INTERNATIONAL COMMISSION

FOR THE

NORTHWEST ATLANTIC FISHERIES

ANNUAL PROCEEDINGS

VOL. 4

for the year

1953-54

Issued from the Headquarters of the Commission

Halifax, N.S., Canada

1954

ROLPH - CLARKE - STONE, MARITIMES, LIMITED
HALIFAX, N. S.
OCTOBER, 1954

CONTENTS

Foreword

At the Third Annual Meeting, May, 1953, the Commission decided to establish its publications in two annual series, a "Statistical Bulletin" and an "Annual Proceedings". Occasional papers from the Commission may be published separately.

The Statistical Bulletin deals with the fisheries statistics of the Convention Area, mainly those for the year in question, but also with statistics for former years collected and compiled by the Commission.

The Annual Proceedings contain the Commission's reports for the year in question: the Administrative Report, the Report of the Annual Meeting, Summaries of Research by participating countries, certain Scientific Papers especially prepared for the Annual Meeting. This year's Proceedings in addition gives a list of scientists engaged in the various branches of the Commission's work, and of main laboratories concerned with this work.

The Statistical Bulletin for the year 1953 will be published towards the end of the year.

A list of the Commission's publications is found on the back of the cover.

Erik M. Poulsen,
Executive Secretary.

Halifax, October, 1954

PART 1

Administrative Report for the Year ending 30 June 1954

BY THE EXECUTIVE SECRETARY, ERIK M. POULSEN

1. Headquarters.

At the Annual Meeting in May, 1953, the Commission decided to establish its permanent headquarters in Halifax, N. S., Canada, and in offices in the Forrest Building of Dalhousie University offered to the Commission by that University. During the summer of 1953 the new office rooms were re-fitted in a most satisfactory way by the University, and the Provincial Government of Nova Scotia provided liberally for the furniture needed in the office rooms. The moving of headquarters from St. Andrews, N. B. to Halifax, N. S. took place during the first days of September, 1953.

The Commission and the Secretariat in particular is greatly indebted to the Atlantic Biological Station of the Fisheries Research Board of Canada for the hospitality, help and friendship given during the two years in which headquarters was established in St. Andrews.

2. Secretariat.

On 27 May, 1954, Miss Johanne Welsh gave due notice of her wish to resign from her position as secretary to the Executive Secretary from 15 September, 1954, owing to her forthcoming marriage. Miss Welsh has during her three years with the Commission carried out her work in a most efficient way and to the complete satisfaction of the Commission.

3. Officers.

At the Annual Meeting, May, 1953, Dr. Stewart Bates (Canada) was elected Chairman of the Commission for the next two years and Captain Tavares de Almeida (Portugal) Vice-Chairman for the same period.

At the same Annual Meeting the following elections of Chairmen for the Panels for the next two years took place:

Panel 1: Mr. Klaus Sunnanaa (Norway)
Panel 2: Mr. Louis S. Bradbury (Canada)
Panel 3: Comm. H. F. Barbier (France)
Panel 4: Mr. Vincente Trelles (Spain)*
Panel 5: Mr. B. M. Knollenberg (U.S.A.)

Further Dr. C. E. Lucas (United Kingdom) was elected Chairman of the Standing Committee on Research and Statistics, and Mr. J. Howard MacKichan (Canada) was re-elected Chairman of the Standing Committee on Finance and Administration for the coming year.

Finally the following elections of Chairmen of Subcommittees took place:

Subcommittee on Cod-Haddock
Dir. G. Rollefsen (Norway)
Subcommittee on Redfish-Halibut
Dr. Herbert W. Graham (U.S.A.)
Subcommittee on Hydrography
Dr. A. W. H. Needler (Canada)

At the Annual Meeting, June 1954, the Chairmen of the two standing committees and of the subcommittees on Cod-Haddock and Redfish-Halibut were re-elected. The vacancy in the chairmanship of the subcommittee on Hydrography, caused by Dr. Needler's leaving the Commission (See Rep. of Fourth Annual Meeting, p. 15), was not filled.

4. Panel Memberships.

Following revision by the Commission at the Annual Meeting June, 1954 Panel memberships are:

Country	Panel No. 1	2	3	4	5	Total
Canada		+	+	+	+	4
Denmark	+					1
France	+	+	+	+		4
Iceland						0
Italy	+	+	+	+		4
Norway	+					1
Portugal	+	+	+	+		4
Spain	+	+	+	+		4
United Kingdom	+		+			2
United States			+	+	+	3
TOTAL	7	5	7	6	2	27

*At the Annual Meeting, June, 1954, Mr. C. L. Chicheri, Spanish Commissioner, took over the Chairmanship of Panel 4.

5. Newsletters.

Four newsletters were distributed from headquarters in order to circulate information relevant to the Commission's activities to Commissioners, Experts and Advisers as well as to certain persons or institutions outside the Commission who would be interested. The newsletters were issued on 20 July, 1953, 2 December, 1953, 17 February, 1954, and 21 May, 1954.

6. Commission's Publications.

According to decision taken at the Annual Meeting May, 1953, the Commission's annual publications are now divided in two series: Annual Proceedings and Statistical Bulletin. Occasional papers may be published separately.

The Annual Proceedings Vol. 3 for the year 1952-53 was distributed during December 1953.

The Statistical Bulletin for the year 1952 was distributed during March 1954.

7. Co-operation with other International Organizations.

During the year the Secretariat was in close contact with the Food and Agriculture Organization of the United Nations (FAO) as well as with the Conseil Permanent International pour l'Exploration de la Mer (ICES).

The Commission was represented at the Annual Meeting of ICES in Copenhagen in October, 1953 by the Executive Secretary. This opportunity was used i.a. for considerations with the General Secretary of ICES regarding various administrative matters, f.i. the exchange of publications and for discussions with the Statistician of ICES of various problems connected with the collecting and treatment of statistical information.

The Commission was represented at the Paris Session of the International Fishing Boat Congress (FAO) in October, 1953 by the Executive Secretary. During a stay in Rome in October, 1953 the Executive Secretary attended the Meeting of the General Fisheries Council for the Mediterranean (FAO) and had conferences with various fisheries officers of FAO, especially concerning the collection of statistical information and the treatment of statistical data.

Further the Commission was represented by its Chairman at the Meeting of the International North Pacific Fisheries Commission in Washington in February, 1954.

During a stay in London in November 1953 the Executive Secretary had considerations with the President of the Permanent Commission set up in connection with the International Fisheries Convention of 1946, Mr. R. G. R. Wall, concerning the possible co-operation between that body and ICNAF. Later, through an exchange of letters (25 March and 14 April, 1954) between the President of the Permanent Commission and the Chairman of this Commission, it was agreed that representatives of each Commission be free to attend the appropriate meetings of the other as observers and that each should freely exchange copies of reports and publications.

The Third Meeting of the Permanent Commission took place in Copenhagen in the first week of May, 1954. Dr. Paul M. Hansen who attended the meeting acted as observer for ICNAF, and has forwarded to the Secretariat a report covering the meeting.

The special collaboration between the Northwestern Subarea Committee of ICES and the Panel for Subarea 1 was continued.

The regular exchange of publications has been maintained with FAO and ICES.

8. Larger Travels.

From September to November the Executive Secretary travelled in Europe. Apart from attending FAO and ICES meetings and having discussions with various officers of FAO, ICES and the Permanent Fisheries Commission (see under item 7) he visited the following countries: Denmark, France, Italy, Spain, Portugal and the United Kingdom. In these countries he visited various fishing ports, fisheries establishments and marine research institutions, and had conversations with the authorities of these countries concerning Commission matters. The travel in Portugal and Spain followed an invitation by the delegations of these countries who attended the Third Commission Meeting.

In October the Commission Statistician visited various marine biological institutions and fishing ports at the coasts of Quebec, the Maritimes, and New England.

9. Meetings within the Commission during the year.

A meeting of the Panel for Subarea 1 was held in Copenhagen on 6 October, 1953, with Klaus Sunnanaa in the Chair. Present were Commissioners, partly with advisers, from the following countries, being members of the Panel: Denmark, France, Norway, Portugal, Spain and the United Kingdom. Observers from Canada, Iceland, and the United States were present. From the Secretariat the Executive Secretary and Miss Johanne Welsh attended the meeting (as the other ICNAF meetings held in Copenhagen). Reports were delivered on research work carried out and on the status of the fisheries in the Subarea. Considerations took place relevant to the collecting of statistics, methods used in reporting of researches, and the planning of future work.

The Subcommittee on Cod-Haddock met in Copenhagen on 7 October, 1953 with G. Rollefsen in the Chair. Nominees from the following countries were present: Canada, Denmark, France, Iceland, Norway, Portugal, Spain, U.K., and U.S.A. The considerations dealt mainly with the problems of standardization of techniques for sampling, and with the investigations of cod in Subareas 1 and 4.

The Subcommittee on Redfish-Halibut met in Copenhagen on 7 October, 1953 with Herbert W. Graham in the Chair. Nominees from Canada, Denmark, France, Iceland, Norway, U. K., and U.S.A. were present. The problem of standardization of techniques for research work was considered. As to redfish it was agreed that in particular the following questions should be studied: The systematics of the North Atlantic redfish, the methods of age-determinations, and tagging. As to halibut it was recommended that measurements of samples be made and proportions of small halibut be recorded.

The Subcommittee on Hydrography met in Copenhagen on 8 October, 1953 with C.E. Lucas (replacing the Chairman A. W. H. Needler) in the Chair. Nominees from Canada, Denmark, France, Iceland, Norway, Portugal, Spain, U.K., and U. S. A. were present. The hydrographic research program for the Convention Area was discussed, and the subcommittee agreed to certain main points that first and foremost should be considered. Further it was recommended that a review of hydrographic conditions in the Area and of the explorations under way should be prepared,* together with a draft form for reporting hydrographic information to ICNAF.

Meetings of the Groups of Advisers to Panels 4 and 5 took place in St. Andrews on 9-11 December, 1953 and in Woods Hole on 3-5 March, 1954. Advisers to Panel 4 had met in Copenhagen on 8 October, 1953. Advisers to Panel 5 reported on the effect of the newly introduced regulations of the haddock fishery in Subarea 5 and considered the planning of the future researches in the Subarea. The Advisers to Panel 4 reported on researches and considered the collecting of statistics from the Subarea, and the planning of future researches. A report on the activity of the Group of Advisers to Panel 5 during the year 1953-54 and a report on the 1953-54 activity of the Group of Advisers to Panel 4 were circulated for the Annual Meeting 1954.

10. Haddock Regulations in Subarea 5.

The Commission's amendments to the regulation of the haddock fishery in Subarea 5, as adopted at the Annual Meeting 1953, were on 11 June, 1953 transmitted to the Depositary Government. On 14 October, 1953 the Secretariat was notified by the Depositary Government that as the proposal for the amendments to the regulations of the haddock fishery in Subarea 5 was accepted by the Governments of Canada and U.S.A.—the two Governments holding memberships in Panel 5—it would come in force for all Contracting Governments on 1 January, 1954. The Depositary Government was further noti-

*See Part 4 of this Annual Proceedings.

fied of the acceptance of the proposal by Norway on 21 September, 1953, by United Kingdom on 23 October, 1953 and by Portugal on 9 March, 1954.

11. Research Summaries.

According to Commission's recommendation at the Annual Meeting, 1953 research summaries for 1953 were forwarded to the Secretariat during January-May, 1954. These summaries, by Canada, Denmark, France, Iceland, Norway, Portugal, Spain, United Kingdom and U.S.A. have been circulated from headquarters as documents for the Annual Meeting, 1954, together with a summary by subareas, and are printed in this Proceedings (Part 3).

12. Research Programs.

According to Commission's decision research programs for 1954 were forwarded to the Secretariat during November, 1953—March, 1954 by Canada, Denmark, France, Iceland, Norway, Portugal, Spain, United Kingdom and U.S.A. They were circulated from headquarters during the same months, together with a summary of the programs.

13. Collecting of Statistics.

The collecting of statistical data for the Commission has during the year developed in a satisfactory way, and in closer accordance with the requirements than formerly. Nearly all landings are now attributed to subareas. Some countries have already reported landings according to subdivisions and/or to months. Collections of data on fishing efforts have been made, and in the Statistical Bulletin for the year 1952 for the first time calculations of catch per fishing units have been published.

In co-operation with FAO and ICES various problems concerning statistics have been considered, i.a. the problems connected with size-categories.

14. Fourth Annual Meeting.

The Fourth Annual Meeting was held in Halifax, N. S. in the days 14-18 June, 1954. It was preceded, 10-12 June, by meetings of subcommittees and groups of Advisers (see this Annual Proceedings, Part 2).

15. Other Matters.

According to Commission's decision the following papers have been circulated from headquarters: (1) annotated lists of pertinent papers published during 1951-53, (2) a list of scientists engaged in Commission's work (see Part 5).

A survey of Commission's Planning of and Reporting on Research Work in the Convention Area, being a compilation of existing recommendations and actions based on them, was circulated from headquarters on 14 August, 1953.

An extract and translation of a German paper by Dr. Arno Meyer concerning German Fishery and Research work in West Greenland waters was circulated from headquarters on 22 December, 1953.

16. Financial Statements for the Fiscal Year ending 30 June, 1954.

The accounts of the Commission for the year ending 30 June, 1954 show an appropriation of $ Can. 33,130.00 and a total expenditure of $29,267.91, leaving an unobligated balance of $3,862.09.

During the year the sum $5,000 transferred in the fiscal year 1952-53 from the Working Capital Fund to the General Fund, was retransferred to the Working Capital Fund.

A transfer of $2,021.24 was made from the Working Capital Fund to the General Fund to cover deductions in contributions billed for 1952-53 (vide Annual Meeting, 1953, Document No. 17).

The accounts are summarized in the three Financial Statements below.

The audit of the Commission's finances for the fiscal year ended 30 June, 1954, was made by the Auditor General's Office of the Government of Canada in August, 1954.

Statement 1

Budget appropriations, obligations incurred, and unobligated balances of appropriations for the fiscal year 1953-54

Purpose of Appropriation	Appropriated by Commission at Annual Meeting 1953	Obligations incurred and liquidated	Unobligated Balances of Appropriations
Personal services	$19,430.00	$19,427.48	2.52
Travel, including subsistence	5,000.00	4,015.83	984.17
Transportation of things	500.00	358.14	141.86
Communication services	800.00	779.31	20.69
Rent and utility services	1,000.00	70.00	930.00
Other contractual services including printing	2,700.00	2,527.25	172.75
Supplies and material	1,000.00	899.23	100.77
Equipment	2,000.00	743.30	1,256.70
Annual Meeting	700.00	447.37	252.63
TOTAL	$33,130.00	$29,267.91	$3,862.09

Statement 2

Statement of income and expenditure for the year ended 30 June, 1954

Income:			
Unobligated balances from the year ending 30 June, 1953			$ 3,374.78
Members' contributions assessed:			
Canada	$ 4,546.12		
Denmark	1,531.52		
France	4,546.12		
Iceland	526.66		
Italy	4,546.12		
Norway	1,531.52		
Portugal	4,546.12		
Spain	3,541.25		
United Kingdom	2,536.40		
United States	3,541.25		
		$31,393.08	
Less credits due to member Governments			
Actual unobligated balances from year ending 30 June, 1953	$ 3,374.78		
Estimated unobligated balances on which contributions were calculated	1,736.92		
		1,637.86	
			$ 29,755.22
TOTAL			$33,130.00
Deduct—obligations incurred (and liquidated) (Statement 1)			$29,267.91
Excess of income over obligations incurred, carried to surplus account			$ 3,862.09

Statement 3

Statement of assets and liabilities as at 30 June, 1954

GENERAL FUND

Assets			Liabilities	
Cash at bank		$ 2,464.71	Credits due to member Governments as per statement 2 for fiscal year ended 30 June, 1953	$ 5,281.97
Contributions receivable			Credits due to member Governments as per statement 2 for fiscal year ending 30 June, 1954	1,637.86
Italy:			Surplus (Statement 2)	3,862.09
1952-53	$3,704.86			
1953-54	4,546.12			
	$8,250.98			
Spain:				
Deficit on exchange rate, contribution				
1951-52	20.73			
1953-54	45.50			
	$ 66.23	$ 8,317.21		
TOTAL:		$10,781.92	TOTAL:	$10,781.92

WORKING CAPITAL FUND

Assets		Liabilities		
Cash at bank	$ 5,793.26	Credits due to member Governments		
Contributions receivable		from Italian contribution	$ 626.97	
Italy:	626.97	from French contribution	526.66	
				1,153.63
		Principal of Fund		5,266.60
TOTAL:	$ 6,420.23	TOTAL:		$ 6,420.23

The Report from the Auditor General's Office, of 7 September 1954, says:

"No provision has been made in the 1953-54 accounts for obligations of approximately $375.00* incurred in June. Subject to this minor reservation I certify, as required by Section 11 (2) of the Financial Regulations for the Commission, that:

(a) the financial statements are in accord with the books and records of the Commission; and

(b) the financial transactions reflected in the statements have been in accordance with the rules and regulations; the budgetary provisions, and other applicable directions; and

(c) monies on deposit have been verified by certificate received direct from the Commission's depositary."

* The amount of $375.00 referred to in the Auditor's certificate represents accounts paid in July 1954 and which were not received in sufficient time to be included in the 1953-54 accounts. Executive Secretary.

PART 2

Report of the Fourth Annual Meeting

14 - 18 June, 1954

BY THE CHAIRMAN — STEWART BATES

1. Time and Place of Meeting.

The Fourth Annual meeting of the Commission was convened on June 14, 1954, in the Board and Senate Room of Dalhousie University, Halifax, Nova Scotia. Following the opening ceremony, the meeting reconvened in the Forrest Building and continued on June 15, 16, 17 and 18. The Commission meeting was preceded by a three-day meeting of the Special Sub-Committees on the Commission's research program.

2. Participants (see Appendix I)

Commissioners were present from Canada, Denmark, France, Norway, Portugal, Spain, the United Kingdom and the United States. Most of them were accompanied by advisers. The Food and Agriculture Organization of the United Nations was represented by an observer, while the International Council for the Exploration of the Sea, the International Fisheries Convention 1946, and the North Pacific Fisheries Commission were represented by various Commissioners.

3. Opening Remarks.

The Chairman, Dr. Stewart Bates, Canada, opened the meeting. Addresses of welcome were given by the Provincial Treasurer, the Hon. R. M. Fielding, Q.C., on behalf of the Premier of the Province, the Hon. Harold Connolly; Mayor Richard A. Donahoe, Q.C., of Halifax; Dean Horace Read, of Dalhousie University Law School, on behalf of the Dalhousie University President; Mr. A. I. Barrow, of the Halifax Board of Trade. The Vice Chairman, Captain Tavares de Almeida of Portugal, thanked the province, city, university and Board of Trade for their hospitality.

4. The Agenda (see Appendix II).

When the meeting reconvened in the Forrest Building, Dr. Bates welcomed the participants. The Agenda, which had been circulated to all Commissioners 60 days prior to the meeting, was adopted on a motion by Norway and seconded by the United Kingdom.

5. Policy with Regard to Publicity for Meeting.

The Chairman informed the meeting that Canada had loaned the services of two press officers to assist in keeping the public informed, and asked for nominations for a two-man committee to approve press releases prepared for issue. Dr. C. E. Lucas (U.K.) and Mr. W. M. Terry (U.S.A.) were appointed.

6. Review of Panel Memberships.

The Chairman of the Standing Committee on Finance and Administration recommended approval of the request of Spain to become a member of Panel 2. The Commission agreed. No other changes in panel memberships were recommended and they exist now as follows:

Canada		2	3	4	5
Denmark	1				
France	1	2	3	4	
Iceland					
Italy	1	2	3	4	
Norway	1				
Portugal	1	2	3	4	
Spain	1	2	3	4	
U.K.	1		3		
U.S.A.			3	4	5

It was noted by the Commission that Italy had not provided information on statistics and catches for the separate subareas on which it had panel membership. The chairman said that this matter would be mentioned to that government when the Executive Secretary wrote regarding arrears in membership contributions.

7. Report on Staff Matters.

The Commission received a report from the special committee appointed to study the matter of superannuation for staff members. The staff gave their approval to the plan, the Commission was advised, and it was decided to implement it promptly if satisfactory arrangements could be effected by the Governments of Canada and the United States. The Commission also accepted a recommendation by the Standing Committee on Finance and Administration that the Executive Secretary be given an increase in salary to $9,000 per annum. It was also agreed that the salary of the stenographic and clerical staff be increased to $3,100 for the senior post and to a maximum of $3,036 for the junior post; that the post of Statistician be abolished on three months notice and that a Biologist-Statistician be engaged at a salary ranging from $4,000 to $5,250.

8. Budget.

The Commission approved the recommendation of the Committee on Finance and Administration to appropriate $33,686 for the year 1954-55 for the following purposes:

Personal Services	$21,386
Travelling	4,000
Transportation	200
Communication Services	1,000
Rent and Utility Services	300
Other Contractual Services including printing	4,400
Supplies and Materials	1,100
Equipment	500
Annual Meeting	800
Total	$ 33,686

At the same time the Committee estimated that the budget for 1955-56 would approximate $35,000. This estimate was noted by the Commission. Mr. J. Howard MacKichan was re-elected chairman of the Committee for another term.

9. Report of the Standing Committee on Research and Statistics.

Several papers dealing with the Commission's statistics, publications, research and editorial work were placed before the Committee and circulated among all delegates. After consideration in an ad hoc sub-committee on Statistics the following recommendations by the Committee were approved by the Commission:

Statistics.

(a) That all Contracting Governments in submitting statistics where the fishing effort is directed toward more than one species, allocate the effort where possible by species, (i.e. cod, haddock, redfish and halibut).

(b) That in cases where special studies are carried out on indices of abundance these indices be submitted as supplementary information appended to the annual statistical report submitted to the Commission.

(c) That in cases where a species is landed in more than one state[1]) and where it is not possible to report the state in which first weighed, an estimate should be supplied of the approximate quantities landed in each state.

(d) That the requirement for monthly statistics (Ann. Proc. 3, rec. no 7, p. 15) be amended to read: "That the participating governments be requested as a minimum to compile their statistics of total catches by subdivisions on a monthly basis and their statistics by gear and effort on an annual basis by subdivisions." It was recognized however that special information might be required from time to time and the Committee noted the suggestions of the sub-committee on statistics concerning certain differences in priority.

(e) That the following classification of fishing vessels be used in submitting statistical reports:

Otter Trawlers, Long Liners and Dory Schooners

Group 1:	50 gross tons and under
Group 2:	51—150 gross tons

[1]) headed, gutted, salted, etc.

Group 3: 151—500 gross tons
Group 4: 501—900 gross tons
Group 5: Over 900 gross tons

(f) That the countries be asked to supply every three years a list of their vessels fishing in the Convention Area to keep the Commission records up to date and to furnish a basis for reviewing the classification of vessels used in submitting statistics.

Conversion Factors.

That in view of the programs under way for 1954 the Commission defer action on revision of conversion factors until the next annual meeting when the whole question should again be reviewed.

Statistical Bulletins.

(a) That a draft copy of the Bulletin as prepared for publication be referred back for checking to individuals in each Government responsible for submission of statistics and that sections of the Statistical Bulletin dealing with interpretations of these statistics should be referred to a referee before publication.

(b) That in subsequent bulletins graphs of landings and indices of abundance by subareas and years be included wherever the pertinent statistics are available.

Ad Hoc Committee on Systematics.

That the report of the ad hoc committee established to consider the problem created by the diversity and confusion of common names of fishes in the languages of the several member nations be approved. (Ad hoc Committee on Systematics, meeting of June 15, App. to Proc. No. 14).

Sub-Committee for Hydrography.

That the report of the Sub-Committee for Hydrography (attached to Proc. No. 11) and its recommendations for the Commission's hydrographic work in the Convention Area be adopted.

Dr. C. E. Lucas (United Kingdom) was re-elected chairman of the Committee for another term.

10. Report on Haddock Regulations for Subarea 5.

The Commission had referred to Panel 5 the question of a proposed amendment to the regulation exempting a specified maximum percentage of the catch of haddock by each country to ensure that there was no hardship on fishermen seeking other lucrative species. The scientific advisers to Panel 5 recommended that no amendment was needed at this time since analysis of U.S. data indicated that among vessels of less than 50 gross tons, there was no undue hardship on the fishermen and that exemption of vessels of 50 gross tons and over would result in an exemption of 10 percent of the catch. The Commission noted the observation of the Panel that important principles of exemption were involved and further serious consideration was required.

11. Reports of Special Committees on the Commission's Research Program.

The reports of the sub-committees on hydrography, cod-haddock, and redfish-halibut, were considered at a special meeting of a group comprising the chairman of the Committee on Research and Statistics and the chairmen of the three sub-committees.

This sub-committee of chairmen agreed (Proc. No. 3) that the various special sub-committees be kept in being and that many other special problems coming before the Committee on Research and Statistics could most suitably be discussed in the first place by ad hoc sub-committees who would terminate their work when they reported back to the parent committee. The Commission approved this report on the recommendation of the Standing Committee on Research and Statistics. The reports of the sub-committees indicated that much progress was being made in the Commission's overall research program.

12. Reports of Meetings of Panels 1 to 5.

The Commission received and approved the reports of Panels 1 to 5. All panels reviewed the status of the fisheries and their research programs in relation to the more comprehensive research program adopted by the Commission last year.

The Commission noted that Panel 1 did not recommend any regulation of the fishery in Subarea 1. Spain reported it intended to start research work in the subarea in the near future. Countries fishing the nearly virgin stock of redfish in the southern part of the subarea will be asked to sample for length, age and sex the commercial catches of redfish. It was recommended that Iceland be asked to take membership in Panel 1 and Germany be invited to consider adherence to the Convention.

The Commission noted that a meeting of Panel 1 would likely be held in connection with the I.C.E.S. meeting in Paris in October, 1954.

Panel 2 reported that the question of the elaboration of a detailed research program for Subarea 2 was deferred until the scientific advisers for the adjacent Panel 3 had reported. It was thought that research work in Subarea 2 would undoubtedly receive some discussion during the various meetings of the scientific advisers to Panel 3.

Panel 3 reported the establishment of a scientific advisory committee with representation from Canada, France, Portugal, Spain, the United Kingdom and the United States. The Commission was advised that the advisory committee held two meetings during the latter part of the annual meeting, elected Dr. Wilfred Templeman (Canada) as chairman and tentatively set future meeting dates for December in St. Andrews, N. B. and for March in St. John's, Newfoundland.

Panel 4 reported that its scientific advisers had no definite recommendation in favour of a regulation providing a minimum mesh size in otter trawls (similar to that in Subarea 5) pending more thorough analysis of existing data and collection of some supplementary data and the completion of experiments in progress on the selectivitity of small otter trawls and line fishing gear. It was hoped that by early winter these further investigations would have reached the stage where recommendations regarding regulations would be possible. In this connection Dr. Bates (Canada) noted that enforcement difficulties arising from the movement of fishing vessels from one subarea to another made it desirable to consider the advisability of bringing such regulations into force simultaneously in all subareas and that this might make action by Panel 4 less urgent.

Panel 5 reported that studies of the effect of mesh regulation corroborated previous observations that the boats using the large-mesh nets catch more large fish than the boats using the small-mesh nets, and the large-mesh boats have landed a greater poundage of fish than the small-mesh boats.

13. Report of Copenhagen Meeting of Panel 1.

The Commission noted and approved the report of the Copenhagen Meeting of Panel 1, October 6, 1953.

14. Submission by FAO.

The Commission noted a paper (See Appensix III) submitted to it at the first plenary session by Dr. G. L. Kesteven (FAO) and agreed to refer it to the Standing Committee on Research and Statistics. The Committee will study F.A.O.'s paper and report back to Commission at the next annual meeting.

15. Special Meetings.

Prior to the first plenary session of the Commission, the sub-committee on cod and haddock held a meeting on June 11, 1954 to receive reports from member countries on fishing efforts, fishing areas and changes in size distribution of cod. The sub-committee on redfish-halibut held a meeting on June 12, 1954, and recommended that the Committee on Research and Statistics organize a symposium on redfish biology at the Fifth Annual Meeting of the Commission.

16. Date and Place of Next Annual Meeting.

The Chairman announced an invitation had been received from the Canadian Government to hold the Fifth Annual Meeting of the Commission in Ottawa. The Commission unanimously agreed to accept the invitation and will meet there on the second Monday of June, 1955.

Concerning the question of where and how often to hold Commission Meetings it was found that this would involve altering the clause in the Convention: Article II 5: "The Commission shall hold a regular annual meeting at its seat or at such place in North America as may be agreed upon by the Commission". It was agreed that the procedure for effecting an alteration should be explored before the 1955 Annual Meeting, and the question brought before the Commission at that Meeting.

17. Statement by Chairman and Votes of Thanks.

The departure of Dr. A. W. H. Needler (Canada) to Canada's west coast where he will devote his scientific energies in another region was referred to by the Chairman, and the Commission heartily endorsed his remarks concerning Dr. Needler's valuable contribution to the work of the Commission since its early days. Mr. A. T. A. Dobson (United Kingdom) voiced the appreciation of the Commission for the hospitality and entertainment provided the delegates by the Nova Scotia Government, the City of Halifax, the Boards of Trade of Halifax and Lunenburg, the Town of Lunenburg, the Canadian Atlantic Salt Fish Producers and the Nova Scotia Fish Packers Association. Mr. Dobson made special mention of the generous facilities extended to the Commission by Dalhousie University. Mr. B. Knollenberg, (United States) warmly supported Mr. Dobson's remarks. Mr. Dobson also moved a vote of thanks to the Canadian Auditor General for auditing the 1952-53 financial statement of the Commission. Dir. G. Rollefsen (Norway) spoke on behalf of the International Fisheries Convention 1946 and expressed the desire of that body to continue to co-operate with the Commission in its fisheries studies.

In his concluding remarks the Chairman expressed the Commission's thanks to all those who had contributed to make the meeting a success, including the chairmen of the various committees. He particularly referred to the contribution of Mr. Dobson to the work of the Commission since its inception. Reference was made to the excellent work of the Secretariat. In this connection the imminent resignation of Miss Welsh was noted with regret and the Commission agreed to vote an honorarium of $250 to her as a token of appreciation for her faithful service.

The observers for I.C.E.S., F.A.O. and the International North Pacific Fisheries Commission thanked the Commission for the opportunity of attending and the meeting then adjourned.

APPENDIX I

LIST OF PARTICIPANTS

CANADA

Commissioners:

Dr. Stewart Bates, Deputy Minister of Fisheries, Ottawa.

Louis S. Bradbury, Chairman, Newfoundland Fisheries Board, St. John's, Newfoundland

J. Howard MacKichan, General Manager of the United Maritime Fishermen, Halifax, Nova Scotia.

Advisers:

Loran E. Baker, Fisheries Department, Eastern Division, Halifax, Nova Scotia.

Allister Fleming, Newfoundland Fisheries Research Station, St. John's, Newfoundland.

Dr. H. B. Hachey, Atlantic Oceanographic Group, Atlantic Biological Station, St. Andrews, N. B.

Dr. J. L. Hart, Director, Pacific Biological Station, Nanaimo, British Columbia.

F. D. McCracken, Atlantic Biological Station, St. Andrew's, N. B.

Dr. W. R. Martin, Groundfish Investigations, Atlantic Biological Station, St. Andrews, N. B.

Dr. A. W. H. Needler, Director, Atlantic Biological Station, St. Andrews, N. B.

Dr. W. Templeman, Director, Newfoundland Fisheries Research Station, St. John's, Newfoundland.

DENMARK

Commissioners:

B. Dinesen, Under Secretary, Ministry of Fisheries, Copenhagen.

Dr. Å. Vedel Tåning, Head, Danish Institute for Fishery Investigations, Charlottenlund Slot, Charlottenlund.

Dr. P. M. Hansen, Head, Greenland Fishery Investigations, Charlottenlund Slot, Charlottenlund.

Advisers:

E. Jacobsen, Royal Danish Consulate General, New York, U.S.A.

L. Thygesen, Danish Westcoast Fishermen's Association, Esbjerg.

FRANCE

Commissioners:

J. Ancellin, Chief of the Scientific and Technical Laboratories of Marine Fisheries, Boulogne s/Mer.

H. F. Barbier, Representative of the French Merchant Marine in the United States and Canada, Washington, U .S. A.

M. Ravel, Assistant Director, Department of Marine Fisheries, Paris.

Adviser:

M. Eude, Chief, Marine Institute, St. Pierre et Miquelon.

ICELAND

Not represented.

ITALY

Not represented.

NORWAY

Commissioners:

B. Rasmussen, Institute of Marine Research, Directorate of Fisheries, Bergen.

G. Rollefsen, Director, Institute of Marine. Research, Directorate of Fisheries, Bergen

K. Sunnanaa, Director of Fisheries, Directorate of Fisheries, Bergen.

PORTUGAL

Commissioner:

Capt. T. de Almeida, Fishery Department, Lisbon.

Adviser:

Dr. Mario Joao de Oliveira Ruivo, Institute, for the Study of Fisheries, Lisbon.

SPAIN

Commissioners:

C. Lopez Chicheri, Commercial Attaché Spanish Embassy, Ottawa.

M. De Carlos, Commander in the Spanish Navy.

Advisers:

Dr. O. Rodriguez Martin, Direccion General de Pesca Maritima, Madrid.

P. Diaz de Espada, Technical Director, PYSBE, San Sebastian.

A. Rojo, Biologist for the ICNAF area.

UNITED KINGDOM

Commissioners:

A. T. A. Dobson, Fisheries Adviser, Ministry of Agriculture and Fisheries, London.

Dr. C. E. Lucas, Director, Marine Laboratory, Scottish Home Department, Aberdeen.

R. S. Wimpenny, Deputy Director, Fisheries Laboratory, Lowestoft.

UNITED STATES

Commissioners:

B. Knollenberg, Chester, Connecticut.

F. W. Sargent, Director, Division of Marine Fisheries, Department of Conservation, Boston, Massachusetts.

A. Suomela, Assistant Director, Fish and Wildlife Service, Washington, D. C.

Advisers:

Dr. Herbert W. Graham, Chief, North Atlantic Fishery Investigations, Fish and Wildlife Service, Woods Hole, Massachusetts.

Lawrence Rosen, Usen Trawling Co., Boston, Massachusetts.

W. M. Terry, Office of Foreign Activities, Department of the Interior, Washington, D. C.

Dr. Lionel A. Walford, Chief, Branch of Fishery Biology, Fish and Wildlife Service, Washington, D. C.

Assistant Advisers:

Howard H. Eckles, Marine Biologist, Branch of Fishery Biology, Fish and Wildlife Service, Washington, D. C.

J. Clark, J. Colton, G. Kelly, C. Taylor, J. P. Wise, R. Wolf; Fish and Wildlife Service, Woods Hole, Massachusetts.

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Observer:

G. L. Kesteven, Fisheries Biology Branch, Food and Agriculture Organization of the United Nations, Rome, Italy.

INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA

Observers:

A. T. A. Dobson, President, International Council for the Exploration of the Sea, Charlottenlund Slot, Charlottenlund, Denmark.

Dr. Å. Vedel Tåning, Vice-President, International Council for the Exploration of the Sea, Charlottenlund Slot, Charlottenlund, Denmark.

INTERNATIONAL FISHERIES CONVENTION 1946

Observer:

Dir. Gunnar Rollefsen, Vice-President of the Permanent Commission, London, England.

INTERNATIONAL NORTH PACIFIC FISHERIES COMMISSION

Observers:

Dr. Stewart Bates, Chairman, International North Pacific Fisheries Commission, Vancouver, British Columbia, Canada.

A. W. H. Needler, Director, Atlantic Biological Station, St. Andrews, New Brunswick, Canada.

A. Suomela, Assistant Director, Fish and, Wildlife Service, Washington, D. C. U.S.A.

PRESS OFFICERS

L. Manchester, Department of Fisheries, Ottawa, Ontario.

A. C. Wyn Rhydwen, Department of Fisheries, Halifax, Nova Scotia.

SECRETARIAT

Dr. Erik M. Poulsen, Executive Secretary.

J. Coté, Statistician.

Miss J. Welsh, Secretary.

Miss T. Devine, Clerk Stenographer.

Secretarial Assistants:

Miss N. E. Henderson, Zoology Department, Dalhousie University, Halifax.

Miss Jean Maclellan, Halifax.

Miss Kaye Morrison, Fisheries Department, Eastern Division, Halifax.

Mrs. M. E. McPhail, Atlantic Fisheries Experimental Station, Halifax.

Miss M. Parker, Fisheries Department, Eastern Division, Halifax.

Miss M. Wambolt, Fisheries Department, Eastern Division, Halifax.

APPENDIX II

AGENDA

1. Introduction by the Chairman
2. Adoption of Agenda.
3. Policy with regard to publicity for the Annual Meeting.
4. Review of Panel memberships.
5. Report on staff matters, including presentation of Administrative Report and Financial Statements for the year 1953/54.
6. Presentation of Auditor's Report for the financial year 1952/53.
7. Consideration of budget estimate for 1954/55.
8. Consideration of advance budget estimate for 1955/56.
9. Proposal for an increase of the Working Capital Fund from $ Can. 5,266.60 to $ Can. 10,000.00.
10. Report on Copenhagen Meeting of Panel 1, 6 October, 1953.
11. Reports on meetings of Subcommittees in Copenhagen, 7-8 October, 1953.
12. Report on meetings of Standing Committee on Finance and Administration, 15-18 June, 1954.
13. Report on meetings of Standing Committee on Research and Statistics, 14-18 June 1954.
14. Proposed amendment to the haddock Regulations for Subarea 5. The Scientific Advisers to Panel 5 recommend that the exemption of a specified maximum percentage of the catch of haddock by each country be allowed in order to ensure that the regulations do not interfere seriously with lucrative fisheries for other species.
15. Reports on Panel 1-5 meetings, 15-18 June, 1954.
16. Date and place of next Annual Meeting, including proposal by the Danish Delegation that no Annual Meeting of the Commission shall be held in 1955.
17. Other business.
18. Adjournment.

APPENDIX III

ADDRESS TO THE COMMISSION

BY DR. G. L. KESTEVEN, F.A.O., ROME

Delivered at Plenary Session, June 14, 1954

We sought this opportunity to speak to the informed and talented people assembled here as the International Northwest Atlantic Fisheries Commission because we wished to make known to you certain matters concerning our programme, and because among these matters there are certain items on which we should like to have your comment and advice, and others in respect of which we should wish to collaborate with you. These matters concern what has been called a survey of living aquatic resources—a subject on which our Division was given a directive by your Governments at the last Conference of FAO. There are, I believe, certain explanations which I should give before dealing with the particular items which I wish to place before you.

We are all aware of the urgency of the world food problem and although we may take different sides in the debate on the Malthusian formulation of this problem, we know that more food must be produced and that as far as we can see into the future we must continue to produce more and more: and this appears true even allowing for improvements which will be made in the arrangements and machinery for distribution. Also we know the gloomy forecasts which have been made concerning the future of food production from the land and, however strong may be our optimism concerning man's technology and his ability to deal with problems such as erosion and soil exhaustion, there must remain some misgivings as to the future if there could be no prospect other than that offered by land. In this situation the tag which proclaims the sea as man's last frontier has an arresting ring, and whatever may be one's opinion of the precise aptness of the phrase, we know that the waters of the world must yield more food. What is more we *know*, and the world now knows with us, that the waters of the world can yield substantially more food even with present technology and in present economies. How much more under these conditions, and how much even greater the yield under developed technology, are the 64-dollar questions. To the Government, to the industry, and to the consumer, the questions are: how much more, where, and by what methods? And it is the responsibility of fisheries science to answer these questions. The importance of finding answers to these questions is emphasized by a consideration of the present status of fisheries among world food industries. A friend of mine recently attempted a very rough evaluation of world production from living natural resources (that is, he had to include timber and fibres): in the total, fisheries production represented some $2\frac{1}{2}$ to 3%; although his calculations were tentative in the extreme, I should not be surprised if the relative value he assigned to fisheries proved to be not far from the mark; and if so, what would it mean to us? One of the papers at the UNSCURR meeting offered the conclusion that world fisheries production could perhaps be increased 25% to its limit: if this were true it would hardly be worthwhile regarding the sea as a kind of frontier in the food battle. Then, can we double, treble, or increase even more the total of fisheries production? I have sometimes said, to provoke my friend, "Ten times as much, eventually, with new technology in primary and secondary phases". You may say "Mere provocation", but whilst I did not seek this opportunity to speak only to propose guessing games, I think you might agree that to be able to suggest the order of magnitude of increase which might be expected would be a useful advance at least for those who are concerned with the world programme of food and agriculture. Yet even this, enlightened guess as it would be, would not be enough. Realistic policy-making and practical developments need answers to the questions: What kinds of fish are there in each distinct area, in what quantities, with what availability (the last including behaviour)? For a few areas a reasonable approximation can be made in respect of a few species; yet even for these, concerning which the data are drawn chiefly from commercial fishing operations, we cannot say how closely this realized exploitation approaches the total potential secondary productivity. There can be no doubt that we shall need eventually to approach this question and indeed, some of the separate parts of the problem are already making some concessions before the ingenuity of men such as Steemann Nielsen and Riley. But what can we say in the near future about the great areas of the waters of the world which at present are little touched or even quite neglected? At the UNSCURR meeting a first attempt was made in this sense: it was a very general statement in answer to the question: what kind of fish, where? But would it not be a good thing if we could have a series of maps, to cover the world, showing all present areas of fishing, followed by a second series showing what we know of the distribution of each important species including seasonal differences in distribution? This is, of course, zoogeography, and in making our maps we would make use of Bartholomew's Zoogeographic Atlas, of Ekman's Zoogeography of the Seas, and de Beaufort's corresponding work on inland waters. Again, it is doubtful whether anything like Hodgson's Herring Atlas could be prepared yet for any other species. On the other hand, these maps would be prepared for our particular, applied use and they would be accompanied by other maps on which would be marked observations of the various factors which we know or think play a role in determining distribution. Then, the transition is at least logically easy to begin to mark on the maps relative abundance within each distribution pattern, and the factors which we know or believe to determine abundance. Again, there would be a similar series concerning behaviour and availability to fishing and the factors influencing these.

When we refer to a resources survey, we mean a programme which will seek to bring together all the information we have which could be used for a purpose such as I have just described In effect, an appraisal of what we know, and if we made this, we should open up two other major avenues of enquiry. Firstly, is our present use of our resources fully consistent with the entire range of our knowledge? Secondly, what new knowledge must we seek? Both of these questions direct attention upon our methods of exploitation of our resources and our theories concerning this; and equally they direct attention upon the theory and methods of our science: how to survey an area, how to appraise its resources, measure its productivity, plan its exploitation.

At this stage, I must explain that I am referring to the resources survey chiefly from the point of view of the Biology Branch of the Fisheries Division. It must not be thought that the technological, and the even more difficult economic, problems of present-day fisheries have been overlooked. I believe that the article in Volume 6, No. 5 of the FAO Fisheries Bulletin, 1953, showed that we recognized the nature and importance of these problems. In the resources survey, also, there will be constant reference to economic and technological aspects.

As I said at the beginning, your Governments at the last Conference of the FAO, gave the Fisheries Division, and more particularly, the Biology Branch, a directive to do work in connection with the survey of living acquatic resources from which would come, among other things, a world manual of fishery maps; the result of which would be to show us what we know at present concerning these resources and what more we need to find out about them; and in the course of this work, we should find ourselves taking stock of the theory and methods of our science and seeking ways to develop and improve it. But how is this to be done?

As we see it, there should be two courses to follow. Along the one we should embark upon a systematic gathering and reduction of already gathered information concerning the resources (and I must stress that when we speak of resources, we naturally include in the term appropriate reference to the environment of the resource per se). In making this compilation and reduction we shall need to make use of modern methods of storing, assembling, and regrouping information; I refer to the techniques of slotted cards, punch-cards, electronic equipment, photographic methods, and so forth; and we shall need to find new ways of using maps, graphs and other kinds of diagrams, to present assemblages of data which we seek to interpret, and to represent the directions and intensities of relations which we have measured. Along the other course of action we should examine the entire theory and methodology of fisheries biology and its relations, first with the other parts of fisheries science, and second with other sciences more especially with oceanography and limnology.

We propose, and here I come to the first point on which we wish to consult this Commission and similar bodies, to carry out the first course of action by collaboration with the regional Councils and Commissions. Perhaps the method would be that we should undertake, under guidance of and with assistance from each regional body, preliminary compilation and presentation in maps diagrams, and so forth, which would then be presented to an Annual Meeting of the body concerned. At such meeting the preliminary work would be considered, discussed, and interpreted and we would receive a directive for a further development of the material. This we would do and submit at a subsequent meeting. Obviously, a plan such as this would require careful management and judicious selection of material for compilation.

For the second course of action we propose in the first instance a series of three subject meetings. The first of these would deal with animal numbers—reproduction mortality, community relations, fluctuations, the methods of population measurement, and so forth. The second would deal with biomass—with food and nutrition, food-chains, primary and secondary productivity. The third would deal with fishing—the impact of fishing operations on natural populations, the measurement of fishing effort, the biological aspects of exploitation. For the third meeting (which for various reasons might need to come earlier in time) would be held, we hope, in conjunction with a world meeting on fisheries gear technology which our Technology Branch plans to convene; we would hope that the two meetings would have joint sessions on such questions as measurement of fishing effort, and that in this work we would have the collaboration also of the economists.

I have referred to two courses: we believe that these two courses should converge upon a world congress on living aquatic resources where we could place the factual material concerning the resources together with our account of and conclusions about the theory and methods of our science. And we believe that the result would be some major conclusions concerning our thinking and our work for the next ten or twenty years: what facts to seek, by what methods, in what places.

The question then is, not shall there be a survey—for in fact the survey, one way and another is in progress, and we have been told to do our part of the job—but, what is the role of FAO in this task, how can it collaborate with ICNAF and similar bodies? Is the plan which I have briefly sketched a workable one, and can we work out the details of collaboration on it?

PART 3

Summaries of Research 1953

(a) Summaries by Countries

I. Summary of Canadian Groundfish Research in the Convention Area During 1953

SUBAREA 2. BY W. TEMPLEMAN

Between September 7 and 18, 1953, Hamilton Inlet Bank was explored by the Investigator II using a No. 36 otter-trawl. Forty sets were made well distributed over the bank and its slopes.

Cod *Gadus callarias*, L. On the western slope of the bank cod catches were usually low and the bottom was rough. Cod fishing on the bank itself, at depths between 150 and 183 m., was good in many areas. On the eastern slope there were excellent catches in several areas from 183 to 208 m. with moderate catches down to 247 m. There were a few minus temperatures but none below -0.5°C. and in the areas where cod were plentiful no temperatures over 2.7°C. Of the largest two catches per hour's dragging the 3700 kg. catch was at 0.1°C. and the 3000 kg. catch at 2.7°C. The six catches of 1500 to 1700 kg. per hour were at temperatures between -0.5 and 0.9°C., and 6 of 1000 to 1100 kg. at temperatures between -0.3 and 1.9°C. In the deeper water, 310 to 350 m. to the east of the bank and with higher temperatures of 3.1 to 3.4°C. cod were scarce and redfish more abundant.

The Hamilton Inlet cod are of medium but mostly commercial size. In the autumn they are in good condition with very fat livers.

American Plaice *Hippoglossoides platessoides* (Fabricius). While there were some American plaice everywhere on the bank, in only one locality were they plentiful enough to supply a commercial fishery for plaice alone. This was at 179 to 183 m. in latitude 54°22′00″N. and longitude 54°48′00″W. where plaice were obtained at the rate of 2800 kg. per hour's dragging. The bottom temperature was 0.4°C. In 1952 the one large catch of plaice was only 12 kilometres from this point in 183 m. and -0.3°C. where plaice were caught at the rate of 3700 kg. per hour's dragging. The good American plaice grounds on this bank therefore are probably limited in area.

Hydrography. During July 31 and August 1 a hydrographic section was taken across the Labrador Current off Domino Point and south of Hamilton Inlet Bank.

SUBAREA 3. BY W. TEMPLEMAN

Cod and Haddock *Melanogrammus aeglefinus* (L.). Recaptures are still being made from the 4715 cod tagged at St. John's and Fogo in 1950. Eliminating the unsuccessful bachelor-button tag the average percentage returns per year have been 1950—6.7, 1951—12.8, 1952—4.5, 1953—1.6. During the first year tagging was deliberately delayed until most of the fishing was over. The most effective tags have been a two-inch red tag of cellulose nitrate attached to the pre-opercular by nickel wire—38.7% return, a 13/16-inch pink cellulose nitrate tag attached below the anterior base of the first dorsal—33.0% return, and a five-inch orange vinylite plastic body cavity tag with a 32.1% return. In returns subsequent to the tagging year the best tags gave 25-32% recapture and the poorest (the bachelor-button type) only 4.6%.

In May an otter-trawl survey of cod and haddock populations on the southern half of the Grand Bank was carried out by the Investigator II. In a good part of the area examined, namely the northern half of the southwest slope of the bank, there was at depths of 71 to 82 m. a well marked contrast in bottom temperatures between adjacent sets only a few kilometres apart from north to south. The large concentrations of haddock were on the southern high temperature side of the temperature break, in temperatures between 2 and 7½°C. and depths between 75 and 93 m.

Where the high temperatures of 4 to 8°C. were present in deeper water of 110 to 180 m. haddock were scarce, showing that by May the haddock were moving toward shallower water and that both depth and temperature were factors. The cod were not in abundance, but were considerably more plentiful on the lower temperature northern side of the break in temperature, at temperatures from 2.0 to less than one degree centigrade and depths from 80 to 59 m.

On both the Grand Bank and St. Pierre Bank the most plentiful group of haddock was the 1949 year-class with a peak length of 36-37 cm. and this year-class, except for the largest specimens, was discarded by Newfoundland trawlers. The haddock landed at St. John's and Burin from the Grand Bank had a peak size of 50-51 cm. and consisted mainly of the 1946 year-class with a significant number of the 1942 year-class and with very few of the intervening year-classes. The 1949 year-class is a very great one which should provide good fishing for several years on both the Grand Bank and St. Pierre Bank.

In two Grand Bank commercial trips investigated, 67% of the haddock by number were discarded as compared with 18% in 1952. The high proportion thrown away in 1953 was due to the large numbers of four-year-old 34 to 40 cm. haddock which were caught this year for the first time, but were too small to land. On St. Pierre Bank during one commercial trip the number of haddock discarded was 74%. The weight of haddock discarded in the three trips as estimated from length frequency data was 42%. In 1952 it was estimated that only 9% of the haddock by weight were discarded.

Redfish *Sebastes marinus* (L.). In the past few years commercial development has been proceeding over much of the redfish area explored by the Investigator II between 1946 and 1950. During July, 1953, commercial development began of the plentiful stocks of large redfish found by the Investigator II in 1950 in 290 to 365 m. off the northeast corner of the Grand Bank. Since late summer to early autumn, 1951, trawlers (mostly United States, but with some Nova Scotian and a few Newfoundland) have been engaging in successful commercial fishing for large redfish in the deep water channels of the Gulf of St. Lawrence where general redfish abundance was indicated by the explorations of the Investigator II from 1947 to 1950. The larger vessels of the United States fleet have been carrying out a good deal of fishing during the past three years on the southwest slope of the Grand Bank which had been successfully explored for redfish down to 365 m. by the Investigator II between 1946 and 1951. The east coast Newfoundland redfish vessels concentrate on the larger redfish of the eastern edge of the Grand Bank. It is evident that over-exploitation of redfish in one favourable area can occur. The formerly abundant redfish population within a few kilometres of Ramea from which many millions of pounds of redfish have been taken since 1946 has apparently been reduced below the level of profitable fishing.

In 1953 the Investigator II carried out in two areas an exploration for redfish in 275 to 595 m. Unsuccessful attempts were made to drag to 730 m. An otter-trawl was used with both otter-boards attached to a single wire. In a July trip to the southwest slope of the Grand Bank redfish were most numerous between 275 and 365 m. and with no commercial amounts below 365 m. although there were some redfish in drags at least as deep as 455 to 550 m. There was a general increase of size in both sexes with depth. In October a similar exploration was carried out in an area northeast of Bonavista. Due to bad weather only 9 drags could be made between 300 and 730 m. The net was apparently not on bottom below 595 m. The best catch of 1850 kg. of redfish per hour's dragging was made at 350 m. and catches of 40 to 110 kg. per hour's dragging were made at 520, 550 and 605 m. In the successful drags in these three latter depths numbers of large grenadiers (*Macrourus*), which are bottom fish, were obtained showing that the net was fishing near the bottom. It is unlikely that the redfish in the 520 to 605 m. sets were caught as the net was passing upward through shallower layers, since in the two drags when the net was fishing at 695 to 730 m. and was not on bottom but was deeper than 605 m. no redfish were caught. There was little or no significant difference in size of the redfish at the various depths.

Redfish otolith age readings are well under way and some differences in growth-rate in various areas are evident.

Examination of redfish stomachs has shown the percentage stomach eversion increasing with depth from 32% at 295 to 345 m. to 65% at 600 m. In 142 stomachs containing food the total volume of food present was made up of 67% amphipods, 18% fish, 13% copepods, 2% squid and 1% euphausians. Numerically 84% of the stomachs contained amphipods, 74% copepods, 16% euphausians, 12% fish and 7% squid. The food generally consisted of free-swimming and not bottom organisms.

American Plaice. Estimations of the age of American plaice from their otoliths show a considerably higher rate of growth for the Grand Bank than for the inshore Notre Dame Bay area. The rate of growth in general appears to be slow and some plaice were over 35 years of age. The numbers of eggs in the ovaries of 9 American plaice ranged from 156,000 at 45 cm. and 12 years to 1,412,000 at 74 cm. and 37 years of age.

Population Identification and Study. Studies of vertebral and fin-ray number were continued on all the main groundfish species. Offshore landings were measured, and scale and otolith samples collected continually at St. John's and Burin. Amounts and location of catches and also effort statistics were obtained from almost all trawlers, also for long-line vessels and Danish seiners. Age estimations were carried out on cod, haddock, redfish, American plaice and witch *Glyptocephalus cynoglossus* (L.).

In the various exploratory fishing operations and in the statistical study of commercial fish landings 72,000 cod, 20,000 redfish, 31,000 haddock and 14,000 American plaice have been measured during 1953.

M.V. "Marinus". In early November a new 19 m. research boat, the Marinus, built at Caraquet, N. B., became available to the Station. This boat is equipped to otter-trawl to three hundred and fifty m. and will also be fitted with longlining gear.

Hydrography. Three hydrographic sections across the southern part of the Grand Bank were occupied in April. These were repeated in July-August together with two additional lines of stations across the Labrador Current, off Bonavista and from St. John's along the 47° latitude line to beyond Flemish Cap.

SUBAREA 4. BY W. R. MARTIN

At the third Annual Meeting of the Commission a group of "Scientific Advisers to Panel 4" was established to review the status of the groundfish stocks and to determine research and conservation requirements in Subarea 4. Canadian groundfish research in the subarea was reviewed at meetings of this group held at Copenhagen in October and at St. Andrews in December, 1953.

Identification of Stocks—A manuscript has been prepared for publication describing the results of vertebral counts on some 38,000 **cod** in 375 samples made in 1933 to 1941. The conclusions are in agreement with the results of tagging carried out during the same period, but more detailed information has been provided on the different cod populations in Subarea 4.

Returns from more than 7,000 **haddock** tagged between 1935 and 1940 have been described in manuscript form for publication. Deep channels, water temperature, spawning and feeding proved to be important factors controlling the movements of haddock populations. A number of discrete populations have been recognized within Subarea 4.

The M.V. "J.J. Cowie" was used during the months of May to October, 1953, to study the distribution and movements of **redfish** along the upper Laurentian channel in the Gulf of St. Lawrence. Redfish were most plentiful off the eastern tip of the Gaspé at depths of 175 to 300 m.; the size modes for males and females were 35 to 36, and 38 to 40 cm. respectively. Larger fish of both sexes were found in deep water. Mature females were 50% spent in June with the largest females spawning first. Both sexes were feeding well in June and early July but from August to October the females were eating less and all males were empty. Fifty percent of the redfish were mature at 25 cm. The appearance of small redfish (down to 20 cm.) in much greater numbers in the St. Pauls-Bird Rocks area of the southern

Gulf suggests that redfish larvae liberated in the Gulf are carried south toward Cabot Strait with resultant outward movement of Gulf water.

Seasonal changes in catches appeared to be related to changes in vertical distribution rather than extensive movements of redfish. There was a consistent decrease in catches after dark with males showing a more pronounced movement off bottom. At spawning time females tended to be off bottom as demonstrated by greater catches of males in bottom dragging.

A manuscript describing "The Seasonal Distribution of the **Winter Flounder** *Pseudopleuronectes americanus* (Walbaum) on the Atlantic Coast" describes changes in depth distribution in relation to environmental factors, particularly temperature and light.

Statistics—Four field technicians collected (1) detailed statistics on area fished and fishing effort for a large proportion of offshore landings; (2) samples for length and age composition of both inshore and offshore landings; (3) measurements of quantities of haddock discarded at sea. These observations, together with statistics of landings collected by the Department of Fisheries, provide essential information on yield, indices of abundance, recruitment, growth and mortalities.

Total groundfish landings decreased during 1953, the most pronounced change being a 27% (28,000 metric tons) reduction in landings of cod from Subarea 4. The decreased cod landings were compensated in part by increased landings of redfish from Subarea 4, and of haddock and flounders from Subarea 3. The drop in cod landings is partially related to the decreased abundance of large steak cod, but a change in economic conditions, involving a 25% decrease in price and buyers' quotas on landings, was the dominant factor in the reduced landings.

In the haddock fishery the 1948 year-class was dominant in landings by Western Nova Scotia boats. In the landings from offshore banks and the Cape Breton area the 1947 year-class was dominant. The 1949 year-class has become important to the haddock fishery in the southern Gulf of St. Lawrence and on Banquereau. In the cod fishery the 1948 and 1950 year-classes were important in the western Nova Scotia area. The 1947 year-class was dominant in landings from offshore banks and the Gulf of St. Lawrence.

Tagging—1,804 cod and 580 haddock were tagged off Lockeport, Nova Scotia, between May 27 and October 20, 1953. The fish were taken by hook and line fishing from the M. B. "Mallotus", with holding tanks and tagging troughs used to facilitate release of fish in good condition. All tags other than strap tags were attached by stainless steel wire between the first and second dorsal fins. The strap tags were clamped on the lower fleshy portion of the tail.

1953 Groundfish Tagging off Southwestern Nova Scotia with Recoveries to December 31, 1953

	Cod			Haddock		
Type of Tag	No. Tagged	No. Recovered	% Recovery	No. Tagged	No. Recovered	% Recovery
Hydrostatic	933	229	24	276	13	5
Red and white disks	305	114	37	98	6	6
Yellow disks	303	92	30	87	8	9
Strap	263	32	12	119	5	4
Total	1 804	467	26	580	32	6

Early returns of tagged cod suggest a relatively high fishing mortality. Recoveries of tagged haddock were low in 1953, but the number of recoveries increased early in 1954. In both species most recaptures have come from the tagging region.

Population Dynamics—Analysis of records of the fishery and of tagging experiments on a distinct population of the winter flounder in St. Mary Bay, Nova Scotia, provided good estimates of growth, natural and fishing mortality and recruitment for the construction of yield- and value- isopleths based on the method described by R. J. H. Beverton. Results provide a basis for judging the desirability of any regulation of this fishery and indicate that under present conditions any restriction of fishing will tend to reduce landings and value. This study has served to demonstrate the usefulness of this method of analysis, and cod and haddock stocks will be studied along similar lines.

Mesh Selections—Experiments with large-mesh cod ends on three commercial otter-trawler trips demonstrated that small haddock and cod are effectively released and as a result the industry is voluntarily adopting large-mesh cod ends of about 4 $\frac{1}{2}$" inside measure after use. Five mesh sizes from 4 $\frac{1}{2}$" to 5 $\frac{1}{4}$" inside measure were compared with the standard 2 $\frac{7}{8}$" mesh by covered net and comparative tow experiments. Mesh sizes larger than that now in use on Georges Bank gave 50% selection points for both cod and haddock which were in line with results of earlier mesh experiments (fig. 8, p. 31, 2nd Annual Report ICNAF). Large catches dampened the selection effect of the meshes.

Hydrography— Canadian hydrographic investigations by the Atlantic Oceanographic Group continue to lay the basis for a better understanding of the natural factors causing changes in the abundance and movements of groundfish and other species.

Seasonal cruises over the Scotian Shelf, Bay of Fundy and Gulf of St. Lawrence were carried out in September and November. Temperature and salinity data from seasonal cruises between 1946 and 1952 have been prepared in the form of plots of temperature and salinity distributions in sections.

A report has been prepared on the bottom temperatures on the Scotian Shelf from the data obtained during seasonal cruises. The three layer stratification of the waters, the influence of the slope water, and of cold waters to the northeast, make bottom temperature a complicated function of depth, location and time. In general, the lowest bottom temperatures are found in the northeast sector and the highest on the shoal banks and in the deep areas of the Scotian Gulf. Maximum bottom temperatures have been observed to be as much as two degrees higher than those recorded over the area in pre-war years.

Continued observations of surface water temperatures, taken twice daily at strategic points along the Canadian Atlantic coast, have shown a general warming of the waters during the last 13 years. The period 1949-52 is recognized as being the warmest quinquenniad on record with peak temperatures occurring in general in 1951. The peak temperatures were equalled or closely approximated in 1953, particularly in the early months of the year. The late fall observations show a considerable abatement.

A better appreciation has been obtained of the rapidity with which major changes can occur. In November, 1952, for example, a large-scale replacement of Bay of Fundy water took place in three weeks. An important study has been made of the "slope waters" lying between the coastal waters of the Scotian Shelf area and the Gulf Stream. Incursions of this water are responsible for sudden changes in conditions on the banks, with greatest influence around Emerald, LaHave and Western Banks.

II. The Danish Researches in Subarea 1 in 1953

By PAUL HANSEN

GROENLANDS FISKERIUNDERSOEGELSER, DENMARK

Three research ships operated in Subarea 1 in 1953: The research ship "Dana" in Davis Strait from 3 July to 11 August, the research cutter "Adolf Jensen" on offshore banks and in coastal waters and fjords, and the research cutter "Immanuel" in coastal waters and fjords from June. The research cutters' work was continued during the winter season.

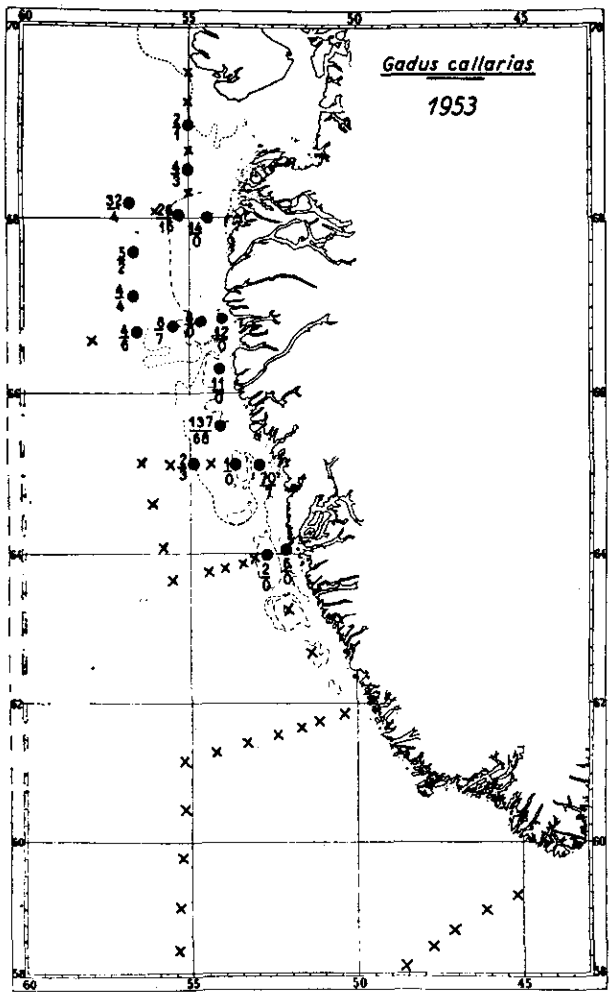

Fig. 1. Catches of cod larvae per 30 minutes haul with 2 m. stramin bag from the "Dana", July-August 1953. Numbers in hauls with a 0-100 m. wire and with a 100-200 m. wire are shown respectively above and below the line.

1. Hydrography.

The hydrographic results are given by Mr. Frede Hermann in the second part of this report.

Compared with the season 1952, the season 1953 can be considered as a warm one. The polar current was only weakly developed and the temperatures on the fishing banks were higher than normal. On Fylla Bank, for instance, the temperatures in July were about 2° higher than at the same time in 1952.

2. Occurrence of eggs and larvae of cod, *Gadus callarias* L.

It appeared from information given by Greenland fishermen, together with fishing for cod eggs and larvae with 1 and 2 m. stramin bags from the "Adolf Jensen" and the "Dana", that the cod spawned earlier than usual. At the end of June practically no cod eggs and larvae were found in the Godthåbfjord, in the coastal area outside the fjord, or on Fylla Bank. At that time the cod fry had already been transported by the current out of the fjord and northwards.

From Fig. 1 it is seen that the largest numbers of larvae were taken between 65°N and 68° 20′N, which is a rather northerly distribution.

In contrast with 1950 and 1952, no larvae were taken south of 64°N, which indicates that there has been no transport to Davis Strait of cod fry from spawning grounds east of Cape Farewell. The length of the cod larvae were between 9-31 mm., the mean length 16.8 mm.

3. Composition of year-classes in catches of cod.

a. Offshore banks.

In all, 2,573 cod otolith samples were collected in offshore waters: 2,187 by the "Dana" from catches taken with handlines in depths between 30-75 m. on the fishing banks, and 386 samples from longline fishing in offshore waters by the "Adolf Jensen".

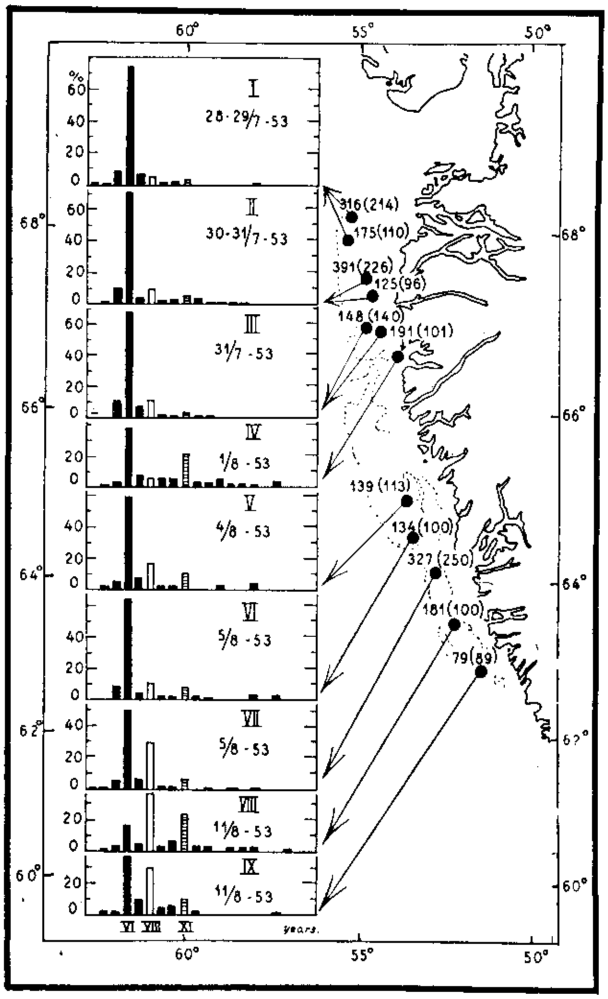

Fig. 2. **Age analyses of cod caught on the Greenland banks in July-August, 1953. The diagrams give the percentage age distribution. Year-class 1945—white columns, 1942—striated columns. Off each station are given numbers of specimens investigated, and in brackets numbers of cod tagged.**

The results of the age analyses are given in Fig. 2 and in Table 1. As would be expected, only three rich year-classes occurred in the catches in 1953. The year-class 1947 predominated in all the samples with exception of one (No. VIII). On the banks from 68°10′N to 64°30′N, the year-class 1947 was exceptionally strong, amounting to more than 60% in three and between 50 to 60% in two of the samples. The year-class 1945, which had been of some importance in the catches in the previous years, was only strong in the three southern samples. On Fiskenæs Bank (VIII) it was the strongest year-class in the catch. As in 1952, this year-class was most abundant in the southern part of the region.

The year-class 1942 dominated only in the sample from the southern side of Disko (see Fig. 4A), where it amounted to more than 35% of the catch.

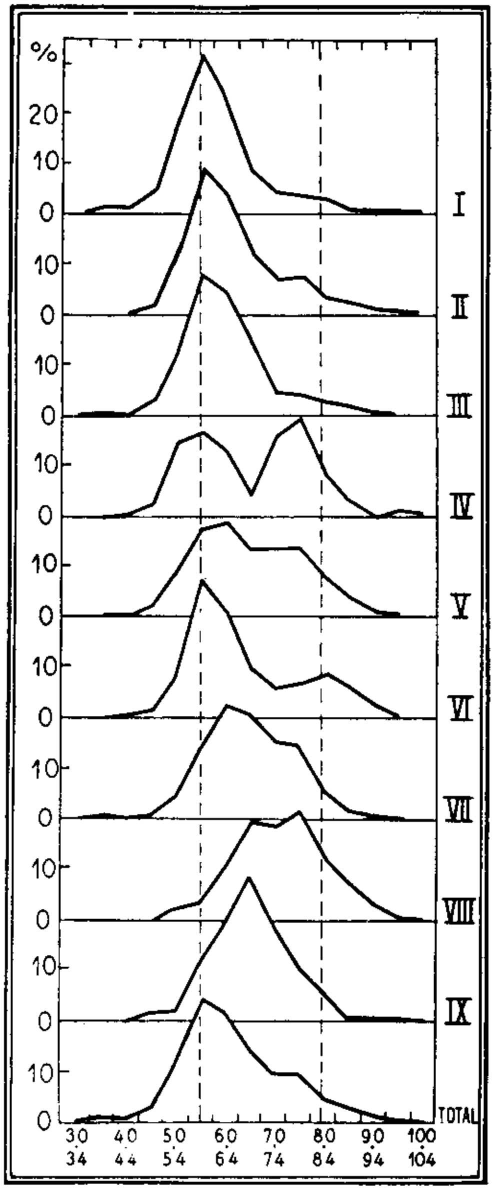

Fig. 3. **Percentage length distribution, by 5 cm. groups of cod caught on offshore banks in 1953. The roman numbers correspond to those given on the map Fig. 2. The curve at the bottom gives the length distribution of the samples I-IX in total.**

In the other samples it was of slight importance, with exception of the longline catch in the Holsteinsborg Deep (IV) (depth 120-200 m.) and on Fiskenæs Bank (VIII), 20.4, and 24% respectively.

Length measurements of cod from the banks.

Fig. 3 gives length distributions in 5 cm. groups. The peaks of the curves correspond well with the occurrence of the dominating year-classes. In Table 1 are given the mean lengths of cod belonging to the different year-classes in the samples from the offshore banks. It is evident that the mean lengths are very low, for the 1947 year-class from 55.8 cm. to 59.6 cm. on the Store and Lille Hellefiske Banks, and a little more than 60 cm. on the southern banks. On the northern part of Store Hellefiske Bank these small cod were very lean and with small livers, which indicates a bad condition. In the catch from the northernmost station many specimens were badly infected in the gills by parasitic copepods. Probably a large number of cod of the year-class 1947 had immigrated to the northern banks from the Disko Bay and the Umanak Fjord.

b. Coastal waters and fjords.

A total number of 5,482 samples of otoliths have been collected, partly through fishing experiments from the "Adolf Jensen", and partly from the Greenlanders' catches. The results of the age analyses are given in Fig. 4. Many of the analyses include samples taken at different times in the season from May to November (mostly July to September). The samples from each fishery station, however, are very similar according to composition of year-classes, even when taken at different times during the season, and they can thus be treated together.

The year-class 1942 dominates in the samples from the northern part of Disko Bay and in the catches west and south of Disko (J, A), the year-class 1947 in the coastal area from about 68°N to about 64°N (B, C, D, E, F). South of 63°N the year-class 1945 dominates with about 56% in the Julianehåb district (I), see Table 2.

These results agree well with the age analyses

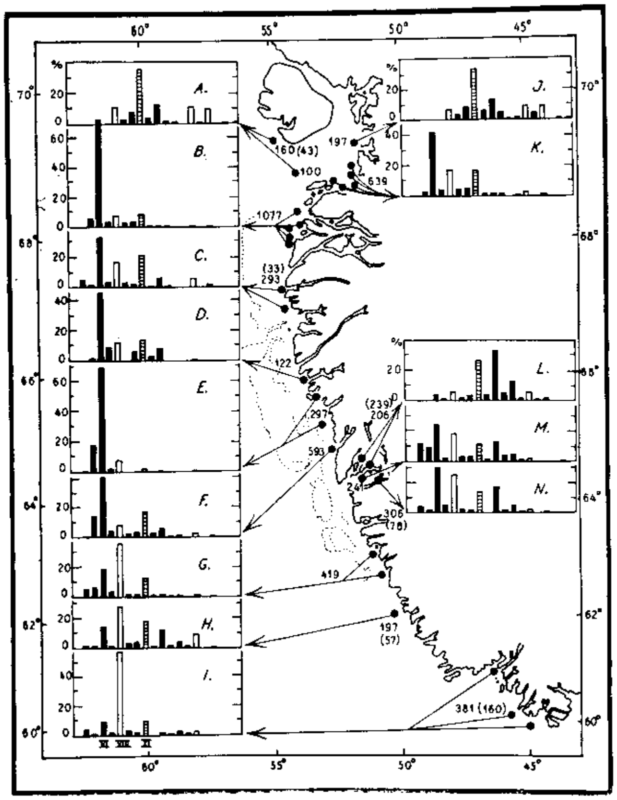

Fig. 4. Age analyses of cod caught in Greenland coastal waters and fjords in 1953. The diagrams give the percentage age distribution. Year-classes 1945, 1936, and 1934—white columns, 1942—striated columns. Off each station are given numbers of specimens investigated, and in brackets number of cod tagged.

from the offshore banks. From Godthåbsfjord we have two different samples, one from May and June from the outer part of the fjord (M), and one from October - November from the inner part of the fjord (L). In the first sample the year-class 1947 dominates with 22.8%, the second best is the year-class 1945 (18.3%), while the year-class 1940 comes as the third biggest (12.0%). The second sample from the interior part of the fjord has the year-class 1940 as the richest one (32%), the year-class 1942 as the next best (26.2%), and the year-class 1938 as third (12.1%). The otoliths are of the special "fjord type" with many secondary rings, while the otoliths from the other sample are rather similar to those found in the coastal area. It may be assumed that the sample from the interior part of the fjord consists of cod belonging to the special fjord population, while the sample from the outer part of the fjord mainly consists of cod from the coastal area.

In the Ameralik Fjord cod from both the coastal region and from the banks spawn in spring and pursue the capelin just after the spawning. In 1953 a pound net fishery on cod was carried out by The Royal Greenland Board of Trade. The output of the fishery was unsuccessful, owing to the early spawning of the cod, together with the fact that the capelin spawned in other places of the fjord than in the warm interior part, where the pound net fishery was carried out. The fishery was stopped in the beginning of June, when most of the fishes caught in the nets were undersized cod belonging to the year-class 1947 (N).

In one of the small branches of Umanak Fjord, Sermerdlit, 70°34'N, 50°43'W (not shown in Fig. 4), was found a large number of cod belonging to the year-class 1947. In a sample of 78 otoliths, 93.6% belonged to this year-class. The cod were taken by jigs and net. The mean length for the year-class 1947 was only 54.9 cm., the lowest mean length for that year-class found in 1953. It is the first time cod of medium age have been seen in Umanak district, where only very old cod and codlings of an age of one and two years were found since 1948. The cod of the year-class 1947 were still immature in 1953. Spawning of cod has never been observed in this northern district. Owing to this fact, it may be expected that when cod of the year-class 1947 reach maturity, probably in 1954 or 1955, a migration to spawning places in the southern part of Davis Strait will take place.

4. Tagging experiments with cod.

A total of 1,539 cod (see Fig. 2) were tagged on the offshore banks onboard the "Dana" in 1953. Ebonite tags were used in the experiments, with exception of 37 cod, which were tagged with yellow Nocathene tags. In coastal waters and in fjords a total of 941 cod were tagged onboard the "Adolf Jensen" (see Fig. 4). Finally 151 cod were tagged in the interior part of Umanak Fjord (70°34'N).

A total of 52 of the cod tagged in 1953 were recaptured in the same year, nearly all near the place of the tagging. Only in three cases were recaptures taken in some distance from the tagging locality, namely, one, recaptured on Store Hellefiske Bank, tagged on Lille Hellefiske Bank, and two tagged in Ameralik Fjord, recaptured on Fylla Bank and on Store Hellefiske Bank respectively.

Among the recaptures taken near the tagging place, 23 were taken on Store Hellefiske Bank, one on Lille Hellefiske Bank (Banana Bank), five on Fylla Bank, 18 in Ameralik Fjord, and 2 in Godthåb Fjord.

Recaptures from tagging experiments in other years were distributed as follows:

Year of Tagging	Recaptured in 1953	
	Greenland	Iceland
1947		1
1948	7	2
1949	11	8
1950	11	1
1951	11	5
1952	117	9
Total	157	26

The number of recaptures from Iceland were higher than in 1952 but compared with the number of recaptures from Greenland insignificant. From all the recaptures in 1953 (cod tagged in 1953 omitted) the recaptures from Iceland only amounted to 14.2% against 13.9% in 1952. The percentages of recaptures from Iceland are very much alike in the two years.

The percentages of recaptures in Iceland waters of cod tagged off West Greenland have been very low in later years. They do not in any way compare to the high percentages of Icelandic recaptures from the tagging experiments in 1933, 1934, 1938 and 1939, respectively 73.1, 67.1, 48.8, and 51.2%.

Of the cod recaptured at Iceland, 17 were tagged in Julianehåb district, 1 in Frederikshåb district, 1 in Ameralik Fjord, 1 in Sukkertoppen district, 2 in Disko Bay, 3 on Fylla Bank and 1 on Lille Hellefiske Bank.

As in previous years the largest numbers of recaptures from Iceland originate from taggings in Julianehåb district.

Otoliths were taken from 22 of the cod recaptured in Icelandic waters. The age analyses gave the following results:

Year class	age group	1947	–48	–49	–50	–51	–52	Total
1940	XIII		1					1
1942	XI	1		3		2	1	7
1943	X		1	2				3
1944	IX					2	1	3
1945	VIII				1	3	4	8
Total		1	2	5	1	7	6	22

It appears from the table that the largest numbers of recaptures from Iceland belong to the two rich year classes 1942 and 1945.

In the report from 1952 it was mentioned that small cod tagged with Lea tags in 1949 in the northern part of the area, Umanak Fjord and Disko Bay, were recaptured in more southerly localities in 1951 (two recaptures) and in 1952 (one recapture). In 1953 two cod more from these experiments were recaptured a long distance south of the tagging locality. One tagged in Umanak harbour 70°40′N, 52°00′W on 6 August 1949 was recaptured on Fylla Bank 64°09′N, 52°57′W 11 August, 1953. It was 24 cm. when tagged and must have belonged to the year-class 1947. The reported length at recapture was not reliable. The distance of migration was about 460 miles. The other cod was tagged off Christianshåb, 68°50′N, 51°10′W, on 26 August, 1949. The length when tagged was 24 cm. and the cod must have belonged to the year-class 1947. The cod was recaptured on Store Hellefiske Bank 67°41′N, 55°00′W, 18 July, 1953, 120 miles south of the tagging locality. The length of the cod when recaptured was 46 cm. As mentioned in the report from 1952, these recaptures in southern localities were from tagging experiments in 1949 with small cod in the northern localities, where enormous quantities of small cod of the year-class 1947occurred in that year, and indicate that intensive southward migrations have taken place in the last years. These successful experiments prove that Lea tags are useful tags for tagging of young cod.

In 1952 a tagging experiment was carried out with 368 cod, mainly of the year-class 1947. The cod were taken in pound nets in Amerdlok Fjord and transported to Holsteinsborg harbour, where they were tagged and released. Up to the present the following 20 recaptures have been reported:

Year of recapture	Banks	Fjords	Total
1952	7	4	11
1953	5	4	9
	12	8	20

Of the recaptures from the offshore banks eleven are from Store Hellefiske Bank and one from Fylla Bank.

It appears from the experiment that the stock of small cod, growing up in the fjord and coastal area, has contributed to the dense aggregation of cod of the 1947 year-class on the adjacent bank.

Age analyses show that the year-class 1947 was especially rich in the coastal area from 69°N to 64°N, and therefore it may be assumed that this year-class, now dominating on the Store Hellefiske Bank, Lille Hellefiske Bank and Fylla Bank, must have got an important recruitment from the adjacent coastal areas; furthermore it may be expected that the amount of the year-class 1947 on the banks will increase in the nearest following years by migration from the coastal waters and the fjords.

Hydrographic Conditions in the Eastern Part of Labrador Sea and Davis Strait, 1953

BY F. HERMANN

DANMARKS FISKERI-OG HAVUNDERSOEGELSER

During July, 1953 the hydrographic stations shown in Fig. 5 were worked by the Danish R/V "Dana".

The distribution of the temperature in 50 meters given in Fig. 5 shows that the arctic component of the West Greenland Current was

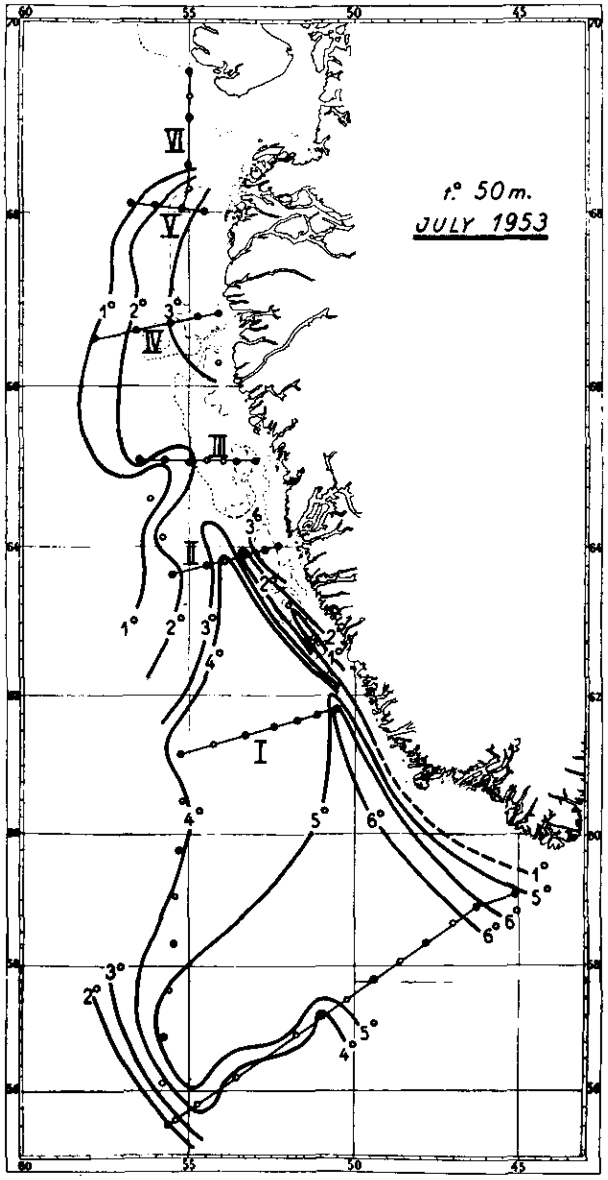

Fig. 5. Location of hydrographic sections I-VI and curves showing distribution of temperature in 50 m. depth. Open circles indicate bathythermograph stations, solid circles regular hydrographic stations.

very weak. Its water masses were off Southwest Greenland restricted to a narrow strip over the banks.

The warm Irminger Current was well developed, its core was found off the slope of the banks with temperatures about 6° north to the Frederikshåb section and above 4° north to the Fylla Bank section. From southwest Greenland a tongue of the warm water is stretching southwestwards towards 56°W. Long., where it meets the cold water masses of the Labrador Current.

North of the Fylla Bank, section II, the Irminger Current is mainly found as an undercurrent. Relative warm conditions are prevailing also over the northern banks.

Phosphate determinations were carried out in the upper 100 meters (see Fig. p. 100). The general features from the distribution of temperature are repeated in the distribution of the phosphate. Thus the highest concentrations of phosphate are found off the slope, i.e. at the same locality as the core of the warm current. The most probable reason for this phenomenon seems to be that the turbulence in the strong current causes vertical mixing, which carries phosphate-rich deep water to the upper layers. From here the warm and phosphate-rich water spreads out in a tongue towards southwest.

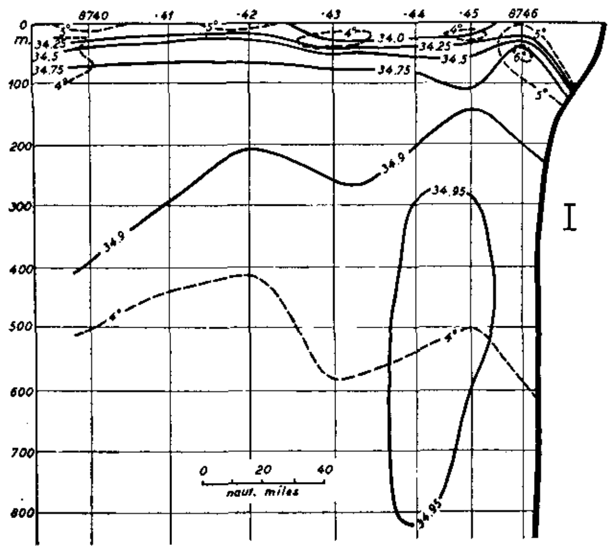

Fig. 6. Section I, off Frederikshaab, 6-8 July 1953.

North to Fylla Bank good conditions should thus prevail for the plankton production off the western side of the banks. In the northern part of the area only small concentrations of phosphate are encountered except on the westernmost station of section IV, at the boundary of the Canadian Polar Current.

The conditions are further illustrated by the vertical sections I to VI, (Figs. 6-11). In all the sections the temperatures are above normal and considerably higher than those found in 1952. Over the shallow part of Fylla Bank the temperatures were thus 1.5° to 2° higher and west of the bank in the upper 100 metres even 2° to 3° higher than the temperatures found in July, 1952.

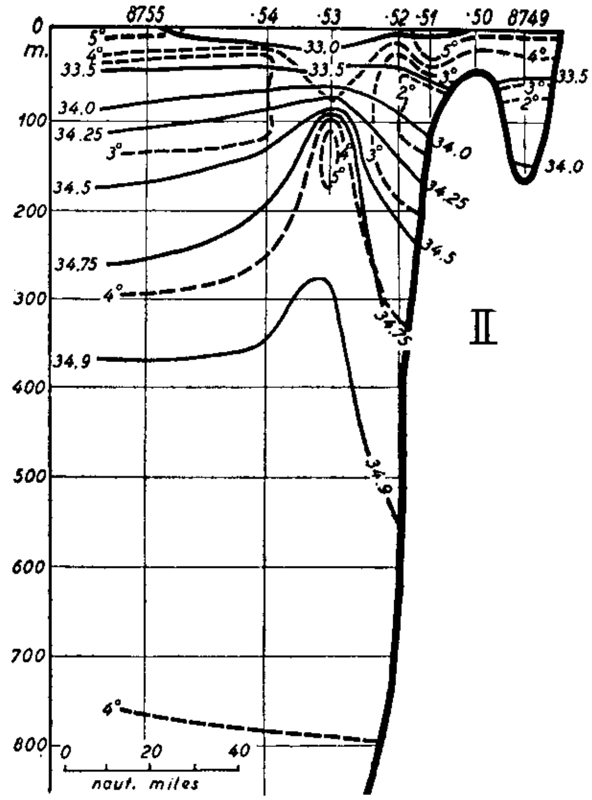

Fig. 7. Section II, across Fylla Bank, 15-16 July, 1953.

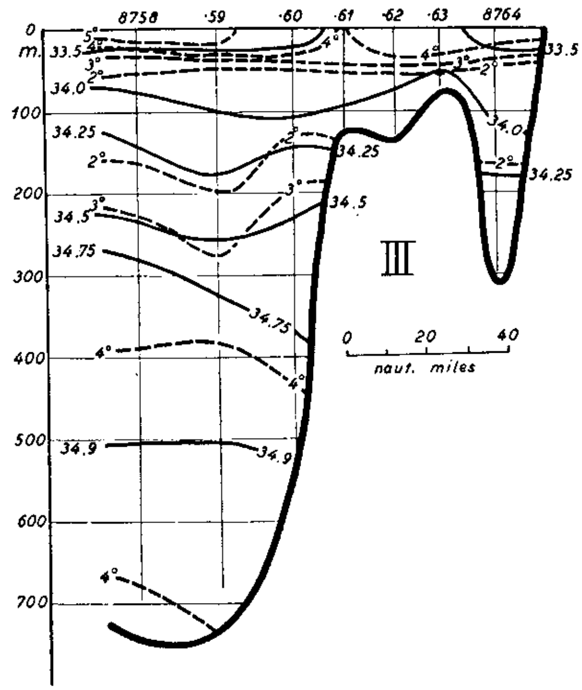

Fig. 8. Section III, across Lille Hellefiske Bank, 16-22 July 1953.

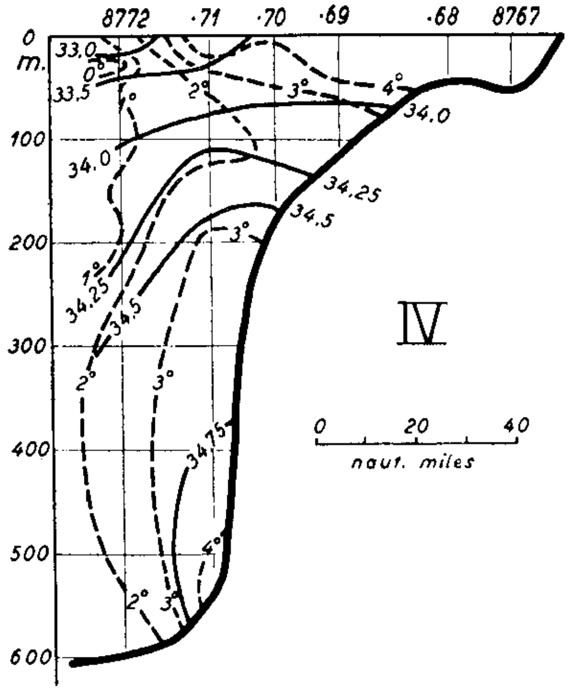

Fig. 9. Section IV, off Holsteinsborg, 23 July, 1953.

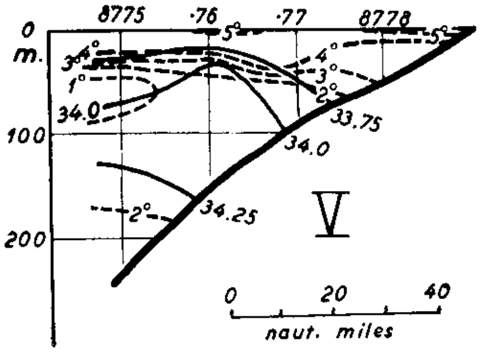

Fig. 10. Section V, across northern part of Store Hellefiske Bank, 24 July, 1953.

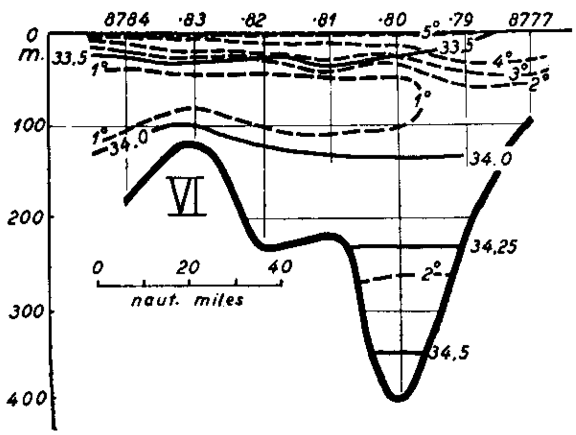

Fig. 11. Section VI, Store Hellefiske Bank—Disco, 24-25 July, 1953.

TABLE I

Year-class	Age	Store Hellefiske Bank 68°01′N 55°04′W and 67°54′N 55°20′W 29 and 30 July		Store Hellefiske Bank 67°29′N 54°42′W and 67°22′N 54°16′W 30 and 31 July		Store Hellefiske Bank 66°51′N 54°38′W and 66°51′N 54°20′W 1 August		Holsteinsborg Deep 66°30′N 53°55′W 19 July	
		%	cm.	%	cm.	%	cm.	%	cm.
1950	III	—	(37.1)	—	—	—	(35.7)	—	—
1949	IV	0.6	(43.8)	0.4	(41.5)	—	—	0.7	(45.0)
1948	V	8.3	50.9	9.2	52.8	10.3	51.5	2.1	(50.0)
1947	VI	75.1	57.5	67.2	59.3	69.4	59.6	37.6	55.8
1946	VII	6.2	64.2	3.7	69.2	5.5	64.7	7.1	64.8
1945	VIII	3.5	71.0	9.6	74.7	10.6	69.9	5.0	68.5
1944	IX	1.0	73.2	1.4	78.3	0.9	(73.5)	6.4	71.1
1943	X	1.2	72.5	2.1	80.2	0.6	(75.0)	4.3	76.2
1942	XI	2.5	77.7	5.1	83.0	2.1	86.5	20.6	77.4
1941	XII	—	—	1.0	88.7	0.3	(90.0)	2.8	(81.0)
1940	XIII	0.2	(81.0)	—	—	0.3	(90.0)	2.8	(72.5)
1939	XIV	—	—	0.4	(93.0)	—	—	5.0	82.2
1938	XV	—	—	—	—	—	—	0.7	(82.0)
1937	XVI	—	—	—	—	—	—	1.4	(78.5)
1936	XVII	1.2	87.0	—	—	—	—	0.7	(77.0)
1935	XVIII	—	—	—	—	—	—	—	—
1934	XIX	—	—	—	—	—	—	2.8	(100.2)
Number:		482		513		330		141	
Depth in m.:		40		32 – 29		33 – 38		120 – 200	
Temperature °C:		3.6		4.2 – 3.9		4.5		—	

TABLE I—CONT.

Year-class	Age	Lille Hellefiske Bank 65°02′N 53°24′W 4 and 5 August		Banana Bank 64°28′N 53°13′W 5 August		Fylla Bank 64°07′N 52°40′W 5 August		Fiskenæs Bank 63°29′N 52°03′W 11 August		Dana Bank 62°45′N 51°11′W 11 August	
		%	cm.	%	cm.	%	cm.	%	cm.	%	cm.
1950	III	—	—	—	—	—	(37.0)	—	—	—	—
1949	IV	0.7	(46.0)	—	—	0.6	(47.0)	0.6	(50.0)	2.5	(47.0)
1948	V	3.6	49.3	7.5	52.9	4.3	53.6	1.7	(52.0)	1.3	(51.0)
1947	VI	58.4	58.9	62.7	60.0	51.7	61.4	16.8	61.7	35.4	60.5
1946	VII	5.1	63.2	3.0	(66.5)	5.8	66.4	3.4	66.7	8.9	64.5
1945	VIII	16.1	72.4	9.7	71.7	29.8	72.8	38.5	72.3	31.6	69.8
1944	IX	1.5	(77.5)	2.2	(76.5)	1.2	(74.9)	2.8	80.0	3.8	(70.7)
1943	X	1.5	(74.5)	1.5	(77.5)	0.6	(76.0)	5.0	73.7	5.1	(69.5)
1942	XI	8.8	77.4	6.7	82.6	4.6	76.9	24.0	77.5	8.9	76.0
1941	XII	—	—	1.5	(78.5)	—	—	2.2	(79.9)	1.3	(83.0)
1940	XIII	—	—	0.7	(87.0)	0.3	(77.0)	1.1	(84.5)	—	—
1939	XIV	1.5	(87.0)	—	—	—	—	—	—	—	—
1938	XV	—	—	—	—	0.3	(79.0)	1.1	(83.5)	—	—
1937	XVI	—	—	—	—	—	—	0.6	(92.0)	—	—
1936	XVII	2.9	(87.5)	3.0	(87.5)	0.6	(85.0)	1.7	(85.7)	—	—
1935	XVIII	—	—	—	—	—	—	—	—	—	—
1934	XIX	—	—	1.5	(83.0)	—	—	—	—	1.3	(99.0)
1933	XX	—	—	—	—	—	—	0.6	(99.0)	—	—
Number :		137		134		325		179		79	
Depth in m. :		52		48		40		53		58	
Temperature °C :		2.6		3.0		3.9		2.4		1.8	

TABLE 2

Year- Age class	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1949 IV	—	—	5.1	—	0.3	0.2	4.8	0.5	3.7	—	0.2	—	11.6	2.9
1948 V	—	5.4	1.4	1.6	17.8	12.6	5.7	0.5	0.5	—	2.3	—	8.3	1.3
1947 VI	2.3	68.4	33.1	45.9	69.7	40.0	29.4	14.2	19.9	—	42.1	2.9	22.8	28.4
1946 VII	—	2.8	3.1	9.0	2.0	2.9	3.6	1.0	1.0	—	4.2	0.5	2.1	3.3
1945 VIII	10.7	6.8	17.0	13.1	7.4	9.1	36.3	27.4	56.2	7.1	18.3	5.8	18.3	23.9
1944 IX	2.7	2.6	3.1	—	—	1.9	1.7	3.0	2.6	3.0	3.4	1.9	2.1	1.0
1943 X	7.3	3.2	1.7	5.7	—	2.4	1.7	4.6	1.5	7.6	4.7	2.4	2.5	0.7
1942 XI	36.6	7.8	21.5	13.9	1.7	17.7	12.2	17.8	9.7	33.5	17.5	26.2	10.8	13.4
1941 XII	3.1	1.0	0.3	2.5	—	2.5	0.7	1.0	—	5.6	1.1	2.4	0.4	—
1940 XIII	13.0	0.5	6.1	7.4	0.6	5.2	1.4	11.7	0.8	12.7	1.4	32.0	12.0	16.7
1939 XIV	1.5	0.4	0.7	—	—	0.3	0.5	2.0	0.5	4.6	0.9	4.4	3.3	1.3
1938 XV	1.5	—	—	—	—	0.8	1.0	4.1	1.8	0.5	—	12.1	3.7	3.9
1937 XVI	—	—	—	—	—	—	—	1.5	0.3	1.5	0.3	0.5	0.4	1.0
1936 XVII	10.7	0.7	5.5	0.8	0.3	3.5	1.0	9.6	1.3	9.6	2.2	6.3	1.2	2.0
1935 XVIII	0.4	—	—	—	—	—	—	—	—	4.1	—	0.5	—	—
1934 XIX	9.5	0.2	1.4	—	—	0.8	0.2	1.0	—	9.1	0.8	1.9	—	0.3
1933 XX	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1932 XXI	0.4	—	—	—	—	—	—	—	—	0.5	—	—	.04	—
1931 XXII	0.4	—	—	—	—	—	—	—	—	0.5	—	—	—	—
Number :	262	1072	293	122	297	593	419	197	381	197	639	206	241	306

III. French Researches carried out from the Frigate "l'Aventure" in 1953

BY P. DESBROSSES

INSTITUT SCIENTIFIQUE ET TECHNIQUE DES PECHES MARITIMES

Hydrography

During its cruise of supervision of fisheries the frigate "l'Aventure" worked 135 hydrographic stations down to a depth of 500 m., 10 surface samplings, and 98 collections of temperatures (with a bathythermograph) between 0-150 m., viz. from surface to bottom. Further the surface temperatures were registered during the whole cruise of the vessel. The hydrographic stations were dispersed in the main along five sections, two from Newfoundland to Greenland and three in the area off Newfoundland. The rest of the stations were spread over the banks.

The samples have been analysed in the chemical laboratory of the Marine in Brest and the content of chlorine was determined by the Knudsen method. The working of the results has not yet been completed.

Biology.

During the cruise the l'"Aventure" collected 99 plankton samples from the surface and principally in the following regions:

Subarea 1:	Fylla Bank
	Store Hellefiske Bank
	Lille Hellefiske Bank
Subarea 2:	Hamilton Inlet Bank
Subarea 3:	The Northern part of the Grand Bank.

Measurements of cod were made during the cruise.

IV. Icelandic Researches

On Trawl-Caught Cod on the West Greenland Banks in 1953

BY JON JONSSON

UNIVERSITY RESEARCH INSTITUTE, REYKJAVIK

During a trip from 27 July to 6 September, 1953 samplings of cod *Gadus callarias* L. were made by Mr. Eyjolfur Thoroddsen on board the Icelandic trawler "Pétur Halldorsson". The trawler was mainly fishing on the Fylla Bank and all the samples presented here are from this locality. The material collected include length measurements, otoliths with length, observations on sex and maturity, and also otoliths taken from loose heads. Most of the samples are from fish which were used for salting, a smaller part from fish which were processed into fish meal.

Age Composition and Onset of Maturity.

The sexual maturity was listed in about two thousand cod which also were analysed with regard to age. At this time of the year the gonads could be described as immature or spent. The following table gives the percentages of spent fish in each age-group:

Age group	Total Number	% Spent
4	11	27
5	56	50
6	826	74
7	201	80
8	700	93
9	61	93
10	61	100

These figures may not be representative for the stock as a whole, but they clearly show that the Greenland cod becomes mature at a remarkably young age.

The percentages of spent fish in each 5-cm. group were as follows:

5 cm. group	45	50	55	60	65	70	75	80
% spent	17	37	61	61	79	91	95	100

In table 1 the age determinations are arranged with regard to age-groups and age at first spawning. The table reveals the fact that the major part of the catch consist of first time spawners. The age composition of these is completely dominated by the two year-classes from 1945 and 1947. The 1942 year-class, now 11 years old, is only represented by mature individuals. The greatest part of this year-class becomes mature at 8 years old and according to table 1 its average age at first spawning was 7.8 years. This is in agreement with Dr. P. M. Hansen's results. For the year-classes 1932, 34 and 36 he gives the following ages at first spawning: 8.1, 7.8, and 7.6 years.

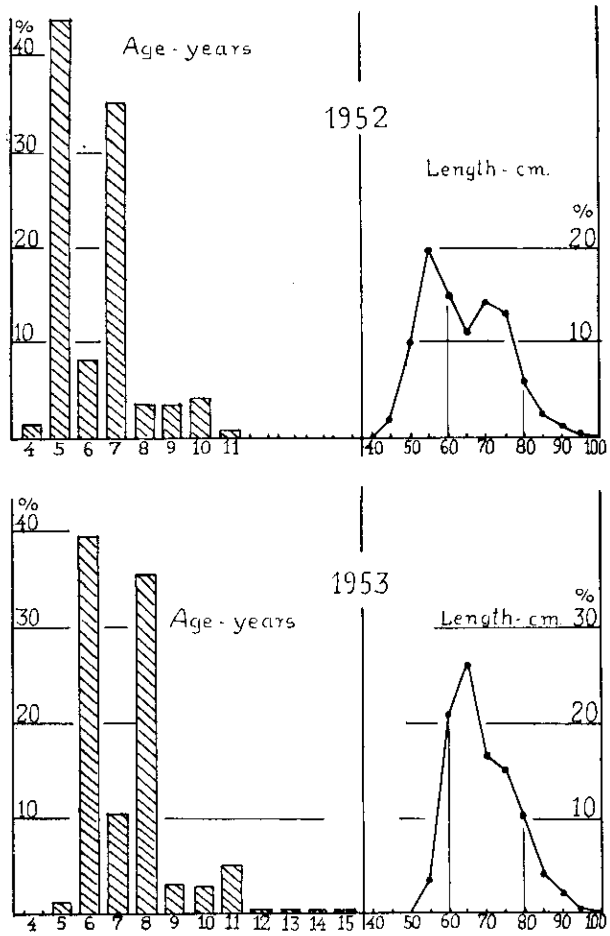

Fig. 1. Percentage age distribution and length distribution by 5 cm. groups of cod caught by Icelandic trawlers on Fylla Bank in September—October, 1952 and July-August, 1953.

From the second spawning class onwards there is a relatively regular decrease in number, except for the fourth spawning class, which is the result of a great spawning of the 1942 year-class when 8 years old.

The age composition (Fig. 1) found for the stock as a whole is in good agreement with the results obtained in 1952. There is a great dominance of the two year-classes 1945 and 1947. A comparison of figures from this year with figures from Fyllas Bank in 1952 shows the following:

	1945 year-class	1946 year-class	1947 year-class
1952	35.3%	8.3%	44.5%
1953	35.9%	10.3%	39.8%

The ratio between these three year-classes is almost the same in both years. The age— and length composition of the fish from Fyllas Bank in 1952 and 1953 is shown graphically on Figure 1.

TABLE I.

Age Composition of Trawl-Caught Cod on Fylla Bank
July 30th—August 15, 1953

Age Group	Age at First Spawning 4	5	6	7	8	9	10	11	?	Immat.	Mature No.	Mature %	Total No.	Total %
3	—	—	—	—	—	—	—	—	1	—	—	—	1	0.1
4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
5	—	8	—	—	—	—	—	—	1	10	8	0.5	19	1.0
6	1	5	556	—	—	—	—	—	6	209	562	35.6	777	39.8
7	—	1	7	160	—	—	—	—	3	30	168	10.6	201	10.3
8	—	2	16	72	534	—	—	—	29	47	624	39.5	700	35.9
9	—	—	4	11	13	25	—	—	4	4	53	3.4	61	3.1
10	—	—	2	14	17	5	10	—	13	—	48	3.0	61	3.1
11	—	1	4	24	49	10	1	1	10	—	90	5.7	100	5.1
12	—	—	—	2	4	—	—	—	2	—	6	0.4	8	0.4
13	—	—	—	—	—	—	—	—	2	—	—	—	2	0.2
14	—	—	1	1	—	1	1	—	—	—	4	0.3	4	0.2
15	—	—	—	—	—	—	1	—	—	—	1	0.1	1	0.1
16	—	—	—	3	5	2	2	1	—	—	13	0.8	13	0.7
17	—	—	1	—	—	—	—	—	—	—	1	0.1	1	0.1
18	—	—	—	1	—	—	—	—	—	—	1	0.1	1	0.1
Total no.	1	17	591	288	622	43	15	2	71	300	1579		1950	
%	0.1	1.1	37.4	18.2	39.4	2.7	0.9	0.1	3.6	15.4				

Spawning Classes

	1	2	3	4	5	6	7	8	9	10	11	12
No.	1294	103	56	69	31	9	3	3	6	3	—	2
%	82.0	6.5	3.5	4.4	2.0	0.6	0.2	0.2	0.4	0.2	—	0.1

The lack of fish older than 11 years is very conspicuous and in good agreement with the age composition of the Icelandic stock of cod.

The Growth Rate.

In Table 2 are listed the average lengths of the various year-classes on Fyllas Bank during the period July 30th to August 15th, 1953.

According to these figures the average growth of the 1947 year-class in the period October, 1952 to August, 1953 was 8.4 cm. The figures for the year-classes 1946 and 1945 are 4.7 cm. and 2.8 cm. respectively.

TABLE 2

Year-class	Age	Females No.	Females cm.	Males No.	Males cm.
1950	3	4	60.0	—	—
1949	4	1	49.0	7	47.4
1948	5	28	54.8	28	54.3
1947	6	397	63.7	429	62.9
1946	7	99	68.9	102	67.1
1945	8	365	75.7	335	73.3
1944	9	27	76.4	34	74.9
1943	10	29	80.1	32	75.2
1942	11	32	79.9	68	77.9
1941	12	5	81.0	3	80.3
1940	13	1	81.0	1	78.0
1939	14	4	82.0	—	—
1938	15	1	82.0	—	—
1937	16	6	83.5	7	82.0
1936	17	1	85.0	—	—
1935	18	1	85.0	—	—

V. On the Norwegian Pelagic Long-Line Fishery in the Holsteinsborg Deep - 1953

BY BIRGER RASMUSSEN

In the season of 1953 altogether 54 Norwegian vessels participated in the Greenland fishery. The total catch was about 10,000 tons of salted cod. As in previous years the Institute of Marine Research had observers on board a commercial vessel. The observers were Birger Rasmussen and his assistant Alfred Frøland who started work in the field on 21 July. The work was mainly carried out in the Holsteinsborg Deep where great concentrations of cod *Gadus callarias* L. in the surface layers were reported at that time.

The Trend of the Fishery.

During the month of May the Norwegian vessels had been long-lining on the western slopes of Fiskenæs, Danas, Fyllas and Banan Banks with good results. In June-July the cod seemed to disappear from these localities, and a part of the fleet moved to the banks off Cape Farewell—Frederikshåb. Towards the end of July and in August good catches could be made on the shallow parts of the banks, but the cod was generally so smallsized that long-lining was deemed unprofitable. The whole fleet finally concentrated their activities in the Holsteinsborg Deep till the end of August when large-sized cod reappeared along the slopes of the banks.

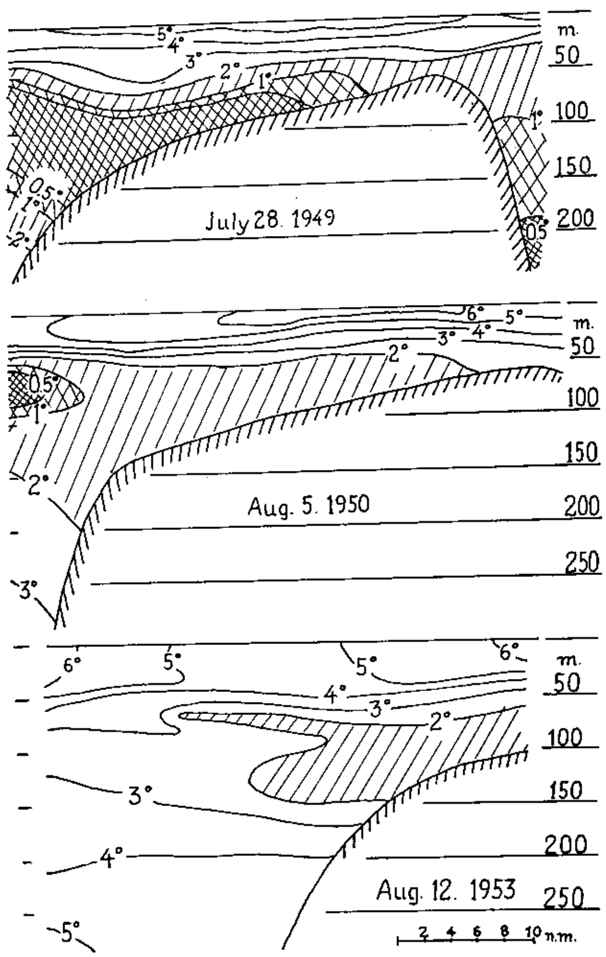

Fig. 1. Lille Hellefiske Bank. Distribution of temperature 28 July, 1949, 5 August, 1950, and 12 August, 1953.

On 12-13 August temperature observations were taken in three sections across the banks, viz. one westwards from the northern edge of the Lille Hellefiske Bank, one westwards from the shallow part of the Lille Hellefiske Bank, and one westwards from Fyllas Bank. In Figures 1 and 2 are shown the temperature conditions in the two latter localities together with corresponding observations in previous years.

In 1953 the temperatures were unusually high. In depths of 150-200 m. on the western slopes, where long-lining usually takes place, the bottom temperature on Lille Hellefiske Bank in 1949 was 0.5-1.5°C, in 1950 1-2°C, and in 1953 2-4°C. For the years 1951 and 1952 observations are lacking. On the Fyllas Bank the bottom temperature in the same depths was below 1°C in 1949, in 1950 1-2°C, in 1951 1-1.5°C. In 1953 the bottom temperatures were as high as 4-5°C. A short distance off the western slope of Fyllas Bank, we found in 1953 a belt of warm water with a central core of 7°C. In earlier years we had found cold water which partly covered the slope itself.

The high temperatures in 1953 may perhaps explain other trends characteristic for the Greenland-fishery that year. In the Holsteinsborg Deep, for instance, in July-August unusually great concentrations of food organisms were observed. In the stomachs of the cod large amounts of capelin were present, likewise sand eels, squids, fish larvae and schizopods. The cod in the Holsteinsborg Deep were of consider-

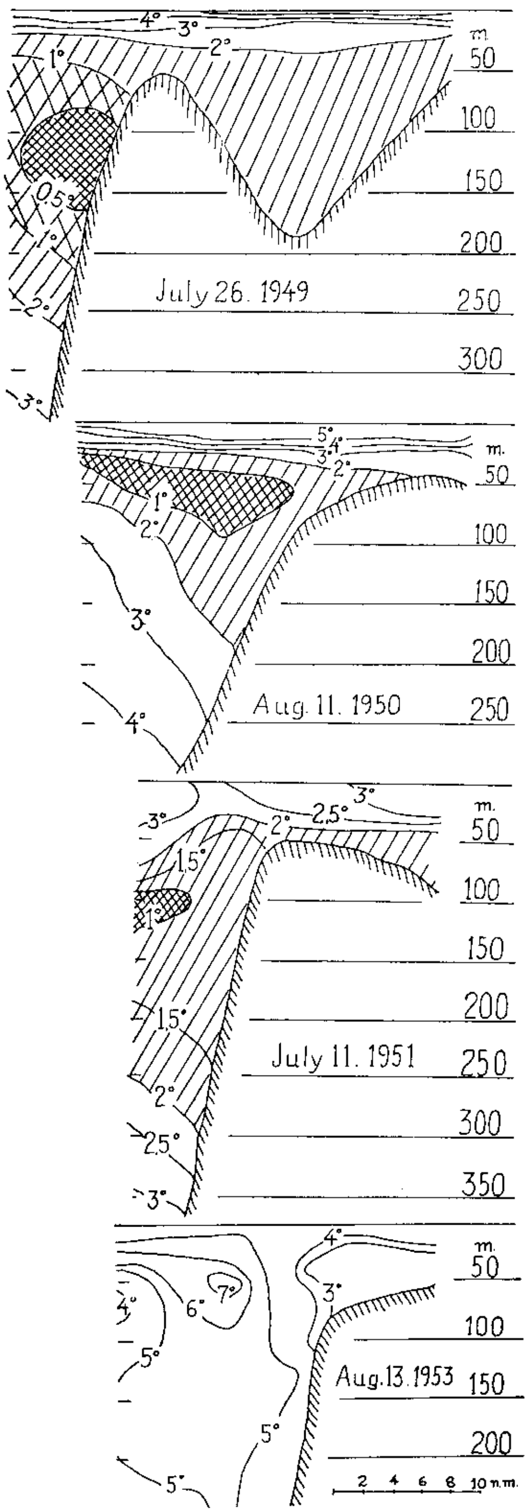

Fig. 2. Fylla Bank. Distribution of temperature 26 July, 1949, 11 August, 1950, 11 July, 1951, and 13 August, 1953.

ably better quality in 1953 than in earlier years. The liver content was above normal, and the yield and quality of the oil produced perhaps the best since 1949.

The Pelagic Fishery in Relation to Temperature.

The Holsteinsborg Deep is a submarine channel leading from the fjords towards the great deep of the Davis Strait between Store—and Lille Hellefiske Bank. From the latter part of July and in August swarms of cod were present in the surface layers and dense shoals were registered on the echosounder. The Norwegian vessels started fishing with floating or pelagic long-lines on 24 July. This type of fishing was tried for the first time in 1951, and has in later years become part of the ordinary fishery off West Greenland. According to the fishermen, the cod was larger in the Holsteinsborg Deep than on the shallow parts of Store—and Lille Hellefiske Bank, where the high percentage of small cod made fishery unprofitable. The same was the case on the southern banks. In the Holsteinsborg Deep the schools contained larger fish. The general temperature patterns observed were largely the same all the time. From 24 July to 10 August the surface-temperatures varied between 4°C and 6°C. The temperature decreased slowly to a depth of 30-55 m. From this point down to a depth of 70-120 m. a rapid transition towards colder water-masses with temperatures of 2.0-2.5°C occurred.

From 24 July to 10 August the layer of warm surface-water increased in thickness. The border of the warm surface-water (4°C) was on 24 July found at 30 m., on 31 July at 36 m., on 5 August at 40 m., and on 10 August at 55 m. The distance from the surface down to the more homogenous and colder deep-water increased in a similar way. On 24 July the border (2.5°C) was found at a depth of 72 m. and on 10 August at 120 m. Repeated fishing trials with hand-lines indicated that the cod in the Holsteinsborg Deep were fairly evenly distributed in all depths from the surface down to 150 m. The fishery with pelagic lines gave, however, the impression that heavier concentrations of fish were present at certain depths, as some parts of the lines would give better catches than others. The question naturally arose if there could be a connection between fish-occurrence and temperature-depth.

A set of pelagic long-lines usually consists of 30 tubs, each with about 180-200 hooks. It took fairly close to one hour to set the whole line with a speed of four knots. For every tub a buoy was set with seven fathoms drag to which the fishing line was attached. The length of fishing line between two buoys was about 386 meters, and the distance between each buoy about 246 meters. Thus the long-line between two buoys describes a half-circle in the sea, with the deepest point at a depth of approximately 136 meters (see Fig. 3). The same figure shows the temperatures in the various depths during the period of observation. During the week 30 July—5 August, the catches were controlled on four different settings.

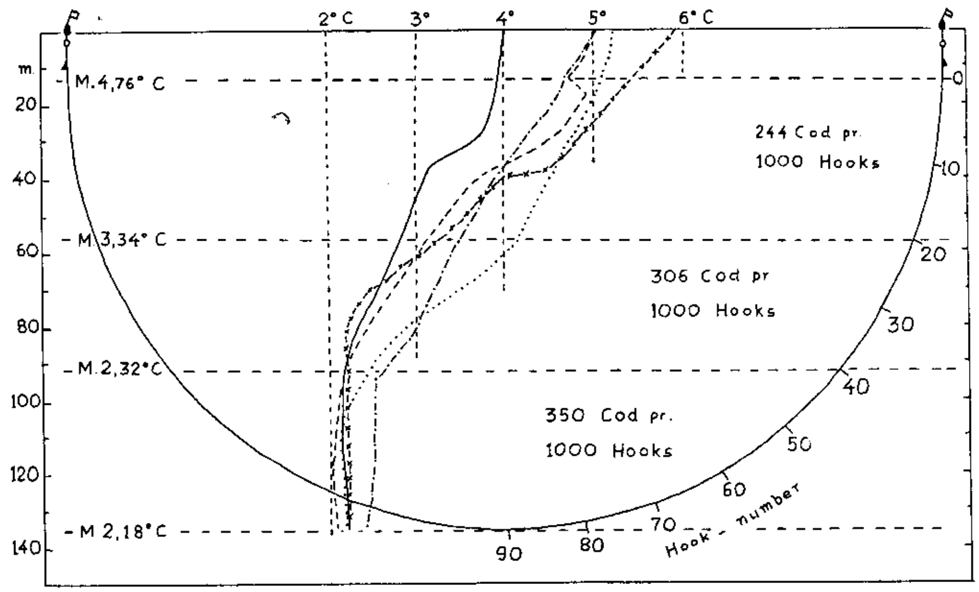

Fig. 3. Schematic drawing of a pelagic long line with temperatures and catch of cod indicated for various depths. From experiments carried out 30 July-5 August, 1953.

From Figure 3 it appears that the surface temperatures vary between 4 and 6°C. The first hook of the line stands in a depth of 13 m. At that depth the average temperature for all days is 4.76°C. The temperature decreases downwards relatively fast. At 90 m. we find a decided borderline between two temperature regions. The surface layers form a relatively warm ceiling above the underlying layers with temperatures between 2-2.5°C. The pelagic long-line fishes through the warm surface-layers and some distance down into the cold water-masses.

Altogether each fish and hook was counted while fishing four settings with 9,540 hooks. The result of the countings is shown in Table I.

From the table it appears that the fishery gives the smallest yield in the surface layers above 57 m., where the temperature decreases from 4.70°C at 13 m. to 3.34°C at 57 m. Between 57 and 92 m. the catches are somewhat better. The temperature here decreases from 3.34°C to 2.33°C. The best catches are made between 107 and 128 m. depth, the temperatures here being 2.33-2.20°C. On the deepest part of the long-line from 128 to 136 m., the catches again decrease. The temperature here is about 2.18°C.

TABLE I.

Hook nos.	Depth meters	Temp. C°	No. Cod Total	No. Cod Per 1,000 hooks
1–10	13– 36	4.70 — 3.34	248	234
11–20	36– 57		268	235
21–30	57– 76	3.34 — 2.33	323	305
31–40	76– 92		324	306
41–50	92–107		354	334
51–60	107–119	2.33 — 2.20	379	358
61–70	119–128		385	363
71–80	128–133		373	352
81–90	133–136	2.18	364	344

Obviously the cod in the Holsteinsborg Deep has a tendency to gather in densest shoals in the relatively cold water just below the warm ceiling found at about 90 m. However, other factors than temperature may play a part. It is for instance possible that the concentration of food organisms has been particularly great just below the ceiling due to current conditions, and that the fish have been particularly attracted to that zone.

It may also be anticipated that the baited hooks may have been actively fishing while sinking through the water with the result that the deepest hooks naturally would catch more fish because they pass twice through the water masses where fish are present. To clarify this point it may be explained that it takes one hour to shoot the long-line, and usually it stays four hours before it is hauled. The hauling of the whole line takes 5-6 hours.

The long-lines and hooks covered by our investigation have been actively fishing in their proper depth for seven hours on an average before being hauled. In general the fish density would be smaller on the first part of the line hauled and show an increase toward the end of the haul. This indicates that the line is mostly fishing when it is floating in its proper depth. However, the liveliness of some single cod showed that they had become hooked when the long-line passed upwards through the water.

The fishermen know from experience that it does not pay to haul the long-line immediately after setting. If an appreciable great number of fish really grabbed the hooks of the sinking or rising long-line the fishermen would naturally have shortened the duration of each line setting.

Size and Age of the Cod.

The cod caught on pelagic long-lines in the Holsteinsborg Deep show comparatively small variations in size from one day to another (Fig. 4). In the period 24-29 July we find among the usual large fish of about 75 cm. a relatively great influx of smaller cod about 60 cm. in length. The mean size of the cod in the said period is 72.97 cm. In the period 31 July - 1 August the influx of small cod is somewhat less, and the mean size increases to 73.53 cm. On 10-11 August a new influx of small-sized cod occurs, whereby the mean size decreases to 71.67 cm.

The total size distribution of cod caught on pelagic long-lines in the Holsteinsborg Deep is illustrated in Figure 5. The curve has two maxima, one at 60 cm. and one at about 75 cm.

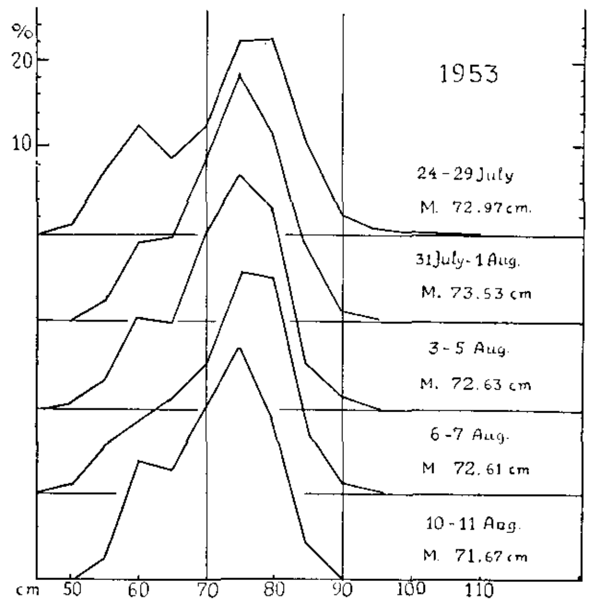

Fig. 4. Percentage size distribution by 5 cm. groups of cod caught on pelagic long lines in Holsteinsborg Deep on various dates from 24 July to 11 August, 1953.

Since 1949 it has been the year-class 1942 which has dominated, and the same is the case in 1953. Fishery investigations by other countries have proved that the year-class 1947 has been very prominent for a couple of years in the trawl catches taken on the banks and in the coastal fishery. In 1952 the 1947 year-class made up 50.7% of the Icelandic trawl-catches on the Greenland banks, while the same year-class yielded only very little to the Norwegian long-line catches of that year. It was not until the season of 1953 that this year-class entered the fishery with long-lines. The cod of the 1947-class are now six years old. In Figure 5 is shown the size-distribution of the 1947 and the 1942 year-classes in the long-line samples from 1953. The mean size of the 1947 year-class is 59.9 cm., that of the 1942 year-class 76.9 cm. The size of the two year-classes corresponds with the two maxima in the length distribution of all fish caught.

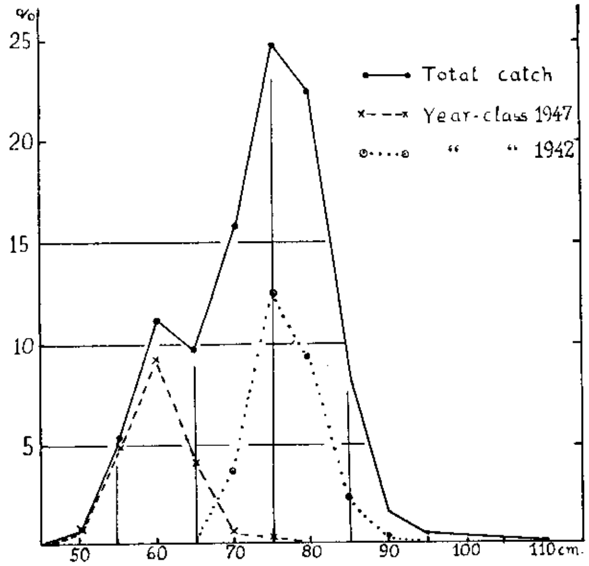

Fig. 5. Total size distribution by 5 cm. groups of cod caught in Holsteinsborg Deep, July-August, 1953 together with cod of the year-classes 1942 and 1947 separately.

The line-caught cod belonging to the year-class 1942 has in the last few years had the following mean lengths:

Year	Age	Length, cm.
1948	6	66.5
1949	7	—
1950	8	73.0
1951	9	73.7
1952	10	75.7
1953	11	76.9

Thus during the last four years the mean yearly increment was only 1.3 cm. The new strong year-class of 1947 appearing in the long-line catches had in 1953 a mean size of only 59.9 cm. Apparently the six year old fish born in 1947 is 6.6 cm. smaller than the six year old fish born in 1942. This fact seems to confirm the supposition that the growth conditions on the West Greenland banks have been unsatisfactory for a number of years.

The age-distribution of the line-caught cod in 1953 is shown in Table II. Besides the material from the Holsteinsborg Deep, a single sample was collected on Fyllas Bank on 13 August.

The 1947 year-class is poorly represented on Fyllas Bank compared to Holsteinsborg Deep. The 1942 year-class, however, is present in both localities in the same quantitites (about 29%). The mean age for all the fish in the Holsteinsborg Deep was in 1952 11.1 years, in 1953 10.0 years. The mean size was in 1952 75.99 cm., and in 1953 72.58 cm. The reason for this decrease in mean age and size is the increasing occurrence of the relatively small cod born in 1947.

TABLE II.

Age	Year class	Holst. b. Deep %	Fyllas Bank %	Mean %
5	1948	0.9	1.0	0.9
6	1947	19.1	5.1	18.3
7	1946	5.3	4.6	5.3
8	1945	9.9	7.8	9.9
9	1944	5.4	3.6	5.3
10	1943	9.4	6.1	9.3
11	1942	28.5	29.0	28.6
12	1941	5.7	4.6	5.6
13	1940	4.3	7.1	4.5
14	1939	3.4	9.7	3.8
15	1938	0.6	1.0	0.7
16	1937	1.5	3.6	1.7
17	1936	2.8	7.1	3.1
18	1935	1.7	2.5	1.7
19	1934	0.9	5.1	1.2
20	1933	0.1	2.5	0.2

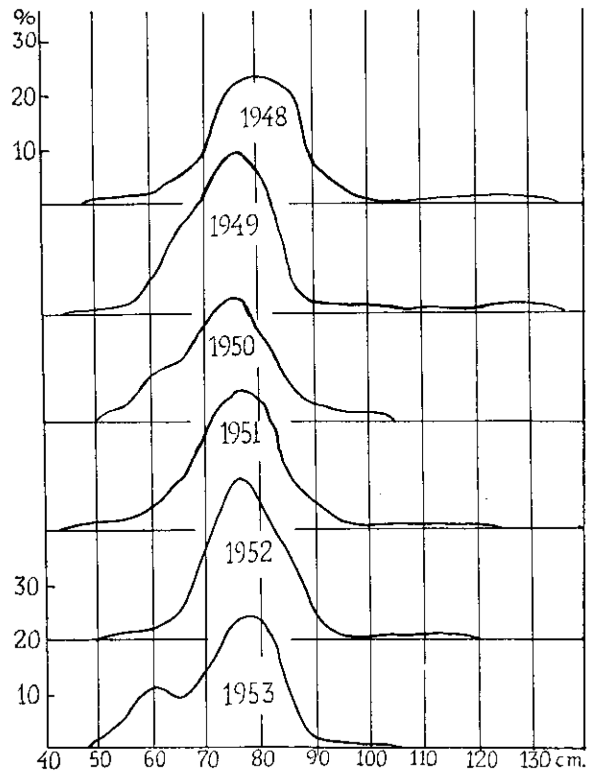

Fig. 6. Percentage length distribution by 5 cm. groups of cod caught by Norwegian vessels on offshore banks in the years 1948-1953.

Figure 6 shows the length distribution of cod caught on long-lines in the different years from 1948 to 1953 The long-line, whether on bottom or pelagic, seems to be a gear with relatively great selective ability in regard to fish-size. Usually the mean length of the cod lies between 70 and 85 cm. In the years 1948-52 between 69 and 87% of the cod had a mean length of 70 to 85 cm. In 1953, 71.2% of the catch was of this size.

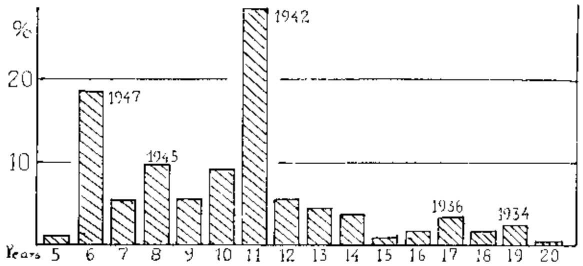

Fig. 7. Percentage age distribution of line caught cod from offshore banks in 1953. The year-class indicated for the rich age groups.

Figure 7 illustrates the age-distribution of cod caught on long-lines in 1953. It is particularly three year-classes which have given a great yield, viz. those from 1934, 1936 and 1942. The rich year-classes seem to keep their strength over a great number of years. The year-classes 1934 and 1936 have thus given a fairly respectable yield as late as in 1952 when the fish were respectively 18 and 16 years old. However, in 1953 they had apparently lost their strength.

The year-class 1942 began to enter the long-line catches in 1948 at an age of six years, and has since been the most important year-class in the long-line fishery. In 1953 it still seemed to have a relatively great strength. Probably the year-class 1942 will also have next year a decisive influence on the yield of the Norwegian long-line fishery.

The year-class 1947 which began to appear in the catches in 1953 will probably increase in numerical strength next year. On account of the small size of fish, however, it will hardly become of any decisive importance for the Norwegian long-line fishery for some years to come.

Tagging of Cod in the Holsteinsborg Deep.

The pelagic cod in the Holsteinsborg Deep distinguishes itself from ordinary bank-cod by its dark coloured back and bluish fins. These cod have possibly migrated from the fjord districts further east. To answer this question tagging was carried out in the Holsteinsborg Deep. A total of 512 individuals were marked with large yellow plastic marks fastened with silver wire to the gill cover.

Up to the end of the year 1953, 13 recaptures had been reported. The recaptures were made 0-70 days after the date of tagging. Four individuals were recaptured in the tagging locality, all the others on Store Hellefiske Bank. The recaptures show a clear tendency for the fish to migrate northwards when leaving the Holsteinsborg Deep. It is perhaps not improbable that the pelagic shoals of cod in the Holsteinsborg Deep may be cod from Store Hellefiske Bank undertaking a feeding migration southwards in the summer and returning to the bank later in autumn. The great influx of individuals belonging to the 1947 year-class in the pelagic shoals also indicates that this may be the case. According to Paul Hansen the 1947 year-class was particularly rich on Store Hellefiske Bank in 1952, while its numerical strength decreased to the south. Our own samples show a similar trend in 1953. In the Holsteinsborg Deep 19.1% of the catches consisted of the 1947 year-class, while Fyllas Bank further south only yielded 5.1%.

It will be of interest in the coming years to study more closely the pelagic shoals of cod. Similar pelagic concentrations of cod are according to the fishermen also to be found in the submarine channel between the banks further south.

VI. Portuguese Researches in 1953

BY JOSE MOUSINHO DE FIGUEIREDO

Soon after the Third Annual Meeting of the ICNAF in New Haven, Conn. U. S. A., 1953, the author sailed on board the dory cod fishing vessel "Capitao Joao Vilarinho" from St. John's, Newfoundland to the fishing grounds off Greenland and started the work in co-operation with Dr. phil. Paul M. Hansen on Dana Bank on 9 June, 1953. Afterwards the author spent two weeks on board the Danish research vessel "Adolf Jensen" and came back to the "Capitao Joao Vilarinho" where he stayed collecting material until the end of July. He also spent one week on board the hospital ship "Gil Eanes".

The author feels deeply grateful for the two last weeks at sea as guest of the Royal Danish research ship "Dana", where he enjoyed the unforgetable experience of becoming acquainted with every kind of research work in which "Dana" was engaged during the trip back to Europe.

1. Conversion Factor Studies (See Fig. 1).

Studies on conversion factors were started in 1953. As they are planned to continue in 1954 they are here dealt with only summarily (details were given in docs. 3, 4, and 6 of Ann. Meeting 1954).

During 1953, every vessel of the Portuguese cod fishing fleet was given two forms to be filled in with the weight figures of the more important parts in which the whole round fresh cod, *Gadus callarias* L., is divided through the processing work on board.

The numbers of forms referring to each of the three subareas studied are as follows; the corresponding numbers of cod investigated are given in brackets:

Subarea 1,	Davis Strait:	17 forms,	(430 cod)
Subarea 2,	Labrador Coast:	11 forms,	(395 cod)
Subarea 3,	Newfoundland Banks:	19 forms,	(474 cod)

The range of the conversion factor figures was found differing from area to area:

Davis Strait: 2.05 to 3.12 Labrador: 2.70 to 3.01
Newfoundland: 2.70 to 3.57

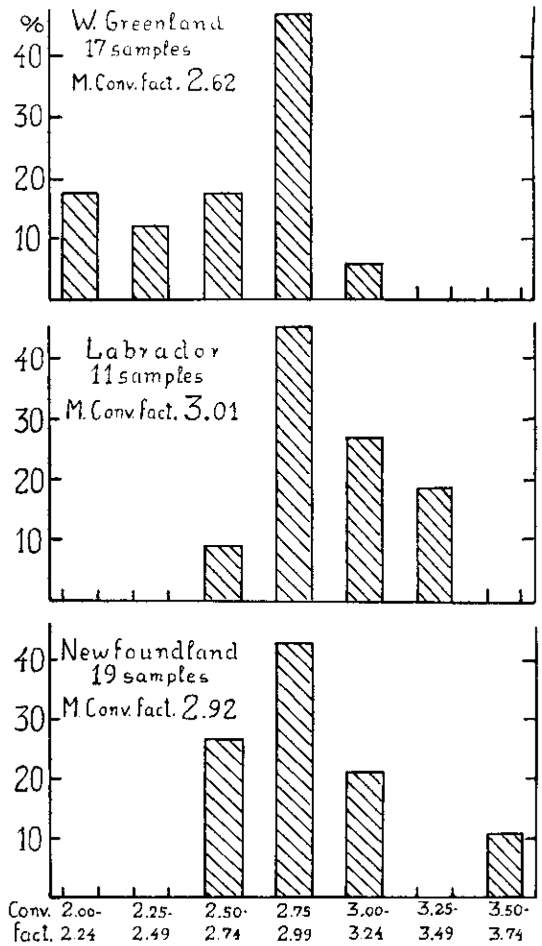

Fig. 1. Summary of results of Portuguese experiments on conversion factors in 1953 in Subareas 1, 2, and 3. Percentage distribution within sizes of conversion factor.

However, the modal frequencies for the conversion factor figures in all the three areas fall in the 2.75/2.99 group.

On board the dory vessel "Capitao Joao Vilarinho" the author weighed, measured and sexed 80 cod and carried out for each fish 12 different weighings of the different parts in which the fish is divided under the usual processing work aboard. These studies were carried out on the Fylla Bank and on the Store Hellefiske Bank, in June and July 1953. The final results broken down by sexes and fishing grounds, confirm the rougher study carried out on board the 47 fishing vessels. In each one of these vessels a lot of 100 kg. fresh whole fish was dealt with. As a final result the author thinks that the total average waste of the fresh cod amounts to 27% against 70% of the recoverable. The respective ratio of recovery being 1.70, i.e. the ratio between the weight of the whole round fish and the weight of the bodies ready for salting.

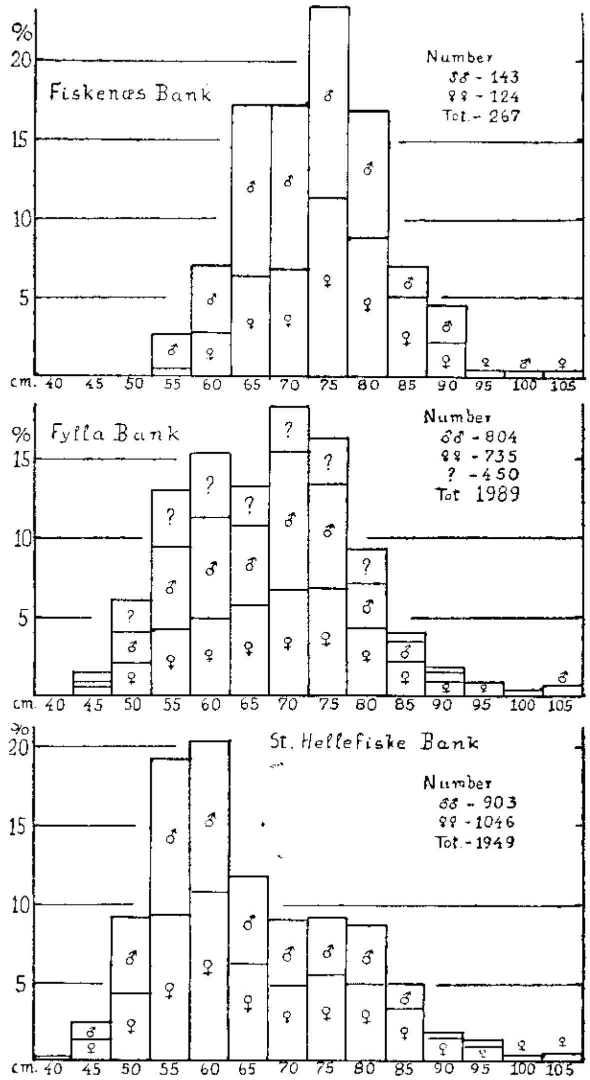

Fig. 2. Percentage length distribution by 5 cm. groups of cod caught by Portuguese dory vessels on West Greenland banks, June-July, 1953.

2. Length Composition of Cod from West-greenland Waters. (Fig. 2).

On board the dory vessel "Capitao Joao Vilarinho", the author sampled and sexed 4,205 cod caught with dory trawl line in the waters off Greenland, in June and July 1953. On Fiskenæs Bank, in early June, 267 fishes were measured and sexed in only one fishing day. The size modes fall in the 75/79 cm. group which later proved to be age-group XI. On the Fylla Bank (June and July) the sampling comprised 1,989 cod and the respective modal group was the 70/74 cm., closely followed by the 75/79 cm. group. On the Store Hellefiske Bank (July) the whole sample was of 1,949 fishes and the modal frequencies conspicuously fall on the two smaller-sized groups, 60/64 cm. and 55/59 cm.

The sex ratio was as follows:

Fiskenaes Bank:	males 53.5%
Fylla Bank:	males 52.8%
Store Hellefiske Bank:	males 46.5%

These studies will be continued on a wider scale in the Convention Area in 1954.

3. Composition of Year Classes in Catches of Cod. (Fig. 3.).

The otoliths used in this study were collected together with the corresponding length measurements from the four principal fishing banks off Greenland:

Dana Bank—61 specimens
Fiskenæs Bank—252 "
Fylla Bank—452 "
Store Hellefiske Bank—302 specimens.

From north to south the results are as follows: On the Store Hellefiske Bank age-group VI was dominant. Its mean length ranged from 58 to 61 cm., the most frequent figures falling in the 60-64 cm. group. On the Fylla Bank the results are not so obvious as those found for the Store Hellefiske Bank. In three samples corresponding to three different days the otolith study gave a modal on age-group VI (mean length 59 to 61 cm.) but in the other three samples the modal classes seem to be either the age-groups VIII or X. However, the total average from Fylla Bank shows a peak for age-group VI. Next to this age-group come age-groups VIII and X.

On the Dana and the Fiskenæs Banks the results were identical, notwithstanding the small-

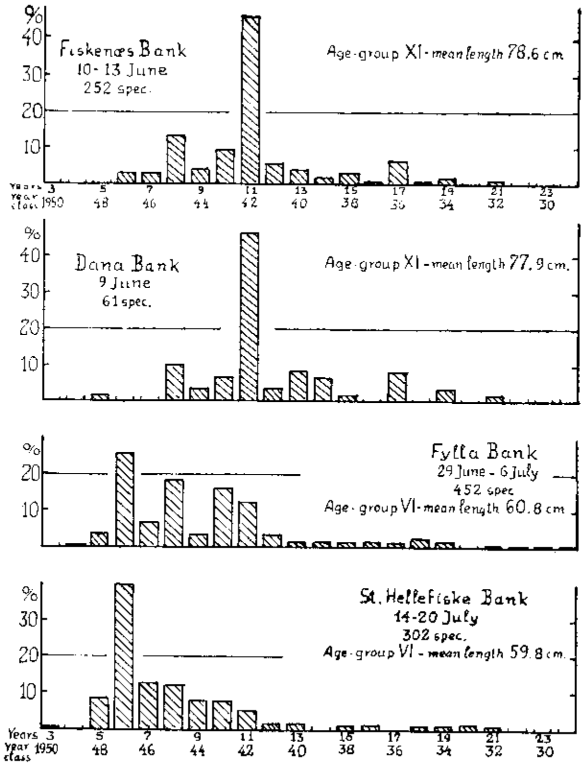

Fig. 3. Percentage distribution of cod caught by Portuguese dory vessels on West Greenland banks, June-July, 1953.

ness of the sample collected on the Dana Bank. The dominant age-group was the XI followed by the VIII. The mean average length of the age-group XI was 78 cm. (Dana) and 79 cm. (Fiskenæs).

These results are presented with some reserve, as the work has the character of a preliminary survey. The otolith collecting work will be continued in Subareas 1, 2 and 3 in 1954.

4. Recaptures of Tags.

Soon after the 1953 cod fishing season was over, the recording service of recaptures of tagged cod was duly organized in Portugal. 66 cod tags were found by Portuguese fishermen in 1953 and the tags were sent to the original laboratories as follows:

Denmark—47 Newfoundland—4 Norway—15

5. Tagging.

On board the hospital ship "Gil Eanes" the author tagged a few cod with ebonite disks and silver wire, just for testing the local conditions. The taggings took place on the Store Hellefiske Bank (67°38′N, 55°00′W) on 24 and 29 July, 1953. Difficulties in carrying out such work were great, firstly since this ship does not fish regularly and intensively, secondly as cod, when available, could not be kept alive, and finally because the railing of this ship is so high that the fish are damaged when put back to sea.

6. Poster.

According to the recommendations of the Third Annual Meeting of ICNAF, a poster was made and distributed to all the Portuguese cod fishing vessels asking the fishermen to pay attention when working on the fishes. This poster also points out the correct procedure in measuring the fish and thus prevents the most common mistakes. It includes some basic information about the Portuguese tags and requests the fishermen to hand over tagged fishes to the skippers.

VII. Report on the cruise carried out by the Spanish vessel "Vendaval" in the waters off Newfoundland February - April 1953*

BY DR. OLEGARIO RODRIGUES MARTIN, BIOLOGIST,
AND DR. RAFAEL LOPEZ COSTA, HYDROGRAPHER

Introduction

With this work Spain begins its scientific collaboration as to the carrying out of the general research program of the International Commission for the Northwest Atlantic Fisheries.

The region in which research work was carried out was the southern part of the Grand Bank of Newfoundland, the St. Pierre Bank, and Banquereau. (See Figure 1).

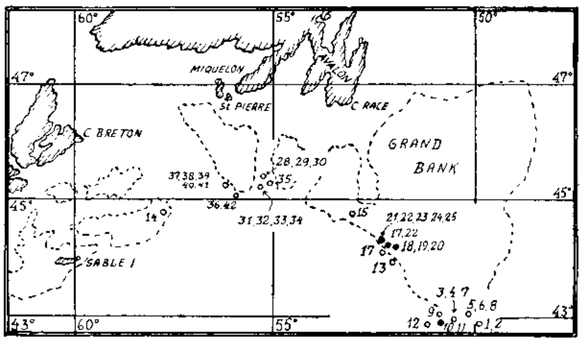

Fig. 1. "Vendaval". Area investigated and stations worked in February-April, 1953. The solid circles along the southwest edge of the Grand Bank denote stations where maximal temperatures were found.

The cruise began during the first days of February and was concluded during the first days of April of the year 1953.

The Spanish cod fishing motor vessel "Vendaval", belonging to the fishing company PYSBE, San Sebastian, was used for the researches. We wish to state here the fact that the fishing company PYSBE, the captain of the "Vendaval", and its crew gave us every possible help with the installation of the scientific gear in port as well as with the working of it at sea.

PART 1—BIOLOGY.

1. The Temperature and the Yield of the Fishery.

The results of temperature observations in connection with fishing show for cod, haddock, pollock, and white hake a very close relation between water temperature and fishing results:

Cod *Gadus callarias* L. Of the four species this is the one preferring the colder water, however, as a rule not below 2°C. Between 1 and 2°C. we caught some large cod, but nearly always in small quantities. The largest catches were made between 2 and 3°C. This temperature is therefore considered optimal for the cod. Here it should, however, be remembered that this observation is based exclusively on investigations carried out in March, 1953 on the Great Bank of Newfoundland.

Haddock *Melanogrammus aeglefinus* (L.). In water layers from 3-4-5°C. the quantities of haddock increase at the same time as those of the cod decrease. The optimal temperature observed for haddock was between 5 and 6°C.

Pollock *Pollachius virens* (L.), and **White Hake** *Urophycis tenuis* (Mitchill). These two species were only fished in small quantities, and therefore the optimal temperature cannot be ascertained with certainty. However, the scarcity indicates that the temperatures are too low for them.

Of all species fished the Spanish trawlers use only cod, haddock, pollock, and white hake, being those best suited to salting.

It is of interest to stress the fact that as the other species are returned to the sea, the Spanish fishing operations do not threaten the stocks of such fishes as redfish, halibut, flatfish, wolffish, etc. Of course it cannot be avoided that these species in varying quantities are occasionally taken by the trawl, but as they are not used by

* A short, preliminary report of the cruise was published in the Annual Proceedings, Volume 3, 1953.

our fishermen, areas where they are abundant are avoided.

2. Size of Fish commercially used. Cullings.

In culling, terms as large cod, medium cod and small cod are used. However, generally the length corresponding to each of these size categories is not defined.

As the cruise was carried out on board one of the boats belonging to PYSBE we shall here deal with the categories for culling used by that firm. The control of the cullings is carried out by means of metallic sheets in various sizes and formed as a bacalada. Bacalada is the Spanish name used for split cod (or other species of the cod group) in the stage ready for salting. From measurements carried out we give here the length of the fish as fresh round, corresponding to the dimensions of the metallic sheets used in the cullings.

	Dimensions (cm.) of sheet		Length of fish fresh round
	Length	breadth	
Large	80	42	from 95 cm.
Medium	60	29	from 70 cm.
Small			below 69 cm.

The minimum size of fish used varies around 40 cm., somewhat depending on personal judgement.

3. Catches per Unit of Fishing Effort.

The material collected was arranged to give the yield per hour of trawl fishing, a) during the day, b) during the night. The results are shown graphically in Figure 2.

The unit of weight used is the "Cesto". The cesto equals about 70 kg. of fish without entrails, head, $\frac{1}{3}$ of backbone and cleaned, viz. fish ready for salting. The cesto corresponds to 36 kg. of salted landed fish and to about 125 kg. of fresh round fish. The maximum yield, 36 cestos per hour, was found on the 24th March, during day time; the minimum yield, 1 cesto per hour, on the 15-16 during night time.

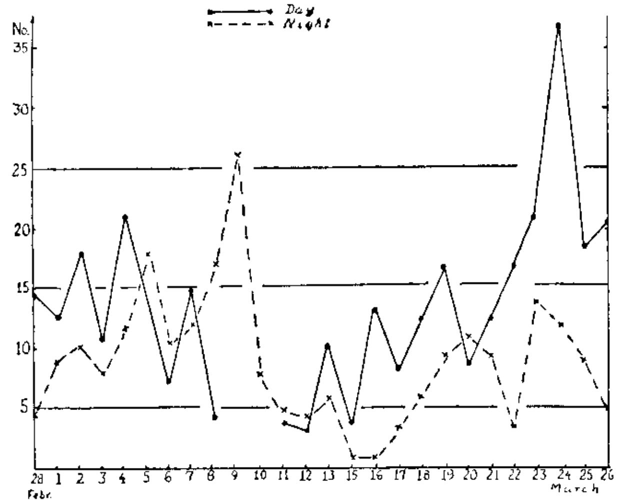

Fig. 2. "Vendaval". Catch of fish in number of cestos (=70 kg.) per one trawl hour by day and by night. February-March, 1953.

Also in general the yield of the fishery during the day is superior to that of the night. This is obviously caused by the cod moving away from the bottom during the night in search of food.

Thus the fish lupe showed that the capelin, *Mallotus villosus* (Müller), the principal food of the cod, was concentrated far from the bottom during night, and this is considered the reason for the diurnal migrations causing the smaller nightly catches. There are however some exceptions from this rule. On the 8th March the nightly yield was 17 cestos per hour against 4 only in day time. However, these big catches during the night of the 8-9 were not cod, but pollock, a species which is more migratory than the cod.

4. Cod.

Size and Age. The cod captured is in general small. Measurements from the point of the snout to the hind margin of the tail fin, of 600 specimens taken at random from the various hauls, gave the following results by 5 cm. groups:

cm.	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70
freq.	24	117	231	123	45	13	13	13
%	4%	19.5%	38.5%	20.5%	7.5%	2.16%	2.16%	2.16%
cm.	71–75	76–80	81–85	86–90	91–95	96–100	More than 100	
freq.	6	6	3	2	2	1	1	
%	1 %	1%	0.5%	0.33%	0.33%	0.16%	0.16%	

From these results, presented graphically in Figure 3a, it is apparent that the dominating sizes of cod are from 36-55 cm., the most common

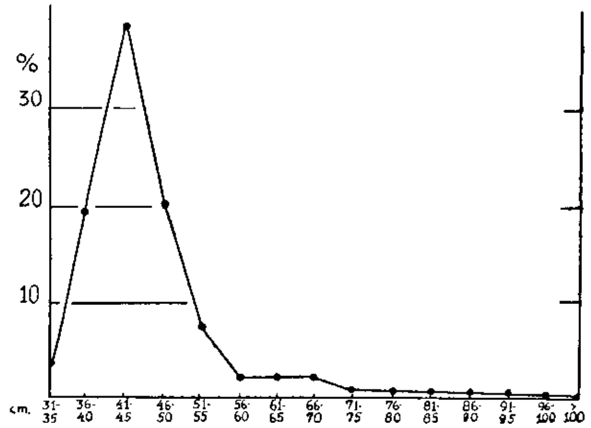

Fig. 3a. **"Vendaval". Percentage length distribution by 5 cm. groups of cod caught on Grand Bank - St. Pierre Bank in March, 1953.**

size being from 41-50 cm. Fig 3b shows the age distribution of a sample of 37 cod from Grand Bank - St. Pierre Bank. The dominating year-classes are 1946 and 1949.

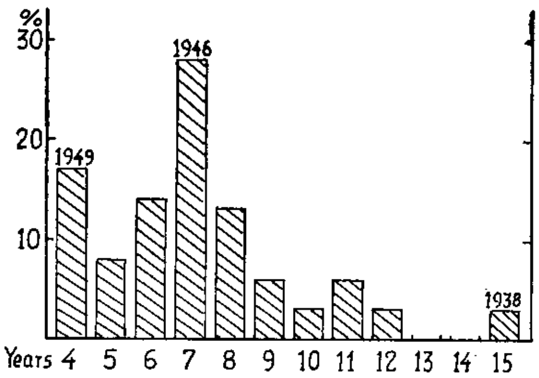

Fig. 3b. **"Vendaval". Percentage age distribution of samples of cod caught on Grand Bank-St. Pierre Bank in March, 1953.**

Sex and Stage of Maturity. For the determination of the stage of maturity we have used the scale in use in St. John's, Newfoundland for the cod family. Our observations are given in the following scheme:

The stages of sexual maturity I and II correspond to individuals below 55 cm. length. In general all individuals of stage V are cod of a size of 60 cm. or more (Table 1 and 2).

TABLE 1

Cod, Great Bank of Newfoundland, March 1953 Length, sex, and stage of maturity.

St. of Mat.	I		II		III		IV		V		VI		Total
Sex	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	
cm.													
31-35	4	1											5
36-40	24	14											38
41-45	37	34											71
46-50	18	10	1										29
51-55	6	8		4		1							19
56-60	8	2		2					1				13
61-65	5				1	1							7
66-70			1		4	1							6
71-75													0
76-80			1	1		1							3
81-85	1		1						3	1			6
86-90				1					2				3
91-130						1			3	5		1	10
Total	103	69	4	8	5	5	0	0	9	6	0	1	210
	172		12		10		0		15		1		

It appears that the cod from the St. Pierre Bank are considerably larger than those from the Grand Bank. Nearly all are mature. Judged from the stage of maturity the spawning should take place in April and May.

Food. The cod, especially the larger ones, have a varied stomach content: crustaceans, molluscs and various species of fish, mainly haddock, flatfish and small cod. In the small cod the stomachs were often filled with capelin.

5. Haddock.

Size and Age. The general size varies between 50-55 cm. Individuals smaller than 32 or larger

Cod—Grand Bank of Newfoundland (March, 1953)

Stage of Maturity	I	II	III	IV	V	VI	No. of specimens
Males	101	4	5	—	9	—	119
Females	71	8	5	—	7	—	91

Cod—St. Pierre Bank (25, 26, 27 March, 1953)

Stage of Maturity	I	II	III	IV	V	VI	No. of specimens
Males	3	2	—	—	10	2	17
Females	1	3	—	—	15	6	25

than 70 cm. are scarce. The dominating year-classes were 1945, 1946, and 1949.

The stage of maturity is shown in the following survey:

Haddock—Grand Bank of Newfoundland (1 March, 1953)

Stage of Maturity	I	II	III	IV	V	VI	No of specimens
Males	8	7	13	12	4	—	44
Females	9	5	6	16	2	—	38

Haddock—St. Pierre Bank (1 March, 1953)

Males	13	12	10	13	—	1	29
Females	16	4	1	—	9	1	31

TABLE 2

Cod, St. Pierre Bank, 25-27 March 1953
Length, sex, and stage of maturity

St. of Mat.	I		II		III		IV		V		VI		Total
Sex	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	
cm.													
41-45		1											1
46-50													0
51-55	1		1									1	3
56-60	1								1				2
61-65	1												1
66-70			1	1					2	2		1	7
71-75									2	4			6
76-80									1	2		2	5
81-85				1						1			2
86-90				1					4	2	2		9
91-95										3		2	5
96-102										1			1
Total	3	1	2	3	0	0	0	0	10	15	2	6	42
	4		5		0		0		25		8		

Tables 3 and 4 show the length distribution in 5 cm. groups. Mature haddock (stage IV to VI) were not found below a size of 50 cm.

Food. The haddock is not so voracious as the cod. In its stomach fishes are rarely found. The content principally consists of echinoderms, crustaceans, worms and molluscs.

TABLE 3

Haddock, Great Bank of Newfoundland, March 1953
Length, sex, and stage of maturity

St. of Mat.	I		II		III		IV		V		VI		Total
Sex	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	
cm.													
33-35	1	2	2										5
36-40	5	5	1	3	1								15
41-45	2	2	1	2	2								9
46-50			2		6	3	1	3		1			16
51-55			1		3	3	7	4	2				20
56-60					1		3	4	2	1			11
61-65							1	5					6
Total	8	9	7	5	13	6	12	16	4	2	0	0	
	17		12		19		28		6		0		82

TABLE 4

Haddock, St. Pierre Bank, March 1953
Length, sex, and stage of maturity.

St. of Mat.	I		II		III		IV		V		VI		Total
Sex	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	
cm.													
33-35		1	1		1								3
36-40	1	5	5	2	2								15
41-45	2	8	6	2	1								19
46-50		2											2
51-55							2						2
56-60							1			2			3
61-65					3					4			7
66-70					2	1				1			4
71-75					1					2			3
76-80											1	1	2
Total	3	16	12	4	10	1	3	0	0	9	1	1	
	19		16		11		3		9		2		60

6. Pollock.

The migratory habits of this species were confirmed by our observations of its greatly changing abundance in trawl hauls from the same place within few hours.

Size and Age. The following survey gives the length distribution in 10 cm. groups:

cm.	30–40	41–50	51–60	61–70	71–80	81–90	91–100	Total
No.	2	2	20	40	4	20	4	92

In general the size of the specimens caught in one and the same haul was very much the same.

The 1947 year-class was dominating in the catches with near to 50%.

Sex and Stage of Maturity.

Stage of Maturity	I	II	III	IV	V	VI	No. of specimens
Males	1	1	1	—	—	13	16
Females	2	2	—	1	3	20	28

Mature specimens were found down to a size of 54 cm. All specimens from 66 cm. and upwards were mature.

Food. The smallest specimens feed on crustaceans. In the stomachs of the larger were found mostly fishes, cod, haddock, and capelin.

Parasites. The surface of nearly all the livers observed was infested by a little worm (Nemathelminth) rolled in a spiral.

7. White Hake.

This species is, owing to its loose flesh, of inferior quality. Only small quantities were caught during the cruise. The rising to the surface of the trawl during hauling reveals the presence of white hake. This is caused by the fact that the belly of the white hake is easily inflated.

Size. The results of the measurements carried out are given in 10 cm. groups in the following scheme:

cm.	40-50	51-60	61-70	71-80	81-90	91-100	abv 100	Total
No.	1	11	14	17	4	4	1	52

The sizes of white hake are thus considerably higher than those found for the three other species.

Stage of Maturity. The following survey gives the results of the investigations:

Stage of Maturity	I	II	III	IV	V	VI	No. of specimens
Males	—	—	2	14	5	—	21
Females	—	6	4	3	5	—	18

The stage of maturity is rather advanced, and males and females are found in the act of spawning.

Food. The white hake is a voracious fish. The food found varied considerably, consisting however principally of fishes (redfish, haddock, cod and hake).

8. Other Observations.

a) **Plankton.** By means of a special plankton indicator constructed by the Instituto Espanol de Oceanografia and by means of nets, samples of plankton were collected for the study of distribution of eggs and larvae of the principal food fishes.

b) **Fauna.** Animals from the bottom and from stomach contents, mostly fish, molluscs, and crustaceans, were collected and conserved.

c) **Age of Fishes.** From the four species treated in the preceding pages were collected otoliths and scales.

d) Experiments on conversion factors were carried out (details reported in Doc. 7, Ann. Meet. 1954). The following factors for converting from landed to fresh round were found for Subarea 3 (March):

Cod:	large 3.80,	medium 3.48,	small 3.20
Haddock:	3.10		
Pollock:	2.64		
White Hake	3.90		

The high figure for large cod is obviously due to these cod being in the spawning stage.

PART II—HYDROGRAPHY

1. Observations on Temperature and Salinity.

The hydrographic observations were made in the period from the end of February to the end of March, viz. during winter and during the period of "invernal stabilization" of the water. The observations showed that this invernal stabilization occurred over most of the area and that consequently the highest temperatures were found in water layers below 50 m. However, there were a few exceptions among the stations taken in the Halibut Channel (see Figure 1 and 4). Here the bottom temperatures were low, between -0.2 and +0.6°C, against +0.2 to +1.0°C for the surface layers. These exceptions

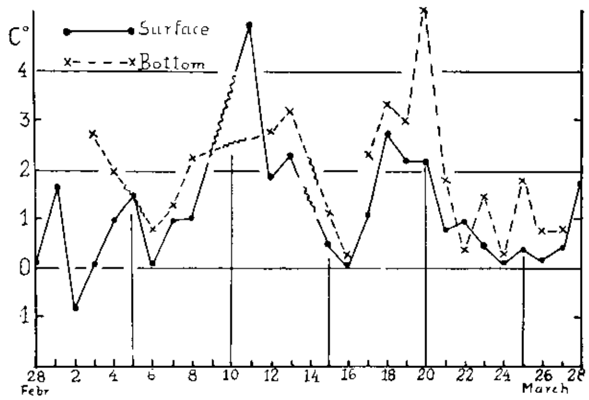

Fig. 4. "Vendaval". Surface-and bottom water temperatures, 28 February-28 March, 1953, area Grand Bank - St. Pierre Bank.

can be explained from the lability of the isotherms, which in this southern area are close together, owing to the northward drive of the Gulf Stream, and from the comparatively low salinity ($32.5^{\circ}/_{00}$) facilitating a rapid thermal change. Thus these exceptional cases are caused by the lower water layers (slope water) having preserved their characteristics ($34^{\circ}/_{00}$ and 2-10°C), whereas the upper water layers have been modified by the Gulf Stream sufficiently for a momentary breaking off of the winter inversion.

The salinity of the bottom water was in the ten first stations below $33^{\circ}/_{00}$, which is in agreement with the general case for this area and season. The same agreement was found for the salinity of the surface water along the whole area investigated between the meridians 50°W and 57°30″W.

The yield of the cod fishery is, as already mentioned, dependent on water temperatures. In certain years it has been observed that the summer temperature has caused the isotherms of +4° C to be replaced from their normal position over the 200 m. depth curve south and east of the Grand Bank to a position closer to land, over depths of 50-75 m. In such cases the yield of the cod fishing in the following winter and spring is prejudiced by the increase in water temperature.

During the "Vendaval" cruise we found temperatures above +4°C and over less depth than 200 m. only on the following stations:

St. 20, Op. 39, 85 m. 5.5°C
St. 22, Op. 43, 82 m. 4.8°C
St. 25, Op. 49, 85 m. 6.6°C
St. 26, Op. 51, 88 m. 6.3°C
St. 27, Op. 53, 85 m. 5.5°C

These stations were all located along the south-western edge of the Grand Bank where the Gulf Stream makes itself felt rather strongly. Therefore these higher temperatures are no indication of higher temperatures on the Grand Bank itself.

The general results of the hydrographic observations during the cruise can be given as follows: the temperatures and salinities found are normal for the season and show that no unfavourable temperature increases of the Bank water had occurred during the latter half of 1952. Therefore a good cod fishery could be expected for the winter, spring and summer of 1953. In fact the results of the Spanish fisheries verified this prediction.

2. Phosphates.

The methods used in the valuation of phosphates is the one generally adopted. The norms for it were however especially adjusted and unified by Dr. **Ricardo Montequi** from the Instituto Espanol de Oceanografia.

The figures found are those that could be expected for that season of the year, when a marked decrease is to be found compared to the high values for the early winter months. The values observed were below 10 mg/m³ and there is little variation from surface to bottom.

VIII. United Kingdom Research Report for the Year 1953

BY C. E. LUCAS

MARINE LABORATORY, SCOTTISH HOME DEPARTMENT

Incidental to the main English programme on the Arcto-Norwegian cod, about 2,000 cod from English trawlers working in the area of Panel 1, near southern Greenland, were measured during the year. From among these fish 250 fin-ray samples were taken for age-determination. (Part of the material was worked up later, see appendix).

Owing to the circumstances of fishing, there has been no work on fish other than cod within the Commission's area, although work continues on the halibut from East Greenland Waters (very few during 1953). In addition, a note has been published on the market sampling of such halibut, which will be annotated in the bibliography of pertinent papers.

APPENDIX (received at Headquarters 19 August 1953)

The English Trawl Fishery at Cape Farewell

BY G. C. TROUT

Only small scale cover of Greenland cod landings was obtained from the Humber markets during 1953. A total of 776 cod were measured. 494 of which were otolithed. The percentage length and age composition is given below and shows the continued importance of the 1945 year class in the commercial catches from this general area.

Compared with the figures for 1952 catches at Cape Farewell were lower than during the previous years and fishing tended to spread outside the immediate area of the Cape, northwards to the West Coast banks.

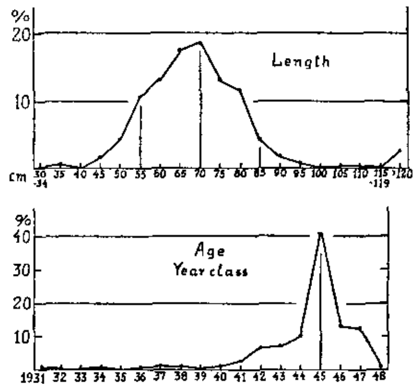

Fig. 1. Length and age distribution of cod caught by U. K. fishing vessels in the Cape Farvel area in summer 1953

Length and Age Distribution of Cod

length cm.	No. of specimens	%
30-34	1	0.1
35-39	3	0.4
40-44	0	0.0
45-49	14	1.8
50-54	33	4.2
55-59	80	10.3
60-64	101	13.0
65-69	135	17.4
70-74	142	18.3
75-79	102	13.1
80-84	91	11.7
85-89	32	4.1
90-94	15	1.9
95-99	5	0.4
100-104	1	0.1
105-109	1	0.1
110-114	1	0.1
115-119	0	0.0
Over 120	19	2.4

Year Class	No. of specimens	%
1948	2	0.4
1947	65	13.2
1946	68	13.8
1945	203	41.1
1944	52	10.5
1943	37	7.5
1942	33	6.7
1941	12	2.4
1940	5	1.0
1939	1	0.2
1938	5	1.0
1937	4	0.8
1936	2	0.4
1935	—	—
1934	2	0.4
1933	—	—
1932	1	0.2
1931	2	0.4

IX. United States Research in Convention Area During 1953

By Herbert W. Graham, Chief, North Atlantic Fishery Investigations, Fish and Wildlife Service, Woods Hole, Massachusetts, U.S.A.

SUBAREA 5

Haddock:

Georges Bank Population in 1953. The 1950 year class which dominated the fishery in 1952 as two-year-olds, causing a preponderance of scrod over large haddock, continued its dominance throughout 1953. The preceding dominant year class (1948) contributed about 17 percent of the catch. In spite of this, the quantity of scrod landed was still slightly more than the quantity of large haddock. This was the fourth consecutive year in which scrod exceeded large.

Total haddock landings from Georges Bank during 1953 were 71 million pounds, which is 11 million pounds less than the quantity taken during the preceding year. Part of this drop is attributed to a decrease in effort of 12 percent. The quantity landed was within 4 percent of the figure predicted last year.

For the coming year the predicted catch is 74 million pounds if the amount of fishing is the same as is 1953. The 1952 year class promises to be a strong one. If it does not come up to expectations there will be a serious decline in the Georges Bank fishery in 1954.

Effects of Mesh Regulation. The 4½ inch mesh was legally adopted June 1, 1953, but complete conversion was not effected until October 1. Eight vessels were licenced during that period to fish with the old small mesh gear in order to assess the effects of the regulation. A comparison of size distribution of samples taken regularly by observers at sea on both large and small mesh vessels demonstrated that the two sizes of nets were selecting haddock precisely as had been predicted by our experimental studies.

The immediate effect of the regulation was expected to be a slight decrease in landings due to a few small marketable fish. This decrease was expected to be less than 10 percent the first year and to be compensated by benefits the second year. Thereafter there were to be increasing benefits until maximum was attained several years later.

The results of the first few months of regulation have been more gratifying than expected. The small fish have been saved but the expected initial decrease in landings has not occurred. Instead there has been a definite benefit enjoyed by the large mesh boats beginning from the time of conversion.

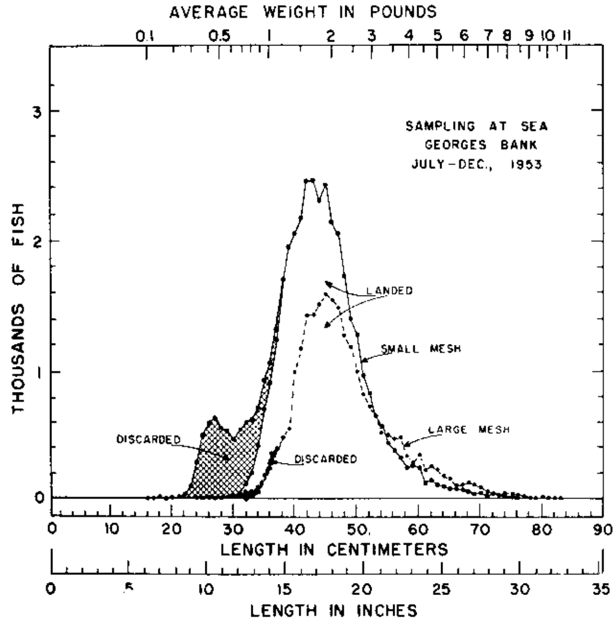

Fig. 1. Size composition of catch of 14 observed trips, July to December, 1953. Vertical scale represents numbers of fish taken by each group of boats.

Figures 1 and 2 present a comparison of size distribution of fish caught by licensed small mesh vessels with that of fish caught by the large mesh vessels. It will be noted first that the quantity of discarded fish was reduced to a negligible amount by the use of the large mesh. Over two million haddock were saved by the use of these nets during the first half year of the regulation and its use was not general for more than three months of that period. Another point demonstrated by these data is the lower landings of marketable fish under 40 cm. in length (2.5 pounds) by large mesh vessels. This loss, however, was more than compensated for by greater numbers of large fish caught and landed. Since these larger fish weigh more per individual, the net result was a benefit to the large mesh boats.

The magnitude of this benefit is shown in Table 1. The average landings of haddock by the large mesh boats during the last three months of 1953 were about 2,000 pounds per trip greater than that of the small mesh boats. Other species of fish such as cod and pollock were also taken in greater quantity by the large mesh boats. The total of all species landed by large mesh boats was about 8,000 pounds greater per trip.

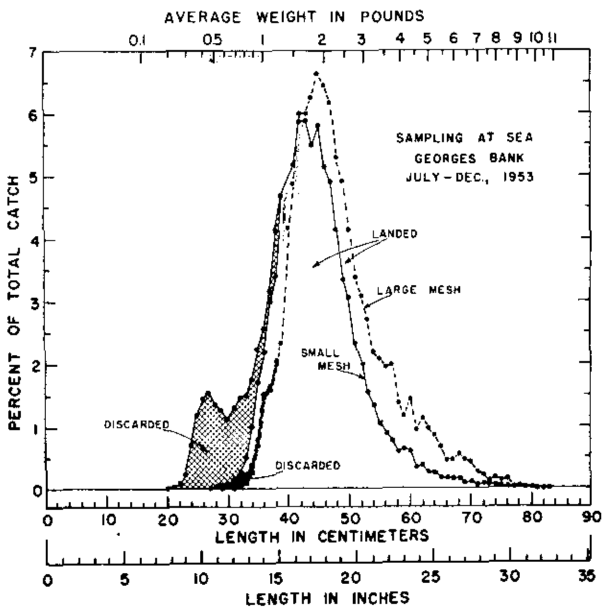

Fig. 2. Size composition of catch of 14 observed trips, July to December, 1953. Vertical scale in percent of total catch of each group of boats.

This direct comparison of landings of small mesh boats and large mesh boats for the same period is not a fair one because no account is taken of different sizes and efficiencies of the vessels represented. A more valid test is a comparison of each group's landings in the three months of 1953 with their respective landings in the same period in 1952. This comparison is also shown in Table 1. It will be noted that in the 1952 period the average catch per trip of haddock by the main part of the fleet, those boats which were subjected to regulation in 1953 (Group B), was less than the average catch per trip of the eight boats which in the 1953 period were licensed to continue fishing with the small mesh (Group A). Their total catch of all species, however, was slightly greater than that of the selected eight boats. Apparently the particular eight boats selected for licensing normally tended to fish in areas in which haddock are proportionately more available than other groundfish.

In 1953, during the period of complete conversion of all regulated vessels, the catch of haddock from Georges Bank was down for all boats but to a greater degree for the licensed study boats. The total catch of all species held steady for the large mesh vessels but went down 10 per cent for the licensed boats.

The landings of groundfish at Boston alone during the three month period amounted to about 33 million pounds, worth about three million dollars as landed. Had the regulation not been in effect, this amount would have been about ten percent less, or down by about $300,000.

During the first quarter of 1954, the large mesh vessels continued to show an advantage over the small mesh vessels.
(Table 2)

In late spring and early summer it is possible that the smaller meshes may catch larger quantities than the larger meshes. During this period a new year class (2-year olds) is regularly recruited. If this incoming year class (1952 year class) should be an exceptionally large one the small mesh boats may enjoy an advantage until the fish in this group reach a size which is retained by the $4\frac{1}{2}$ inch mesh. This period would last for a few months. The net effect over a year's period of time, however, is expected to be an advantage to the large mesh vessels even if the incoming year class is a large one.

Effects of Exemptions. A study was made of the effects which exempting part of the fleet would have on the benefits of the mesh regulation for haddock fishing on Georges Bank.

Certification of Nets. In order to arrive at the measurement of new nets which could be certified for haddock fishing in Subarea 5 it was necessary to study the shrinkage and stretching of cod ends with use. A series of nets were measured before use and after varying amounts of use in regular fishing operations. The U.S. Government decided to certify new cod ends constructed of 45 yard doubled twine measuring $5\frac{5}{8}$ inches between knot centers since this size stabilized at about $4\frac{1}{2}$ inches inside dimension at the half life of the average cod end.

Food Habits. The first year of haddock stomach collections has been completed. Information obtained so far suggests there are three food-type areas on eastern Georges Bank as follows:

(1) Southeast Part—characterized by:
Echinarachnius (sand dollar)
Byblis (amphipod)
Leptocuma (cumacean)

(2) Northeast Peak—characterized by:
Ophiopholis (brittlestar)
Hyas (toad crab)
Marphysa (annelid)

(3) Northern Edge—characterized by:
Euthemisto (amphipod)
Meganyctiphanes (euphausid)
Cuspidaria (pelecypod)

Seasonal and annual fluctuations in the bottom fauna may have great importance on the abundance and migration of groundfish. A continuance of food habits studies for a period of five years should decide this question.

Drift of Eggs and Larvae. Four cruises of the Albatross III were devoted to the study of the fate of haddock eggs spawned on Georges Bank. Hardy plankton recorders were used as collecting instruments. Results indicate that the 1953 spawn drifted westward as anticipated, but got caught up in the Gulf Stream before assuming the demersal habit so that most were lost to the fishery. Almost no young of the year were found on the bottom on Georges Bank during the fall cruise. Drift bottle returns corroborate the conclusion that the 1953 spawn was mostly lost. A test of this hypothesis will come next year when the 1953 year-class is due to enter the fishery.

Redfish:

Age and Growth. Periodical sampling of a single population of redfish in the Gulf of Maine throughout the year provided material for demonstrating the growth of the fish and increments on otoliths. The opaque zone at the edge of the otoliths increases progressively during the year and is followed by a clear zone laid down between November and February. The principal growth of the fish corresponds to the growth of the opaque zone. Thus, one ring is formed annually. However, the age at which the first clear zone is formed has yet to be determined. The assigned ages may have to be adjusted by one year when this point has been clarified. Thus, we now feel certain that our original concept of the redfish as a very slowly growing fish is correct.

Abundance. With the problem of the growth rate of the redfish largely settled and a method of aging at hand it is now possible to investigate mortality rates and other aspects of the biology with a view toward assessing the effect of fishing on the productivity of stocks. Age analysis of samples of the commercial catch will be intensified and work will be concentrated on catches from selected areas.

The overall abundance of redfish in the Gulf of Maine as shown by catch per day's fishing appears to have stabilized, but the catch per day on the very productive grounds on the Grand Banks showed a decrease of 15 percent in 1953.

SUBAREAS OTHER THAN 5

Haddock of Subarea 4. United States vessels increased their fishing effort on Nova Scotian Banks in 1953. In 1953, 34 percent of the catch came from Subarea 4 while in 1952 only 29 percent came from that area. This trend continued in the early part of 1954. U.S. biologists have been sampling catches from Nova Scotian Banks since 1930. In this report year an analysis of the collected data was started. Attention for the present is being concentrated on the stock on Sable Island Bank, since records from this area are more complete. These studies are designed to shed light on the amount of fishing which should be applied to this stock in order to produce the optimum yield.

Observers on commercial vessels made nine trips to Subarea 4 sampling fish retained and fish discarded on vessels with regulation nets as well as on vessels licensed to fish with small mesh nets.

Haddock: Egg and Larvae Drift. The results of the Albatross III plankton studies emphasize the importance of the drift of eggs and larvae on the biology of groundfish. Although there may be little intermingling of adult populations of haddock on Georges Bank in Subarea 5 with those on Browns Bank in Subarea 4, there is the possibility that Georges Bank populations are derived at least in part from eggs spawned on Browns Bank.

Future plankton surveys will be designed to follow the drift of Browns Bank eggs and larvae as well as those spawned on Georges Bank.

Cod. Sampling of the commercial catch of cod principally from Browns Bank for length frequencies was started this year. Records of these samplings will be useful to Canadian biologists doing intensive work on Nova Scotia stocks.

Redfish. Market samples are taken from all vessels landing in U.S. ports. Since a large proportion of U.S. landings of redfish comes from Subareas 3 and 4, a good sample of redfish from these areas was obtained. These redfish were used for the abundance studies mentioned above.

TABLE 1. Comparison of Landings of Small Mesh and Large Mesh Vessels from Georges Bank

A. Average catch per trip* for period October, November, December, 1953

Group	Haddock Pounds	All Fish Pounds
Group A (8 Small Mesh Boats)	47,700	67,300
Group B (32 Large Mesh Boats)	49,600	75,500

B. Comparison of landings during October, November, December, 1952 with same period in 1953.

Group	Landings of Haddock Pounds per trip			Landings of All Fish Pounds per trip		
	1952	1953	% change	1952	1953	% change
Group A (8 boats)	60,900	47,700	–21.7	75,200	67,300	–10.5
Group B (32 boats)	54,800	49,600	– 9.5	75,400	75,500	+0.1

*The number of days fished per trip is fairly standard as the length of trip is subject to union regulation.

TABLE 2. EFFECT OF HADDOCK REGULATION DURING 1ST. QUARTER OF 1954

Groundfish Landings from Georges Bank by Boston Trawlers, January - March, 1954, compared with same period, 1953

	1953	1954	% Change
Total landings of haddock for 3-month period by all vessels, pounds	14,892,000	7,276,000*	–51.1

	Landings of haddock Pounds per trip			Landings of all groundfish Pounds per trip		
	1953	1954	% Change	1953	1954	% Change
Group A (Small mesh	65,500	56,500	–13.7	83,500	85,400	+2.3
Group B (Large mesh)	74,300	63,700	–14.3	96,000	101,000	+5.2

Groundfish Landings from Nova Scotian Banks by Boston Trawlers January-March, 1954, compared with same period, 1953

	1953	1954	% Change
Total landings of haddock for 3-month period by all vessels, pounds	13,700,000	20,360,000*	+48.6

	Landings of haddock Pounds per trip			Landings of all groundfish Pounds per trip		
	1953	1954	% Change	1953	1954	% Change
Group A (Small mesh)	113,200	104,700	–7.5	135,600	139,700	+3.0
Group B (Large mesh)	100,400	93,300	–7.1	123,000	128,500	+4.5

*March estimated from hails.

(b) Compilation of Research Reports by Subareas

BY THE EXECUTIVE SECRETARY, ERIK M. POULSEN

Summaries of researches in 1953 were received from the following countries: Canada, Denmark, France, Iceland, Norway, Portugal, Spain, United Kingdom, and U.S.A.

The table below shows the distribution of research by countries and by subareas.

Subarea	1	2	3	4	5
Canada		++	++	++	
Denmark	++				
France	+	+	+		
Iceland	+				
Norway	+				
Portugal	+	+	+		
Spain			+	+	
United Kingdom	+				
U.S.A.			+	++	++

xx indicates researches from special research vessels.

This survey is not intended to be a summary of research reports, but rather a compilation of them with comparisons of results for subareas where several countries have worked on the same subjects. Therefore such subareas (1 and 3) are treated more comprehensively than others, where the researches were made entirely or almost entirely by one country (4 and 5).

It is to be noted that in 1953 Portugal started researches in Subareas 1, 2, and 3, Spain in Subareas 3 and 4.

Subarea 1.

Research vessel "Dana" (Denmark), 3 July-11 August.
Research cutter "Adolf Jensen" (Denmark), May-December.
Research cutter "Immanuel" (Denmark), June-December.
Frigate "l'Aventure" (France).
Commercial trawler "Pétur Halldorsson" (Iceland), July-December.
Commercial long liner (Norway), July-August.
Dory Vessel "Capitao Joao Vilarinho" (Portugal), June-July.
Commercial trawlers, samplings of cod measurements (United Kingdom).

1. Hydrography.

Six sections from the coast and westward between Cape Farewell and Egedesminde, hydrographic stations between sections (Denmark).
Three sections across Lille Hellefiske Bank and Fylla Bank, observations of temperatures in connection with line fishing for cod (Norway).
Two sections Newfoundland-Greenland (France).

Compared with 1952, 1953 must be considered a warm season. The polar current was weak; on the banks the temperature in July-August was about 2°C. higher than in 1952 and 1 - 3°C. higher than in 1949 and 1950.

A comparison of the Danish sections from the middle of July and the Norwegian ones in the same areas about 3 weeks later shows nearly the same main features in both periods, f.i. the Fylla Bank was overlaid with water of about 2 - 3°C. On the western slope of the Bank the temperature was higher in August than in July; in depths between 100 and 200 m. 2 - 3°C in July against 3 - 5°C. in August.

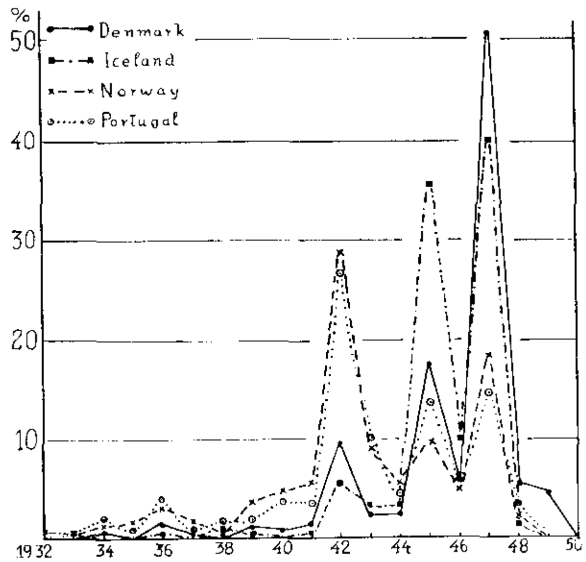

Fig. 1. Subarea 1, cod. Percentage distribution of year-classes. Comparison of Danish, Icelandic, Norwegian, and Portuguese samples from the Greenland banks, summer, 1953.

a. Spawning of cod, *Gadus callarias* L., and larval distribution.

The Danish investigations show an early spawning in 1953. Larvae were found between 64 and 69°N. Contrary to 1952 no larvae were found off the S.W. coast. The number of larvae found between 64 and 70°N. per haul with the ring trawl was twice as large in 1953 as in 1952.

b. Age - and size-composition of samples of cod.

Researches were carried out by Denmark, Iceland, Norway and Portugal, partly in the same areas.

The percentage **age-**distribution of the cod sampled from the whole bank area by the four countries separately is shown in Figure 1. The results agree very closely with peaks for the year-classes 1934, 1936, 1942, 1945, and 1947. However, one outstanding difference is found in that the predominance of the year-classes 1945 and 1947 is stronger in Danish and Icelandic samples than in Norwegian and Portuguese samples.

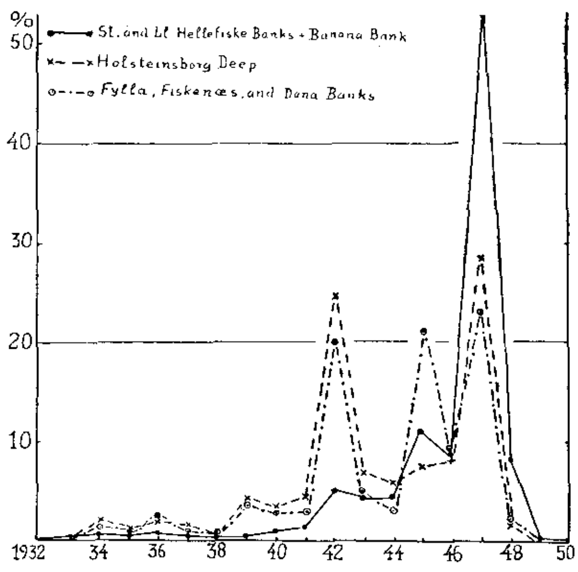

Fig. 2. Subarea 1, cod. Percentage distribution of year-classes on the separate banks. Compilation of Danish, Icelandic, Norwegian, and Portuguese samples, summer, 1953.

A pooling of the results by all four countries (Fig. 2) shows that on the northern banks (St. and Ll. Hellefiske Banks and Banana Bank) the younger year-classes from 1947 are dominating. In the Holsteinsborg Deep and on the southern banks (Fylla, Fiskenæs, and Dana Bank), the older year-classes, and especially the 1942, play a considerable rôle.

Length measurements were reported by Denmark, Iceland, Norway, and Portugal. Figure 3 gives a comparison of the length distribution in samples from the same areas by the separate countries. On the whole the length distribution found by the various countries is very much the same, cfr. St. Hellefiske Bank and Fiskenæs Bank. However, the curves show in cases, a somewhat lower size for cod caught by Denmark and Iceland than for cod caught by Norway and Portugal, consistent with the lower age of the cod caught by Denmark and Iceland.

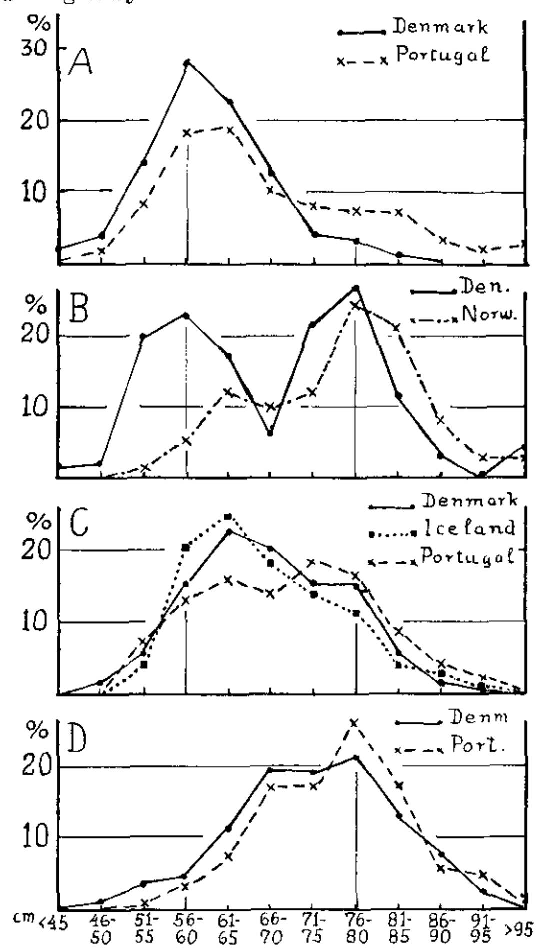

Fig. 3. Subarea 1, cod. Length distribution by 5 cm. groups. A—Store Hellefiske Bank, B—Holsteinsborg Deep, C—Fylla Bank, and D—Fiskenaes Bank. Comparison of Danish, Icelandic, Norwegian, and Portuguese samples.

Growth and size by age-groups or year-classes are reported by Denmark, Iceland, Norway, and Portugal. Figure 4 shows for same areas the mean lengths of the year-classes 1942-48. Apart from Holsteinsborg Deep where the Norwegians—perhaps owing to a different mode of fishing—do not catch in comparable numbers the smaller individuals of the younger year-classes, there is a very close agreement in growth figures found by the various countries. This is especially the case for the rich year-classes (1942, 1945, and 1947) yielding a sufficiently large material. For these year-classes the differences found do not amount to more than 1-3 cm. This indicates that samples from the various countries are equally reliable and mutually comparable.

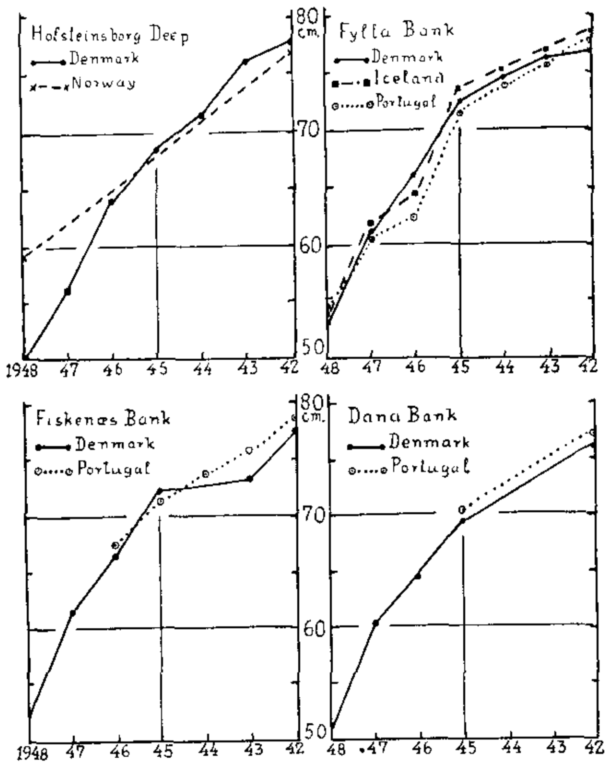

Fig. 4. Subarea 1, cod. Mean length of year-classes 1942-48 in samples from the summer 1953 from various banks by countries.

Compiling the results for the four countries the following mean length (cm.) of the dominating year-classes are found for the three main fishing areas (see also Figure 5):

Year-class	1936	1942	1945	1947
St. and Ll. Hellefiske Banks	83.8	81.2	72.9	59.3
Holsteinsborg Deep	77.0	77.2	68.5	57.9
Fylla, Fiskenaes, and Dana Banks	85.4	77.7	71.7	61.6

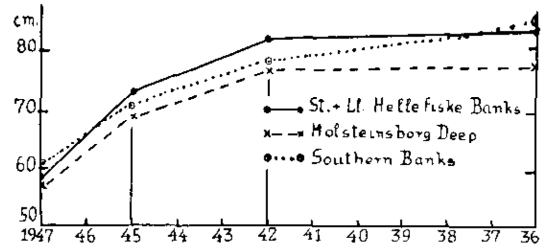

Fig. 5. Subarea 1, cod. Mean length of the rich year-classes (1947, 1945, 1942, and 1936) in the summer 1953 in various areas. Compilation of material from Denmark, Iceland, Norway, and Portugal.

For all four year-classes the Holsteinsborg cod are somewhat smaller, up to 7 cm., than the cod from the other areas. Otherwise the growth picture is much the same for the three regions. It should be noted that this picture does not apply to Greenland bank cod in general, but to cod of the rich year-classes only, i.e. cod for which a comparatively low growth rate may be expected.

c. Taggings.

Denmark, Norway, and Portugal report taggings and tagging results.

United Kingdom has sampled length measurements of cod from the southern part of Subarea 1, a region not sampled by the other countries. For results see end of this report.

Samples of surface plankton and measurements of cod were taken by the frigate "l'Aventure". Results are not reported.

Subarea 2.

Research vessel "Investigator II" (Canada), 7-18 Sept. Hydrographic observations (Canada), 31 July - 1 August Frigate "l'Aventure" (France).

Conversion factor studies, commercial fishing vessels (Portugal).

1. **Hydrography.**

A section across the Labrador Current off Domino Point and south of Hamilton Inlet Bank (Canada).

Two sections Newfoundland—Greenland (France).

2. Fishes.

Excellent catches of cod were made (Canada) in depths of 183-208 m. with temperatures between -0.5° and ca. 2°C. In deeper water, more than 300 m., cod were scarce and redfish, *Sebastes* marinus (L.), more abundant. The cod caught were of medium, but mostly commercial size, in autumn in good condition. It can here be noted that France in 1953 carried out extensive cod fishery in Subarea 2.

American plaice *Hippoglossoides platessoides* (Fabr.) were plentiful in a restricted area around 54°22′N and 54°48′W (ca. 180 m.).

Measurements of cod and sampling of surface plankton were carried out (France).

The Portuguese experiments on conversion factor for cod are reported (see Part 3, A, VI). They were carried out mainly in the Hamilton Inlet Bank and the Belle Isle areas.

Subarea 3.

Research vessel "Investigator II" (Canada) through the year.
Research vessel "Marinus" (Canada), through the year.
Researches from various commercial fishing vessels (Canada).
Researches from frigate "l'Aventure" (France).
Conversion factor studies, commercial fishing vessels (Portugal).
Commercial fishing vessel "Vendaval" (Spain), Febr.-April.
Samplings of redfish (U.S.A.).

1. Hydrography.

Three sections across the south part of the Grand Bank (Canada), April and July-August.
A section across the Labrador Current off Bonavista (Canada), July-August.
A section St. John's—beyond Flemish Cap (Canada), July-Aug.
Two sections Newfoundland-Greenland (France).
Observations in connection with fishery along the south and southwest part of the Grand Bank (Spain), February-March.

The Spanish Research Report states temperatures and salinities found to be normal for the area and season. Values of phosphates were below 10 mg/m³. Results of the Canadian and French observations were not reported.

2. Fishes.

a. Cod, *Gadus callarias* L.

In May cod were found most plentifully in the northern part of the area investigated (southern half of the Grand Bank) in water between ca. 1 and 2°C, at depths between 60-80 m. The study of number of vertebrae and finrays was continued. (Canada).

The Spanish experimental fishing yielded the largest catches in day-time—this indicates a movement of cod away from the bottom during night. The cod were rather smallsized, the peak of the size curve being between 41-45 cm. These small cod, belonging mainly to the year-class 1949, were immature. Mature cod were generally of a length from 60 cm. and upwards. Investigations on food were carried out.

Both the Canadian and the Spanish researches show the alternating abundance of cod and haddock in relation to temperature.

Experiments on conversion factors were carried out by Portugal and Spain, see Part 3, A, VI and VII.

Length measurements were carried out by France (together with samplings of surface plankton).

b. Haddock, *Melanogrammus aeglefinus* (L.).

Experimental fishery by Canada in May showed large concentrations of haddock on the southernmost part of the Grand Bank at temperatures from 2° to 7½°C. The results indicated a movement toward shallower water during spring. The year-class 1949 with a length peak around 34-37 cm. dominated on the Grand Bank and the St. Pierre Bank.

In the samples from the Grand Bank another peak was also found around 50-51 cm, mainly the year-class 1946, but including also a fair number of the year-class 1942. The 1949 year-class (in 1953 still below marketable size) is very rich and expected to yield good catches for a series of future years.

These results are in complete agreement with those reported by Spain, showing peaks in length distribution at 36-40 and 51-55 cm. for the Grand Bank haddock. For St. Pierre Bank the peaks are a little higher on the length scale, at 36-45 cm. and 61-70 cm.

The Spanish report includes measurements of pollock and white hake, together with investigations on sex and maturity of the four species of the genus cod.

c. Redfish, *Sebastes marinus* (L.).

Based on exploratory work by Canada a considerable development of the fishery for redfish has taken place during later years in various parts of Subarea 3 (as well as of Subarea 4). An overexploitation of stocks has already been observed for the area off Ramea. This calls for a thorough and extensive study of the biology of the redfish in the near future.

The experimental fishery shows a general increase in size of both sexes with increasing depth. At depths below 360-400 m. the catch decreased; in cases, however, successful drags were made down to 600 m. This indicates the possibility of extending the fishery beyond depths now exploited. On the other hand the results bear evidence to the fact that fishery is now carried out within the main area of distribution, and not along the fringe of a stock having its main distribution in still deeper water.

Subarea 4.

Various research vessels (Canada), through the year.
Commercial fishing vessel "Vendaval" (Spain), March.
Observers on commercial vessels (U.S.A.), through the year.
Research vessel "Albatross III" (U.S.A.), spring months.

1. Hydrography.

Seasonal cruises, Scotian Shelf, Bay of Fundy, and Gulf of St. Lawrence (Canada), September and November.
Daily observations of surface temperatures in selected places (Canada), through the year.
Observations in connection with fishing (Spain), March.

The Canadian researches show bottom temperatures to be up to 2°C higher in later years than in prewar years. A general warming of surface water during the last years is observed with peaks in 1951 and early 1953.

The displacement of water masses has been especially studied, and incursions of slope water have been found to cause great changes on the banks.

2. Fishes.

a. Cod.

The results of vertebral counts in the years 1933-41 have been worked up (Canada). The conclusions as to discreteness of stocks agree with those achieved through taggings.

Taggings were continued in Nova Scotian waters. During the period May-December around 25% were recovered. Disk-marks yielded the highest percent of recoveries.

Experiments on mesh selection were carried out for cod (and haddock) by Canada. Effective release of smaller fish was shown to agree with earlier catches. Heavy catches decrease the selective effect.

Commercial catches from Browns Bank were sampled by U.S.A.

b. Haddock.

The results of Canadian taggings in 1935-40 have been worked up. Migrations were found to be controlled by channels, temperature, spawning, and feeding. Several discrete populations were recognized. It is to be noted, however, that U.S.A. researches show the probability of a considerable exchange of eggs and larvae from one bank-area to another.

Taggings were carried out in Nova Scotian waters. (Canada). From May to December about 6% were recaptured. For cod disk-marks yielded the best results.

Mesh selection studies, see a. cod.

U.S.A. sampled catches from commercial.

vessels of retained as well as discarded haddock. The drift of egg and larvae were studied.

c. Redfish.

Canadian investigations on the distribution and movements of redfish along the upper Laurentian Channel (Gulf of St. Lawrence) were carried out in May and October. The distribution of small redfish indicates a transport of larvae from the Gulf toward the Cabot Strait. Observations on growth, maturity, and feeding habits are reported.

Sampling of commercial catches were undertaken by U.S.A.

Subarea 5.

Extensive researches, especially on haddock and redfish were carried out by U.S.A. No other country worked in Subarea 5, and therefore compilation or comparisons are not called for.

A comparison* between age and length of cod caught by U.K. vessels fishing in the area off Cape Farvel with age and length of cod caught by vessels of other nations fishing on the banks farther to the north in Subarea 1 shows some marked differences between the stocks off Cape Farvel and on the western banks.

The 1945 year class is absolutely dominating in the Cape Farvel area. This year class is also rich in the area of the banks, there, however, overshadowed by the very rich year class 1947 and equalled by the rich 1942 year class. These latter year classes are only poor in the Cape Farvel area. The age distribution in the Danish samples from the southernmost banks and from the coastal area off Cape Farvel coincides well with that of the U.K. samples. The size distribution of the U.K. samples differs from that found on the northern banks but is fairly much the same as that found in other nations' samples from the southern banks and especially the coastal waters west of Cape Farvel.

A comparison of the length and age curves from the U.K. samples indicates a mean size of nearly 70 cm. for cod of the year class 1945. This is in good accordance with the mean size found for this year class in the samples from other nations' fishing, especially on the southern banks.

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*The part of the U.K. research report dealing with age and length was only received when this "Compilation of Research Reports" was with the printers.

PART 4

Scientific Papers Specially Prepared for the Annual Meeting

June, 1954

I. The Waters of the ICNAF Convention Area

BY H. B. HACHEY,[1] F. HERMANN,[2] AND W. B. BAILEY[3]

CONTENTS

1. Chief Oceanographer, Canadian Joint Committee on Oceanography.
2. Hydrographer, Danmarks Fiskeri-og Havùndersògelser.
3. Oceanographer, Atlantic Oceanographic Group.

Introduction

At the request of the Hydrographic Subcommittee of the International Commission for the Northwest Atlantic Fisheries which met in Copenhagen on October 8, 1953, the authors provide in this report a short general review of certain features of the waters of the Western North Atlantic that make up the ICNAF Convention Area. As a matter of convenience the waters are discussed by sectors under each main heading. Hydrographic investigations are carried out by most of the signatory nations. Investigations which are repeated more regularly year by year are shown in Figure 1 which outlines the Convention Area.

General Submarine Physiography

The northwestern-north Atlantic as is discussed here has been described in general terms in the report of the Marion and General Greene Expedition to Davis Strait and the Labrador Sea (Smith, Soule and Mosby, 1937). It is described as that portion of the western Atlantic Ocean embraced by the normal drift of Arctic ice, and thus embraces the waters around and on the Grand Banks and northward, between North America and Greenland to the 70°N. parallel of latitude.

The bathymetric features of this area are shown in Figure 2. From 50°N. to 63°N. the bottom rises gradually to form, between Greenland and Labrador, the Labrador Basin, with depths extending to greater than 2200 fathoms. In the region of Davis Strait, there is an area with depths less than 400 fathoms, a ridge which separates the Labrador Basin from the Baffin Bay Basin where depths are greater than 1000 fathoms. The Labrador side of the Labrador Sea with its well defined continental shelf is in contrast with the narrow continental shelf on the Greenland side. As may be seen in Figure 2 the basins are readily outlined by the 600 fathoms isobath while the continental shelves are less than 200 fathoms. The intervening areas between the two contours, the continental slopes, may be steep, as along the west coast of Greenland, or broad as along the Labrador coast, particularly in its southern limits. To the north, however, the Greenland shelf broadens, and the 200 fathom *contour is found to extend 80 miles (148 km.)* off the coast. This broader shelf is divided into three principal shoals, Fylla, Little Hellefiske and Great Hellefiske Banks. Off northern Labrador, the shelf has a width of 70 miles (130 km.) which broadens to a width of 180 miles (333 km.) off Newfoundland, and in the vicinity of the Grand Banks becomes one of the broadest of continental shelves. The northeasterly extension of the 600

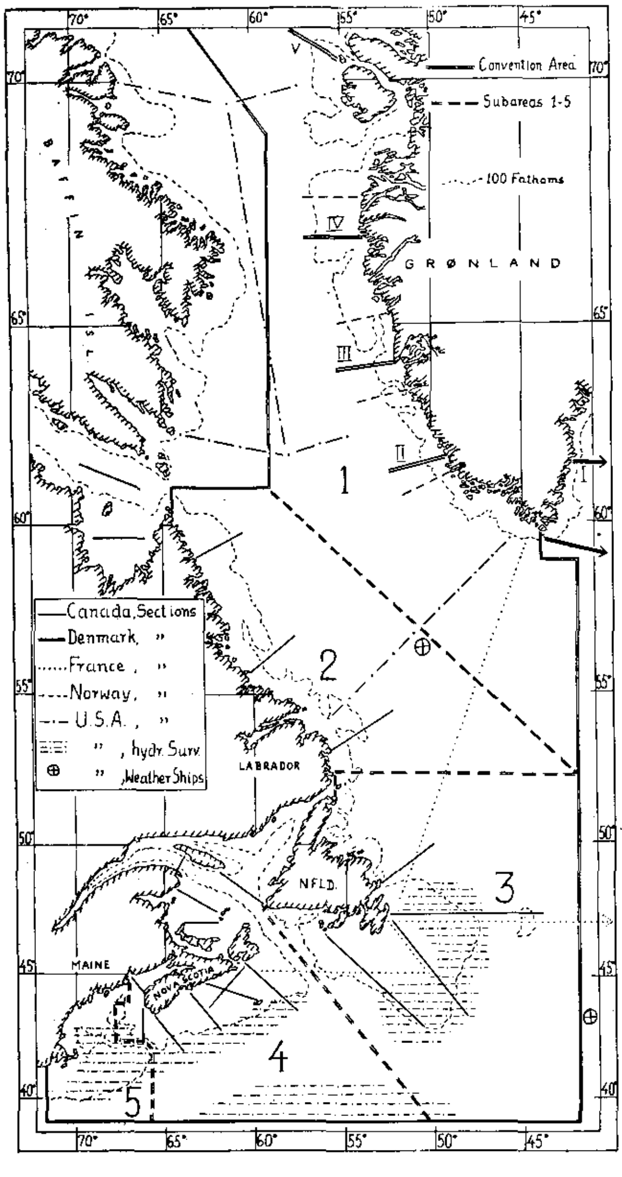


Fig. 1. Routine hydrographic work in the Convention Area. Most of the sections shown are repeated, at least, yearly. Of the sections passing the right frame of the figure the northernmost one (I) reaches Iceland, that from Cape Farvel and that from Newfoundland reach the English Channel.

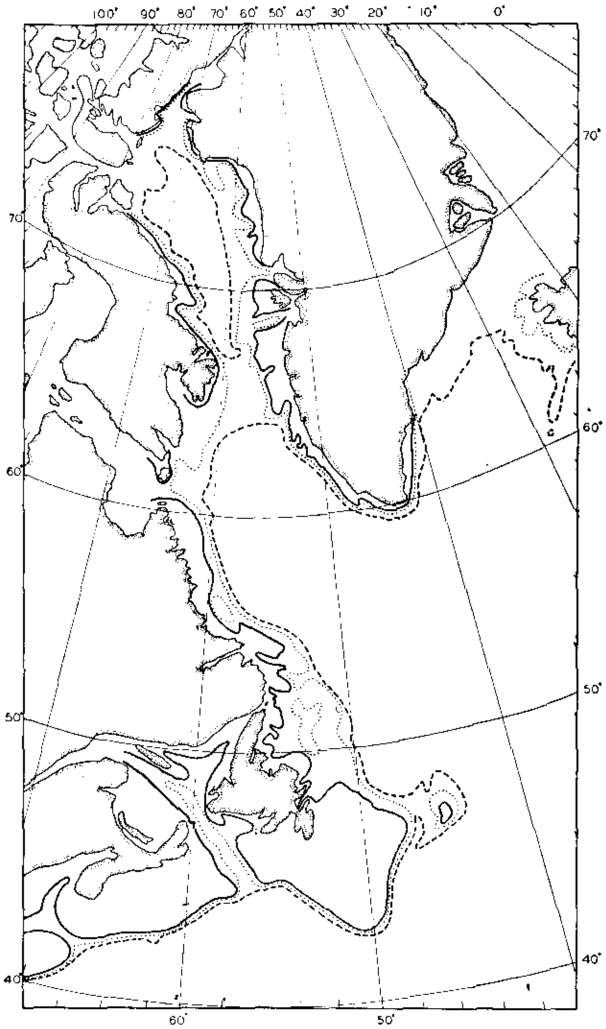


Fig. 2. Bathymetric map of Northwestern North Atlantic showing the 100 fathom———, the 200 fathom ...., and 600 fathom - - - - - contours. (Simplified after Smith, Soule and Mosby, 1937).

fathoms isobath between the Greenland slope and Reykjanes Ridge creates an eastern appendage and a heart-shape form to the Labrador Basin. The waters in this northeasterly extension of the Labrador Basin are generally referred to as the Irminger Sea. Although this sector is not included in the area under discussion, the waters from the Irminger Current and the East Greenland Sea, which skirts it, contribute in a large measure to the waters in the Labrador Sea. West of the Grand Banks, the continental shelf is broad, forming the Scotian Shelf and Georges Bank. Features of the submarine physiography of the American Continent are the three great channels which cut deeply into the continental shelf and into the continent itself. These are, from north to south respectively, Hudson Strait, the Laurentian Channel and the Fundian Channel. These channels have a very significant influence on the oceanography of the shelf waters in that they bring waters of deep oceanic origin close to the shores of the continent. A more detailed description of the continental shelf from Labrador to Cape Cod is given by H. B. Hachey in the following chapter.

The Continental Shelf from Labrador to Cape Cod

It is a general fact that soundings from the shore of the continents towards the sea show that the depth increases slowly to a certain figure of about 100 fathoms, after which the increase in depth is more rapid. The location of this more rapid increase in depth is defined by oceanographers as the "edge" of the continental shelf, leading to the specific definition of the "continental shelf" as that part of the sea bottom between the shore and this "edge".

The edge of the continental shelf from Labrador to Cape Cod has been traditionally outlined by the location of the 100 fathom isobath. The details of this continental shelf, thus outlined, may be closely followed by plotting the isobaths of 25, 50, 75 and 100 fathoms, the results of which are illustrated in Figure 3.

It should be appreciated that the delimitation of the continental shelf is not as simple as indicated above, and particularly where matters of international law or rights are concerned. The general subject has been dealt with by Sverdrup et al. (1942), Shepard (1948), and Moulton (1952). In particular, reference is made to a detailed map by Veatch and Smith (Moulton, p. 13, 1952), which extends 530 miles along the east coast of the United States. As indicated by this map, the more rapid increase in depth, which might be used to locate the edge of the continental shelf, is near the 60-80 fathom depth. According to Shepard (1948) on a world-wide basis, the average depth at which the greatest change in slope occurs is 72 fathoms.

The submarine physiography of the continental shelf under consideration is illustrated in Figure 3. To the southeast of Newfoundland,

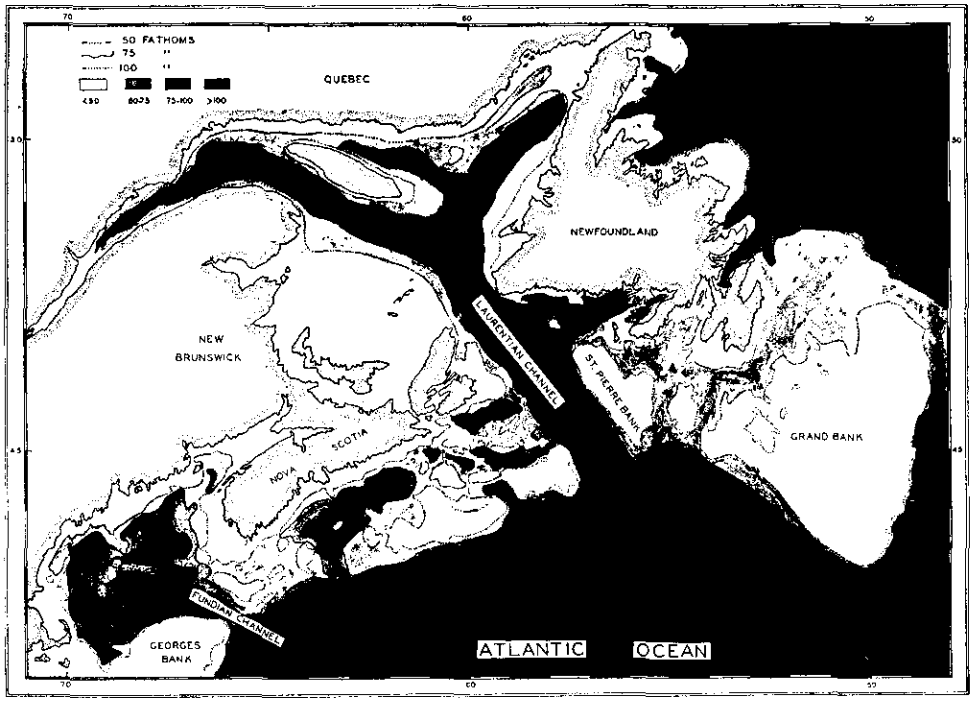


Fig. 3. Submarine physiography of the continental shelf from Labrador to Cape Cod.

the outer shelf consists of a mass of irregular banks which constitute the well known Grand Banks, chief of which are Grand Bank and St. Pierre Bank. Although the depths on these banks average about 30 fathoms, there are many places nearer the land with depths greater than 100 fathoms.

Separating the Grand Banks from the Scotian Shelf is the submerged Laurentian Channel with depths from 100 to 300 fathoms, and extending from the St. Lawrence river outwards into the Gulf of St. Lawrence and thence completely across the continental shelf. The Esquiman and Mingan Channels within the Gulf are branches of this Laurentian Channel extending respectively, northeastward toward Belle Isle Strait and northwestward above Anticosti Island.

The Scotian Shelf is an irregular shaped submarine plateau of irregular topography extending outwards from the coast to a distance of 100 to 150 miles. The more important elevations on this shelf are Sable Island, and Middle, Western, Roseway, LaHave, Emerald, and Sambro Banks, as well as the banks known as Banquereau, Canso, and Misaine. With the exception of several basins of limited extent whose depths are greater, the Scotian Shelf as a whole, is less than 100 fathoms below the sea surface. A large western area of the Scotian Shelf is of depths greater than 50 fathoms and less than 100 fathoms. Bounded as it is, on the north by the mainland of Nova Scotia, on the east by Canso Bank, Middle Ground, and Sable Island Bank, and on the west by Brown's Bank, and with its greater depths extending to the edge of the continental shelf to the southward, this submarine area has been termed the Scotian Gulf. Roseway, LaHave, Sambro, and Emerald Banks form elevations over this portion of the sea floor.

The Fundian Channel with depths greater than 100 fathoms separates the Scotian Shelf from Georges Bank and provides a comparatively deep submerged channel into the Gulf of Maine. Georges Bank is about 140 miles in length by 80 miles in width when based on the location of the 50 fathoms contour, and hence occupies an area of approximately 11,000 square miles. In the Gulf of Maine area the same type of bottom topography is found as farther north (Murray, 1947). On the inside is the Gulf of Maine with its troughs, basins and rises which resemble the Gulf of St. Lawrence The complexity of the relief of the floor of the Gulf of Maine has been illustrated by Murray (1947), basing his contours on the soundings of the U.S. Coast and Geodetic Survey. On the outer shelf, Georges Bank with its shoals is comparable with the Grand Banks, but not as wide. The shelf beyond the shoals of Georges Bank is comparatively smooth except for its irregular margin.

According to Shepard (p. 107, 1948) in this zone of irregular topography extending from Newfoundland to the Gulf of Maine, the bottom character follows a definite pattern. On the banks, sand bottom predominates, although gravel and stones are found in many localities. The inner deeps and the troughs are mud-covered but samples reveal a considerable number of stones mixed with mud. The inner zones along the shore have a rock or boulder bottom, and ridges rising above the inner deeps are also reported as being rocky.

Geologists tell us that in Preglacial Times eastern Canada extended to the edge of the continental shelf, 140 miles beyond the present southeastern coast of Nova Scotia, and Newfoundland was a part of the mainland. The old St. Lawrence River channel can be followed by soundings to the edge of the enlarged continent, where the shallow water ends, and the bottom descends towards the depths of the sea (Coleman, 1922). The fishing banks, extending from Newfoundland to Cape Cod are said to represent "a submerged upland of the Atlantic coastal plain", and the Gulf of Maine is the "drowned inner lowland" between the Banks and the oldlands of New England (Johnson, 1925). According to Johnson too, the "broad and shallow submerged platform bordering the Gaspé Peninsula and the shores of the St. Lawrence embayment—— appear to be normal subaerial features formed above sea level, then submerged and very slightly modified by marine agencies".

A submarine escarpment, sometimes divided into two or more branches and bordering one of the major fault fractures of North America, is discovered under the waters of the Gulf of Maine and traced to its connection with topographic features bordering the northwestern side of the Bay of Fundy. Students of continental faulting have been attempting to trace the faults of Cape Breton across the Cabot Strait to Newfoundland, and have suggested that the Laurentian Channel is in part of the nature of a "fault graben" (Gregory, 1929; Keith, 1930; Hodgson, 1930). Shepard (1931) made a complete study of the various charts of the Laurentian Channel, combined with a special investigation of Cabot Strait. From this study he concluded that the St. Lawrence trough probably was started by river erosion, possibly in part along fault lines. Later during the glacial period, tongues of ice moved down the valley causing great deepening and widening. The present form of the trough is believed to be due principally to this glaciation making it a submarine glacial trough.

The submarine physiography of the continental shelf from Labrador to Cape Cod is pertinent, even to considerable detail, to the study of oceanographical conditions and particularly in relation to fisheries. This continental shelf is in the area of confluence of the Labrador Current and the Gulf Stream where large scale mixing processes occur which provide a type of "slope water" that contributes largely to the characteristic waters that are in contact with the continental shelf and which penetrate toward the coast at the greater depths. The variations in the features of the sea floor determine the distribution of these "slope waters" and provide contrasting bottom water conditions within contiguous areas.

General Circulation

The circulation of waters of the upper layers in the northwest-north Atlantic as shown in Figure 4, consists of a northward flow along the Greenland slope, the West Greenland Current, a southward movement along the Canadian side, the Baffin Land and Labrador Currents, and, a northward set, the Atlantic Current in the southern part of the Labrador Sea. The waters over the Labrador Basin undergo a slow cyclonic movement. The West Greenland Current is composed of the East Greenland and the Irminger Currents which become re-energized on rounding Cape Farewell. The Labrador Current is composed of the Baffin Land Current and the West Greenland Current, and it too is re-energized on passing the mouth of Hudson Strait as waters from Hudson Bay and Foxe Channel are added to the current.

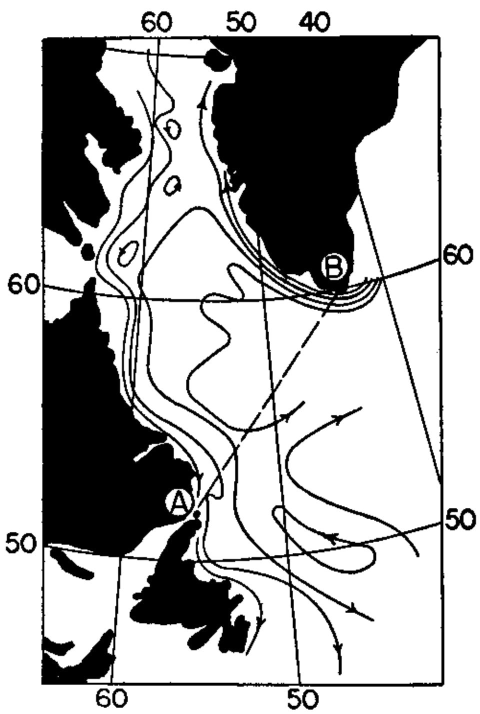


Fig. 4. The system of circulation of the upper water layers in the northwestern North Atlantic (after Smith, Soule and Mosby, 1937).

West Greenland Current.

In the waters of West Greenland, currents of widely different origin and characteristics meet and mix, and the resultant oceanographic conditions are dependant upon which of the currents is dominant at any given time.

The main features of the current system around Greenland are shown in Figure 5. The East Greenland Current, which forms the main outlet from the Polar Sea is found near the East Greenland coast. Off south-east Greenland, this current is mainly restricted to the shelf area, while off the shelf and in part underneath the polar current, the warm Irminger Current of Atlantic origin is found. As they flow towards Cape Farewell the two mix intensively, and this mixing continues as they round Cape Farewell and proceed northwards along the West Greenland coast.

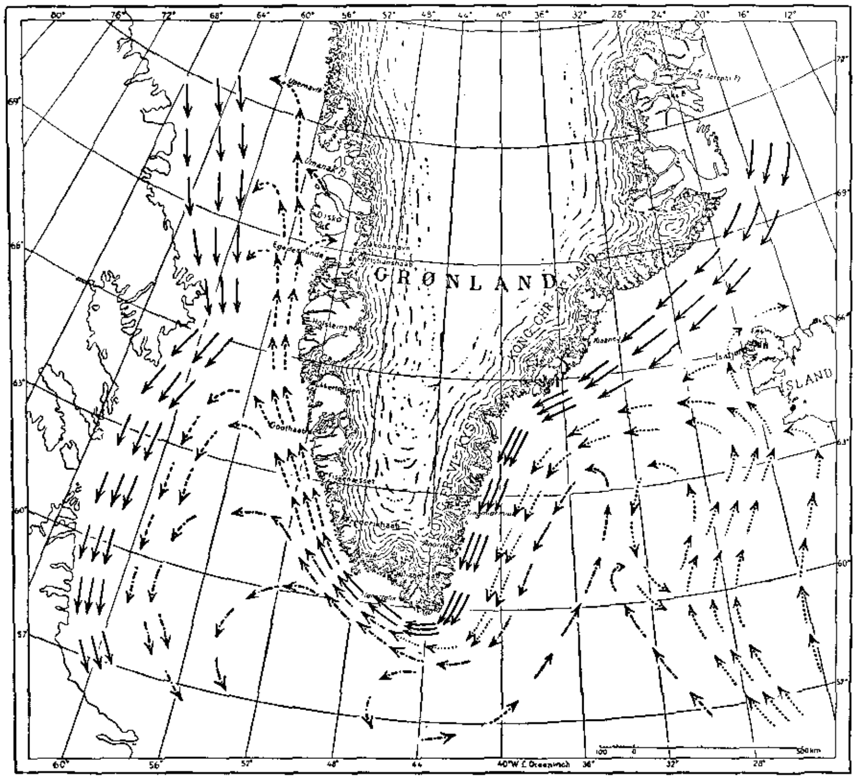
The mixing of the two water masses is the main cause of the very pronounced difference in the oceanographic conditions as found off East Greenland and West Greenland. While the East Greenland Current carries great masses of heavy polar ice, which block that coast for the greater part of the year, the West Greenland current appears, in most years, as temperate and nearly ice free from Frederikshåb to Holsteinsborg. In the polar water nearest the coast of East Greenland, practically no fishing takes place, while the warmer waters of West Greenland provide suitable conditions for a rich population of cod, which has made this region an important fishing area.

The Irminger Current because of its greater salinity has a tendency to sink beneath the Polar Current. This tendency is more pronounced off West Greenland where its core is found in progressively deeper layers as the current proceeds northwards.

As the West Greenland Current flows northward part of it branches off westward, especially in the latitude of Godthåb, while the remainder continues northward losing velocity. Its influence is, however, traceable as far north as Upernavik.

In the western part of Davis Strait and the Labrador Sea is found the Baffin Land Current which transports the cold water masses from

Baffin Bay and the Canadian Archipelago southwards. Off the southern part of Baffin Island, the current is joined by the West Greenland Current to form the Labrador Current.



Baffin Land Current and Labrador Current. West Greenland Current.
Irminger Current. Subartic Mixed Currents.

Fig. 5. The sea current round Greenland. (Simplified after Kiilerich, 1939, Hermann and Thomson 1946).

The Water Transport of Currents in the Greenland Area.

From considerations of the water budgets of the Norwegian Sea and the Polar Sea, Sverdrup, Johnson and Fleming (1949) estimated that the water transport of the East Greenland Polar Current through Denmark Strait was of the order of $3.6x10^6 m^3/sec$. This current is joined by the Irminger Current and the two currents together form the West Greenland Current. The following values of the water transport of the West Greenland Current are taken from the results of the Marion Expedition in July-September, 1928 (Smith, Soule and Mosby, 1937).

Table I.

Section	Volume of Flow
Off Cape Farewell	$3.2 \times 10^6 m^3/sec$
,, Invigtut	7.4
,, Fiskenaesset	6.6
,, Godthaab	5.3
,, Holsteinsborg	1.3
,, Egedesminde	1.3
,, Disko Island	0.9

Disregarding the value for the Cape Farewell section which is obviously in disagreement with the other sections, we find that the West Greenland Current off southwest Greenland is about twice the volume of the East Greenland Polar Current off East Greenland, which indicates that the water transport of the East Greenland Polar Current and the water transport of the warm Irminger Current are of about the same magnitude. These values are based on observations from a single season. The mean value of seven sections off Cape Farewell and of four off Ivigtut given by Smith, Soule and Mosby, (1937) gives a water transport of the West Greenland Current of $6.0x10^6 m^3/sec$.

The most pronounced feature indicated in Table I is the very strong decrease in the volume flow between Godthåb and Holsteinsborg. The reason for this is that the main part of the West Greenland Current at this locality bends westward and follows the slope of the ridge between

Greenland and Baffin Island until it joins the Baffin Land Current.

Labrador Current.

The Labrador Current has been described (Iselin 1927) as a cold water stream which flows southward over the continental shelf inside of the comparatively motionless homogeneous mass of North Atlantic water. As compared with the main body of water in the Labrador Sea the current is characterized by its low salinity and temperature. As a result of the investigations of the "Marion" and "General Greene" expeditions (Smith, Soule and Mosby, 1937), the Labrador Current is found to have its origin in the vicinity of Cumberland Sound where the West Greenland and Baffin Land Currents join.

The Labrador Current may be divided into two streams, an inshore and an offshore one. The inshore stream contains the greater volume of cold water and is confined to the continental shelf. This stream enters Hudson Strait on the Baffin Land side, and flows as far as Big Island before it recurves southward to mix with the waters flowing out of Hudson Bay, and flows out past Cape Chidley (Smith, Soule and Mosby, 1937). The offshore stream, which contains waters that are characteristic of the warmer West Greenland Current, tends shoreward near the mouth of Hudson Strait, but does not enter, and continues to flow southward over the continental slope (Smith, Soule and Mosby, 1937). Continuing down the coast, the Labrador Current follows an easy sinuous course which exhibits two major bends, the one between Cape Harrigan and Cape Harrison, Labrador, and the other between Cape Bauld and Funk Island, Newfoundland (Smith, Soule and Mosby, 1937).

The characteristic low temperatures of the Labrador Current persist as the water flows southward, the great stability of the water layers preventing the penetration of solar heat by convection. On reaching the vicinity of Belle Isle Strait, water from the inshore stream is carried at times, through Belle Isle Strait into the Gulf of St. Lawrence. Water moving outward along the southern side of Belle Isle Strait enters into the southward flow of the Labrador Current. Continuing southward of Belle Isle Strait, the Labrador Current meets the northern face of the Grand Banks in the latitude of St. John's, and is split, the slope branch continuing down the edge of the Grand Banks while an inshore branch follows the gully past Cape Race (Smith, Soule and Mosby, 1937). A velocity diagram of the Labrador Current from Smith, Soule and Mosby (1937), is shown in Figure 6 and the axis of maximum flow is indicated by the velocities in miles per day.

The Gulf Stream System.

The Gulf Stream System, which with the Labrador Current, constitutes the main feature of the circulation system of the waters of the Western North Atlantic, may be recognized off the Atlantic seaboard by its comparatively high temperature. Off Halifax, the northern edge of the Stream may be within 230 miles (425 km.) of the coast and as far away as 420 miles (780 km.). Its meanderings, as shown by changing position of its northern edge, have an indirect effect on the waters between it and the coast due to the adjustments in the water masses that are associated with these shifting positions. Gulf Stream waters, breaking away from the system, and carrying with it many forms of marine life associated with more tropical waters, are incorporated in the water masses close to the coasts, and thus directly effect the characteristics of these waters. It is, however, in the area of the confluence of the Labrador Current and the Gulf Stream in the southwestern area of the Grand Banks and to the westward, that large scale mixing processes occur, which provide a type of "slope water" that contributes largely to the characteristic waters that are in contact with the continental shelf, and penetrate at greater depths even into the Gulf of St. Lawrence. These "slope waters" have a profound influence on the waters on the Scotian Shelf, both indirectly through gradual mixing processes, and directly when incursions of these slope waters take place.

Gulf of St. Lawrence.

The circulation of the waters, in the upper layers, in the Gulf of St. Lawrence are in general cyclonic (Bjerkan 1919). Waters that enter the Gulf past Cape Ray, Newfoundland, are deflected to the right and flow northeastward along the west coast of Newfoundland. Along the north

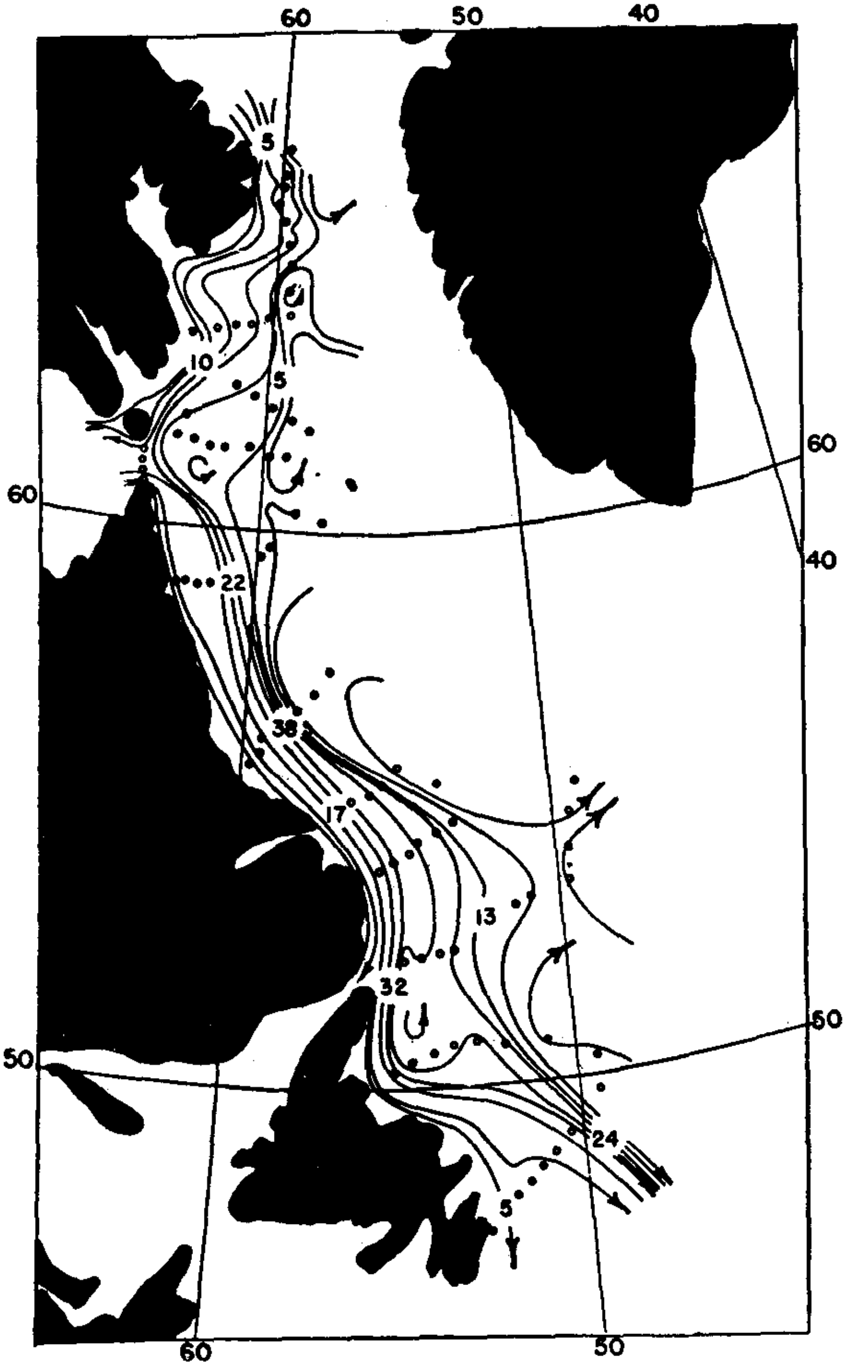


Fig. 6. Labrador current July 22 - Sept. 17, 1928. The velocities shown in miles per day indicate the axis of maximum flow.

shore of the Gulf there is a westward drift of a water type that may have had its origin north of the Strait of Belle Isle, while part of the north-east flow is deflected by Mekattina Bank, lying across the head of the Esquiman Channel. Investigations have shown the circulation of the waters in the Strait of Belle Isle to consist of (a) a progressive inward movement of Labrador coastal water on the north side, (b) a progressive outward movement of Gulf of St. Lawrence water on the south side, (c) a dominant outward flow of Gulf water (Huntsman, Bailey and Hachey, 1954,) and (d) a dominant inflow of Labrador coastal water (Dawson, 1907). The westward flow through Belle Isle Strait rounds Cape Whittle to enter Jacques Cartier Passage. Part of the movement in Jacques Cartier Passage appears to be closely allied to tidal movements, so that there is a net westward movement of water past the western end of Anticosti Island, while at the eastern end there is an eastward movement possibly caused by the shallowing water in the Passage. This current recurves and flows west along the south coast of Anticosti Island where it enters the general circulation of the estuary of the St. Lawrence River.

In the Gaspé Passage between Anticosti Island and the Gaspé Peninsula, there is a preponderance of movement to the east in the form of the Gaspé Current. This current is very strong and its effects can be seen and felt for many miles from the coast. It keeps well to the Gaspé Peninsula but loses a considerable amount of its velocity on passing into the shallows of the southern portion of the Gulf. The waters in this southern Gulf area form a general eastward flow which works toward Cabot Strait, where the main efflux of the Gulf of St. Lawrence takes place. Dawson (1913) described the efflux of the Gulf of St. Lawrence in Cabot Strait as the Cape Breton Current, and as being a constant current flowing to the southeast. The waters borne by the Cape Breton Current on passing through Cabot Strait round Cape Breton Island and flow along the Scotian Shelf.

Scotian Shelf.

Water movements over the Scotian Shelf follow a general southwest direction. Eddies are frequently found, and are considered to be due to bottom configuration. There are frequent incursions of slope water which considerably alter oceanographic conditions from time to time (Hachey 1953). In general, the waters from the Gulf of St. Lawrence flood the eastern portion of the shelf but on proceeding westward are confined to an inshore band. In the western portion, the waters are strongly influenced by offshore waters. The mixture of the two enters the Gulf of Maine and Bay of Fundy circulation after passing Cape Sable at the southern tip of Nova Scotia.

Gulf of Maine and Bay of Fundy.

The physical oceanography of the Gulf of Maine has been extensively dealt with by Bigelow (1928). He described the circulatory movements (Figure 7) as follows: In the eastern side of the Gulf, the tendency is northward along Nova Scotia into the Bay of Fundy on its southern side, northward towards New Brunswick, and out of the Bay along the south side of Grand Manan with a counterflow into the Bay via Grand Manan Channel. Recent observations disagree with earlier ideas regarding residual movements in Grand Manan Channel. McLellan (1951) concluded from hydrographic observations that there is no conclusive evidence of residual currents in Grand Manan Channel, while MacGregor and McLellan (1952) observed net southward movements from Geomagnetic Elektrokinetograph (Von Arx, 1950) measurements.

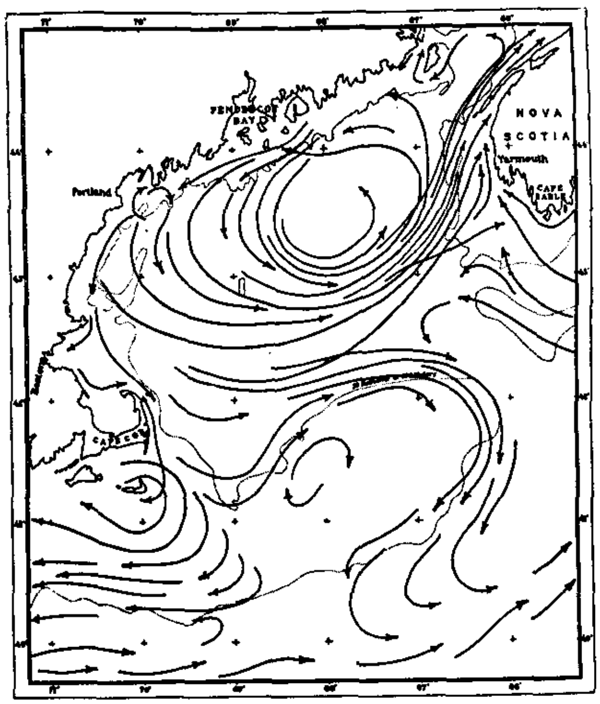


Fig. 7. Schematic representation of the dominant non-tidal circulation of the Gulf of Maine, July to August. (After Bigelow, 1928).

General results of drift bottle experiments show a southwestward movement along the coast of Maine to the vicinity of Cape Elizabeth. Bigelow (1928) states further that off Cape Elizabeth the general drift is southerly. In the region of Massachusetts Bay, two drifts were noted, one anticlockwise around its coast and the other southerly across its mouth and down along Cape Cod. The drift is out to the eastward from Nantucket Sound, and generally southerly and eastward past Nantucket Sound. A general clockwise movement is suggested around Georges Bank.

General Circulation as shown through the Distribution of Ice.

The distribution, characteristics, and various problems of sea ice and icebergs have been discussed extensively in a number of supplements to the Pilot Chart of the North Atlantic, issued by the United States Hydrographic Office. In the supplement of May, 1952, ocean currents and the seasonal distribution of ice are discussed under the title: "Artic Ice and Its Drift into the North Atlantic Ocean".

In the Greenland area, three types of ice are encountered, namely: Storis, West Ice and Winter Ice. Storis refers to the sea ice which has drifted southward along the east coast of Greenland. It is formed in the Arctic basin, often attaining forms and thickness which even the most severe uniform freezing could not produce. It is the result of repeated freezing and rafting of various flows, combined with snowfall. The Storis encountered in south Greenland must be assumed to be mostly 2 and 3 years old. It moves southward along the east coast of Greenland (Figure 8), and in season rounds Cape Farewell to move northward along the west coast of Greenland. This ice clearly outlines the influence of the East Greenland Current.

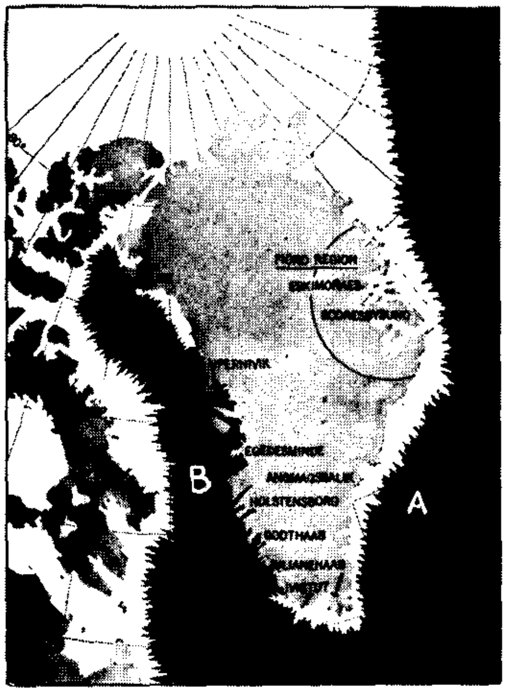


Fig. 8. Distribution of Storis (A) and West Ice (B). After U.S. Hydrographic Office Suppl. to Pilot Chart of North Atlantic Ocean, May, 1952.

The extension of Storis varies much with the seasons and from year to year. Off Southwest Greenland, the first Storis often appears at Cape Farewell in late January, but only in small scattered amounts. It arrives in greater quantities in March, and during the months of April to June it has its greatest extension along the west coast. In severe ice years, the Storis reaches north of Godthåb, but in most years, the northern limit is found between Frederikshåb and Fiskenæsset. From July onwards the ice decreases in quantity and from the middle of August to the end of the year all of the west coast of Greenland is generally free from Storis. These remarks refer to conditions as found in recent years. The distribution of ice, however, has been greatly affected by the climatic changes which have taken place during the last fifty years.

In Figure 9, the average limits of the Storis in April and in August are shown for the two periods 1898-1913 and 1919-1942. The limits shown for the first period are those given by Speerschneider (1917), and the limits for the second period are the 50% frequency curves given by the Deutsches Hydrographisches Institut (1950). Although the limits were calculated in somewhat different ways, it is probable that they give a fairly correct picture of the regression of ice during this century.

West Ice resembles Storis but reaches Baffin Bay through the various channels in the Canadian Archipelago. In Greenland, west ice is generally confined to the northwestern portion but favourable wind conditions may move it to the Greenland part of the Davis Strait sector.

Winter Ice is that which is formed in the harbours and fiords during the coldest part of the

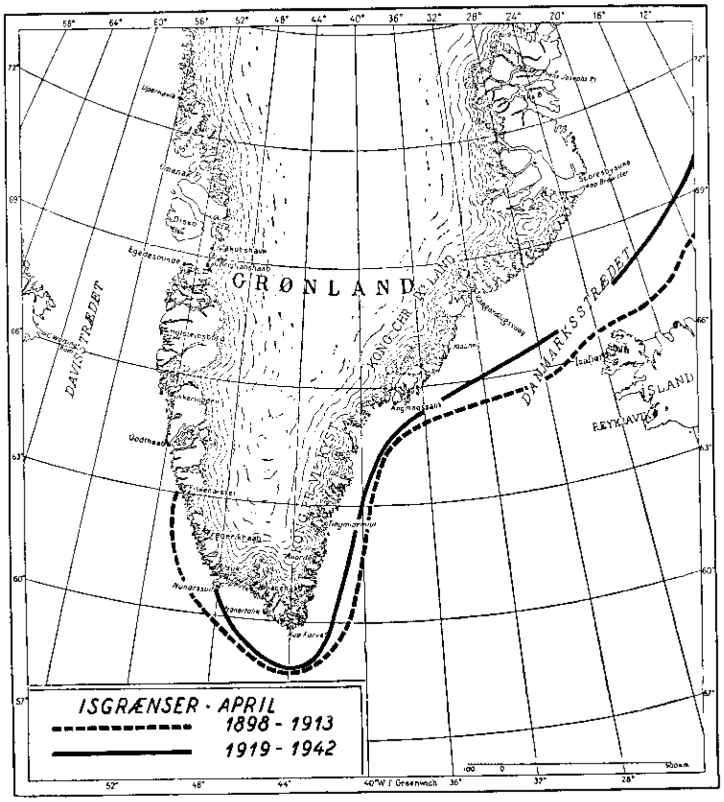


Fig. 9A. Average limits of Storis for April in Greenland waters.

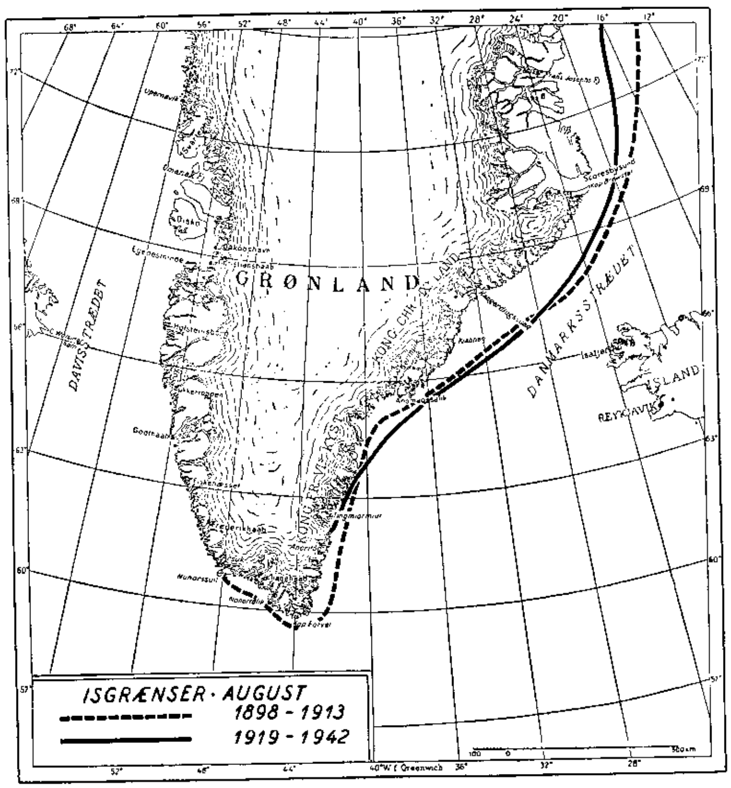


Fig. 9B. Average limits of Storis for August in Greenland waters.

year and may attain a thickness up to 3 feet. It is most prevalent in East Greenland and north of Davis Strait. Winter Ice plays an important role in sealing up icebergs and preventing their dispersal.

In discussing the Arctic Ice in relation to the Labrador Current, it is apparent that the two chief sources of ice encountered in the western Atlantic are Davis Strait and Foxe Channel. The pack ice from Baffin Bay reaches Hudson Strait in late October or early November and is there joined by heavy flows from Foxe Channel. The combined streams move south along the coast arriving off Belle Isle Strait in December. Heavy flows of true arctic type often extend 100 miles east of the entrance of Belle Isle Strait, and much of this ice enters the Strait. From January until after March, currents and winds govern the distribution of ice often as far south as latitude 46°N. Large quantities of it may drift along the eastern edge of the Grand Banks, while some of it extends along the east coast of Newfoundland, around Cape Race and thence southward and southwestwardly over the neighbouring banks. Large quantities of ice which enter the Gulf of St. Lawrence through Belle Isle Strait leave it on the Cape Breton side of Cabot Strait and then spread southward and southwestward toward Sable Island. The distribution of field ice on the Atlantic Coast of North America (after Huntsman (1930) and the U.S. Hydrographic Office Supplement to the Pilot Chart of the North Atlantic Ocean, 1948) is shown in Figure 10.

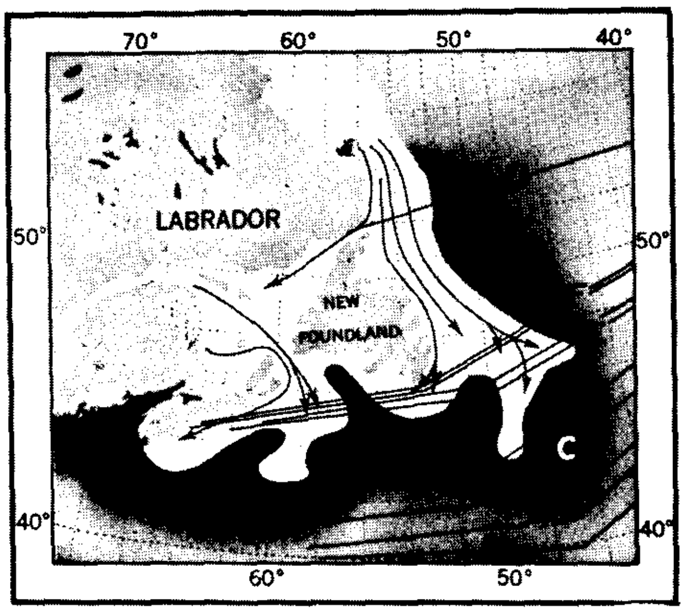


Fig. 10. **The distribution of Field Ice south of Newfoundland. The lettered lines represent steamer tracks. (After Huntsman, 1930, and U.S. Hydr. Off. Suppl. to Pilot Chart of N. Atlantic Ocean, May, 1952).**

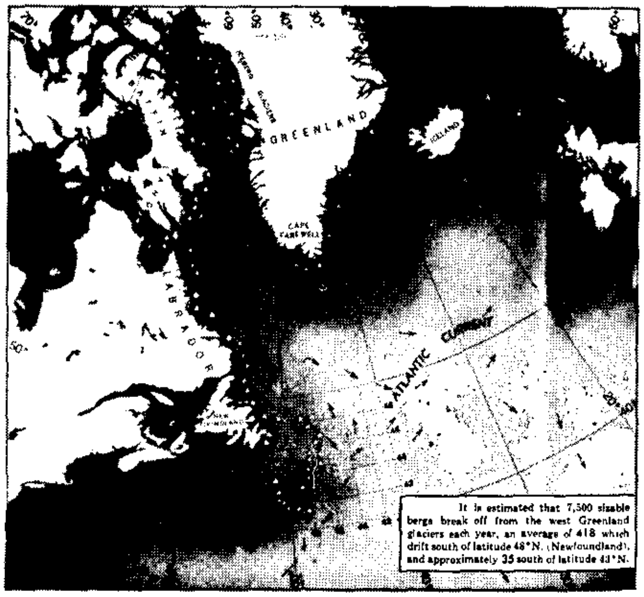


Fig. 11. **Drift of icebergs from their source into the North Atlantic. (After U.S. Hydr. Off. Suppl. to Pilot Chart of the N. Atlantic Ocean, May, 1952).**

In addition to pack ice, which is entrained by the various currents and shifted about by the winds, there are the icebergs which because of their greater draft are less effected by the winds and more by the currents. Figure 11 shows the drift of icebergs from their source into the North Atlantic. The principal source of icebergs in the North Atlantic is the west coast of Greenland, although a few are produced from glaciers on Ellesmere Island. Many icebergs from East Greenland are transported to Cape Farewell, where scattered bergs are met as much as 100 to 200 miles south of this promontory. The main stream of bergs drifts northward as far as Holsteinsborg. North of Holsteinsborg is the northern iceberg area which is the main source of icebergs encountered near Newfoundland. These bergs are carried by the northward movement of that part of West Greenland Current which enters Baffin Bay. They then enter the southerly drift along the east coast of Baffin Land and enter the eastern ends of Frobisher Bay and Hudson Strait, following the same general pattern as the field ice from Baffin Bay. They are found as far west as Big Island in Hudson Strait and everywhere in Ungava Bay. Icebergs which follow the inshore part of the Labrador Current are, in general, caught up in the various breaks in the coast line, while those which are carried in the offshore branch of the Labrador Current, reach the tail of the Grand Banks.

The Labrador Current and the ice follow a definite course from the Arctic to the tail of the Grand Banks. The effect of wind upon the drift of icebergs being small, their subsequent movements depend largely upon the complex and variable current patterns which exist along the boundary between the Labrador and the Atlantic Currents. During the latter part of March and the first part of April, the flooding Labrador Current holds closely to the eastern slope of the Grand Banks and sometimes curls around the tail and extends for a considerable distance northwestward along the southwestern slope. As the volume of the discharge increases, the mixing zone between the two currents moves further offshore to the southwest, south, and southeast of the tail, and bergs fan out along the edge of the Gulf Stream System. During the summer however, the Labrador Current dwindles in volume in this region, and bergs remain near the banks or are turned northeastward by the currents before reaching the tail of the Grand Banks. During this cycle in the flow of the Labrador Current, the volume of flow of the Atlantic Current is also changing, and the resulting changes in relative strength of the two currents produce complicated changes in the location of their common boundary and in the courses, drift rates, and life expectancy of bergs reaching this vicinity (Supplement to Pilot Chart of North Atlantic Ocean, May, 1952).

Horizontal Distribution of Temperature and Salinity in the Summer.

The charts presented (Figures 12-15) in the following discussion of temperature and salinity are based on observations made over a network of stations used by the Atlantic Oceanographic Group and the Newfoundland Fisheries Research Station of the Fisheries Research Board of Canada. These networks are illustrated in Figure 1. The 1950 post seasonal cruise of the International Ice Patrol from Labrador to Greenland was used to give data for the Labrador Sea and West Greenland Current. A considerable amount of additional data collected by various United States and Canadian agencies were used in a supplementary manner. All data used were collected during the period between the last week of July and the first week of September, 1950. These diagrams form part of a series presented by Bailey and Hunt (1954).

Most of the major ocean currents in the area are recognizable from the surface temperature distribution (Figure 12). South of Greenland, the northward flowing West Greenland Current has surface temperatures ranging from 2°C. inshore to 8°C. offshore. The main body of the Labrador Sea exhibits temperatures above 8°C. while the southward flowing Labrador Current shows the influence of decreasing latitudes and mixing with warmer waters from offshore as its temperatures increase from 3°C. in the north to 7°C. at the tail of the Grand Banks. In the triangle between the Grand Banks and the Scotian Shelf, the slope water is seen to increase from a narrow band off Cape Cod to a wide one south of Cape Ray. Temperatures in the slope water are higher than 17°C. but less than 25°C. In the longitude of 60°W. an eddy from the northern edge of the Gulf Stream may be seen intruding into the slope water. Surface temperatures at the northern edge of the Gulf Stream are generally greater than 25°C., and traces of it just reach into the diagram.

Over the shallow portions along the coast and over the banks, surface temperatures show only small variations from one area to another, ranging in general from 13° to 16°C. Along the south coast of Newfoundland where temperatures are less than 15°C., there is the suggestion of a movement from the east coast of Newfoundland into the Gulf of St. Lawrence. Increasing temperatures along the Gaspé coast illustrate the warming of the Gaspé Current as it loses velocity and enters the shallow area in the southwestern Gulf. Along the southeast coast of Nova Scotia, the lowered temperatures off Halifax illustrate the upwelling of colder sub-surface waters. In the area south of Cape Sable, temperatures as low as 10°C. are observed which appear to be the result of strong tidal mixing over the shallows in this area. In the Bay of Fundy area, tidal mixing is extremely important. Temperatures there, during this period, are somewhat higher than on the Nova Scotia coast.

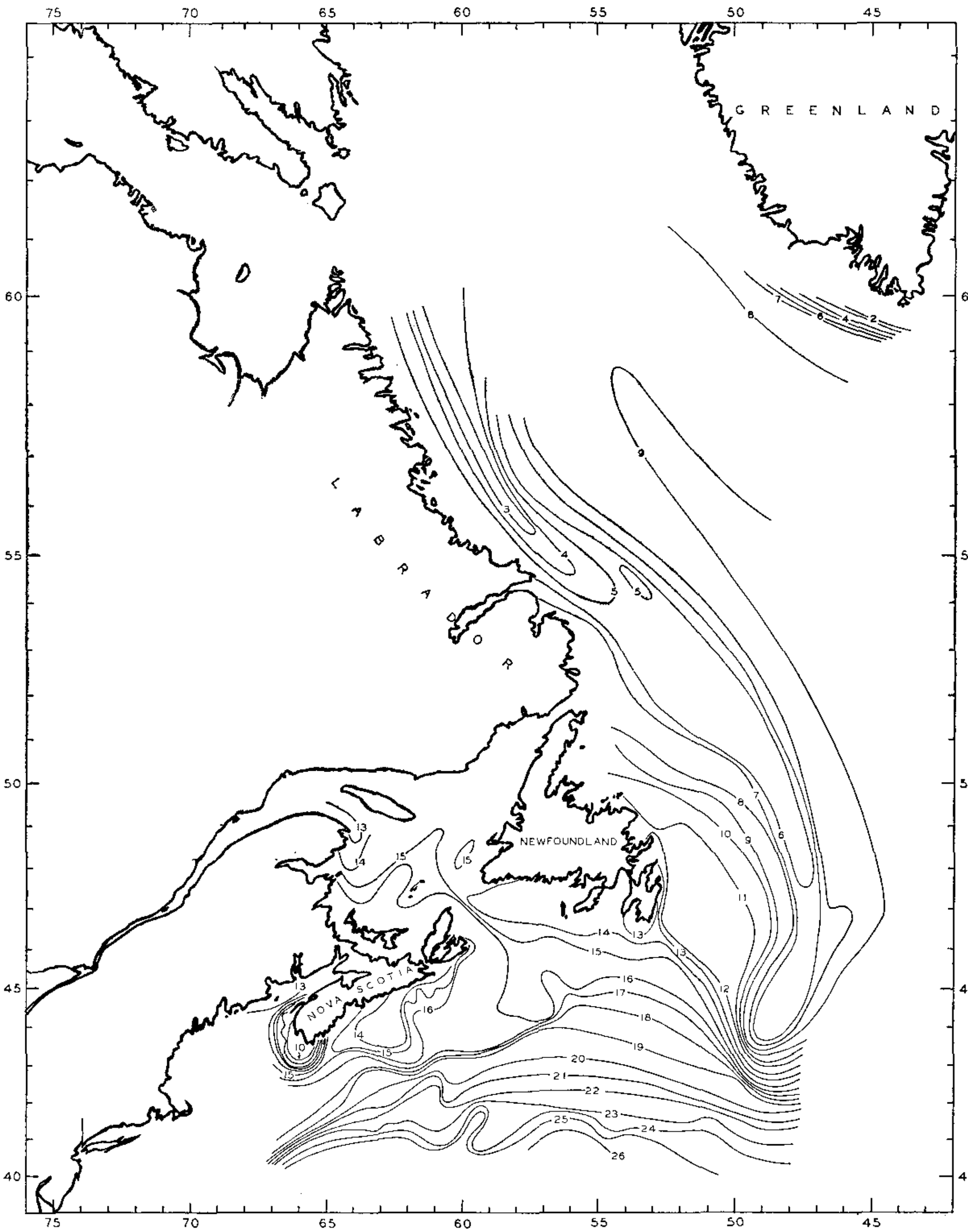


Fig. 12. Surface temperature distribution, August, 1950.

At 100 metres (Figure 13) the nature of the several currents is better revealed by their temperatures than at surface where solar heating and wind stirring tend to obliterate the contrasts. The influence of the bottom topography is most pronounced because the main banks are of depths less than 100 metres. At this level, the nature of the West Greenland Current is revealed. The

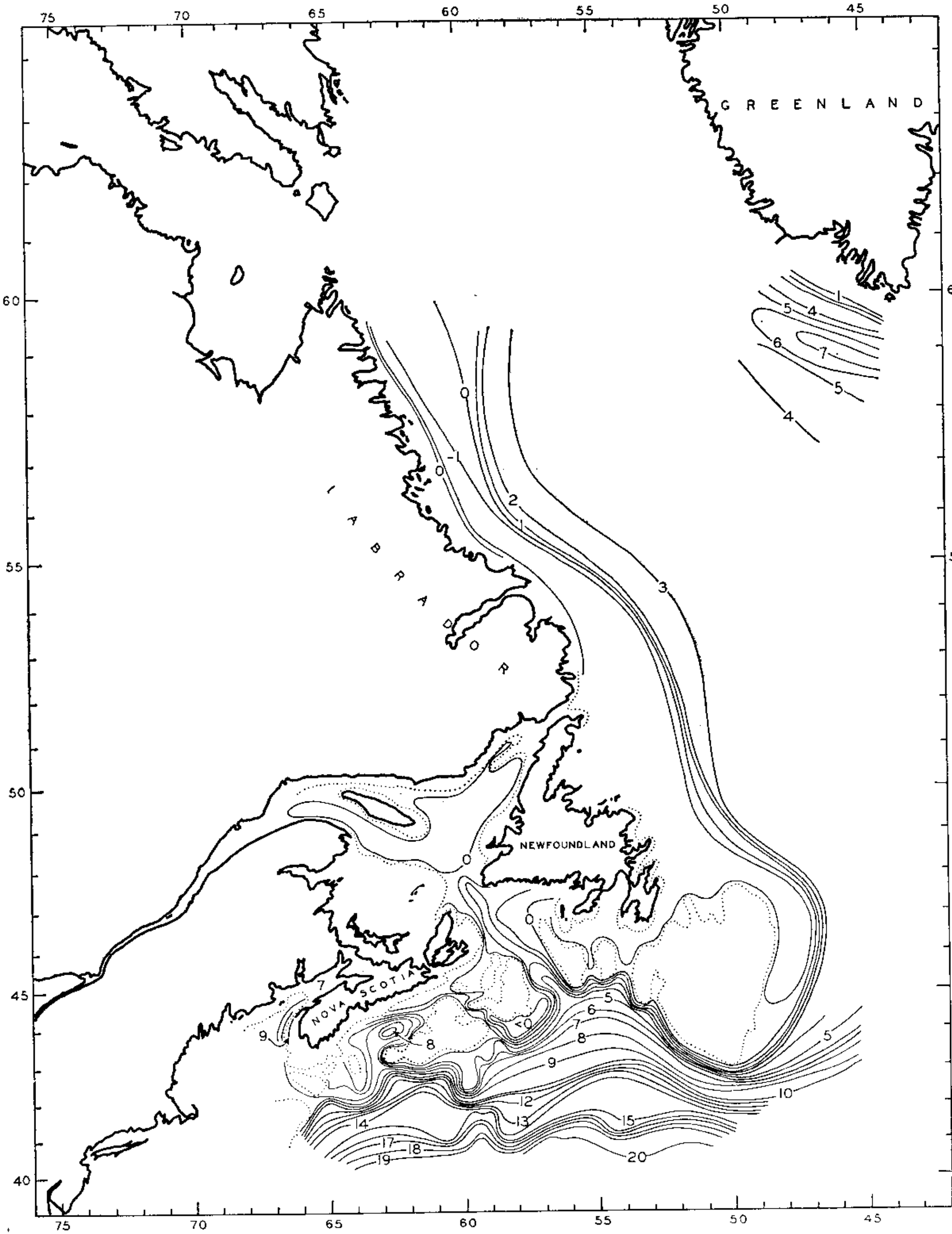


Fig. 13. Temperature distribution at 100 metres, August, 1950.

water from the East Greenland Current is inshore while a tongue of Irminger water with temperatures greater than 7°C. flows northwestward offshore. The main body of Labrador Sea water has temperatures between 3° and 4°C. This level appears to cut through the top of the large mass of nearly homogeneous water found in the Labrador Sea. In the Labrador Current, tem-

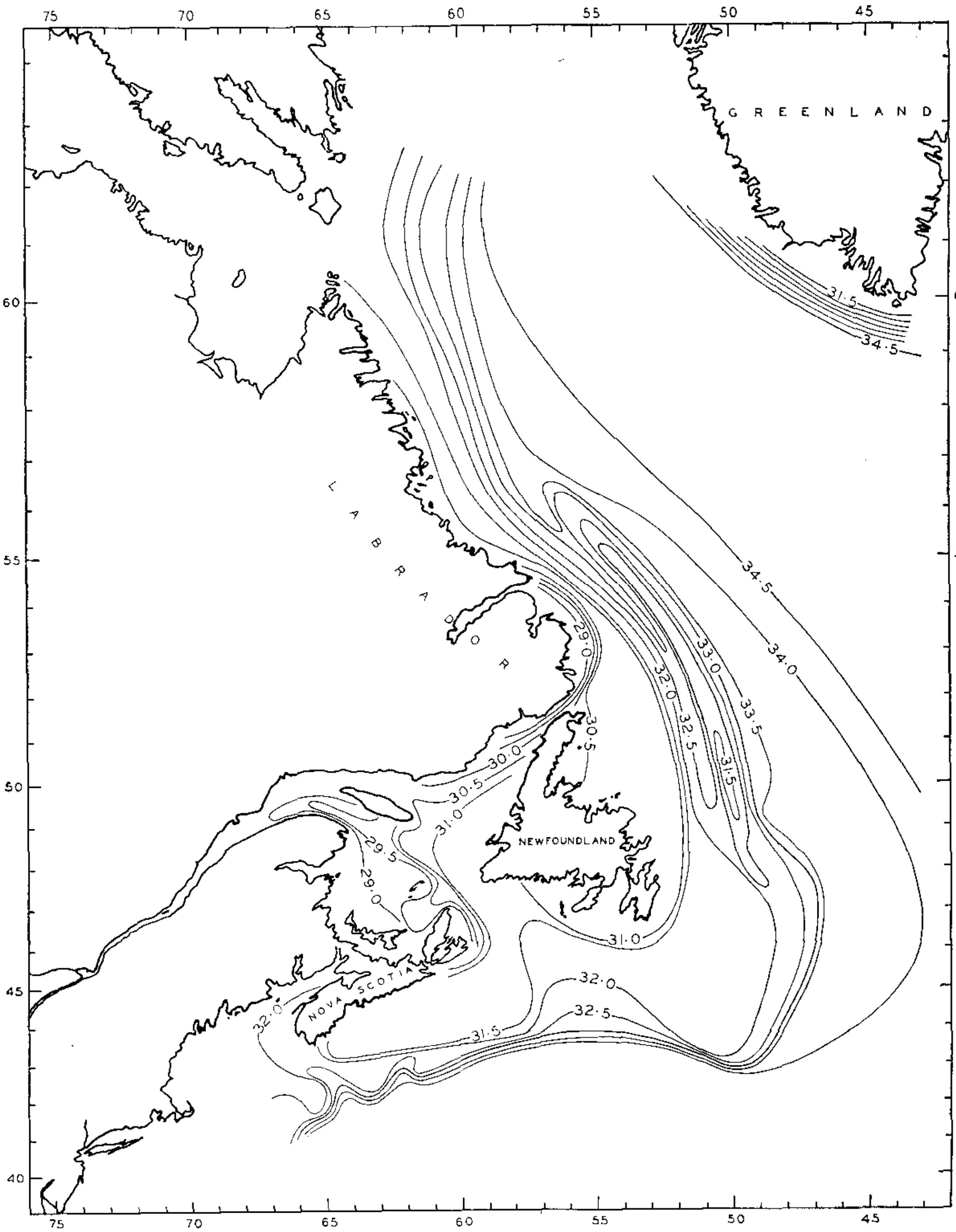


Fig. 14. Surface salinity distribution, August, 1950.

peratures are less than -1°C. A major feature of the chart is the extent of this large mass of Arctic water which extends from the Arctic Sea to the edges of the Grand Banks at latitude 45°N., half way to the equator. This Arctic water does not reach the Gulf of St. Lawrence nor the Scotian Shelf. In the Gulf of St. Lawrence, temperatures at 100 metres are all below 0°C. This water

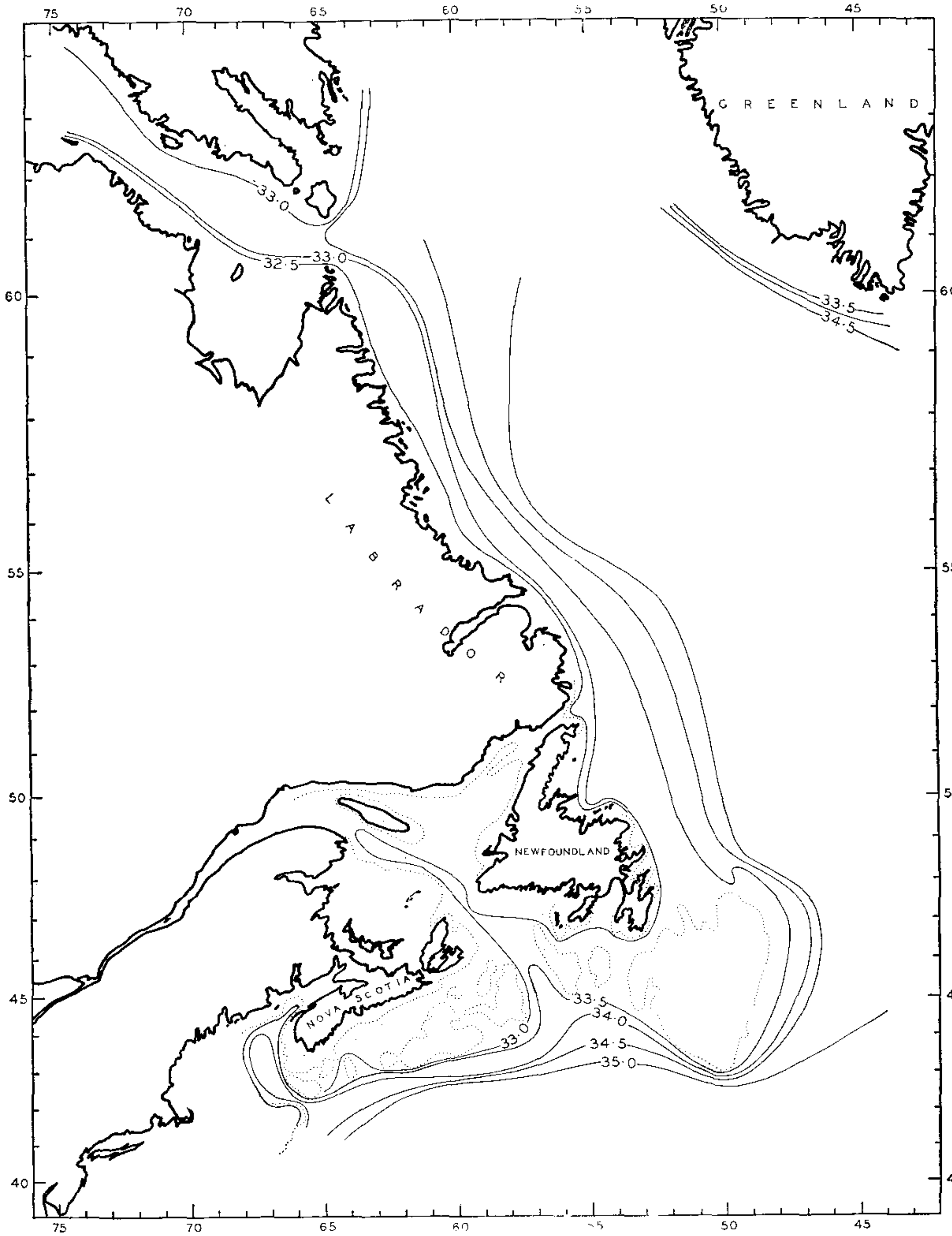


Fig. 15. Salinity distribution at 100 metres, August. 1950.

probably originated, in part, outside of the Gulf at an earlier time, and in part, was formed inside the Gulf through winter chilling. Lauzier and Bailey (1952) estimate that the amount of locally formed cold water (less than 0°C.) to be between one-third and one-half of the total volume of cold water found in the Gulf. Outside of the Gulf of St. Lawrence in the Laurentian Channel, the outline is noted of the upper portion of the wedge of slope water that reaches into the Gulf of St. Lawrence at lowered depths. This wedge reaches well into the estuary of the St. Lawrence river. At the eastern edge of the Scotian Shelf, a small isolated body of Arctic water is in evidence. The exact origin of this water is not certain but it may have come through the channels between the banks south of Newfoundland, or have worked westward from the tail of the Grand Banks after a flooding in the early spring, as suggested by Bjerkan (1919).

South of Nova Scotia in the deep channels that penetrate the shelf, there is a small body of relatively warm water which appears to have been left from an incursion of slope water that took place at an earlier date. The undulating boundary between the slope water and the shelf probably causes this phenomenon to occur at fairly frequent intervals when the slope water lies close to the edge of the shelf, as has been observed at times. Hachey (1953) describes such a case that occurred during the winter of 1949.

The distributions of salinity are based almost wholly on observations made by the Atlantic Oceanographic Group and the Newfoundland Fisheries Research Station. One section across the Labrador Current from South Wolf Island, Labrador, to Cape Farewell, Greenland, made by the International Ice Patrol, was used, as well as, occasional observations made by the Canadian Hydrographic Service.

Most of the waters sampled were coastal with salinities generally less than 33.0.$^{\circ}/_{oo}$ Some slope water with salinities as high as 34.5$^{\circ}/_{oo}$ was observed. There were no observations of Atlantic water in southern sectors which has salinites higher than 35.0$^{\circ}/_{oo}$. In the Labrador Sea salinities were greater than 34.5$^{\circ}/_{oo}$ but less than 35.0.$^{\circ}/_{oo}$.

The salinity distribution at the surface (Figure 14) shows that the waters in the Labrador Current are composed of many tongues and eddies. This is particularly true in the offing of Belle Isle. Smith, Soule and Mosby, (1937), show an eddy in the same area and suggest that this region is unmistakably associated with currents coming from farther south in the Atlantic.

The efflux from Hamilton Inlet appears to have some influence on the surface waters off southern Labrador and in the vicinity of the Strait of Belle Isle. The lowered salinities in the southwestern Gulf show the effect of the St. Lawrence river discharge. In Cabot Strait, the outflow is traceable to the Scotian Shelf, and an inflow of surface water is evident along the west coast of Newfoundland.

At the 100 metre level (Figure 15), salinities were everywhere above 33.0$^{\circ}/_{oo}$ except in Ungava Bay. In Hudson Strait there were no observations in 1950 but the isohalines were drawn after Bailey and Hachey (1950) to illustrate how the ocean water under-runs the coastal waters and reaches inland in the deep channels to bring ocean water near the shores. This is clearly evident in Hudson Strait, the Laurentian Channel, and the Fundian Channel. In the Hudson Strait and the Bay of Fundy, this condition has a profound influence on the waters in the two areas because they are thoroughly mixed through tidal stirring.

WATER CHARACTERISTICS

The Water Masses in the Greenland Area.

The distribution of the different water masses in the Greenland area is best illustrated by five vertical sections, the locations of which are shown in Figure 1 (I-V). The sections were selected from years in which the summer conditions in the sea around Greenland were regarded as normal according to the standards of recent years.

In the section (I) off southeast Greenland (Figure 16A), the Polar Current, with temperatures below 2°C. is found over the shelf, and has a width of only about 30 miles. Beneath, and outside the Polar water, the warm Irminger Current is found. The core of this current is found off the slope of the shelf, and has temperatures above 5°C. and corresponding salinities greater than 35$^{\circ}/_{oo}$. On account of its greater density, the Irminger Current has a tendency to sink beneath the less saline Polar water. Thus a relatively warm bottom water is found nearly everywhere along the East Greenland shelf, where depths exceed 200 metres.

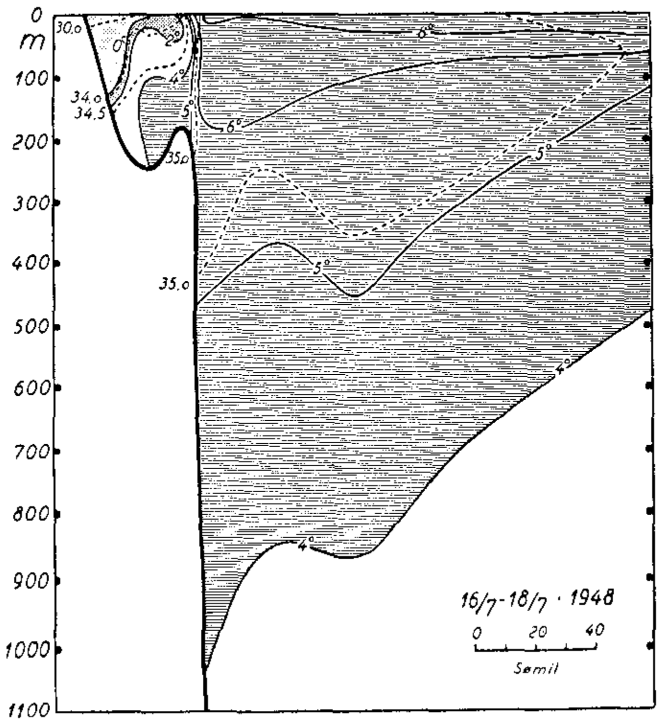


Fig. 16A. Temperature and salinity, Section I, off southeast Greenland, 16-18 July, 1948.

In Section II off Frederikshåb (Figure 16B), on the west coast, both the Polar water and the Irminger water are found, but due to mixing and summer warming the difference between the temperatures of the two currents is much less in this area than on the east coast. The remainder of the Polar Current is again found nearest the coast in the upper 100 metres, but the temperature in its core is now only slightly below 1°C. The warm current appears near the coast as an undercurrent, but reaches to the surface at approximately 60 miles offshore. The temperatures in the core of the warm current are between 4° to 5°C. and its salinity is less than 35°/oo.

Section III, (figure 16C), illustrates the oceanographic conditions of Fylla Bank, one important to the Greenland Fisheries. In this section, the current has lost its polar characteristics. In the deep channel between the bank and the coast, and off the western slope at a depth of

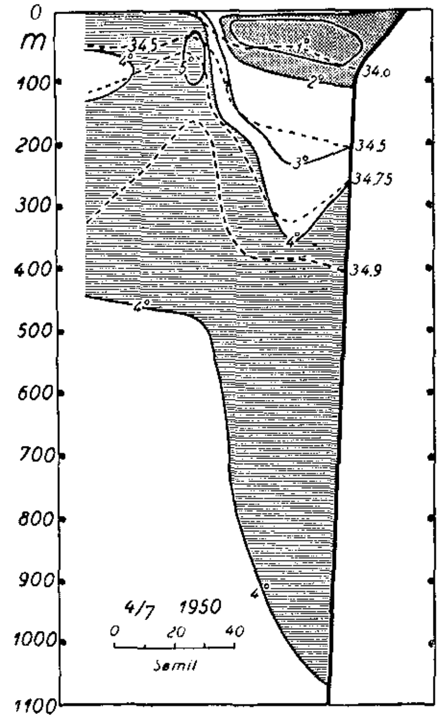


Fig. 16B. Temperature and salinity, Section II, off Frederikshaab, 4 July, 1950.

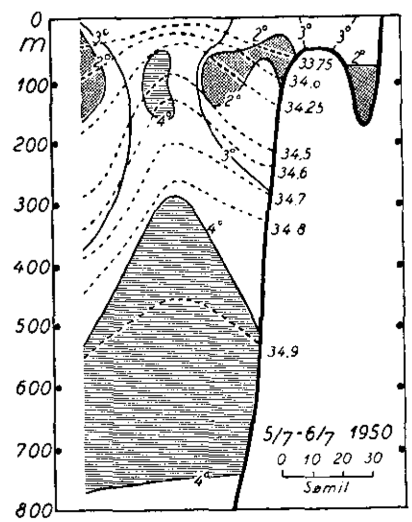


Fig. 16C. Temperature and salinity, Section III, Fylla Bank, 5-6 July, 1950.

about 100 metres, water colder than 2°C. is found. This is the last trace of the East Greenland Polar Current. Over the shallowest part of the bank summer warming has increased the temperature to more than 3°C. In the main portion of the section, water with temperatures between 2° and 4°C. is found, which is produced through the mixing of Polar water and Irminger water. Irminger water warmer than 4°C. is found in rather large quantities at depths between 300 and 800 metres. In the westernmost part of the section, colder water is encountered, which is a branch of the West Greenland Current which has turned west and southwestwards and mixed with water from the Canadian Polar Current.

In Section IV off Holsteinsborg (Fig. 16D), the western part is dominated by Canadian Polar water with temperatures less than -1°C. The West Greenland Current has decreased considerably in its passage from the Godthåb section, and this is because the main body of water follows the west going branch of this current. The remaining part of it is, however, of sufficient volume to keep the cold water of the Canadian Current away from the Greenlandic slope and shelf.

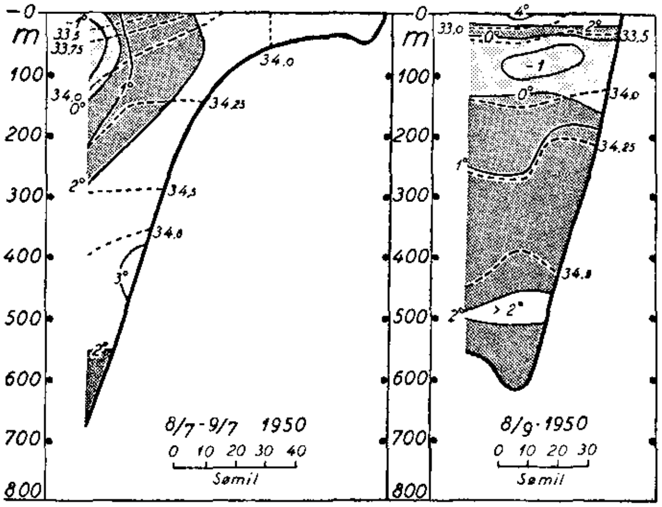


Fig. 16D. (left) and **E.** (right). **Temperature and salinity, Section IV (D), off Holsteinsborg, 8-9 July, 1950, and Section V (E), southeastern part of Baffin Bay, 8 September, 1950.**

The conditions as found in the southeastern part of Baffin Bay are illustrated by section V. (Figure 16E) Below the summer warmed layer, of approximately 30 metres thickness, a cold layer with negative temperatures formed by winter chilling, extends down to about 150 metres. Below this cold layer, the warm West Greenland Current exists. Its maximum temperature being slightly greater than 2°C., the current still has sufficient strength to cause positive temperatures to a depth of 1000 metres in the southeastern part of Baffin Bay.

The above sections illustrate the oceanographic conditions as found during what may be regarded as normal years. The conditions, however, can differ considerably from these because they are greatly influenced by fluctuations in the strength of both the East Greenland and Irminger Currents, and by variations in the meteorological conditions, particularly the winter temperatures off West Greenland.

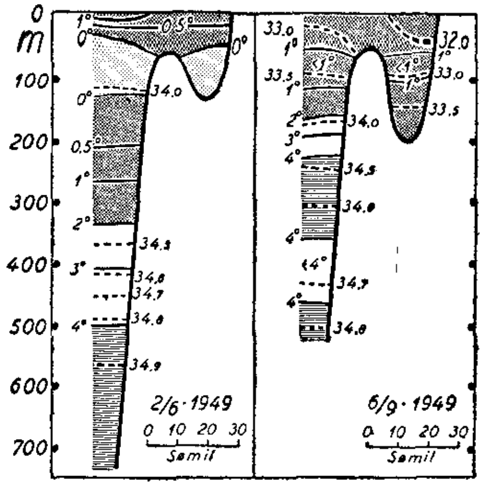


Fig. 17A. Temperature and salinity in sections across Fylla Bank in a "cold" year, 2 June and 6 Sept., 1949.

To illustrate the variations in the oceanographic conditions that take place in the waters off West Greenland Figures 17A and B, representing oceanographic conditions over Fylla Bank in a cold year, 1949, and a warm year, 1947, are to be compared with those shown in Figure 16C 1950. Conditions in 1947 were the warmest attained in the post-war period. In June, 1949, Fylla Bank was surrounded by ice-cold Polar

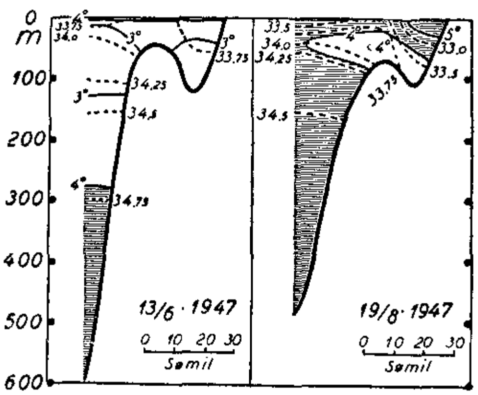


Fig. 17B. Temperature and salinity in sections across Fylla Bank in a "warm" year, 13 June and 19 August, 1947.

water, and even in September, temperatures at depths between the 50 and 100 metre level were less than 1°C. In 1947, almost no trace of Polar water was found, and August temperatures exceeded 4°C. over the greater part of the section.

Labrador Water.

On the basis of observations made in 1931 by the "Marion" and "General Greene" expeditions, temperature-salinity correlation curves were obtained for all observations below a depth of 50 metres in the Labrador Current (P. 112, Smith, Soule and Mosby, 1937). These correlation curves show that the main water mass of the Labrador Current is a mixture of two characteristic waters as follows:

(1) Baffin Land water exhibiting average temperatures of -0.5°C. and average salinities of 33.5‰.
(2) West Greenland water exhibiting temperatures as high as 3.8°C. and salinities as high as 34.6‰.

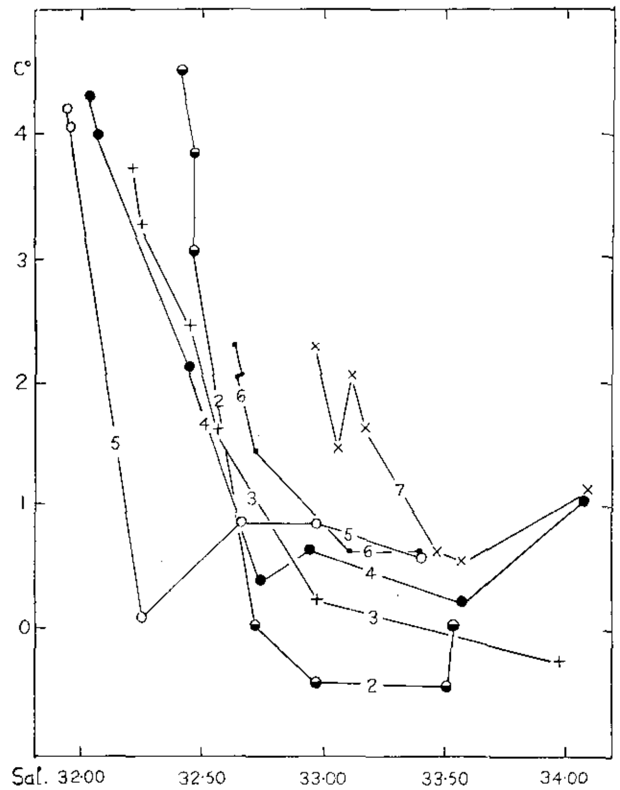


Fig. 18. Temperature-salinity correlation curves for Labrador coastal waters in September, 1948.

A temperature-salinity diagram constructed from the 1948 data collected by the "Haida" (Bailey and Hachey, 1950) is given in Figure 18. As the "Haida" data were collected only along the axis of the Labrador Current and to depths not exceeding 300 metres, the diagram gives preeminence only to two characteristic water masses as follows:

(1) Water exhibiting temperatures greater than 3.0°C. and salinities between 32.0 and 32.5‰.
(2) Water exhibiting temperatures between -0.5°C. and 1.0°C. and salinities between 32.7 and 34.0‰.

The first of these is therefore representative of the coastal contributions to the Labrador Current, and confined, in the main, to the upper fifty metres within the coastal belt. The second is obviously water of the Baffin Land Current, while no sampling of the waters of the West Greenland Current is in evidence.

Gulf of St. Lawrence and Strait of Belle Isle.

Temperature-salinity relationships of the waters in and adjacent to the Strait of Belle Isle are illustrated in Figure 19. The T-S diagram

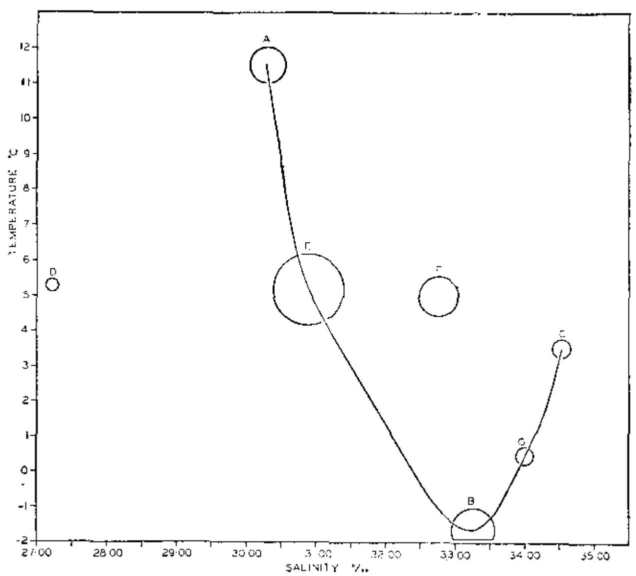


Fig. 19. Temperature-salinity relationships from the observations of the Belle Isle Strait expedition of 1923.

is based on observations by the Belle Isle Strait expedition of 1923 as presented by Huntsman, Bailey and Hachey (1954). The main water masses involved in the Strait as well as those which do not enter are indicated by circles.

On the basis of the T-S diagram, the waters in and adjacent to Belle Isle Strait are, in general, composed of three different water masses having the following characteristics:

(1) A-water, with temperatures greater than 11.0°C. and salinities of approximately 30.5°/$_{oo}$, found in the upper 25 metres in the western portion of Belle Isle Strait and in the Gulf of St. Lawrence, has the characteristics of waters from the surface layers of the Gulf of St. Lawrence.

(2) B-water, having temperatures and salinities of approximately -1.6°C. and 33.3°/$_{oo}$ respectively, is true Arctic water, which forms a layer 200 metres thick near the Labrador coast, and which decreases to a thickness of 100 metres near the edge of the Labrador shelf.

(3) C-water, exhibiting temperatures and salinities generally greater than 3.5°C. and 34.5°/$_{oo}$ respectively, is Labrador Sea water modified by waters of the West Greenland Current (3.5°C., 34.8°/$_{oo}$ Smith, Soule and Mosby, 1937). This water mass was not found in the Strait as such.

In addition to the above mentioned water masses, there are four distinct water masses that show influence of varying degrees upon the waters in Belle Isle Strait, with the following characteristics:

(4) D-water, with temperatures and salinities of 5.0°C. and 27.2°/$_{oo}$, respectively, found at the surface, is Labrador coastal water that has been largely influenced by land drainage.

(5) E-water, having temperatures between 4.5 and 6.5°C. and salinities between 30.5 and 31.5°/$_{oo}$ is Labrador coastal water. This water comprises the greater portion of the surface waters on the northern side of the Strait and near Belle Isle.

(6) F-water, exhibiting temperatures from 5.0 to 6.0°C. and salinities from 32.5 to 33.1°/$_{oo}$ comprises the surface layer of the Labrador Current. This water mass has the characteristics of the surface waters of the Labrador Current, which exhibits normal seasonal changes in its southward progress.

(7) G-water, with a temperature of 0.5°C. and salinites between 33.8 and 34.1°/$_{oo}$ found at the greater depths in the Labrador current, is Labrador Sea water (Dunbar, 1951).

In addition to the mixing that takes place between the different water masses that fall on the T-S curve, there is evidence of direct mixing between the isolated water masses and those on the T-S curve. A-water mixes with B-water, D-water with E-water, and F-water with B-water. There is however, no evidence of E-water mixing with F-water.

Scotian Shelf.

The waters of the Scotian Shelf are coastal in nature and are distributed in a three layer system described by Hachey (1942). The upper layers, of comparatively low salinity display a great variation in temperature with the seasons. The salinity of this layer increases outwards from the coast from less than 30°/$_{oo}$ to approximately 33°/$_{oo}$ and temperatures are generally higher offshore than at the coast. The intermediate layer appears throughout the greater part of the year, as a layer of minimum temperatures, generally less than 5.0°C. This layer results from waters which flood the area from the northeast (Hachey 1938), and is often divided into two distinct phases by the outer banks (McLellan and Trites, 1951). Inshore, the coldest water in the intermediate layer is associated with a salinity of approximately 32.5°/$_{oo}$, while beyond the outer banks it displays salinities very close to 33.0°/$_{oo}$. The deep layer in the coastal water region is warmer and more saline than the intermediate layer and is present only beyond the outer banks and over the deeper portions of the shelf.

Hachey (1942) has summarized the characteristics of the three main layers as follows:

TABLE II.

		Thickness (m.)	Temperature (°C.)	Salinity (°/°°)
	Spring	0–85		
"Upper"	Summer	20–60	>5	<32.0
	Winter	0–115	<5	
	Spring	40–85		
"Intermediate"	Summer	55–90	<5	
	Winter	30–85	(generally)	32.0–33.5
	Spring	Limited by		
"Bottom"	Summer	bottom con-	>5	>33.5
	Winter	figuration.	(generally)	

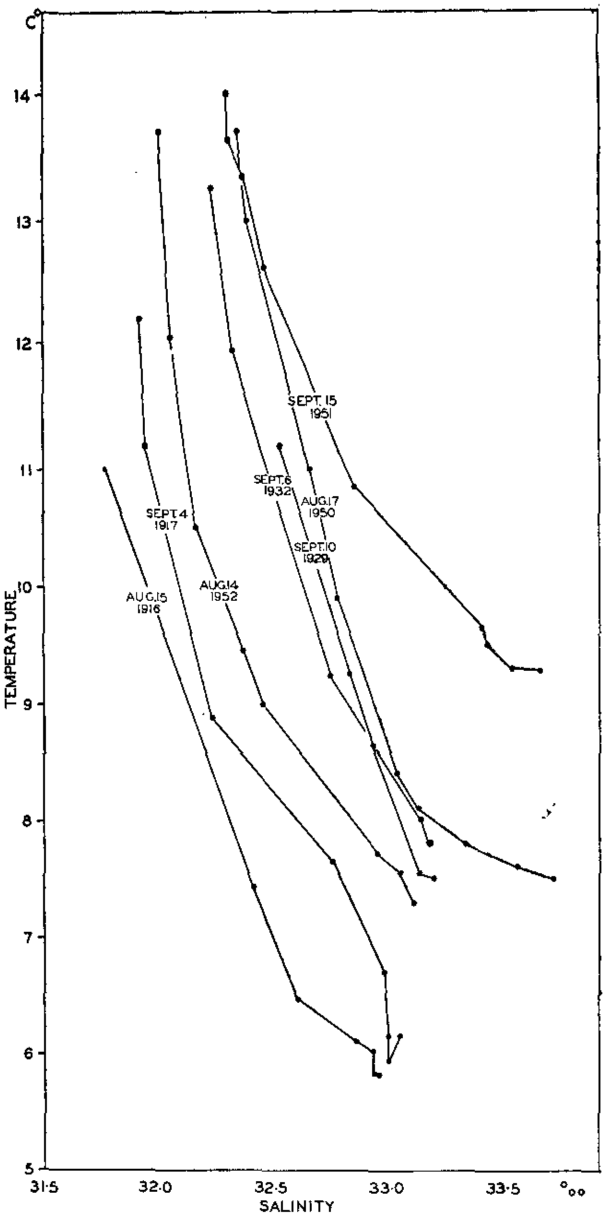


Fig. 20. **T-S diagrams for the summer months at Prince Station 3 and at Station 3 for different years.**

Readers who are interested in further details of the origins of the waters of the Scotian Shelf, are referred to a paper by McLellan (1954).

Gulf of Maine and Bay of Fundy.

The waters in the Gulf of Maine are chiefly derived from an influx of surface water past Cape Sable and a "draw-in" of water from the edge of the continental shelf. The surface water temperatures and salinities are extremely variable depending upon the seasons of the year, the surface salinities being less than $32.0^\circ/_{oo}$. At approximately the 100 metre level, the waters may be considered as being unaffected by seasonal variations having an average temperature of 7.5°C. and an average salinity of $33.5^\circ/_{oo}$. This is water from the edge of the continental shelf. Lying below this is "slope water" having a temperature of 10.3°C. and a salinity of $34.8^\circ/_{oo}$. It is the mixture of these waters in varying proportions which form the waters in the Bay of Fundy and Gulf of Maine. Typical T-S diagrams from the Bay of Fundy are shown in Figure 20, the location of station 3 being Latitude 44°39′N., Longitude 66°28′W.

The Slope Water off the Scotian Shelf.

The slope water off the Scotian Shelf forms a well defined band between the coastal waters and the Gulf Stream. Its boundaries fluctuate widely with no apparent systematics, sometimes transgressing upon the shelf (McLellan, Lauzier, and Bailey, 1953).

The T-S curves for selected stations occupied during November, 1951 (Figure 21) give a picture of the way in which slope water is formed. The curve lying to the lower right of the figure represents the characteristics of Central Atlantic waters deeper than 400 metres (Iselin, 1936). Stations 25 and 70 taken well within the Gulf Stream, illustrate surface T-S relationships there. The deeper waters at these stations fall almost exactly along Iselin's curve, though water found at 600 metres in the Sargasso Sea was found at 400 metres at station 25. Station 31 is representative of the deeper coastal stations, and station 120, off the Newfoundland coast, shows the full development of the cold intermediate layer. The other stations belong to the slope water regime or the outer fringe of the coastal waters.

At the surface, all observations lay close to a straight line running from the surface characteristics of the most coastal (Station 31) to those of

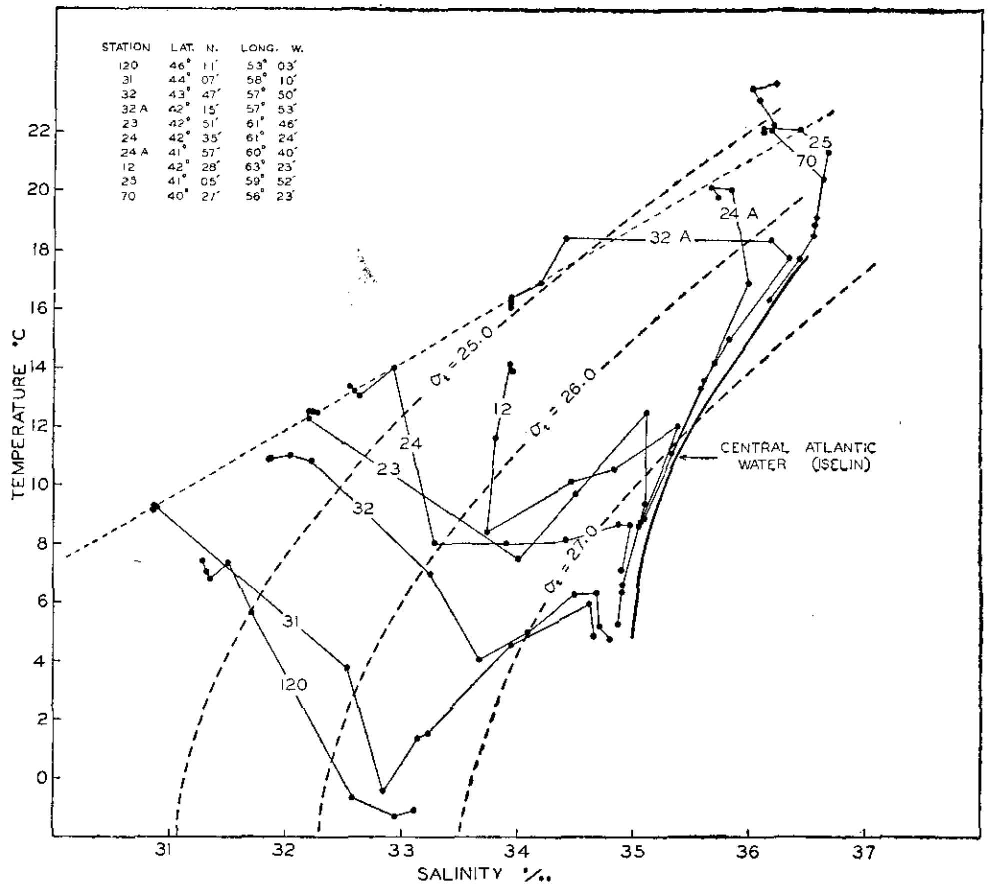


Fig. 21. Temperature-salinity relationships for the selected stations occupied in the slope water off the Scotian Shelf in November, 1951.

the Gulf Stream (Station 25), indicating that direct mixing of these waters takes place. The observations at 30 metres at stations 24 and 32A fell on the same line, and each was warmer and more saline than the corresponding surface waters. This shows that some of the water formed by surface mixing sinks and flows shoreward under the lighter, more coastal waters. A definite bend in the T-S curves of all but the most seaward stations indicates the influence of the cold water layer.

The deep waters of all stations have T-S characteristics which fall on a smooth curve that nearly parallels Iselin's curve for Central Atlantic water. The depth at which these water types occur, however, is much less than that at which similar types are found in the Sargasso Sea. Water closely resembling that found at 1000 metres in the Sargasso Sea is found at 400 metres in the slope water. Iselin (1936) has remarked upon the apparent upwelling and the fact that water of a given temperature is less saline in the slope water than in the Central Atlantic.

A straight line drawn for T = 1.3°C., S =

32.95‰, a point representative of the core of the cold water, to a point representative of similar depths in the Gulf Stream (19.0°C., 36.6‰) falls along a section of the deep water curve paralleling Iselin's Central Atlantic curve. Here, then, we have two types of water, with approximately the same density, efficiently mixed to produce waters of greater density which sink and flow under the lighter waters. The subsurface layers of the slope water must be formed in this way, and by a mixture of water so formed with Central Atlantic waters upwelled against the continental slope (McLellan, Lauzier and Bailey, 1953).

SEASONAL AND LONG TERM VARIATIONS IN TEMPERATURES

Seasonal Variations.

The annual variations in temperature and of which the seasonal variations are a part, are controlled at the surface by a large number of factors, chief of which are radiation, the character of the currents and the prevailing winds. In the surface layers the temperature variations, as pointed out by Sverdrup, Johnson and Fleming (1949) are due to the variation in the amount of heat that is absorbed at different depths, to the effect of heat conduction, to variations in the currents related to lateral displacement of water masses, and to the effect of vertical motion.

In the northwestern-north Atlantic, there are too few observations for the production of curves showing annual variations, and the calculation of annual means such as were produced from shore station data (Hachey and McLellan, 1948, and Bailey, MacGregor and Hachey, 1954). However, Smith, Soule and Mosby, (1937), used observations from various cruises to discuss the annual cycles for the various sectors.

In the West Greenland sector, observations of Smith, Soule and Mosby (1937), show that throughout the year, cold-low salinity water (East Greenland-Arctic) prevails in the surface layers next to the coast, while further offshore at deeper levels, warmer and saltier water persists, (Irminger-Atlantic). Although complete data are not available, it is probable that the temperature in the Irminger-Atlantic current off Cape Farvel rises from a minimum in February of about 4°C. to a maximum of slightly over 8°C. in September. In the fresher water near the coast, the temperature probably rises from -1.3°C. at the end of the winter to approximately 3° or 4°C. at the end of the summer.

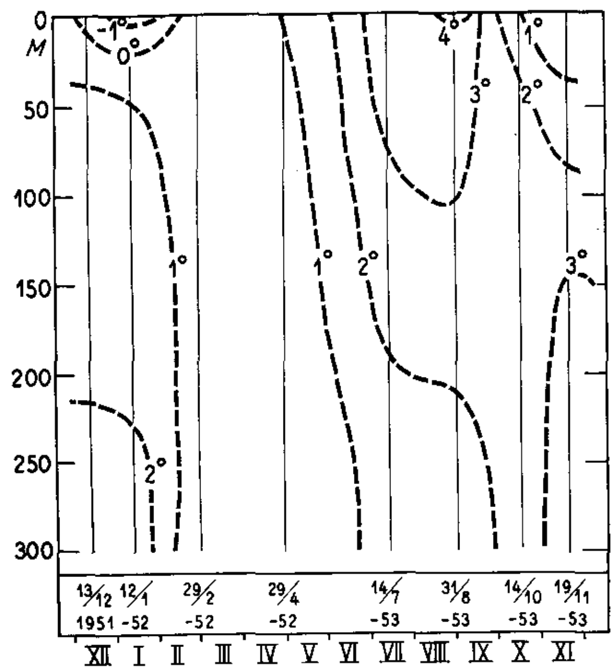


Fig. 22. Variations of temperature throughout the year in the entrance to Godthaab Fjord.

In the coastal area of West Greenland, a fixed hydrographic station at the entrance to the deep Godthåb Fjord has been occupied throughout the year. It is believed that many of the features in the variation of temperature at this station are representative of those for the middle part of the West Greenland area. Figure 22 illustrates the variation of temperature throughout the year. The most striking feature of the diagram is that the bottom water is shown to reach its maximum temperature as late as November, and at times as late as January. The warm bottom water must originate from the Irminger Current and it appears to reach its maximum temperature in late autumn or early winter in the latitude of Godthåb. Observations from Julianehåb Bay indicate that similar conditions prevail there. At this locality the maximum bottom temperature seems to be reached approximately two months earlier than at Godthåb Fjord. The explanation is presumably that the water mass of the Irminger Current reaches its maximum temperature in the Irminger Sea in August, but it is late autumn or early winter before this water arrives in the vicinity of Godthåb Fjord. Since this current is deep off West Greenland, it is not subjected to heat exchanges with the atmosphere and thus undergoes only slight temperature changes in its northward progress.

During late February the density of the winter cooled surface layer increases to the point where vertical mixing through convectional overturn reaches to the bottom. At this time, the warm bottom waters disappear from the entrance to Godthåb Fjord, but in the inner part of the fjord, where the stability of the surface layer is very great, the warm bottom water persists throughout the spring and summer months.

The inflow of warm water to West Greenland during the winter time is one of great importance to the fish population in that area, since it offsets the effects of winter chilling and prevents sea temperatures from falling below a critical value.

On the middle West Greenland Banks (Fiskenæs Bank, Fylla Bank and Lille Hellefiske Bank), the yearly variations are broadly as follows: In early spring the water over the shallowest part of the banks (less than 50 metres) is, in general, cooled to approximately 0°C., but off the western edge of the banks where the water is influenced by the Irminger Current, the temperature is nearly always positive below 50 metres. During the spring and summer months, the upper layers are heated by radiation from the sun. At the same time, the intensity of the Arctic component of the West Greenland Current increases, and this often causes decreasing temperatures over the deeper parts of the banks during June and July. On the western edge of Fylla Bank in depths of about 100 metres, the year's minimum temperature will often occur as late as June or July. During August and September temperatures rise at all depths, and observations from the entrance to Godthåb Fjord make it seem probable that the temperature in the Irminger Current on the western slope of the banks continues to rise during the autumn and early winter.

On Store Hellefiske Bank the oceanographic conditions differ somewhat from those described above. The West Greenland Current here is weak, so that temperature conditions are more dependant upon local meteorological conditions than upon the sources of the water masses. As a result summer temperatures are often higher on this bank than on the more southerly ones.

The main feature of the variations in salinity is the decrease in the salinity of the surface layers during the summer months due to land drainage. In the deeper layers, the salinity of the Irminger Current increases during the late summer and autumn, and will often reach $35^{\circ}/_{oo}$ off the western slope of Fylla Bank during August and September.

In the areas north of the Grand Banks there are not sufficient data to make any real estimates of seasonal variations of temperature. It is reasonable to assume that winter chilling cools the surface waters to the freezing point (a function of salinity) and that the temperatures reach those shown in Figure 12. In the Grand Banks sector, it has been generally considered that the Labrador Current exhibits freshet conditions during the spring, through the release of water from melting snow and ice, and then dwindles or disappears from the Grand Banks region in the fall and winter. When the distances involved and the rate of transport are considered, however, a flood wave comes much too early to be associated with summer or even vernal warming. The seasonal range in the minimum temperature of Labrador Current may be wide. Temperatures as low as -1.6°C. have been recorded at a depth of 100 metres, and as high as 2.9°C. along the east side of the Grand Banks. Fluctuations in this area are of such magnitude that the determination of an annual cycle is practically impossible.

On the Scotian Shelf, Hachey (1942), used data taken in 1938 to illustrate the oceanographic conditions at various seasons in that area.

In winter, temperatures at the surface are as low as -0.5°C., and at the bottom as high as 7.9°C. Salinities at the surface are as low as $30.55^{\circ}/_{oo}$ and at the bottom as high as $34.45^{\circ}/_{oo}$. East of Sable Island Bank, at all depths, low temperatures (less than 2°C.) and low salinities (less than $32.9^{\circ}/_{oo}$) prevail.

In spring, vernal warming is shown by a warm surface layer extending even to 74 m. depths and distinct from the subjacent "intermediate cold water layer". Penetration of warmer water at

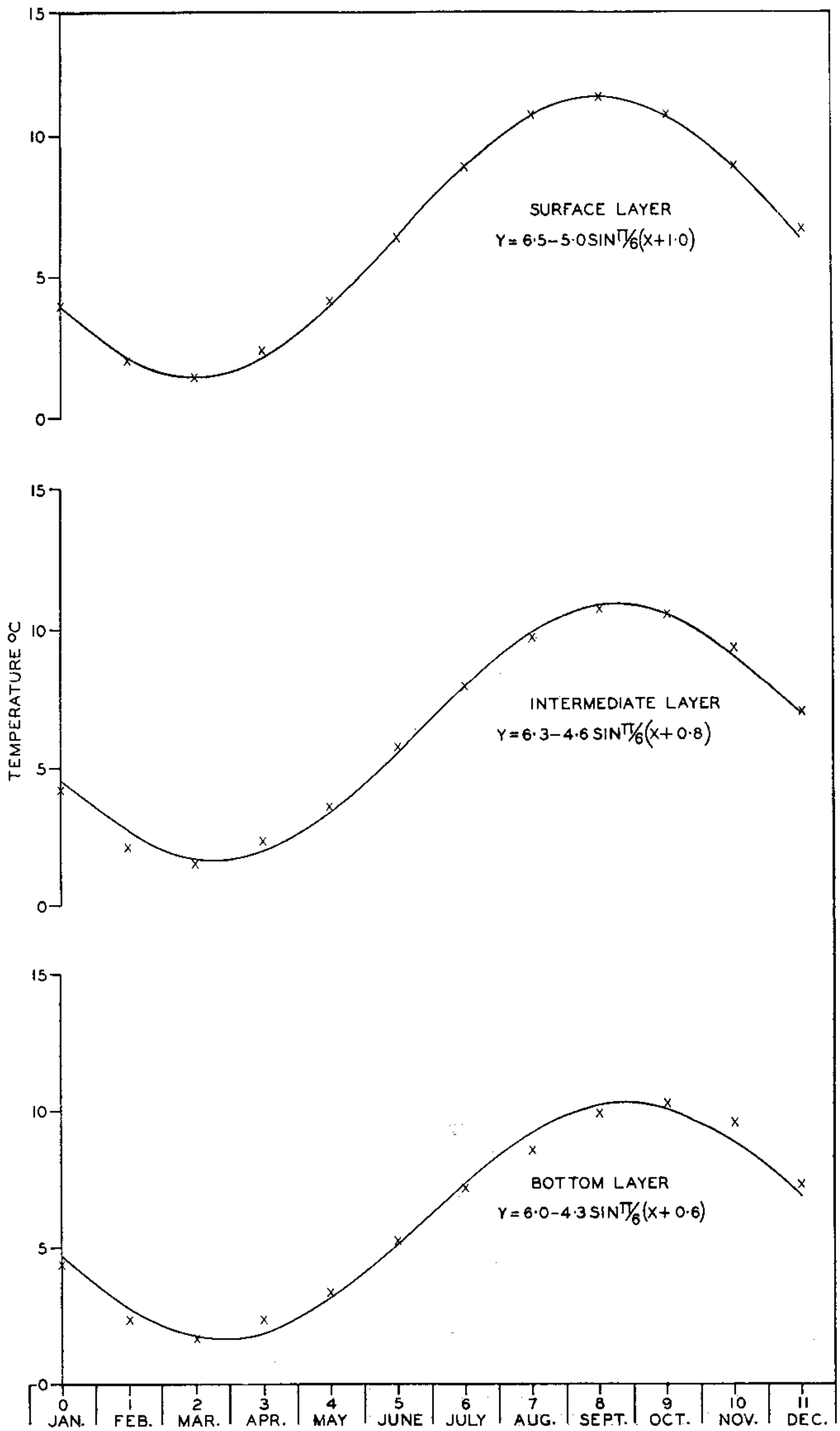


Fig. 23. Normal theoretical temperature-time curves for the surface, intermediate, and bottom layers at Station 5 (Bay of Fundy).

the bottom in certain areas is shown by temperatures as much as 2° higher than in winter.

In summer, there is full development of the warm "upper layer", and complete isolation of the cold "intermediate layer".

Inshore waters on the Scotian Shelf have temperatures at the surface, ranging from -1.0° to 19.8°C., and at 50 m. as low as -1.6°C. The winter minimum generally occurs in February and the summer maximum usually in September.

At several selected points along the Canadian Atlantic coast, Hachey (1939) demonstrated how the normal monthly mean surface water temperatures vary from season to season. Following the same general method, Bailey, MacGregor and Hachey (1954) determined the equation for the normal mean monthly temperature curves for three different layers in the Bay of Fundy, as shown in Figure 23.

The salient features are presented in Table III.

TABLE III.

Important features of the normal mean monthly temperature curves in three layers in the Bay of Fundy.

	Max.	Date	Min.	Date	Annual Mean
Surface Layer	11.46°C.	15 Sept.	1.47°C.	15 Mar.	6.51°C.
Intermediate Layer	10.74	30 Sept.	1.54	15 Mar.	6.29
Bottom Layer	10.26	15 Oct.	1.67	15 Mar.	6.01

An interesting fact is that the maxima occur approximately two weeks later in successive layers. As the warming of the deeper waters is carried out almost wholly by vertical mixing this time-lag is a measure of the efficiency of the tidal mixing in the area. In the case of the minima, on the other hand, autumnal and winter cooling reduces the stability of the upper layers so that more efficient mixing takes place, and the time-lag is practically zero.

The T-S cycle (Figure 24), was used by Bailey, MacGregor and Hachey (1954) to demonstrate the annual cycle in the oceanographic conditions in the Bay of Fundy. It is seen that the entire cycle of oceanographic conditions at station 5 (Lat. 44°56′N., Long. 66°48′W.) are clearly defined by the T-S diagram. The normal values of temperature and salinity are illustrated as well as the normal annual ranges. Bailey (1953) has illustrated the T-S cycle for 1952. In viewing Figure 24, it may be noted that between the middle of February and the middle of March, there is normally a short period when the water column at station 5 is nearly homogeneous with respect to temperature and salinity. The surface layer continues to cool while the bottom layer begins to warm. Until April-May with the land drainage at a maximum, the salinity in each layer becomes progressively fresher with the greatest changes taking place in the surface layer. By the middle of April, the waters are isothermal, but show a considerable difference in salinity. In May, minimum salinities are reached in all layers while temperatures are increasing. During the summer months both temperatures and salinities increase in value. In the bottom layer an increase of salinity in August causes a very noticeable change in the trend of the T-S cycle. This would seem to be related to a phenomenon of replacements of Bay of Fundy waters. Undoubtedly, a steady replacement is involved during the time of "spring freshets", but vertical mixing on a large scale almost completely masks the possible increases in salinity that such replacements might entail. Thus it is not until the middle of summer when the river discharges are at a minimum that replacements can be readily detected. By the middle of September, the temperature has reached a maximum in the surface layer, and the salinities have increased in all layers. The maximum temperature of the surface layer is reached in late September, and by the end of the month all layers have reached their highest salinities. Temperatures and salinities decrease at a comparatively steady rate in all layers until February, when the waters have nearly the same characteristics from top to bottom.

Long Term Variations.

It is generally contended by a large number of authors that the present upswing of water

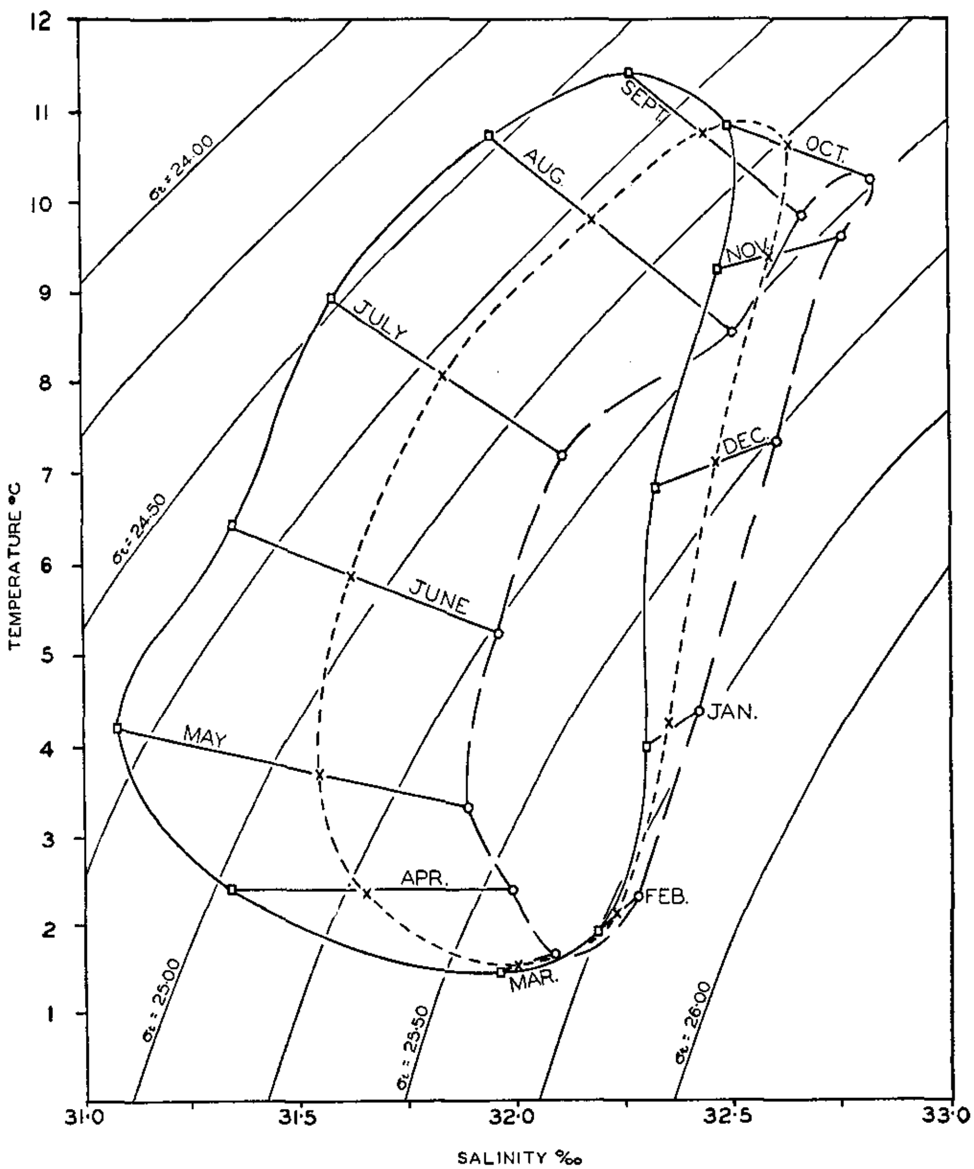


Fig. 24. **Normal T-S curves for each month, and the normal annual T-S cycle for the surface———, intermediate - - - - - - -, and bottom— —— — layers, Station 5 (Bay of Fundy).**

temperatures in the North Atlantic is mainly due to an increased atmospheric circulation. A great many papers have been written regarding one phase or another of this subject and its attendant climatic changes, and its effects upon the distribution of plants and animals in various regions. Regular oceanographic observations were few in West Greenland waters before the middle of the 1920's, but the Danish Meteorological Institute has collected, since 1876, surface temperature observations taken along shipping routes, and presented them as monthly means for each degree square. These data have been worked up by Smed (1953), who calculated the monthly anomalies for each one degree square and averaged the greater areas. Shown in Figure 25 are the five-year running means of these anomalies for Smed's areas A and B. The figure shows the very pronounced increase in temperature in the 1920's. From the 1930's, the temperature has decreased somewhat, and at present is about 0.5°C. lower than during the maximum. While the direct temperature measurements at sea are only available for the past 65 years, infor-

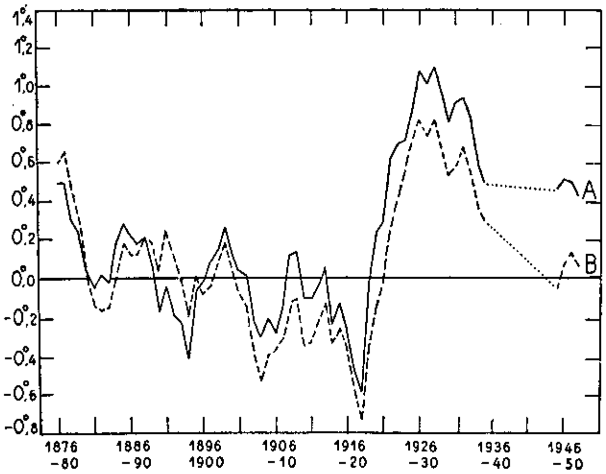


Fig. 25. Five year running means of surface temperature anomalies for Smed's (1953) areas A (W. Greenland) and B (S. Greenland).

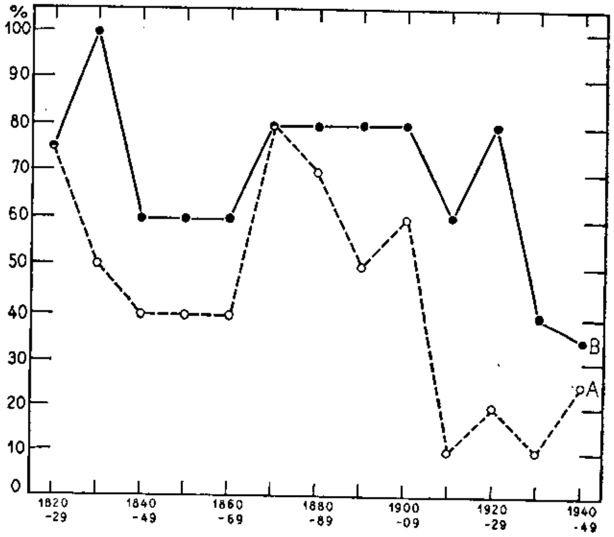


Fig. 26. Frequency of years in which the Storis reached as far north as Godthaab (A. broken line) and to Fiskenaesset (B. full line).

mation on the amount of Storis carried by the East Greenland Polar Current to West Greenland, is available for a considerably longer period. Speerschneider (1931) collected information about Storis from log books of ships visiting Greenland. Since there is assumed to be a close connection between sea temperatures and the presence of Storis a consideration of the ice conditions can be expected to yield information concerning climatic changes at sea.

Speerschneider (1931) produced in tabular form a summary of the maximum extension of ice along the west coast of Greenland. On the basis of this summary and from information provided by the Danish Meteorological Institute for the years 1930-1949, Figure 26 has been drawn. The points for curve A give, for each decade, the percentage of the years in which Storis reached at least to the neighbourhood of Godthåb during its maximum extension northward, while those for curve B give the analogous curve for Fiskenæsset. The most striking feature in curve A is the strong decrease in the frequency of Storis off Godthåb from about 1910, and off Fiskenæsset from about 1930. Furthermore, there seems to have been a period with relatively favourable ice conditions from about 1840 to 1870.

In the Bay of Fundy at St. Andrews, N. B., temperatures have been observed twice daily since 1921. Analyses of these data were made by Hachey and McLellan (1948), in which they compared the annual mean surface water temperature at St. Andrews with various points along the Atlantic coast of North America. From this comparison, it is obvious that the outstanding cycles and trends as exhibited in the surface water temperatures at St. Andrews, N. B. are common to the waters of the main portion of the Atlantic coast of North America. With this in mind, it is of interest to regard an analysis of the St. Andrews data on the basis of a twelve-month running average. The period shown in Figure 2 is from 1940 to 1951. Lauzier (1952) compared the same curve, but from 1936-1951, with comparable data from Sambro Light Vessel (off Halifax, N. S.). During the 1940-50 decade, the waters of the Bay of Fundy have shown a fairly definite trend towards higher temperatures with a maximum in 1949, with an appreciable decrease in 1950. From 1921 to 1940, the variations of the running average ranged between 59.0 and 91.8 degree-months, and since 1941 maxima of 93.5, 100.9 and 103.4 were reached in 1947, 1949 and 1951, respectively. The minimum recorded in 1950 was a high as the maximum of the 1921-1940 period.

Temperature and salinity relationships in Hudson Bay in 1930 (Hachey, 1931) show the characteristic Arctic water exhibiting temperatures between -0.5° and -1.8°C. and salinities between 31.0 and 33.2‰, while in 1948 (Bailey and Hachey, 1950), temperatures were between

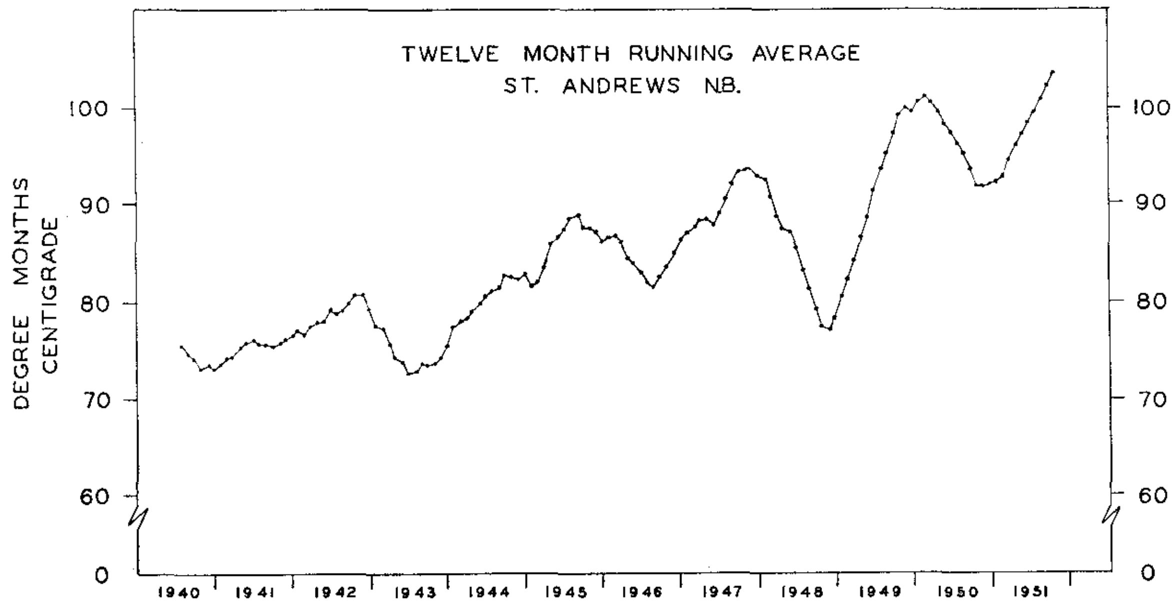


Fig. 27. Twelve months running average of surface water temperatures at St. Andrews, N. B., 1940-51.

-0.5 and -1.5°C., and salinities between 32.0 and 33.5°/₀₀. In addition, it may be pointed out that salinities greater than 32.8°/₀₀ were found only at one station in 1930, but at all stations in 1948. Oceanographic conditions at the 175 metre level in the Bay of Fundy, for a period from 1916 to 1918, were compared with those for a period from 1950-1952 by Bailey (1953). The data showed an increase in temperature of approximately 3.2°C. and an increase in salinity of approximately 0.5°/₀₀. These differences as observed in Hudson Bay and Bay of Fundy reflect an increased Atlantic influence in the deeper waters off the Canadian Atlantic coast.

It is of interest to note that in Greenland waters, 1949 was considered a "cold year" while data from St. Andrews represented it as a "warm year". On the other hand, 1947 was represented as a warm one in both areas. These observations would seem to suggest that although an increasing Atlantic influence has been generally experienced, the local reactions differ to some extent.

INFLUENCE OF TEMPERATURE ON THE FISH POPULATION

Temperatures and Occurrence of Cod.

The occurrence of cod in West Greenland waters has been periodical and the two best known rich cod periods are 1845-1851, and 1924 to the present.

Figure 26 shows that during both periods relatively favourable ice conditions prevailed. These rich cod periods seem thus to coincide with periods of relatively warm climate. This becomes still more apparent when the beginning of the latest cod period is compared with the surface temperatures shown in Figure 25. At the same time as the temperature rose sharply, the cod, previously a rare fish, appeared in greater and greater quantities and over larger and larger areas off the West Greenland coast. Therefore the cod fishery developed into the main source of income for the Greenlanders. In this connection, it is alarming that the temperatures since the late 1930's have shown a decreasing trend, especially in the south Greenland area. A continued decrease may cause a catastrophy in the Greenland cod population.

During the various seasons of the year, the occurrence of cod is greatly influenced by variations in the oceanographic conditions. In the spring, when the water on the shallow parts of the banks is cold after winter chilling, the cod are found mainly in the deeper waters and especially over the western edge of the banks, where the warm Irminger Current is dominant. During June and July, when the deeper parts of the banks are often covered by colder water, the cod will migrate to the shallow parts of the banks or they will be found pelagic in the upper 50 metres in the summer warmed layers.

Different attempts have been made to determine the most profitable fishing temperatures. Birger Rasmussen (1952) states that profitable fishing for cod cannot be expected if bottom temperatures are below 2°C. Faroe line fishermen, who used reversing thermometers, have reported that practically no fish were caught when the temperature of the water was below 0°C., and that the fishery first became profitable at temperatures above 1°C. Birger Rasmussen (1953) found in 1952 that the greatest concentration of pelagic cod occurred in temperatures between 3° and 4°C.[1]). During the English Investigations in the Cape Farewell region in 1952, G.C. Trout (1953) found that the bulk of the cod stay in water with temperatures less than 2°C.

The relationship between occurrence of cod in Greenland waters and sea temperature seems to be rather complicated. The cod seem to avoid water with temperature below 1°C., but at higher temperatures the concentration of cod is probably more related to food concentration than to water temperature.

Influence of Temperature on the Strength of Cod Year-Classes.

Since the cod in Greenlandic waters is living near its northern limit, it is reasonable to try to explain the great fluctuations in the strength of the year-classes in terms of fluctuations in the temperature conditions during the larval stage. The cod spawn in spring on the western part of the mid Greenland Banks and in June, the larvae are found mainly over Fylla and Lille Hellefiske Banks. In the following, bottom temperatures in June for the shallow part of Fylla Bank (40 m.) are given for all years in which observations are available, and arranged in order of increasing temperatures:

Year:	1938	08	49	09	25	48	37	28	50	36	26	24	34	47
Date:	1	24	2	8	13	10	2	18	10	10	12	24	24	13
Temp:	0.04	0.10	0.10	0.60	0.80	(1.30)	1.34	1.77	(1.8)	1.95	2.21	2.50	2.69	3.39

The temperatures in brackets are interpolated from neighbouring months and must be treated with reserve.

It is remarkable that the years with the highest temperatures (1936, 1926, 1924, 1934, and 1947) coincide with the best year-classes of cod in recent years, while only unimportant year-classes have arisen from the colder years. Figure 28 shows the yield up to 1946 of cod year-classes in the Greenland fishery as a function of temperature over Fylla Bank in June. The close connection between the strength of the year-class and the temperature makes it probable that the variations in temperature during the larval stage are the principal cause of the fluctuations in the strength of the various year-classes.

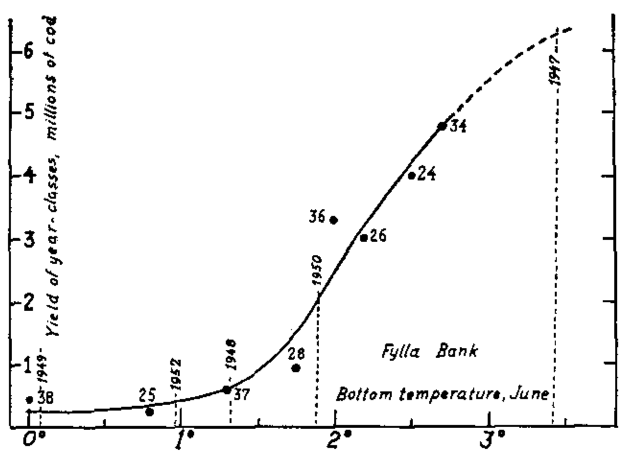


Fig. 28. Yield of cod year-classes in the Greenland fishery as a function of temperature over Fylla Bank in June. Temperatures of recent years are marked by dotted lines.

1) According to the Norwegian Research Report for 1953 (see p. 42) the greatest concentrations of pelagic cod were in that year observed in water layers with temperatures between 2.2 and 2.4°C. (Ex. Secr.).

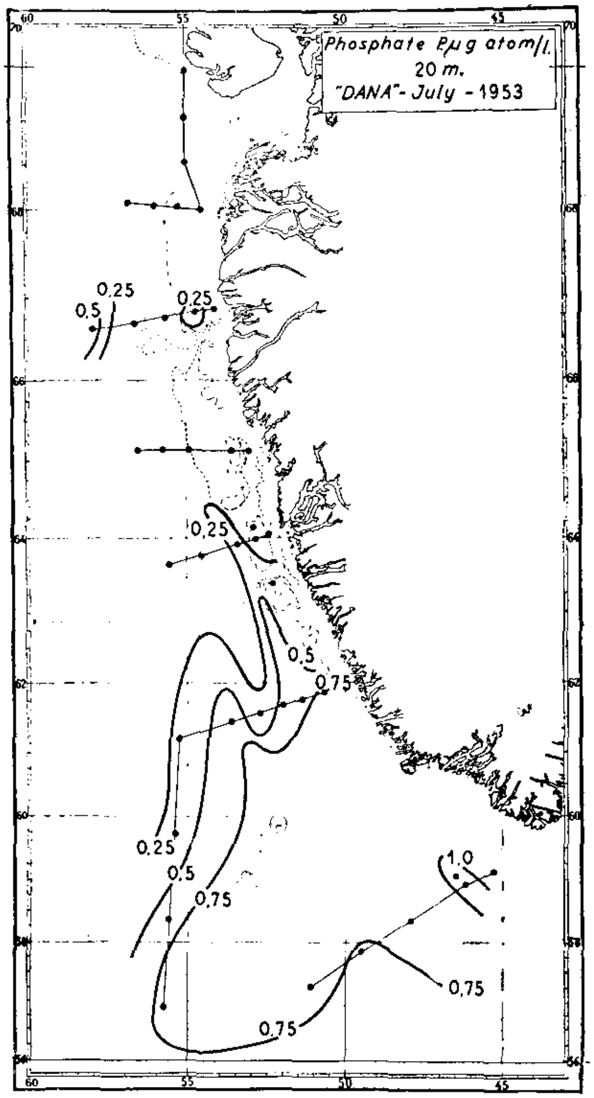


Fig. 29. Distribution of Phosphate off West Greenland, July, 1953.

NUTRIENT SUPPLY

The production of organic matter by phytoplankton depends to a very high degree on the presence of nutrient salts in the surface layers of the seas. In the deeper layers, below 100 metres, these salts are always present in sufficient concentration, but in the surface layer they are frequently almost completely removed by the phytoplankton. In Greenland waters, as in most waters of high latitude, winter cooling of the surface layers will cause a vertical mixing which brings the deeper layers, rich in nutrient salts, to the surface. In the spring, when the water is stabilized, a rich plankton production sets in, and the nutrients are removed except in areas where vertical mixing brings a continuing supply of the nutrient-rich deep water to the surface. The distribution of inorganic phosphate at 20 metres in July, 1953, for West Greenland waters is shown in Figure 29. The highest concentrations are met off the Greenland slope where the turbulence in the strong current causes vertical mixing. Good conditions for plankton production on the western side of the banks should prevail as far north as Fylla Bank. In the northern part of the area only small concentrations of phosphate are encountered, with the exception of the westernmost station in the Davis Strait section, which lies near the edge of the Canadian Polar Current.

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PART 5

Lists of Scientists and Laboratories Engaged in the Various Branches of the Commission's Work

I. LIST OF SCIENTISTS

Canada		
W. Templeman	Director	Newfoundland Fisheries Research Station, St. John's, Nfld.
A. M. Fleming	(cod, haddock, statistics)	
B. G. H. Johnson	(haddock)	,, ,, ,, ,,
T. K. Pitt	(cod)	,, ,, ,, ,,
R. W. Ellis	(fishing gear)	
R. S. Keir	(pleuronectids)	,, ,, ,, ,,
D. G. Lambert	(redfish)	,, ,, ,, ,,
R. P. Hunt	(hydrography)	,, ,, ,, ,,
D. E. Sergeant	(marine mammals)	
J. L. Hart	Director	Atlantic Biological Station, St. Andrew's, N. B.
W. R. Martin	(groundfish, statistics, liaison with ICNAF)	
F. D. McCracken	(groundfish, fishing gear)	
R. A. MacKenzie	(cod, haddock)	,, ,, ,, ,,
L. M. Dickie	(pleuronectids)	,, ,, ,, ,,
H. B. Hachey	(hydrography)	,, ,, ,, ,,
H. J. McLellan	(hydrography)	,, ,, ,, ,,
L. M. Lauzier	(hydrography)	,, ,, ,, ,,
W. B. Bailey	(hydrography)	,, ,, ,, ,,
D. G. MacGregor	(hydrography)	,, ,, ,, ,,
H. D. Fisher	(marine mammals)	,, ,, ,, ,,
Denmark		
Paul M. Hansen	(cod, statistics) Chief	Grønlands Fiskeri-undersøgelser, Charlottenlund. Slot, Charlottenlund
E. Smidt	(various groundfish)	
Aa. Vedel Taaning	(redfish, cod Director)	Danmarks Fiskeri- og Hav-undersøgelser. Charlottenlund Slot, Charlottenlund
Frede Hermann	(hydrography)	,, ,, ,,
France		
P. Desbrosses	(cod, haddock)	Inst. Scient. et Techn. des Pêches Maritimes, 59 Av. Raymond-Poincaré, Paris XVI[e]
R. Letaconnoux	(haddock)	Laboratoire de l'Office des Pêches, 74 Allée du Mail, La Rochelle
J. Ancellin	(Pleuronec cod, haddock)	Laboratoire d'Oceanographie, Boulogne sur Mer
Nedelec	(redfish)	,, ,, ,,
A. Gougenheim	(hydrography)	Serv. Hydr. de la Marine, 13 Rue de l'Université, Paris
Iceland		
Jon Jónsson	(cod, redfish, hydrography)	Fish Industry Department, University, Borgartun 7, Reykjavik
J. Magnusson	(redfish)	Reykjavik
J. Oskarsson	(cod)	,, ,, ,,
U. Stephânsson	(hydrography)	,, ,, ,,
Italy		
Norway		
G. Rollefsen	(cod) Director	Directorate of Fisheries, Inst. of Marine Research, Bergen

B. Rasmussen	(cod, redfish)	Inst. of Marine Research, Bergen
	Fishery consultant	" " " "
F. Devold	(pleuronectids, hydrography)	
	Fishery consultant	" " " "
J. Eggvin	(hydrography)	
	Fishery consultant	" " " "
Portugal		
Tavares de Almeida	(cod, hydrography)	Comissao Cons. Nac. das Pescarias do Noroeste do Atlantico, Gabinete de Estudos das Pescas, Av. da Liberdade 211, 4°, D°, Lisbon
Mario Joao de Oliveira Ruivo	(cod, haddock)	" " " "
Spain		
J. M. Guitian Vieito	(hydrography, statistics)	Direccion General de Pesca Maritima, Alarcon 1, Madrid
A. Varela Reducto	(statistics)	" " " "
O. Rodrigues Martin	(fishes)	" " " "
R. Lopez Costa	(hydrography)	Laboratorio Oceanografico, Felipo Sanches 20, Vigo
Alfonso Rojo	(cod, haddock)	?
United Kingdom		
C. E. Lucas	(fishery ecology)	Marine Laboratory, Wood Street, Torry, Aberdeen
	Director	
M. Graham	(cod)	Fisheries Laboratory, Lowestoft
R. S. Wimpenny	(fishery ecology)	
G. C. Trout	(cod, haddock)	" " " "
R. Jones	(haddock)	Marine Laboratory, Wood Street, Torry, Aberdeen
McIntyre	(redfish, halibut)	
United States		
L. A. Walford	(statistics, fishes)	Fish and Wildlife Service, Washington, D. C.
Herbert W. Graham	(fishery biology)	Fish and Wildlife Service, Woods Hole, Massachusetts
J. R. Clark	(haddock)	" " " "
G. F. Kelly	(redfish)	" " " "
R. S. Wolf	(redfish)	" " " "
J. P. Wise	(haddock)	" " " "
J. B. Colton	(hydrography, plankton)	Fish and Wildlife Service, Woods Hole, Massachusetts
Clyde Taylor	(haddock, statistics)	" " "
Giles Mead	(general fish taxonomy)	" " "
Roland Wigley	(food habits)	" " "
Ernest Premetz	(haddock)	" " "

II. LIST OF LABORATORIES

Canada:	Atlantic Biological Station, St. Andrews, N. B.
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	Danmarks Fiskeri- og Havundersøgelser, Charlottenlund Slot, Charlottenlund
France:	Centre des Recherches de l'Institut Scient. et Techn. des Pêches Maritimes, Boulogne s/Mer
Iceland:	Fish Industry Department, University of Iceland, Borgartun 7, Reykjavik
Italy:	Ministero della Marina Mercantile, Piazza della Minerva, Rome
Norway:	Institute of Marine Research, Directorate of Fisheries, Bergen
Portugal:	Gabinete de Estudos das Pescas, Av. da Liberdade, 211, 4°, D°, Lisbon
Spain:	Direccion General de Pesca Maritima, Alarcon 1, Madrid
	Laboratorio Oceanografico, Felipo Sanches 20. Vigo
United Kingdom:	Marine Laboratory, Wood Street, Torry, Aberdeen.
	Fisheries Laboratory, Lowestoft.
U.S.A.:	*Fish and Wildlife Service, Woods Hole, Massachusetts.*