three or four days beginning on 3 September 1998. Consequently, it would be premature to judge fishing prospects at this meeting.

B.4.iv. Coordination of age determination methods for pollock

Dr. Dan Kimura (USA) presented the results of the Second Workshop on Ageing Methodology of Walleye Pollock (*Theragra chalcogramma*) held at the Alaska Fisheries Science Center in Seattle on 17-20 March 1998. The report of the Workshop is provided at Attachment 10. Participants in the workshop concluded that age readers from different laboratories were able to arrive at reasonably similar results, but that repeatability was difficult to achieve. It is difficult to get the same accuracy of results without the ability of age readers to meet face-to-face. The issues of false rings and miss-identification of other cod species for juvenile pollock were also explored at the Workshop. It is the general opinion of the Science Group that such workshops are useful and should be continued. They are valuable in enabling the Parties to continue to refine and standardize ageing techniques.

C. Review cooperative research plans

The United States informed the other Parties that the NOAA research vessel *MILLER FREEMAN*, which has conducted pollock biomass surveys in the Bering Sea since 1978, is being sent to the shipyard for repairs. Although completion of the repair work is expect by late February 1999, it will be too late for the *MILLER FREEMAN* to conduct the annual echo integration-trawl survey in the Bogoslof Island area.

Japan distributed an outline of a cruise plan for an echo integration and midwater trawl survey on pelagic pollock in the central Bering Sea (Attachment 11). This cruise will be a cooperative survey with the United States, due to the unavailability of the *MILLER FREEMAN*. Japan will utilize the *KAIYO MARU* for the survey. The primary objectives of the survey are (1) to determine the geographical distribution of pollock in the southeastern Aleutian Basin area and in the southern part of the eastern Bering Sea shelf; (2) to collect echo integration data to determine

the biomass of pollock in the area, (3) to collect biological information on pollock in the basin and shelf areas, and (4) to collect information on the oceanographic and biological environments in the area. The main survey would run from late January to mid-March 1999, and would cover the area historically surveyed by the *MILLER FREEMAN*. The Japanese delegation indicated that there will be room on board the vessel for two or three scientists from the other Parties.
All Parties indicated an interest in participating in the *KAIYO MARU* cruise. Japan said it would need to make final arrangements for participation by scientists from the other Parties by the end of October 1998, so Parties should submit requests as soon as possible.

In order to duplicate the historic survey trackline of the *MILLER FREEMAN*, the *KAIYO MARU* will need to conduct portions of the survey within three miles of the Aleutian Islands, and possibly in sensitive areas, such as Steller sea lion rookeries. Permission to conduct the survey within U.S. territorial waters will need to be granted by the U.S. Department of State.
The Science Group supports this important survey cruise and feels that it is critical that the *KAIYO MARU* be granted access to U.S. territorial waters, including sensitive areas within those waters.

The U.S. delegation thanked Japan for continuing the important work of the *MILLER FREEMAN* and for inviting participation by the other Parties.

The Japanese delegation informed the other Parties that Japan is pleased to be able to continue the survey work in the absence of the *MILLER FREEMAN* in 1999. However, Japan can't promise that it will be able to send the *KAIYO MARU* to the Bering Sea to conduct such research in following years.

The Korean delegate stated that Korea is replacing the *PUSAN 851* with a new research vessel. Korea intends to continue conducting research cruises in the central Bering Sea. However, because Korea has not yet taken delivery of the new vessel, the timing of the next cruise has not been determined. Korea hopes to announce its research cruise plans at the Annual Conference in Tokyo. The Korean delegate said that the new vessel will have room to accommodate several scientists from the other Parties. He extended an invitation to scientists from the other Parties to participate in the next cruise.

No other Parties indicated any plans for research cruises in 1999.

Future Research: In addition to discussing research cruise plans, the Science Group discussed possible research topics for future consideration by the Parties. Participants expressed a desire for more information on such topics as pollock year class synchrony between areas, age determination, migration, and stock genetics. The Science Group specifically discussed a number of projects that should be undertaken in order to better understand the processes influencing population dynamics in the Aleutian Basin area. These included:

(1) The definition of pollock stock structure through the use of mass marking (specifically tagging) and recovery, and genetic studies. The Science Group discussed the possibility of the coordinated collection of genetic material by the Parties during the pollock spawning season and on trial fishing vessels, and the use of genetic markers to determine distribution of stocks. The U.S. delegation provided the other Parties with a document outlining a sampling method for

microsatellite DNA analyses (Attachment 12). The Group also discussed the use of acoustic surveys to monitor the out-migration of post-spawning pollock. The Russian delegation informed the other Parties that genetic studies of closely related pre-spawning groupings of pollock (Unimak, Pribilof, St. Mathew, and Navarin) found in similar habitats may fail to show differences. Based on Russia's experience, pollock population structure studies are possible only within comprehensive research of pollock stocks.

(2) The definition of potential pollock migratory corridors. This could be accomplished through the development of the 3-dimensional circulation model for the Bering Sea (Section B.3 above) and maps of bottom temperatures and the extent of sea ice. Parties could conduct retrospective analyses of adult fish age/spatial distributions relative to major oceanographic features.

(3) The definition of potential density dependent processes on eastern and western Bering Sea shelf regions. Parties discussed conducting seasonal analyses of pollock food habits and bioenergetics.

The Chairman stated his belief that the best way to begin pursuing such projects is for the Parties to begin interacting on a scientist-to-scientist basis. He cited the example of coauthoring papers on the above topics. As a first step in this process, the Science Group agreed to dedicate at least one half day at its 1999 meeting to the exchange and discussion of papers on genetic studies conducted by the Parties.

<u>Research Within the Coastal States' 200-mile Zones</u>: Russia will conduct a research cruise in the western Bering Sea in 1999 utilizing the R/V *PROFESSOR KAGANOVSKIY*. The objectives of the cruise are to assess pollock stock biomass and to study the structure of pollock populations. The cruise may be conducted jointly with the United States and may include surveying a portion of the U.S. zone, depending on funding. There is also a possibility that Russia will conduct an ichthyoplankton survey of the western Bering Sea, particularly the Karagin area, in spring 1999.

Regarding research within the U.S. zone, the Alaska fisheries Science Center's acoustics group will conduct research in the eastern Bering Sea or the Gulf of Alaska in 1999. The U.S. annual bottom trawl survey for the eastern Bering Sea is scheduled for the summer (June to August) of 1999. The survey is conducted using two chartered commercial fishing vessels.

D. Review trial fishing plans

Poland indicated that it has tentative plans to conduct trial fishing operations in the central Bering Sea in 1999. The Polish representative explained the difficulty in providing detailed trial fishing plans at intersessional meetings of the Scientific and Technical Committee when the AHL for the next year is not determined until the Annual Conference. Poland provided a general cruise plan for trial fishing operations in 1999 (Attachment 13) and informed the Science Group that more detailed information will be provided to the Parties on trial fishing operations well in advance of vessels entering the area.

China indicated that it may also wish to conduct trial fishing operations in 1999. It will provide detailed information to the Parties later.

E. Observer plans

There was no discussion of observer plans. The Chairman observed that, in the future, there should be an orderly process for placing observers on fishing vessels. For the purposes of the Science Group, the function of the observer is to collect scientific information. The procedures for doing this have already been addressed in the Observer Manual previously addressed by the Parties.

List of Attachments

Attachment Number*/Title

1. Agenda
2. List of participants
3. Status of Bering Sea Basin Fishery Information Database. (AFSC, USA)
4. Information about Polish fishing trial on pollock in the international waters of the Bering Sea in 1997. (Jerzy Janusz, Poland).
5. Cruise results of mid-water trawl survey on pelagic pollock in the international waters of the Bering Sea, winter 1997. (FAJ, Japan)
6. NOAA Ship *MILLER FREEMAN* Cruise No. 98-02: Preliminary cruise results, echo integration-trawl survey of the southeastern Aleutian Basin near Bogoslof Island. (AFSC, USA)
7. Walleye pollock (*Theragra chalcogramma*) abundance in the southeastern Aleutian Basin near Bogoslof Island during March, 1998. (Taina Honkalehto and Neal Williamson, USA)
8. Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. (North Pacific Fishery Management Council, USA).
9. Pollock stock assessment documents. (Russia)
10. Report from the Second Workshop on Ageing Methodology of Walleye Pollock (*Theragra chalcogramma*). (AFSC, USA)
11. Outline of cruise plan for echo integration and mid-water survey on pelagic pollock in the Bering Sea (tentative plan). (NRIFSF, FAJ, Japan)
12. Pollock genetic stock structure: Sampling for microsatellite DNA analyses. (AFSC, USA)
13. Cruise plan for Polish fishing trial operations on pollock in the international waters of the central Bering Sea in 1999. (Poland)

* - As referenced in the 2-4 September 1998 Report of the Science Group

Meeting of the Science Group of the Scientific and Technical Committee for the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea

2-4 September 1998
Seattle, Washington

Agenda

A. Election of chairperson and rapporteur
B. Pollock stock assessments
B.1. Update catch and effort statistics
B.2. Present results of trial fishing
B.3. Review results of 1997/1998 research cruises
B.4. Review and update status of pollock stocks
  i. Relative and absolute abundance of pollock resources in the Aleutian Basin
  ii. Biomass of pollock in the area identified in Annex Part 1(b)
  iii. The status of pollock stocks in the central Bering Sea and fishery prospects
  iv. Coordination of age determination methods for pollock
C. Review cooperative research plans
D. Review trial fishing plans
E. Observer plans

Meeting of the Science Group of the Scientific and Technical Committee for the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea

2-4 September 1998
Seattle, Washington

List of Participants

People's Republic of China

Ming Li	China National Fisheries Corporation, U.S. Representative Office, Seattle
Eric Dai	China National Fisheries Corporation, U.S. Representative Office, Seattle
Louie Han	China National Fisheries Corporation, U.S. Representative Office, Seattle
Baoxiu Zhang	China National Fisheries Corporation, U.S. Representative Office, Seattle

Japan

Tokimasa Kobayashi	Hokkaido National Fisheries Research Institute, Fisheries Agency of Japan
Akira Nishimura	National Research Institute of Far Seas Fisheries, Fisheries Agency of Japan
Yoshitsugu Shikada	Resources Development Department, Fisheries Agency of Japan

Republic of Poland

Ireneusz Wojcik	"DALMOR" S.A., Deep Sea Fishing Co., Gdynia
Jerzy Janusz	Sea Fisheries Institute, Gdynia

Republic of Korea

Yang Won-Seok	National Fisheries Research & Development Institute

Russian Federation

Boris Kotenev	Director of VNIRO, Moscow
Albina Maksimova	Department of Fisheries, Moscow
Leonid Borets	TINRO, Vladivostok
Yuri Ryazantsev	VNIRO, Moscow

United States

Richard Marasco	Alaska Fisheries Science Center, National Marine Fisheries Service
Loh-Lee Low	Alaska Fisheries Science Center, National Marine Fisheries Service
Neal Williamson	Alaska Fisheries Science Center, National Marine Fisheries Service
Taina Honkalehto	Alaska Fisheries Science Center, National Marine Fisheries Service
Anne Hollowed	Alaska Fisheries Science Center, National Marine Fisheries Service
James Ianelli	Alaska Fisheries Science Center, National Marine Fisheries Service
Dan Kimura	Alaska Fisheries Science Center, National Marine Fisheries Service
Betty Goetz	Alaska Fisheries Science Center, National Marine Fisheries Service
Mike Canino	Alaska Fisheries Science Center, National Marine Fisheries Service
Paul Niemeier	Office of Sustainable Fisheries, National Marine Fisheries Service
Fran Bennis	Alaska Marine Conservation Council
Wally Pereyra	ProFish International

SG Attachment 3

Table 1. Walleye pollock catch (in metric tons) by Bering Sea areas

Year	Donut	W. Bering Sea (a)	Navarin Area (b)	Aleutians	Bogoslof (c)	E. Bering Sea	Total
1964						175,600	175,600
1965						230,000	230,000
1966						261,800	261,800
1967						551,800	551,800
1968						704,900	704,900
1969						862,500	862,500
1970						1,253,600	1,253,600
1971						1,733,200	1,733,200
1972						1,869,300	1,869,300
1973						1,763,300	1,763,300
1974						1,580,300	1,580,300
1975						1,364,900	1,364,900
1976			467,000			1,180,800	1,647,800
1977			180,000	7,600		973,400	1,161,000
1978			25,400	6,300		976,700	1,008,400
1979			28,500	9,500		935,700	973,700
1980			620,000	58,200		958,300	1,636,500
1981			900,000	55,500		973,500	1,929,000
1982			804,000	58,000		956,000	1,818,000
1983			722,000	59,000		981,500	1,762,500
1984	181,200		503,000	81,800		1,092,100	1,858,100
1985	363,400		488,000	58,700		1,139,700	2,049,800
1986	1,039,800		570,000	46,600		1,142,000	2,798,400
1987	1,326,300		463,000	28,700	377,000	859,400	3,054,400
1988	1,395,900		852,000	43,000	87,800	1,228,700	3,607,400
1989	1,447,600		684,000	15,500	36,100	1,229,600	3,412,800
1990	917,400		232,000	79,000	151,700	1,455,200	2,835,300
1991	293,400	309,000	178,000	78,600	264,800	1,217,300	2,341,100
1992	10,000	281,000	316,000	54,000	200	1,164,400	1,825,600
1993	2,000	363,000	389,000	57,100	900	1,326,600	2,138,600
1994	0	210,000	178,000	58,600	600	1,363,500	1,810,700
1995	0	86,000	320,000	63,000	300	1,262,800	1,732,100
1996	0	56,000	753,000	29,100	400	1,192,800	2,031,300
1997	0	70,000	680,000	25,000	200	1,112,800	1,888,000
1998	0					1,099,200	1,099,200

(a) Russian EEZ, west of 176 degrees E Longitude

(b) Russian EEZ, east of 176 degrees E Longitude

(c) Bycatch only from 1992

Table 2. 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)	Asian North Pacific	Total	FAO Data
1964	1,100	175,600						176,700	
1965	2,700	230,000						232,700	
1966	8,900	261,800						270,700	
1967	6,300	551,800						558,100	
1968	6,200	704,900						711,100	
1969	17,600	862,500						880,100	
1970	9,300	1,253,600						1,262,900	
1971	9,500	1,733,200						1,742,700	
1972	34,100	1,869,300						1,903,400	
1973	36,800	1,763,300						1,800,100	
1974	61,900	1,580,300						1,642,200	
1975	59,500	1,364,900						1,424,400	
1976	86,500	1,180,800						1,267,300	
1977	112,100	973,400						1,085,500	
1978	90,800	976,700						1,067,500	
1979	98,500	935,700						1,034,200	
1980	110,100	958,300						1,068,400	
1981	139,200	973,500				900,000	3,799,800	5,812,500	4,176,800
1982	168,700	956,000				804,000	3,259,700	5,188,400	4,478,200
1983	215,600	981,500				722,000	2,817,200	4,736,300	4,858,100
1984	306,700	1,092,100		181,200		503,000	3,617,400	5,700,400	5,986,300
1985	284,900	1,139,700		363,400		488,000	3,396,200	5,672,200	6,132,300
1986	93,600	1,142,000		1,039,800		570,000	3,393,100	6,238,500	6,758,900
1987	69,500	859,400	377,000	1,326,300		463,000	3,083,700	6,178,900	6,724,000
1988	65,600	1,228,700	87,800	1,395,900		852,000	2,778,200	6,408,200	6,658,600
1989	78,200	1,229,600	36,100	1,447,600		684,000	2,692,000	6,167,500	6,320,900
1990	90,500	1,455,200	151,700	917,400		232,000	2,720,500	5,567,300	5,736,100
1991	107,500	1,217,300	264,800	293,400	309,000	178,000	2,757,100	5,127,100	4,893,500
1992	93,900	1,164,400	200	10,000	281,000	316,000	2,860,100	4,725,600	4,987,000
1993	108,200	1,326,600	900	2,000	363,000	389,000	2,053,000	4,242,700	4,617,000
1994	111,200	1,363,500	600	0	210,000	178,000	1,861,900	3,725,200	4,299,000
1995	67,000	1,262,800	300	0	86,000	320,000	2,072,000	3,808,100	
1996	49,800	1,192,800	400	0	56,000	753,000		2,052,000	
1997	74,100	1,112,800	200	0	70,000	680,000		1,937,100	
1998	120,800	1,099,200		0				1,220,000	

(a) Russian EEZ, west of 176 degrees E Longitude
(b) Russian EEZ, east of 176 degrees E Longitude

Table 3 Bering Sea "donut hole" pollock catches (in metric tons) and catch per unit effort (in t/hour, t/day, or t/trawl) by country by quarter, 1985-1993.

Year	Quarter	CHINA[1] T	CHINA[1] T/HR	JAPAN[2] T	JAPAN[2] T/HR	KOREA[3] T	KOREA[3] T/HR	POLAND[2] T	POLAND[2] T/HR	USSR/FSU[4] T	USSR/FSU[4] T/TRAWL	TOTAL[5] T
1985	Q1	?		136,315	?	68,841	6.6	30,392	6.23			235,548
	Q2	?		8,429	?	11,789	6.7	67,472	7.50			87,690
	Q3	?		2,549	?	0	-	94	3.36			2,643
	Q4	?		16,213	?	1,814	11.7	17,916	9.82			35,943
	TOT	1,600		163,506	4.8	82,444	6.6	115,874	7.39			363,424
1986	Q1	?		381,012	7.7	79,758	6.86	72,396	7.26	?	?	533,166
	Q2	?		76,000	6.7	11,394	4.80	49,435	7.31	?	?	136,829
	Q3	?		6,514	2.2	0	0.00	345	3.03	?	?	6,859
	Q4	?		242,095	12.4	64,566	11.91	41,073	6.47	?	?	347,734
	TOT	3,200		705,621	8.5	155,718	8.02	163,249	7.00	12,000	?	1,039,788
1987	Q1	0	0	345,917	8.0	60,729	9.07	86,968	6.80	?	?	493,614
	Q2	0	0	80,103	4.5	16,753	5.38	86,142	5.66	?	?	182,998
	Q3	34	0.88	905	0.9	26,176	3.58	16,157	6.00	?	?	43,272
	Q4	16,495	4.61	376,625	11.2	138,212	8.75	41,051	4.07	?	?	572,383
	TOT	16,529	4.57	803,550	8.4	241,870	7.35	230,318	5.64	34,000	?	1,326,267
1988	Q1	849	1.83	126,089	4.4	17,524	3.66	58,929	2.85	?	?	203,391
	Q2	0	0	85,880	4.4	32,233	4.13	102,646	5.72	?	?	220,759
	Q3	343	1.75	34,262	5.8	60,546	3.70	54,106	4.90	?	?	149,257
	Q4	17,227	3.76	503,751	9.1	158,296	6.43	83,033	4.39	?	?	762,307
	TOT	18,419	3.51	749,982	6.8	268,599	5.01	298,714	4.38	61,000	?	1,396,714
1989	Q1	1,138	1.43	110,289	3.7	24,882	2.92	41,047	3.42	?	?	177,356
	Q2	0	0	138,490	10.8	134,209	5.20	105,481	6.15	?	?	378,180
	Q3	16,991	2.95	34,658	5.3	91,625	3.16	44,660	3.72	?	?	187,934
	Q4	13,010	2.85	371,472	6.3	91,580	3.61	77,382	4.82	?	?	553,444
	TOT	31,139	2.80	654,909	6.0	342,296	3.86	268,570	4.51	150,700	34.3	1,447,614
1990	Q1	3,207	1.51	74,267	2.3	15,454	1.65	17,331	2.08	?	?	110,259
	Q2	4,093	2.66	165,488	4.4	120,534	2.94	102,176	3.52	?	?	392,291
	Q3	13,997	2.03	50,744	4.2	75,462	2.53	55,976	2.63	?	?	196,179
	Q4	6,529	1.73	126,521	2.4	32,821	1.48	47,971	2.50	?	?	213,842
	TOT	27,826	1.94	417,020	3.1	244,271	2.39	223,454	2.87	4,800	22.9	917,371
1991	Q1	132		12,880	.6	3,913	0.5	1,714	0.82	270	9.6 T/D	18,909
	Q2	4,978	.8	71,766	3.0	35,770	1.6	38,072	1.90	3,201	23.4 T/D	153,787
	Q3	10,540	1.1	33,203	2.6	29,196	1.3	15,073	1.66	0	0	88,012
	Q4*	1,003	.9	22,601	1.3	9,080	0.4	7	0.08	0	0	32,691
	TOT	16,653	1.0	140,450	1.8	77,959	1.0	54,866	1.76	3,471	18.5 T/D	293,399
1992	Q1	408	14.9 T/D	0		0		0	.	0?	.?	409
	Q2	3,565	17.4 T/D	2,695	1.2	4,018	0.8	0	.	0?	.?	10,137
	Q3	0	.	-	.-	35	0.5	0	.	-	.-	35
	Q4	0	.	-	.-	0	.-	0	.	-	.-	-
	TOT	3,973	17.1	2,695	1.2	4,053	0.8	0	.-	0	.-	10,581
1993	Q1	-	.-	-	.-	-	.-	-	.	-	.-	-
	Q2	-	.-	66	0.6	232	0.5	595	0.76	-	.-	-
	Q3	-	.-	30	0.3	244	0.3	-	.-	-	.-	-
	Q4	-	.-	3	.-	-	.-	-	.-	-	.-	-
	TOT	-	.-	99	0.4	476	0.4	595	0.76	-	.-	-

*preliminary data 1-Data provided by China. 2-Data provided at the 1991 and 1992 Seattle pollock workshops. 3-Compiled from data provided by Korea at 1990 Khabarovsk symposium and at 1991 and 1992 Seattle workshops; cpue data was interpolated from a graph presented at the 1990 Khabarovsk symposium. 4-Data presented at US-USSR bilateral meetings, from 1991 and 1992 Seattle pollock workshops and from 1991 Washington DC meeting. 5-Quarterly totals may not sum to the yearly total if a quarterly breakdown was not available. Updated through October 31, 1995

Additional notes on Korean data: CPUE data in t/day are as follows

1991 Q1	10.0	1992 Q1	-	1993 Q1	-
1991 Q2	25.0	1992 Q2	12.5	1993 Q2	5.5
1991 Q3	1.3	1992 Q3	7.0	1993 Q3	5.2
1991 Q4	0.4	1992 Q4	-	1993 Q4	-

Additional notes on data from Poland: CPUE data in t/day are as follows

1985 Q1	49.75	1986 Q1	49.24	1987 Q1	43.47	1988 Q1	24.52
1985 Q2	56.05	1986 Q2	49.73	1987 Q2	51.02	1988 Q2	56.21
1985 Q3	47.00	1986 Q3	20.31	1987 Q3	68.50	1988 Q3	55.49
1985 Q4	58.90	1986 Q4	43.90	1987 Q4	41.86	1988 Q4	51.33
Annual	54.50	Annual	47.70	Annual	47.00	Annual	43.80
1989 Q1	27.38	1990 Q1	18.40	1991 Q1	6.40	1992 Q1	-
1989 Q2	59.01	1990 Q2	40.30	1991 Q2	19.50	1992 Q2	-
1989 Q3	39.88	1990 Q3	31.30	1991 Q3	18.30	1992 Q3	-
1989 Q4	41.76	1990 Q4	20.90	1991 Q4	0.60	1992 Q4	-
Annual	42.94	Annual	29.50	Annual	18.00	Annual	-
1993 Q3	12.90						

INFORMATION ABOUT POLISH FISHING TRIAL ON POLLOCK IN THE INTERNATIONAL WATERS OF THE BERING SEA IN 1997

Jerzy Janusz
Sea Fisheries Institute,
Kollataja 1, 81-332 Gdynia, Poland

The trial fishing in the international waters of the Bering Sea (Donut hole) was carried out by Polish fishing vessel m/t ACAMAR in the period from October 12 through October 15, 1997. Because of the difficulty in access to the vessel, the time and scope of the cruise was a little different than presented in the cruise plan. The period of work was limited only to four days and because of that it was decided to make echosounding along northeast and south border of Donut hole (Fig. 1).

During the echosounding there were no indications of pollock. Occasionally, at the depth 200-250 m, small indications were observed on the echograms. In these places three control hauls were made. There was not a single pollock in the hauls; and only some myctophids, jellyfish, squids and Pacific lamprey were noticed.

The Haul Summary and Species Composition Forms (Attachment 1) were fulfilled by scientific observer - Radosław Zaporowski - who was placed on the vessel.

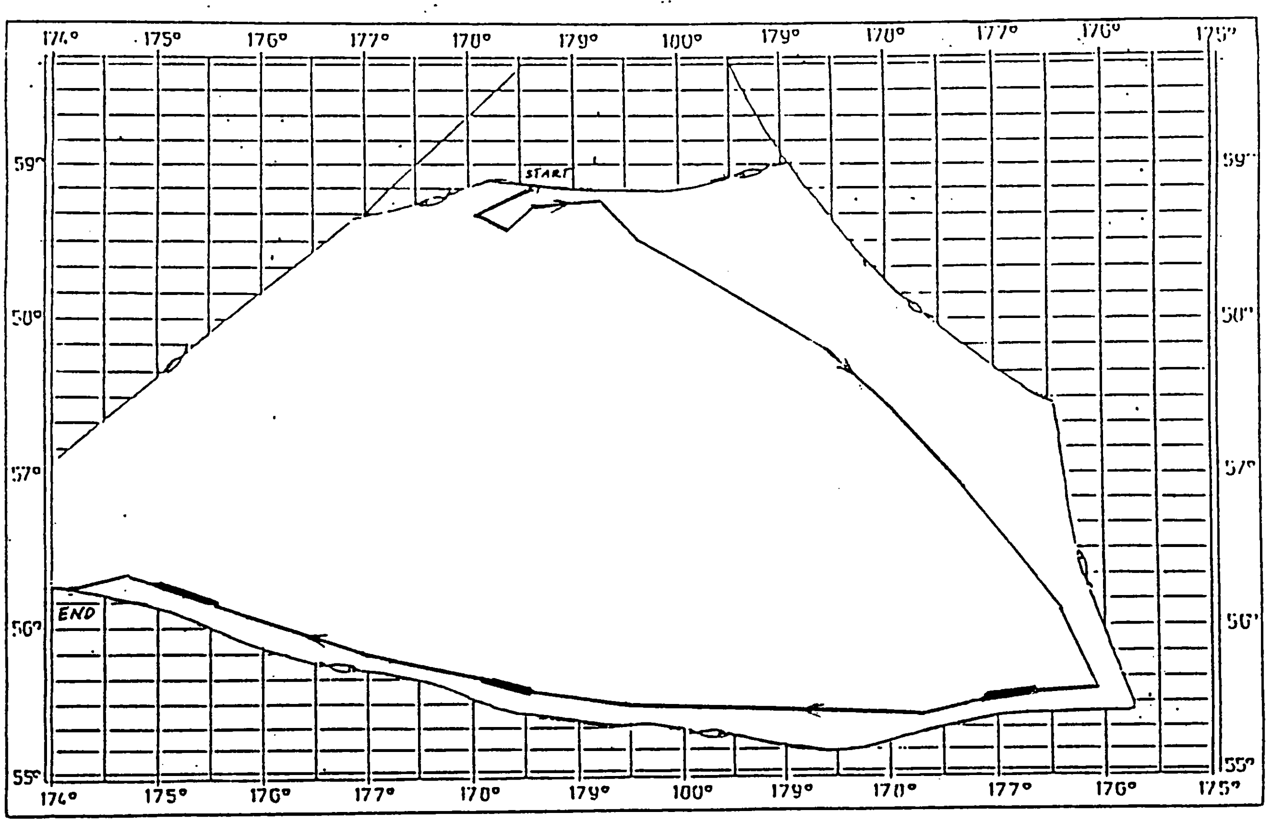


Fig. 1 Hydroacoustic trackline and hauls (solid lines) conducted during trial fishing of Polish vessel m/t ACAMAR in the intrnational waters of the

Attachment 1

HAUL SUMMARY FORM

PAGE 1 OF ____

CRUISE #		VESSEL CODE					YEAR	
2	3	4	5	6	7	8	9	10
I	V	S	Q	R	J		9	7

OBSERVER NATION
1 2 3 (4) 5

VESSEL NATION
1 2 3 (4) 5

OBSERVER NAME
R. Zaporowski

VESSEL NAME
M/T ACAMAR

DATE		HAUL #	GEAR TYPE	GEAR PERFORMANCE	HAUL POSITION			FISHING TIMES IN GMT		FISHING DURATION IN MINUTES	AVERAGE FISHING DEPTH	AVG. SPEED KNOTS	OBSERVER TOTAL CATCH ESTIMATE (MT)	VESSEL TOTAL CATCH ESTIMATE (MT)	SEA SURFACE TEMP. (C)	FISHING DEPTH TEMP. (C)	SEA STATE
MONTH	DAY				LATITUDE (NORTH)	1/2	LONGITUDE	NETS AT DEPTH	BEGIN RETRIEVAL								
11 12	13 14	15 - 17	18	19	20 - 23	24	25 - 29	30 - 33	34 - 37	38 - 40	41 - 43	44-45	46 - 50	51 - 55	56 - 59	60 - 63	64
10	13	129	1	1	5531	2	17652	12.40	3.20	160	350	4.2	0.005	0.	8.5	b.d	
10	14	130	1	1	5533	1	17810	0535	07.50	135	120	4.2	0.002	0.	8,5	b.d	
10	14	131	1	1	5604	1	17527	14.30	17.00	150	225	4,2	0.002	0.	8,5	b.d	

SPECIES COMPOSITION FORM

Page ______ of ______

Observer Name R. Zaporozhets

Observer Nation 1 2 3 (4) 5

Vessel Name m/t ACAMAR.

Vessel Nation 1 2 3 (4) 5

Species:						
Wt. of above:						
No. weighed:						
Avg. weight:						

CRUISE #			VESSEL CODE					YEAR		MONTH		DAY	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
X	I	V	S	Q	R	7		8	7	1	0	1	3

ST = Sampling Type
(1) = whole haul
2 = partial haul
3 = weighed sample

Haul (15 - 18)	Species name	Species code	ST	Number	Species weight in kg. w/ decimal	Sample weight in kg. w/ decimal
129		19 - 21	22	23 - 28	29 - 37	38 - 46
	(keypunch check)	999	X			X
	Myctophidae	12	1	50	2,0	
	Aptocyclus ventricosus	13	1	20	3,0	
	Decapoda	06	1	1	0,1	

Haul (15 - 18)	Species name	Species code	ST	Number	Species weight in kg. w/ decimal	Sample weight in kg. w/ decimal
130		19 - 21	22	23 - 28	29 - 37	38 - 46
	(keypunch check)	999	X			X
	Oncorhynchus keta	18	1	1	0,6	
	Myctophidae	12	1	45	2,0	
	Decapoda	06	1	1	0,5	

SPECIES COMPOSITION FORM

Page ______ of ______

Observer Name R. Zaporowski

Observer Nation 1 2 3 (4) 5

Vessel Name m/t Acamar

Vessel Nation 1 2 3 (4) 5

Species:						
Wt. of above:						
No. weighed:						
Avg. weight:						

CRUISE #			VESSEL CODE					YEAR		MONTH		DAY	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
X	i	V	S	Q	R	J		9	7	1	0	1	4

ST = Sampling Type
1 = whole haul
2 = partial haul
3 = weighed sample

Haul (15 - 18)	Species name	Species code	ST	Number	Species weight in kg. w/ decimal	Sample weight in kg. w/ decimal
		19 - 21	22	23 - 28	29 - 37	38 - 46
131	(keypunch check)	999	X			X
	Myctophidae	12	1	20	1,0	
	Aptocyclus ventricosus	13	1	8	1,0	
	Decapoda	06	1	2	0,5	

Haul (15 - 18)	Species name	Species code	ST	Number	Species weight in kg. w/ decimal	Sample weight in kg. w/ decimal
		19 - 21	22	23 - 28	29 - 37	38 - 46
	(keypunch check)	999	X			X

Document for STC meeting, Seattle
Sept, 1998

Cruise Results of Mid-water Trawl Survey on Pelagic Pollock in the International Waters of the Bering Sea, winter 1998

Fisheries Agency of Japan
(NRIFSF)

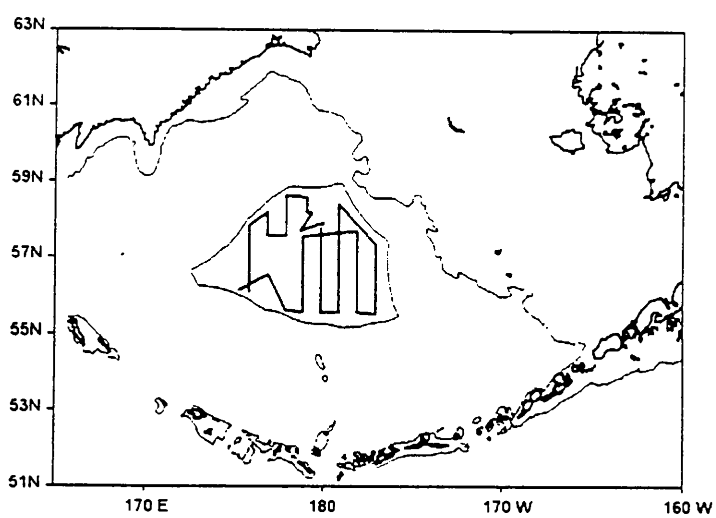
Objectives

The objectives of the 1998 winter cruise were to collect information about pollock distribution and their biological characteristics in the international waters of the Bering Sea, in winter.

Survey outline

The *Shoyo Maru* (Stern trawler; 279 t) was chartered for scientific research vessel of Fisheries Agency of Japan. Ecogram of vessel equipped acoustic system was collected continuously along the transects (Fig. 1). Acoustic survey was conducted from Jan. 4 to 13. During this survey period, no significant echo sign of adult walleye pollock was observed in the international waters. In this survey, there was no pollock catch and we could not get any biological data.

Fig. 1. Transect line during 1998 DH survey by *Shoyo Maru*.



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Alaska Fisheries Science Center
Resource Assessment and Conservation Engineering Division
7600 Sand Point Way Northeast
BIN C15700, Building 4
Seattle, Washington 98115-0070

May 5, 1998 F/AKC2:TH

NOAA SHIP MILLER FREEMAN
Cruise No. 98-02
Preliminary Cruise Results
Echo Integration-Trawl Survey of the Southeastern Aleutian Basin near Bogoslof Island

Midwater Assessment and Conservation Engineering
Alaska Fisheries Science Center
Seattle, WA 98115

Scientists from the Alaska Fisheries Science Center (AFSC) investigated the population distribution and characteristics of spawning walleye pollock (*Theragra chalcogramma*) in the southeastern Aleutian Basin near Bogoslof Island March 1-10, 1998, (10 sea days) using echo integration-trawl (EIT) survey techniques aboard the NOAA ship *Miller Freeman*. This research cruise was the tenth in a series that began in 1988 and has been continued annually with the exception of 1990 as part of long-term monitoring of Bering Sea walleye pollock. In 1998, the cruise began and ended in Dutch Harbor, Alaska, and was a cooperative effort involving scientists from the United States, Japan, and South Korea.

The vessel's itinerary was as follows:

Feb 27	Embark scientists in Dutch Harbor, AK.
Mar 1	Standard sphere calibration in Nateekin Bay, AK.
Mar 2-9	Echo integration-trawl survey of the Bogoslof Island region.
Mar 10	Standard sphere calibration in Captains Bay, Dutch Harbor, AK; end of cruise.

The primary cruise objectives were to collect echo integration data and midwater trawl data essential to determine the distribution, biomass, and biological composition of walleye pollock in the southeastern Aleutian Basin. The 38 kHz and 120 kHz scientific acoustic systems were calibrated using standard sphere techniques. Sea surface temperature and salinity were monitored continuously, and water column profiles were collected at selected sites. An acoustic Doppler current profiler was operated continuously in the water profiling mode.

Secondary objectives involved a number of separate projects and investigators from the AFSC, the University of Alaska, and the Alaska Department of Fish and Game (ADF&G).

METHODS

Sampling Equipment

Acoustic data were collected with a Simrad EK500[1] quantitative echo-sounding system on board the NOAA ship *Miller Freeman*, a 66-m (216 ft) stern trawler equipped for fisheries and oceanographic research. The Simrad 38 kHz and 120 kHz split-beam transducers were mounted on the bottom of the vessel's centerboard. With the centerboard fully extended, the transducers were 9 m below the water surface. System electronics were housed inside the vessel in a permanent laboratory space dedicated to acoustics. Data from the Simrad EK500 echo sounder/receiver were processed using Simrad BI500 echo integration and target strength data analysis software on a SUN workstation. Results presented in this document are based on the 38 kHz data.

Midwater echo sign was sampled using an Aleutian Wing 30/26 trawl (AWT), a full mesh wing trawl constructed of nylon except for polyethylene towards the aft section of the body and the codend. Headrope and footrope lengths each measured 81.7 m (268 ft) and mesh sizes tapered from 325.1 cm (128 in) in the forward section of the net to 8.9 cm (3.5 in) in the codend. The net was fitted with a 3.2 cm (1.25 in) codend liner. It was fished with 82.4 m (270 ft) of 1.9 cm (0.75 in) diameter 8x19 non-rotational dandylines, 227.3 kg (500-lb) tom weights on each side, and 5 m^2 "Fishbuster" doors [1,250 kg (2,750 lb)]. Vertical and horizontal net opening and depth were monitored with a WesMar third wire netsounder system attached to the headrope of the trawl.

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1 Reference to trade names or commercial firms does not constitute U.S. Government endorsement.

Temperature/depth data were collected with a micro bathythermograph (MBT) attached to the headrope of all trawls. Conductivity-temperature-depth (CTD) data were collected with a Seabird CTD system at calibration sites and selected locations. While transecting, we collected temperature-depth profile data at one location using an expendable bathythermograph (XBT). Sea surface temperature and salinity, environmental data, and data for the Marine Operations Abstract (MOA) were collected using the *Miller Freeman*'s Scientific Collection System (SCS). Ocean current profile data were obtained using the vessel's acoustic Doppler current profiler system whose transducer is mounted in the centerboard.

Survey Methods

Four standard sphere calibrations of the acoustic systems were made in conjunction with the survey (Table 1). No significant differences were observed in the 38 kHz system parameters among the four calibrations. Results from calibration of the 120 kHz system are not presented here as that system was not used in the acoustic data analysis.

We surveyed the Bogoslof Island spawning area between March 2 and 9 covering about 1500 nautical miles (nmi) of transects (Fig. 1). The trackline consisted of 27 north-south parallel transects beginning at about long. 166° W and ending near long. 170° 20'W. Transect spacing at the eastern end was 10 nmi and decreased to 5 nmi between transects 5.0 and 16.0. Southern transect endpoints were at approximately 100 m bottom depth on the Aleutian shelf but varied depending on bottom depth and fish echo sign. The northern extent of the 10 nmi-spaced transects was similar to that during previous winter surveys in the Bogoslof region (i.e., between latitudes 54°30'N and 54°40'N east of long. 168°W and between latitudes 54°N and 54°30'N west of long. 168°W).

Echo integration and trawl data were collected 24 hours a day. Vessel speeds averaged 11.5 kts during acoustic data collection and ranged between 5 and 15 kts, depending upon weather conditions. We collected echo integration data from 14 m below the surface to either within 0.5 m of the bottom or to 1000 m, depending on bottom depth. These data were thoroughly scrutinized by one or more scientists and stored in an INGRES database. When properly scaled, they were used to provide estimates of pollock density.

Midwater trawl hauls were made at selected locations to identify echo sign and provide biological data and pollock samples. Haul duration was kept to the minimum necessary to ensure an adequate sample. Average trawling speed was about 3 kts. The AWT's vertical opening averaged about 24 m. Each trawl catch was completely sorted unless it exceeded about 1000 kg, at which point representative splits of the catch were sorted instead. Total weights and numbers of individuals, by species, were determined for each catch. Individual pollock were further sampled to determine sex, fork length, body weight, age, maturity, and ovary weight. Both otoliths were removed and stored in a solution of 50% ethanol. An electronic scale was used to determine all weights taken from individual pollock specimens. Fish lengths were determined to the nearest cm with a polycorder measuring device (a combination of a bar code reader and a hand-held computer). Since the winter of 1996, maturities have been determined by visual inspection of gonads based on an internationally accepted 8-stage scale. Expressed in terms of the older 5-stage scale, the stages were categorized as: immature, developing 1 & 2, pre-spawning 1 & 2, spawning, and post-spawning 1 & 2.

Several special projects were completed in addition to species collections associated with the estimation of pollock biomass. Mature walleye pollock were spawned and the fertilized eggs cultured for laboratory experiments on eggs and larvae. Pollock ovaries were collected from pre-spawning females for a study of interannual variation in fecundity. Fin, muscle, heart, and liver samples were taken from walleye pollock for FOCI/ADF&G genetic research. Samples of forage fishes (myctophids) were frozen for a University of Alaska (Fairbanks) study on seabird food habits. Whole pollock were collected and frozen for the Observer Program, AFSC. Grenadier were collected for AFSC biologist, Jerry Hoff.

PRELIMINARY RESULTS

Biological data were collected and samples preserved from 14 midwater trawls (Fig. 1, Tables 2-4). Pollock dominated the catches in both weights and numbers (Table 5), but large numbers of lanternfish were also caught.

Pollock distribution was similar to that in 1997. Except for one very dense school observed just northeast of Umnak Island, light to moderate concentrations of pollock were encountered between longitudes 166°-166°30'W and in the southern portion of the survey area along the Aleutian Island chain between longitudes 166°30'-168°30'W (Fig. 2). As in the previous two years' Bogoslof area surveys, most pollock (73% of the biomass) were concentrated in Samalga Pass between Umnak Island and the Islands of Four Mountains (long. 169°-170°W). They were distributed in spawning aggregations 5-12 miles in horizontal extent and 200-300 m in vertical extent between 300-700 m in the water column.

The average sizes of pollock increased from east to west. The eastern-most hauls (hauls 1 and 2) caught pollock with lengths averaging 49 cm/46 cm for females/males, respectively (Fig. 3a). Between longitudes 167°-168° W, average lengths were 54 cm/50 cm for females/males (Fig. 3b). Lengths of pollock encountered west of long. 168°W averaged 56 cm/52 cm for females/males, respectively (Fig. 3c). Sampled lengths ranged from 34-68 cm for sexes combined. The male sex ratio by haul ranged from 0.03 to 0.91 (average = 0.49). Preliminary estimates indicated that most pollock maturities were pre-spawning 1 & 2 (coded 4 and 5 in the current 8-point scale); 74% of males and 91% of females were pre-spawning (Fig. 4). Only 3% of females were actively spawning. The mean gonadosomatic index (GSI) for prespawning females was 0.18 (Fig. 5). At just under 0.5 million tons, total pollock biomass in the Bogoslof area (Fig. 6) appeared to be slightly higher than it was in 1997.

Oceanographic data were collected from 14 successful MBT casts (Table 2), 8 CTD casts, and 1 XBT cast (Table 6). Temperature profiles showed a well-mixed water column. Average temperature by 50 m depth bin ranged from 4.5-3.1°C between the surface and 850 m (Fig. 7). Surface temperatures (Fig. 8) ranged from around 3.0 to 5.0 degrees C. Near-shore areas west of long. 167°30'W (where most pollock echo sign was detected) had warmer surface temperatures than regions farther offshore or east of long. 167° 30'W.

SCIENTIFIC PERSONNEL

Name	Sex/ Nationality	Position	Organization
Taina Honkalehto	F/USA	Chief Scientist	AFSC
Daniel Twohig	M/USA	Electronics Tech.	AFSC
Neal Williamson	M/USA	Fish. Biologist	AFSC
Steve de Blois	M/USA	Fish. Biologist	AFSC
Mike Guttormsen	M/USA	Fish. Biologist	AFSC
Kevin Landgraf	M/USA	Fish. Biologist	AFSC
Yoshimi Takao	M/Japan	Fish. Acoustician	NRIFE
Seok-Gwan Choi	M/Korea	Fish. Acoustician	NFRDI

AFSC - Alaska Fisheries Science Center, Seattle, WA
NFRDI - National Fisheries Research and Development Institute, Pusan, South Korea
NRIFE - National Research Institute for Fisheries Engineering, Hasaki, Japan

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For further information contact Dr. Gary Stauffer, Director, Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, National Marine Fisheries Service, 7600 Sand Point Way NE., Building 4, BIN C15700, Seattle, WA 98115-0070 Telephone (206) 526-4170

Table 1. Summary of sphere calibrations conducted before, during, and after the winter 1998 pollock echo integration-trawl survey of the Bogoslof Island region.

Date (1998)	Location	Freq (kHz)	Water Temp (deg. C) at Transducer*	Water Temp (deg. C) at Sphere	Sphere Range from Transducer (m)	TS Gain (dB)	SV Gain (dB)	Along 3 dB Beam Width (deg.)	Angle Offset Along	Angle Offset Athwart
05 Feb	Port Susan, WA	38	9.4	10.0	28.3	27.2	27.2	6.73	0.01	-0.03
01 Mar	Nateekin Bay, AK	38	3.6	3.8	26.8	27.0	--	--	--	--
10 Mar	Captains Bay, AK	38	3.8	3.7	32.1	27.1	27.1	6.79	0.01	-0.03
24 Mar	Spidiron Bay, AK	38	5.3	5.4	34.4	27.1	27.1	--	--	--
Feb-Mar	System settings during surveys	38	--	--	--	27.1	27.1	6.70	-0.09	-0.02

* The transducer is located approximately 9 m below the water surface.

Note: Gain and beam pattern terms are defined in the "Operator Manual for Simrad EK500 Scientific Echo Sounder (1993)" available from Simrad Subsea A/S , Standpromenaden 50, P.O. Box 111 N-3191 Horten, Norway.

Table 2. Summary of midwater trawl stations and catch data from the winter 1998 pollock echo integration-trawl survey of the Bogoslof Island area.

Haul No.	Date (GMT)	Time (GMT)	Duration (minutes)	Start Position Latitude (N)		Start Position Longitude (W)		Depth (m) Gear	Depth (m) Bottom	Temp. (deg. C) Gear	Temp. (deg. C) Surface	MBT No.	Pollock Catch kg	Pollock Catch number	Other Catch kg
1	2 Mar	11:04	26	54	23.59	166	0.20	516	549	3.5	3.8	2	438.5	584	15.0
2	2 Mar	18:39	25	54	12.69	166	17.85	487	523	4	3.7	3	966.5	1,160	6.1
3	4 Mar	1:10	8	53	37.14	167	43.43	447	922	3.7	4.7	4	1,075.0	933	7.7
4	4 Mar	8:52	30	54	34.31	167	43.96	348	831	4.3	3.8	5	0.0	0	2.2
5	7 Mar	10:41	2	53	12.91	169	4.07	330	678	4.1	4.7	6	3,781.8	2,472	8.2
6	7 Mar	14:41	21	53	6.48	169	6.90	479	683	4	4.4	7	468.5	324	6.6
7	7 Mar	20:26	31	53	11.49	169	11.51	512	809	3.8	4.6	8	692.0	606	14.0
8	7 Mar	23:53	16	53	13.32	169	7.78	489	582	3.8	4.7	9	1,445.3	1,248	2.0
9	8 Mar	5:12	2	53	6.10	169	9.64	342	918	4.3	4.7	10	1,132.3	1,195	0.8
10	8 Mar	10:50	45	53	3.51	169	21.02	583	896	3.7	4.8	11	1,143.3	968	114.9
11	8 Mar	15:35	6	53	3.28	169	15.12	459	903	4.1	4.8	12	2,766.0	2,421	0.0
12	8 Mar	20:07	14	53	8.86	169	8.57	480	1138	3.8	4.7	13	1,368.1	1,276	11.8
13	10 Mar	5:11	6	53	37.61	167	40.33	429	1113	4	4.6	14	1,613.4	1,421	3.0
14	10 Mar	7:14	10	53	38.54	167	46.98	431	816	4.1	4.5	15	1,693.7	1,482	16.3

Table 3. Summary of pollock biological samples and measurements collected during the winter 1998 echo integration-trawl survey of the Bogoslof Island area.

Haul	Length	Maturity	Otoliths	Fish Weight	Ovary Weight
1	322	94	94	94	40
2	309	75	75	75	36
3	275	73	73	73	31
5	269	52	52	52	47
6	324	79	79	51	44
7	296	122	122	61	10
8	310	116	116	63	10
9	317	140	140	64	5
10	382	89	89	89	17
11	301	88	88	59	14
12	288	89	89	89	58
13	310	126	71	71	51
14	310	118	103	103	86
Totals	4,013	1,261	1,191	944	449

Table 4. Summary of biological samples collected for special projects during the winter 1998 pollock echo integration-trawl survey of the Bogoslof Island area (MF9802).

Haul	Pollock Spawning (M/F)	Observ.Pro. Samples POL/RF[1]	Frozen MYC[2]	Pollock Ovary Collection	Pollock // Genetics #1[3]	Pollock // Genetics #2[4]	NMML Steller S.L. Prey Items	Macrourid Collection	Korean Ovaries Collection
1	-	POL	MYC	11	100	-	SQ	-	-
2	-	POL	MYC	29	-	-	SQ	-	-
3	-	SA	MYC	5	100	-	SA, SQ	-	-
4	-	-	MYC	-	-	-	SQ	-	-
5	-	-	-	1	-	-	-	-	50
6	-	-	MYC	-	100	-	SQ	-	-
7	-	-	-	-	-	20	-	-	-
8	-	POL	-	1	-	20	POL	-	-
9	-	-	-	-	-	20	-	-	-
10	-	-	MYC	-	-	-	SQ	6	-
11	-	-	-	-	-	20	-	-	-
12	-	POL	MYC	-	-	20	SQ	-	-
13	(3/~5)(3/~5)	-	MYC	-	-	-	-	-	-
14	-	SA	MYC	-	-	-	SA, SQ	-	-
Total	18,000 EGG	POL, SA	MYC	47	300	100	SA,SQ,POL	6	50

[1] Pollock/Rockfish/Salmon
[2] Myctophidae
[3] #1-Fin clips only
[4] #2-Muscle, Heart and liver

Y - collection made
POL-Pollock, SA-Salmon, SQ-Squid

Table 5. Summary of catch by species in 14 Aleutian Wing trawls during the 1998 echo integration-trawl survey of the Bogoslof Island area.

Common Name	Scientific Name	Weight (kg)	Weight (%)	Numbers
Walleye Pollock	*Theragra chalcogramma*	18,584.3	98.9	16,090
Lanternfish Unidentified	Myctophidae	111.0	0.6	10,158
Giant Grenadier	*Albatrossia pectoralis*	25.8	0.1	6
Squid Unidentified	Teuthoidea	16.0	0.1	158
Smooth Lumpsucker	*Aptocyclus ventricosus*	10.1	0.1	4
Pacific Lamprey	*Lampetra tridentata*	9.6	0.1	23
Arrowtooth Flounder	*Atheresthes stomias*	9.4	0.1	9
Jellyfish Unidentified	Scyphozoa	6.6	<0.1	0
Octopus Unidentified	Octopoda	5.0	<0.1	10
Greenland Turbot	*Reinhardtius hippoglossoides*	4.0	<0.1	1
Northern Smoothtongue	*Leuroglossus schmidti*	2.8	<0.1	588
Salmon Unidentified	Salmonidae	2.5	<0.1	15
Chinook Salmon	*Oncorhynchus tshawytscha*	1.3	<0.1	1
Sponge Unidentified	Porifera	1.2	<0.1	1
Magistrate Armhook Squid	*Berryteuthis magister*	0.9	<0.1	1
Pacific Ocean Perch	*Sebastes alutus*	0.6	<0.1	1
Pacific Viperfish	*Chauliodus macouni*	0.6	<0.1	16
Sea Fan	Gorgonacea	0.5	<0.1	7
Golden King Crab	*Lithodes aequispina*	0.4	<0.1	1
Slender Barracudina	*Lestidiops ringens*	0.2	<0.1	8
Shrimp Unidentified	Decapoda	0.2	<0.1	90
Eulachon	*Thaleichthys pacificus*	0.1	<0.1	1
Eelpout Unidentified	Zoarcidae	<0.1	<0.1	3
Viperfish Unidentified	Chauliodontidae	<0.1	<0.1	1
Totals		18,793.2		27,193

Table 6. Summary of conductivity-temperature-depth (CTD) and expendable bathythermograph (XBT) casts made prior to and during the winter 1998 echo integration-trawl survey of the Bogoslof Island area.

Cast type	Number	Date	Time (GMT)	Latitude (N)	Longitude (W)	Depth (m) Cast	Depth (m) Bottom
CTD	500	5 Feb	14:30	48 10.41	122 26.01	82	106
CTD	501	2 Mar	2:41	53 53.14	166 37.9	69	75
CTD	502	2 Mar	6:10	54 6.63	166 28.94	449	500
CTD	503	7 Mar	12:31	53 13.32	169 3.91	354	641
CTD	504	7 Mar	16:47	53 6.32	169 8.90	392	835
CTD	505	8 Mar	7:43	53 6.04	169 9.92	788	918
CTD	506	10 Mar	9:25	53 38.16	167 46.15	728	792
CTD	507	10 Mar	23:50	53 51.9	166 34.8	88	92
XBT	1			*** bad cast ***			
XBT	2	9 Mar	20:35	54 3.72	169 25.03	809	>1,500

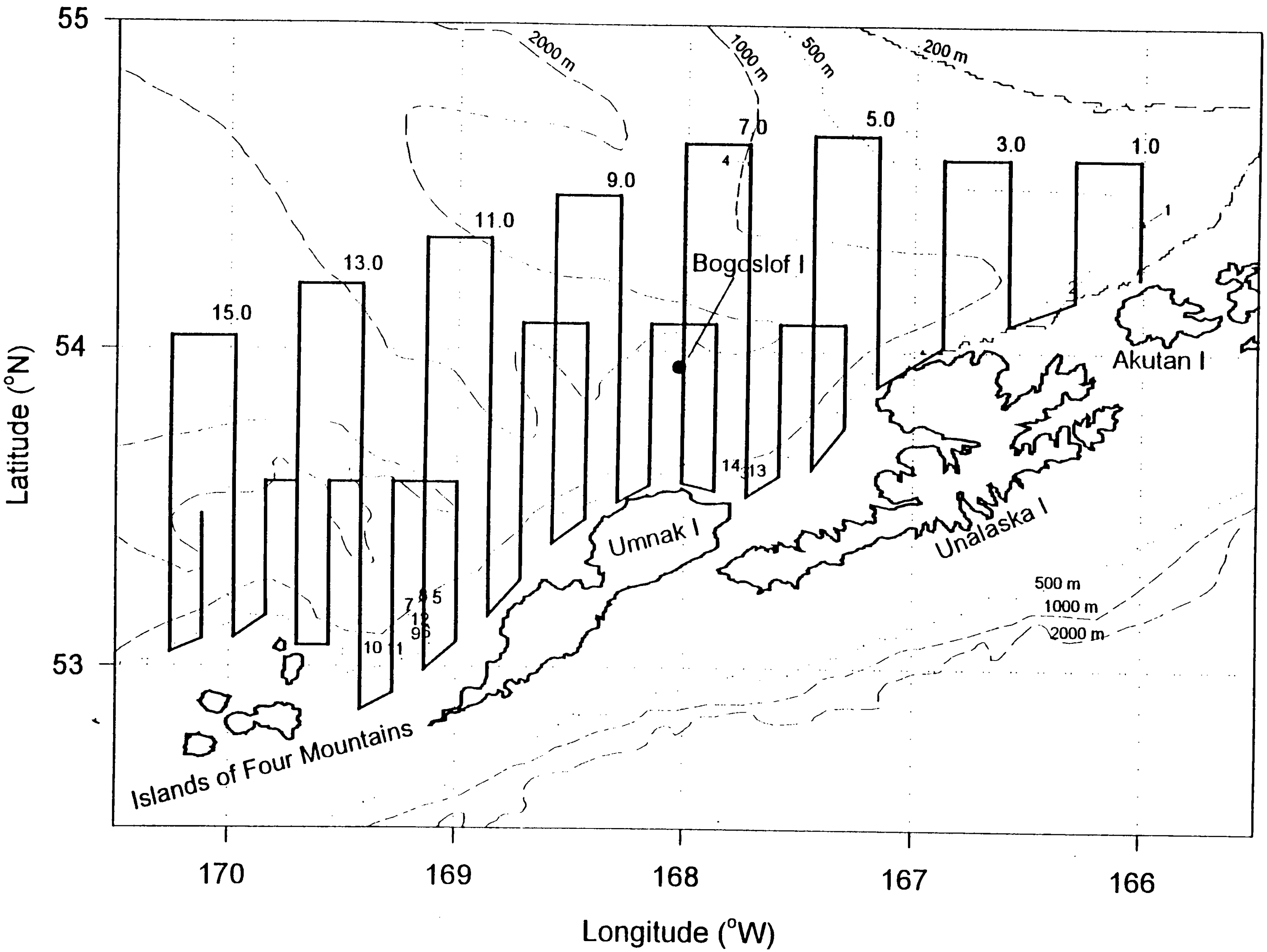

Figure 1. Trackline and haul locations from the winter 1998 echo integration-trawl survey of the Bogoslof Island area.

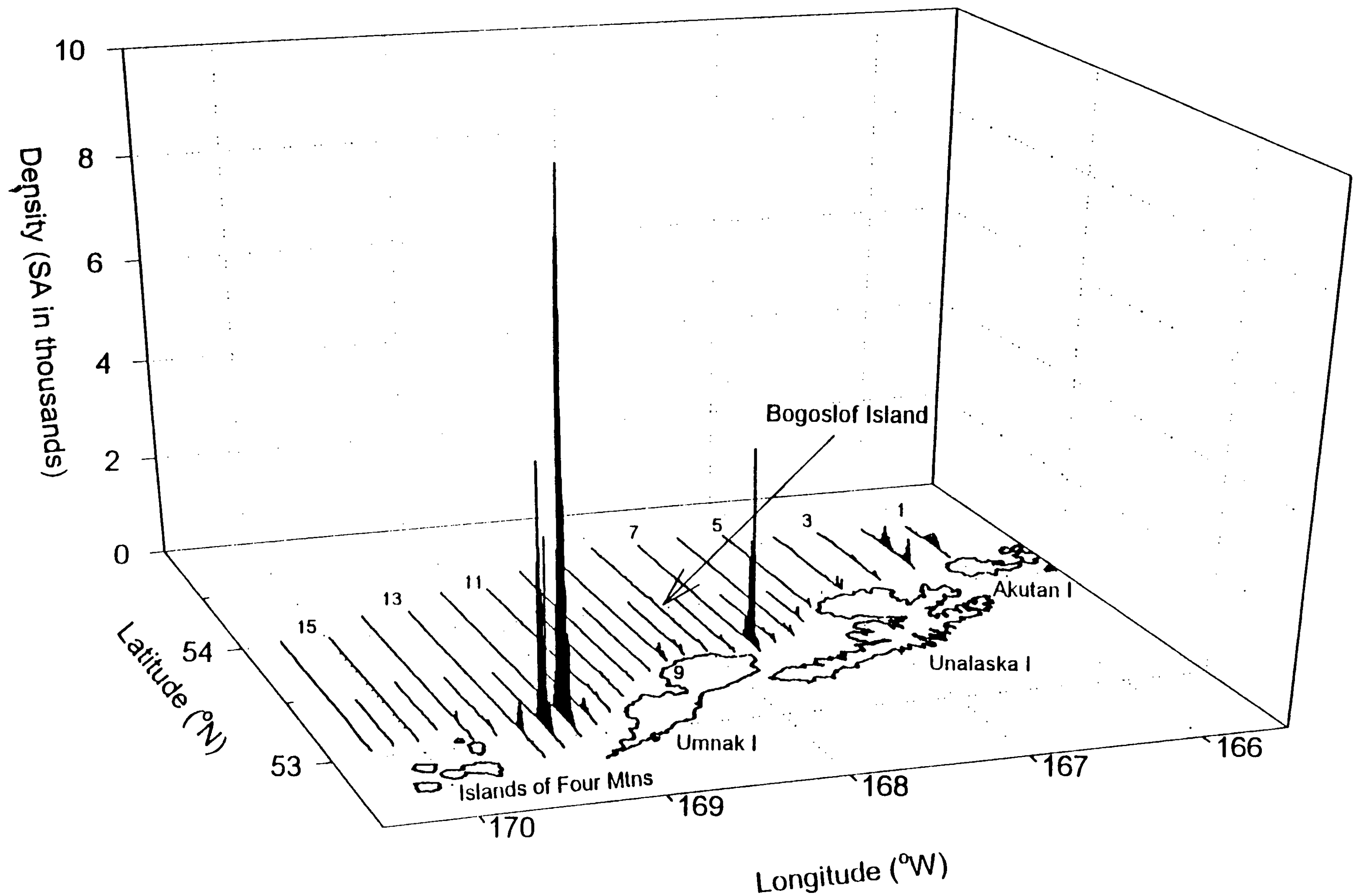

Figure 2. Relative pollock density along trackline from the winter 1998 echo integration-trawl survey of the Bogoslof Island area. Transect numbers are indicated.

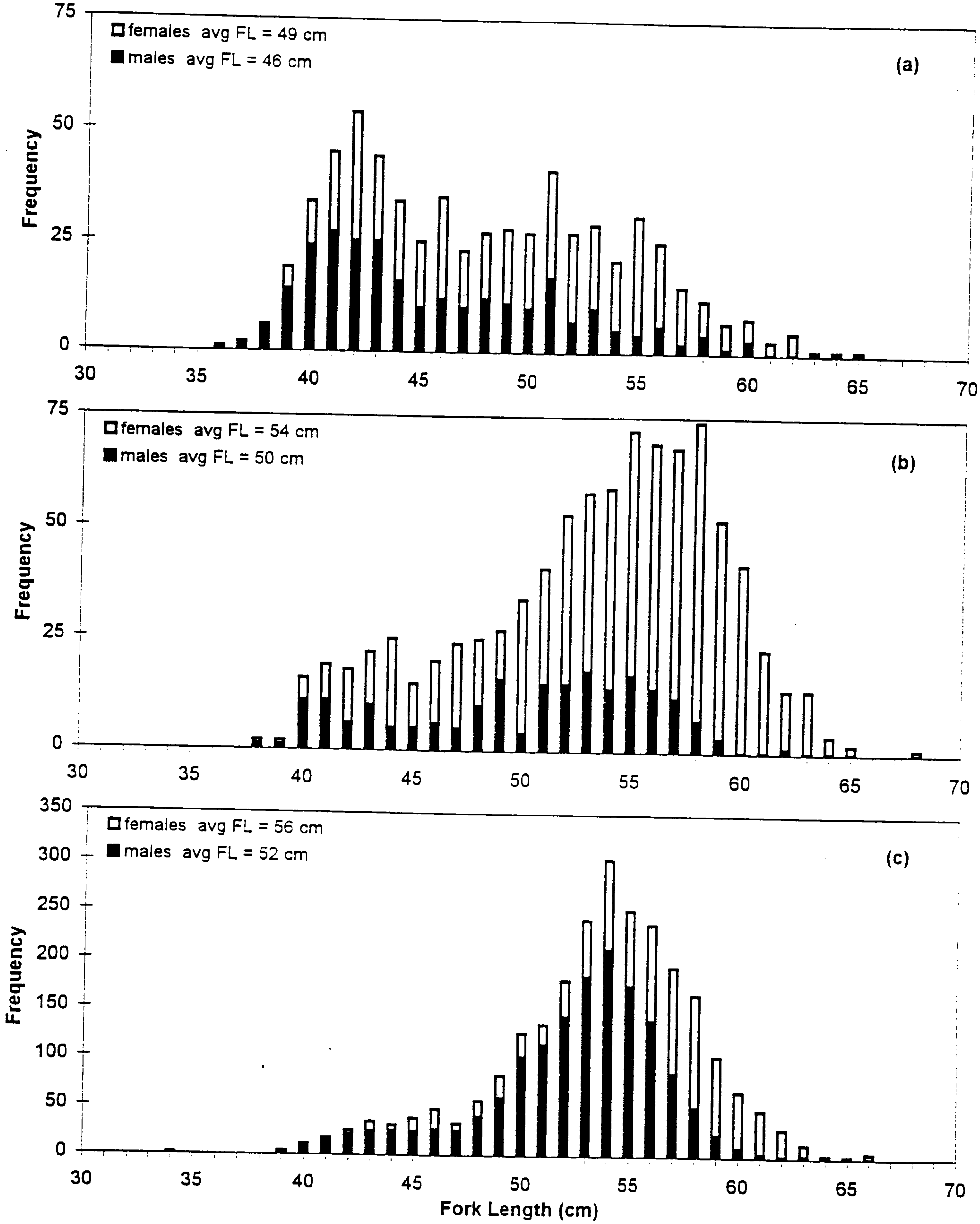

Figure 3. Pooled raw length frequencies from midwater trawls (a) east of 167 deg. W, (b) between 167 and 168 deg. W, and (c) west of 168 deg. W from the winter 1998 echo integration-trawl survey of the Bogoslof Island area.

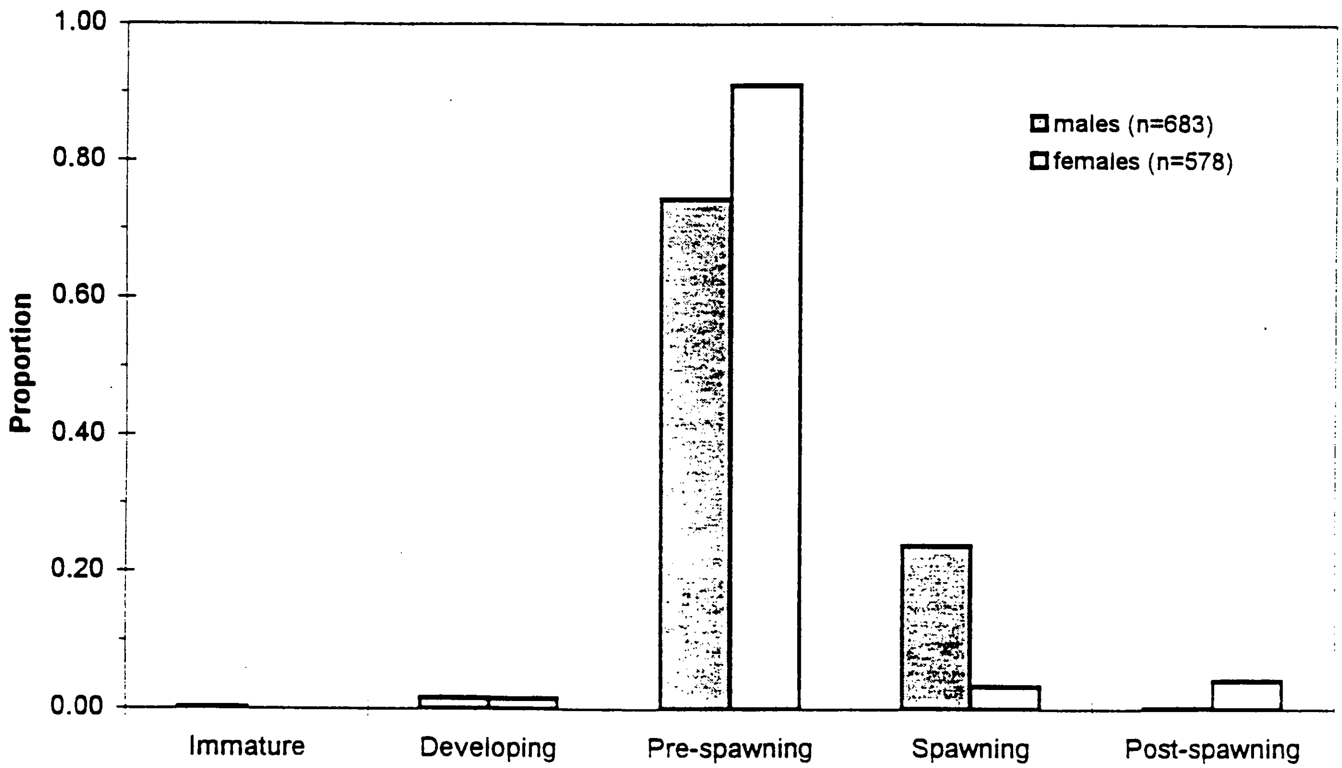

Figure 4. Maturity stages of pollock observed during the winter 1998 echo integration-trawl survey of the Bogoslof Island area.

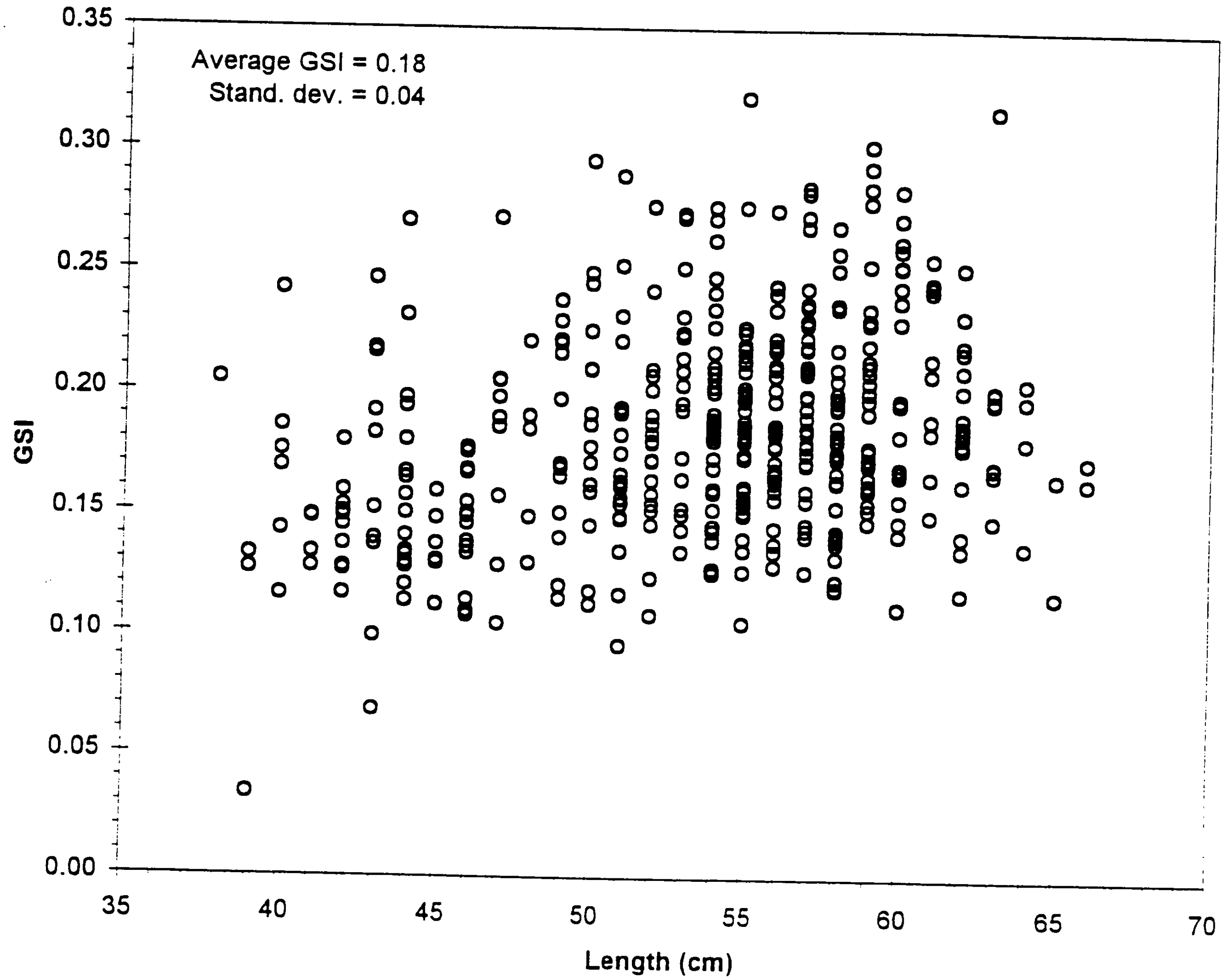

Figure 5. Pollock gonado-somatic indices for mature females plotted as a function of length from the winter 1998 echo integration-trawl survey of the Bogoslof Island area.

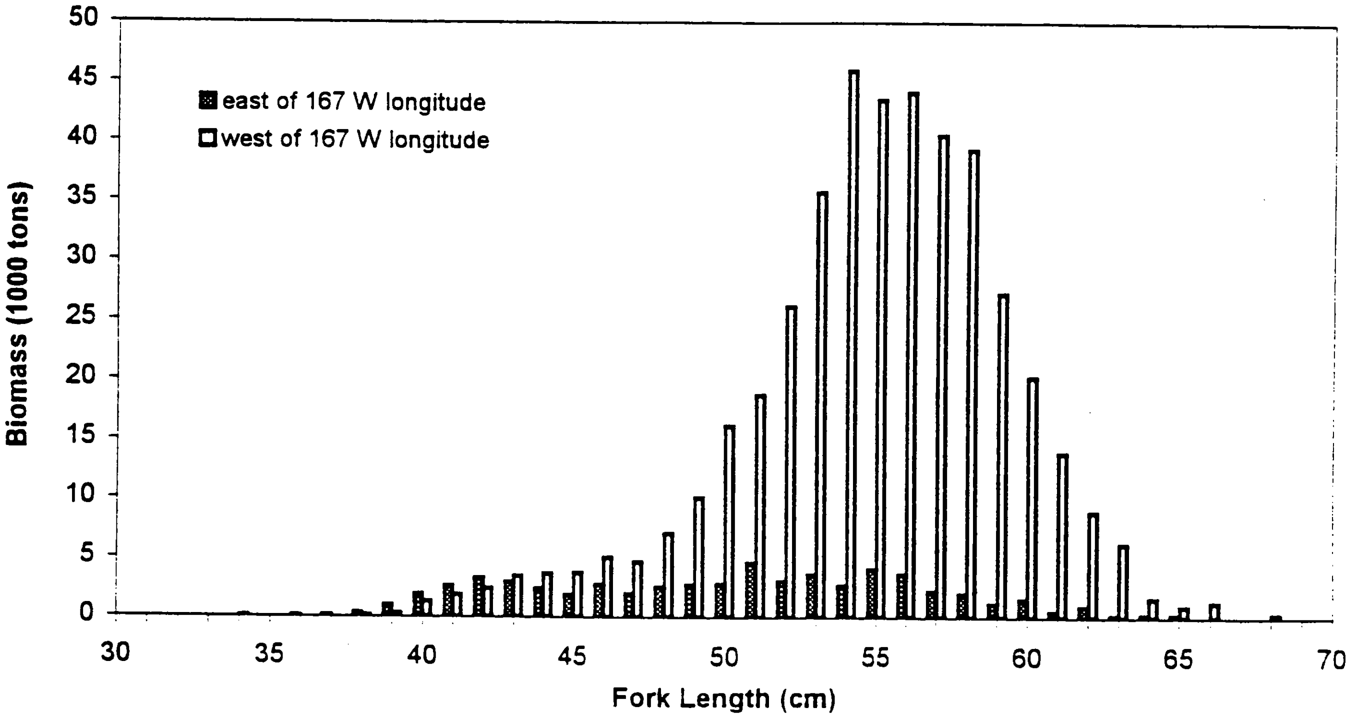

Figure 6. Preliminary estimate for pollock biomass at length from the winter 1998 echo integration-trawl survey of the Bogoslof Island area.

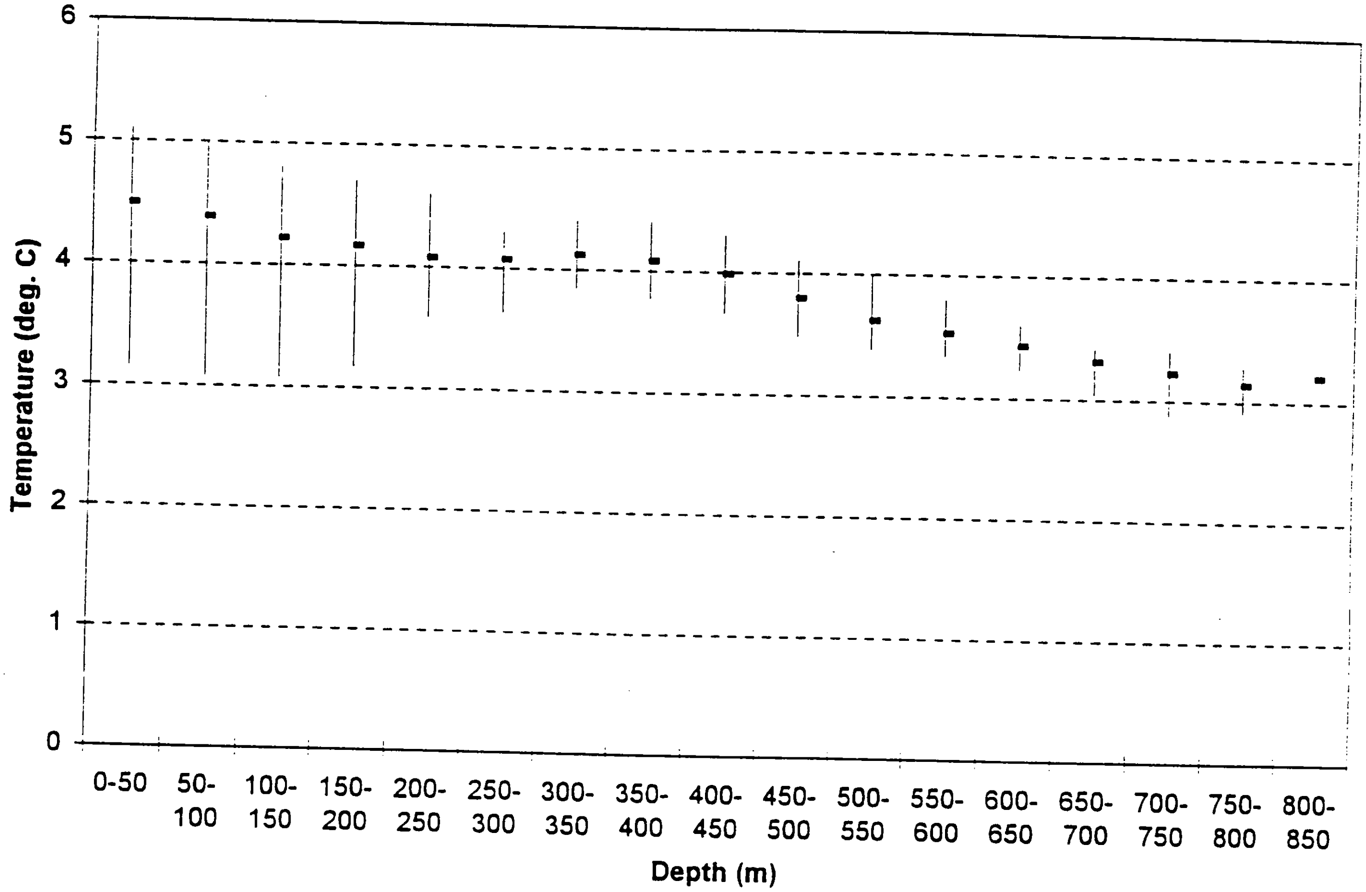

Figure 7. Average temperature (with min-max range) by 50-m depth sections observed during the winter 1998 echo integration-trawl survey of pollock in the Bogoslof Island area. Data compiled from CTD, MBT, and XBT casts.

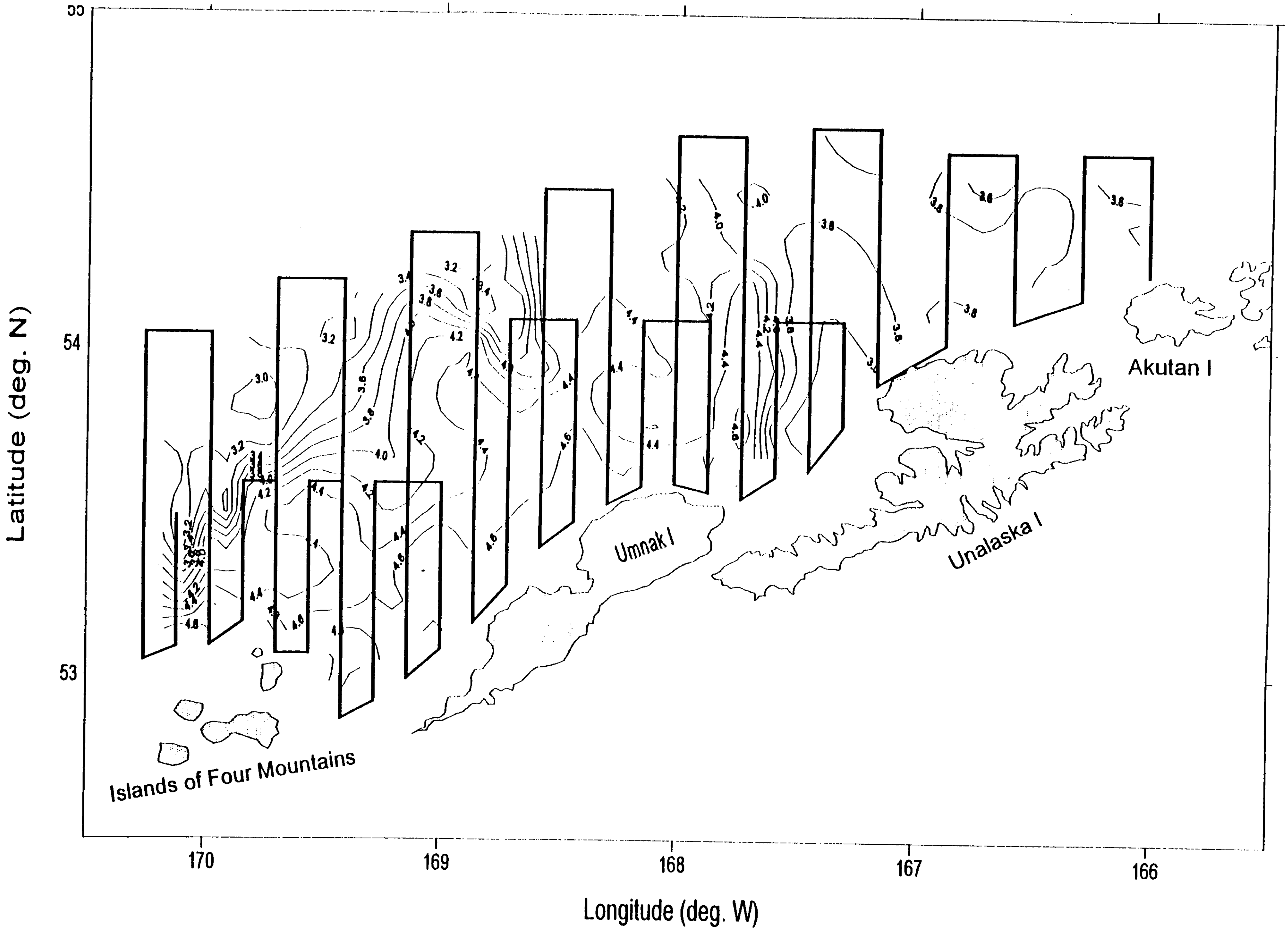

Figure 8. Transect lines with surface temperature contours (in degrees C) during the winter 1998 pollock echo integration-trawl survey of the Bogoslof Island area.

Walleye Pollock (*Theragra chalcogramma*) abundance in the Southeastern Aleutian Basin near Bogoslof Island during March, 1998

by Taina Honkalehto and Neal Williamson

INTRODUCTION

Since 1988, with the exception of 1990, the distribution and abundance of spawning walleye pollock (*Theragra chalcogramma*) in the southeastern Aleutian Basin near Bogoslof Island have been investigated using echo integration-trawl (EIT) survey techniques. In the late 1980's, a directed domestic fishery on Bogoslof pollock existed, but it was halted in 1991 due to declining catches in the Donut Hole (central Aleutian Basin) and a drop in biomass in the Bogoslof area (Honkalehto and Williamson 1996). Tracking the abundance of pollock that spawn near Bogoslof remains important for management of the U. S. pollock fishing industry and to Central Bering Sea Convention member nations. Results presented here are from the pollock survey carried out 1-10 March 1998 between Akutan Island and the Islands of Four Mountains, Alaska. Scientists from the United States, Japan and South Korea participated.

METHODS

Acoustic data were collected with a Simrad EK 500[1] quantitative echo-sounding system (Bodholt et al. 1989) on the NOAA ship *Miller Freeman*, a 66-m stern trawler equipped for fisheries and oceanographic research. Two split-beam transducers (38 kHz and 120 kHz) were mounted on the bottom of the vessel's centerboard extending 9 m below the water surface. System electronics were housed inside the vessel in a permanent laboratory space dedicated to acoustics. Data from the echo sounder/receiver were processed using Simrad BI500 echo integration and target strength analysis software (Foote et al. 1991) on a SUN workstation. Results presented here were based on the 38 kHz data. Midwater echo sign was sampled using an Aleutian Wing 30/26 trawl and 5 m^2 "Fishbuster" doors (1,250 kg).

In winter 1998, the EIT survey covered about 1500 nautical miles (nmi) of transects across the Bogoslof spawning area (Fig. 1). The trackline consisted of 27 north-south parallel transects beginning at about 166° 00'W and ending near 170° 20'W. Transects 1-4 were spaced 10 nmi apart and transects 5-16 were 5 nmi apart. Echo integration data collected continuously at about 11.5 kts vessel speed were examined for pollock and stored at a SV threshold of -69 decibels (dB). Estimates of pollock backscattering strength in the area represented by each transect were generated. These values were then summed and scaled using a previously derived relationship between target strength and fish length (TS = 20 Log FL - 66; Traynor 1996) to estimate the numbers and weight of pollock for each length category using pollock size compositions and a length-weight relationship derived from trawl catch information. Although trawl hauls sampled a

[1] Reference to trade names or commercial firms does not constitute U.S. Government endorsement.

slightly higher percentage of females than males on average, we assumed a 50:50 sex ratio for population size composition. This is because we cannot easily obtain a representative sex ratio, as Bogoslof spawning pollock are highly aggregated and stratified by sex (Honkalehto and Williamson 1995; 1996). Size compositions used to scale the acoustic data in each area were obtained using a weighting procedure described in Honkalehto and Williamson (1996). A combined male and female length-weight relationship was obtained by pooling trawl data and minimizing the sum of squares using an iterative non-linear approach. Age data are not yet available.

Numbers and biomass of pollock were estimated for the entire geographic area covered by the survey, using data from all trawl hauls (Fig. 1). Echo sign characteristics as well as pollock length and maturity data from trawl catches led to classification of echo integration and trawl data into two strata: pollock "east of 167°W" (transects 1-4, hauls 1 and 2), and "west of 167°W" (transects 5-16, hauls 3, 5-14). Estimates were made for pollock inside North Pacific Fisheries management area 518, which is equivalent to the "Specific Area" as it is defined in the Central Bering Sea Convention[2] and will be referred to as "area 518/CBS convention area". This area corresponds to the "west of 167°W" area minus half of transect 15, and excluding all of 15.5 and 16 and the northern 5.5 nmi of transect 5.0 (Fig. 1). EIT survey and biomass estimation methods are discussed in detail in Honkalehto and Williamson (1996).

Error bounds on the acoustic data were derived using two different approaches. We used the one-dimensional (1D) geostatistical approach described in Petitgas (1993) and Williamson and Traynor (1996) on the majority of the data. The 1D method requires equal spacing between transects, and no fewer than 10 transects (Petitgas, pers. comm.). We divided transects west of 167°W (5-16) into an inshore area at 5 nmi spacing using data from all 23 transects (5.0, 5.5, etc.), and an offshore area at 10 nmi spacing using data from the northern portions of the 12 whole numbered transects (5.0, 6.0, etc.). We then calculated the error (± 2 relative estimation error) using the 1D approach. As they numbered fewer than 10, we treated transects east of 167°W (1-4) differently, and computed a conservative error bound (± 2 sqrt(var/n)/mean) using the random sample variance. Variances from west (inshore and offshore) and east were added to compute an overall error bound. Acoustic error bounds can be used to provide error bounds on the point estimate of biomass. These error bounds quantify only acoustic data sampling variability; other sources of error (e.g. target strength, trawl sampling) are not included. This treatment of error provides a general idea of the acoustic sampling variability of the survey.

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[2]The "specific area" is defined in the Annex to the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea as "the area south of a straight line between a point at 55° 46' N lat. and 170° W long. and a point at 54° 30' N lat., 167° W long. and between the meridian 167° W long. and the meridian 170° W long. and the north of the Aleutian Islands and straight lines between the islands connecting the following coordinates in the order listed: 52° 49.2 N 169° 40.4 W, 52° 49.8 N 169° 06.3 W, 53° 23.8 N 167° 50.1 W, 53° 18.7 N 167° 51.4 W.

RESULTS

The geographic distribution of pollock was similar to that in 1997, but appeared to be more patchy. Pollock dominated 13 of 14 midwater trawl catches in both weight and numbers. Their echo sign ranged in appearance from dense spawning layers to faint layers of single fish. In the eastern portion of the survey area north of Akutan Island, pollock aggregations formed moderately dense layers between 400-600 m in the water column. Layers were relatively contiguous along the center of transects 1-4. North of Unalaska and Umnak Island we observed smaller, less dense aggregations of pollock hugging the shelf edge, and one large, extremely concentrated aggregation about 7 nmi long by 5 nmi wide northeast of Umnak Island which we sampled in the same location at near the start and end of the survey (Fig. 2, hauls 3, 13 and 14). West of 167° W and north of 54° N, pollock were very sparsely distributed. In this region, diffuse "myctophid" scattering layers, often present above pollock layers, periodically strengthened and persisted at about 300 m water depth for 10– nautical miles at a time. One haul (haul 4) targeted one of these scattering layers and caught myctophidae, a few jellyfish, and only one adult pollock. Most pollock (about 73% of the total biomass) were observed in extremely dense aggregations 5-12 nmi in horizontal extent and 200-500 m in vertical extent between 200-800 m in the water column in the Samalga Pass area northeast of the Islands of Four Mountains (between approximately 169° 00' - 169° 45' W long., and 52° 50'- 53° 30' N lat.). These pollock scattering layers often displayed complex vertical structure, with 2-3 dense layers separated by more diffuse layers of pollock. Temperature profiles in the surveyed region were similar to those from previous years in March: the water column was well-mixed with average temperatures ranging between 4.5 and 3.1 °C between the surface and 800 m.

Walleye pollock caught during the survey had lengths ranging from 34 to 68 cm (Fig. 3). East of 167° W, hauls 1 and 2 caught pollock with average lengths of 46 cm (males) and 49 cm (females). West of 167° W, hauls 3 and 5-14 caught pollock with average lengths of 52 cm (males) and 55 cm (females). Sex ratio by haul for the entire area ranged from 8% to 97% female and averaged 51% female.

Maturity composition was similar for pollock east and west of 167° W. Ninety-one percent of females (n=578) and 74% of males (n=683) were pre-spawning (Fig. 4). The mean gonadosomatic index (GSI), defined as the ratio of gonad weight to total body weight for pre-spawning females, was 0.18 (Fig. 5).

Abundance and biomass estimates were generated for the entire survey area, east and west of 167° W, and for the 518/CBS convention area (Table 1, and Fig. 1). The biomass of pollock for the entire Bogoslof survey area was 492 thousand tons; 59 thousand tons in the east area, and 433 thousand tons in the west (Table 1). The biomass error bound for the east area was 0-140 thousand tons and for the west area was 268-598 thousand tons. The relative estimation error was higher in 1998 than in 1997. This was probably due to the increase in pollock concentration in the Samalga Pass area in 1998 compared to 1997, and to the extremely patchy distribution over the survey area. Pollock totaled 435 million fish--72 million in the east and 363 million in the west. Inside the area 518/CBS convention area, pollock biomass was 432 thousand tons and pollock numbered about 363 million. Pollock otoliths collected during this cruise have not yet been aged and thus estimates of age composition are not available.

Bogoslof pollock have experienced a gradual decline in abundance from their 1988 and 1989 levels of over 2 million tons (Fig. 6). In recent years the geographic distribution of the main spawning aggregations has shifted westward, from deeper basin waters near Bogoslof Island to slope waters in Samalga Pass near the Islands of Four Mountains. In 1998, pollock were even more highly concentrated in Samalga Pass than in 1997 (73% vs. 60% of the biomass, in 1998 vs. 1997, respectively). From 1988 through 1993, increasing average fish length indicated an aging population with little recruitment (Table 2, Figs. 6 and 7). In 1994 a relatively strong 1989 year class began to recruit to the population (Table 3, Fig. 8). In 1995, recruitment from the 1989 year class continued, and we estimated a larger biomass than in 1994--1.1 million tons (Honkalehto and Williamson 1996, Fig. 6). Numbers of '89 year-class pollock decreased during 1996-97, and numbers of '90 year class pollock appear to have peaked in 1996, relative to what they were in 1995 and 1997 (Table 3). Although total abundance declined in 1996-1997, in 1998 it appeared to be up slightly, at 0.49 million tons.

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Table 1. Estimates of numbers, biomass and acoustic return of spawning pollock near Bogoslof Island from the 1998 echo integration-trawl survey.

Estimate	Biomass (thousand tons)	Biomass Error Bounds	Numbers (millions)	Acoustic return (Sm)[1] (1000 m^2)	Acoustic Error Bounds	Transects	Hauls
East	59	(0-140)	72	518	(+/- 137%)	1-4	1,2
West	433	(268-598)	363	3311	(+/- 38 %)	5-16	3. 5-14
Total	492	(305-679)	435	3829	(+/- 38 %)	1-16	1-3, 5-14
Area 518	432		363	3307		5-(1/2)15	3, 5-14

[1] $Sm = \sum_{1}^{n} Sa \cdot A_n$, where n is the number of 0.5 nmi intervals along the transect, Sa is meters^2 of pollock backscattering cross section per nmi^2 and $A_n = 0.5 \cdot w$, where w is the width assigned to the interval and varies depending on transect spacing.

Table 2. Population at length estimates (millions of fish) from February-March echo integration-trawl surveys of spawning pollock in the Bogoslof Island area. No survey was conducted in 1990.

Length	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
10	0	0	–	0	0	0	0	<1	0	0	0
11	0	0	–	0	0	0	0	<1	0	0	0
12	0	0	–	0	0	0	0	1	0	0	0
13	0	0	–	0	0	0	0	<1	0	0	0
14	0	0	–	0	0	0	0	<1	0	0	0
15	0	0	–	0	0	0	0	0	0	0	0
16	0	0	–	0	0	0	0	0	0	0	0
17	0	0	–	0	0	0	0	0	0	0	0
18	0	0	–	0	0	0	0	0	0	0	0
19	0	0	–	0	0	0	0	0	0	0	0
20	0	0	–	0	0	0	0	0	0	0	0
21	0	0	–	0	0	0	0	0	0	0	0
22	0	0	–	<1	0	0	0	0	0	0	0
23	0	0	–	2	0	0	0	0	0	0	0
24	0	0	–	1	0	0	0	0	0	0	0
25	0	0	–	0	0	0	0	0	0	0	0
26	0	0	–	<1	0	0	0	0	0	0	0
27	0	0	–	0	0	0	0	0	0	0	0
28	0	0	–	0	0	0	0	0	0	0	0
29	0	0	–	0	0	0	0	0	0	0	0
30	0	0	–	0	0	0	0	0	0	0	0
31	0	0	–	0	<1	0	0	0	0	0	0
32	0	0	–	0	<1	0	0	0	0	0	0
33	0	0	–	0	<1	0	0	0	0	0	0
34	0	0	–	0	0	0	0	<1	<1	0	<1
35	0	0	–	0	0	0	0	<1	0	<1	0
36	0	0	–	0	<1	0	0	<1	<1	<1	<1
37	9	3	–	<1	0	0	0	<1	<1	<1	<1
38	6	0	–	2	<1	1	0	1	1	<1	1
39	16	4	–	5	0	2	<1	4	1	1	3
40	24	3	–	7	1	4	3	12	4	1	7
41	27	4	–	19	3	5	6	20	8	2	9
42	48	23	–	23	7	7	9	40	14	3	11
43	118	33	–	31	14	6	14	40	17	4	11
44	179	54	–	36	18	7	21	41	21	5	10
45	329	159	–	46	28	8	21	50	23	7	9
46	488	177	–	55	32	13	21	53	31	10	11
47	547	389	–	79	42	22	18	40	36	14	9
48	476	434	–	130	68	28	17	55	36	15	12
49	389	431	–	168	102	46	16	47	37	18	15
50	248	366	–	205	129	69	39	52	40	21	20
51	162	279	–	189	144	76	46	58	45	24	23
52	80	168	–	160	118	73	52	78	52	26	28
53	48	85	–	122	106	73	49	81	52	26	35

Table 2. continued.

Length	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
54	19	50	–	63	67	66	43	88	53	31	41
55	12	13	–	40	41	50	37	81	48	28	38
56	4	5	–	17	27	29	26	69	40	24	35
57	3	8	–	8	13	14	17	58	37	22	30
58	1	1	–	4	6	9	10	47	28	17	27
59	0	0	–	1	5	3	6	31	19	13	18
60	0	0	–	1	1	1	3	17	12	12	13
61	2	0	–	1	<1	1	2	7	6	6	8
62	0	0	–	<1	<1	<1	1	4	2	3	5
63	0	0	–	0	0	0	<1	2	1	1	3
64	0	0	–	0	1	<1	0	1	<1	1	1
65	0	0	–	<1	0	0	0	<1	<1	<1	1
66	0	0	–	0	0	0	0	<1	0	<1	1
67	0	0	–	0	0	0	0	0	0	0	0
68	0	0	–	0	0	0	0	1	0	0	<1
Totals	3236	2687	–	1419	975	613	478	1081	666	337	435

Table 3. Bogoslof spawning pollock population estimates (millions of fish) from February-March echo integration-trawl surveys. No survey was conducted in 1990.

Age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998*
0	0	0	–	0	0	0	0	0	0	0	–
1	0	0	–	0	0	0	0	1	0	0	–
2	0	0	–	4	0	0	0	0	0	0	–
3	0	0	–	0	1	1	0	2	0	0	–
4	0	6	–	2	2	33	21	6	<1	<1	–
5	28	15	–	12	27	17	86	75	6	4	–
6	327	58	–	46	54	44	26	278	96	16	–
7	247	363	–	213	97	46	38	105	187	55	–
8	164	147	–	93	74	48	36	68	85	88	–
9	350	194	–	160	71	42	36	80	40	38	–
10	1201	91	–	44	55	28	17	53	37	28	–
11	288	1105	–	92	57	51	27	54	24	16	–
12	287	222	–	60	33	25	23	19	24	16	–
13	202	223	–	373	34	27	13	59	12	13	–
14	89	82	–	119	142	42	9	32	36	7	–
15	27	90	–	41	164	92	45	12	18	13	–
16	17	30	–	38	59	47	36	31	4	5	–
17	7	60	–	29	8	25	28	103	16	4	–
18	3	0	–	32	15	11	16	60	35	12	–
19	0	0	–	56	22	11	4	18	26	12	–
20	0	0	–	4	42	11	4	5	12	7	–
21	0	0	–	2	13	10	8	5	3	2	–
22	0	0	–	0	3	1	2	6	2	1	–
23	0	0	–	0	1	1	2	6	1	<1	–
24	0	0	–	0	0	0	1	2	0	1	–
25	0	0	–	0	0	0	0	0	0	0	–
Totals	3236	2687	–	1419	975	613	478	1081	666	336	

*not available

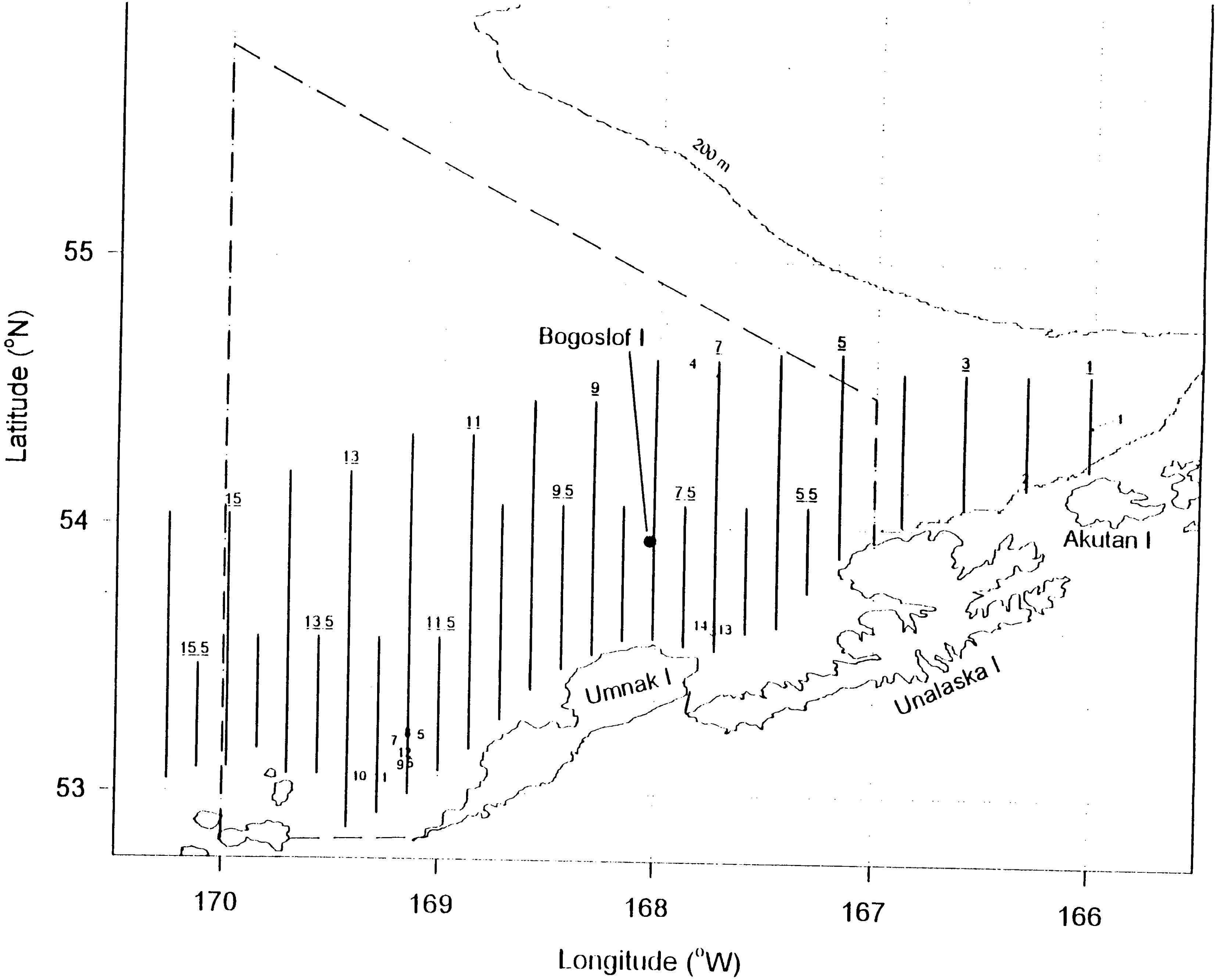


Figure 1. Echo sign sample points along north-south transects from the winter 1998 echo integration-trawl survey of the Bogoslof Island area. Transect numbers (underlined) and trawl hauls are indicated. Dash-dotted line is boundary of U.S. fisheries management area 518/CBS convention area.

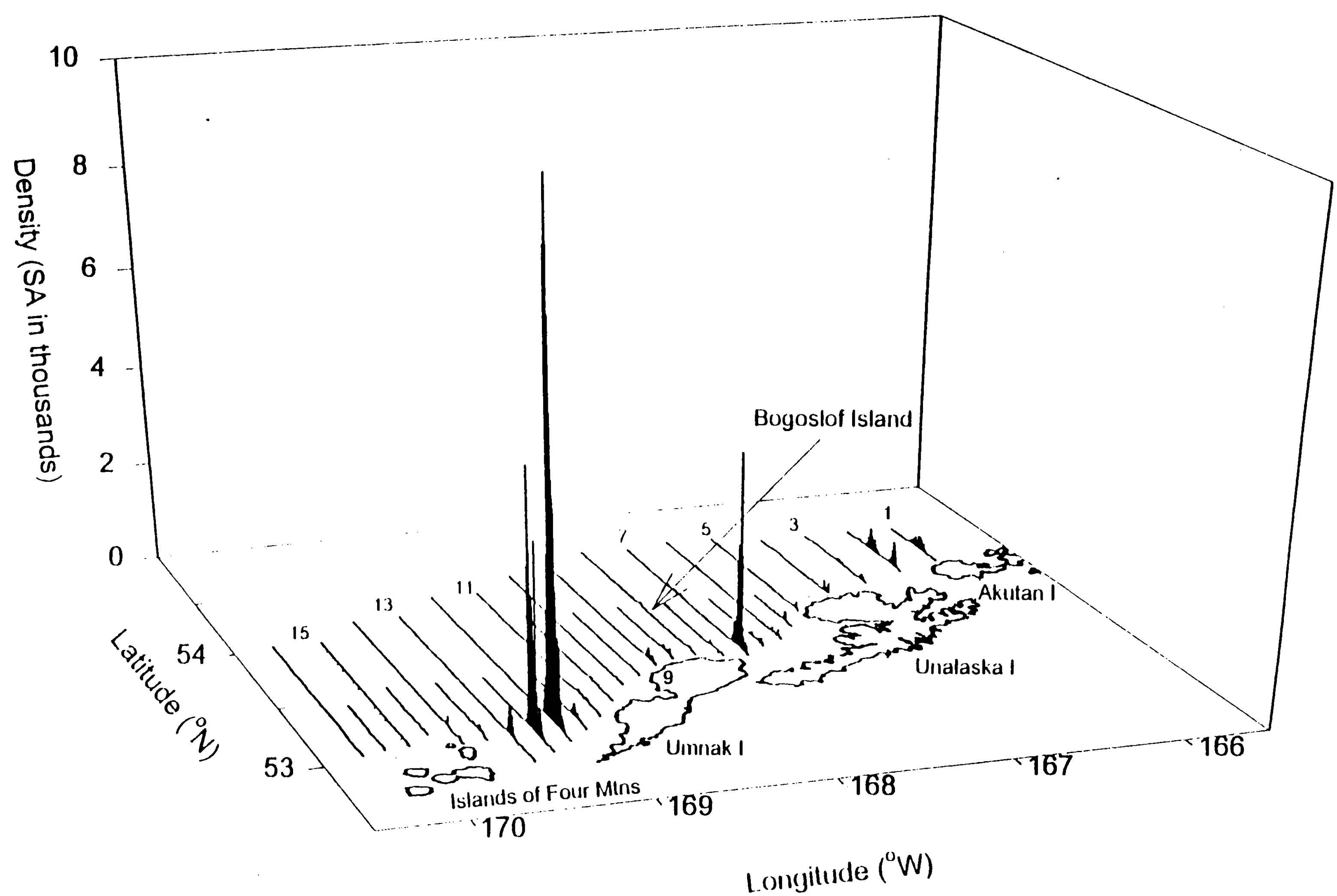


Figure 2. Relative pollock density along trackline from the winter 1998 echo integration-trawl survey of the Bogoslof Island area. Transect numbers are indicated.

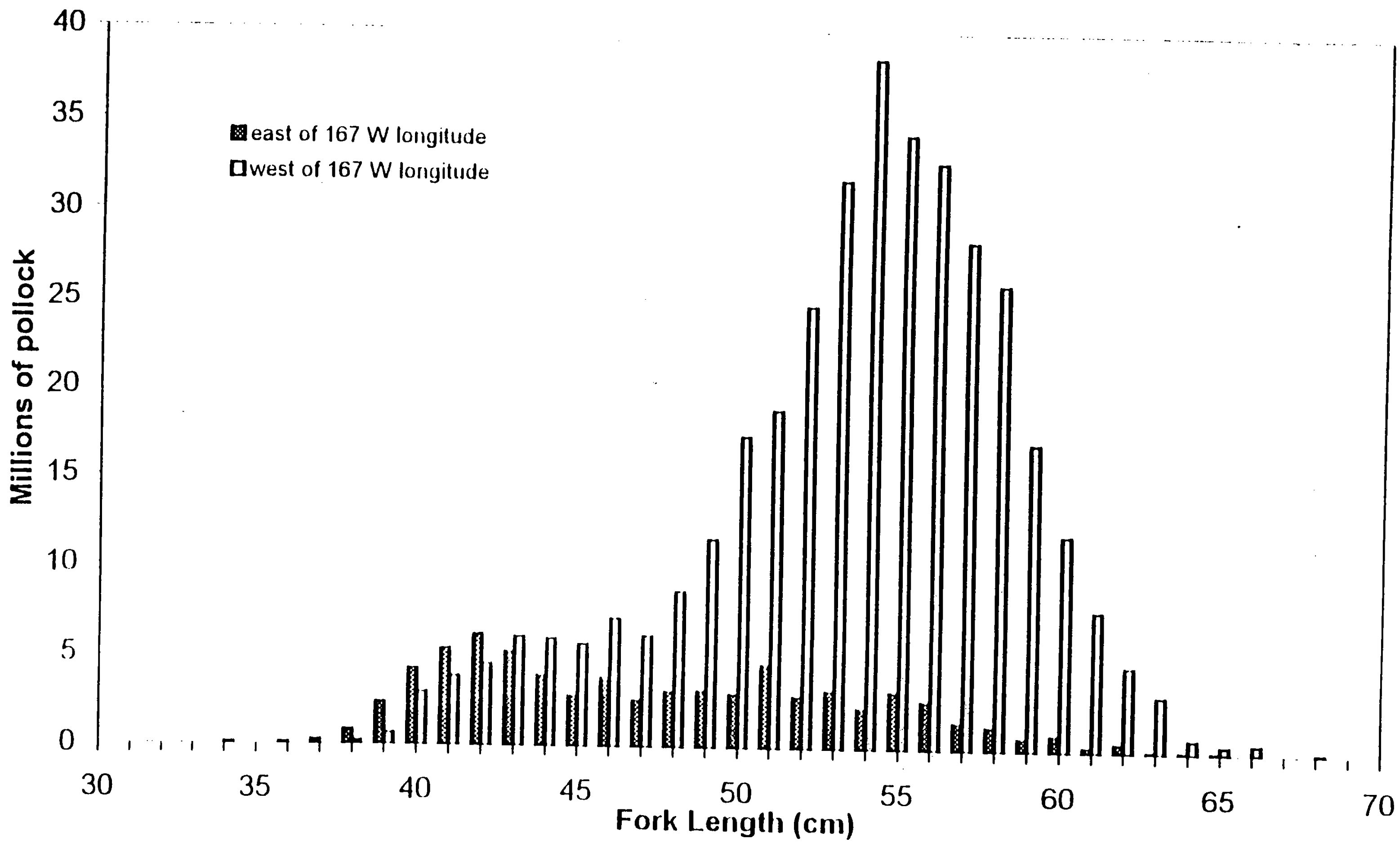


Figure 3. Estimated pollock numbers at length from the winter 1998 echo integration-trawl survey of the Bogoslof Island area.

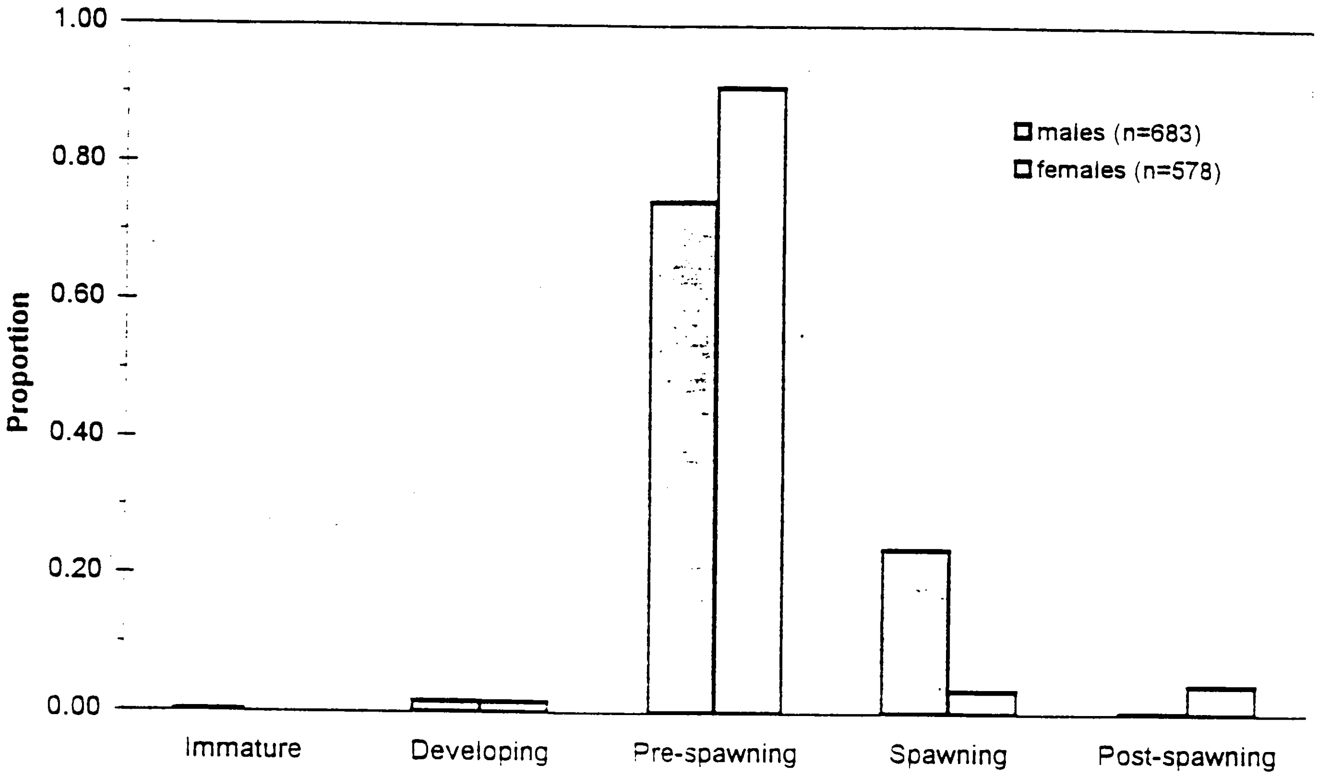


Figure 4. Maturity stages of pollock observed during the winter 1998 echo integration-trawl survey of the Bogoslof Island area.

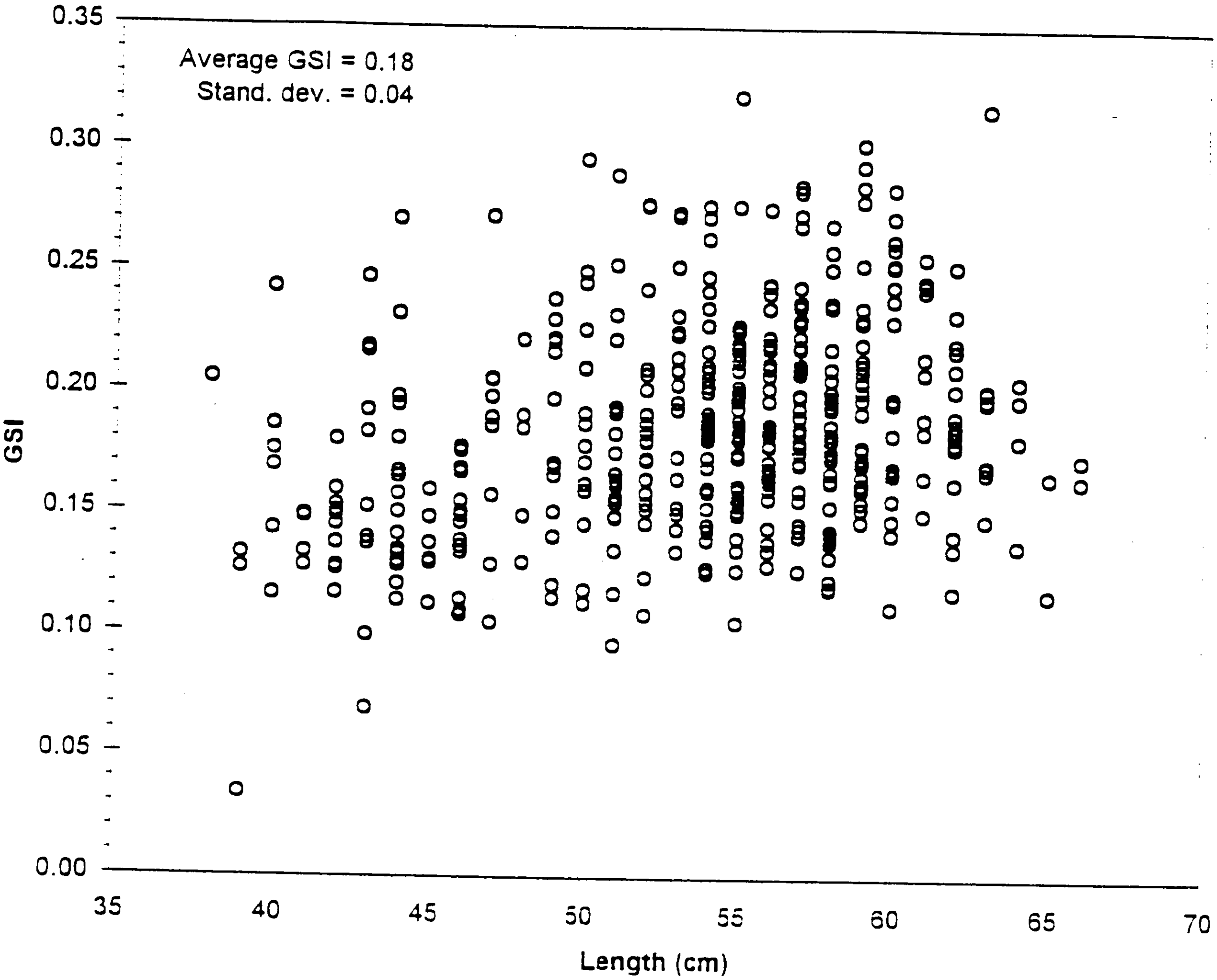


Figure 5. Pollock gonado-somatic indices for mature females plotted as a function of length from the winter 1998 echo integration-trawl survey of the Bogoslof Island area.

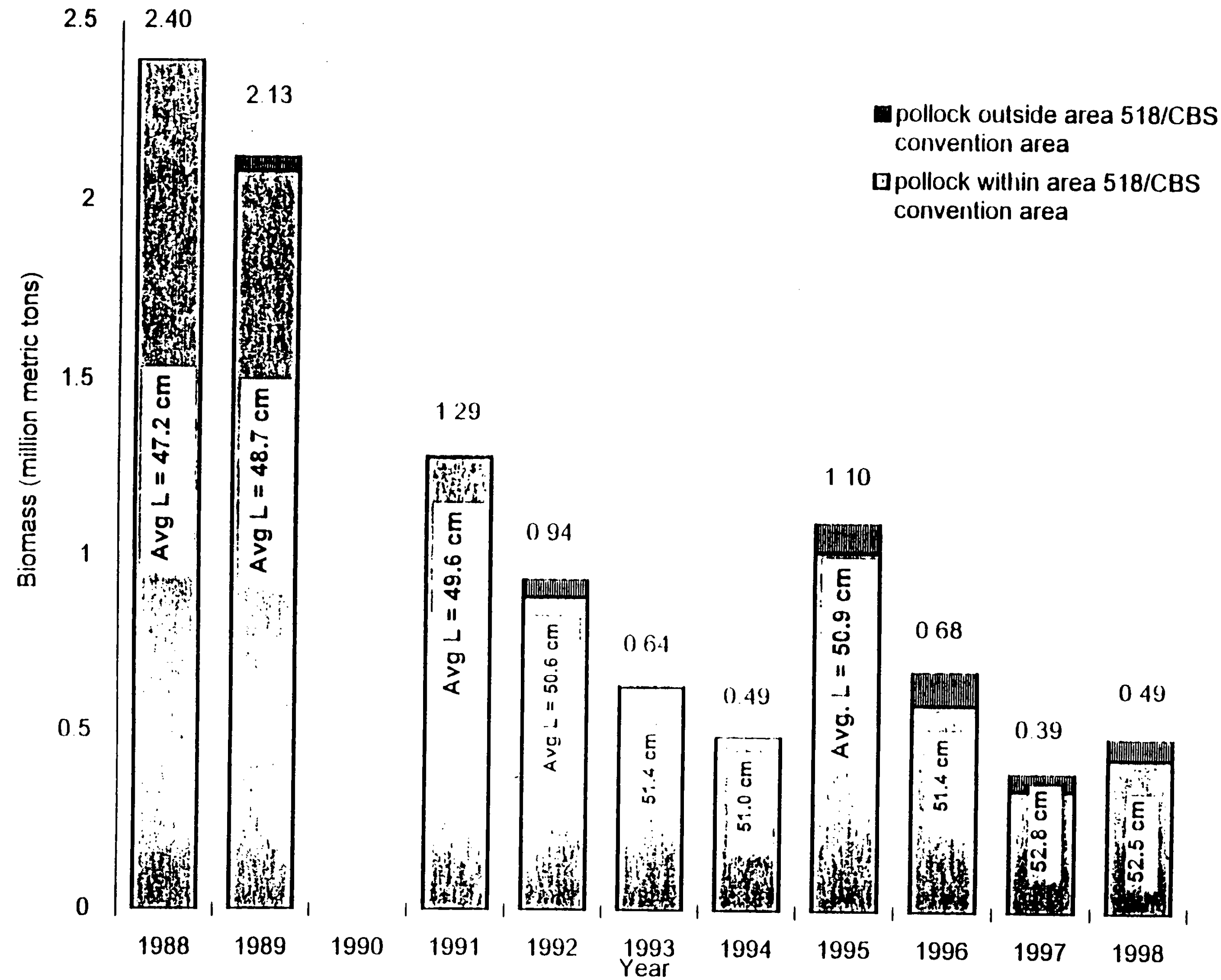


Figure 6. Biomass estimates and average fork lengths obtained during winter echo integration-trawl surveys for spawning walleye pollock near Bogoslof Island, 1988-98. There was no survey in 1990. Total pollock biomass for each survey year is indicated.

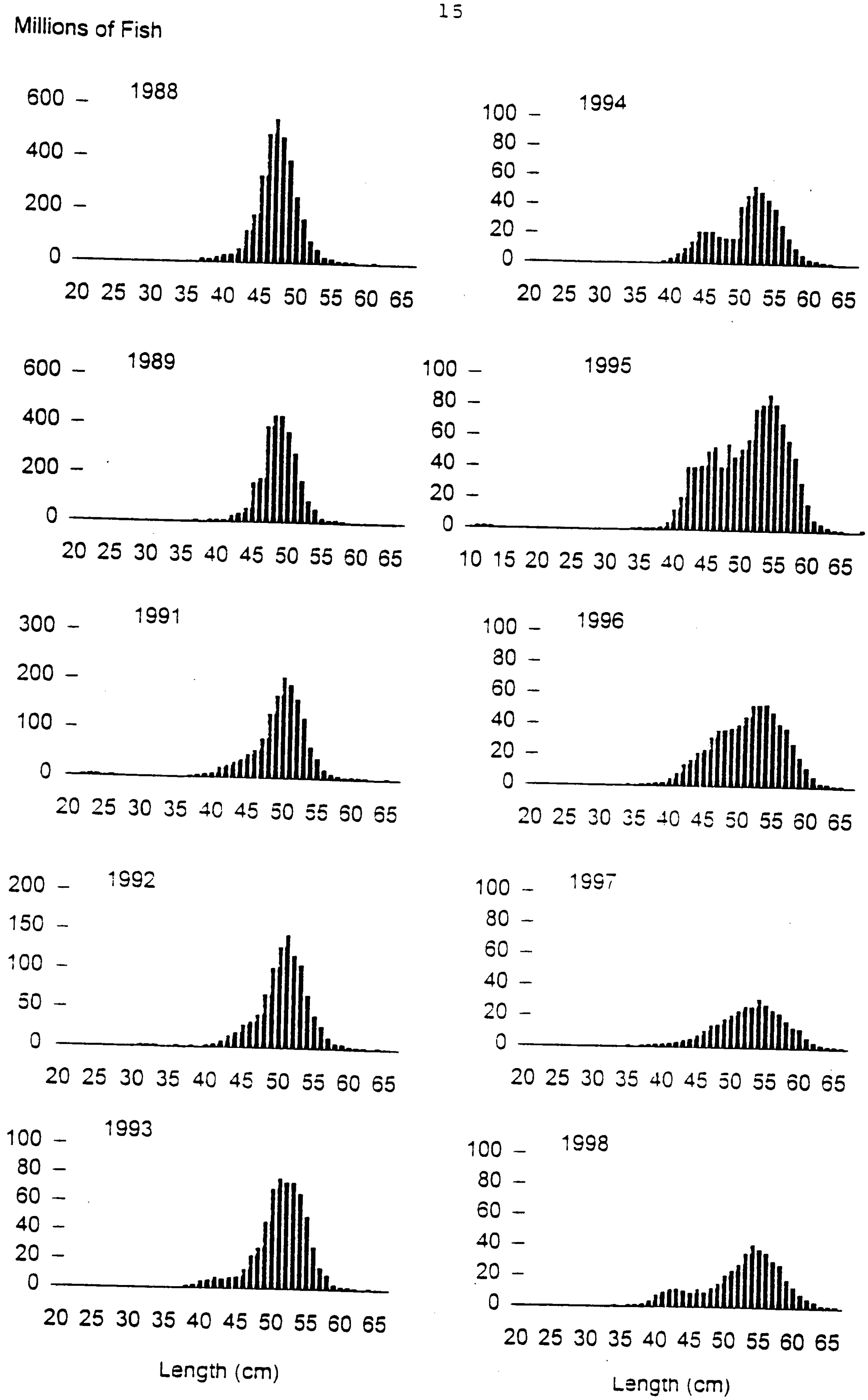
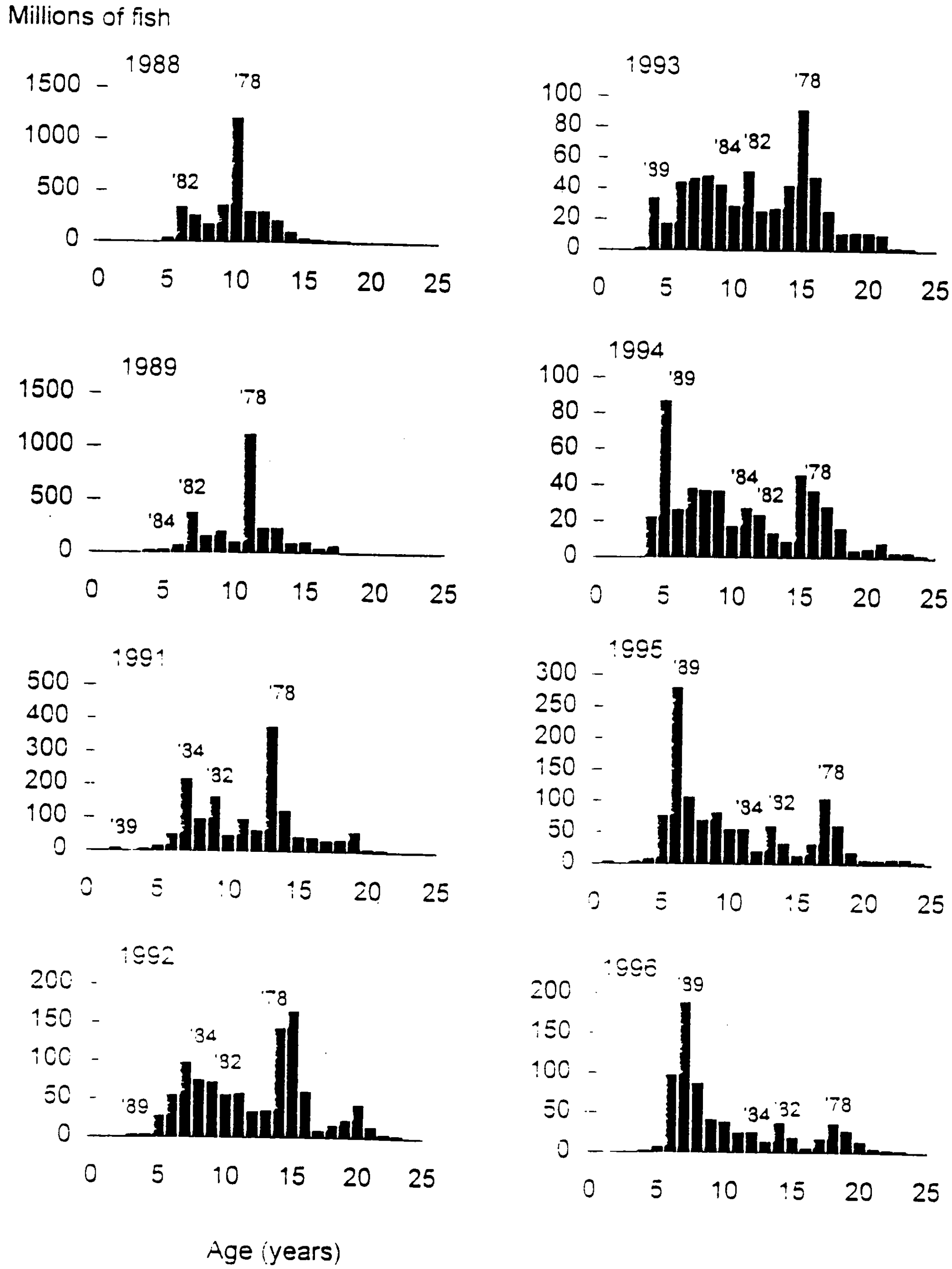


Figure 7. Population-at-length estimates obtained during echo integration-trawl surveys of spawning walleye pollock near Bogoslof Island in winter 1988-98. Note y-axis scale differences. No survey was conducted in 1990.



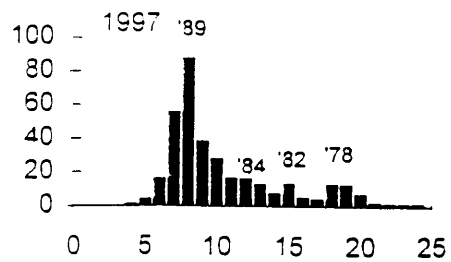


Figure 8. Population-at-age estimates obtained during echo integration-trawl surveys of spawning walleye pollock near Bogoslof Island in winter 1988-98. Major year classes are indicated. No survey was conducted in 1990. Note y-axis scale differences.

1998*
* Age data not yet available.

STOCK ASSESSMENT AND FISHERY EVALUATION REPORT

FOR THE GROUNDFISH RESOURCES

OF THE BERING SEA/ALEUTIAN ISLANDS REGIONS

Compiled by

The Plan Team for the Groundfish Fisheries
of the Bering Sea and Aleutian Islands

With Contributions by

M. Dorn, L. Fritz, J. Fujioka, T. Honkalehto,
J. Ianelli, D. Ito, S. Lowe, T. Sample, M. Sigler,
G. Thompson, G. Walters, V. Wespestad, T. Wilderbuer,
G. Williams, N. Williamson, and D. Witherell

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North Pacific Fishery Management Council
605 West 4th Ave., Suite 306
Anchorage, AK 99501

Stock Assessment and Fishery Evaluation Report
for the Groundfish Resources
of the Bering Sea/Aleutian Islands Region

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Bering Sea-Aleutian Islands Walleye Pollock Assessment for 1998

Vidar G. Wespestad, James N. Ianelli, Lowell Fritz,
Taina Honkalehto, Neal Williamson and Gary Walters

Summary

Pollock stocks in the eastern Bering Sea and Aleutian Islands (excluding the central Bering Sea and the Bogoslof Island Region) are expected to be in the 5.8-6.1 million t range in 1998. The eastern Bering Sea biomass in 1997 was estimated to be 5.62 million t. by combined bottom trawl and echo integration trawl (EIT) surveys.

The 1998 assessment incorporates catch data from the 1996 eastern Bering Sea and Aleutian Islands area fisheries. Also included are biomass estimates and age composition estimates from the 1997 eastern Bering Sea bottom trawl and EIT surveys. These data are used in catch-age models to estimate the current population size and project 1998 biomass and ABC estimates. A catch-age model is used to provide a fisheries based estimate of abundance for the Aleutian Islands area along with results from a 1997 bottom trawl survey. The results of a 1997 Bogoslof Island EIT survey are included as Appendix 1.B.

Specific issues raised by the NPFMC's SSC involved examining the sensitivity of alternative harvest rates and a more explicit accounting of uncertainty in the assessments. We approached this by deriving a novel method of showing uncertainty in yield under the assumed $F_{40\%}$ target harvest and the $F_{30\%}$ for our overfishing definition. We examined alternative weightings of survey data and investigated the influence of different ways to model recruitment. This included a limited evaluation of the effect of a hypothesized environmental covariate on subsequent year-class strengths available to the fishery. Standard errors were available for all parameters estimated and where appropriate, they are presented below. Risk analyses for pollock are presented based on use of the harmonic mean value for yield under an $F_{40\%}$ harvest strategy. If the $F_{40\%}$ rate is used as a proxy for MSY then, by extension, a risk-averse policy would be related to the harmonic mean of this harvest level based on Thompson's (1996) analyses.

Summary of ABC estimates for 1998 by area and comparison to previous years are as follows:

Eastern Bering Sea	**1996**	**1997**	**1998**	**F**
$F_{40\%}$ (ABC)	1.29 million t	1.10 million t	**1.11 - 1.30** million t	0.36 (average)
$F_{30\%}$ overfishing		1.98 million t	1.70 – 1.98 million t	0.65 (average)
Aleutian Islands				
F_{abc}	26,200 t	17,413 – 28,000 t	23,760 t	0.225 = 0.75 M
$F_{overfishing}$		24,000 – 38,000 t	31,680 t	0.3 = M
Bogoslof Island				
$F_{40\%}$	286,000 t	115,000 t	67,400 t	0.27
$F_{overfishing}$		157,500 t	92,400 t	0.37

1.1. Introduction

Throughout the history of pollock fishing in the eastern Bering Sea catch has averaged 1.1 million t and has ranged from a minimum of 0.2 million t in 1964 to a maximum of 1.9 million t in 1972. Since the advent of the U.S. EEZ in 1977 the annual average eastern Bering Sea pollock catch has been 1.2 million t and has ranged from 0.9 million in 1987 to 1.6 million t in 1991 while stock biomass has ranged from a low of 4-5 million to highs of 12-14 million t. The stability of the eastern Bering Sea pollock stock is remarkable in light of trends in most Asian pollock stocks and North Atlantic gadoid stocks which have collapsed or undergone strong fluctuations in catches and abundance. It appears that eastern Bering Sea pollock catches in the range of recent years are sustainable, and within the productive capacity of the stock and stock fluctuations observed over the history of the fishery.

The stock structure of Bering Sea pollock is not well defined. In the U.S. portion of the Bering Sea pollock are considered to form three stocks for management purposes. These are: eastern Bering Sea which consists of pollock occurring on the eastern Bering Sea shelf from Unimak Pass to the U.S.-Russia Convention line; Aleutian Islands Region which encompasses the Aleutian Islands shelf region from 170°W to the U.S.-Russia Convention line; and Central Bering Sea -Bogoslof Island pollock, which are thought be a mixture of pollock that migrate from the U.S. and Russian shelves to the Aleutian Basin around the time of maturity.

In the Russian EEZ, pollock are considered to form two stocks, a western Bering Sea centered in the Gulf of Olyutorski, and a northern stock located along the Navarin shelf from 171°E to the U.S.- Russia Convention line. The northern stock is believed to be a mixture of eastern and western Bering Sea pollock with the former predominant.

This assessment updates the 1997 assessment by including results from 1997 eastern Bering Sea echo integration-midwater trawl and bottom trawl surveys, the 1997 Bogoslof echo-integration trawl (EIT) survey, and data from 1996 pollock fisheries.

Two age-structured population dynamics models have been employed to assess EBS pollock: traditional cohort analysis model (Pope 1972); and a statistical age structured model (SAM). The SAM analysis was introduced as an appendix to last year's SAFE. This year we present these results within this document, particularly in application to the eastern Bering Sea stock. To accommodate these changes, this SAFE document has been slightly re-organized. We begin with an overview of the fisheries and catch data then present results and methods used by the NMFS resource surveys. A discussion of the biological parameters used for the different regions precedes descriptions of the models where they are used. We then present the details of an analysis of available data for the Aleutian Islands. We conclude with a section on the Aleutian Basin-Bogoslof Island area and stock and fishery considerations. The outline of this document is thus:

1.2. Catch history and fishery data

1.2.1. Eastern Bering Sea

From 1954 to 1963, pollock were harvested at low levels in the Eastern Bering Sea and directed fisheries began in 1964. Catches increased rapidly during the late 1960s and reached a peak in 1970-75 when catches ranged from 1.3 to 1.9 million t annually (Fig. 1.1). Following a peak catch of 1.9 million t in 1972, catches were reduced through bilateral agreements with Japan and the USSR.

Since implementation of the Magnuson Fishery Conservation and Management Act (MFCMA) in 1977, catch quotas have ranged from 0.95 to 1.3 million t (Fig. 1.1). In 1980 United States vessels began harvesting pollock and by 1987 they were able to take 99% of the quota. Since 1988 the harvest has been taken exclusively by U.S. vessels. The 1996 catch, including discards was 1.19 million t.

1.2.2. Aleutian Islands

Catches in the Aleutian region have always been less than those in the Eastern Bering Sea. The catch increased from 1980 to 1984 as a result of increased foreign effort and then decreased in recent years as the foreign fishery was phased out. Joint venture landings increased in 1986 through 1988, but JV catch for those years was about half of the average foreign catch for 1980 through 1985. In 1989 the catch declined to 16 thousand t, but increased to 79 thousand t in 1990 and 1991, and decreased to 54 and 26 thousand t in 1992 and 1993, respectively. Catches increased to 63 thousand t in 1995 and decreased to 29 thousand t in 1996.

1.2.3. Aleutian Basin

Foreign vessels begin fishing in the mid-1980's in the international zone of the Bering Sea (commonly referred to as the "Donut Hole"). The Donut Hole is entirely contained in the deep water of the Aleutian Basin and is distinct from the customary areas of pollock fisheries, namely the continental shelves and slopes. Japanese scientists began reporting the presence of large 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 1984, the donut hole catch was only 181 thousand t (Fig. 1.1, Table 1.1). The catch grew rapidly and by 1987 the high seas catch exceeded the pollock catch within the U.S. Bering Sea EEZ. The extra-EEZ catch peaked in 1989 at 1.45 million t and has declined sharply since then. By 1991 the donut hole catch was 80% less than the peak catch, and data for 1992 and 1993 indicate very low catches (Table 1.1). A fishing moratorium was enacted in 1993 and only trace amounts of pollock have been harvested from the Aleutian Basin by resource assessment fisheries.

The Bogoslof fishery occurs in deep water off the Eastern Bering Sea shelf. In 1987 the catch was 377 thousand t, but decreased to 88 thousand t in 1988 and decreased further, to 36,073 t, in 1989 (Fig. 1.1). Estimates for 1990 indicated that catch in the Bogoslof area increased to 152 thousand t and to 265 thousand t in 1991. The catch in Area 518 has primarily been composed of fish from the 1978, 1982, 1984 and 1989 year-classes, similar to the catch from the rest of the Aleutian Basin, suggesting that harvests came from the same group of fish. Directed pollock fishing was prohibited in the Bogoslof area in 1992 and only a small amount of pollock was taken as by-catch in other fisheries.

Since 1987, catches in the Bogoslof Island area (area 518) have not been included in the Eastern Bering Sea analysis because the age composition and growth characteristics of pollock in area 518 are different from that observed in catches from the Eastern Bering Sea shelf, but similar to the pollock harvested in the "Donut Hole." The pollock catch from the Bogoslof Island area is included with the catch from the "Donut Hole" and other areas of the Aleutian Basin.

1.2.4. 1996-97 fishery characteristics

A-Season: Since the closure of the Bogoslof management district (518) to directed pollock fishing in 1992, the A-season pollock fishery on the eastern Bering Sea (EBS) shelf has been concentrated primarily north and west of Unimak Island (see Figs. 1.3-1.5 in Wespestad et al. 1996). Depending on ice conditions and fish distribution, there has also been effort along the 100 m contour between Unimak Island and the Pribilof Islands. This pattern has continued for the A-seasons of 1996 and 1997 (Figs. 1.2 and 1.3). In the 1996 A-season, the modal length of pollock caught outside of the catcher vessel operational area (CVOA; 43 cm) was 6 cm smaller than inside the CVOA (49 cm); in 1997, there was no difference in the modal length of pollock caught by the fishery (47 cm) inside and outside of the CVOA

(Fig. 1.4). (While the CVOA has been an exclusive shoreside-delivery vessel operating area only during the B-season, it was used here only to delineate catches during the A-season).

In the Aleutian Islands, the fishery has fished further west each A-season from 1994-96. In 1994, almost all of the AI pollock were caught in the eastern sub-area 541 north of the Islands of Four Mountains, Amukta Pass, and near Seguam Island. Much of this catch may have been "Basin" fish particularly since most of the fishery was pelagic and in deep water (e.g., > 500 m). Beginning in 1995, the fishery moved west to an area north of Atka Island and another north of Kanaga Island (around Bobrof Island). These two areas were exclusively used in 1996 and 1997 with little or no effort in the eastern Aleutian sub-area (Figs. 1.2 and 1.3). As in previous years, the fishery catches had very few fish smaller than 40 cm and the modal lengths were in the upper 40s and mid 50 cm ranges (Fig. 1.4).

B-Season: After 1992, the B-season fishery has been conducted to a much greater extent east of 170°W than it had been prior to 1992 (see also Figs. 1.3-1.5 in Wespestad et al. 1996). This is a reflection of the implementation of the CVOA in 1992, the distribution of pollock by size on the eastern Bering Sea shelf, and the desire of the fleet to catch pollock larger than 35 cm. While there was some fishing north of Zhemchug Canyon and along the edge of the US-Russia Convention Line in 1996 (Fig. 1.2), pollock caught there had modal lengths almost 15 cm smaller than those east of 172° 30'W (Fig. 1.4). Pollock caught on the NW shelf were predominately members of the 1992 year-class.

1.2.5. Fisheries catch Data

Observation of catch indicates that pollock discard is of significant magnitude that must be taken into account in estimation of population size and forecasts of yield. Observer length frequency observations indicated that discarded pollock include both large and small pollock. Since observers usually sample the catch prior to discarding, the size distribution of pollock sampled closely reflects the actual *total* catch. Discard data as compiled by the NMFS Alaska Regional Office have been included in estimates of total catch since 1990.

Pollock catch in the eastern Bering Sea and Aleutian Islands by area from observer estimates of retained and discarded catch, 1990-1996 are shown in Table 1.2. Discarded pollock since 1990 has ranged from a high of 11% of total pollock catch in 1991 to a low of 6.3% in 1996. Pollock discards in 1994 were 7.7%, slightly lower than in 1993, and decreased further in 1995 to 7.4%, and 6.3% in 1996.

We estimate catch age composition using the methods described by Kimura (1989) and modified by Dorn (1992). Briefly, length-stratified age data are used to construct age-length keys for each stratum and sex. These keys are then applied to randomly sampled catch length frequency data. The stratum-specific age composition estimates are then weighted by the catch within each stratum to arrive at an overall age composition for each year. Data were collected through shore-side sampling and at-sea observers. The three strata for the EBS were: 1) INPFC area 51 from January - June (the "A" season); 2) INPFC area 51 from July -December (the "B" season); and 3) INPFC area 52 from January - December. This method was used to derive the age compositions from 1991-1995 (the period for which all the necessary information is readily available). Prior to 1991, we used the same catch - age composition estimates as presented in Wespestad et al. (1996). The 1996 estimates of the catch at age (by A and B seasons in the EBS is given in Figure 1.5 and the time series of the proportion estimated at each age is presented in Fig. 1.6. Data values used in both the cohort analyses and statistical age-structured model (SAM) for catch-at-age for 1979-1996 are given in Table 1.3 while the estimates available for the Aleutian Islands region are given in Table 1.4.

1.3. Resource surveys

1.3.1. Bottom trawl surveys

Trawl surveys have been conducted annually by the AFSC to assess the abundance of crab and groundfish in the Eastern Bering Sea. Until 1975 the survey only covered a portion of the pollock range. In 1975 and since 1979, the survey was expanded to encompass most of the range of pollock. Table 1.5 shows the biomass estimated from a standardized area from these surveys. Since 1984 the biomass estimates have been relatively high and showed an increasing trend through 1990 (Table 1.5). Between 1991 and 1996 the bottom trawl survey biomass estimate has ranged from 3.2 to 5.5 million t. The 95% confidence intervals indicate the estimates are not significantly different between years, except for 1996 relative to 1993 (Fig. 1.7).

The 1997 AFSC crab/groundfish bottom trawl survey was conducted from June 7- July 26. The standard survey area, outlined in Fig. 1.8, covered 463,000 km2 using 356 stations. An additional 20 stations above the northwest corner of the survey covered 34,000 km^2. The distribution of walleye pollock was similar to previous years with major concentrations around the Pribilof Islands, and in the northwest corner of the survey area (Fig. 1.8). The abundance estimate for the bottom trawl survey was 3,031,000 t with a 95% confidence interval of +/- 20% based on sampling variability alone. An additional estimate of 826,000 t was made for the small area outside the standard survey to the northwest. This is the lowest biomass estimate for the bottom trawl portion in the standard survey area since 1981.

Preliminary 1997 abundance estimates by length revealed dominant length modes at 17 cm and 36 cm north and west of the Pribilof Islands area, and around 50 cm near the Pribilof Islands and to the south and east. Fish northwest of the Pribilof Islands were, on average, smaller than fish near the Pribilof Islands and east. Nearly all fish less than 35 cm were observed northwest of the Pribilof Islands, with most near the U.S./Russia convention line. Pollock abundance by age in the northwest area was quite different than that from the southeast areas, reflecting the pattern observed in the population length distribution. In the northwest, the 1992 year class (age 5) dominated, followed by the 1996 year class (age 1). South and east of the Pribilof Islands, the 1989 year class (age 8) was most numerous.

The age composition estimates for 1997 for the entire area surveyed are shown in Figure 1.9. As is normally the case, ages 2 and 3 are not well represented in bottom trawl samples. Other than age 1 fish, ages 5 through 8 dominated the catch. Age readers noted a particular problem determining fish aged 2 and 3 years from the 1997 collections. Therefore, the relative proportions of these fish may not represent the true distribution well.

Aleutian Islands

Survey effort has not been as extensive in the Aleutian Region as in the eastern Bering Sea. Bottom trawl surveys were conducted in 1980, 1983, 1986, 1991, 1994, and 1997. Recently, biomass estimates for the Aleutian Islands Region have been recalculated using revised estimates of survey area (Harrison 1993; Ronholt, Teshima and Kessler 1994). Table 1.6 shows the trend of pollock biomass from the triennial Aleutian Islands groundfish surveys. Two estimates are shown, one for the Aleutian Islands Region proper, and one for the Aleutian Islands Region and the Unalaska-Umnak area (Unimak Pass to Islands of Four Mountains). Historically, the total biomass from the Aleutian Islands and from the Unalaska-Umnak area have been combined as the Aleutian Islands biomass estimate. The Unalaska-Umnak area in the Aleutian Islands estimates was not surveyed as part of the eastern Bering Sea survey. Since the biomass should be accounted for in yield determination, we therefore include this portion biomass as part of the Aleutian Islands estimates.

Table 1.6 shows that pollock abundance peaked in 1983 and has been generally decreasing since that time. This trend is similar to the eastern Bering Sea. The biomass of pollock in the Aleutian Islands Region in 1997 compared to 1994 was distributed as follows:

Area	Range	1994 Biomass	1997 Biomass	1997 avg. wt. kg
Western Aleutian	(177E-170E)	15,153 t	20,807 t	1.20
Central Aleutian	(177E-177W)	33,326 t	46,794 t	1.07
Eastern Aleutian	(170W-177W)	37,895 t	37,999 t	1.11
Total	(170W-170E)	86,374 t	105,600 t	1.11
Unalaska-Umnak	(170W-165W)	65,070 t	100,166 t	1.08

By far, the greatest densities and biomass occur in the Unalaska-Umnak area. Within the Aleutian Islands, the highest densities and biomass were from the Central Aleutians followed by the Eastern and Western areas. This pattern is similar to the distribution of abundance observed in 1994 (Fig. 1.10). Length frequency distributions from the 1997 bottom trawl survey are similar between areas of the Aleutian Islands, particularly between the Unalaska-Umnak area and the rest of the Aleutians (Fig. 1.11). The largest fish were generally found in the Western Aleutians although mean sizes were similar throughout all areas. These biomass estimates do not include mid-water pollock and therefore represent an unknown portion of total biomass. The biomass in this area may be greater if the on-bottom/off-bottom distribution is similar to that of the eastern Bering Sea.

1.3.2. Echo-integration trawl (EIT) surveys

Whereas bottom trawl surveys are conducted annually and assess pollock from the bottom to 3 m off bottom, EIT surveys have been conducted triennially since 1979 to estimate pollock in midwater (Traynor and Nelson 1985). An EIT survey was also conducted in 1996 (outside the triennial series) to address concerns about recruitment.

The most recent EIT pollock survey was carried out 16 July - 6 September, 1997 westward from Port Moller, Alaska to the U.S./Russia Convention Line. The trackline consisted of north-south transects spaced 20 nmi apart and was designed to coincide with lines of groundfish trawl stations sampled by bottom trawl survey vessels. Pollock were distributed throughout the survey area with the highest densities encountered in the regions west and south of St. Matthew Island and between Unimak Island and St. George Island (Fig. 1.12). Biomass of pollock in midwater (from near the surface to 3 m from the bottom) was estimated at 2.59 million tons with 0.8 million tons east of 170° W longitude and 1.8 million tons west of 170° W longitude. Pollock ranged in length from 10 to 73 cm with a major mode at 16 cm and minor modes at 27 and 40 cm (Fig. 1.13a). East of 170° W longitude, pollock numbers were dominated by the 1996 year class (age 1; Fig. 1.13b). West of 170° W longitude, the 1996 year class was again the most numerous, followed by the 1995 (age 2) and 1992 (age 5) year classes. The 1996 year class totaled 12.4 billion fish for the survey area. In terms of biomass, the 1992 year class accounted for 0.9 million tons and the 1996 and 1995 juvenile year classes made up 0.4 million tons each. The time series of estimated EIT survey proportions at age is presented in Fig. 1.14.

1.4. Biological parameters

Natural Mortality and maturity at age

Wespestad and Terry (1984) estimated M=0.9, 0.45, and 0.3 for ages 1, 2, and 3+ respectively. These latter values have been used since 1982 in catch-age models and forecasts and appear to approximate the true rate of natural mortality for pollock. Maturity at age was assumed to be the same as that given in Wespestad (1995).

Age of Recruitment, and Maximum Age

Pollock are commonly taken at age 2 by the commercial fishery, but are considered to be too small for effective utilization. Some age 3 fish are commonly utilized by the fishery. Full recruitment is not until age 4, however catch-age modeling indicates that the age 4 fish still have a partial selectivity less than 1.0, particularly in recent years. The oldest recorded pollock is a 31-year-old specimen taken in 1990, however the average life span of pollock is much shorter. The average age of pollock in the catch since 1964 is 4.8 years old.

Length and Weight at Age

Length, weight, and age data have been collected extensively for pollock. Length-age and weight-length relationships for each stratum of pollock samples indicate that there are growth differences by sex, area, and year-class. General characteristics of length-weight-age relationships and other fishery parameters are given below:

Age	Natural mortality rate	Mean length (cm)			Mean weight (kg)	Selectivity 1977-1994 Average	Maturity
		Area 51	Area 52	EBS	EBS		
2	0.45	29.8	25.9	28.2	0.170	5%	1%
3	0.3	36.1	31.9	34.5	0.303	27%	29%
4	0.3	41.1	36.7	39.5	0.447	50%	64%
5	0.3	45.1	40.6	43.4	0.589	70%	84%
6	0.3	48.2	43.7	46.6	0.722	90%	90%
7	0.3	50.7	46.2	49.1	0.840	100%	95%
8	0.3	52.6	48.3	51.1	0.942	88%	96%
9	0.3	54.2	49.9	52.7	1.029	89%	97%
10	0.3	55.4	51.2	54.0	1.102	77%	97%
11	0.3	56.4	52.3	55.0	1.163	79%	100%
12	0.3	57.1	53.1	55.8	1.212	79%	100%
13	0.3	57.7	53.8	56.5	1.253	77%	100%
14	0.3	58.2	54.4	57.0	1.286	87%	100%
15	0.3	58.6	54.8	57.4	1.312	87%	100%

Of note is that growth in length in Area 52 (northeast shelf) is less than in Area 51 (southeast shelf). This difference also occurs in weight and as a consequence biomass elaboration and yield is proportionately lower in Area 52. For modeling purposes, we used annual estimates of mean weight at age to account for potential changes in growth.

Growth parameters for the eastern Bering Sea and the two subareas, Aleutian Basin, and Aleutian Island area are shown below.

Area	L_∞	k	to	W_∞	alpha	beta	M
E. Bering Sea	59	0.228	-0.854	1.42	1.14E-05	2.877	0.3
Area 51	60.05	0.234	-0.929	1.53	1.19E-05	2.872	0.3
Area 52	56.63	0.217	-0.814	1.21	1.43E-05	2.812	0.3
Aleutian Basin	55.66	0.171	-2.474	1.28	1.29E-06	3.436	0.2
Aleutian Island	52.81	0.368	-0.584	1.04	2.73E-05	2.651	0.3

These parameters were used to compute biological reference points for pollock in each area with knife-edge selectivity at age 3.

M = 0.2 is used for the Aleutian Basin, and M=0.3 is used for the Aleutian Island pollock under the assumption that mortality in this area is similar to the eastern Bering Sea.

1.5. Eastern Bering Sea

To the extent possible, both models were "tuned" using identical fishery and auxiliary information from the triennial EIT and bottom trawl surveys.

1.5.1. Cohort analysis methods

The cohort analysis model tuning requires three assumptions: 1) the relative age compositions of pollock obtained from the combined EIT-bottom trawl surveys are unbiased estimates of the age composition of the age 3+ population, 2) interannual changes in survey abundance are proportional to actual abundance changes in the population, and 3) the index of age 1 pollock in the bottom trawl survey is proportional to year-class strength, even though age 1 is not fully recruited to the survey gear.

Under the first assumption the terminal F values were adjusted until the proportional 1996 age composition from the model was identical to the estimated proportional age composition observed in the 1996 survey as shown below:

	Numbers		1996 Age Composition	
Age	(billions)	F	Model	Survey
2	1.070	0.011	7.62%	7.63%
3	0.875	0.027	6.23%	6.37%
4	4.329	0.012	30.83%	29.49%
5	2.217	0.079	15.79%	15.88%
6	2.279	0.197	16.23%	16.01%
7	2.010	0.330	14.32%	14.34%
8	0.649	0.417	4.62%	4.22%
9	0.157	0.278	1.12%	1.01%
10	0.133	0.139	0.94%	0.97%
11	0.080	0.139	0.57%	0.67%
12	0.176	0.060	1.26%	1.30%
13	0.051	0.097	0.37%	0.39%
14	0.015	2.087	0.11%	1.72%

The 1996 F values were then adjusted so the total number of age 3+ pollock in the cohort analysis approximated the trend in age 3+ pollock in the 1979-96 combined triennial EIT and bottom-trawl surveys.

Year		1979	1982	1985	1988	1991	1994	1996	1997
Age 3 + Numbers in Billions	Model	7.15	20.75	22.72	16.93	9.76	15.27	10.55	7.53
Numbers	Survey	10.42	22.73	23.52	22.72	7.38	11.46	9.09	7.44

Terminal F for year-classes prior to the 1978 year-class was set equal to the average of the 3 preceding ages in the same year.

The cohort analysis was also fit using the solver function of Excel to obtain a variance minimization solution. An objective function consisting of three sets of sums of squared differences (model prediction versus observed data):

1) the estimated population relative age composition and survey relative age composition in triennial survey years;
2) the age 3 recruitment estimate and the age 1 recruitment index; and
3) the relative change in age 3+ estimated population numbers and the relative age 3+ combined EIT and bottom-trawl survey numbers in triennial survey years.

A weight of 10 was placed on the population trend which gives less emphasis to the relative age composition and recruitment index. The relative age composition was given a lower weight because of the concentration of catch and biomass in a few year-classes. It was felt that the relatively lower number of older fish in conjunction with aging error forced poor model fits with a greater level of emphasis on relative age composition.

The value of the above objective function was minimized by solving for a terminal year (1997) F, a terminal year selectivity. The selectivity function for age i is:

$$S_i = \alpha\, i^{\gamma} e^{-\beta i}$$

where

$$\alpha = \left(\frac{\beta}{\gamma}\right)^{\gamma e^{\gamma}}, \gamma = S_{max} + \beta$$

The variables S_{max}, β, terminal year F, were estimated by the model. The terminal F for year-classes (ages 14+) prior to the terminal year were set equal to the terminal F for age 14+ in the terminal year of the analysis.

1.5.2. Statistical age-structured modeling (SAM) methods

The SAM analysis was introduced last year as an appendix to the regular stock assessment. The primary differences between this model and the cohort analysis are:

1) the EIT survey data are modeled separately from the bottom trawl survey;
2) the bottom trawl survey age composition estimates are used from age 1 - 15+ for the years 1982-1997;
3) computations for SPR rates (e.g., $F_{40\%}$) were based on average fishery selectivity values rather than assuming knife-edged selectivity;
4) a robust likelihood method is applied and evaluated; and
5) a more complete statistical treatment of available data is made.

Changes from last year's analyses include:

- the addition of 1995 and 1997 bottom trawl survey age composition data, 1996 fishery catch-at-age estimates, and 1997 EIT survey data
- presenting a novel way of evaluating the uncertainty in estimates of yields under alternative harvest rates (e.g., $F_{40\%}$, $F_{30\%}$).
- explicit modeling of recruitment both as a function of spawning stock size and some limited environmental hypotheses.

The details of this model and the changes from last year are presented in Appendix 1.A.

Model alternatives

Since there are many new assumptions to be evaluated, we attempted to simplify the presentation in a somewhat hierarchical fashion. The main model combinations can be described as follows:

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Description	*Baseline*	Fit survey precisely	Ignore survey	Constant recruitment	Environment model	Constant selectivity
Survey CVs	*Moderate*	Low	High	Moderate	Moderate	Moderate
Sample size survey age composition	*Moderate*	High	Low	Moderate	Moderate	Moderate
Recruitment Model	*Ricker*	Ricker	Ricker	Constant	Ricker+Environ.	Ricker
Fishery Selectivity	*Variable*	Variable	Variable	Variable	Variable	Constant

Several comments on these models are needed. First, in all models recruitment is allowed to be stochastic with a coefficient of variation in excess of 90%. This means that the model will not restrict the predicted numbers at age 1 to tend toward some expected value of recruitment (be it constant—Model 4—or density dependent as in the others). Model 2 is specified to have high fidelity to all the survey data (that is, fitting survey observations as if there were only very minor errors) while in Model 3, we essentially ignore all survey data. Model 4 contrasts the effect of linking the expected recruitment (given stochasticity) to a simple mean value rather than to a stock-recruitment curve. Model 5 examines the effect of adding a simple environmental correlate and Model 6 gives results under the assumption of constant fishery selectivity.

Results

Differences between the six models can be observed in Table 1.7. In this table there are three sections to summarize results: 1) details pertaining to stock condition, 2) details on projected 1998 yield, and 3) model fit to the available data. The model fits are based on two main criteria, the "effective sample size" (McAlister and Ianelli, 1997) and the root-mean squared error (RMSE) on the log-ratios of observed versus predicted values.

The model fits to the survey data were highest for Model 2 and lowest for Model 3 based on the effective sample size and the RMSE. This reflects the extreme emphasis values given to the survey data between these models. The median $F_{40\%}$ harvests are 1.57 and 2.25 million tons with CV's of 37% and 43% for Models 2 and 3 respectively. Also, the 1998 female spawner biomass is about 85% of the $B_{40\%}$ level under Model 2 while for Model 3 the current stock size is above the $B_{40\%}$ level. This suggests that had there been no survey data available, the estimates of stock status would be much less precise and would result in a more optimistic yield forecast.

Results under Model 4 configuration (where the expected value of recruitment is based on a single mean value rather than from a stock-recruitment curve) gives results that are less optimistic compared to our baseline Model 1 although the estimated strength of the 1996 year-class is slightly higher.

This year, both the EIT and bottom trawl surveys provided estimates of the 1996 year-class. Adding the environmental effect (Model 5 versus Model 1) gave only minor differences in the values for the 1996 year-class and no change in the level of uncertainty about those values (Table 1.7). Adding the environmental component also gave nearly identical results to estimates of biomass and 1998 harvest levels under $F_{40\%}$.

Model 6, which assumes constant fishery selectivity over time, yielded very poor fits to the fishery data (effective N drops from 263—Model 1—to 137. There is also some degradation in fits to the survey data. Our confidence on Model 6 results is therefore low. Also it seems unlikely that a fishery which depends on strong year-classes would have constant selectivity over time. The estimated Model 1 selectivity pattern for the fishery shows how estimates of selectivity change over time (Fig. 1.15). An example of how well the model fit the fishery age-composition data is given in Fig. 1.16.

Selectivity was allowed to vary slightly over time for both surveys. This was done to account for potential changes in fish distribution rather than to question the standard survey methods employed. For example, it seems reasonable to assume that the presence of 1-year-olds available to the bottom-trawl gear on the shelf might be variable, even when the abundance is the same. In fact, the variability in estimates of selectivity for the bottom trawl survey gear is minor (Fig. 1.17). Not surprisingly, this variability allowed for good fits to the age composition estimates (Fig. 1.18).

The Model 1 fit and estimated selectivity for the EIT survey data shows a failure to estimate the 1979 total age 1+ numbers very well. This is due to the large number of 1 and 2-year old fish apparent in the survey that year (Fig. 1.19). This is illustrated in the model fit to the survey age composition data (Fig. 1.20). The proportions at age observed in the survey are generally consistent with what appeared later in the bottom-trawl survey and fishery. Estimated numbers-at-age for Model 1 are presented in Appendix 1.C.

The main differences between 1996 and 1997 estimates is in the absolute numbers at age (Fig. 1.21). The biggest change is probably due to increases in our estimates of the current abundance of the 1989, 1990, and 1991 year-classes. Relative to last year, our estimates of the 1992 year-class is somewhat lower. Please note, however, that these differences are not great considering the uncertainty of these values expressed in both years. In the longer term, this year's estimate of the 1996 year-class is significantly greater than that predicted in last year's assessment. This is due to the fact that in last year's assessment, the projected recruitment of the 1996 year-class was solely based on the expected value of recruitment (mean over all years).

1.5.3. Abundance and exploitation trends

The eastern Bering Sea bottom trawl survey estimates exhibited an increasing trend during the 1980s, were relatively stable from 1991 to 1995, and decreased sharply in 1996 but rose slightly in 1997. This may be due, in part, to age related distributional changes within the pollock population. Results from combined bottom trawl and EIT surveys, which more fully sample the population, have shown that older pollock are more vulnerable to bottom trawls than younger pollock (Table 1.5).

In 1979 when a large proportion of the population consisted of age groups 1 to 3, most of the pollock were located in mid-water. However, as the population, composed primarily of 1978 and 1982 year-classes, aged through the 1980s, the bottom trawl proportion increased. The proportion in the bottom trawl decreased in 1994 due to the large numbers of 1989 and 1992 year-class pollock in mid-water. The ratio of demersal to pelagic pollock remained similar between 1994 and 1997, with between 60-64% of the biomass distributed near bottom.

Current exploitable biomass estimates (ages 3 and older) derived from catch-age models and survey abundance estimates suggest that the abundance of eastern Bering Sea pollock remained at a fairly high level from 1982-88, with estimates ranging from 13 to 15 million t. Peak biomass occurred in 1985 and declined to about 7 million t in 1991, then increased to over 9 million t in 1993. Results from the most recent combined bottom trawl-EIT survey (1997) estimate the biomass for all ages as 6.4 million t. Catch-age models estimate 1996 biomass near 6 million t, comparable to survey results.

All estimates show a strong increase in biomass from 1979 to the mid-1980's that resulted from a very strong 1978 and relatively strong 1982 and 1984 year-classes recruiting to the fishable population (Table 1.8, Fig. 1.22). From 1985-86 to 1991 the fishable stock declined as these above average year-classes decreased in abundance with age and were replaced by weaker year-classes. In 1992 an upturn in abundance began with the recruitment of a strong 1989 year-class, but biomass has been decreasing since 1993, the year-classes entering the fishery in recent years have been weak except for the 1992 year-class. An increase in abundance is expected in future years as apparently above average 1995 and 1996 year-classes recruit to the exploitable population.

The abundance and exploitation pattern for the SAM analyses (Model 1) shows that the average fishing mortality (ages 1-15) peaked in recent years at nearly 0.4 in 1992 and has recently leveled off to around 0.2 (Fig. 1.23). This figure also shows the historical trajectory of the age 3+ biomass with 95% confidence bounds.

The observed variation in pollock abundance is primarily due to natural variation in the survival of individual year-classes. Compared to other major gadid stocks, where exploitation has been in excess of 50%, pollock are relatively lightly exploited. Table 1.8 shows that since 1979 the exploitation of eastern Bering Sea pollock has varied from 7 to 22%, and has averaged 13%. These levels of fishing removals have been well below the MSY level (30%), and too low to have influenced stock abundance. Exploitation above the MSY level does reduce the spawning stock and affects recruitment and stock abundance.

The reason for the low levels of exploitation appears to be partially due to the tendency toward producing conservative biomass estimates in the most recent assessments. This was shown in retrospective analyses for the statistical age structured analysis (Ianelli 1996).

1.5.4. Recruitment

Variation in pollock abundance is primarily due to variation in recruitment. Since recruitment is highly variable, it is difficult to predict and often to measure. It is becoming clear that there is a great deal of spatial variation in the distribution of pre-recruit pollock, both in depth and aerial distribution. To a large extent, the SAM approach takes this into account since age 1 fish are modeled and data from both the EIT and bottom trawl survey are used. Previously, the primary measure of pollock recruitment has been the relative abundance of age 1 pollock (or pollock smaller than 20 cm when age data are unavailable) in the annual eastern Bering Sea bottom-trawl survey. Also, survey age 1 recruitment estimates regressed against age 3 pollock estimates from catch-age models indicate a linear relationship which has been used to project age 3 numbers in population forecasts. This regression is a crude way to estimate age-1 year-class strength but appears to have a general tendency to under-estimate year-class abundance. The SAM methods do not require external regressions (which have be criticized on the basis of statistical properties) since the accounting is done explicitly, within a standard age-structured method. The key advantage in this approach is that the observation and process errors are maintained at the appropriate level.

It appears that the annual bottom trawl survey does not fully cover the distribution of age 1 pollock. This is especially evident for the 1989 year-class which the survey found to be slightly below average, but upon recruitment to the fishery was a very strong year-class. Similarly, the 1992 year-class was estimated to be slightly above, but in the fishery and in more recent surveys appears to be a strong year-class. For both of these year-classes it appears that a significant amount was distributed in the Russian EEZ—beyond the standard survey area—or unavailable to bottom trawl gear (perhaps in mid-water). In 1996 Russian scientists reported the 1995 year-class to be strong, but it appeared to be below average in the U. S. survey. However, in the 1997 EIT survey the 1995 year-class was abundant adjacent to the Russian EEZ.

Availability to the two survey types is mixed. With in the same year the number of age 1 pollock can be greater in either type (Fig. 1.24). In 1979 the very strong 1978 year-class was abundant in the bottom trawl survey, and very abundant in the EIT survey. Strong year-classes did were rarely observed in other years in which there were combined bottom and EIT surveys, although the 1996 year-class appears to be much stronger in the EIT survey than the bottom trawl survey where it classifies as an above average year-class. Numbers of pollock estimated in the bottom trawl survey are generally low relative to the numbers estimated at age 2 in EIT surveys (Fig. 1.25). This provides further evidence that recruitment projections based on the age 1 abundance index from the bottom trawl survey tends to underestimate the true relative size of most pollock year-classes.

The coefficient of variation or "CV" (reflecting uncertainty) on the strength of the 1996 year-class is about 45% for Model 1. This compares with 63% had there been no survey (Model 3) and 38% given high fidelity to the survey data (Model 2). The 1996 year-class appears to be moderately strong. However, the 95% confidence bounds for the 1996 year-class slightly overlaps with the mean recruitment for all years since 1978 (Fig. 1.26).

It has been suggested that incorporation of environmental variables may lead to better recruitment forecasts (e.g., Fair 1994, Fair and Quinn In prep.). For our analyses the inclusion of an environmental covariate showed very minor differences in the values for the 1996 year-class and no change in the level of uncertainty about those values (Table 1.7). **This is probably due to the fact that there are two surveys which give some indication about the strength of this year-class.** Also, the methods used here are integrated with all observations such that the decomposition of a single index (say the 1-year olds from the EBS bottom trawl survey) is not required. That is, introducing environmental variables to explain the discrepancy between 1-year olds estimated in the survey and subsequent abundance estimates after observations through the fishery models two processes. These are the effect of the environment on the availability of 1-year old fish to the survey and the effect of the environment on *real* differences in abundance. In the approach of Fair and Quinn (op. cit.) these effects are necessarily confounded. In our approach we rely on multiple data sources and internal consistency to analyze environmental effects on *real* changes in abundance. The observation error part of the survey data is treated separately (e.g., allowing for variable selectivity over time for the survey data).

The prognosis for the 1997 year-class is therefore restricted to the expected value of recruitment given our model structure. Based on warm apparent temperatures in the summer of 1997, we speculate that conditions are favorable for a strong 1997 year-class. However, strong year-classes have not occurred back-to-back over the history of our observations. Also noteworthy is that strong year-classes have occurred in the year following major El Niño events.

For continuity, we include past methods (used with the cohort-analyses) for short and long-term projections for comparison. The recruitment estimates for use in short term prognoses of future stock abundance have relied on a relationship between the number of age 1 pollock estimated in the annual groundfish trawl survey and the number of age 3 pollock estimated from cohort analysis models. The regression of cohort analysis age 3 pollock estimates on survey estimated age 1 pollock is: age 3= 1.7249+2.5588*age 1. From catch-age models, the estimate of the median number of age 3 pollock entering the population between 1979 and 1996 is 4.7 billion. Age 3 recruitment has varied from a high of 19 billion in 1981 to 0.7 billion in 1997. The projected age 3 recruitment in 1998 is 5.1 billion and in 1999 is 7.5 billion. The projected 1998 recruitment is below the 1979-1996 average of 6.5 billion, and the 1999 projection is above average. For long-term population forecasts and the examination of fishery policies a spawner-recruit relationship, derived from a non-linear regression of catch-age model estimates of age 3 numbers and total number of mature pollock, has been used. The relationship is:

$$R = 2.545S\,e^{0.1357S}$$

1.5.5. Maximum Sustainable Yield

Maximum sustainable yield for eastern Bering Sea pollock has been estimated using several different models. These include: an age-structured model (Walters 1969) that incorporates the Beverton and Holt (1957) yield equation, a population decay function, and a spawner recruit function; a surplus production model; and a delay-difference model. Detailed information on the models and the data utilized are contained in Wespestad (1990) and Wespestad and Terry (1984) for the Walters model and in Quinn and Collie (1990) for the other two models.

The results of the models are presented in the following table:

	Walters	Delay-Difference	Surplus Production
MSY	1.88	1.82	1.73
Biomass MSY	6.00	6.06	6.33
F_{MSY}	0.38	----	0.34
MSY/BMSY	0.31	0.3	0.27

The results of the models are quite similar in all of the MSY parameters. MSY is about 1.8 million and is achieved at an exploitation rate of 30% of biomass. In the absence of fishing Quinn and Collie (1990) estimated that the eastern Bering Sea pollock stock would stabilize at 11.9 million t and the Walters model estimated an unfished population of 13.4 million t. We developed the framework for undertaking this type of analysis within the SAM approach and we anticipate including this after further research. In particular, we anticipate using Bayesian methods for developing risk-averse strategies which incorporate stock-recruitment uncertainty.

1.5.6. Yield projections—ABC and overfishing levels

Currently, the biomass of eastern Bering Sea pollock is near the 6.0 million t level that will produce the MSY of 1.8 million t. Historically, eastern Bering Sea pollock ABC has been set at the $F_{0.1}$ level of fishing, derived from the yield per recruit model with knife-edge recruitment at age 3 which is F=0.31, U=0.23. The $F_{0.1}$ fishing level is similar to the $F_{40\%}$ level of fishing where (assuming knife-edge selectivity) F=0.30, U=0.23 based on spawning biomass per recruit calculations.

Results from projecting the **cohort** analysis population estimates forward from 1996 and using recruitment estimates gives an estimated catch of 1.19 million t for 1997, the estimated harvest at the

$F_{40\%}$ level is projected to be **1.08 to 1.14 million t in 1998** (Table 1.9). Beyond 1998 the exploitable biomass and yields are expected to increase with the recruitment (as age 3-year olds) of above average year-classes.

Based on the range of models evaluated under the **SAM** analyses, the $F_{40\%}$ harvest yield (using average selectivity estimates from 1993-1997) gives a broad range of values, most of which are higher than the recommendation from the cohort analyses (Table 1.7). Accounting for the possibility that the 1998 projected female spawner biomass is below a target $B_{40\%}$ level, the adjusted yield ($B_{1998}/B_{40\%}$) x ABC would be between **1.109 and 1.297** million t under Models 4 and 1, respectively. Here the ABC value is based on the harmonic mean yield estimated for 1998.

The estimates for overfishing levels (harvest under the $F_{30\%}$) are between 2.0 and 2.3 million tons for **SAM** Models 4 and 1 respectively. The estimated overfishing level based on the harmonic mean values under the $F_{30\%}$ harvest rate (adjusted as for the ABC) gives values between **1.699 and 1.984** million tons for Models 4 and 1 respectively.

The degree of uncertainty in deriving estimates of yield under these harvest rates is illustrated in Fig. 1.27. These show the (approximate) probability of *actual* harvest being equal to the target value associated with the $F_{40\%}$ rate. For example, under Model 1, if one wants to ensure with 75% probability that the overfishing definition is not exceeded, then the lower 25 percentile applies and the overfishing level would be set to 1,908 thousand tons. Also shown are the locations of the harmonic means for $F_{40\%}$ and $F_{30\%}$. In some cases, the harmonic means have been shown to provide a reasonable approximation to risk-averse harvest policies when applied to F_{msy} values (Thompson 1996). Here we extend this by stating 1) that the $F_{40\%}$ harvest rate approximates F_{msy}, 2) it is reasonable to extend the uncertainty in estimates of the 1998 stock size, and 3) that our approximations to the posterior probability distributions are reasonable.

Projecting the $F_{40\%}$ (unadjusted) harvest policy to the future shows that we are slightly below the target for 1998 but with the incoming year-class, projections are for an increase (Fig. 1.28).

1.6. Aleutian Islands

Last year the NPFMC SSC requested that the data for the Aleutian Islands region be examined for the potential of an age structured stock assessment analysis. We responded by presenting a preliminary analysis of the available data. These analyses have been expanded this year, but not investigated to the extent of the eastern Bering Sea model. Geographically, there are large questions as to the appropriateness of defining pollock caught in the "Aleutian Islands" region as being from a separate stock. Clearly the potential that a very large fraction of removals from this area are from the EBS stock makes interpretation of results presented below questionable. With these caveats in mind, we present an update of last year's analyses.

Survey estimates of pollock in the Aleutian Island region are available from 1980, 83, 86, 91, 94 and 1997 (Table 1.5). These values were used to tune a forward model with numbers and catch at age modeled as presented in Appendix 1.A (i.e., instantaneous mortality rates and the Baranov catch equation). We assumed that the survey estimates represented the biomass of age 3 and older pollock. Catch biomass estimates for this area are presented in Table 1.1. An asymptotic selectivity form was estimated and assumed to be constant over time. Within the model, the annual fishing mortality rates were estimated so that the predicted catch biomass matched the observed catch biomass precisely (CV = 1%). Catch-at-age data were available for the years 1978-82, 1984-85, 1991-1996 (Table 1.4). These were fit assuming a multinomial likelihood function with an assumed sample size of 100 individuals per year. Estimated model parameters were:

- annual recruitment (1978-1994, 17 parameters)
- annual fishing mortality rates (1978-1997, 20 parameters)
- initial age composition (11 parameters)
- fishery/survey selectivity (2 parameters).

Three models were evaluated:

AI-Model 1) Age 4+ natural mortality set to 0.2, survey selectivity set equal to fishery estimate
AI-Model 2) Age 4+ natural mortality set to 0.3, survey selectivity set equal to fishery estimate
AI-Model 3) As in Model 2 but with survey assumed to have knife-edged selectivity at age 3+

These contrasts gave a large range of both estimated 1998 stock size and yield recommendations (Table 1.10). As with last year's analyses, the model fit to the survey biomass estimates suggested that a significant portion of the Aleutian stock is not surveyed by the bottom trawl gear. Our model fit the available age composition data reasonably well (Fig. 1.29) but only at the expense of fitting the survey abundance series. This problem with consistency between the data is due to the apparent persistence of year-classes moving into the "stock" area. That is, while age-structured data over time provide information on the depletion of cohorts (accounting for natural mortality) and consequently, historical abundance levels, such methods will fail if the "stock" experiences significant movement of fish from outside the area. The selectivity estimate suggests that the fishery in this region has harvested primarily fish older than 6 years of age (Fig. 1.30). This is substantially older than what has been observed in the EBS and Gulf of Alaska fisheries and is the main reason that the $F_{40\%}$ recommendations are so high.

1.6.1. Abundance and exploitation trends

The 1997 Aleutian Island bottom trawl survey estimated biomass at 105.6 thousand t, an increase over the 1994 survey estimates of 86.4 thousand t. Survey biomass in this region peaked in 1983 and declining to the 1994 level. The 1994 survey indicated a strong mode of either age 1 or 2 pollock; 1992 or 1993 year-class. These fish appeared to have entered the fishable population in 1996 and have stabilized or increased pollock biomass in the Aleutian Islands.

Catch-age data for an Aleutian Islands region assessment are limited. Analysis is also confounded by the question of stock definition. The available data suggest that the operational "stock" for this region is currently on the order of 100 - 200 thousand tons (for age 3+; Fig. 1.31 top panel) and harvests in the most recent year have been on the order of 30 thousand tons. Continued harvests at around that level represent about a 20% harvest rate. This has been shown to be an appropriate level for pollock in other areas. Since the selectivity seems to be on older individuals, this rate would also be conservative on a per-recruit basis (Fig. 1.31 lower panel).

1.6.2. Recruitment

The age-structured model fit does provide an index of recruitment for the Aleutian Islands based on the year-classes that have appeared in the fishery. We found strong year-classes to be similar to those estimated for pollock in the EBS (Fig. 1.32). This suggests that there may be movement from the EBS stock into the Aleutians or that favorable recruitment conditions coincided for both "stocks."

1.6.3. ABC, overfishing, and MSY

In the Aleutian Islands region the status and dynamics of pollock are not well understood. Catch-age data are limited, and most data are from the eastern Aleutians. Trawl survey data show that most of the biomass is located in the eastern Aleutian Islands and along the north side of Unalaska-Umnak islands in the eastern Bering Sea region. Biomass from the Unalaska-Umnak islands area was included in the Aleutian Islands Region estimate because this area was surveyed as part of the Aleutian Islands survey, and was never included the eastern Bering Sea trawl survey. However, we do not believe it is appropriate to include biomass from the Unalaska-Umnak islands area in the Aleutian Islands estimates, because pollock in that area are included in the eastern Bering Sea catch, and assessed via catch-age models.

It is likely that pollock in the eastern Aleutian Islands is not a discrete stock, since pollock are continuously distributed from the eastern Bering Sea. In prior assessments it was assumed that stock dynamics in the Aleutian Islands are similar to that of eastern Bering Sea pollock and the biomass trend the same. Analyses on MSY values for Aleutian Islands pollock were not pursued given, among other things, potential problems with stock definition and paucity of data for this region.

Although limited number of age-structured model runs were done on this stock this year, the results showed a fair amount of ambiguity. Consequently, until the issues of stock definition and survey interpretation are resolved, we recommend continuing the use of the most recent survey biomass estimate applied to an adjusted natural mortality. This gives an ABC based on Tier 5 (1997 survey biomass•*M*•0.75) of **23,760** t at a biomass of 105,600 t. The OFL based on Tier 5 (1997 survey biomass•*M*) gives **31,680** t at a biomass of 105,600 t.

1.7. Aleutian Basin-Bogoslof Island Area

Aleutian Basin pollock spawning in the Bogoslof Island area have been surveyed annually since 1988. Pollock harvested in the Bogoslof Island fishery (Area 518) are of a noticeably different age composition than those taken on the eastern Bering Sea shelf (Wespestad and Traynor 1989). The following survey results show that population decline occurred between 1988 and 1994, and then increased in 1995. The movement of pollock from the 1989 year-class to the Bogoslof Island area 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. This suggests that the 1995 estimate may have been over-estimated, or that conditions in that year affected the apparent abundance of pollock. The current population levels on the eastern Bering Sea shelf, and the absence of extremely large year-classes, suggests that pollock abundance will not increase significantly in the Bogoslof area in the coming years. A full report of the 1997 survey is attached (Appendix 1.B) with summary Bogoslof Island EIT survey biomass estimates, 1988-1997, as follows:

Biomass (million t)									
1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
2.4	2.1	--	1.3	0.9	0.6	0.49	1.1	0.68	0.39

The survey estimated abundance of pollock in the Bogoslof area decreased in 1997 (Appendix 1.B). Based on the 1997 survey estimate of exploitable biomass of 0.392 million t and M = 0.2 the estimated 1998 biomass is projected to be about 0.321 million t. Using the 0.321 million t estimate and an $F_{40\%}$ exploitation rate computed from growth parameters of F=0.27 which equates to an exploitation rate of 21% then the 1998 ABC is estimated to be **67.4** thousand t for the Bogoslof Island pollock fishery.

Overfishing under the $F_{30\%}$ harvest (assuming knife-edged selection at age 3) gives F=0.37 which translates to **92,400** t for overfishing. A target biomass level (e.g., $B_{40\%}$ or B_{msy}) for the Bogoslof area is not available at this time.

The information available for pollock in the Aleutian Basin and the Bogoslof Island area indicates that these fish belong to the same "stock", which as 4-5+ old adults, are distinct from eastern Bering Sea pollock. Data on the age structure of Bogoslof-Basin pollock show that a majority of pollock in the Basin originated from year-classes that are strong on the shelf, 1972, 1978, 1982, 1984, 1989. The mechanism causing pollock to move from the shelf to the Basin appears to be density related, with the abundance in the Basin proportional to year-class size.

Differences in spawning time and fecundity have been documented between eastern Bering Sea pollock and Aleutian Basin pollock. In addition Aleutian Basin pollock are smaller at a given age than pollock on the eastern Bering Sea shelf. Pollock in the northern shelf have a similar size at age as Aleutian Basin pollock although a very different age composition.

However, Aleutian Basin pollock are likely not an independent stock. Very few pollock younger than 5 years old have ever been found in the Aleutian Basin including the Soviet portion. Recruits to the basin are coming from another area, most likely the surrounding shelves either in the US or Russian EEZ.

1.8. Stock and Fishery Considerations

Recent information obtained from wide-scale Bering Sea EIT surveys, and from Russian scientists indicates that the eastern Bering Sea pollock stock has a distribution that is continuous into the Russian EEZ. The 1994 and 1997 Miller Freeman EIT survey found a contiguous distribution of pollock from Bristol Bay to south of Cape Navarin, and in 1996-97 a continuous distribution to the U.S.- Russia Convention Line. Russian data also suggest that pollock in the Russian EEZ east of 176 E. are predominantly of eastern Bering Sea origin (Shuntov et al. 1993).

Further, it is thought that most of the juvenile fish in this area will recruit to the eastern Bering Sea spawning stock as adults. This was evident with the 1989 year-class, which was found in relatively low abundance in the US EEZ, but was found to be very abundant in the Russian EEZ early in life. The 1989 year-class subsequently was found to be the one of the largest year-classes produced within the eastern Bering Sea.

The problem of a straddling pollock stock is that the western Bering Sea pollock stock is currently at a low level of abundance. With the decease in western Bering Sea pollock abundance Russian and joint-venture fishing effort have increased in the Russian EEZ northern area. If significant harvests of juvenile pollock that will recruit to the eastern Bering Sea exploitable population occur in the Russian EEZ, then there may be a reduction in the exploitable biomass and yield in the US EEZ. The following table contains the reported catch for the Navarin area (176E to the Convention Line) received from TINRO, the catch as a percentage of the total western Bering Sea catch, and the age composition of the catch for ages 1,2,3, and 4 and older:

Year	Navarin Catch 1,000's tons	Percent of Total Russian Bering Sea EEZ Catch	Catch at age 0	1	2	3	4+
1976	467	85%	0.0%	0.0%	4.7%	77.8%	17.5%
1977	180	68%	0.0%	0.0%	3.4%	13.2%	83.5%
1978	254	61%	0.1%	2.8%	6.1%	20.5%	90.6%
1979	285	52%	14.0%	22.8%	54.9%	5.6%	2.7%
1980	620	49%	0.0%	0.7%	14.7%	78.1%	6.5%
1981	900	75%	0.0%	0.2%	6.1%	39.1%	54.7%
1982	804	64%	0.0%	0.5%	9.9%	22.8%	66.8%
1983	722	65%	8.4%	30.0%	2.5%	20.7%	38.6%
1984	503	50%	0.0%	5.7%	0.2%	1.7%	95.4%
1985	488	58%	0.3%	43.7%	31.0%	13.8%	11.2%
1986	570	69%	0.0%	8.0%	44.9%	14.2%	32.9%
1987	463	63%	0.0%	0.0%	5.8%	27.6%	66.6%
1988	852	76%	0.0%	1.0%	6.6%	22.0%	69.6%
1989	684	70%					
1990	232	53%					
1991	178	39%					
1992	316	53%					
1993	389	46%	0.0%	1.8%	7.0%	11.1%	80.1%
1994	178	43%	0.0%	0.3%	10.9%	17.4%	69.7%
1995	320	98%	0.0%	0.1%	15.6%	22.1%	62.2%
1996	432	95%					
1997**	600	93%					
Average	458	62%	1.4%	7.4%	14.0%	25.5%	53.0%

** Unofficial estimated

The average catch since 1976 in the Navarin area has been 458 thousand t, which was 62% of the entire western Bering Sea catch. The proportion of total catch has risen in recent years, presumably as a result of the decline of "western Bering Sea" stock of pollock. The age composition of the catch (in numbers) indicates that 53% of the catch consists of adult pollock (4+), and juveniles, ages 2 and 3, respectively average 14 and 26%. In the eastern Bering Sea during the same time period the catch (in numbers) of ages 2 and 3 were 4% and 14%, and age 4+ was 82%.

TINRO conducted surveys of the pollock resource within the Navarin area in 1996 and reported the biomass to be 1.1 million t. A 1997 survey is being conducted in October-November 1997, but results from this survey will be unavailable until 1998.

The historic level of fishing within the Navarin area does not appear to have had an adverse impact on the eastern Bering Sea stock. However, eastern Bering Sea stocks have been at high levels and have decreased to lower levels in recent years. It is a possibility that the eastern Bering Sea stock could be impacted at lower stock levels by current fishing practices in the Russian EEZ.

The age 4 pollock harvested in this region are likely resident, or have a low probability of moving to the US EEZ, however, this is not the case for younger pollock. A pollock increases in weight 3 to 4-fold between ages 2 to 4, so the harvest of juvenile pollock in the Russian EEZ could have a substantial impact on eastern Bering Sea biomass.

The problem may be acute if, as suggested from several sources, unreported juvenile pollock are being taken in large numbers Russian and foreign fishing vessels. Reports from the 1997 fishery in the Navarin area indicate that the size of pollock has increased over previous years. Length frequency data from the fishery indicate that a large portion of the catch may continue to be from the 1992-1994 year-classes. It has been reported that fishery regulations have been changed to require the use of larger mesh size and an increase in minimum retention size.

Cooperative research and the collection and exchange of resource and fisheries data is needed with Russian fishery authorities to improve analyses and the monitoring of pollock trends in the Bering Sea.

Another potential problem in 1998 may be an increase in the bycatch of juvenile pollock. If the 1996 year-class is strong then it is likely that the bycatch will increase in 1998 as in 1991 and 1992 when the abundant 1989 year-class caused bycatch to rise to 10 to 11%. Most of the juvenile bycatch will occur in the 1998 B season. One method of reducing the potential bycatch is to increase the proportion of the A season catch.

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1.10. Tables

Table 1.1 Catch from the eastern Bering Sea by area, the Aleutian Islands and the Bogoslof Island area, 1979-95.

	Eastern Bering Sea			Aleutians	Donut Hole	Bogoslof I.
Year	Southeast	Northwest	Total			
1979	368,848	566,866	935,714	9,504		
1980	437,253	521,027	958,280	58,156		
1981	714,584	258,918	973,502	55,516		
1982	713,912	242,052	955,964	57,978		
1983	687,504	293,946	981,450	59,026		
1984	442,733	649,322	1,092,055	81,834	181,200	
1985	604,465	535,211	1,139,676	58,730	363,400	
1986	594,997	546,996	1,141,993	46,641	1,039,800	
1987	529,461	329,955	859,416	28,720	1,326,300	377,436
1988	931,812	296,909	1,228,721	30,000	1,395,900	87,813
1989	904,201	325,399	1,229,600	15,531	1,447,600	36,073
1990	640,511	814,682	1,455,193	79,025	917,400	151,672
1991	712,206	505,095	1,217,301	78,649	293,400	264,760
1992	663,457	500,983	1,164,440	48,745	10,000	160
1993	1,095,314	231,287	1,326,601	57,132	1,957	886
1994	1,183,360	180,098	1,363,458	58,637	NA	566
1995	1,170,828	91,939	1,262,766	64,429	trace	264
1996	1,086,840	105,938	1,192,778	29,062	trace	387
1997			1,112,810	25,478	trace	168

1979-1989 data are from Pacfin.
1990-1995 data are from NMFS Alaska Regional Office, includes discards.

Table 1.2. Estimated retained, discarded, and percent discarded of total catch in the Aleutians, Northwest and Southeastern Bering Sea, 1990-1996.

Year Area	Catch Retained	Discard	Total	Discard Percentage
1990				
Southeast (51)	582,660	57,851	640,511	
Northwest (52)	764,369	50,313	814,682	
Aleutians	69,682	9,343	79,025	
Total	1,416,711	117,507	1,534,218	7.7%
1991				
Southeast (51)	614,889	97,317	712,206	
Northwest (52)	458,610	46,485	505,095	
Aleutians	73,608	5,041	78,649	
Bogoslof	245,467	19,293	264,760	
Total	1,318,966	163,095	1,482,061	11.0%
1992				
Southeast (51)	600,861	62,596	663,457	
Northwest (52)	445,811	55,172	500,983	
Aleutians	45,246	3,498	48,745	
Total	1,091,919	121,266	1,213,185	10.0%
1993				
Southeast (51)	1,011,020	84,294	1,095,314	
Northwest (52)	205,495	25,792	231,287	
Aleutians	55,399	1,733	57,132	
Total	1,271,914	111819	1,383,732	8.1%
1994				
Southeast (51)	1,091,547	91,813	1,183,360	
Northwest (52)	164,020	16,078	180,098	
Aleutians	57,325	1,311	58,637	
Total	1,312,892	109,202	1,422,094	7.7%
1995				
Southeast (51)	1,083,381	87,447	1,183,360	
Northwest (52)	82,226	9,713	91,939	
Aleutians	63,047	1,382	64,429	
Total	1,228,654	98,542	1,339,728	7.4%
1996				
Southeast (51)	1,015,473	71,367	1,086,840	
Northwest (52)	101,100	4,838	105,938	
Aleutians	28,067	994	29,062	
Total	1,145,133	77,206.23	1,222,339	6.3%

Table 1.3. Eastern Bering Sea walleye pollock catch by age in numbers (millions), 1979-1996.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	Total
1979	101.4	543.2	720.0	420.2	392.6	215.5	56.3	25.7	35.9	27.5	17.6	7.9	3.0	0.5	2567.3
1980	9.8	462.4	823.3	443.5	252.2	211.0	83.7	37.6	21.8	23.9	25.5	15.9	7.7	2.5	2420.7
1981	0.6	72.2	1012.9	638.0	227.0	102.9	51.7	29.6	16.1	9.4	7.5	4.6	1.5	0.6	2174.6
1982	4.8	25.3	161.4	1172.4	422.4	103.7	36.0	36.0	21.5	9.1	5.4	3.2	1.9	0.7	2003.7
1983	5.1	118.6	157.8	313.0	817.0	218.3	41.4	24.7	19.8	11.1	7.6	4.9	3.5	1.7	1744.5
1984	2.1	45.8	88.6	430.8	491.9	654.3	133.9	35.6	25.1	15.7	7.1	2.5	2.9	1.7	1938.0
1985	2.7	55.3	382.2	122.1	366.7	322.3	444.3	112.8	36.7	25.9	24.9	10.7	9.4	4.0	1919.9
1986	3.1	86.0	92.3	748.5	214.1	378.1	221.9	214.2	59.7	15.2	3.3	2.6	0.3	1.2	2040.4
1987	0.0	19.9	112.2	78.0	415.8	139.6	123.2	91.2	248.6	54.4	38.9	21.6	29.1	6.1	1378.5
1988	0.0	10.7	455.2	422.8	252.8	545.9	225.4	105.2	39.3	97.1	18.3	10.2	3.8	5.5	2192.2
1989	0.0	4.8	55.3	149.5	452.6	167.3	574.1	96.6	104.1	32.5	129.5	10.9	4.0	2.6	1783.8
1990	1.3	33.2	57.3	220.7	201.8	480.3	129.9	370.4	66.1	102.5	9.1	60.4	8.5	4.7	1746.2
1991	1.0	60.9	40.7	85.4	141.5	156.9	396.4	51.6	217.1	22.1	114.7	15.2	74.4	60.9	1438.8
1992	0.0	79.0	721.7	143.5	98.1	125.0	145.4	276.8	109.3	165.4	59.4	50.2	14.2	91.0	2079.0
1993	0.1	9.2	275.0	1144.5	103.0	64.3	62.2	53.5	84.9	21.8	34.5	12.6	13.1	26.5	1905.2
1994	0.3	31.5	59.8	383.4	1109.5	180.5	54.9	21.0	13.5	20.1	9.1	10.7	7.6	15.7	1917.5
1995	0.0	0.3	75.3	146.6	398.4	764.7	131.8	34.9	10.9	6.0	15.3	4.4	7.1	11.3	1606.9
1996	0.0	9.5	19.7	43.8	144.9	350.7	486.3	190.4	32.9	14.8	8.9	8.8	4.1	11.3	1326.1

Table 1.4. Numbers of pollock by age in the Aleutian Islands pollock catch 1978-1996.

Year	Age											
	3	4	5	6	7	8	9	10	11	12	13	14
1978	0.016	0.220	0.615	0.292	2.116	0.682	0.967	1.210	0.945			
1979	0.000	1.300	1.648	2.049	2.323	2.148	1.400	1.268	0.082			
1980	3.554	2.384	3.729	6.916	14.123	10.584	10.127	4.835	4.746			
1981	0.000	9.664	8.161	6.301	7.611	12.720	12.848	11.019	8.117			
1982	0.000	0.083	46.090	9.933	4.506	6.383	9.177	8.720	4.752			
1983												
1984	0.057	2.600	0.000	8.036	38.166	18.855	24.567	17.379	11.305			
1985	0.161	0.692	11.886	3.010	7.963	32.382	10.880	7.782	7.448			
1986												
1987												
1988												
1989												
1990												
1991	0.055	0.812	2.145	12.561	20.702	5.404	15.423	2.390	7.727	6.735	10.400	6.939
1992	1.032	0.325	1.930	3.694	1.985	5.520	1.231	5.981	3.645	3.582	2.426	12.779
1993	0.334	3.783	1.753	4.420	5.267	2.578	6.520	3.072	3.367	2.884	1.346	2.542
1994	0.045	1.224	11.103	3.163	4.393	5.344	4.571	3.280	1.586	3.708	1.330	1.094
1995	0.206	0.714	2.064	14.116	2.016	5.316	4.940	1.607	2.836	2.278	4.006	0.864
1996	0.145	0.229	0.971	2.598	7.463	2.560	2.434	1.468	1.173	0.865	0.277	0.828

Table 1.5. Biomass (age 1+) of eastern Bering Sea walleye pollock in as estimated by surveys 1979-1997 (millions of tons).

Year	Bottom trawl survey (t)	EIT Survey (t)	EIT Percent age 3+	Total (t)	Near bottom biomass
1979	3.20	7.46	(22%)	10.66	30%
1980	1.00				
1981	2.30				
1982	4.04	4.90	(95%)	8.94	46%
1983	4.80				
1984	4.00				
1985	5.52	4.80	(97%)	10.32	54%
1986	4.30				
1987	5.00				
1988	7.51	4.68	(97%)	12.19	63%
1989	4.80				
1990	7.70				
1991	5.11	1.45	N/A	6.56	79%
1992	4.30				
1993	5.50				
1994	4.98	2.89	(85%)	7.86	64%
1995	5.40				
1996	3.20	2.31	(97%)	5.51	60%
1997	3.03	2.59	(70%)	5.62	54%

Table 1.6. Pollock biomass estimates from the Aleutian Islands Triennial Groundfish Survey, 1980-1997.

	Aleutian Islands and Unalaska-Umnak area (~165W-170W)	Aleutian Region(170E-170W)
1980	308,745	252,013
1983	778,666	495,982
1986	550,517	448,138
1991	183,303	179,653
1994	151,444	86,374
1997	205,766	105,600

Table 1.7. Results from the SAM model runs. Effective N (sample size) computations are as presented in McAlister and Ianelli (1997). See text for model descriptions.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Stock Condition						
1998 Age 3+ Biomass	6,147	6,369	6,354	5,824	6,151	5,260
B40%	2,715	2,791	2,670	2,678	2,716	2,589
CV B40%	19%	19%	19%	19%	19%	19%
Unfished Spawners	6,788	6,977	6,676	6,696	6,791	6,473
CV Unfished Spawners	8%	7%	7%	8%	8%	7%
1998 Spawners	2,380	2,383	2,741	2,213	2,381	2,045
CV 1998 Spawner Biomass	24%	19%	27%	26%	24%	23%
1996 year-class	37,817	52,834	26,729	39,375	38,030	33,089
CV 1996 year-class	45%	38%	63%	45%	45%	44%
Yr 2002 Spawners $F_{40\%}$	3,375	3,715	2,761	2,631	3,378	3,161
CV yr 2002 Spawners $F_{40\%}$	35%	32%	41%	37%	35%	36%
Avg Recruitment (all yrs)	24,423	25,104	24,021	24,094	24,435	23,291
Std. Dev. Log(recruitment)	0.800	0.792	0.960	0.796	0.801	0.821
Avg F 1990-1997	0.223	0.220	0.248	0.234	0.223	0.250
Percent of B40% spawners	88%	85%	103%	83%	88%	79%
Recruitment RMSE						
due to Stock	0.134	0.118	0.234	NA	0.133	0.132
due to environment	0.000	0.000	0.000	0.000	0.012	0.000
Residual	0.666	0.675	0.726	0.796	0.656	0.689
Total	0.800	0.792	0.960	0.796	0.801	0.821
Yield considerations						
1998 Yield $_{F40\%\%}$	1,628	1,571	2,249	1,489	1,628	1,301
CV 1998 Yield $F_{40\%}$	39%	37%	43%	41%	39%	36%
Harmonic mean yield, $F_{40\%}$	1,479	1,443	2,005	1,343	1,478	1,196
Harmonic mean yield, $F_{30\%}$	2,262	2,206	3,035	2,056	2,261	1,775
Lower 25th Percentile, $F_{40\%}$	1,249	1,226	1,679	1,130	1,248	1,018
Lower 25th Percentile, $F_{30\%}$	1,908	1,868	2,552	1,727	1,906	1,508
$F_{40\%}$	0.361	0.343	0.463	0.359	0.361	0.383
Stdev $F_{40\%}$	0.151	0.138	0.216	0.150	0.151	0.138
$F_{30\%}$	0.654	0.617	0.861	0.650	0.654	0.642
Stdev $F_{30\%}$	0.339	0.312	0.474	0.336	0.339	0.272
Fits						
Effective N						
Fishery	263	252	286	263	263	137
Bottom trawl survey	164	277	15	165	164	155
EIT survey	72	180	5	72	72	69
RMSE $\sqrt{\frac{\sum \ln(obs/pred)^2}{n}}$						
Bottom trawl survey	0.035	0.004	0.124	0.036	0.036	0.029
EIT survey	0.139	0.012	0.512	0.133	0.139	0.145

Table 1.8. Estimates of biomass and exploitation levels from the various catch-age models, 1979-1997.

	Age 3+ Biomass (million t)				Exploitation Level (Catch/Biomass)		
	SAM (Model 1)	**VPA (solver)**	**VPA (tuned)**	**Catch (million t)**	**SAM**	**VPA (solver)**	**VPA (tuned)**
1979	3.210	4.494	4.489	0.94	29%	21%	21%
1980	4.660	5.718	5.702	0.96	21%	17%	17%
1981	9.266	10.547	10.513	0.97	10%	9%	9%
1982	10.625	11.586	11.546	0.96	9%	8%	8%
1983	11.685	12.686	12.645	0.98	8%	8%	8%
1984	11.173	12.401	12.361	1.09	10%	9%	9%
1985	13.031	15.266	13.858	1.14	9%	7%	8%
1986	11.966	14.479	12.953	1.14	10%	8%	9%
1987	12.116	14.874	13.430	0.86	7%	6%	6%
1988	11.162	13.690	12.367	1.23	11%	9%	10%
1989	9.330	11.563	10.478	1.23	13%	11%	12%
1990	7.341	9.249	8.439	1.46	20%	16%	17%
1991	5.787	7.618	7.350	1.61	28%	21%	22%
1992	9.799	9.197	9.564	1.44	15%	16%	15%
1993	12.659	9.168	10.083	1.39	11%	15%	14%
1994	11.224	8.630	9.870	1.36	12%	16%	14%
1995	10.606	8.695	9.765	1.26	12%	14%	13%
1996	8.663	7.194	8.150	1.20	14%	17%	15%
1997	7.057	5.594	6.406	1.10	16%	20%	17%
Average	9.545	10.140	9.998	1.18	14%	13%	13%

SAM = Jan 1. biomass estimates

VPA solver = Jan 1. biomass estimates from Cohort Analysis using least squares fit

VPA Tuned = Jan 1 biomass estimates from Cohort Analysis tuned to survey trend and 1996 survey age composition

Table 1.9. Eastern Bering Sea pollock population and catch projections are based on results from cohort analysis using three methods

Procedure	Year	Age 3+ Biomass Million t	Catch Million t	Age 3 Recruits Billions	F	Exploitation	Numbers (age 3+) Billions	Spawners Billions
SAM (Model 1)								
	1997	7.057	1.196	1.6771	0.186	17%	9.631	7.420
	1998	6.147	1.628	2.8264	0.361	26%	8.736	6.045
	1999	7.844	1.211	9.7350	0.386	15%	14.533	6.748
	2000	8.826	1.197	6.2827	0.364	14%	15.726	8.576
	2001	9.555	1.555	6.2850	0.362	16%	16.474	9.677
	2002	9.718	1.758	6.2855	0.362	18%	16.593	9.873
Ad hoc tuned								
	1997	6.408	1.192	0.675	0.255	19%	9.151	7.671
	1998	5.958	1.137	5.049	0.300	19%	10.494	8.181
	1999	6.537	1.038	7.477	0.300	16%	13.784	7.162
	2000	7.468	1.103	7.973	0.300	15%	16.440	8.703
	2001	8.216	1.252	7.821	0.300	15%	17.872	9.909
	2002	8.820	1.391	8.092	0.300	16%	18.932	10.711
Solver								
	1997	5.582	1.196	0.660	0.255	21%	8.222	6.786
	1998	5.356	1.080	5.184	0.300	20%	9.956	7.618
	1999	6.338	1.011	8.268	0.300	16%	14.192	6.990
	2000	7.294	1.160	8.155	0.300	16%	16.657	8.633
	2001	7.993	1.354	7.987	0.300	17%	17.849	9.733
	2002	8.498	1.483	8.124	0.300	17%	18.623	10.379

Table 1.10. Results from three alternative models on pollock for the Aleutian Islands Region.

	AI-Model 1	**AI-Model 2**	**AI-Model 3**
Description	Low M, survey-selectivity = fishery	M=0.3 survey-selectivity = fishery	M=0.3 survey-selectivity = fishery
Age 4+M	0.2	0.3	0.3
Abc $F_{40\%}$	78,561	193,239	64,186
1998 Female Spawner Biomass	109,291	163,876	74,028
$B_{40\%}$	99,424	127,185	97,941
1998 age 3+ Biomass	275,923	442,560	230,017
RMSE Survey	0.195	0.224	1.958
Age composition –ln Likelihood	209	238	220
SPR Ratio	40%	40%	40%
F (full selection)	0.950	5.000	3.000
Survey Q	1.000	1.000	1.000

1.11. Figures

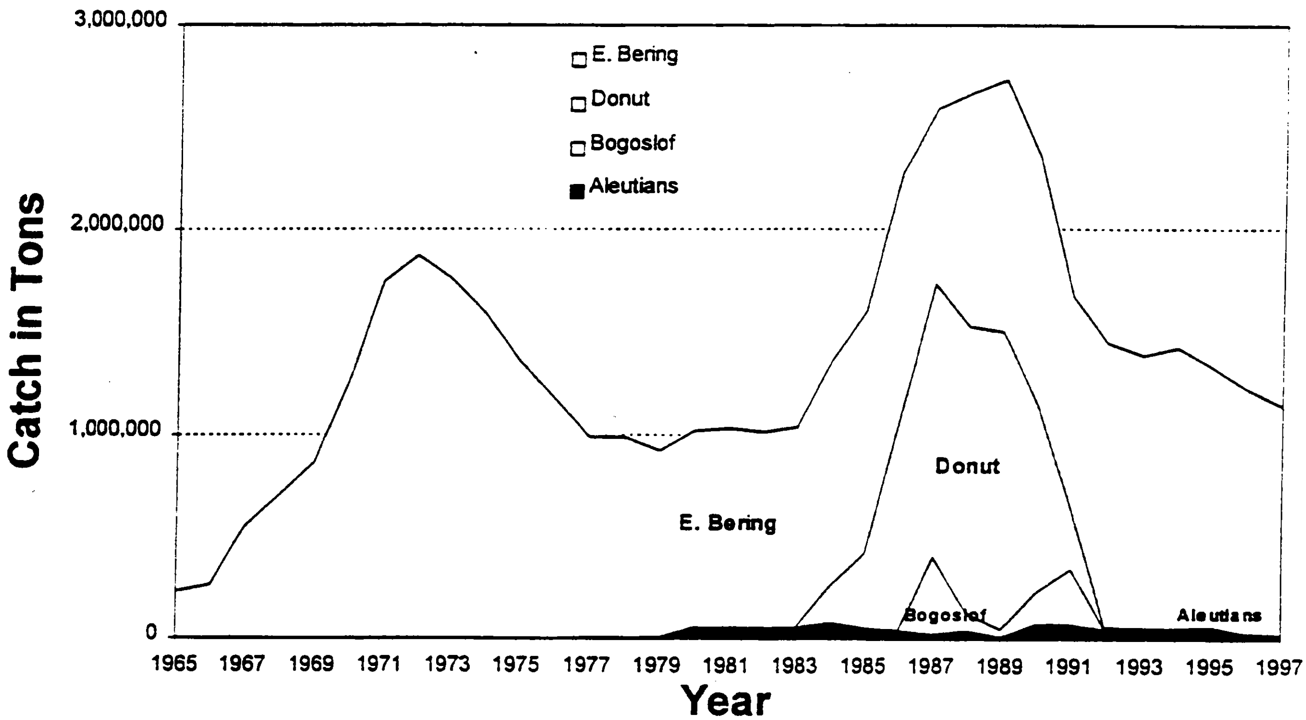


Figure 1.1. Walleye pollock catch in the eastern Bering Sea, Aleutian Islands, Bogoslof Island, and Donut Hole, 1964-1997.

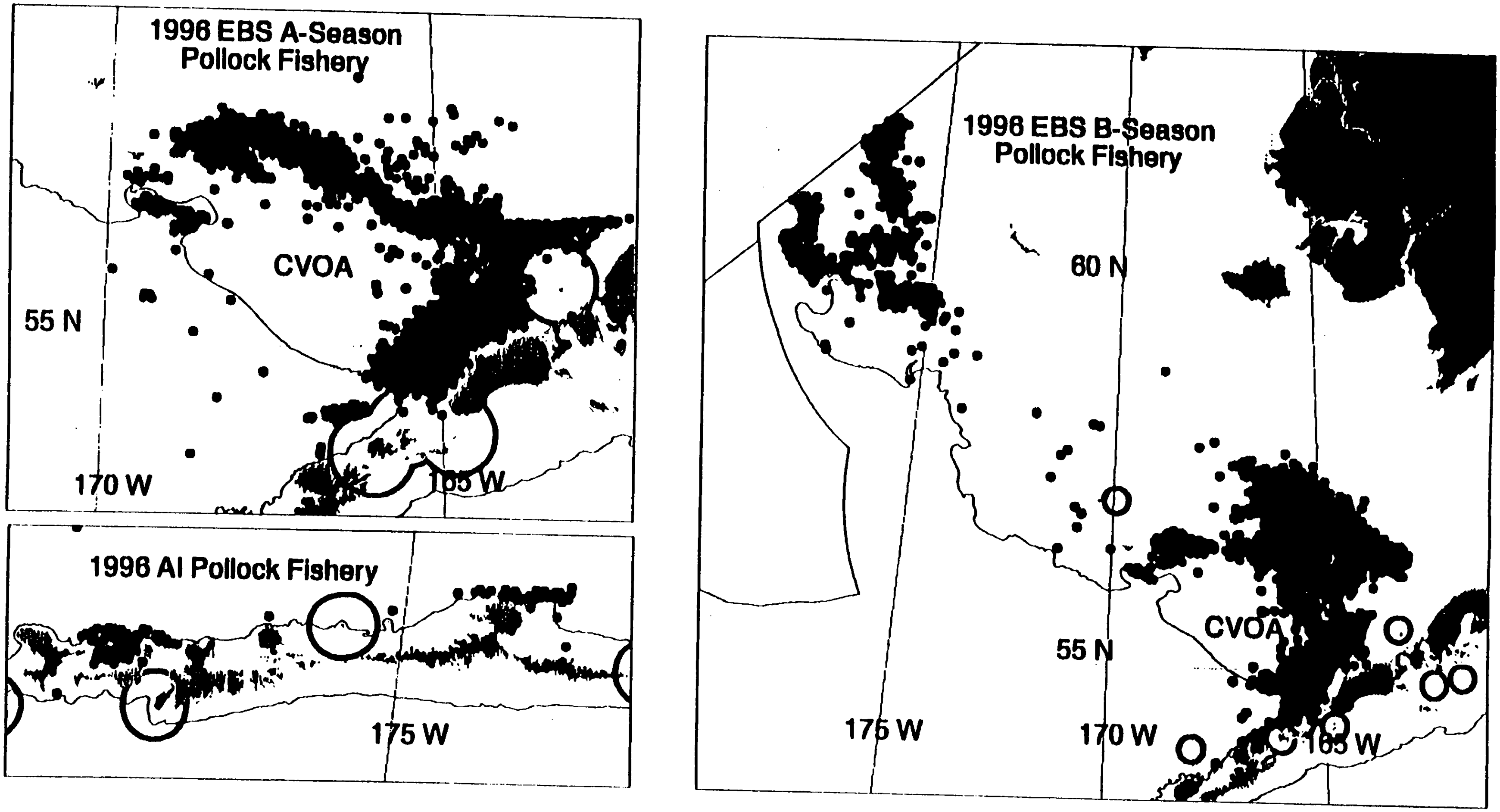
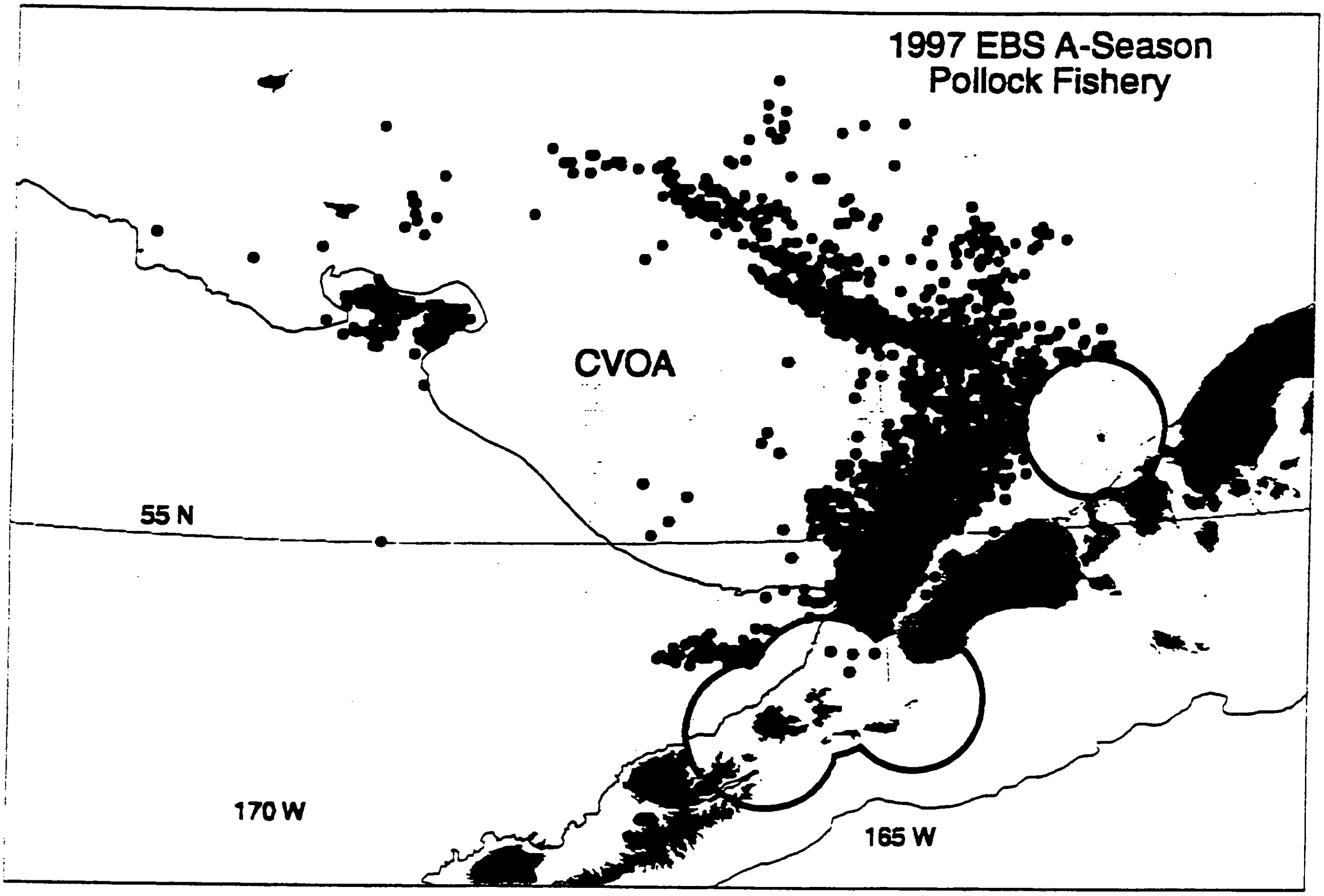


Figure 1.2. Observed locations of the 1996 pollock fishery in the A and B-seasons on the EBS shelf and in the Aleutian Islands (AI). The locations of the Catcher Vessel Operational Area (CVOA) and 20 nm (EBS) and 10 nm (AI) trawl exclusion zones around Steller sea lion rookeries are shown.



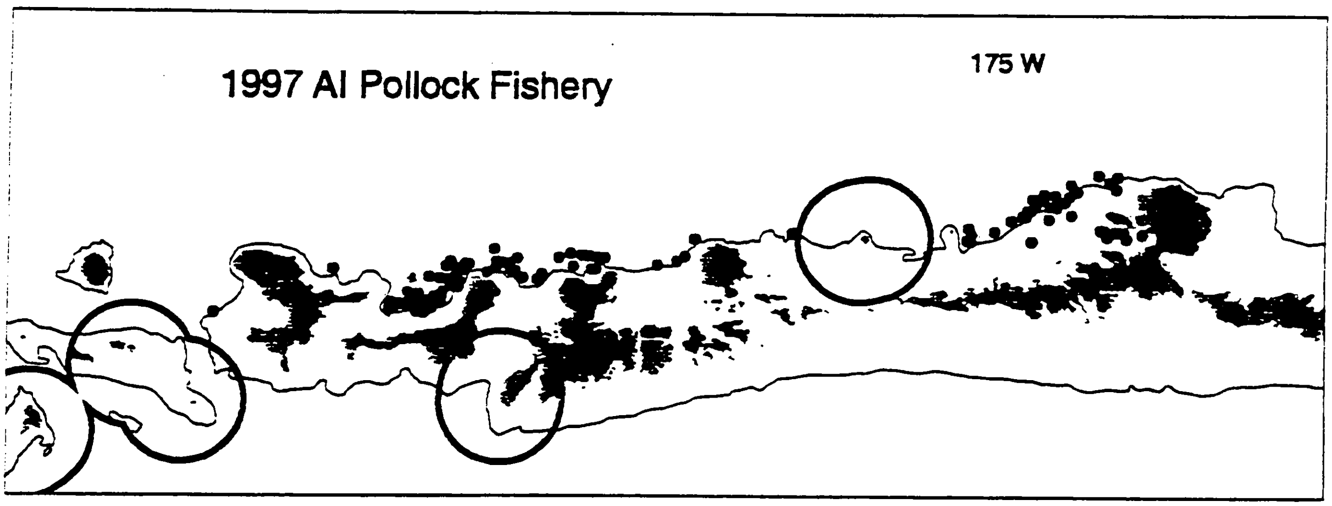


Figure 1.3. Observed locations of the 1997 pollock fishery in the A and B-seasons on the (Eastern Bering Sea (EBS) shelf (top) and in the Aleutian Islands (AI; bottom). The locations of the Catcher Vessel Operational Area (CVOA) and 20 nm (EBS) and 10 nm (AI) trawl exclusion zones around Steller sea lion rookeries are shown.

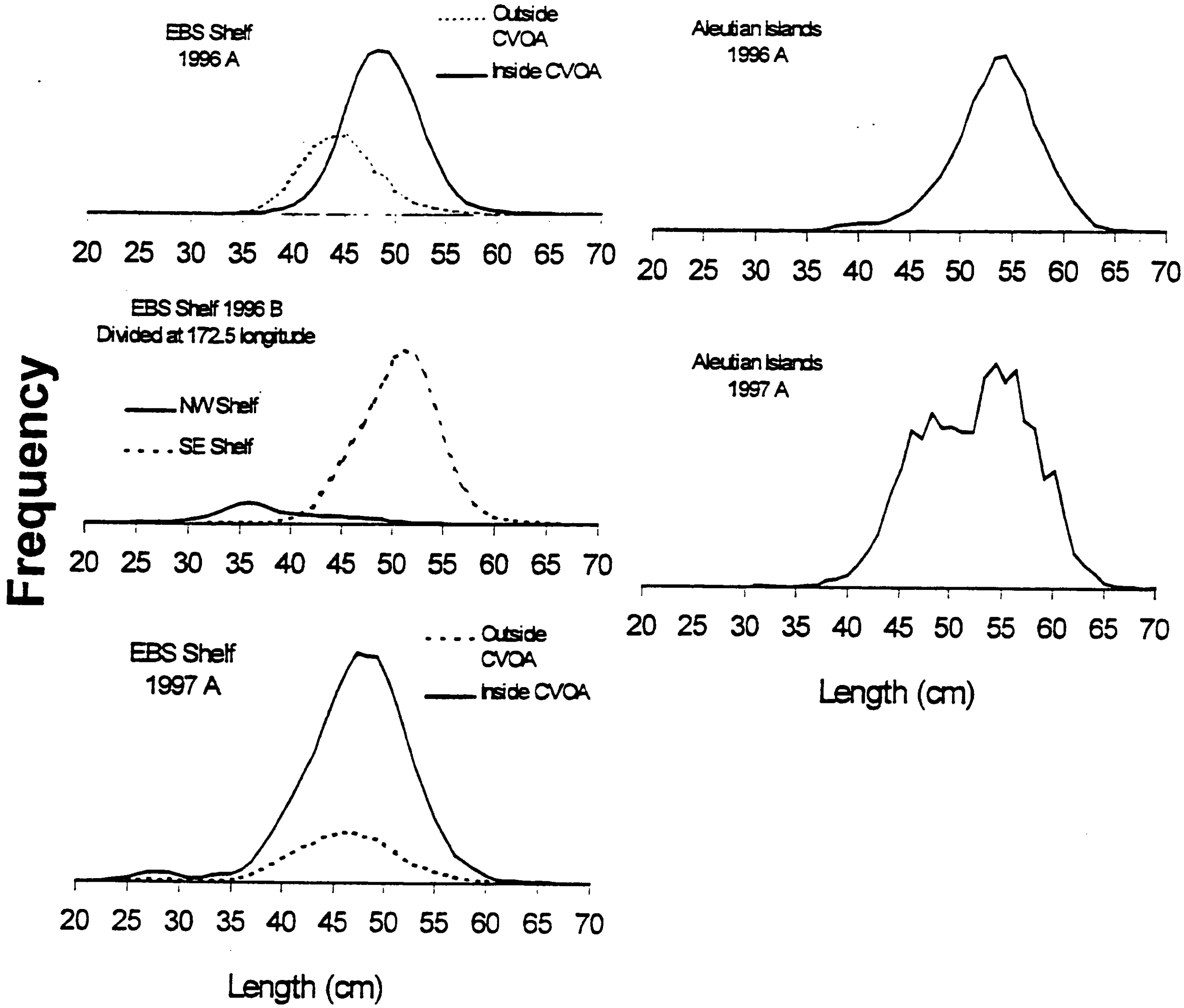


Figure 1.4. Length-frequencies of pollock caught by the fishery in the 1996 and 1997 A-seasons on the eastern Bering Sea shelf and in the Aleutian Islands and during the 1996 B-season on the NW and SE portions of the eastern Bering Sea shelf.

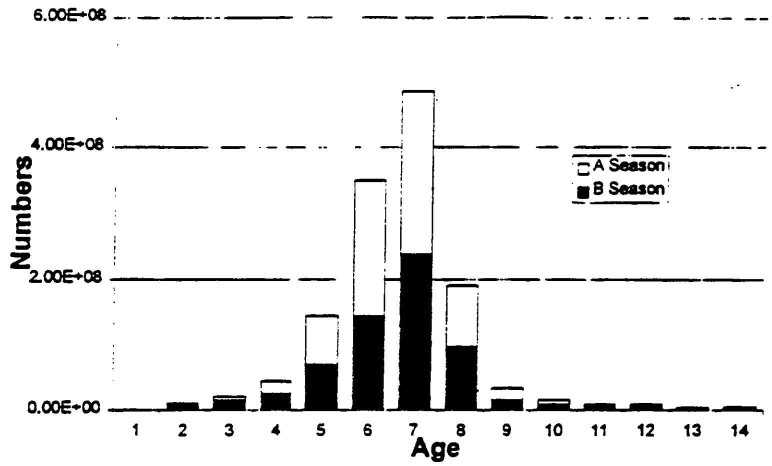


Figure 1.5. 1996 Fishery catch-at-age composition estimates.

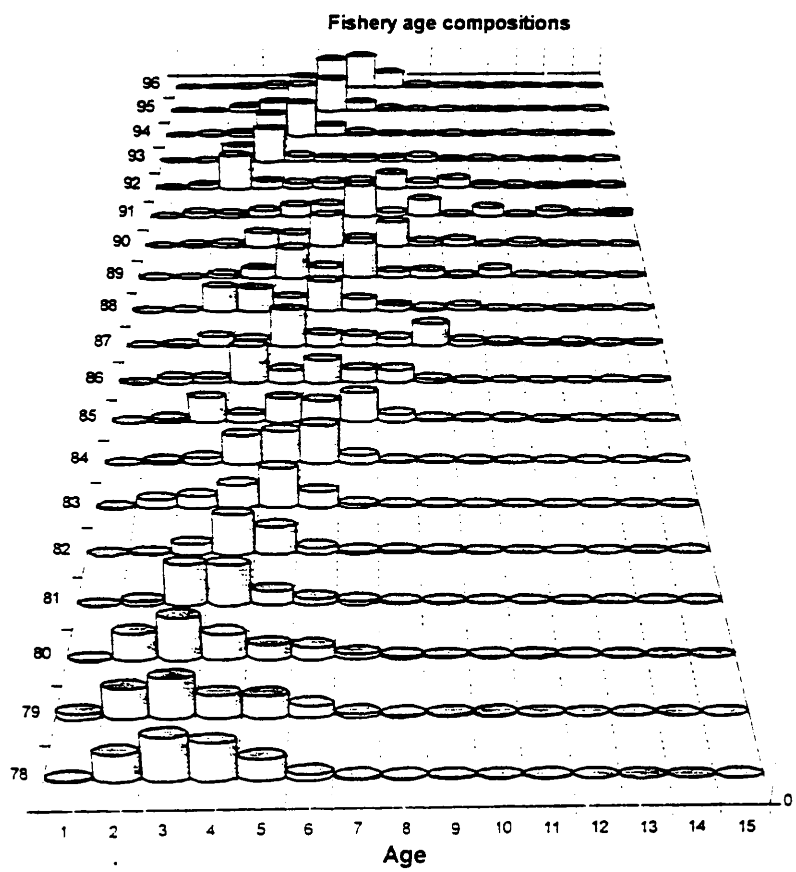


Figure 1.6. Fishery catch-at-age data (proportions).

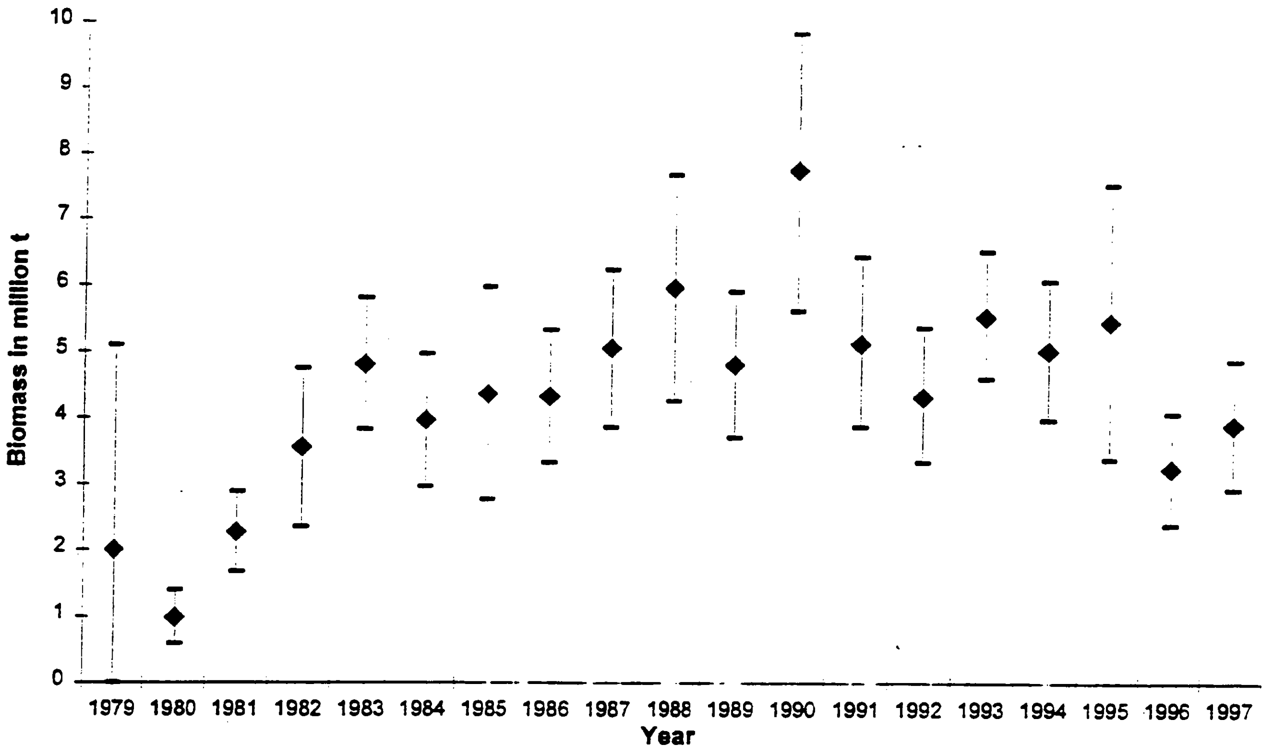


Figure 1.7. Bottom-trawl survey biomass estimates, 1979-1997 (note that the 1979-1981 estimates were not used in the SAM analyses since the survey sampling gear changed).

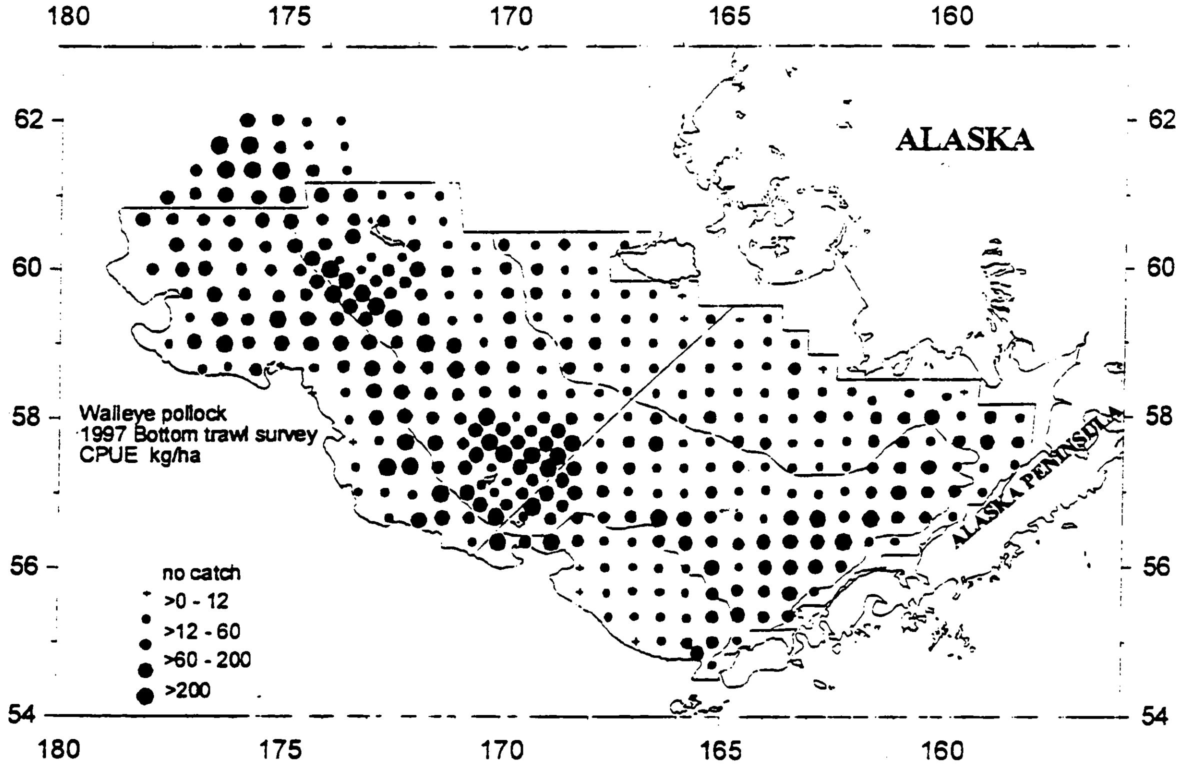


Figure 1.8. Map showing catch-per-unit effort (CPUE) for walleye pollock in the 1997 bottom-trawl survey.

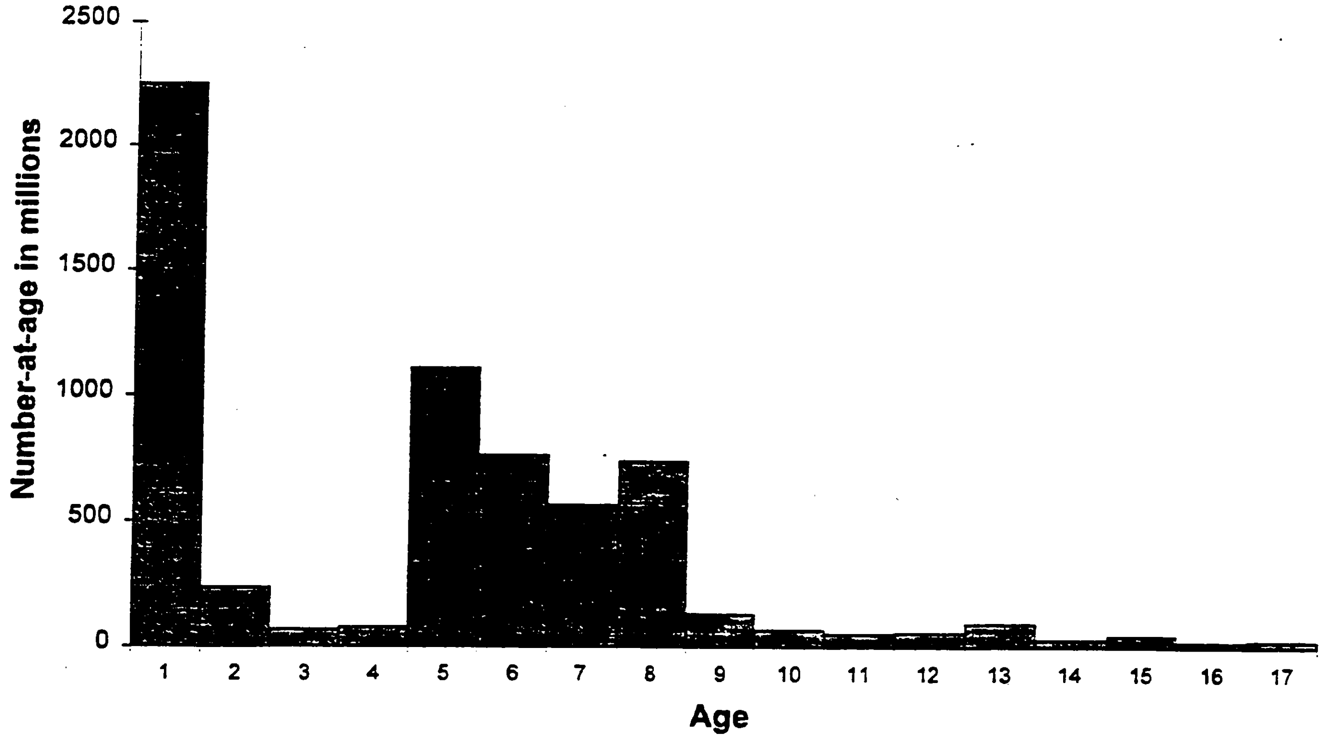


Figure 1.9. Estimates of 1997 Eastern Bering Sea bottom-trawl survey age compositions.

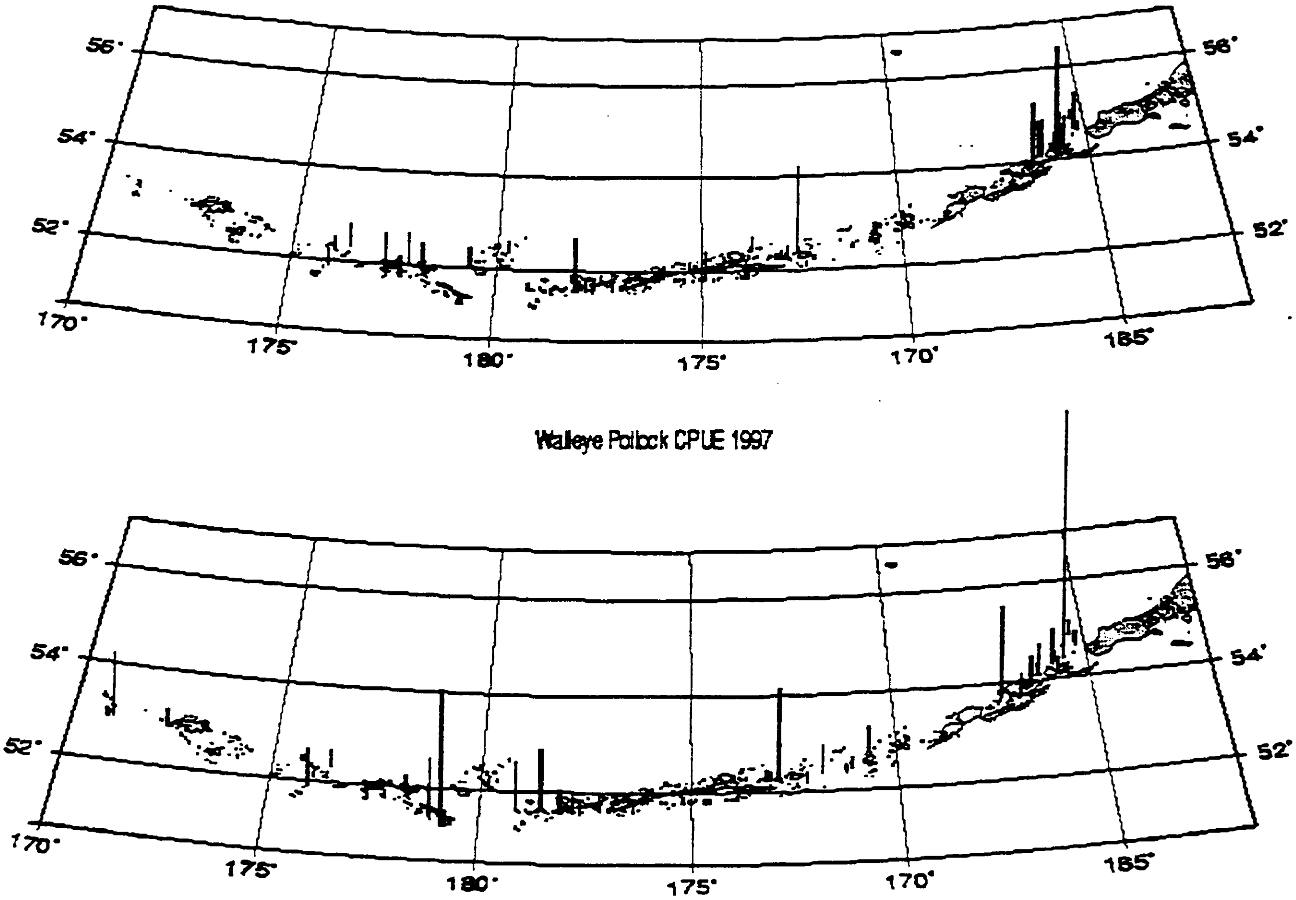


Figure 1.10. Distribution of pollock from the Aleutian Islands triennial surveys for 1994 (upper panel) and 1997 (lower panel).

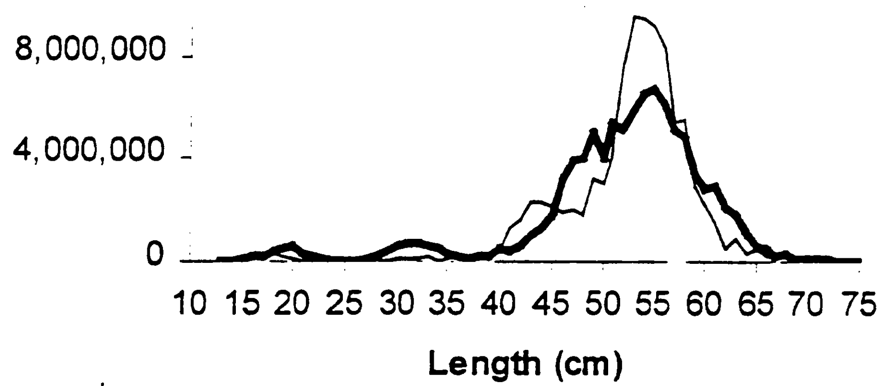


Figure 1.11. Size composition of pollock from the Aleutian Islands 1997 triennial survey. The thin line represents the south-east Bering Sea (SEBS) portion of the survey and the thick line is for the remainder of the Aleutian Islands region.

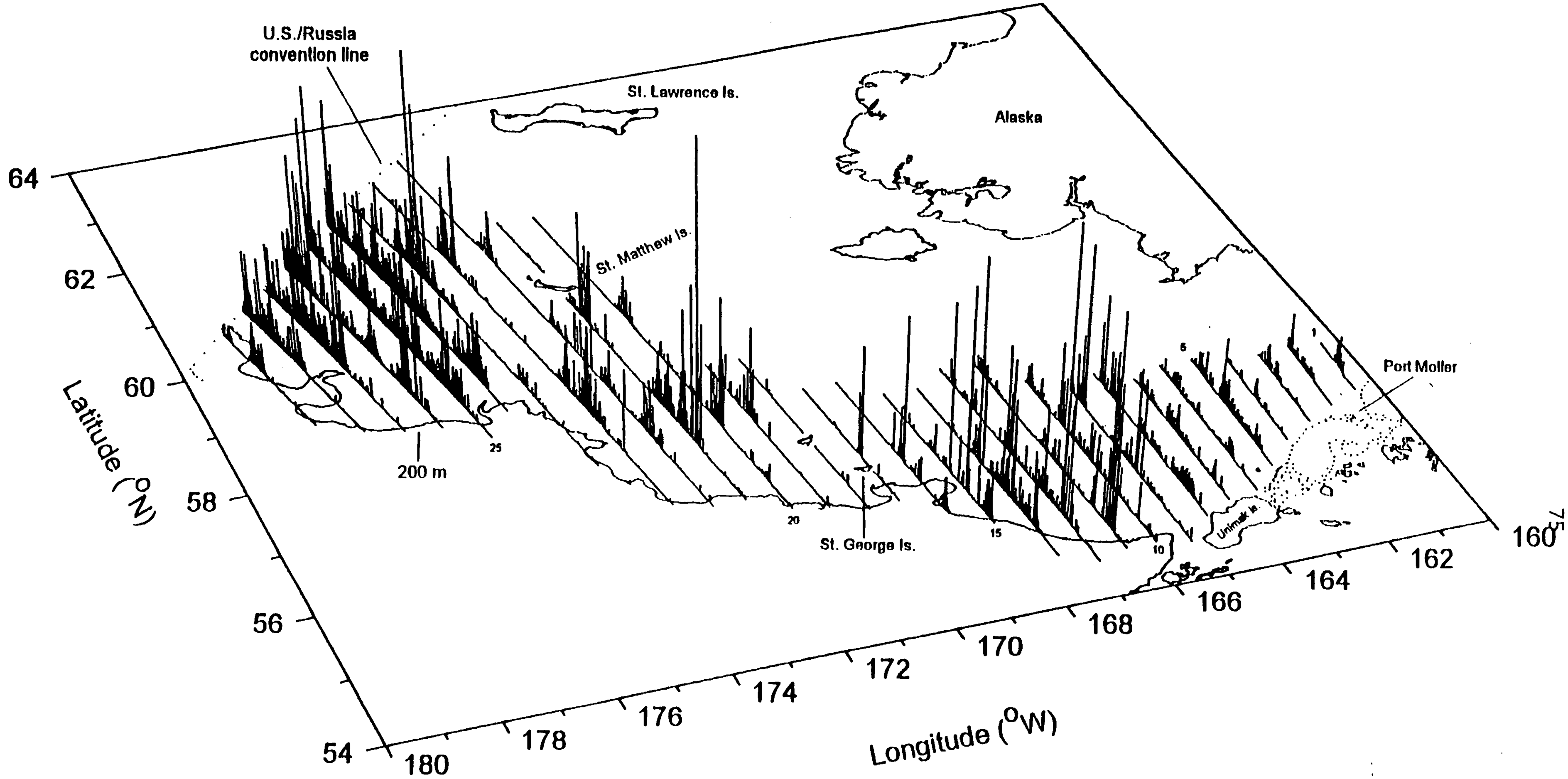


Figure 1.12. Relative pollock density along tracklines during the summer 1997 hydroacoustic survey of the eastern Bering Sea shelf. Transect numbers are indicated.

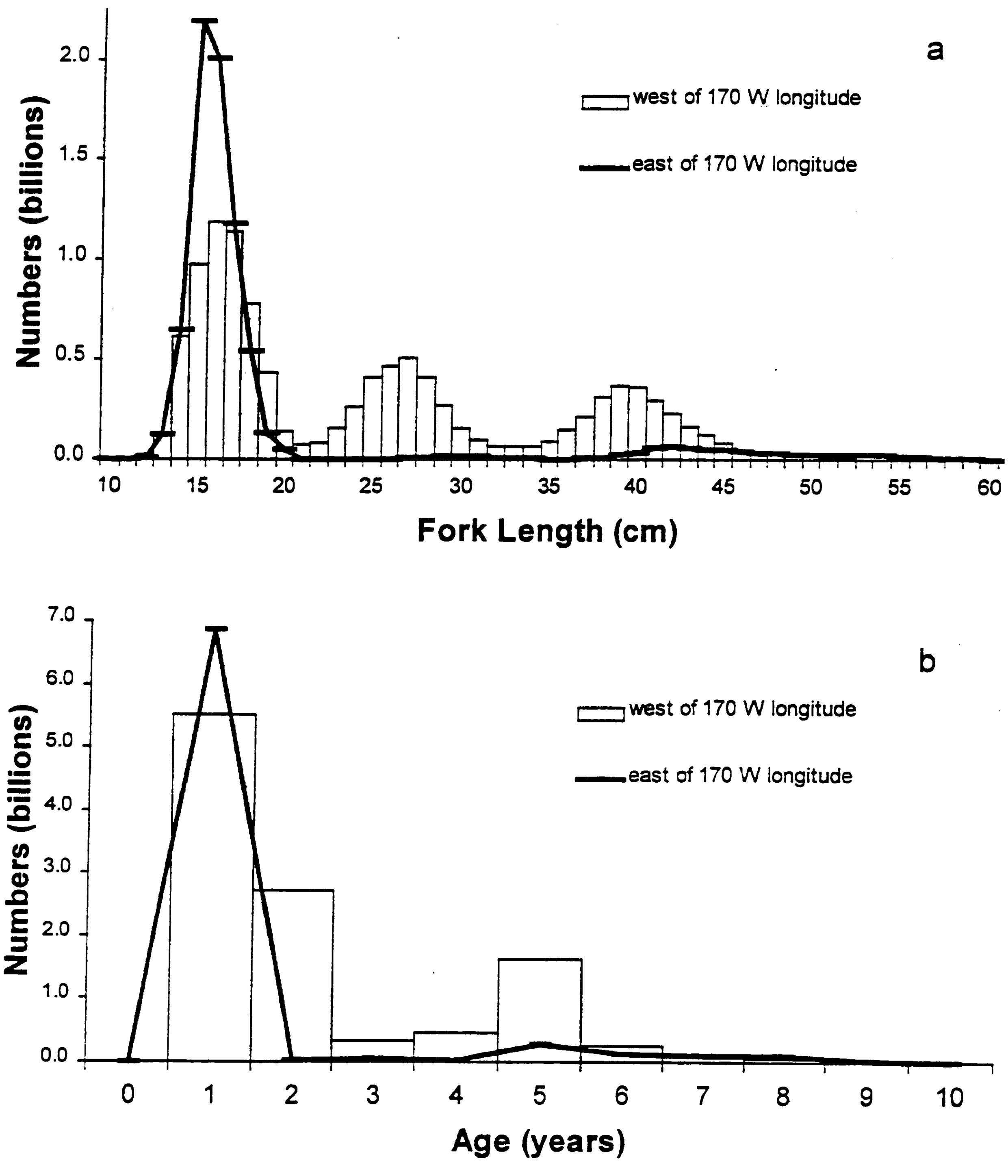


Figure 1.13. Preliminary estimate for pollock numbers at length (a) and numbers at age (b) from the 1997 EIT survey of the eastern Bering Sea shelf. Fish from near the surface to 3 m off bottom were included in this analysis.

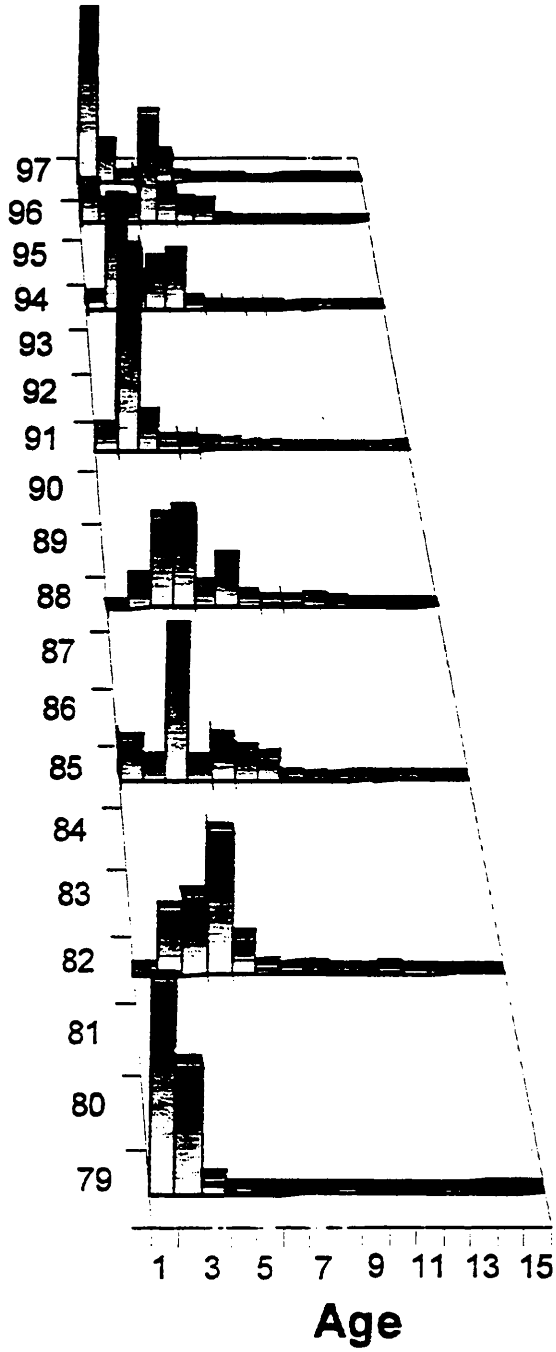


Figure 1.14. Time series of estimated proportions at age from the EIT surveys, 1979-1997.

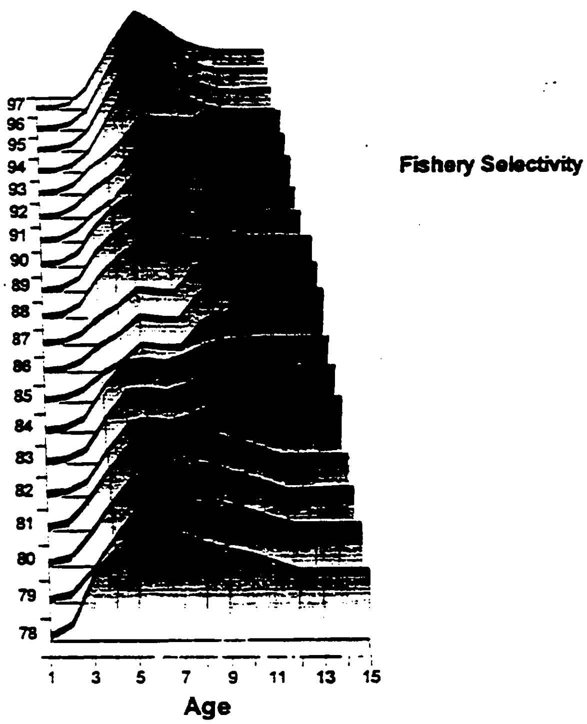


Figure 1.15. Selectivity at age estimates for the fishery, 1978-1997, SAM Model 4.

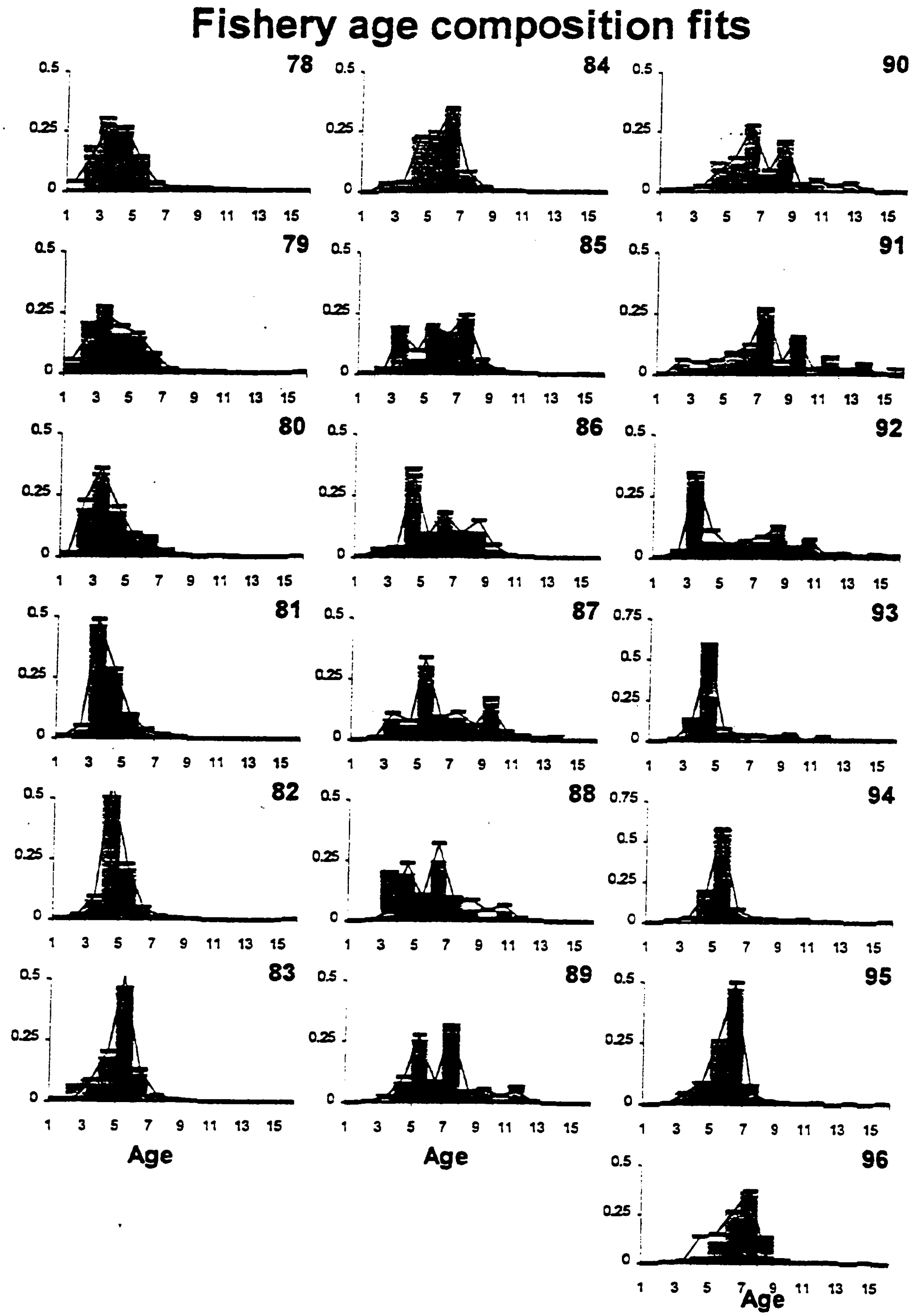
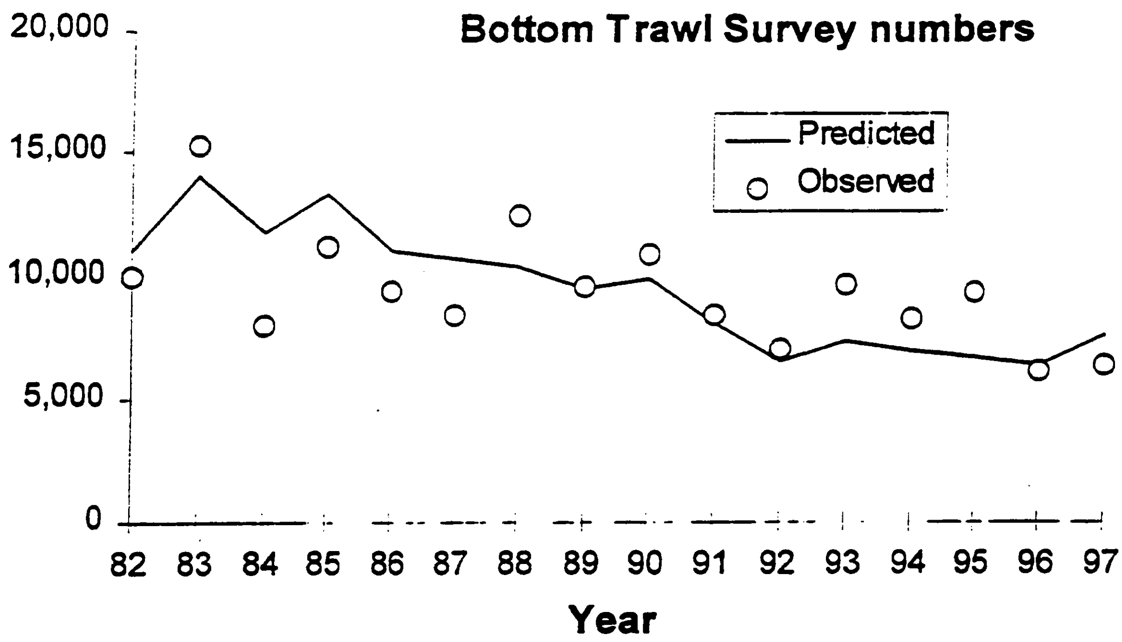


Figure 1.16. Model fits to the fishery age composition estimates for Model 4. Lines represent model predictions while the vertical columns represent the data.



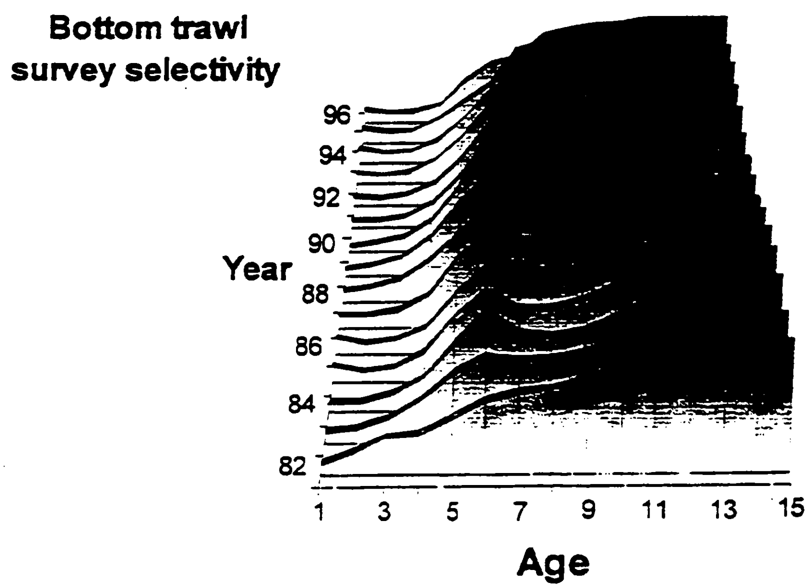


Figure 1.17. Model 4.estimates of bottom-trawl survey numbers (upper panel) and selectivity-at-age over time (lower panel).

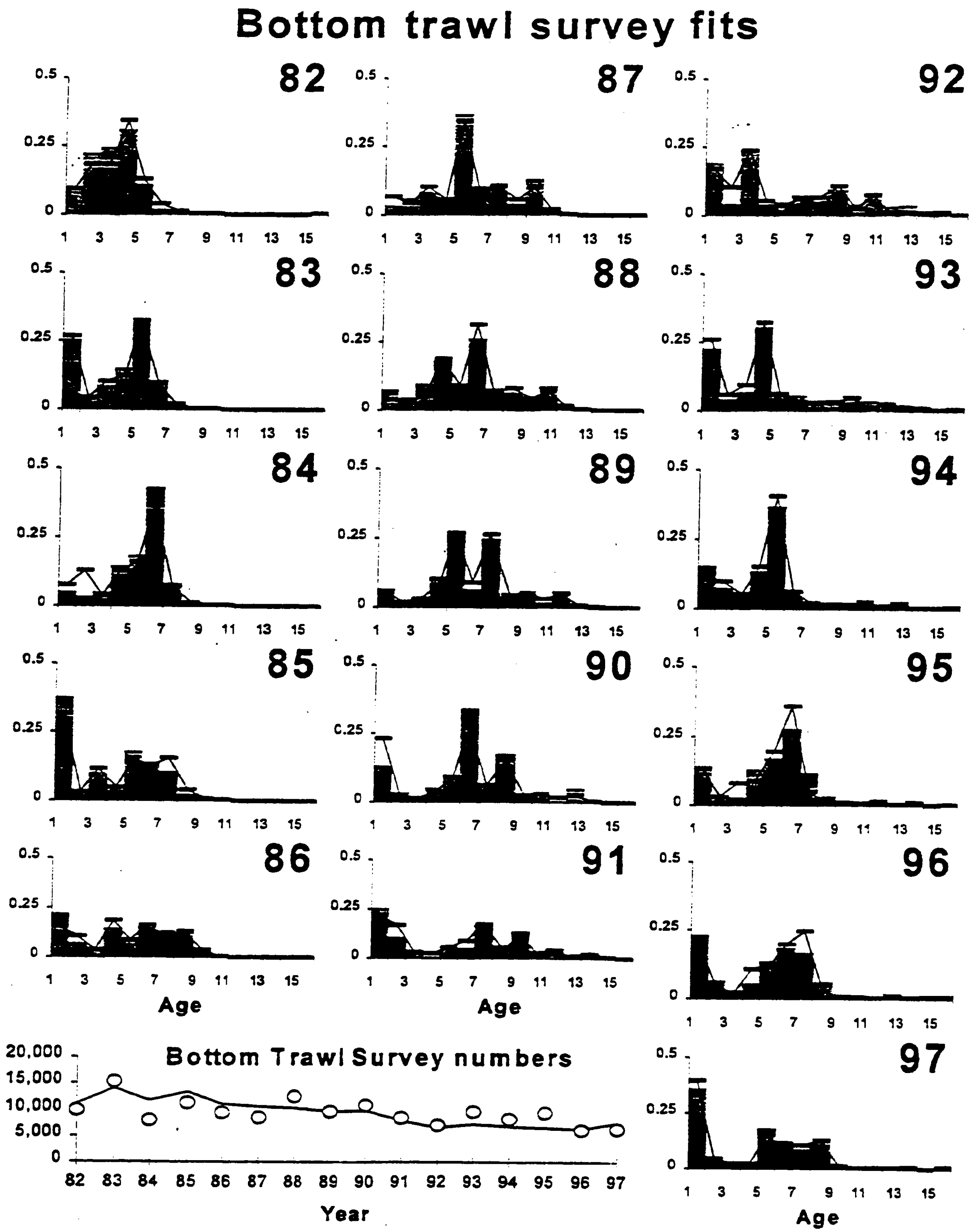


Figure 1.18. Model fit to the bottom trawl survey age composition data (proportions). Lines represent model predictions while the vertical columns represent the data.

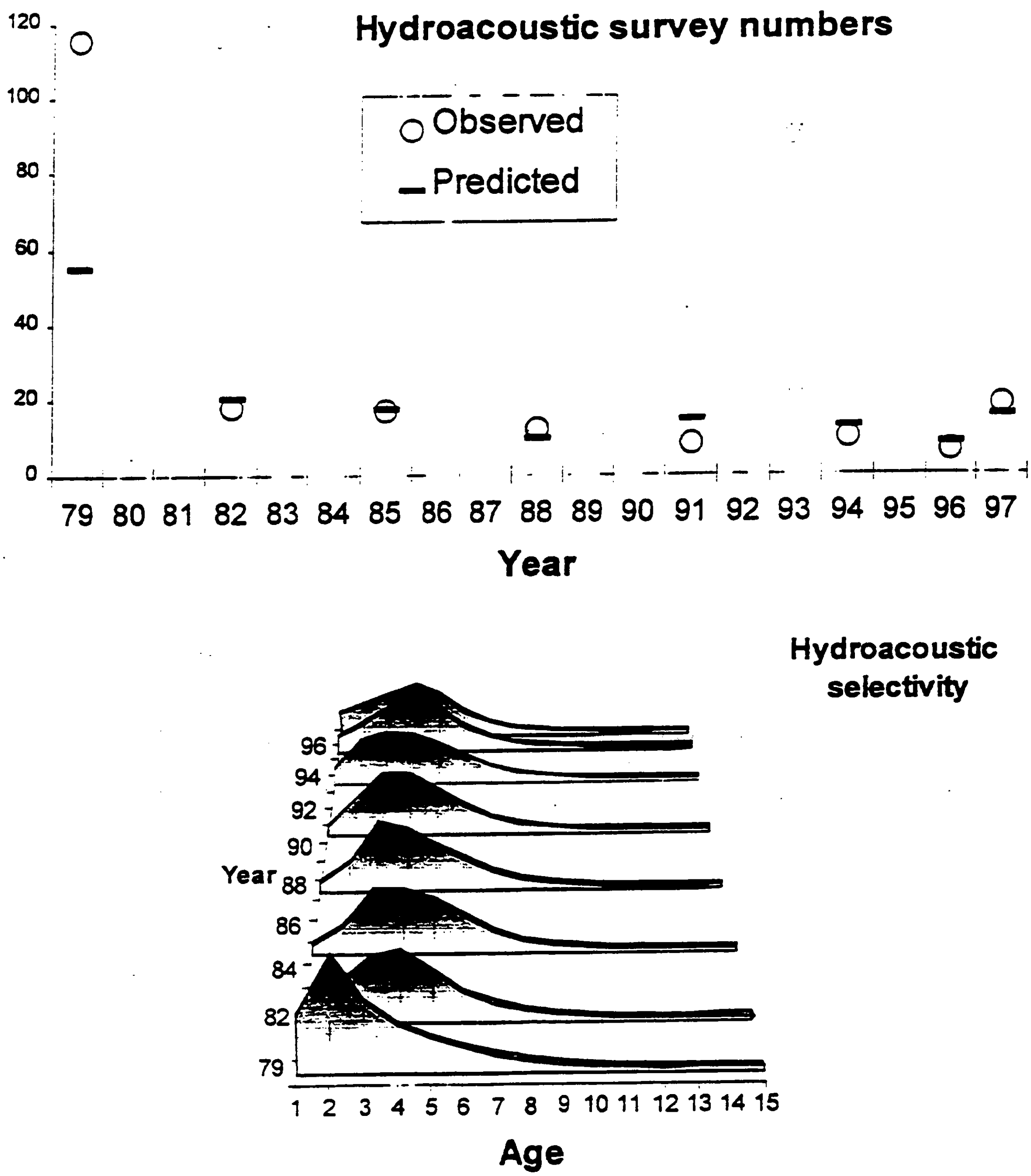


Figure 1.19. Model 4 estimates of EIT survey numbers (upper panel) and selectivity-at-age over time (lower panel).

Hydroacoustic survey fits

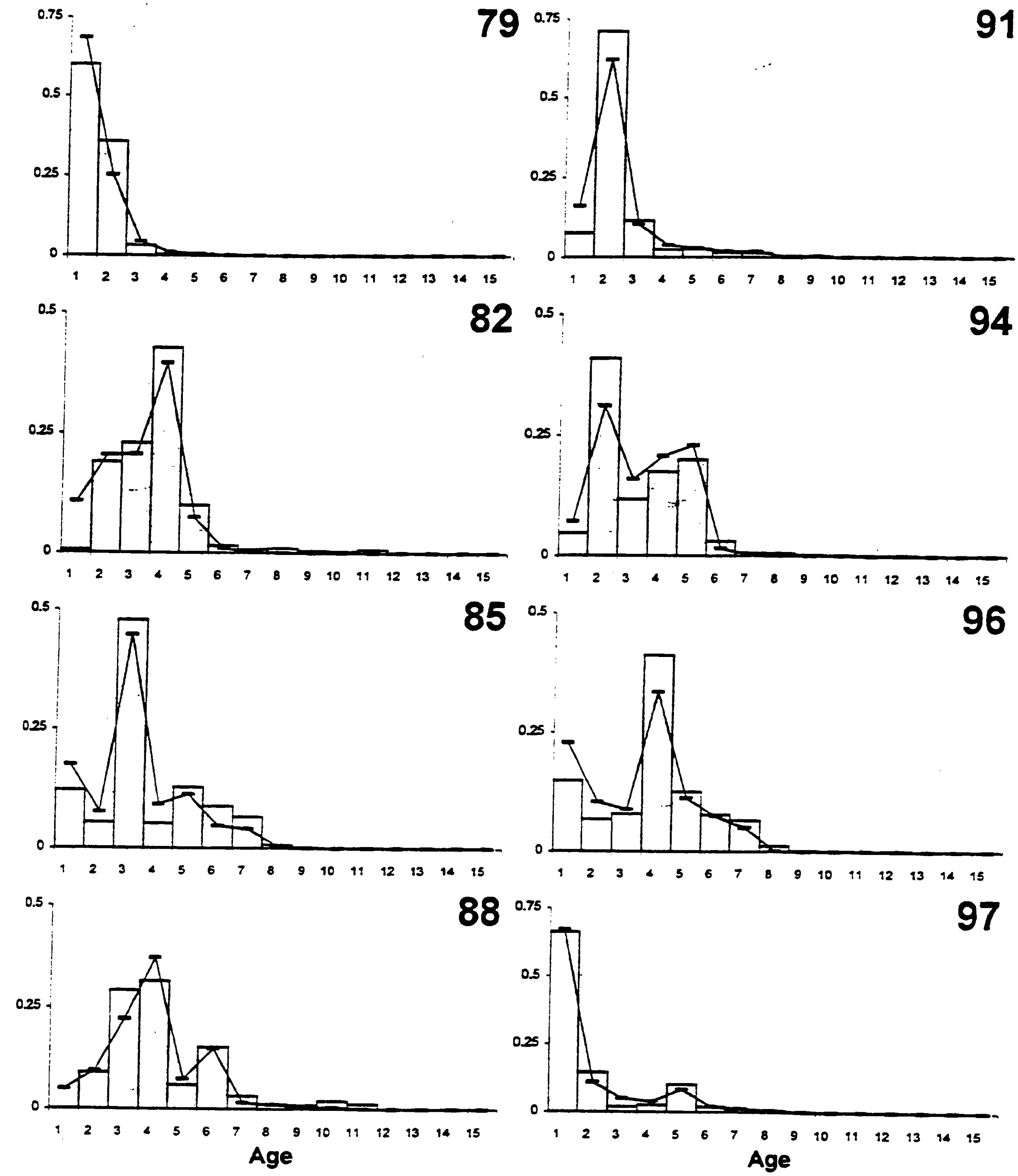


Figure 1.20. Model fit to the EIT survey age composition data (proportions). Lines represent model predictions while the vertical columns represent the data.

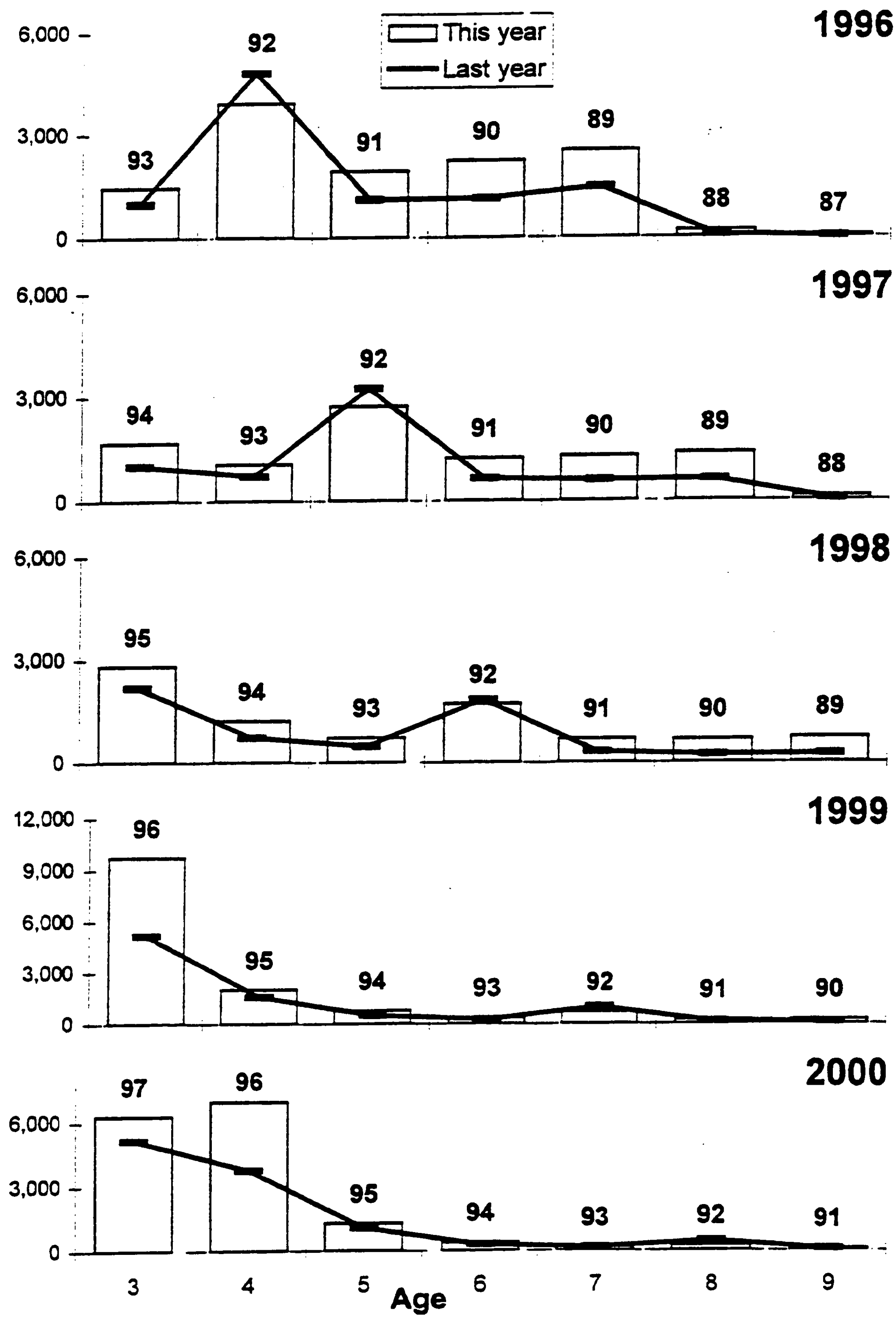


Figure 1.21. Model 4 projected population numbers at age compared with those presented in last year's appendix document (Wespestad et al. 1996).

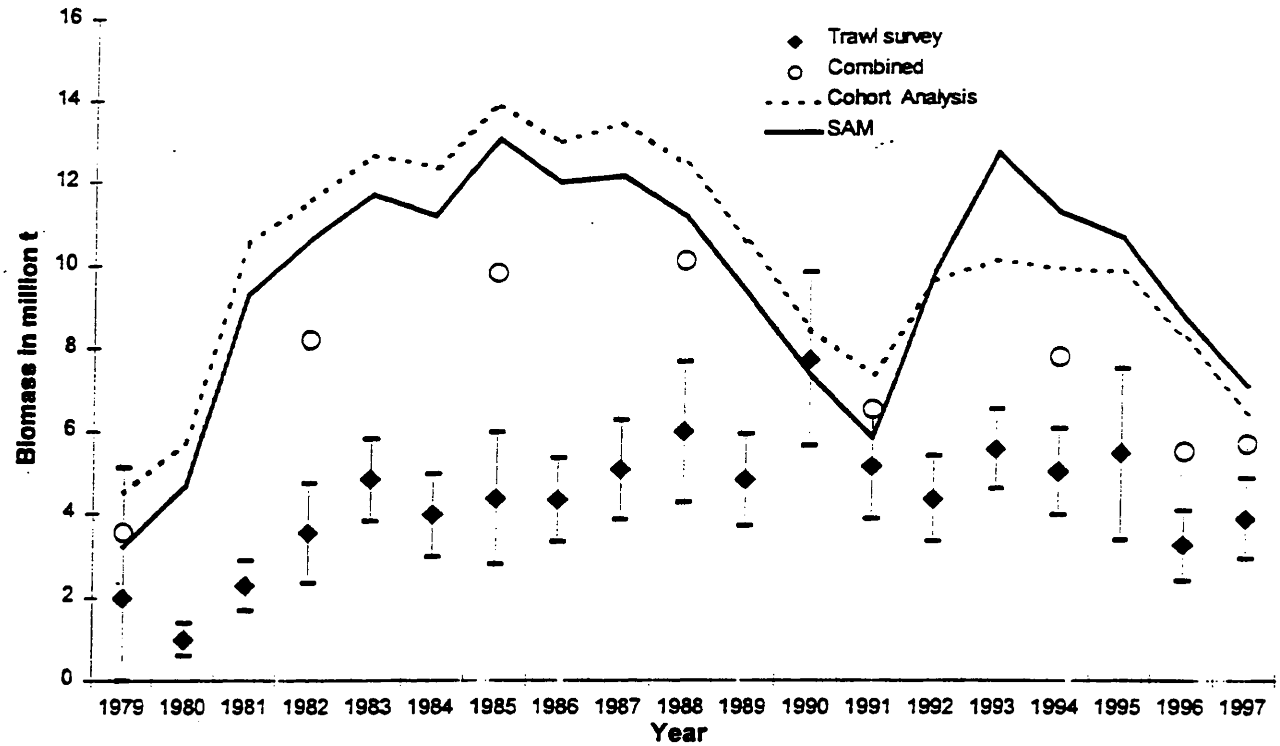


Figure 1.22. Eastern Bering Sea pollock abundance trends, 1979-1997 as estimated in bottom trawl surveys, combined EIT-bottom trawl surveys, and catch-age models (cohort analysis and SAM Model 4). Bottom-trawl survey biomass estimates are shown with 95% confidence bounds.

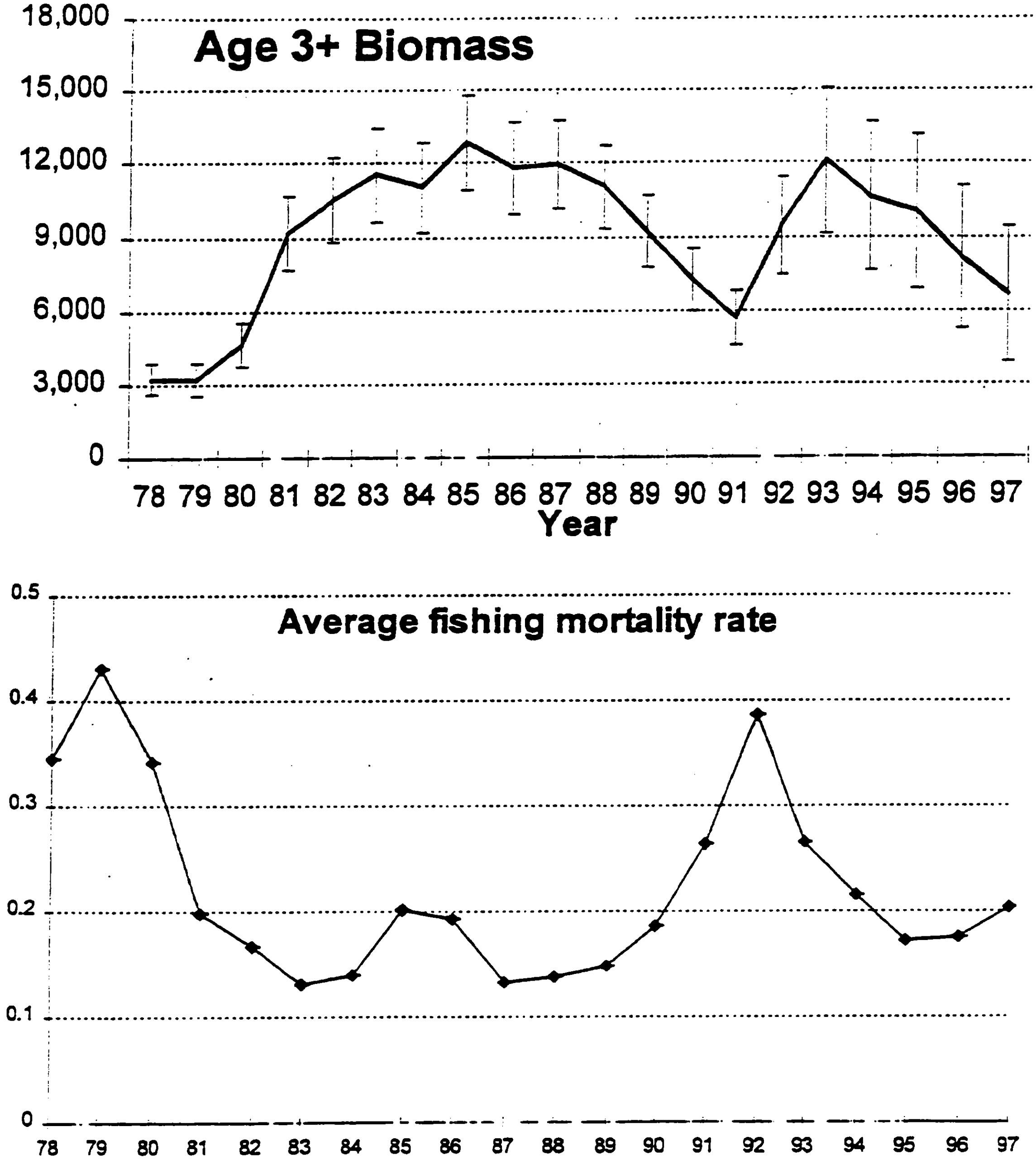


Figure 1.23. Estimated age 3+ biomass and fishing mortality under Model 4.

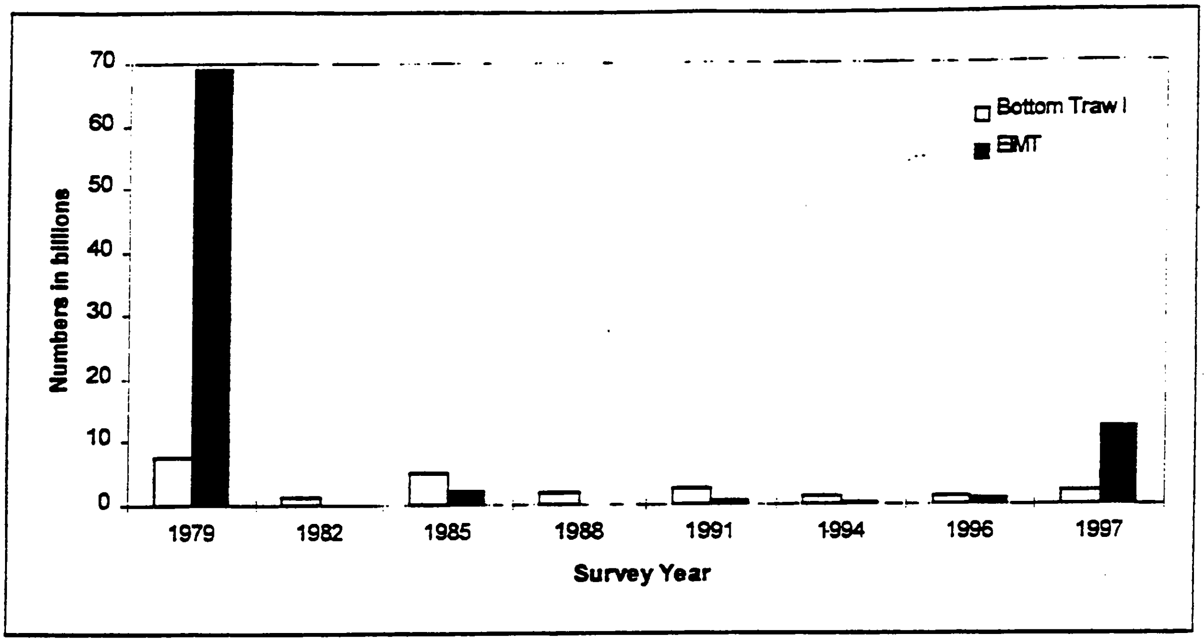


Figure 1.24. Numbers of age 1 pollock in bottom trawl and EIT surveys in the eastern Bering Sea, 1979-1997.

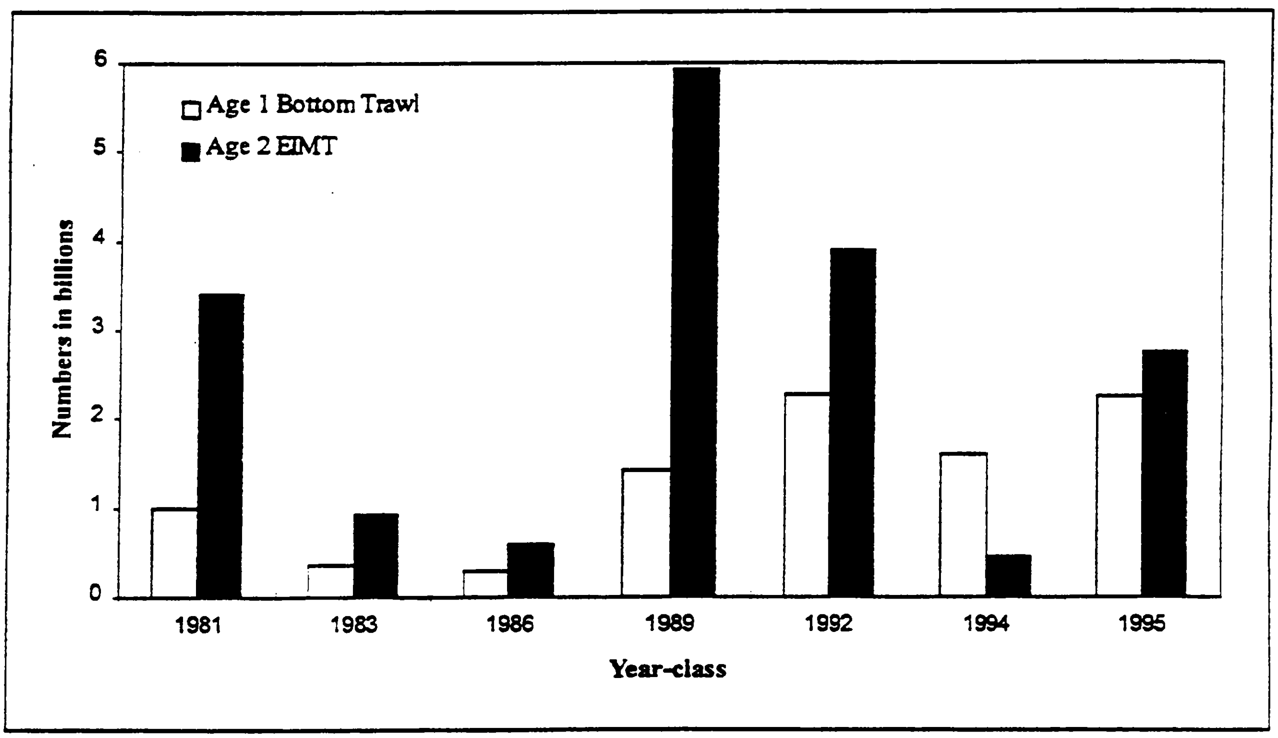


Figure 1.25. Estimated abundance of eastern Bering Sea pollock at age 1 in bottom trawl surveys and at age 2 in EIT surveys for year-classes with observations at age 1 and age 2.

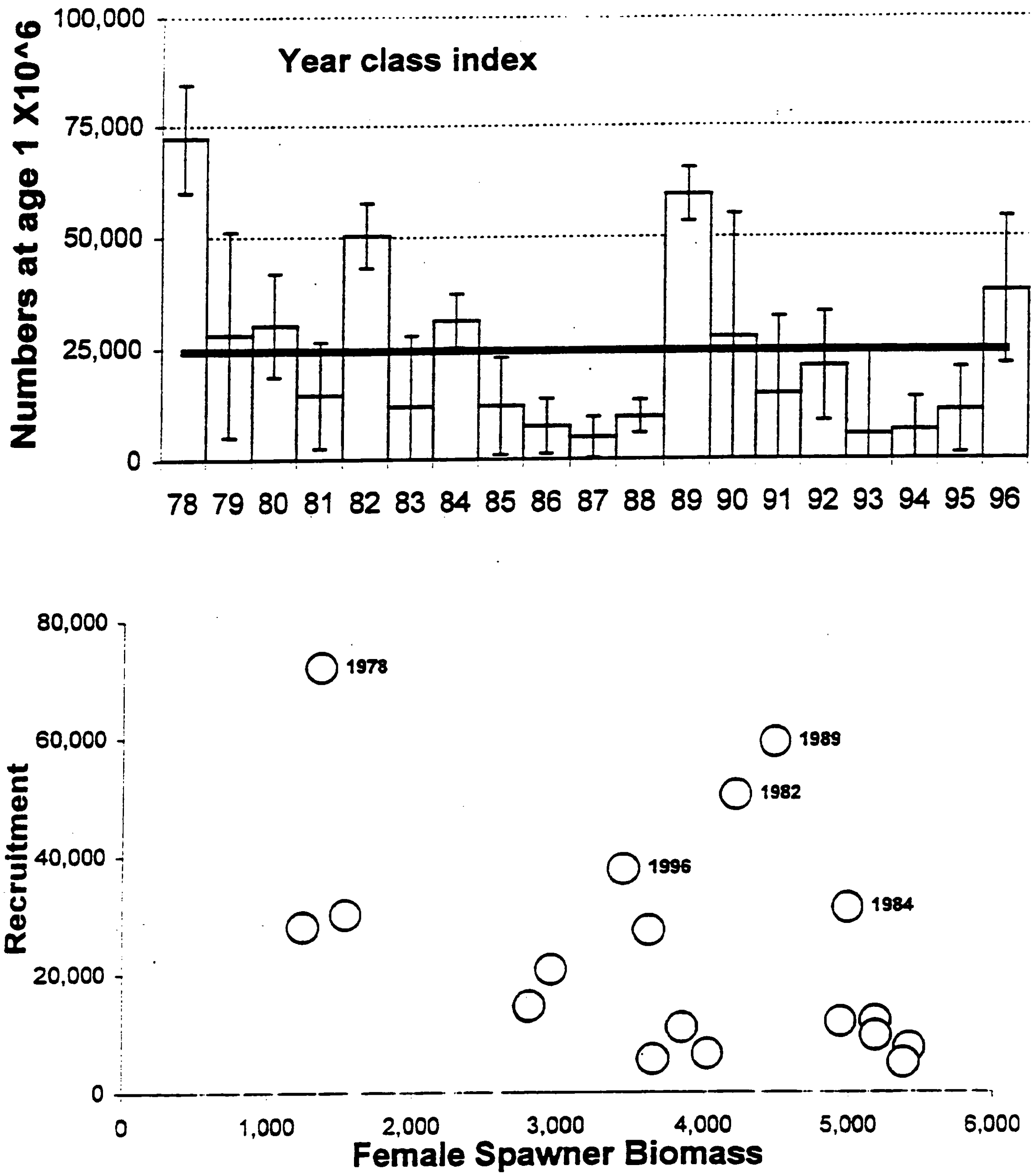


Figure 1.26. Year-class strengths by year (as age-1 recruits, upper panel) and relative to female spawner biomass (thousands of tons, lower panel) for Model 4. Solid line in upper panel represents the mean recruitment for all years since 1978.

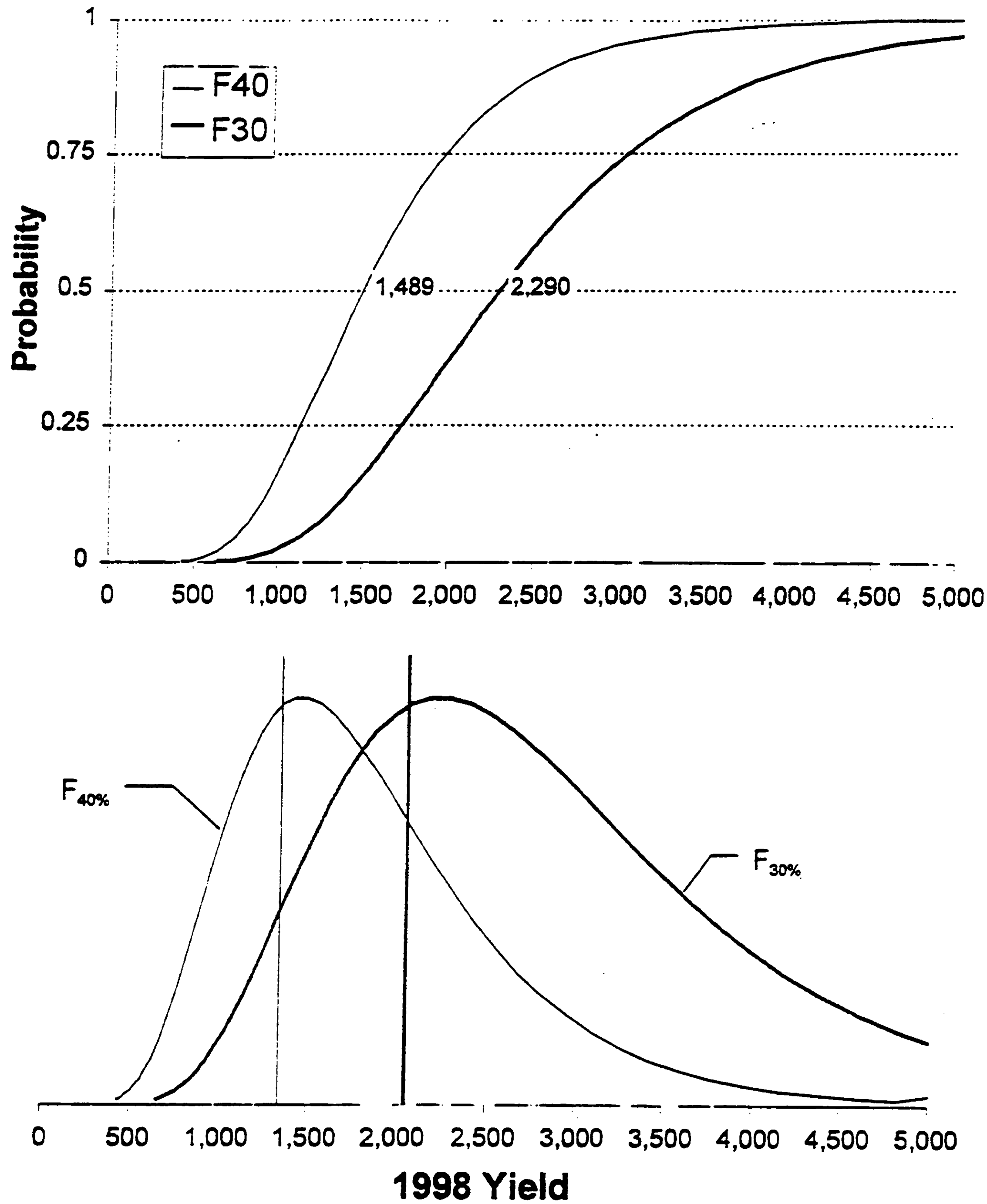


Figure 1.27. SAM Model 4 measures of uncertainty in 1998 yield as a cumulative distribution (upper panel) and relative probability distribution (lower panel). Vertical lines on lower figure represent harmonic mean values for $F_{40\%}$ and $F_{30\%}$ rates, respectively.

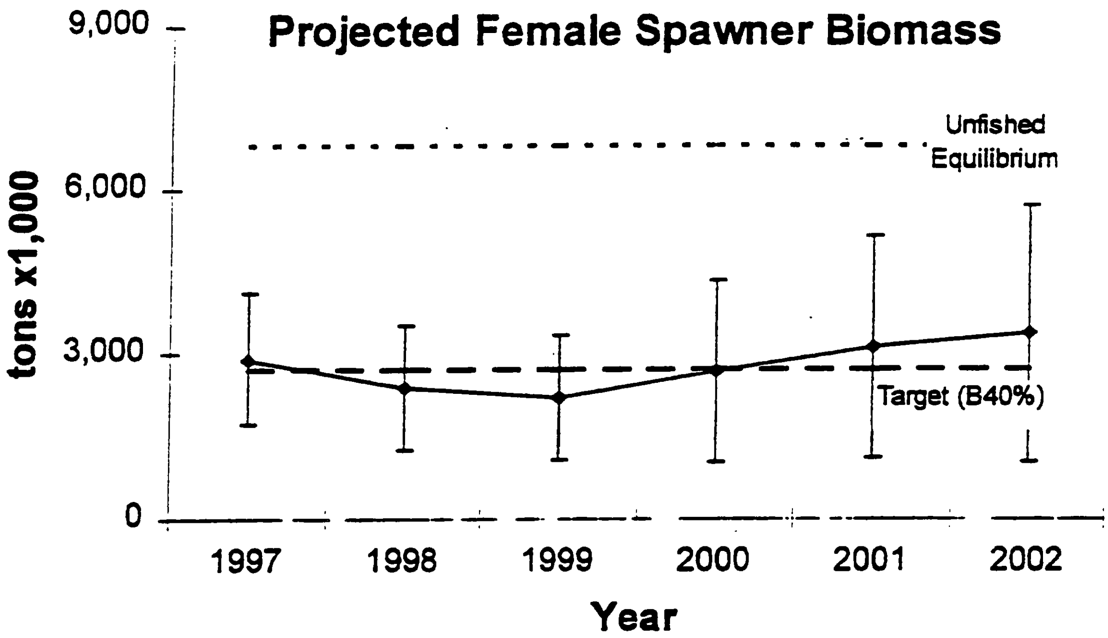
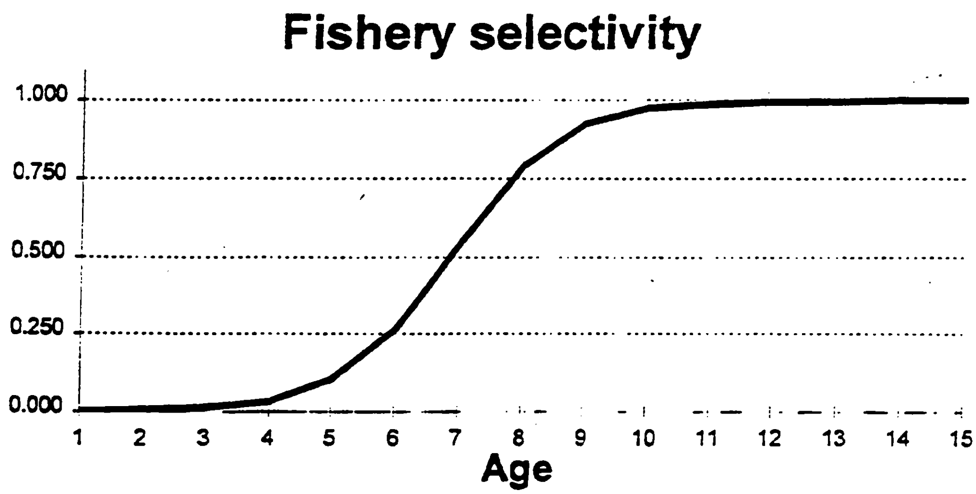


Figure 1.28. Projected **Female spawner biomass** projections relative to the $B_{40\%}$ target and the theoretical unfished equilibrium (SAM Model 4, based on the average recruitment estimated from1978-1996). Future harvest rates are assumed equal to an unadjusted $F_{40\%}$ rate.



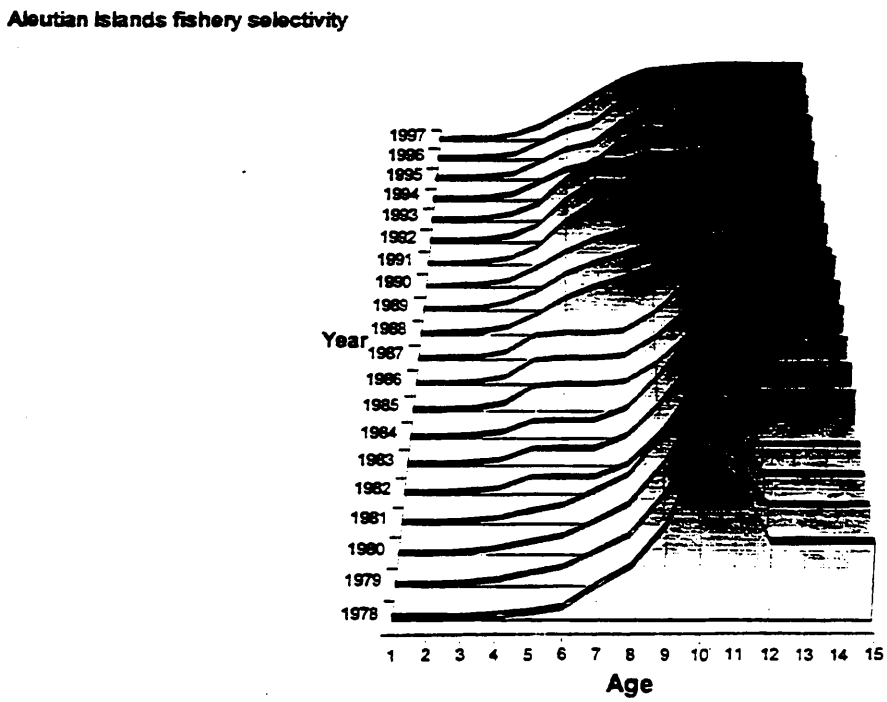


Figure 1.29. Selectivity estimates for the Aleutian Islands fishery (AI Model 3, upper panel) compared with model allowing variable selectivity (lower panel).

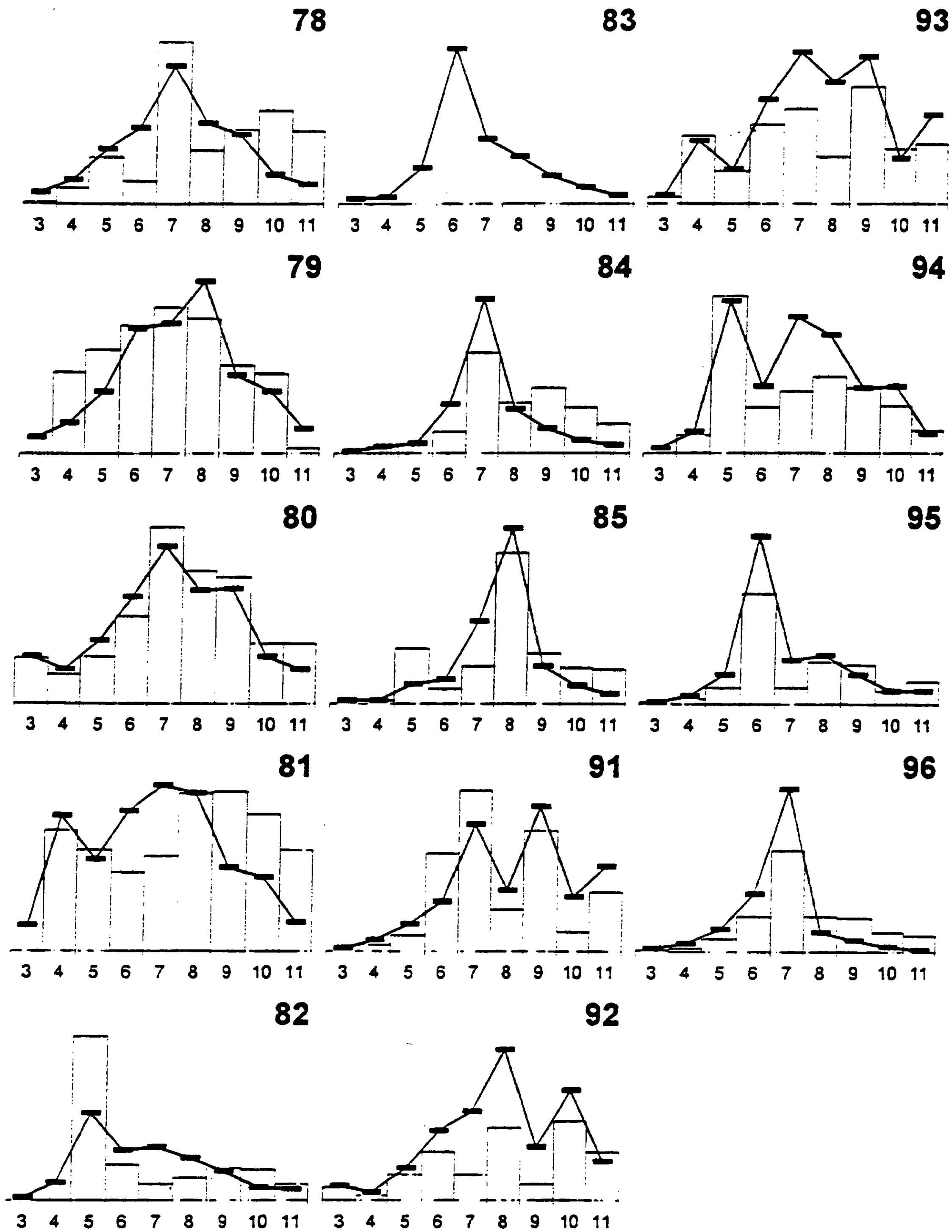


Figure 1.30. Model fit to the Aleutian Islands fishery catch-at-age data (proportions AI Model 3). Lines represent model fits and vertical columns represent the data.

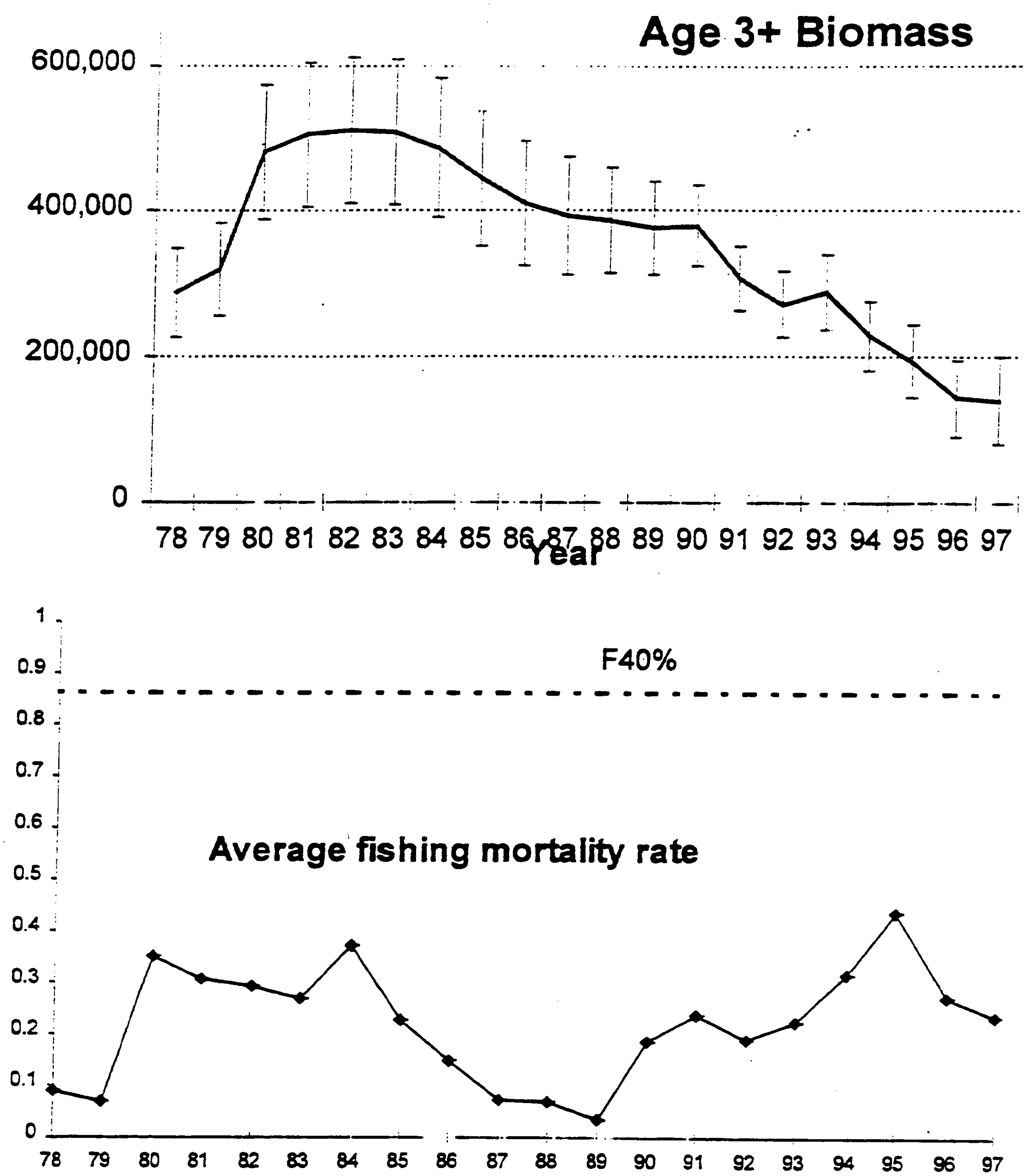


Figure 1.31. Estimated Age 3+ biomass trajectory (upper panel) and average fishing mortality (lower panel) for the Aleutian Islands SAM analysis.

$s_{t,a}$ is the selectivity for age class a in year t, , and

μ^F is the median fishing mortality rate over time.

If the selectivities ($s_{t,a}$) are constant over time then fishing mortality rate decomposes into an age component and a year component. This assumption creates what is known as a separable model. If selectivity in fact changes over time, then the separable model can mask important changes in fish abundance. In our analyses, we constrain the variance term (σ_s^2) to allow selectivity to change slowly over time–thus improving our ability to estimate the $\gamma_{t,a}$. Also, to provide regularity in the age component, we placed a curvature penalty on the selectivity coefficients using the squared second-differences. We selected a simple random walk as our time-series effect on these quantities. Prior assumptions about the relative variance quantities were made. For example, we assume that the variance of transient effects (e.g., σ_E^2) is large to fit the catch biomass precisely. Perhaps the largest difference between the model presented here and those used for other groundfish stocks is in how we model "selectivity" of both the fishery and survey gear types. The approach taken here assumes that large differences between a selectivity coefficient in a given year for a given age should not vary too much from adjacent years and ages (unless the data suggest otherwise). The magnitude of these changes is determined by the prior variances as presented above. Last year we investigated the sensitivity of model results with different prior variances for comparison.

In the SAM analyses, recruitment (R_t) represents numbers of age-1 individuals. Last year our model treated recruitment simply as a stochastic process about a (geometric) mean value (R_0):

$$N_{t,1} = R_t = R_0 e^{\tau_t}, \qquad \tau_t \sim \mathrm{N}\left(0, \sigma_R^2\right) .$$

This year we added a stochastic Ricker function of spawning stock biomass:

$$R_t = B_{t-1} e^{\alpha\left(1 - \frac{B_{t-1}}{\beta}\right) + \tau_t}, \qquad \tau_t \sim \mathrm{N}\left(0, \sigma_R^2\right),$$

and also a stochastic Ricker function with an environmental component (κ_t):

$$R_t = B_{t-1} e^{\alpha\left(1 - \frac{B_{t-1}}{\beta}\right) + \kappa_t + \tau_t}, \qquad \tau_t \sim \mathrm{N}\left(0, \sigma_R^2\right) .$$

Mature spawning biomass during year t was defined as:

$$B_t = \sum_{a=1}^{15} w_a \phi_a N_{at}$$

where ϕ_a, the proportion of mature females at age, was the same as that presented in Wespestad (1995).

The environmental component discussed above is derived from Wespestad et al. (1997) study on factors that appear to be critical for EBS pollock recruitment. They presented hypotheses about the relationship between surface advection during the post-spawning period and pollock survival. They found that during years when the surface currents tended north-north westward along the shelf that year class strength was improved compared to years when currents were more easterly. They used the OSCURS model to simulate drift. In a subsequent analyses (Ianelli and Fournier, In Prep.) their analysis was extended to apply within a stock assessment model context. The procedure is briefly outlined as follows:

1) run the OSCURS model for 90 days in each year starting at 165W and 55.5N storing the daily locations;

2) compute the average location of the simulated drifter over the 90 day period within each year using the GMT program (Wessel and Smith 1991) `fitcircle`.

3) plot these points and create a geographic grid (A) centered such that it covers all mean values over all years,

4) create an indicator matrix (Ψ) dimensioned such that the rows correspond to the number of years needed for the model (here 1964 – 1997) and the columns represent either the row or column index of the geographic grid. For example, say the average location of a drifter in 1980 fell within the bounds of the geographic grid cell represented by the 2nd column and 4th row, then the indicator matrix would have 2 and 4 as entries for the row corresponding to 1980.

Submit the indicator matrix as data to be read in to the model so that the values of the geographic grid matrix can be estimated where:

$$\kappa_t = A(\Psi_{t,1}, \Psi_{t,2}), \qquad \kappa_t \sim \mathrm{N}(0, \sigma_\kappa^2).$$

The idea is simply that there are "good" circulation patterns and "bad" circulation patterns within the first few months after spawning.

The computation for predicting survey proportions at age assumed that the survey was completed at the beginning of the year (prior to the fishery), and that removals by the survey were insignificant. Consequently, a set of analogous catchability and selectivity terms were estimated for fitting the survey observations as:

$$N_{t,a}^s = N_{t,a} q_t^s s_{t,a}^s$$

where the superscript s denotes quantities pertaining to the survey processes. For these preliminary analyses we chose to keep survey catchabilities constant over time (though they are estimated separately for the EIT and bottom trawl surveys).

Parameter estimation

The objective function was simply the product of the negative log-likelihood function and prior distributions. To fit large numbers of parameters in nonlinear models it is useful to be able to estimate certain parameters in different stages. The ability to estimate stages is also important in using robust likelihood functions since it is often undesirable to use robust objective functions when models are far from a solution. Consequently, in the early stages of estimation we use the following log-likelihood function for the survey and fishery catch at age data (in numbers):

$$f = n \cdot \sum_{a,t} p_{at} \ln(\hat{p}_{at}),$$

$$p_{at} = \frac{O_{at}}{\sum_a O_{at}}, \quad \hat{p}_{at} = \frac{\hat{C}_{at}}{\sum_a \hat{C}_{at}}$$

$$\hat{C} = C \cdot E_{ageing}$$

$$E_{ageing} = \begin{pmatrix} b_{1,1} & b_{1,2} & b_{1,3} & \cdots & b_{1,15} \\ b_{2,1} & b_{2,2} & & & \\ b_{3,1} & & \ddots & & \\ \vdots & & & \ddots & \\ b_{15,2} & & & & b_{15,15} \end{pmatrix},$$

where A, and T, represent the number of age classes and years, respectively, n is the sample size, and O_{at}, $\hat{C}_{at}$ represent the observed and predicted numbers at age in the catch. The elements $b_{i,j}$ represent ageing mis-classification proportions are based on independent agreement rates between otolith age readers. For initial model runs presented here, we assumed that ageing errors were insignificant. Sample size values were fixed at 200 for the fishery data, 100 for the bottom trawl survey, and 50 for the EIT survey. Strictly speaking, the amount of data collected for this fishery indicates higher values might be warranted. However, it is well known that the standard multinomial sampling process is not robust to violations of assumptions (Fournier et al. 1990). Consequently, as the model fit approached a solution, we invoke a robust likelihood function which fit proportions at age as:

$$\prod_{a=1}^{A}\prod_{t=1}^{T}\frac{\left(\exp\left\{-\dfrac{\left(p_{t,a}-\hat{p}_{t,a}\right)^2}{2\left(\eta_{t,a}+0.1/T\right)\tau^2}\right\}+0.01\right)}{\sqrt{2\pi\left(\eta_{t,a}+0.1/T\right)}\tau}$$

Taking the logarithm we obtain the log-likelihood function for the age composition data:

$$-1/2\sum_{a=1}^{A}\sum_{t=1}^{T}\log_e\left(2\pi\left(\eta_{t,a}+0.1/T\right)\right)-\sum_{a=1}^{A}T\log_e(\tau)$$

$$+\sum_{a=1}^{A}\sum_{t=1}^{T}\log_e\left[\exp\left\{-\frac{\left(p_{t,a}-\hat{p}_{t,a}\right)^2}{2\left(\eta_{t,a}+0.1/T\right)\tau^2}\right\}+0.01\right]$$

where $\eta_{t,a} = \hat{p}_{t,a}\left(1-\hat{p}_{t,a}\right)$

and $\tau^2 = 1/n$

gives the variance for $p_{t,a}$

$$\left(\eta_{t,a}+0.1/T\right)\tau^2.$$

Completing the estimation in this fashion reduces the model sensitivity to outlier data.

The contribution to the log-likelihood function for the observed total catches is given by

$$\lambda_c \sum_t \left(\log\left(O_{t.} / \hat{C}_{t.} \right)^2 \right)$$

where λ_c represents prior assumptions about the accuracy of the observed catch data. Similarly, the contribution of prior distributions (in negative log-density) to the log-likelihood function include

$\lambda_\varepsilon \sum_t \varepsilon_t^{\,2} + \lambda_\gamma \sum_{ta} \gamma_{t,a}^{\,2} + \lambda_\delta \sum_t \delta_t^{\,2}$ where the size of the λ's represent prior assumptions about the variances of these random variables. For the model presented below, over 540 parameters were estimated. Most of these parameters are associated with year-to-year and age specific deviations in selectivity coefficients. For a presentation of this type of Bayesian approach to modeling errors-in-variables, the reader is referred to Schnute (1994). To easily estimate such a large number of parameters in such a non-linear model, automatic differentiation software extended from Greiwank and Corliss (1991) and developed into C++ class libraries was used. This software provided the derivative calculations needed for finding the posterior mode via a quasi-Newton function minimization routine (e.g., Press et al. 1992). The model implementation language (ADModel Builder) gave simple and rapid access to these routines and provided the ability estimate the variance-covariance matrix for all dependent and independent parameters of interest. For key quantities of interest, e.g., current stock size, the software also produces likelihood profiles which avoids the assumption that the likelihood shape is quadratic (implied when the inverse Hessian estimates are used).

APPENDIX B

Walleye Pollock (*Theragra chalcogramma*) abundance in the Southeastern Aleutian Basin near Bogoslof Island during February-March, 1997

by Taina Honkalehto and Neal Williamson

INTRODUCTION

Since 1988, with the exception of 1990, the distribution and abundance of spawning walleye pollock (*Theragra chalcogramma*) in the southeastern Aleutian Basin near Bogoslof Island have been investigated using echo integration-trawl (EIT) survey techniques. In the late 1980's, a directed domestic fishery on Bogoslof pollock existed, but it was halted in 1991 due to declining catches in the Donut Hole (central Aleutian Basin) and a drop in biomass in the Bogoslof area (Honkalehto and Williamson 1996). Tracking the abundance of pollock that spawn near Bogoslof remains important for management of the U. S. pollock fishing industry and to Central Bering Sea Convention member nations. Results presented here are from the pollock survey carried out 28 February-11 March 1997 between Akutan Island and the Islands of Four Mountains, Alaska. Scientists from the United States, China, Poland and South Korea participated.

METHODS

Acoustic data were collected with a Simrad EK 500[1] quantitative echo-sounding system (Bodholt et al. 1989) on the NOAA ship *Miller Freeman*, a 66-m stern trawler equipped for fisheries and oceanographic research. Two split-beam transducers (38 kHz and 120 kHz) were mounted on the bottom of the vessel's centerboard extending 9 m below the water surface. System electronics were housed inside the vessel in a new permanent acoustics laboratory that replaced the portable laboratory used on previous cruises. Data from the echo sounder/receiver were processed using Simrad BI500 echo integration and target strength analysis software (Foote et al. 1991) on a SUN workstation. Results presented here were based on the 38 kHz data. Midwater echo sign was sampled using an Aleutian Wing 30/26 trawl and 5 m^2 "Fishbuster" doors (1,250 kg).

Between 1 and 10 March, two EIT survey passes were run through the Bogoslof spawning area (Fig. 1). Pass 1 (1-8 March) covered about 1400 nautical miles (nmi) of transects. The trackline consisted of 27 north-south parallel transects beginning at about 165° 44'W and ending near 170° 20'W. Transects 1-6 were spaced 10 nmi apart and transects 7-17 were 5 nmi apart. Pass 2 (9-10 March, transects 21-38) covered 525 nmi, and was run from west to east between 170° W and 167° 30'W at 5 nmi spacing. Pass 2 transects were positioned mid-way between pass 1 transects. Echo integration data collected continuously at about 11.5 kts vessel speed were examined for pollock and stored at a SV threshold of -69 decibels (dB). Estimates of pollock backscattering strength in the area represented by each transect were generated. These values were then summed and scaled using a previously derived relationship between target strength and fish length (TS = 20 Log FL - 66; Traynor 1996) to estimate the numbers and weight of pollock for each length category using pollock size compositions and a length-weight relationship derived from trawl catch information. Although trawl hauls sampled a higher percentage of females than males on average as they have in the past several years' surveys, we assumed a 50:50 sex ratio for population size composition and computed length-weight relationships. This is because we cannot easily obtain a representative sex ratio, as Bogoslof spawning pollock are highly aggregated and stratified by sex (Honkalehto and Williamson 1995; 1996). Size compositions used to scale the acoustic data in each area were obtained using a weighting procedure described in Honkalehto and Williamson (1996). Separate male and female length-weight relationships

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[1] Reference to trade names or commercial firms does not constitute U.S. Government endorsement.

obtained by pooling trawl data were averaged together into one regression by minimizing the sum of squares between the two curves using an iterative non-linear approach. Age data are not yet available.

Numbers and biomass of pollock were estimated for the entire geographic area covered by the survey (Fig. 1), using data from all trawl hauls (Fig. 2). Separate estimates were made for the area covered by pass 1 and pass 2. Assuming little or no migration to or from the area covered in pass 2, "pass 1 and 2 combined" numbers and biomass were estimated by averaging pass 1 and 2 data in this area and adding it to an estimate for the remaining geographic area. Echo sign characteristics as well as pollock length and maturity data from trawl catches led to classification of echo integration and trawl data into three strata: "transect 1" (haul 1), "east Bogoslof" (transects 2-5, hauls 2, 15, and 16) and "west Bogoslof" (transects 6-17 and 21-38, hauls 3-14). Estimates were made for pollock inside North Pacific Fisheries management area 518, which is equivalent to the "Specific Area" as it is defined in the Central Bering Sea Convention[2] and will thus be referred to as "area 518/CBS convention area". This area corresponds to "west Bogoslof" area estimates minus portions of transects 6 and 16 and excluding all of 16.5 and 17 (Fig. 1). EIT survey and biomass estimation methods are discussed in detail in Honkalehto and Williamson (1996).

Error bounds on the acoustic data were derived using the one-dimensional (1D) geostatistical approach described in Petitgas (1993) and Williamson and Traynor (1996). The 1D method requires equal spacing between transects and no fewer than 10 transects (Petitgas, pers. comm.). For this reason, transects 2-5 were treated separately from transects 6-17, 21-38. For transects 2-5 (n=4), a conservative error bound can be calculated using the sample variance of the transect cumulates - i.e. error = ± 2 sqrt(var/n)/mean. For the remaining area (west of transect 5), 95% of the total acoustic return (Sm) is contained in the region covered at 2.5 nmi spacing. We calculated the error (± 2 relative estimation error) using the 1D approach and all data from transects 7-16, 21-38 and assuming 2.5 nmi spacing. These acoustic data error bounds can be used to provide error bounds on the point estimate of biomass. These error bounds only quantify acoustic data sampling variability; other sources of error (e.g. target strength, trawl sampling) are not included. This treatment of error - though not statistically rigorous - provides a general idea of the acoustic sampling variability of the survey.

RESULTS

Pollock were observed throughout the survey area, either as dense spawning layers or aggregations or as faint layers of single fish. They dominated the 16 midwater trawl catches in both weight and numbers. Low to moderately dense pollock aggregations were distributed in the eastern portion of the survey area north of Akutan Island and along the shelf edge north of Umnak Island (Figs. 3 and 4). Most pollock (about 60% of the biomass from pass 1) were observed in extremely dense aggregations 1-10 nmi in horizontal extent and 200-400 m in vertical extent between 200-700 m in the water column in the Samalga Pass area northeast of the Islands of Four Mountains (between approximately 169° 00' - 169° 45' W long., and 52° 50'- 53° 30' N lat.). Temperature profiles in the surveyed region were similar to those from previous years in March; the water column was well-mixed with an average temperature of 3.9° C between the surface and 500 m.

Walleye pollock caught during the survey had lengths ranging from 33 to 66 cm and average lengths increased from east to west (Fig. 5). At the eastern edge of the survey area near transect 1, fish lengths from a single haul averaged 41.9 cm (males) and 44.0 cm (females). Hauls in the east Bogoslof area caught

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[2]The "specific area" is defined in the Annex to the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea as "the area south of a straight line between a point at 55° 46' N lat. and 170° W long. and a point at 54° 30' N lat., 167° W long. and between the meridian 167° W long. and the meridian 170° W long. and the north of the Aleutian Islands and straight lines between the islands connecting the following coordinates in the order listed: 52° 49.2 N 169° 40.4 W, 52° 49.8 N 169° 06.3 W, 53° 23.8 N 167° 50.1 W, 53° 18.7 N 167° 51.4 W.

pollock with average lengths of 46.8 cm (males) and 50.0 cm (females). West Bogoslof hauls caught pollock with the largest average lengths; 51.8 cm (males) and 55.4 cm (females). The sex ratio by haul ranged from 29% to 96% female and averaged 62% female.

Maturity composition data revealed differences between pollock in haul 1 and those from hauls 2-16 (Fig. 6). Among 38 females from haul 1 only 34% were pre-spawning/spawning/ post-spawning, whereas 66% were immature/developing. Conversely, females in hauls 2-16 (n=609) were >99% pre-spawning/spawning/post-spawning and < 1% immature/developing. Males in haul 1 (n=40) were less mature as well, 55% pre-spawning (none was spawning or post-spawning), and 45% immature/developing, whereas in hauls 2-16 (n=534) they were 98% pre-spawning/spawning/post-spawning and only 2% immature/developing. The mean gonadosomatic index (GSI), defined as the ratio of gonad weight to total body weight for pre-spawning females, was 0.20. However, most females from haul 1 had a much lower GSI than the average (Fig. 7). Because haul 1 fish were caught in shallower water (<400 m bottom depth), had smaller mean lengths, and were less mature than those from all other hauls, they were classified as non-Bogoslof fish and not included in the overall Bogoslof spawning biomass estimate.

Abundance and biomass estimates were generated for pass 1 east and west, pass 2 (entirely in the west area) and a combination of data from the two passes (Table 1, and Fig. 1). Using the combined estimate, the biomass of pollock for the entire Bogoslof survey area in winter 1997 was 392 thousand tons; 50 thousand tons in the east area, and 342 thousand tons in the west (Table 1). The biomass error bound for the east area was 4-96 thousand tons and for the west area was 301-383 thousand tons. Pollock totaled 337 million--57 million in the east and 280 million in the west. Inside the area 518/CBS convention area, pollock biomass was 342 thousand tons and pollock numbered 279 million. Transect 1 pollock, considered to be non-Bogoslof fish, numbered 23 million and totaled about 14 thousand tons. Pollock otoliths collected during this cruise have not yet been aged and thus estimates of age composition are not available.

Bogoslof pollock have experienced a gradual decline in abundance from their 1988 and 1989 levels of over 2 million tons (Fig. 8). In recent years the geographic distribution of the main spawning aggregations has shifted westward, from deeper basin waters near Bogoslof Island to slope waters in Samalga Pass near the Islands of Four Mountains. From 1988 through 1993, increasing average fish length indicated an aging population with little recruitment (Table 2, Fig. 9). In 1994 a relatively strong 1989 year class began to recruit to the population (Table 3, Fig. 10). In 1995, recruitment from the 1989 year class continued, and we estimated a larger biomass than in 1994--1.1 million tons--that appeared to reverse the declining trend (Honkalehto and Williamson 1996, Fig. 8). However this reversal was short-lived. Abundance declined in 1996 and again in 1997 and is currently at its lowest level yet observed--0.39 million tons.

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Table 1. Estimates of numbers, biomass and acoustic return of spawning pollock near Bogoslof Island from the 1997 echo integration-trawl survey.

Estimate	Biomass thousand tons)		Numbers (millions)	Acoustic return (Sm)[1] (1000 m^2)		Transects	Hauls
1. Pass 1							
East	50		57	425		2-5	2,15,16
West	271		221	2023		6-17	3-14
Total	321		278	2448		2-17	2-16
Area 518	270		221	2018		6-16	3-14
2. Pass 2	397		325	2970		21-38	3-14
		Biomass Error Bounds			Acoustic Error Bounds		
3. Pass 1 & 2 combined							
East	50	(4-96)	57	425	(+/-91%)	2-5	2,15,16
West	342	(301-383)	280	2560	(+/-12%)	6-17,21-38	3-14
Total	392		337	2985		2-17,21-38	2-16
Area 518	342		279	2555		6-16,21-38	3-14

[1] $Sm = \sum_{1}^{n} Sa * A_n$, where n is the number of 0.5 nmi intervals along the transect, Sa is meters^2 of pollock backscattering cross section per nmi^2 and $A_n = 0.5 * w$, where w is the width assigned to the interval and varies depending on transect spacing.

Table 2. Population at length estimates (millions of fish) from February-March echo integration-trawl surveys of spawning pollock in the Bogoslof Island area. No survey was conducted in 1990.

Length	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
10	0	0	-	0	0	0	0	<1	0	0
11	0	0	-	0	0	0	0	<1	0	0
12	0	0	-	0	0	0	0	1	0	0
13	0	0	-	0	0	0	0	<1	0	0
14	0	0	-	0	0	0	0	<1	0	0
15	0	0	-	0	0	0	0	0	0	0
16	0	0	-	0	0	0	0	0	0	0
17	0	0	-	0	0	0	0	0	0	0
18	0	0	-	0	0	0	0	0	0	0
19	0	0	-	0	0	0	0	0	0	0
20	0	0	-	0	0	0	0	0	0	0
21	0	0	-	0	0	0	0	0	0	0
22	0	0	-	<1	0	0	0	0	0	0
23	0	0	-	2	0	0	0	0	0	0
24	0	0	-	1	0	0	0	0	0	0
25	0	0	-	0	0	0	0	0	0	0
26	0	0	-	<1	0	0	0	0	0	0
27	0	0	-	0	0	0	0	0	0	0
28	0	0	-	0	0	0	0	0	0	0
29	0	0	-	0	0	0	0	0	0	0
30	0	0	-	0	0	0	0	0	0	0
31	0	0	-	0	<1	0	0	0	0	0
32	0	0	-	0	<1	0	0	0	0	0
33	0	0	-	0	<1	0	0	0	0	0
34	0	0	-	0	0	0	0	<1	<1	0
35	0	0	-	0	0	0	0	<1	0	<1
36	0	0	-	0	<1	0	0	<1	<1	<1
37	9	3	-	0	0	0	0	<1	<1	<1
38	6	0	-	2	0	1	0	1	1	<1
39	16	4	-	5	0	2	0	4	1	1
40	24	3	-	7	1	4	3	12	4	1
41	27	4	-	19	3	5	6	20	8	2
42	48	23	-	23	7	7	9	40	14	3
43	118	33	-	31	14	6	14	40	17	4
44	179	54	-	36	18	7	21	41	21	5
45	329	159	-	46	28	8	21	50	23	7
46	488	177	-	55	32	13	21	53	31	10
47	547	389	-	79	42	22	18	40	36	14
48	476	434	-	130	68	28	17	55	36	15
49	389	431	-	168	102	46	16	47	37	18
50	248	366	-	205	129	69	39	52	40	21
51	162	279	-	189	144	76	46	58	45	24
52	80	168	-	160	118	73	52	78	52	26
53	48	85	-	122	106	73	49	81	52	26

Table 2. continued.

Length	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
54	19	50	–	63	67	66	43	88	53	31
55	12	13	–	40	41	50	37	81	48	28
56	4	5	–	17	27	29	26	69	40	24
57	3	8	–	8	13	14	17	58	37	22
58	1	1	–	4	6	9	10	47	28	17
59	0	0	–	1	5	3	6	31	19	13
60	0	0	–	1	1	1	3	17	12	12
61	2	0	–	1	<1	1	2	7	6	6
62	0	0	–	<1	<1	<1	1	4	2	3
63	0	0	–	0	0	0	<1	2	1	1
64	0	0	–	0	1	<1	0	1	<1	1
65	0	0	–	<1	0	0	0	<1	<1	<1
66	0	0	–	0	0	0	0	<1	0	<1
67	0	0	–	0	0	0	0	0	0	0
68	0	0	–	0	0	0	0	1	0	0
Totals	3236	2687	–	1419	975	613	478	1081	666	337

Table 3. Bogoslof spawning pollock population estimates (millions of fish) from February-March echo integration-trawl surveys. No survey was conducted in 1990. Numbers for 1991-1995 were reanalyzed and may vary slightly from those in previous reports.

Age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997*
0	0	0	–	0	0	0	0	0	0	–
1	0	0	–	0	0	0	0	1	0	–
2	0	0	–	4	0	0	0	0	0	–
3	0	0	–	0	1	1	0	2	0	–
4	0	6	–	2	2	33	21	6	0	–
5	28	15	–	12	27	17	86	75	6	–
6	327	58	–	46	54	44	26	278	96	–
7	247	363	–	213	97	46	38	105	187	–
8	164	147	–	93	74	48	36	68	85	–
9	350	194	–	160	71	42	36	80	40	–
10	1201	91	–	44	55	28	17	53	37	–
11	288	1105	–	92	57	51	27	54	24	–
12	287	222	–	60	33	25	23	19	24	–
13	202	223	–	373	34	27	13	59	12	–
14	89	82	–	119	142	42	9	32	36	–
15	27	90	–	41	164	92	45	12	18	–
16	17	30	–	38	59	47	36	31	4	–
17	7	60	–	29	8	25	28	103	16	–
18	3	0	–	32	15	11	16	60	35	–
19	0	0	–	56	22	11	4	18	26	–
20	0	0	–	4	42	11	4	5	12	–
21	0	0	–	2	13	10	8	5	3	–
22	0	0	–	0	3	1	2	6	2	–
23	0	0	–	0	1	1	2	6	1	–
24	0	0	–	0	0	0	1	2	0	–
25	0	0	–	0	0	0	0	0	0	–
Totals	3236	2687	–	1419	975	613	478	1081	666	* not available

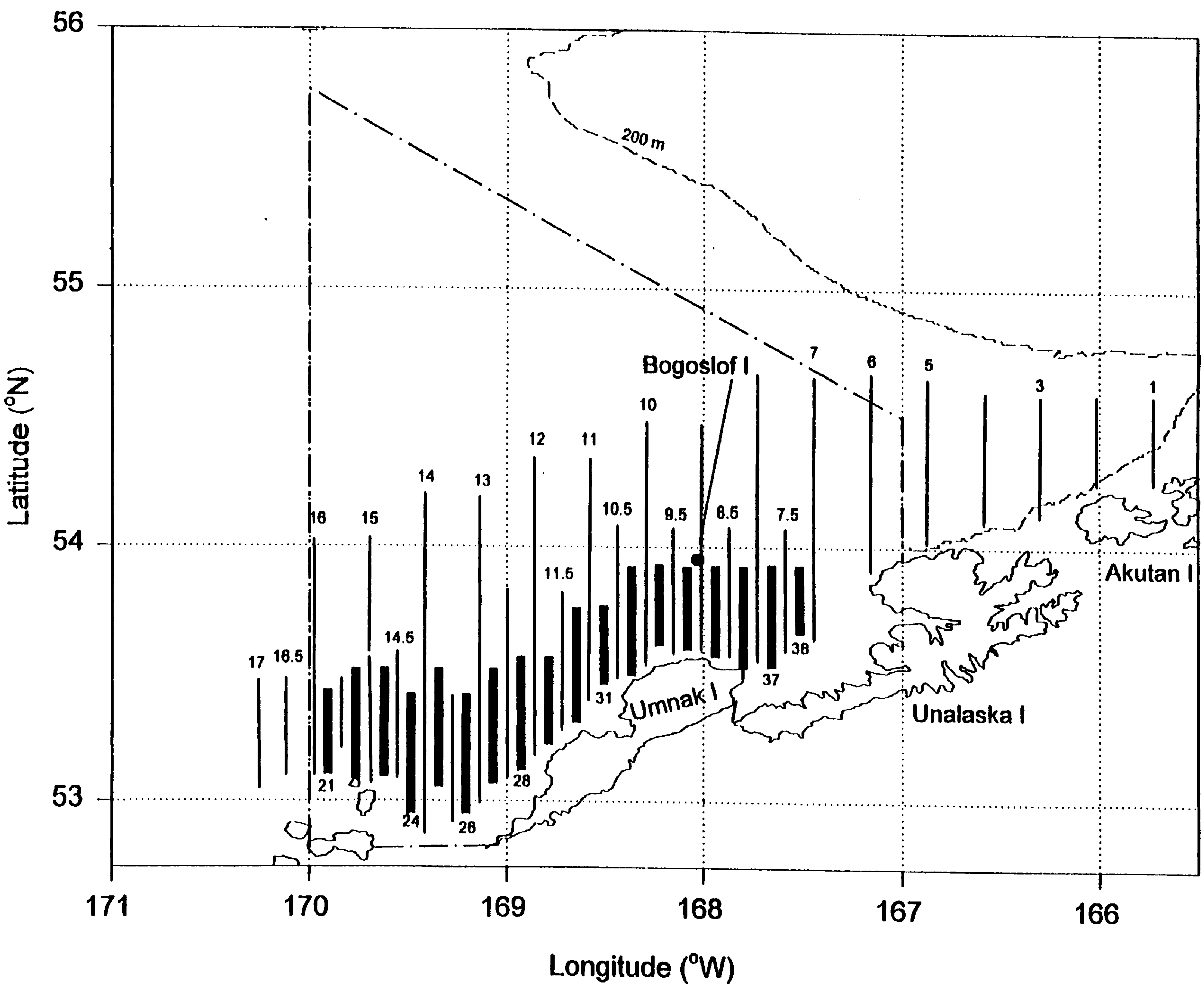

Figure 1. Echo sign sample points along north-south transects from the winter 1997 echo integration-trawl survey of the Bogoslof Island area. Thin solid lines are pass 1, thick solid lines are pass 2. Transect numbers are indicated. Dash-dotted line is boundary of U.S. fisheries management area 518/CBS convention area

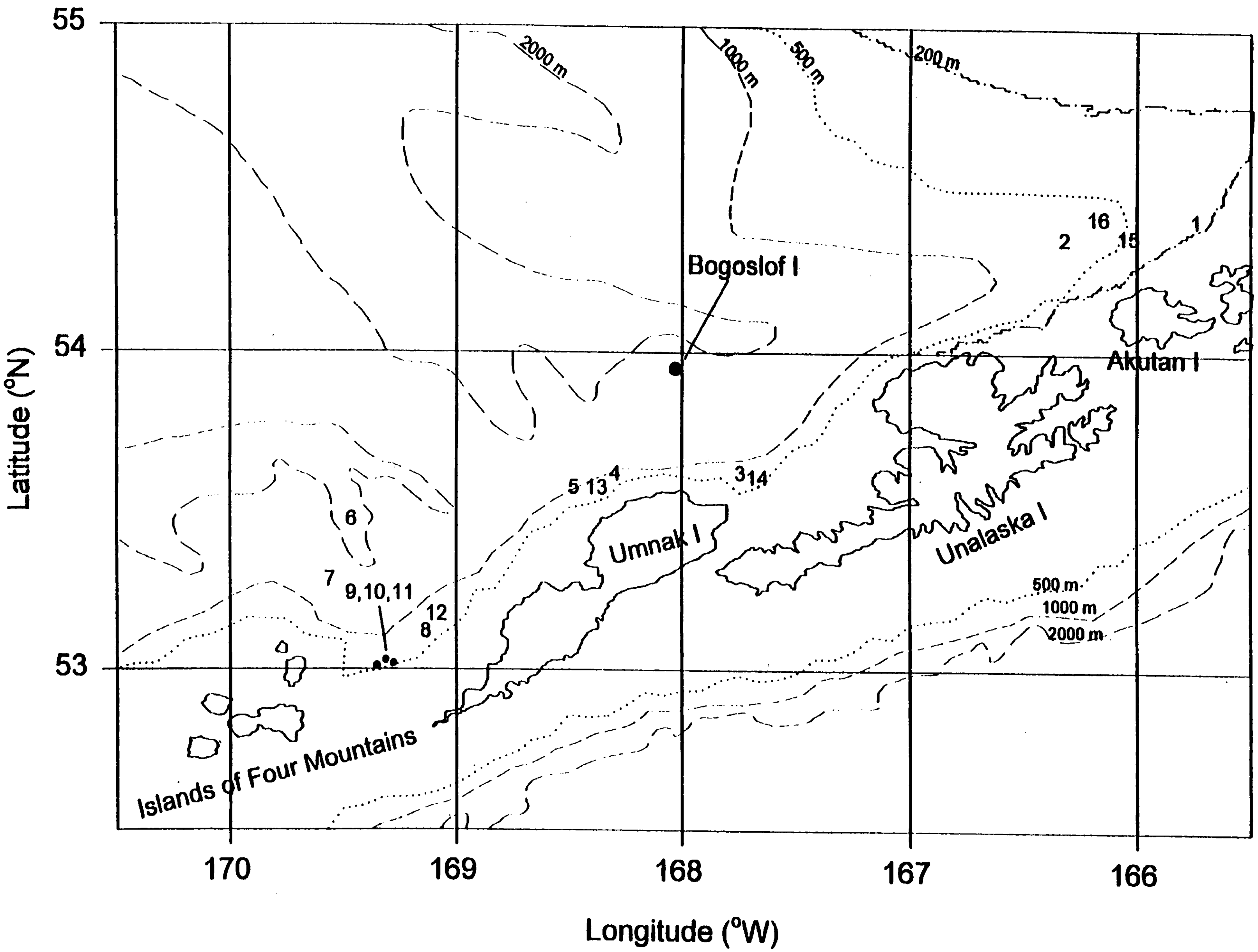

Figure 2. Haul locations (1-16) from the winter 1997 echo integration-trawl survey of the Bogoslof Island area.

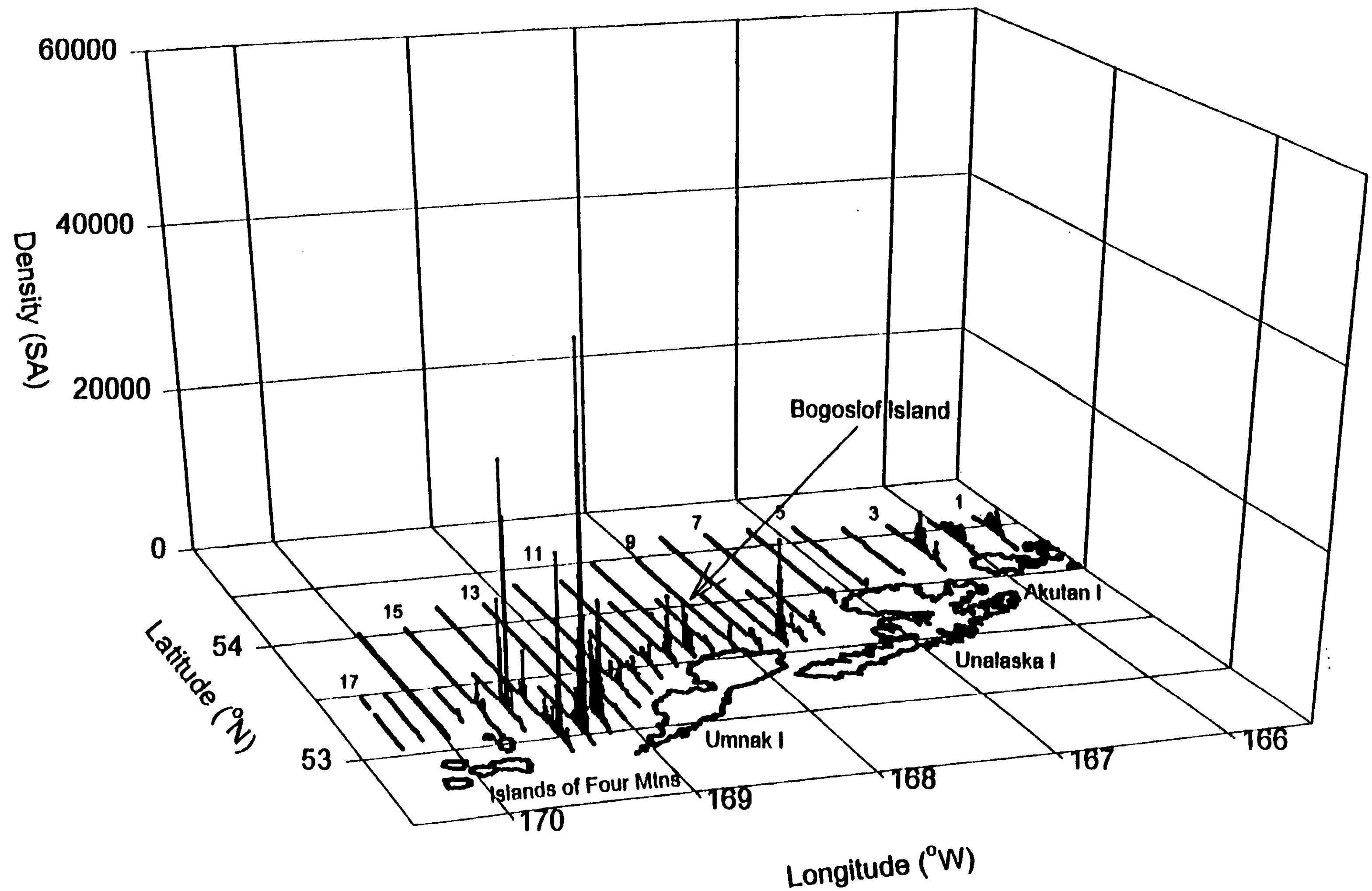

Figure 3. Relative pollock density along trackline from pass 1 of the winter 1997 echo integration-trawl survey of the Bogoslof Island area. Transect numbers are indicated.

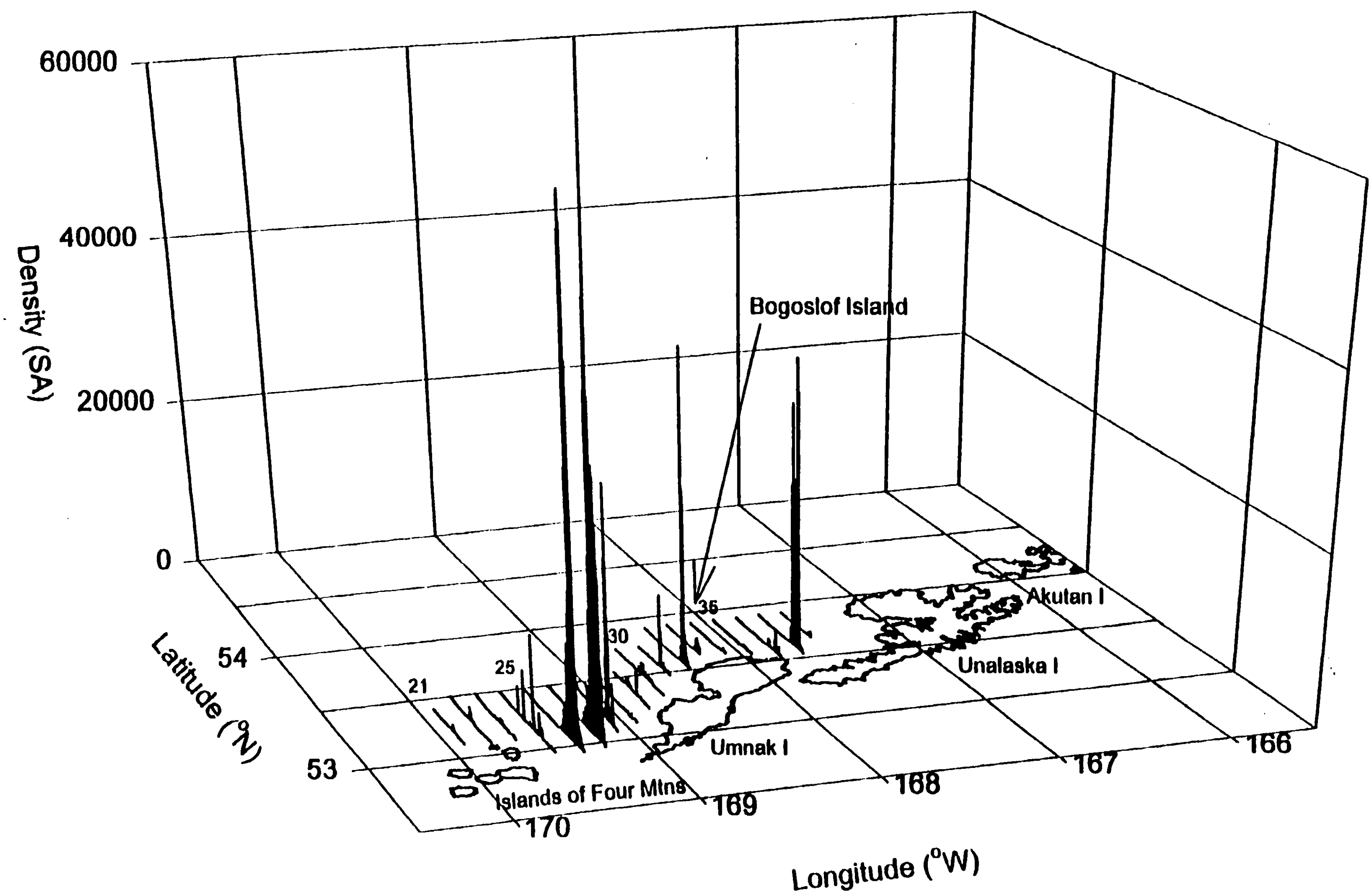

Figure 4. Relative pollock density along trackline from pass 2 of the winter 1997 echo integration-trawl survey of the Bogoslof Island area. Transect numbers are indicated.

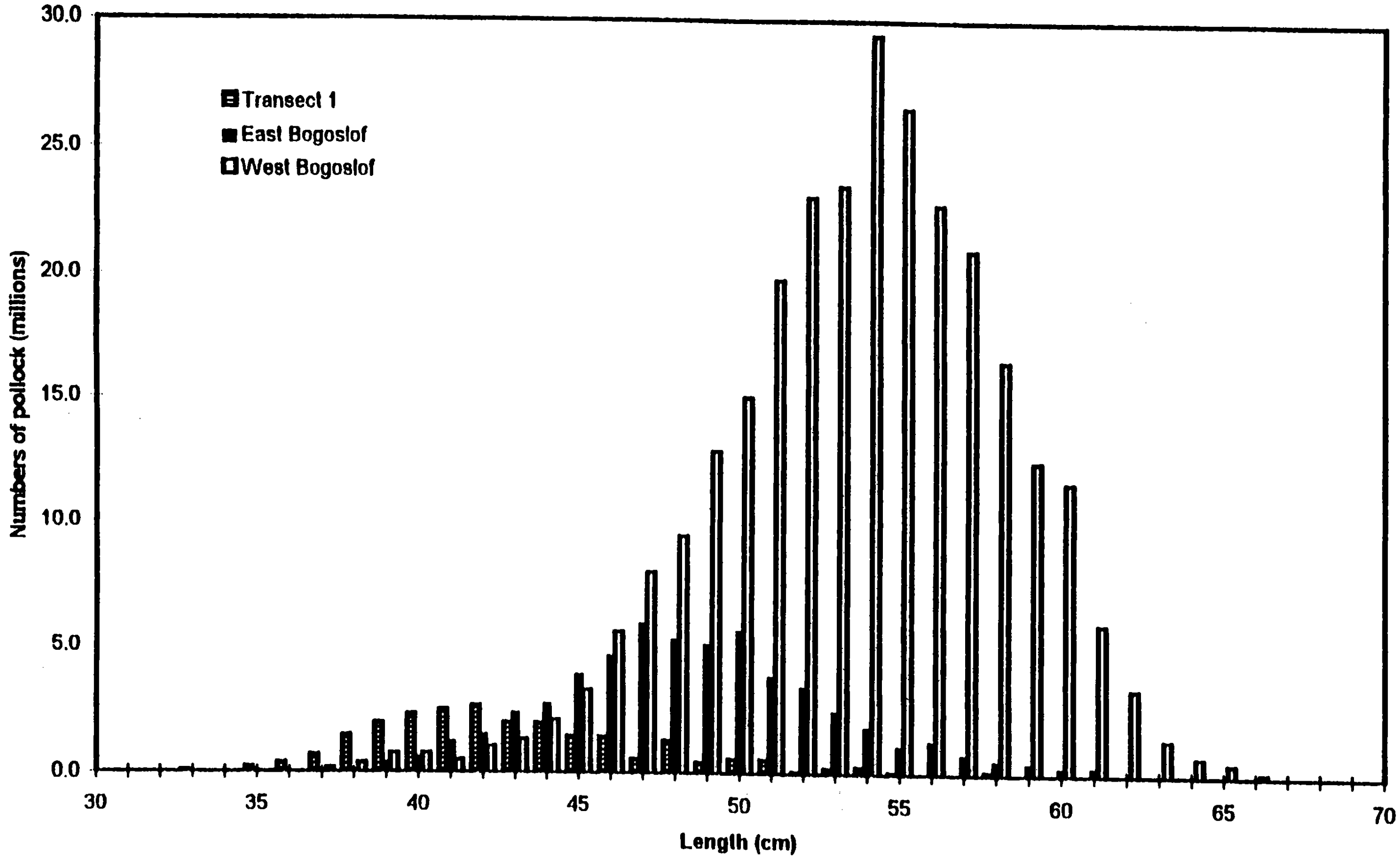

Figure. 5 Pollock numbers at length from the 1997 winter echo integration-trawl survey of the southeastern Aleutian Basin near Bogoslof Island. Transect 1 is east of 166 deg. W, outside the Bogoslof spawning area as defined here. East Bogoslof is between approximately 166 deg. W and 167 deg. W (transects 2-5); West Bogoslof is west of 167 deg. to the western boundary of the survey area (transects 6-17,21-38).

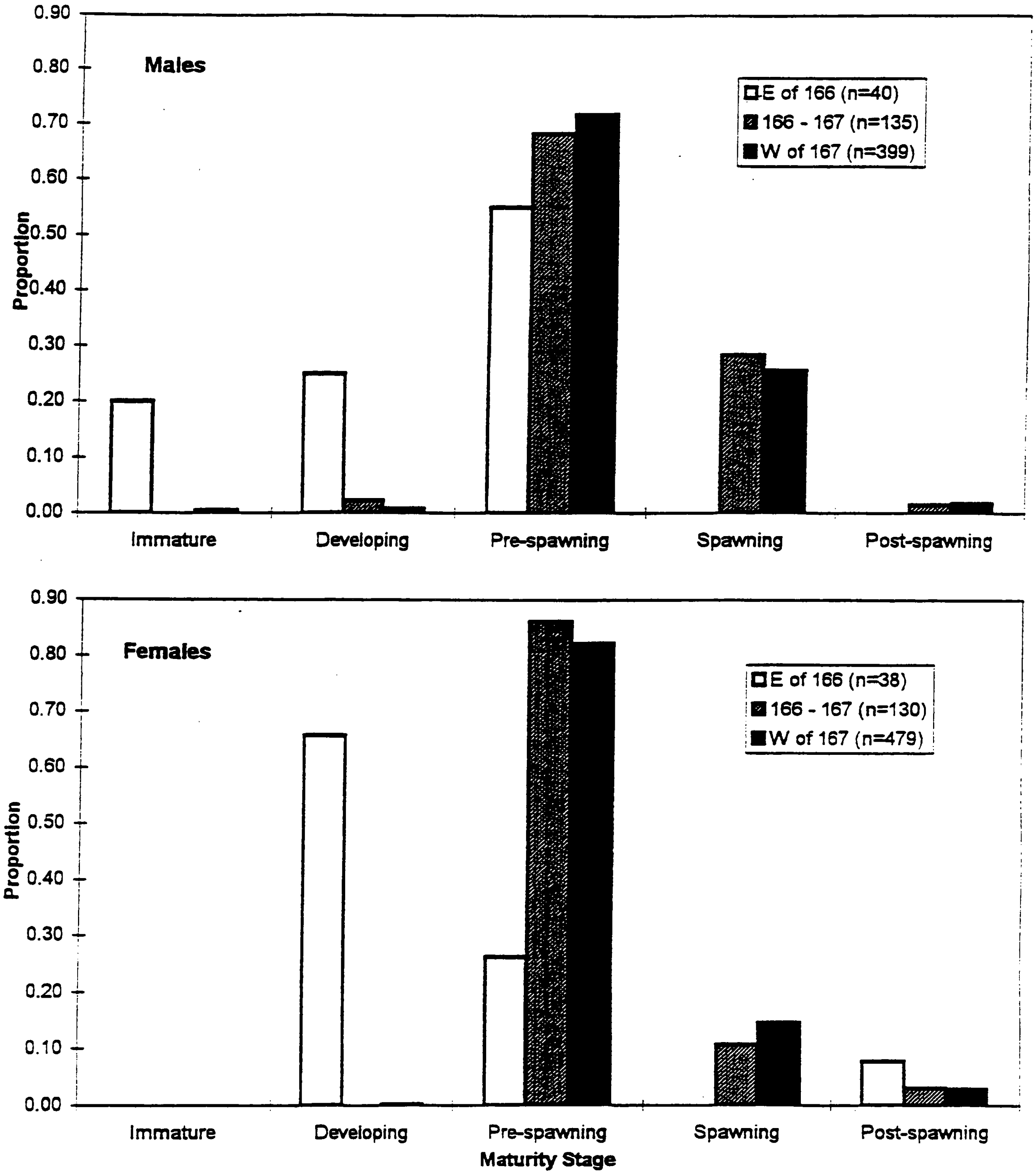

Figure 6. Maturity stages of pollock observed during the winter 1997 echo integration-trawl survey of the Bogoslof Island area. Haul 1 (E of 166° W) is contrasted with hauls 2, 15, and 16 (166 - 167° W), and hauls 3-14 (W of 167° W).

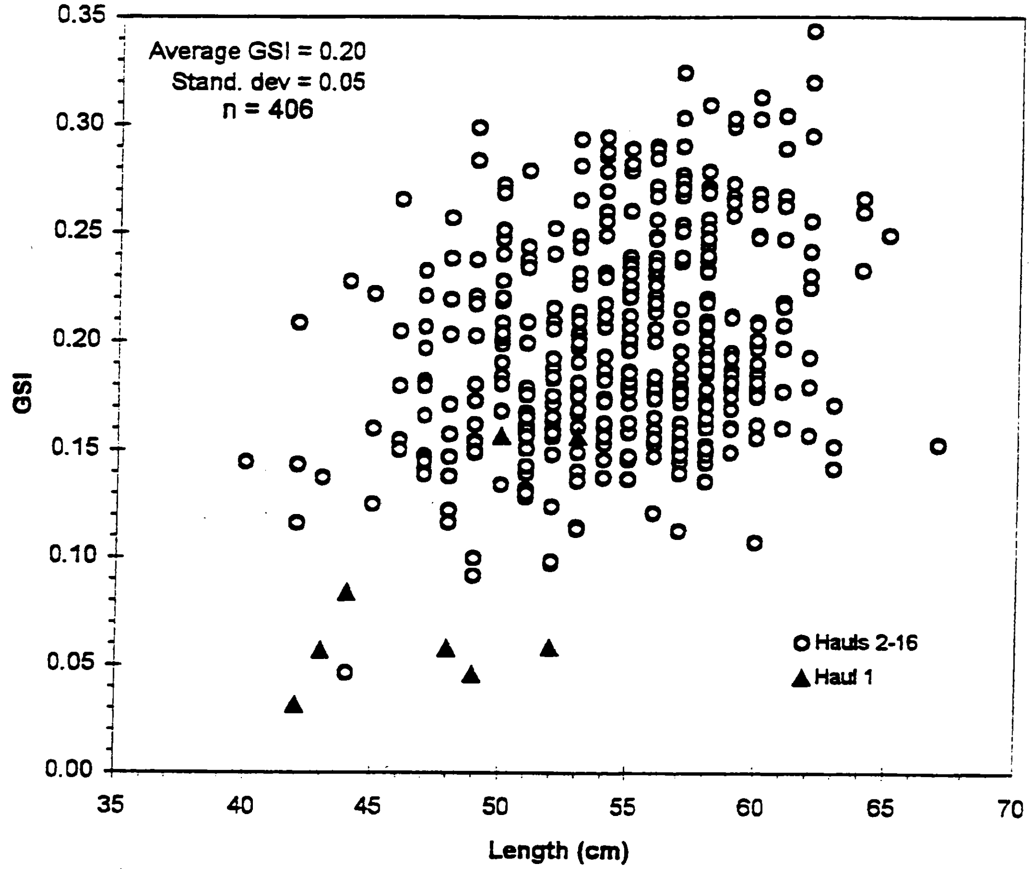

Figure 7. Pollock gonado-somatic indices for mature females plotted as a function of length from the winter 1997 echo integration-trawl survey of the Bogoslof Island area.

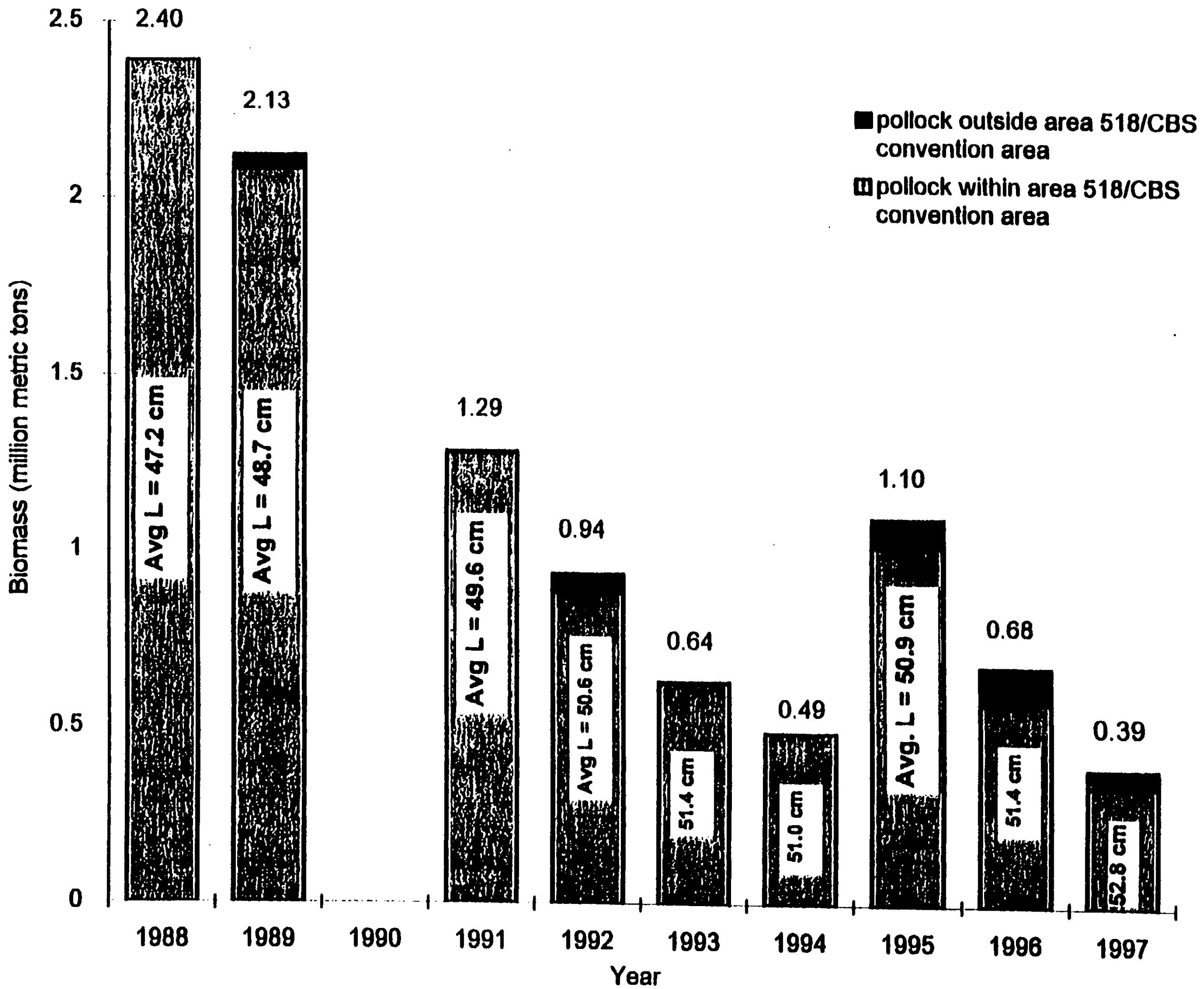

Figure 8. Biomass estimates and average fork lengths obtained during winter echo integration-trawl surveys for spawning walleye pollock near Bogoslof Island, 1988-97. There was no survey in 1990. Total pollock biomass for each survey year is indicated.

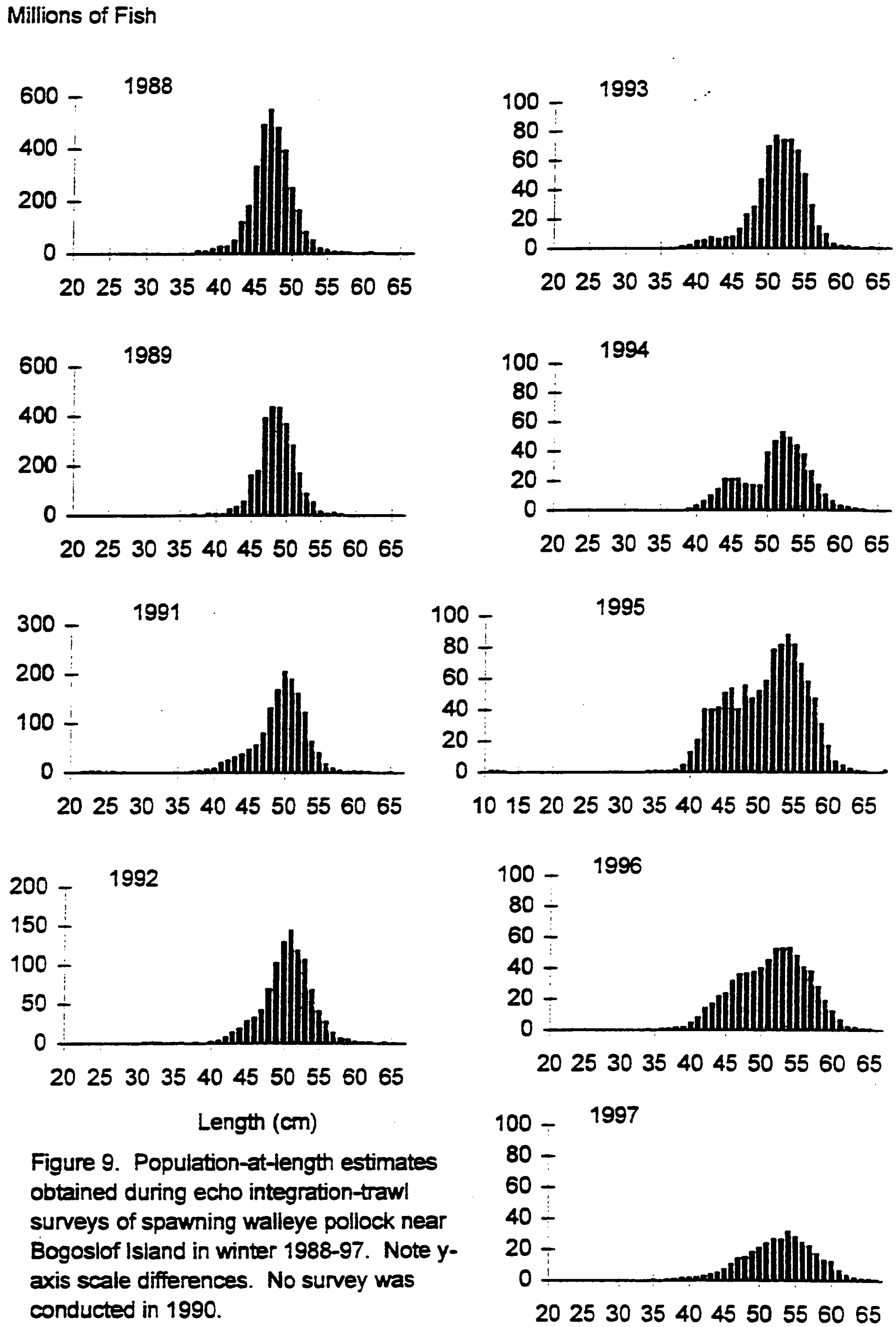

Figure 9. Population-at-length estimates obtained during echo integration-trawl surveys of spawning walleye pollock near Bogoslof Island in winter 1988-97. Note y-axis scale differences. No survey was conducted in 1990.

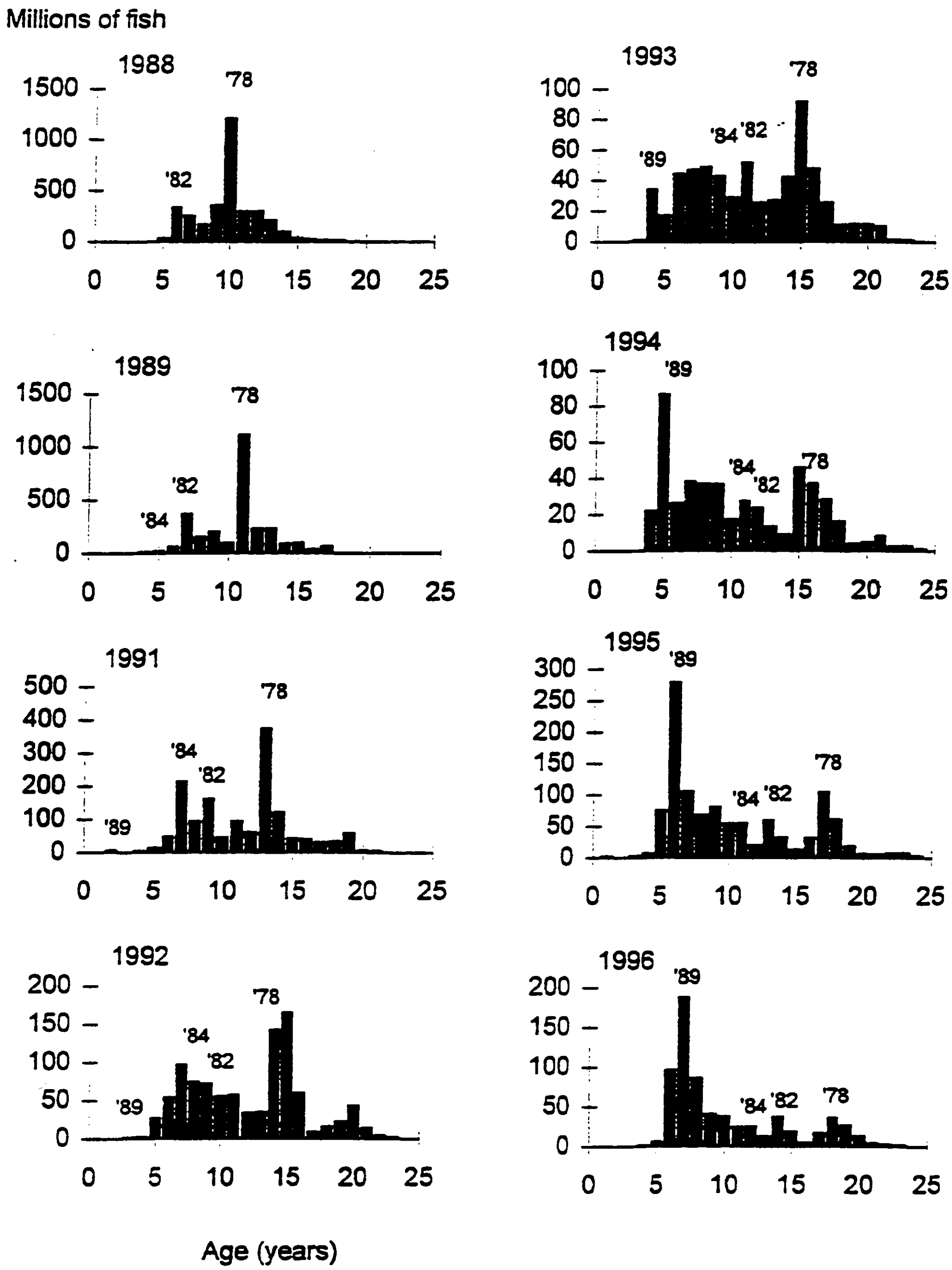

Figure 10. Population-at-age estimates obtained during echo integration-trawl surveys of spawning walleye pollock near Bogoslof Island in winter 1988-89,1991-95. Major year classes are indicated. No survey was conducted in 1990. Note y-axis scale differences.

1997*

* Age data not yet available.

1.14. Appendix C. Tables of estimates

Table 1.C.1. Estimates of numbers at age for the EBS stock under Model 1 (billions)

	Age									
Year	1	2	3	4	5	6	7	8	9	10+
78	32.65	6.25	2.72	1.95	0.92	0.24	0.11	0.11	0.11	0.45
79	72.21	13.22	3.74	1.50	0.94	0.41	0.11	0.05	0.05	0.29
80	28.11	29.29	8.17	2.33	0.77	0.41	0.16	0.04	0.02	0.16
81	30.19	11.41	18.22	5.28	1.29	0.37	0.18	0.07	0.02	0.09
82	14.50	12.26	7.17	12.47	3.30	0.75	0.21	0.10	0.04	0.07
83	50.37	5.89	7.78	5.16	8.29	2.06	0.46	0.13	0.06	0.06
84	11.91	20.47	3.74	5.63	3.51	5.37	1.33	0.30	0.08	0.08
85	31.27	4.84	13.00	2.71	3.82	2.26	3.44	0.85	0.19	0.10
86	12.05	12.71	3.07	9.35	1.85	2.51	1.41	2.16	0.54	0.17
87	7.50	4.89	8.06	2.21	6.41	1.22	1.57	0.89	1.37	0.41
88	4.98	3.05	3.11	5.85	1.55	4.39	0.81	1.05	0.59	1.12
89	9.58	2.02	1.94	2.24	3.97	1.01	2.77	0.48	0.64	1.07
90	59.36	3.89	1.28	1.40	1.52	2.56	0.63	1.63	0.29	1.05
91	27.49	24.12	2.47	0.92	0.92	0.94	1.53	0.35	0.94	0.79
92	14.62	11.17	15.31	1.76	0.60	0.57	0.54	0.79	0.18	0.89
93	20.81	5.94	7.07	10.74	1.10	0.35	0.29	0.24	0.35	0.48
94	5.60	8.46	3.77	5.05	7.06	0.68	0.20	0.15	0.12	0.43
95	6.49	2.27	5.37	2.74	3.47	4.33	0.37	0.10	0.08	0.32
96	10.94	2.64	1.45	3.92	1.91	2.21	2.52	0.20	0.06	0.24
97	37.82	4.45	1.68	1.06	2.73	1.22	1.29	1.37	0.11	0.18

Table 1.C.2. Estimates of catch-at-age of EBS pollock for Model 1.

Year	1	2	3	4	5	6	7	8	9	10+
78	89.8	314.8	612.3	591.3	314.4	84.8	36.0	34.9	31.4	109.4
79	113.4	325.1	516.7	403.4	339.4	173.0	44.4	19.7	20.5	93.9
80	34.9	571.1	908.2	513.6	228.5	145.4	54.2	14.1	6.4	42.1
81	21.7	129.5	1205.7	713.6	240.7	84.0	39.6	14.8	3.9	15.0
82	5.7	45.1	181.4	1107.3	452.0	105.6	28.0	14.9	6.7	12.0
83	15.4	16.9	154.3	362.0	902.8	231.1	50.4	15.0	8.2	9.0
84	3.9	62.1	78.3	416.2	402.1	633.5	151.4	37.1	11.4	11.6
85	13.3	22.6	332.6	181.4	373.6	311.6	453.7	111.4	35.1	22.5
86	4.9	56.8	75.2	600.7	173.7	332.5	178.3	270.1	95.0	35.3
87	2.1	15.1	136.9	99.2	422.9	114.6	141.0	78.7	172.4	61.4
88	1.3	9.2	68.2	420.7	165.7	561.8	136.4	155.3	79.9	151.8
89	2.6	6.5	45.4	172.2	452.2	137.3	497.4	76.1	92.2	159.9
90	20.4	15.8	37.8	133.4	213.6	430.3	138.5	316.4	51.7	190.8
91	9.6	92.9	78.9	91.0	127.6	187.3	402.5	88.7	240.7	212.0
92	7.4	62.3	703.0	246.6	117.1	156.9	191.1	272.3	63.5	314.9
93	7.2	22.5	222.6	1048.0	149.9	68.3	75.7	59.4	90.0	127.7
94	2.0	24.2	63.1	320.8	1057.8	157.4	56.3	39.8	29.4	82.2
95	1.9	5.1	71.0	138.2	416.9	808.5	86.2	21.4	15.0	47.6
96	3.2	6.0	19.1	198.0	230.1	413.8	583.2	43.5	10.7	35.4
97	12.5	11.5	25.4	60.9	373.8	257.3	334.8	330.7	24.5	29.9

Pollock Stock Assessment Documents

Submitted by

the Russian Party

for the

Meeting of the Science and Technical Committee

Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea

September 2 - 4, 1998

Seattle, USA

Table of contents

Documents

Assessment of the west Bering Sea pollock stock for 1999

V.K.Babayan, T.I. Bulgakova (VNIRO), P.A.Balykin, O.G.Zolotov (KamchatNIRO)

1.1 Introduction

In 1990s the west Bering Sea pollock stock is in depressive state. For 1999 the minimal TAC values were determined. Migration of pollock to the deepwater sea is not possible.

1.2 Materials

1. Age composition of catches (1970-1996)
2. Weights at age (1980-1994, 1996); for 1970-1979 their values are taken as the mean long-term values; for 1995 they equal to values for 1994.
3. Total catch (1970-1996)
4. Catches of f large-tonnage and mid-sized fleet (1970-1994)
5. Number of trawlings by year for the large-tonnage fleet (1970-1993)
6. Number of trawlings by year for the mid-sized fleet (1970-1993)
7. Shares of matured fishes by age and fishing year: data averaged over the 5-year period are given (1976-1980, 1981-1985, 1986-1990, 1991-1996).
8. Three variants of natural mortality coefficients as functions of age M(a) are considered (Fig. 1): variant I – M(a) is obtained by method of Tyurin (Balykin, 1990); variant II- assessment used for the east Bering Sea and Alaska pollock stocks (Wespestad et al., 1995); variant III- assessment of M(a) obtained as endogenious parameter RISVPA (Vasilyev & Kizner, 1997, 1998) for the given stock.

1.3 Methods

Methodology includes several successive stages which ensure detailed quantitative analysis of stock state and prospects of their commercial exploitation:

1. Quantitative analysis of state and production ability of the stock.
2. Assessment of biological reference points.
3. Forecasting of biologically allowable withdrawal.

The following methods were used for calculations:

- VPA with tuning and complex of diagnostic procedures used by ICES Working Groups (Darby & Flatman, 1994);
- RISVPA (Resistant instantaneous separable VPA) (Kizner & Vasilyev, 1997, 1998). The method allows to obtain M(a) assessment on the basis only of the data on age composition of the catches;
- Y/R and SSB/R analysis;
- Dependence "stock-recruitment" R(SSB) by Ricker (takes into account cannibalism as one of the factors of density regulation of pollock abundance);
- Dynamic production model DPM (Babayan & Kizner, 1988).

At the second stage the keying values of stock biomass and fishing mortality were assessed, which might be used for TAC assessment as biological reference points. Along with traditional reference points such as F_{MSY}, B_{MSY}, F_{max}, B_{max}, $F_{0.1}$, $B_{0.1}$, F_{med}, $F_{40\%}$ the points of B_{crush} and B_{loss} were also found.

Selection of the obtained reference points from the point of view of their possible use in the procedures of TAC assessment for the given pollock stock was carried out by the method of risk-analysis under requirement of ensuring the rather high biological safety of the stock at the given degree of uncertainty. F_{max} is chosen as limiting biological reference point. For each F value considered as potential target reference point (TRP) the possibility of risk was calculated, i.e. possibility of exceeding the F_{max} value due to the possible error in estimation of F(5-7). The standard error of estimation of F-coefficient for risk-analysis was taken from the results of diagnosis of VPA tuning for age groups which were the most representative in catches (5-7). By this, we suppose that error is distributed according to lognormal law.

At the third stage the multi-optional TAC assessment was conducted both by the traditional methodology (use of the constant criterion of management in the whole forecasted layer) and scheme of precautionary approach (ICES. 1997. 1998). In last case the assessment of recommended fishery intensity was calculated according to the ratio between current B. minimally acceptable. B_{lim}, and target biomass. B_{tg}, of spawning stock. According to this scheme the recommended value of F(5-7) F_{rec} is calculated as follows:

$F_{rec} = 0$ for $B <= B_{lim}$

$$F_{rec} = \frac{F_{tg} (B - B_{lim})}{B_{tg} - B_{lim}} \quad \text{for } B_{lim} < B < B_{tg}$$

$F_{rec} = F_{tg}$ for $B >= B_{tg}$

1.4 Quantitative analysis of stock state.

The lacking values of the abundance index (CPUE) for 1994-1996 were extrapolated with the use of the exponential smoothing method. Dynamics of the index demonstrates the stable state of the stock with the slight decrease in its level during the last years.

Retrospective assessments of the stock were obtained by the VPA method with Loreck-Shepherd tuning procedure. For these calculations the instantaneous natural mortality rates at age were taken as correspondent to variant III (Fig. 1). VPA tuning was carried out using standardized fishing effort for 1979-1996 . The results of retrospective calculations for the 1970-1996 period are given in Fig.2

1.5 Assessment of biological reference points.

Production features of the stock were examined with the use of the Y/R and SSB/R analysis.

VPA-based recruitment assessments (year-class abundance at age 4) and corresponding SSB values allowed to estimate reference points F_{high}, F_{low}, and F_{med} and plot the Ricker's relationship R(SSB) (Fig. 3)). In its turn, this relationship was used for estimation of candidate LRPs by F and spawning biomass. The obtained reference points are given in Table 1.

F_{max}=1.1 was chosen as the final LRP, and $F_{40\%}$=0.5 as TRP (note that the latter is close to F_{med}=0.48).

Because for the given stock the error of F estimation was very high, the possibility of exceeding the LRP level for the most of the reference points was also high, in particular for $F_{40\%}$ it was about 30% (Table 2).

To use the precautionary approach for TAC assessment the target spawning stock biomass was also estimated, B_{tg}=350,000 tons, (see

Table 2), and LRP by spawning stock biomass was set as equal to its minimal level, which get broken not more than 10% of cases over the whole period of observations, namely B_{lim}=100,000 tons (see Fig. 3).

1.6 Forecasting of allowable fishery withdrawal.

Six scenarios of forecasts for two levels of recruitment (mean long-term for 1970-1994 and 10% from the mean long-term recruitment) and three management strategies are performed:

- fishing intensity for 1997 is assumed to be F_{tg} =0.5 while for 1998, 1999 and 2000 it is calculated by the scheme of the precautionary approach;
- for the whole forecasted period the recommended fishing intensity is equal to fishing mortality in 1996;
- fishing intensity for 1997 and 1998 is chosen to adapt to the TAC figures already accepted (120,000 and 150,000 tons, respectively), whereas for 1999 and 2000 it is calculated by precautionary approach. Alternatives are put together in Table 2.

1.7 Conclusions

Model analysis of all the fishing data available from the stocks of west Bering Sea pollock west of 174 E made it possible to track down some trends in stock dynamics, though in most cases numerical values proved to be insufficiently reliable because of the absence or very inferior quality of the basic information in recent years.

According to the results obtained there was a virtually linear stock rise between 1970 and 1980 which ended in a short stabilization at a relatively high level; this was followed by a sharp decline which somewhat slowed down by 1995. The radical change towards the

Table 3 . Prediction of stock sizes and TAC , 1000 t

Weight-at-age and maturity rate are averaged for 1987-1997

Spawning stock - at time of spawning

Recruitment R(1) =3*10^9 averaged for 1970-1994

Recruitment R(1) =3*10^8 - 10% of averaged one for 1970 -1994

F(5-7)=F40% - 0.5 for 1997, later precautionary approach

	Year 1997	1998	1999	2000
TSB	1294	1098	1130	1175
FSB(4+)	874	535	576	620
SSB	576	392	339	351
Catch	308	190	180	215
F(5-7)	0.5	0.5	0.48*	0.5

	Year 1997	1998	1999	2000
TSB	1146	795	632	479
FSB(4+)	874	535	576	424
SSB	576	392	319	295
Catch	308	185	152	127
F(5-7)	0.5	0.5	0.44*	0.39*

F(5-7)=Fstq=0.11 for all years

	Year 1997	1998	1999	2000
TSB	1294	1322	1486	1458
FSB(4+)	874	752	925	1060
SSB	576	563	610	690
Catch	83	68	78	95

	Year 1997	1998	1999	2000
TSB	1146	1018	980	888
FSB(4+)	874	752	925	832
SSB	576	563	590	620
Catch	83	67	73	78

Catch for 1997 and 1998 is equil to adapted TAC, later precautionary approach

	Year 1997	1998	1999	2000
TSB	1294	1284	1355	1300
FSB(4+)	874	715	797	746
SSB	576	533	510	450
Catch	120	150	257	256
F(5-7)	0.168	0.28	0.5	0.5

	Year 1997	1998	1999	2000
TSB	1146	980	850	587
FSB(4+)	874	715	795	530
SSB	576	533	488	383
Catch	120	150	240	190
F(5-7)	0.168	0.285	0.5	0.5

Natural mortality as function of age, M(a):
I - from Balykin,1995; II -from Wespestad,1995; III-obtained by RISVPA

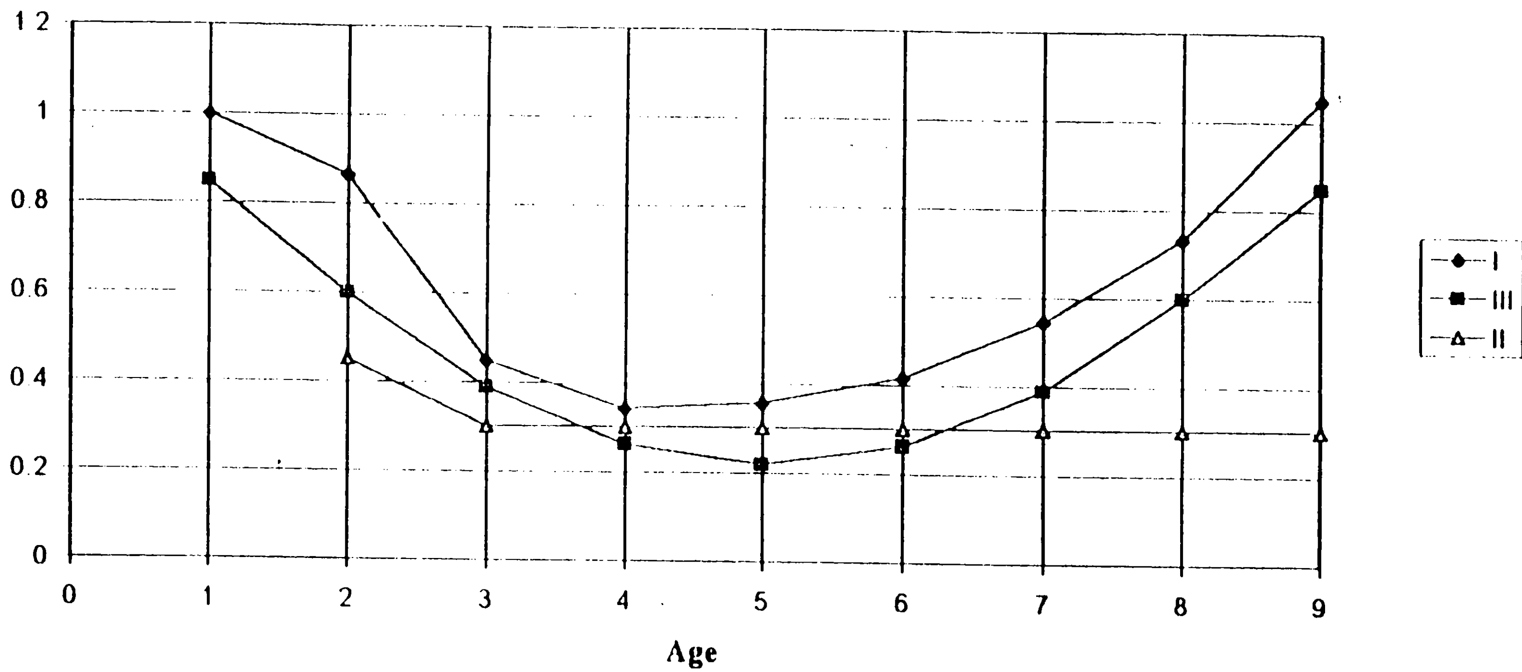

FIG.1

Dynamics of fishing stock biomass, FSB, spawning stock biomass, SSB, catch and F(5-7)

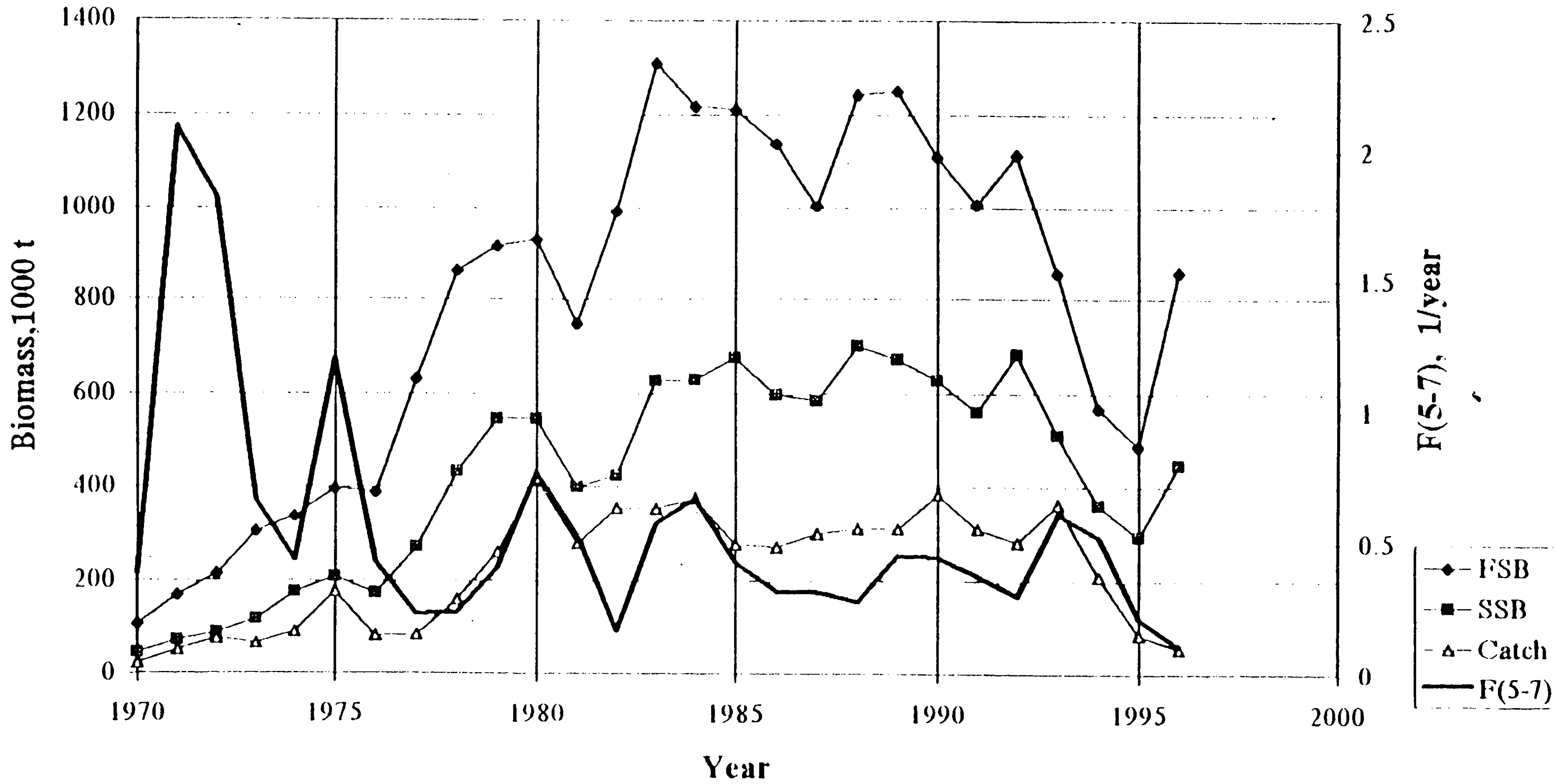

FIG. 2

Recruitment of age group 4 as function of SSB (Ricker model)
R(4)=2.9*SSB*EXP(-0.00126*SSB)

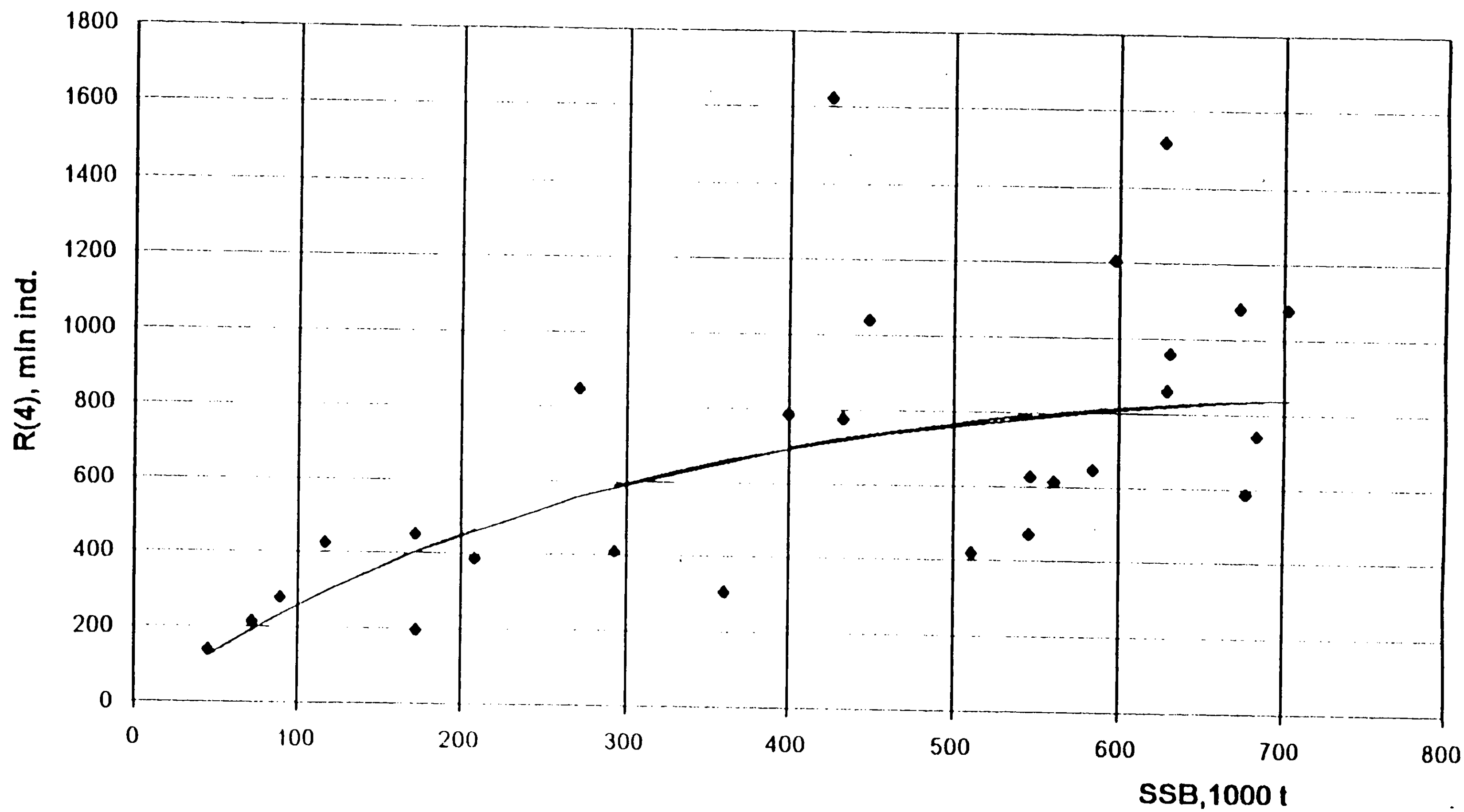

FIG 3

2. Stock assessment of Navarin pollock for 1999

L.A. Borets, V.I. Radchenko, A.V. Smirnov (TINRO-center),
P.A. Balykin, A.I. Varkentin (KamchatNIRO),V.K. Babayan,
A.I. Glubokov, V.V. Kuznetsov, B.N. Kotenev (VNIRO)

2.1 Introduction

Structure and status of Navarin pollock stock of the Bering Sea were analyzed retrospectively in 1997 - 1998 (176° E - USA/Russian convention line). Unlike the western Bering Sea pollock this stock was marked by stable reproduction in the 1990-s.

The 1997 survey results data were used to assess stock biomass at 1.6-2.8 million tons.

The AHL for 1998 was estimated at 730 thousand tons, for 1999 - 840 thousand tons; catch in that area by August 23, 1998 was 356000 tons.

In order to limit by catch of juveniles trawls of 100 - 110 mm mesh size were permitted for large tonnage vessels in the area beginning from 1998.

In 1999 departure of pollock from this area to the deepwater Aleutian basin is not expected.

2.2 Navarin pollock stock

Since the structure of Bering Sea pollock stock has not been filly determined (Wespestad et. al., 1997), experts of TINRO-center, KamchatNIRO and VNIRO made in 1996 - 1998 a retrospective analysis of the data for 1971 - 1997 regarding the distribution and quantity of ichthyoplankton (eggs, larvae), fish of the year and mature pollock

(Figures 1-12) which indicated the existence of an independent stock in the area with its own center of spawning, feeding of larvae, fish of the year and juveniles (Fig.6) which have little association with centers of spawning, feeding of larval and fish of the year of both west and east Bering Sea pollock (Pollock in the Navarin-Anadyr Bering Sea ecosystem, to be published).

The data from the egg survey made in late July, 1996 (Fig.1-3) revealed notable concentrations of larval pollock on Navarin and South Anadyr Bay shelf (Smirnov, Ivanov, being published). The authors detected mostly their subsurface distribution which lowers their potential intensive transport by current. Hence, the smallest catches of larvae were typical of the subsurface layer (1.7 ind. per 10 minutes' haul at stations where larvae were available). Their occurrence there was 28 percent. Over the pycnocline layer (5 - 35 mm) average catches went up to 7/2 ind., occurrence was up to 41 percent. The largest catches were recorded under the layer of pycnocline (12 - 72 m: usually 20 - 40 m). The average catch was 23/1 ind., occurrence 59 percent. As is known, the speed of currents diminishes essentially with depth (Khen, 1989), and it is less by one order of magnitude in the layer of larval concentrations under the pycnocline. As should have been expected, the maximum catches of larval were recorded in the zone of Navarin anticyclonic.

The size composition of larvae in the above collections assumed their local origin or, at least, transport after hatching to quite limited distance (Smirnov, Ivanov, to be published). In late July their length had one pronounced peak within 10 - 14 mm; however, the largest individuals of 30 mm and longer occurred, as separate instances, over depths of 100 - 200 m in the south-eastern part of the survey. Reverse calculation of timing of larval hatching made for the modal group of 10 -

12 mm at their average growth rate of 0.28 - 0.34 mm a day (limits of 0.19 to 0.43 mm a day by Kendall et. al., 1987; Balykin, Bonk, 1987) showed that their age was approximately 35 - 45 days (55 - 56 days after hatching). This agrees with the data on the average size of two month old larval: 14.4 mm in the western Bering Sea and 23 mm in the Gulf of Alaska (Shuntov et. al., 1993). Hence, these larval are progeny of the population or spawning group of pollock whose spawning peak was in May.

If it is assumed that they drift to Navarin region from the eastern Bering Sea, there could not be a transport from the place of hatching to over 280 miles even if the developing eggs get to the western slope periphery of the Central Bering Sea where the carrying speed of water is about 10 cm/sec (Kotenev, 1995). However, the relative number of such larvae was not great in 1996 (0-15%).

About 2 billion individuals of pollock of the year were recorded in autumn of 1986 in Navarin area (Sobolevsky et. at., 1991). In 1996 it was only 58.3 million individuals, as is shown by the data collected by A. Savin from SRTM "Shursha". These data are comparable to the larval abundance stock estimates obtained: they indicate lack of mass transport of eggs and larvae from the U. S. EEZ in 1996. The calculated abundance of larvae in the area surveyed was $4.26 \times 10^{11} \pm 2 \times 10^{11}$ (Smirnov, Ivanov, in press). This value is, of course, only for general reference because of the limited area of survey, and imperfect technique of collecting; still it is quite essential. On the contrary, as N.S. Fadeev (1990) points out, the share of eggs and larvae in 1983 - 1988 collections that are recorded in the north-western Bering Sea happened to be extremely low. The overwhelming amount of both eggs and larvae (90-95 %) was aggregated in the south-eastern part of the sea. Despite the much higher spawning biomass of pollock in the Bering Sea in the 1980-s, the average abundance of larval suggested for Navarin area was 1.26 x 10^{11} (Fadeev, 1990), i.e. two to five times less than by the 1996 data. Apparently the pattern of spatial distribution of pollock larvae in the Bering Sea in the 1990-s changed considerably in accordance with the spawning intensity variations at various cores of spawning.

The data presented confirm V.M. Radchenko's view (in press) that conditions for spawning of the Navarin spawning stock fish improved significantly as compared to the 1970-s and 1980-s which contributes to the emergence of strong year-classes there.

The annual catch of all species of fish during the trawl survey of the area in September 1997 from R/V "Shursha" was 2.2 tons per one hour of which 85.6 % was pollock.

Its maximum concentrations were in the waters of Navarin current: 3.57 tons per one hour haul. As compared to the 1996 survey average catches of pollock went up from 1.06 to 1.89 tons an hour.

The largest pollock concentrated in the zone of distribution of colder and freshened water mass of the Anadyr Bay. The share of fish over 50 cm made up 83.1 % of the abundance.

The length of adult pollock in catches there varied from 48 to 83 cm, the average being 62.5 cm. As is known, the spawning season in large pollock inhabiting the near-bottom layers on the shelf is extended. Hence, in September 1997 fluid gonades were found in 8.8 % of mature pollock examined, spawned gonades in 8.7 %. The largest share of small-sized pollock of 13 - 17 cm (82.1 %) was typical of frontal zone concentrations.

The near-bottom pollock biomass recorded among the bottom concentrations off Navarin and in Anadyr Bay, as calculated using Map

In 1996 the areas of big catches of pollock were more vast; in 1997 they were more localized, though with greater catches (i.e. greater densities).

Hydroacoustic surveys show that in 1996 pelagic biomass was greater that in 1997. This difference is related to the high abundance of the strong year class of 1995 most of which had apparently moved in 1997 to the near-bottom layer. As was noted, this was confirmed by the increasing density of near-bottom concentrations in 1997.

Bottom trawl and hydroacoustic surveys of 1997 showed that the biomass of pollock was 1.3 million tons at 1.0 trawl catchability coefficient, and 2.3 - 2.8 million tons at 0.4 - 0.5. The stock was assessed by R/V Shurma data at 1.6 million tons (TINRO-center).

It is difficult to assess the share of migrating pollock today. However, as it was noted the use of various fishing gears in the Navarin-Anadyr region (long-line on the shelf and slope; trawls and bottom net on the outer shelf and upper slope (200 - 300 m) showed that given the same age fish in differing ecological biotopes differ greately by growth rate and weight (Table 1); their morphometric and weight characteristics are also different among various subareas of the Anadyr-Navarin ecosystem (Figs. 13-14,Table 2-3).

These data point to the great sedentary feature in pollock of Navarin area. Most likely this is associated with the high bioproduction of water and biotope diversity governed both by the relief of bottom and by the presence of currents of various vectors, large number of water masses and separating fronts. It is known for long that this bioproductive region is the area of feeding for sea birds and mammls.

In 1996 - 1997 approaches of Navarin pollock to the deepwater Aleutian Basin were recorded. A similar situation is being observed in 1998.

Given the present status of the major stocks of pollock in the Bering Sea (eastern and western) no considerable arrivals of fish from these areas to Navarin area are expected. Therefore Navarin pollock will not migrate to the deepwater Aleutian Basin which means that its contribution to the fishery situation in the Central Bering Sea will be zero.

2.3 Assessment of Navarin pollock TAC for 1999.

In the absence of the necessary data for traditional mathematical stock assessment techniques TAC is determined by simplified semi-empiric procedure based on the idea of the amount of optimal fishery withdrawal. In application to pollock, namely to stock which is in the stable state (i.e. able to recover its production ability to MSY level under decrease in fishing pressure), a share of recommended withdrawal is 30%. Deterioration in stock state will require a corresponding decrease in this share. Non-dimensional share of fishery withdrawal is called exploitation coefficient (E) and is measured as ratio between biomass of annual catch (C) and biomass of fishery stock in the beginning of the year (B):

$$E=C:B \qquad (1)$$

Total allowable catch of Navarin pollock in the year i is calculated according to expression (1) under the given Ereci which is determined by analysis of stock state:

$$TAC_i < Ereci\ B_i^{RF} \qquad (2) \quad ,$$

where RF index corresponds to stock and TAC values in the Russian EEZ.

Now along with the opinion given in Section 2.2 (hypothesis I) there is a supposition that commercial concentrations in the Navarin area are formed due to the eastern Bering Sea pollock stock (hypothesis II).

Expression (2) may be used for calculation of Navarin pollock TAC in case of acceptance of hypothesis I. When using the hypothesis II, the expression will be as follows:

$$TAC_i < Ereci\,(B_i^{US} + B_i^{RF}) - TAC_i^{US} \qquad (3),$$

where US index corresponds to stock and TAC values in the United States EEZ.

It is obvious that inequality (3) is true only in case the population identity of the Navarin and eastern Bering Sea pollock stocks is proved, and their state is recognized as being the same. By now the available data do not allow to confirm simply the first mentioned condition and the solution of the second task is extremely difficult because of the different degree of study on these two stocks and a lack of coordinated methodology for assessment and comparison of parameters characterizing their state.

Proceeding from the above, we will accept that at the present level of knowledge about population structure and dynamics of pollock complex of the Bering Sea it is reasonable to consider the Navarin stock as conditionally isolated stock for fishery management purposes.

According to the data of Russian scientists, the abundance of year-classes which will be the basis of the Navarin pollock catches in 1999-2000, is higher than its mean long-term value. By this, year-class of 1996 is the strongest over the last decade. Thus, for the nearest future stock state does not excite apprehension and may be characterized as stable, and the exploitation coefficient for 1999 is chosen as 0.3.

The assessment of fishery stock biomass by the beginning of 1999, based on the analysis of all available results of investigations over the last 3 years, is equal to 2.8 mln tons (VNIRO).

Thus (see expression 2), TAC for 1999 may be recommended as being within 840,000 tons.

This TAC will be changed on results of surveys and catch of 1998, because it is more on 90,000 and 160,000 ton , catches of 1996 (753,000 ton), 1997 (680,000 ton) and possible catch of 1998 (730,000 ton.).

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Table 1

Dependence of size and weight of pollock on age for different fishing gears and different biotops (July-September 1997)

Age, years	Trawl		Danish seine		Bottom nets		Bottom long-line	
	Size, Cm	Weight, kg	Size, Cm	Weight, kg	Size, Cm	Weight, kg	Size, Cm	Weight, kg
2+	33,8	0,209						
3+	35,8	0,312						
4+	40,9	0,455	44,9	0,65	44,0	0,45	43,7	0,543
5+	46,3	0,668	47,6	0,772	47,3	0,67	46,0	0,778
6−	49,3	0,811	51,5	0,959	49,6	0,78	52,9	0,973
7−	52,4	1,015	54,3	1,123	51,7	0,91	57,8	1,318
8−	55,7	1,269	57,5	1,405	53,7	0,98	60,5	1,44
9−	61,2	1,695	61,3	1,539	57,7	1,33	64,4	1,958
10−	62,4	1,904	66,3	2,133	60,8	1,41	67,7	2,053
11−	64,4	1,95	67,0	1,99	62,1	1,46	70,5	2,218
12+			70,0	2,1	65,7	1,66	71,7	2,413
13−							72,1	2,58
>14−							74,0	2,53
<16−							78,0	2,68

Table 2. Morphometry of pollock in the Navarin area of the Bering Sea in June- July, 1997.

Sub-region	Sex	L,cm	aD,%	aA,%	h1D,%	O1D,%	3D	No. inds.
I	females	53.57	28.95 ± 0.10	42.11 ± 0.13	14.40 ± 0.07	69.48 ± 0.08	18.74 ± 0.11	97
	males	49.70	28.55 ± 0.09	41.17 ± 0.12	14.73 ± 0.09	69.58 ± 0.09	18.79 ± 0.12	82
	average	51.80	28.77 ± 0.07	41.68 ± 0.10	14.55 ± 0.06	69.52 ± 0.06	18.76 ± 0.08	179
II	females	52.36	28.97 ± 0.09	42.72 ± 0.13	14.17 ± 0.08	70.15 ± 0.10	18.81 ± 0.14	91
	males	50.36	28.62 ± 0.11	41.46 ± 0.13	14.85 ± 0.10	70.00 ± 0.09	19.14 ± 0.13	87
	average	51.38	28.80 ± 0.07	42.11 ± 0.10	14.50 ± 0.07	70.08 ± 0.07	18.97 ± 0.09	178
III	females	49.40	29.02 ± 0.09	42.00 ± 0.12	14.40 ± 0.08	69.65 ± 0.10	18.92 ± 0.11	84
	males	49.00	28.69 ± 0.09	41.19 ± 0.12	14.70 ± 0.08	69.76 ± 0.08	18.74 ± 0.11	96
	average	49.19	28.84 ± 0.06	41.57 ± 0.09	14.56 ± 0.06	69.71 ± 0.06	18.82 ± 0.08	180
IV	females	51.54	29.22 ± 0.09	42.72 ± 0.13	14.32 ± 0.08	69.94 ± 0.13	18.72 ± 0.13	82
	males	51.23	28.76 ± 0.10	41.42 ± 0.12	14.69 ± 0.08	70.08 ± 0.09	18.56 ± 0.12	97
	average	51.37	28.97 ± 0.07	42.02 ± 0.10	14.52 ± 0.06	70.01 ± 0.08	18.63 ± 0.09	179
V	females	53.88	28.80 ± 0.09	42.11 ± 0.15	14.24 ± 0.12	69.94 ± 0.12	18.94 ± 0.13	48
	males	53.65	28.56 ± 0.10	41.08 ± 0.10	15.10 ± 0.09	70.05 ± 0.10	18.59 ± 0.12	73
	average	53.75	28.65 ± 0.07	41.49 ± 0.11	14.76 ± 0.08	70.00 ± 0.08	18.73 ± 0.09	121

Table 3. Some biological parameters of pollock in the Navarin region of the Bering Sea in June-August, 1997.

Parameter	Subregion				
	I	II	III	IV	V
Size, cm	51.6±0.4 34.0-63.0	51.8±0.4 39.0-65.0	46.1±0.3 22.0-74.0	53.0±0.5 37.0-88.0	57.4±0.5 43.2-76.0
Total body weight, kg	1.02±0.03 0.26-1.98	1.02±0.02 0.40-1.92	0.74±0.02 0.07-2.70	1.04±0.03 0.39-3.90	1.25±0.03 0.18-2.90
Body weight without guts, kg	0.87±0.02 0.24-1.68	0.88±0.02 0.35-1.60	0.63±0.01 0.06-2.20	0.90±0.02 0.33-3.40	1.09±0.03 0.40-2.60
Fatness coefficient	0.61±0.01 0.47-0.77	0.62±0.01 0.39-0.81	0.60±0.01 0.45-0.75	0.58±0.01 0.45-0.77	0.55±0.01 0.42-0.67
Fullness of stomach, average point	1.63	1.97	1.46	1.33	1.76
Degree coefficient in equation of the weight-size dependence	2.93	2.75	2.94	2.89	2.83
Share of males,%	37.3	36.6	36.4	39.9	40.9
Size of males relative to females, %	92.2	94.1	95.7	98.4	95.7
No.of ind.	184	219	396	229	201

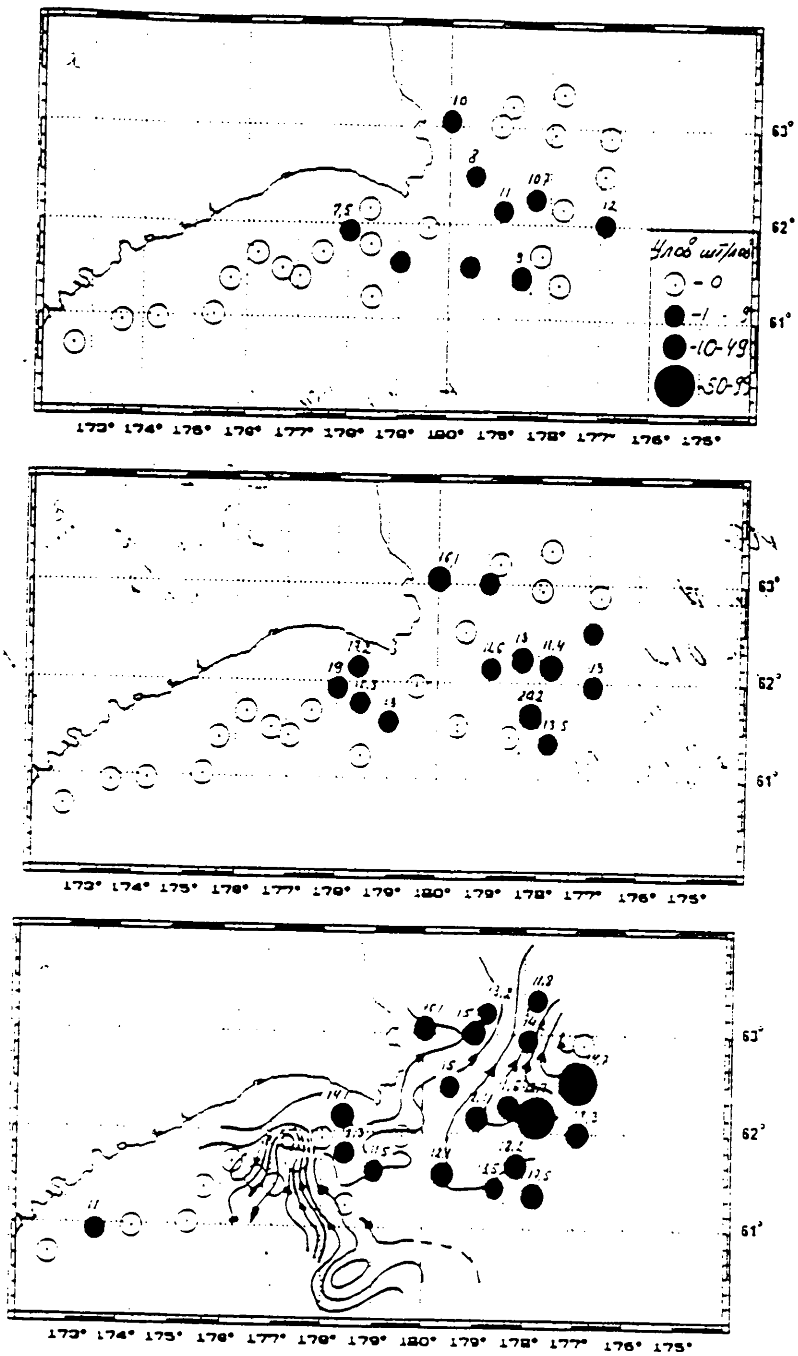


Fig. 1 Distribution of pollock larvae in the Navarin area, 21-27 July 1996 in the surface layer (a), over pycnocline (b), under pycnocline (c). Numbers over circles denote the mean size of larvae (mm) in the catches. Arrows show the direction of surface geostrophic currents.

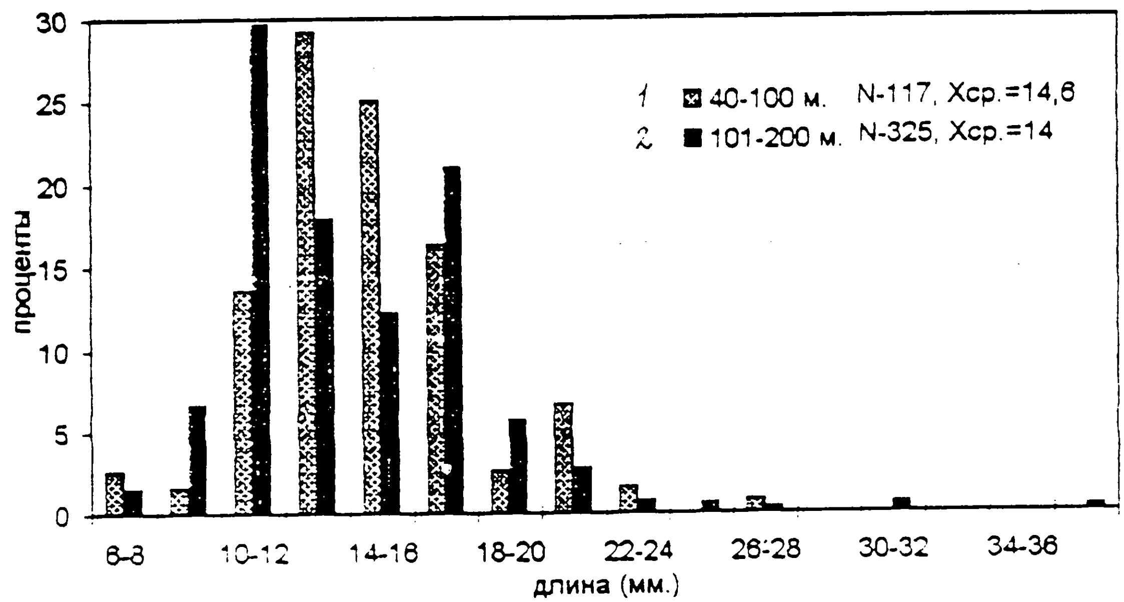


Fig. 2 Size composition of pollock larvae in the Navarin area depending on depth of fishing grounds. 21-27 July, 1996: 1- over pycnocline; 2- under pycnocline.

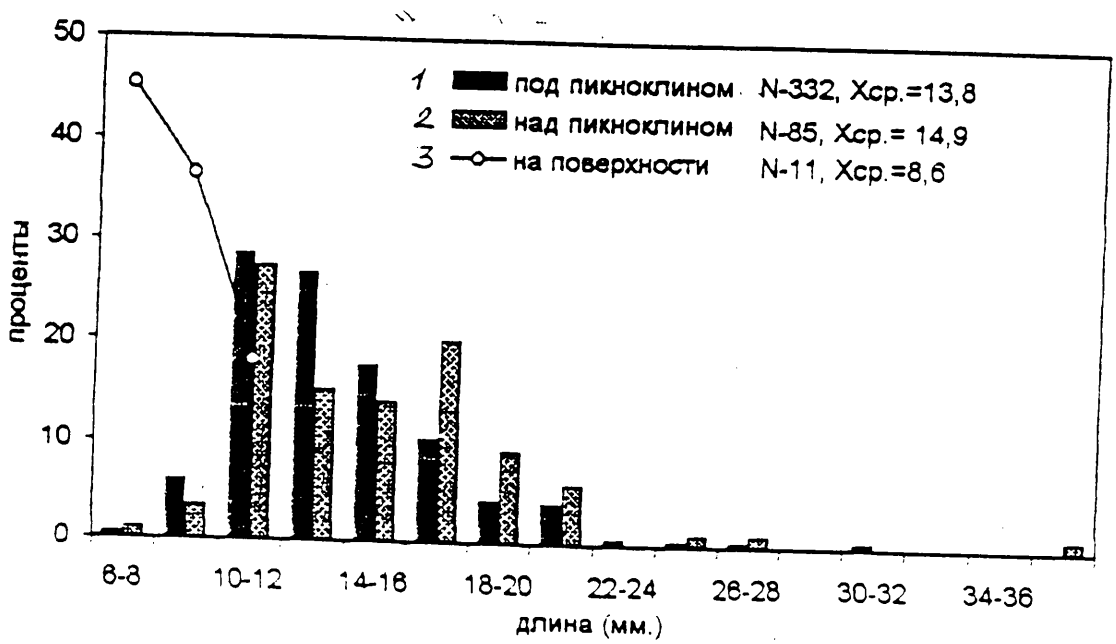


Fig. 3 Size composition of pollock larvae in the Navarin area depending on fishing depth. 21-27 July, 1996: 1- under pycnocline; 2- over pycnocline; 3- at the surface.

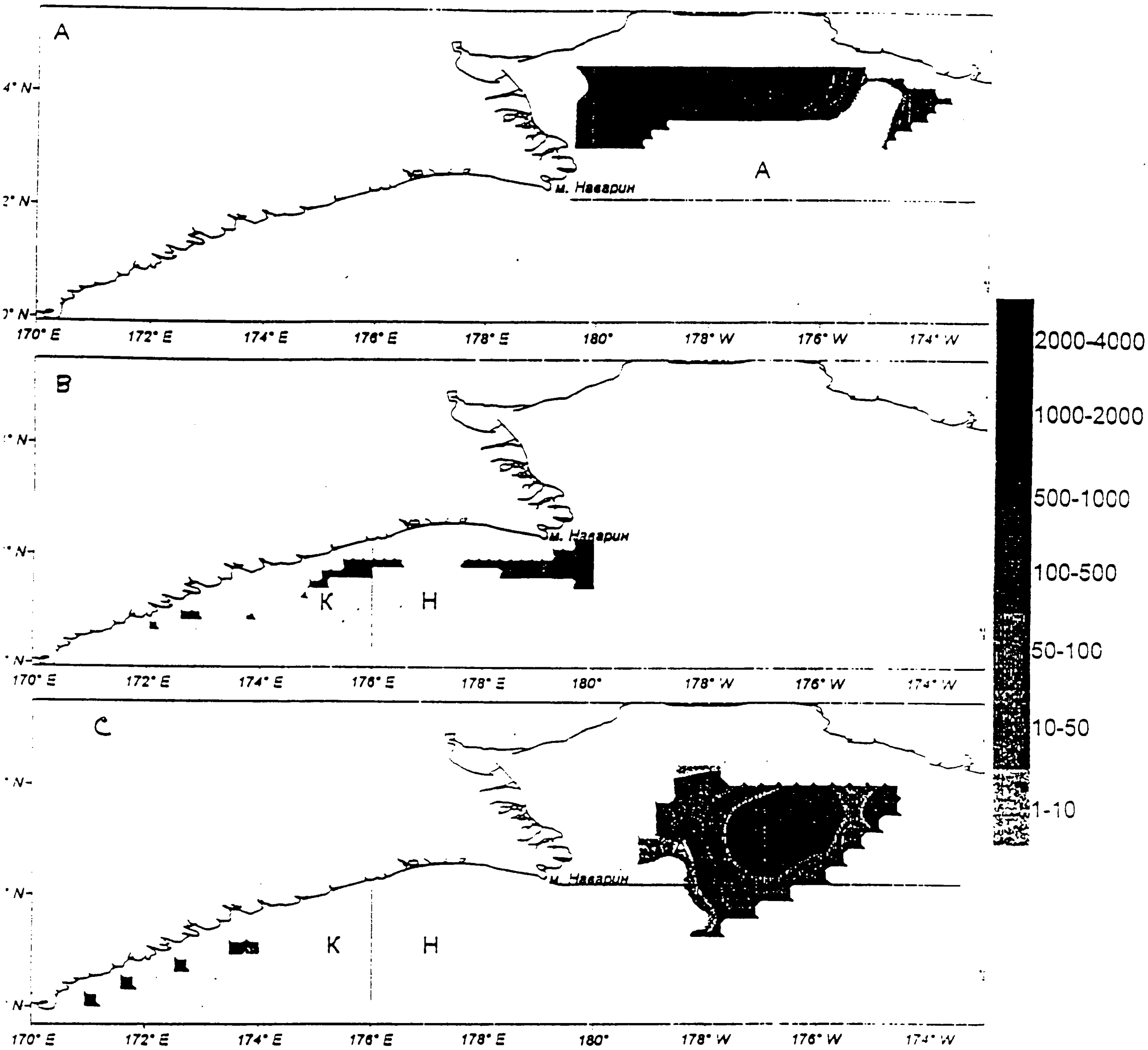
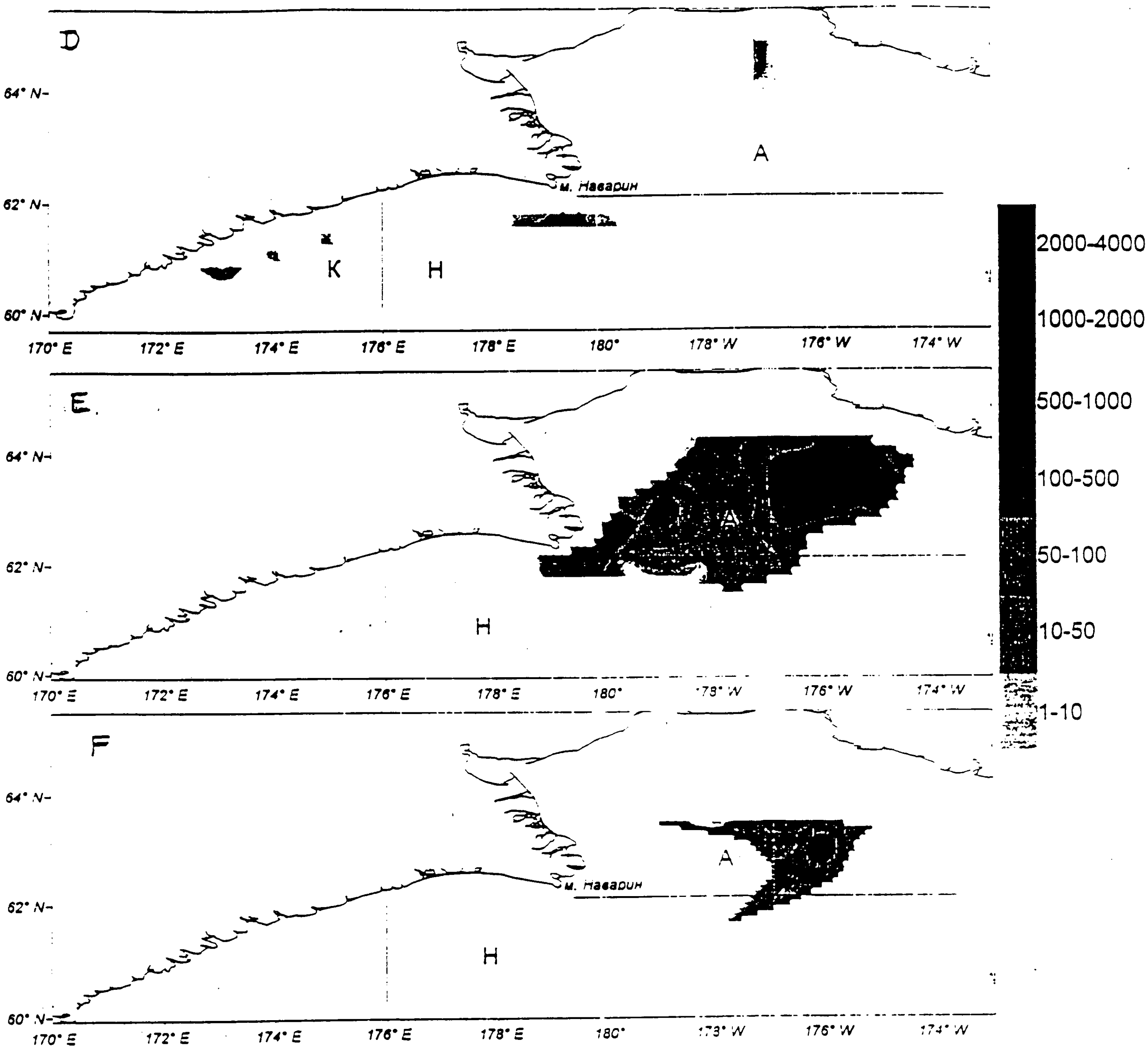


Fig.4 Distribution of pollock at age 0+ (samples per trawling) according to results of bottom trawling surveys in October, 1978 (A), December, 1979 (B), November, 1983 (C), October-November, 1985 (D), November, 1988 (E), December, 1996 (F).


D
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10-50
1-10

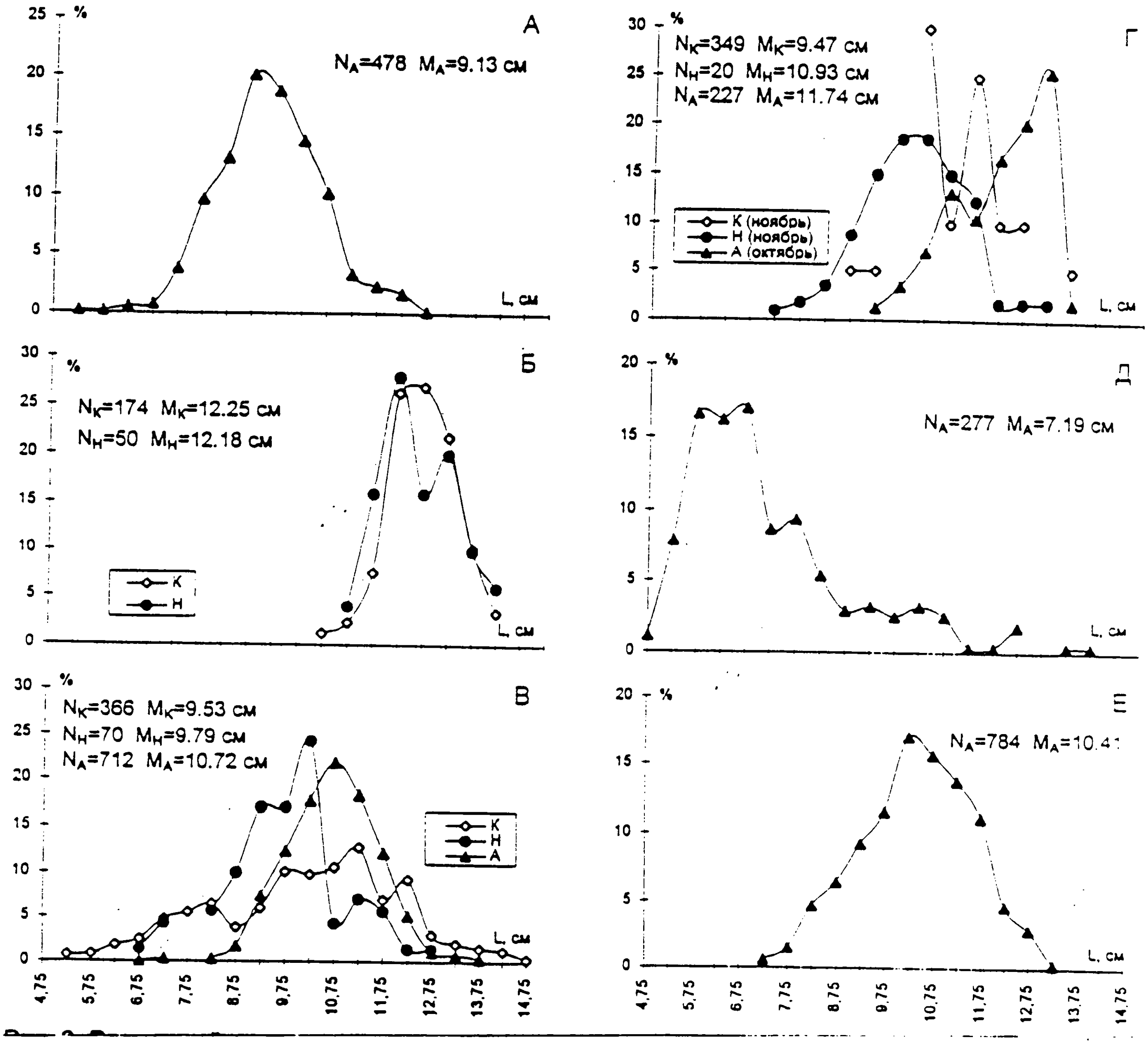


Fig. 5 Size composition of pollock at age 0+ in October, 1978 (A), December, 1979 (B), November, 1983 (C), October-November, 1985 (D), December, 1996 (E).

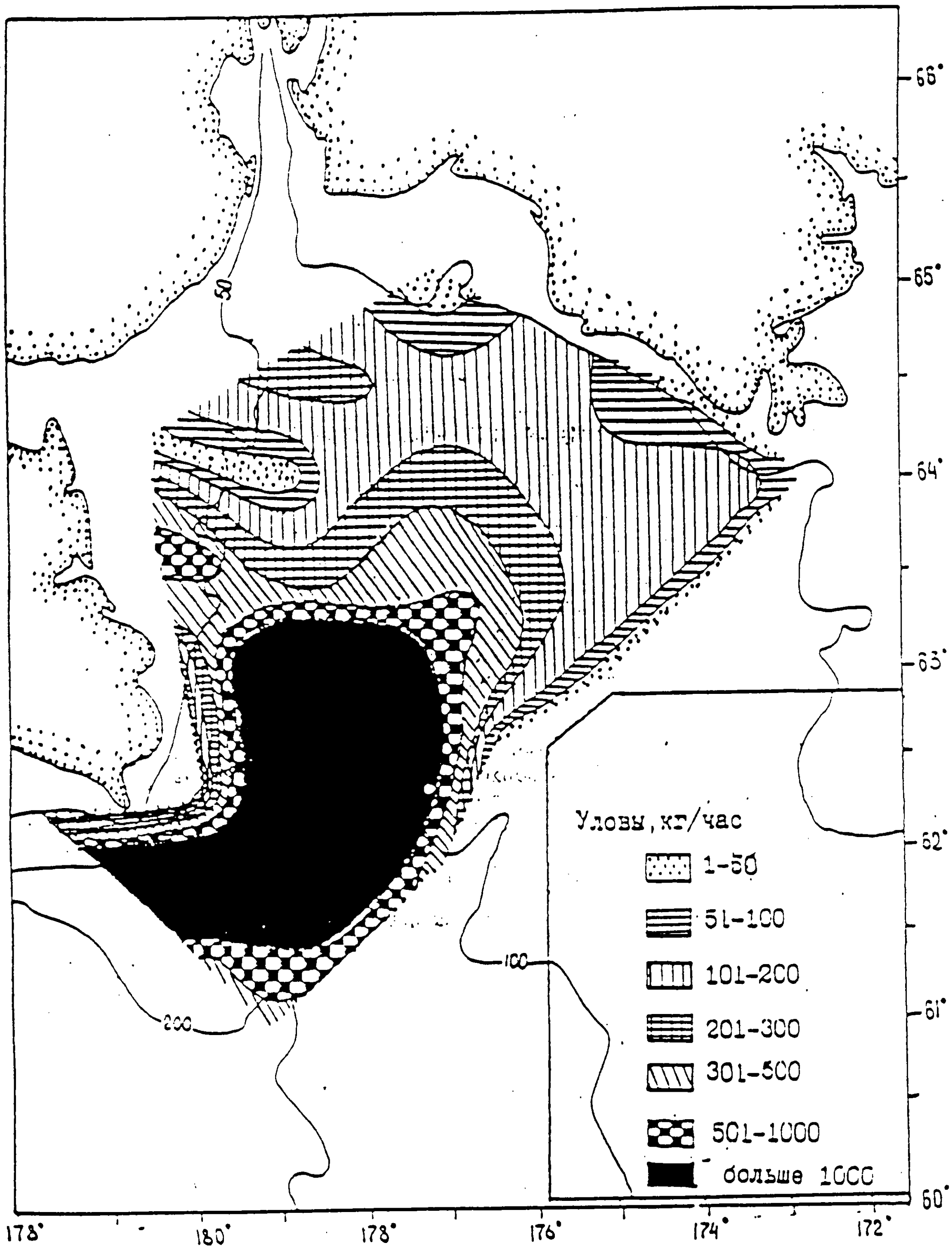


Fig. 7 Distribution of pollock catches in the Anadyr-Navarin area in 1995 according to results of bottom trawling survey from RFV "Shurma", 20 September-1 October, 1995 (Radchenko and Feshchenko, 1996)

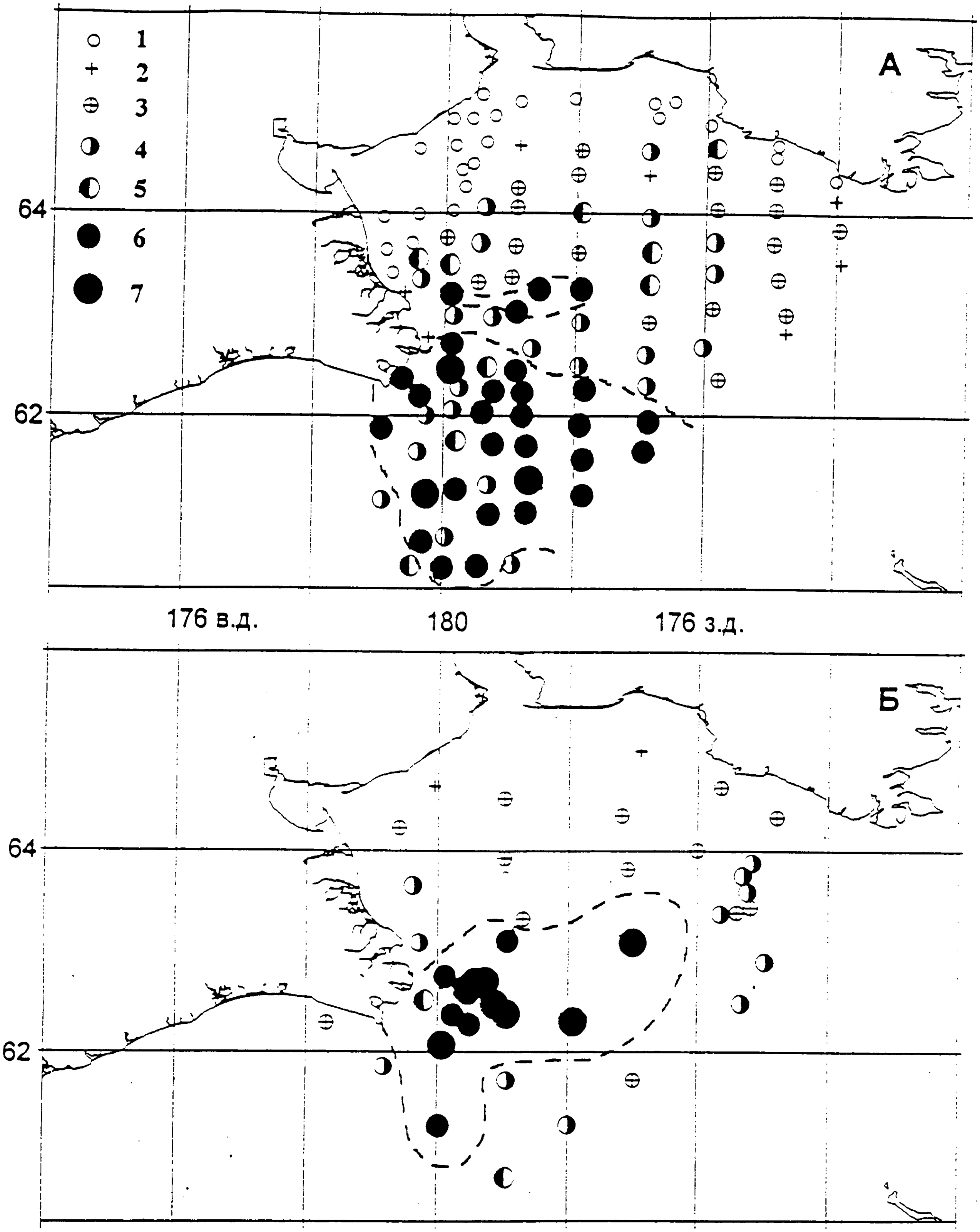


Fig. 8 Distribution of pollock catches in the northwestern Bering Sea according to results of bottom trawling surveys from RFV "Mys Tikhyi", 31 August-20 September, 1985 (A), and RFV "Shurma", 3-15 September, 1997 : 1- no catches; 2- up to 0.01, 3- 0.01-0.1; 4- 0.1-0.5; 5- 0.5-1.0; 6- 1-5; 7- more than 5 tons per trawling hour. Dashed lines contour the areas with catches more than 1 ton per trawling hour.

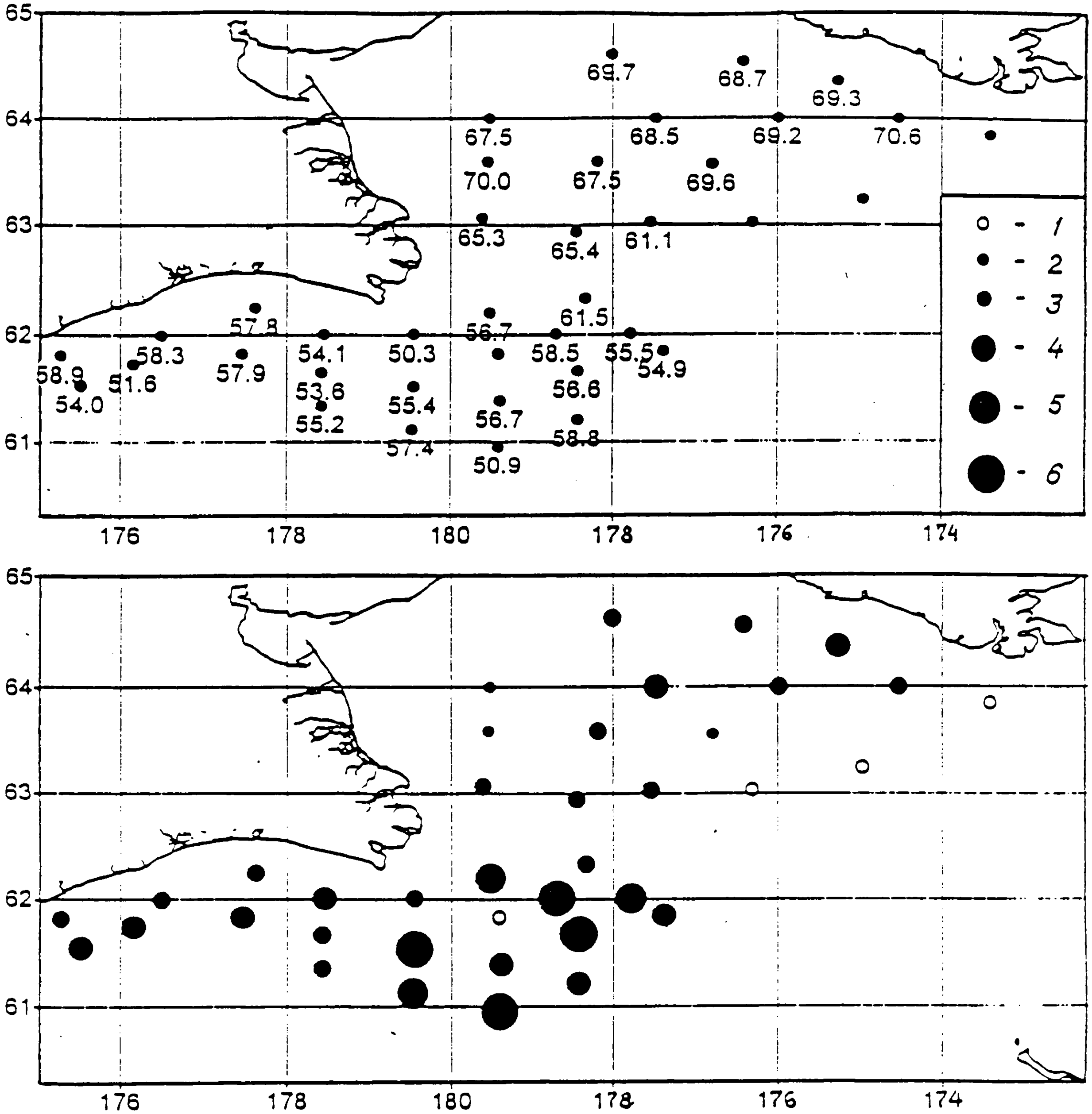


Fig. 9. Mean size AC (cm) and distribution of pollock catches by long-line in the northwestern Bering Sea, 25 August-29 September, 1992: 1- no catches; 2- up to 25; 3- 25-250; 4- 251-500; 5- 501-1000; 6- more than 1000 samples per one long-line staging.

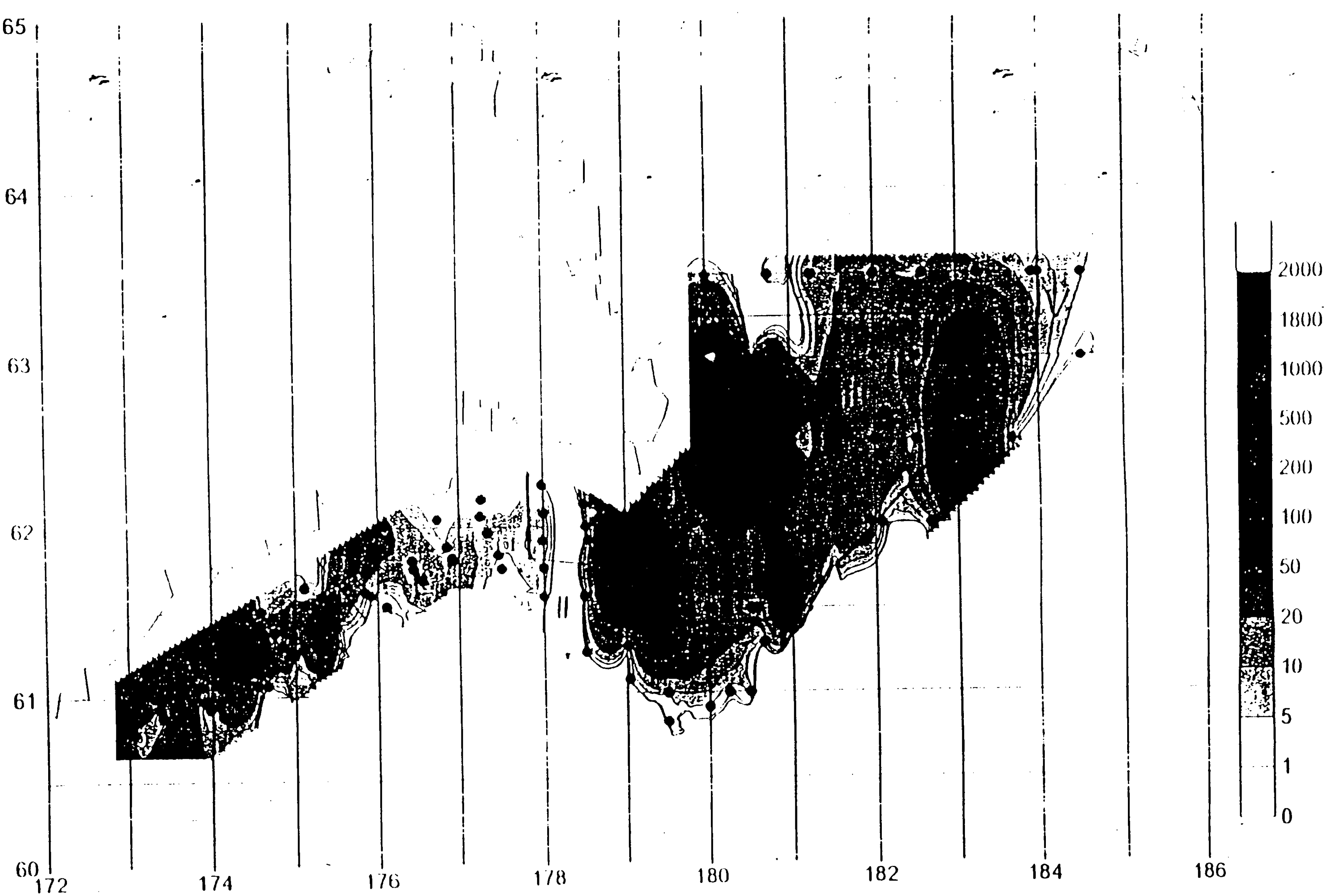


Fig 10 Distribution of pollock by concentration density (tons per square mile) in the Navarin area of the Bering Sea according to results of bottom survey conducted in July August, 1995. Coefficient of catchability is 1.0

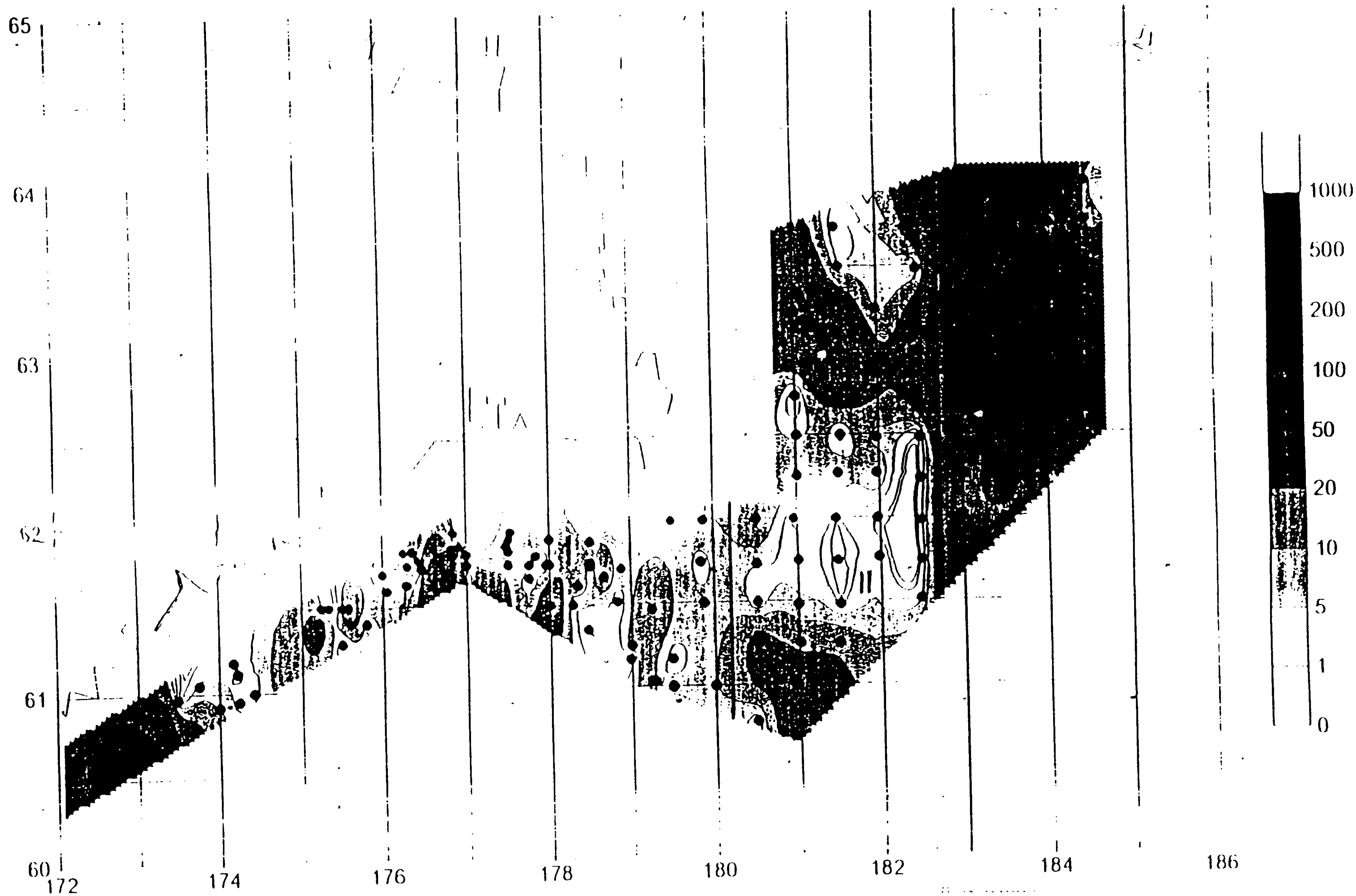


Fig.11 Distribution of pollock by concentration density (tons per square mile) in the Navarin area of the Bering Sea according to results of bottom survey conducted in September-October, 1996. Coefficient of catchability is 1.0.

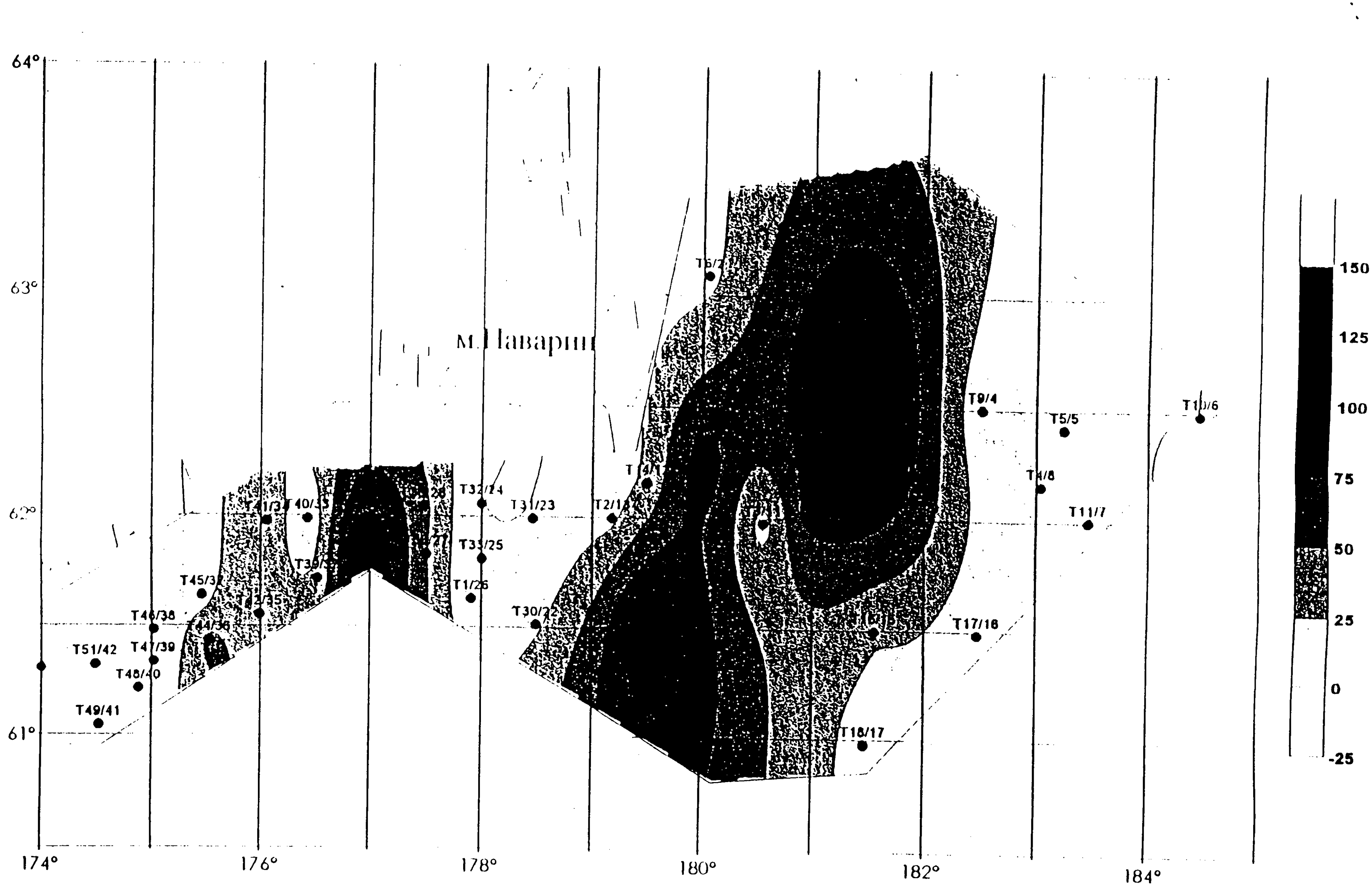


Fig. 12 Density of pollock concentrations according to results of bottom trawling survey, June-July, 1997 (tons per square mile).
Coefficient of trawl catchability is 1.0.

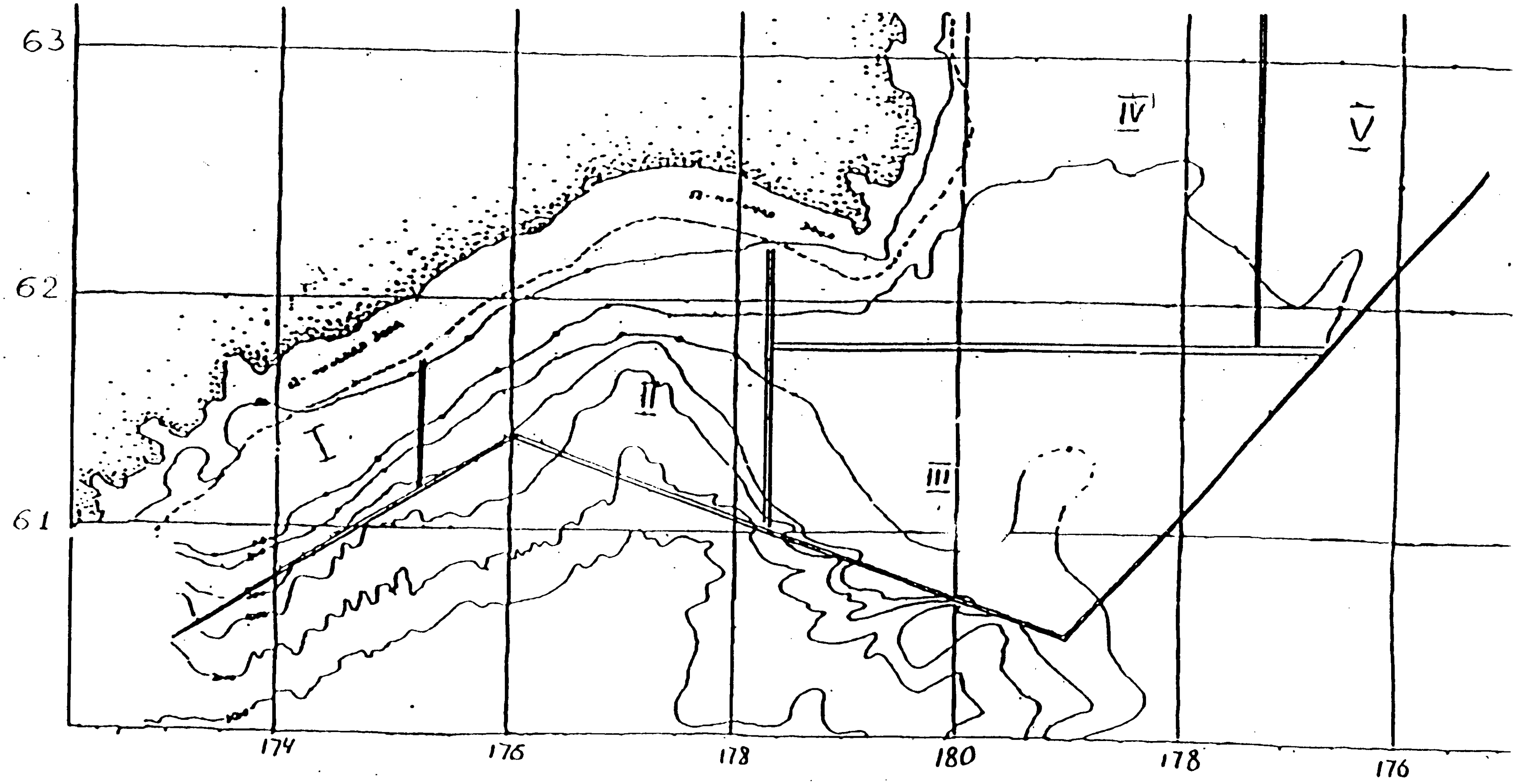
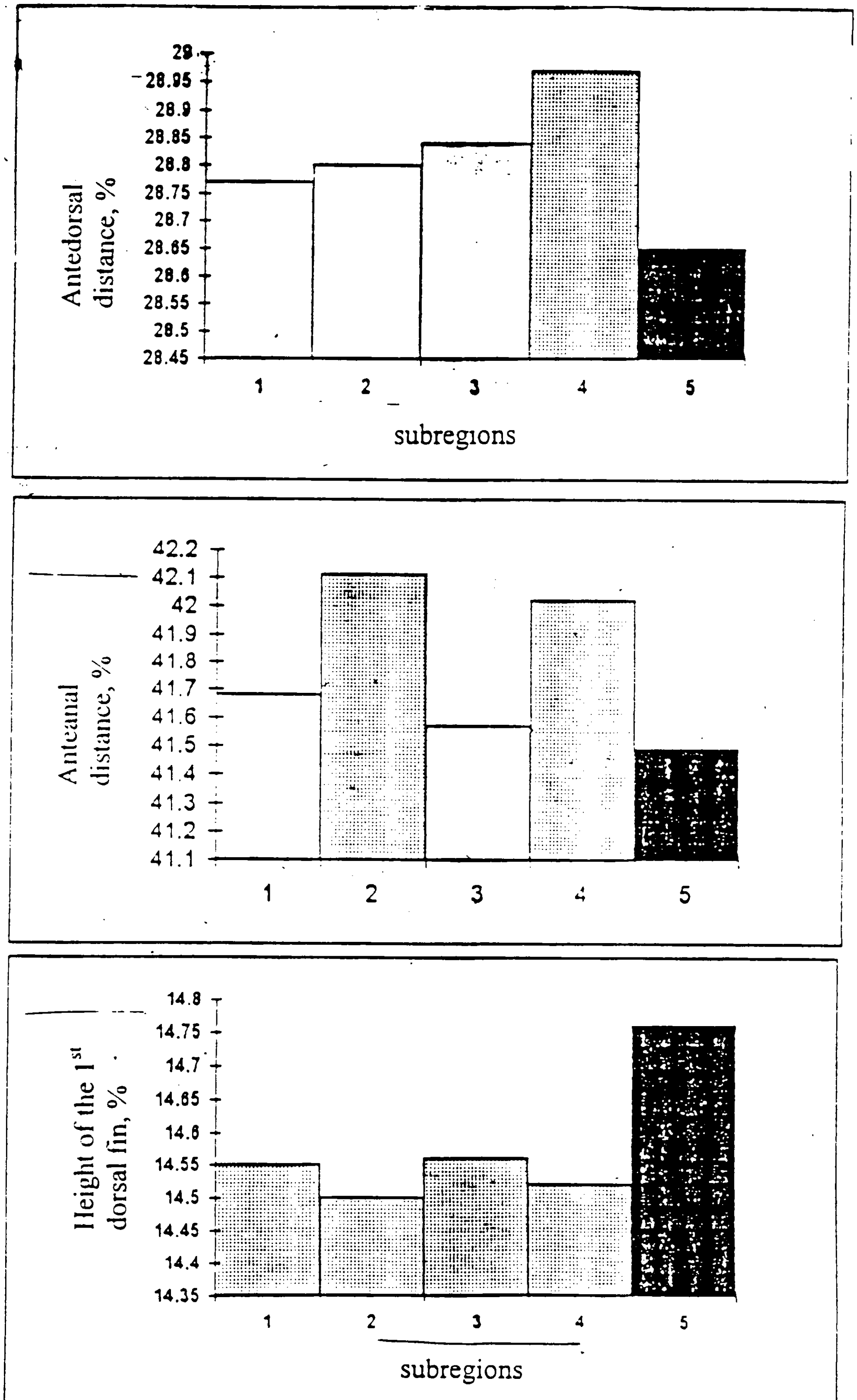


Fig. 13 Scheme of division of the Navarin region into subregions (for Fig.14 and Tables 2-3).

Fig. 14 Morphometry of pollock in the Navarin region of the Bering Sea, June-July, 1997



Note: grey bars show the statistically significant differences with subregion 5.

Report from the Second Workshop on Ageing Methodology of Walleye Pollock (*Theragra chalcogramma*)

Held at the Alaska Fisheries Science Center
Seattle, Washington, U.S.A.
March 17-20, 1998

At the "Second Annual Conference of the Parties to the Convention on the Conservation of the Pollock Resources in the Central Bering Sea," held November 3-7, 1997, in Seattle, Washington, a plan for further research on Donut Hole pollock in the Bering Sea was adopted. One of the items in this plan was that a workshop on the ageing of walleye pollock should take place from March 17-20, 1998, at the Alaska Fisheries Science Center (AFSC), in Seattle, Washington

This age determination workshop follows approximately 7 ½ years after the "Workshop on Ageing Methodology of Walleye Pollock (*Theragra chalcogramma*), held September 10-14, 1990 in Gdynia, Poland (see AFSC Processed Report 91-06, 1991). The participants at the Gdynia workshop "unanimously agreed that under our present knowledge that the break and burn method provides the best method for ageing walleye pollock." The goal of the present workshop is therefore, to standardize the otolith ageing methodology and criteria for Bering Sea walleye pollock.

Participants at the Seattle workshop were (see Appendix 1):

1. Japan:
   a. Dr. Akira Nishimura, National Research Institute of Far Seas Fisheries, Shimizu, Japan.
   b. Mr. Keizou Yabuki, Hokkaido National Fisheries Research Institute, Hokkaido, Japan.

2. Poland, Ms. Magdalena Kowalewska-Pahlke, Sea Fisheries Institute, Gdynia.
3. Russia:
   a. Dr. Valery M. Pashchenko, Vladivostok Lab,
   b. Dr. Elena N. Kusnetsova, Moscow
   c. Mr. Alexander V. Buslov, Kamchatka Lab
4. United States, Dr. Daniel K. Kimura, Ms. Betty J. Goetz, Ms. Nancy E. Roberson, Mr. Charles E. Hutchinson, Alaska Fisheries Science Center.

Ageing Methodology by Nation

The workshop began with each country reviewing their ageing methodology. When otolith ageing was employed, generally the surface, or break and burn methods were used.

Japan

For the most part, Japan does not age adult pollock from the Bering Sea. Otoliths from adults are collected dry and sent to Poland for ageing. When adult pollock are aged at the Shimizu Lab, otoliths are broken, polished and burned. Hatch date and growth in the first year is analyzed using daily growth ring methods. Fish aged 1-2 yr are examined using frontal sections.

The Hokkaido Lab uses two age readers , both ageing 100% of the samples. Local pollock are read using sections mounted in black resin.

Poland

At the Sea Fisheries Institute, in Gdynia, only otoliths are used. About 2,000 pollock are aged yearly from the Bering and Okhotsk Sea. Ageing methods are very similar to the United States, with the exception that otoliths are stored dry, in envelopes. At the Sea Fisheries Institute there was a group of readers dealing with otoliths of different species other than walleye pollock from the Bering Sea and Okhotsk Sea. This group does not exist anymore due to the small number of otoliths available for reading, so at present, there is only one age reader

Russia

At the Vladivostok, TINRO Lab, both otoliths and scales are used. All fish are aged using otoliths and scales. Mostly scales are used, for a maximum age of 15yr. However, both otoliths and scales have been collected, and are stored dry or in alcohol. Two age readers are involved in ageing approximately 3,000 pollock annually from all areas of the Bering Sea and Okhotsk Sea. Age-length keys are constructed using 5 or more fish for each 1 cm length groups, by area, sea, and year. Keys are available annually, and by decade for the 1970's, 1980's, and 1990's.

At the Kamchatka Lab, both otoliths and scales are used for age determination. There is one otolith age reader and three scale age readers. Approximately 7,000 pollock are aged mostly from the western Bering Sea and Kamchatka regions using otoliths and scales. Due to the workload, another otolith age reader is needed.

At the Russian Federal Research Institute, in Moscow, a 500 pollock sample, collected from the northwest Bering Sea was aged using scales, otoliths, and finrays. For fish up to 30 cm, otoliths and scales compare well, with finrays giving older ages. For fish up to between 30 cm and 46 cm, there is good agreement between otoliths, scales, and finrays. For fish over 46 cm, scales age low, but otoliths and finrays compare well. The conclusion is that break and burn otoliths work well for all lengths. A similar study is being carried out for the Okhotsk Sea and northern Kuril Islands.

United States

At the Alaska Fisheries Science Center approximately 12,000 pollock are aged annually from otoliths. Collection methods are similar for fishery observer samples and survey vessels. Fish sex, length and weight are recorded, and both sagitta are removed, cleaned and placed in a buffered solution of 70% ethanol. Readers are provided with cruise number, specimen number, length, weight, date of collection, and collection area. Readers are provided with the option of assigning surface ages when the surface pattern is clear. If the surface pattern is not clear, the otolith is sawed using either an Isomet low speed saw, or Tyslide diamond tool cutting machine. The cut surface is often polished with a fine grit sandpaper. Otoliths are burned over an alcohol flame, and coated with either cedar or mineral oil. The whole otolith is viewed in a water filled petri dish with a dark velvet background. Broken and burned otoliths are inserted in modeling clay. Both are viewed under a dissecting microscope, and surface lit with a fiber optic lighting. The reader assigns a raw age and a readability code, edge code and appropriate coded comments. The data is entered into a computer database and summary data, mainly size or weight at age are generated. A precision test sample is selected (20% of the sample) for independent viewing by a second age reader. The second age reader ages the test sample without knowledge of the age assigned by the first age reader.

Edge Interpretation

The interpretation of growth on the edge of the otolith is a very difficult part of standardizing ageing methods. It is the desire of the Alaska Fisheries Science Center to standardize the so called January 1st international birthday. Under this system, all fish are aged 1 yr older following January 1st (i.e., they have a birthday). Therefore, otoliths that have nearly a year's growth in Oct.-Dec, would not have their edge counted, but the same fish collected in Jan.-Feb, would have its edge counted. Each nation was asked if it used the international birthday ageing convention of January 1st. All nations agreed that they apply the international birthday when they age Bering Sea pollock. Japan noted that in local fisheries outside the Bering Sea an April 1st convention is used. The Alaska Fisheries Science Center reference sample described below was selected year around so that edge interpretation would be necessary.

Reported Research

Dr. Kevin Bailey, of the AFSC Bering Sea FOCI group, gave a presentation concerning stock structure and spawning times for pollock in the Bering Sea. He noted that mitochondrial DNA studies can generally distinguish between the Gulf of Alaska, the Bering Sea , and the Western Pacific. Within the Bering Sea, spawning is believed to occur from Jan.-Feb in the Aleutian Basin, March-April around Unimak Pass, May-June northward, and March 1-10th in Bogoslof. However, the April-May spawning period was thought to encompass perhaps 90% of the spawning. Larvae from later spawning fish were thought to have poor prospects of survival due to the unavailability of food.

Dr. Akira Nishimura presented his paper titled "False ring observed in the otolith of age 1 walleye pollock collected in the Bering Sea." This paper was previously presented at the "Meeting of the Science Group of the Scientific and Technical Committee for the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea" held in Gdynia, Poland, September 3-5, 1997. The problem posed is an important one since if false rings are counted, fish will obviously be over-aged. The author analyzed 130 age 1 walleye pollock collected in the summer of 1989. Examining the frontal section of the otoliths, 3 different growth patterns were recognized: Type A, which had a single annulus, Type B, which had two marks, and Type C which had three marks. By counting daily growth rings, the author was able to conclude that the inner rings on Type B and C otoliths were checks and should not be counted as annual rings. Also, Dr. Nishimura noted that true annuli and false rings have different microstructure. Finally, Dr. Nishimura concluded that false rings could be excluded from annual ring counts on the long axis of the frontal section, by excluding rings whose long axis measured to the outer diameter was less than about 4.0 mm.

Ms. Betty Goetz noted that following a reading of Dr. Nishimura's paper, age readers at the AFSC searched for otoliths that were aged 1 or 2 yr-old and had small first years. Generally, what AFSC age readers were calling first years, were large enough to fit Dr. Nishimura's measurement criterion for a true annulus. However, there were a few otoliths that did appear to have small first years. Consulting with colleagues at the AFSC suggested that there was a possibility that some fish identified as walleye pollock might actually be arctic cod (*Boreogadus saida*). Special collections of small walleye pollock and other gadid species (less than 20 cm) will be collected, and positively identified so that this problem can be evaluated. AFSC age readers noted that age 1 or 2 yr fish are usually aged from the surface where the checks are less visible. Originally, age readers at the AFSC rationalized the small size of some first years as being due to late spawning times, but this interpretation may be incorrect according to Dr. K. Bailey's presentation.

Dr. Nishimura (co-authored with T. Yanagimoto from the Shimizu Lab, Japan, and J. Janusz, from the Sea Fisheries Institute, Poland) also presented a paper titled "Ageing results of Aleutian basin pollock collected in 1993 and 1996." All age data in this report was from otoliths collected by the Japanese and aged later than 1990 in Poland, using the break and burn method. An interesting figure in this report compares size at age 9-10 yr for fish aged in 1978 and 1987, with those collected in 1990, 1991, 1993, and 1996. A large increase in size at age was reported in the 1990's. These results are consistent with density dependent growth for pollock in the Donut Hole.

Mr. A. Buslov presented a paper titled "The analysis of the ages estimated from scale and otolith samples and general population parameters of walleye pollock from the western Bering Sea." The author's results show that otoliths and scales give nearly the same age for fish having otolith ages of 9 yr or less. However, scales give statistically significant younger ages for fish aged with otoliths at 11yr and older. This is consistent with previous studies. The author concluded that since growth parameters are not strongly affected by the method of ageing, "that general insights to the size-age structure and the abundance of mentioned population wouldn't be extensively transformed when changing the method of age estimation." However, Dr. D. Kimura noted that the implied natural mortality rate from using otoliths rather than scales would suggest a much more conservative harvest strategy.

Dr. V. Paschenko reported on "The morphological characteristics of otoliths from the Bering Sea and the Okhotsk Sea." Bering Sea samples were available from 1996-97, and Okhotsk Sea samples were available from 1996. Otolith mass, width, and length were significantly greater for a given length fish for Okhotsk Sea pollock, compared with

Bering Sea pollock. For the Bering Sea, the relationship between fish length and otolith dimensions was highly consistent between 1996 and 1997. Small samples of fish size and otolith measurements is all that is needed to distinguish samples of fish from the two seas.

Otolith Reference Samples

Representatives from different nations brought samples they wished to have examined or aged at the workshop.

Japan

Dr. A. Nishimura brought 10-20 age 1 yr frontal sections, and 20-30 age 1 yr whole otoliths. These were from the eastern Bering Sea.

Mr. K. Yabuki brought 48 transverse cut otolith halves mounted in resin. Some of these were burned whole before mounting in resin.

Poland

Ms. M. Kowalewska-Pahlke brought 10 otolith samples from the Cape Navarin shelf, and 10 otolith samples from the Okhotsk Sea collected from August to October, 1997.

Russia

Mr. A. Buslov brought 100 otolith samples, collected in October, 1995-96, from the western Bering Sea.

United States

The Alaska Fisheries Science Center reference sample was selected from 1996 survey and fishery samples from the Bering Sea. The reference sample attempted to cover the complete age range, and three time periods from throughout the year (January-February (20), June-July (20), September-November (27)). This collection was designed so that the age readers must take into account the time of collection, so that fish age can be assigned according to the January 1st birthday.

Results

The samples from Dr. A. Nishimura allowed a viewing of the materials used in his paper on false rings. He described how daily rings were evaluated to distinguish false rings from true annuli. Twenty four whole otoliths were hydrated in order to examine growth patterns for false rings. All showed clear first years. The otoliths mounted in resin by Mr. Yabuki for Hokkaido pollock were very fine preparations that showed the usefulness of black resin for mounting whole otoliths. His method of burning whole otolith before mounting in resin drew considerable interest. However, the preferred preparation now is not to burn the otoliths, because burning can cause brittleness and breakage.

Readers from all nations aged the reference samples, using equipment supplied by the AFSC, and interpreting edge growth using the January 1st international birthday.

The samples brought by Ms. M. Kowalewska-Pahlke were chosen for their difficulty. This is evident in the variability of ages provided from age readers (Table 1).

Due to time constraints, only half of the sample supplied by Mr. A. Buslov was aged at the workshop. Although the results from ageing this sample appeared to be generally good, several of the specimens appeared to be difficult, resulting in a considerable range of ages (Table 2).

The samples supplied by the AFSC, were from winter, summer, and fall, and were designed to test the ability of age readers to interpret edge growth when assigning a final age (Table 3). Generally, the results from reading this sample appears to be quite good.

Conclusions

Generally, the results from ageing reference samples from this workshop did not differ greatly from that of the first workshop held in Gdynia, September, 1990. In both workshops, age readers from distant labs, and varying experience levels ageing walleye pollock otoliths, were able to age reference samples and arrive at quite similar ages. As indicated from the Polish sample, when specimens are difficult to age, there will be considerable variability in the assigned ages. However, ages will become more similar with increased experience levels, and the ability of age readers to work together under a double scope to compare their ages.

Although differences in ageing criteria can be uncovered by mailing exchanges of reference samples, the resolution of discrepancies can be difficult without the age readers traveling to the same geographic location for face to face discussions.

At the first workshop on ageing walleye pollock, held in Gdynia, two research issues were described for the ageing of walleye pollock: identifying the first annulus, and validating break and burn ages. To a significant extent, the paper by Dr. Nishimura addresses identifying the first year in walleye pollock. He validates the first year using daily growth techniques, and documents how counting checks can be avoided. A brief examination of AFSC age data indicates that miss-identifying the first year does not appear to be a significant problem. This may be due to the practice at the AFSC to age 1-2 yr olds from the surface, or break and burns, where checks are less visible. Older fish also need to be examined to further assure that checks are not being counted. Also, there may have been some miss-identification of another cod species for juvenile pollock in the AFSC collections.

Further Research:

1. As a follow up to the present meeting, the AFSC asked Dr. Nishimura to provide samples of frontal sections of 1 yr old walleye pollock showing "false rings," along with the corresponding whole otolith pair. Just a few samples of this type might give us more insight into whether the AFSC is counting false rings. This verification would assume that the same checky pattern appears on both otoliths.
2. The break and burn method has yet to be fully validated for pollock. One of the difficulties for age validation is that pollock have poor survivability following tagging.

Table 1. Results from age readers reading the Polish sample collected from Cape Navarin and the Sea of Okhotsk (August-October). Sample was selected to be difficult. Readers are identified by initials, Japan (A.N., K.Y.); Poland (M.P.); Russia (V.P., E.K., A.B.); and the U.S. (B.G., N.R., C.H.).

Polish Sample

Specimen	Length	Date	A.N.	K.Y.	M.P.	V.P.	E.K.	A.B.	B.G.	N.R.	C.H.
98	34	7/25/97	4	5	5	5	4	5	5	5	5
106	35	7/25/97	3	5	4	5	4	4	4	4	5
114	360	7/25/97	3	6	4	4	4	5	5	5	5
115	36	7/23/97	4	5	6	5	4	4	5	4	4
26	26	8/5/97	3	4	3	3	3	3	3	3	3
65	32	8/5/97	4	4	4	4	4	4	4	4	4
143	59	8/5/97	8	7	12	12	10	9	9	9	10
66	36	9/8/97	5	6	6	5	5	5	6	5	5
47	39	9/25/97	4	5	6	6	5	5	5	5	5
85	47	10/8/97	6	7	9	7	7	7	7	6	7
35	31	10/25/97	4	4	4	5	4	4	4	4	4
44	32	10/25/97	5	6	6	7	6	6	6	6	6
86	37	10/25/97	4	8	7	6	6	6	8	7	8
87	37	10/25/97	3	-1	5	6	5	5	6	4	4
89	37	10/25/97	4	5	8	6	5	5	6	4	5
105	39	10/25/97	7	9	9	8	5	7	-1	7	9
110	40	10/25/97	5	8	12	7	5	7	-1	9	9
132	43	10/25/97	5	9	13	8	6	8	-1	9	12
19	31	10/19/97	3	4	4	5	4	3	4	4	4
76	38	10/19/97	-1	8	9	6	6	7	9	9	10

Table 2. Results from ageing the Russian sample from the western Bering Sea, October, 1997. Readers are identified by initials. Japan (A.N., K.Y.); Poland (M.P.); Russia (V.P., E.K., A.B.); and the U.S. (B.G., N.R., C.H.).

Russian Sample

Specimen	Length	Date	A.N.	K.Y.	M.P.	V.P.	E.K.	A.B.	B.G.	N.R.	C.H.
902	54	October 1997	6	4	7	9	8	7	-1	-1	-1
904	61	October 1997	13	10	11	11	11	11	11	11	9
906	58	October 1997	8	8	8	10	9	10	8	8	8
908	55	October 1997	10	8	7	9	8	8	10	7	7
910	65	October 1997	9	9	11	12	10	9	11	10	9
912	58	October 1997	6	6	7	9	8	8	7	7	8
914	55	October 1997	7	7	11	8	8	8	7	7	8
916	59	October 1997	20	12	16	9	17	17	18	19	19
918	56	October 1997	8	7	9	9	8	8	7	8	7
920	61	October 1997	8	10	8	12	10	9	10	8	10
922	58	October 1997	5	9	-1	-1	9	10	-1	-1	-1
924	55	October 1997	5	10	8	9	8	8	7	7	9
926	55	October 1997	8	9	10	11	9	9	10	10	9
928	60	October 1997	9	11	11	12	10	10	10	11	12
930	55	October 1997	8	8	8	9	8	8	7	8	8
932	53	October 1997	8	8	8	8	9	7	8	8	9
934	54	October 1997	4	7	9	10	8	8	7	7	7
936	55	October 1997	8	9	9	9	9	9	9	8	9
938	60	October 1997	14	15	14	11	15	14	14	15	14
940	54	October 1997	8	8	8	8	8	8	6	7	7
942	53	October 1997	10	9	10	8	10	10	11	11	10
944	51	October 1997	6	6	7	8	8	7	6	7	7
946	54	October 1997	8	6	8	9	8	8	9	9	9
948	62	October 1997	14	14	16	11	14	15	16	16	15
950	56	October 1997	7	6	7	9	8	7	6	7	7
1052	52	October 1997	3	3	4	8	7	3	3	3	3
1054	52	October 1997	5	5	5	7	7	5	5	5	5
1056	58	October 1997	7	6	8	10	10	7	7	8	8
1058	56	October 1997	8	9	9	9	9	8	8	8	7
1060	54	October 1997	11	12	12	10	11	12	14	14	13
1062	44	October 1997	-1	-1	-1	-1	8	-1	-1	-1	-1
1064	42	October 1997	10	8	6	5	8	8	10	8	8
1066	55	October 1997	5	6	6	8	8	6	5	5	5
1068	52	October 1997	5	6	6	8	8	6	5	5	5
1070	61	October 1997	5	7	6	10	8	6	5	5	5
1072	50	October 1997	8	5	7	7	7	7	5	5	6
1074	52	October 1997	5	5	6	8	7	6	5	5	5
1076	45	October 1997	6	5	5	5	6	5	5	5	5
1078	48	October 1997	5	4	6	6	7	5	5	5	5
1080	58	October 1997	5	5	5	7	7	5	5	5	5

Table 2 Continued

Table 2 Continued

1082	44	October 1997	5	5	6	6	6	5	5	5	5
1084	50	October 1997	8	7	8	8	8	7	7	7	7
1086	43	October 1997	6	8	7	5	8	8	8	8	8
1088	52	October 1997	8	8	10	9	9	9	10	9	9
1090	52	October 1997	8	8	8	10	10	10	10	10	9
1092	43	October 1997	8	7	6	6	7	7	8	8	7
1094	54	October 1997	7	5	7	9	8	7	7	7	8
1096	51	October 1997	8	7	8	8	8	8	8	8	8
1098	44	October 1997	7	6	6	7	7	6	6	6	6
1100	48	October 1997	5	5	6	7	6	5	5	5	5

Table 3. Results from ageing the reference sample prepared by the AFSC. Collections were from three time periods of the year (Jan.-Feb), (June-July), and (Sept.-Nov.), so that age readers made an interpretation of age according to the January 1st international birthday. Readers are identified by initials, Japan (A.N., K.Y.); Poland (M.P.); Russia (V.P., E.K., A.B.); and the U.S. (B.G., N.R., C.H.).

AFSC Sample Cruise	Vessel	Specimen	Length	Date	A.N.	K.Y.	M.P.	V.P.	E.K.	A.B.	B.G.	N.R.	C.H.
3740	A078	24	44	960130	4	4	6	6	5	5	5	5	6
3740	A078	30	49	960130	5	5	6	6	6	5	6	6	6
3740	A078	55	49	960204	7	7	8	7	7	7	7	7	7
3740	A078	108	68	960214	15	14	15	14	19	15	15	15	16
3740	A078	140	50	960218	-1	6	7	4	7	5	4	5	4
3740	A078	146	60	960220	16	11	13	13	12	12	12	13	13
3740	A078	147	53	960220	8	9	9	9	10	8	9	9	8
3740	A078	160	44	960222	5	5	6	6	6	5	5	5	5
3828	P009	129	49	960128	6	6	9	7	10	7	7	7	7
3828	P009	137	52	960128	6	6	9	9	10	7	7	7	7
3828	P009	171	61	960130	13	14	13	13	15	12	13	14	14
3828	P009	172	58	960130	9	9	11	10	10	9	9	10	10
3828	P009	179	61	960130	19	16	18	14	17	18	18	18	18
3828	P009	274	47	960224	4	6	6	6	7	5	6	6	6
3828	P009	1112	44	960214	7	7	7	6	7	6	8	7	8
3828	P009	1116	45	960214	5	6	7	5	7	6	6	6	7
3828	P009	1140	59	960216	19	18	18	18	19	19	18	18	18
3828	P009	1151	45	960218	4	5	7	6	7	5	5	5	5
3769	A293	177	39	960223	4	4	5	4	5	4	4	4	4
3769	A293	179	39	960223	4	5	5	5	6	4	5	5	5
961	88	4	62	960611	11	10	11	10	11	10	11	10	11
961	88	12	65	960611	14	14	13	14	13	13	14	14	13
961	88	40	68	960611	18	18	16	14	17	18	18	19	18
961	88	47	61	960611	11	11	12	12	12	11	12	12	12
961	88	65	55	960613	6	6	6	6	8	6	6	6	6
961	88	69	60	960613	5	7	8	8	10	8	7	7	6
961	88	73	55	960613	7	7	8	7	8	7	7	7	6
961	88	81	36	960613	3	3	3	3	3	3	3	3	3
961	88	102	28	960613	3	2	2	2	3	2	2	2	2
961	88	103	56	960613	9	6	8	7	8	8	7	7	6
961	88	119	14	960613	1	1	1	1	1	1	1	1	1
961	88	127	12	960614	1	1	1	1	1	1	1	1	1
961	88	153 .	44	960614	5	5	5	5	6	5	5	5	5
961	88	165	45	960614	7	7	7	7	6	7	8	8	7
961	88	211	25	960615	2	2	2	2	2	2	2	2	2
961	88	225	34	960615	2	2	2	2	3	2	2	2	2
961	88	226	37	960615	3	4	3	4	4	3	3	3	4
961	88	315	74	960702	13	12	11	13	12	12	12	12	11
961	88	544	45	960713	5	5	5	5	5	5	5	5	5
961	88	806	60	960726	11	9	10	10	10	10	12	12	11

Table 3 Continued

Table 3 Continued

4029	A134	1	52	960918	6	6	8	8	8	6	6	6	6
4029	A134	7	59	960918	7	7	10	8	8	7	7	7	7
4029	A134	17	52	960918	4	4	8	6	7	6	6	7	6
4029	A134	51	63	960920	11	11	12	11	10	10	13	12	13
4029	A134	80	48	960922	4	4	7	6	6	5	5	5	5
4027	P009	141	53	960926	4	5	10	8	8	8	10	8	8
4027	P009	144	51	960926	6	7	8	7	8	7	8	8	8
4027	P009	146	61	960926	7	5	11	8	8	10	7	8	7
4027	P009	156	67	960928	12	13	15	13	12	12	13	13	13
4027	P009	309	57	961006	14	14	14	12	13	14	15	15	15
4027	P009	318	49	961007	3	5	7	6	6	6	6	6	6
4027	P009	322	63	961008	14	14	16	15	14	14	15	15	17
4027	P009	350	47	961013	5	5	6	6	6	5	5	5	5
4166	P022	255	53	960907	6	6	8	8	7	7	7	7	7
4166	P022	259	35	960907	3	3	3	4	3	3	3	3	3
4166	P022	275	30	960907	2	2	2	3	3	2	2	2	3
4166	P022	281	29	960912	2	2	2	3	3	2	2	2	2
4166	P022	293	47	960912	9	7	9	7	8	8	9	8	8
4166	P022	298	50	960912	8	7	8	8	8	8	8	7	7
4074	P013	61	59	960910	10	10	12	11	11	12	15	12	14
4074	P013	72	59	960912	15	13	13	10	13	14	15	14	15
4074	P013	73	56	960912	16	16	17	12	18	17	17	18	19
4074	P013	78	61	960912	9	9	10	10	10	10	11	11	11
9701	795	6	44	971105	5	5	6	6	6	5	5	5	6
9701	795	77	20	971106	1	1	2	2	1	1	1	1	1
9701	795	111	26	971106	2	2	2	2	2	2	2	2	2
9701	795	126	42	971107	4	4	5	4	5	4	4	4	4

Appendix 1

Second Workshop on Ageing Methodology of Walleye Pollock
Held in Seattle, WA, U.S.A., March 17-20, 1997

List of Participants

Japan

1. Dr. Akira Nishimura

National Research Institute of Far Seas Fisheries
5-7-1 Orido
Shimizu. 424. Japan

Tel. 81-543-36-6036, Fax 81-543-35-9642
e-mail: anishimu@enyo.affrc.go.jp

2. Mr. Keizou Yabuki

Hokkaido National Fisheries Research Institute
116, Katsurakoi, Kushiro
Hokkaido. Japan

Tel. 81-154-91-9136. Fax 81-154-91-9355
e-mail: yabuki@affrc.go.jp

Poland

3. Ms. Magdalena Kowalewska-Pahlke

Sea Fisheries Institute
Ul. Kottataja 1
81-332 Gdynia
Poland

Tel. +48 58 620 17 28 ext. 211
Fax +48 58 620 28 31
e-mail: magda@mir.gdynia.pl

Russia

4. Dr. Valery M. Pashchenko

Pacific Scientific Research Center
(TINRO-Centre)
4. Shevchenko Alley
Vladivostok. 690600
Russia

5. Dr. Elena N. Kusnetsova

Russian Federal Research Institute of Fisheries and Oceanography (VNIRO)
17. V. Krasnoselskaya
Moscow. 107140. Russia

Tel. (095) 264-95-32
Fax (095) 264-91-87

6. Mr. Alexander V. Buslov

Russia Kamchatka Fisheries and Oceanography Research Institute
Petropavlovsk-Kamchatsky. 683602
Naberezhnaya Street 18

Tel. (415-22)-2-19-35
Fax (415-22)-2-37-05

United States

7. Dr. Daniel K. Kimura 206-526-4200
8. Ms. Betty J. Goetz 206-526-4217
9. Ms. Nancy E. Roberson 206-526-4219
10. Mr. Charles E. Hutchinson 206-526-6502

Alaska Fisheries Science Center
Bldg. 4, BIN C15700
7600 Sand Point Way N.E.
Seattle, WA 98115-0070, U.S.A.

Fax. 206-526-4066
e-mail: Dan.Kimura@noaa.gov
Betty.Goetz@noaa.gov
Nancy.Roberson@noaa.gov
Charles.Hutchinson@noaa.gov

Document for STC meeting, Seattle
Sept. 1998

Outline of cruise plan for Echo integration and mid-water trawl survey on pelagic pollock in the Bering Sea (Tentative Plan)

National Research Institute of Far Seas Fisheries
Fisheries Agency of Japan

1. Cruise description and objectives

National Research Institute of Far Seas Fisheries (NRIFSF) will conduct an echo integration mid-water trawl survey of walleye pollock (*Theragra chalcogramma*) in the southeastern Aleutian Basin and eastern Bering Sea shelf area aboard the R/V *Kaiyo Maru* of Fisheries Agency of Japan. The primary objectives of the survey are:

1) To determine the geographical distributions of the walleye pollock in the southeastern Aleutian basin area and in the southern part of the eastern Bering Sea shelf.
2) To collect echo integration data to determine the biomass of walleye pollock in the area.
3) To collect biological information on walleye pollock in the basin and shelf area.
4) To collect the information on the oceanographic and biological environments during the winter in the area.

This survey will be a cooperative survey between NRIFSF/HNF and Alaska Fisheries Science Center (AFSC). Detailed survey plan will be discussed between the institutions and all data and information will be exchanged freely among the different agencies. The survey results will be used to determine biomass in the Specific Area that is defined in the Annex Part1-b in the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea.

2. Research Vessel

Name:	*Kaiyo Maru* (Fisheries Agency of Japan, Tokyo)
Type:	Stern trawler
Length:	93.01 meters
Tonnage:	2,630 tons
Hull color:	White

Radio call sign: JNZL

3. Crew and researchers on board

1) Crew: Captain Masaru Tanabe and 45 crew

2) Japanese Researchers

<u>Preliminary survey</u>

Akira Nishimura, National Research Institute of Far Seas Fisheries (NRIFSF)

Takashi Yanagimoto, NRIFSF

Youichi Miyanohana, National Research Institute of Fisheries Engineering (NRIFE)

Yoshimi Takao, NRIFE

Kouichi Sawada, NRIFE

Tsuyoshi Okumura, NRIFE

<u>Main survey</u>

Japanese researchers

Akira Nishimura, NRIFSF, (Chief scientist; biology)

Takashi Yanagimoto, NRIFSF, (Acoustic and oceanography)

Yoshimi Takao, NRIFE, Leg 1 (Acoustic)

Assistant researchers

Mitsutoshi Hamada, Tokyo University of Fisheries, (Acoustic)

Seiji Katakura, Hokkaido Tokai University, (Biology)

Undecided, (Biology & oceanography)

Undecided, (Oceanography)

Foreign researchers

(Undecided: Maximum 3-4 rooms are available)

4. Vessel Itinerary (Tentative)

Preliminary survey (in the adjacent waters of Tokyo)

Dec. 15, 1998	leave Tokyo
Dec. 16-21	Acoustic system calibration and noise measurements
Dec. 22	arrive Tokyo

Main survey (in the Bering Sea)

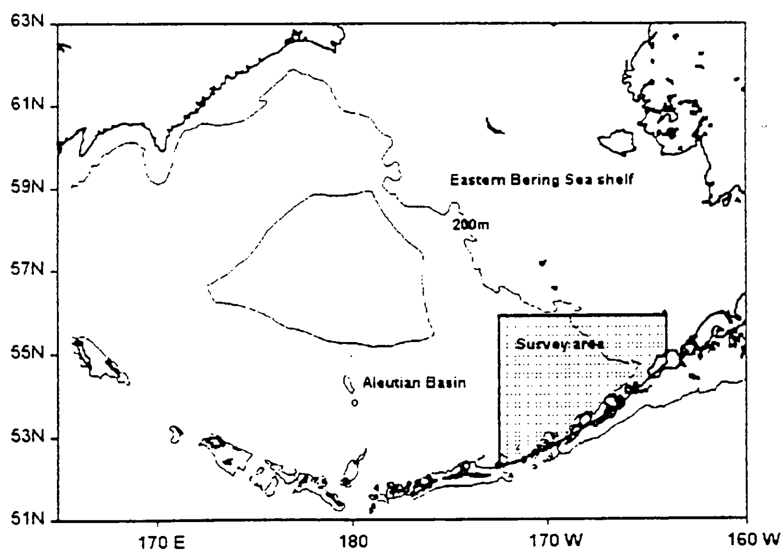
Jan. 21, 1999	leave Tokyo

Jan. 30-31 (U. S. date)	System calibration in the Captain's Bay of Unalaska Is.
Feb. 1-12	Leg 1 survey
Feb. 15	arrive Kodiak
Feb. 19	leave Kodiak
Feb. 22-23	System calibration in the Captain's Bay of Unalaska Is.
Feb. 23-Mar. 4	Leg 2 survey
Mar. 12 (Japanese date)	arrive Kushiro
Mar. 16	leave Kushiro
Mar. 19	arrive Tokyo; end of cruise

5. Research area

Southeastern part of the Aleutian Basin, and southern part of the eastern Bering Sea shelf area. All these survey areas are included in the U.S. EEZ.

Acoustic system calibration and pollock sampling by hook and line will be carried out in the Captain's Bay of Unalaska Island, inner 12-miles territorial limit seaward. We also plan to conduct our survey in the Specific Area (Bogoslof area) that is defined by the Annex Part 1 of the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea. To get the accurate biomass estimates of walleye pollock in the Specific Area, it is necessary to conduct a survey within the U.S. 12-miles territorial limit.



6. Research items

1) Preliminary survey (Dec. 15-21, 1998)

・Operation check of the acoustic systems

·Calibration of transmitter and receiver system

·Noise measurements

·Determination of standard parameters for acoustic systems

·Calibration between two systems (KJ2000 and EK500)

2)Main survey (Jan. 21-Mar. 19, 1999)

① Acoustic survey

·Calibration of acoustic system

·Target strength estimation by split-beam method

·Abundance estimation of walleye pollock by echo integration

·Inter-system calibration between KJ2000 and EK500

·Analysis of relationship between behavior of walleye pollock and echo strength

②Midwater trawl survey

·Weight and number measurement of catch by species

·Body length, weight measurement and collect biological data from gonad, otolith, stomach, and DNA sample.

·Collection of frozen samples of walleye pollock.

② Biological operation

·At selected stations, adult pollock will be collected by hook and line.

·Double NORPAC nets (0.154 and 0.333 mm mesh size) sampling

·ORI net sampling

·Continuous counting of zooplankton and monitoring of surface environment by EPCS (Electric Plankton Counting System)

④Oceanographic observation

·CTD casts and water sampling will be conducted at selected stations.

·Vertical profile of water temperature will be observed by XBT system.

·Collection of satellite data (NOAA HRPT)

7. Other measurements and observation for weather and sea conditions will be recorded.

POLLOCK GENETIC STOCK STRUCTURE
SAMPLING FOR MICROSATELLITE DNA ANALYSES

Project Overview:

Samples from populations of walleye pollock are being requested for population studies by researchers at National Marine Fisheries Service and the University of Washington. Genetic DNA markers of adult pollock will be used to determine population structure in the Bering Sea and Gulf of Alaska.

Fin Clip Samples

Fin clip samples are easy to collect and provide good quality DNA for extraction. Two general methods of preserving the tissues have been shown to yield acceptable DNA template: freezing in seawater and preservation in ethanol (ETOH). Both methods are outlined below.

For population analysis, fin clips from approximately 100 adult pollock should come from a single haul and be sampled as soon as is practical after they are on the deck. These tissues may be preserved as a group or individually as time, resources, or interest allow. If data on individuals (e.g. length, weight, sex, etc.) are being collected, than a fin clip from each individual may be preserved in a 1.5 ml microfuge tube in seawater (frozen) or ETOH.

Only a small amount of tissue is needed regardless of the method of preservation. Consider that a fin clip the size of a paper match will yield enough DNA for 10,000 assays. This becomes an important factor when preserving tissue with ETOH, where the ETOH/sample volume must be high to prevent sample degradation.

- **Ethanol (ETOH) preservation:**

Fill a 32oz. sample jar about 2/3 full of 95% ethanol. Grasp the first dorsal fin with the forceps and cut a **small** piece off from each adult. The risk of cross-contamination between fish is quite low but it is a good idea to rinse the tools (forceps, scissors, etc.) occasionally. **Not much tissue is needed; a piece about the size of paper match is enough. The volume ratio of ethanol:tissue should be about 4:1 or greater in the preservation jar or vial.** If it is less than 4:1, please use two jars and take smaller clips. There's no further DNA degradation once the samples are in ethanol so you need not worry about temperature once the samples are in the jar.

- **Preservation by freezing**:

Please put the fin clips in a plastic ziplock baggie, add enough seawater to cover them, and freeze them away at -20°C or colder.

Please record the date, latitude and longitude where the fin clips were collected. If individual samples are collected, please provide copies of data recorded on those individuals.

CRUISE PLAN FOR POLISH FISHING TRIAL OPERATIONS ON POLLOCK IN THE INTERNATIONAL WATERS OF THE BERING SEA IN 1999

1. Institution

Polish Deep Sea Fishing Companies - to be decided later

2. Polish Vessels

Name: to be decided later
Type:
Length:
Tonnage:
Radio call sign:
Immarsat no.

Detailed information will be provided to all Parties at least one month prior to commencement of trial fishing.

3. Research area

International waters of the Bering Sea. The detailed hydroacoustic trackline will depend on the availability of the vessels and will be determined before the cruise.

4. Time of trial fishing operation

To be decided later

5. Purpose

The purpose of trial fishing operation is:

a/ to determine the geographical distribution of pollock in the international waters of the Bering Sea;
b/ to estimate total catch weight for as many hauls as possible;
c/ to calculate the CPUE data;
d/ to determine species composition of catches;
e/ to collect biological data on pollock (length, sex, body weight, maturity);
f/ to complete forms as recommended in "Observer Manual for Sampling of Central Bering Sea Pollock Fisheries" March 1997 that is:

- Haul Summary Form,
- Species Composition Form,
- Length Frequency Form,
- Biological Samples Form.

6. Scientific observers

Observers will be trained and certified in the Sea Fisheries Institute, Gdynia in accordance with the procedures established by Poland and consistent with relevant aspects of the training for observer provided by the United States in March 1997.

7. Results

The reports and data collected during the cruises will be available to all Parties concerned.