REPORT OF THE INTERNATIONAL FISHERIES COMMISSION

APPOINTED UNDER THE TREATY BETWEEN THE UNITED STATES
AND CANADA FOR THE PRESERVATION OF THE
NORTHERN PACIFIC HALIBUT FISHERY

NUMBER 9

LIFE HISTORY OF THE PACIFIC HALIBUT

(2) DISTRIBUTION AND EARLY LIFE HISTORY

BY

WILLIAM F. THOMPSON AND RICHARD VAN CLEVE

COMMISSIONERS:

WILLIAM A. FOUND	EDWARD W. ALLEN
FRANK T. BELL	JOHN PEASE BABCOCK Chairman

SEATTLE, WASHINGTON
1936

FOREWORD

Treaties between the United States and Canada created the International Fisheries Commission to investigate the halibut fishery of the northern Pacific Ocean, including Bering Sea, and to take steps to preserve and restore this fishery. The present is the ninth report upon the scientific investigations of the Commission.

Formerly there was a huge supply of halibut on the banks, and an abundance of spawners. Overfishing cut this down to a very serious point. This decline in the amount of fish on the banks has been fully dealt with in previous reports of the Commission. There was not only a decline in the catch per unit of gear, but also in the total catch taken from the banks. The catch per unit of standard size fell from 272 pounds in 1906 to about 36 pounds in 1930 on the grounds off British Columbia. Off Southeastern Alaska the catch fell from 180 pounds per unit in 1914 to 54 pounds in 1928. In the Gulf of Alaska the fall was from 320 pounds per unit in 1915 to 65 pounds in 1930. The total quantity taken from the grounds south of Cape Spencer fell from 60 million pounds in 1912 to 22½ million pounds in 1930.

It was reasonable to expect that regulation to stop this decline should seriously affect the catch of the fishing fleet. The boats might have been required to reduce their landings greatly. Yet this has not occurred. On the contrary, the Commission allowed the fleet to continue catching just as much poundage as the fleet was catching at the time the Commission took charge. Nevertheless the abundance on the grounds between Dixon Entrance and Vancouver Island has increased as shown by the catch per set of a unit of gear, from 36 pounds in 1930 to about 60 pounds in 1935. There have been similar increases on other grounds.

There is nothing to indicate that the increase in the amount of fish on the banks is as yet due to any increase in the young which come to commercial size each year. But the increase is due to the length of time that each year's addition of young is allowed to remain on the banks. If there were unrestricted fishing, nearly the entire annual addition might be removed in one year and there might never be much more on the grounds at any one time than the young which had been added in that year. But the Commission has reduced the fraction of each annual addition which may be removed each year. The annual additions are now remaining, on the average, much longer than formerly, and consequently there are more of these annual additions on the banks at the same time. Although the fishermen are taking each year a smaller part of each annual addition, they are taking from a greater number of them, the total take being equally great.

There is an accumulated stock, actually some 60 per cent greater than when the Commission began. Accordingly the catch per unit of gear is much greater, and an amount equal to the annual additions is more quickly taken. But if the take of fish should be more than the annual addition, the stock would quickly decrease again, just as a reservoir of water would empty if more were taken out than came in. The intake must equal the outflow regardless of the size of the reservoir.

In addition to the larger supply of fish which is now found on the banks because the incoming young are allowed to remain there longer before being caught, there is also some increase due to the fact that the longer a fish is left on the banks the larger it grows. It becomes a more valuable fish.

To take a larger proportion of each annual supply of fish off the banks within the year reduces the accumulated stock and requires a larger amount of fishing to get the same sized catch; it requires a longer trip to get the same poundage than if the fish are allowed both to accumulate and to increase in size. The fisherman loses by excessive fishing. He must work longer to get the same sized fare. Such excessive fishing accomplishes nothing more than to remove the fish before they grow and before they spawn. If the supply of spawners is cut down, the annual addition of young is certain to become smaller. In the end the total annual catch will be less.

The accumulation on the banks has naturally caused the fishermen to find that they can now catch more per set of a unit of gear. Because of this they may think that they should be allowed a greater poundage for the season. But if they were allowed to catch more fish, it would simply increase the speed with which the fish are removed and place the banks back in the bad shape they were in when the Commission took charge. The annual addition of young and the total yield from the banks would both decrease. The total yield had decreased from 60 million to 22½ million pounds at the time regulation was adopted. If there had been no regulation the yield would have fallen off at least four million pounds more by this time.

The longer the fish are left on the banks before being caught, the greater the number which have a chance to spawn. The greater the number that spawn, the greater the amount of eggs and young which can be expected. There is no other way to increase them, because the eggs and young cannot be artificially propagated in anything approaching sufficient quantity.

The regulations of the Commission are aimed at making sure that a sufficient number of fish reach spawning age to produce the necessary supply of eggs. It is now carefully watching the increase of eggs and young. It is trying to measure this in two ways; (1) by noting the increase in mature fish as they appear in the fishermen's catches; (2) by noting the number of eggs recovered from year to year in the Commission's specially constructed egg nets.

The Commission cannot allow an increase in the amount of fish to be caught until it finds that there has been a sufficient increase in the amount of eggs and young. Fish enter the commercial catch as early as five years of age, but, on the average, they do not spawn until they are twelve. To build up the number twelve years of age requires time. Even after the spawn is produced, additional time is necessary for the young to reach commercial size.

The problem may be stated in this simple manner, but the actual investigation and regulation of a deep sea fishery such as that for the halibut is far from simple. The work of this Commission constituted the first attempt at international deep sea fishery regulation. Practically all the scientific facts and the principles of their application had to be discovered and evolved. To obtain the necessary facts has not only required ingenuity and skill but an enormous and continuous amount of hard work on the part of the Commission's experts. The Commission has never possessed a boat of its own. Appropriations for its work have been very moderate, but with such resources as have been available, the Commission has been able to make great strides in its study of the life history of the halibut—the various races and their different habits and characteristics, where and when the fish spawn, what becomes of the eggs, how and where the young live, and innumerable related questions. Theories and methods have been developed which have received world wide recognition. And because of the scientific work which has been done, the Commission has been able to accomplish practical results by securing a substantial restoration of the supply of halibut on the banks.

Report No. 8 of the Commission dealt with the distribution of the various stocks. It was shown that the stocks were separate and that a separate supply of spawn must be obtained to maintain each stock. It was shown how this could be done and what was the effect of different intensities of fishing. The relationship of incoming supply, natural mortality, and human fishery to the yield was analyzed.

In this present report the eggs and larvæ are described stage by stage so that they can be distinguished from the many other species of fish which also float in the ocean currents, and so that their abundance can be measured. The eggs are shown to float in the slower moving deeper currents of heavier water. Then the larvæ rise toward the surface, and the young, at an age of five to six months, drift into the shallow shore waters. As they mature they change from the normal type of fish, back up and sides similar to other fish, to the one-sided mature form familiar in the commercial catch. They settle on the inshore banks and later migrate as five, six, or seven year old fish to the deeper banks from which they are taken by the fishermen. Their drift is not sufficient to carry them from one regulatory area to another in appreciable number.

Another subject dealt with is the distribution of halibut in both the Atlantic and Pacific Oceans. This subject was investigated to learn under what conditions halibut are apt to be found. Knowing this, the likelihood of new banks being discovered may be determined. The depths at which halibut ordinarily live were ascertained. An interesting feature of this study was the development of the fact that in order to find halibut the temperature of the water on the banks must be within the average range of 3° to 8° C. (37° to 47° F.) It was found that the location of waters having the proper range of temperature is dependent upon the points of contact between arctic and warm oceanic currents. Application of this knowledge to the Pacific Ocean indicates that the greater part of all existing stocks of halibut is already known and that no large unknown source of eggs or spawning adults remains.

The International Fisheries Commission, on its organization, created a Scientific Advisory Board with which the scientific program has been discussed. The Board consists of four members: Dr. C. McLean Fraser, Professor of Zoology, University of British Columbia; Dr. W. A. Clemens, Director of the Pacific Biological Station at Nanaimo, B. C.; N. B. Schofield, Chief of the Bureau of Commercial Fisheries, Division of Fish and Game, California; and Dr. Willis H. Rich, Professor of Zoology, Stanford University.

The International Fisheries Commission also created a Conference Board consisting of members elected by the Deep Sea Fishermen's Unions and the Fishing Vessel Owners' Associations of the United States and Canadian ports on the Pacific. The members of this Board are annually called into conference with the Commission and the Director at the conclusion of each fishing season to discuss conditions. By this method the fishermen and vessel owners are kept constantly informed of the conclusions reached by the staff and the Commission keeps in touch with the views of the fleet.

Investigations have been carried on by a staff under the direction of Dr. William F. Thompson. Heretofore the headquarters and laboratory have been in the United States Bureau of Fisheries Building, at Seattle, Washington. They have now been installed at the School of Fisheries of the University of Washington. To both the Bureau of Fisheries and the University the Commission is deeply indebted.

JOHN PEASE BABCOCK, Chairman
Victoria, B. C.
WILLIAM A. FOUND
Ottawa, Ontario.
FRANK T. BELL
Washington, D. C.
EDWARD W. ALLEN, Secretary
Seattle, Wash.

REPORTS BY THE INTERNATIONAL FISHERIES COMMISSION

1. Report of the International Fisheries Commission appointed under the Northern Pacific Halibut Treaty, by John Pease Babcock, Chairman, and and William A. Found, Miller Freeman, and Henry O'Malley, Commissioners. Dominion of Canada, Ottawa, 1928.

   Same. Report of the British Columbia Commissioner of Fisheries for 1928, pp. 58-76. Victoria, 1929.

   Same. Report of the United States Commissioner of Fisheries for 1930, Appendix 1. United States Bureau of Fisheries Document No. 1073. Washington, 1930.

2. Life History of the Pacific Halibut (1) Marking Experiments, by William F. Thompson and William C. Herrington. Victoria, B. C., 1930.

3. Determination of the Chlorinity of Ocean Waters, by Thomas G. Thompson and Richard Van Cleve. Vancouver, B. C., 1930.

4. Hydrographic Sections and Calculated Currents in the Gulf of Alaska, 1927 and 1928, by George F. McEwen, Thomas G. Thompson, and Richard Van Cleve. Vancouver, B. C., 1930.

5. The History of the Pacific Halibut Fishery, by William F. Thompson and Norman L. Freeman. Vancouver, B. C., 1930.

6. Biological Statistics of the Pacific Halibut Fishery (1) Changes in Yield of a Standardized Unit of Gear, by William F. Thompson, Harry A. Dunlop, and F. Heward Bell. Vancouver, B. C., 1931.

7. Investigations of the International Fisheries Commission to December 1930, and their Bearing on Regulation of the Pacific Halibut Fishery, by John Pease Babcock, Chairman, William A. Found, Miller Freeman, and Henry O'Malley, Commissioners. Seattle, Washington, 1930.

8. Biological Statistics of the Pacific Halibut Fishery (2) Effect of Changes in Intensity upon Total Yield and Yield per Unit of Gear, by William F. Thompson and F. Heward Bell. Seattle, Washington, 1934.

9. Life History of the Pacific Halibut (2) Distribution and Early Life History, by William F. Thompson and Richard Van Cleve. Seattle, Washington, 1936.

Further reports will bear serial numbers and will be issued separately by the Commission.

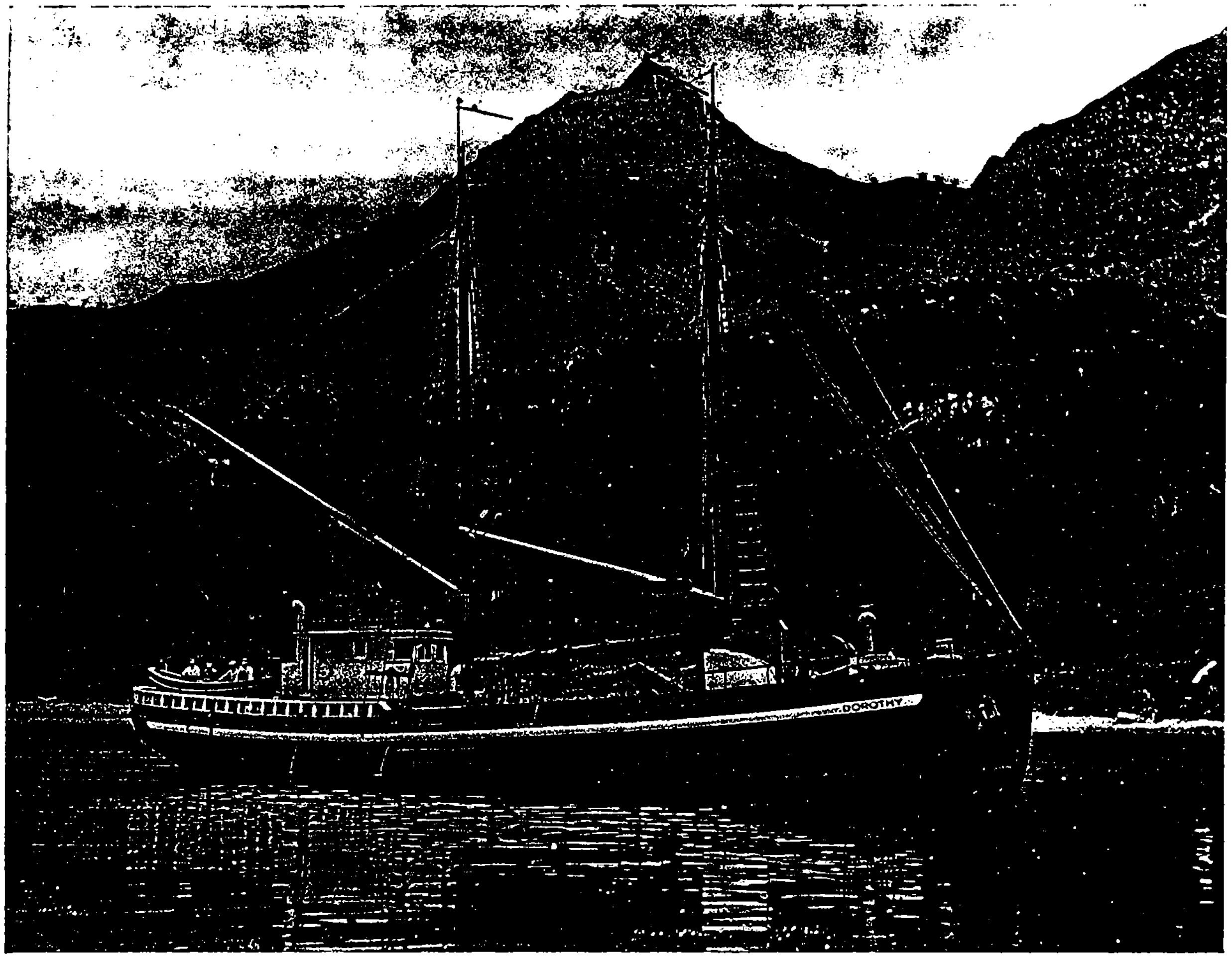

Figure 1.—Motorship "Dorothy" in Mitrofania Bay.

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CONTENTS

INTRODUCTION

As has been made clear by previous publications of the International Fisheries Commission, the halibut of the Pacific had until 1930 declined greatly in abundance as a result of the intense fishery to which it had been subjected. Not only had the yield per set of a unit of gear shown this great decline, but the total yield from the older parts of the fishing banks had decreased greatly also, despite the very large increase in the amount of gear fished. The scientific work carried on under the terms of the treaty between the United States and Canada for conservation of the halibut is for the purpose of understanding and preventing this decline and of increasing the yield.

This report is the ninth by the Commission. Previous reports, Nos. 5, 6, and 8, have dealt with the fishery and the changes which have occurred in its yield. Report No. 2 has given the results of marking experiments, whereby the migrations and the rate of death of the adult fish have been studied. The present report deals with the eggs and young, with the ocean currents in which they drift, and with the distribution of the species.

In order that the program followed may be brought together in coherent form, the problems faced by the Commission have been discussed in a following section (I). This consists essentially of introductory remarks for the several following sections, brought together to establish their connection one with another rather than presented separately.

ACKNOWLEDGMENTS

The vessels employed in making the net hauls and securing the hydrographic data which have given the material for this report were the "Scandia," Captain O. O. Hvatum, from 1926 until her wreck in 1927; the "Dorothy," Captains Hvatum and Olaf Servold, from 1927 to 1931; the "Zapora," Captain Lars Voge, during the summer of 1932; the "Eagle," Captain Jacob Engdal, from 1932 to 1934; and the "Paragon," Captain Peter Jacobsen, during the winter of 1934-1935. These are all, with the exception of the "Zapora," large schooners capable of carrying a sufficient staff and of enduring winter weather in the Gulf of Alaska. Their crews and captains have given in every case the most loyal and interested service.

Of the crews, two mates, Conrad Knutsen and Nels Rockness, deserve special mention for their long and intelligent service.

Almost every member of the scientific staff has had part in the work at sea on eggs and larvæ. O. E. Eriksen has been on every trip. J. L. Kask and L. D. Townsend have not only assisted but have at various times been in charge of the vessel used. Others who have aided from time to time have been H. A. Dunlop, W. C. Herrington, W. M. Chapman, A. C. DeLacy, and R. T. Smith. The junior author has been in direct charge of most of the trips. Messrs. Townsend, Chapman, and DeLacy have carried through the major part of examination of the hauls. Miss Grace Shirk has organized, checked, and aided in compiling the bibliography.

Aid secured from scientists other than those on the staff has been acknowledged in the text.

I. THE PROBLEM AND PROGRAM

It is generally accepted that the regulations of the Commission, based on its scientific reports, have been successful in increasing the abundance of fish on the halibut banks, as measured by the yield per unit of effort. The banks south of Cape Spencer show an increase since 1930 of 60 per cent, those west 35 per cent. It is of the greatest importance that the nature of this increase and its significance, primarily as a contribution to the spawning stock, be understood.

The Commission has gathered the biological statistics necessary to analyze these changes. The increase has been produced by a reduction in the intensity of the fishery. This is essentially a change—a reduction—in the rate of mortality.

Thompson and Bell (1934) have analyzed in detail the effect of this change, showing that as long as the natural mortality is balanced or exceeded by growth, the lessening of fishing mortality maintains, or may even increase, the total weight of fish ultimately taken by the fisherman from each age class after it enters the commercial sizes. The lessening may produce as great, or even greater, annual yield at less effort from a given number of incoming young. Where natural mortality is not high it is expected to give a larger yield because of the more efficient utilization by capture at a larger average size, allowing the increase by growth of fish otherwise taken too young. It is shown that the lessened mortality rate allows of a longer survival, whereby a greater number reach spawning age. It is also shown that in the stock left on the grounds each and every age of commercial size except the very youngest immediately increases in abundance. The increase is plain in all age classes at first, but as the years go on it becomes greater in the older ages, because it is cumulative in effect. These results of reduced intensity of fishing have been observed in process in the commercial catch, not merely deduced on a basis of theory. They are plainly evident in the past records of the fishery and its yield, so far as these are adequate, and are independent of any change in the number of young produced.

But lessened fishing intensity on a depleted bank allows the accumulation of a greater number of mature adults. This is of great ultimate interest to the enlargement of the annual catch because of the anticipated effect of the increased number of spawners in producing more eggs and consequently a greater number of young. Each immediate increase in the stock left on the banks should be followed by a later increase in the young from which this stock is built. This should continue until the time comes when the natural factors limiting increase become sufficiently effective.

It has therefore become plain that in the case of the given stock there are two main problems. The first is to make the best use possible of these young within the limits set by the necessity of allowing sufficient survivals to spawning age. This problem is one of balancing growth against losses by death and judging the proper age for capture, and does not concern the present report. (See Thompson and Bell, 1934.) The second is to determine upon and to preserve a proportion of spawning fish sufficient to maintain the annual supply of eggs and young at the desired level. This report lays a basis for study of the latter problem, by indicating where, how, and when the production of eggs and young must be measured, as the most direct way of judging when this production is great enough and when it is no longer profitable to increase the stock of spawners.

The Commission has therefore under its control a method of increasing the production of halibut through its power to vary the intensity of the fishery, hence to alter the rate of survival and the proportion of spawners. Unless this method is to be used blindly, so that the regulations adopted will be inadequate, excessive, or negative, its operation must be understood. Its results must at least be proved and if possible accurately observed and measured.

It will be imperative that this be done if the regulations necessary to maintain the present increased abundance are to be justified and the support of the governments retained.

In connection with such measurements and the needed proof of results, as well as in the formulation of regulations, the existence of distinct stocks of halibut becomes of great importance, because each such stock is a separate problem.

THE EXISTENCE OF DISTINCT STOCKS OF HALIBUT

It has already been found (Thompson, Dunlop, and Bell, 1931) from statistics, that the fisheries to the north and west of Cape Spencer have maintained a totally different level of abundance and of yield from the very beginning as compared to those south and east. These levels have reacted differently to the strain of the fishery, indicating virtual independence. When studied from a biological viewpoint, the fish from these sections have shown that type of structural difference which accompanies exposure to differing conditions during growth and which can be perpetuated only by isolation. By marking experiments on fish of marketable size, the extent of this independence and isolation has been determined and measured (Thompson and Herrington, 1930). Hence it is proper to conclude that as far as the marketable sizes are concerned, the fishery cannot draw upon the resources of one section of the coast by fishing in another, except within the limits of the individual stocks, and accordingly protection of one stock cannot be regarded as protection of another.

The marking experiments (Thompson and Herrington, 1930) showed that the mature fish (l. c. pp. 33 and 56), forming the greater part of the commercial catch west of Cape Spencer (latitude 58° 12′ N., longitude 136° 39′ W.), were freely migratory along the coast from the eastern side of the

Gulf of Alaska to the Aleutian Islands. They form a stock which has declined more or less as a unit (Thompson, Dunlop, and Bell, 1931, p. 62) despite the greater amount of fishing on the nearest banks. The marking experiments indicate by the percentage returns that the intensity of the fishery for this western stock has been approximately one-fourth that on the older southern grounds where it has taken about 40 per cent annually (Thompson and Herrington, 1930, p. 91).

Other stocks of mature fish have been studied, but not yet reported upon, off Cape St. James at the southern end of the Queen Charlotte Islands, and off Cape Knox at the northern end. Each of these has a district within which the adults migrate some distance. They are much depleted, in accord with the great intensity of the fishery. They indicate, however, the original existence, south of Cape Spencer, of a number of such stocks which are now so reduced in number and in average size of individuals by the intense fishery there that the immature only are of much importance. The commercial catch from this area is therefore largely of immatures. These sizes have been shown by the marking experiments to migrate but little, the average movement of recovered fish being about 22 miles, as compared with 209 in the case of the mature western fish (Thompson and Herrington, 1930, p. 105). Hence for all practical purposes the stocks south of Cape Spencer are at present composed of a number of small units, the area each inhabits coinciding with that of the banks on which they are found. They are more or less alike in their lack of mature fish and in their stage of depletion, hence may be grouped in one regulatory area separate from that west of Cape Spencer.

The duration of life of an individual is dependent on its chances of survival, and this southern fishery, taking approximately 40 per cent annually, has left but few fish to survive the seven years of fishing between five and twelve years of age, the period between entry into the commercial catch and average age at maturity. And although the actual census of the existing stock on these grounds is difficult, the existing lack of mature fish in the commercial catch, corroborated by the evidence as to the intensity of the fishery given by the marking experiments, is sufficient evidence of a lack of spawning adults. The condition of these stocks should be reflected in the amount of spawn produced. It is therefore to be expected that eggs and early larvæ will be much less abundant on southern depleted grounds than on the western, a difference which justifies fundamentally different regulation.

THE DRIFT OF EGGS AND LARVÆ WITH THE CURRENTS

As might have been expected from the existent knowledge of marine fishes, the eggs and young of the halibut are pelagic, that is, found suspended in the sea water, so that research has led directly to investigation at sea with fine meshed plankton nets and the equipment necessary to study conditions in the ocean.

There hence remains, after the adults have been studied as a group of units, the further question as to whether there is an interchange of eggs and young by drift between these units. This is of basic importance, because if the eggs and young originate on the western grounds and drift to those of British Columbia in the south, the already determined relative independence of the marketable stocks would be of a significance to regulation very different than were such drift not existent. It would, for instance, be an error to allow the spawning stock in one region to be depleted and to protect the stock to which it contributes. Again, it is conceivable, once the separate units of the population, or stocks, are studied and their characteristics determined, that some of them may be found to have a sufficient supply of eggs, the major problem of conservation then being simply the proper use of what young are produced. But it is far more probable that the supply of incoming young will be found to have declined, and that it will increase with adequate regulation, contributing notably to the final stabilized and permanent yield. There is no need to discuss further the possibilities of such relationships, as they are plainly many. They will modify not only the type of regulations, but the character of the results expected and the methods of observation which must be used.

To study the interchange by drift of eggs and larvæ between the different stocks has necessitated a background of knowledge as to certain very broad problems. These pertain to: first, the distribution of the species; second, the currents within this range with which the young may drift; and third, the history and characteristics of the eggs and larvæ.

THE DISTRIBUTION OF THE SPECIES

The distribution of the species must be considered because all possible sources of eggs and young are important whether at the limit of the range of the species or at the center. It must necessarily be studied from the standpoint of relative abundance, because mere presence or absence is of little significance either biologically or economically. The best measure of this relative abundance is the success of commercial fishing. Yet even this fails in part because the extent of depletion on the intensively fished banks near landing ports greatly modifies natural relative abundance; because the annual yield is not a good measure of the stock left on the banks; and because in the Pacific the most northern areas have not yet been properly explored. In consequence an attempt has been made to understand the marine factors controlling the distribution in the Atlantic and to apply the same reasoning to the distribution in the Pacific, thereby enabling us to gain some idea as to the limits there.

Incidentally, the distribution of the species is important for reasons beyond the scope of this report; first, because upon it depends the possibility of expanding the fishery, and second, because it determines whether there can be any extensive immigration of adults from unexploited ground. The fact that the opportunity is taken of discussing this distribution in connection with the eggs and larvæ does not indicate that the subject is any the less important from these other viewpoints.

THE OCEAN CURRENTS

The study of distribution has led directly to the study of currents, because they determine the factors, such as temperature, which limit distribution of the adults. The currents are equally important in the drift of eggs and young. Since spawning occurs along the whole Pacific coast from Vancouver Island to Bering Sea, and along the edge of the continental shelf, the currents to be studied are parts of the greater oceanic drifts.

Being thus important from two standpoints, an attempt is made in this report to give a clear picture of those currents on our coast. Although it has been beyond the powers of the research staff to undertake any original contributions to the study of the major North Pacific current, called the Japanese Current or Kuroshio, it has contributed where necessary and possible to that of the coastwise currents by use of drift bottles and by studies of temperature and salinity (Thompson and Van Cleve, 1930; McEwen, Thompson, and Van Cleve, 1930).

THE LIFE HISTORY OF THE EGGS AND LARVÆ

The effect of these currents depends, of course, upon where and at what level the young are found and for what period of time they are carried. The eggs are spawned on certain banks and hence are subject to the currents there. They float at certain levels during each stage of life and are carried by slow or fast currents accordingly. They develop at a certain rate, variable with temperature, which must be considered in connection with the speed of the currents to determine how far they travel. And before their distribution or drift can be studied, each stage must be distinguished from those of a great variety of other fishes like it found hidden in the masses of invertebrate plankton taken by the net hauls. These hauls have been necessarily very numerous and have been distributed over a large area throughout a season of six months more or less. To make and sort them and to analyze their results has been a major task.

MEASUREMENT OF THE ABUNDANCE OF EGGS AND LARVÆ

It cannot be said that such things as the distribution of the species, the currents, etc., can or need be understood with absolute exactness at this stage of regulation. They are rather the general facts which it is necessary to have before the effect of the drift of young on the relative independence of the stocks of halibut can be determined. Moreover, they are needed before a system of periodically repeated net hauls can be devised to allow of a reasonably accurate determination of the relative abundance of spawn from year to year in any one stock as it alters under regulation.

This system must be to haul for the eggs in the most suitable region, at the most advantageous level, at a time when the maximum return can be expected, and with the ability to distinguish the several stages. The exact definition of these conditions must be by a second, more quantitative section of the research now under way. It is believed by the authors that this report defines the occurrence of eggs as to district and depth with sufficient accuracy to place such a system within practicable reach.

It is necessary before the system is established to know something of the character of the change it is expected to measure and how precise in method it must be.

Two questions arise in this regard, and some answer is attempted to both. First, what are the natural limits to increased abundance in the stock of each district? By watching for changes in the rates of growth and of natural mortality, it may be possible to determine when the population of halibut has reached a desirable maximum which will be all that the available ground and food will support, the assumptions being made that competition for food and an increase in natural deaths as the limit to the term of life is approached will set this maximum. Yet this cannot well be determined in advance, it may vary from region to region, and natural mortality in particular is as yet difficult to determine. It will hence be exceedingly valuable to have as a guide a knowledge of the natural abundance at the beginning of exploitation, as indicating at least the order of magnitude of the changes which may be expected or which may be attained as the stock is replaced, and as indicating the extent of the depletion which has occurred.

Second, within the stock as it at present exists, what change in production of spawn should logically result from a given restriction of the fishery? It has already been shown that restriction of the intensity greatly increases the numbers of spawning adults (Thompson and Bell, 1934). It should be possible to calculate from our knowledge of fecundity at each size or age what this increased number should mean in production of spawn, and to deduce from this whether the net hauls for eggs and larvæ might be expected to show the changes effectively.

If this system of observation proves feasible it would seem to be the most satisfactory and direct index to the effect of regulation. An alternative exists in examination of the commercial catch to determine the proportion of adults and to deduce from this the production of spawn. Although such an alternative has not been neglected in the research plans of the Commission, there are difficulties in its use. The number of adults *in the commercial catch* is not significant unless it is known what fraction it represents of the stock of adults left *on the bank;* in other words, what the intensity of the fishery is for each size. And promising as the research in that direction may be, it has as yet not provided an exact method. (See Thompson and Herrington, 1930.) The same consideration complicates any use of the proportion of young as an indication of final increased addition to the commercial catch. Confusing factors are: changes in proportion of adults in the stock on the banks due to overfishing; changes in the relative intensity of the fishery for the young or for the adults; and the fortuitous survival of an unusually great part of the spawn, causing a so-called "dominant" year class. These may, by altering the proportion of young, obscure the part played by successful regulation. Because of these difficulties, it is most necessary that if possible a means of direct measurement of the production of spawn be developed.

Moreover, as has been shown clearly by the research on plaice in the North Sea (Bückmann, 1932; Russell, 1931; Garstang, 1926) a simple relationship between proportion of adults, amount of spawn produced, and young entering the commercial catch is not to be expected. As abundance increases, the number of adults undoubtedly will reach a natural limit, limiting in turn the production of spawn. Or if the spawn increases indefinitely, the number surviving to commercial sizes undoubtedly will reach a limit, due to competition for food or otherwise. Hence regulation to increase the amount of spawn can be expected ultimately to cease being effective, leaving as the only possibility of increased yield a better use of what young are produced. There is no way of forecasting when these limits will be reached. But if regulation continues on its present path, sooner or later the question will have to be faced whether regulation which has produced increased spawning is continuing so to do. If it is doing what is expected of it, the further question will arise as to whether the greater amount of spawn is effective in producing the younger commercial sizes. To answer these questions, some measurement of the abundance of spawn will be imperative, enabling what is produced now to be contrasted with that in the future and correlated with changes in the commercial catch. This measurement should be made periodically, the oftener the better for clear understanding; and, of course, in such a way as to allow for a possible wide difference between stocks in the several areas.

II. THE DISTRIBUTION OF THE SPECIES

The halibut had until 1904 been regarded as a circumpolar species, common to Atlantic and Pacific. In that year P. J. Schmidt described the halibut of the Okhotsk Sea (specimens from Aniva Bay, Sakhalin Island) as a distinct species, *Hippoglossus stenolepis,* distinguished from the Atlantic halibut, *H. hippoglossus* (Linnæus), by narrower scales, the manner in which they are set in the skin, the number of fin-rays, and general shape of the body. In 1929 he compared specimens from Japan, Bering Sea, and Vancouver Island, and stated (1930) that they were identical with *H. stenolepis* and distinct from the Atlantic form.

Somewhat more recently Rendahl (1931), examining a specimen from Petropawlowsk, Kamchatka, in comparison with four specimens from Bohuslän, Sweden, expressed the opinion that it was intermediate between the Atlantic halibut, *Hippoglossus hippoglossus* (Linnæus) and *H. stenolepis* Schmidt, and he termed it *H. hippoglossus çamtchaticus.*

In view of the existence of races of halibut in the Pacific, and presumably in the Atlantic, which vary greatly in body proportions and other characters, it is not surprising that halibut from the two oceans differ. The exact significance of these differences and their magnitude as compared to the variation within either ocean is a subject beyond the scope of the present report.

It is, however, safe to say that the two forms or species are very closely allied, with very similar habits and life history. Nevertheless, conclusions as to range of distribution, larval stages, and characters must be carried from one to the other with reservations as to their application, valuable and suggestive as comparisons of this kind have proved.

A. DISTRIBUTION IN THE ATLANTIC

In the Atlantic there can be little doubt but that the commercial fishery has spread completely over the range of the halibut. It is carried on as far north as is feasible in view of ice and weather, and the use of motherships since 1926 has led to exploitation of the most remote banks. Because of this, a study of the distribution in the Atlantic should be particularly useful for comparison with studies of the Pacific halibut.

The extreme range of the halibut is shown by records in zoological literature of occurrences of individual fish. This is particularly the case in so far as the southern limit is concerned. There great fisheries for other species exist, and halibut are taken whenever they stray far from their usual haunts. The reverse is true of the northern boundaries, because scientific expeditions to the Arctic which devote much time to fish are few, and the occasional collections cannot hope to include rare migrants except by most unusual good fortune. The commercial fishery has, in fact, indicated as extreme a northern range in the Atlantic as has the scientist. It follows that assumptions as to the total absence of halibut in the strictly arctic waters north of Siberia or America should be accepted with caution.

In Table 1 the existing scientific records as to the extreme range of Atlantic halibut are presented. It will be noted that New Jersey on the west and the Bay of Biscay on the east form the southern boundaries, not differing greatly in latitude. Doubtful records are off the coast of Delaware and in the Gulf of Cadiz. On the north the Baffin Land-Greenland Ridge, the north coast of Iceland, Spitzbergen, and Cape Kanin provide records that reflect the extent of commercial fisheries. Thus the records by Goode (1884) and Jensen (1925) may be compared with the "Fishing News" of September 6, 1930, p. 29, in which the "Northland," a large commercial mothership, is noted as fishing off Disko Bay, 69° N. at the eastern end of the Baffin Land-Greenland Ridge.

TABLE 1.—*Records of occurrence of halibut in the North Atlantic showing their extreme range.*

Locality	Reference
Eastern Atlantic—Northern Records	
Barents Sea. April: near 69° 50′ N., 32° 30′ E. Sept. to Oct.: Cape Kanin (68° 45′ N., 43° 30′ E.)	Averinzev (1927b)
Spitzbergen. West of Spitzbergen in 115 m.	Ehrenbaum (1901)
Eastern Atlantic—Southern Records	
Baltic Sea. As far as Mecklenburg coast	Möbius and Heincke (1882)
Atlantic Ocean. June 12, 1922. 170 m. at 48° 40′ N. latitude. June 5, 1922. 190 m. at 49° N. latitude	Belloc (1925)
Biarritz (Bay of Biscay). 1884	Moreau (1881)
Gulf of Cadiz (Doubtful record)	Buen (1926). From Borja y Goyeneche (1920)
Western Atlantic—Northern Records	
Davis Strait. North to 70° N. latitude	Goode (1884)
Disko Bay (69° N.)	Fishing News (1930)
Near coast between 67° 30′ N. and 66° N.	Jensen (1925)
Western Atlantic—Southern Records	
Fishers Island, Connecticut	Goode and Bean (1895)
South to 40th parallel (New Jersey)	Goode (1887)
Off Delaware coast (Doubtful record)	Collins, Bean, and Rathbun (1889)

Records of the commercial yield of halibut in the Atlantic are given in Table 2, the areas referred to being shown in Figure 2. These are the areas adopted for statistical purposes by the International Council for the Exploration of the Sea for the eastern and northern Atlantic, and by the North American Council on Fishery Investigations for the western Atlantic. The most productive areas are shown to be, from east to west: Barents Sea, Spitz-

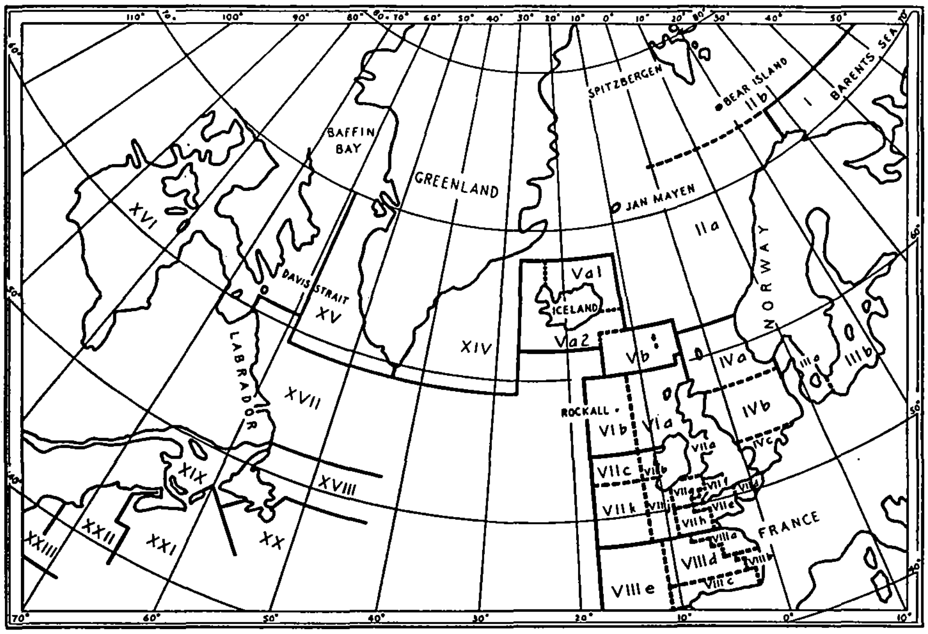

FIGURE 2.—The Atlantic Ocean north of 40° N. latitude, showing the statistical areas as defined by the International Council for the Exploration of the Sea and the North American Council on Fishery Investigations. The Roman numerals indicate the area numbers.

TABLE 2.—*Commercial halibut landings in the North Atlantic for 1932 by areas.*

Area Number[1]	Location and Region	Pounds
IV	North Sea	1,667,700
IIIa	Kattegat Skagerak Belts	19,842
Va	Iceland Grounds	6,516,800
Vb	Faeroes Grounds	2,786,620
IIa	Norwegian Sea	9,285,800
I	Barents Sea	2,189,200
IIb	Spitzbergen and Bear Island	1,882,700
VIb	Rockall	26,455
VIa	N.W. coast Scotland, N. Ireland	928,150
VIId-e	English Channel	6,614
VIIa, f	Irish Sea, Bristol Channel	11,023
VIIb, c	West coast Ireland	26,455
VIIg-k	South coast Ireland	15,432
XIV-XV	Greenland	7,923,400
I-XV	Mixed or unknown grounds	1,344,800
XIX	Gulf of St. Lawrence	257,482
XX	Grand Bank and St. Pierre Bank	366,074
XXI	Off Nova Scotia	3,364,612
XXII	Gulf of Maine	859,731

[1] Areas I to XV taken from Conseil Permanent International pour l'Exploration de la Mer. Bulletin Statistique (1934, p. 41). Quantities in kilos have been changed to pounds.

Areas XIX to XXII taken from United States Bureau of Fisheries and Canadian Bureau of Statistics.

TABLE 3.—*Halibut landed*[1] *in British ports by fishing vessels from western Atlantic (pounds)*

Year	West Greenland	Labrador
1926	(2,240,000)[2]	
1927	(6,874,000)	
1928	5,701,136	
1929	12,577,600	
1930	10,351,712	
1931	11,557,168	
1932[3]	7,685,888	
1933	6,235,600	579,376
1934	7,646,576	415,632

[1] Landings in Scotland from Scottish Fishery Board, in England and Wales from Ministry of Agriculture and Fisheries.

[2] Figures in parentheses are estimates from individual expeditions.

[3] The International Council gives for 1932 a total of 7,923,400 pounds for its Areas XIV and XV, the first being Eastern Greenland, which is apparently not included in the above table.

bergen and Bear Island, Norwegian Sea, Faeroes Grounds, Iceland, West Greenland, and off Nova Scotia.

Of these areas the more distant and last opened to exploitation are the least depleted. Thus Barents Sea, Spitzbergen, Bear Island, and West Greenland may perhaps be considered as at present more productive than will ultimately be the case. This is especially true of Greenland, where large motherships have recently been operating intensively. It is said in 1935 the yield there has already fallen off, the Labrador Banks being increasingly resorted to. (See Table 2.) Such considerations are, however, rather intangible, and the most that can be concluded is that Iceland, Faeroe Islands, and the Norwegian Sea may ultimately prove to be naturally the most productive.

Statistics do not indicate that halibut are taken in any quantity as far south as there are scientific records of occurrence, the southernmost productive fishery on the European side being the northwest coast of Scotland and Ireland, 600 miles north of the Bay of Biscay, the most southern record, and on the American side the Gulf of Maine, 200 miles north of Sandy Hook. The difference in these distances reflects the more abrupt change in conditions, especially temperature, on the American coast due to the Gulf Stream.

Although detail is lacking in the picture thus far, there is a distinct general correlation between this distribution and temperature. The areas in which halibut are found in quantity are all in the cooler parts of the Atlantic. The distribution of temperature is, of course, greatly modified by the oceanic currents. The records of occurrence on the north mark the dividing line between arctic and boreal waters, where the warmer currents have penetrated furthest. They throw no light upon the occurrence of halibut in the southward-bound cold currents of arctic water. If the halibut distribution is correlated with that of water temperature, it will necessarily reflect the distribution of the warm and cold currents.

A closer examination of the currents and of the halibut banks is necessary. These are shown in Figure 3. In this figure the Gulf Stream system of currents is shown diagrammatically, and the halibut banks have been drawn with what accuracy has been possible. The greatest care has been taken to search the literature for precise studies of distribution, but it is obvious that such could be made only through the medium of carefully recorded commercial operations of considerable magnitude in which the yield per unit of time or effort has been computed by depth and area. In only one case, that of the North Sea, have such studies been made in enough detail to indicate relative abundance. The careful description of the banks between Cape Cod and Newfoundland by Collins and others (1883 to 1887), at a time when halibutting was more important there than at present, has given much valuable information. The reports of Hjort and Ruud (1929), and of Jensen (1925), as to fishing in Greenland waters have been most useful. The detail of the Gulf Stream, or rather of the Gulf Stream system, has been kindly revised by Iselin and Helland-Hansen for the American and European sides

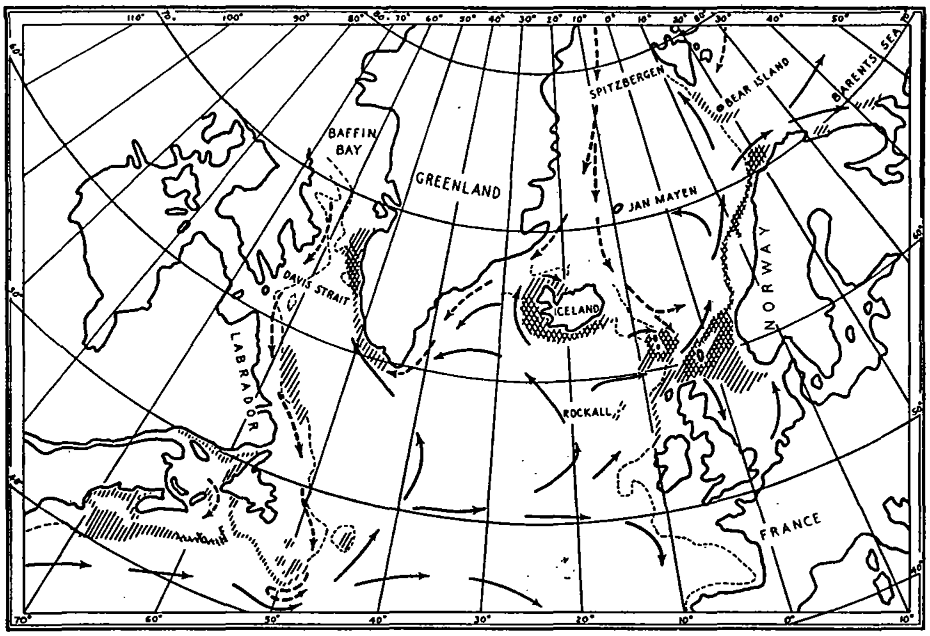

FIGURE 3.—The Atlantic Ocean north of 40° N. latitude. The arrows indicate the direction of flow of the principal ocean currents and the shaded areas the locations of the commercial halibut fisheries. Warm currents are shown by the solid arrows, cold currents by the broken arrows. The regions producing the most halibut are indicated by cross hatching.

of the Atlantic respectively. These have been supplemented and checked by letters received from Harold Thompson, Newfoundland, and from Mark Hellyer and J. W. Bennett of England. In other reports sufficient material is at hand to justify a general delimitation of the banks, although without accurate indication of abundance.

In presenting such data it is realized that they must include many inaccuracies which a person intimately acquainted with each of the banks could avoid.

The Gulf Stream flows northeastward along the Atlantic coast of the United States, spreads over the North Atlantic, and sends its branches into all its straits and seas, meeting everywhere cold southbound currents of arctic water. The distribution of these cold and warm currents is in conformity with the recognized law that currents are deflected to the right in the northern hemisphere, due to the effect of the rotation of the earth. A cold southbound stream, turning to the right, follows naturally that side of a strait or passage which lies on its right; and since the northbound current also follows the side on its right, the opposite sides of such straits have very different temperatures and opposing currents. This results in a general relationship of peculiar interest to the distribution of halibut. Whenever the arctic currents, carrying water of low temperature and low chlorinity, meet Atlantic water, or where Atlantic currents, carrying water of high temperature and high chlorinity, meet arctic water, an area of mixing

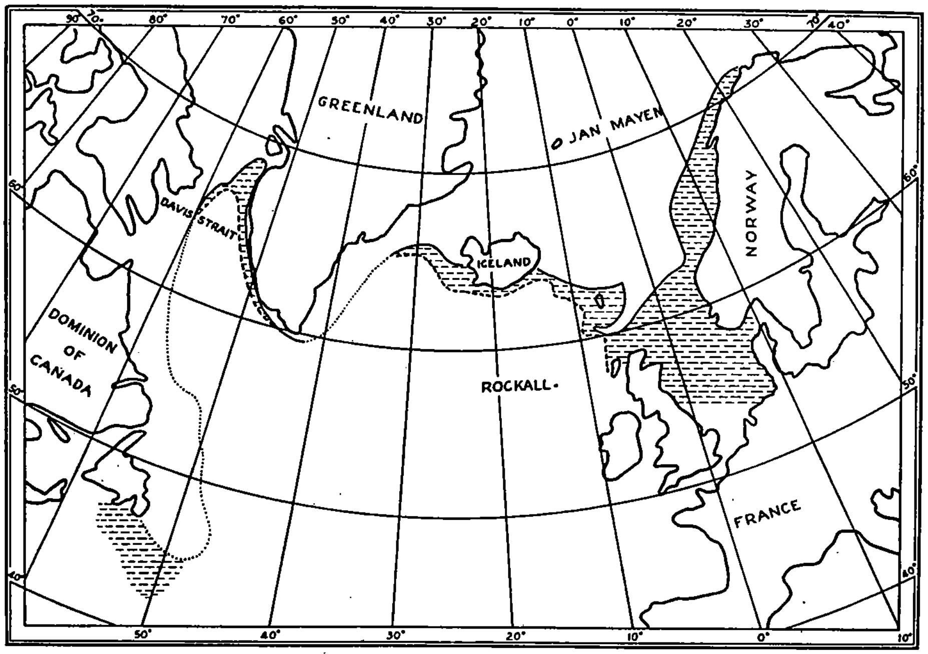

FIGURE 4.—The boreal regions in the North Atlantic as shown by Broch (1933, Figure 5).

and cooling results; and it is in this intermediate or boreal water that halibut are found.

Cold southward bound streams are particularly obvious along the eastern coasts of Greenland and of Labrador as far as the Grand Banks. No important halibut fisheries are found in these streams. But along the outer edge of the Labrador Current, warmer Atlantic water touches the edge of the continental shelf (see Iselin, 1932, Figures 4 and 8) and provides a summer halibut fishery which has been taken advantage of recently. The Labrador Current, passing southward over the Grand Banks, meets the warm Gulf Stream, and a similar fishery along the edge of the continental shelf results. This is continued into the Gulf of Maine by an inshore body of cooler water, limited offshore by the Gulf Stream. Here the seasonal warming and cooling accompanies a movement of the fishery from inshore in summer into deeper water in winter (Bigelow and Welsh, 1925; Goode and Collins, 1887).

The warmer streams, passing northward, provide great fisheries on the south and west sides of Iceland, the Faeroes, the northern slope of the North Sea, and the Norwegian coast. Where they penetrate during the summer months along the eastern side of Davis Strait, the northern coast of Iceland, Spitzbergen, Bear Island, and Barents Sea, seasonal fisheries for halibut are found according to the seasonal waxing and waning of the currents.

It is interesting to note that other animals show the same correlation with the current system as is shown by the halibut. Broch (1933), discussing the distribution of various species of invertebrates, gives a chart showing the boundaries of Arctic and Atlantic bottom regions, shading his Boreal or intermediate zone. This is reproduced in Figure 4. It is remarkably similar to the chart showing distribution of halibut, even though it is lacking in some of the detail of the latter. Broch apparently did not consider the Nova Scotia and Gulf of Maine Banks, nor those beyond North Cape, Norway. The resemblance is, however, so close as to justify classification of Atlantic halibut as a boreal organism, confined to regions of intermixture of Arctic and Atlantic waters except where seasonal heating or cooling is sufficient to provide proper conditions.

Convincing as this evidence of correlation between the currents and distribution is, any exact analysis of a single factor, such as bottom temperatures, is as yet generally impossible. Both detail as to halibut catches and variation in physical conditions are usually lacking. Direct evidence is found only in the case of the Greenland fisheries and in those of the North Sea.

The Greenland fisheries are carried on along the eastern side of Davis Strait where banks are found as far north as Disko Bay, latitude 68° 40′ N. The waters of Davis Strait are separated here from the deep waters of Baffin Bay by a submarine ridge. Disko Bay marks the northernmost locality from which halibut have been recorded (Fishing News, Sept. 6, 1930), and the principal fishing banks are to the south. North of this ridge the fauna is distinctly arctic. The northbound deep current sets in along the eastern side of Davis Strait, gradually diminishing in width until it is lost near Holsteinborg. Smith (1931) indicates a northbound surface current of 5 to 20 miles per day velocity extending around the north shores of Baffin Bay. The southbound Labrador Current of very cold arctic water follows the western side of Davis Strait. Halibut are taken in the water warmed by the northbound deep current, and since 1926 motherships and accompanying powered dories from England have carried on an active fishery here.

Captain Baldersheim, who has headed the expeditions from Hull to the Greenland Banks in recent years, has apparently observed with some care the physical condition of the water in which he has found halibut. He states (1929, p. 28): "The halibut seems to avoid water below the temperature of +3° C." Again, "As the warm water makes its way in summer across the banks towards the coast, the fish likewise draw closer in . . . I believe that e.g. the halibut caught off Holstenborg does not go far south, but rather westward to the deeper layers of water, which are sufficiently warm for it to pass the winter there . . ." And (p. 25), "It was only when we began to fish at depths between 400 and 500 fathoms that we found halibut on the west side of the banks. Later on in June and July the fish gradually rose to shallower water, but did not, in this year, come up to really shallow water of less than 70 fathoms."

Jensen (1925, p. 17) reports of these Greenland banks: "this fish does not spend all its time in the Greenland water. It appears first in the early summer, in the deep and constantly 'warm' water outside the Great Greenland Halibut Bank ('Store Hellefiskebanke'). As the summer advances, a rise in temperature takes place above this bank, the comparatively shallow waters of which are gradually heated by the atmosphere and the sun; not until then do the halibut move in over the bank towards the coast . . ." "experience in other waters (Norway, the Færoes and Iceland) has clearly shown that the halibut avoid ice-cold water." "We found considerable depths with a temperature of 3° C. at the bottom . . . we got 18 halibut on two lines . . . it is evident that the halibut are to be sought for in the deep and constantly warm water outside the banks . . ." "In the autumn, when the coastal water turns colder, the halibut are again forced to move back to the deep waters of Davis Strait, where the bottom water remains warm all through the year, and it is here that they have their true home" (p. 18).

Hydrographic sections across Davis Strait (Figure 5) illustrate the relative positions of the warmer and colder water. As will be noted from Figure 3, the banks on which halibut are taken in greatest abundance lie on the eastern or warm side of the strait.

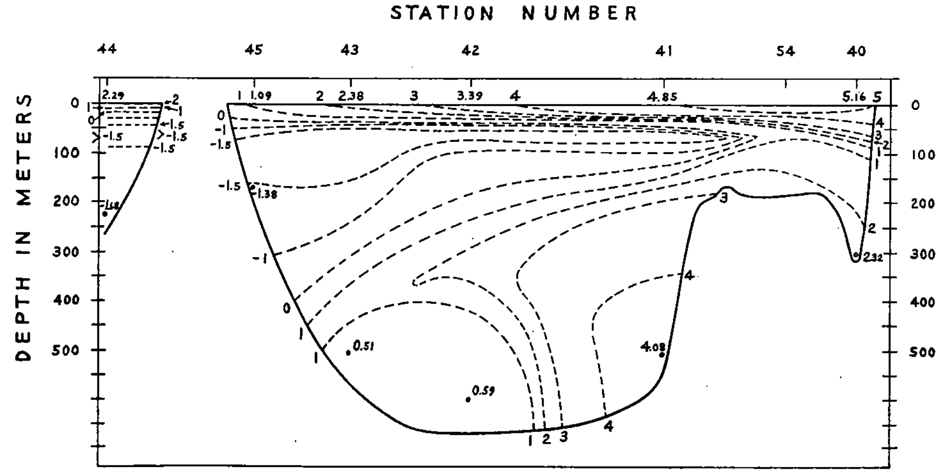

FIGURE 5.—Distribution of temperature in Davis Strait showing the position of the warm northbound current to the right and the cold southbound current to the left. Reproduced from Martens (1929, Figure 20).

As to the upper limits of temperatures which are suitable for halibut there are less definite statements. For the one region near the southern limit which has been accurately studied, namely, the North Sea, an interesting figure is given by Borley and Thursby-Pelham (1926, Chart 21) from whom Figure 6C is taken (see also Fulton, 1913, and D. W. Thompson, 1908). Figure 6B, giving the maximum temperatures in the North Sea, can be compared with this. This indicates that halibut diminish to an inconsiderable amount (less than one cwt. per hundred hours of fishing by steam trawler) where the maximum temperature is 8° C. It disappears completely as far as commercial catches are concerned where temperatures exceed 14° or 15° C. The minimum temperature (Figure 6A) is everywhere above 3° C., so that it can play little part as a limiting factor.

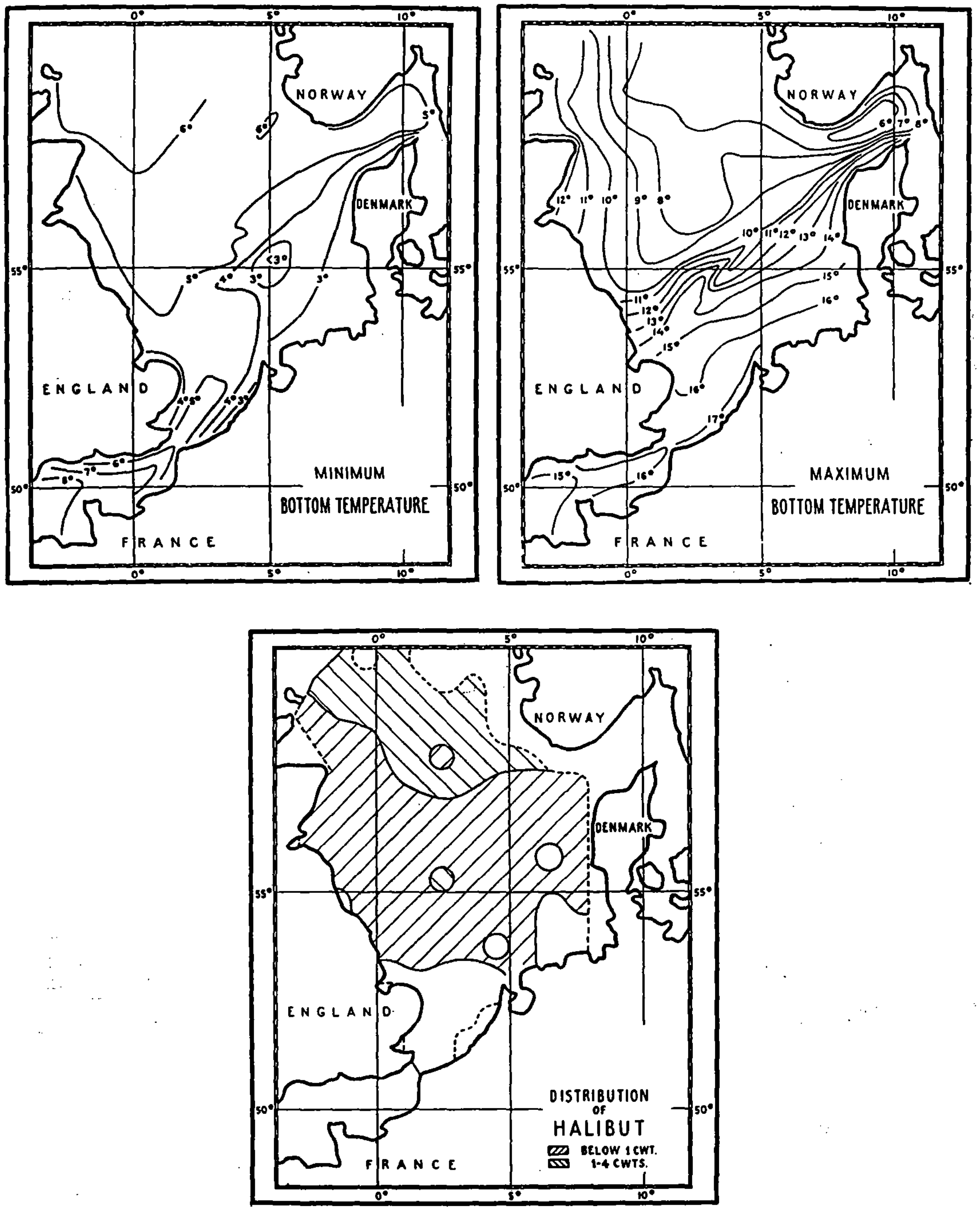

FIGURE 6.—Distribution of halibut and bottom temperatures in the North Sea. The minimum and maximum temperatures at the bottom are averaged for the period from August, 1902, to May, 1906 (from Conseil Permanent International pour l'Exploration de la Mer, 1909a). The distribution of halibut is taken from Borley and Thursby-Pelham (1926, Chart 21). Their abundance is indicated by the average catch in hundred weights per 100 hours of trawling.

With these approximations in mind, the bottom temperatures of the fishing banks in the North Atlantic can be explored for broad correlations between the presence and absence of halibut and the existence of temperatures between these extremes.

We have found that when areas of the banks are taken sufficiently large to provide any considerable amount of recorded hydrographic data for the bottom, the variability, even within a given month, is surprisingly great. The extent of this variability illustrates graphically the difficulty which must exist in deciding what temperature limits the distribution of halibut, because this temperature limit may be anything between the mean annual temperature and the occurrence of a single extreme. It may be surmised that the halibut can migrate and avoid extremes; that they may be able to endure such extremes for limited periods of time; that certain small parts of the banks may have more consistent temperatures; or that some other factor associated with temperature may be the real limit. At all events the problem becomes one for exact observations on each limited part of the banks, continued over a sufficient period, and including the abundance of halibut and hydrographic conditions simultaneously.

Nevertheless, it has seemed worth while to tabulate the available bottom temperatures, according to depth, whenever suitable representative hydrographic sections could be found. As winter season observations were in general lacking, only temperatures taken during the months from June to September were used. Sections which crossed inshore gullies, or were in any way not representative, were avoided, only those temperatures on the outer slope of the banks being included.

Several regions were rather arbitrarily distinguished and shown in Table 4. Table 4A includes the coastal banks immediately south and outside of the commercial fishery; Table 4B, those where small fisheries exist, as the Rockall Bank and Georges Bank off Cape Cod; Table 4C, those having considerable fisheries, as Faeroes, Iceland, West Greenland, Sable Island; Table 4D, those on the northern edge of commercial fishing, as Bear Island and off Cape Harrison outside the Labrador Current, etc.; and Table 4E, those beyond the colder boundary of halibut fishing. The sections are each designated by number referring to a supplementary table (Table 5) giving locality and source of information.

The temperatures shown in this table may be summarized.

4A. At the southern boundary, where occasional records of occurrence are extant, the temperatures are above 8° or 9° C. and as high as 14°.

4B. Along the southern edge of the fishery, where small quantities of halibut are taken, 80 per cent of the records are between 8° and 11° C., with but two below 6° C. These are due to the incursion of the cold Cabot Current at the southern tip of Nova Scotia. Whether halibut is taken in this last mentioned cold current is doubtful.

4C. Inshore temperatures above 8° C. are found in only four of the

TABLE 4[1].—*Bottom temperatures on coastal banks within the range of the Atlantic halibut fishery.*

Depth in Meters	A. Southern Boundary of Range				B. Southern Edge of Fishery									C. In Region of Principal Fisheries (Continued on page 30)									
	West			East	West		East							West			Davis Strait					Iceland	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0	......	......	......	......	......	....	....	....	....	....	....	....	......	....	....	....	5.0	....	....	....	....	....	....
30	9.0	7.8	12.1	......	......	....	....	....	....	....	....	....	10.0	....	....	....	4.0	....	2.7	2.7	....	5.3	....
60	9.0	8.0	9.7	10.0	10.8	2.0	....	....	....	....	....	....	......	2.8	-1.2	1.0	3.0	....	3.0	2.0	....	....	....
90	11.0	10.0	......	10.6	9.0	2.0	....	....	8.5	....	....	....	10.2	2.8	1.4	4.0	1.0	....	....	1.0	0.1	4.7	6.8
120	11.8	11.7	......	......	......	6.5	....	8.7	....	....	....	9.0	......	4.0	2.0	7.0	1.0	0.3	....	....	....	....	....
150	......	......	11.4	......	10.8	....	....	8.4	9.9	8.6	8.6	....	......	....	....	7.3	....	....	....	....	....	....	....
180	......	......	......	......	10.0	8.3	....	....	....	....	....	9.2	......	....	5.0	....	3.0	0.5	....	1.0	1.0	....	....
210	......	......	10.0	......	8.0	....	....	....	....	....	....	....	......	....	....	....	....	....	....	....	2.0	5.3	....
240	......	......	......	......	......	8.0	....	....	....	....	....	9.7	......	4.0	....	....	....	1.0	3.8	2.0	2.5	....	6.0
270	......	......	......	......	......	....	....	....	....	....	....	....	......	....	....	....	....	....	....	....	....	....	....
300	......	......	......	......	......	....	....	....	....	9.5	....	....	......	....	....	....	....	2.0	....	3.0	3.0	....	....
330	......	......	......	......	......	....	....	....	....	....	....	....	......	....	....	....	....	....	....	....	....	....	....
360	......	......	......	......	6.0	....	....	....	....	....	8.6	....	......	....	....	....	4.0	....	....	....	....	....	....
390	......	......	......	......	......	6.0	....	....	....	....	....	....	......	....	....	....	....	....	....	....	....	....	....
420	......	......	......	......	......	....	....	....	....	....	....	....	......	....	....	....	....	3.0	....	....	....	....	....
450	......	......	7.3	......	......	....	....	....	....	9.2	....	....	......	....	....	....	....	....	....	....	....	....	6.0
480	......	......	......	......	......	....	....	....	....	....	....	....	......	....	....	....	....	3.0	....	....	....	....	....
510	......	......	......	......	......	4.9	8.6	....	....	....	....	....	......	....	....	....	4.1	....	....	....	....	5.3	....
540	......	......	......	......	......	....	....	....	....	....	....	....	10.5	....	....	....	....	....	....	....	....	....	....
570	......	......	......	......	......	....	....	....	....	....	....	....	......	....	....	....	....	3.5	....	....	....	....	....
600	......	......	......	......	......	....	....	....	....	....	....	....	......	....	....	....	....	....	....	....	....	....	....
630	......	......	......	......	......	....	....	....	....	....	....	....	......	....	....	....	....	....	....	....	....	....	....
660	......	......	......	......	......	....	....	....	9.0	....	....	....	......	....	....	....	....	....	....	....	....	....	....
690	......	......	......	......	......	....	....	....	....	....	....	....	......	....	....	....	....	....	....	....	....	....	....
720	......	......	......	......	......	....	....	....	....	....	....	....	......	....	....	....	....	....	....	....	....	....	....
750	......	......	......	......	......	....	....	....	....	....	....	9.5	......	....	....	....	....	....	....	....	....	....	....
780	......	......	......	......	......	....	....	....	....	....	....	....	......	....	....	....	....	....	....	....	....	....	....
810	......	......	......	10.0	......	....	....	....	....	....	....	....	10.0	....	....	....	....	....	....	....	....	....	5.5
840	......	......	......	......	......	....	....	....	....	....	....	....	......	....	....	....	....	....	....	....	....	....	....
870	......	......	......	......	......	....	....	....	....	....	....	....	......	....	....	....	....	....	....	....	....	....	....
900	......	......	......	......	......	....	....	....	....	....	....	....	......	....	....	....	....	3.5	....	....	....	....	5.0
1000	......	......	......	9.5	......	....	8.2	8.1	....	....	6.9	9.0	9.5	....	....	....	....	....	....	3.5	....	....	....

[1] The sections as numbered here are explained in Table 5.

TABLE 4[1]—(*Continued*)

Depth in Meters	C. In Region of Principal Fisheries Continued from page 29)											D. Northern Edge of Fishery								E. Northern Boundary of Range			
	Iceland	East										West			Iceland		East			West		East	
	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
0	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
30	....	....	....	....	....	....	....	....	....	....	....	....	....	....	7.0	7.0	....	....	....	0.0	....	....	....
60	8.0	....	....	....	....	....	....	....	....	....	....	....	....	–0.5	4.8	....	....	....	....	–1.0	–0.1	....	....
90	....	....	....	7.9	....	9.0	9.6	....	....	....	....	–1.5	....	....	....	....	....	....	–0.2	–1.5	—	0.9	—
120	....	7.6	....	....	....	....	7.2	....	....	....	....	–1.6	....	....	....	....	....	....	....	....	–0.2	1.1	....
150	7.5	....	8.5	....	....	9.2	....	....	....	....	7.0	....	–1.7	0.0	4.0	4.0	....	....	....	....	–0.2	....	–0.8
180	....	....	....	7.1	....	....	7.0	....	....	....	6.1	....	....	0.0	....	3.9	....	....	....	–1.4	....	....	–0.5
210	....	....	7.0	....	....	....	....	7.8	....	....	....	....	....	0.5	....	2.5	4.2	2.1	....	....	1.2	–0.1	....
240	7.5	....	....	....	....	....	....	....	6.4	6.4	6.1	0.0	0.0	....	....	....	....	1.6	2.1	....	....	....	....
270	....	....	....	6.8	....	....	....	....	6.5	....	....	....	....	1.0	....	2.0	....	....	....	....	....	....	....
300	....	....	6.0	....	....	....	....	7.3	....	....	....	....	2.8	....	0.3	....	3.3	1.8	....	–1.0	1.7	....	0.0
330	....	....	4.0	6.0	....	9.0	....	6.0	....	....	5.0	....	....	2.0	....	....	1.5	....	2.0	....	....	....	0.5
360	....	....	....	....	....	....	6.0	....	....	....	....	1.0	....	....	....	....	....	....	....	....	....	....	1.0
390	....	....	....	....	....	6.4	....	4.0	6.0	....	4.4	....	....	2.5	....	....	....	....	....	0.0	....	....	....
420	....	....	2.0	....	....	6.0	....	....	....	4.0	1.0	....	....	....	....	....	....	....	1.0	....	....	....	....
450	7.0	....	....	....	....	....	....	2.0	....	....	....	2.0	....	....	....	....	....	....	....	1.0	....	....	....
480	....	....	1.0	....	....	2.0	....	....	....	2.0	....	....	....	....	....	....	....	....	....	....	....	....	....
510	....	....	....	2.0	8.6	1.0	....	....	4.0	....	....	....	....	....	....	....	....	....	....	0.5	....	....	....
540	....	....	....	1.0	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
570	....	....	....	....	8.0	0.0	....	....	0.0	....	....	....	....	....	....	....	....	....	....	....	....	....	....
600	....	....	....	....	7.0	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
630	....	7.7	....	....	2.0	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
660	....	....	....	....	....	–0.5	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
690	6.0	....	0.0	0.0	0.0	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
720	....	7.5	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
750	....	....	....	....	....	....	....	....	....	....	....	3.0	....	....	....	–0.6	....	....	....	....	....	....	–0.6
780	....	....	....	....	–0.5	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
810	....	....	....	....	....	....	....	....	....	....	....	....	....	....	–0.4	....	....	....	....	....	....	....	....
840	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
870	....	7.0	....	–0.5	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
900	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1000	5.3	3.1	....	....	–0.9	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

[1] The sections as numbered here are explained in Table 5.

TABLE 5.—*Sections given in Table 4.*

No	Locality	Date	Source
1	Off Cape May, 38° 45′ N., 74° 55′ W.	May 17 to 20, 1930.	Bigelow, 1933, p. 43, Fig. 28 B, Stations 20739, 20740, 20749-20751.
2	Off New York, 40° 24′ N., 73° 46′ W.	May 16, 1930.	Bigelow, 1933, p. 42, Fig. 27 B, Stations 20729-20733.
3	Off Martha's Vineyard, 41° 03′ N., 70° 51′ W.	Aug. 25 to 26, 1914.	Bigelow, 1928, p. 618, Fig. 60, Stations 10258-10262.
4	British Channel West, 49° 58′ N., 3° 50′ W.	May 8 to 10, 1922.	Helland-Hansen and Nansen, 1926, Pl. 15, Sect. IXa, Stations 1-4.
5	Across east end of Georges Bank, 42° 03′ N., 66° 57′ W.	July 22 to 23, 1914.	Bigelow, 1928, p. 617, Fig. 59, Stations 10220-10224.
6	Off Cape Sable, 43° 29′ N., 65° 08′ W.	June 23 to 24, 1914.	Bigelow, 1928, p. 581, Fig. 41, Stations 10291-10295.
7	Wyville-Thompson Ridge, South, 59° 59′ N., 6° 38′ W.	Aug. 22, 1909.	Conseil Permanent International pour l'Exploration de la Mer, 1911, Pl. VIII.
8	Hebrides, 58° 02′ N., 8° 00′ W.	June 6 to 7, 1905.	Nielsen, 1907, Pl. II, Sect. VII, Stations 55-57.
9	South of Hebrides toward Rockall, 56° 52′ N., 7°55′ W.	May 28, 1908.	Nansen, 1913, p. 31, Fig. 7, Stations Da A, Da B.
10	Rockall Bank East, 57° 11′ N., 14° 00′ W.	May 29, 1908.	Nansen, 1913, p. 31, Fig. 7, Stations Da D, Da E.
11	Rockall Bank West, 57° 11′ N., 14° 00′ W.	May 29 to 30, 1908.	Nansen, 1913, p. 31, Fig. 7, Stations Da E, Da F, Da G.
12	West Coast Ireland, 52° 02′ N., 10° 57′ W.	May 7 to 8, 1906.	Conseil Permanent International pour l'Exploration de la Mer, 1907, Pl. XXVI, Sect. Atlantic III.
13	South Coast Ireland, 51° 24′ N., 8° 18′ W.	June 18 to 21, 1905.	Nielsen, 1907, Pl. II, Sect. IX, Stations 66-69.
14	Across Sable Island Bank, 43° 50′ N., 60° 04′ W.	May 30, 1915.	Bjerkan, 1919, Pl. II, Sect. V, Stations 8-10.
15	Green Bank, 45° 50′ N., 54° 20′ W.	June 1 to 2, 1915.	Bjerkan, 1919, Pl. II, Sect. VI, Stations 19-22.
16	Tail of Grand Bank, 45° 58′ N., 51° 25′ W.	July 1 and June 30, 1910.	Murray and Hjort, 1912, p. 110, Fig. 95, Stations 71-73.
17	Off Holsteinborg, 66° 30′ N., 54° 15′ W.	Aug. 8, 16, 1924.	Martens, 1929, p. 17, Fig. 20, Stations 40, 41, 54.
18	Across Little Hellefiske-banke, 64° 45′ N., 54° 00′ W.	June 20, 1925.	Baggesgaard-Rasmussen and Jacobsen, 1930, p. 18, Fig. 11.
19	Off Godthaab, 64° 35′ N., 53° 20′ W.	Aug. 6, 7, 1924.	Martens, 1929, p. 14, Fig. 15, Stations 35, 38.
20	Across Fyllas Bank, 63° 56′ N., 52° 41′ W.	July 21, 1925.	Baggesgaard-Rasumssen and Jacobsen, 1930, p. 19, Fig. 17.
21	Off Frederikshaab, 61° 57′ N., 49° 55′ W.	July 10, 1925.	Baggesgaard-Rasmussen and Jacobsen, 1930, p. 17, Fig. 10.
22	Iceland Northwest Coast, 66° 18′ N., 23°44′ W.	June 13, 14, 1903.	Nielsen, 1904, Pl. III, Sect. XIII, Stations 36-39.
23	Iceland Southwest Coast, 64° 10′ N., 23° 22′ W.	June 10 to 12, 1903.	Nielsen, 1904, Pl. III, Sect. XII, Stations 29-33.
24	Iceland South Coast, 63° 24′ N., 20° 02′ W.	July 12, 14, 17, 1903.	Nielsen, 1904, Pl. III, Sect. XI, Stations 50, 53, 54.
25	Southwest Faeroes, 61° 06′ N., 8° 30′ W.	May 11, 12, 1904, 28, 1905.	Nielsen, 1907, Pl. III, Sect. IV, Stations 37, 38, 50.
26	North of Faeroes, 62° 36′ N., 6° 20′ W.	Aug. 2, 1904.	Conseil Permanent International pour l'Exploration de la Mer, 1905, Pl. V, Stations Da Atl 2, Da Atl 3.

TABLE 5.—(*Continued*)

No.	Locality	Date	Source
27	East of Faeroes, 62° 00′ N., 6° 12′ W.	June 21, 1909.	Conseil Permanent International pour l'Exploration de la Mer, 1910, Pl. VIII, Stations Sc 15A, Sc 15B, Sc 16, Sc 16A.
28	North side of Wyville-Thompson Ridge, 59° 59′ N., 6° 38′ W.	Aug. 22, 1909.	Conseil Permanent International pour l'Exploration de la Mer, 1911, Pl. VIII.
29	West of Shetlands, 59° 46′ N., 2° 21′ W.	June 25 to 26, 1909.	Conseil Permanent International pour l'Exploration de la Mer, 1910, Pl. VIII, Stations Sc 19A, Sc 19B, Sc 20A, Sc 21, Sc 21A.
30	East of Shetlands, 59° 40′ N., 1° 14′ W.	Aug. 7, 28, 1907.	Conseil Permanent International pour l'Exploration de la Mer, 1909b, Pl. VI, Stations Sc 5-Sc 8.
31	Off Sognefjord, 61° 51′ N., 1° 12′ E.	May 22, 1904.	Helland-Hansen and Nansen, 1909, Pl. XXIVa, Fig. 1, Stations N4, N4C, N5, N62A.
32	Helgeland, 66° 04′ N., 9° 39′ E.	June 5, 6, 1904.	Helland-Hansen and Nansen, 1909, Pl. XXIVa, Fig. 3, Stations N25, N26, N27A, N28A.
33	Off Lofoten, 67° 12′ N., 10° 08′ E.	June 2, 3, 1904.	Helland-Hansen and Nansen, 1909, Pl. XXIVa, Fig. 4, Stations N23, N23A, N24.
34	Along 19th Meridian, 70° 30′ N., 19° 00′ E.	Sept. 10 to 11, 1927.	Schulz and Wulff, 1929, Pl. II, Stations 92-97.
35	Cape St. Francis toward the Flemish Cap, 47° 21′ N., 49° 31′ W.	July 25, 26, 1914.	United States Coast Guard Bulletin, 1915, Stations 73-75.
36	Off Cape Harrison, 54° 53′ N., 57° 08′ W.	June 6, 1928.	Conseil Permanent International pour l'Exploration de la Mer, 1929, p. 88, Stations 14, 15.
37	Across Northern Store Hellefiskebanke, 68° 00′ N., 54° 30′ W.	June 26, 1925.	Baggesgaard-Rasmussen and Jacobsen, 1930, p. 18, Fig. 13; also Conseil Permanent International pour l'Exploration de a Mer, 1926.
38	Iceland North Coast, 66° 14′ N., 17° 28′ W.	July 21 to 22, 1904.	Nielsen, 1905, Pl. II, Sect. VI, Stations 73-77.
39	Northeast Coast Iceland, 66° 10′ N., 14° 29′ W.	Aug. 12 to 14, 1904.	Nielsen, 1905, Pl. II, Sect. VII, Stations 99-101.
40	North on 30th Meridian, 70° 45′ N., 30° 00′ E.	Aug. 7, 1927.	Schulz and Wulff, 1929, Pl. III, Stations 26-29.
41	Off Ribachi Peninsula, 69° 30′ N., 33° 30′ E.	Aug. 21 to 22, 1927.	Schulz and Wulff, 1929, Pl. IV, Stations 63-67.
42	Bear Island West, 74° 06′ N., 18° 50′ E.	Sept. 4, 5, 1900.	Helland-Hansen and Nansen, 1909, Pl. XIVa, Fig. 4, Stations 61-63.
43	West Coast Davis Strait, Cape Walsingham, 66° 21′ N., 61° 05′ W.	Aug. 9, 13, 1924.	Martens, 1929, p. 17, Fig. 20, Stations 43, 45.
44	East Coast Davis Strait, Disko Bay, 69° 41′ N., 55° 01′ W.	July 13, 14, 1928.	Conseil Permanent International pour l'Exploration de la Mer, 1929, p. 89, Stations 47-51.
45	East Coast Iceland, 64° 58′ N., 13° 25′ W.	May 14, 16, 1903.	Nielsen, 1904, Pl. II, Sect. VI, VIII, Stations 11, 17-19.
46	Barents Sea South of Franz Josef Land, 78° 40′ N., 58° 00′ E.	Sept. 4, 5, 1929.	Wiese and Laktionoff, 1931, p. 16, Fig. 6, Stations 17-19.

twenty-two sections on the banks supporting the principal commercial fisheries. They are all in the vicinity of the Faeroe and Shetland Islands. In some the temperatures are below 3° C. inshore, increasing at greater depths; and in each such case the best fisheries are seasonal and offshore, as in Davis Strait (Table 4C, sections 17 to 21). In others the cold water is offshore, as at the Faeroes (sections 26 and 27), where the deeper records are in the arctic water of the depths of the Norwegian Sea. In such deep water the boreal species are replaced by arctic forms, among which halibut are not included. The effect of the Gulf Stream is obvious between Sable Island and the Grand Bank (sections 14 to 16, Table 4C) in producing higher temperatures offshore. The same is true in Davis Strait (sections 17 to 21) of the branch of the Irminger Current which enters there. And along the entire region from Iceland to Trömso (sections 22 to 34) the influence of the Gulf Stream extends down to depths of 330 to 600 meters. Below these depths there is a rapid fall to the subzero temperatures of the deeper Norwegian Sea. In each district the depth at which this change occurs varies from season to season and year to year. Nevertheless, the productive banks have waters which in every case include temperatures between 3° C. and 8° C. at some depth.

4D. Along the colder edge of the halibut fisheries, temperatures below 3° C. prevail, rarely above. Here, too, warmer areas occur offshore, as at Cape St. Francis, Cape Harrison, and Davis Strait, due to the interaction of the cold Labrador and warm Atlantic water, providing the present offshore Labrador fishery (sections 35 to 37). North of Norway and in Barents Sea (sections 40 to 42), the warmer waters are inshore where the principal halibut fisheries are found. The temperatures are in general markedly lower than in Table 4C.

4E. In the sections shown as beyond the colder edge of the fishery the Labrador Current, the arctic waters of Baffin Bay, the Norwegian Sea, and Barents Sea are represented. The temperatures are well below 2° C., frequently subzero.

From these records it would appear that the temperature range between 3° C. and 8° C. on the bottom is that most favorable to halibut in the Atlantic. It is a truly boreal form, whether it is temperature, salinity, or food which limits its distribution. The correlation might be stated as with mean annual surface temperatures (see Schott, 1926). But such would not be as satisfactory in detail as the above treatment nor would it allow as clear an explanation of the peculiar distribution caused by the characteristic relationships of warm and cold currents. The major controlling influence at all levels is, of course, the distribution of the Gulf Stream. The need for closer comparisons between fishing localities and bottom temperatures is obvious.

Some caution is necessary in accepting 3° C. as a minimum. There is some likelihood that weather conditions and ice in the colder currents have contributed to the difficulty of utilizing what halibut exist there. With declining abundance in the more favorable districts there is little doubt but that the supplies which may possibly exist in the colder currents will be exploited, temporarily obscuring the correlation.

B. DISTRIBUTION IN THE PACIFIC

In the Pacific, exploitation has not been carried into every corner of the range of halibut. As yet no fishing of note has been carried on in Bering Sea, and the possibility of any existing there can be judged only by study of the physical environment as compared to that in the Atlantic.

As in the Atlantic, great fisheries for other species exist along the southern border of the range, so that it is well known. Extreme records are beyond the commonly accepted southern limit of the commercial fisheries. (See Table 6 for a list of extreme records, both northern and southern.) On the American coast there are records of occurrence at San Francisco and Monterey and a very well authenticated record with a photograph for Santa Rosa Island, California, latitude 34° N. (Walford, 1928). The southernmost commercial fishery is at Eureka, California, 40° 45′ N., 450 miles north of Santa Rosa Island (see Table 6). This great distance is correlated with a very gradual change in oceanic conditions, the first abrupt change occurring at Point Conception just north of Santa Rosa Island.

TABLE 6.—*Records of occurrence of halibut in the North Pacific showing the extremes of their distribution.*

Locality	Reference
Eastern Pacific—Northern Records (Bering Sea)	
St. Michaels. 63° 25′ N. latitude	Turner (1886).
Above confirmed	Bean (1880 and 1882).
St. Paul Island and Unalaska	Jordan and Gilbert (1899).
Head of Bristol Bay. "Albatross" Stations 3238 and 3239	Gilbert (1895).
Slime and Baird Banks	U. S. Bureau of Fisheries (1893).
Slime Bank and Pribilofs	Alexander and Joyce (1913).
Eastern Pacific—Southern Records	
Santa Rosa Island. 100 fm.	Walford (1928).
Monterey	Starks (1918).
Near Farallon Islands	Aeyrs (1863 and 1873).
Near Farallon Islands	Lockington (1879).
Near San Francisco	Cronise (1868).
Near San Francisco	Lockington (1880).
Western Pacific—Northern Records	
Aniva Bay; Commander Islands, and Bering Island, Olyutorsky Bay	Schmidt, P. J. (1930).
Anadir Bay; West coast Kamchatka; East coast Sakhalin; absent from Japan Sea and North coast Okhotsk Sea	Schmidt, P. J. (1934).
West Coast Kamchatka (near 53° 30′ N. latitude)	Soldatov and Lindberg (1930).
Western Pacific—Southern Records	
All coasts of Hokkaido south to Hakodate	Hikita (1934).
South along East coast Hokkaido to latitude 41° 50′ N., South on West coast Hokkaido to 43° 20′ N.	Marukawa (1935).

On the Asiatic side halibut are recorded as far south as Hakodate, 41° 46′ N., on the island of Hokushu (Hokkaido). Hikita (1934) records halibut from many localities on both the Japan Sea and Pacific sides of this island from the latitude of Hakodate north. P. J. Schmidt (1934) says halibut are not taken in the Japan Sea. In a letter Marukawa (1935) gives the same distribution as does Hikita, but states that from the commercial view, fisheries for halibut exist only on the coasts of the north and east sides of Hokkaido. In an accompanying sketch (Figure 7) he shows the fishing grounds to extend but slightly through La Perouse (Soya) Strait into the Japan Sea. The distance between the southernmost record and the fishing banks is less than sixty miles, in keeping with the abrupt transition in physical conditions there as the result of the Kuroshio. It is in contrast to the greater distance and less abrupt transition on the American coast.

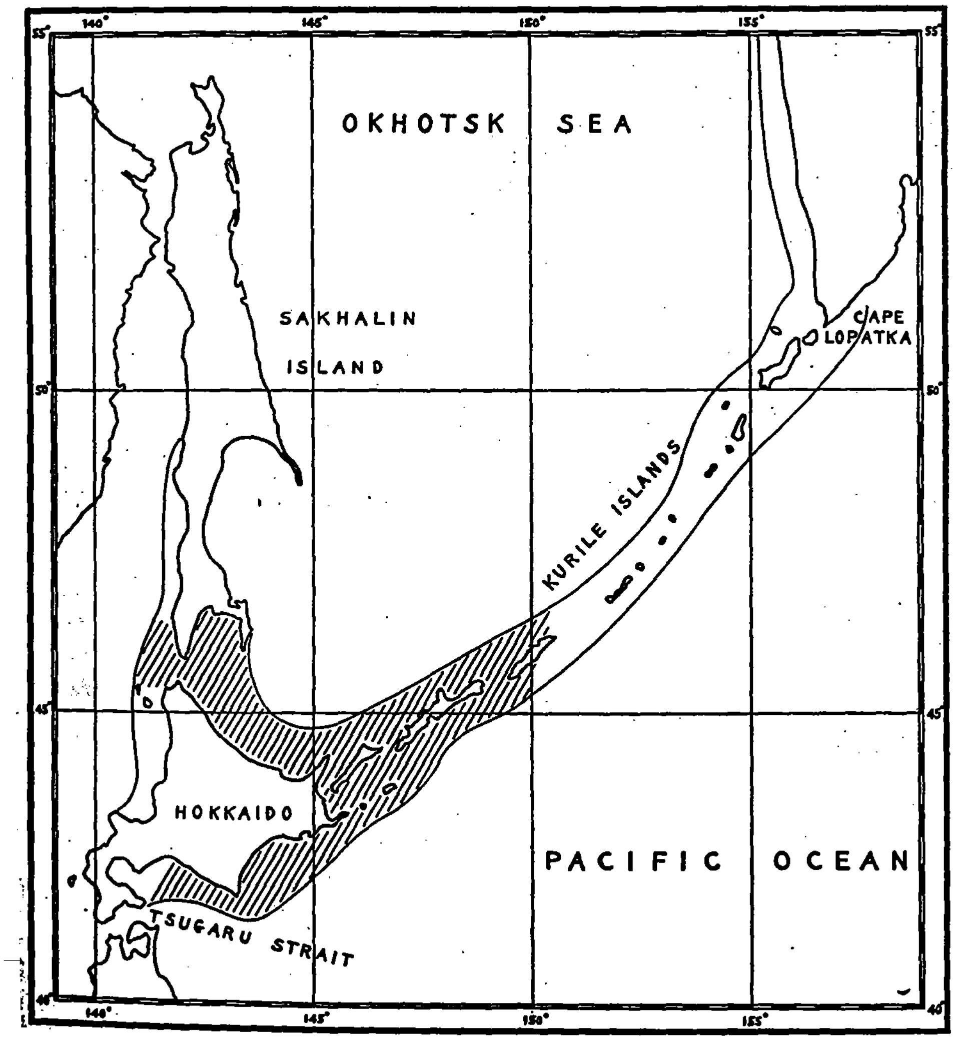

FIGURE 7.—Distribution of commercial halibut fisheries in Asiatic waters from information by Marukawa (1935).

The same contrast in distance between occasional southern records and the occurrence in commercial abundance on the eastern and western sides of the Pacific can therefore be made as in the Atlantic.

The extreme northern record on the American side of the Pacific is that from St. Michaels, on the southern side of Norton Sound, 63° 31′ N. latitude (Turner, 1886; Bean, 1880 and 1882). The nearest commercial fishery is at the Shumagin Islands, 55° N. latitude, some 500 miles south. The intervening area is of special interest to us and will be dealt with later.

On the Asiatic side specific records from Aniva Bay (Schmidt, P.J., 1930) and the River Kikchik, 53° 30′ N. latitude (Soldatov and Lindberg, 1930), indicate the boundaries in the Okhotsk Sea, although the whole eastern side of Sakhalin Island is included by P. J. Schmidt (1934). In the western Bering Sea the northern boundary is given as "a line traced from the mouth of the Anadyr River (64° 30′ N. latitude) to a point midway between St. Lawrence and St. Mathew's Islands" (Schmidt, P. J., 1934), although the northernmost recorded specimens are from Olyutorsky Bay. The nearest commercial fishery to the south is on the Asiatic side, but it is commonly accepted that one could exist along the Aleutians, 700 miles south, were the banks there large enough.

Practically the whole of Bering Sea and the half of the Okhotsk Sea south of 53° N. latitude are therefore included in the range of at least occasional occurrence of the halibut. This is well to the northward of the existing commercial fisheries, contrasting with the condition in the Atlantic. There the commercial fishery has reached the known northern limit of distribution.

It is possible to advance a tentative explanation for this condition, if it is taken for granted that commercial development of Bering Sea fishing will not greatly alter the present concept of abundance there. On the eastern side of Bering Sea there is seemingly no direct contact between sharply marked warm currents and very cold currents such as characterize the western Pacific and the western North Atlantic. The temperature gradient is therefore much less abrupt, and habitable waters do not extend to as clearly marked a boundary. Northern distribution in the Pacific apparently terminates gradually as it does to the southward in both eastern Pacific and eastern Atlantic.

In general, the distribution outlined above corresponds with that in the Atlantic. In both oceans it is more sharply marked and limited on the western side than on the eastern. The latter has the greater extent of coast line inhabited by halibut. This peculiarity is due in the Atlantic to the Gulf Stream and in the Pacific to the Kuroshio or Japanese Current.

The International Fisheries Commission has studied the distribution of the halibut in two ways. The coast line between Bering Sea and California has been divided into areas, each including 60 miles of the general trend of the coast, as shown in Figure 8. For each of these areas the *total* yield has

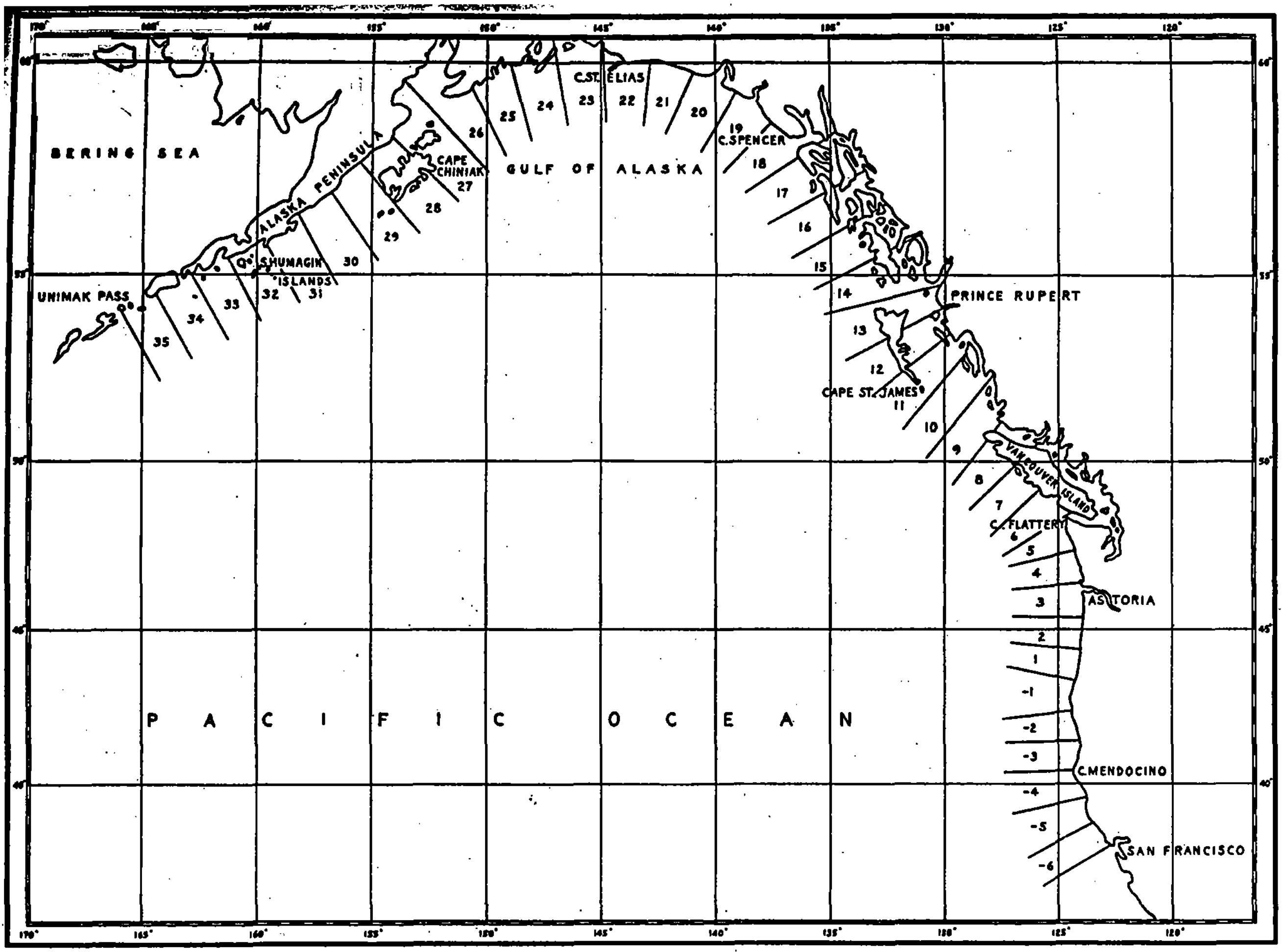

FIGURE 8.—Pacific coast of America north of 35° N. latitude, showing the statistical areas as defined by the International Fisheries Commission.

been obtained, as recorded by the log books of the fishing vessels (and from smaller vessels by inquiry). This is shown for the years 1926, 1927, and 1928 as given by Thompson, Dunlop, and Bell (1931, Figure 26). There has also been obtained the *yield per set* of a standard unit of gear, as indicative of the abundance of the stock (l. c., Figure 24).

The two do not agree as measures of abundance, because the total yield is dependent upon the amount of fishing as well as upon the abundance. The abundance varies with the past intensity of the fishery and the rate at which it is replaced when removed. It has been reduced in each area as far as is consistent with the cost of operating at the given distance from the landing ports (l. c., p. 68). Strictly speaking, therefore, a fishery which has been actively exploited does not provide an accurate measure of relative natural abundance.

For comparison with recent records of catch per set of a unit of gear, the Commission has similar earlier records which show the decline in catch per set for certain groups of the areas used (l. c., Table 12). From these the abundance has been calculated for the years 1915, 1916, and 1917 combined. Finally, the earliest available records have been used to give what may have been the original levels of abundance. These are very fragmentary and untrustworthy and are hardly more than estimates, yet may be relied on to give a general idea of what once existed. All three series of records have been smoothed manually for presentation in Figure 9.

The picture obtained is not accurate in detail yet indicates certain outstanding facts. As would be expected, the progressive depletion which

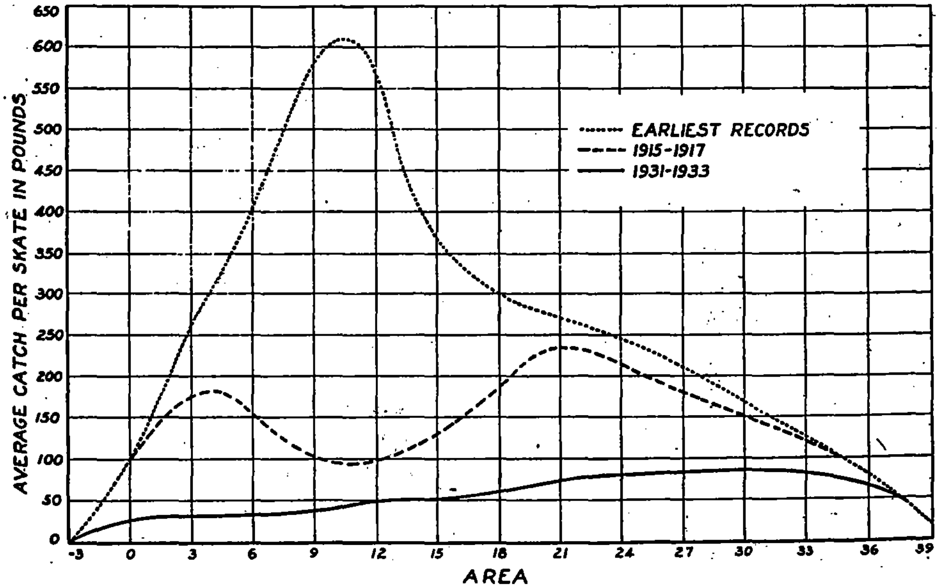

FIGURE 9.—The distribution of abundance of halibut along the Pacific coast of America as indicated by the average catch per skate in each area (see Figure 7). The approximate original distribution of abundance is shown by the earliest records, and subsequent changes due to fishing are indicated by the later records.

has been so characteristic of the banks is well shown, as is also the unevenness of this depletion, indicating a high degree of independence between certain groups of areas (l. c., 1931, p. 64). The very great abundance which once existed in areas 8 to 14 contrasts with the present depletion there. The fishery was at one time almost entirely concentrated in these areas, as a result reducing the abundance to less than that west and south.

The areas to the south, 1 to 5, were exploited intensively for a brief period in 1915 and 1916 (Thompson and Freeman, 1930, p. 41), the supply disappearing quickly without replacement. It was as though much of the stock there had been slowly built up by immigration or by relatively unsuccessful reproduction, without strong powers of recuperation. A very small fishery now suffices to keep the abundance at a low level. As will be seen later in the section reviewing the ocean currents, spawn produced there may in great part be swept southward or seaward into the California trades, hence into unfavorable regions.

The areas to the west of area 18 maintained a comparatively high level of abundance during the great reduction on southern grounds. This corroborates the conclusion as to the relative independence of that district reached by marking experiments and by study of physical characters. Its decline was rapid but limited by the deterring effect of the distance which exploiting vessels had to travel. Growth is slower, even though a smaller fraction of the stock is annually removed.

It is therefore apparent that the quantitative distribution of the halibut is affected greatly by the history of its exploitation and also by the rapidity with which the catch is replaced in different areas. The biological relationship to its environment is complex. In fact, a very close simple correlation between the exact level of abundance and any particular temperature or degree of salinity cannot be expected. The fact that the abundance originally was a maximum in areas 8 to 14 of Figure 9, and declined in either direction to minima in Bering Sea and the northern coast of California, must be taken as a general description of the abundance.

For the only remaining commercial fishery in the Pacific, that in Japan, no reports are at hand in the published literature available to us. Through the Canadian Legation (Langley, 1930) a report has been obtained indicating that the total catch in Japanese (Hokkaido) waters has never been great and that the district of Nemuro produces the most heavily. The fishing in this district takes place in a sea inclosed by the most southern of the Kurile chain of islands and the northeastern corner of the island of Hokkaido. The northern and eastern coasts of the latter island are also productive but to a lesser extent. Quoted in the report are statistics furnished by the Hokkaido government of landings as follows:

1920	1,063,665	pounds	1925	912,020	pounds
1921	1,043,477	"	1926	583,932	"
1922	984,518	"	1927	869,406	"
1923	1,667,661	"	1928	871,488	"
1924	1,214,699	"	1929	460,330	"

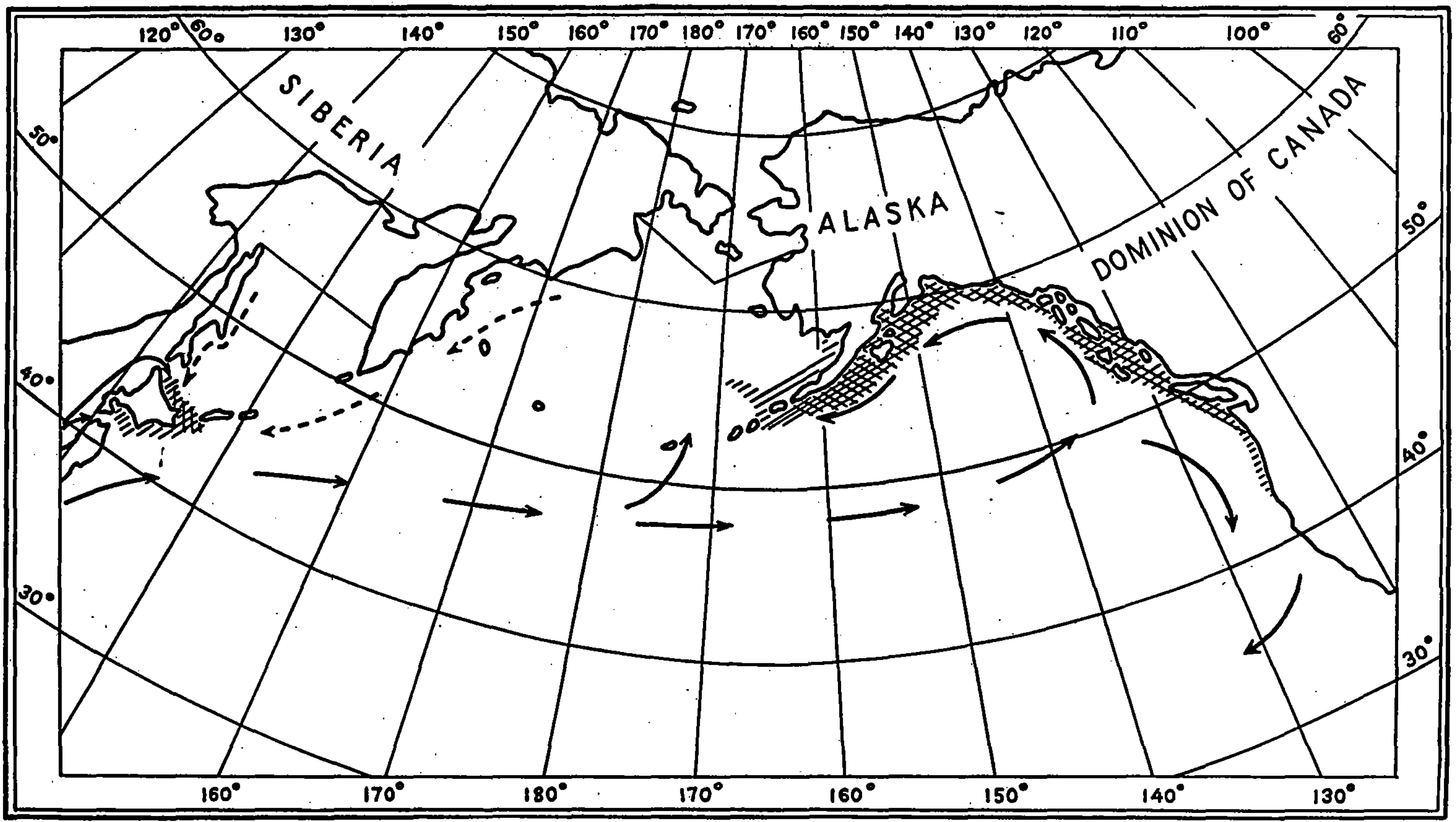

FIGURE 10.—The Pacific Ocean north of 40° N. latitude, showing the halibut banks as shaded areas and the principal warm and cold currents which are indicated by the solid and broken arrows respectively. The banks producing the most halibut are cross hatched.

The districts in which these landings are made are not consistent with those given in the main body of the report as fishing grounds. Marukawa in the letter quoted above (p. 35) corroborates the presence of a commercial fishery on the north and east coasts of Hokkaido but gives no detail. His sketch map is reproduced. In view of the difficulty of interpreting the commercial catch from the standpoint of biological abundance any greater accuracy is not necessary to our present purposes, especially as the total production is small.

Between the American and Japanese coasts there are two chains of islands, the Kurile on the Asiatic side, the Aleutian on the American. Along these islands the available banks are small and narrow, the tides are rapid, and fishing conditions are said to be unfavorable.

In the eastern Bering Sea no commercial fishing for halibut has taken place except at Makushin Bay, Unalaska Island, and in that vicinity. But the United States Bureau of Fisheries vessels, as reported by various authors (Jordan and Gilbert, 1899; Gilbert, 1895; United States Bureau of Fisheries, 1893; Alexander and Joyce, 1913), record halibut in some quantity in shallow water at the head of Bristol Bay, on Slime and Baird Banks which lie along the Alaska Peninsula, and at the Pribilof Islands. This distribution along the southern edge of Bering Sea and on the western edge of the shallow part of the sea is correlated with the bottom temperatures there, as will be seen below.

The distribution is shown in Figure 10 for the North Pacific in a fashion similar to that of Figure 3 for the Atlantic.

CORRELATION OF DISTRIBUTION AND TEMPERATURE IN THE PACIFIC

The outstanding feature of the range of halibut in the Pacific is that it forms a huge triangle with one angle at the Island of Hokkaido, one in the eastern Bering Sea, and another off California. The isotherms at a depth of 100 meters (54.7 fathoms) (Schott and Schu, 1910) have a similar distribution, coming together at Hokkaido, spreading widely on the American coast. The temperature range from 1° C. to 8° C. on the Asiatic coast is between 45° N. and 40° N. latitude, between the southernmost of the Kurile Islands and the northern part of Honshu. The isotherms spread from there in a fan-shaped manner over the whole Pacific north of 40° N. latitude.

The same distribution of temperatures (Schulz, 1911, Plate 17) is shown on the surface, especially clearly in February, when the entire range of the halibut is included north of the isotherm for 10° C. The gradient from 0° to 10° is especially steep off Hokkaido. Here also is to be found the maximum seasonal range of temperatures (Schulz, 1911, p. 255), as much as 19°; whereas on the American side this range is about 7° C. The isotherms for February, after Schulz (1911, Plate 17, Figure 6), are reproduced in Figure 11 modified in the Gulf of Alaska according to McEwen, Thompson, and Van Cleve (1930).

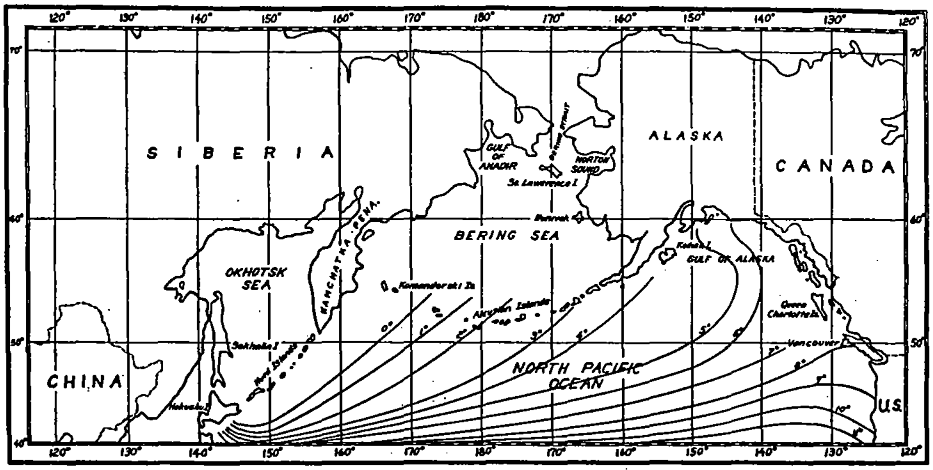

FIGURE 11.—Surface isotherms in the North Pacific Ocean north of 40° N. latitude taken from Schulz (1911), corrected in the Gulf of Alaska for temperatures taken by the International Fisheries Commission.

This may be compared with Figure 10 in which the halibut banks are shown. It is of course the bottom temperatures which should be correlated with this distribution, and the February temperatures for the surface are colder and the isotherms farther south than would be true of those for the bottom or for the remainder of the year. Nevertheless, the general characteristics of temperature and halibut distribution are the same. The rapid change with latitude on the Asiatic side is associated with a small productive area along a short coast line, the gradual change on the American with a great fishery along two thousand miles of coast. The coasts of Kamchatka and the Kuriles are paralleled by the isotherms from 0° to 2° C. on this arm of the triangle, and cold coastal water and winter ice prevail near there.

The temperatures are low, navigation being blocked by ice during much of the year. The water along these coasts is also exceedingly deep, leaving but narrow banks. The tides are very strong between the Kurile Islands, passing to and fro between the Okhotsk Sea and the Pacific. The latter sea, which projects into the cold Siberian land mass and which can communicate with the warm Pacific only over a ridge of the Kuriles, is arctic in character, especially in the shoaler northern half where at 50 meters depth subzero temperatures are found. It is unlikely that any large supply of halibut will be found there or along the Kurile Islands, although proof of this must await more thorough trial of commercial fishing. To date none has been reported.

These coasts present conditions which in the case of Labrador are relatively unproductive of halibut. But there a warm offshore current reaches the edge of the continental shelf and provides something of a fishery. Here this is lacking as far as has been determined to date.

This cold water along the coast to the north of Japan contrasts sharply with that to the south of Hokkaido. The sudden increase in temperature there (Schott and Schu, 1910) terminates the distribution of halibut with equal abruptness. As off the coast of California, so here a large flounder takes its place in warmer waters, accompanied by sardines, tuna, mackerel, and other species of a different life zone.

A careful correlation of distribution with temperature conditions is possible along the American coast. The banks are stretched with some regularity along 2000 miles of coast. They are not distributed among passages like those through which arctic water reaches the Atlantic. Extremely cold water does not alternate with warm; so that, although clear cut correlation between individual currents and the presence or absence of halibut banks is not found, as in the Atlantic, yet along this American coast, in what may be called one large unit, a simple, easily examined relationship exists. This allows a definition of the range of temperature tolerated by the halibut.

In Figure 9 the abundance of halibut, as shown by the catch per set of a standard unit of gear is given. As was indicated on page 38, this is of somewhat doubtful significance, because the fishery has so profoundly modified it. It was therefore necessary to reconstruct the original abundance. Even this is qualified in significance, because it is the result of complex biological and physical conditions. For instance, the rate of replacement varies widely in different areas, presumably with the rate of growth and with the effect of currents in carrying the young away, and abundance may mean in one place rapid reproduction, in another merely a slowly accumulated large stock. Abundance may be due to any or all of the factors affecting growth and mortality. For these reasons the correlation with temperature here shown is not given as a case of simple cause and effect.

The same areas along the coast as were used in Figure 9 to indicate abundance are used as a base for presentation of the bottom temperatures available throughout the range of the halibut. The division of the coast into areas has, however, been extended to area -6 which lies off San Francisco, hence to the south of the commercial fishery at Eureka in area -3. In each of these areas the records have been averaged according to depth and presented in Figure 12. The graph is so arranged that if the upper edge is placed parallel to the coast and the lower edge out to sea, then north and south and the scale of depths are in a position corresponding to those of the coastal shelf along which fishing occurs. Lines have been drawn through depths having similar temperatures.

These isotherms are based principally upon bottom temperatures taken by the United States Bureau of Fisheries steamer "Albatross," but those in areas 7 to 12 are based entirely upon data furnished by J. P. Tully of the Biological Board of Canada and T. G. Thompson of the University of Washington. After grouping by area, the temperatures were averaged by 30 fathom intervals. They were all taken during the late spring or summer between the last of May and early September.

As may be seen from the figure, the 8° isotherm lies nearly parallel to the coast along the 45-fathom line from area 2 off the Columbia River in

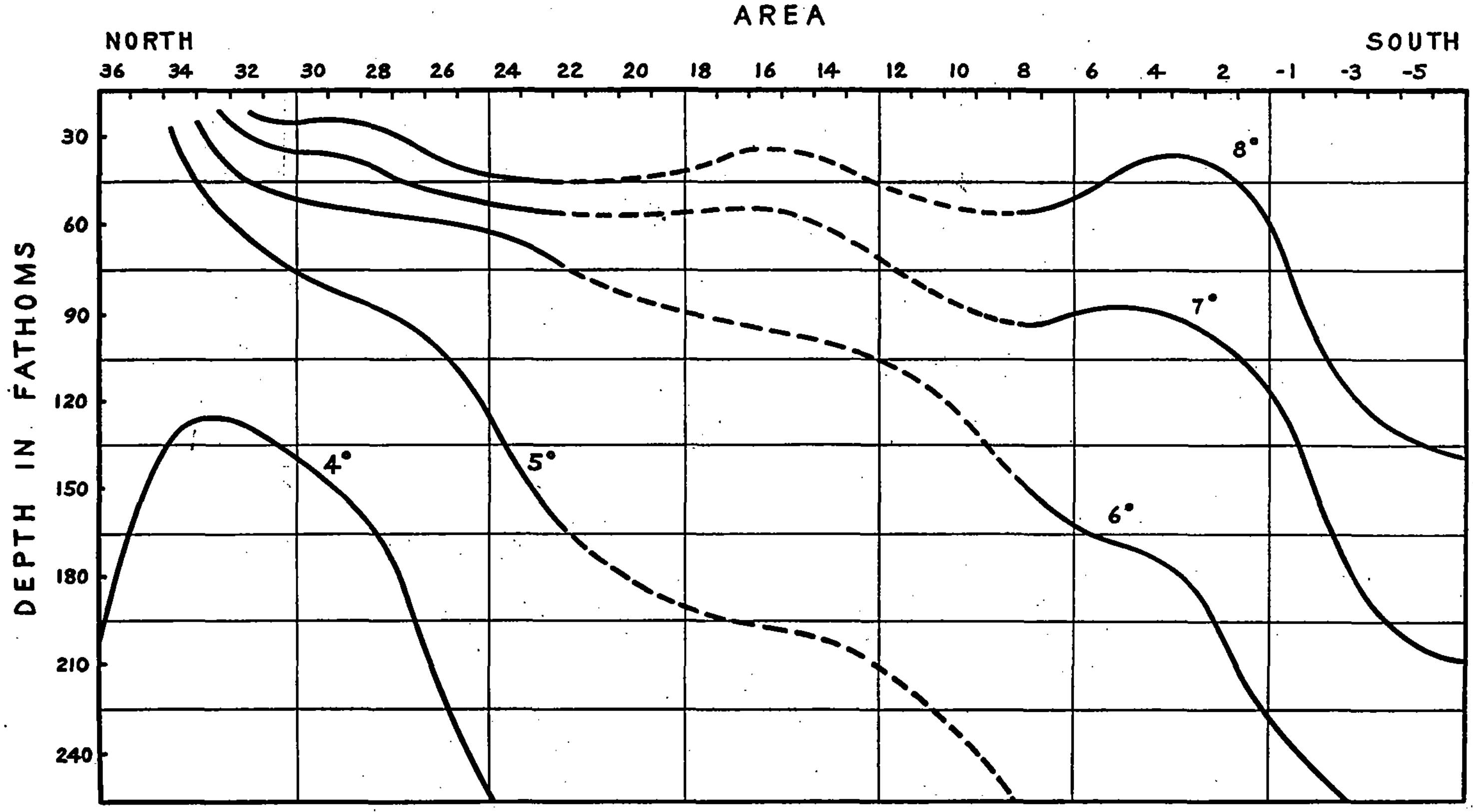

FIGURE 12.—Isotherms on the bottom along the Pacific coast of America. The area numbers are those shown in Figure 8. When held with the scale of areas along the coast, the depths take their proper relative positions.

latitude 46° N. to area 24 off Cape Cleare in latitude 60° N. and longitude 148° W. This indicates the very gradual change along the coast at this depth. Below this the change with depth in area 24 is more rapid than at area 2, falling to 4° C. at 250 fathoms in the former and but to 5.5° C. in the latter. A 4° isotherm rises to 120 fathoms in areas 33 and 34 at the entrance to Bering Sea, while the 5° isotherm approaches the surface. These areas are therefore the coldest part of the coastal banks south of the Aleutians. South of area 2 the higher temperatures tend rather abruptly to reach greater depths. Between areas 2 and 24 the bottom temperature in depths less than 100 fathoms therefore tends to be rather uniform, and at all depths less than 250 fathoms has a range of about 4° to 8° C. In fact, the fishing banks as a whole lie within the range 3° to 9° C., and although the seasonal change may depress the inshore temperatures from 8° to 6° or 7°, it does not greatly affect those in deeper water.

Bering Sea is more or less separated from the foregoing banks by the Aleutians. Since no commercial fisheries exist there, a correlation between abundance and temperature cannot be obtained. But records of occurrence are given for the banks along the northern side of the Alaska Peninsula, at the head of Bristol Bay, and at the Pribilofs. Because of these and because of the correlations found in the Atlantic and along the Pacific coast of

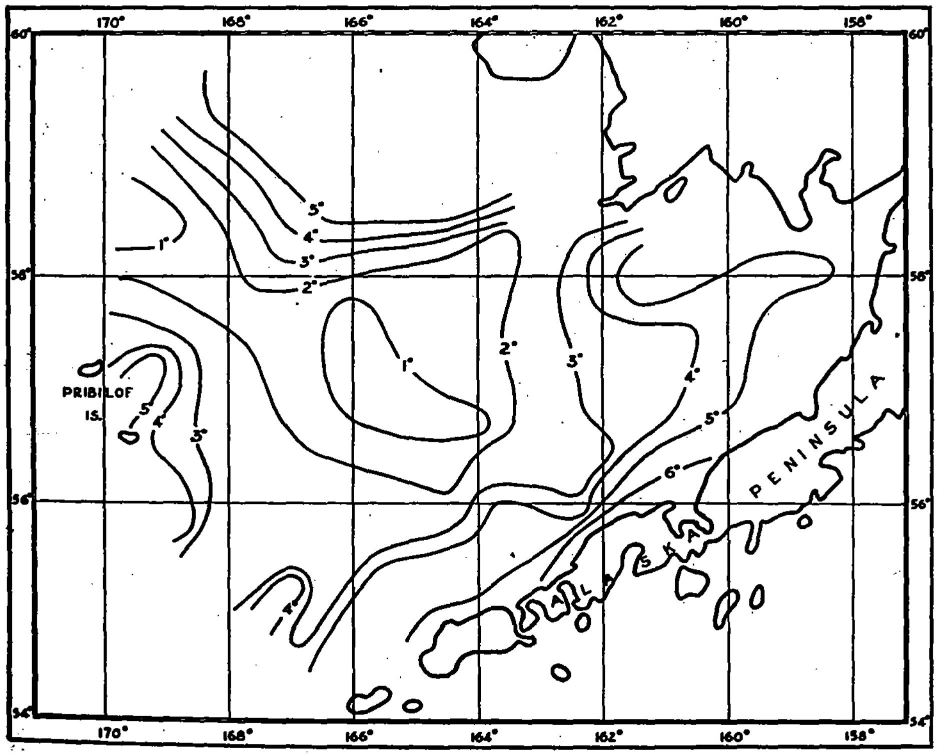

FIGURE 13.—Isotherms at the bottom in the southeastern Bering Sea. The isotherms are limited by the 100-fathom contour between the Pribilof and the Aleutian Islands. The bottom rises uniformly to the eastward from the 100-fathom contour to the shore.

TABLE 7[1].—*Bottom temperatures on the coastal banks within the range of the halibut fishery on the Pacific coast of Asia.*

Depth in Meters	A. East and North Coast of Hokushu Island					B. West Coast of Hokushu and Sakhalin Islands								C. South and East Coasts of Sakhalin Island					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
20	......	......	......	......	......	17.6	......	6.7	3.1	......	......	......	3.5	......	......	......	......	......	6.8
40	......	......	......	......	......	......	......	......	2.7	7.0	......	......	......	7.5	......	-0.1	3.0	......	1.1
60	16.3	......	......	8.0	......	......	10.0	5.8	2.7	......	......	......	......	......	4.7	......	......	0.0	......
80	......	5.8	......	......	......	......	......	6.4	3.0	......	7.3	5.3	2.2	-0.6	-0.3	......	......	1.5	......
100	12.8	......	......	......	7.3	......	......	6.4	......	......	......	......	......	-1.3	-1.0	......	......	-1.5	......
120	......	......	......	......	......	5.5	......	......	2.9	6.3	6.0	......	2.2	......	......	......	......	-1.5	......
140	......	......	2.6	......	......	......	5.3	5.3	3.1	......	......	4.6	2.2	......	......	-0.1	-1.2	......	-1.1
160	......	......	......	5.7	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
180	......	1.8	......	......	......	......	......	......	......	......	......	......	......	......	......	......	-1.0	......	......
200	10.8	......	......	......	......	......	......	......	1.9	......	......	......	......	......	......	......	......	......	......
220	......	......	......	......	......	......	......	......	2.1	......	......	2.1	......	......	......	......	......	......	-1.5
240	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
260	......	......	......	......	......	......	......	......	......	......	......	......	1.5	......	......	......	......	......	......
280	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
300	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1.1	-0.4	......	......
320	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
340	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
360	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
380	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
400	......	......	......	......	4.3	......	......	......	......	......	......	......	......	......	......	......	-0.8	-0.8	0.5

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[1] The sections as numbered here are explained in Table 8.

America, the physical conditions in the eastern Bering Sea are of great interest.

The bottom temperatures in the southeastern Bering Sea are shown in Figure 13, as obtained from "Albatross" records, supplemented by records north of the Pribilof Islands, obtained from T. G. Thompson. Depths are not shown. However, the 100-fathom line limits the isotherms on the southwest, and the sea shoals steadily toward the east. Places of equal temperature are connected by isotherms as was the case in Figure 12 for depths of equal temperature. They were taken during May, June, July, and August, 1890, and August, 1895 (U.S. Bureau of Fisheries, 1901). The effects of the warm water entering from the south are seen in the higher temper-

TABLE 8.—*Sections given in Table 7.*

No.	Locality	Date	Source
1	Hakodate to Oma Saki, 41° 43′ N., 140° 46′ E.	Sept. 28, 1928.	Japan. Imperial Fisheries Institute, March, 1929, Pl. 30.
2	South off Yerimo Zaki, 41° 46′ N., 143° 16′ E.	Aug. 12, 1930.	Japan. Imperial Fisheries Experimental Station, March, 1931, p. 22.
3	South off Kushiro, 42° 48′ N., 144° 24′ E.	Aug. 13, 1930.	Japan. Imperial Fisheries Experimental Station, March, 1931, p. 23.
4	Northeast off Mombetsu, 44° 29′ N., 143° 30′ E.	June 20, 1932.	Japan. Imperial Fisheries Experimental Station, Dec., 1932, p. 134, Sect. 74.
5	Northeast off Yesashi, 45° 03′ N., 142° 45′ E.	June 19, 1932.	Japan. Imperial Fisheries Experimental Station, Dec., 1932, p. 134, Sect. 75.
6	North off Rebun To, 45° 29′ N., 141° 06′ E.	July 31, 1930.	Japan. Imperial Fisheries Experimental Station, March, 1931, p. 109.
7	Northeast off Rebun To, 45° 29′ N., 141° 06′ E.	July 23, 1926.	Japan. Imperial Fisheries Institute, Dec., 1926, Pl. 15.
8	Southwest off Nishi Notoro Misaki, 45° 54′ N., 142° 05′ E.	July 23, 1926.	Japan. Imperial Fisheries Institute, Dec., 1926, Pl. 15.
9.	West off Soni Misaki, 46° 03′ N., 141° 53′ E.	May 31, 1931.	Japan. Imperial Fisheries Experimental Station, Nov., 1931, p. 79, Sect. 40.
10	South off Kaiba To, 46° 14′ N., 141° 16′ E.	July 31, 1931.	Japan. Imperial Fisheries Experimental Station, March, 1931, p. 109.
11	West off Kaiba To, 46° 15′ N., 141° 12′ E.	Aug. 9, 1931.	Japan. Imperial Fisheries Experimental Station, March, 1932, p. 84, Sect. 49.
12	East off Kaiba To, 46° 15′ N., 141° 18′ E.	May 31, 1931.	Japan. Imperial Fisheries Experimental Station, Nov., 1931, p. 79, Sect. 40.
13	West off Rakuma, 47° 11′ N., 142° 01′ E.	June 4, 1931.	Japan. Imperial Fisheries Experimental Station, Nov., 1931, p. 78, Sect. 39.
14	East off Nishi Notoro Misaki, 45° 54′ N., 142°09′ E.	Aug. 2, 1926.	Japan. Imperial Fisheries Institute, Dec., 1926, Pl. 15.
15.	West off Naka Shiretoko Misaki, 46° 02′ N., 143° 22′ E.	Aug. 2, 1926.	Japan. Imperial Fisheries Institute, Dec., 1926, Pl. 15.
16	East off Naka Shiretoko, 46° 02′ N., 143° 26′ E.	July 26, 1928.	Japan. Imperial Fisheries Institute, Jan., 1929, Pl. 19.
17	Northeast off Airo Misaki, 46° 52′ N., 143° 26′ E.	Aug. 4, 1929.	Japan. Imperial Fisheries Experimental Station, March, 1930, p. 165.
18	Southwest off Kaihyo To, 48° 28′ N., 144° 37′ E.	Aug. 4, 1929.	Japan. Imperial Fisheries Experimental Station, March, 1930, p. 165.
19	East off Kaihyo To, 48° 30′ N., 144° 39′ E.	Aug. 5, 1929.	Japan. Imperial Fisheries Experimental Station, March, 1930, p. 165.

atures along the northern shores of the Alaska Peninsula and around the Pribilof Islands. The warm temperatures found to the north of the Pribilofs lie on the shallow bank off the Kuskokwim River and are probably due to summer warming. The cold temperatures lie in a tongue of water extending down from the north above the Pribilofs in depths of 30 to 60 fathoms.

The correlation between these temperatures and the known occurrence of halibut is very interesting. The temperatures are, however, near the lower extreme of those which can be deemed favorable, and the prospect for any great abundance would seem to be very doubtful.

To the north of St. Matthew Island (latitude 60° N., longitude 172° W.), and up to Bering Strait, summer temperatures as low as –1° C. are found, extending at least as far as the north end of St. Lawrence Island in latitude 64° N. Along the eastern shore of Bering Sea the summer warming may raise the temperatures of the shallow coastal banks as high as 8° in some places. It is not impossible that some halibut may be found along these inshore banks, but since the warming is not due to incoming currents, as in the Barents Sea, cases parallel to this with which a comparison can be made are not available in the Atlantic.

Although a great number of hydrographic observations have been made in late years by the Japanese, most of the sections off Japan are carried no deeper than 200 meters and few deeper than 400. It is therefore possible to obtain only a relatively restricted idea of the distribution of bottom temperatures in the vicinity of the fisheries. As was indicated on page 39 the latter are not known to us with the precision which is desirable. In general, they lie around the island of Hokkaido, on its north coast, in the Sea of Nemuro, which lies between Hokkaido and the Kuriles, and on its southeastern coast.

The bottom temperatures from sections taken along the east and north coasts of Hokkaido during the summer are shown in Table 7A. The key to the localities is given in Table 8. Those off Hakodate, in Tsugaru Straits, are relatively high, and judging by what has been found elsewhere, are too high for anything but occasional migrants. More favorable temperatures are off Yerimo Zaki and Kushiro, although the temperatures in the deeper layers are evidently low, due to the cold current from the north which passes along the Kurile Islands to flow beneath the warmer waters of the Kuroshio. The most favorable temperatures are in the Sea of Nemuro off Mombetsu and along the north coast where they lie between 3° and 8° C. In the Sea of Nemuro, where the principal fisheries are said to be, the bottom temperatures in May, shown by Marukawa (1933, Figure 21), compare with those found in summer along the Murman coast in the Barents Sea. Summer temperatures are, no doubt, higher and still more favorable.

The temperatures in the Japan Sea along the northwestern coast of Hokkaido and the southwestern coast of Karafuto (Sakhalin) (see Table 7B) in places lie within the range wherein the greatest halibut fisheries of the North Atlantic are found. Nevertheless, we have been unable to find that any fishery is carried on in this region. P. J. Schmidt (1934) says halibut are never taken in the Japan Sea, but Hikita (1934) states that they are found along the entire west coast of Hokkaido. Other factors than temperature may be adverse.

Bottom temperatures along the south and east coasts of Sakhalin Island, below the depth of 60 meters (see Table 7C) are for the most part well below zero even in August and correspond to those along the western shores of Davis Strait where no halibut are taken. Farther to the north, in the extremely cold waters of the Okhotsk Sea, temperatures are still lower.

Temperature records are lacking along the western side of Bering Sea, and although P. J. Schmidt (1934) gives the northern limit of distribution as the Anadir River, no fisheries have developed. It would seem unlikely that they would be found in numbers in the cold southbound current along these coasts.

Correlation of the distribution of halibut seems in general to be, in the Pacific as in the Atlantic, with temperatures between 3° and 8° C. This seems to be clear enough on the American coast between California and Bering Sea, and to be indicated in Bering Sea from records of occurrence. On the Asiatic side the needed temperatures seem to exist wherever halibut fisheries are found, and in general the limits to their distribution are correlated with the rapid change within a short distance from the cold Okhotsk Sea and Kamchatka currents to the warm Kuroshio. From the available records it does not seem probable that the Bering Sea or the Japanese coast will produce halibut in the quantities characteristic of the American Pacific coast or of such regions as the Norwegian and western Greenland coasts in the Atlantic. The western Bering Sea and Okhotsk Sea are still less favorable. Exploration of these regions will be awaited with much interest. It may be that with the exhaustion of the more abundantly stocked banks even the less favorable regions may be made to produce. But at present the distribution of the commercial fishery for halibut conforms in general, in both Atlantic and Pacific, to that of the temperatures between 3° and 8° C. Since the temperatures are in general closely correlated with the ocean currents, these are briefly described in the following section.

III. CURRENTS OF THE NORTH PACIFIC

The Kuroshio or Japanese Current is the most important feature of the superficial water circulation in the North Pacific, just as the Gulf Stream is in the Atlantic. It has been known for many years from a variety of evidence. Vessels en route across the Pacific, especially as they approach Japan, meet with changes in temperature of the water which show the existence of a warm current from the south. These vessels are displaced on their courses by this current, and from these displacements the direction and speed of the currents have been calculated. Driftwood of kinds grown only in the Orient is cast on the American coast from Alaska to California. Japanese fishing vessels, which for one reason or another have been disabled, have been driven ashore after a long drift of a year or more across the Pacific. The most recent case was that of the "Reioyei Maru," its crew dead from starvation, which was sighted south of Cape Flattery at the entrance to the Strait of Juan de Fuca. Glass floats, of a pattern used only in Japan and bearing Japanese inscriptions, are taken in great numbers on every sandy beach in British Columbia, Washington, and Oregon. During the operations of the "Paragon," chartered by the International Fisheries Commission in the winter of 1934-35, the vessel was stormbound on the western coast of the Queen Charlottes, and two members of the staff (DeLacy and Chapman) found several hundred of these floats. There seems therefore to be no doubt as to the existence of a general eastward drift across the North Pacific, rcognizable as the Kuroshio or Japanese Current.

This Japanese Current, although well defined and rapid as it leaves the coast of Japan, becomes less so as it spreads over the Pacific. It is, however, perpetuated and driven on by the prevailing winds of this region.

These winds result from the interaction of a high pressure area called the "Pacific High," situated off the coasts of California some 800 miles on the average, and a low pressure area usually centered near the Aleutians, hence termed the "Aleutian Low." These are shown for a representative day in Figure 14. Their positions vary widely, however, from day to day and with the seasons, and the Aleutian Low may at certain seasons be dissipated. The circulation of air is, in the northern hemisphere, clockwise (anticyclonic) around a high pressure area and counter-clockwise (cyclonic) around a low. The result is, as shown in Figure 14, that between the two areas of different pressure the winds blow from west to east.

The observations given by the United States Weather Bureau for any given day are too few in number to clearly illustrate this point, because they are dependent on the number of transpacific vessels which happen to be in the district at the time. Moreover, the shifting position of the areas changes the direction of the winds at any one spot from time to time, so that it

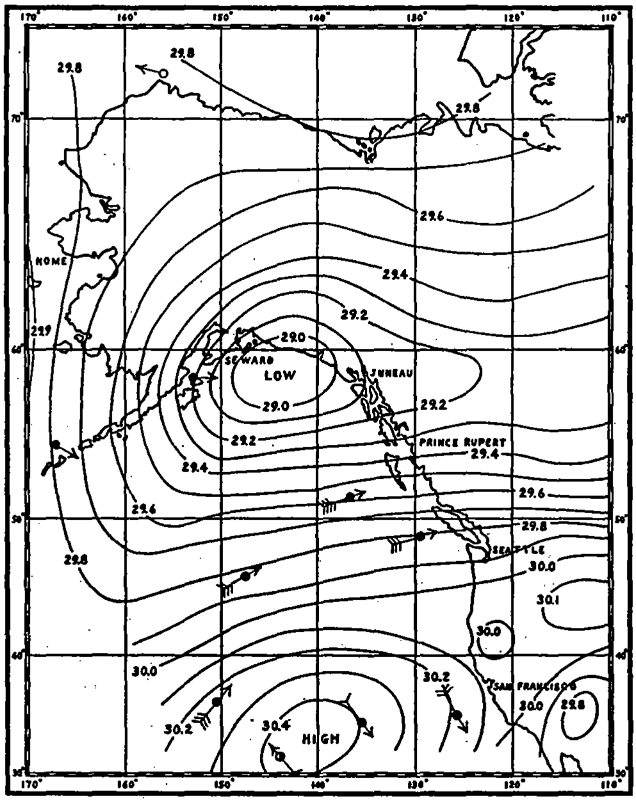

FIGURE 14.—The weather chart for February 11, 1935, published by the United States Weather Bureau, showing the centers of high and low atmospheric pressure and the direction of the winds in their vicinity.

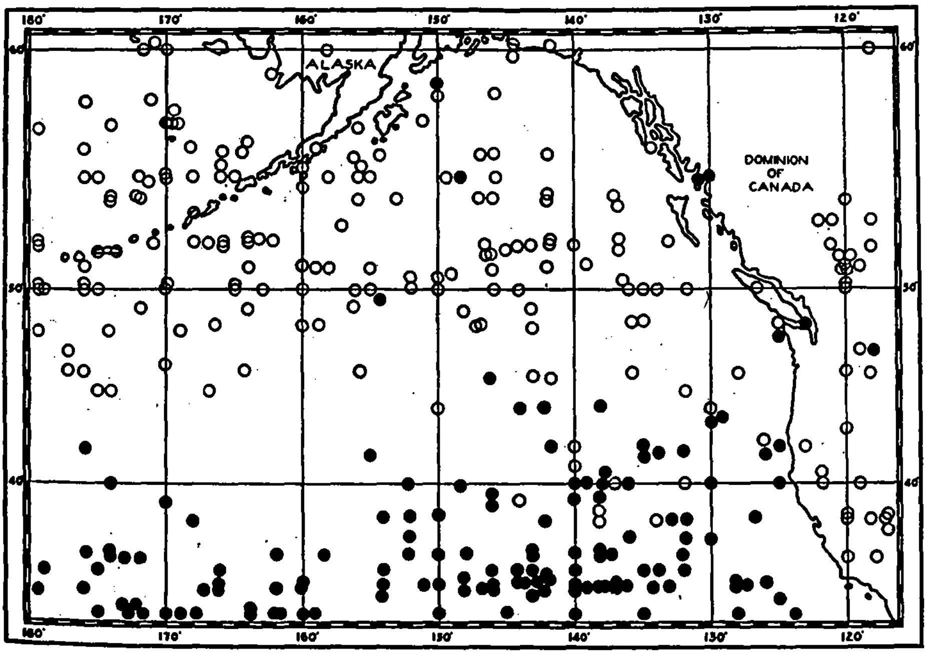

FIGURE 15.—The Pacific Ocean north of 32° N. latitude and west of 180° W. longitude. The semi-daily locations of the centers of high (dots) and low (circles) atmospheric pressures are shown for the period of March 26 to June 2, 1932, immediately following the release of the 1932 drift bottles. (From data supplied by the U. S. Weather Bureau).

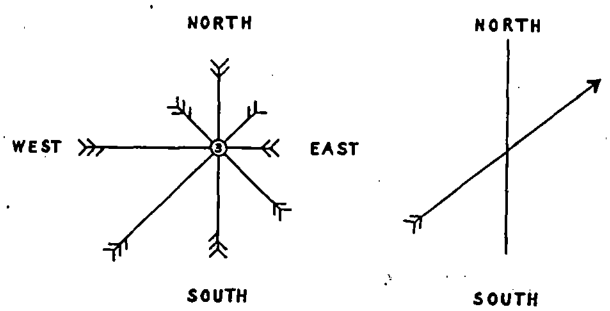

FIGURE 16.—A wind rose (left) as shown on the pilot charts published by the U. S. Hydrographic Office and the calculated resultant (right) wind movement and direction. The length of the arrow indicates the percentage of time during which the wind blew from that direction during the period in question. The number of feathers indicates the average strength according to the Beaufort Scale. The figure in the center of the circle to the left indicates the percentage of hours of calm.

becomes necessary to determine for each such spot from which direction the winds of greatest force and persistence come throughout each season. We have been unable to find in the literature anything which answers this purpose, nor has the Commission carried on any research with regard to these winds.

There are given, however, on the pilot charts of the North Pacific, published for each month by the United States Hydrographic Office, summaries of the wind observations obtained from ships and shore stations. They are grouped in rectangles of 5° latitude by 5° longitude and are recorded as the percentage of time during which the wind blew from each of 8 directions of the compass. The average force of the wind, according to the Beaufort Scale, is shown as the number of feathers on arrows. There is an arrow for each direction, and each varies in length according to the percentage of the total time during which the wind from each such direction prevailed. (See Figure 14 showing circulation around high area.)

For our present purposes we are, however, interested only in the net result of these varying winds, and it was necessary to determine what this net result would be after winds of contrary direction were balanced against each other. To do this the resultant winds were calculated[1] for each rec-

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[1] The technical methods used were similar to those described by Carruthers (1926) for the analysis of the results of current meter observations. The wind observations are given on the pilot charts as the number of hours in 100; i.e., the percentage of total hours observed during which the wind blew from or near to each of 8 directions of the compass. To calculate the resultant of these vectors each was weighted by multiplying by the corresponding average force of the wind. The residual direction and length (resultant) of all the weighted vectors was then computed for each three month season and for each 5° rectangle (Figure 16). The computation consists briefly of adding the vectors in each quadrant (i.e., northwest to northeast quadrant), then subtracting the sums of opposite direction to finally obtain residuals in the north or south and east or west directions. The resultant of these two vectors is then determined. This is divided by the weighted average of the wind force calculated from the pilot chart data. The quotient gives the resultant percentage of time, and the direction is the resultant of those of the original vectors. The resultant vectors are shown in Figure 17 in the same manner as on the original pilot charts. The lengths of the arrows, which fly with the wind, are proportional to the percentage of time of prevalence, and the number of feathers on the arrow gives the average force of the wind according to the Beaufort Scale. The use of the figures of the Beaufort Scale for weighting the vectors may be criticised for its lack of accuracy because of the variable forces represented by consecutive figures in the scale. However, the use of the pilot chart data and the results desired preclude any attempt at greater accuracy.

tangle for the four seasons, three months being combined in each. The winter season was taken as December, January, and February, the others accordingly. This procedure, whatever the inadequacies in data which it ignores, illustrates the dominance of winds from west to east between the high and low pressure areas.

There is shown in these charts (Figure 17) the Pacific high pressure area with its accompanying anticyclonic winds. It moves north in summer, south in winter. In winter (December, January, and February) the center

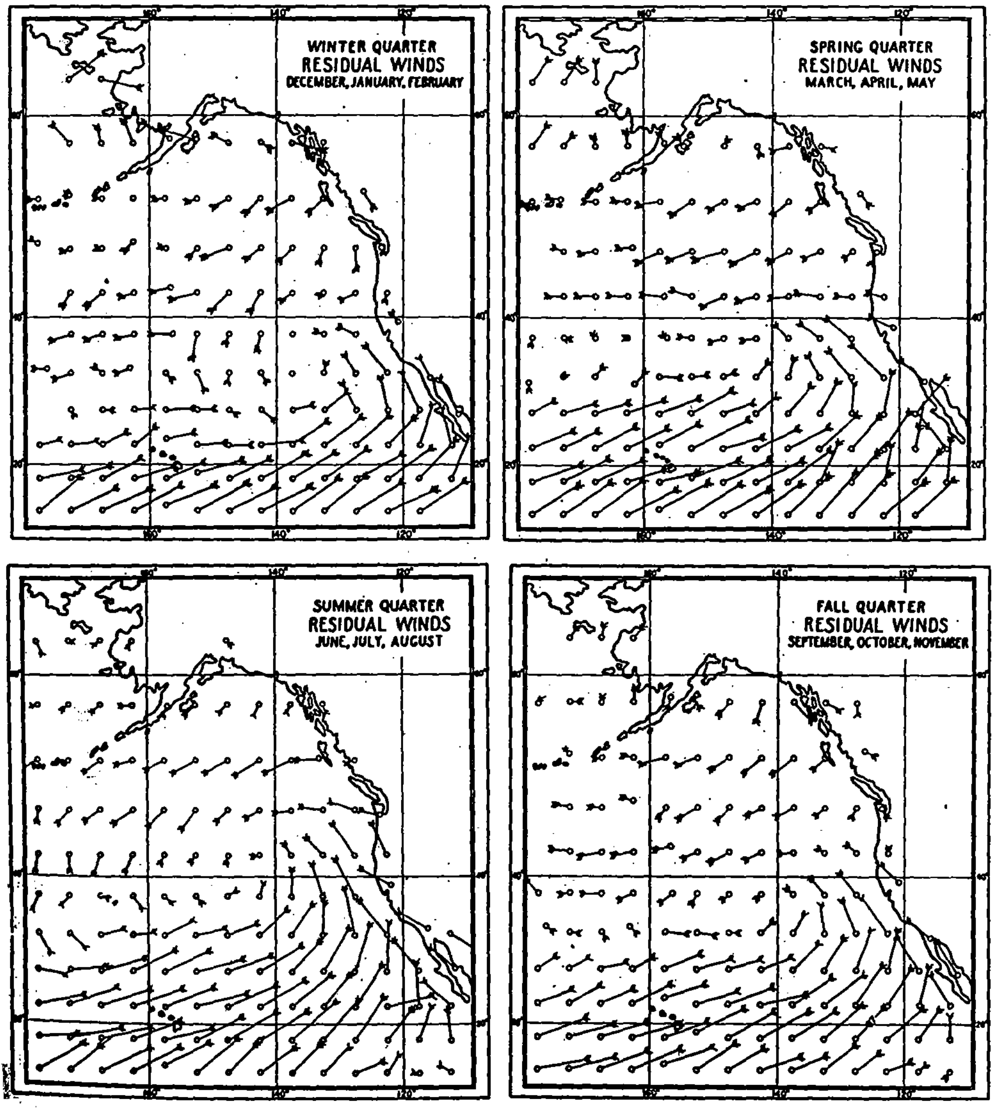

FIGURE 17.—The Pacific Ocean north of 10° N. latitude and east of 170° W. longitude, showing the residual winds calculated for the four seasons from the data given on the pilot charts published by the U. S. Hydrographic Office. The length of the arrows is proportional to the resultant drift, while the number of feathers on the arrows gives the average force according to the Beaufort Scale.

of these winds is 36° N., 138° W.; in spring it is less well defined but in the same latitude and westerly of 144° W.; in summer 40° N. and 144° W.; in fall 38° N. and westerly of 142° W.[2] The Aleutian low pressure area is not clearly shown by these charts, perhaps because of the disturbing influence of the continents, and the variability in its position from day to day. All that can be said is that it is in the vicinity of the Aleutians and the Alaska Peninsula.

The variability in position from day to day of the centers of low and high pressure is shown in an interesting manner by the daily charts issued by the United States Weather Bureau, on which are given the telegraphic reports received from ships as to wind and barometric pressure. These are the only available records which can be used to illustrate day by day variability. On each chart the centers of the low and high pressure areas are given according to the judgment of the Weather Bureau officials. In Figure 15 these centers are shown for the northwest Pacific during the two months following the drift bottle releases by the International Fisheries Commission in March, 1932. The low pressure centers are shown as circles, the high as dots. The definite positions given to these pressure centers in the preceding paragraph are hence an average for the given season. It is evident that the two distinct regions in which the two types of centers are found are separated by a zone some 500 miles wide, trending across the Pacific somewhat north of east. Even though much accuracy cannot be expected of such day by day estimates, this zone does illustrate the reason for a predominance of west to east winds, and the persistence of the Kuroshio.

The onshore winds of this zone divide into northerly and southerly winds near the American coast. During the winter quarter (December, January, and February) the southerly component is the greater as far north as 40° N.; in spring, 42° N.; in summer, 52° N.; and in the fall, 45° N. It is these southerly winds which vary most strikingly in latitude with the season, in sympathy with the shifting of the California trade winds on the southeasterly side of the Pacific high pressure area. The winds along the coast to the north of the latitudes given above have a northerly component in all seasons, but in summer they seem very indeterminate in the Gulf of Alaska.

In accord with these winds the Japanese Current divides[3] as the coast

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[2] According to Schulz (1911), the location of the Pacific high pressure area is in winter 30° to 40° N. and 130° to 140° W.; in summer 35° to 45° N. and 140° to 155° W.

[3] Davidson (1869) estimated this division to be at about 46° to 50° N. latitude, and 148° W. longitude. Schott and Schu (1910), in an analysis of water temperatures over the entire Pacific Ocean, indicated the course of the Japanese Current across the North Pacific by the course of the isotherms. The isotherms of 10° to 15°, spreading out as they approached the west coast of North America, indicated the splitting of the current, and the isotherms for temperatures of less than 10° C. were found to bend northward around the Gulf of Alaska. Schulz (1911, pp. 242-246) states the division of currents to take place at 140° W. longitude and 49° N. latitude in July and September, 40° N. in winter, and 43° N. in April to June. Schulz used data from ships' logs as to wind, water temperature, and current displacements. He had no data north of 53° N. in winter, but believed from the character of the winds and the trend of the isotherms that the Alaska Current was present in winter as in summer (p. 242) and not, as has continued to be shown until recently on pilot charts of the Pacific, easterly in winter along the coast of the Alaska Peninsula. (See also Thorade, 1909, Plate 5, No. 4.) McEwen, Thompson, and Van Cleve (1930), from hydrographic sections made in January, showed the Alaska Current present and westerly in direction during the winter. McManus (1934), analyzing the current data on the Northeast Pacific collected between 1904 and 1924 by the Hydrographic Office of the United States Navy, shows on his charts the presence of northerly and westerly currents around the Gulf of Alaska throughout the year.

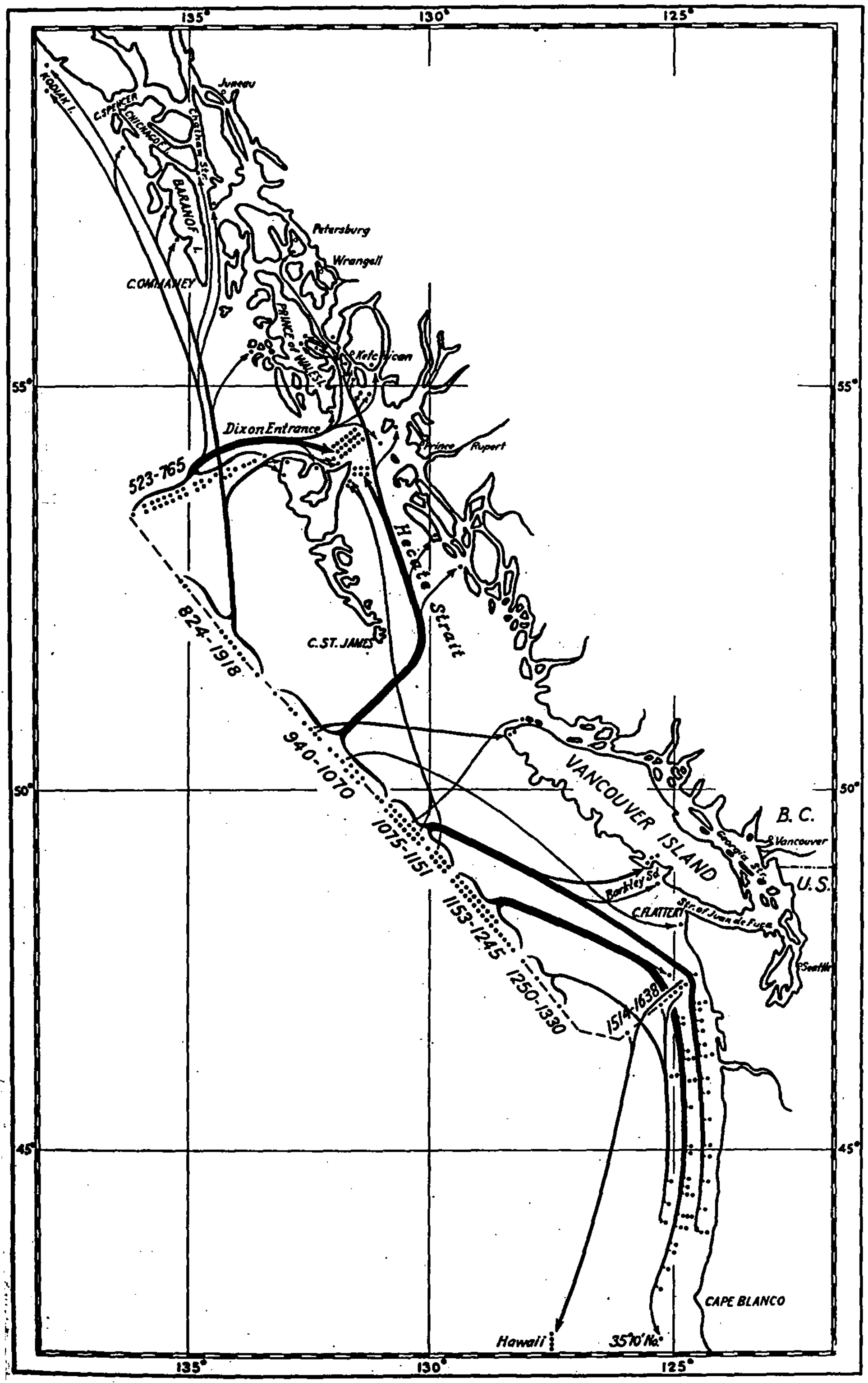

FIGURE 18.—Returns from the drift bottles released between July 30 and August 2, 1931. The width of each line is proportional to the number of bottles following that path, and the arrows indicate the direction of drift. The number of dots represents at one end of each line the number of bottles recovered from the experiment from which the arrow arises, and at the other end the number of bottles recovered in one locality.

is reached, carrying warmer water into the Gulf of Alaska and forming the California Current which flows south.

The point of division of the Alaskan and Californian branches of the Japan Stream has been very clearly shown by the drift bottle experiments carried on by the Commission the last of July and first of August, 1931 (Figure 18). These bottles were released along a line roughly paralleling the coast about 100 miles offshore. The returns showed that these bottles were separated by the currents into three divisions: one north of 51° 30′ N. from which recoveries were made to the north; one between 50° and 51° 30′ from which recoveries were made to the north but also in Hecate Strait and its adjoining waters; and one south of 50° from which recoveries were made to the south, off the coasts of Washington and Oregon and even Hawaii. The division is, then, at 50° N. in August.

The drift bottle experiment of March, 1932, the results of which are shown in Figure 19, with the same locality of release, showed that bottles as far south as 47° were carried north, and that the division was accordingly well south of that latitude. This compares well with the winds of the period March to May (Figure 17). Recoveries were made as far as Kodiak Island, showing the presence of the Alaska Current during the spring months.

Similar experiments, carried on in the Gulf of Alaska north of 58° N. begun in March to June of 1930 (Figure 20), January, 1933 (Figure 21), and in January and February, 1934, indicate clearly the existence of the northerly and westerly Alaska Current during both winter and summer, hence in all seasons of the year. The Alaska Current passes west along the coast of the Alaska Peninsula and even into Bering Sea through the Aleutian passes. Whether it contributes finally to the returning stream of the Kuroshio, joining as the latter approaches the Aleutians, does not seem to have been determined.

This Alaska Stream, or great eddy, has been known since the work of Davidson (1869). Dall (1875) reported strong westerly currents along the southwest shores of the Alaska Peninsula, but he pictured the currents as flowing south throughout the Gulf of Alaska. However, in 1899 he gave in his work on the mollusks of the Pribilof Islands a chart of the currents of the Northeast Pacific which agreed in all points with Davidson's description. Schulz (1911) states that the westerly current along the Alaska Peninsula attains a velocity of one-half to three-fourths knots.

Lack of detailed information concerning the surface currents in the Gulf of Alaska throughout the winter months during which the halibut spawn, as well as a complete lack of data on the sub-surface currents, led to the institution of a brief hydrographical survey that was carried out in 1927, 1928, and 1929 by the Commission.

The 1927 and 1928 work was based upon one short hydrographic section run in January, 1927, south from Ocean Cape to just beyond the edge of the bank, and three similar sections run in January, 1928; the first, south from

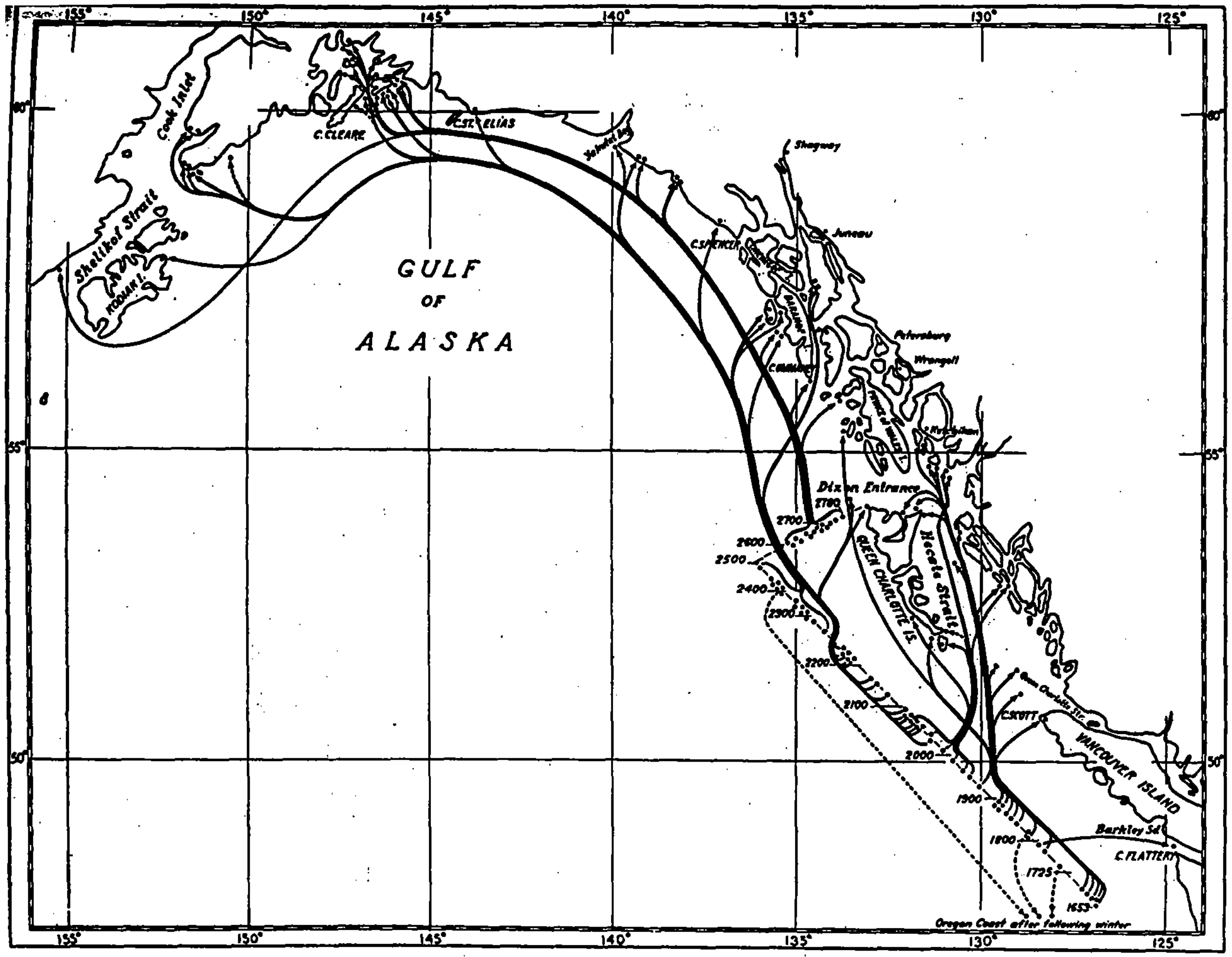

FIGURE 19.—Drift as indicated by the returns from the drift bottles released between March 22 and 25, 1932.

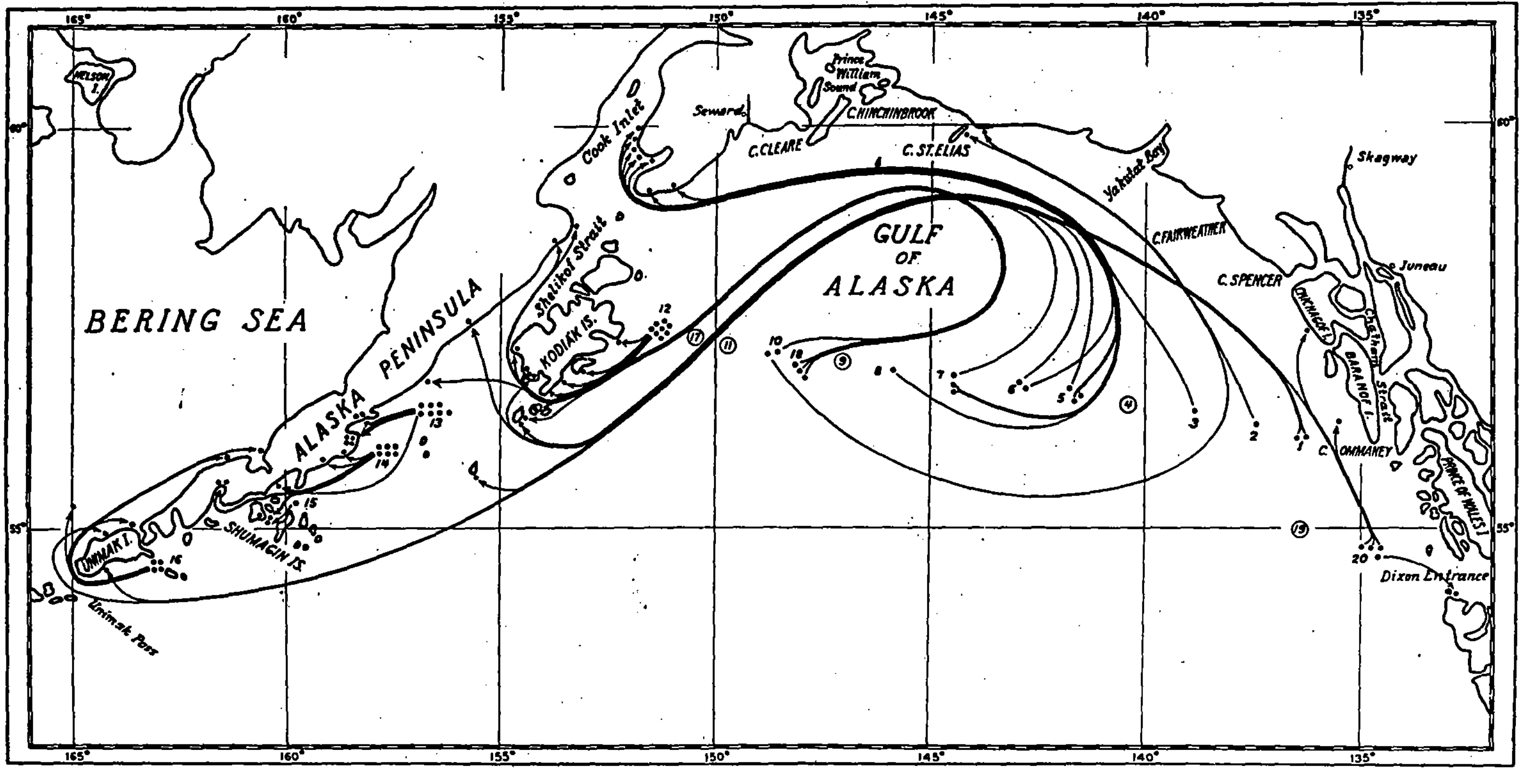

Figure 20.—Returns from the drift bottles released between May 19 and June 23, 1930.

Ocean Cape; the second, southeast from Cape Cleare; and the third, east-southeast from Cape Chiniak. Analysis of the data (McEwen, Thompson, and Van Cleve, 1930) indicated a predominant flow to the westward which was strongest just outside the edge of the banks where the greatest numbers of eggs and larvæ were found in the 1928 net hauls.

In January, 1929, the three hydrographic sections were extended farther out into the Gulf, 224 miles on the Ocean Cape section, 234 miles off Cape Cleare, and 175 miles off Cape Chiniak. The results of this survey (Thompson, McEwen, and Van Cleve, MS.) showed a definite westward current just over the edge of the continental slope at the Ocean Cape and Cape Chiniak sections, reaching a velocity of .8 and 1.1 knots respectively at the surface. At Cape Cleare a westward current of .3 knots was found about twenty-five miles outside the "edge" increasing to .44 knots twenty miles farther out, while an eastward surface current of .73 knots was found along the edge. While the currents throughout all sections varied in direction from west to east, the westward currents predominated and extended down to depths of 600 to 1200 meters just off the edge. The variation in direction throughout the sections indicates, however, that the currents in this region are quite complex and are not as simple as previous reports indicate.

The Alaska Current, after its division from the California Current, is deflected to the right into the passages of British Columbia and Southeastern Alaska. Haight's investigations (1926) of the currents in the inside passages of Southeastern Alaska show a non-tidal current flowing to the north and northwest in Chatham and Clarence Straits. The drift bottle experiments of the Commission indicate entry of this current, first, into Hecate Strait and Dixon Entrance, then into Clarence Strait, and second, into Chatham Strait. No recoveries were obtained in the Strait of Juan de Fuca, or in Icy Strait, and recoveries were not obtained in Dixon Entrance in the March, 1932, experiment when the northward drift on the outside coast seemed most pronounced. This would seem to indicate entry of water into Hecate and Chatham Straits, and an outflow from Juan de Fuca and Icy Strait, with a reversal according to season in Dixon Entrance.

In its passage the Alaska Current forms a smaller secondary eddy in latitude 58° N., longitude 148° W., as is evidenced by the drift bottles (p. 170), by the presence of offshore winds there with southerly components in winter and spring quarters (p. 53, figure 17), and as will be shown later, by the distribution of halibut eggs in these seasons.

We have no data as to the amount of water carried into the eastern Bering Sea either by diversion from the Kuroshio as it approaches the western Aleutians or from the westbound Alaska Current through the passes of the eastern Aleutians. Presumably the temperate water around the Pribilofs is from the Pacific, while the temperate southeastern edge of the sea is warmed to some extent by the water from the Gulf of Alaska Current.

The currents on the Asiatic side of the Pacific, in their modification of temperatures there, are of importance from the standpoint of distribution

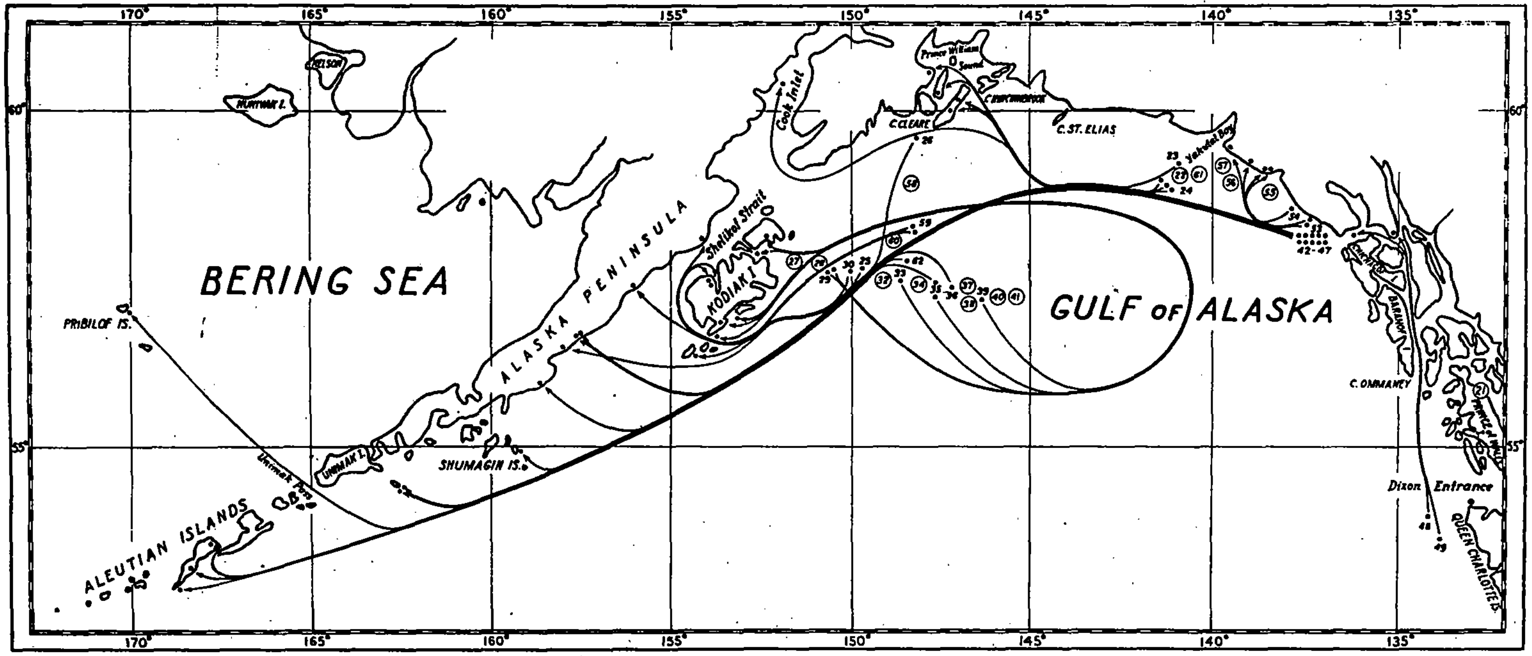

FIGURE 21.—Returns from the drift bottles released between January 3 and March 7, 1933, and January 9 and February 25, 1934.

of halibut. The western Bering and Okhotsk Seas are arctic in character, and from them cold currents follow the coasts of Kamchatka and Sakhalin Island to the island of Hokkaido. Here they meet warmer currents and form an intermediate belt of cool water. The Kamchatka Current is most pronounced in winter and at that season meets the Kuroshio off the coast of Hokkaido. In summer the cold water of the western Bering Sea is said to be overlaid by northward flowing warmer water, a reversal of the Kamchatka Current. The cold current from the Okhotsk, which follows the eastern coast of Sakhalin Island, meets a warmer current entering La Perouse (Soya) Strait from the Japan Sea. The northern shore of Hokkaido is therefore intermediate in temperature, but the temperature gradient is abrupt, because it is between the Kuroshio and the cold southbound currents. The extent of coast favorable to halibut is accordingly small compared to that on the American coast.

IV. HALIBUT EGGS AND YOUNG[4]

A complete series of halibut eggs, larvæ, and postlarvæ has been obtained during the eight seasons of work from 1927 to 1934. From these the life history of the halibut from spawning to the assumption of bottom life has been traced. Most of the material has come from the northern and western parts of the Gulf of Alaska, the number of spawning adults on the southern more depleted banks being too few to enable a complete story to be written.

The material has been preserved in formaldehyde. Ova were taken both from the plankton and directly from the spawning fish. The plankton was secured during the seasons from 1926 to 1934, and killed in 3 to 4 per cent formaldehyde. It was sorted as soon thereafter as possible, and the separated eggs were examined, measured, and permanently preserved in the same solution.

A. HALIBUT OVA

The halibut ova, taken in the plankton during the several seasons, numbered 2824. Of these, 2049 have been measured. They range in size from 2.90 mm. to 3.80 mm., averaging 3.273 mm. (See Table 10.) Their identity has been proved by comparison with ova taken from spawning females.

They contain a comparatively large yolk, and the perivitelline space is very small (Figures 22 and 23). Though the yolks showed considerable shrinkage after preserving, the average size of 1970 ova from the 1928 net hauls was 3.31 mm. outer diameter compared to a yolk diameter of 2.95 mm. Better values for the relative sizes of yolk and ova were obtained from measurements taken during an experiment in artificial rearing during the winter of 1934. The average diameter of 166 of these ova, measured within a few days of preservation, was 3.331 mm., while that of the yolks of 79 of them was 3.175 mm.

The yolk is colorless and devoid of oil globules in living ova. After

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[4] In the description of the larval and postlarval stages which follow, the terminology has been adopted from Goodrich (1904, p. 465), and Whitehouse (1910a, p. 134). Many of the terms used are found in dictionaries and textbooks or are sufficiently obvious from the context. Because they are not readily found, the following words are defined here for the benefit of the non-technical reader.

Actinotrichia: Delicate unjointed and usually unbranched rays found in the embryonic fin and at the distal free edge of the adult fins of living bony fishes, sturgeons, etc. (Teleostomi).

Lepidotrichia: Dermal fin-rays, jointed and branched, or modified into unjointed simple fin-spines. They are developed characteristically in the adult and are distinct from the actinotrichia in origin.

Epural: Any skeletal element lying above the axis of the skeleton, directly connected with the vertebral column, and supporting one or more caudal fin-rays distally.

Hypural: Skeletal elements corresponding to the epurals, but lying ventral to the vertebral column.

Caudal radials: Those elements not directly connected with the vertebral column, yet bearing caudal fin-rays. They are dorsal or ventral according to their relationship to the vertebral column.

Pterygiophore: Internal skeletal element supporting a median fin-ray and consisting usually of a primitively three segmented radial, often fused or modified.

preserving, a number of small oil droplets, irregular in size, may separate from the yolk and collect around the edge of the embryo, but these are seen only in the eggs containing embryos well past the stage of closure of the blastopore.

The outer surface of the ripe ovarian egg, when observed under a high powered lens by reflected light without a covering liquid, appears to be punctured by numerous small holes, giving it a honeycombed appearance (Figure 27). The shell, when removed and mounted, appears clear and glass-like, without other than the minute honeycombed structure. The only structures which might be the "stellate cross hatching" described by McIntosh as characteristic of the shell of the egg of the Atlantic halibut appear rarely as lines of varying length, irregularly spaced; and in the examination of 2815 ova no specimen has been found with a regular cross hatching. The lines are superimposed upon the honeycombed structure and seem to be artifacts, seldom present.

The micropyle is simple, and the shell presents no special markings in its vicinity.

The embryo shortly before hatching is colorless (see Figure 23), and in preserved specimens the eyes of even the oldest are unpigmented. The yolk is so large that the largest embryos do not completely encircle it.

Halibut eggs have previously been described by Brook (1886a), McIntosh (1892), Williamson (1911), and W. F. Thompson (1915) from spawning fish. Brook stated the maximum diameter to be 4.25 mm. The range of diameter given by McIntosh was from 3.07 to 3.81 mm., and that given by Williamson was 3.00 to 3.35 mm. Thompson gave the range as 3.3 mm. to 4.2 mm., and the average as 3.671 mm. The diameters given by Brook and Thompson agree, but in both cases the fish from which the ova were taken were dead; the ova were placed in sea-water and may have swollen abnormally both in the sea-water and the preservative. The measurements of McIntosh and Williamson agree with those given above.

There is, however, considerable variation in the ova taken in different years and in different regions, and also according to the time in preservative before measurement. Those taken directly from the fish do not correspond exactly to those taken in the plankton. The variation of the size of ova with the size of the fish from which they are taken has not been investigated.

The average size of 588 ova taken from a live spawning fish November 23, 1926, and preserved in formaldehyde and sea-water ranged from 2.05 to 3.85 mm. and averaged 3.17 mm. The size frequencies are shown in Figure 24, compared with those of halibut ova taken in the plankton. The average of the former is 0.1 mm. less than that of the latter. The smaller sizes, below 2.85 mm. in diameter, are plainly immature, and it is probable that the lower average size of ova from spawning fish as compared to those from plankton is due to a certain degree of immaturity. However, size and all other characters prove the identity of the plankton eggs.

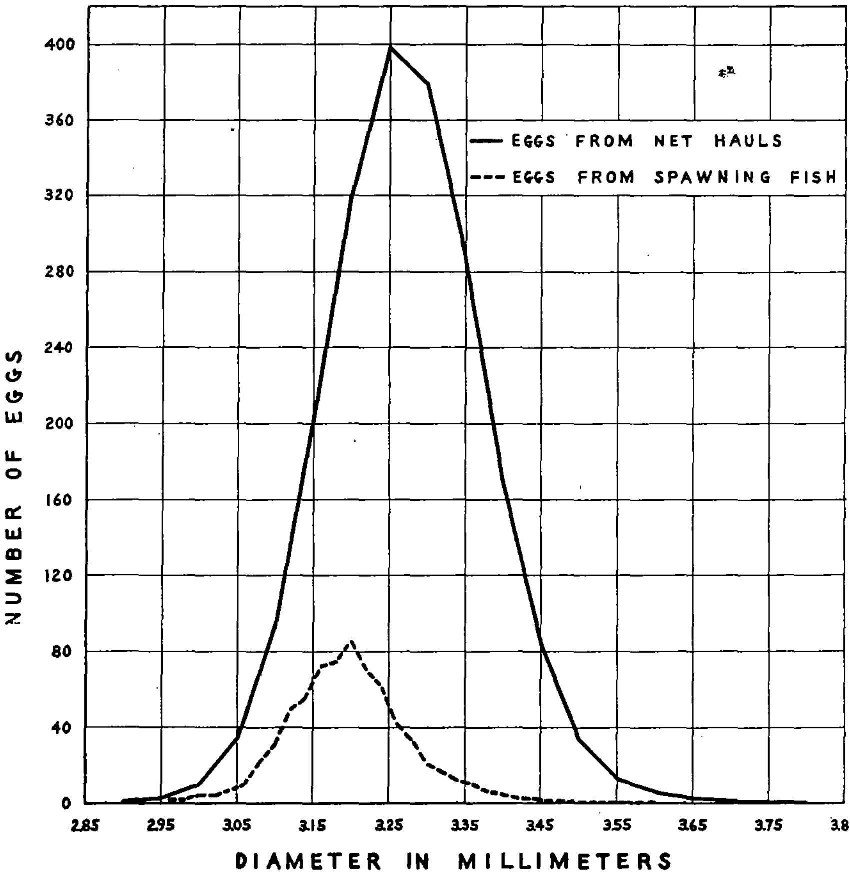

FIGURE 24.—Size distribution of 2044 halibut ova taken in the net hauls and of 711 ova taken from spawning fish on Yakutat Bank, November 23, 1926.

Due to the character of the program necessary, measurement of the eggs at a definite time after preservation was not possible, although exactly the same technique and equipment were used throughout the investigation. This difference in time undoubtedly has led to a variation in size. In the case of the ova taken during 1933, the eggs were all measured as soon as they were sorted from the net hauls in the spring of 1934. Later on, in August, 1934, they were measured again. These two measurements gave the results shown in Table 9, where the differences between the averages obtained are about .03 mm. for those taken in the vicinity of Portlock Bank and .05 mm. for those taken near Middleton Island and .06 mm. for the "W" to Yakutat Banks. The standard errors of the differences are equal to .01 for all three. Although the yolks showed considerable shrinkage, this was not investigated.

The present material is therefore insufficient to determine the variation in size of the ova with the season or locality. The observed variations shown in Table 10, should for this reason be accepted with caution. Thus five halibut ova taken off the coast of Baranof Island, Southeastern Alaska, in

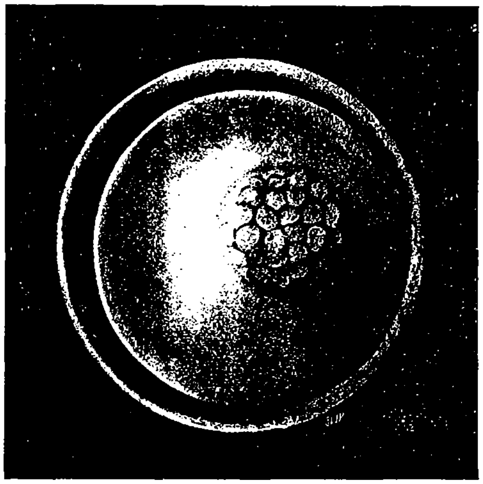

FIGURE 22.—Halibut ovum in an early stage of development showing the germinal disc in about the 16-cell stage. 21 times natural size.

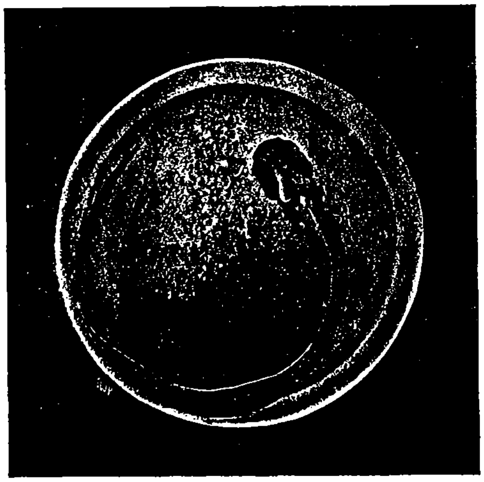

FIGURE 23.—Halibut ovum showing the embryo shortly before hatching. 21 times natural size.

TABLE 9.—*Comparison of two measurements of the 1933 halibut ova made six months apart to show the effects of preservation. The means are shown with* σ_m

Locality in Which Eggs Were Taken	Means of Measurements Made in March, 1934	Means of Measurements Made in August, 1934	Difference Between Means	Standard Error Difference
Portlock	3.169 ± .010	3.140 ± .008	.029	.013
Middleton	3.214 ± .008	3.161 ± .010	.053	.013
W and Yakutat	3.243 ± .007	3.178 ± .011	.065	.013

TABLE 10.—*Size distributions of halibut ova by years.*

Diameter Mm.	Year						Total
	1926 and 1927	1928	1929	1933	Northern 1934	Southern January, 1934	
2.90	....	....	....	1	....	....	1
2.95	....	....	....	....	....	....	....
3.00	....	....	....	2	2	....	4
3.05	....	3	2	4	2	5	16
3.10	3	9	13	15	1	6	47
3.15	4	75	33	28	3	17	160
3.20	6	110	64	81	16	72	349
3.25	10	417	15	39	9	32	522
3.30	19	322	19	37	8	22	427
3.35	10	261	9	12	5	7	304
3.40	19	93	2	5	....	4	123
3.45	9	42	....	....	....	2	53
3.50	15	5	....	....	....	....	20
3.55	5	1	....	....	....	....	6
3.60	7	....	....	....	....	....	7
3.65	1	....	....	....	....	....	1
3.70	3	....	....	....	....	....	3
3.75	....	....	....	....	....	....	....
3.80	1	....	....	....	....	....	1
Totals	112	1338	157	224	46	167	2044
Means	3.388	3.288	3.207	3.219	3.223	3.224	3.273
σ_m	0.013	0.002	0.006	0.005	0.012	0.006	0.002

March, 1930, were not measured until the spring of 1934. Though plainly halibut eggs, their diameters vary from 2.60 to 2.96 mm. The small diameter is most probably due to shrinkage. A locality or time difference does occur, but the present material was not gathered or measured with this particularly in mind.

Halibut ova may be separated from most of the other ova occurring in the pelagic plankton by size alone. Measurements of 915 ova from four of the 1928 net hauls gave a difference of 1.1 mm. between the diameter of the smallest halibut ovum and that of the largest of the other eggs in the same net haul. However, the eggs of at least three other species of fish have been discovered which are as large as, or larger than, those of the halibut. Since the time of spawning of two of these species evidently coincides in part with that of the halibut, some care in identification is necessary.

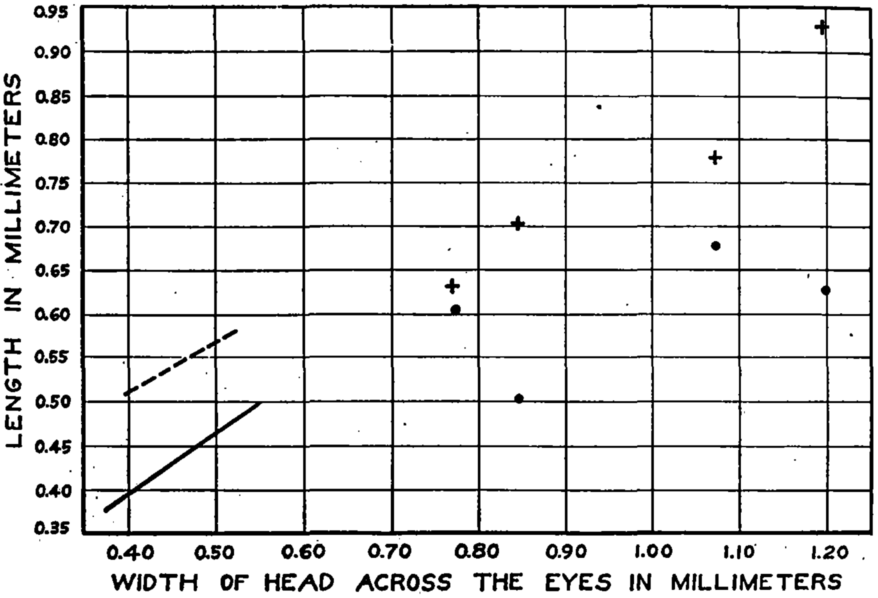

FIGURE 28.—Comparison of the heads of halibut and Type A embryos. The solid line and dots representing the halibut and Type A embryos respectively show the relation between the distance from the anterior end of the brain to the posterior border of the eyes and to the width of the head across the eyes. The dashed line and crosses represent the distance from the anterior end of the brain to the posterior edge of the optic lobes as plotted against the width of the head across the eyes of the halibut and Type A embryos respectively.

One ovum was taken in haul No. 306 C in 1930; four in 1932, one in each of hauls No. 659 A and 663 B and two in 660 B; and three in 1934 hauls No. 1032, 1050, and 1141, all of which evidently belong to one species. They may be designated as of Type A (Figure 25). They are on the average smaller than but yet so similar to the halibut ova in size that they might easily be mistaken for such. Their outside diameters vary from 2.80 to 3.10 mm., averaging 2.98 mm., and that of the yolks still remaining on the embryos from 2.24 to 2.88 mm. The embryos are pigmented, and chromatophores are also scattered over the yolk. The oldest halibut embryos are not pigmented. The embryos differ from the halibut in form, size, and degree of development attained; but they differ most in the form and size of the brain, in the position of the eyes, and in the development of the fins. The eyes are set well forward, giving the anterior end of the head a broad, blunt appearance, while the eyes of the halibut embryo lie on either side of the head well back from the anterior end of the brain. Figure 28 demonstrates these differences clearly. The size of the brain of the largest halibut embryo falls well below that of the smallest of the others of Type A, which is at the same time less well developed. The myotomes are in the vicinity of 110 or more in number, while those of the halibut are about 50.

In the oldest Type A embryo the anterior ray of the dorsal fin has become modified into a long filament which is over two-thirds as long as the specimen. A pigmented tassel-like knob is developed at the tip, and an

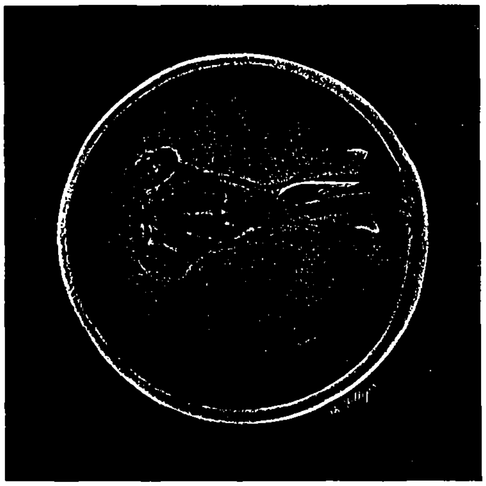

Figure 25.—Type A ovum. 17 times natural size. The anterior ray of the dorsal fin is noticeably lengthened and before hatching develops into a long filament bearing enlarged pigmented knobs.

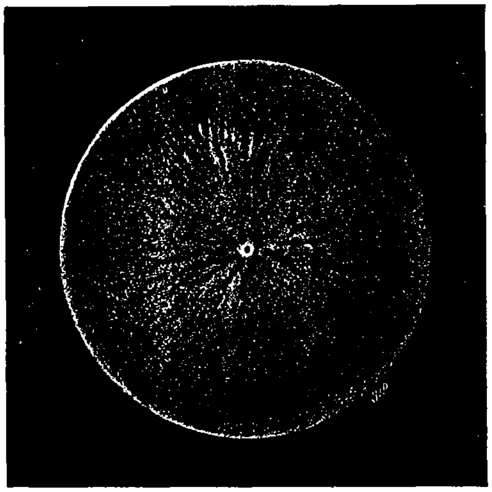

Figure 26.—Type B ovum. 12 times natural size. The micropyle with the irregular lines radiating from it is characteristic.

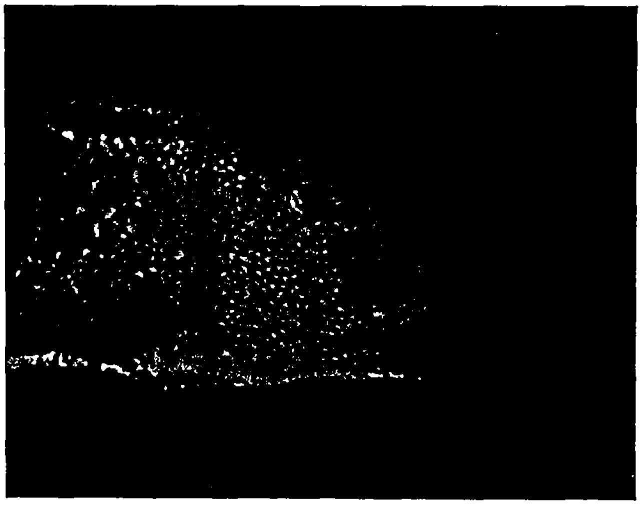

Figure 27.—The shell of a halibut ovum photographed by reflected light to show the punctate appearance of the surface. About 460 times natural size.

enlargement, bearing a few chromatophores and of about the same volume as the terminal knob, is situated about three-fourths of the length away from the base. Two smaller enlargements with fewer chromatophores are located between this and the base. The filament is thus divided into four sections of which the proximal one is slightly the longest.

The pectoral fins are large fan-like structures, while each of the pelvic fins has a single filament about one-fourth as long as the body. Their tips bear small pigmented knobs similar to that on the end of the dorsal fin filament.

The embryonic caudal fin is still protocercal in form, but unlike that of the halibut, an area of increased density of tissue is visible in the ventral lobe close to the border of the notochord.

The younger stages of these eggs, if they are found, may be separated from those of the halibut by the more abundantly and deeply lined shell. These lines are much more numerous and are markedly different from the few which are to be found on the shell of the halibut eggs. The clear, glass-like shell of the latter is very uniform in appearance when mounted and examined under high powers of the microscope. Of over 70 such mounts, not one showed any approach to the comparatively rough, deeply lined shell of Type A. No such small oil droplets are found in any of the yolks of Type A as are seen in the later stages of halibut ova after preservation.

Five other unidentified ova, which may be designated as Type B (Figure 26), might also possibly be confused with the halibut. The diameter of these eggs varies from 3.60 to 4.23 mm., averaging 3.95 mm. They are distinguished by their size, being the largest pelagic ova thus far found in this region, and by yolk filled with small uniform globules approximately .07 mm. in diameter. The latter are unlike any seen at any stage in the halibut. The ova have a small perivitelline space. The micropyle is surrounded by diffuse radiating lines lacking on the halibut, and the surface is finely granular, opaque, and lacks the honeycombed appearance. A few lines or folds are present which are finer than those occurring on the halibut ova. The eggs were taken in hauls No. 392 B in 1931; 671 C on April 16, and 754 B on May 14, 1932; and in 1010 C on January 4, and 1129 C on March 15, 1934. Three of the specimens were taken in 1931 and 1932 after the end of the halibut spawning season. One of them, 3.95 mm. in diameter, was caught at station 671 C on April 16, 1932, southeast of Cape St. James. A large germinal disk is present in about the 128-cell stage. The shell exhibits a few creases or folds and is marked as are the other specimens, contains the same type of yolk, but does not show the micropyle and its radiating lines. It is assigned with some question to the same species. The single specimen found in haul No. 754 B off Kodiak Island, with a diameter of 3.60 mm., contains a disk that is between the 4 and 8-cell stage. The yolk material, although similar to that of the other Type B eggs, is shrunken. But the outer yolk membrane is in place and extends from the margin of the disk out and around the inner surface of the shell. Its largest diameter is 3.5 mm.

The egg of *Hippoglossoides elassodon*, although of comparable size, ranging between 2.75 and 3.75 mm. and averaging 3.27 mm., is easily recognized by the large perivitelline space.

In addition to the identification of the halibut eggs by their anatomical characters, their homogeneity has been examined by statistical treatment of the size distribution.

The sources of variation have already been remarked on previously. They include method of preservation, the time after preservation at which the eggs were examined, the bank of origin, and the year of spawning. Mathematical tests for homogeneity must start from the assumptions, first, that the resultant variations are either inconsequential or that they neutralize each other by their own symmetrical distribution, and second, that the expected size distribution of halibut eggs is that of a normal probability distribution. If these assumptions are justified, inclusion of eggs of other species might be expected to show itself by a departure from such a distribution.

The size distributions of eggs taken in different years is given in Table 10, using those years in which a sufficient sample was obtained. Thus, for instance, the variation between the eggs taken in 1928 and those taken in 1933, with mean sizes of 3.29 and 3.22 mm. is .07 mm. with a standard error of the difference of the means of .005 mm. (Yule, 1927, p. 345). This would indicate that the difference in means is significant. The 1926 and 1927 samples are still more divergent from that of 1933.

This being true, the distribution of all eggs taken during the period of the investigation cannot be expected to show complete homogeneity. Tested for conformity to a normal probability curve by the methods given by Fisher (1930, p. 52) $\gamma_1 = +.435 \pm .054$ and $\gamma_2 = +2.421 \pm .108$, indicating a slight skewness toward the larger sizes and a greater concentration in the center of the range than in a curve of normal error. The total X^2 calculated from the original distribution, omitting the three smallest ova, is 21.876, and the probability of X^2 being larger for $n = 13$ is about .06. The distribution of sizes in the combined samples evidently does not conform closely to the shape of a normal frequency curve.

A key is given below for the identification of the ova found in the net hauls between December and March, after which the halibut embryos are usually identifiable.

Key to pelagic ova greater than 2.75 mm. in diameter taken in net hauls in the Gulf of Alaska, prior to March:

A. Large perivitelline space; diameter of yolk one-half or less the outside diameter of the egg. *Hippoglossoides elassodon.*

AA. Perivitelline space small; yolk nearly filling the outer membrane.

  B. Diameter 3.6 to 4.2 mm.; surface finely granular, honeycombed appearance lacking; micropyle surrounded by radiating lines; yolk filled with small uniform sized globules about .07 mm. diameter. Type B.

BB. Diameter 2.9 to 3.8 mm.; oil globules small and few in number and irregular in size if present.

C. Diameter 2.9 to 3.1 mm.; surface rough and abundantly and deeply lined (as compared to halibut); embryos pigmented on body; eyes opposite anterior end of brain; dorsal, pectoral, and pelvic fins developing in egg; filamentous appendages on fins. Type A.

CC. Diameter 2.9 to 3.8 mm.; surface smooth, shell of homogeneous transparent texture, fine lines usually lacking on surface; embryo unpigmented; eyes on either side of brain back from its anterior end; pelvic fins not developed; pectorals, dorsal, and anal fins larval in oldest embryos. Halibut.

B. HALIBUT LARVÆ AND POSTLARVÆ

For the purposes of description and convenience in following their drift and development the pelagic young have been separated into arbitrarily defined stages of development. These are based upon morphological changes and not upon size alone because of the great variability of the latter. They are described in greater detail than necessary for distinction from other species, since it is desired to use them in a study of the changes in distribution with advancing development.

Identification of the larvæ has been accomplished by completion of a full series of all stages from the known egg to that at which the characters are plainly those of the adult halibut. The egg as taken from the female (Figure 24) and compared to those found in the plankton has already been described.

As soon as they can be counted, the numbers of myotomes and fin-rays serve to identify the larvæ. The number of myotomes, which are equivalent to vertebral counts, can be determined with accuracy only after the caudal structures have begun to develop. Before this it is impossible to locate the position of the myotome which corresponds to the last vertebra, as several

TABLE 11.—*Comparison of vertebral counts of adult and larval and postlarval halibut.*

Number of Vertebræ	Number of Specimens	
	Larvæ and Postlarvæ	Adults[1]
49	10	22
50	91	392
51	55	177
52	0	1
Average Number of Vertebræ	50.29	50.27
P.E. (Mean)	.010	.005

[1] Manuscript data from F. Heward Bell.

TABLE 12.—*Comparison of numbers of dorsal and anal fin-rays of adult and postlarval halibut*

Dorsal Fin-rays			Anal Fin-rays		
Number Rays	Postlarval Halibut	Adult Halibut	Number Rays	Postlarval Halibut	Adult Halibut
89	..	1	64	..	1
90	1	1	65	..	1
91	1	2	66	..	1
92	..	4	67	..	..
93	2	8	68	1	2
94	2	13	69	..	4
95	3	30	70	4	18
96	3	37	71	5	37
97	21	54	72	9	69
98	20	68	73	29	97
99	24	81	74	20	110
100	20	99	75	35	99
101	27	73	76	32	77
102	18	59	77	17	56
103	13	45	78	14	35
104	11	26	79	14	9
105	9	16	80	5	6
106	6	10	81	5	1
107	4	3	82	1	..
108	..	2	83	..	..
109	1	1	84	1	..
110	1	..	85	..	..
Total	187	633	....	192	623
Mean	100.40	99.58	....	75.43	74.28
σ_m	0.24	0.12	....	0.19	0.093

segments are always formed posterior to it. The development of the tail structures was traced backwards from the time of formation of the vertebræ to the first appearance of the subchordal proliferation of cells in order to make accurate counts possible, and its development is described below (p. 83). Table 11 shows how closely the resulting counts correspond to those of the adults. The last vertebræ, with which the hypural plates are fused, is not counted.

The fin-ray counts are given in Table 12, compared to those of adults. They may be determined from the pterygiophores as early as Stage 5 (Figure 34). The caudal rays, 19 in number, are readily counted in Stage 6 (Figure 35). The following key, using counts by Townsend (MS.), will suffice to distinguish the halibut larvæ from those of other species of flatfish in the Pacific.

A. Vertebræ less than 47; dorsal rays less than 90.
Majority of Pacific Pleuronectidæ.
AA. Vertebræ more than 46; dorsal rays more than 90.
B. Vertebræ 47-54.
C. Anal rays more than 80.
D. Vertebræ 50-54; caudal rays 20-22.
Microstomus.
DD. Vertebræ 47-49; caudal rays 17.
Atheresthes.
CC. Anal rays less than 81.
E. Vertebræ 49-51; caudal rays 19.
Hippoglossus.
BB. Vertebræ 62-65; anal rays 79-93; caudal rays 21-24.
Glyptocephalus.

TABLE 13.—*Average lengths of halibut larvæ and postlarvæ with average body proportions expressed as percentage of length.*

Stage	Total Number[1] Specimens	Average Standard[2] Length	Average Total[2] Length	Percentage of Length							Dates of Capture	
				Depth	Caudal Peduncle	Head Length	Snout to Anus	Eye	Maxillary	Lower Jaw	Earliest	Latest
1	199	......	11.2	5.3	2.6	......	36.8	4.6	......	6.5	Jan. 10	Apr. 12
2	180	......	13.4	5.4	2.5	......	35.8	4.7	6.0	9.3	Jan. 17	Apr. 12
3	33	......	15.0	5.4	2.7	......	35.9	4.5	6.3	8.5	Jan. 30	Apr. 12
4	11	......	15.2	10.7	4.2	......	38.6	5.1	9.2	12.5	Mar. 4	May 2
5	10	......	16.2	20.9	6.7	......	39.7	5.4	9.4	13.4	Mar. 23	May 20
6	20	15.9	......	33.1	9.6	26.9	41.1	5.7	10.5	14.7	May 1	May 31
7	23	17.8	......	40.7	10.4	28.0	39.2	5.5	10.6	14.6	May 1	June 8
8	25	19.6	......	42.9	10.5	27.8	36.8	5.6	10.7	14.2	May 4	June 8
9	30	20.8	......	44.8	10.7	28.7	35.0	5.6	10.5	14.0	May 6	June 10
10	72	21.3	......	44.1	10.9	29.0	32.2	6.0	10.6	13.7	May 6	June 21
11	35	22.1	......	44.2	10.9	30.1	29.9	6.5	10.4	13.6	May 10	June 17
12	16	25.7	......	41.4	10.5	30.1	32.2	7.2	9.9	13.7	May 31	June 17

[1] Number of specimens recorded is the total taken, but the number used for computing the averages varies according to the number of specimens suitable for each measurement.

[2] The standard length is measured to the end of the hypural plate. The total length is measured to the tip of the notochord.

As an aid to identification and the distinction of different stages, the body length and measurements of head; depth of caudal peduncle; diameter of eye; length of maxillary, of lower jaw, and of the distance between the tip of the snout and the anus, are given in Table 13. All measurements were made with a Gaertner micrometer used with a compound microscope and read directly to .01 mm. In the first five stages the lengths were measured to the end of the notochord, but thereafter they were necessarily measured to the end of the hypural plate. In the younger forms the body depth was measured just behind the anus where the maximum depth occurs. In Stage 4 the growth of tissues which form the posterior wall of the abdominal cavity, and in which the first hæmal spine develops, is sufficiently well defined to be measurable, and in this and later stages the depth is measured to the ventral tip of this growth. The diameter of the eye, length of head, and distance from snout to anus are measured parallel to the horizontal axis of the body between perpendiculars to the points in question. The head lengths are measured to the posterior tip of the operculum, and since the opercle of the earliest stages is very delicate and frequently injured and distorted, this measurement is not recorded for specimens younger than Stage 5.

The separation of specimens into stages has necessarily been arbitrary since the development has been continuous. Certain changes have, however, formed natural dividing points. Thus hatching from the egg separates larva from embryo. The presence of yolk distinguishes the larva from the postlarva. But we know of no definite point at which the postlarva can be said to become juvenile, unless the completion of the eye change is such. Characters used for separation are not always equally advanced in any one specimen. Thus the development of the caudal structures and the stomach used to separate Stages 1 and 2 do not always coincide, and the character showing the most advanced development is used in deciding the stage of specimens which happen to be close to the borderline. A key to the stages is presented below.

A. Width of myotome zones (*c* and c^1)[5] less than 11.5 per cent of length to end of notochord and more than 58 per cent of total width of body (measured across the mid-point of the body); fin-rays absent in D and A; eyes symmetrically placed; anal insertion posterior (under 15th myotome); secondary caudal symmetry lacking or incomplete, exserted notochord visible; chromatophores not grouped in a spot pattern.

  B. Yolk present; notochord straight at posterior tip; larvæ.

    C. Stomach rotated through less than 90°; no or few chromatophores; no distinct hypural cartilages; caudal protocercal. Stage 1.

    CC. Stomach rotated through 90° or more; chromatophores appear in numbers but not in the definite postlarval pattern; hypural cartilages appear; fin-rays in caudal. Stage 2.

  BB. No yolk present; notochord flexed upward at tip; postlarvæ.

    D. Myotome zones *b* and *a* absent. Stage 3.

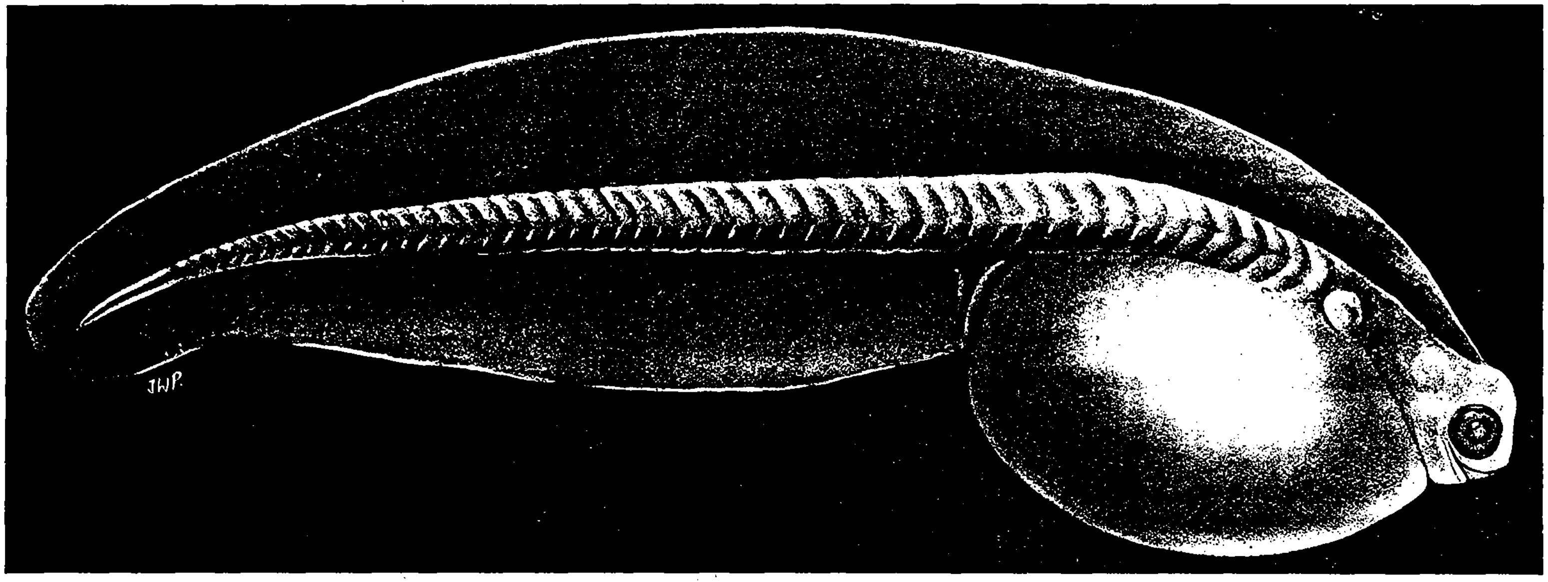

FIGURE 29.—Stage 1 larva. 21 times natural size.

DD. Myotome zone *b* visible.

  E. No distinct pterygiophores or fin-rays in D and A; but increased body depth appreciable; myotome zone *a* absent; 8 well developed caudal rays. Stage 4.

  EE. Pterygiophore cartilages of D and A distinct in part, increasing the body depth; myotome zone *a* developing; 18 caudal rays distinguishable; no fin-rays visible. Stage 5.

AA. Width of myotome zones (*c* and c^1)[5] more than 11.5 per cent of body length to end of hypural plate and less than 57 per cent of total body width; rays developed in D and A complete in number; eyes unsymmetrically placed; anal insertion forward of 15th myotome.

F. Width of myotome zones (*c* and c^1)[5] more than 45 per cent of total width of body; fin-rays in D and A complete in number but not complete to the outer edge of the fins; small portion of exserted notochord occasionally visible externally; no ventral rays visible. Stage 6.

FF. Width of myotome zones (*c* and c^1)[5] less than 45 per cent of total body width; rays in D and A complete to outer edge of fins; caudal externally symmetrical; ventral rays visible.

  G. Width of myotome zones (*a* and a^1) (*b* and b^1)[5] 25 per cent or less of body length; pigment pattern incomplete postlarval.

    H. Postlarval chromatophore pattern (see diagram Figure 37) absent; ventral fin-rays 3; chromatophores grouped along edges and bases of fins and in longitudinal series. Stage 7.

    HH. Postlarval chromatophore pattern definite but incomcomplete; ventral rays 5. Stage 8.

  GG. Width of myotome zones (*a* and a^1) (*b* and b^1)[5] more than 25 per cent of standard length; pigment pattern postlarval or adult.

    I. Left eye on left side or on ridge of body; pigment pattern postlarval; pectoral fin larval.

      J. Postlarval pigment pattern incomplete. Stage 9.

      JJ. Pigment pattern complete. Stage 10.

    II. Left eye on right side of body; pectoral fin reduced in size, or adult in form; pigment pattern in transition to that of adult; pectoral rays developed.

      K. Color pattern postlarval rather than adult; colorless spaces on trunk remain; pectoral margin rounded. Stage 11.

      KK. Color pattern predominately adult and diffuse; pectoral margin falcate. Stage 12.

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[5] See diagram, Figure 33.

Stage 1 (Figure 29) includes the newly hatched larvæ. The lengths vary from 7.8 to 15.0 mm., averaging 11.2 mm. The body is symmetrical, and the trunk is long, nearly circular in cross section, and tapers gradually to the posterior tip of the notochord. The head is bent ventrally around the large yolk in the youngest specimens, and its dorsal profile is regularly rounded, as the snout is short and not yet developed. In these youngest specimens the mouth is a small triangular opening on the ventral side of the head close to the anterior end of the yolk sack, while in the older ones included in this stage the cartilaginous lower jaw is apparent. The eyes are comparatively large, nearly covering each side of the head. Their color is brownish in the preserved specimens of this stage, though it is black in all the later stages. The yolk sack, corresponding in size to the large egg (3 mm. or more long on the newly hatched larvæ), is oval with its long axis lying parallel to that of the fish. The slender gut extends along the dorsal surface of the yolk and around its posterior end to about the middle of its posterior border.

During Stages 1 and 2 the stomach is formed by the enlargement of a portion of the gut about midway between the pharnyx and the rectum. The forepart of the gut grows posteriorly and to the left, while the rectal end grows anteriorly, thus reversing the position of the stomach, while the growth of the latter in length and size allows it to sag ventrally into a loop. As a result the stomach is rotated through an angle of 180°. In the oldest of Stage 1 specimens the stomach has rotated less than 90°, while all specimens in which the rotation has proceeded farther are considered to belong to Stage 2.

The larval pectoral fins are small fan-shaped structures lying close to the anterior end of the yolk sack. The vertical larval fin-fold is continuous from the posterodorsal surface of the head around the posterior end of the trunk to the anus. No preanal fin-fold is developed. The primitive fin-folds show no sign of developing fin-rays or lepidotrichia, and the caudal region is supported only by actinotrichia or larval rays. (See p. 62.) The posterior tip of the notochord is straight, and the caudal is therefore protocercal (see below, p. 86). Though a thickening of the tissues occurs in the ventral lobe of the caudal fin-fold in the larger specimens, no definite structures are as yet visible.

Pigment is entirely lacking except in the retina of the eye in the youngest specimens, but a few chromatophores may occur in the posterior end of the fin-folds in the more highly developed larvæ of this stage.

At this stage the most characteristic features are the large size of the larva as compared to its primitive stage of development, the large yolk sack, and a complete lack of pigment except in the eyes.

Stage 2 (Figure 30) includes specimens ranging from 9.8 to 17.8 mm. and averaging 13.4 mm. in length. They are distinguished from the Stage 1 specimens by the presence of the ventral caudal cartilages representing the developing hypurals and by the rotation of the stomach through an angle of more than 90°. They are separated from Stage 3 by the presence of yolk.

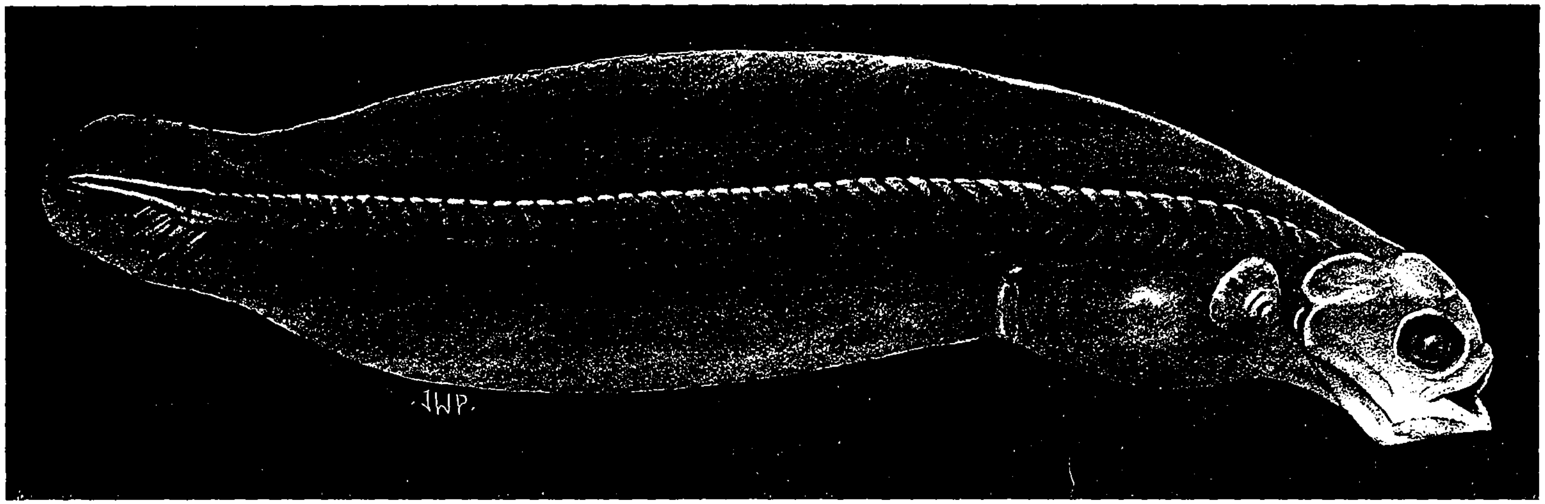

FIGURE 30.—Stage 2 larva. 14 times natural size.

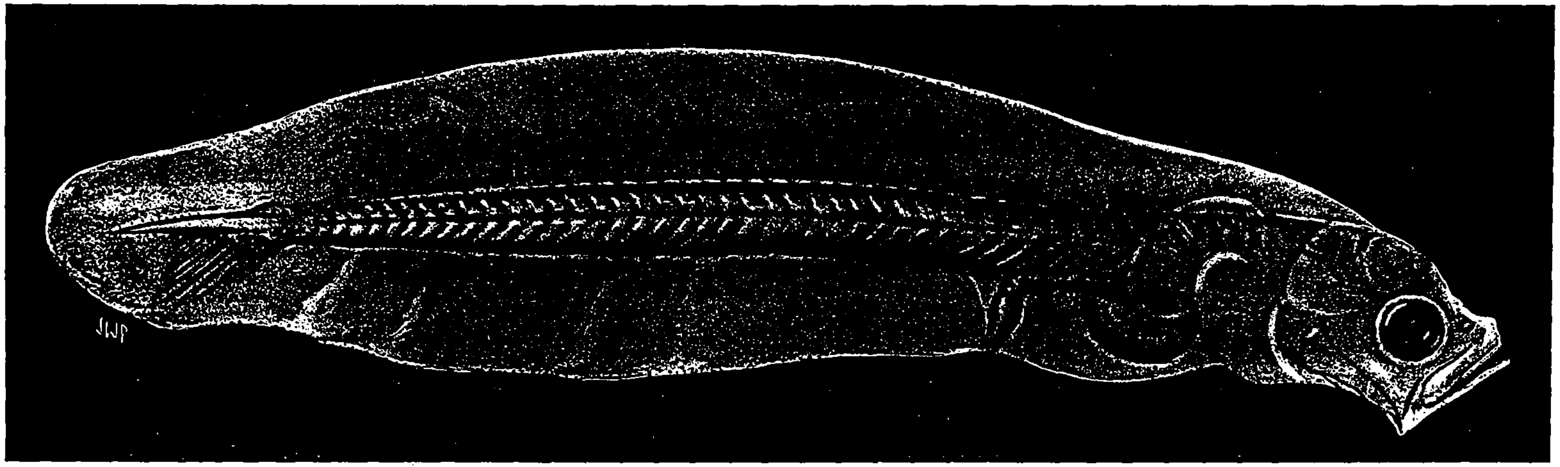

FIGURE 31.—Stage 3. The young of this stage are now called postlarvæ because all yolk has been absorbed. 12 times natural size.

Thus Stage 2 includes the oldest larval specimens, while Stage 3 includes the youngest postlarvæ.

The lower jaw is well developed and comparatively long and straight. The snout has increased in length but is still shorter than the diameter of the eye. Actinotrichia have appeared throughout the length of the dorsal and anal fin-folds but are most highly developed in the caudal region. The posterior tip of the notochord is still straight, though ventrally the caudal structures are apparent, and the rudiments of three or four rays, or lepidotrichia, are usually visible in the tail region as thickened areas lying along the posteroventral border of the developing caudal cartilages.

A marked development is noticeable in the increased but still sparse amount of pigment in the form of scattered chromatophores which lie along the posterior half of the outer border of the dorsal fin-fold, along the outer border of the anal fin-fold, and along the dorsal and ventral margins of the caudal end of the notochord as far forward as the developing caudal rays, with a few spots on the rays themselves. In some specimens a few chromatophores are also scattered along the ventrolateral surface of the trunk, always lying between the myotomes. The primitive pigmentation, totally lacking in groups of chromatophores, and the comparatively great length at this stage of development serve to distinguish the halibut from similar stages of other species, and identification may be further checked by means of accurate myotome counts.

Stage 3 (Figure 31) includes specimens ranging from 11.2 to 18.5 mm. in length, averaging 15.0 mm. It includes all specimens which have completely absorbed the yolk, hence are definitely postlarval, but which as yet show no signs of growth in depth of the trunk or the development of the sigmoid shape of the myotomes (Figure 33).

In spite of their relatively great total length, there is as yet no sign of asymmetry, and the body and pigment do not differ greatly in form from the Stage 2 larvæ. The lower jaw has assumed its characteristically straight profile and projects upward and forward at an angle of about 45° to the horizontal body axis. The snout has grown in length until it is only slightly shorter than the diameter of the eye and has become decidedly pugged. (See Schmidt, J., 1904.)

No sign of developing lepidotrichia has appeared in the dorsal and anal fin-folds, though as many as seven or eight rays may be distinguished in the caudal fin. The end of the notochord is at this stage slightly flexed upward (Figure 51c), and the shape of the hypural plate is becoming apparent. In the older specimens a small notch has developed in the caudal fin-fold, separating the larval caudal lobe from the developing permanent caudal fin, and a larger indentation marks the separation of the permanent caudal from the anal fin-fold.

The pectorals are unchanged in form though larger in size.

The pigmentation still consists of scattered chromatophores, the num-

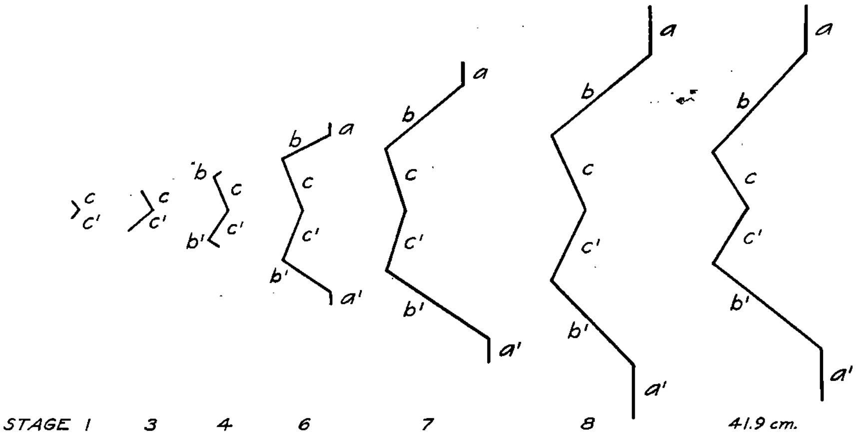

FIGURE 33.—Diagram illustrating the development of the different zones of muscles in the body. The figures are drawn from actual measurements of the myotomes of the trunk made at about one-fourth the distance from the anus to the tail.

bers of which have increased, but they show no signs of grouping. A number of chromatophores lie over the caudal fin-rays, and a number have also appeared over the abdominal region. A few spots may also appear over the side of the head.

Stage 4 includes specimens ranging from 13.6 to 17.8 mm. and averaging 15.2 mm. in total length (Figure 32). While the small size may be due in part to the fact that six of the specimens were taken in 1929 when the larvæ of all stages averaged shorter in length than the corresponding stages of other years, the average sizes of the fourth stage in both 1929 and 1930 were less than those of the third stage taken during the same years. Development of the heterocercal tail with the turning up of the tip of the notochord evidently involves a slight decrease in total length; i.e., the growth in length is not rapid enough to compensate for the loss due to the flexing of the posterior end of the notochord. The change from a dependence on yolk to use of captured food may also affect growth. The number of specimens is too few, however, to determine the extent or nature of this change.

The body has become deeper and more oval in cross section with the beginning development of the sigmoid shape of the myotomes characteristic of the adult. The Stage 4 specimens are easily separated from those of Stage 3 by the resulting alteration in form (Figure 33). The ventral growth of tissues from which the first hæmal spine and the most anterior interhæmal supports of the anal fin develop has become well defined behind the vertical rectum. With the increase in body depth the length of the lower jaw has also increased markedly, and the pugged appearance of the snout is further developed.

Fin-rays have not yet appeared in either the dorsal or anal fin-folds, but the thickening of the tissues in the middle region of the base of the latter indicates the position of first appearance of the fin anlage. The lack of intermediate stages between the first appearance of the elements of the

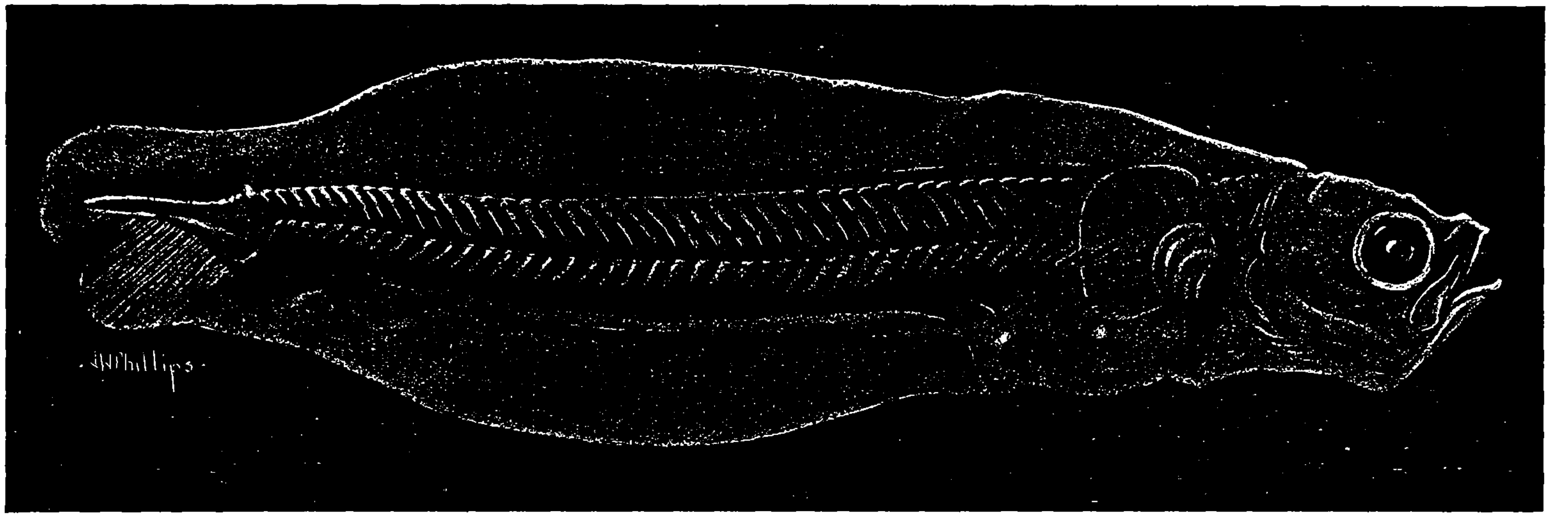

FIGURE 32.—Stage 4 postlarva. 11 times natural size.

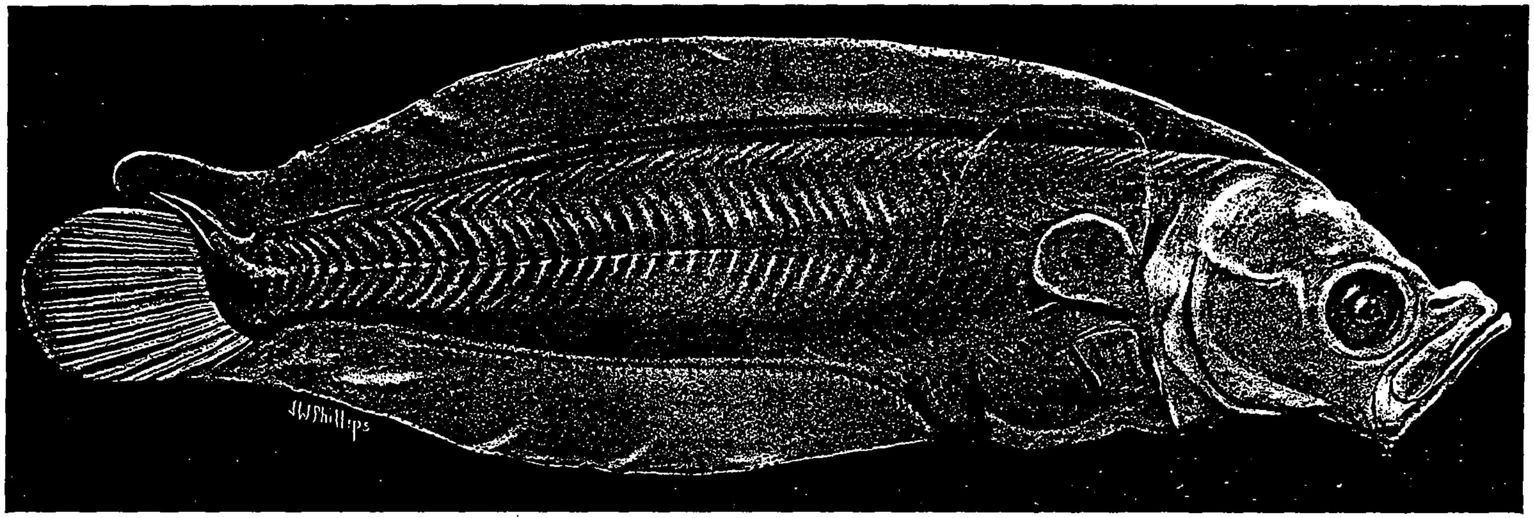

FIGURE 34.—Stage 5 postlarva. Note especially the appearance of the basal structures in the dorsal and anal fins. 12 times natural size.

dorsal and anal fins and the development found in the next stage, where the greater part of the basal structure of the fins has appeared, indicates that the first growth of these tissues is very rapid. The separation of Stages 4 and 5 depends principally on this character.

The notochord tip is now turned upwards (Figure 51d) at an angle of 10° to 12° to the horizontal body axis, assuming the true heterocercal appearance, and at least 8 lepidotrichia are well developed along the ventral border of the caudal cartilages. The most dorsal, or 19th, caudal fin-ray has appeared dorsal to the notochord. The notch dividing the permanent caudal from the larval fins has deepened, and the larval caudal lobe has become sharply differentiated.

The pectoral fins remain large and larval in form, and their bases are inclined upward and forward at an angle of about 60° to the longitudinal body axis. A thickening of the ventral abdominal tissues just posterior to the pectoral arch later forms the pelvic skeleton, but as yet there is no external evidence of the formation of the pelvic fins.

The only change in pigmentation, other than an increase in the numbers of chromatophores in the regions described for the younger stages, is the appearance of several solitary chromatophores which lie along the dorsolateral surface of the trunk, forming a broken line lying slightly above the mid-lateral line in the region midway between the anus and the tail.

At Stage 5 (Figure 34) the average total length from the snout to the tip of the notochord, computed from 7 specimens, is 16.2 mm., varying from 15.0 to 17.7 mm. The increase in depth to an average of 3.06 mm. is very marked, and the growth in depth relative to the increase in length is greatest during this period of development. Increase in depth has involved the growth in depth of the peripheral muscles (b and c, Figure 33), as well as the median ones (a, Figure 33). The head is also much deeper, and the characteristic long straight lower jaw, as well as the deeply indented dorsal profile described by Schmidt, is well developed. The nostrils are now plainly seen as large open pits symmetrically placed just in front of the eyes.

The pterygiophore cartilages are well developed in both dorsal and anal fin regions and distinguish this stage from the preceding one. The anal fin pterygiophores are best developed anteriorly, less well developed posteriorly. The dorsal pterygiophores are most highly developed in the mid-region of the fin, less well differentiated posteriorly. They are shorter and lie farther apart anteriorly, and they are difficult to make out at the forward end. A thickening of the tissues along the base of the fin is noticeable, especially in the mid-region, and the bases of several fin-rays are now defined in the middle of the dorsal and near the anterior end of the anal fin. Though a few posterior pterygiophores are as yet undeveloped, the number of those found is characteristic of the numbers of halibut fin-rays. Table 12 gives the distribution of the fin-ray counts of the adults and those of the older postlarval halibut.

The posterior end of the notochord is raised at an angle of about 45°, and 18 caudal rays may be distinguished along the posterior border of the hypural cartilages. The larval caudal lobe (Figure 51f), now much reduced in size, is confined to a small space around the tip of the notochord. The last dorsal (19th) caudal ray, developing opposite the tip of the first epural, is at this stage represented by a thickened area in the dorsal larval fin-fold.

A small ventrolateral pelvic fin-bud has been developed just posterior to the ventral end of the pectoral arch. The base of the bud lies parallel to the horizontal body axis and at the posterior end of the dense area of tissue of which the pelvic skeleton is later formed. The pectoral fin remains large and larval with no sign of developing rays.

The pigmentation is still very simple with no sign of grouping of the chromatophores over the body. A new series of widely scattered chromatophores has appeared along the base of the anal fin, and the number of chromatophores has increased generally. A few have appeared at the angle of the jaw. The pectoral fins are as yet free of pigment.

A series of large dense chromatophores has appeared along the dorsolateral surface of the vertebral column that is visible only in specimens treated in clearing solution. The chromatophores lie near the bases of the neutral arches and occur singly or doubly on each segment and aid in counting the vertebræ.

The average standard length of 15 specimens of Stage 6 (Figure 35), all caught during 1932, is 15.9 mm. This is 0.3 mm. less than the average total length of the Stage 5 postlarvæ. A change in the length measurements has become necessary because of the reabsorption of the posterior tip of the notochord and the further development of the hypural plate. The distance from the tip of the snout to the end of the hypural plate is used instead of that to the end of the notochord. The lengths vary from 14.1 to 17.3 mm. The trunk has broadened considerably, and the body is more regularly ovoid in section. The profile of the base of the anal fin is concave ventrally. The depth at the anus averages 33 per cent of the length of body.

The eyes are large and asymmetrically placed; that is, the left eye lies higher than the right, and in the older specimens its dorsal margin is visible above the profile of the head. The snout is about the same length as the diameter of the eye.

The lepidotrichia are now well enough developed in the dorsal and anal fins to make accurate fin-ray counts possible. The outer part of the fin-fold is still supported by actinotrichia only, thus distinguishing this from Stage 7. The reabsorption or loss of the fin-folds on the caudal peduncle has begun, marking the posterior limits of the dorsal and anal fins.

Externally the caudal fin is almost symmetrical in form. Only a short tip of the exserted part of the notochord remains (Figure 52, a and b). Eighteen rays are well developed along the posterior border of the hypural cartilages, and the larval fin has been reduced to the region posterior and

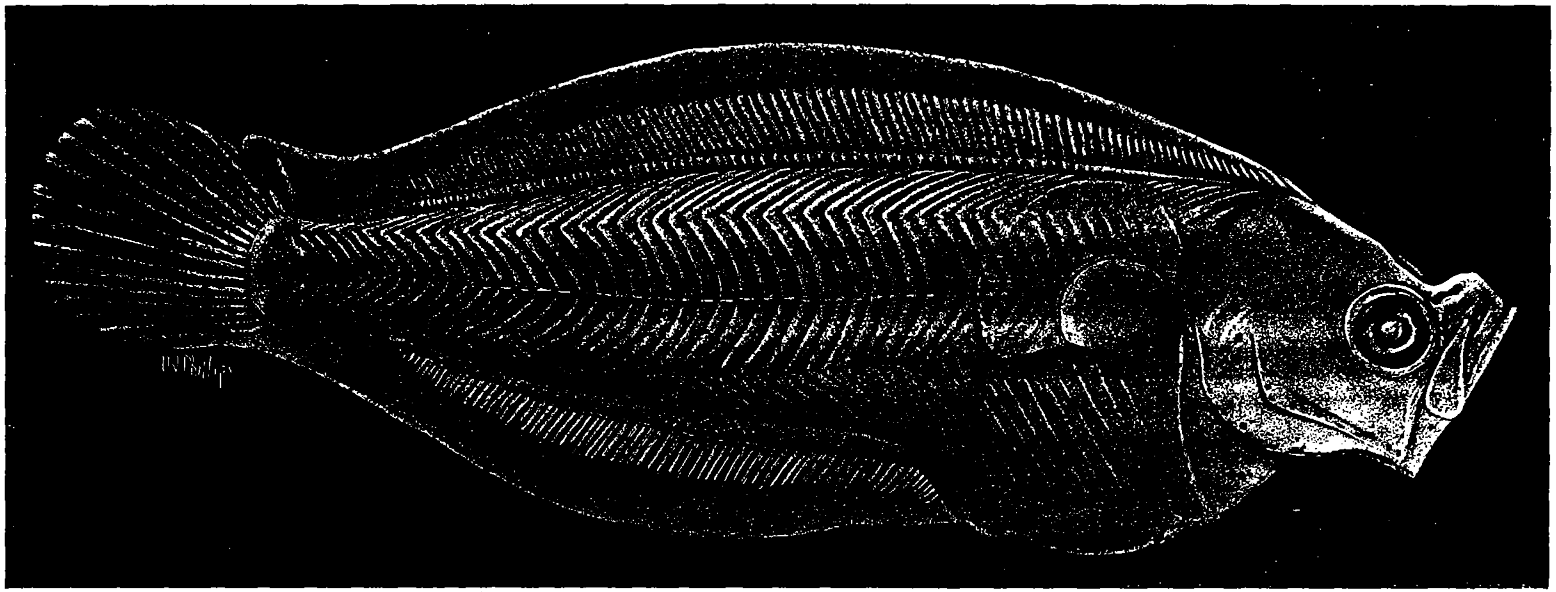

FIGURE 35.—Stage 6 postlarva. 11 times natural size. Fin-rays are well developed in the dorsal and anal fins but have not completely replaced the larval folds.

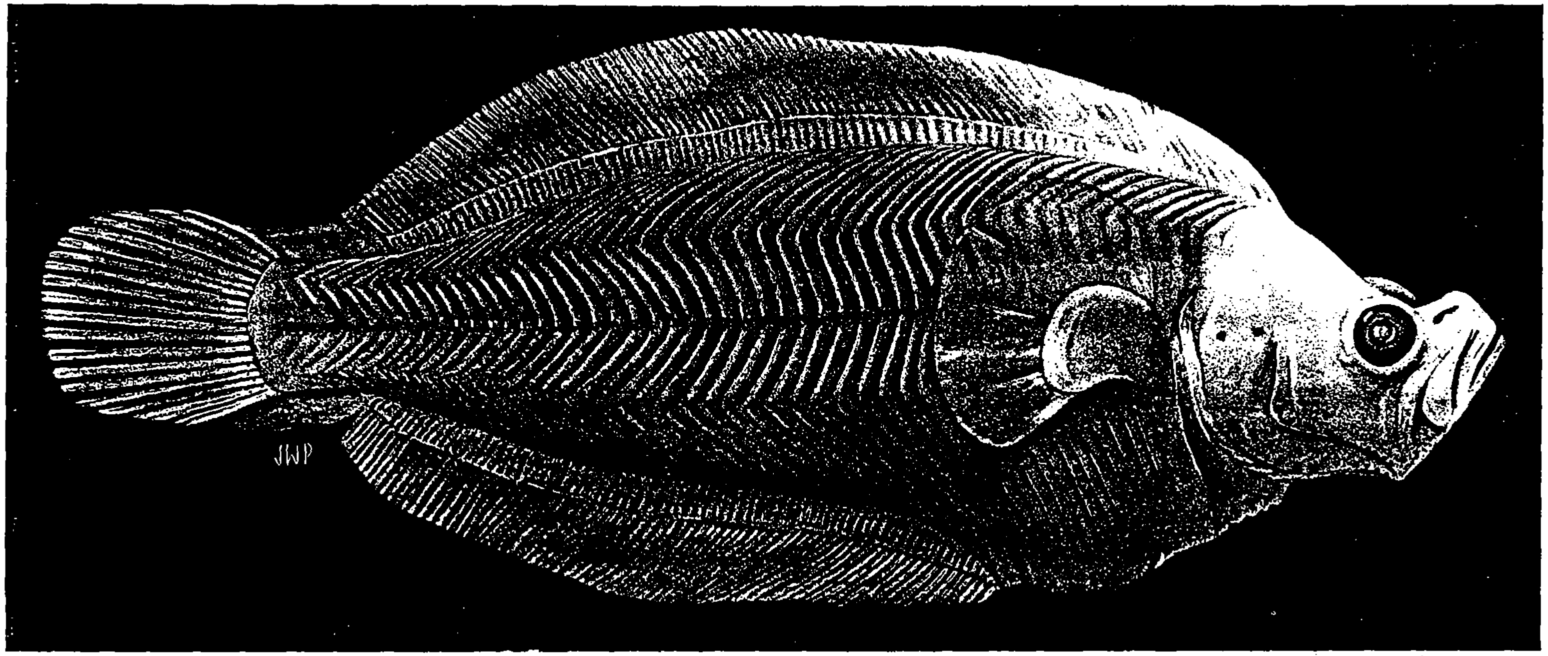

FIGURE 36.—Stage 7 postlarva. 9 times natural size.

dorsal to the tip of the notochord. The nineteenth caudal fin-ray developing at the tip of the epural cartilage, limits the larval caudal anteriorly.

The cartilaginous pelvic arch is now defined, extending posteriorly from a short distance dorsal to the ventral tip of the pectoral arch. The pelvic fin-bud is considerably enlarged, and its shape is roughly semicircular, though no structural differentiation is yet visible.

The pectorals show no external structural changes.

Little change has been made in the pigmentation except that the number of chromatophores and intensity of pigmentation have increased everywhere except on the caudal fin and on the dorsolateral surface of the trunk. Four or five minute chromatophores are usually visible on the ventral and posterior borders of the pectoral fin. The pigmentation of the pectorals does not develop beyond this primitive state until Stage 11 when the development of the fin is completed.

The middle zone of muscles (a, Figure 33) from this stage throughout the remaining postlarval development increases very little in width. The peripheral zones b and c, however, grow rapidly.

In Stage 7 (Figure 36) a considerable growth in length and depth has occurred. The average length is 17.8 mm. (range 14.7 to 19.9 mm.), and the depth averages 41 per cent of the length. The length-depth ratio has thus increased, and asymmetry is more apparent. The left eye is visible above the dorsal profile of the head, and in the older specimens of this stage as much as one-third of it can be seen from the right side.

The posterior end of the gut has grown down and forward beneath the stomach, the hæmal spine and the anterior radials of the anal fin following it, reducing the distance between the anus and the pectoral fin-buds.

Dorsal and anal fin-rays extend the full width of the fins, and the larval folds are confined to the region of the caudal peduncle, distinguishing this from Stage 6. The exserted portion of the notochord has practically disappeared, and the caudal fin is nearly symmetrical externally.

The pelvic girdle is now well formed, and the fin-bud has assumed the characteristic triangular shape. It lies a short distance behind the pectoral arch and is widely separated from the anus. Only three fin-rays have appeared, whereas five are present in Stage 8.

Though Stage 7 exhibits the first signs of development of the postlarval pigment, the grouping of the chromatophores is as yet too indefinite to identify the localities of the various spots. Definite grouping first appears in Stage 8.

The pigmentation on the body of the halibut is of importance in distinguishing this form from other large-mouthed Pleuronectids in the Pacific, especially *Hippoglossoides elassodon.* A diagrammatic chart of the pigment groups is therefore presented (Figure 37) in which the principal ones are numbered and lettered according to their position on the body. The

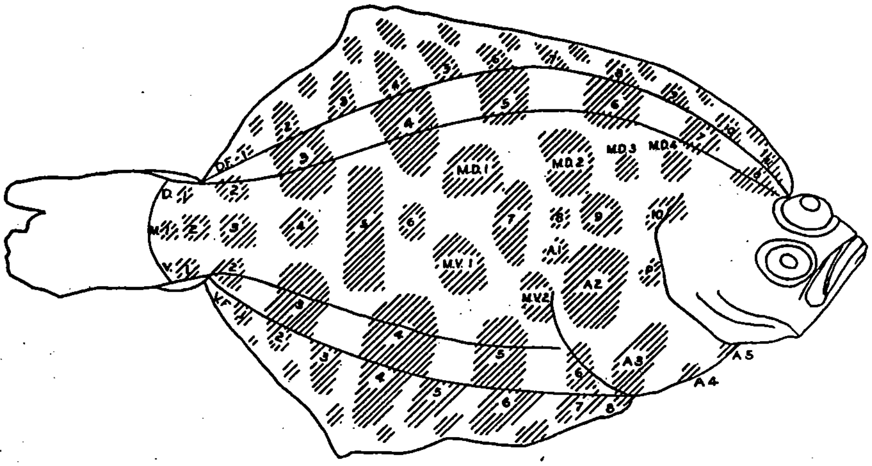

FIGURE 37.—Chart of the characteristic pigment pattern of the halibut postlarvæ.

pigmentation of the head shows no definite design except for two small spots on the posterior end of the maxillary.

While the position, relative size and intensity of color of some of the groups may vary in different specimens and stages, they are on the whole very constant.

The average length of specimens of Stage 8 (Figure 38) is 19.6 mm., varying from 17.9 to 21.4 mm. The depth behind the anus averages 43 per cent of the length, a smaller proportional increase over Stage 7 than that of Stage 7 over Stage 6. The shape is approaching that characteristic of the older fish.

The upper border of the left eye projects farther above the profile, and as much as one-half is visible from the right side in the older specimens. The right eye has started to move ventrally.

Coincident with the absorption of the end of the notochord and disappearance of the protruding tip, the nineteenth, or most dorsal caudal ray, has grown in length and with the growth of the epural cartilages has become more closely approximated to the eighteenth caudal ray. The larval caudal fin has thus gradually disappeared, until at this stage it is represented only by the wider space between the two most dorsal rays.

Five rays are now developed in the pelvic fin, and the posterior growth of the pelvic girdle and fin, as well as the forward movement of the vent, has shortened the distance between them.

Though many of the primitive characters of the larval pigment are retained at this stage, a definite grouping of the chromatophores and development of the postlarval arrangement have started, and in general the primitive pigmentation has begun to disappear. The entire edge of the anal fin is thickly dotted with chromatophores, and one or two of the central

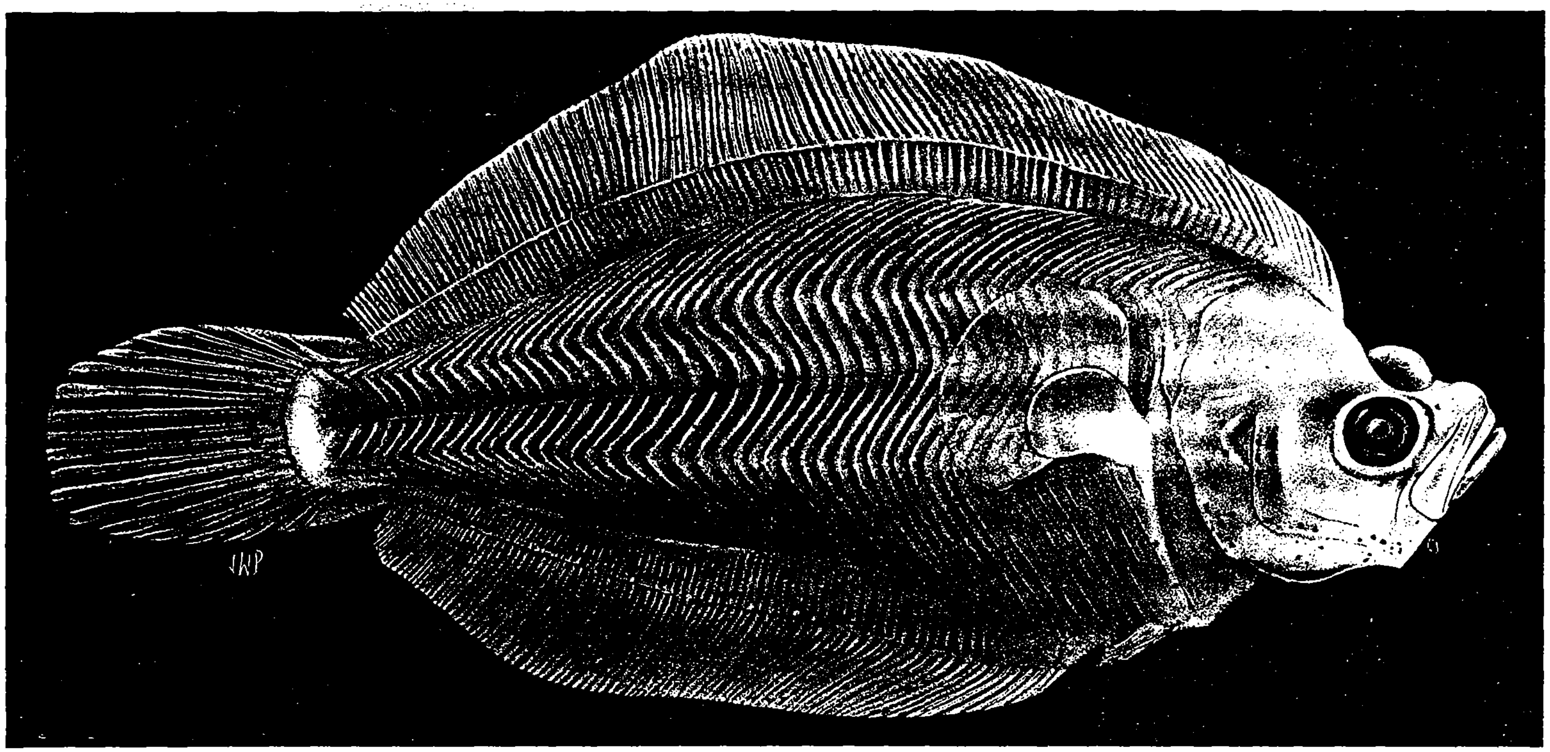

FIGURE 38.—Stage 8 postlarva. 8 times natural size. Definite grouping of chromatophores into the postlarval pattern first becomes evident at this stage.

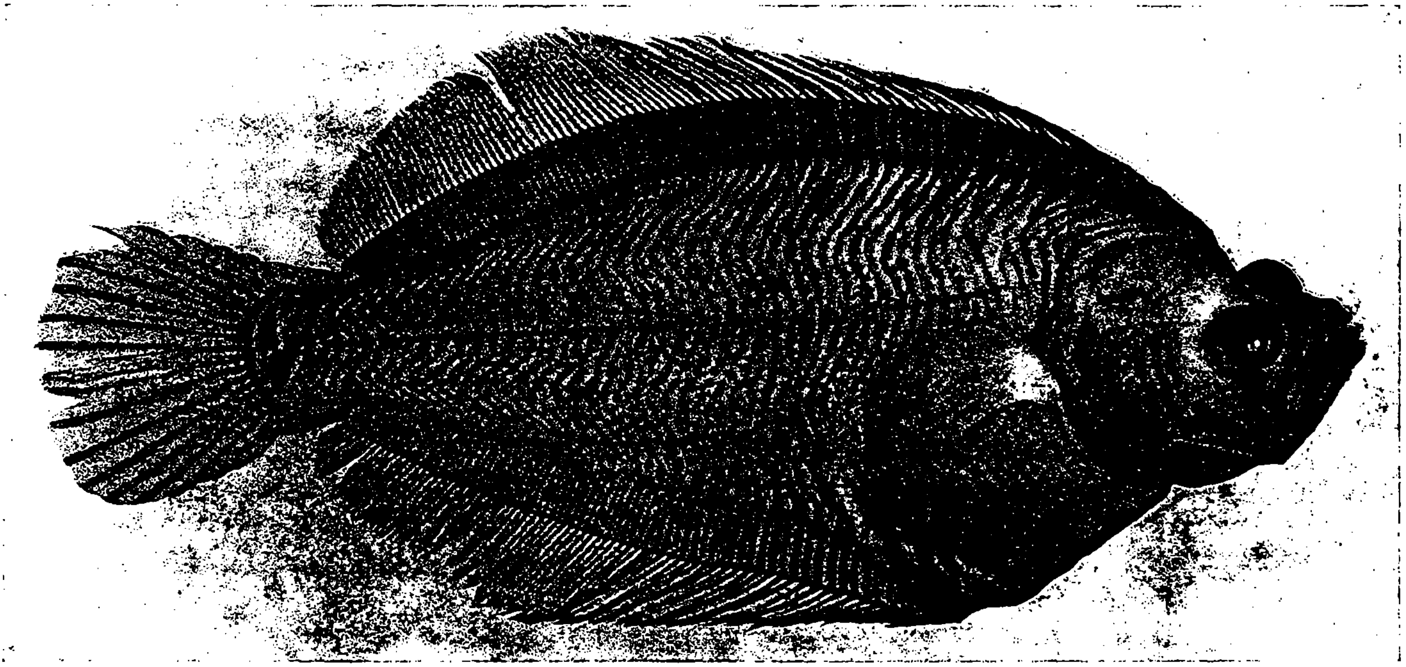

FIGURE 39.—Stage 9 postlarva. 7 times natural size. The postlarval pigment pattern is nearly complete. Compare Figure 37.

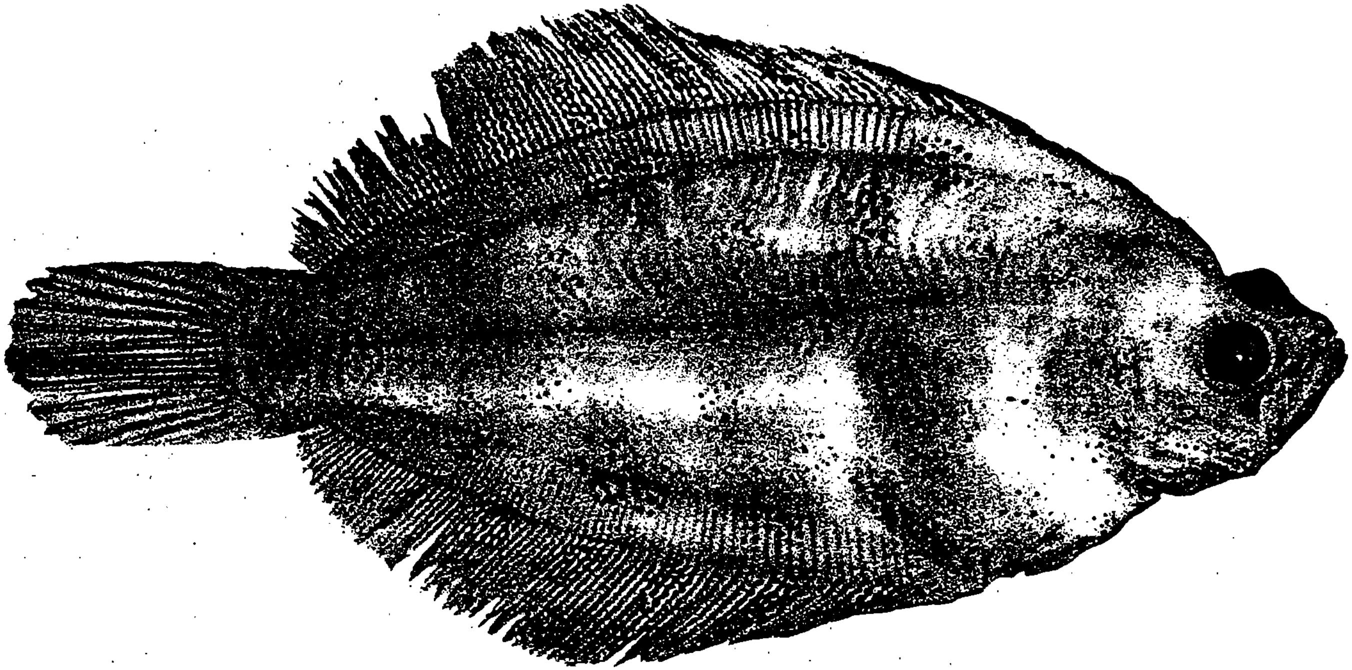

FIGURE 40.—Stage 10 postlarva. 7 times natural size. The postlarval pigment pattern, shown in Figure 37, is completed in the next 3 figures, all of which represent Stage 10 specimens.

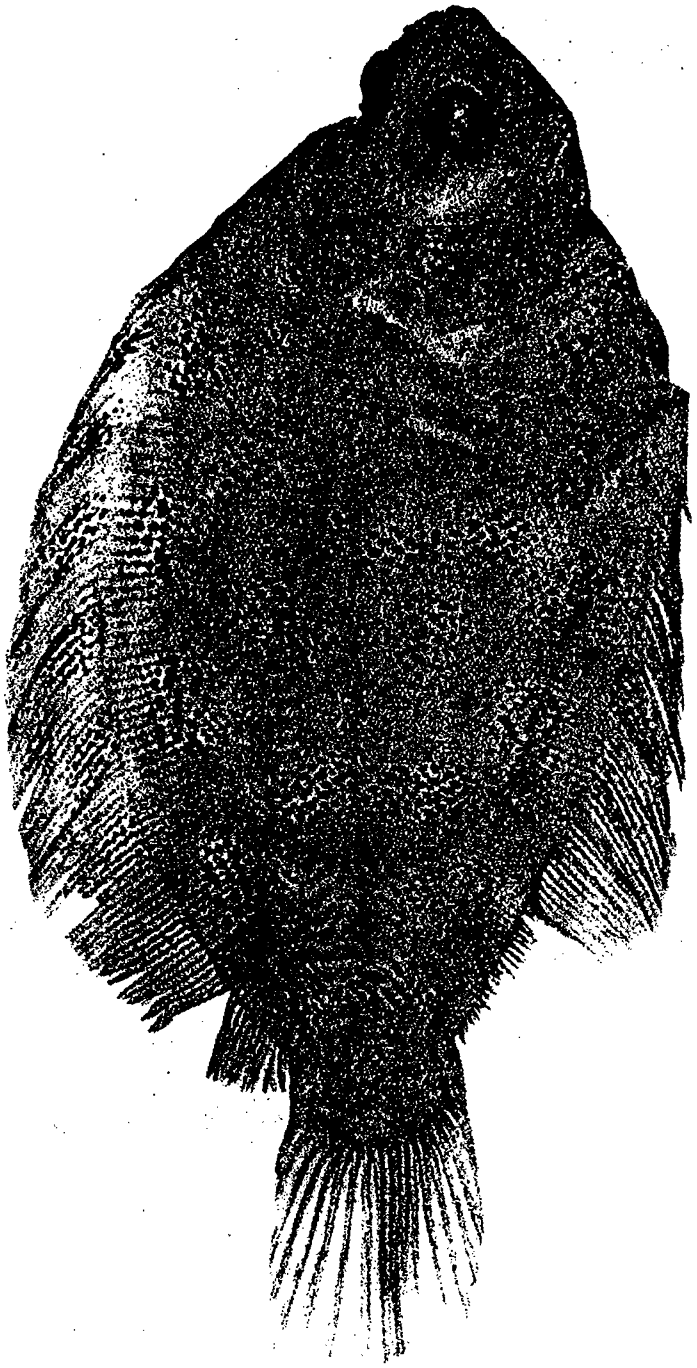

FIGURE 41.—Stage 10 postlarva. 7 times natural size.

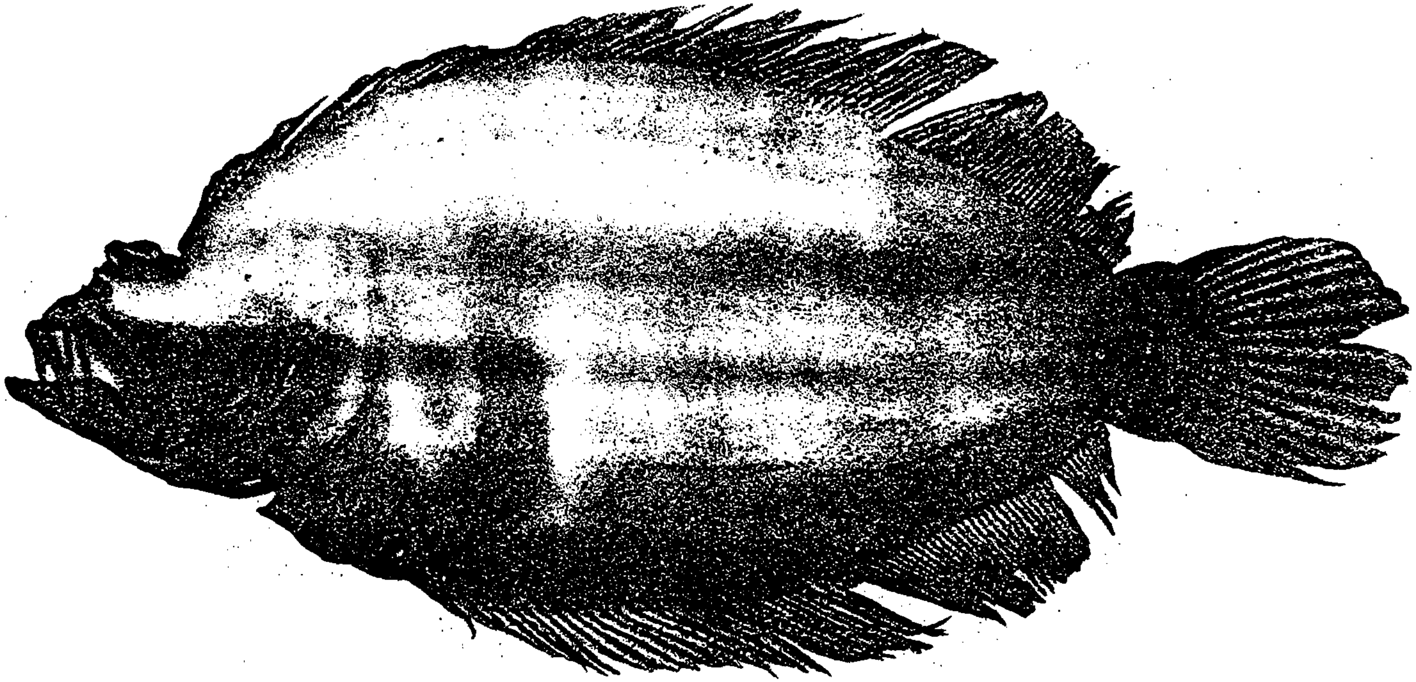

FIGURE 42.—The left side of a Stage 10 postlarva. 7 times natural size. Some pigment is evident since the postlarval pattern begins to form on this side but later fades.

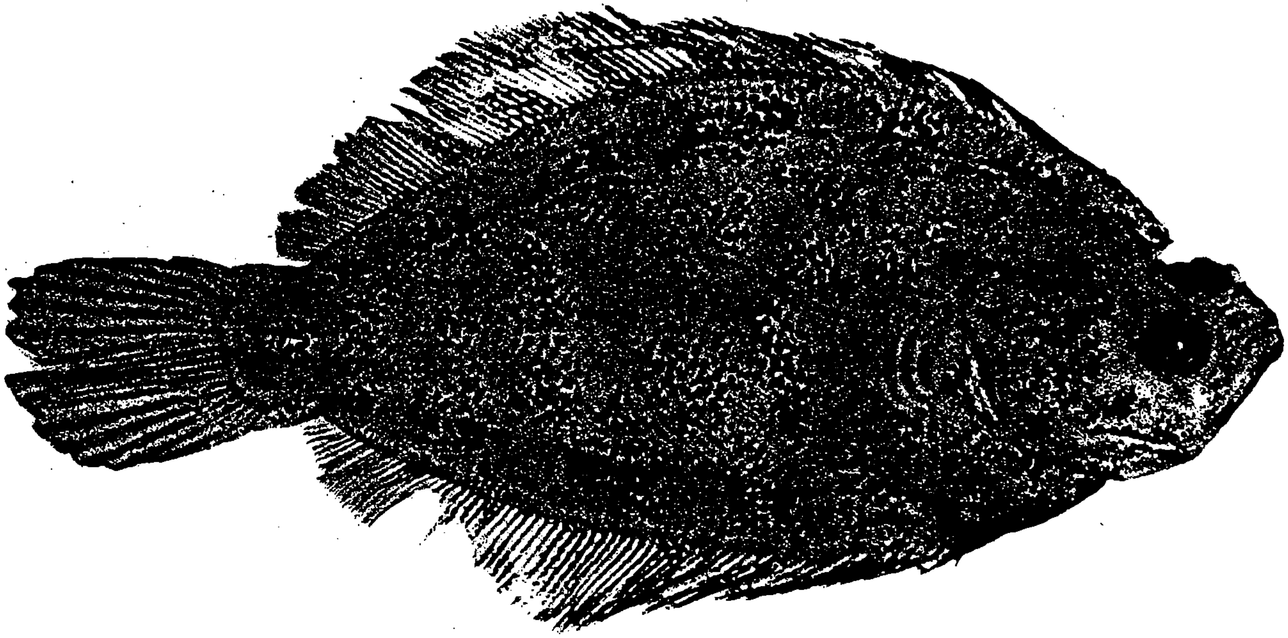

Figure 43.—Stage 10 postlarva. 7 times natural size. The eye has not quite reached the dorsal profile of the head and the pectoral or "side" fin is still large and very delicate and thin in structure.

groups may be formed. The grouping on the trunk is still very primitive, however, and is entirely lacking in front of the M. 5 and D. 5 groups in the oldest specimens of this stage.

The pigment is still symmetrical, and that of the left side appears to be forming groups corresponding to those on the right side. However, the chromatophores are not as numerous on the left side of the abdomen or operculum as they are on the right.

The large size and primitive pigmentation distinguish halibut at this stage of development from most other species. Its pigment is intermediate in character between that of Stages 7 and 9.

The location of the pigment groups is particularly useful in distinguishing it from *Hippoglossoides elassodon.*

At Stage 9 the average length is 20.8 mm. (Figure 39) and varies from 18.4 to 23.7 mm.

Individual variability in rate of development of body and pigmentation is especially notable during the late postlarval stages, as seen in Stage 9. Variation in length and degree of development is very marked during this period and is most apparent in the relative positions of the eyes, length of body, and development of the pectoral fins.

The left eye has nearly reached the dorsal margin of the head, and one-third or more of its diameter is visible above the dorsal profile. The right eye has moved a little ventrally.

The most characteristic feature besides the general body proportions is the further development of pigment. The postlarval grouping of the pigment is well developed, although the separate groups are still made up of small and widely separated chromatophores. The pigment in the middle trunk region has developed farthest, while that on the caudal peduncle, fin, and over the abdominal region is more backward.

From this stage on, the pigment pattern is very characteristic. The detailed changes in it may be followed from the illustrations.

The asymmetry in the pigment is apparent at this stage and consists in a retardation of the development of the pigment on the left side. While grouping of the chromatophores is noticeable, the pigment spots are more scattered and give an appearance of sinking into, or being overgrown by, the body tissues.

The caudal fin pigment is practically unchanged from that of the preceding stage.

In Stage 10, the development of the postlarval pigment (Figures 40 to 43) is rapid and takes place with very little change in length. The average length of all the postlarvæ corresponding to the four figures, 40 to 43 inclusive, is 21.3 mm. with a total range of 18.9 to 23.7. The average size of the least pigmented specimens (Figure 40) is 20.9 mm., and that of the most pigmented (Figure 43) is 22.0 mm. The depth at the anus of all the specimens of this group averages 44.1 per cent of the length.

The body has become broad, and the base of the anal fin has become more decidedly convex ventrally, so that the deepest part of the body now lies behind the anus which has moved anteriorly to a position below the base of the pectoral fin and between the posterior ends of the pelvic fins. These are well developed despite the fact that the pectoral fins are still large and larval. The greatest depth measurements are now made across the posterior end of the body cavity.

At the end of the period covered by this development, the eye finally comes to lie on the dorsal margin of the head, and the anterior end of the dorsal fin arches slightly over its posterior margin.

The result of a retarded development of pigment on the left side of the body is shown in Figure 42.

Included in Stage 11 (Figures 44 to 47 inclusive) are specimens showing the transition from the postlarval to the adult pigmentation. The average length of 33 specimens is 22.1 mm., ranging from 18.7 to 24.6 mm. The depth averages 44 per cent of the length (Table 13).

The left eye has just passed the dorsal margin of the head in Figure 44, and the dorsal fin has grown forward along the dorsal edge of the orbit. In Figure 47 the base of the most anterior fin-ray lies forward of the posterior edge of the orbit.

With a reduction in size (Table 14) and thickening of the tissues (Figure 44)' the pectoral fin begins to develop into the adult form. The lobate base as well as the fan-like periphery is affected and becomes greatly reduced in size. After the fin has become reduced to a length of about one-half that of the larval structure the fin-rays appear (Figure 46). The outer border of the fin remains rounded in Stage 11 specimens as contrasted to the pointed shape of the pectorals of Stage 12 specimens.

TABLE 14.—*Pectoral fin measurements showing reduction in size with the completion of development.*

Stage	Figure	Average Total Length Mm.	Average Length of Base, Mm.
10	43	3.05	1.97
11	44	2.60	1.72
11	45	2.26	1.33
11	46	1.27	0.90
12	48	1.66	0.80

The pigmentation found on the completely metamorphosed specimens is developed by the spreading of the postlarval pigment groups and the

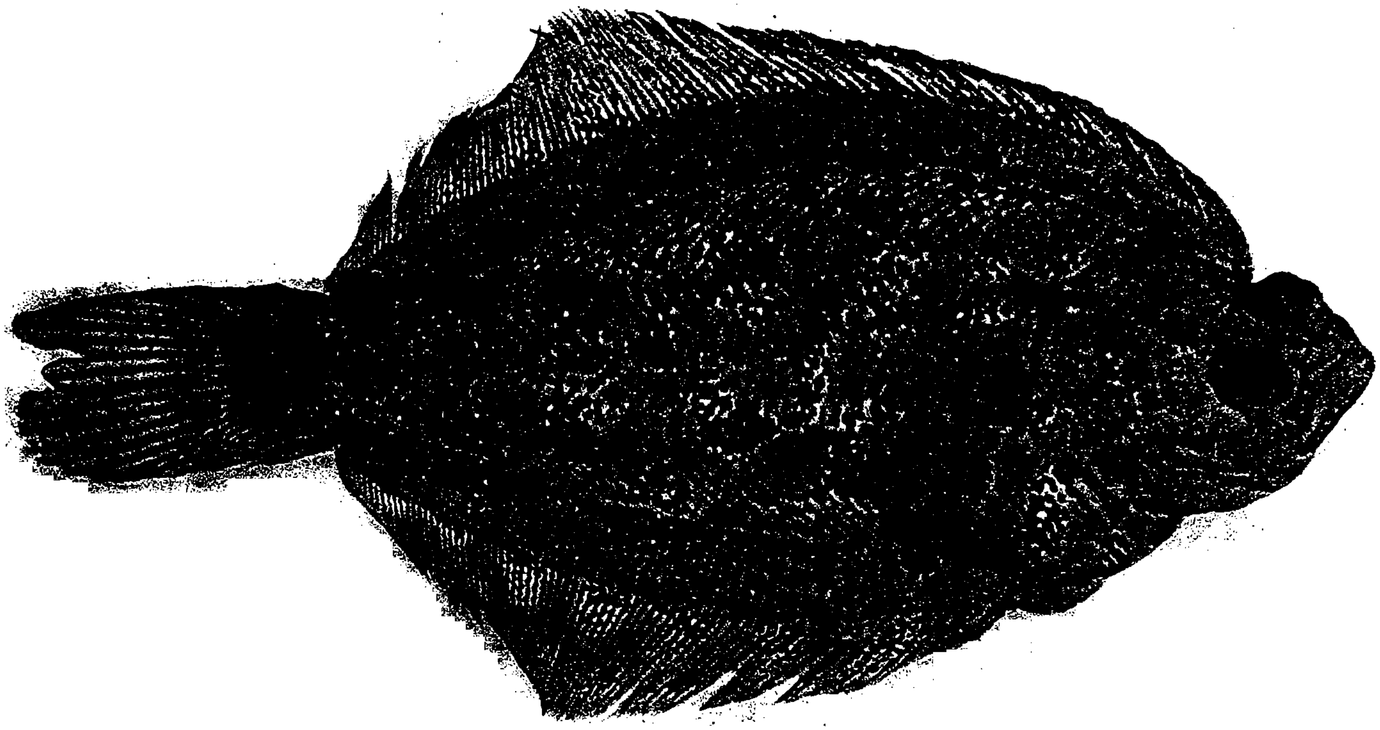

FIGURE 44.—Stage 11 postlarva. 7 times natural size. In Figures 44 to 47 the postlarval pattern is gradually lost while the pectoral fin is reduced in size. The left eye has passed the dorsal profile of the head.

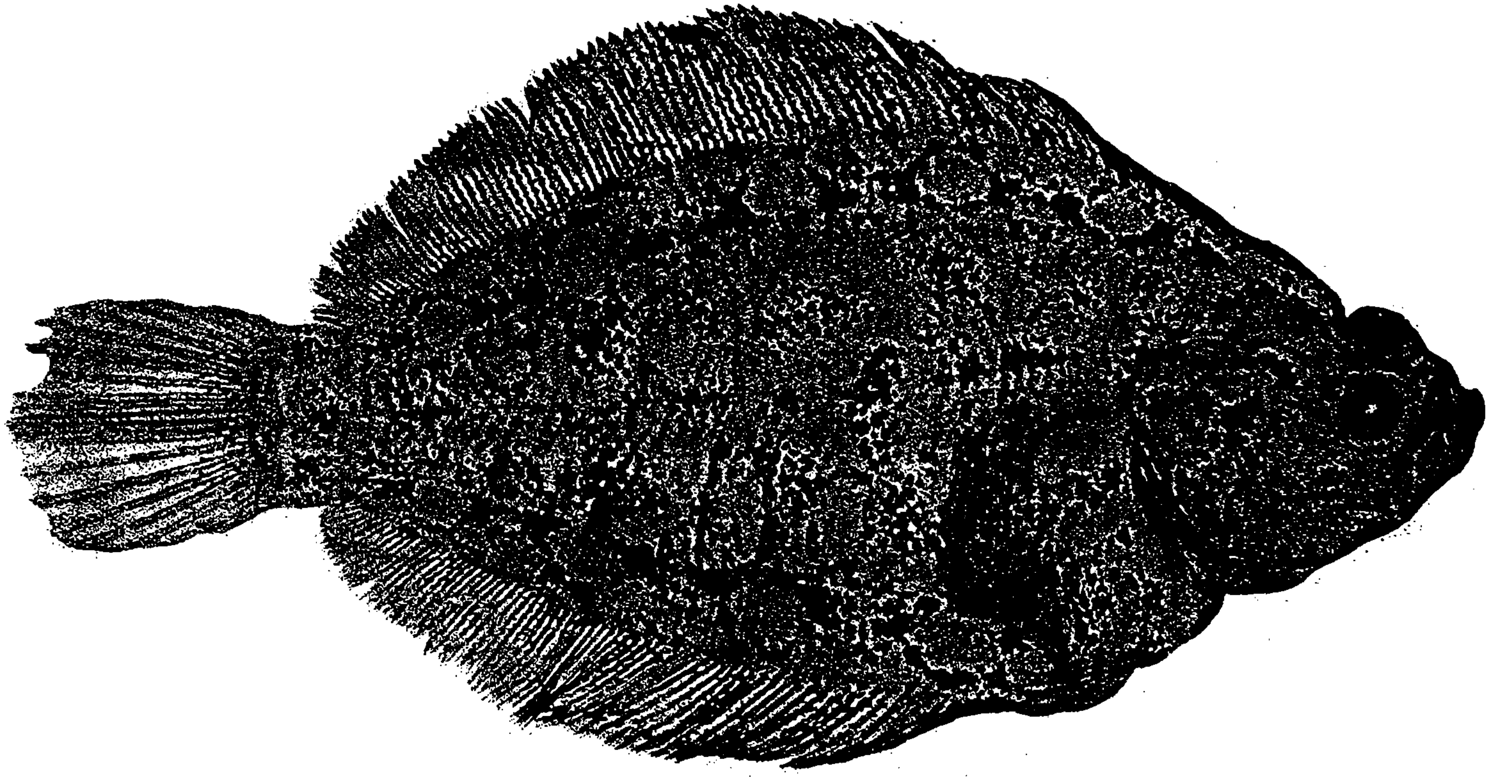

Figure 45.—Stage 11 postlarva. 7 times natural size.

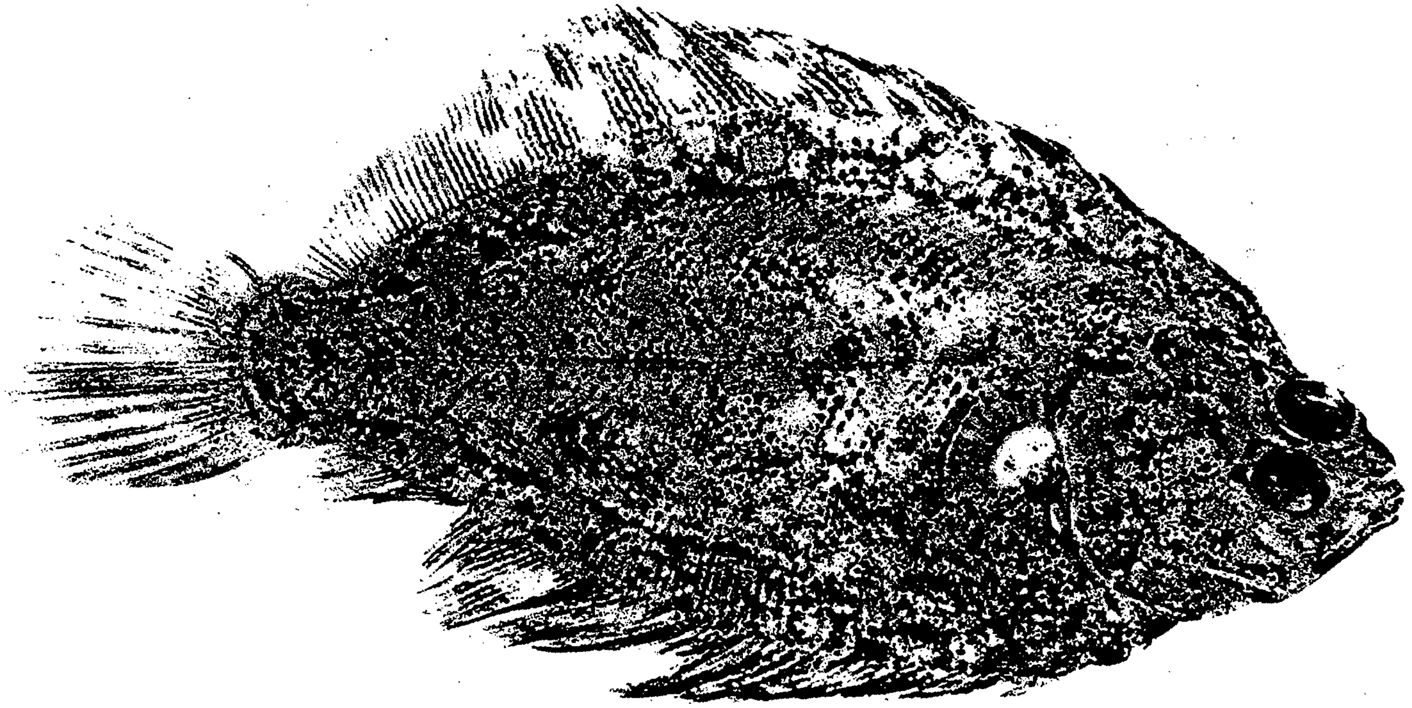

FIGURE 46.—Stage 11 postlarva. 7 times natural size.

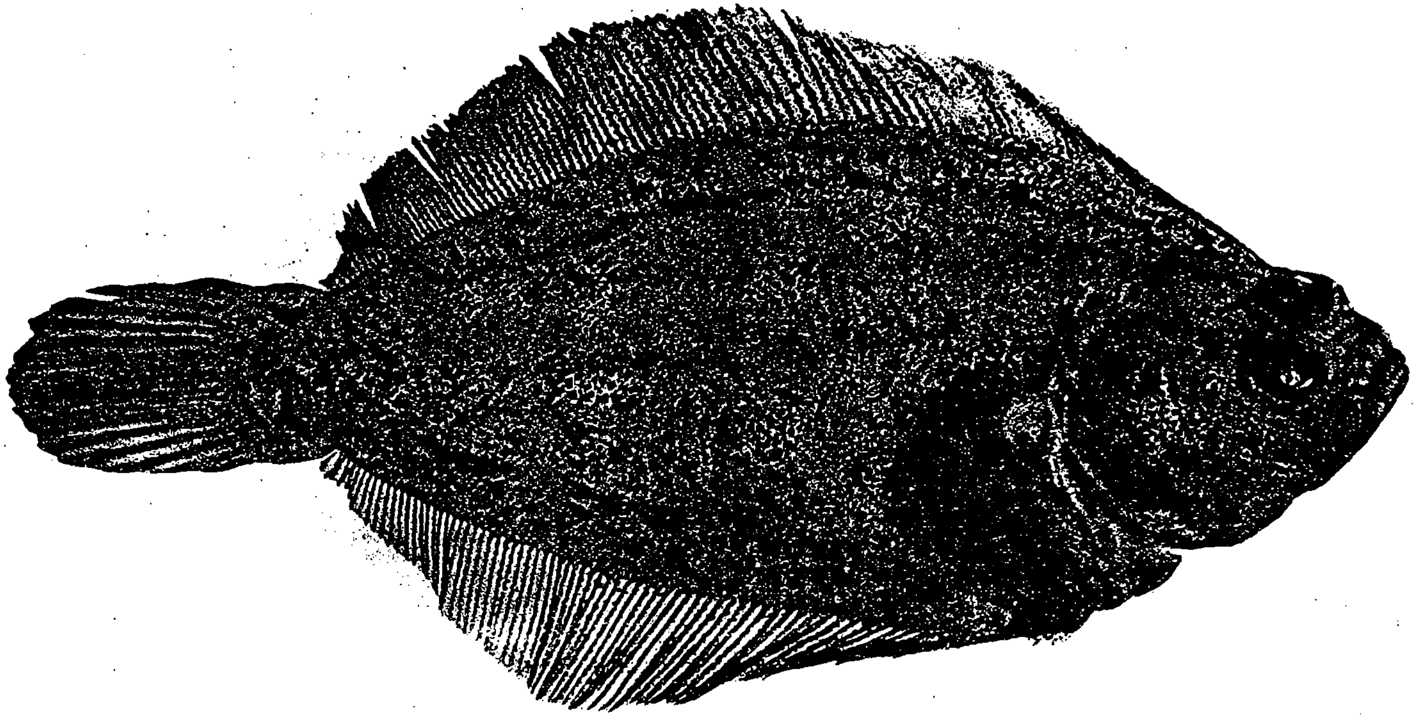

Figure 47.—Stage 11 postlarva. 7 times natural size. The pectoral fin is still rounded and fan-shaped, although fin-rays are apparent in it.

Figure 48.—Stage 12. 7 times natural size. The pectoral fin has become pointed in profile and is now by actual measurement shorter than was the base of the larval pectoral in Stage 10.

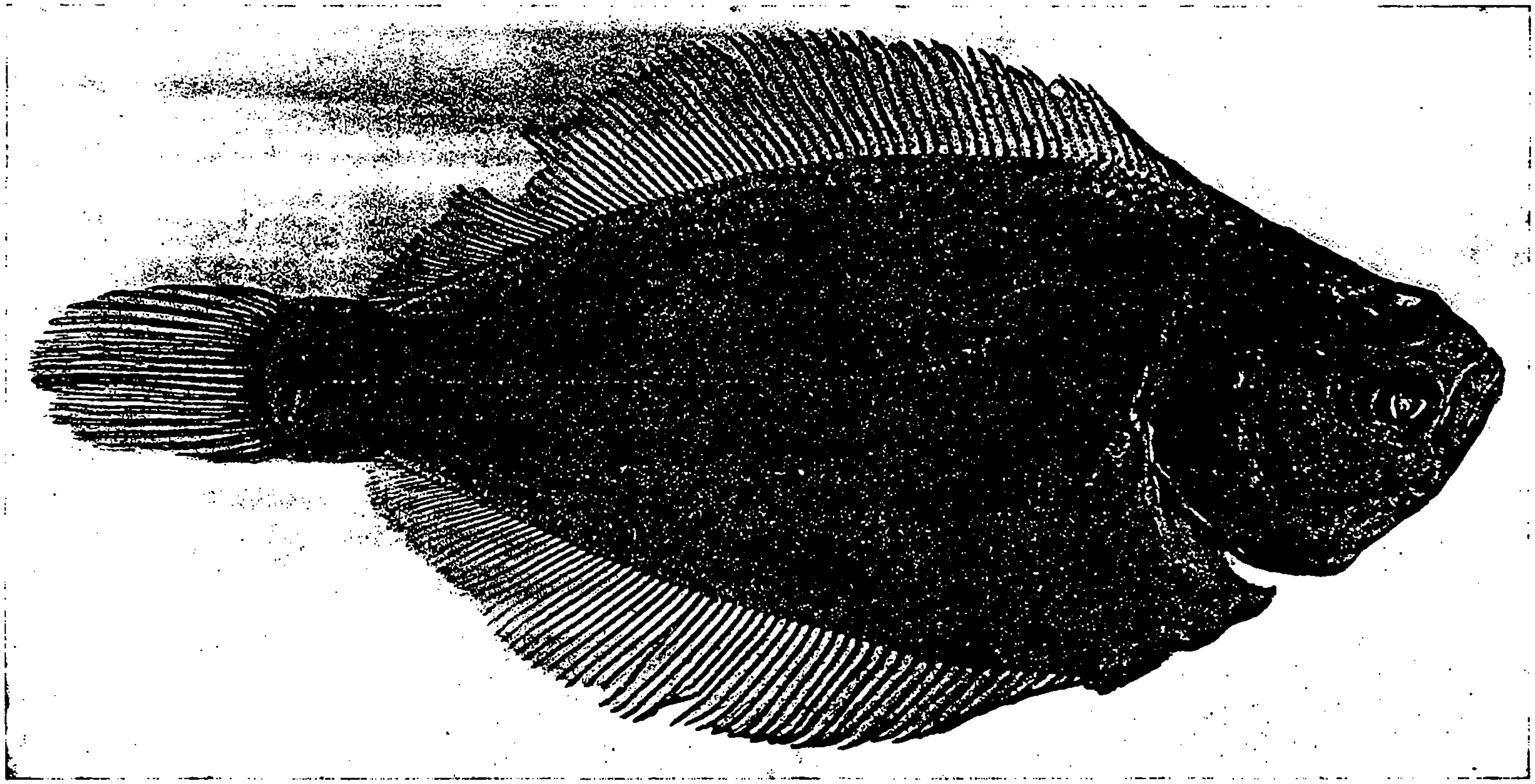

FIGURE 49.—Young halibut. 6 times natural size. Length, 28.8 mm.

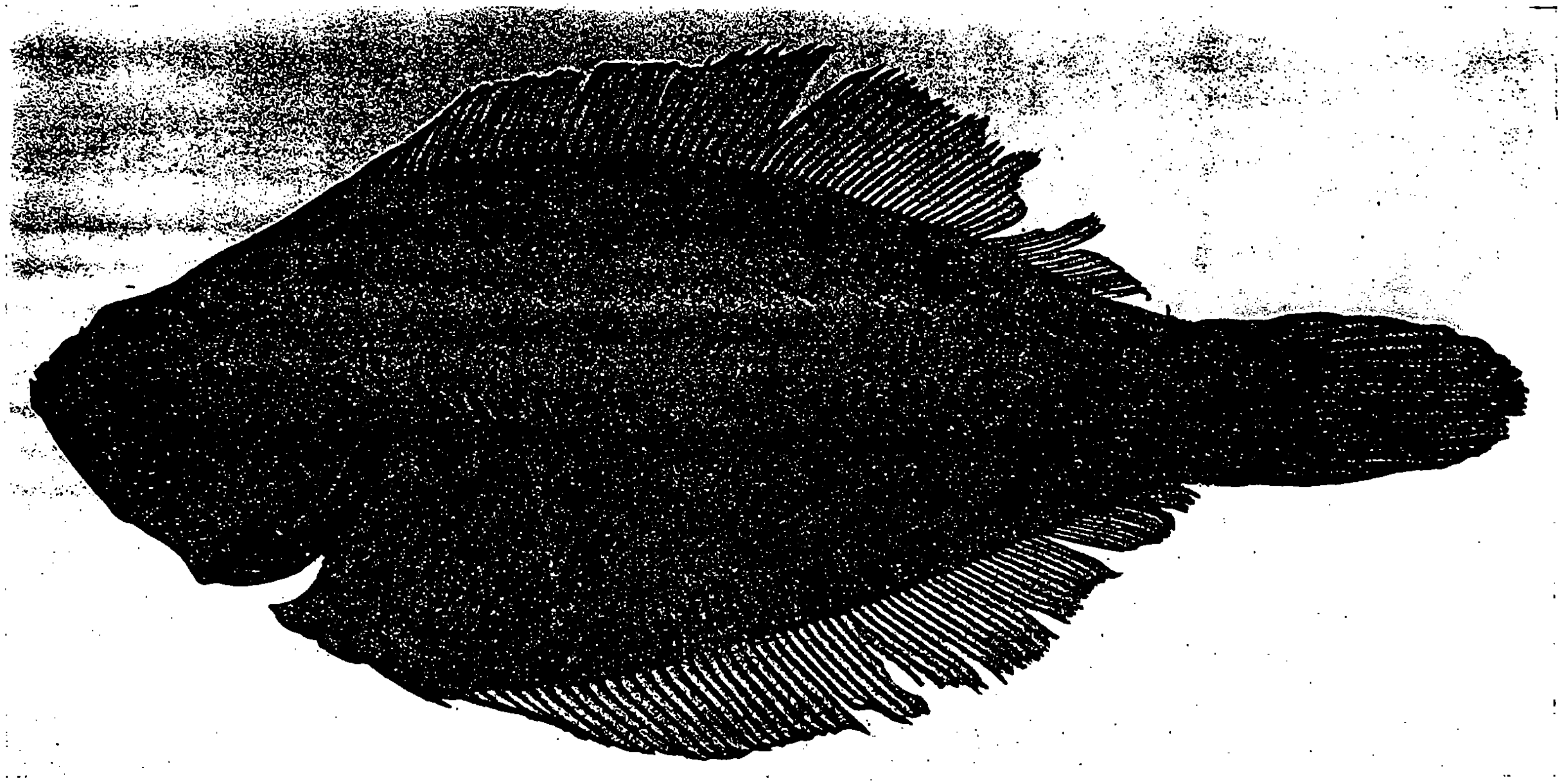

FIGURE 50.—Blind side of a young halibut. 6 times natural size. At this stage a complete lack of pigment upon the blind side is characteristic.

filling in of the spaces between. Figures 44 to 47, arranged in the order of degree of development of their pigment, illustrate the gradual disappearance of the pattern developed in Stage 10. The dorsal part of M. D. 2 and the ventral part of M.V. 2 and the dorsal and ventral ends of the M. 5 and M. 3 groups develop into five dark spots that are characteristic of the small halibut (Figure 49).

At Stage 12 (Figure 48) the adult form and coloration are well enough developed to make possible their identification from adult characters. The length of 15 specimens varies from 22.3 to 28.8 mm., averaging 25.7 mm. The depths average 41 per cent of the length. The comparatively long slender shape of the body, as contrasted to the postlarval form, approaches that of the adult. The eyes are very large, their longitudinal diameter being nearly twice the length of the snout, and the ratio of head to eye diameter is 3.5 to 1. The dorsal or former left eye still lies close to the dorsal margin of the body.

The fully developed pectoral fins are about equal in length to the base of the postlarval structure. The pelvic fins now lie immediately in front of the vent and extend posteriorily on either side of the second or third anal fin-ray.

The postlarval pigmentation is nearly lost in the general increase in depth of color. The characteristic lighter spots over the dorsal and anal interspinous regions are much reduced in most cases and are difficult to see. At a length of 28.8 mm. the blind side (Figure 50) has assumed the colorless appearance characteristic of the adult.

DEVELOPMENT OF CAUDAL FIN

In the study of the development of the caudal fin structures only the gross features have been considered, inasmuch as the principal objective was the accurate location of the future position of the last vertebra in the early larvæ, and the determination of stage of development was secondary. The nomenclature used follows that of Whitehouse (1910, a and b).

The following symbols are used in the figures illustrating the development of the caudal skeleton:

DCR^1: dorsal caudal radial.
DCR^2: distal or proximal portions of the second dorsal caudal radial.
EP: epural.
HY: hypurals (HY^1—1st hypural, HY^2—2nd hypural, etc.)
VCR: ventral caudal radial.
HS: hæmal spine.
NS: neural spine.
N: notochord.
MY: myomere.
U: urostyle.
LC: larval lobe of the caudal fin-fold.

The tail of the newly hatched larva (Stage 1, Figure 51a) is symmetrical

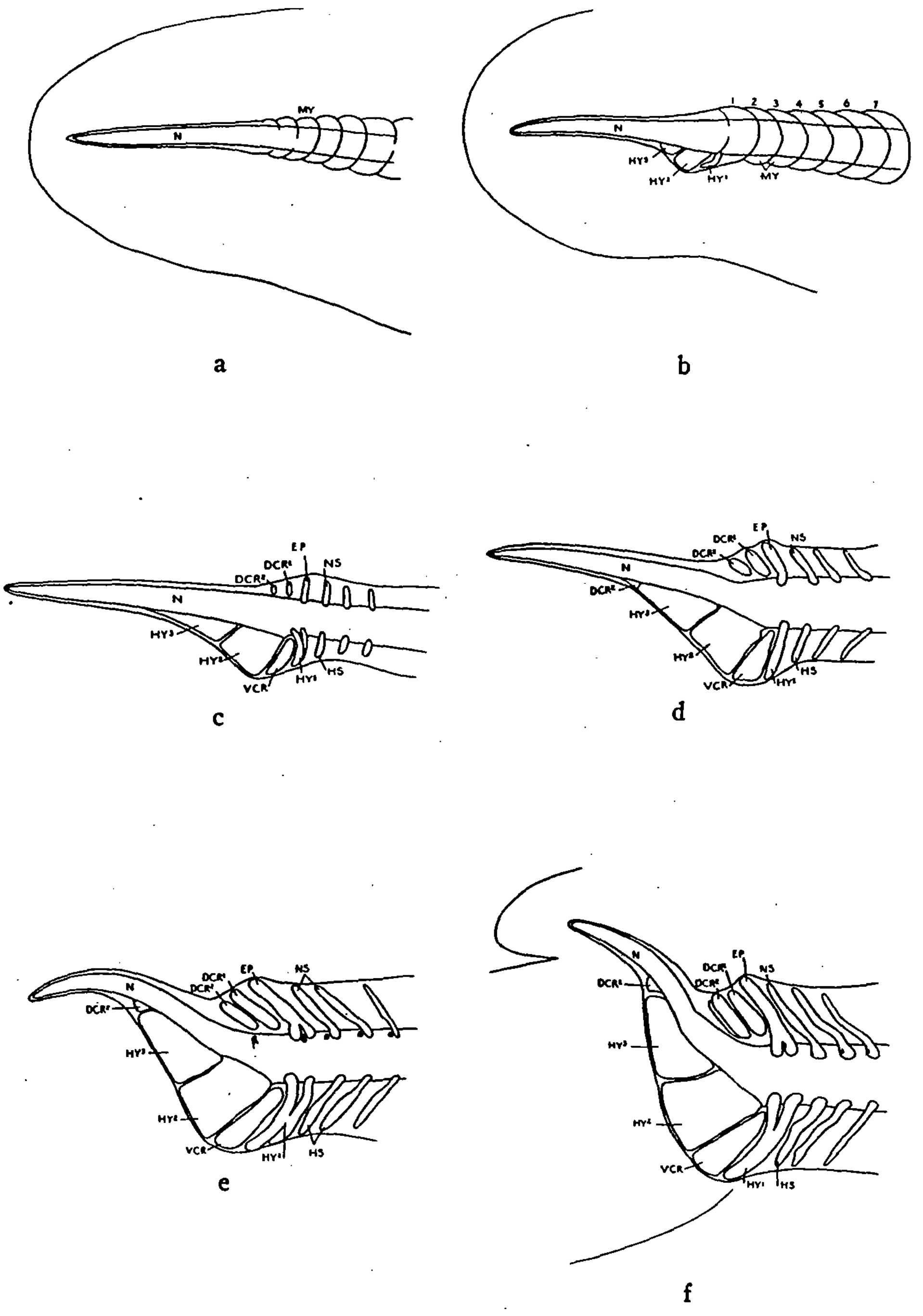

FIGURE 51.—Caudal fin and its cartilagineous skeleton; (a) Stage 1, (b) Stage 2, (c) Stage 3, (d) Stage 4, (e) early Stage 5, (f) late Stage 5. See p. 83 for interpretation of the symbols. 25 times natural size.

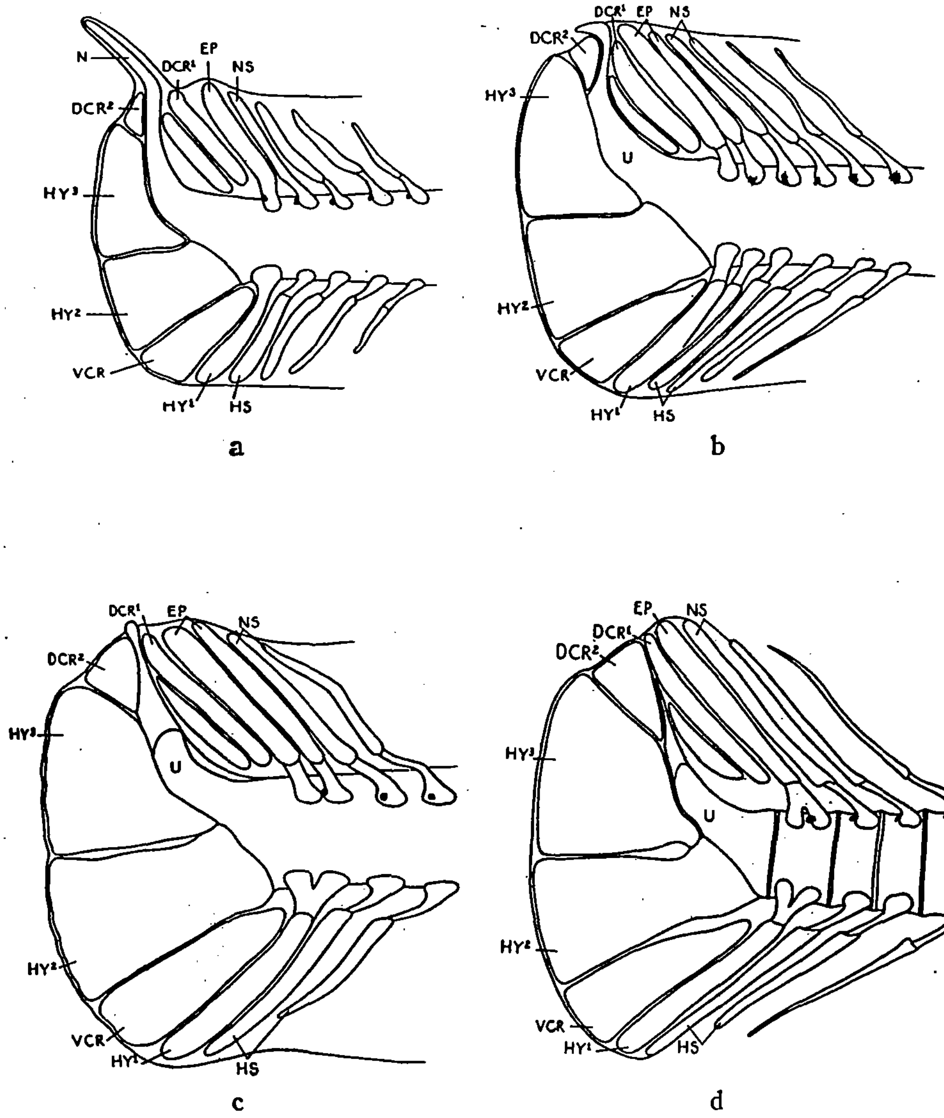

FIGURE 52.—Postlarval caudal fin skeleton (a) of an early Stage 6 specimen, (b) a late Stage 6, (c) Stage 7, (d) Stage 10. 40 times natural size.

in both external form and internal structure and may be designated as a true protocercal tail. The tip of the notochord is straight, and the dorsal and ventral myotomes taper uniformly to end not far from where the cartilages of the caudal fin are later formed. The entire caudal fin region is supported by actinotrichia or larval fin-rays.

Shortly after hatching, the base of the larval fin-fold becomes thickened below the notochord in the region where the caudal fin cartilages later develop. At the same time a slight increase in depth of the ventral myotomes at this point is the first appearance of asymmetry. The position of the last myotome to be counted as corresponding to the last vertebra, determined in the youngest larvæ by reference to its position in succeeding stages, is easily located at the anterior end of the ventral thickened area (Figure 51b).

The second and third hypural cartilages are the first to become visible in the mass of subchordal tissue shortly followed by the first (Stage 2, Figure 51b). The anterior tip of the second hypural marks the future position of the posterior border of the last vertebra counted.

In Stage 4 (Figure 51d) the cartilage that later forms the distal portion of the second dorsal caudal radial (DCR^2) has appeared just behind the third hypural. Later it grows around the notochord, and with the absorption of that section of the chorda (Stage 10, Figure 52d), grows forward to fuse with the most posterior of the dorsal cartilages. Its final relative position in the adult fin (Figure 54) gives it the name of the second dorsal caudal radial, but it originates in the same manner and in a position analagous to that of the hypural bones. In Stage 10 the vertebral centra have become differentiated, and calcification is apparent.

The presence of the two spines in place of a single one on the penultimate vertebra is a variable character, and the dorsal and ventral spines vary independently; that is, a double based single dorsal or ventral spine may occur with two ventral or dorsal spines respectively, or both may be single or double, etc. (See Figures 52a and 52c.) It is apparent that the adult penultimate vertebra may arise from a single primitive element or from the early fusion of two elements (see Kändler, 1932).

The tail of a specimen 53.6 mm. long (Figure 53) shows the complete reabsorption of the end of the notochord and the reduction in size of the urostyle. The urostyle has also been enclosed by cartilage that has grown around it and fused it with the third hypural.

Fusion of the paired spines on the penultimate vertebra, or growth of the single ones, has broadened the first epural and first hypural, and both are broadly keeled anteriorly. Calcification of the arches on the penultimate vertebra has obscured signs of their earlier double origin.

Faint indications of subdivision of the first three hypurals, the second dorsal caudal radial, and the ventral caudal radial, into segments correspond-

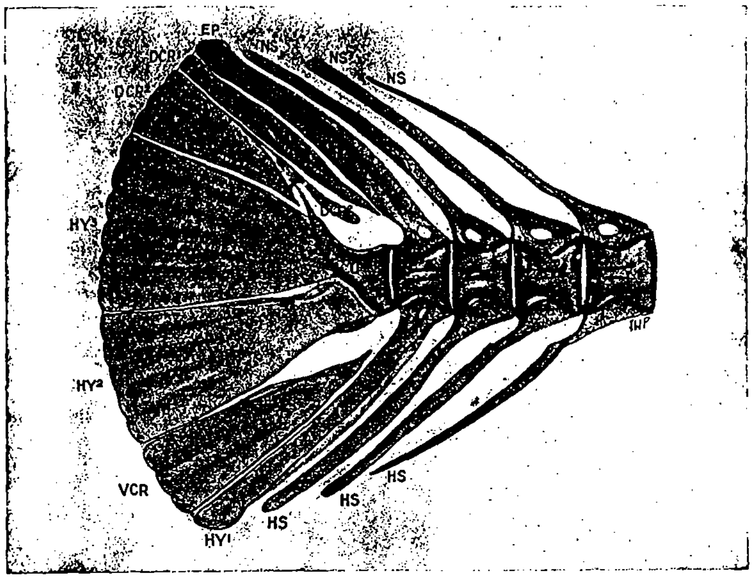

Figure 53.—Caudal fin skeleton; 53.6 cm. specimen. 17 times natural size.

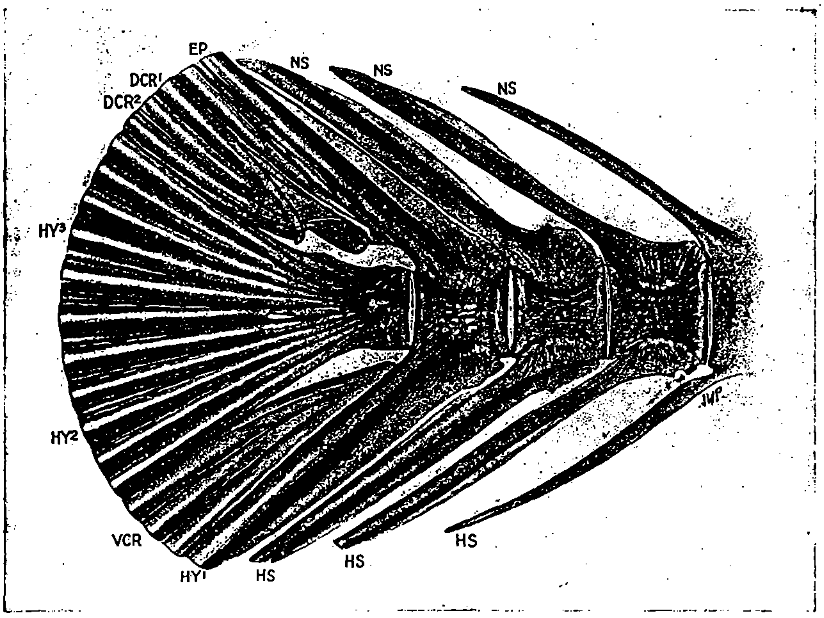

Figure 54.—Caudal fin skeleton; 23 cm. specimen. 4 times natural size.

ing to the separate fin-rays have appeared along the posterior edge of the caudal plate. Each groove corresponds to a slight indentation on the edge of the cartilage and lies between places of attachment of the fin-rays.

The tail of a specimen 23 cm. long (Figure 54) approaches very closely to perfect symmetry about the end of the vertebral column, and few indications of the earlier form remain. Both the first epural and first hypural, borne by the penultimate vertebra, bear a single fin-ray, and the spines of the first antepenultimate vertebra are placed symmetrically along the anterior borders of the caudal plate. The second and third hypurals have fused except for a small gap near their proximal end. The second dorsal caudal radial and ventral caudal radial appear to be nearly equal in size, and by the fusion of the two parts of the dorsal radial they have become very nearly mirror images of one another.

The secondary division of the hypurals and radials into segments is complete, and the smaller divisions tend to mask the primitive larger ones. The distinct divisions of the plates are hollow and cone-shaped and are connected by narrow cartilaginous, later bony, septæ. The adult caudal approaches nearer to secondary symmetry than is the case in other flounders examined. The caudal plate of a 15 cm. specimen of *Hippoglossoides elassodon* thus compares in degree of specialization with that of the 54 mm. halibut in that the hypurals and epurals remain distinct. No sign of the secondary segmentation found in the halibut is seen in the caudal of *H. elassodon.* A similar subdivision of hypurals and radials has been found in *Paralichthys californicus* (see Jordan, 1905, Figure 69).

The canal formed in the DCR^2 around the tip of the notochord has not entirely disappeared. The first dorsal caudal radial is still distinguishable though fused with the epural. The most anterior of the three divisions of the DCR^2 and DCR^1 together support a single fin-ray. Thus there appears to be one more division in the caudal plate than there are rays. In a 100 cm. specimen, fusion of these two segments has occurred, and the number of divisions in the caudal plate corresponds to the number of fin-rays.

Comparison of the postlarvæ of the Pacific halibut with those described by J. Schmidt (1904) shows a marked difference in size of specimens of corresponding stages of development.

The most notable character in which the Pacific species differs from that of the Atlantic is the complete lack of pigment on the brain in the Pacific form. This was described by Schmidt as typically present in his Atlantic specimens. Furthermore, chromatophores occur on the caudal fin of the Pacific halibut throughout later larval and postlarval development, while they are lacking in the Atlantic form. Specimens have been observed only after preservation in formaldehyde, so that the reddish pigment described by Schmidt in the live specimens has not been seen.

As far as can be determined the late postlarval pigmentation of the Atlantic halibut other than that described above is identical with that of the Pacific, but a great difference exists in the size (lengths) at which it is developed. The pigmentation and development of Schmidt's 29.5 mm. specimens (Schmidt, 1904, Figure 11) corresponds to that of Stage 9 which averages only 20.7 mm., and his largest specimen, which was 34 mm. long, shows the same development as the late Stage 10 specimens (Figure 43) which average 21.9 mm., and at a length of 28.8 mm. the Pacific halibut has completed its larval development and has approached the form and pigmentation of the adult.

C. DISTRIBUTION OF THE EGGS AND LARVÆ

METHODS

The distribution of halibut eggs and larvæ has been investigated by means of plankton nets, hauled at 1161 stations during the years 1926 to 1934. The stations were distributed from Cape Flattery to the Sanak Islands, Alaska, including the coasts of British Columbia and Alaska to the entrance of Bering Sea, and throughout the Gulf of Alaska north of 54° N. latitude.

The scattered and sparse occurrence of both the eggs and larvæ, as well as the extensive region over which they are distributed, made it necessary to adopt a net that would filter a maximum volume of water in a minimum amount of time. A silk net one meter in diameter at the mouth and constructed with a mesh of 24 to the inch in the cone and 14 to the inch in the cylinder was used as a standard type for the winter work because of its ease of handling and efficiency.[6] In milder weather and shallow water, nets of silk grit gauze with rings two meters in diameter and Petersen young fish trawls made of one-fourth inch mesh cotton netting have been used to capture the larger postlarvæ and first bottom forms.

Present methods of making quantitative horizontal net hauls were found to be too time consuming to be practical. The vertical hauls were also found to be useless because of the small volume of water filtered. Accordingly, a standardized method of hauling was adopted which, though not quantitative, gave results that are roughly comparable, and the numbers of halibut eggs and larvæ taken by these net hauls are considered as indicative of their relative abundance in the various regions.

In this standardized haul three 1-meter nets were put on the cable at intervals of 300 meters, when the depth was great enough, and a total of 900 meters of cable was let out. At the end of every 20 minutes of hauling, 100 meters of cable were taken in, and at the end of one hour the nets were brought aboard. The top net was therefore hauled for 20 minutes with each of the following lengths of cable: 100, 200, and 300 meters, and the other two nets at corresponding levels 300 meters and 600 meters below. In shallower water the levels of hauling and number of nets were of course modified according to the soundings. The depths recorded were the amount of cable put out, but since the angle at which the cable was towed was kept

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[6] The equipment used by the International Fisheries Commission is to be described in a separate paper to be published.

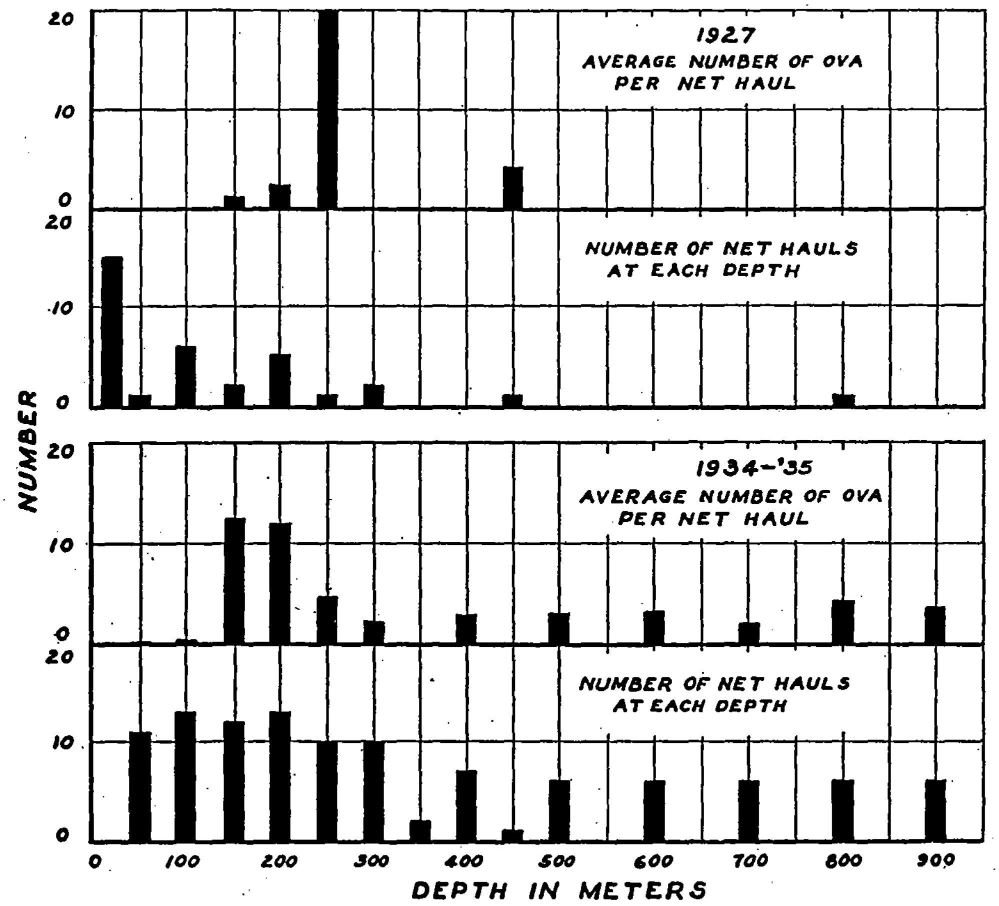

FIGURE 55.—Average number of ova and number of net hauls taken at various levels using only the hauls taken in 1927 and 1934 that were made by hauling a one-meter net for one hour at a single depth. The depths shown are meters of cable and should be reduced to about 85 per cent of that given in order to obtain the true depth.

as constant as possible, near 30°, the levels should be comparable. It was estimated that for each 100 meters of cable the depth was between 80 and 85 meters. A correction of 15 per cent has therefore been used when necessary to transform cable lengths into depths.

The necessity for carrying on the phases of the investigation other than those on early life history has limited the field work each year to a comparatively short period. The spawning and subsequent drift of the eggs and young of any one year class has therefore not been followed through. The different parts of the developmental period have been investigated in different years, and in all it has taken six seasons of work to follow the larval and postlarval development to completion.

The exact levels at which the eggs and larvæ float have not been investigated in the majority of hauls. However, experimental hauls were made in 1927 and continued in the winter of 1934-35 that show plainly the depths to which they are limited. In these two seasons net hauls were made by

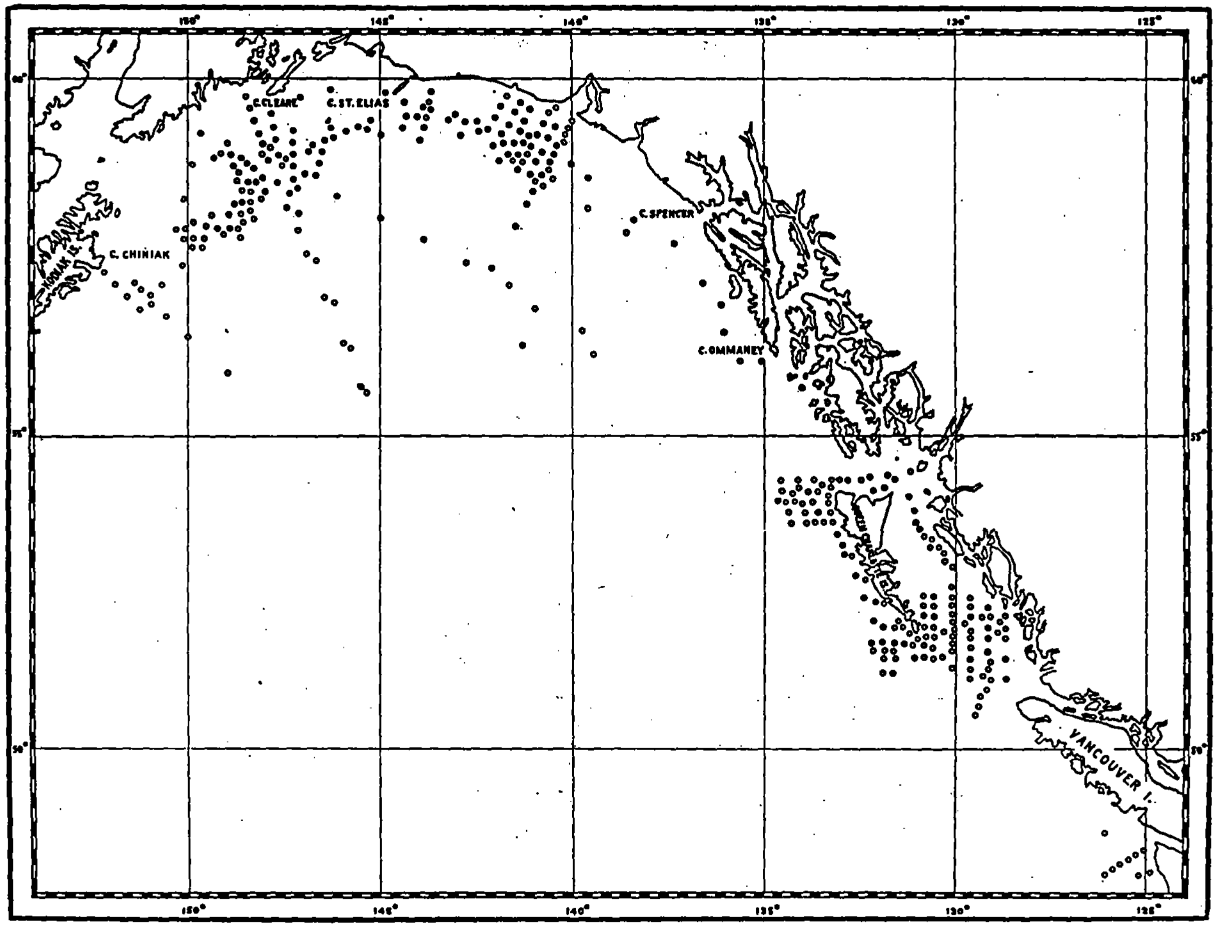

FIGURE 56.—Group 1 net hauls. Locations at which stations were taken during the period from January 1 to March 31.

hauling for an hour at but one level. The average number of eggs taken per haul and the number of hauls at 50-meter intervals are shown in Figure 55. No eggs were taken with less than 100 meters of cable in 1927, while most of the eggs were taken with 250 meters. In the winter of 1934-35 three eggs were taken in 13 hauls with 100 meters, and one egg was taken in 11 hauls made with 50 meters. However, comparison with the average of 12.5 and 12.2 eggs found in the net hauls taken with 150 and 200 meters of cable respectively, indicates that only an occasional egg floats up into the shallower depths. It is impossible to tell whether or not the eggs taken with more than 300 meters were caught during the time of hauling or while the net was being put out or hauled in. The important fact, however, as far as the drift of the eggs is concerned, is that they are not found in the surface layers. In order to save time therefore the surface layers above 50 meters were not sampled by the ordinary net hauls, and most of the hauls were made with 100 meters of cable or more.

NET STATIONS

The detailed records of the net stations are given in Appendix A with the numbers of eggs and larvæ, locations and depths of the hauls, etc. In all, 1161 stations had been taken up to March 31, 1934, at each of which from one to five net hauls were made.

In order to show the distribution of the net stations throughout the winter and spring months they have been divided into three groups that correspond roughly to three periods of the early development of the halibut. The first group (Figure 56) includes all net stations which have been taken during the months of January through March during the years of 1928 to 1934. This period includes the entire spawning season and the months during which the greatest numbers of the early larval stages are found. The following 413 stations are included in this group: in 1928, stations 1 to 33; in 1929, stations 101 to 214, and also station 233; in 1930, stations 234 to 256, 302 to 304, and 378 to 380; in 1932, stations 609 to 627; in 1933, stations 948 to 981; and in 1934, stations 1005 to 1194. In 1934, stations 1060, 1071, 1078, 1082, as well as stations 982 to 1004 of 1933, have been omitted, since these stations include vertical hauls and horizontal quantitative hauls made with the use of closing devices and which are not comparable with the standard hauls.

From the chart it may be seen that both the western and southern spawning banks have been well covered during this season, and a comparison with Figure 65 shows that the stations extend well beyond the range of geographical distribution of the ova. Moreover, a sufficient number of stations has been taken in the Gulf of Alaska to show the offshore drift of the eggs and larvæ. The stations over the southern grounds were designed principally as a survey of the spawning banks to ascertain the presence and intensity of spawning and are being used as a basis for a yearly study of the fluctuations in the spawning activities of the southern fish.

The second group of stations (Figure 57) covers the period of April 1

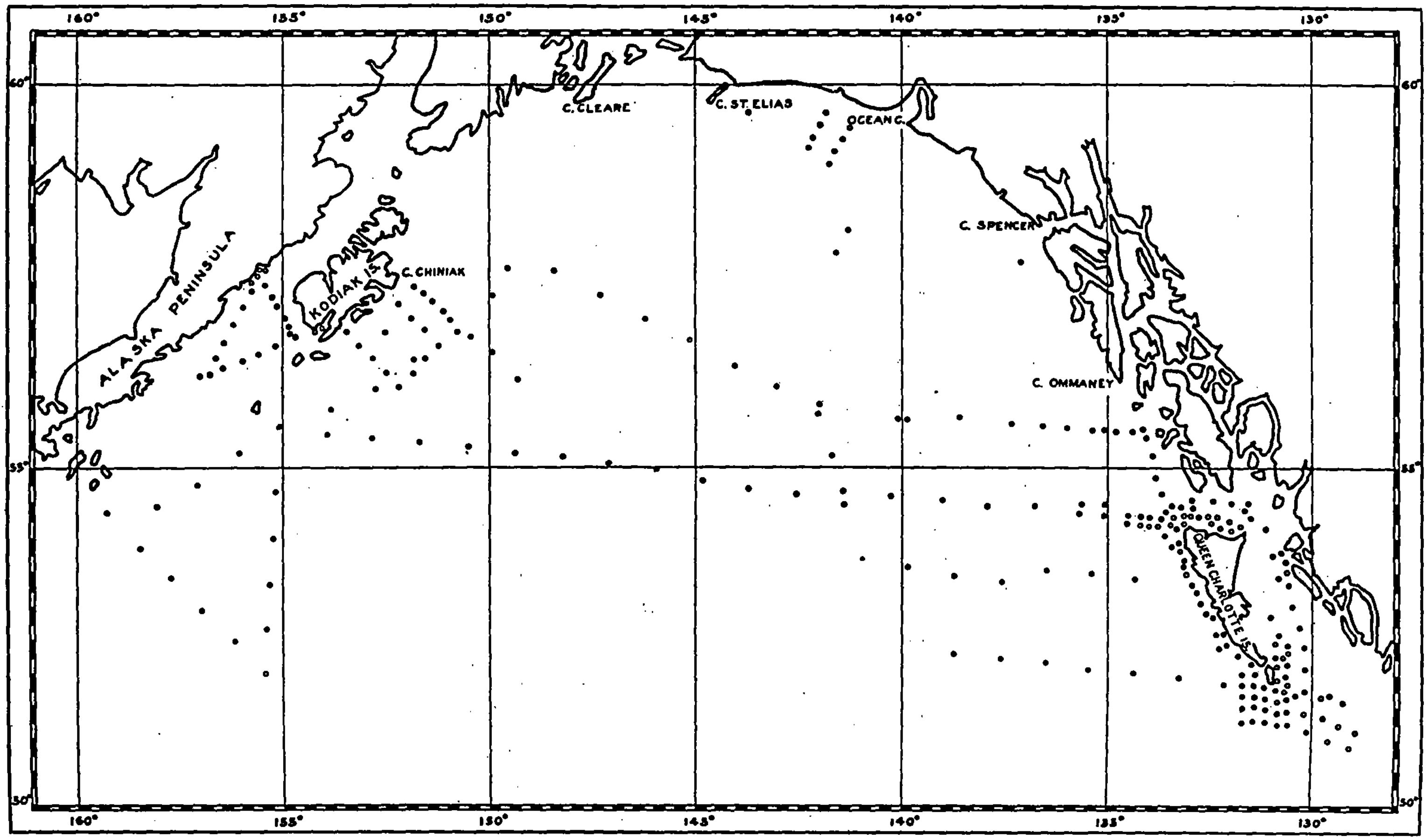

FIGURE 57.—Group 2 net hauls. Location of stations taken between April 1 and May 21 inclusive.

to May 21; that is, the period during which the halibut on the average is undergoing its metamorphosis from a symmetrical pelagic larva into an asymmetrical bottom living adult. The stations included are: in 1929, stations 215 to 232; in 1930, stations 257 to 301 and 305 to 377; in 1931, stations 381 to 388; and in 1932, stations 628 to 769 and trawl stations 843 to 865.

Having discovered the offshore drift in the region of Cape Cleare, the hauls during 1930 and 1931 were for the most part designed (1) to find out whether or not any of the larvæ originating in the Gulf reached the shores of lower Southeastern Alaska and British Columbia, (2) to find out what change in distribution occurred in a typical shore section, and (3) to provide further for a study of the anticipated changes in amount of spawning on southern grounds due to regulation. Hence the long offshore sections off the Southeastern Alaska and British Columbia coasts and across the lower part of the Gulf were taken during this second period. The known distribution could not be intensively investigated with the resources at command, so the inshore hauls were made near Kodiak Island only. It was thought that this region offered the best opportunity for discovering what happens to the older larvæ and postlarvæ.

The entire Gulf offshore is not as well covered in this April to May period as in the previous, which no doubt explains the capture of comparatively few young postlarvæ (Stages 3 to 4). The southern spawning areas are well covered, however, as is the western region around Kodiak Island where a number of the stations over the outer Albatross Bank and inside of the Trinity and Semidi Islands were visited repeatedly throughout May and June, 1932.

The third group of stations (Figure 58), which covers the period from May 22 to June 21, continues the observation of possible offshore drift and the study of the inshore grounds where final change to bottom stages was expected to occur. It omits a number of net stations taken during 1931 over the area between Kodiak Island and the Sanak Islands, during late June and July, in which no halibut were found. It does, however, cover the last part of the postlarval development of the halibut during which the completion of the postlarval stages is accompanied by the young fish settling to the bottom. The stations included are: in 1931, net stations 389 to 468; in 1932, net stations 770 to 842; and in 1932, trawl stations 867 to 947.

VERTICAL DISTRIBUTION OF THE EGGS AND YOUNG

It is a well known fact that both the speed and direction of the ocean currents vary with depth. The rate and direction of drift of pelagic organisms must therefore vary according to the depths at which they float. Although the exact depths at which the halibut larvæ and young float have not yet been completely investigated, the analysis of their distribution in the net hauls, here recorded according to the average depth at which the haul was made, has yielded results which make possible the explanation of their horizontal distribution. The distribution, as shown by plotting the total

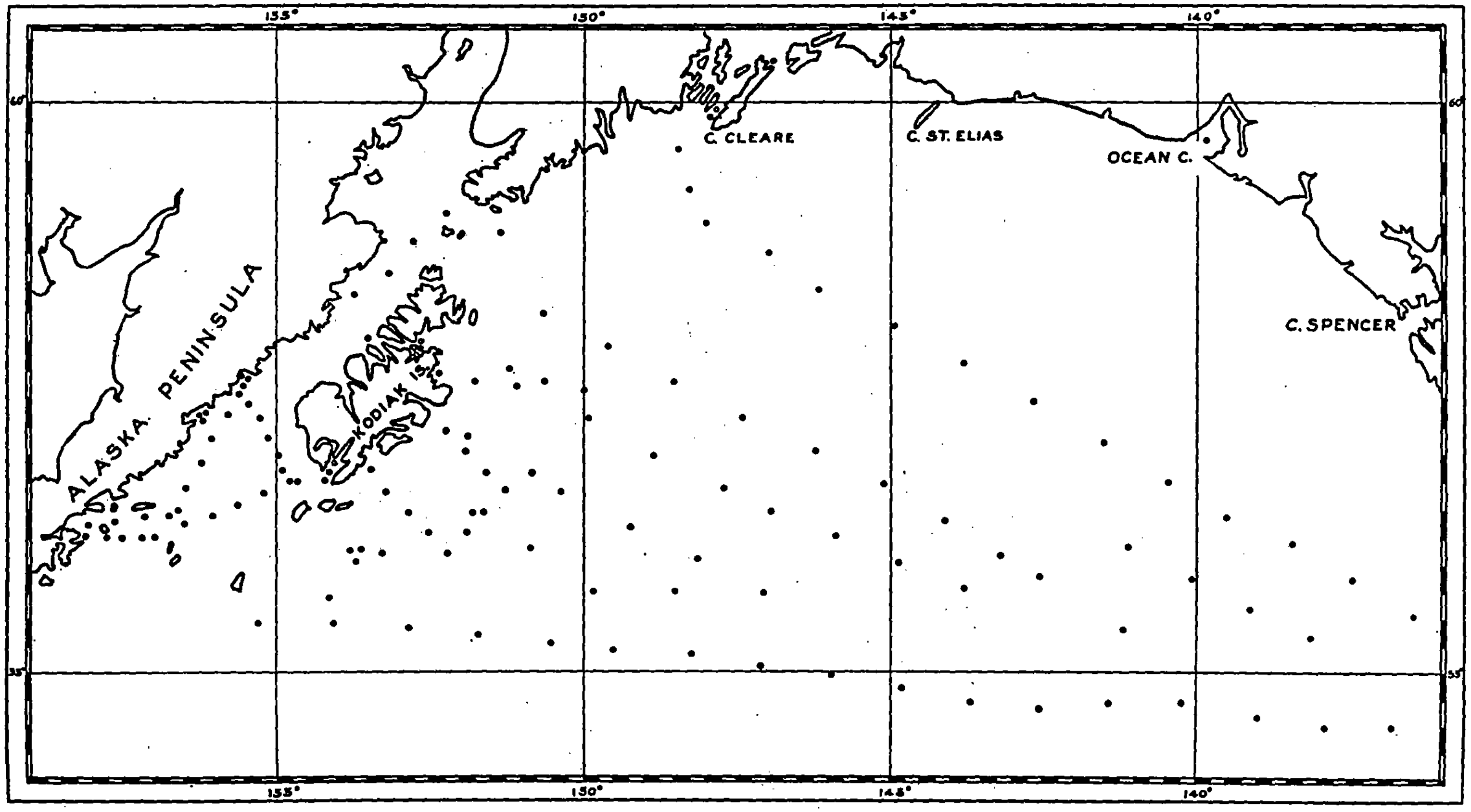

FIGURE 58.—Group 3 net hauls. Net stations taken between May 22 and June 27 inclusive.

number of captures at the various depths, shows absence or relative scarcity at certain depths and regions.

In constructing the charts (Figures 59 to 64) the bottom profiles are made to follow approximately the slope of the banks in the northern part of the Gulf of Alaska. The outer edge of the bank has been given a more gradual slope than is actually found in order to group the net hauls into 25-meter depth intervals.

The distribution of all of the halibut ova, according to depth of haul and position relative to the edge of the bank, is shown in Figure 59 for the seasons of 1928 to 1934. They are found along the outer edge of the bank and over the deep water outside. Ninety-eight per cent were taken at stations where the depths were 275 meters or more, and 67 per cent of the total over depths of more than 400 meters. As for the depth of capture, 88 per cent of the ova were taken between the levels of 85 and 425 meters (with 100 and 500 meters of cable), and 68 per cent of the total between 85 and 212 meters, the remainder down to 680 meters.

Comparing the distribution of the ova with the distribution of water density as shown by the 1929 hydrographic sections, they are seen to lie within and below the region of rapidly changing density, the so-called layer of intermediate water (McEwen, Thompson, and Van Cleve, 1930). None float up into the lighter, less saline surface water.

The youngest larvæ, comprising the Stage 1 group, whose distribution with depth is shown in Figure 60, are confined to the region just outside of the edge of the bank over bottom depths of 425 meters or more. Ninety-two per cent of them were taken in hauls made over bottom depths of 750 meters or more, while none were caught in the net hauls above 320 meters, and only 9.4 per cent of them were taken above 425 meters. If the distribution of the density shown in Figure 59 may be considered typical, the young larvæ float well down in the deep ocean water of high and very uniform density and under very uniform temperature conditions. The drift in these lower layers is probably very leisurely as compared to that of the surface water, and the early growth of the larvæ is no doubt relatively slow due to the low temperatures of 3.5° to 4.5° C. found in these depths.

Of the 222 larvæ in the second stage of development, 8, or 3.6 per cent, were taken between the depths of 128 and 170 meters (150 to 200 meters of cable) (Figure 61). The two specimens found at station 206 at a depth of about 128 meters over a bottom depth of 200 meters are 15.05 and 15.31 mm. in length and lie near the upper end of the size distribution for Stage 2 larvæ (average 13.48 mm.) they are among the farthest advanced of that stage. Eight larvæ found at the 170-meter level average 13.74 mm. in length —slightly larger than the mean size for their stage of development. However, they are still floating over the deep water and have not yet been carried into the shallow water over the banks.

These few specimens indicate the beginning of an upward movement

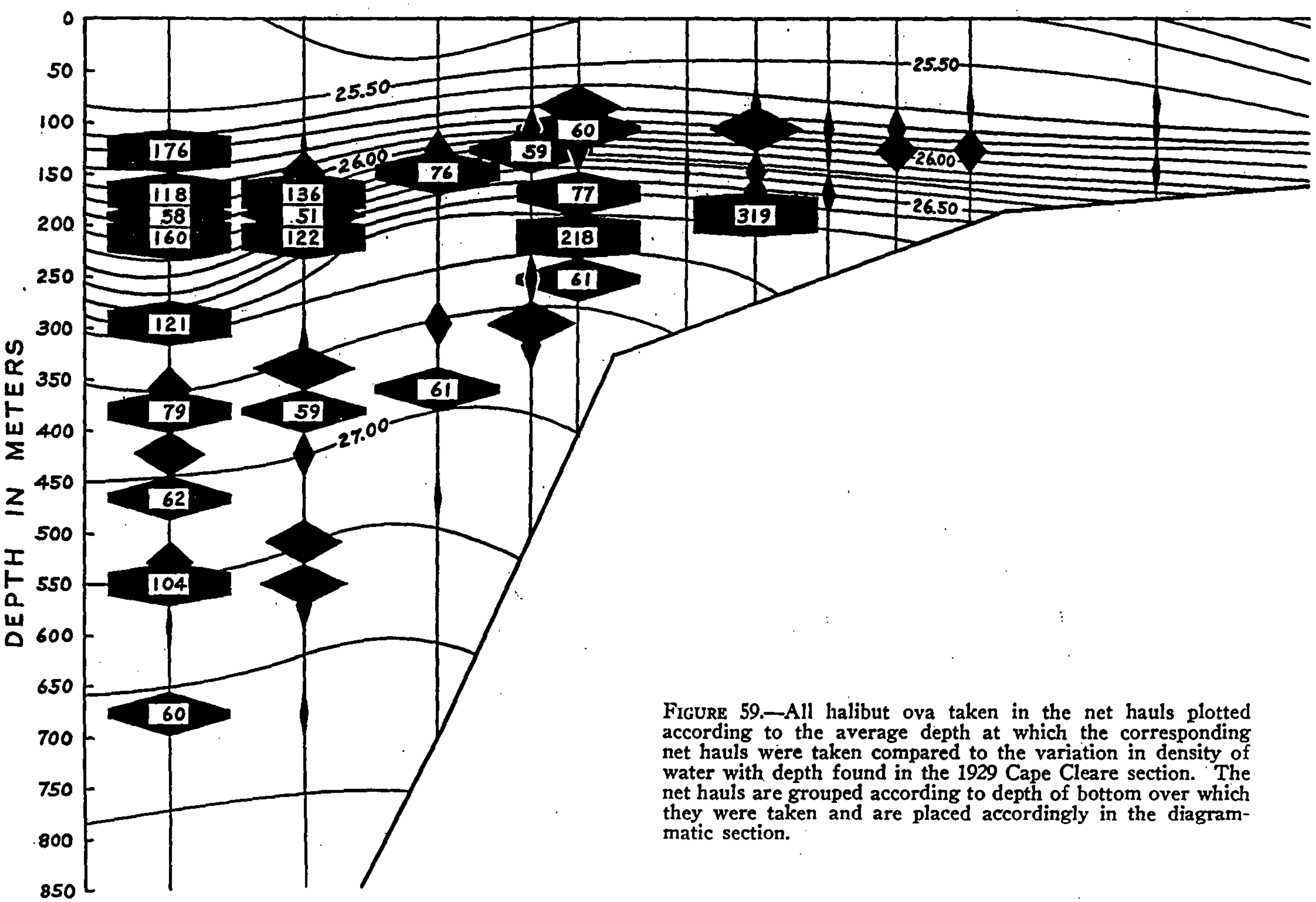

FIGURE 59.—All halibut ova taken in the net hauls plotted according to the average depth at which the corresponding net hauls were taken compared to the variation in density of water with depth found in the 1929 Cape Cleare section. The net hauls are grouped according to depth of bottom over which they were taken and are placed accordingly in the diagrammatic section.

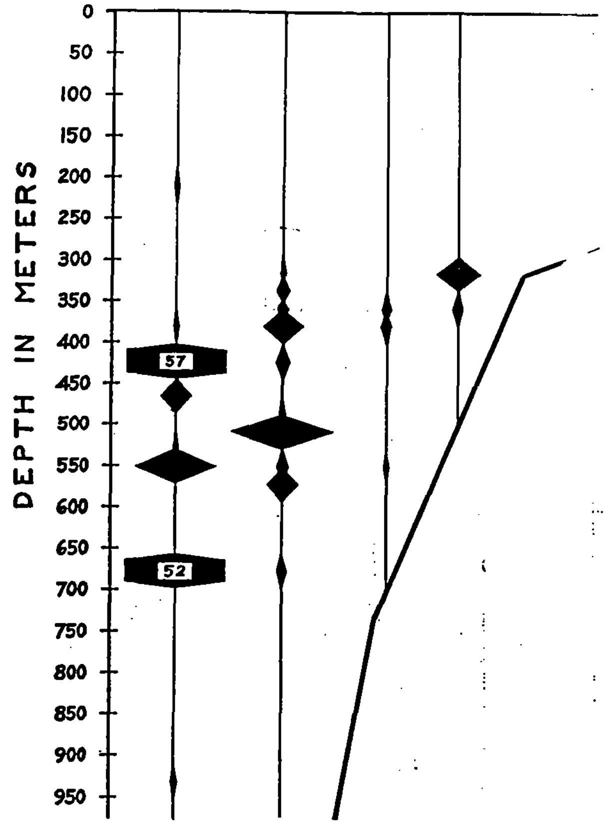

FIGURE 60.—Stage 1 larvæ plotted, as in Figure 59, according to depth in which they were taken.

which becomes more apparent in the next older larvæ. The greatest numbers of the remainder of the Stage 2 larvæ were, however, still found in the deep hauls taken in water over 1000 meters in depth. Ninety-two per cent were found over depths of 750 meters or more, while 88 per cent were taken in the net hauls at the 425 to 935-meter levels. Fifty and twenty-eight per cent were taken at 425 and 680 meters, respectively, because of the greater number of hauls taken at these depths (136 and 135, respectively) during the winter season. However, a still greater number of hauls (140) were taken at 170 meters, but only 2.7 per cent, or 8 of the larvæ, were found there.

The postlarvæ of Stage 3, in which the yolk is completely absorbed but the larval form is still retained, and of Stage 4, which show the first signs of increasing depth and development of the compressed form of body, are very similar in their depth distribution and are therefore considered together (Figure 62). They clearly show an intermediate type of depth distribution, as they are found in the deepest hauls, and one specimen was taken at a depth of 42 meters. A few specimens were found well over the banks inshore as far as a bottom depth of 150 meters. However, the greater number (71 per cent) were still found over the deep water outside the edge of the continental slope, and 81 per cent were taken between the levels of 170 and 935

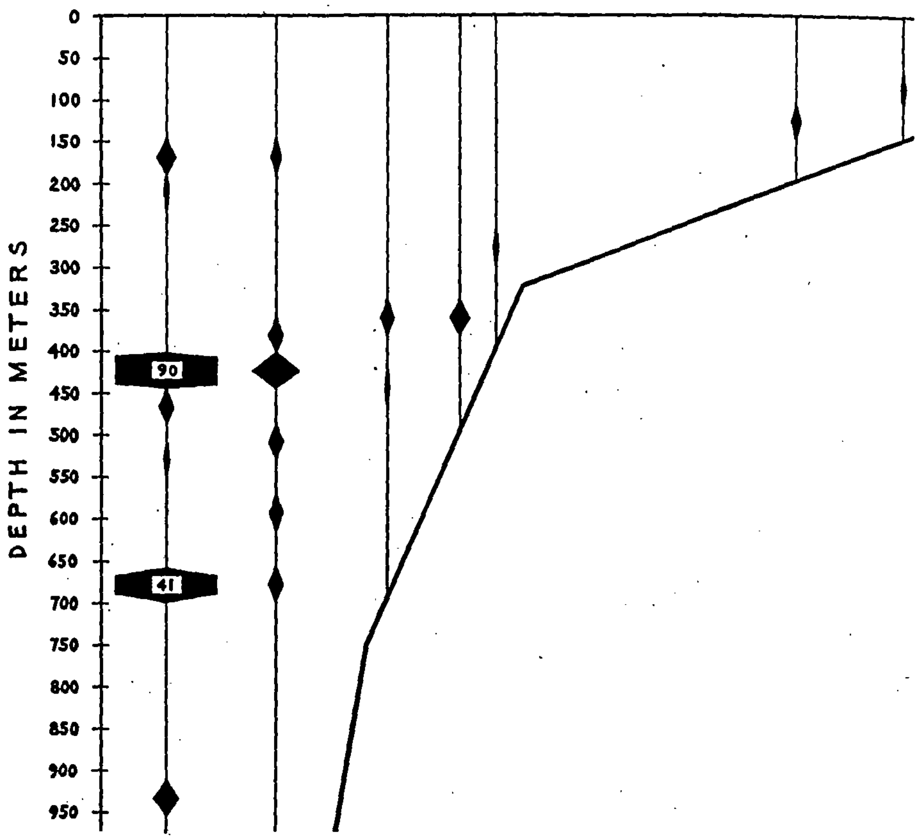

FIGURE 61.—Distribution of all Stage 2 larvæ with depth.

meters. Twelve per cent were taken at the 170-meter level compared to 29 and 21 per cent each at 425 and 680 meters. Compared to the distribution of Stage 2 this indicates a movement toward the surface.

By the time the postlarvæ have reached the age and development shown at Stage 5, where deepening of the body is well along, they are no longer found in hauls deeper than 170 meters, and their distribution over the bank is much the same as the later postlarval stages through Stage 9. One Stage 5 larva was taken in a deep haul but may have been taken by the net in its passage through the upper layers. Grouping Stages 5 to 9 together, it is plain that they have risen into the upper layers of water which have carried them toward the shore (Figure 63). The frequency of their occurrence with depth is just the reverse of that of the earlier stages, the greatest numbers occurring in the shallow inshore water with only a scattered few over the outer banks. Sixty-one per cent of the 105 specimens were found inside the 100-meter contour line, and 90 per cent within a depth of 250 meters, while 85 per cent were found in net hauls at depths of 85 meters or less. Only eight specimens were taken outside the 1000-meter contour line, and these were all (with the one exception noted above) found at the 170-meter level. The larger specimens, including Stages 8 and 9, were taken for the most part

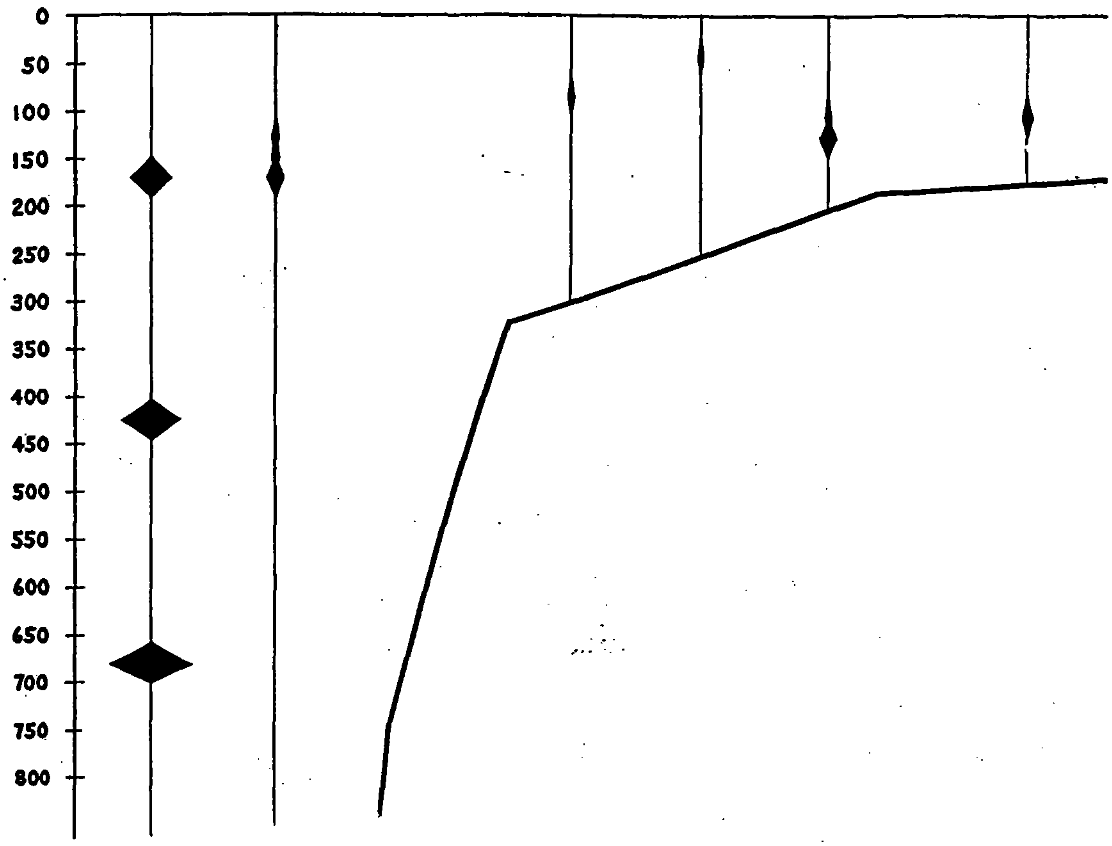

FIGURE 62.—Distribution of all Stage 3 and 4 postlarvæ according to depth.

on the bottom by trawls in depths of 10 to 25 meters. A well pronounced inshore drift has completely changed the character of the distribution.

The distribution of the later postlarvæ and first bottom forms included in Stages 10 to 12 shows the completion of the inshore drift when they settle to the bottom in the shallow bays (Figure 64). Of the 133 specimens taken, 124, or 93.2 per cent, were taken in the bottom trawl hauls in depths averaging 12 meters, while three were taken by chance in tide pools, though no systematic search was made for them on the beach. Only six specimens, or 4.6 per cent of the total, were found in water averaging deeper than 12 meters, though numerous trawl and net hauls have been taken during the month of June when the late postlarval halibut is found in greatest numbers.

It is probable that the young halibut settle down on the banks outside the bays and perhaps in deeper water than is indicated by their distribution in the net hauls. The rough, rocky bottom over most of the shallow grounds along the coast makes bottom trawling impossible with the light gear used for capturing the small fish. Sampling of the bottom has therefore been confined to the bays where stretches of smoother ground could be found. Outside the bottom trawl hauls, however, the net stations have been as well distributed as was possible under the circumstances.

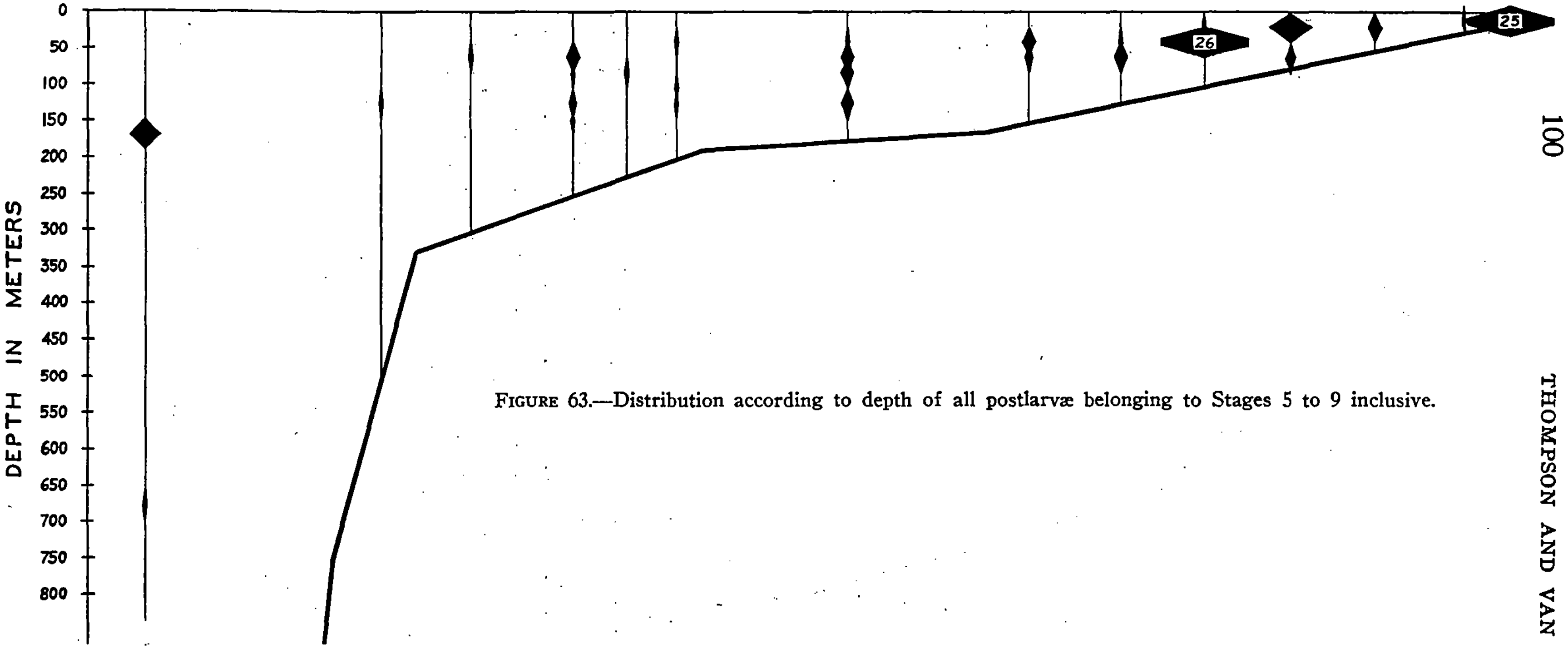

FIGURE 63.—Distribution according to depth of all postlarvæ belonging to Stages 5 to 9 inclusive.

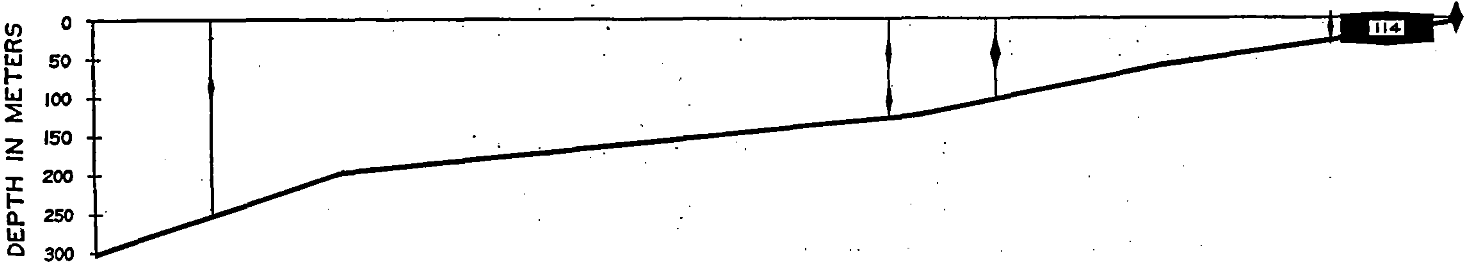

FIGURE 64.—Distribution according to depth of all postlarvæ belonging to Stages 10 to 12 inclusive.

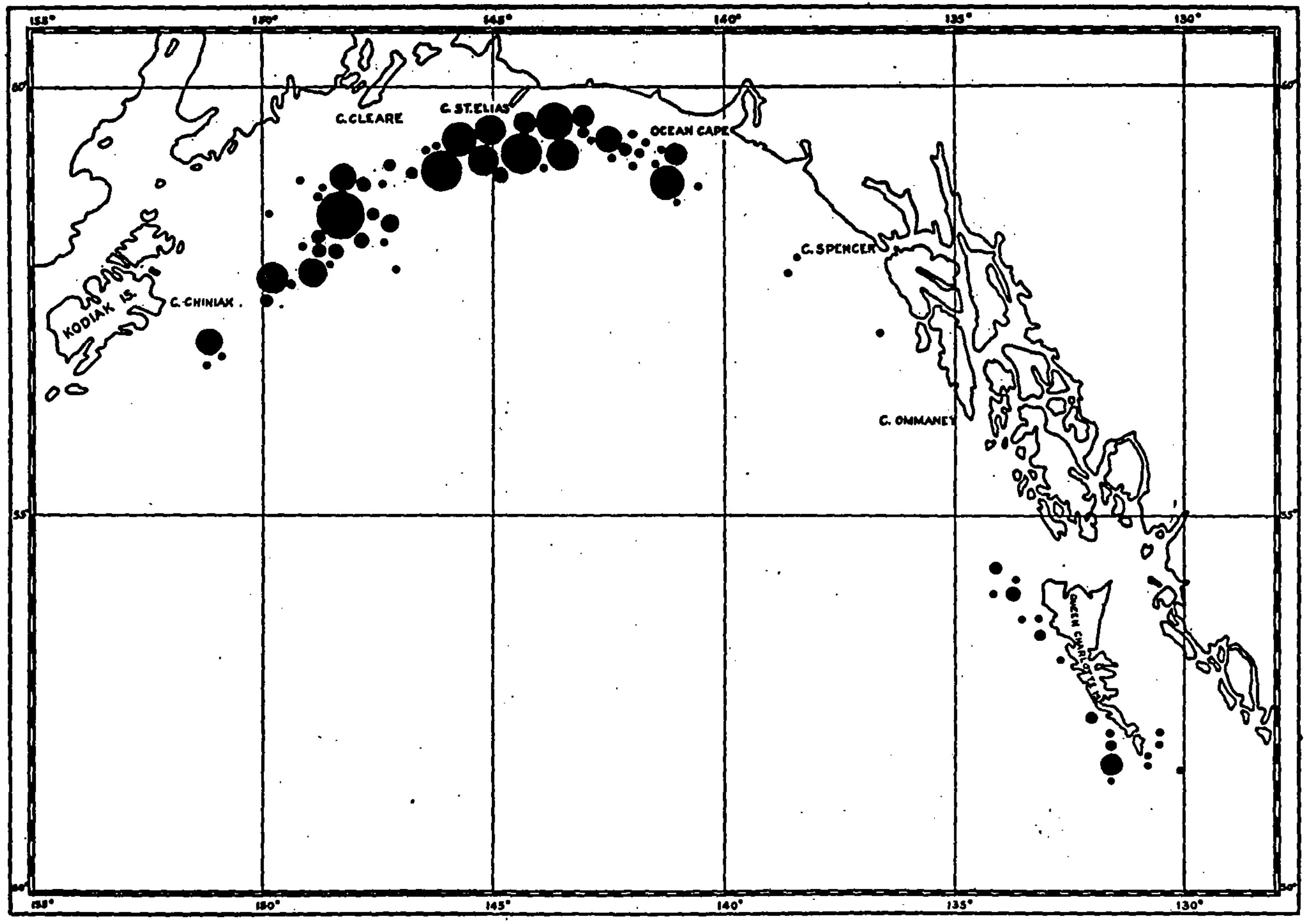

FIGURE 65.—Horizontal distribution of all halibut ova. The area of each circle is proportional to the total number of eggs taken at that locality in all the net hauls taken there.

The changes in level occurring during the larval and postlarval development, culminating in the inshore drift of the later stages to settle on the bottom, is clearly demonstrated.

HORIZONTAL DISTRIBUTION OF THE EGGS AND YOUNG

The horizontal distribution of the halibut ova taken in the net hauls is shown in Figure 65. The simultaneous occurrence of eggs in all stages of development in net hauls between Yakutat and Portlock Banks precludes the detection of drift along the edge of these banks by a consideration of the distribution of the various stages. The presence of the early stages throughout the areas in which eggs are found indicates that spawning occurs throughout the region between Yakutat and Cape Chiniak as well as on the Whaleback Bank to the westward of North Island (Queen Charlotte group) and off Cape St. James. Net hauls are lacking during the spawning period along the coast of Southeastern Alaska north of Dixon Entrance as far as the southeastern edge of the Yakutat Bank, as well as to the westward of Cape Chiniak (Figure 56).

The limitation of the range of distribution of the eggs to the heavier, more dense intermediate layers of water profoundly modifies their horizontal distribution. Most are found outside the edge of the banks as shown above and therefore drift with the deeper offshore currents. While the principal direction of drift in the northern part of the Gulf is alongshore, an offshore drift is indicated by the presence of one ovum in an early stage and of two ova in late stages at station 106, 40 miles east-southeast of the 1000-fathom contour off Cape Cleare, as well as of two more in the late stages 20 miles farther out at station 105. The eddy, the presence of which was demonstrated in the surface currents of the Gulf by means of surface drift bottles, evidently extends down to depths of over 100 meters.

Apparently most of the eggs spawned on the Cape St. James Bank drift into the deeper water and are carried northward along the west coast of the Queen Charlotte Islands. Only a few are found floating in the deep gullies in southern Hecate Strait. More work will be necessary over these banks as well as in the vicinity of the Whaleback Grounds to follow the drift of the eggs and larvæ produced there.

Stage 1 larvæ, the distribution of which is shown in Figure 66, are found scattered along the entire coast wherever net hauls have been taken in January or February. They occur in greatest numbers in the region between Cape St. Elias and Portlock Bank, and in keeping with the limitation to the lower denser layers of water, they occur only along the outer edges of the banks. The capture of nine specimens at station 104, 133 miles southeast of Cape Cleare, and nine at station 249, 100 miles south-southeast of Cape St. Elias, shows a definite offshore drift which must carry great numbers of the larvæ away from the banks and out into the Gulf.

Fifteen larvæ of this stage were taken at station 237, 33 miles south by west of Cape Spencer, while two more were taken off Baranof Island and

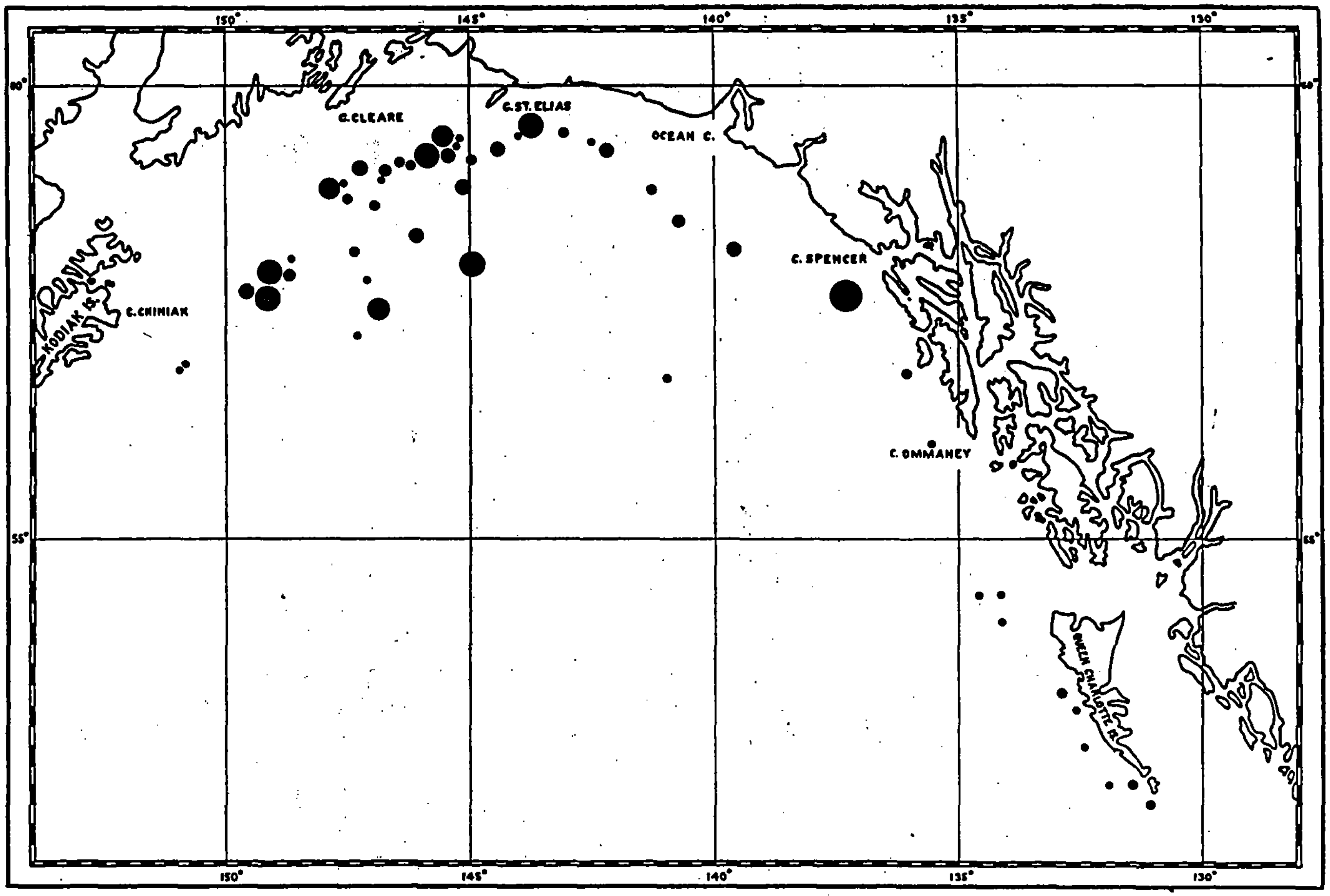

FIGURE 66.—Horizontal distribution of all Stage 1 larvæ. The area of each circle is proportional to the total number of specimens taken in that locality.

three off the edge of the Fairweather Bank. A total of five have been captured along the outer edge of the banks off the Queen Charlotte Islands, a disproportionately small number in view of the number of hauls taken.

The larvæ of the earliest stage are therefore very little more widely scattered than the ova. They are less numerous in the net hauls than the larvæ of Stage 2, perhaps because the development is completed in a shorter period of time.

Larvæ of Stage 2 (Figure 67) are scattered over the entire Gulf except south of the 56th parallel. A gap in their occurrence in the center of the Gulf indicates that the Alaska Stream does not form a single, simple eddy in the Gulf. The complete absence of larval halibut anywhere offshore south of the 56th parallel between Cape Ommaney and the Whaleback and along the shores of Southeastern Alaska and British Columbia is due to the lack of net hauls in that region during the months of January to March, when larvæ in this stage of development are found. More work here is needed to complete the picture.

South of this region a total of 25 specimens of Stage 2 was taken in the net hauls off the west coast of the Queen Charlotte Islands. Twenty-three of these were taken during March, 1934, in the first intensive survey made in that region during the early part of that month. It is impossible to compare this number with the few Stage 1 specimens taken in this region because of the lack of net stations along this part of the coast during the month of February.[7] Little can be told of the drift in this region except that the larvæ seemed to be scattered along the west coast of the Queen Charlotte Islands, apparently drifting there from both the Cape St. James and Whaleback Banks.

Stages 3 and 4 are so few in number that their distribution in the hauls cannot be considered typical. Offshore drift is still indicated by these stages which are shown together in Figure 68, although neither one occurs as far out in the Gulf as does Stage 2. Both stages are still found off the coast of Baranof Island. Only five specimens were found around the Queen Charlotte Islands.

Only four Stage 3 and one Stage 4 specimens have been taken south of the 56th parallel, and none have been taken along the coast between that latitude and Dixon Entrance in the numerous net hauls taken there during the months of April and May (Figure 57).

No Stage 5 specimens are found in the hauls taken outside the edge of the bank, in spite of the fact that the stations are well scattered over the Gulf throughout April to June (Figures 57 and 58), and none have ever been taken to the southeastward of the Yakutat Bank. The inshore movement, started at Stages 3 and 4 with their rise toward the surface layers (Figure 62), is further shown by the distribution of postlarval Stages 5 to 9 (Figure

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[7] A survey of this region extending from December 15 to March was carried out in the winter of 1934-35 the results of which have not yet been worked up.

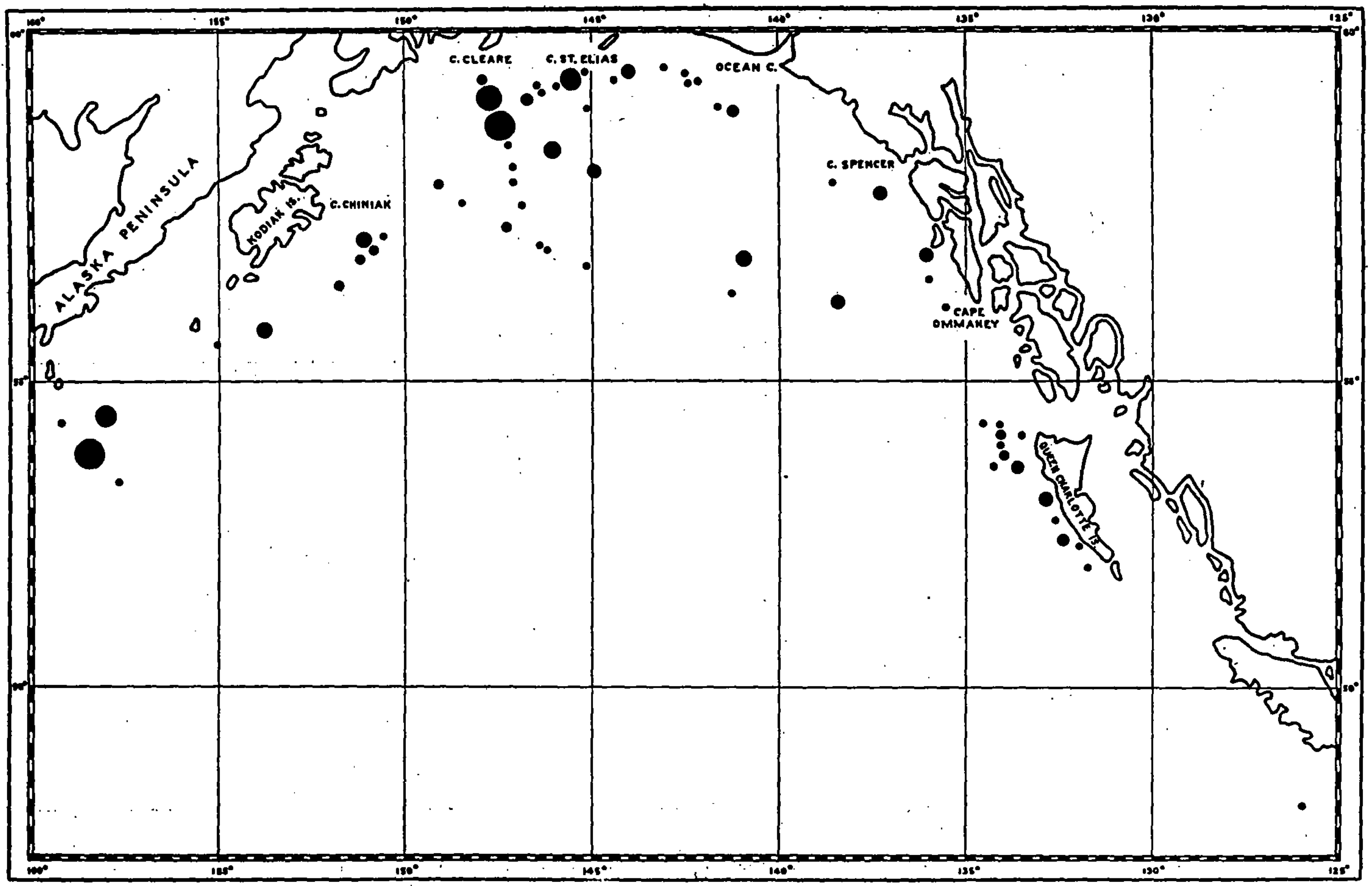

FIGURE 67.—Horizontal distribution of all Stage 2 larvæ. The area of each circle is proportional to the total number of larvæ that have been taken in that locality.

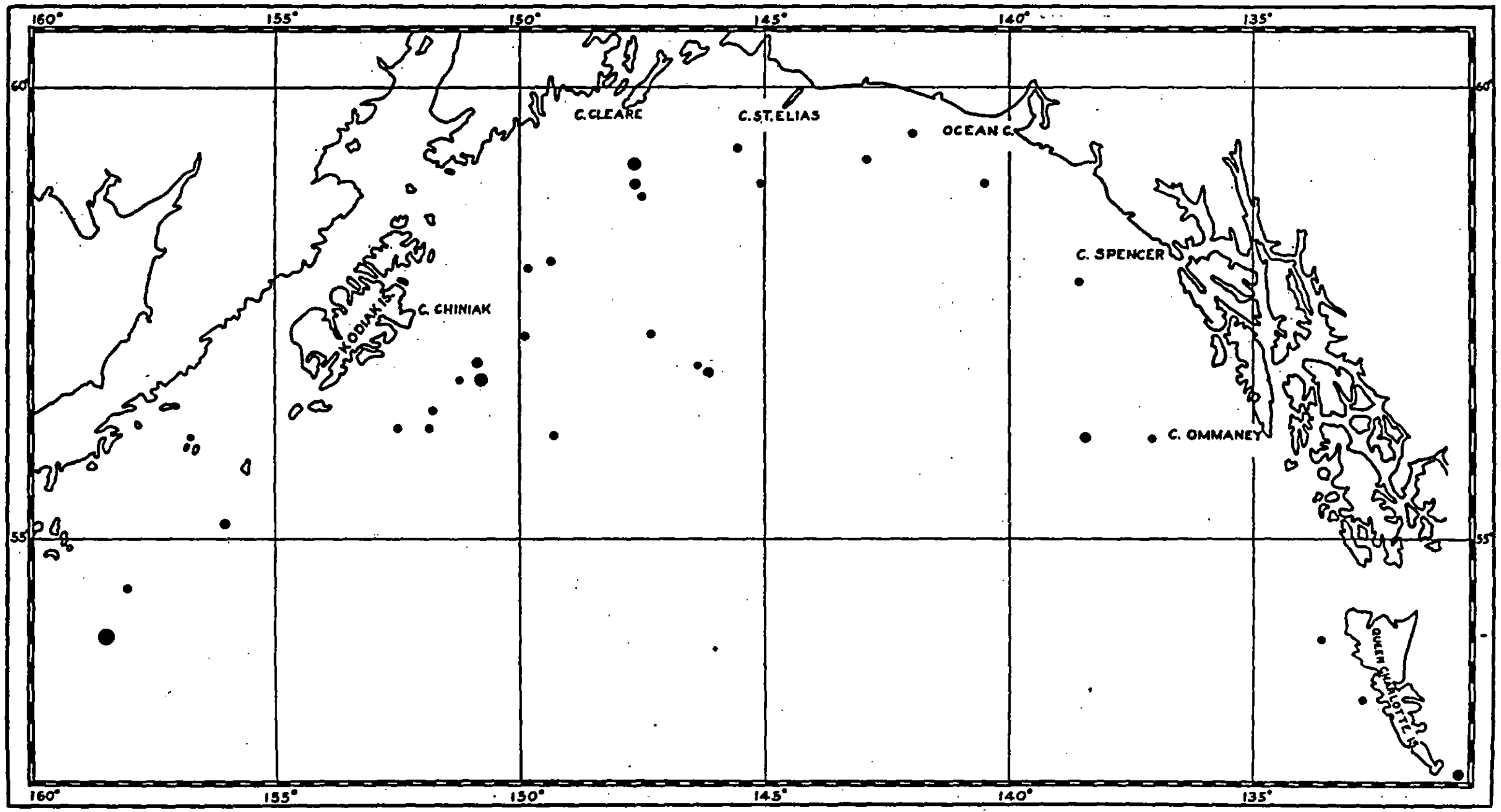

FIGURE 68.—Horizontal distribution of all postlarvæ belonging to Stages 3 and 4. The area of each circle is proportional to the total number of specimens that have been taken in that locality.

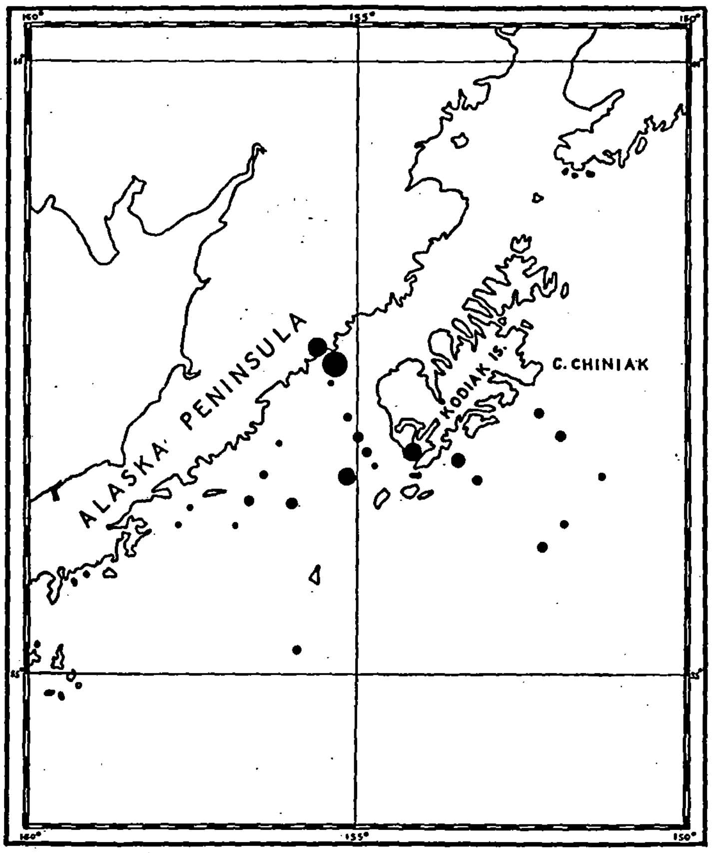

FIGURE 69.—Horizontal distribution of all postlarvæ belonging to Stages 5 to 9 inclusive. The area of each circle is proportional to the total number of specimens that have been taken in that locality.

69). Although some specimens of these later stages were still found outside the edge of the bank, the greater number were taken in shallow water, and some of the larger, older specimens were taken in the bottom trawl hauls in the shallow bays.

No Stage 5 postlarvæ have been taken in the southern region. In this case the lack of specimens along the coast between Cape Ommaney and Dixon Entrance is significant due to the numerous net stations that have been taken there in the months during which this stage is found elsewhere in the Gulf. Considered in the light of the results of the current observations, especially of the drift bottle experiments, it definitely establishes the lack of drift of larvæ from the western banks southward to the southern banks.

The distribution and drift of the later postlarval stages of halibut have been investigated only along the section of the coast between Cape Cleare and the Sanak Islands where they have been found in some numbers. Their distribution elsewhere is as yet unknown. However, their drift in this one region illustrates the essential facts of their drift and clearly demon-

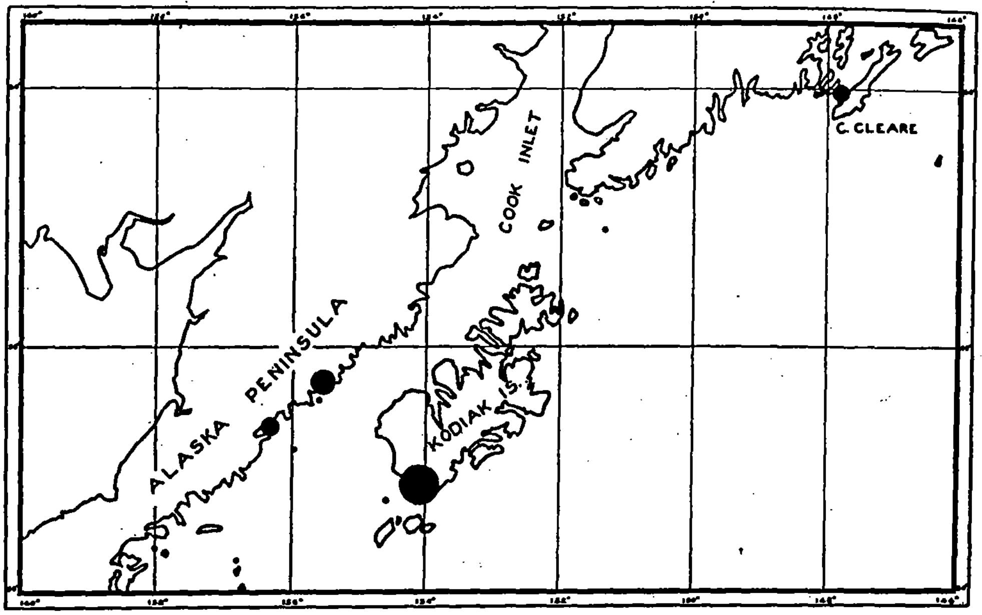

FIGURE 70.—Horizontal distribution of all postlarvæ belonging to Stages 10 to 12 inclusive. The area of each circle is proportional to the total number of specimens that have been taken in that locality.

strates the effects of the change in the level at which they float.

The distribution of Stages 10 and older (Figure 70), compared to that of Stages 5 to 9 shows the completion of the inshore drift into the shallow bays and even as far as the tide pools where two specimens were taken on May 10, 1932, in Alitak Bay on Kodiak Island.

The adaptation of the halibut to the currents in the Gulf of Alaska is therefore sufficiently clear. The mature fish migrate to the eastward within the western areas and spawn along the edge of the continental slope, for the most part in the region between Yakutat and Kodiak Island. At spawning the eggs are released into the intermediate and lower layers of denser ocean water where the slowly-moving currents carry them along or offshore. Their development at the relatively cold temperatures (3.5° to 6.5° C.) at the depths at which they occur is undoubtedly slow. From these banks some of the eggs and young are carried offshore in the gulf eddy, but are not carried southward of the 56th parallel. As the postlarvæ grow in size they gradually rise into the shallower depths, and are carried inshore. At the age of 6 to 7 months in May and June they have completed their metamorphosis and have been found on the bottom in the shallow bays along the southern coast of the Alaska Peninsula.

The stock of fish inhabiting Area 3, proved by tagging, growth, and racial work to be distinct from the fish in Area 2, are also distinct during embryonic and larval development due to the currents in the Gulf. None of the young produced on the western banks in Area 3 are carried southward onto the southern banks which are therefore entirely dependent upon their own spawning stock for their supply of young.

D. ABUNDANCE OF EGGS AND LARVÆ

An exact measure of the abundance of the younger stages is out of the question in view of the nature of the nets and the manner of hauling them. But since the hauls have been made in a similar way throughout, they can be dealt with as giving an approximate means of comparing the relative abundance. The comparison of one year with another and the correlation of changes in any one stock with changes in abundance of eggs and young must be left for a later report. But since depletion has already been measured and is known to have advanced much further on southern grounds than it has on the western, its effects on the production of spawn can be examined to some extent by means of a comparison of the hauls made in the two regions.

To accomplish this it is necessary that hauls should be compared which have been taken at the same part of the season and in representative areas. Since many of the net hauls have been taken in regions where eggs and larvæ have not so far occurred, and since the numbers of such blank hauls vary greatly in different localities and in different depths, the comparisons of the January to March hauls are confined to the 1-meter net hauls located within 40 miles of the 1000-fathom contour and not more than 15 miles inside the 100-fathom contour. They are thus confined to the regions of active spawning, since work has been concentrated over the spawning grounds. During May and June the inshore drift of the postlarvæ is shown by their capture in the inshore hauls, and in those months all net hauls within 40 miles of the 1000-fathom line and into shore are used. The hauls made with 2-meter nets are not numerous enough to form the basis for a comparison, and the trawl hauls are confined to the 1932 work in the vicinity of Kodiak Island.

In making such a comparison it is necessary to point out that we do not know whether there is a difference in the time at which the maximum spawning occurs, so that until this is known for both areas, somewhat different parts of the season may be unwittingly compared. The rapidity with which the eggs are scattered by currents may differ; and the areas covered by the spawning schools have not yet been mapped. In short, the system of sampling the eggs has not been perfected, and the differences shown by a comparison must be large and consistent within the series of samples taken to be acceptable.

The average catch of eggs and larvæ is shown in Table 15 in which the net hauls have been limited as described above. During January, averages of 25.5 eggs and one larva were taken in 75 net hauls in the region west of Cape Spencer, while south of Cape Spencer an average of 2.6 eggs was taken in 65 net hauls. These results indicate a density of ova about 10 times greater on the western grounds than on the southern. The southern hauls

TABLE 15.—*Average catch of eggs and young per net haul. Only hauls made with one-meter nets and situated within 40 miles of the 1000-fathom line and not more than 15 miles inside the 100-fathom line are included.*

Month	North and West of Cape Spencer					South and East of Cape Spencer				
	Number Hauls	Number Young	Average	Number Ova	Average	Number Hauls	Number Young	Average	Number Ova	Average
January	78	68	1.0	1989	25.5	65	1	..	170	2.6
February	172	81	0.5	467	2.7	4	2	.5	0	..
March	56	129	2.3	4	.1	247	75	.3	6	..
April	73	75	1.0	0	0	135	5	..	0	..
May	198	81	0.4	0	..	26	0	..	0	..
June 1-21	69	11	0.2	0	..	0	..	..	..	..

were concentrated over two spawning areas occupying only 130 miles of coast line, while the western hauls extended over 380 miles along the edge of the banks so that the areas covered were in the ratio of approximately 1 to 3. Therefore the ratio of total eggs produced in the two areas must be close to 30 to 1. Records of spawning fish taken west of Cape Spencer by the commercial fishermen indicate the presence of spawning on banks to the westward of the region covered by the net hauls, while the spawning banks covered by the hauls off the British Columbia coast are the only ones now known to exist in that region. The above estimate of relative total numbers of eggs produced in the two regions may therefore be considered a conservative one.

The February averages are not comparable because of the lack of a sufficient number of hauls in the southern region.

In March comparison is again possible between the average numbers of larvæ. The average of 2.3 on the western differs markedly from the .3 larvæ per haul on the southern grounds.

The comparison in April is even more striking when 75 larvæ were taken in 73 hauls on the western grounds to five larvæ in 135 hauls on the southern. No postlarvæ farther advanced in development than Stage 4 have been taken south of Yakutat Bank.

The gradual scattering and decrease in numbers of pelagic postlarvæ is plainly shown in the western region by the decrease in average numbers taken from 2.3 in March to 1.0 in April, 0.4 in May, and 0.2 in June.

The decrease in numbers of ova in the western hauls during February and March is undoubtedly due to the falling off of spawning intensity. However, the relatively few eggs and larvæ taken in the hauls over the southern banks is indicative of their scarcity there and is a further indication of the scarcity of spawning adults on those banks.

E. THEORETICAL RELATIONSHIP BETWEEN FISHING INTENSITY AND EGG PRODUCTION

While it is possible to compare egg production, as in the preceding section, by means of net hauls, such comparison is by necessity inexact. A system of sampling the abundance of eggs must not only be considered from the standpoint of the nets employed, but also from those of the concentration and extent of spawning schools and the dispersal of the eggs. Each of these factors introduces errors of unknown importance and may leave the system capable of reflecting only large variations. Were the egg production to vary but slightly in response to major changes in abundance of fish, detection of the variations due to this cause might be a difficult matter. It will therefore be of the greatest interest to know something of the theoretical relationships which would indicate whether expected changes will be of sufficient magnitude to be detected by a system of net hauls.

The first consideration is as to the effect of changes in the intensity of the fishery upon the abundance of adults. This has already been discussed by Thompson and Bell (1934, pp. 24 to 27), and the theoretical expectation shown to correspond to the events in the actual fishery. It is shown that the abundance of all sizes in the commercial fishery increases as the fishing intensity (number of units of gear fished) decreases. But they also show, by means of a comparison of two hypothetical stocks, that the older fish should increase to a greater extent than the younger. The ratio of survivors in one stock to those in another which had been subject to a higher intensity increased greatly in the successive age classes, being 1.3 to 1.0 in Age V, the second year of the commercial catch, and 10 to 1 in Age XII, the ninth year.

The two hypothetical stocks thus compared were assumed to have a constant mortality throughout life. But the actual age-weight relationships were used for growth. These happen to approximate an even rate of increase within the range of ages dealt with.

A more generalized statement of the simple theory involved is desirable, in view of the variations which may occur from age to age in growth and death rates. The following symbols are used:

P = the total poundage of fish entering the commercial catch in the youngest age class.
$g_1, g_2 \ldots g_r \ldots$ etc. = growth rate in years 1, 2, ... r ... etc.
$n_1, n_2 \ldots n_r \ldots$ etc. = rate of survival from natural deaths in years 1, 2, ... r ... etc.
$f_1, f_2 \ldots f_r \ldots$ etc. = rate of death from fishing in the successive years.
a = factor of increase or decrease in the death rate due to fishing, dependent for its value upon the amount of gear fished.

Then, $1-f_1$ = rate of survival from fishing of the original stock in year 1.
$1-af_1$ = rate of survival from fishing of the stock as modified by a changed fishing intensity.

Then the poundage surviving the first year in the original stock would be $Pg_1n_1(1-f_1)$ and at the end of the second year $P[g_1n_1(1-f_1)][g_2n_2(1-f_2)]$, or at the end of the rth year $P(g_1g_2g_3 \ldots g_r)(n_1n_2n_3 \ldots n_r)[(1-f_1)(1-f_2)(1-f_3) \ldots (1-f_r)]$. The corresponding poundage in the changed fishery with the rate of death increased by the factor a, would be at the rth year of age, $P(g_1g_2g_3 \ldots g_r)(n_1n_2n_3 \ldots n_r)[(1-af_1)(1-af_2)(1-af_3) \ldots (1-af_r)]$. Hence the ratio of the number of survivors in the rth year of age in the stock left by the changed fishery to those of the original fishery would be

$$\frac{P(g_1g_2g_3 \ldots g_r)(n_1n_2n_3 \ldots n_r)[(1-af_1)(1-af_2)(1-af_3) \ldots (1-af_r)].}{P(g_1g_2g_3 \ldots g_r)(n_1n_2n_3 \ldots n_r)[(1-f_1)(1-f_2)(1-f_3) \ldots (1-f_r)].}$$

This ratio would therefore be equal to the product of the fractions

$$\left(\frac{1-af_1}{1-f_1}\right)\left(\frac{1-af_2}{1-f_2}\right) \ldots \left(\frac{1-af_r}{1-f_r}\right).$$

If $a < 1$ as would be the case in a reduced fishery, $\frac{1-af_1}{1-f_1} > 1$, and the increase would be correspondingly greater as the ratios of the successive years of age were multiplied. If $f_1=f_2=f_3=\ldots=f_r$, the ratio of the poundage in the rth year of age resulting from the less intense fishery to that at the same age in the original fishery would be $\left(\frac{1-af}{1-f}\right)^r$. In such a case, the greater the value of f, as in a very intense fishery, the greater the effect of a.

In the hypothetical case given by Thompson and Bell (l.c., p. 24, Table 5), the fishing mortality was .4 annually, with a equal to .5. Substituting above, with $r=8$ for Age XII, $\left(\frac{1-af}{1-f}\right)^r = (4/3)^8 = 10-$, which corresponds to the ratio shown for Age XII.

If the abundance of fish of Age XII were to be doubled, and $f = .4$, $\left(\frac{1-af}{1-f}\right)^8 = 2$, whence $a = .86$ indicating that a decline of 14 per cent in intensity would double the XII year old fish. This is a relatively minor change to postulate in the fishery in view of those which have already occurred in recent years. When it is borne in mind that maturity is reached, on the average, at about 12 years, and that the ratio would increase in the older ages, the significance of the theory is plain.

The great possible extrapolated values for such a ratio can be illustrated by the fact that halibut frequently live to an age of 25 years, when $r = 20$. The ratio when $a = .5$ and $f = .4$ would be $(4/3)^{20} = 314\pm$. This would assume an unchanged value of f throughout life, whereas it is reasonable to assume that it decreases greatly as age approaches its limit. What this limit is we do not know. Hence the calculations of extreme cases are of doubtful value.

But within the limited range of ages left by an intense fishery, and when, moreover, only those ages of commercial importance are considered, there is little reason to doubt the applicability of the theory, in view of the results of Thompson and Bell. The less the range of age, the less the possibility either that intensity or rates of death by fishing will vary greatly within that range. It is therefore highly probable that within the ages now abundant on the banks, the older age classes will respond with sufficient sensitiveness to changes in the fishery to multiply the degree of change many times.

There are two main and necessary qualifications to the use of this reasoning. The first is that the full effect must take as many years to be reached as the particular age class has been in the range of commercial sizes. The second is that if the fishery is concentrated within one or two ages the value of $\frac{1-af}{1-f}$ would approach unity in the remaining years. There is therefore no manner in which the calculation can become reasonably exact until the fishing mortality, f, for each age is known. Of perhaps lesser importance is the probability that the fishing mortality does not vary directly as the number of sets of gear, or that it cannot be calculated in accord with the method suggested by Thompson and Bell (1934, pp. 37 and 39) for "intensity" or mortality due to fishing. That this is not serious is indicated by their comparison of actual with "theoretical" catches.

It is, in view of this discussion, highly probable that the changes produced by a regulated fishery, in number of mature adults, hence of eggs produced, will be of sufficient magnitude to be shown by our roughly quantitative net hauls, repeated periodically, if the regulation is effective in any noteworthy degree. The completion of the change to be measured will, however, require a number of years.

V. SUMMARY AND CONCLUSIONS

The present report is concerned with the early life history of the halibut and with the related problem of distribution of the adults. The distribution and drift of the eggs and larvæ confirm the results of tagging, racial, and growth investigation of the adults in indicating the separation of two main stocks of halibut. The study of the conditions determining the distribution of the adults has made it possible to estimate the probable presence or absence of halibut in commercial quantity in regions not yet exploited and to predict the limits of expansion of the North Pacific halibut fishery. Knowing this distribution and the ocean currents which carry the young, it is possible to determine approximately the interdependence of the banks and to say that the supply of eggs and larvæ for our present fishery must come from banks at present known and exploited. These facts have a vital bearing on regulation.

The direct study of halibut distribution in the more distant parts of the Pacific is impossible because such studies must depend upon commercial fishing records. However, conditions determining relative abundance have been capable of study in the North Atlantic where fisheries have been extended to cover all known and accessible banks.

The locations of the halibut banks in the North Atlantic Ocean, shown in Figure 3, demonstrate plainly the relationship that exists between the distribution of halibut and the cold and warm currents. The warm currents arising from the Gulf Stream and North Atlantic drift flow northward. The rotation of the earth deflects them to the right in the northern hemisphere with the result that they move into the sub-polar and polar seas along the eastern sides of the channels. On the other hand the southward moving cold currents of Arctic origin flow along the western sides. The halibut banks are found in the regions where the mixing of the cold and warm waters of the two types of currents results in intermediate temperatures and transitional hydrographic conditions. Their distribution corresponds closely to that of invertebrate organisms which are termed boreal by biologists (see Figure 4).

In both Davis Strait and the North Sea definite information as to distribution of halibut and bottom temperatures indicates that the occurrence of halibut is in general associated with water temperatures of 3° to 8° C. A further comparison of the total halibut landings and observations of bottom temperatures over the different banks shows definitely that the greatest fisheries are found on the banks where the bottom temperatures lie between 3° and 8° C. (37.4° to 46.4° F.) The southern limits of commercial fishing are found where temperatures of 10° to 11° C. prevail, while little fishing occurs where the temperature falls below 2° C.

Conditions in the Pacific on the known banks agree remarkably with those in the North Atlantic. Comparison of the distribution of halibut banks with the courses of warm and cold currents, as shown in Figure 10, indicates a similar limitation to the regions of intermediate hydrographic conditions. In keeping with the rapid change from warm to cold water along the northern coast of Japan due to the direct contact there between the cold southward flowing Oyashio and the warm northward flowing Kuroshio, the area covered by the Asiatic halibut fishery is very small. On the eastern side of the Pacific, as in the Atlantic, uniformly temperate conditions are found along several thousand miles of coast, and the great halibut banks are located accordingly. They extend from northern California into the Bering Sea.

More accurate comparison of bottom temperatures and abundance of halibut along this coast line again indicates that the greatest numbers of halibut are to be found where bottom temperatures of 3° to 8° C. prevail. The center of this region lies off the coast of British Columbia where the halibut formerly existed in greatest abundance. On either side of this region the abundance drops gradually to reach the point of scarcity to the south where temperatures of 9° and higher prevail, while to the northward the records of abundance are incomplete but show a marked decline in the region of temperatures less than 3° or 4° C.

Records of occurrence as compared to those of commercial fisheries are of especial significance in the Bering Sea. Due to the gradual transition in temperature and other hydrographic conditions, occasional records of halibut extend between 500 and 700 miles beyond the commercial fisheries. This is different from the distribution in the Atlantic where favorable conditions extend up to the boundaries of sharply marked southward bound cold currents from the Arctic. The connection of Bering Sea with the Arctic is not great enough to permit such currents. Bottom temperatures in the southeastern part indicate that halibut may be taken there in quantities approaching those taken in the Atlantic where the fisheries are seasonal and not highly productive. The cooling effect of the Okhotsk Sea and the presence of a cold current along the Asiatic side make it very doubtful that halibut will be found in any quantities. Little development beyond the present bounds in the vicinity of Hokkaido is to be expected there. The direction of the currents indicates that the eggs and young produced in the Bering Sea remain there, and it is quite probable that young drift northward through the passes of the eastern Aleutian Islands into Bering Sea.

The banks of greatest abundance are those now being fished, and the future of the fishery depends not upon further expansion to new grounds but upon the correct utilization and perpetuation of the stocks already exploited. These are the objectives at which the present regulations of the Pacific halibut fishery are aimed.

The eggs and larvæ are pelagic for four to five months after spawning, and because of this pelagic period during which the eggs and young halibut float helplessly with the ocean currents, some knowledge of the latter has been necessary.

Hydrographic sections, run in 1927, 1928, and 1929, showed that in general a westerly drift prevailed in the deep as well as the surface water along the edge of the continental slope in the Gulf of Alaska. Further information concerning the surface currents in the Gulf has been obtained from the release of drift bottles. An analysis of wind data, as given on the pilot charts published by the United States Hydrographic Office, has also contributed toward an explanation of some of the peculiarities of the surface currents.

In general it has been found that the eastward flowing warm surface currents are given added impetus off the American coast by the prevailing west to southwest winds. On reaching the coast the currents and winds divide. The point of division varies with the season, reaching a latitude of 50° N. in August and moving south to about 40° N. latitude in winter. The south arm of the current becomes the California Current, while the northern division flows into the Gulf of Alaska and westward along the southern shore of the Alaska Peninsula, part finally entering the Bering Sea through the eastern Aleutian Islands. An eddy of variable extent is formed in the Gulf of Alaska.

The westward current along the edge of the banks is deflected to the right due to the effect of the rotation of the earth and causes an inshore movement over the banks which is of great importance to the young halibut.

A complete series of drawings and photographs of all stages of halibut eggs, larvæ, postlarvæ, and young is presented with keys and detailed descriptions which not only serve to separate them from other species but also define a number of stages of development. These are used in the present paper to follow the drift of the eggs and young during development and will be necessary in further more exact work along these lines.

The halibut eggs, shown in Figures 22 and 23, are distinguished from other species by their size, the large yolk, the structure of the shell, lack of markings around the micropyle, and a complete lack of pigment in the embryo. They are not the largest pelagic eggs, as has been stated so often in the literature, as another type of egg has been taken which averages over one-half millimeter more in diameter. The halibut larvæ and postlarvæ, shown in Figures 29 to 50 inclusive, are distinguished from those of other species by their size at the early stages of development, the lack of a definite pigment pattern in the larval and early postlarval stages, and a characteristic pigment pattern in the late postlarval stages. The number of dorsal and anal fin-rays and number of vertebræ are also distinctive. A detailed description of the development of the caudal fin skeleton (Figures 51 to 54 inclusive) is given for the determination of the location relative to the muscle segments of the last vertebra before its formation. Accurate vertebral counts have thus been made possible at the earliest larval stages.

The halibut eggs are first found in the deep water along the outer edge of the spawning banks. While exact depth hauls have not been made as yet they have been found principally in nets towed at depths of 100 to 200 meters but are occasionally taken as shallow as 40 meters and as deep as 935. Their complete absence in the shallower net hauls shows that they are not found in the surface water of low salinity and low specific gravity and that they drift with more slowly moving deep currents.

The newly hatched larvæ float at even lower levels than the eggs. All are found outside the edge of the continental slope and below depths of 200 meters. However, as the larvæ develop they rise into the upper layers. At the age of 3 to 5 months (Stages 5 to 9) all of them are taken at depths of 100 meters or less. With their rise into the surface layers they are carried inshore by the currents and have been found on the bottom of the shallow bays along the Alaska Peninsula during the months of May and June. Since spawning begins in December, their age at the completion of their pelagic life is 6 or 7 months.

The effect of the changing distribution of the eggs and larvæ with depth is plainly shown by their horizontal distribution. The eggs are spawned along the outer edge of the banks, and in the case of those in the Gulf of Alaska they are carried slowly to the westward with the deep currents. Some are carried offshore in the gulf eddy, but evidently the movement is so slow that the larvæ hatch before the eggs move far out from the banks. The offshore distribution of the larvæ is most widespread at the age of 2 to 3 months (Stage 2) when they are found scattered over the entire Gulf of Alaska north of 56° N. latitude. With their rise into the surface layers at Stages 3 and 4 and later, more and more of the young halibut are taken in the shallow water over the banks, until in May the first specimens appear in the shallow bays. By the time they have reached the stage of development shown in Figure 40 they are found only in the shallow inshore water, and several have been taken in tide pools on the southern coast of Kodiak Island.

Numerous net hauls along the coast of British Columbia and Southeastern Alaska and throughout the Gulf show that the larvæ and postlarvæ arising from the banks west of Cape Spencer, though carried offshore in the gulf eddy, come back to shore somewhere north of 56° N. latitude. There is no evidence that any of them are carried south as far as the banks off British Columbia. These banks are therefore dependent upon their own spawning stock for their supply of eggs and young.

Spawning has been so much reduced in the southern region that the numbers of eggs and young taken there have not been sufficient to work out their drift. No postlarvæ later than Stage 4 (Figure 32) in development have been found there.

Using only the hauls made with one-meter nets taken where eggs or larvæ occur, an average of 25.5 eggs per net haul was taken on the western grounds during January as compared to an average of 2.6 for the southern grounds. These results indicate a density of eggs about 10 times greater upon the western grounds than upon the southern. However, the western spawning area covered by the net hauls was about 3 times greater than the total area of southern spawning grounds, and the total number of eggs produced in the western region must be close to 30 times more than was produced in the region off the north and south ends of the Queen Charlotte Islands.

It was proved by Thompson and Bell (1934) that a reduction of fishing intensity is followed by an increase in the abundance of all sizes. However, it was also shown that the effect was disproportionately greater in the older age classes. A more generalized statement of the theory underlying the relationship is here given.

It is thus shown that a 14 per cent decrease in the intensity of a fishery from a fishing rate of .40 annually, which probably prevailed in the southern fishery in the period 1926 to 1929, should result in doubling the numbers of 12 year old fish in a stock that enters the fishery at 5 years of age. A decrease of 50 per cent would increase the number of 12 year old fish 10 times. That these changes in intensity are well within the ranges found in the actual halibut fishery was shown by Thompson and Bell (1. c.).

The relative change in the number of spawners that a decrease of fishing intensity may be expected to produce is therefore great enough so that the coincidental changes in numbers of eggs and young produced should be detectable by ordinary quantitative methods. Such changes will take place over an extended period of time, and periodic observation during the spawning and larval seasons will be necessary to observe them.

The proposed program to follow the effect of regulation upon (1) the number of adults, (2) the eggs produced, and (3) the number of young entering the commercial catch is discussed from the standpoint that it is necessary to prove the benefit from regulations and to guide their formation and application.

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APPENDIX A.

TABLE 16.—*Net hauls made for halibut eggs and larvæ in the North Pacific.*

Haul[1] Number	Type Net[2]	Date	Time	Location		Time	Depth	Depth Bottom	No. Larvæ	No. Ova
				North Lat.	West Long.	Minutes	Meters	Meters		
1	2	3	4	5	6	7	8	9	10	11
Year 1926										
1 V	x	11–17	1:00 p.m.	58:55	141:14	5¾	247 to surf.	247	....	....
2 V	“	“	2:00 p.m.	“	“	2¼	283 to 174	283	....	....
3 V	“	“	3:00 p.m.	“	“	9½	311 to surf.	311	....	....
4 AV	“	12–12	11:00 a.m.	58:59	141:36	12½	293 to surf.	293	....	....
BV	“	“	“	“	“	“	293 to 146	“	....	....
5 AV	“	“	12 noon	“	“	13¾	293 to surf.	320	....	....
BV	“	“	“	“	“	“	293 to 183	“	....	....
6 AV	“	“	1:15 p.m.	“	“	10	256 to surf.	256	....	....
BV	“	“	“	“	“	“	256 to 183	256	....	....
7 AV	“	“	2:15 p.m.	“	“	13	293 to surf.	320	....	....
BV	“	“	“	“	“	“	293 to 183	“	....	....
8	“	12–19	....	58:39	140:58	15	surf.	329	....	....
9	“	“	....	“	“	30	“	“	....	....
10	“	“	....	“	“	“	“	“	....	....
11	“	“	....	“	“	45	“	“	....	....
12 V	“	“	7:30 p.m.	“	“	....	293 to 183	“	....	....
13 V	“	“	8:15 p.m.	“	“	....	256 to surf.	“	....	....
14 A	“	“	9:00 p.m.	“	“	40	46 to 64	“	....	....
B	“	“	“	“	“	“	110 to 137	“	....	....
15 A	“	“	10:00 p.m.	“	“	60	155 to 192	“	....	....
B	“	“	“	“	“	“	73 to 100	“	....	20
Year 1927										
16 A	x	1–31	10:39 a.m.	59:36	139:54	70	surf.	183	....	....
B	1	“	“	“	“	“	net lost	“	....	....
C	x	“	“	“	“	“	64	“	....	....
D	1	“	“	“	“	“	net lost	“	....	....
E	x	“	“	“	“	“	183 net on bottom filled with mud	“	....	....
17 A	“	2–1	11:10 a.m.	59:41	141:25	35	5 to 15	100	....	....
B	1	“	“	“	“	10 ea.	82, 55, 27, 0	“	....	....
18 A	x	“	12:25 p.m.	59:43	141:26	30	5 to 11	79	....	....
B	1	“	“	“	“	10 ea.	60, 27, 0	“	....	....
19 A	x	“	1:25 p.m.	59:45	141:24	40	5 to 11	73	....	....
B	1	“	“	“	“	10 ea.	60, 42, 24, 0	“	....	....
20 A	x	“	2:30 p.m.	59:48	141:23	40	5 to 11	40	....	....
B	1	“	“	“	“	30, 10	27, 18	“	....	....
21 A	x	2–2	8:40 a.m.	58:58	142:02	80	5 to 11	n.b.	....	....
B	1	“	“	“	“	20 ea.	274, 201, 137, 73	“	....	38
22 A	x	“	11:00 a.m.	59:00	142:00	120	silk off while towing	732 n.b.	....	....
B	1	“	“	“	“	20 ea.	366, 304, 243, 183, 121, 60	“	....	24
23 A	x	2–5	“	“	“	40	net lost	439	....	....
B	1	“	“	“	“	15, 25, 20, 20	384, 293, 201 110	“	....	....
24	“	2–13	10:50 a.m.	59:25	143:16	15 ea.	457, 302, 155, 0	1372	8	6
25 A	x	“	1:07 p.m.	“	“	63	0	“	....	....
B	“	“	“	“	“	“	155	“	....	2
C	“	“	“	“	“	“	311	“	....	....
D	1	“	“	“	“	“	777	“	....	....
26 A	x	“	3:10 p.m.	“	“	60	0	“	....	....
B	“	“	“	“	“	“	155	“	....	....
C	“	“	“	“	“	“	311	“	....	....
D	1	“	“	“	“	“	467	“	9	4

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[1] All hauls are horizontal unless they are labelled "V" in which case they are vertical. Number 1004 VV is a horizontal haul.

[2] Figures indicate the diameter of the mouth of the net in meters. "x" is a half-meter diameter net. D.T. signifies a 2-meter conical net made of stramin. Tr., a Peterson young fish trawl. B.S., a beach seine.

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
27	x	2–13	4:50 p.m.	59:25	143:16	20, 20, 10	15, 73, 0	1372	....	3
28 A	"	"	11:40 p.m.	59:16	142:07	60	18	330	....	....
B	"	"	"	"	"	"	110	"	....	....
C	1	"	"	"	"	"	247	"	....	20
29 A	x	2–14	1:15 a.m.	59:17	142:06	"	18	256	....	....
B	1	"	"	"	"	"	91	"	....	....
C	x	"	"	"	"	"	183	"	....	2
30 A	1	"	2:55 a.m.	59:19	142:04	"	18	210	....	....
B	x	"	"	"	"	"	91 silk cap lost	"		
C	"	"	"	"	"	"	183	"	....	2
31 A	"	"	4:20 a.m.	59:20	142:03	"	18	"	....	....
B	"	"	"	"	"	"	91	"	....	....
C	1	"	"	"	"	"	183	"	....	7
32 A	x	"	5:45 a.m.	"	142:02	"	18	201	....	....
B	1	"	"	"	"	"	91	"	....	....
C	x	"	"	"	"	"	183	"	....	....
33 A	1	"	7:15 a.m.	59:23	141:59	"	9	183	....	....
B	x	"	"	"	"	"	82	"	....	....
C	"	"	"	"	"	"	174	"	....	....

Year 1928

1	2	3	4	5	6	7	8	9	10	11
1 A	1	1–17	3:55 p.m.	58:56	141:14	30 ea.	250, 125	594	....	30
B	"	"	"	"	"	"	500, 375	"	3	43
2 A	"	"	5:25 p.m.	"	"	"	250, 125	"	....	46
B	"	"	"	"	"	"	500, 375	"	2	18
3 A	"	"	9:45 p.m.	59:09	141:48	"	400, 100	832	....	—
B	"	"	"	"	"	"	500, 200	"	....	....
C	"	"	"	"	"	"	600, 300	"	....	1
4 A	"	1–18	2:00 a.m.	59:18	142:24	"	200, 100	1005 n.b.	....	1
B	"	"	"	"	"	"	400, 300	"	....	....
C	"	"	"	"	"	"	600, 500	"	1	4
5 A	"	"	9:35 a.m.	59:37	143:43	"	150, 75	329	....	31
B	"	"	"	"	"	"	300, 225	"	....	145
6 A	"	"	11:50 a.m.	59:29	143:50	"	200, 100	1005 n.b.	....	88
B	"	"	"	"	"	"	400, 300	"	....	13
C	"	"	"	"	"	"	600, 500	"	....	13
7 A	"	1–21	6:40 p.m.	58:55	147:22	40, 30	200, 100	1371 n.b.	....	1
B	"	"	"	"	"	40, 30	400, 300	"	....	1
C	"	"	"	"	"	40, 30	600, 500	"	....	....
8 A	"	1–22	8:35 a.m.	59:15	144:57	30 ea.	200, 100	"	....	23
B	"	"	"	"	"	"	400, 300	"	....	3
C	"	"	"	"	"	"	600, 500	"	2	3
9 A	"	"	11:55 a.m.	59:21	144:23	"	200, 100	"	....	63
B	"	"	"	"	"	"	400, 300	"	....	104
C	"	"	"	"	"	"	600, 500	"	7	42
10 A	"	"	2:30 p.m.	59:30	144:17	"	150, 75	347	....	....
B	"	"	"	"	"	"	300, 225	"	....	53
11 A	"	1–25	11:20 a.m.	59:26	145:13	"	700, 600	1152	....	63
B	"	"	"	"	"	"	500, 400	"	....	31
C	"	"	"	"	"	"	300, 200	"	15	19
12 A	"	"	2:20 p.m.	59:22	145:31	"	300, 200	1371 n.b.	....	56
B	"	"	"	"	"	"	500, 400	"	....	25
C	"	"	"	"	"	"	700, 600	"	4	24
13 A	"	"	5:25 p.m.	59:17	145:50	"	250, 150	859	....	82
B	"	"	"	"	"	"	450, 350	"	3	33
C	"	"	"	"	"	"	650, 550	"	9	30
14 A	"	"	8:20 p.m.	59:12	146:11	"	300, 200	777	....	103
B	"	"	"	"	"	"	500, 400	"	....	52
C	"	"	"	"	"	"	700, 600	"	1	35
15 A	"	1–26	12:05 a.m.	59:03	146:45	"	300, 200	1371 n.b.	....	6
B	"	"	"	"	"	"	500, 400	"	....	2
C	"	"	"	"	"	"	700, 600	"	1	2
16 A	"	"	5:50 a.m.	58:39	148:03	"	150, 75	357	....	....
B	"	"	"	"	"	"	350, 275	"	....	....
17 A	"	"	8:25 a.m.	58:47	148:17	"	125, 67	274	....	3
B	"	"	"	"	"	"	250, 183	"	....	75
18	"	"	10:50 a.m.	58:55	148:32	"	200, 100	229	....	2
19	2	"	1:25 p.m.	58:46	148:41	"	250, 150	283	....	9
20 A	1	"	4:35 p.m.	58:35	148:22	"	150, 100	274	....	37
B	"	"	"	"	"	"	250, 200	"	....	244
21 A	"	"	7:30 p.m.	58:24	148:03	"	300, 200	1371 n.b.	....	17
B	"	"	"	"	"	"	500, 400	"	....	9
C	"	"	"	"	"	"	700, 600	"	....	3
22 A	"	1–30	8:05 p.m.	56:59	150:58	"	250, 150	"	....	....
B	"	"	"	"	"	"	450, 350	"	....	....
C	"	"	"	"	"	"	650. 550	"	....	....

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
23 A	1	1–30	10:55 p.m.	57:06	151:11	30 ea.	200, 100	439	....	48
B	"	"	"	"	"	"	400, 300	"	....	35
24	2	1–31	1:20 a.m.	57:12	151:24	"	95, 50	91	....	....
25 A	1	"	6:25 a.m.	57:16	150:31	"	250, 150	1298 n.b.	....	....
B	"	"	"	"	"	"	450, 350	"	....	....
C	"	"	"	"	"	"	650, 550	"	1	....
26 A	"	"	10:45 a.m.	57:27	150:07	"	250, 150	768	....	....
B	"	"	"	"	"	"	450, 350	"	....	....
C	"	"	"	"	"	"	650, 550	"	....	....
27 A	"	"	3:05 p.m.	57:44	149:37	"	300, 200	1298 n.b.	....	....
B	"	"	"	"	"	"	500, 400	"	....	....
C	"	"	"	"	"	"	700, 600	"	....	....
28 A	"	"	5:40 p.m.	57:50	149:49	"	175, 100	347	....	60
B	"	"	"	"	"	"	350, 275	"	....	57
29	"	"	8:05 p.m.	57:58	150:02	60	100	119	....	....
30 A	"	2–1	10:35 a.m.	57:55	149:03	30 ea.	300, 200	1005	....	62
B	"	"	"	"	"	"	500, 400	"	1	12
C	"	"	"	"	"	"	700, 600	"	12	12
31 A	"	"	3:30 p.m.	58:11	148:27	"	300, 200	795	....	19
B	"	"	"	"	"	"	500, 400	"	....	....
C	"	"	"	"	"	"	700, 600			
							net lost	"	....	....
32 A	"	2–2	8:10 p.m.	59:28	143:06	20 ea.	300, 240, 180	1298 n.b.	....	....
B	"	"	"	"	"	"	500, 440, 380	"	....	....
C	"	"	"	"	"	"	700, 640, 580	"	....	....
33 A	"	"	11:05 p.m.	"	142:44	"	300, 235, 170	"	....	....
B	"	"	"	"	"	"	500, 435, 370	"	....	1
C	"	"	"	"	"	"	700, 635, 570	"	....	....
34 A	"	2–3	2:10 a.m.	59:26	142:28	"	300, 235, 170	"	....	50
B	"	"	"	"	"	"	500, 435, 370	"	....	17
C	"	"	"	"	"	"	700, 635, 570	"	2	13

Year 1929

1	2	3	4	5	6	7	8	9	10	11
101 A	1	1–29	12 noon	55:44	145:27	20 ea.	300, 200, 100	1463 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
102 A	"	"	6:13 p.m.	56:22	145:54	"	800, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
103 A	"	1–30	12:31 a.m.	57:00	146:23	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	1	....
C	"	"	"	"	"	"	900, 800, 700	"	1	....
104 A	"	"	6:42 a.m.	57:37	146:51	"	800, 200, 100	"	14	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	3	....
105 A	"	"	10:39 a.m.	57:57	147:06	"	300, 200, 100	"	....	2
B	"	"	"	"	"	"	600, 500, 400	"	10	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
106 A	"	"	2:48 p.m.	58:16	147:21	"	300, 200, 100	"	....	1
B	"	"	"	"	"	"	600, 500, 400	"	1	1
C	"	"	"	"	"	"	900, 800, 700	"	1	1
107 A	"	"	7:05 p.m.	58:35	147:37	"	300, 200, 100	"	....	11
B	"	"	"	"	"	"	600, 500, 400	"	....	5
C	"	"	"	"	"	"	900, 800, 700	"	....	....
108 A	"	"	11:20 p.m.	58:55	147:51	"	225, 150, 75	494	....	11
B	"	"	"	"	"	"	450, 375, 300	"	17	8
109	2	1–31	1:58 a.m.	59:05	147:59	30 ea.	125, 60	143	....	....
110	"	"	8:35 a.m.	59:15	148:08	"	100, 50	119	....	....
111	"	"	11:02 a.m.	59:26	148:11	20 ea.	110, 75, 40	121	....	....
112 A	1	2–8	4:20 a.m.	55:50	148:56	"	300, 200, 100	1463 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
113 A	"	"	10:28 a.m.	56:26	149:59	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
114 A	"	"	4:50 p.m.	56:57	150:57	"	350, 225, 100	768	....	3
B	"	"	"	"	"	"	700, 575, 450	"	1	....
115	"	"	7:35 p.m.	57:05	151:10	"	170, 110, 50	179	....	....
116	"	"	9:58 p.m.	57:12	151:23	30 ea.	65, 35	73	....	....
117 A	"	2–9	10:30 p.m.	56:43	150:32	20 ea.	300, 200, 100	1463 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
118 A	"	2–12	7:13 a.m.	59:45	147:00	30 ea.	85, 45	186	....	....
B	"	"	"	"	"	"	170, 130	"	....	....
119	2	"	10:50 a.m.	59:51	146:14	60	75	82	....	....
120	"	2–13	7:35 a.m.	59:49	144:50	30 ea.	125, 75	137	....	....
121	"	"	11:07 a.m.	59:41	144:20	"	140, 80	155	....	....
122 A	1	"	3:03 p.m.	59:36	143:41	"	300, 175	768	....	48
B	"	"	"	"	"	"	525, 400	"	4	6
C	"	"	"	"	"	"	750, 625	"	5	4

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
123 A	1	2–13	7:22 p.m.	59:30	143:03	20 ea.	300, 200, 100	1335	....	6
B	"	"	"	"	"	"	600, 500, 400	"	3	4
C	"	"	"	"	"	"	900, 800, 700	"	....	3
124 A	"	2–14	2:26 a.m.	59:20	142:09	"	300, 200, 100	896	....	13
B	"	"	"	"	"	"	600, 500, 400	"	3	1
C	"	"	"	"	"	"	885, 785, 685	"	2	3
125	2	"	5:17 a.m.	59:29	141:59	30 ea.	185, 100	201	....	5
126	"	"	7:55 a.m.	59:38	141:50	"	165, 100	174	....	....
127	"	"	10:32 a.m.	59:47	141:41	60	75	82	....	....
128	"	"	1:25 p.m.	59:42	141:20	"	70	78	....	....
129	"	"	3:57 p.m.	59:33	141:29	30 ea.	140, 75	150	....	....
130	1	"	6:26 p.m.	59:25	141:38	"	175, 100	183	....	2
131	"	"	10:28 p.m.	59:16	141:38	"	190, 100	205	....	6
132 A	"	2–15	1:35 a.m.	59:18	141:57	20 ea.	300, 200, 100	1408	....	2
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	1
133 A	"	"	5:07 a.m.	59:00	141:37	"	300, 200, 100	1463 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	1	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
134	"	"	8:05 a.m.	59:09	141:28	"	330, 215, 100	338	....	1
135	2	"	10:49 a.m.	59:18	141:18	"	300, 200, 100	329	....	1
136	"	"	1:30 p.m.	59:27	141:12	"	250, 150, 75	256	....	....
137	"	"	3:55 p.m.	59:36	141:06	60	65	73	....	....
138	"	"	7:00 p.m.	59:33	140:34	30 ea.	200, 100	218	....	....
139	"	"	9:34 p.m.	59:24	140:43	20 ea.	250, 175, 100	265	....	....
140	"	2–16	12:06 a.m.	59:15	140:52	30 ea.	140, 75	155	....	....
141	"	"	2:30 a.m.	59:07	141:02	"	185, 100	201	....	....
142	"	"	5:02 a.m.	58:58	141:11	20 ea.	260, 180, 100	274	....	8
143 A	1	"	7:58 a.m.	58:49	141:20	"	300, 200, 100	1463 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
144 A	"	"	11:10 a.m.	58:44	141:03	"	300, 200, 100	"	....	2
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
145	2	"	2:10 p.m.	58:53	140:53	30 ea.	185, 100	201	....	....
146	"	"	4:50 p.m.	59:02	140:44	60	170	183	....	....
147	"	"	7:17 p.m.	59:13	140:35	"	140	155	....	....
148	"	"	9:48 p.m.	59:22	140:26	20 ea.	270, 200, 100	283	....	....
149	1	2–17	12:14 a.m.	59:37	140:27	60	65	73	....	....
150	2	"	4:50 a.m.	59:20	140:04	"	115	128	....	....
151	"	"	7:18 a.m.	59:11	140:13	30 ea.	115, 70	"	....	....
152	"	"	9:40 a.m.	59:02	140:23	"	145, 100	155	....	....
153	"	"	12:07 p.m.	58:53	140:32	"	180, 100	192	....	1
154 A	1	"	2:33 p.m.	58:44	140:41	60	125	256	....	....
B	"	"	"	"	"	"	250	"	....	....
155 A	"	"	5:24 p.m.	58:35	140:50	20 ea.	300, 200, 100	1463 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
156 A	"	"	9:28 p.m.	58:18	141:09	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
157 A	"	2–18	1:50 a.m.	58:01	141:27	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
158 A	"	"	8:50 a.m.	57:25	142:03	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
159 A	"	2–20	8:35 a.m.	58:52	139:59	60	100	179	....	....
B	"	"	"	"	"	"	140	"	....	....
160 A	"	"	12:12 p.m.	58:40	139:32	30 ea.	100, 60	192	....	....
B	"	"	"	"	"	"	185, 145	"	....	....
161 A	"	2–21	1:20 a.m.	58:06	138:21	60	100	186	....	....
B	"	"	"	"	"	"	180	"	....	3
162	2	3–7	9:29 a.m.	48:15	125:04	"	105	117	....	....
163	"	"	11:53 a.m.	48:10	125:16	"	100	109	....	....
164	"	"	2:59 p.m.	48:05	125:29	30 ea.	135, 70	144	....	....
165 A	1	"	5:26 p.m.	48:00	125:41	20 ea.	240, 160, 80	497	....	....
B	"	"	"	"	"	"	480, 400, 320	"	....	....
166 A	"	"	8:20 p.m.	47:54	125:54	"	300, 200, 100	1362	....	....
B	"	"	"	"	"	"	600, 500, 400	"	1	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
167 A	"	"	11:25 p.m.	47:49	126:07	"	800, 200, 100	1463 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
168 A	"	3–8	5:50 a.m.	47:47	125:11	"	210, 140, 70	448	....	....
B	"	"	"	"	"	"	430, 360, 290	"	....	....
169	"	"	8:56 a.m.	47:51	124:53	60	85	91	....	....
170 A	"	"	6:06 p.m.	48:33	126:06	20 ea.	200, 130, 60	411	....	....
B	"	"	"	"	"	"	400, 330, 260 net ripped by swell.			
171 A	"	3–10	3:36 p.m.	50:34	129:27	"	300, 200, 100	1463 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....

Table 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
172 A	1	3–10	6:42 p.m.	50:43	129:23	20 ea.	300, 200, 100	1463 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
173	"	"	9:20 p.m.	50:53	129:20	30 ea.	170, 100	183	....	....
174	"	3–11	12:46 a.m.	51:12	129:11	20 ea.	260, 200, 100	274	....	....
175	2	3–12	9:55 a.m.	52:06	128:48	30 ea.	185, 100	201	....	....
176	"	"	12:19 p.m.	51:56	128:52	"	175, 100	192	....	....
177	1	"	2:40 p.m.	51:46	128:56	20, 40	65, 55	79	....	....
178	"	"	6:08 p.m.	51:27	129:05	60	40	53	....	....
179	"	3–13	1:50 a.m.	52:09	129:15	30 ea.	170, 150	183	....	....
180	2	3–15	12:17 p.m.	52:03	129:45	60	100	117	....	....
181	"	"	3:47 p.m.	51:56	130:16	20 ea.	310, 200, 100	329	....	....
182	1	"	7:12 p.m.	51:50	130:46	30 ea.	205, 100	218	....	....
183 A	"	3–15	9:58 p.m.	51:47	131:02	20 ea.	300, 200, 100	1463 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
184 A	"	3–16	12:48 a.m.	51:44	131:17	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
185 A	"	"	7:45 a.m.	52:25	131:57	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	1	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
186 A	"	"	3:52 p.m.	53:18	132:55	30 ea.	210, 100	439	....	....
B	"	"	"	"	"	"	420, 310	"	....	....
187 A	"	3–17	11:45 p.m.	54:10	133:31	"	185, 100	384	....	....
B	"	"	"	"	"	"	370, 285	"	1	....
188	"	"	2:21 a.m.	54:09	133:48	20 ea.	260, 200, 100	274	....	....
189 A	"	"	5:09 a.m.	54:08	134:06	"	300, 200, 100	1244	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
190 A	"	"	9:45 a.m.	54:14	133:18	30 ea.	190, 100	384	....	....
B	"	"	"	"	"	"	370, 280	"	....	....
191	2	"	12:25 p.m.	54:20	132:59	20 ea.	280, 200, 100	289	....	....
192	"	"	4:20 p.m.	54:22	132:18	"	265, 200, 100	274	....	....
193	"	"	7:50 p.m.	54:24	131:44	"	270, 200, 100	283	....	....
194	"	"	11:14 p.m.	54:27	131:11	60	130	187	....	....
195	"	3–20	8:08 a.m.	55:42	133:59	20 ea.	255, 200, 100	269	....	....
196 A	1	"	1:56 p.m.	56:06	135:01	30 ea.	190, 100	384	....	....
B	"	"	"	"	"	"	370, 280	"	....	....
197 A	"	3–21	4:48 p.m.	56:54	136:03	20 ea.	250, 175, 100	516	....	....
B	"	"	"	"	"	"	500, 425, 350	"	6	....
198	2	3–23	11:30 a.m.	59:23	140:01	30 ea.	190, 100	201	....	....
199	"	"	1:52 p.m.	59:15	140:10	60	110	119	....	....
200	"	"	4:12 p.m.	59:06	140:20	60	125	137	....	....
201	"	"	6:30 p.m.	58:57	140:29	30 ea.	170, 100	183	1	....
202 A	1	"	11:30 p.m.	58:39	140:47	20 ea.	300, 200, 100	1463 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
203 A	1	3–24	2:20 a.m.	58:30	140:58	20 ea.	300, 200, 100	1463 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
204	2	3–25	8:10 p.m.	59:32	147:48	60	100	109	....	....
205	"	"	10:35 p.m.	59:21	147:44	30 ea.	170, 100	183	....	....
206	"	3–26	1:00 a.m.	59:11	147:39	"	200, 100	210	6	....
207 A	1	"	3:40 a.m.	58:59	147:35	20 ea.	300, 200, 100	933	4	....
B	"	"	"	"	"	"	600, 500, 400	"	9	....
C	"	"	"	"	"	"	900, 800, 700	"	4	....
208 A	"	"	6:38 a.m.	58:49	147:30	"	300, 200, 100	1463 n.b.	1	....
B	"	"	"	"	"	"	600, 500, 400	"	20	....
C	"	"	"	"	"	"	900, 800, 700	"	5	....
209 A	"	"	10:36 a.m.	58:30	147:14	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	600, 500, 400	"	....	....
D	"	"	12:05 p.m.	"	"	"	900, 800, 700	"	1	....
210 A	"	"	3:40 p.m.	58:11	147:04	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	1	....
211 A	"	"	9:32 p.m.	57:32	146:37	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
212 A	"	3–27	3:35 a.m.	56:55	146:07	"	300, 200, 100	"	1	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	1	....
213 A	"	"	9:35 a.m.	56:16	145:44	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	600, 500, 400	"	....	....
214 A	"	"	3:32 p.m.	55:38	145:22	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
215	"	4–3	10:30 a.m.	57:27	151:48	60	70	82	....	....
216	"	"	12:45 p.m.	57:20	151:34	"	60	73	....	....
217	"	"	3:00 p.m.	57:14	151:21	"	120	128	....	....
218 A	"	"	5:35 p.m.	57:07	151:07	20 ea.	265, 180, 95	805	....	....
B	"	"	"	"	"	"	530, 445, 360	"	2	....

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
218 C	1	4–3	5:35 p.m.	57:07	151:07	20 ea.	795, 710, 625	805	3	....
219 A	“	“	8:28 p.m.	57:00	150:53	“	300, 200, 100	1463 n.b.	2	....
B	“	“	“	“	“	“	600, 500, 400	“	4	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
220 A	“	4–4	12:18 a.m.	56:46	150:26	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
221 A	“	“	4:12 a.m.	56:33	149:58	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
222 A	“	“	9:04 a.m.	56:12	149:18	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	1	....
223	2	4–7	12:17 a.m.	59:39	141:49	30 ea.	150, 100	164	....	....
224	“	“	2:39 a.m.	59:30	141:59	“	170, 100	183	1	....
225 A	1	“	5:10 a.m.	59:21	142:09	“	215, 100	439	1	....
B	“	“	“	“	“	“	430, 315	“	....	....
226 A	“	“	7:56 a.m.	59:12	142:20	20 ea.	300, 200, 100	1463 n.b.	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
227 A	“	“	11:56 a.m.	59:02	141:45	“	300, 200, 100	1372 n.b.	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
228	2	“	2:30 p.m.	59:11	141:32	30 ea.	235, 110	247	....	....
229	“	“	4:50 p.m.	59:20	141:25	“	230, 115	238	....	....
230	“	“	7:13 p.m.	59:28	141:16	“	175, 100	177	1	....
231 A	1	4–8	5:30 a.m.	58:12	141:16	20 ea.	300, 200, 100	1463 n.b.	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
232 A	“	“	9:20 a.m.	57:54	141:35	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
233	2	3–23	8:49 p.m.	58:48	140:38	30 ea.	190, 100	201	1	....

Year 1930

1	2	3	4	5	6	7	8	9	10	11
234 A	1	2–26	12:04 p.m.	56:06	135:34	40	350	671	....	....
B	“	“	“	“	“	“	650	“	1	....
C	“	“	2:14 p.m.	“	“	20 ea.	350, 225, 100	“	....	....
D	“	“	“	“	“	“	650, 525, 400	“	1	....
235 A	“	3–2	5:25 p.m.	56:31	136:00	“	300, 200, 100	1060	....	....
B	“	“	“	“	“	“	600, 500, 400	“	1	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
236 A	“	3–3	12:38 a.m.	57:12	136:34	“	300, 200, 100	1463 n.b.	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	1
C	“	“	“	“	“	“	900, 800, 700	“	....	....
237 A	“	“	9:09 a.m.	57:46	137:18	“	300, 200, 100	1188	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	26	....
238 A	“	“	5:16 p.m.	57:55	138:34	“	300, 200, 100	1463 n.b.	....	4
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	3	....
239 A	“	3–4	12:15 a.m.	58:16	139:34	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	2	....
C	“	“	“	“	“	“	900, 800, 700	“	1	....
D	“	“	“	“	“	“	1200, 1100, 1000	“	1	....
240 A	“	“	7:58 a.m.	58:34	140:43	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	2	....
C	“	“	“	“	“	“	900, 800, 700	“	1	....
241 A	“	“	2:47 p.m.	58:53	141:52	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
242 A	“	“	9:11 p.m.	59:14	142:52	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	1	....
D	“	“	“	“	“	“	1200, 1100, 1000	“	....	....
243 A	“	3–8	2:02 p.m.	59:28	143:57	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	5	....
C	“	“	“	“	“	“	900, 800, 700	“	1	....
D	“	“	“	“	“	“	1200, 1100, 1000	“	....	....
244 A	“	“	6:42 a.m.	59:20	145:20	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	1	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
245 A	“	3–7	10:55 p.m.	59:07	146:41	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	3	....
C	“	“	“	“	“	“	900, 800, 700	“	4	....
246	“	“	11:50 a.m.	59:01	147:56	30 ea.	140, 100	151	....	....
247 A	“	“	5:58 p.m.	58:44	146:54	20 ea.	300, 200, 100	1463 n.b.	....	....
B	“	“	“	“	“	“	600, 500, 400	“	3	....
C	“	“	“	“	“	“	900, 800, 700	“	5	...

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
248 A	1	3–9	5:12 a.m.	58:25	146:04	20 ea.	300, 200, 100	1463 n.b.	....	....
B	“	“	“	“	“	“	600, 500, 400	“	19	....
C	“	“	“	“	“	“	900, 800, 700	“	6	....
249 A	“	“	11:17 a.m.	58:07	144:56	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	17	....
C	“	“	“	“	“	“	900, 800, 700	“	7	....
250 A	“	“	5:50 p.m.	57:49	143:50	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
251 A	“	3–10	12:28 a.m.	57:30	142:43	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
252 A	“	“	6:50 a.m.	57:10	141:37	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
253 A	“	3–30	1:40 p.m.	56:50	140:58	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	4	....
C	“	“	“	“	“	“	900, 800, 700	“	1	....
D	“	“	“	“	“	“	1200, 1100, 1000	“	1	....
254 A	“	“	7:49 a.m.	56:32	139:42	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
255 A	“	“	1:15 a.m.	56:12	138:25	“	300, 250, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 550, 500, 400	“	5	....
C	“	“	“	“	“	“	900, 850, 800, 700	“	1	....
256 A	“	“	8:28 p.m.	56:19	141:16	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	1	....
257 A	“	4–1	6:29 p.m.	55:47	142:00	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700 net torn	“		
258 A	“	4–2	2:29 a.m.	56:06	143:02	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
259 A	“	“	9:56 a.m.	56:24	144:04	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
260 A	“	“	9:40 p.m.	56:43	145:09	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	1	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
261 A	“	4–3	7:24 a.m.	57:01	146:13	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	1	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
262 A	“	“	3:15 p.m.	57:19	147:17	“	300, 200, 100	“	1	....
B	“	“	“	“	“	“	600, 500, 400	“	3	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
263 A	“	“	11:13 p.m.	57:38	148:26	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	1	....
264 A	“	4–8	5:55 a.m.	57:41	149:32	30 ea.	200, 100	429	....	....
B	“	“	“	“	“	“	400, 300	“	....	....
265 A	“	“	10:41 a.m.	57:18	149:54	20 ea.	266, 176, 86	832	1	....
B	“	“	“	“	“	“	534, 444, 354	“	....	....
C	“	“	“	“	“	“	800, 710, 620	“	....	....
266 A	“	“	5:41 p.m.	56:50	150:47	“	300, 200, 100	1463 n.b.	....	....
B	“	“	“	“	“	“	600, 500, 400	“	2	....
C	“	“	“	“	“	“	900, 800, 700	“	1	....
267 A	“	4–9	1:06 a.m.	56:28	151:47	“	300, 200, 100	“	1	....
B	“	“	“	“	“	“	600, 500, 400	“	1	....
C	“	“	“	“	“	“	900, 800, 700	“	2	....
268 A	“	“	8:24 a.m.	56:04	152:45	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
269 A	“	“	3:12 p.m.	55:47	153:48	“	300, 200, 100	1280	....	....
B	“	“	“	“	“	“	600, 500, 400	“	2	....
C	“	“	“	“	“	“	900, 800, 700	“	1	....
D	“	“	“	“	“	“	1200, 1100, 1000	“	2	....
270 A	“	“	10:36 p.m.	55:33	155:02	“	270, 180, 90	841	....	....
B	“	“	“	“	“	“	540, 450, 360	“	1	....
C	“	“	“	“	“	“	810, 720, 630	“	....	....
271 A	“	4–15	12:21 a.m.	55:27	153:55	“	280, 180, 90	877	....	....
B	“	“	“	“	“	“	560, 460, 370	“	....	....
C	“	“	“	“	“	“	840, 740, 650	“	....	....
272 A	“	“	6:20 p.m.	55:24	152:48	“	300, 200, 100	1463 n.b.	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
273 A	“	4–16	1:12 a.m.	55:20	151:40	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
274 A	1	4-16	9:35 a.m.	55:16	150:31	20 ea.	300, 200, 100	1463 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
275 A	"	"	5:29 p.m.	55:12	149:22	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
276 A	"	4-17	1:37 a.m.	55:08	148:14	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
277 A	"	"	11:42 a.m.	55:03	147:05	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
278 A	"	"	7:01 p.m.	54:58	145:55	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
279 A	"	4-18	1:38 a.m.	54:50	144:48	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
280 A	"	"	8:10 a.m.	54:43	143:40	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
281 A	"	"	2:47 p.m.	54:39	142:33	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
D	"	"	"	"	"	"	1200, 1100, 1000	"	....	....
282 A	"	"	9:55 p.m.	54:42	141:25	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
283 A	"	4-19	4:10 a.m.	54:37	140:15	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
284 A	"	"	10:38 a.m.	54:34	139:00	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
285 A	"	"	5:12 p.m.	54:28	137:55	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
286 A	"	"	11:39 p.m.	54:29	136:46	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
287 A	"	4-20	6:24 a.m.	54:30	135:37	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
288 A	"	"	11:06 a.m.	54:30	135:03	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
D	"	"	"	"	"	"	1200, 1100, 1000	"	....	....
289 A	"	4-11	2:16 a.m.	55:10	156:03	"	300, 200, 100	"	1	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	2	....
290 A	"	"	9:25 a.m.	54:46	157:01	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
291 A	"	"	4:39 a.m.	54:27	158:03	"	300, 200, 100	1371	....	....
B	"	"	"	"	"	"	600, 500, 400	"	10	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
D	"	"	"	"	"	"	1200, 1100, 1000	"	2	....
292	"	"	11:08 p.m.	54:22	159:16	30 ea.	140, 70	155	1	....
293 A	"	4-12	5:53 a.m.	53:52	158:29	20 ea.	300, 200, 100	1463 n.b.	3	....
B	"	"	"	"	"	"	600, 500, 400	"	16	....
C	"	"	"	"	"	"	900, 800, 700	"	10	....
294 A	"	"	1:26 p.m.	53:25	157:42	"	300, 200, 100	"	1	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700			
							net torn	"	....	....
295 A	"	"	8:37 p.m.	52:57	156:56	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
296 A	"	4-13	3:48 a.m.	52:30	156:08	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
297 A	"	"	10:17 a.m.	52:00	155:23	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
298 A	"	"	4:25 p.m.	52:40	155:20	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
299 A	"	"	10:43 p.m.	53:20	155:16	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
300 A	"	4-14	5:12 a.m.	54:00	155:13	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
301 A	1	4–14	11:38 a.m.	54:40	155:10	20 ea.	300, 200, 100	1463 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
302 A	"	3–8	10:20 p.m.	58:57	145:06	"	300, 200, 100	"	1	....
B	"	"	"	"	"	"	600, 500, 400	"	5	....
C	"	"	"	"	"	"	900, 800, 700	"	1	....
303 A	"	3–29	12:01 p.m.	56:05	135:48	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
304 A	"	"	6:46 p.m.	56:09	137:05	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	1	....
D	"	"	"	"	"	"	1200, 1100, 1000	"	....	....
305 A	"	4–20	4:29 p.m.	54:18	134:28	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
306 A	"	"	7:50 p.m.	54:16	134:12	"	300, 200, 100	1188 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
307 A	"	"	11:08 p.m.	54:15	133:54	"	300, 200, 100	1280	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
308	"	4–21	1:59 a.m.	54:14	133:38	30 ea.	220, 110	237	....	....
309	"	"	4:35 a.m.	54:15	133:23	20 ea.	310, 200, 100	347	....	....
310	2	4–24	2:38 p.m.	54:40	133:40	30 ea.	230, 115	246	....	....
311	"	"	5:39 p.m.	54:54	133:48	"	125, 75	140	....	....
312	"	"	8:37 p.m.	55:09	133:55	"	160, 80	182	....	....
313	"	"	11:50 p.m.	55:23	134:03	"	120, 60	137	....	....
314	"	4–25	3:17 a.m.	55:32	134:09	"	140, 70	155	....	....
315	"	"	5:50 a.m.	55:28	134:22	"	160, 80	197	....	....
316	"	"	8:20 a.m.	55:29	134:48	20 ea.	270, 180, 90	283	....	....
317 A	1	"	11:29 a.m.	55:30	135:05	"	240, 160, 80	502	....	....
B	"	"	"	"	"	"	480, 400, 320	"	....	....
318 A	"	4–26	5:41 p.m.	"	135:23	"	300, 200, 100	1463 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
319 A	"	"	9:50 p.m.	55:32	136:00	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
320 A	"	4–27	2:04 a.m.	55:33	136:34	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
321 A	"	"	6:52 a.m.	55:35	137:21	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
322 A	"	4–28	12:03 a.m.	55:40	138:36	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
323 A	"	"	7:00 a.m.	55:39	139:53	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
324 A	"	"	1:55 p.m.	"	141:07	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
325 A	"	"	7:30 p.m.	55:47	142:00	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
326 A	"	4–29	5:20 a.m.	55:09	141:41	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
327 A	"	"	11:54 a.m.	54:30	141:21	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
328 A	"	"	6:59 p.m.	53:42	140:57	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
329 A	"	4–30	1:15 a.m.	53:36	139:50	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
330 A	"	"	7:36 a.m.	53:29	138:41	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
331 A	"	"	1:44 p.m.	53:23	137:32	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
332 A	"	"	8:00 p.m.	53:34	136:26	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
D	"	"	"	"	"	"	1200, 1100, 1000	"	....	....
333 A	"	5–1	2:37 a.m.	53:30	135:19	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
334 A	1	5–1	8:59 a.m.	53:25	134:16	20 ea.	300, 200, 100	1463 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
D	"	"	"	"	"	"	1200, 1100, 1000	"	....	....
335	2	"	2:20 p.m.	53:20	132:51	"	220, 150, 80	238	....	....
336 A	1	5–3	9:30 a.m.	52:36	132:14	"	300, 200, 100	1463 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
D	"	"	"	"	"	"	1200, 1100, 1000	"	....	....
337 A	"	"	4:16 p.m.	52:20	131:47	"	300, 200, 100	1371 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
338 A	"	"	8:34 p.m.	51:50	131:08	"	300, 200, 100	1463 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
339 A	"	5–4	3:37 a.m.	51:51	132:10	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
340 A	"	"	10:22 a.m.	51:57	133:15	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
D	"	"	"	"	"	"	1200, 1100, 1000	"	....	....
341 A	"	"	5:59 p.m.	52:02	134:20	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
342 A	"	5–5	1:24 a.m.	52:05	135:25	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
343 A	"	"	9:50 a.m.	52:11	136:30	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
344 A	"	"	7:36 p.m.	52:15	137:36	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
345 A	"	5–6	6:25 a.m.	52:19	138:43	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
346	2	5–8	7:30 a.m.	51:41	129:35	30 ea.	80, 40	88	....	....
347	"	"	10:36 a.m.	51:35	129:13	60	50	53	....	....
348	T	"	11:57 a.m.	"	"	15	200 cable	54	....	....
349	"	"	3:43 p.m.	51:38	129:44	30 ea.	164, 328 cable	164	....	....
350	2	"	8:07 p.m.	51:42	130:24	12 ea.	500, 400, 300, 200, 100	548	....	....
351	"	5–9	8:08 a.m.	51:57	130:40	10 ea.	270, 180, 90	274	....	....
352	T	"	11:24 a.m.	52:17	130:41	30 ea.	244, 122 cable	122	....	....
353	2	"	3:14 p.m.	52:36	130:48	30	80	82	....	....
354	T	"	6:14 p.m.	52:53	130:59	60	60 cable	53	....	....
355	"	5–10	7:27 a.m.	53:27	130:47	30	100 "	100	....	....
356	"	"	10:41 a.m.	53:46	130:56	60	67 "	68	....	....
357	2	"	2:53 p.m.	54:10	131:06	30	30	36	....	....
358	"	"	6:09 p.m.	54:18	131:29	"	135	139	....	....
359	"	"	8:04 p.m.	54:27	131:33	10	270, 180, 90	274	....	....
360	T	5–11	9:18 a.m.	54:12	131:43	30	140 cable	73	....	....
361	2	"	11:08 a.m.	54:09	131:58	"	60 "	55	....	....
362	T	"	1:14 p.m.	54:10	132:14	60	182 "	91	....	....
363	2	"	4:00 p.m.	54:16	132:28	30 ea.	200, 100	201	....	....
364	"	"	6:20 p.m.	54:19	132:44	20 ea.	330, 220, 110	338	....	....
365	"	"	8:50 p.m.	"	133:01	12 ea.	470, 376, 282, 188, 94	475	....	....
366	"	5–12	8:46 a.m.	54:10	133:19	30 ea.	180, 90	182	....	....
367	"	"	12:47 p.m.	53:57	133:15	30	40	44	....	....
368	"	"	2:43 p.m.	53:50	133:14	30 ea.	190, 100	201	....	....
369	"	"	5:35 p.m.	53:38	133:08	10 ea.	660, 550, 440, 330, 220, 110	667	....	....
370	"	"	8:25 p.m.	53:30	133:02	30 ea.	200, 100	210	....	....
371	"	5–13	1:01 a.m.	53:54	133:24	20 ea.	340, 230, 120	347	....	....
372	"	"	3:39 a.m.	54:03	133:34	15 ea.	360, 270, 180, 90	365	....	....
373	"	"	6:15 a.m.	54:13	133:44	20 ea.	285, 190, 95	296	....	....
374	"	"	8:56 a.m.	54:21	133:37	30 ea.	220, 110	228	....	....
375	"	"	11:25 a.m.	54:29	133:24	"	330, 220, 110	338	....	....
376	"	"	2:59 p.m.	54:28	133:11	20 ea.	250, 170, 90	256	....	....
377	"	"	4:25 p.m.	54:29	132:50	15 ea.	390, 300, 200, 100	398	....	....
378 A	1	3–28	8:49 a.m.	56:10	134:29	20 ea.	280, 190, 100	599	....	....
B	"	"	"	"	"	"	580, 490, 400	"	....	....
379 A	"	"	12:28 p.m.	56:30	134:27	30 ea.	225, 100	466	....	....
B	"	"	"	"	"	"	450, 325	"	....	....
380 A	"	"	3:20 p.m.	56:39	134:30	20 ea.	305, 205, 105	640	....	....
B	"	"	"	"	"	"	615, 515, 415	"	....	....

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
Year 1931										
381	2	5–19	4:48 a.m.	54:15	133:05	60	20	27	----	----
382	"	"	7:27 a.m.	54:16	133:22	20 ea.	360, 240, 120	373	----	----
383	"	"	10:10 a.m.	54:17	133:40	"	240, 160, 80	247	----	----
384 A	1	"	1:54 p.m.	54:18	133:57	"	300, 200, 100	1371 n.b.	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
385 A	"	5–21	6:30 a.m.	"	134:10	"	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
386 A	"	"	9:40 a.m.	54:18	134:27	"	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
387 A	"	"	1:30 p.m.	54:21	135:03	"	300, 200, 100	"	----	----
B	"	"	3:44 p.m.	"	"	"	600, 500, 400	"	----	----
C	"	"	1:30 p.m.	"	"	"	900, 800, 700	"	----	----
D	"	"	"	"	"	"	1200, 1100, 1000	"	----	----
388 A	"	"	7:40 p.m.	54:24	135:38	"	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
389 A	"	5–22	3:00 a.m.	54:29	136:46	"	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
390 A	"	"	10:12 a.m.	54:28	137:54	"	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
391 A	"	"	5:12 p.m.	54:34	139:00	"	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
D	"	5–25	2:54 a.m.	"	"	"	300, 200, 100	"	----	----
E	"	"	"	"	"	"	600, 500, 400	"	----	----
F	"	"	"	"	"	"	900, 800, 700	"	----	----
392 A	"	"	9:23 a.m.	54:37	140:15	"	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
393 A	"	"	5:54 p.m.	54:42	141:25	"	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
D	"	"	3:52 p.m.	"	"	"	1200, 1100, 1000	"	----	----
E	"	"	"	"	"	"	1500, 1400, 1300	"	----	----
394 A	"	5–26	12:11 a.m.	54:39	142:33	"	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
395 A	"	"	6:54 a.m.	54:43	143:40	"	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
396 A	"	"	1:12 p.m.	54:46	144:48	"	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
397 A	"	"	7:20 p.m.	54:58	145:55	"	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
D	"	"	"	"	"	"	1200, 1100, 1000	"	----	----
398 A	"	5–27	1:21 a.m.	55:03	147:05	"	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
399 A	"	"	7:38 a.m.	55:08	148:14	"	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
400 A	"	"	1:32 p.m.	55:12	149:29	"	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
401 A	"	"	7:09 p.m.	55:16	150:30	"	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
D	"	"	"	"	"	"	1200, 1100, 1000	"	----	----
402 A	"	5–28	12:41 a.m.	55:20	151:40	"	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
403 A	"	"	6:56 a.m.	55:24	152:48	"	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
404 A	"	"	2:48 p.m.	55:27	154:00	"	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
405 A	"	"	11:38 p.m.	55:28	155:16	"	300, 200, 100	950	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
406 A	"	5–29	7:16 a.m.	55:41	154:06	"	300, 200, 100	1243	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
407 A	1	5–29	3:35 p.m.	56:07	153:16	20 ea.	300, 200, 100	1051	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
408 A	"	"	11:53 p.m.	56:28	151:47	"	240, 160, 80	749	....	....
B	"	"	"	"	"	"	480, 400, 320	"	....	....
C	"	"	"	"	"	"	720, 640, 560	"	....	....
409 A	"	5–30	6:40 a.m.	56:07	150:52	"	300, 200, 100	1371 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
410 A	"	"	3:35 p.m.	55:45	149:50	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
D	"	"	1:35 p.m.	"	"	"	1200, 1100, 1000	"	....	....
E	"	"	"	"	"	"	1500, 1400, 1300	"	....	....
411 A	"	"	10:13 p.m.	"	148:26	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
412 A	"	5–31	5:41 a.m.	55:44	147:02	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
413 A	"	"	12:11 p.m.	56:03	148:06	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
D	"	"	"	"	"	"	1200, 1100, 1000	"	....	....
414 A	"	"	6:47 p.m.	56:20	149:14	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
415 A	"	6–1	1:13 a.m.	56:39	150:19	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
416 A	"	"	5:29 a.m.	56:50	150:47	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
417	2	"	11:29 a.m.	57:09	151:51	60	75	85	....	....
418	"	"	5:04 p.m.	57:43	152:20	30	50	128	....	....
419	"	6–2	9:36 p.m.	57:37	151:43	"	80	91	....	....
420	1	6–3	1:00 a.m.	57:36	151:01	60	70	87	....	....
421 A	"	6–4	5:36 p.m.	57:18	149:54	20 ea.	300, 200, 100	1371 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
422 A	"	6–5	12:50 a.m.	56:59	148:48	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
423 A	"	6–6	4:21 a.m.	56:41	147:42	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
424 A	"	"	9:43 a.m.	56:28	146:55	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
425 A	"	"	4:14 p.m.	56:16	145:51	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
426 A	"	"	10:52 p.m.	56:02	144:50	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
427 A	"	6–7	5:15 a.m.	55:47	143:46	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
428 A	"	"	11:46 a.m.	55:49	142:32	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
429 A	"	6–7	9:08 p.m.	55:25	141:12	"	300, 200, 100	"	....	....
B	"	"	7:11 p.m.	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
D	"	"	"	"	"	"	1200, 1100, 1000	"	....	....
E	"	"	"	"	"	"	1500, 1400, 1300	"	....	....
F	"	"	9:08 p.m.	"	"	"	220, 120, 20	"	....	....
430 A	"	6–8	7:01 a.m.	56:05	143:11	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
431 A	"	"	12:58 p.m.	56:24	144:04	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
D	"	"	"	"	"	"	1200, 1100, 1000	"	....	....
432 A	"	"	7:14 p.m.	56:43	145:05	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
433 A	"	6–9	1:16 a.m.	57:01	146:13	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
434 A	"	"	7:41 a.m.	57:19	147:22	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
D	"	"	"	"	"	"	1200, 1100, 1000	"	....	....

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
435 A	1	6–9	2:13 p.m.	57:38	148:26	20 ea.	300, 200, 100	1371 n.b.	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
D	“	“	“	“	“	“	1200, 1100, 1000	“	....	....
436 A	“	“	8:21 p.m.	57:56	149:32	30 ea.	200, 100	438	....	....
B	“	“	“	“	“	“	400, 300	“	....	....
437	2	6–10	2:17 a.m.	58:14	150:39	30	80	96	....	....
438	D.T.	6–12	8:24 p.m.	59:53	147:49	“	27	36	....	....
439	1	6–12	9:12 p.m.	59:53	147:49	“	“	“	....	....
440	D.T.	6–13	12:39 a.m.	59:36	148:22	30 ea.	200, 100	212	....	....
441	“	“	4:00 a.m.	59:16	148:13	60	110	123	....	....
442 A	“	“	7:29 a.m.	59:00	147:56	15 ea.	440, 330, 220, 110	457	....	....
B	1	“	9:04 a.m.	“	“	30 ea.	220, 110	“	....	....
C	“	“	“	“	“	“	440, 330	“	....	....
443	D.T.	“	3:08 p.m.	58:44	146:54	7 ea.	900 to 100[3]	1371 n.b.	....	....
444 A	1	“	8:00 p.m.	58:25	146:04	20 ea.	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
D	“	“	“	“	“	“	1200, 1100, 1000	“	....	....
445	D.T.	6–14	2:32 a.m.	58:07	144:56	7 ea.	900 to 100[3]	“	....	....
446 A	1	“	8:36 a.m.	57:47	143:47	20 ea.	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
447	D.T.	“	2:38 p.m.	57:27	142:38	7 ea.	900 to 100[3]	“	....	....
448 A	1	“	9:04 p.m.	57:05	141:29	20 ea.	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
D	“	“	“	“	“	“	1200, 1100, 1000	“	....	....
449	D.T.	6–15	3:02 a.m.	56:44	140:25	7 ea.	1500 to 100[3]	“	....	....
450 A	1	“	9:51 a.m.	56:25	139:29	20 ea.	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
451	D.T.	“	3:28 p.m.	56:12	138:25	7 ea.	900 to 100	“	....	....
452 A	1	6–15	9:41 p.m.	55:52	137:25	20 ea.	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
D	“	“	“	“	“	“	1200, 1100, 1000	“	....	....
453	D.T.	6–16	4:01 a.m.	55:32	136:25	7 ea.	1500 to 100	“	....	....
454 A	1	“	12:53 p.m.	55:18	138:07	20 ea.	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
455	D.T.	“	7:00 p.m.	55:35	139:06	7 ea.	900 to 100	“	....	....
456 A	1	6–17	1:43 a.m.	55:52	140:03	20 ea.	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
457	D.T.	“	8:09 a.m.	56:10	141:02	7 ea.	900 to 100	“	....	....
458	“	6–18	7:15 p.m.	57:34	150:00	15 ea.	430, 315, 210, 105	439	....	....
459	“	“	10:42 p.m.	57:39	150:35	30	100	109	....	....
460	“	6–19	1:44 a.m.	57:46	151:12	“	65	74	....	....
461	“	6–20	8:23 a.m.	57:56	152:40	“	100	121	....	....
462	“	“	10:10 a.m.	57:48	152:52	“	36	57	....	....
463	“	“	1:44 p.m.	58:01	153:26	“	80	91	....	....
464	“	6–21	6:13 a.m.	58:23	153:40	15 ea.	170, 85	183	....	....
465	“	“	9:41 a.m.	58:33	153:07	30 ea.	160, 80	169	....	....
466	“	“	1:09 p.m.	58:50	152:45	“	160, 80	173	....	....
467	“	“	5:37 p.m.	59:03	152:11	60	125	137	....	....
468	“	“	10:45 p.m.	58:55	151:16	“	120	128	1	....
469	“	6–22	3:52 a.m.	58:47	150:21	30 ea.	160, 80	168	....	....
470	“	“	8:37 a.m.	58:39	149:26	“	140, 70	146	....	....
471	“	“	1:41 p.m.	58:46	148:30	20 ea.	260, 180, 90	274	....	....
472	“	“	5:17 p.m.	58:29	148:11	10 ea.	600 to 100	653	....	....
473	“	“	10:03 p.m.	58:20	149:10	30 ea.	160, 80	174	....	....
474	“	6–23	2:47 a.m.	58:10	150:17	“	145, 75	155	....	....
475	“	“	7:17 a.m.	58:01	151:17	60	75	91	....	....
476	“	“	10:53 a.m.	58:05	151:52	30	80	96	....	....
477	“	“	1:15 p.m.	58:01	152:20	15 ea.	65, 35	78	....	....
478	“	“	8:09 p.m.	57:56	154:05	30 ea.	190, 100	201	....	....
479	“	6–24	12:27 a.m.	57:43	154:47	“	220, 110	233	....	....
480	“	“	4:39 a.m.	57:32	155:29	20 ea.	270, 180, 90	283	....	....
481	“	6–24	9:05 a.m.	57:08	156:01	60	75	78	....	....
482	“	“	1:16 p.m.	56:43	156:39	30 ea.	130, 65	140	....	....
483	“	“	3:36 p.m.	56:33	156:36	“	160, 80	173	....	....
484	“	“	9:00 p.m.	56:24	156:32	“	170, 90	183	....	....
485	“	“	11:07 p.m.	56:14	156:28	15 ea.	175, 85	183	....	....
486	“	6–25	1:07 a.m.	56:03	156:24	“	220, 110	229	....	....
487	“	“	3:05 a.m.	55:51	156:19	10 ea.	240, 160, 80	251	....	....
488	“	“	5:00 a.m.	55:42	156:16	15 ea.	220, 110	256	....	....
489	“	“	6:56 a.m.	55:32	156:14	“	200, 100	219	....	....
490	“	“	8:55 a.m.	55:19	156:11	“	190, 100	201	....	....
491	“	“	11:07 a.m.	55:07	156:07	7 ea.	900 to 100	1005	....	....
492	“	“	2:12 p.m.	54:56	156:05	“	“ “ “	1371 n.b.	....	....
493	“	“	8:01 p.m.	54:41	157:07	“	“ “ “	“	....	....
494	“	6–26	2:22 a.m.	54:19	158:17	“	“ “ “	“	....	....
495	“	“	9:23 a.m.	54:05	159:38	“	“ “ “	“	....	....

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[3] The depths given as 900 to 100 or 1500 to 100 indicate that the net was towed for the time shown in column 7 at each 100 meters from the 900 or 1500 to 100-meter levels.

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
496	D.T.	6–26	1:45 p.m.	54:19	160:03	20 ea.	280, 200, 100	291	....	....
497	"	"	4:28 p.m.	54:29	160:11	60	115	128	....	....
498	"	"	6:58 p.m.	54:39	160:18	30	90	100	....	....
499	"	"	8:54 p.m.	54:51	160:20	30	75	91	....	....
500	"	"	10:41 p.m.	55:00	160:22	"	70	85	....	....
501	"	6–27	2:20 p.m.	55:15	160:28	"	100	118	....	....
502	"	"	4:15 p.m.	55:26	160:32	15 ea.	120, 60	133	....	....
503	"	"	6:24 p.m.	55:23	160:55	30	90	100	....	....
504	"	"	8:10 p.m.	55:20	161:12	"	30	39	....	....
505	"	"	10:07 p.m.	55:20	161:32	"	70	78	....	....
506	"	6–28	8:16 a.m.	55:07	161:14	"	60	68	....	....
507	"	"	10:14 a.m.	54:58	161:10	15 ea.	130, 65	137	....	....
508	"	"	12:13 p.m.	54:47	161:04	30	100	114	....	....
509	"	"	2:12 p.m.	54:37	161:00	15 ea.	90, 45	98	....	....
510	"	"	4:08 p.m.	54:28	160:56	"	120, 60	131	....	....
511	"	"	5:57 p.m.	54:18	160:50	"	110, 55	116	....	....
512	"	"	8:09 p.m.	54:08	160:47	12 ea.	900, 700, 500 300, 100	1005	....	....
513	"	6–29	3:31 a.m.	54:38	159:41	30	75	87	....	....
514	"	"	5:36 a.m.	54:30	159:29	15 ea.	160, 80	153	....	....
515	"	"	7:57 a.m.	54:21	159:16	7 ea.	900 to 100	1371 n.b.	....	....
516	"	6–30	12:47 p.m.	55:02	159:29	30	40	50	....	....
517	"	"	2:02 p.m.	55:00	159:24	"	26	36	....	....
518	"	7–1	6:30 a.m.	55:11	159:25	"	30	60	....	....
519	"	"	8:55 a.m.	55:21	159:22	15 ea.	160, 80	183	....	....
520	"	"	10:47 a.m.	55:28	159:35	"	140, 70	151	....	....
521	Tr.	"	1:14 p.m.	55:36	159:43	20	....	35	....	....
522	D.T.	"	1:45 p.m.	"	"	30	18	34	....	....
523	"	"	6:00 p.m.	55:41	159:52	10	Unknown	149	....	....
524	"	7–2	1:50 p.m.	55:06	160:46	15 ea.	100, 50	110	....	....
525	"	"	4:13 p.m.	54:52	160:40	"	90, 45	98	....	....
526	"	"	6:38 p.m.	54:37	160:34	"	130, 65	137	....	....
527	"	"	8:57 p.m.	54:22	160:28	"	130, 65	144	....	....
528	"	"	11:47 p.m.	54:07	160:21	12 ea.	900, 700, 500, 300, 100	1371 n.b.	....	....
529	"	7–3	4:22 a.m.	54:11	159:43	"	900, 700, 500 300, 100	"	....	....
530	"	"	8:58 a.m.	54:13	159:06	7 ea.	900 to 100	"	....	....
531	"	"	1:05 p.m.	53:53	159:02	"	" " "	"	....	....
532	"	"	6:10 p.m.	54:02	158:18	"	" " "	"	....	....
533	"	"	9:43 p.m.	54:15	158:23	"	" " "	"	....	....
534	"	7–4	1:15 a.m.	54:30	158:31	"	" " "	"	....	....
535	"	"	4:34 a.m.	54:44	158:40	15 ea.	100, 50	105	....	....
536	"	"	7:03 a.m.	54:59	158:49	30	80	91	....	....
537	"	"	9:45 a.m.	55:14	158:58	15 ea.	170, 85	183	....	....
538	"	"	12:15 p.m.	55:28	159:08	"	140, 70, 20	152	....	....
539	"	"	3:04 p.m.	55:42	159:16	"	90, 45	101	....	....
540	"	"	5:55 p.m.	55:48	158:42	30	65	76	....	....
541	"	"	8:09 p.m.	55:33	158:34	15 ea.	120, 60	137	....	....
542	"	"	10:38 p.m.	55:20	158:25	"	140, 70	151	....	....
543	"	7–5	1:07 a.m.	55:04	158:15	"	" "	"	....	....
544	"	"	3:38 a.m.	54:50	158:07	"	100, 50	112	....	....
545	"	"	6:17 a.m.	54:36	157:59	7 ea.	900 to 100	1234	....	....
546	"	"	9:24 a.m.	54:21	157:49	"	" " "	1371 n.b.	....	....
547	"	"	1:18 p.m.	54:23	157:14	"	" " "	"	....	....
548	"	"	4:47 p.m.	54:36	157:16	"	" " "	"	....	....
549	"	"	8:05 p.m.	54:52	157:31	15 ea.	450, 340, 220, 100	466	....	....
550	"	"	11:11 p.m.	55:06	157:40	8, 22	80, 65	91	....	....
551	"	7–6	1:35 a.m.	55:21	157:49	30	75	93	....	....
552	"	"	3:56 a.m.	55:35	157:57	30	100	128	....	....
553	"	"	6:17 a.m.	55:49	158:06	"	90	107	....	....
554	"	"	8:43 a.m.	56:03	158:14	15 ea.	100, 50	112	....	....
555	"	"	12:10 p.m.	56:13	157:41	30	75	87	....	....
556	"	"	2:35 p.m.	55:58	157:34	"	"	83	....	....
557	"	"	4:35 p.m.	55:47	157:27	15 ea.	90, 45	105	....	....
558	"	"	7:19 p.m.	56:00	157:00	"	100, 50	109	....	....
559	"	"	9:44 p.m.	56:14	157:04	30	80	94	....	....
560	"	7–13	7:58 a.m.	57:26	154:54	15 ea.	210, 100	222	....	....
561	"	"	9:50 a.m.	57:35	155:03	10 ea.	240, 160, 80	246	....	....
562	"	"	11:46 a.m.	57:44	155:12	"	280, 190, 100	292	....	....
563	B.S.	"	2:30 p.m.	57:45	155:44	....	....	......	....	....
564	"	"	....	57:45	155:44	....	....	......	....	....
565	D.T.	"	6:20 p.m.	57:43	155:35	15 ea.	12, 17	16	....	....
566	"	"	8:57 p.m.	57:30	155:41	30	35	39	....	....
567	"	"	11:17 p.m.	57:16	155:27	10 ea.	270, 180, 90	274	....	....
568	"	7–14	1:45 a.m.	57:03	155:14	"	240, 160, 80	259	....	....
569	"	"	4:14 a.m.	56:49	155:01	15 ea.	100, 50	111	....	....
570	"	"	6:47 a.m.	56:35	154:48	30	15	21	....	....
571	"	"	10:16 a.m.	56:12	155:06	"	12	32	....	....
572	"	"	12:35 p.m.	55:59	154:53	"	45	61	....	....
573	"	"	3:06 p.m.	55:45	154:40	8 ea.	800 to 100	822	....	....
574	"	"	6:21 p.m.	55:30	154:27	7 ea.	900 to 100	1371 n.b.	....	....
575	"	"	10:52 p.m.	55:44	153:57	"	" " "	1097	....	....

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
576	D.T.	7–15	2:17 a.m.	55:59	154:11	30	100	109	----	----
577	"	"	4:43 a.m.	56:13	154:25	"	75	83	----	----
578	"	"	6:35 a.m.	56:22	154:34	"	20	27	----	----
579	"	"	11:05 a.m.	56:26	155:19	"	45	54	----	----
580	"	"	1:29 p.m.	56:39	155:32	15 ea.	200, 100	256	----	----
581	"	"	4:00 p.m.	56:53	155:45	10 ea.	290, 200, 100	297	----	----
582	"	"	6:30 p.m.	57:06	155:58	15 ea.	210, 100	219	----	----
583	"	"	8:20 p.m.	57:18	156:11	30	110	128	----	----
584	"	7–16	12:21 a.m.	56:52	156:21	15 ea.	170, 100	191	----	----
585	"	"	2:43 a.m.	56:39	156:14	10 ea.	250, 170, 90	256	----	----
586	"	"	5:20 a.m.	56:26	156:01	15, 10	210, 100	219	----	----
587	1	"	9:13 a.m.	56:13	155:48	30	50	68	----	----
588	"	7–18	8:55 a.m.	56:00	155:35	60	30	39	----	----
589	D.T.	"	12:42 p.m.	55:47	155:22	30	50	63	----	----
590 A	1	"	3:25 p.m.	55:33	155:10	20 ea.	240, 160, 80	712	----	----
B	"	"	"	"	"	"	480, 400, 320	"	----	----
C	"	"	"	"	"	"	720, 640, 560	"	----	----
591 A	"	"	7:08 p.m.	55:20	154:57	"	300, 200, 100	1280	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
592 A	"	7–19	12:16 a.m.	55:03	155:34	"	300, 200, 100	1371 n.b.	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
593 A	"	"	5:11 a.m.	54:49	156:10	"	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
594 A	"	"	9:28 a.m.	55:02	156:28	"	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
595	D.T.	"	12:54 p.m.	55:17	156:35	15 ea.	140, 70	146	----	----
596	"	"	3:25 p.m.	55:31	156:44	30	80	91	----	----
597	"	"	5:48 p.m.	55:45	156:50	"	80	"	----	----
598	"	"	8:44 p.m.	55:30	157:17	"	80	85	----	----
599	"	7–20	11:03 a.m.	56:23	158:02	15 ea.	145, 70	155	----	----
600	Tr.	7–22	9:20 a.m.	57:43	155:38	30	50 cable	13	7	----
601	"	"	10:10 a.m.	"	"	40	60 "	"	8	----
602	"	"	11:14 a.m.	"	"	45	50 "	"	10	----
603	"	"	12:20 p.m.	"	"	"	50 "	"	11	----
604	"	"	1:25 p.m.	"	"	"	50 "	"	25	----
605	"	"	2:28 p.m.	"	"	"	50 "	"	2	----
606	"	"	3:30 p.m.	"	"	"	60 "	"	10	----
607	"	7–28	6:30 a.m.	54:06	131:52	20	50 "	------	----	----
608	"	"	7:30 a.m.	"	131:48	"	50 "	------	----	----

Year 1932

609 A	1	3–26	9:18 a.m.	54:20	133:13	30 ea.	200, 100	457	----	----
B	"	"	"	"	"	"	400, 300	"	----	----
610 A	"	"	12:15 p.m.	"	133:40	"	175, 75	366	----	----
B	"	"	"	"	"	"	375, 275	"	----	----
611 A	"	"	2:59 p.m.	54:10	133:36	"	175, 75	384	----	----
B	"	"	"	"	"	"	350, 250	"	----	----
612	"	"	5:10 p.m.	"	133:15	"	90, 45	110	----	----
613	"	3–27	6:33 a.m.	54:00	133:18	30	50	64	----	----
614	"	"	9:54 a.m.	"	133:42	20 ea.	300, 200, 100	311	----	----
615 A	"	"	1:00 p.m.	"	134:04	"	300, 200, 100	1289	----	----
B	"	"	1:00 p.m.	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	2	----
616 A	"	"	4:15 p.m.	54:10	"	"	325, 225, 125	728	----	----
B	"	"	"	"	"	"	625, 525, 425	"	----	----
617 A	"	"	7:10 p.m.	54:20	"	"	350, 250, 150	786	----	----
B	"	"	"	"	"	"	700, 600, 500	"	----	----
618 A	"	3–28	7:50 a.m.	"	134:31	"	300, 200, 100	1372 n.b.	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
619 A	"	"	10:55 a.m.	54:10	134:30	"	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
620 A	"	"	2:05 p.m.	54:00	134:25	"	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
621 A	"	"	5:10 p.m.	53:50	134:20	"	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	----	----
622 A	"	"	8:12 p.m.	53:40	134:15	15 ea.	300, 200, 100	"	----	----
B	"	"	"	"	"	"	600, 500, 400	"	----	----
C	"	"	"	"	"	"	900, 800, 700	"	1	----
623	"	3–31	7:09 a.m.	53:50	133:15	30	40	46	----	----
624 A	"	"	9:45 a.m.	"	133:34	20 ea.	250, 150, 50	604	1	----
B	"	"	"	"	"	"	500, 400, 300	"	----	----

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
625 A	1	3–31	12:52 p.m.	53:50	133:55	20 ea.	300, 200, 100	1372 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	2	....
626 A	"	"	4:00 p.m.	53:40	133:50	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
627 A	"	"	7:10 p.m.	"	133:29	"	300, 200, 100	1234	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
628	"	4–1	6:45 a.m.	"	133:08	"	150, 100	165	....	....
629	"	"	9:09 a.m.	53:29	133:03	30 ea.	200, 100	256	....	....
630 A	"	4–2	8:40 a.m.	53:15	132:47	20 ea.	600, 500, 400	768	....	....
B	"	"	"	"	"	"	300, 200, 100	"	....	....
631 A	"	"	11:50 a.m.	53:05	132:40	"	600, 500, 400	878	....	....
B	"	"	"	"	"	"	300, 200, 100	"	1	....
632 A	"	"	3:09 p.m.	52:56	132:34	"	300, 200, 100	1372 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	2	....
633 A	"	"	6:27 p.m.	52:49	132:21	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
634 A	"	4–3	7:36 a.m.	52:38	132:12	"	300, 200, 100	1042	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
635 A	"	"	10:55 a.m.	52:28	132:04	"	300, 200, 100	1372 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	1	....
636 A	"	"	2:28 p.m.	52:19	131:47	"	300, 200, 100	1244	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
637	"	"	5:45 p.m.	52:11	131:28	15 ea.	300, 150	512	....	....
638 A	"	4–4	7:45 a.m.	52:01	131:23	20 ea.	300, 200, 100	988	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
639 A	"	"	11:23 a.m.	52:01	131:41	"	300, 200, 100	1372 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	1	....
640	"	4–7	7:08 a.m.	54:29	131:32	30 ea.	250, 125	293	....	....
641	2	"	10:25 a.m.	54:32	131:56	30	125	203	....	....
642	"	"	12:35 p.m.	54:33	132:23	"	150	219	....	....
643	"	"	3:20 p.m.	"	132:52	20 ea.	300, 200, 100	384	....	....
644	"	"	6:23 p.m.	54:20	132:55	"	300, 200, 100	435	....	....
645	"	4–8	8:15 a.m.	54:20	132:34	30 ea.	200, 100	256	....	....
646	"	"	10:31 a.m.	"	132:18	"	200, 100	238	....	....
647	1	"	1:50 p.m.	54:13	132:00	"	100, 50	137	....	....
648	"	"	3:30 p.m.	54:10	131:57	30	50	82	....	....
649	"	4–10	12:23 p.m.	53:51	130:43	30 ea.	50, 25	88	....	....
650	"	"	3:05 p.m.	53:41	130:38	"	50, 25	73	....	....
651	"	"	5:21 p.m.	53:33	130:31	"	50, 25	73	....	....
652	2	4–11	6:30 a.m.	53:21	130:32	"	75, 25	110	....	....
653	"	"	10:20 a.m.	53:03	130:26	"	100, 50	152	....	....
654	"	"	2:07 p.m.	52:44	130:16	"	100, 50	143	....	....
655	"	"	6:00 p.m.	52:26	130:09	20 ea.	200, 150, 100	274	....	....
656	"	"	9:45 p.m.	52:06	"	"	350, 250, 150	411	....	....
657	"	4–12	1:38 a.m.	51:46	"	30 ea.	200, 100	238	....	....
658 A	1	"	5:46 a.m.	51:25	130:09	20 ea.	300, 200, 100	1234	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
659 A	"	"	9:28 a.m.	51:21	129:44	30 ea.	100, 50	384	....	....
B	"	"	"	"	"	"	300, 250	"	....	....
660 A	"	"	12:55 p.m.	51:15	129:19	"	50, 25	293	....	....
B	"	"	"	"	"	"	200, 175	"	....	....
661	2	"	4:14 p.m.	51:09	128:56	"	100, 50	124	....	....
662	1	4–13	9:12 a.m.	50:55	129:05	"	75, 35	91	....	....
663 A	"	4–14	6:40 a.m.	51:01	129:35	"	100, 50	278	....	....
B	"	"	"	"	"	"	200, 150	"	....	....
664 A	"	"	10:41 a.m.	51:08	130:05	"	200, 100	887	....	....
B	"	"	"	"	"	"	400, 300	"	....	....
C	"	"	"	"	"	"	600, 500	"	....	....
665 A	"	"	3;06 p.m.	51:16	130:35	20 ea.	300, 200, 100	1372 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
666 A	"	4–16	5:55 a.m.	51:55	130:52	30 ea.	50, 25	164	....	....
B	"	"	"	"	"	"	100, 75	"	....	....
667 A	"	"	8:13 a.m.	51:47	"	"	100, 50	179	....	....
B	"	"	"	"	"	"	200, 150	"	....	....
668 A	"	"	11:08 a.m.	51:36	"	20 ea.	300, 200, 100	1152	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
669 A	"	"	2:21 p.m.	51:26	"	"	300, 200, 100	1372 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
670 A	"	"	5:32 p.m.	51:16	"	"	300, 200, 100	"	....	....

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
670 B	1	4–16	5:32 p.m.	51:16	130:52	20 ea.	600, 500, 400	1372 n.b.	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
671 A	"	"	9:16 p.m.	51:26	130:35	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
672 A	"	4–17	12:21 a.m.	51:38	"	30 ea.	200, 100	790	....	....
B	"	"	"	"	"	"	400, 300	"	....	....
C	"	"	"	"	"	"	600, 500	"	....	....
673 A	"	"	3:10 a.m.	51:48	"	"	150, 75	365	....	....
B	"	"	"	"	"	"	300, 225	"	....	....
674 A	"	"	5:48 a.m.	51:59	130:38	"	125, 50	265	....	....
B	"	"	"	"	"	"	250, 175	"	....	....
675	"	"	8:10 a.m.	52:08	130:35	"	150, 50	182	....	....
676	2	"	10:24 a.m.	52:18	130:37	"	125, 75	155	....	....
677	"	"	12:55 p.m.	52:27	130:35	"	100, 50	110	....	....
678	"	"	3:06 p.m.	52:28	130:52	"	100, 50	134	....	....
679	"	"	5:17 p.m.	52:16	"	"	100, 50	139	....	....
680	"	"	7:28 p.m.	52:06	130:51	"	100, 50	122	....	....
681 A	1	4–18	7:30 a.m.	51:48	131:08	20 ea.	300, 200, 100	1372 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
682 A	"	4–19	7:01 a.m.	51:50	131:24	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
683 A	"	"	10:10 a.m.	51:40	"	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
684 A	"	"	1:20 p.m.	51:30	"	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
685 A	"	"	4:30 p.m.	51:17	"	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
686 A	"	"	7:44 p.m.	"	131:08	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
687 A	"	"	11:07 p.m.	51:27	"	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
688 A	"	4–20	3:56 a.m.	51:37	"	"	300, 200, 100	"	....	....
B	"	"	2:24 a.m.	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
689 A	"	"	8:45 a.m.	51:50	131:40	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
690 A	"	"	12:01 p.m.	51:40	131:40	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
691 A	"	"	3:11 p.m.	51:29	"	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
692 A	"	"	6:25 p.m.	51:16	"	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
693 A	"	4–27	8:39 a.m.	57:46	137:06	30 ea.	150, 75	411	....	....
B	"	"	"	"	"	"	300, 225	"	....	....
694 A	"	4–28	10:36 a.m.	59:13	142:15	"	200, 100	801	3	....
B	"	"	"	"	"	"	400, 300	"	....	....
C	"	"	"	"	"	"	600, 500	"	....	....
695 A	"	"	6:20 p.m.	59:38	143:41	"	50, 25	137	....	....
B	"	"	"	"	"	"	100, 75	"	....	....
696	2	5–1	9:36 a.m.	57:12	152:12	"	50, 25	82	....	....
696 A	1	"	10:47 a.m.	"	"	"	25, 10	"	....	....
B	"	"	"	"	"	"	50, 35	"	1	....
697 A	"	"	1:32 p.m.	57:01	151:52	"	25, 10	"	....	....
B	"	"	"	"	"	"	50, 35	"	3	....
698 A	"	"	4:28 p.m.	56:51	151:33	"	75, 37	201	....	....
B	"	"	"	"	"	"	150, 123	"	....	....
699 A	"	"	7:47 p.m.	56:40	151:14	20 ea.	300, 200, 100	1372 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
700 A	"	"	11:21 p.m.	56:29	151:32	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
701 A	"	5–2	3:00 a.m.	56:17	151:50	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	1	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
702 A	"	"	6:20 a.m.	56:06	152:09	"	300, 200, 100	"	1	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
703 A	"	"	9:47 a.m.	56:17	152:29	"	240, 160, 80	823	1	....
B	"	"	"	"	"	"	480, 400, 320	"	....	....
C	"	"	"	"	"	"	720, 640, 560	"	....	....

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
704	1	5–2	1:03 p.m.	56:28	152:48	30 ea.	50, 25	69	....	....
705	2	"	3:52 p.m.	56:38	153:08	"	100, 50	146	1	....
706	1	"	6:35 p.m.	56:49	153:28	"	100, 50	78	....	....
707	"	5–4	5:16 a.m.	56:45	154:43	"	35, 17	42	....	....
708	"	"	8:03 a.m.	56:38	155:09	"	100, 50	73	3	....
709 A	"	"	10:54 a.m.	56:32	155:34	"	50, 25	190	....	....
B	"	"	"	"	"	"	100, 75	"	....	....
710 A	"	"	1:49 p.m.	56:26	155:59	"	100, 50	252	2	....
B	"	"	"	"	"	"	200, 150	"	....	....
711 A	"	"	4:45 p.m.	56:21	156:25	"	100, 50	265	....	....
B	"	"	"	"	"	"	200, 150	"	....	....
712	"	5–5	2:54 a.m.	56:15	156:50	"	50, 25	91	1	....
713 A	"	"	6:02 a.m.	56:28	156:38	"	75, 50	176	....	....
B	"	"	"	"	"	"	150, 125	"	....	....
714 A	"	"	9:09 a.m.	56:41	156:25	"	100, 50	201	....	....
B	"	"	"	"	"	"	200, 150	"	....	....
715 A	"	"	12:14 p.m.	56:55	156:11	"	75, 35	"	....	....
B	"	"	"	"	"	"	150, 115	"	1	....
716 A	"	"	3:30 p.m.	57:09	155:58	"	100, 50	274	....	....
B	"	"	"	"	"	"	200, 150	"	....	....
717 A	"	"	6:36 p.m.	57:31	155:45	"	100, 50	256	....	....
B	"	"	"	"	"	"	200, 150	"	....	....
718 A	"	"	9:45 p.m.	57:34	155:32	"	100, 50	"	....	....
B	"	"	"	"	"	"	200, 150	"	1	....
719	"	5–7	6:21 a.m.	57:37	155:29	30	25	55	1	....
720 A	"	"	8:40 a.m.	57:26	155:24	30 ea.	100, 50	271	....	....
B	"	"	"	"	"	"	200, 150	"	....	....
721 A	"	"	11:16 a.m.	57:17	155:15	"	100, 50	241	....	....
B	"	"	"	"	"	"	200, 150	"	....	....
722 A	"	"	1:50 p.m.	57:09	155:07	"	100, 50	223	....	....
B	"	"	"	"	"	"	200, 150	"	....	....
723	"	"	4:19 p.m.	57:00	154:59	"	50, 25	73	....	....
724	"	"	6:45 p.m.	56:51	154:50	"	25, 12	35	....	....
725	"	5–8	5:24 p.m.	56:51	154:13	20	10	24	....	....
726	"	5–9	5:14 a.m.	56:45	154:43	30 ea.	25, 12	35	....	....
727	"	"	8:20 a.m.	56:38	155:09	"	50, 25	55	....	....
728 A	"	"	11:11 a.m.	56:32	155:34	"	" "	135	....	....
B	"	"	"	"	"	"	100, 75	"	....	....
729 A	"	"	2:19 p.m.	56:26	155:59	"	100, 50	267	....	....
B	"	"	"	"	"	"	200, 150	"	....	....
730 A	"	"	5:08 p.m.	56:21	156:25	"	100, 50	227	....	....
B	"	"	"	"	"	"	200, 150	"	....	....
731	"	"	7:44 p.m.	56:15	156:50	"	75, 35	86	....	....
732 A	"	"	10:49 p.m.	56:28	156:38	"	80, 40	179	1	....
B	"	"	"	"	"	"	160, 120	"	2	....
733 A	"	5–10	2:00 a.m.	56:41	156:25	"	75, 35	190	1	....
B	"	"	"	"	"	"	150, 115	"	....	....
734 A	"	"	5:07 a.m.	56:55	156:11	"	75, 35	192	....	....
B	"	"	"	"	"	"	150, 115	"	....	....
735 A	"	"	8:18 a.m.	57:08	155:58	"	100, 50	256	....	....
B	"	"	"	"	"	"	200, 150	"	....	....
736 A	"	"	11:27 a.m.	57:21	155:45	"	100, 50	263	....	....
B	"	"	"	"	"	"	200, 150	"	....	....
737 A	"	"	2:41 p.m.	57:35	155:32	"	100, 50	300	....	....
B	"	"	"	"	"	"	200, 150	"	....	....
738	"	"	8:19 p.m.	57:44	155:33	30	10	13	....	....
739	"	5–11	4:53 a.m.	57:40	155:34	"	75	91	....	....
740	"	"	5:40 a.m.	57:41	155:30	"	35	55	....	....
741 A	"	"	7:45 a.m.	57:26	155:24	30 ea.	100, 50	293	1	....
B	"	"	"	"	"	"	200, 150	"	....	....
742 A	"	"	10:15 a.m.	57:18	155:15	"	100, 50	269	1	....
B	"	"	"	"	"	"	200, 150	"	....	....
743 A	"	"	12:45 p.m.	57:09	155:06	"	100, 50	252	....	....
B	"	"	"	"	"	"	200, 150	"	....	....
744	"	"	3:09 p.m.	56:54	154:52	"	75, 35	88	1	....
745	"	"	4:50 p.m.	56:49	154:48	"	40, 20	55	....	....
746	"	5–12	4:00 p.m.	56:51	154:09	30	15	18	1	....
747	"	"	4:38 p.m.	56:50	"	"	20	27	....	....
748	"	5–13	8:39 a.m.	56:49	153:28	30 ea.	75, 35	91	6	....
749	"	"	11:40 a.m.	56:38	153:09	"	100, 50	157	1	....
750	"	"	2:40 p.m.	56:28	152:48	"	50, 25	55	....	....
751 A	"	"	6:10 p.m.	56:17	152:29	20 ea.	300, 200, 100	1372 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
752 A	"	"	10:30 p.m.	56:06	152:09	"	300, 200, 100	"	1	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
753 A	"	5–14	2:15 a.m.	56:17	151:50	"	300, 200, 100	"	1	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	1	....
754 A	"	"	6:00 a.m.	56:29	151:32	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
755 A	1	5–14	9:58 a.m.	56:40	151:14	30 ea.	200, 100	878	....	....
B	“	“	“	“	“	“	400, 300	“	....	....
C	“	“	“	“	“	“	600, 500	“	....	....
756	“	“	1:00 p.m.	56:51	151:33	“	75, 35	......	....	....
757 A	“	“	3:53 p.m.	57:01	151:52	“	50, 25	135	....	....
B	“	“	“	“	“	“	100, 75	“	1	....
758	“	“	6:50 p.m.	57:12	152:12	“	100, 50	165	2	....
759	“	5–19	3:54 a.m.	“	“	“	75, 35	88	....	....
760	“	“	6:45 a.m.	57:01	151:52	“	“ “	91	....	....
761 A	“	“	9:48 a.m.	56:50	151:31	20 ea.	300, 200, 100	731	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
762 A	“	“	1:15 p.m.	56:39	151:12	“	300, 200, 100	1372 n.b.	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
763 A	“	“	4:51 p.m.	56:29	151:32	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
764 A	“	“	8:30 p.m.	56:17	151:50	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
765 A	“	5–20	12:10 a.m.	56:06	152:09	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
766 A	“	“	3:57 a.m.	56:17	152:29	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
767 A	“	“	7:37 a.m.	56:28	152:48	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
768	“	“	10:48 a.m.	56:38	153:09	30 ea.	50, 25	77	1	....
769	“	“	1:33 p.m.	56:49	153:28	“	75, 35	75	....	....
770	“	5–22	5:55 a.m.	56:45	154:43	“	25, 12	33	2	....
771	“	“	8:40 a.m.	56:38	155:09	“	45, 25	66	9	....
772	“	“	11:33 a.m.	56:32	155:34	“	100, 50	155	....	....
773 A	“	“	2:27 p.m.	56:26	155:59	“	100, 50	252	1	....
B	“	“	“	“	“	“	200, 150	“	....	....
774 A	“	“	5:26 p.m.	56:21	156:25	“	100, 50	238	....	....
B	“	“	“	“	“	“	200, 150	“	....	....
775	“	“	8:30 p.m.	56:15	156:50	“	60, 30	91	1	....
776	“	5–23	4:39 a.m.	56:28	156:38	“	100, 50	179	....	....
777 A	“	“	7:28 a.m.	56:41	156:25	“	75, 35	208	....	....
B	“	“	“	“	“	“	150, 115	“	....	....
778 A	“	“	10:24 a.m.	56:55	156:11	“	75, 35	205	....	....
B	“	“	“	“	“	“	150, 115	“	....	....
779	“	“	1:30 p.m.	57:08	155:58	“	75, 35	88	....	....
780 A	“	“	4:32 p.m.	57:21	155:45	“	100, 50	252	....	....
B	“	“	“	“	“	“	200, 150	“	....	....
781	“	“	7:28 p.m.	57:35	155:82	“	100, 50	165	1	....
782	“	5–27	3:43 a.m.	57:40	155:30	“	20, 10	36	....	....
783	“	“	5:15 a.m.	57:39	155:28	“	60, 20	88	....	....
784 A	“	“	8:45 a.m.	57:26	155:24	“	100, 50	278	....	....
B	“	“	“	“	“	“	200, 150	“	....	....
785	“	“	11:16 a.m.	57:18	155:15	20 ea.	200, 150, 100	260	....	....
786	“	“	1:35 p.m.	57:09	155:06	“	200, 150, 100	252	2	....
787	“	“	3:48 p.m.	57:00	154:59	30 ea.	100, 50	133	1	....
788	“	“	6:10 p.m.	56:51	154:50	“	40, 20	55	2	....
789	“	5–28	5:43 a.m.	56:45	154:43	“	25, 15	40	....	....
790	“	“	8:45 a.m.	56:38	155:09	“	40, 20	55	....	....
791	“	“	11:56 a.m.	56:32	155:34	“	50, 25	88	....	....
792	“	“	3:08 p.m.	56:26	155:59	“	150, 75	230	....	....
793	“	“	6:17 p.m.	56:21	156:25	“	200, 100	265	....	....
794	“	“	10:03 p.m.	56:15	156:50	“	50, 25	86	....	....
795	“	5–29	12:18 a.m.	“	157:08	“	100, 50	95	....	....
796	“	“	3:05 a.m.	“	157:28	“	100, 50	174	....	....
797	“	“	5:59 a.m.	“	157:45	“	75, 35	128	1	....
798	“	“	8:45 a.m.	“	158:04	“	100, 50	198	....	....
799	“	“	4:02 p.m.	56:22	158:00	“	75, 40	113	1	....
800	“	5–30	3:40 a.m.	56:24	157:33	“	50, 25	79	1	....
801	“	“	6:39 a.m.	56:26	157:05	“	100, 50	181	....	....
802	“	“	9:37 a.m.	56:28	156:38	“	60, 30	106	....	....
803	“	“	12:36 p.m.	56:41	156:25	“	150, 75	227	1	....
804	“	“	3:35 p.m.	56:55	156:11	“	150, 75	229	....	....
805	“	“	6:32 p.m.	57:08	155:58	“	60, 30	124	....	....
806	“	5–31	6:53 p.m.	57:21	155:45	“	150, 75	274	....	....
807	“	“	10:08 p.m.	57:35	155:32	“	75, 35	88	20	....
808	“	6–1	12:25 a.m.	57:26	155:24	“	150, 75	302	....	....
809	“	“	2:45 a.m.	57:18	155:15	“	150, 75	265	....	....
810	“	“	4:58 a.m.	57:09	155:06	“	150, 75	245	1	....
811	“	“	7:15 a.m.	57:00	154:59	“	125, 60	186	3	....
812	“	“	9:30 a.m.	56:51	154:50	“	50, 25	95	....	....
813	“	6–2	11:55 a.m.	“	154:14	30	18	27	....	....
814	“	“	8:55 p.m.	56:46	153:23	30 ea.	90, 45	113	1	....

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
815	1	6–2	11:47 p.m.	56:38	153:09	15 ea.	100, 50	155	....	....
816	"	6–3	2:36 a.m.	56:28	152:48	"	50, 25	77	....	....
817 A	"	"	5:57 a.m.	56:17	152:29	20 ea.	300, 200, 100	1372 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
818	"	6–8	12:55 a.m.	57:12	152:12	30 ea.	50, 25	97	....	....
819	"	"	4:05 a.m.	57:01	151:52	"	" "	86	....	....
820 A	"	"	7:31 a.m.	56:50	151:31	"	200, 100	1097	....	....
B	"	"	"	"	"	"	400, 300	"	....	....
821 A	"	"	11:10 a.m.	56:40	151:14	20 ea.	300, 200, 100	1372 n.b.	2	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
822 A	"	"	2:53 p.m.	56:29	151:32	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
823 A	"	"	6:40 p.m.	56:17	151:50	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
824 A	"	"	10:25 p.m.	56:06	152:09	"	300, 200, 100	"	2	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
825	"	6–10	5:11 a.m.	56:45	154:43	30 ea.	25, 15	36	....	....
826	"	"	8:05 a.m.	56:38	155:09	"	30, 15	46	....	....
827	"	"	10:58 a.m.	56:32	155:34	"	75, 35	84	....	....
828	"	"	1:54 p.m.	56:26	155:59	15 ea.	125, 60	252	....	....
829	"	"	4:21 p.m.	56:21	156:25	"	" "	238	1	....
830	"	6–11	4:35 a.m.	56:15	156:50	30 ea.	50, 25	91	....	....
831	"	6–12	4:54 a.m.	56:28	156:38	"	125, 60	182	....	....
832	"	"	8:09 a.m.	56:41	156:25	"	150, 75	205	....	....
833	"	"	11:22 a.m.	56:55	156:11	"	" "	"	....	....
834	"	"	2:36 p.m.	57:08	155:58	15 ea.	" "	245	....	....
835	"	"	5:25 p.m.	57:21	155:45	"	200, 100	287	1	....
836	"	"	8:04 p.m.	57:35	155:32	"	25, 15	40	....	....
837	"	6–13	1:20 p.m.	57:40	155:28	"	25, 12	49	....	....
838	"	"	4:10 p.m.	57:26	155:24	"	150, 75	227	....	....
839	"	"	6:21 p.m.	57:18	155:15	"	200, 100	241	....	....
840	"	"	8:26 p.m.	57:09	155:06	"	150, 75	208	....	....
841	"	"	10:31 p.m.	57:00	154:59	"	50, 25	88	....	....
842	"	6–14	12:28 a.m.	56:51	154:50	"	75, 35	110	....	....
843	Tr.	5–6	7:10 a.m.	57:44	155:34	30	18, 6		28	....
844	"	"	7:48 a.m.	"	"	"	15, 5			
845	"	"	8:33 a.m.	"	"	"	"			
846	"	"	9:22 a.m.	"	"	"	9, 5			
847	"	"	10:15 a.m.	"	"	20	......			
848	"	"	11:06 a.m.	"	"	30	22, 5			
849	"	"	12 noon	"	"	"	7			
850	"	"	12:46 p.m.	"	"	"	16, 13			
851	"	5–8	3:04 p.m.	56:53	154:15	"	27, 5		12	....
852	"	"	3:52 p.m.	"	"	"	"			
853	"	"	4:36 p.m.	"	"	"	22, 5			
853 A	B.S.	"	8:00 a.m.	"	"	....	......		1	....
854	Tr.	5–10	6:56 p.m.	57:44	155:34	15	16, 9		3	....
855	"	"	7:25 p.m.	"	"	"	15, 9			
856	"	"	7:51 p.m.	"	"	"	......			
856 A	......	"	....	56:53	154:15		Tide Pool		2	....
857	Tr.	5–12	9:25 a.m.	"	"	30	37, 9		9	....
858	"	"	10:11 a.m.	"	"	"	18, 5			
859	"	"	10:52 a.m.	"	"	15	13, 5			
860	"	"	11:30 a.m.	"	"	30	16, 4			
861	"	"	12:05 p.m.	"	"	"	15, 4			
862	"	"	12:46 p.m.	"	"	"	"			
863	"	"	1:35 p.m.	"	"	"	13, 4			
864	"	"	2:50 p.m.	"	"	15	"			
865	"	"	5:20 p.m.	"	"	30	13, 5			
866	"	5–26	5:30 a.m.	57:44	155:34	"	18, 11		1	....
867	"	5–31	7:01 a.m.	57:23	156:20	"	27, 5		14	....
868	"	"	8:18 a.m.	"	"	15	"			
869	"	"	8:40 a.m.	"	"	"	"			
870	"	"	9:01 a.m.	"	"	"	18, 4			
871	"	"	9:35 a.m.	"	"	"	5			
872	"	"	10:11 a.m.	"	"	"	"			
873	"	"	10:46 a.m.	"	"	"	"			
874	"	6–2	5:20 a.m.	56:53	154:15	30	18, 4		54	....
875	"	"	6:04 a.m.	"	"	"	"			
876	"	"	6:48 a.m.	"	"	"	"			
877	"	"	7:33 a.m.	"	"	"	22, 5			
878	"	"	8:11 a.m.	"	"	"	22, 7			
879	"	"	8:55 a.m.	"	"	"	15, 5			
880	"	"	9:38 a.m.	"	"	"	"			
881	"	"	10:27 a.m.	"	"	"	11, 4			
882	"	"	11:11 a.m.	"	"	"	9, 4			
883	"	6–9	12:15 p.m.	"	"	"	11		....	....
884	"	"	1:00 p.m.	"	"	"	22, 4		....	....

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
885	Tr.	6–9	1:50 p.m.	56:53	154:15	30	7, 2		....	....
886	"	"	2:35 p.m.	"	"	"	16, 7		....	....
887	"	"	3:20 p.m.	"	"	"	27, 7		....	....
888	"	"	4:09 p.m.	"	"	"	46, 15		....	....
889	"	"	4:55 p.m.	"	"	"	46, 5		....	....
890	"	"	5:40 p.m.	"	"	"	46, 15		....	....
891	"	6–13	4:59 a.m.	57:44	155:34	15	15, 7		6	....
892	"	"	5:20 a.m.	"	"	30	"			
893	"	"	6:02 a.m.	"	"	"	11, 5			
894	"	"	6:48 a.m.	"	"	"	5, 4			
895	"	"	7:35 a.m.	"	"	"	15, 4			
896	"	"	8:18 a.m.	"	"	"	9, 4			
897	"	"	9:01 a.m.	"	"	"	29, 7			
898	"	"	9:43 a.m.	"	"	"	27, 4			
899	"	"	10:30 a.m.	"	"	"	11, 5			
900	"	"	11:10 a.m.	"	"	"	15, 6			
901	"	"	12:03 p.m.	"	"	"	24, 4			
902	"	6–14	9:45 a.m.	56:53	154:15	"	11, 4		2	....
903	"	"	10:29 a.m.	"	"	"	7, 4			
904	"	"	11:08 a.m.	"	"	"	5, 1			
905	"	"	11:47 a.m.	"	"	"	5, 3			
906	"	"	12:43 p.m.	"	"	"	55			
907	"	"	1:58 p.m.	"	"	"	64			
908	"	"	2:50 p.m.	"	"	"	55			
909	"	"	3:45 p.m.	"	"	"	64, 18			
910	"	"	4:25 p.m.	"	"	"	11, 4			
911	"	6–15	5:34 a.m.	56:10	153:38	"	201, 155			
912	"	"	6:58 a.m.	"	"	"	" "			
913	"	"	7:51 a.m.	"	"	60	" "			
914	"	"	9:17 a.m.	"	"	"	" "			
915	"	"	11:06 a.m.	"	"	"	" "			
916	"	"	12:32 p.m.	"	"	"	" "			
917	"	6–17	9:58 a.m.	59:58	147:42	7	16		12	....
918	"	"	10:20 a.m.	"	"	30	4, 3			
919	"	"	11:17 a.m.	"	"	15	27, 4			
920	"	"	11:56 a.m.	"	"	20	11, 5			
921	"	"	12:59 p.m.	"	"	15	....			
922	"	"	1:23 p.m.	"	"	"	5, 4			
923	"	"	1:54 p.m.	"	"	"	11, 3			
924	"	"	2:26 p.m.	"	"	5	....			
925	"	"	2:45 p.m.	"	"	10	....			
926	"	"	3:16 p.m.	"	"	15	27, 4			
927	"	"	3:57 p.m.	"	"	"	11, 5			
928	"	"	4:26 p.m.	"	"	....	36, 18			
929	"	"	5:09 p.m.	"	"	15	7, 4			
930	"	"	5:46 p.m.	"	"	30	7, 4			
931	"	6–18	9:43 a.m.	60:18	147:01	15	4			
932	"	"	10:11 a.m.	"	"	"	49, 16			
933	"	"	10:42 a.m.	"	"	"	46			
934	"	"	11:12 a.m.	"	"	5	55, 7			
935	"	"	11:52 a.m.	"	"	15	46, 37			
936	"	"	12:24 p.m.	"	"	"	37, 3			
937	"	"	12:55 p.m.	"	"	"	46, 36			
938	"	"	1:31 p.m.	"	"	"	55, 46			
939	"	"	2:15 p.m.	"	"	60	73, 46			
940	"	6–21	11:12 a.m.	59:33	139:47	10	....			
941	"	"	11:27 a.m.	"	"	15	55			
942	"	"	11:55 a.m.	"	"	"	....			
943	"	"	12:30 p.m.	"	"	30	....			
944	"	"	1:14 p.m.	"	"	"				
945	"	"	2:02 p.m.	"	"	"	55, 27			
946	"	"	2:48 p.m.	"	"	"	64			
947	"	"	3:36 p.m.	"	"	20	55, 5			

Year 1933

1	2	3	4	5	6	7	8	9	10	11
948	1	1–7	10:38 p.m.	59:14	141:07	20 ea.	300, 200, 100	357	....	63
949 A	"	2–22	4:40 a.m.	56:49	151:14	"	300, 200, 100	1056 n.b.	1	2
B	"	"	"	"	"	"	600, 500, 400	"	1	1
C	"	"	"	"	"	"	900, 800, 700	"	2	....
950	"	2–11	3:38 p.m.	59:50	143:38	"	150, 100, 50	191	....	....
951 A	"	"	6:20 p.m.	59:40	143:42	"	130, 90, 50	250	....	....
B	"	"	"	"	"	"	250, 210, 170	"	....	....
952 A	"	"	9:42 p.m.	59:31	143:47	"	300, 200, 100	1188 n.b.	....	4
B	"	"	"	"	"	"	600, 500, 400	"	....	2
C	"	"	"	"	"	"	900, 800, 700	"	....	....
953 A	"	2–12	1:12 a.m.	59:21	143:51	"	300, 200, 100	1152 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
954 A	1	2–12	4:25 a.m.	59:11	143:56	20 ea.	300, 200, 100	1152 n.b.	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	1
955	“	“	6:00 p.m.	59:22	146:15	“	150, 100, 50	190	....	2
956 A	“	“	9:09 p.m.	59:12	146:20	“	300, 200, 100	1188 n.b.	....	3
B	“	“	“	“	“	“	600, 500, 400	“	1	....
C	“	“	“	“	“	“	900, 800, 700	“	2	....
957 A	“	2–13	12:26 a.m.	59:02	146:26	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
958 A	“	“	3:32 a.m.	58:52	146:32	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
959 A	“	“	6:33 a.m.	58:42	146:37	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
960 A	“	“	11:00 a.m.	58:31	147:08	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
961 A	“	“	2:12 p.m.	58:39	147:12	“	300, 200, 100	1060 n.b.	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
962 A	“	“	5:42 p.m.	58:49	147:14	“	300, 200, 100	1060 n.b.	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
963 A	“	“	9:08 p.m.	58:59	“	“	300, 200, 100	“	....	32
B	“	“	“	“	“	“	600, 500, 400	“	....	3
C	“	“	“	“	“	“	900, 800, 700	“	....	4
964 A	“	2–14	12:37 a.m.	59:09	“	“	300, 200, 100	“	....	1
B	“	“	“	“	“	“	600, 500, 400	“	5	4
C	“	“	“	“	“	“	900, 800, 700	“	....	5
965	“	“	3:42 a.m.	59:19	“	“	150, 100, 50	164	....	....
966	“	2–15	9:53 p.m.	59:16	149:41	“	75, 50, 25	127	....	....
967	“	2–16	2:35 a.m.	58:50	149:52	“	210, 140, 70	237	....	2
968	“	“	7:27 a.m.	58:23	150:05	“	120, 80, 40	160	....	....
969	“	“	11:58 a.m.	57:58	150:17	“	150, 100, 50	173	....	....
970	“	“	2:30 p.m.	57:50	150:04	“	180, 120, 60	209	....	....
971 A	“	“	5:02 p.m.	57:42	149:52	“	180, 120, 60	457	....	7
B	“	“	“	“	“	“	360, 300, 240	“	....	5
972 A	“	2–17	12:00 noon	57:48	149:32	“	300, 200, 100	no sound	....	3
B	“	“	“	“	“	“	600, 500, 400	“ “	5	3
C	“	“	“	“	“	“	900, 800, 700	“ “	....	3
973 A	“	“	4:14 p.m.	57:55	149:05	“	225, 150, 75	822	....	1
B	“	“	“	“	“	“	450, 375, 300	“	4	3
C	“	“	“	“	“	“	675, 600, 525	“	19	1
974 A	“	“	7:30 p.m.	58:00	148:42	“	255, 170, 85	868	....	18
B	“	“	“	“	“	“	510, 425, 340	“	2	1
C	“	“	“	“	“	“	765, 680, 595	“	1	3
975 A	“	“	10:46 p.m.	58:04	148:33	“	210, 140, 70	713	....	11
B	“	“	“	“	“	“	420, 350, 280	“	....	11
C	“	“	“	“	“	“	630, 560, 490	“	....	2
976 A	“	2–18	4:20 a.m.	58:07	148:20	“	300, 200, 100	1060 n.b.	....	....
B	“	“	6:16 a.m.	“	“	“	600, 500, 400	“	....	....
C	“	“	4:20 a.m.	“	“	“	900, 800, 700	“	....	....
977 A	“	“	12:00 noon	58:28	147:59	“	300, 200, 100	914 n.b.	....	....
B	“	“	“	“	“	“	600, 500, 400	“	1	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
978	“	“	3:55 p.m.	58:37	148:22	30 ea.	100, 50	133	....	....
979	“	“	7:02 p.m.	58:46	148:45	“	80, 40	119	....	....
980	“	2–20	11:55 a.m.	59:45	148:29	“	130, 65	179	....	....
981	“	“	2:25 p.m.	59:36	148:22	20 ea.	150, 100, 50	189	....	....
982	“	2–21	5:47 p.m.	57:20	152:10	60	50	abt. 70	....	....
983	“	“	9:52 p.m.	57:10	151:51	“	50	88	....	....
984	“	2–22	12:50 a.m.	57:00	151:32	“	60	81	....	....
985	Cl.	1–8	12:12 a.m.	59:14	141:07	“	250 Cl. fail.	357	....	....
986	“	“	1:40 a.m.	“	“	“	250 “ “	“	....	....
987	“	“	4:30 a.m.	“	“	“	200 “ “	“	....	....
988	“	“	11:45 a.m.	“	“	15	150 “ “	“	....	....
989	“	“	1:30 p.m.	“	“	60	100 “ “	“	....	....
990	“	“	10:15 p.m.	59:09	141:14	“	250 “ “	362	....	....
991	“	1–18	4:50 p.m.	58:59	141:22	“	900 “ “	1207	....	....
992	“	“	11:56 p.m.	“	“	“	800 “ “	1170	....	....
993	“	1–19	8:00 p.m.	“	“	“	700 “ “	1097	....	....
994	“	1–20	2:25 a.m.	“	“	“	700 “ “	1150 n.b.	....	....
995	“	“	8:27 p.m.	“	“	“	250 “ “	“	....	....
996	“	1–10	9:00 a.m.	58:55	141:27	“	1850 “ “	1371 n.b.	....	....
997	“	1–21	2:30 p.m.	“	“	“	1250 “ “	1190 n.b.	....	....
998 V	2	1–29	7:10 a.m.	59:14	141:07	Vert.	350 to surf.	357	....	....
999 V	“	“	8:15 a.m.	59:09	141:14	“	330 “ “	338	....	1
1000 A	1	1–8	8:07 a.m.	59:14	141:07	Quant.	250	357	....	2
B	“	“	10:20 a.m.	“	“	“	200	“	....	7
C	“	“	12:03 p.m.	“	“	“	150	“	....	7
D	“	“	3:02 p.m.	“	“	“	100	“	....	....
E	“	“	4:15 p.m.	“	“	“	50	“	....	....

[4] All hauls designated as “Quant.” were made with the horizontal closing apparatus and were one hour in duration.

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
1001 A	1	1–8	8:47 p.m.	59:09	141:14	Quant.[4]	300	362	....	4
B	"	"	11:38 p.m.	"	"	"	250	"	....	3
C	"	1–9	1:00 a.m.	"	"	"	200	"	....	2
D	"	"	2:19 a.m.	"	"	"	150	"	....	....
E	"	"	7:10 a.m.	"	"	"	100	"	....	....
F	"	"	8:26 a.m.	"	"	"	50	"	....	....
1002 A	"	"	10:49 a.m.	59:04	141:17	"	300	351	....	....
B	"	"	12:15 p.m.	"	"	"	250	"	....	1
C	"	"	1:55 p.m.	"	"	"	200	"	....	1
D	"	"	3:11 p.m.	"	"	"	150	"	....	1
E	"	"	4:28 p.m.	"	"	"	100	"	....	1
F	"	"	5:40 p.m.	"	"	"	50	"	....	....
1003 A	"	1–9	8:23 p.m.	58:59	141:22	"	1000	1097	....	....
B	"	1–10	5:50 a.m.	"	"	"	950	"	....	....
C	"	1–18	7:48 p.m.	"	"	"	900	"	....	....
D	"	"	9:57 p.m.	"	"	"	850	"	....	....
E	"	1–19	2:08 a.m.	"	"	"	800	"	....	....
F	"	"	4:20 a.m.	"	"	"	750	"	....	....
G	"	1–20	5:42 a.m.	"	"	"	700	"	....	1
H	"	"	7:34 a.m.	"	"	"	650	"	....	....
I	"	"	9:01 a.m.	"	"	"	600	"	....	....
J	"	"	11:17 a.m.	"	"	"	550	"	....	....
K	"	"	1:15 p.m.	"	"	"	500	"	....	....
L	"	"	2:47 p.m.	"	"	"	450	"	....	....
M	"	"	4:17 p.m.	"	"	"	400	"	....	....
N	"	"	5:39 p.m.	"	"	"	350	"	....	....
O	"	"	7:04 p.m.	"	"	"	300	"	....	....
P	"	"	9:50 p.m.	"	"	"	250	"	....	....
Q	"	"	11:10 p.m.	"	"	"	200	"	....	....
R	"	1–21	12:34 a.m.	"	"	"	150	"	....	....
S	"	"	1:51 a.m.	"	"	"	100	"	....	....
T	"	"	3:10 a.m.	"	"	"	50	"	....	....
1004 A	"	1–9	11:22 p.m.	58:55	141:27	"	1400	1371 n.b.	....	....
B	"	1–21	8:54 a.m.	"	"	"	1350	"	....	....
C	"	"	11:25 a.m.	"	"	"	1300	"	....	....
D	"	"	4:40 p.m.	"	"	"	1250	"	....	....
E	"	"	6:56 p.m.	"	"	"	1200	"	....	....
F	"	"	9:09 p.m.	"	"	"	1150	"	....	....
G	"	"	11:09 p.m.	"	"	"	1100	"	....	....
H	"	1–22	1:08 a.m.	"	"	"	1050	"	....	....
I	"	"	3:18 a.m.	"	"	"	1000	"	....	....
J	"	"	5:14 a.m.	"	"	"	950	"	....	....
K	"	"	7:12 a.m.	"	"	"	900	"	....	....
L	"	"	8:57 a.m.	"	"	"	850	"	....	....
M	"	"	10:52 a.m.	"	"	"	800	"	....	....
N	"	"	12:37 p.m.	"	"	"	750	"	....	....
O	"	"	2:25 p.m.	"	"	"	700	"	....	....
P	"	"	4:00 p.m.	"	"	"	650	"	....	....
Q	"	"	5:34 p.m.	"	"	"	600	"	....	....
R	"	"	7:08 p.m.	"	"	"	550	"	....	....
S	"	"	8:36 p.m.	"	"	"	500	"	....	....
T	"	"	10:02 p.m.	"	"	"	450	"	....	....
U	"	"	11:29 p.m.	"	"	"	400	"	....	....
VV	"	1–23	1:04 a.m.	"	"	"	350	"	....	....
W	"	1–30	1:55 p.m.	"	"	"	300	"	....	....
X	"	"	3:12 p.m.	"	"	"	250	"	....	....
Y	"	"	4:33 p.m.	"	"	"	200	"	....	....
Z	"	"	5:46 p.m.	"	"	"	150	"	....	....
AA	"	"	7:00 p.m.	"	"	"	100	"	....	....
BB	"	"	8:07 p.m.	"	"	"	50	"	....	....
V	"	"	9:16 p.m.	"	"	Vert.	1400 to surface	"	....	1

Year 1934

1005	1	1–1	2:34 p.m.	54:20	132:21	20 ea.	150, 100, 50	245	....	....
1006	"	"	6:01 p.m.	"	132:47	"	210, 150, 100	265	....	....
1007	"	1–2	9:38 a.m.	"	133:14	"	400, 250, 100	475	....	....
1008	"	1–4	1:46 a.m.	"	133:40	"	150, 100, 50	244	....	....
1009 A	"	"	5:02 a.m.	54:20	134:05	"	300, 200, 100	930	....	12
B	"	"	"	"	"	"	600, 500, 400	"	....	3
1010 A	"	"	9:15 a.m.	54:10	134:04	"	300, 200, 100	1400 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
1011	"	"	12:47 p.m.	"	133:39	"	180, 120, 60	238	....	1
1012	"	"	3:45 p.m.	"	133:15	"	240, 160, 80	446	....	....
1013	"	1–5	10:27 a.m.	54:00	133:19	"	75, 50, 25	82	....	....
1014 A	"	"	1:51 p.m.	"	133:44	"	300, 200, 100	738	....	24
B	"	"	"	"	"	"	600, 500, 400	"	....	3
1015	"	1–9	9:00 a.m.	53:50	133:15	"	60, 40, 20	73	....	....

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
1016 A	1	1–9	11:45 a.m.	53:50	133:34	20 ea.	300, 200, 100	800	....	4
B	“	“	“	“	“	“	600, 500, 400	“	....	....
1017 A	“	“	3:09 p.m.	“	133:55	“	300, 200, 100	1140	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
1018 A	“	“	6:50 p.m.	54:00	134:09	“	300, 200, 100	1500 n.b.	....	1
B	“	“	“	“	“	“	600, 500, 400	“	....	1
C	“	“	“	“	“	“	900, 800, 700	“	....	1
1019 A	“	“	11:49 p.m.	53:40	133:50	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
1020 A	“	1–10	3:15 a.m.	“	133:31	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	1
C	“	“	“	“	“	“	900, 800, 700	“	....	....
1021 A	“	“	6:41 a.m.	“	133:12	“	300, 200, 100	800	....	1
B	“	“	“	“	“	“	600, 500, 400	“	....	1
1022 A	“	“	9:55 a.m.	53:29	133:04	“	400, 200, 100	1100	....	8
B	“	“	“	“	“	“	800, 600, 500	“	....	6
1023 A	“	“	3:10 p.m.	53:08	132:41	“	300, 200, 100	1160	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	1
1024 A	“	“	9:20 p.m.	52:46	132:18	“	300, 200, 100	1500 n.b.	....	....
B	“	“	“	“	“	“	600, 500, 400	“	1	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
1025 A	“	1–11	3:20 a.m.	52:25	131:54	“	300, 200, 100	“	....	7
B	“	“	“	“	“	“	600, 500, 400	“	....	4
C	“	“	“	“	“	“	900, 800, 700	“	....	4
1026	“	1–17	10:35 a.m.	52:05	131:29	“	600, 400, 200	850	....	8
1027 A	“	“	1:28 p.m.	52:00	131:35	“	300, 200, 100	1500 n.b.	....	6
B	“	“	“	“	“	“	600, 500, 400	“	....	2
C	“	“	“	“	“	“	900, 800, 700	“	....	3
1028 A	“	“	6:00 p.m.	51:45	“	“	300, 200, 100	“	....	50
B	“	“	“	“	“	“	600, 500, 400	“	....	4
C	“	“	“	“	“	“	900, 800, 700	“	....	9
1029 A	“	“	10:55 p.m.	51:30	“	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
1030 A	“	1–18	5:05 a.m.	“	131:03	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
1031	“	1–19	9:10 a.m.	52:10	130:49	10 ea.	150, 100, 50	200	....	....
1032	“	“	11:10 a.m.	52:20	130:49	“	105, 70, 35	130	....	....
1033	“	“	1:02 p.m.	52:30	“	“	90, 60, 30	109	....	....
1034	“	“	2:55 p.m.	“	130:32	“	180, 120, 60	210	....	....
1035	“	“	4:51 p.m.	52:20	“	“	180, 120, 60	246	....	....
1036	“	“	6:55 p.m.	52:10	“	“	300, 200, 100	340	....	3
1037	“	“	9:12 p.m.	52:00	“	“	270, 180, 90	310	....	1
1038	“	“	11:32 p.m.	51:50	“	“	600, 400, 200	1030	....	....
1039	“	1–20	3:05 a.m.	51:40	130:05	“	180, 120, 60	240	....	1
1040	“	“	6:20 a.m.	52:00	“	“	105, 70, 35	150	....	....
1041	“	1–21	3:43 a.m.	52:38	“	“	210, 140, 70	260	....	....
1042	“	“	10:05 a.m.	52:59	“	“	180, 120, 60	220	....	....
1043	“	“	12:07 p.m.	53:06	130:15	“	150, 100, 50	200	....	....
1044	“	“	1:56 p.m.	53:12	130:21	“	120, 80, 40	164	....	....
1045	“	“	3:45 p.m.	53:20	130:36	15 ea.	100, 50	127	....	....
1046	“	“	5:34 p.m.	53:27	130:47	“	70, 35	91	....	....
1047	“	“	7:25 p.m.	53:34	130:57	30 ea.	35, 18	42	....	....
1048	“	1–22	7:50 a.m.	52:28	129:36	10 ea.	150, 100, 50	170	....	....
1049	“	“	11:17 a.m.	52:08	“	“	180, 120, 60	216	....	....
1050	“	“	2:26 p.m.	51:49	“	“	150, 100, 50	278	....	....
1051	“	“	5:34 p.m.	51:29	“	“	120, 80, 40	147	....	....
1052	“	“	8:42 p.m.	51:19	129:07	“	75, 50, 25	102	....	....
1053	“	“	10:49 p.m.	51:29	“	15 ea.	50, 25	60	....	....
1054	“	1–23	2:07 a.m.	“	128:41	“	35, 20	45	....	....
1055	“	“	5:50 a.m.	51:49	“	“	50, 25	64	....	....
1056	“	“	9:16 a.m.	“	129:07	“	50, 25	72	....	....
1057	“	“	1:35 p.m.	52:19	“	10 ea.	150, 100, 50	184	....	....
1058 A	“	2–6	9:00 p.m.	59:00	149:06	20 ea.	90, 60, 30	206	....	....
B	“	“	“	“	“	“	180, 150, 120	“	....	....
1059	“	2–9	12:18 p.m.	58:59	149:10	“	180, 120, 60	247	....	3
1060 V	“	“	1:50 p.m.	“	“		200 to surf.	“	....	....
A	Cl.	“	2:35 p.m.	“	“	60	200 net failed to close	“	....	2
1061	1	2–19	2:39 p.m.	59:08	148:57	20 ea.	135, 90, 45	152	....	....
1062 A	“	“	5:25 p.m.	58:59	148:51	“	120, 80, 40	260	....	....
B	“	“	“	“	“	“	240, 200, 160	“	....	....
1063	“	“	8:10 p.m.	58:48	148:44	“	180, 120, 60	226	....	2
1064	“	“	10:57 p.m.	58:38	148:39	“	100, 75, 50	116	....	....
1065	“	2–20	1:36 a.m.	58:30	148:34	“	105, 70, 35	120	....	....
1066	“	“	4:11 a.m.	58:20	148:29	“	120, 80, 40	132	....	....
1067	“	“	6:49 a.m.	58:10	148:24	“	210, 140, 70	232	....	5
1068	“	“	1:39 p.m.	58:28	148:21	“	240, 160, 80	260	....	1

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
1069	1	2–20	5:27 p.m.	58:38	148:15	20 ea.	180, 120, 60	220	....	5
1070	“	“	7:33 p.m.	“	“	60	50	201	....	....
1071 A	Cl.	“	9:50 p.m.	“	“	“	50	“	....	....
B	“	“	11:10 p.m.	“	“	“	100	“	....	....
C	“	2–21	1:51 a.m.	“	“	“	150	“	....	1
D	“	“	12:33 a.m.	“	“	“	150, failed to close	“	....	6
1072 A	1	“	9:47 a.m.	58:55	148:33	20 ea.	120, 80, 40	279	....	....
B	“	“	“	“	“	“	240, 200, 160	“	....	....
1073	“	“	3:51 p.m.	59:04	147:56	“	210, 140, 70	250	....	....
1074 A	“	“	9:43 p.m.	58:56	147:55	“	150, 100, 50	330	....	....
B	“	“	“	“	“	“	300, 250, 200	“	....	8
1075 A	“	2–22	1:20 a.m.	58:51	148:26	“	300, 200, 100	1500 n.b.	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
1076	“	“	5:30 p.m.	58:18	148:44	“	210, 140, 70	232	....	1
1077 A	“	“	8:25 p.m.	58:10	148:54	“	150, 100, 50	334	....	1
B	“	“	“	“	“	“	300, 250, 200	“	....	6
1078 A	Cl.	2–23	12:02 a.m.	“	“	60	50	190	....	....
B	“	“	4:12 a.m.	“	“	“	100	“	....	1
C	“	“	10:13 a.m.	“	“	“	150	“	....	1
D	“	“	11:33 a.m.	“	“	“	165	“	....	....
1079	1	“	8:55 a.m.	“	“	30	150	190	....	....
1080	“	“	8:02 p.m.	58:09	149:21	20 ea.	180, 120, 60	199	1	....
1081	“	2–24	1:01 a.m.	58:03	149:49	“	210, 140, 70	256	....	....
1082 A	Cl.	“	6:40 a.m.	“	“	60	50	“	1	....
B	“	“	8:22 a.m.	“	“	“	100	“	....	....
C	“	“	9:57 a.m.	“	“	“	150	“	....	....
D	“	“	11:28 a.m.	“	“	“	200	“	....	....
1083	1	“	2:40 p.m.	58:00	149:30	20 ea.	120, 80, 40	140	....	....
1084 A	“	“	5:40 p.m.	57:57	149:12	“	270, 180, 90	600	....	....
B	“	“	“	“	“	“	net lost	“	....	....
1085 A	“	“	9:30 p.m.	57:54	148:55	“	300, 200, 100	1200 n.b.	....	1
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	1
1086 A	“	2–25	1:50 a.m.	57:51	148:37	“	300, 200, 100	1500 n.b.	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
1087 A	“	“	5:02 a.m.	58:01	148:35	“	300, 200, 100	660	....	1
B	“	“	“	“	“	“	600, 500, 400	“	....	....
1088	“	“	8:12 a.m.	58:11	148:36	“	90, 60, 30	108	....	....
1089	“	“	10:54 a.m.	58:21	“	“	120, 80, 40	169	....	....
1090 A	“	2–28	10:10 p.m.	59:12	146:19	“	300, 200, 100	1200	....	....
B	“	“	“	“	“	“	600, 500, 400	“	1	....
C	“	“	“	“	“	“	900, 800, 700	“	1	....
1091 A	“	3–1	4:45 a.m.	59:22	145:31	“	300, 200, 100	1500 n.b.	....	....
B	“	“	“	“	“	“	600, 500, 400	“	15	....
C	“	“	“	“	“	“	900, 800, 700	“	5	....
1092	“	3–8	7:30 p.m.	54:20	132:21	“	280, 200, 100	306	....	....
1093	“	“	10:39 p.m.	“	132:48	“	390, 260, 130	420	....	....
1094 A	“	3–9	1:48 a.m.	54:19	133:13	30 ea.	215, 100	460	....	....
B	“	“	“	“	“	“	430, 315	“	....	....
1095	“	“	5:10 a.m.	54:20	133:40	20 ea.	180, 120, 60	210	....	....
1096 A	“	“	8:35 a.m.	“	134:06	“	300, 200, 100	1218	....	....
B	“	“	“	“	“	“	600, 500, 400	“	1	....
C	“	“	“	“	“	“	900, 800, 700	“	1	....
1097 A	“	“	12:34 p.m.	“	134:32	“	300, 200, 100	1300 n.b.	....	....
B	“	“	“	“	“	“	600, 500, 400	“	2	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
1098 A	“	“	4:27 p.m.	54:10	134:30	“	300, 200, 100	1500 n.b.	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
1099 A	“	“	8:25 p.m.	“	134:04	“	300, 200, 100	1300 n.b.	....	....
B	“	“	“	“	“	“	600, 500, 400	“	2	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
1100	“	“	11:52 p.m.	“	133:39	“	210, 140, 70	244	....	....
1101 A	“	3–10	3:07 a.m.	54:12	133:22	30 ea.	200, 100	450	....	....
B	“	“	“	“	“	“	400, 300	“	....	....
1102	“	“	6:06 a.m.	54:00	133:18	“	60, 30	90	....	....
1103 A	“	“	9:23 a.m.	54:00	133:44	20 ea.	300, 200, 100	950	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
1104 A	“	“	1:13 p.m.	“	134:08	“	300, 200, 100	1500 n.b.	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
1105 A	“	“	5:04 p.m.	“	134:35	“	300, 200, 100	1300 n.b.	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
1106 A	“	“	8:50 p.m.	53:50	134:20	“	300, 200, 100	1400 n.b.	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....
1107 A	“	3–11	12:40 a.m.	53:40	134:16	“	300, 200, 100	“	....	....
B	“	“	“	“	“	“	600, 500, 400	“	....	....
C	“	“	“	“	“	“	900, 800, 700	“	....	....

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
1108 A	1	3–11	4:46 a.m.	53:40	133:50	20 ea.	300, 200, 100	1500 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
1109 A	"	"	7:58 a.m.	53:50	133:54	"	300, 200, 100	1400 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
1110 A	"	"	11:37 a.m.	"	133:34	"	300, 200, 100	1500 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	1	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
1111	"	"	2:38 p.m.	"	133:15	30 ea.	90, 45	120	....	....
1112 A	"	3–12	11:30 a.m.	53:39	133:12	20 ea.	300, 200, 100	680	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
1113 A	"	"	3:03 p.m.	53:40	133:37	"	300, 200, 100	1300 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	2	....
C	"	"	"	"	"	"	900, 800, 700	"	1	....
1114	"	"	7:35 p.m.	53:29	133:03	"	210, 140, 70	216	....	....
1115 A	"	"	11:55 p.m.	53:09	132:50	"	300, 200, 100	1500 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	6	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
1116 A	"	3–13	4:39 a.m.	52:49	132:35	"	300, 200, 100	1300 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	1	....
1117 A	"	"	9:25 a.m.	52:28	132:22	"	300, 200, 100	1500 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	2	....
C	"	"	"	"	"	"	900, 800, 700	"	2	....
1118 A	"	"	2:02 p.m.	52:06	132:07	"	300, 200, 100	1300 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
1119 A	"	"	8:43 p.m.	51:45	131:54	"	300, 200, 100	1170 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
1120 A	"	3–14	12:41 a.m.	51:44	132:10	"	300, 200, 100	1400 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
1121 A	"	"	3:34 a.m.	51:38	132:08	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
1122 A	"	"	7:00 a.m.	51:37	131:51	"	300, 200, 100	1260 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
1123 A	"	"	10:25 a.m.	51:36	131:36	"	300, 200, 100	1300 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	1	1
1124	"	"	2:59 p.m.	51:53	131:12	"	340, 220, 100	370	....	....
1125 A	"	"	5:26 p.m.	52:00	131:22	"	270, 180, 90	580	....	....
B	"	"	"	"	"	"	540, 450, 360	"	3	....
1126 A	"	"	8:33 p.m.	"	131:36	"	300, 200, 100	1400 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
1127 A	"	3–15	12:34 a.m.	"	131:52	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	1	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
1128 A	"	"	7:30 a.m.	51:30	"	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
1129 A	"	"	11:24 a.m.	51:15	"	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
1130 A	"	"	2:36 p.m.	"	131:36	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
1131 A	"	"	6:37 p.m.	51:30	131:36	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
1132 A	"	"	10:55 p.m.	51:45	"	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
1133 A	"	3–16	3:30 a.m.	51:44	131:19	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
1134 A	"	"	8:20 a.m.	51:45	131:03	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	5	....
1135 A	"	"	11:44 a.m.	51:43	130:47	"	120, 80, 40	260	....	....
B	"	"	"	"	"	"	240, 200, 160	"	1	3
1136 A	"	"	8:42 p.m.	51:29	130:32	"	300, 200, 100	1400 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
1137 A	"	"	7:08 p.m.	51:30	130:47	"	300, 200, 100	"	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....

TABLE 16—(*Continued*)

1	2	3	4	5	6	7	8	9	10	11
1138 A	1	3–16	10:30 p.m.	51:30	131:08	20 ea.	300, 200, 100	1400 n.b.	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	net lost	"	....	....
1139	"	3–19	9:55 a.m.	52:10	130:48	"	180, 120, 60	206	....	....
1140	"	"	12:15 p.m.	52:00	130:48	"	240, 160, 80	270	....	....
1141	"	"	2:31 p.m.	51:51	130:47	"	240, 160, 80	"	....	1
1142 A	"	"	5:47 p.m.	51:40	130:38	"	300, 200, 100	1140	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
C	"	"	"	"	"	"	900, 800, 700	"	....	....
1143 A	"	"	9:30 p.m.	51:30	130:20	"	300, 200, 100	720	....	....
B	"	"	"	"	"	"	600, 500, 400	"	....	....
1144	"	3–20	12:46 a.m.	51:20	130:04	"	250, 170, 90	280	....	....
1145	"	"	4:42 a.m.	51:09	129:36	"	250, 170, 90	"	....	....
1146	"	"	7:47 a.m.	50:59	129:08	"	90, 60, 30	104	....	....
1147	"	"	11:31 a.m.	51:09	128:40	"	120, 80, 40	146	....	....
1148	"	"	3:08 p.m.	51:29	"	"	150, 100, 50	170	....	....
1149	"	"	6:48 p.m.	51:49	128:41	"	120, 80, 40	140	....	....
1150	"	"	9:15 p.m.	51:59	"	"	120, 80, 40	142	....	....
1151	"	"	11:47 p.m.	52:09	"	"	120, 80, 40	148	....	....
1152	"	3–21	3:31 a.m.	52:19	129:07	"	150, 100, 50	170	....	....
1153	"	"	5:56 a.m.	52:09	"	"	150, 100, 50	"	....	....
1154	"	"	8:21 a.m.	51:59	129:08	"	150, 100, 50	164	....	....
1155	"	"	10:42 a.m.	51:49	"	30 ea.	60, 30	70	....	....
1156	"	"	1:00 p.m.	51:35	"	60	50	60	....	....
1157	"	"	3:03 p.m.	51:29	"	30 ea.	80, 40	100	....	....
1158 A	"	"	5:30 p.m.	51:19	"	20 ea.	120, 80, 40	250	....	....
B	"	"	"	"	"	"	240, 200, 160	"	....	....
1159 A	"	"	7:58 p.m.	51:09	"	"	135, 90, 45	276	....	....
B	"	"	"	"	"	"	270, 225, 180	"	....	....
1160 A	"	3–22	12:12 a.m.	51:19	129:36	"	150, 100, 50	312	....	....
B	"	"	"	"	"	"	300, 250, 200	"	....	....
1161 A	"	"	3:25 a.m.	51:30	"	"	320, 210, 100	650	....	....
B	"	"	"	"	"	"	620, 510, 400	"	....	....
1162	"	"	6:51 a.m.	51:40	"	"	150, 100, 50	170	....	....
1163 A	"	"	9:27 a.m.	51:49	"	"	150, 100, 50	312	....	....
B	"	"	"	"	"	"	300, 250, 200	"	....	....
1164	"	"	12:21 p.m.	51:56	"	"	200, 140, 70	214	....	....
1165	"	"	3:02 p.m.	52:09	"	"	210, 140, 70	220	....	....
1166	"	"	5:22 p.m.	52:19	"	"	180, 120, 60	200	....	....
1167	"	"	7:50 a.m.	52:29	"	"	120, 80, 40	134	....	....
1168 A	"	"	11:17 p.m.	"	130:04	"	135, 100, 50	296	....	....
B	"	"	"	"	"	"	270, 235, 185	"	....	....
1169 A	"	3–23	1:56 a.m.	52:21	"	"	150, 100, 50	310	....	....
B	"	"	"	"	"	"	300, 250, 200	"	....	....
1170 A	"	"	4:45 a.m.	52:12	"	"	150, 100, 50	"	1	....
B	"	"	"	"	"	"	300, 250, 200	"	....	....
1171	"	"	7:12 a.m.	52:03	"	"	230, 140, 70	240	....	....
1172	"	"	9:30 a.m.	51:54	"	"	180, 120, 60	200	....	....
1173	"	"	12:00 noon	51:45	"	"	210, 140, 70	224	....	....
1174 A	"	"	4:30 p.m.	51:50	130:31	"	180, 120, 60	370	....	....
B	"	"	"	"	"	"	360, 300, 240	"	....	....
1175	"	"	7:15 p.m.	52:00	"	"	210, 140, 70	220	....	....
1176	"	"	9:45 p.m.	52:10	130:32	"	150, 100, 50	160	....	....
1177	"	3–24	12:11 a.m.	52:20	"	30 ea.	104, 52	114	....	....
1178	"	"	2:36 a.m.	52:21	130:47	60	90	100	....	....
1179	"	"	5:10 a.m.	52:30	"	30 ea.	90, 45	100	....	....
1180	"	"	7:39 a.m.	52:30	130:32	20 ea.	120, 80, 40	140	....	....
1181 A	"	"	11:14 a.m.	52:39	130:04	"	105, 70, 35	230	....	....
B	"	"	"	"	"	"	210, 175, 140	"	....	....
1182 A	"	"	1:20 p.m.	52:49	"	"	120, 80, 40	250	....	....
B	"	"	"	"	"	"	240, 200, 160	"	....	....
1183 A	"	"	4:00 p.m.	52:58	"	"	110, 75, 40	240	....	....
B	"	"	"	"	"	"	220, 185, 150	"	....	....
1184 A	"	"	6:42 p.m.	53:06	130:15	"	105, 70, 35	220	....	....
B	"	"	"	"	"	"	210, 175, 140	"	....	....
1185	"	"	9:05 p.m.	53:13	130:25	30 ea.	40, 20	48	....	....
1186	"	"	11:33 p.m.	53:23	130:40	20 ea.	120, 80, 40	124	....	....
1187	"	3–25	1:34 a.m.	53:29	130:48	30 ea.	90, 45	100	....	....
1188	"	"	4:05 a.m.	53:37	131:00	60	40	50	....	....
1189	"	"	7:10 a.m.	53:51	131:05	30 ea.	60, 30	64	....	....
1190	"	"	10:15 a.m.	54:05	131:11	60	28	30	....	....
1191	"	"	12:51 p.m.	54:20	131:35	20 ea.	160, 100, 50	178	....	....
1192	"	"	3:08 p.m.	54:13	131:49	"	140, 100, 50	144	....	....
1193	"	"	5:32 p.m.	54:10	132:08	30 ea.	70, 35	76	....	....
1194 A	"	"	9:18 p.m.	54:20	132:22	20 ea.	120, 80, 40	244	....	....
B	"	"	"	"	"	"	240, 200, 160	"	....	....

APPENDIX B.

DRIFT BOTTLE EXPERIMENTS

This report describes the results of drift bottle experiments made between 1930 and 1934 between the coast of Washington and the Alaska Peninsula by vessels chartered by the International Fisheries Commission primarily for marking halibut or for research on its eggs and larvæ. The bottles were prepared and thrown overboard by the various members of the staff who have taken part in these research cruises. Messrs. William C. Herrington, Ernest Pegler, Lawrence D. Townsend, Harry A. Dunlop, John Laurence Kask, Allan C. DeLacy, W. M. Chapman, and the junior author have been responsible at various times.

The experiments were primarily to throw light upon the drift of the pelagic eggs and larvæ of the halibut as it is affected by the surface currents. The eggs are spawned largely in January and February, and consequently the experiments between January and June are particularly pertinent. Those south of Dixon Entrance in March, 1932, and those north of Dixon Entrance in January and February of 1933 and 1934 and in May and June of 1930, were during this period of drift. Those of August, 1931, were not, but they aid in understanding the currents and their changes throughout the year.

The currents shown by these bottles are reviewed in the main text of the report (see p. 56), and it is unnecessary to do so here. The comments in the following pages will suffice for whatever additional discussion is needed.

In the experiments south of Dixon Entrance in 1931 and 1932, the bottles were liberated during a period of three days in each case. The course and time were determined in view of the special problem presented by the division of the onshore transpacific current. The experiments in the Gulf of Alaska were more scattered, and since the drift was in the one direction only, they are dealt with as a whole for each year, the lapse of time between the first and last bottles liberated being one month in 1930, two months in 1933, and one and one-half months in 1934.

The delay in return of the bottles was very considerable. Thus in the experiments of May to June, 1930, in the Gulf of Alaska, returns were received during some seven or eight months in considerable numbers, with straggling recoveries thereafter. This is not extraordinary in view of the character of the 1200 miles of coast from which the returns of that experiment came. But it does render somewhat difficult the interpretation of seasonal changes in currents.

That a high proportion of these returns had lodged on the beaches or in the bays and harbors to be recovered slowly by chance voyagers seems most likely in view of the seldom visited spots from which bottles came. But the delay in the first returns (often 60 days and up) argues a considerable lapse of time before such lodgment. Under such circumstances it is interesting to note that the currents are not reversed during this period of time in a degree sufficient to complicate the results. It seems to us, without precise grounds for such opinion, that it is advisable to use these results as indicative of the currents during the four months or less following each experiment.

The experiments in 1930, 1933, and 1934 were not as unified in plan as in 1931, 1932, and 1935. In the latter, bottles were distributed along the course of the ship between Dixon Entrance and the coast of Washington. In the former, the bottles were released at stations which were convenient for the work of the ship at the time. For that reason the stations for the years 1930, 1933, and 1934 are numbered up to 62, as shown in Tables 19, 25, and 27.

The bottles used in the experiments after the 1930 and 1931 cruises were 11-ounce jugs with glass handles on the necks. These were weighted with sand so that the buoyancy was barely sufficient to carry the drag and wire which were later attached. The interior of the bottle was coated with red lead paint at the bottom, which floated upward. Cards were enclosed for return, offering a reward of 25 cents. The jug was closed with a cork dipped in molten marine glue, and the mouth of the bottle was then dipped in this to complete the sealing. The wire and drag were of copper. The wire was 6 feet long when attached to the glass handle of the jug. The drag, of 27-gauge copper sheeting, was 5 inches square, cut and folded to expose flat surfaces in all possible directions.

The type of bottle used in 1930 and 1931 was a magnesium citrate bottle without handle but of the same size. A galvanized iron wire frame around the bottle was used to attach the drag. Due to probable loss by corrosion the use of two metals was later discontinued.

The data have been compiled with the aid of Miss Dorothy Myers, who carried on all correspondence in connection with the returns, answering the many inquiries from finders. Lawrence D. Townsend and Milner B. Schafer have assisted with the analysis.

I. EXPERIMENTS SOUTH OF DIXON ENTRANCE

Two experiments south of Dixon Entrance have been completed prior to this publication; one in early August of 1931 and one in the latter part of March, 1932. Another in December, 1934, has not, at time of writing, given any returns.

The three form a series four months apart covering the coast between Dixon Entrance and the State of Washington.

THE EXPERIMENT OF AUGUST, 1931

In this experiment the course of the ship is shown on the chart (Figure 18). The course, leaving North Island Light at the southern side of the mouth of Dixon Entrance, was SW. ½ S. (magnetic) for 120 miles, SE. x E. for a distance of 536 miles, then E. x N. 40 miles and NNE. 73 miles to a point near Destruction Island on the coast of Washington. Of the 1152 drift bottles released, 114 were returned, or 10 per cent. They were released at periods of 2 to 6 minutes along the course shown, as summarized in Table 21. (See also Table 23.)

The drift bottles of this experiment, July 30 to August 2, 1931, may be divided into two main divisions, those freed south and those freed north of 51° 30′ N. latitude, including in the southern division those bottles numbered from 940 to 1646, in the northern those from 523 to 939.

Considering the southern division, it will be noted (Figure 18) that many came back from Hecate Strait and the passages of Southeastern Alaska. Of this southern division not a single return has been made from the outer coast north of 51° 30′.

The returns of bottles in this division which were liberated north of 50° (between 50° and 51° 30′ N.) are principally from Hecate Strait and its continuation into Alaska, Clarence Strait, while those liberated south of 50° have been returned from the Washington and Oregon coasts with the exception of four found on Vancouver Island. Three of these had been found nearly true east of their points of liberation, one somewhat northeast. The returns from this division of the experiment, therefore, show a southerly current, with the possible exception of the inshore Vancouver Island coast.

The currents, therefore, seem to divide at 50° N., one branch going south and one into Hecate Strait. At 51° 30′ N., another division occurs between a northbound current and that into Hecate Strait. Presumably these three branches are divisions of the inshore current usually termed the Japanese or Kuroshio, if such continues from across the Pacific.

For study of the distribution of bottles carried by the most southern branch of the three, the experiment south of 50° N. is divided into four parts, as shown in Figure 18. Three of these are on the southeasterly course of the ship, the fourth on the final northeasterly and inshore leg. For each part there is shown in diagrammatic fashion the distribution of returns along the Oregon and Washington coasts. Disregarding time of recovery, it is apparent that distribution of returns from the first three parts is the same. The fourth is markedly different.

In Figure 71 the latitude of recovery is plotted against the time between liberation and return to show certain differences in distribution not brought out in Figure 18.

Those bottles carried by the southernmost of the three current branches and picked up on the coasts of Vancouver Island, Washington, and Oregon south of 51° N., were taken during two distinct periods. These are worthy of study because the beaches in question are frequently visited by many people, lending some significance to the dates of discovery and return of bottles found there. The experiment began about August 1, and 98 days later, on November 7, the first bottle card was returned from these beaches. From then until December 5 there were sixteen recoveries. There were no others until December 22, when a solitary card was returned. But beginning January 2 there were returns until the early part of April. The bottles were therefore found in two distinct periods, during November and during January to April.

How distinct these periods were for liberations recovered south of 51° N. can be seen by reference to Figure 71.

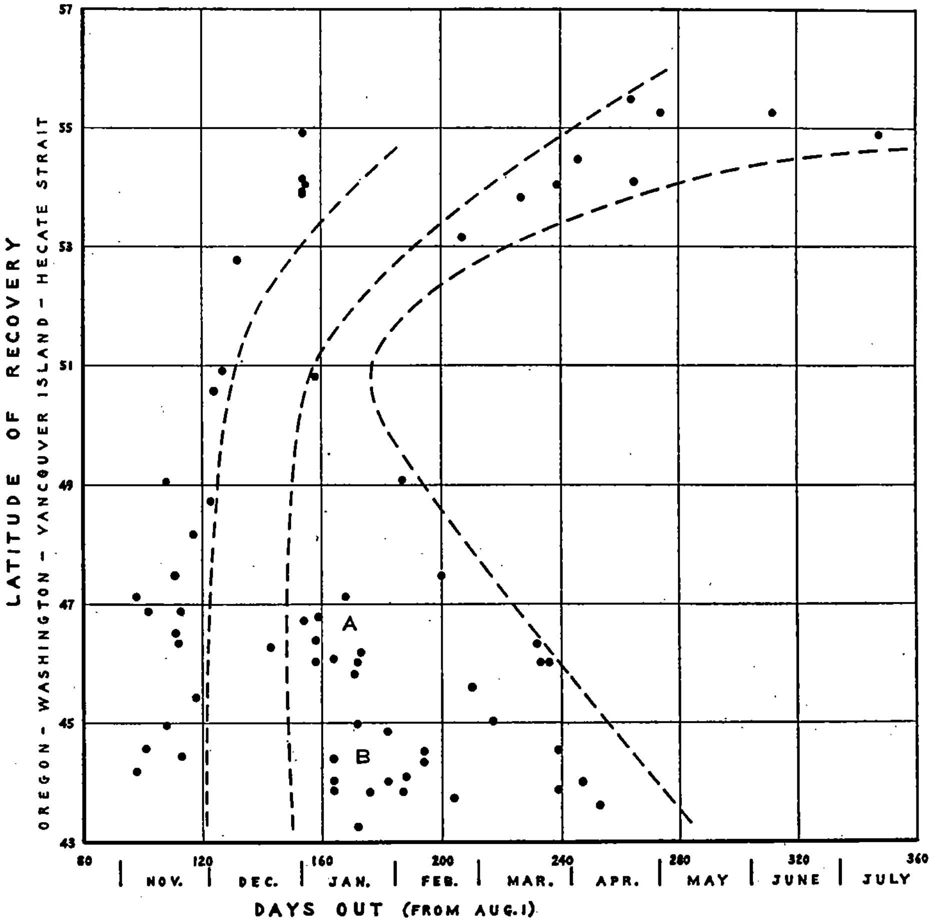

FIGURE 71.—The returns of drift bottles from the 1931 experiment plotted according to the latitude of recovery and number of days between release and recovery calculated from August 1.

From this figure it will also be seen that the returns prior to December 5 between 44° and 49° N. were well distributed along the coast, on the whole somewhat more northerly than those received later, which were largely between 43° N. and 47° N.

Immediately after January 2, a group (A in Figure 71) was returned from between 46° and 47° N., just north of the Columbia River, with a second (B) after January 9 from farther south between 43° and 45° N. It is apparent that distinct periods of inshore drift occurred prior and subsequent to December, possibly due to an interruption in the normal seasonal weather holding the bottles offshore during that month.

The time of return is also instructive. By referring to Figure 71, it will be seen that, considering the initial November group of returns in contrast to those of January to April, and Group A in contrast to B, each successive lot was predominantly from farther south. Moreover, the last return from each latitude of recovery was later the farther south. Therefore, not merely were the bottles recovered from more southerly latitudes than those of liberation, but the times of the recoveries indicate a southerly drift and final disappearance of bottles first from northern latitudes then from southern, at about 43° N.

The sparsity of returns from the west coast of Vancouver Island (Figure 71, 49° N. to 51° N.) is to be regretted as detracting from the clarity of the picture. So rugged and difficult a coast with but a scattering of inhabitants cannot be expected to yield many returns, as will be seen again when considering the west coast of the Queen Charlottes. There remains the natural doubt as to whether the currents set inshore there as they seemingly did elsewhere.

Williams (1927, p. 7) records an experiment on the west coast of Vancouver Island with 90 bottles freed and but 3 returns. One set free July 11, 25 miles off the coast of Vancouver Island near Barkley Sound, was retaken August 1, 6 miles south of Grays Harbor, Washington. The other two were retaken ashore near the point of release. As far as his results are concerned, they point to a southern current alongshore during the summer.

In the southern division of the experiment (bottles 940 to 1646) returns from north of 51° are all from interior waters. A few were retaken on the eastern side of Hecate Strait, but more were returned from its western side, on Graham Island near Rose Spit, the dividing line between Dixon Entrance and Hecate Strait. Some 8 bottles were thus retaken, numbered 954, 1013, 1017, 1026, 1038, 1065, 1120, and 1138, hence all liberated south of 51° 30′ N. latitude. On the other side of Rose Spit, in Dixon Entrance, 19 bottles were recovered, numbered from 523 to 886, hence all liberated north of 51° 30′ N. latitude. The majority of the latter group were returned about a hundred days prior to those from Hecate Strait after a short period of 60 days from their liberation. There is, therefore, no doubt as to the distinctness of the groups both as to time and location of release. The currents, therefore, had set north in Hecate Strait and east in Dixon Entrance during the course of the experiment to bring these bottles to opposite sides of Rose Spit, the dividing line between these two bodies of water. It is interesting in this connection to consider whether this long sandy spit does not owe its permanence to the meeting of the two currents, carrying sand along the two sides of Graham Island to their junction. (See Figure 18.)

A number of bottles were recovered in Clarence Strait, which is a northward continuation of the junction of Hecate Strait and Dixon Entrance. These bottles were numbered 576, 665, 696, 708, and 765 from north of 51° 30′ and 940, 958, 971, 1002, 1008, and 1023 from south of 51° 30′, hence mixed in origin. Two bottles, namely 691 and 995, were retaken at the junction of the three passages. Seven were returned within the year and six during the next year. The earliest arrivals prior to November 1, 576, 696, and 691, were apparently through Dixon Entrance and corresponded in time to the group taken in September at Rose Spit.

Since the returns from Clarence Strait are a mixture from the two divisions of the experiment and no mixture occurred either in Hecate Strait or Dixon Entrance, it is fair to assume that the currents in the latter two passages merged to flow northerly through Clarence Strait, and in all probability out through Sumner Strait, the only considerable avenue of escape.

Referring again to Figure 71, in which the latitudes of the recoveries are plotted against the days out, it will be seen that the division of returns (considering only those within one year) into two groups according to the time of arrival persists in latitude 53° to 55° 30′ N. Each group is, however, later in arrival than its fellow off the southern coast. The first group retaken in Hecate Strait (about latitude 54° N.) was recovered during the last of December (150 to 160 days out) hence nearly a month later than those of the same group retaken prior to December 1 from south of 49° N. The group retaken during January to April in the south corresponds to a group taken February or later (200 to 350 days out) in the northern part of Hecate and Clarence Straits. The figure indicates the delay in recovery as the bottles drifted north.

It remains to note that five bottles drifted completely out of the general area of the experiment. One, Number 1208, was retaken on Oceano Beach, February, 1932, 914 miles south of the point of liberation. Four were returned from the Hawaiian Islands, Numbers 1514, 1596, 1606, 1638, somewhat over a year later. These five had been liberated on the inshore leg of the ship's course. (See Figure 18.) But one other of the last three hundred bottles liberated there was retaken, Number 1631, near the Columbia River, six months later. It is plain that the southbound current swept these bottles southward and into the California Trades. thence to the Hawaiian Islands, prior to whatever change it was which brought the mass of November recoveries from the more northerly and offshore releases. It is another indication of variability in current or wind action, comparable to that causing the December lack of returns.

The whole group of bottles seems to have moved down the coast together until driven in. This is shown clearly in Figure 71 by the November recoveries between latitudes 44° and 49° or 51° N. Within this November group of recoveries (14 in number) there is little correlation between time out and distance. The majority were returned after an absence of 110 to 120 days but showed a variety of distances between 200 and 330 miles.

Nevertheless, some correlation was maintained between the latitudes of release and of recovery. For the 47 bottles released south of 50° N. and recovered on the Washington and Oregon coasts (between 43° and 48° N.), the correlation coefficient was $+.43 \pm .08$.

The rate of drift which can be calculated involves a delay in discovery of the bottles. This should be a minimum in the first recoveries. When the distances travelled are compared with the days out, the first recoveries along the Washington and Oregon coasts about 100 days after release showed seeming rates of drift varying between 1.75 and 3 miles per day. One bottle, out 109 days, had drifted 3.5 miles per day, another, out 174 days, had drifted .5 miles per day, and the mass of the recoveries were scattered between these extremes.

Due to the small number of returns with drags attached, it was not possible to study the effect of these drags upon the rate of drift. This is, however, attempted in the case of the March, 1932, experiment.

Perhaps something may be deduced from the dates of last recoveries, as the beaches were much frequented. The assumption may be made that the bottles at sea were swept southward and disappeared offshore in latitude 43°. The recovery in latitude 51° after 159 days, those in latitude 46° after 230 to 235 days and in latitude 43° to 44° after 247 to 253 days were the last in each latitude and might argue a southward disappearance in about 100 days at a distance of 480 miles, showing a movement of 4.8 miles per day. The calculation would be hardly worth mentioning did not the disposition of the recoveries shown in Figure 71, later than 150 days and south of 47° N., indicate that such recoveries were progressively later to the south.

In Hecate Strait the likelihood of prompt return is so slight as to lend little value to any calculations of rate of drift.

It remains to discuss the returns from the northernmost of the three "branches" of the onshore current. These were liberated north of 51° 30′ N. There were two distinct groups, those taken in Dixon Entrance, for the most part at Rose Spit, and those retaken on the outer coast line.

As shown in Figure 18, the bottles were distributed along a course at first southwesterly away from the coast, then southeasterly parallel to the coast. The bottles on the first leg of the course were numbered from 501 to 758, those on the second from 759 to 927 in latitude 51° 30′ and to 1652 in the whole experiment. Of the 27 recoveries in Dixon Entrance, 24 were from the first and but three were from the second, while of the 10 recoveries on the outside coast 7 were from the second. It is apparent that the bottles along the first course were carried directly inshore and into the nearby Dixon Entrance.

It is doubtful as to what happened to the bottles liberated along the second course of the ship, since this was along the difficult and deserted western coast of the Queen Charlotte Islands. A large proportion may have been carried inshore. Of the 27 returns (10.5 per cent) from the 257 bottles in the first course, but 3 were retaken outside, 1 after the lapse of a year. And of the 10 returns (6 per cent) from the 168 bottles in the second course, but 7 were retaken outside, 3 of them a year later. Where the returns are so small in number, the difference is not significant. The returns (10.5 per cent) from the first course of the ship are an even lesser percentage of the total there released than the returns (13 per cent) from the 123 released between 50° and 51° 30′ opposite the entrance to Hecate Strait. Hence, neither in the small percentage of returns from the outside coast nor in the percentage of total returns is there anything significant other than the effect of the uninhabited coast in preventing recovery.

Nineteen returns from these bottles were made from Rose Spit at the junction of Dixon Entrance with Hecate Strait, a period of 43 to 62 days after release. As this district has a number of inhabitants it would seem that some measure of the rate of drift in Dixon Entrance could be obtained. However, recoveries were closely grouped as to time, 8 being made by one person on a Sunday, and it is difficult to say whether the bottles had accumulated on the beach or had been swept in together. They indicate that the bottles liberated at the most distant points had travelled most rapidly. The highest rate shown was 3.5 miles per day.

Of the recoveries on the outer coast little can be said as to rate of travel. The highest was 4.3 miles per day, but there was no definite correlation between time free and distance travelled.

To show the general northward drift there are 13 recoveries, 10 on the outer coast, 3 in Dixon Entrance. But 2 of the 13, Numbers 582 and 918, were returned from beyond 58° N., the first after a year, the second after two years, hence are of doubtful significance. The northward movement along the outer coast shown by this August experiment was therefore not as pronounced as that for the 1932 experiments beginning in March.

Two of these bottles were returned from Chatham Strait after an absence of 89 and 163 days. They indicate a northward movement of water in this strait as in Hecate and Clarence Straits.

The 1931 experiment as a whole, made about August 1, and representing recoveries beginning during October and continuing during the winter, does not indicate rapid currents but does show a clear division of the onshore current into three main branches. One of these passes south, one into Hecate Strait, and one northward dividing to pass into Dixon Entrance and Chatham Strait.

THE EXPERIMENT OF MARCH, 1932

In 1932 bottles were distributed over nearly the same vessel course as in the 1931 experiment, but they were released between March 22 and 25, some 4 months earlier in the year than August 1, the date of the 1931 experiment. There were 1136 bottles liberated with 68 recoveries, or 6 per cent, whereas of the 1152 bottles in the 1931 experiment, 114, or 10 per cent, were returned. In 1932 the returns for the whole experiment were as sparse as from that section of the 1931 experiment between 51° 30′ N. and 53° 30′ N., from which but 6 per cent were recovered, whereas other sections showed as high a percentage as 13.

The returns were, however, in all but 4 cases (3 of which were not recovered until or subsequent to the following winter) from parts of the coast north of the position of release, whereas in the August, 1931, experiment recoveries were divisible into distinct sections, one which went north and one which went south. The returns in 1932 also were from points much farther north and west than in 1931. Whereas but 2 bottles were retaken (after 10 and 24 months, respectively) beyond Cape Spencer in 1931, 29 were thus retaken in 1932. Of these, 23 were out less than 10 months. The current shown by the March, 1932, experiment was, in fact, a well defined one, extending from Washington along the coast of Alaska to Kodiak Island. (See Figure 19, Tables 23 and 24.)

It is difficult to define the exact period during which this current must have prevailed. Although a few returns came in within 25 days, the majority of the more distant recoveries were returned between 125 and 175 days after liberation. The four months following March were evidently decisive in determining the distribution of returns.

In contrast to the experiment of 1931, no evidence of a southerly current off the Canadian or Washington coasts was obtained. The 3 bottles showing southerly drift (Numbers 1817, 1753, and 2403) were out long enough to have retraced their first northerly movement. An additional bottle, Number 1794, was returned from its latitude of release, from the entrance to the Strait of Juan de Fuca.

The returns from Hecate Strait again indicated a northerly current, but while in 1931 bottles liberated as far north as 51° 30′ were returned from that strait, in 1932 all recoveries there came from south of 51°, hence well south of the entrance to Hecate Strait, and indeed from as far south as the bottles were freed. The current evidently had set northward along the whole coast off which the bottles were distributed. No bottles originating north of 51° in 1932 were found in Hecate Strait, all of these having been carried along the outer coast to Alaska and the Gulf.

The evidence seems clear enough that the currents set northward through Hecate Strait. However, 3 bottles retaken on the mainland side just within its entrance (Numbers 1963, 1674, and 1779) were returned over a month later than the first of those at the northern end (Numbers 1657, 1661, and 1853). In view of the great delay in discovery of bottles on this rugged coast this cannot be regarded as of any significance.

Two returns only from Dixon Entrance are reported (Numbers 1880 and 1661) both from that section of the experiment south of 50°. As they were liberated well south of the entrance to Hecate Strait, they may have traversed the latter. There is, therefore, no positive evidence of an eastward current through Dixon Entrance, as in the case of the August, 1931, bottles. There is evidence to the contrary. As in 1931, numerous bottles were distributed close to the ocean end of Dixon Entrance along a course extending in a southwesterly direction. It is remarkable that none of these have been recovered from either Rose Spit, where so many of the 1931 bottles were found, or from any other part of Dixon Entrance and Clarence Strait.

The evidence of a northward current in the latter is equally lacking. The only bottles recovered in Clarence Strait were from the southern section of the experiment, 3 liberated off Vancouver Island having evidently passed north through Hecate Strait (Numbers 1879, 1891, and 1837). These were, however, retaken at the southern end of Clarence Strait and are not evidence of a northward current there.

As in 1931, the correlation between position of release along the course of the ship and the position of recovery along the coast line is very low. It is true that those released south of 51° N. were retaken for the most part either at the south end of, or in, Hecate Strait, or near its northern end. All recoveries but two of those released north of 51° were retaken well beyond the northern end of Hecate Strait. To the extent that Hecate Strait seemed to have caught the bottles drifting past its southern entrance there is a correlation.

But if the northern part of the experiment, free from this influence, is regarded as a unit, those released north of 50° 30′, which were recovered north

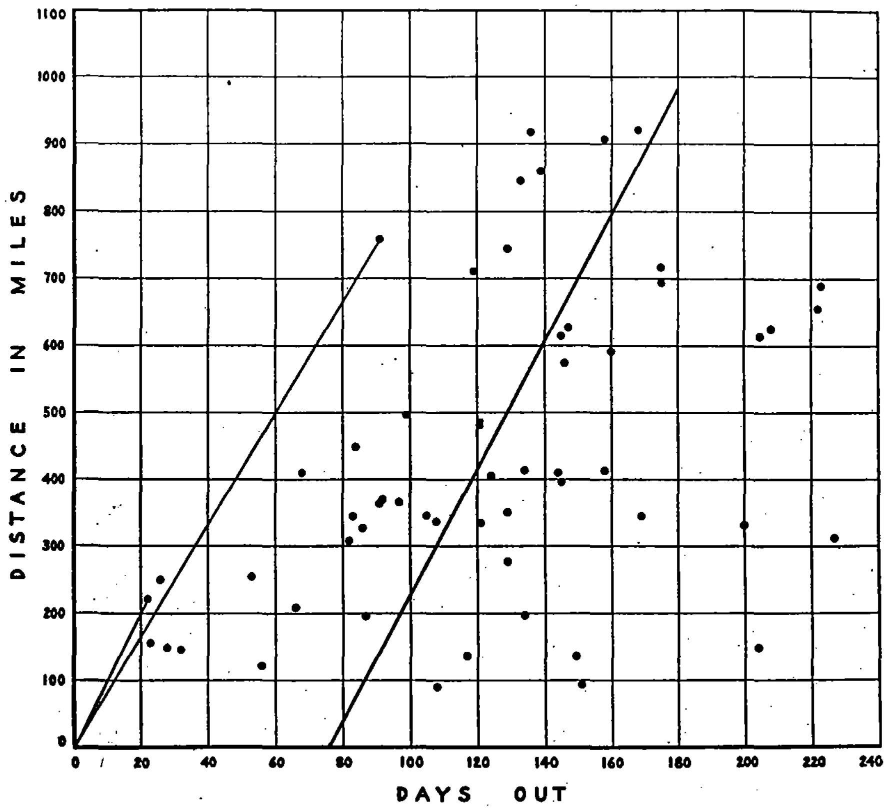

FIGURE 72.—Recoveries from the 1932 drift bottle experiment plotted according to distance travelled and number of days between release and recovery.

of 57°, showed practically no significant correlation between positions of release and recovery, r being $+.11\pm.105$. The bottles drifting northward and around the Gulf as far as Kodiak Island were driven ashore at all points en route, and there is no reason to doubt that all these bottles traversed the same course.

The correlation between time out and distance travelled is high. If the distance is plotted against the days out, Figure 72 results. From this it should be possible to derive some concept of the rapidity of movement. The first recoveries at any given distance should show the minimum delay in their discovery after reaching the beach. If the delay in discovery were approximately the same in each district of the coast, then the average time of discovery in each such district should be roughly the same time later than the first arrivals. Thus in Figure 72 the slope of the lines joining the first arrivals is roughly that of the line joining the average times out for the various distances. The line as shown in Figure 72 is that determined by the regression of days out on distance travelled. It was thought preferable to use the data excluding recoveries in Hecate Strait.

The rate of travel should hence be about 9.4 miles per day (regression line). This is a much more rapid drift than anything which was found in the August, 1931, experiment.

It may be noted that again the recoveries on the rugged western coasts of the Queen Charlotte Islands and of Vancouver Island are nearly lacking. There is no reason to doubt but that many bottles were washed on the beaches of these islands and never discovered.

The experiment of 1932 was carried on with bottles of an improved pattern, the drag and wire being of the same metal, copper, and fastened to a glass handle on the neck of the bottle. Whereas in 1931 but a small proportion of the bottles was returned with drags still attached, in 1932 a very considerable number was, 26 out of 68, or 38 per cent. In 1931 the majority of such returns, 14 per cent of the total, was received in about 60 days after release, and mainly from one locality, Rose Spit, where the recoveries were early. Corrosion, aided by electrolytic action between the galvanized wire and copper of the 1931 bottles, evidently led to the early loss of the drags. The 1932 experiment therefore gives a more favorable basis for study of the effect of the drag.

The distribution of returns is the same in all essential respects. The percentage returned from inside waters was the same as that from the outer. The bottles which lost their drags before recovery were carried somewhat farther, to Kodiak Island rather than Prince William Sound the farthest point reached by bottles with drags. The difference does not change the evidence of a continuous northerly coastwise current, with the southern end diverted into Hecate Strait.

The correlation between distance traversed and the time of freedom is, however, very much closer in the case of bottles recovered with drags. For the whole March, 1932, experiment $r=+.66\pm.08$ for these bottles, while for those which had lost the drag $r=+.35\pm.11$. The difference is particularly striking within the first 125 days. The precise significance of this is difficult to determine. Those which lost their drags show a much greater range of distances travelled in each given length of time as though some were carried faster and farther while others were washed ashore during the early stages of their travel.

The recoveries were on the whole earlier in the case of the bottles which had their drags when recovered, perhaps because bottles were continually losing their drags, and if at sea long enough the drags were almost certain to be dropped. Of bottles without drags, 24 per cent were recovered within 100 days and 63 per cent within 200 days. Of those with drags, 35 per cent were recovered within 100 days and 90 per cent within 200 days.

Due to the fact that the bottles which had lost their drags showed a great range of apparent speeds of travel, the apparent time required to travel 800 miles was about 150 days, whereas those bottles which had travelled less than 100 miles averaged 100 days. If the difference of 50 days accounted for a distance of 700 miles traversed, the rate of travel would be about 14 miles per day (15.4 to be exact). The same reasoning applied to the bottles with drags indicated a speed of 5.5 miles per day. In both cases not the actual averages, but the regression lines of average distance per unit of time, were used. The contrast illustrates forcibly the unreliability of any calculation from these bottles of the speed of currents.

Probably the maximum speeds only are of any significance in each case. For distances of 200 to 250 miles, this would be about 10 miles per day in both cases; for distances in excess of 700, this would be 6 miles per day in the case of bottles with drags and 8 miles without. Bottles 1717, with drag, and 1712, without, showed rates of travel of 9.5 and 10 miles per day, respectively, and were recovered 249 and 220 miles from the point of liberation, respectively. Bottle 2027, with a drag, was recovered 846 miles distant and showed 6.4 miles per day, while 2219, without, was recovered 758 miles distant, and had travelled 8.3 miles per day.

II. EXPERIMENTS IN THE GULF OF ALASKA NORTH AND WEST OF DIXON ENTRANCE

Both the August, 1931, and March, 1932, experiments south of Dixon Entrance proved the existence of a current passing northwest along the shores of the Gulf of Alaska. The 1931 experiment for the fall months had not extended beyond Cape Spencer (58° N.), but the current was very decisively indicated during the spring and early summer months of 1932.

THE EXPERIMENT OF MAY TO JUNE, 1930

In the Gulf itself this current had already been studied by the experiments of May 19 to June 23 of 1930. At each of 20 stations across the Gulf from Cape Ommaney to Cape Chiniak, and thence to Unimak Island, as shown in Figure 20, 25 bottles were liberated. Of the 500, about 10 per cent, or 49, were recovered. This high percentage was at the time a considerable surprise in view of the sparse population along this rugged coast. The recoveries began within 20 days of release (for example, west of Kodiak Island), and the bulk of returns was distributed over the following 7 months. (See Tables 19 and 20.)

Movement shown was westward in all but two of the 49 returns. One, Number 492, freed near Dixon Entrance, was retaken slightly southerly, near Cape Knox at the north end of the Queen Charlotte Islands. This bottle, liberated June 23 and recovered August 19, may indicate a beginning of the eastward current toward and into Dixon Entrance prior to August when it is well marked. (See p. 165.) Another, Number 250, freed in longitude 148° 36′ W., latitude 57° 15′ N., was returned from Cape St. Elias, 144° W. and 60° N., directly across the general westward drift of the majority of bottles. The latter return is to be explained only by the existence of a secondary eddy in the Gulf.

In Figure 20, the westward drift of the majority of bottles is clearly shown. Those from certain release stations show peculiarities of distribution which are worthy of discussion, as indicating (1) the above mentioned eddy in the middle of the Gulf of Alaska, (2) a current around the southwestern end of Kodiak Island and northward through Shelikof Strait, and (3) passage of water through Unimak Pass into Bering Sea.

From the 25 bottles liberated at the westernmost (Figure 20) station, Number 16, all four returns were from Bering Sea, the probable route having been through Unimak Pass and toward Bristol Bay.

The 75 bottles freed at stations 13, 14, and 15, west of Kodiak Island, yielded 14 returns. In common with those of station 16, the returns were 18 per cent, extraordinarily high for this type of coast, probably due to the frequency with which the beaches there are searched by the natives during the summer months. All were returned from less than 150 miles, except 2 of those which reached Bering Sea. As a rule, the time out was short, 5 being returned in 18 days or less, 10 in less than 100 days, and the longest in 256. The recoveries were for the most part from near the station of release.

Of the 25 from station 12 at the eastern end of Kodiak Island, 8 were returned (Table 17). The localities of recovery were from the coast 29 miles distant, westward along the southern side of Kodiak Island, at the nearby Trinity Islands, and thence northward in Shelikof Strait. None of them continued westward beyond the Trinity Islands. The average drift per day, greatest in the bottles which had lost their drags, was between .7 and 1.7 miles per day. The distance traversed shows in both cases a correlation with time out. From stations 17 and 11 there were no recoveries.

TABLE 17.

Recovered with Drag			Recovered without Drag		
Days	Miles	Average per Day	Days	Miles	Average per Day
59	79	1.3	43	29	.7
147	95	.7	72	122	1.7
173	104	.6	117	152	1.3
203	120	.6	229	243	1.1

From station 10, May 21, there are two returns, one (Number 247) out 3½ years, was retaken nearby, 152 miles distant, on Kodiak Island. The other (Number 250) was retaken at Cape St. Elias in a very different direction after 238 days. Our interpretation of these is that both were carried eastward through the returning arm of a great eddy in the Gulf of Alaska, one to be dropped at Cape St. Elias after a drift of 238 days, the other to continue for an indefinite time, perhaps lying on the beach for a large part of the 3 years which elapsed.

But a month later, June 21, at station 18, which was near station 10, the currents seemed to have approximated those of station 12. The three returns from station 18 were from the same regions of Kodiak Island and Shelikof Strait as those of station 12. The delay in recovery might have allowed time for passage through the eddy already mentioned, and we have so shown in Figure 20. Stations 10 and 18 are therefore seemingly situated on the border between the westward current and the gulf eddy, with the returns from 18 at least subject to doubtful interpretation.

From the stations 3 to 8, which stretch across the Gulf to Cape Spencer, 150 releases gave 11 returns, mainly from Cook Inlet. ~~The fact that one pre~~viously mentioned (Number 250 from station 10) and 7 from stations 3 to 8

(Numbers 143, 166, 183, 193, 102, 67, and 117) were returned from localities across the westward stream gives grounds for concluding that an eddy exists. Further evidence is found in the fact that the seeming rate of travel of bottles from the more western of these several stations is much less than that of bottles from the more eastern, as though the more western had been credited with much less distance than they had actually traversed. Arranging the recoveries from Cook Inlet and station 10 according to the calculated rates of travel, using the most direct (not the supposed) distance between release and recovery, Table 18 is obtained. Note the inverse correlation between days out and apparent distance travelled, resulting in the variable rates of travel.

From stations 1 and 2, recoveries were at the eastern end of Kodiak Island and Shelikof Strait and one from Cape St. Elias. No conclusions as to the eddy mentioned can be drawn from this simple western movement.

TABLE 18.

Bottle Number	Station Number	Rate of Travel	Days Out	Distance
67	3	5.3	82	434
102	5	3.3	118	387
143	6	2.4	148	362
173	7	2.4	128	301
166	7	1.8	180	318
117	5	1.3	251	323
183	8	.7	419	287
250	10	.9	238	222
247	10	.1	1422	152

Station 20, off the mouth of Dixon Entrance, gave returns characteristic of the experiments off the Queen Charlotte Islands in 1931 and 1932, two bottles being recovered on the outer coast of Southeastern Alaska and one from the Trinity Islands (150° W.).

The evidence from this experiment therefore indicates a summer current along the coast, continuing that which passes along the Queen Charlotte Islands around the Gulf and the southern side of the Alaska Peninsula. There is evidence of an eddy in the center of the Gulf, a current flowing north through Shelikof Strait and one entering Bering Sea.

The difference in behavior of the bottles that had lost and had not lost their drags again arises. As would be expected the returns which had been out a short time had not lost their drags, so that inshore stations with quick recoveries showed drags still attached, while those which had been out a long time to cover a long distance between station and coast had lost the drags. This produced a difference according to station, and no comparison of value can be made except where a single station is considered, as station 12 (Table 17). There the bottles which had lost their drags travelled faster, but the conclusions as to direction of currents, etc., deduced from the two categories did not differ. This agrees with the result of the comparison in the 1932 experiment (p. 171).

The greatest rate of travel was shown by bottles 332 and 67. The first was recovered in 19 days after travelling 100 miles, about 5.3 miles per day, between station 14 and the Shumagin Islands. Bottle 67 travelled 434 miles in 82 days, between station 3 and Cook Inlet, an average of 5.3 miles per day. Both retained their drags. Since it is plain that the probable great delay in discovery after reaching the beach renders only the earliest returns of significance from the standpoint of time, these rates of travel are, in all likelihood, the most acceptable of any which can be derived.

THE EXPERIMENTS OF JANUARY AND FEBRUARY, 1933 AND 1934

The experiments of 1933 and 1934 may be considered together. Those of 1933 covered the period from January 3 to March 7, those of 1934 from January 9 to February 25. Both were in the waters of the Gulf of Alaska, except for one division from which 120 bottles were liberated in January, 1934, off Cape St. James and off Cape Knox. There were 887 bottles in the experiment of 1933, 359 in that of 1934. (See Figure 21 and Tables 25, 26, 27 and 28.)

The preceding experiment in those waters was that of 1930, in May and June; hence about six months later in the year. Nevertheless, the recoveries indicate the same currents, although not as clearly in some cases. All recoveries were from points more northerly or westerly than the point of liberation. A current into Chatham Strait, northwesterly along the eastern shore of the Gulf, an eddy in the Gulf, a return current around the southern end of Kodiak Island and up Shelikof Strait, a continued southwesterly current along the Alaska Peninsula, and a branch through Unimak Pass into Bering Sea, are indicated, as in 1930.

Up to January, 1935, there have been but 24 recoveries, or 2.7 per cent from the 1933 releases and 2.2 per cent from those of 1934. As before, the recoveries of bottles with drags were greatest early in the season, the drags apparently being lost as the season progressed despite the improvements in design. Eleven out of 17 retaken within 200 days had drags, 12 out of 15 retaken later than 200 days did not have drags. No difference in the currents indicated was found, although, as might be expected, the bottles which had been out longest and were without drags had travelled farthest.

Of 72 bottles freed off Cape St. James, in 1934, none have been returned. The same may be said of 24 freed off Lincoln Rock, Clarence Strait.

Of 48 bottles freed off Cape Knox (latitude 54° N.) in 1934, two have been returned, one from Icy Strait, and one from the junction of Chatham Strait and Icy Strait. None were retaken in Dixon Entrance, past which these bottles must have drifted. This is the same result as that in the March, 1932, experiment and contrasts with that of the August, 1931, experiment when many were recovered in Dixon Entrance. Presumably the bottles were carried northerly and into Chatham Strait, thence to Icy Strait.

Off Cape Spencer, but on the northern side of the entrance to Icy Strait, 143 bottles were freed March 7, 1933. None were retaken in Icy Strait. Four were returned from the coast immediately northwest, four from Prince William Sound, one from Cook Inlet, and one from the coast between Kodiak Island and the Shumagin Islands. This distribution follows the previously determined course of the current westward along the shores of the Gulf of Alaska.

In contrast to these results, 120 bottles (Numbers 3797 to 3916), which were freed January 29, 1934, from 10 to 15 miles offshore along the coast between Cape Spencer and Yakutat, in waters which must have been traversed by the bottles mentioned above, showed no recoveries from the Gulf of Alaska, although three were recovered from midway in Shelikof Strait inside Kodiak Island. And again, 312 bottles (Numbers 2813 to 3124) freed in January, 1933, about 60 miles off Yakutat, gave but four returns, all from the coast west of Kodiak Island (two of these from the same bay), whereas the bottles freed off Cape Spencer were with one exception returned from east of that island.

It seems fair to conclude from these experiments that the currents are not regular and constant, although they are in the main westerly.

The experiments in 1930 gave interesting results for the western side of the Gulf, along a course easterly from Afognak Island (east end of Kodiak) (stations 8, 9, 10, 11, 12, 17, and 18 of 1930), indicating the presence of a minor eddy within the great gulf eddy. This was necessary to explain the bottles from the above stations at points such as Cape St. Elias, Cook Inlet, etc., seemingly across the prevailing drift westward.

The same type of distribution is visible in the returns of 1933 and 1934. Of the 12 from this line of stations (Numbers 25, 27 to 41, 59, and 62), all except two were found southwesterly along the peninsula as would be expected from a current along those coasts. The two exceptions, Numbers 3371 and 3484, were freed at stations 25 and 39, respectively, two of the stations most distant from the coast. They were returned from almost directly across the course of a westward current. This is in accord with the returns in 1930, and is explainable only by supposing an eastward and northward flowing eddy in the center of the Gulf, which later joins the westward current.

The returns may be taken to indicate a current northerly into Shelikof Strait around the western end of Kodiak Island, since they conform to the findings in 1930. Numbers 3945, 3826, 3802, and 3806 were retaken there. Yet there is no certain proof that they did not enter the northern end of the strait, their distribution not being continuous around the southern end of Kodiak Island.

Three bottles were returned from Unimak Island (one of the Aleutians) and one from the Pribilof Islands in Bering Sea. These recoveries would indicate a flow westward along the Aleutians and into Bering Sea.

The greatest rate of travel in 1933 (see Table 26) was 4.3 miles per day for bottle 3571, which was released off Cape Spencer, March 7, and recovered near Mitrofania Island (158° 39′ W.). Others of the same group of releases which travelled across the Gulf as far as Prince William Sound showed nearly as high a rate of travel (Numbers 3544 to 3629), about 3 miles per day and up.

Those bottles released off Yakutat (Numbers 2987 to 3109) travelled between 1.0 and 1.5 miles per day. Others released near Kodiak Island were long en route for a short drift, the rate of travel of those recovered along its southern coast being from .2 to .5 miles per day. The same was true of releases near Cape Spencer which were retaken along the sparsely inhabited coast to the immediate north. In such cases the usual delay in recovery, exaggerated by the character of the coast, was undoubtedly disproportionate to the actual time en route.

The bottles released in the 1934 experiment showed a uniformly high rate of travel (see Table 28). Number 3945, released in the western side of the Gulf, 148° 29′ W., travelled 350 miles in 39 days, or 9 miles per day. Number 3806, released January 29 on the eastern side of the Gulf a short distance from where Number 3571 was released in 1933, travelled 690 miles in 78 days, or 8.8 miles per day, to be recovered in Shelikof Strait. This rate was about double that of Number 3571.

TABLE 19.—*Drift Bottle Releases, 1930 Experiment.*

Bottle Numbers	Release Date	Station Number	Location of Release	
			North Latitude	West Longitude
1-25	5-19-30	1	56:17	136:09
26-50	"	2	56:24	137:30
51-75	"	3	56:31	138:51
76-100	"	4	56:38	140:15
101-125	"	5	56:44	141:43
126-150	5-20-30	6	56:50	143:06
151-174, 180	"	7	56:57	144:28
175-179, 181-200	"	8	57:03	145:51
201-225	"	9	57:09	147:14
226-250	5-21-30	10	57:15	148:36
251-275	"	11	57:22	149:59
276-300	"	12	57:29	151:22
301-325	5-22-30	13	56:33	156:51
326-350	"	14	56:02	157:56
351-375	5-23-30	15	55:21	159:51
376-400	5-24-30	16	54:30	163:08
401-425	6-20-30	17	57:26	150:33
426-450	6-21-30	18	57:02	148:04
451-475	6-23-30	19	55:04	136:20
476-500	"	20	54:47	134:43

TABLE 20.—*Drift Bottle Recoveries, 1930 Experiment.*

Bottle Numbers	Recovery Date	Location of Recovery		Days Out	Distance Travelled	Bottles Recovered with Drag Attached
		North Latitude	West Longitude			
1	12-31-30	56:54	154:19	226	615	
3	2-14-31	57:39	155:40	271	697	*
47	10-25-30	60:00	144:15	159	304	
67	8- 9-30	59:08	151:31	82	434	*
102	9-14-30	59:37	151:26	118	387	
117	1-25-31	59:12	150:59	251	323	
118	4-28-32	54:54	164:15	710	880	
140	1-20-31	54:29	164:20	245	730	
143	10-15-30	60:01	151:43	148	362	
161	11-16-30	....	....	180	......	
166	11-16-30	59:55	151:45	180	318	
170	12-15-32	55:50	155:45	940	375	
173	9-25-30	59:39	151:41	128	301	
183	7-13-31	59:53	151:48	419	287	*
247	4-12-34	57:04	153:20	1422	152	
250	1-14-31	59:59	143:54	238	222	
280	7- 3-30	57:22	152:16	43	29	
281	7-19-30	56:54	153:35	59	79	*
290	9-15-30	57:22	154:43	117	152	
291	10-15-30	56:44	154:03	147	95	*
292	12-10-30	56:28	154:35	203	120	*
295	8- 1-32	56:59	154:29	72	122	
296	1- 5-31	58:36	153:47	229	243	
300	11-10-30	56:34	154:04	173	104	*
301	6- 9-30	56:14	158:17	18	52	*
302	6- 9-30	56:14	158:17	18	52	*
313	7-12-30	56:31	158:09	51	42	
317	10-10-30	56:28	158:09	141	46	
318	6- 9-30	56:14	158:17	18	52	*
319	6- 9-30	56:14	158:17	18	52	*
325	10-17-30	55:39	160:19	148	136	*
330	8-23-30	55:59	158:44	93	77	*
332	6-10-30	55:11	160:28	19	100	*
335	6-14-30	55:12	160:30	23	100	*
338	9-15-30	55:30	161:35	116	140	*
342	7-24-30	55:38	161:37	63	145	*
345	6- 8-30	55:55	159:07	17	41	*
362	9- 9-30	55:11	160:29	109	24	*
376	10-19-30	56:00	160:32	148	256	
383	11-18-30	55:03	163:38	178	106	*
388	6-10-31	55:55	161:22	382	225	
389	11-11-30	....	....	171	......	
427	5-21-31	58:50	153:16	334	360	
431	12-30-30	56:59	156:33	192	283	
438	12-23-30	57:00	154:32	185	225	
479	1-10-31	56:28	154:35	201	683	
482	10- 9-30	56:21	135:31	108	102	*
484	4-26-31	57:37	136:14	307	180	*
492	8-19-30	54:12	132:59	57	65	

TABLE 21.—*Drift Bottle Releases, 1931 Experiment.*

Bottle Numbers	Date Released	Ship's Course	Distance between Individual Releases (Miles)	Location of Release of First Bottle in Series	
				North Latitude	West Longitude
501-758	7-30-31	SW.½S.	.46	54:15:30	133:06
759-772	"	SE.xE.¾ E.	.92	53:29	136:11:30
773-1012	7-31-31	"	.93	53:20	135:58:30
1013-1253	8-1-31	"	.93	50:33	131:57
1254-1303	8-2-31	"	.94	47:44	128:08
1304-1370	"	"	.46	47:08:30	127:26:30
1371-1389	"	E x N.	.46	46:45	126:58
1390-1497	"	"	.30	46:43:30	126:51
1498-1531	"	NNE.	.29	46:36	126:08
1532-1590	"	"	.72	46:41:30	125:52:30
1591-1601	"	"	.45	47:11	125:04
1602-1652	"	"	.30	47:14	124:59

TABLE 22.—*Drift Bottle Recoveries, 1931 Experiment.*

Bottle Numbers	Recovery Date	Location of Recovery		Days Out	Distance Travelled	Bottles Recovered with Drag Attached
		North Latitude	West Longitude			
523	10-3-31	54:11	131:39	65	60	*
543	9-30-31	54:09	131:41	62	68	
564	9-11-31	54:11	131:39	43	77	
576	10-10-31	55:27	132:11	72	128	
582	6-22-32	57:17	152:55	328	900	*
592	9-27-31	54:11	131:39	59	90	
596	9-16-31	54:08	131:41	48	91	
602	5-6-32	54:07	131:44	281	94	
621	9-10-31	54:11	131:39	42	104	*
623	9-30-31	54:10	131:39	62	104	
627	3-30-32	57:39	136:11	244	232	
629	9-27-31	54:11	131:39	59	107	
640	9-7-31	54:12	132:05	89	99	
656	1-9-32	57:02	134:31	163	200	
665	8-1-32	55:22	131:18	368	173	
670	9-27-31	54:11	131:39	59	126	*
688	9-27-31	54:11	131:39	59	135	*
690	9-27-31	54:11	131:39	59	137	*
691	9-11-31	54:19	130:53	43	165	*
693	9-23-31	54:09	131:40	55	136	
696	10-28-31	56:30	132:52	90	264	
702	1-27-32	54:07	131:44	181	110	
708	5-25-32	54:45	132:00	300	142	*
719	10-9-32	54:02	132:11	71	138	*
725	9-30-31	54:09	131:40	62	152	*
735	9-27-31	54:11	131:39	59	155	
737	9-27-31	54:11	131:39	59	156	
765	1-10-34	55:35	132:34	895	225	
824	4-3-32	53:56	133:12	247	100	
826	5-17-34	54:12	133:00	1021	120	
872	11-24-31	55:25	133:36	117	199	
878	9-22-31	54:05	131:45	53	189	
886	9-27-31	54:11	131:39	58	187	*
897	4-21-33	56:39	135:10	630	280	
904	10-28-31	57:28	134:48	89	344	*
909	10-16-31	57:02	135:38	77	329	
918	7-30-33	57:25	152:38	730	738	
940	7-13-32	54:53	131:12	348	273	
954	1-1-32	53:53	131:47	154	207	
958	5-26-34	55:35	132:34	1030	302	
971	4-20-32	55:30	131:59	264	289	
982	12-2-31	50:35	128:14	124	161	
993	12-5-31	50:55	128:00	127	164	
995	4-2-32	54:28	130:59	246	253	
1002	6-7-32	55:16	131:46	312	279	
1008	1-1-32	54:56	131:36	154	262	
1012	11-25-31	48:10	124:44	117	314	
1013	1-2-32	53:55	131:46	154	214	
1017	1-3-32	54:03	131:42	155	223	
1023	5-1-32	55:15	131:40	274	292	
1026	1-2-32	54:08	131:40	154	234	
1038	4-22-32	54:06	131:41	265	238	
1045	12-11-31	52:46	129:24	132	173	
1065	3-27-32	54:02	131:42	239	251	
1070	2-24-32	53:09	129:54	207	200	*
1075	3-19-33	49:00	125:39	596	200	
1076	1-2-32	46:43	124:05	154	317	
1077	11-20-31	46:31	124:03	111	268	
1088	11-17-31	44:58	124:01	108	388	
1092	11-22-31	46:53	124:07	113	303	
1093	3-20-32	46:20	124:04	232	326	
1097	1-7-32	50:49	128:15	159	105	
1101	12-2-32	48:44	125:13	123	207	
1111	11-7-31	47:07	124:11	98	279	*
1113	11-11-31	46:53	124:07	102	284	

TABLE 22.—*Drift Bottle Recoveries, 1931 Experiment*—(*Continued*).

Bottle Numbers	Recovery Date	Location of Recovery		Days Out	Distance Travelled	Bottles Recovered with Drag Attached
		North Latitude	West Longitude			
1120	6-10-33	54:00	131:45	679	290	
1121	11-27-31	45:26	123:56	118	328	
1123	1-24-32	43:51	124:10	176	410	
1125	11-21-31	46:21	124:03	112	298	
1126	11-17-31	49:03	125:44	108	196	
1127	1-29-32	44:52	124:02	181	356	
1128	3-24-32	46:01	123:56	236	313	
1137	1-16-32	47:07	124:10	168	258	
1138	3-15-32	53:50	131:50	227	233	
1141	2-5-32	44:06	124:08	188	373	
1143	11-20-31	47:30	124:21	111	233	
1145	2-21-32	43:44	124:11	204	383	
1146	1-19-32	45:49	123:58	171	297	
1147	2-11-32	44:31	124:06	194	361	
1151	2-4-32	49:04	125:48	187	146	
1153	3-5-32	45:02	124:01	217	327	
1154	1-20-32	44:59	124:01	172	328	
1156	12-22-31	46:16	124:05	143	287	
1159	12-13-33	46:55	124:10	865	243	
1162	2-4-32	43:51	124:10	187	362	
1163	1-20-32	43:15	123:23	172	395	
1174	3-27-32	43:53	124:09	239	353	
1175	2-11-32	44:20	124:06	194	355	
1176	1-7-32	46:48	124:05	159	234	
1183	1-12-32	44:02	124:08	164	342	
1184	1-6-32	46:03	123:56	158	260	
1191	3-27-32	44:33	124:04	239	314	
1195	3-6-33	43:30	124:15	583	180	
1197	2-17-32	47:28	124:17	200	205	
1198	3-10-32	42:57	124:28	222	315	
1199	2-27-32	45:36	123:58	210	268	
1208	2-2-32	35:10	120:45	185	914	
1209	4-4-32	44:01	124:08	247	317	
1215	1-30-32	44:01	124:08	182	311	
1218	11-22-31	44:27	124:55	113	289	
1226	1-6-32	46:24	124:03	158	210	
1227	3-21-32	46:01	123:56	233	224	
1228	1-12-32	44:24	124:05	164	264	
1239	1-21-32	46:11	123:59	173	208	
1245	4-10-32	43:37	124:13	253	301	
1250	1-12-32	46:05	123:56	164	202	
1284	1-13-32	43:52	124:09	164	258	
1330	11-11-31	44:35	124:04	101	201	
1514	8-14-32	21:10	157:10	378	2465	
1568	11-8-31	44:12	124:07	98	176	
1596	8-28-32	21:21	157:42	392	2555	
1606	8-7-32	19:57	155:10	371	2450	
1631	1-21-32	46:01	123:55	172	87	
1638	9-17-32	21:21	157:42	412	2480	

TABLE 23.—*Drift Bottle Releases, 1932 Experiment.*

Bottle Numbers	Release Date	Location of Release	
		North Latitude	West Longitude
1653-1664	3-22-32	47:29	126:53
1665-1676	"	47:35	127:02
1701-1712	"	47:41	127:10
1713-1724	"	47:46	127:18
1677-1688	"	47:52	127:27
1689-1700	"	47:58	127:36
1725-1736	"	48:03	127:44
1737-1748	"	48:09	127:53
1749-1760	"	48:14	128:02
1761-1772	"	48:21	128:10
1773-1784	"	48:26	128:19
1785-1796	"	48:32	128:28
1797-1808	"	48:37	128:36
1809-1820	"	48:43	128:45
1821-1832	"	48:48	128:53
1833-1844	"	48:54	129:02
1845-1856	"	49:00	129:10
1857-1868	"	49:05	129:19
1869-1880	"	49:11	129:28
1881-1892	"	49:16	129:36
1893-1904	"	49:22	129:45
1905-1916	"	49:28	129:54
1917-1928	3-23-32	49:33	130:03
1929-1940	"	49:39	130:11
1941-1952	"	49:44	130:20
1953-1964	"	49:50	130:28
1965-1976	"	49:56	130:37
1977-1988	"	50:01	130:46
1989-2000	"	50:07	130:54
2001-2012	"	50:12	131:02
2013-2024	"	50:18	131:11
2025-2036	"	50:23	131:20
2037-2048	"	50:28	131:29
2049-2060	"	50:34	131:37
2061-2072	"	50:40	131:46
2073-2084	"	50:45	131:54
2085-2096	"	50:50	132:03
2097-2108	"	50:56	132:12
2109-2120	"	51:02	132:21
2121-2132	"	51:07	132:30
2133-2144	"	51:13	132:39
2145-2156	"	51:18	132:48
2157-2168	"	51:24	132:56
2169-2180	"	51:31	133:06
2181-2192	"	51:35	133:15
2193-2204	"	51:41	133:24
2205-2216	3-24-32	51:46	133:33
2217-2228	"	51:52	133:42
2229-2240	"	51:57	133:51
2241-2252	"	52:04	134:01
2253-2264	"	52:09	134:10
2265-2276	"	52:15	134:19
2277-2288	"	52:21	134:29
2289-2300	"	52:26	134:38
2301-2324	"	52:32	134:48
2325-2348	"	52:38	134:58
2349-2372	"	52:43	135:06
2373-2396	"	52:49	135:16
2397-2420	"	52:55	135:25
2421-2444	"	53:01	135:35
2445-2468	"	53:06	135:45
2469-2492	"	53:12	135:54
2493-2516	"	53:18	136:03
2517-2540	"	53:22	135:51
2541-2564	"	53:26	135:40
2565-2588	"	53:30	135:27
2589-2612	"	53:34	135:15
2613-2636	"	53:38	135:04
2637-2660	"	53:42	134:51
2661-2684	"	53:45	134:39
2685-2708	3-25-32	53:49	134:27
2709-2732	"	53:53	134:15
2733-2756	"	53:57	134:03
2757-2780	"	54:02	133:49
2781-2788	"	54:05	133:39

TABLE 24.—*Drift Bottle Recoveries, 1932 Experiment.*

Bottle Numbers	Recovery Date	Location of Recovery		Days Out	Distance Travelled	Bottles Recovered with Drag Attached
		North Latitude	West Longitude			
1657	5-29-32	53:52	130:31	68	411	
1661	6-14-32	54:05	131:48	84	449	
1674	7-21-32	52:58	129:27	121	334	*
1712	4-13-32	51:14	128:48	22	220	
1717	4-17-32	51:37	129:32	26	249	*
1753	1-23-33	45:00	124:00	307	257	
1779	7-29-32	52:52	130:44	129	277	*
1794	7-17-32	48:31	125:02	117	136	*
1810	6-23-33	52:07	131:17	458	222	
1817	11-4-32	44:30	124:12	227	311	
1837	6-21-32	54:49	131:21	91	363	*
1853	6-16-32	54:09	131:40	86	327	
1857	4-30-32	51:32	128:59	39	148	*
1879	6-27-32	55:06	131:37	97	366	
1880	7-8-32	54:02	132:11	108	337	
1885	8-14-32	55:22	133:30	145	396	*
1891	9-7-32	54:54	131:22	169	344	*
1920	8-21-32	50:45	128:30	151	93	
1950	8-14-32	54:46	130:44	144	409	
1963	8-4-32	53:05	129:11	134	198	
1979	3-15-33	52:10	131:10	357	122	*
2010	8-19-32	52:26	131:46	149	136	*
2027	8-3-32	60:27	146:39	133	846	*
2031	7-9-32	51:53	131:01	108	91	
2057	3-10-33	57:33	134:35	352	420	
2068	11-1-33	60:00	143:55	223	690	*
2070	7-25-32	57:00	135:43	124	405	*
2072	6-14-32	54:37	130:55	83	344	*
2084	5-28-32	54:11	133:05	66	208	*
2086	8-4-32	57:10	135:48	134	413	
2088	8-28-32	57:28	134:35	158	413	*
2132	8-28-32	59:07	151:38	158	907	
2148	7-16-33	60:42	147:27	480	653	
2167	9-7-32	59:33	151:32	168	921	
2208	7-31-32	60:40	146:20	129	744	*
2209	6-14-32	56:48	135:29	82	308	*
2219	6-23-32	60:52	147:34	91	758	
2228	7-1-32	59:21	139:17	99	496	
2231	4-25-32	54:17	133:34	32	146	*
2265	10-15-32	60:27	146:09	205	615	*
2288	11-1-33	60:20	146:12	587	614	
2289	4-10-33	59:20	150:45	382	672	
2300	10-11-33	60:00	147:30	566	625	
2303	7-21-32	60:44	147:23	119	710	
2323	8-7-32	59:37	151:31	136	918	
2336	9-15-32	59:08	151:52	175	694	
2344	5-16-32	56:53	134:15	53	255	*
2391	11-1-32	57:53	152:25	222	656	
2403	1-15-34	46:38	124:00	662	577	
2410	9-15-32	59:08	151:52	175	717	
2412	8-18-32	60:20	146:12	147	627	
2419	10-10-32	58:22	137:05	200	332	
2424	10-14-32	57:10	135:28	204	148	
2476	10-6-33	59:30	139:45	561	390	
2589	6-19-32	56:50	135:33	87	196	
2609	4-16-32	56:10	134:38	23	156	*
2613	7-31-32	59:04	138:21	129	351	
2614	7-7-32	59:02	138:10	105	347	*
2653	8-16-32	60:27	146:39	145	614	*
2658	8-10-32	57:47	155:18	139	859	
2672	7-5-32	....	....	103	......	*
2687	5-18-33	60:23	146:10	419	555	
2695	8-18-32	60:20	146:12	146	574	
2699	5-20-32	55:50	133:53	56	122	
2708	10-1-32	....	....	190	......	
2709	9-1-32	60:20	146:12	160	592	*
2753	10-19-32	60:46	147:58	208	625	
2757	6-25-32	59:19	139:13	92	369	

TABLE 25.—*Drift Bottle Releases, 1933 Experiment.*

Bottle Numbers	Release Date	Station Number	Location of Release	
			North Latitude	West Longitude
2789-2812	1-3-33	21	56:03	132:40
2813-2932	1-9-33	22	59:04	141:17
2933-3004	1-26-33	23	59:14	141:07
3005-3124	1-30-33	24	58:55	141:27
3125-3148	2-16-33	25	57:42	149:52
3149-3172	2-20-33	26	59:36	148:22
3173-3196	3-2-33	27	57:49	151:32
3197-3220	"	28	57:46	151:04
3221-3244	"	29	57:44	150:37
3245-3268	"	30	57:41	150:10
3269-3292	"	31	57:38	149:42
3293-3316	"	32	57:36	149:15
3341-3364	"	33	57:33	148:47
3317-3340	3-3-33	34	57:30	148:20
3365-3388	"	35	57:28	147:52
3389-3412	"	36	57:27	147:25
3413-3436	"	37	57:23	147:03
3437-3460	"	38	57:13	147:00
3461-3484	3-4-33	39	57:17	146:32
3485-3508	"	40	57:18	146:10
3509-3532	"	41	57:20	145:47
3533-3556	3-7-33	42	58:12	137:17
3557-3580	"	43	58:12	137:11
3581-3604	"	44	58:12	137:05
3605-3628	"	45	58:12	136:59
3629-3652	"	46	58:12	136:53
3653-3675	"	47	58:12	136:47

TABLE 26.—*Drift Bottle Recoveries, 1933 Experiment.*

Bottle Numbers	Recovery Date	Station Number	Location of Recovery		Days Out	Distance Travelled	Bottles Recovered with Drag Attached
			North Latitude	West Longitude			
2987	3-23-34	23	56:42	157:33	421	565	
3037	4-14-34	24	56:23	154:40	439	455	*
3049	6-3-34	24	54:20	162:30	489	755	
3109	3-25-34	24	56:42	157:33	419	545	
3126	12-24-33	25	53:30	167:40	311	690	
3157	5-16-34	26	54:20	162:40	450	593	
3237	7-20-34	29	56:50	153:45	505	115	
3244	3-12-34	29	57:00	153:15	365	95	*
3255	10-6-34	30	57:08	170:10	583	815	
3359	2-15-34	33	56:42	153:53	350	177	
3367	12-7-34	35	53:00	168:15	279	750	
3371	2-22-34	35	58:00	152:52	356	162	
3402	2-3-34	36	52:43	168:55	337	800	
3484	3-25-34	39	58:05	152:35	386	200	*
3538	7-20-33	42	59:21	139:17	135	92	*
3544	6-14-33	42	59:59	147:24	99	370	
3571	8-18-33	43	55:57	158:39	164	702	
3572	6-23-33	43	60:28	148:00	108	370	*
3579	7-19-33	43	60:09	147:46	134	387	*
3593	8-23-33	44	60:20	152:05	169	547	*
3639	6-19-33	46	60:07	147:15	104	317	*
3650	4-17-33	46	59:10	138:40	41	72	
3651	4-2-33	46	59:10	138:40	26	72	
3654	9-8-33	47	59:31	139:50	185	125	*

TABLE 27.—*Drift Bottle Releases, 1934 Experiment.*

Bottle Numbers	Release Date	Station Number	Location of Release	
			North Latitude	West Longitude
3677-3700	1-9-34	48	54:00	134:09
3701-3720 3722-3724	"	49	53:40	133:50
3725-3748	1-17-34	50	51:45	131:35
3749-3772	1-18-34	51	51:30	131:35
3773-3796	"	52	51:30	131:03
3797-3820	1-29-34	53	58:24	137:22
3821-3844	"	54	58:38	137:56
3845-3868	"	55	58:53	138:30
3869-3892	"	56	59:07	139:07
3893-3916	"	57	59:22	139:44
3917-3940	2-19-34	58	58:59	148:51
3941-3964	2-20-34	59	58:20	148:29
3965-3988	2-23-34	60	58:10	148:54
3989-4012	1-30-34	61	59:04	141:17
4013-4036	2-25-34	62	57:51	148:37

TABLE 28.—*Drift Bottle Recoveries, 1934 Experiment.*

Bottle Numbers	Recovery Date	Station Number	Location of Recovery		Days Out	Distance Travelled	Bottles Recovered with Drag Attached
			North Latitude	West Longitude			
3688	6-11-34	48	58:12	135:07	153	256	•
3719	4-1-34	49	58:14	136:20	82	305	•
3802	6-3-34	53	57:35	154:00	125	690	
3806	4-17-34	53	57:35	154:00	78	690	•
3826	6-7-34	54	58:10	154:15	129	650	
3945	3-31-34	59	57:30	156:04	39	350	•
3956	10-15-34	59	56:35	157:45	237	353	
4015	4-26-34	62	55:00	159:20	60	395	•