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THE GREENLAND HALIBUT

(*REINHARDTIUS HIPPOGLOSSOIDES* (WALB.))

ITS DEVELOPMENT AND MIGRATIONS

BY

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WITH 4 PLATES AND 1 FIGURE AND 6 CHARTS IN THE TEXT

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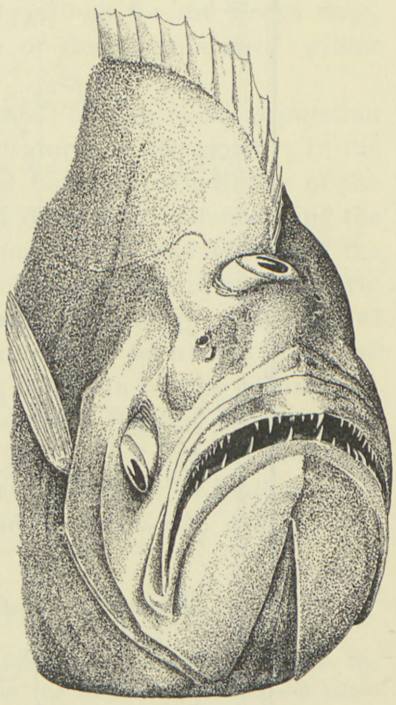
Introduction.

The Flat-fish discussed here shows a great resemblance to the Common Halibut (*Hippoglossus hippoglossus* (L.)) and various authors call it "The little Halibut"; one of the names (Netarnârak) given it by the Greenlanders also means "The little Halibut". In systematic works it is often referred to the genus *Hippoglossus* but is so distinct in several respects, that it has been rightly regarded as the type of a special genus: *Reinhardtius*. This name was given it by GILL in 1861 and has priority of the name used by some authors *Platysomatichthys*, introduced a year later by BLEEKER.

The genus *Reinhardtius*, which only contains the single species *R. hippoglossoides* (Walb.) (Pl. IV, Figs. 10 a and b)[1], is specially characterized by the two sides of the body having very nearly the same appearance, both being equally muscular and dark coloured, though the left side is slightly less dark than the right; further by the fact, that the eye of the left side is situated on the dorsal ridge of the head, though inclined more to the right side (see the figure in the text).[2]

These peculiar characteristics in a Flat-fish give *Reinhardtius* a less asymmetrical appearance than one finds in other northern Flat-fishes.

Reinhardtius hippoglossoides, "Greenland Hali-



Head of Greenland Halibut viewed from in front, fish on left side, head raised. In this position the right gill-cover is pressed out slightly to the side, making head appear somewhat broader than it really is.

[1] From Japan a species *Reinhardtius matsuurae* Jordan & Snyder has been described, known only from the type, a stuffed specimen, and probably identical with *R. hippoglossoides* (according to the recently published, monumental work of J. R. NORMAN: "A systematic revision of the Flatfishes (*Heterosomata*)", Vol. I, p. 290; London 1934).

[2] We sometimes meet with a specimen where it is the eye of the right side that sits on the ridge and where correspondingly the right side is somewhat less dark than the left, but these sinistral specimens are so rare, that only two cases have come to my knowledge, one in 1914 and one in 1922.

Chart A. Survey Chart of region dealt with, showing localities mentioned in the text.

but" of the Americans, "Blue Halibut" of the English fishermen, "Hellefisk" of the Danes and "Kaleralik" of the Greenlanders, is a deep-water fish (ca. 250—1600 m.)[1] which occurs in fairly large numbers in the Davis Strait and especially at several places of the west coast, namely, Umanak Fjord, Kekertak in the Ritenbenk District and especially the iceberg banks of Jakobshavn, again at Claushavn in Christianshaab District and in some fjords of the Julianehaab District. It may be met with in smaller numbers or sparsely along the whole west coast, from the south point right up to Smith Sound; on the east coast it occurs at some places in the Angmagssalik District.

The Greenland Halibut, which reaches a weight of 5—10 kg, has a considerable value commercially in Denmark, the fineness of its flesh and its extreme fatness permitting it to be smoked like salmon.[2] The export to Denmark amounts to 2000—3000 barrels each year. Large quantities, especially of undersized fish, are used by the Greenland population as food, whilst the fat skimmed from the water, in which the Halibut is cooked, is used as lamp oil. In North Greenland strips of the flesh are dried, just as in the case of the Common Halibut ("Raeklinger"). In North Greenland also this fish is used a good deal as food for the sledge dogs, which must be kept in good condition for the sake of the Greenlanders' winter hunting and fishing.

In consequence of the economic importance of this Flat-fish to the population of Greenland, it is of interest to determine the main features of its biology. In the following I shall summarize the investigations into the biological conditions of the species, which I have been able to make in the West Greenland waters during the expeditions under my direction, the "Tjalfe" Expeditions of 1908 and 1909 and the "Dana" Expedition of 1925, and regarding which only preliminary notices have hitherto been published, and without charts or illustrative figures (cf. literature at the end of the present paper, under JENSEN). In addition, materials have been used from the "Godthaab" Expedition of 1928 and I have been able to obtain further information from Danes and Greenlanders connected with the Greenland Halibut fishery there.

It will be seen from the following account, that quite apart from its economic importance the Greenland Halibut offers more than usual interest in biological regards, in its reproduction and migrations connected therewith as also development and metamorphosis.

[1] A 77 cm. long specimen was taken at the considerable depth of 1600 m. on the "Godthaab" Expedition 1928 in the Davis Strait (67°48′ N. L., 60°46′ W. L.).

[2] The method of curing is as follows: After removal of the head, tail and fins along with the intestines, the side pieces (fillets) of the flesh are cut away from the backbone, cleaned and salted down in barrels; these are sent to Copenhagen and sold to the kipperers, who unsalt and smoke the flesh for distribution among the fish dealers and others. Cut in slices and laid on buttered bread it makes an excellent substitute for the dearer smoked salmon, owing to its richness in fat. The "inner fins" (interspinous portions above and below) remain, each on its half of the fish, and are likewise salted at the same time, but in the smoke-house these strips are cut away and separately smoked, with the bones in; they are known in the trade as "Hellefiskefinner" (Greenland Halibut fins).

Reproduction of the Greenland Halibut; migrations connected therewith and occurrence of the larvae.

In large females the number of eggs amounts to about 300,000.[1]

Females with ripe eggs I have only obtained three times and only one specimen each time. One was 700 mm. long, taken 6.VII.1908 in the Davis Strait west of Great Hellefiske Bank at 66°45′ N. L., 56°39′ W. L., at a depth of 384—458 m. Its ovaries were large (190 and 160 mm. long) and contained in addition to many small eggs (up to ca. 1 mm. in diameter) quite a number of ripe eggs 4—4.5 mm. in diameter. The latter were glass-clear and lying loose in the central cavity of the ovary, thus ready to be set free. The small unripe eggs on the other hand were still attached to the walls of the ovary and obviously would not be ready for spawning until the next period. The second ripe female was taken on 2.VI.1909 in the Davis Strait off the Fylla Bank (64°41′—64°40′ N. L., 56°37′—56°39′ W. L.) at a depth of 720—775 m. It was 650 mm. long and the ovaries measured 110 and 115 mm. in length. A score of eggs were found in the cavity not yet spawned; they were loose and transparent, 4—4.2 mm. in diameter; all the other eggs reserved for the next spawning period remained attached to the walls of the ovary and had a diameter of 0.6—1.4 mm. Along with the last-mentioned, some other females were taken which had obviously already spawned, as their ovaries were comparatively small (total length 670 mm., ovaries 85 and 90 mm. long; total length 610 mm., ovaries 75 and 80 mm.) and the eggs undeveloped (diameter 0.5—1.3 mm.). Some few days later (8.VI.1909) likewise in the Davis Strait (63°54′ N. L., 53°15′ W. L., 988—1400 m.) females were caught which had obviously spawned, being quite thin and their ovaries small (only 80 mm. long in a female of 720 mm., 60 mm. long in one of 635 mm. and 50 mm. in one of 620 mm.), whilst the eggs were quite undeveloped (ca. 0.25—0.75 mm.) and white.

To judge from these observations spawning has been coming to an end at this time (beginning of June—beginning of July); the main spawning certainly takes place much earlier in the year. And I imagine that the third specimen with ripe eggs must be judged from this standpoint. It was 780 mm. long, taken on 21.VIII. 1909 in Agdluitsok Fjord; its ovaries were 180 and 200 mm. long and contained many opaque eggs of only 1 mm. in diameter; the majority of the eggs were 1.8 mm. and white, not a few were 2—2.2 mm. and half clear, whilst about 10 eggs were 4—4.4 mm. and clear. The many transitional stages in the size of the eggs and their nature indicate that this specimen was just approaching ripeness. In a number taken at the same time and from the same fjord the ovaries examined were undeveloped and eggs still very small; in 21 females of 620—1050 mm. the length of the ovaries varied between 45 and 230 mm. and the diameter of the eggs from 0.2

[1] This estimate was made on 25.VII.1908 from a female 1010 mm. long; its ovaries measured 200—230 mm. and the eggs 1.5 mm. in diameter.

to 1.5 mm. In numerous specimens taken round the outpost Narssak in the Julianehaab District at the end of July (1909) the ovaries were likewise undeveloped and eggs small (at most 0.7—1.5 mm.). A number of specimens examined at the end of July and beginning of August (1908) at Jakobshavn, Kekertak and various places in the Umanak Fjord likewise had small eggs, at most 1.5 mm. in diameter, though in a single specimen 930 mm. long they were about 2 mm. in diameter.

From these observations we may presumably draw the following conclusions: in summer the ovaries are as a rule small and the eggs of small size, in general about 0.5—1.5 mm. in diameter, exceptionally about 2 mm.; towards autumn and in winter the ovaries become relatively large and the eggs of good size, whilst in winter and towards spring the eggs reach their full size 4—4.5 mm. in diameter.

So far as the males are concerned, we have the information from the "Godthaab" Expedition, that a specimen of 55 cm. in length taken on 5.X.1928 in the Davis Strait (63°36′ N. L., 55°15′ W. L., depth 1200 m.) had "well developed genital organs", and was thus approaching ripeness.

In favour of this view that reproduction takes place early in the year we have the fact, that large numbers of the larvae were taken in the Davis Strait at the same period as the few straggling spawners, partly quite young fry just hatched in great depths (bathypelagic) and also somewhat larger larvae in the upper layers (pelagic).

In 1909 bathypelagic fry of the Greenland Halibut were taken by the "Tjalfe" at the following places.[1]

Station	Date	N. L.	W. L.	Depth m.	Metres wire	Spec.	Length in mm.
333	7/5	63°18′	54°55′	ca. 1300	1530	21	10—15
336	8/5	64°06′	55°18′	1040—1100	1200	45	11—16 (17)
344	10/5	64°22′	55°48′	1040	1200	20	12—16
345	10/5	64°22′	55°51′	ca. 1040	1000	10	13—16
348	11/5	64°35′	56°18′	ca. 800	900	19	12—16 (17)
363	18/5	66°21′	57°04′	680	800	13	13—18
373	21/5	66°45′	56°31′	?	750	2	13—15
434	9/6	62°53′	54°15′	1660	1500 og 1200	4	14—16 (17)

The position of the stations can be seen from Chart B indicated by the mark ●.

The depth at which these young larvae of the Greenland Halibut were taken, was estimated at about 600—1000 m., and the depth of the sea at the places in question about 680—1660 m. They were quite tiny larvae, 10—18 mm. long[2], and many still had the yolk-sac attached, showing that they had just come from the egg.

I have thus been able to show, that on the one hand ripe Greenland Halibut

[1] The description of these larvae will be found on p. 20.

[2] As a rule only 10—16 mm. long; it is possible, however, that the relatively few larvae of 17—18 mm. were taken in the apparatus when passing through the upper layers on hauling in; at least, at St. 344 and St. 345, where the closing net was used (thus excluding organisms from less depths than those fished in) no specimen over 16 mm. was taken.

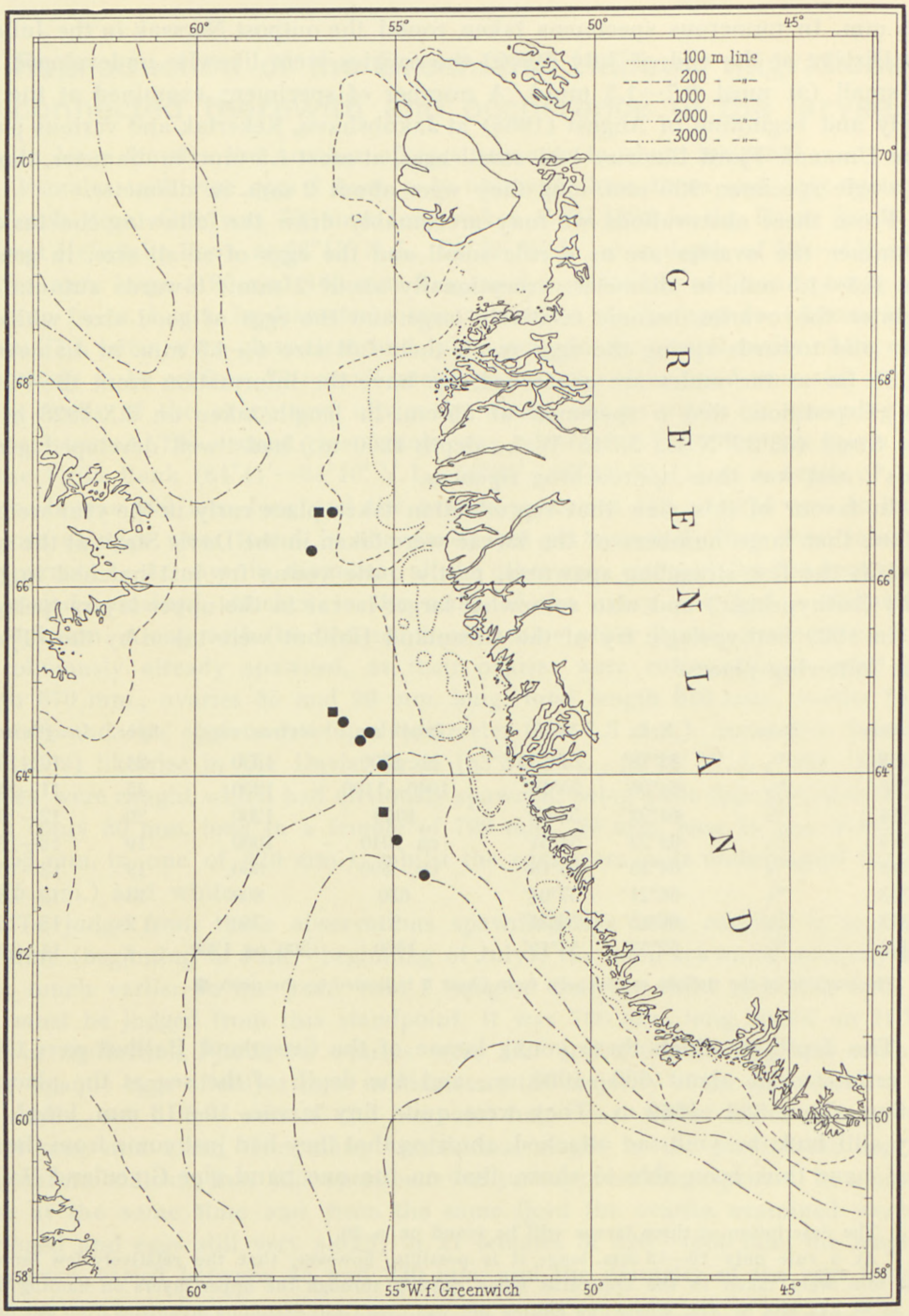


Chart B. ■ Adult fish with ripe sexual products. ● Just hatched bathypelagic fry. "Tjalfe" 1908—09.

occur in the deep part of the Davis Strait as far north as 66°45 N. L. (on Chart B these places are marked with ■), and on the other that newly hatched larvae are found there as far north as 66°45′ N. L. in great depths (bathypelagic) (on Chart B marked with ●).

This should be sufficient evidence, that the Greenland Halibut has its spawning places out in the depths of the Davis Strait. And so far as one can judge, this species only spawns at West Greenland in the deep, southern part of the Davis Strait (in the north as far as 66¾° N. L.). The tiny fry have not been found at other places. Fishing was carried on with the same apparatus (ring trawl) at different depths and many other places, on the Banks, in Disko Bay, west of Disko, in Umanak Fjord, Baffin Bay as well as in the fjords of South Greenland, but not a single specimen of the tiny larvae was taken except at the places and depths mentioned above.

The tiny larvae of the Greenland Halibut gradually rise up in the water towards the surface; here they were taken in quantities (up to 321 specimens in one haul) by the "Tjalfe" both in 1908 and 1909, during the period 6.V.—25.VI. The places where the pelagic fry were taken, are noted below.[1]

Station	Date	N. L.	W. L.	Metres wire	Spec.	Length in mm.
30 a	7/6 1908	63°04′	56°32′	500	16	16—17
30 b	7/6 1908	63°04′	56°32′	70	161	16—17
33 a	8/6 1908	63°25′	54°34′	70	249	16—19
34	8/6 1908	63°40′	52°47′	70	88	17—20
73	23/6 1908	63°55′	53°14′	200	1	?
79 a	25/6 1908	64°45′	54°02′	30—100	55	18—22
326	6/5 1909	62°05′	53°41′	100	1	20
332	7/5 1909	63°18′	54°55′	80	2	20—21
342	10/5 1909	64°24′	55°24′	100	2	20—21
347	11/5 1909	64°31′	56°18′	100	1	19
349	11/5 1909	64°37′	56°18′	75	1	18
403	2/6 1909	64°34′	56°36′	100	16	18—22
405	2/6 1909	64°25′	56°12′	100	38	18—21
411	3/6 1909	64°21′	55°10′	120—100	52	18—23
412	3/6 1909	64°21′	54°36′	120—100	34	17—21
413	3/6 1909	64°21′	53°57′	120—100	2	18—23
414	4/6 1909	64°10′	53°34′	120—100	4	21
423	7/6 1909	65°03′	54°16′	120— 80	321	17—24
424	7/6 1909	64°41′	53°46′	120— 80	8	17—24
425	8/6 1909	64°24′	53°05′	120— 80	6	18—20
427	8/6 1909	63°54′	53°15′	120— 80	4	19—21
432	9/6 1909	63°09′	53°43′	100	3	18—19
433	9/6 1909	63°05′	54°21′	120— 80	9	17—19
435	10/6 1909	62°59′	52°58′	120— 80	3	17—20
438	10/6 1909	63°17′	51°59′	120— 80	4	17—20
439	11/6 1909	63°05′	51°19′	100	1	20

[1] Cf. also Chart C, which also shows however the places where the bathypelagic fry were taken.

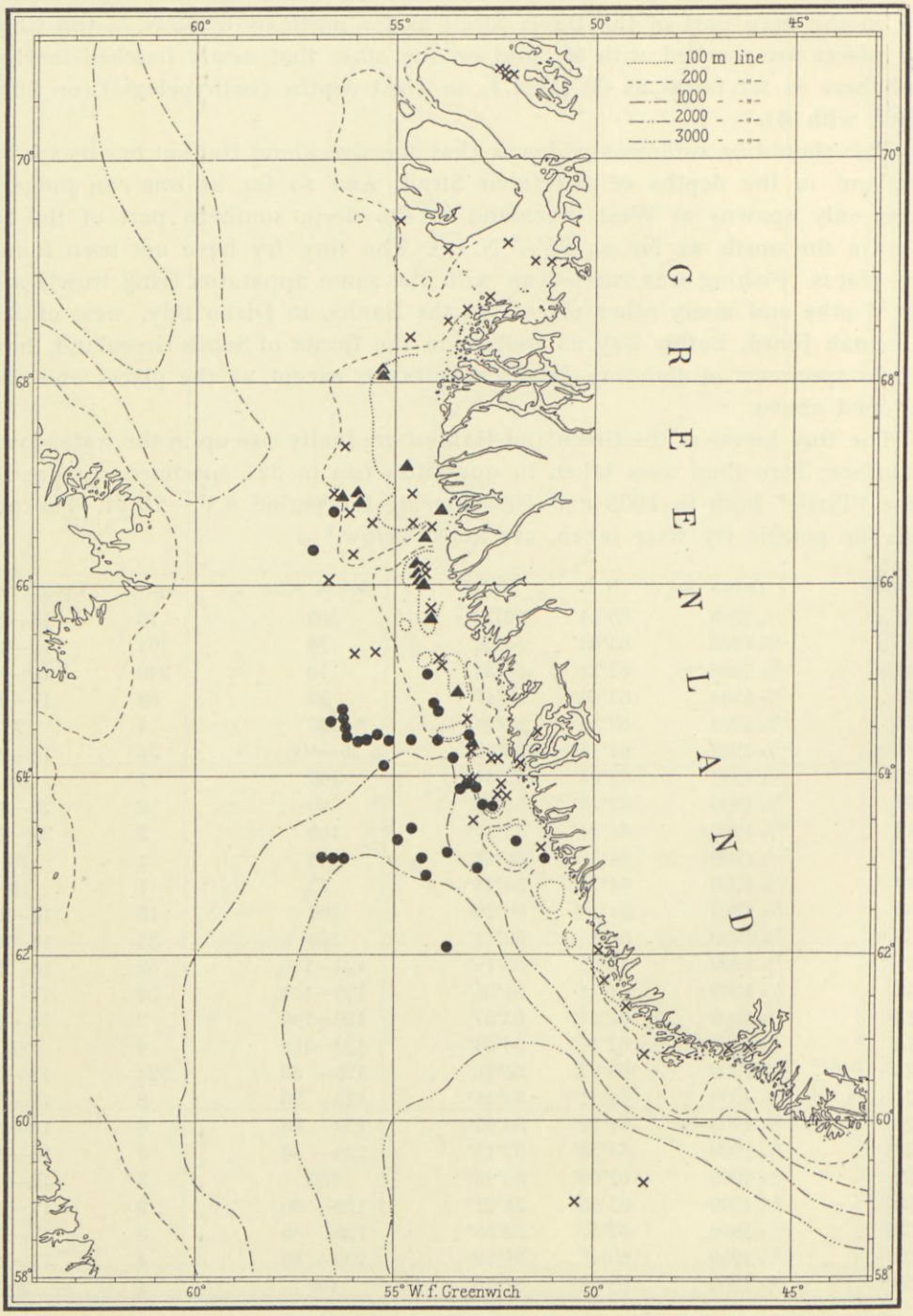


Chart C. ● The distribution of the larvae in May-June, ▲ in August. × Negative stations. "Tjalfe" 1908—09.

The duration of the hauls was half an hour as a rule, sometimes three-quarters.

These larvae of the Greenland Halibut[1], in length 16—24 mm., were not taken exactly on the surface (none were taken when the net skimmed the surface), but about 30 m. lower down, and not only over great depths (down to 2650 m.) but also over the shallow coastal banks (lowest depth 45 m.); they come to the latter either by active movements or with the currents; see Chart D, showing the eastern boundary of the distribution of the larvae in the beginning (6.—11.) of May 1909 and the limit a month later in the beginning (2.—11.) of June 1909. Their distribution extended from 62°05′—65°03′ N. L.

We see from the list that in 1908 pelagic fry of the Greenland Halibut were taken in June as far north as 64°45′ N. L. In July numerous hauls were made with the same apparatus from off Holstensborg northwards to the waters off Egedesminde District, in Disko Bay, Vaigat, Umanak Fjord and west of Disko, without a single larva being taken. In 1909 the bathypelagic and pelagic fry of the Greenland Halibut were met with in May and June as far north as 66°45′ N. L.; farther north no investigations were made that year.

On the "Dana" Expedition of 1925 the pelagic larvae of *Reinhardtius hippoglossoides* were taken 81 times at 54 stations distributed over the Davis Strait, during the period 5.VI—22.VII, both over the deep water off the banks and over the shallow coastal banks (Dana Bank, Fiskenaes Bank, Fylla Bank and Little Hellefiske Bank) as well as in towards the coast (see Chart Fig. E). The southernmost place of capture was at 60°13′ N. L., the northernmost at 66°38′ N. L. Though many pelagic hauls were made farther north, right up to 69°30′ N. L. (west of Disko Island), no larvae of the Greenland Halibut were taken north of the latitude mentioned (cf. Chart E), and this in spite of the fact, that the negative hauls in the north were made at a period (24.VI—30.VI) lying between the periods for the positive hauls in the south (5.VI—23.VI and 1.VII—22.VII). The largest number of larvae taken in one haul was 125. To begin with the larvae were of similar size to those mentioned from the "Tjalfe" Expedition, but from about 20.VI they became larger, quite naturally as all the catches by the "Tjalfe" except one were made before that time. Round 20.VI the larvae taken by the "Dana" reached a length of 17—28 mm., about 1.VII they were 19—30 mm., 10.VII from 24—37 mm. and about 20.VII from 25—41 mm.

The "Godthaab" Expedition of 1928 worked mostly in the northern parts of West Greenland (Baffin Bay) and thus made no great collection of the Greenland Halibut fry; those taken were all caught at 8 stations in the Davis Strait (cf. Chart F) northwards to 64°02′ N. L., during the period 29.V to 19.VI; they were 17—27 mm. in length. North of the above latitude not a single larva of the species was caught, though many hauls were made with the same apparatus northwards from 66°50′ N. L. right up to Smith Sound (the northernmost station at 78°15.5′ N. L.). And when the Expedition returned from the northern cruise to the waters where pelagic

[1] They are described pp. 20—21.

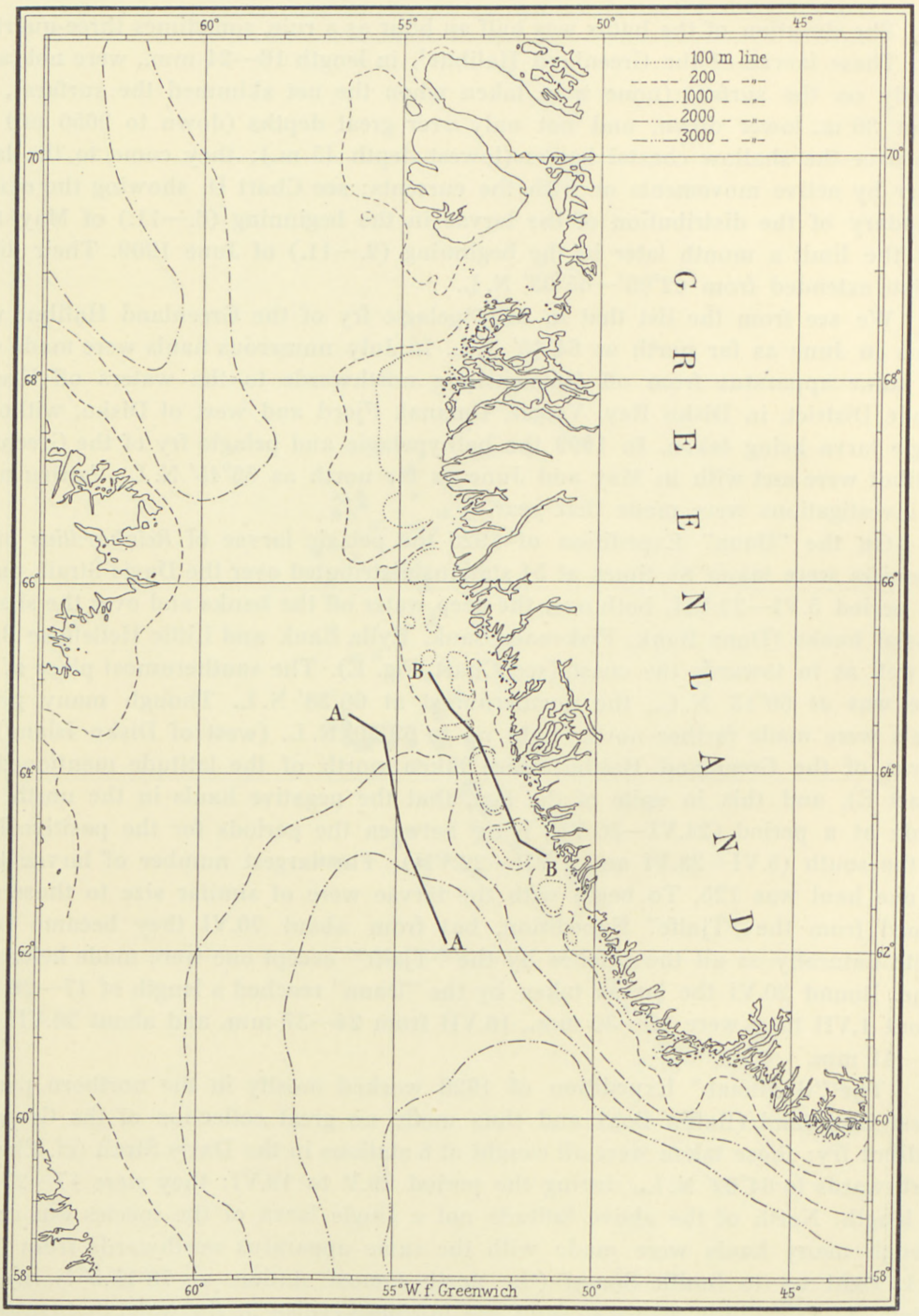


Chart D. A—A the eastern boundary of the larvae in the beginning of May, B—B in the beginning of June. "Tjalfe" 1909.

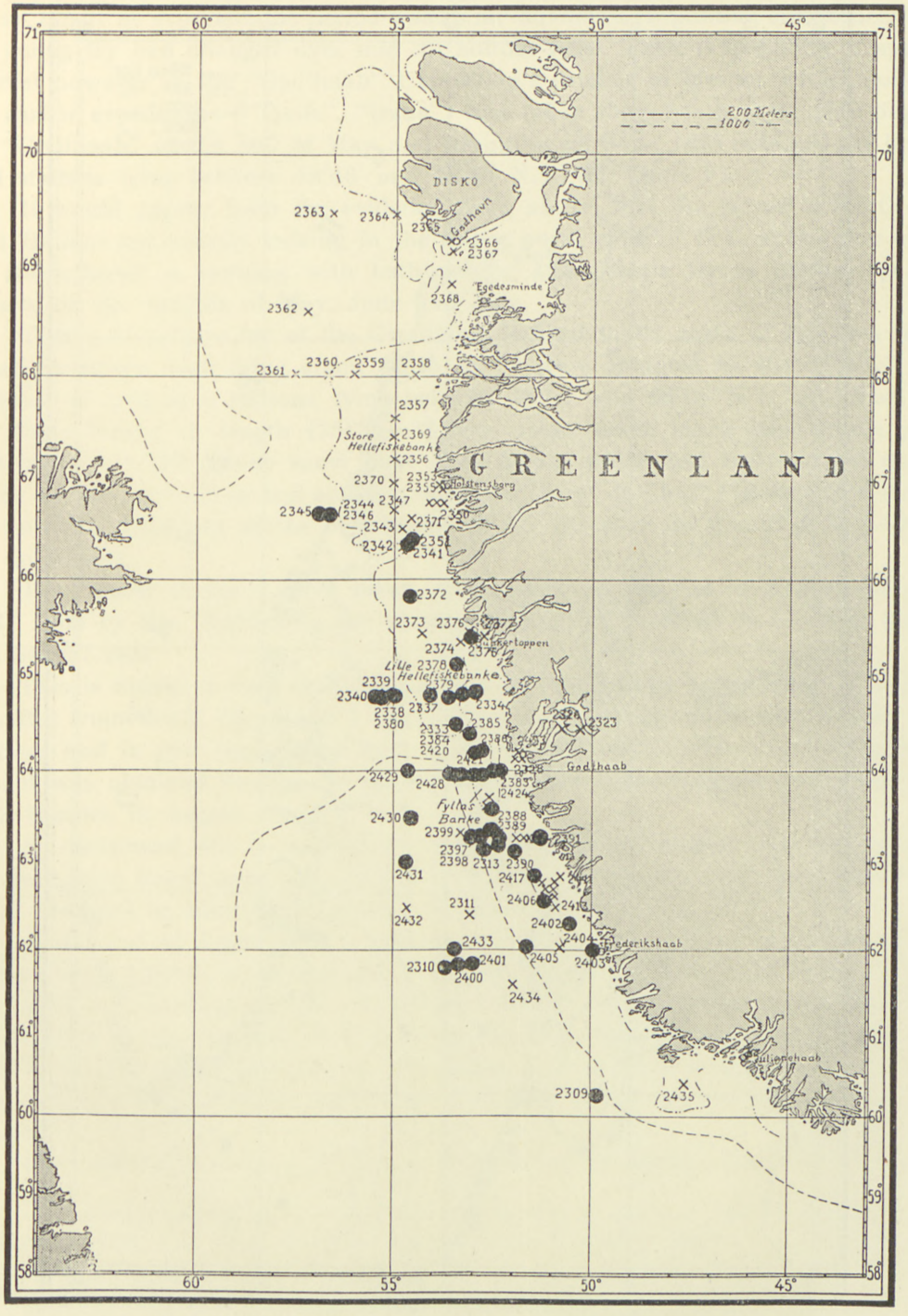


Chart E. ● Pelagic larvae. × Negative stations. "Dana" 1925.

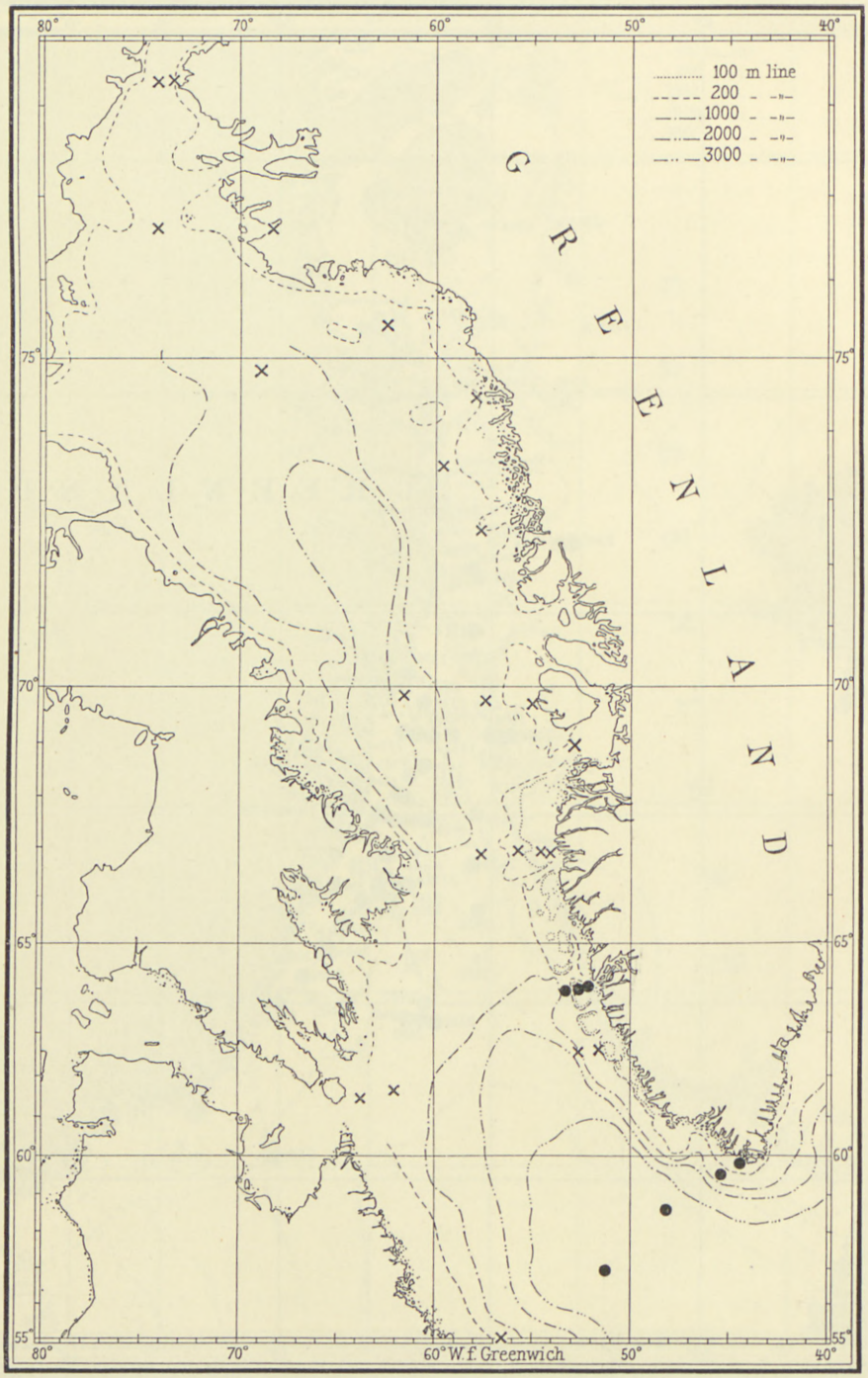


Chart F. ● Pelagic larvae. × Negative stations. "Godthaab" 1928.

larvae might be expected, the period was so far advanced (beginning of October) that the young fry had changed over into the bottom-stage. There is one point of special interest however in the "Godthaab" Expedition's catches of larvae; whilst none of the earlier expeditions ("Tjalfe", "Dana") had taken them south of the 60th degree, the "Godthaab" at the end of May and beginning of June 1928 obtained the larvae at 4 stations lying between 59°48′ and 56°56′ N. L. (cf. Chart F).

It would appear from the evidence given above, that the larvae of the Greenland Halibut are entirely lacking in the waters north of 66$^3/_4$° N. L. at the time when the Davis Strait is teeming with bathypelagic and pelagic larvae of that species, namely, in the months of May, June and July.

The only pelagic fry of the Greenland Halibut taken north of the area mentioned (northern limit lying about 66°45′ N. L.) were obtained by the "Tjalfe" Expedition of 1908 at 6 stations lying between 66°52′ and 68°05′ N. L. (cf. Chart C). But these larvae, in length (25) 31—38 mm., were taken much later in the year, namely 19—21.VIII; these must have been larvae which had been carried northwards by the currents or had actively wandered there; cf. Chart Fig. C, which shows the northern boundary of the distribution of the larvae in the month of May—June and in August.

The largest larvae I have taken, were caught at the end of August (27—29. VIII) 1908 by the "Tjalfe" on the stretch from 64°20′ to 66°45′ N. L.; their length was 34—57 mm.

This is indeed a very considerable size for the pelagic larval stage of a Flatfish. But from South Greenland I have a specimen as large as 68 mm., which with its clear and in part transparent body gives the impression of having lived pelagically; it was obtained floating on the surface in Skovfjord, northern part of Julianehaab District, in August 1914.[1]

As mentioned, the larvae taken in the latter half of August were still pelagic, but they were found somewhat deeper in the water on an average than the surface stages obtained in May—July, namely in depths of 40—75 m.

At the end of August and beginning of September the larvae, now about 60—70 mm. long, appear in at the coast at some places in such large numbers, that they form an essential portion of the food of the Cod in certain years, as determined from an examination of Cod stomachs. This phenomenon has been observed in 1909 in the neighbourhood of Nanortalik and in the sounds at Cape Farewell, also in the years 1924, 1926, 1927 and 1928 in the neighbourhood of Sukkertoppen.[2]

The observations discussed above when taken all together lead us to the fol-

[1] The smallest bottom-stages I have obtained were some 85 mm. long, taken with the trawl on 27.VI.1925 at 69°30′ N. L., 56°32′ W. L. at a depth of 200 m. ("Dana" St. 2363).

[2] It is not every year however that these larvae of the Greenland Halibut are found in Cod stomachs. In 1929 and 1932 there were no Greenland Halibut larvae in the Cod taken round Cape Farewell; nor were the larvae found in Cod stomachs at Sukkertoppen in 1932 and 1933.

lowing conclusions regarding the reproduction of the Greenland Halibut and occurrence of the larvae.

The Greenland Halibut spawns early in the year, in the deep parts of the Davis Strait south of 66¾° N. L.; the eggs are large, 4—4.5 mm. in diameter, transparent, floating in the deeper layers and hatching out there. The tiny larvae of 10—16 mm. are likewise bathypelagic, living in depths of about 600—1000 m. As time goes on the larvae rise up towards the surface and live pelagically; these surface larvae are found not only over the great depths, where the eggs have been spawned, but are scattered also over the shallow coastal banks. In May—June they have a length of 16—28 mm., in July 19—41 mm.; in August they are 25—57 mm. in length and are now to be found not only within the area mentioned (south of 66¾° N. L.), but also farther north. At the end of August and beginning of September the larvae are 60—70 mm. long and in process of changing over to the bottom-stage; they are now met with right in at the coast.

It is somewhat surprising that the Greenland Halibut does not spawn at the places where the Greenlanders fish for the adult fish, namely in the fjords and along the coasts of Greenland. The places where a considerable fishery of the species is carried on lie, as mentioned, partly in the south in certain fjords of the Julianehaab District and partly in the north at some places on the east side of Disko Bay (Claushavn, Jakobshavn, Kekertak) and in Umanak Fjord. But the adult Greenland Halibut may also be found, though in smaller numbers, at many other places in deep water (at least ca. 300 m.) right down to Cape Farewell and up to Smith Sound, very seldom however in the intervening districts (Godthaab, Sukkertoppen and Holstensborg). The spawning places however lie far from the areas and districts mentioned, out in the Davis Strait; this is a long way from North Greenland especially.

We may add further, that at Jakobshavn in North Greenland it is well known from many years' experience, that the large Greenland Halibut disappear from there in September to January; also from Agdluitsok Fjord in South Greenland we have the information, that an emigration of mature Greenland Halibut with comparatively large roes takes place from the fjords in the latter half of October and in November. These observations are further confirmation of the fact, that in autumn the Greenland Halibut migrate out from the fjords and coasts to the spawning places in the Davis Strait.

On the other hand, we have the information from Agdluitsok Fjord, that in the middle of February a return migration takes place of the large Greenland Halibut from the deep water into the fjord.[1]

[1] It may be remarked here, that the extensive fishery of Greenland Halibut which used to be carried on in this fjord has almost entirely ceased in recent years, almost no Greenland Halibut now appearing in the fjord. This probably is due to changed hydrographical conditions which on the other hand have had the result, that southern fish Herring (*Clupea harengus*), Coalfish (*Gadus virens*) and above all Cod (*Gadus callarias*) now occur in quantities there. Cf. Ad. S. Jensen & Paul M. Hansen: Investigations on the Greenland Cod, pp. 39—40 (Rapports et Procès Verbaux, Vol. LXXII, 1931).

Apparent cause of spawning migrations of the Greenland Halibut.

The reason why the Greenland Halibut migrates, and this is a matter of very great distances so far as North Greenland is concerned, to reach the places suitable for spawning, must be sought for in the hydrographical conditions. As already mentioned several times, the Greenland Halibut is a deep-water fish, but for spawning purposes it apparently requires a certain degree of warmth in the water. We find also, that the water with the highest temperature at the depths where the Greenland Halibut spawns (ca. 600—1000 m.) occurs out in the Davis Strait to the south of the submarine ridge, which extends across from Greenland to America almost at 67° N. L. (Holstensborg-Cumberland Ridge). This forms a well-marked boundary between the two areas Davis Strait and Baffin Bay. Whilst the deeper layers in question south of the ridge are of Atlantic origin, with a temperature of 3.5°—4.5° C. and salinity over 34.50 ‰, the corresponding layers north of the ridge are mixed with polar water and have almost everywhere a temperature of less than 2° C. and salinity below 34.50 ‰. Consequently, this ridge forms the northern boundary of the spawning area for the Greenland Halibut.

In the Greenland Halibut we have an example of a species, which has adapted itself to live under varied conditions and thus has spread over a wide area, whilst in the period of reproduction it seeks a definite, comparatively restricted area more uniform in hydrographical regards.

Nursery grounds of young Greenland Halibut.

The "Tjalfe" and "Dana" investigations have supplied us with information regarding the places where the Greenland Halibut grows up, after changing over to the bottom-stage. In one haul with the trawl, of one hour's duration, made 27.VI 1925 by the S/S "Dana" west of Disko Island, Station 2363 (see Chart E), 69°30′ N. L., 56°32′ W. L., the large number of 666 small Greenland Halibut, 85—125 mm. long, were taken at a depth of 202 m. on soft bottom. By far the most of them (493 specimens) were 100—110 mm., representing apparently the I-group. Further we have a number of trawl hauls made by the "Tjalfe" in Disko Bay in the summer of 1908, which showed that young Greenland Halibut (114—480 mm. long) occurred everywhere in rich quantities, where the bottom consisted of clay or mud at a depth of ca. 300—450 m., and enormous areas up there satisfy these conditions. These extensive areas with soft bottom round the island of Disko have an extremely rich life of small animals of many kinds — small fish, Crustacea, worms etc. — and thus obviously form excellent nursery grounds for the growing Greenland Halibut. In the outer part of Umanak Fjord also the trawl hauls of the "Tjalfe" at the

end of July discovered considerable quantities of young Greenland Halibut (285—410 mm.) at a depth of 520 m. — As evidence that young growing Greenland Halibut occur also in the fjords of South Greenland it may be mentioned, that in the course of years I have had a score of small Greenland Halibut sent me, down to a size of 110 mm., which had been washed up at the fishing station in Agdluitsok Fjord (south district of Julianehaab). On 28. and 29.IX.1919 almost all the larger Cod taken in the Ikertok Fjord (Holstensborg District) had their stomachs full of small Greenland Halibut (130—235 mm.); and in Amerdlok Fjord in the same district fishermen trawling the deep-water prawn (*Pandalus borealis*) in depths of 350—500 m. in May 1935 obtained a considerable number of small Greenland Halibut at the same time, in some days as many as 50—100 specimens 150—300 mm. in length. It is on the whole remarkable, that small Greenland Halibut may occur in several fjords of South Greenland from which no or only a few adult specimens are known.

Dimensions of Greenland Halibut.

The size at which the Greenland Halibut becomes adult (sexually ripe) is still not known; we only know from the foregoing, that the female may be mature at a length of 650 mm. and the male at 550 mm. Regarding the dimensions of adult specimens the following information may be given: the average weight of 2259 Greenland Halibut bought at Jakobshavn in the summer of 1908 was 8.7 kg.; the average weight of 4805 Greenland Halibut dealt with in the winter of 1908—09 was 9.3 kg. In the southern parts of Greenland the fish is on the whole smaller than in the northern. During the fishing experiments in Agdluitsok Fjord (south part of Julianehaab District) in 1909 I had 2753 Greenland Halibut weighed, which the Greenlanders had caught from kajaks with hand-lines, and the average weight was 5.2 kg., whilst the average weight of 1133 fish caught on lines by the Expedition in the same fjord was 6.1 kg. Measurements of several thousands of Greenland Halibut from the same fjord showed, that the males are much smaller than the females; whereas the females could reach a length of 114 cm. and a weight of 17.5 kg., the largest male was only 83 cm. long and weighed 6.5 kg.; of the males weighed only 11.5 % were 4 kg. or more. Thus among these, on the whole large fish the males were decidedly in the minority; of 2632 Greenland Halibut examined as to sex only 6.7 % were males. It may be remarked further, that these statements of weight etc. can hardly be taken as representing the conditions of the present day; under the influence of the increasing fishery it would appear that the average size is decreasing. — The largest Greenland Halibut I have received information about from Greenland was 120 cm. long and weighed 44.5 kg.[1]

[1] This is probably the maximum size which the Greenland Halibut is able to attain to. There are statements in the literature of the species reaching up to 80 kg., but these are certainly mere fables.

Metamorphosis of Greenland Halibut and later changes.

Previous accounts.

The Copenhagen Zoological Museum contains from an earlier period a young specimen, 51 mm. long, of a Flat-fish from Greenland determined as *Reinhardtius hippoglossoides*; this was mentioned quite briefly as well as figured by C. G. Joh. Petersen (1893).[1] In a later paper (1904) Petersen expressed a doubt, whether the specimen should not rather be referred to *Hippoglossus vulgaris*. The first determination however was quite correct.

In 1895 the Danish "Ingolf" Expedition obtained two, still smaller specimens in the Davis Strait (34 and 36.5 mm.), which I determined as *Reinhardtius hippoglossoides*. I mentioned this discovery to Johs. Schmidt at the time he was writing a paper on the pelagic larvae of the Halibut and he was pleased naturally at being able to include the related Greenland Halibut; in his report (1904) Schmidt gave a detailed description with figures of the "Ingolf" specimens. At the same time Schmidt gave an account of some larger specimens (51—125 mm.), which came from West Greenland and like the foregoing had been preserved in the Zoological Museum under the name of *R. hippoglossoides*.

Schmidt, who referred the species to the genus *Hippoglossus* and called it *H. hippoglossoides*, gave as its chief characteristics: "The development and metamorphosis is, compared with that of other pleuronectids, exceedingly slow. Thus in the specimen of 34 mm. the rays are not quite formed and it is nearly quite symmetrical, only the left eye being situated a trifle higher than the right. Among the flat-fishes it is also quite an exceptional fact, that the migration of the eye should not be completed till a length of 70 mm. It is also most characteristic by its exceedingly elongated narrow shape."

Schmidt also notes, that we possess an excellent character in the number of vertebrae for the separation of the two species of Hippoglossus, *H. vulgaris* having usually 16 + 34, *H. hippoglossoides* 18 + 44 vertebrae.[2]

A shortcoming in the Museum material was, that the preserving liquid (alcohol) had washed out the pigment.

On the "Belgica" cruise in the northern Polar Sea a 24 mm. long specimen of *R. hippoglossoides* was taken in Treurenberg Bay at Spitsbergen (79°55′ N. L., 16°55′ E. L.) on 17.VI.1905; it has been figured and briefly described by the biologist of the Expedition, Einar Koefoed (1906).

H. M. Kyle (1921) has also mentioned and figured the earliest larval stage of this form from specimens in my collection.

[1] See list of literature at end of the present paper.

[2] Schmidt's specimens were taken to the east of Iceland. In 4 adult specimens from West Greenland I have found the following number of vertebrae: 17 + 43, 17 + 43, 17 + 43 and 17 + 44; in 3 small specimens (97—114 mm.) 60—63 vertebrae were counted.

Present investigations.

The materials for the present study are mainly those collected by myself on the "Tjalfe" Expedition of 1908 and 1909 and "Dana" Expedition of 1925; other material has also been obtained from West Greenland at various times.[1]

Bathypelagic larvae (10—18 mm.).

Larvae with yolk-sac (Pl. I, Figs. 1 & 2).

The length of the yolk-sac occupies about $^1/_4$—$^1/_6$th of the length of body. From the top of the head round to the gut the body is surrounded by a continuous embryonic fin, without rays. Pectorals are present, consisting of a more solid peduncle and a membranous hind portion with fine fibrillar lines (embryonic fin-rays) at the base. The notochord is not yet bent upwards at the end but remains straight the whole way.

Some specimens (Pl. I, Fig. I) are quite lacking in dark pigment, even the iris is unpigmented or shows only a faint indication of dark pigment. Other specimens (Pl. I, Fig. 2) show a faint pigmentation in the hindmost part of the caudal region, especially under the notochord a little in front of its tip, where later the caudal fin elements will be laid down. In some specimens a row of dark spots extends forwards along the under side of the body and dark pigment may also occur on the hindmost part of the gut. In these the eye is also pigmented, in a ring round the pupil, and more or less dense pigment is present on the remaining part of the eye-ball.

Larvae with reduced or almost wholly consumed yolk-sac.[2]

In these specimens the pigment has developed and now extends, not only over the parts mentioned in the pigmented larvae of the previous group, but also on to the abdominal region; the pigmentation has now essentially the same distribution as in the younger pelagic larvae (Pl. I, Fig. 3). The hypural elements of the caudal fin may now be present and the notochord bent upwards slightly.

Pelagic larvae, transitions to the bottom-stage and later changes.

Young pelagic stages (16—24 mm.).

In a 17 mm. long specimen (Pl. I, Fig. 3) the shape is still symmetrical, but the left eye is slightly higher than the right.

The body is very elongated, its height (behind the gut) being only about one-

[1] Up to the present only preliminary notices, not illustrated by figures or charts, have been published regarding these investigations (Ad. S. Jensen 1909, 1925, 1926; cf. literature p. 30).

[2] Authors generally call these stages where the yolk-sac is still present "Larval stages", and the later stages when the yolk has been absorbed "postlarval". I prefer to use the term "larvae" for all the stages, including those in metamorphosis. Mayhoff has rightly objected to the former definition: "so wären auch die Kaulquappen der Anuren und was nicht sonst (?) als "Postlarven" zu bezeichnen" (Zur Ontogenese des Kopfes der Plattfische; Zool. Anz., 43. Bd., 1913—1914, p. 390, Note 7).

twentieth of the length of the body; including the vertical, marginal fin-membrane, the greatest height is only about one-fifth of the total length.

The hindmost part of the gut (rectum) descends obliquely in the vertical fin-membrane and can be seen as a projecting tube or process under the body; the anus is situated close behind the end of the anterior third of the whole body.

The end of the notochord is straight or more or less bent upwards. Of fin-rays in the continuous marginal fin only traces of those of the caudal fin can be detected, and they lie under the notochord. The pectoral fins are comparatively large, with only embryonic rays; ventral fins wanting.

Of the dark pigment we find a row of short streaks, composed of small dots, along each side of the lower half of the body, from the caudal fin to the gut, at streak for each muscle segment and lying on the lines between the segments. In continuation of these a row of stellate spots above the gut, but under the surface (skin) through which however they can be seen plainly. Pigmentation is also present over the posterior parts of the vertical fin-membrane (arranged in rows along the rays of the caudal) and also partly on the lower part for a shorter or longer distance forward towards the gut. The descending, rectal part of the gut is also pigmented, as also the "stomach" and a vertical line from the posterior corner of the gill-cover down to the ventral margin.

Lastly, we may observe (especially by transmitted light) a series of dark spots along the sides of the body, above the notochord, but deeply situated though more or less apparent through the tissues; they are arranged on the lines between the muscle segments. The iris is very deeply pigmented, in part black. — A further extension of the pigmentation is seen in the largest specimens (23—24 mm.), some dark spots being added on the top of the head and neck, extending also partially over the upper part of the body.

Older pelagic larvae (25—57 mm.).

When the larva has reached a length of about 25 mm. (Pl. I, Fig. 4) we notice a faint streak or ridge appearing above and below the contour of the body, from the root of the tail some distance forward; this is the beginning of the interspinous region.[1] At a length of 26 mm. already these streaks may extend as far forward as a line through the anus; at the same time we can detect in them short vertical rays, the beginnings of the interspinous bones (Pl. I, Fig. 5).

At this length (26 mm.), though generally later, the rays of the dorsal and anal fins begin to show; they project from the interspinous region out into the unpaired fin-membrane (Pl. I, Fig. 5), posteriorly at first and then farther forwards; in the beginning the rays are quite short but they gradually become more extended (Pl. II, Fig. 6) and finally reach right out to the margin of the fin at a length of 35 mm. or a little more.

[1] The first, faint rudiment of the interspinous region may also be observed already in some specimens of only 22 mm. in length.

After these general remarks we may examine more closely some specimens.

a. A specimen of 25 mm. is figured on Pl. I, Fig. 4. The height of the body is contained about 13 times in the total length; including the marginal fin the height is about 5 times in the length.

The end of the notochord is so strongly bent upwards, that the caudal fin-rays forming on its under side lie almost at the end of the body.

An interspinous region has begun to form as a low border posteriorly along a part of the dorsal and ventral margins of the body, beginning a little in front of the base of the caudal fin and not reaching as far forward as the anus. In the pectoral fins the fibrillar rays reach about $^2/_3$rds of the way out to the margin.

In consequence of the appearance of the interspinous region the pigment row along the ventral aspect of the body now seems to be higher up on the body, and a series of extremely fine pigment grains is now present on the lower interspinous region, partly also on the upper. The deeper lying pigment row above the notochord can be detected, though the sides of the body have become relatively thicker. Pigment is also present on the other regions mentioned in the previous stage (head, abdominal region, hindmost part of the gut etc.).

b. A specimen of 27 mm. is figured on Pl. I, Fig. 5. The greatest height, including the interspinous region, is contained about 9 times in the total length, and about $4^1/_2$ times when the vertical fin is included.

The end of the notochord is so strongly bent upwards that the caudal fin lies at the end of the body as in the adult fish and contains fully formed rays. The interspinous region is very distinct, developed along its whole length, and with ossified elements; along its posterior portions the rays for the dorsal and anal fins have begun to develop.

Pigment spots are present at the base of the caudal fin and on its rays as well as on the membrane connecting it with the other unpaired fins; on these and on the interspinous regions the pigment is at places dense, thus forming indications of cross bars; pigment is also scattered over the abdominal region, on the upper part of the gill-cover, head, preoperculum, lower jaw and on the snout. Further, fine grains of pigment are seen on the sides of the body along the septa between the muscle segments, as a continuation of the pigment streaks along the lower side of the body, which are also deposited along the septa.

c. A specimen of 32 mm. is shown in Figs. 6 a and b of Pl. II.

This specimen is considerably farther on in development than the previous stage.

The greatest height, including the interspinous regions, is contained about 6 times in the total length, including the marginal fin quite 4 times.

The segmentation of the muscles, already visible in the earlier stages, now shows up very distinctly, and the pigment is very clearly arranged along the zigzag lines separating the segments. The pigment grains are most distinct on the uppermost and lowermost lines, less dense on the intermediate, lateral lines (relatively most dense at the angles along the middle). The pigment grains on the dorsal and

anal fins are not uniformly dense, but are heaped up at certain places into cross-bands, which are continued on to the interspinous regions (in part also on the body itself). The end of the caudal peduncle is bordered by a dense row of pigment, which continues above as a dark line along the upper edge of the caudal fin (traces of this line were also present in the previous stage). Pigment is also present on the top of the head, snout, lower jaw, gill-cover, abdominal region, membrane connecting the unpaired fins, as also on the caudal fin and membrane of the pectoral fins.

Specimens of 33—43 mm. resemble the above in all essentials. Some variation is present however, perhaps due in part to the state of preservation. In some specimens, for example, the upturned end of the notochord extending out over the upper corner of the tail can be distinctly seen. Further, the deeply situated dark spots above the notochord can still be seen in some of these comparatively large larvae.

The incipient depression in the marginal fin behind the dorsal and anal fins now becomes gradually deeper, so that these fins are now definitely limited posteriorly; the rayless part of the membrane remains as a low fold of skin above and below at the root of the tail. At a length of 33—35 mm. the embryonic rays of the pectoral fins are fully developed, reaching from the peduncle right out to the margin of the fin.

On the abdominal wall also the pigment is arranged in lines along the myomeres.

The number of vertebrae can be determined in specimens of 33—35 mm. in length and appears to lie between 61—63 (it is difficult to give the exact number, as the first and last parts of the vertebral column are very indistinct).

The larva is still perfectly symmetrical and similarly pigmented on the two sides, but the left eye is just a trifle higher up on the head than the right eye (cf. Pl. II, Figs. 6 a and 6 b).

d. Length 54—57 mm. (Pl. II, Figs. 7 a and 7 b).

The greatest height, including the interspinous region, is contained quite 4 times in the total length.

The form is still bilaterally symmetrical, though signs of the later obliquity are present; thus the eye of the left side is distinctly higher up than that of the right, its upper edge appearing above the profile of the head. And, though the dark pigmentation is practically the same in distribution on both sides, yet it is stronger on the right side (Fig. 7 a) than on the left side (Fig. 7 b).

The pectorals have only embryonic rays. The ventrals or pelvics are now present, with well-developed rays (they are present already, though extremely small, in a specimen 43 mm. long).

The dark cross-bands of pigment on the dorsal and anal fins are very distinct, also extending in over the interspinous regions (still marked off from the body). A very distinct pigment row runs along the upper and lower edge of the body, below and above the interspinous region. The lower edge of the upper and lower jaw is pigmented; otherwise, the pigmentation is much the same as in stage c.

e. A specimen 65 mm. long (Pl. III, Figs. 8a and 8b) which was driven on shore on 5.IX.1916 at Sydprøven (south district of Julianehaab).

The greatest height, across the anus, is contained 4 times in the total length.

The eye of the left side has now mounted so high up that it occupies almost an intermediate position between the side and upper ridge of the head.

The left side (Fig. 8b) is much paler than the right; we still find on the left side the previously mentioned, characteristic distribution of the pigment (along the posterior edge of the myomeres or muscle segments), but the pigment spots are fewer in number than on the right side (Fig. 8a), where the markings are prominently displayed. The dark cross-bands on the dorsal and anal fin are very distinct on the right side, and also over the interspinous regions; on the right side also we find larger and smaller dense patches of pigment, which give this side a blotchy appearance (Fig. 8a). The pectorals, in addition to the embryonic rays, now show the beginnings of true rays.

A 68 mm. specimen, found drifting on the surface in August 1914 in Skovfjord (north district of Julianehaab), has essentially the same markings as the above.

In specimens of 70, 74 and 75 mm. the "wandering" eye advances still farther up the side of the head; in a specimen of 79 mm. it is situated right on the upper edge. These specimens were sent from Greenland without any information as to how or where they were taken.

In specimens of 85 mm. the "migration" of the eye may be regarded as finished, the eye of the left side now lying on the upper ridge of the head, but inclining towards the right side, so that two-thirds of the eye lie to the right of a line from the mid-point of the snout to the dorsal fin. These specimens of 85 mm. have been living on the bottom; the "Dana" has obtained specimens down to a length of 85 mm. in the bottom-trawl (cf. p. 17). In specimens of this size (85 mm.) and above, up to the mature, there is but little variation in the position of the eye; it is placed constantly on the ridge of the head, though inclining so much to the right side, that two-thirds or three-quarters of it lie to the right of a line from the mid-point of the snout to the front end of the dorsal fin.

That the larvae still live pelagically at a length of 57 mm. is well-known (cf. p. 15); the 68 mm. specimen mentioned above has also been pelagic in all probability (it was taken floating on the surface and its body is still in parts transparent etc.).

At a length of 33 mm. rudiments of teeth are seen in the premaxillaries and lower jaw; at a length of 35 mm. there are 2—3 distinct teeth in the front part of the premaxillaries.

The scaly covering is present along the lateral line in a specimen 70 mm. long and traces can also be seen elsewhere. In a specimen of 79 mm. in length both sides are covered with scales; similarly in an 85 mm. specimen.

Regarding the pigmentation these stages of 70—79 mm. do not yield good information, as they have been preserved in spirit and the pigment has thus been

more or less washed out. In specimens of 85 mm., where the pigment is well preserved, the left side is quite clear, but little pigment remaining and this is only seen under the lens; but the dorsal and anal fins show distinct cross-bands. The right side is quite dark, the dark pigment grains now lying very closely together; in addition, there are many smaller and larger, dark spots or blotches. In others, 95—115 mm. long, the left side is white with fine pigment dots chiefly along the upper jaw and anterior margin of the head as well as on the caudal region and partly on the interspinous regions. The cross-bands are apparent on the dorsal and anal fins. The right side has become very dark in consequence of a very great increase in number of the pigment grains; further we find quite a number of dark patches, especially on the anterior half of the body. The head is almost quite black.

In a specimen 125 mm. long, well-preserved in formalin (Pl. III, Figs. 9 a and 9 b) the left side (9 b) appears white to the naked eye, but under the lens some extremely fine, dark grains of pigment can be seen, especially at the following places: along the lower edge of the lower jaw, on the front and upper edge of the snout, preopercular area, abdominal region and caudal peduncle, but especially on the dorsal and anal fins, where the cross-bands are still distinct. On the right side (9 a) the cross-bands are still prominent on the dorsal and anal fins, partly also on the interspinous regions, though the intervening spaces between the bands are now somewhat densely pigmented. On the body itself the fine grains of pigment are densely strewn over the whole surface, so that the total picture of the right side is quite dark; in the background also there is a fairly large number of larger and smaller, still darker brown patches. The snout is almost quite black. The caudal fin is very little pigmented and thus shows up light, whereas the paired fins are more densely pigmented. The pectorals now have only the permanent rays. — A second specimen of 125 mm. in length likewise shows a perfectly white left surface to the naked eye, and with the lens still fewer, dark pigment grains can be noticed.[1]

The further development of the pigmentation on the two sides tends in the later sizes in the direction of evening out the differences between the left and right side. In a specimen 153 mm. long (from Jakobshavn) the left side is certainly still very light-coloured, but the dark spots of pigments have increased considerably. In a specimen of 160 mm. ("Tjalfe" Expedition) the dark pigment points have already become quite dense on the left side. In two specimens of 167—168 mm. ("Tjalfe" and "Dana" Expeditions) the colour distribution is quite different from that of the

[1] A peculiar variation is shown by a 143 mm. specimen taken 18.IX.1916 in Kangamiuts Havn. The left side is completely white, even with the lens pigment spots can hardly be detected (only a narrow dark streak right forward along the border of the snout and quite weak pigmentation at one or two places on the dorsal and anal fins). The right side is without patches and cross-bands, entirely clear on the hindmost part of the body, which in front assumes a faintly greyish sheen whilst right in front there is dark pigment on the head. Excluding the right side of the head, one might call this specimen an "albino". As a very rarely occurring irregularity it may also be mentioned, that in 1921 a Greenland Halibut was taken in Agdluitsok Fjord, 4 kg in weight, which was tinged reddish-yellow like a gold-fish, thus an example of xantochroism.

specimens of 125 mm., the left side no longer being white but now densely strewn with black pigment points, which give this side a greyish or light-brown appearance, though still somewhat light by comparison with the very dark right side. Some variation is present however; a specimen of 174 mm., even one of 198 mm., showing a comparatively lighter left side. In specimens of 195, 210, 212 and 222 mm. the left side is fairly dark, with densely packed dots of pigment, and in specimens of 243, 252, 252, 262, 289 and 307 mm. these are even more dense, so that the colour is becoming darker and approximating to that of the right side; this condition persists in the larger, more grown-up specimens.

When the dark patches on the right side disappear, to leave it uniformly pigmented, cannot be determined with certainty. They are not to be seen in the specimen of 153 mm., nor in those of 160, 167 and 174 mm.; but as these specimens were preserved in alcohol, it is conceivable that the speckled markings had been lost, though this is hardly probable, as they are distinctly seen in smaller specimens preserved in alcohol. In any case, no spots can be observed in specimens of 195 and 198 mm. preserved in formalin.

The dark cross-bands on the dorsal and anal fins can still be seen distinctly in two specimens of 198 and 210 mm. (partly even in a specimen of 222 mm.), but some variation occurs in their disappearance, as they cannot be seen in a specimen of 195 mm., in which the dorsal and anal fins are already very dark and uniformly pigmented. In the somewhat older there is a narrow, light strip along the free, outer margin of these fins.

In the fully pigmented fish (Pl. IV, Figs. 10 a and 10 b) the colour is thus very dark on the right side, sooty in colour, whilst the left side is similar but less dark; the outer part of the unpaired fins is black, but with a light strip along the margin.

To determine how far the shape of the body undergoes changes in the later stages, I have measured the dimensions of 36 specimens, 65—400 mm. long; in these the greatest height of the body (fins not included) is contained from $3^1/_{10}$ to 4 times in the whole length of the body; some difference thus prevails, but it is individual, and this proportion cannot be said, on the whole, to change with age. In a much larger specimen (690 mm.) the greatest height (212 mm.) is contained $3^1/_4$ times in the total length.

Summary of reproduction and developmental history of the Greenland Halibut.

The number of eggs in large females amounts to ca. 300,000. When the eggs are ripe, they have a diameter of 4—4.5 mm. and are glass-clear.

The Greenland Halibut does not spawn in the fjords or bays of West Greenland, nor at the coasts, but in great depths out in the Davis Strait, south of the

submarine ridge which extends across from Greenland to America almost along the Polar Circle; the northern boundary of its spawning area lies about $66^{3}/_{4}°$ N. L.

The tiny fry, 10—18 mm. long, occur bathypelagically in the Davis Strait, south of the submarine ridge mentioned, at a depth of ca. 600—1000 m.; later they rise towards the surface and in the summer time, at sizes from 16 mm. onwards, they are found in the upper layers about 30 m. below the surface, not only over great depths, but also — scattered by marine currents and by active wanderings — over the banks and in the coastal waters.[1]

Even at the considerable size of 54—57 mm. the larvae are still bilaterally symmetrical, though with signs of the oncoming asymmetry; thus, the eye of the left side lies distinctly higher up than that of the right side, so that its upper border reaches above the profile of the head, and the dark pigmentation is stronger on the right than on the left side.

At a length of 68 mm. the eye of the left side has advanced so far upwards that it occupies an intermediate position between the side and top of the head; the left side is much paler than the right.

In a specimen of 85 mm. the shifting of the eye is completed, the eye of the left side lying on the upper edge of the head, but inclining to the right side.

The young fry are still living pelagically at a length of 57 mm., and thus towards the end of the summer are able to spread to the north of the boundaries of the spawning areas. The pelagic mode of life ends probably about a length of 70 mm., possibly even a little over that.

After the fry have changed over into the bottom-stage, the left side loses its pigment more and more and gradually becomes quite light, quite white to the naked eye, whilst the right side is dark with still darker spots; the condition is thus as is usual in Flat-fishes. And we still find this in specimens of 125 mm. in length. But the further development of the pigmentation moves gradually in the opposite direction to the usual. In a specimen of 153 mm. the left side is certainly still very light coloured, but its covering of dark pigment dots has increased considerably; at the same time the dark patches on the right side have been disappearing, and this side has become uniformly dark. In a specimen of 160 mm. the dark dots now lie densely over the left side, and at 167 mm. the left side no longer appears white, but has a light-brownish tinge of colour, though still light by comparison with the very dark right side; even at a length of 200 mm. the left side may still be comparatively light coloured. From a length of 250 mm. onwards the colour of the left side is always dark, approximating to that of the right side.

[1] At East Greenland larvae of the Greenland Halibut were taken at the following places: 61°13′ N. L., 40°57′ W. L., 25.VII.1925. "Dana" Exped.; 50 m. w.; 1 spec.; 40 mm. 100 m. w.; 2 spec.; 44 & 47 mm. — Nanusek Fjord (small fjord just N. of Lindenow Fjord); 26.VIII.32. Eel seine. Paul Hansen. 1 spec. ca. 70 mm. — 65°38′ N. L., 37°16′ W. L. Tasiusarsik Fjord. "7. Thule" Exped. (E. Bertelsen). 21.VII.1933; 4 spec. 35, 38, 44 and 55 mm.; taken with dip-net at ice foot (still living then).

Cause of the distinctive features in the metamorphosis of the Greenland Halibut.

If one should ask, what reason can there be for the differences and change in the Greenland Halibut, which to begin with goes through the same transformation as other "dextral" Flat-fish: — symmetrical in the beginning as tiny larva, then becoming asymmetrical which leads to the right side being coloured, the left side white — but later passes over into a new (and final) appearance, where the left side is coloured. I believe the answer to this problem can be found in a consideration of a characteristic feature in the mode of life of the species, namely, that the Greenland Halibut unlike other Flat-fishes is not markedly a bottom-fish, but lives at times up in the intermediate layers. This peculiarity has been determined during the fishery of the Greenlanders in Agdluitsok Fjord (south district of Julianehaab).

In spring the Greenland Halibut fishery with long-lines may be a failure, whereas at the same period the fishery with hand lines yields a good booty. Both sorts of apparatus are used at places where the depth is 300 m., but whilst the hooks of the long lines lie on the bottom, the hand-fishers have only 200 m. line out; they fish therefore at a depth of 200 m. and make their catches at this depth. At this time therefore the Greenland Halibut is not living at the bottom, but has come up into the higher layers, about 100 m. above the bottom. And as the fish taken under these conditions prove to be full of Capelin, the Greenland Angmassat (*Mallotus villosus*), we may suppose that the Capelin shoals are moving about at this level and that the Greenland Halibut leave the bottom and mount into the free, upper layers just in their pursuit.[1] During this pursuit in the intermediate layers not only the right, but also the left side is exposed to the light[2] and becomes coloured, though to a less degree than the right side, since the Greenland Halibut at other times passes its life on the bottom, presumably lying on the left side. The structural feature, that the eye of the left side has not migrated completely over to the right side, but remains on the ridge of the head, may also be explained by reference to this condition, that the Greenland Halibut at times rises from the bottom and travels about in the free layers of water in pursuit of small fish (Capelin). Under such conditions it is naturally an advantage for the Greenland Halibut, that the one eye is situated on the forehead; since, whether it occupies a vertical or oblique position during its movements in the water, its field of vision must be

[1] The wide gape equipped not only with ordinary pointed teeth, but also with strong tusks in front (cf. the figure p. 3) would indicate that the Greenland Halibut is a roving, rapacious fish.

[2] There can scarcely be any doubt, that some of the rays of light at any rate may be able to penetrate down to this depth, even if the conditions in these northern waters are far from being comparable with those in the Sargasso Sea, where the influence of sunlight may be detected by photographic plates even at a depth of 1000 m. under specially favourable conditions (cf. Murray & Hjort: The Depths of the Ocean, p. 663 (London 1912).

considerably greater than if both eyes were situated on the same side. — But it is not only in the spring that the Greenland Halibut pursues the Capelin. I have myself very frequently found this fish in their stomachs in the period from beginning of June to the first half of August; in the south-western part of Disko Bay I have found the Greenland Halibut quite full of Capelin about the middle of July. I have discovered also, that the food of the Greenland Halibut consists in addition to an essential extent of the Polar Cod (*Gadus saida*), small Red Fish (*Sebastes marinus*), prawns (*Pandalus borealis*) and the 10-armed squid, thus animals that are not restricted exclusively to the bottom but wander about in the open waters higher up.[1]

From the smaller degree of asymmetry (position of the one eye on the dorsal surface of the head and colour of the blind side) one might suppose, that *Reinhardtius* was a primitive form among the Flat-fishes, i. e. closer to the typical Teleosts. Its ontogenetic development however is all against this; the metamorphosis proceeds in the main just as in other Flat-fishes. We may imagine, that the arrest of the left eye at an early stage, when it has reached the top of the head, is a secondary adaption to the divergent mode of life of the adult Greenland Halibut; whilst, later, the free swimming in the intermediate layers probably has the effect, that the left side becomes almost as much coloured as the right side and for the same reason its musculature becomes developed.

The drawings for this paper have been made by Professor C. M. Steenberg, Mag. sc. I. Lieberkind and the artist P. Winther, whom I wish to thank for their efforts. I have also to thank Dr. H. M. Kyle for translating the Danish manuscript into English.

Résumé.

It has been shown that the Greenland Halibut (*Reinhardtius hippoglossoides*) does not spawn where the fishery of the adult fish is carried on, namely, in the fjords and bays of West Greenland. The spawning places lie far from there, out in the deep parts of the Davis Strait south of the submarine ridge, which extends about 67° N. L. from Greenland over to America. This ridge forms a hydrographical boundary in such a way, that the deep waters south of the ridge, to which the Greenland Halibut migrate to spawn, are of Atlantic origin with relatively high

[1] Some months after this paper had been written, I received the following information in a letter from the settlement of Godthaab, dated 8.VI.1935; it came from Cand. mag. Paul Hansen, who is carrying out fisheries investigations at Greenland and in the course of these marking a number of Greenland Halibut for the purpose of throwing light on their migrations: "It appeared that the fish (Greenland Halibut caught on hooks) bore the hauling up and marking extremely well, as they quickly descended in the water thereafter. Apparently the Greenland Halibut swim like ordinary fishes with the dorsal edge (fin) upwards; we observed this when the fish were liberated." The passage emphasized by me is further support for the suggestion put forward above, that the Greenland Halibut takes up a vertical position when swimming freely in the water.

temperature and salinity, whilst the corresponding layers north of the ridge are mixed with polar water. The eggs and tiny larvae are bathypelagic and are found at depths of 600—1000 m. The larvae later rise towards the surface, where they live pelagically and are gradually scattered on the one hand in towards the coasts of South Greenland, on the other northwards towards North Greenland. Not till a length of about 70 mm. do they change over to the bottom-stage. At first the larvae go through the same transformation as other Flat-fishes, symmetrical in the beginning, thereafter asymmetrical — the left side becoming white and its eye wandering over towards the right side; but in contrast to other northern Flat-fishes the left eye here does not migrate right over to the right side, but remains on the upper edge of the head, whilst the left side becomes coloured and gradually almost as dark and muscular as the right side. This phenomenon is connected with the fact that the Greenland Halibut unlike the other Flat-fish does not always remain at the bottom, but at times comes up into the intermediate water-layers in pursuit of other fishes.

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Contents.

Explanation of the Plates.

(The dimensions given indicate the natural size).

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Fig. 1. Bathypelagic larva, 15 mm.; "Tjalfe" 8.V.09, St. 336.
- 2. Bathypelagic larva, 16 mm.; "Tjalfe" 10.V.09, St. 345.
- 3. Pelagic larva, 17 mm.; "Dana" 7.VI.25, St. 2313.
- 4. Pelagic larva, 25 mm.; "Dana" 3.VII.25, St. 2378.
- 5. Pelagic larva, 27 mm.; "Dana" 3.VII.25, St. 2378.

Plate II.

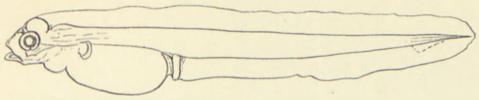
Figs. 6 a & b. Pelagic larva, 32 mm. from right and left side; "Dana" 14.VII.25, St. 2421.
- 7 a & b. Pelagic larva, 57 mm. from right and left side; "Tjalfe" 28.VIII.08. St. 221.

Plate III.

Figs. 8 a & b. Specimen 65 mm. from right and left side, in transition to bottom-stage; stranded in Agdluitsok Fjord 5.IX.16.
- 9 a & b. Specimen 125 mm. from right and left side; bottom-stage. Agdluitsok Fjord 16.X.11.

Plate IV.

Figs. 10 a & b. Specimen 400 mm.; final appearance, from right and left side.



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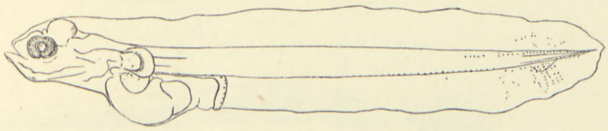

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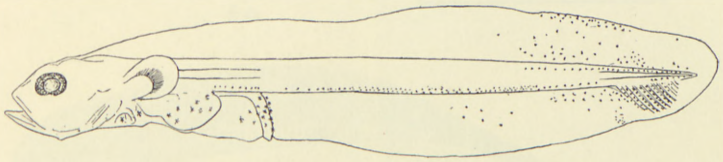

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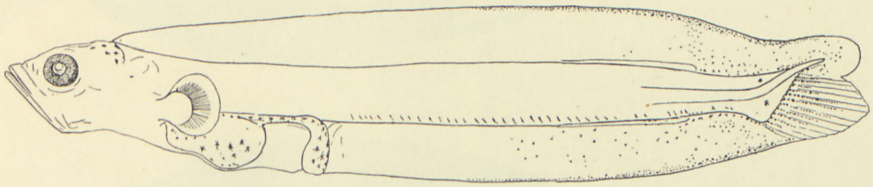

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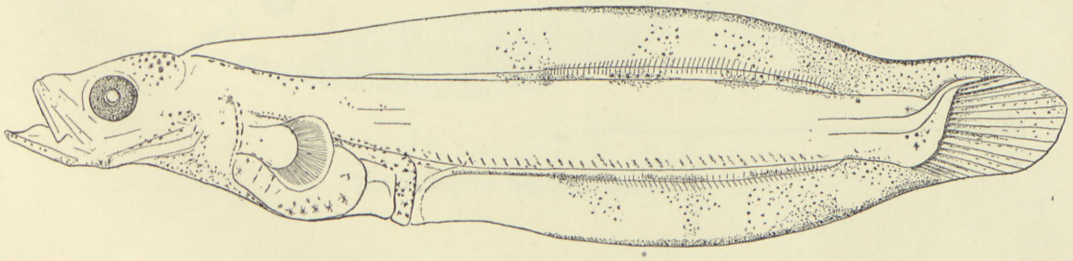

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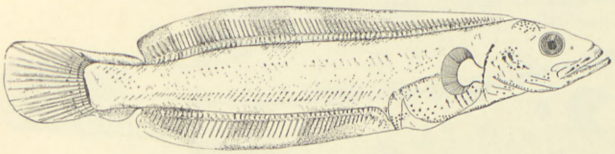

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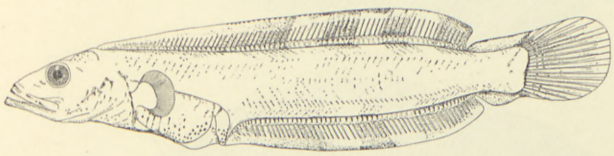

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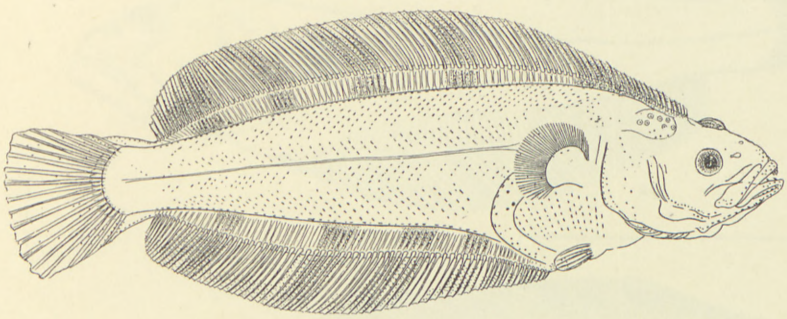

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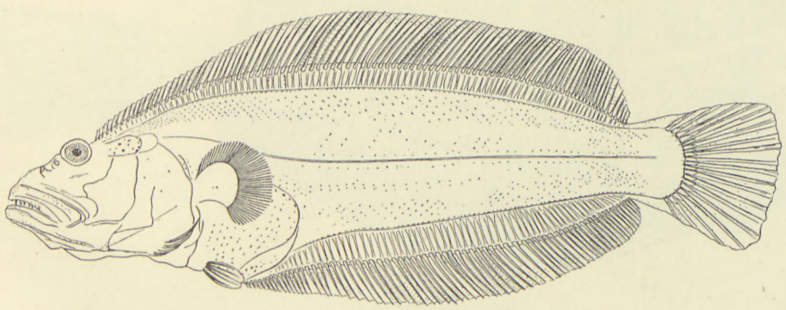

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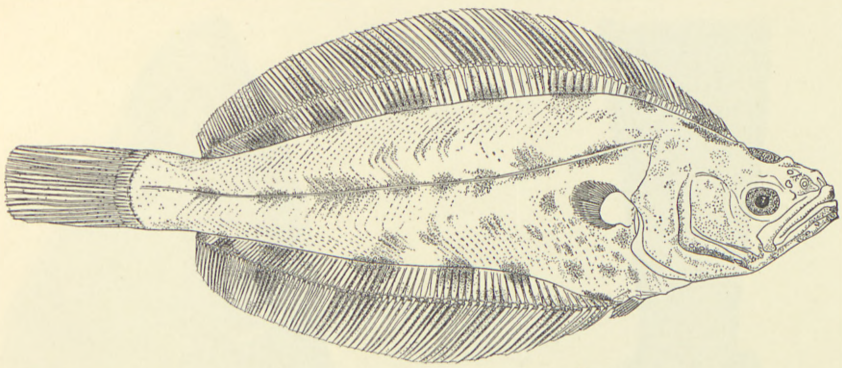

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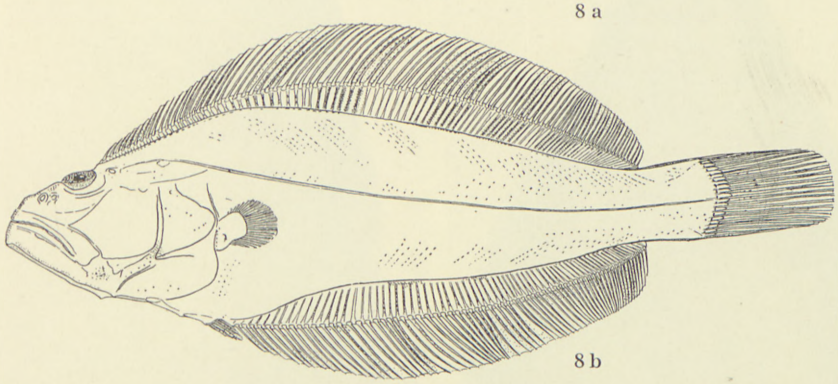

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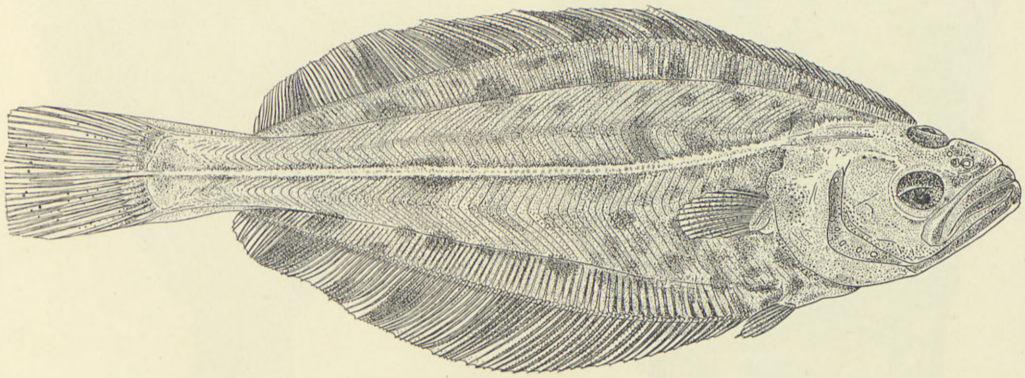

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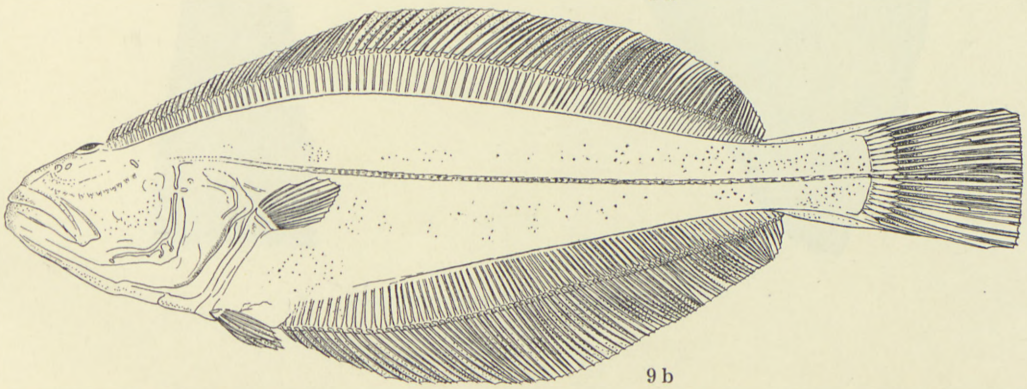

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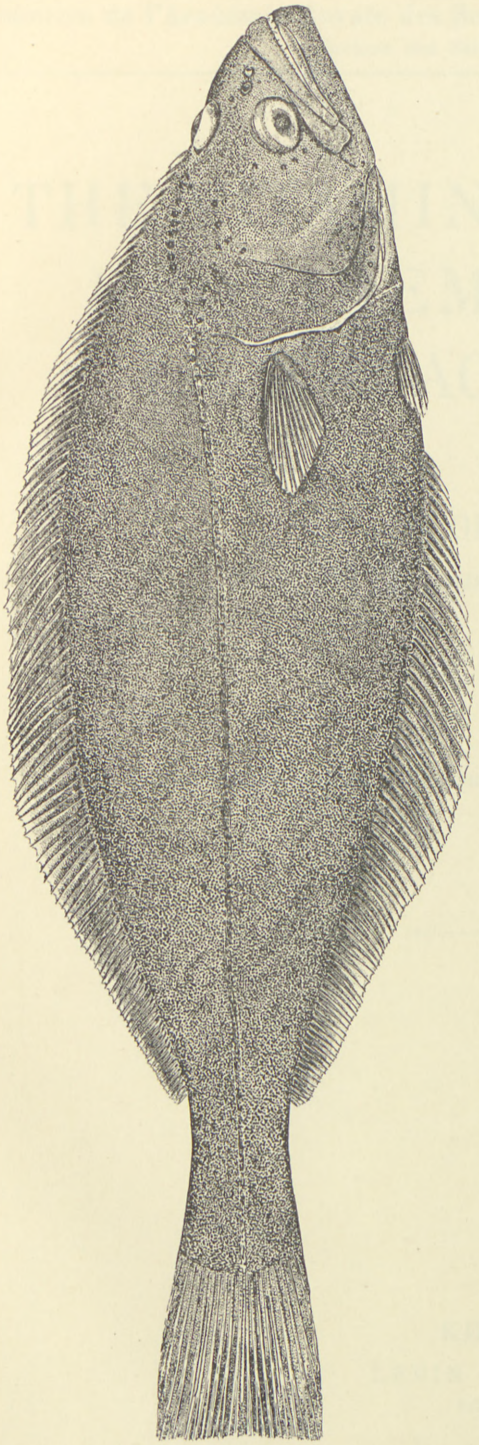

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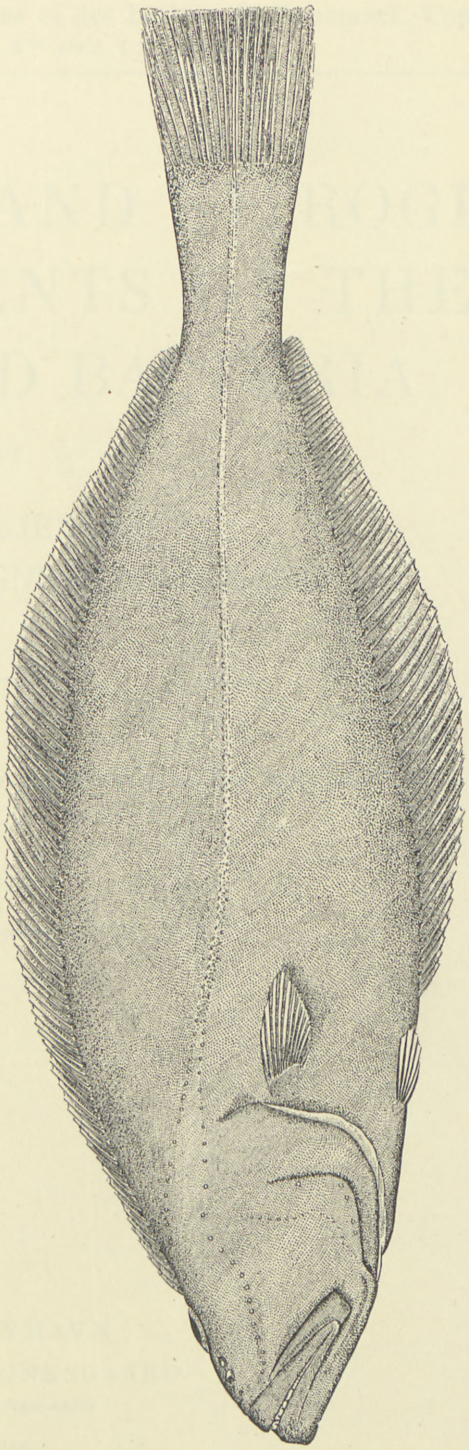

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Reinhardtius hippoglossoides.