

XXVI.—THE PROPAGATION AND GROWTH OF THE HERRING AND SMALL-HERRING, WITH SPECIAL REGARD TO THE COAST OF BOHUSLÄN.

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[Translated from the Swedish by Herman Jacobson.]

The great importance of the herring-fisheries to the Scandinavian countries has led to scientific investigations for the purpose of gaining increased knowledge of all those conditions on which the proper management and administration of these fisheries depend, and with a view of making them as productive as possible. The principal results of these investigations which have been carried on in Norway and Denmark have been given from time to time in the "*Tidsskrift for Fiskeri*" and the "*Nordisk Tidsskrift for Fiskeri*"; and the author of this little treatise hopes to give an account of the Swedish investigations as they are gradually progressing. As such a work may be considerably furthered by observations furnished by those specially interested in the fisheries, who have special opportunities for observing, I have determined to follow the example of two former contributors to this journal, *Axel Boeck* and *G. Winther*, and to work up historically and systematically those portions of the various sciences having a bearing on the subject towards which important contributions may be expected from a large class of people outside of scientific circles, and whose more general knowledge may be of importance for our fisheries. In order to enlighten and benefit this class of people, as well as to derive the fullest possible benefit of their co-operation, it is important that by a short and clear résumé of what has been done hitherto, they should be enabled to gain an insight into the condition of our fisheries.

Among the phases in the life of our salt-water fish whose knowledge may be considerably increased by observations and contributions by the common people, the *visible phenomena accompanying the propagation and growth of the herring* occupy an important place. And with the view of throwing more light on this subject, I wrote this treatise four years ago, and have now reproduced it, embodying all the results of recent investigations, especially those of the German Fish Commission.¹

* *Om sillens och skarpsillens fortplantning och tillväxt, med särskild hänsyn till Bohusläns skärgård.* Af A. V. LJUNGMAN.—[From "*Nordisk Tidsskrift for Fiskeri*," 5th year, part 4, Copenhagen, 1879.]

¹ *Jahresbericht der Commission zur wissenschaftlichen Untersuchung der deutschen Meere in Kiel*, iv-vi. Berlin, 1878.

The coast-herring living in the Skagerack spawns during spring, in suitable places on the coast, few of which seem to have been known to those authors who have written on this subject. The cause of this is probably found in the circumstance that net-fishing, which is best suited for catching herrings during the spawning season, is not very common in Bohuslän, as nets can only in exceptional cases be used in those places where the herrings spawn. An even sand-bottom, free from rocks and stones, is very rare on the coast of Bohuslän, and the drag-nets which are the best for use during the spawning-season cannot easily be drawn across a rocky bottom, which forms the most suitable spawning-place. The herrings, however, seem also to spawn on clayey bottoms overgrown with aquatic plants. Good spawning-places are found quite frequently farther out along the whole coast of Bohuslän, and it is certain that the herrings, though perhaps not in very large numbers, spawn in these places every year; at any rate much more frequently than was thought formerly, when such an occurrence was considered a rare exception.² There has been, even quite recently, a tendency to underrate the number of our coast-herring which spawn in spring.³

With regard to the nature of the bottom on which the herrings spawn the observations made by different authors all agree. As suitable bottoms we generally find mentioned rocky or stony bottom, sand-bottom, bottoms overgrown with algæ or other aquatic plants, whilst it is generally denied that herrings can spawn on soft, muddy bottoms without any vegetation. *Mitchell's* assertion, that herrings cannot spawn on sand bottoms,⁴ may find its cause in the circumstance that the waves stir up the sand on the more shallow banks near the coast of Scotland, which would, of course, disturb the eggs; but his assertion, that the herrings lay their eggs also on hard, clayey bottom,⁵ cannot be properly substantiated. The assertion that the herrings prefer a bottom overgrown by a "peculiar kind of algæ," which "limits the number of their spawning-places to very few,"⁶ is likewise without proper foundation. Although the herring is, therefore, not limited in the choice of its spawning-place, we cannot agree with *Valenciennes*, who says that the herring spawns almost anywhere, in calm weather even out in the open sea.⁶ It is on the contrary our opinion that the herring chooses spawning-places which are not only suitable for hatching the eggs, but also for feeding and protecting the young fish. The herring prefers calm water during spawn-

² WRIGHT, W. V., "*Handlingar rörande sillfisket i bohüslänska skärgården*. Stockholm, 1843, p. 166.—ECKSTRÖM, C. U., *Öfversigt of Kgl. Vetenskaps-Akademien's Förhandlingar*, I, 1844, p. 26, 82.—HOLMBERG, A. E., *Bohusläns historia och beskrifning*. III. Uddevalla, 1845, p. 215.—NILSSON, S., *Skandinavisk Fauna*. IV. Lund, 1855, p. 509.

³ YHLEN, G. V., *Nya handlingar rörande sillfisket i bohüslänska skärgården*. I. Göteborg, 1874, p. 12.

⁴ The herring, its natural history and national importance. Edinburgh, 1864, p. 294.

⁵ The herring, &c., p. 29 and p. 32.

⁶ LOVÉN, S., *Handlingar rörande sillfisket*, p. 160.

⁶ *Histoire naturelle des poissons*, xx, Paris, 1847, pp. 79-80.

ing, and when spawning in fiords and sounds generally keeps near the land. The choice between neighboring spawning-places often depends upon the weather, and it has several times been observed that violent and continued storms have compelled the herrings to spawn at some distance from the coast in places which otherwise were not suitable; as likewise, that in too cold or too warm weather they seek deeper spawning-places, for even prior to spawning they prefer an even temperature. According to *Ekström*, they also prefer places where there is a current.⁷ It has also been observed that the older and larger herrings prefer those spawning-places which are near to the open sea, whilst the smaller and younger ones go nearer the coast or higher up the fiords.

Besides those herrings which regularly spawn at or near the coast, there seem to be some which generally spawn in the open sea on banks suitable for the purpose, located at a sufficient depth to afford protection against any violent commotion of the waves; and it is an old conjecture, that those herrings which during long periods have in large numbers visited the western coasts of Scandinavia for the purpose of spawning, during the intervals visit such banks in the North Sea.⁸ As those portions of the eastern Skagerack near the coast of Bohuslän which are suitable for spawning are limited in extent, are not very well protected, and are generally found to have a comparatively small depth, it will easily be understood why they have not become permanent spawning-places. The supposition that a large race of herrings spawns there regularly every year is therefore not in accordance with the actual facts.

Regarding the depth in which the herrings spawn it seems that they generally prefer a depth of a few fathoms; more recent observations have proved, however, that occasionally they may spawn at a very considerable depth (60 to 100 fathoms), and that the eggs may be hatched there. It is not certain, however, that such a depth is favorable to the raising of the young fish.¹¹ Along the coast of Bohuslän there are probably few spawning-places deeper than 10 to 15 fathoms¹², most of them, especially those higher up the fiords, being only 2 to 5 fathoms deep.

It has long been known and has been mentioned among others by *Pennant* and *Naël de la Morinière*, that considerable quantities of fish-eggs are found floating near the surface of the open sea; the Dutch fishermen even believe that most of the herrings are raised from such floating masses of fish-eggs ("herring-beds"); but, as we shall endeavor to prove, this cannot be the case, as the eggs of the herring are heavier than water and can therefore not float on the surface. In order that the eggs may be fastened to suitable objects, the spawning process should go on near the bottom, and these so-called "herring-beds" owe

⁷ *Die Fische in den Scheeren von Mörkö*. Berlin, 1835, pp. 216, 223.

⁸ A. BOECK, "Om Silden og Sildestekerierne." I. Christiania, 1871, pp. 128-129.—*Tidsskrift för Fiskeri*. VII, p. 39.—*Nordisk Tidsskrift för Fiskeri*. II, p. 263-264.

¹¹ H. KRÖYER, "Danmarks Fiske." III. Copenhagen, 1846, p. 163.

¹² They are nearly all located near the northern portion of the coast, especially from the Väder Islands to Koster.

their existence probably to some species of codfish, to judge at least from the time of the year when they are found.¹³

Regarding the spawning-time of our Bohuslän coast herring it has already been mentioned that it is in spring or from the middle of March till the middle of May, chiefly in April.¹⁴ It must be supposed, however, that the larger herrings, especially on the northern coast, occasionally spawn somewhat earlier, sometimes in February, whilst on the southern coast the spawning season sometimes lasts till June.¹⁵ Hydrological conditions, especially the temperature of the water, exercise a considerable influence on the time when the spawning-season begins; it generally begins earlier on the northern than on the southern coast, on the outer than on the inner coast; earlier also after a mild winter and particularly favorable weather. Cold and especially the formation of ice seem to have a great influence on the time of the propagation of the herring.¹⁶ No race of herrings, as far as known, spawns about the time of the winter solstice, but either so long before this period that the young fish may grow to some size before the hardest winter weather sets in, or so long after it that the newly-hatched fish soon meet with mild weather, or are at least not exposed to the dangers consequent upon the formation of ice. The herrings do therefore not spawn on the coast of Scandinavia during December and the first half of January, nor during the latter half of November.¹⁷ It is probable that the spawning-season of a race of herrings has in course of time been fixed according to the varying occurrences of the food required for the young fish, which chiefly seems to consist of young mollusks and small crustaceans.¹⁸ The spawning-season of the herring in a given locality does doubtless to some extent depend on the propagation of these small marine animals.

As those herrings which spawn in March and April are generally larger than those which spawn in May, these latter are probably herrings which spawn for the first time.¹⁹ The three-year-old herring, which

¹³*Verelag van den Staat der Nederlandsche Zeevischerijen over 1860*, p. 29—*Uitkomsten verkregen uit de journalen der haring-schepen. Berigt bij het koninklijk Meteorologisch Instituut over 1860*, p. 6-7.

¹⁴When speaking of the "spawning-time" of a race of herrings, we always mean the time when large numbers of fish are spawning; and no one should be led to consider another season as the "spawning-time" because both before and after that time some herrings will spawn.

¹⁵P. DUBB, "*Anteckningar om sillfisket Bohuslän.*" Kgl. Vetensk. Acad. Handl. f. år 1817, pp. 35, 44.

¹⁶Compare Professor KRÖYER's excellent remarks (*Danmarks Fiske*, III, p. 170) regarding the influence of the ice on the spawning-time of the herrings in the Baltic.

¹⁷See note 14, as also NILSSON, "*Handlingar rörande sillfisket,*" p. 56. EKSTRÖM, "*Die Fische in den Scheeren von Mörkö,*" p. 220, 223, and: "*Jahresbericht der Commission zur wissenschaftlichen Untersuchung der deutschen Meere.*" IV-VI., pp. 100, 237, 248, 249.

¹⁸*Stockholmsläns Kgl. Hushållnings-Sällskaps handlingar*. VI, Stockholm, 1855, p. 197.—BOECK, "*Om Silden og Sildefiskerierne,*" p. 15.

¹⁹The same opinion has already been advanced by A. W. MALM in "*Göteborgs och Bohusläns Kgl. Hushållnings Sällskaps handlingar,*" 1857, p. 21.

do not finish their spawning in spring, are found early in autumn with strongly developed sexual organs, and therefore spawn somewhat earlier than the other herrings of the same age. It is chiefly these herrings, besides the older and larger ones, which also spawn somewhat earlier on the outer coast, and which, therefore, are not so frequently caught in nets, which have given rise to the assertion that autumn or winter spawning herrings occur on the coast of Bohuslän.²⁰ The sexual organs of the herring develop much slower during winter when food is not so plentiful; for this reason the spring-spawning herrings have their sexual organs developed much longer before the spawning-time than is the case with the autumn-spawning herrings. Whenever, therefore, herrings are observed during autumn with well-developed, firm and hard roe or milt, this is a sure indication that the herrings will soon commence to spawn. The erroneous opinion, which in a similar case has been advanced by *Ström, Malberg, Lybecker, Nilsson, Krøyer, Löberg, Axel Boeck*, and others, concerning the spawning of the Norwegian summer and autumn herring²¹, should be a warning example against hasty opinions based on insufficient observations or data regarding the spawning-season of the herring.²² It is also well known from olden times that the different age of the herrings has an influence on the varying spawning-season.²³ *Nilsson* thus reports that the young herrings at Skelderviken and the coast of North Holland spawn sooner than the old herrings,²⁴ whilst in the Sound the old herrings, according to *Winther*, spawn sooner.²⁵ It seems that those herrings which spawn during winter and spring are, in this respect, the very reverse of those which spawn towards the end of summer and during autumn.

The spawning-time of our Bohuslän coast herrings seems to have remained the same, at least as far as can be judged with any degree of certainty from the more or less distinct notices regarding these fisheries in the "*Trangrums-acten*" (law regarding the refuse from train-oil refineries), in the reports of Mr. *Olancey*, superintendent of herring-fisheries in

²⁰ See my "*Preliminär berättelse för 1874-'75*," pp. 10-12.

²¹ H. STRÖM, "*Physisk og oconomist Beskrivelse over Fogderiet Søndmør*." I. Sörö, 1762, p. 308.—C. R. MOLBERG, "*Afhandling om Saltvandsfiskerierne i Norge*" (Kgl. danske Landhusholdnings-Selskabs Skrifter, iii, Copenhagen, 1790), p. 370.—I. L. LYBECKER, "*Om Fiskene og Fiskerierne; Almindelighed samt om Silde-Fiskerierne i Särdeleshed*," Copenhagen, 1792, p. 82.—NILSSON, "*Skandinavisk Fauna*," iv, pp. 496, 511.—KRØYER, "*Danmarks Fiske*," iii, p. 170.—O. N. LÖBERG, "*Norges Fiskerier*," Christiania, 1864, p. 93.—BOECK, "*Om Silden og Sildefiskerierne*," p. 122.—See, also, G. O. SÆRS, "*Indberetning om de i Aarene 1870-'73, anstillede praktisk-videnskabelige Undersøgelser*," Christiania, 1874, p. 37.

²² Nearly all similar opinions regarding the spawning-time of the herring and the small-herring are also based on the erroneous idea that all successful herring-fisheries must necessarily be spawning-herring fisheries.

²³ See M. E. BLOCH, "*Oeconomische Naturgeschichte der Fische Deutschlands*." I. Berlin, 1782, p. 191.

²⁴ *Handlingar rörande sillfisket*, pp. 56, 58, 60.

²⁵ *Nordisk Tidsskrift för Fiskeri*, iii, p. 12.

Dubb's "*Anteckningar om sillfisket i Bohuslän*," "*Handlingar rörande sillfisket*," and in *Ekström's* and *Malm's treatises*.²⁶

As has been mentioned before, the coast of Bohuslän is at long intervals also visited by large numbers of "genuine sea-herrings," whose spawning-season seems to be towards the end of summer or the first part of autumn, as far as can be judged from the reports on the herring-fisheries during the eighteenth century.²⁷ Among these "sea-herrings" there were found especially on the northern coast a small number of herrings whose spawning seems to have occurred *towards the end of winter or the beginning of spring*,²⁸ but whose relationship could be ascertained with a greater degree of certainty than even that of the great mass of herrings. It is highly probable that the herrings in question which spawn towards the end of winter and generally in the beginning of spring belong permanently to our coast and to its race of coast-herrings, and are in fact its largest, strongest, and, with regard to the sexual organs, earliest developed representatives; it is likewise probable that it is owing to the sea-herrings coming from the North Sea that so many more herrings were caught in nets during the last fishery-period than later. The masses of herrings coming from more distant parts of the ocean drive those herrings which are nearer the land towards the coast, where both are caught together. The same takes place, though to a less extent, with the rich herring-fisheries which occasionally occur in the beginning of the year, which also explains the prevalent opinion that in these fisheries herrings resembling the so-called "old" herrings are caught.²⁹ During the latter part of the last great fishing-period no other fully matured herrings were caught but these last-mentioned ones.

Regarding the spawning-time of the herring, it should here be mentioned that the opinion has been advanced that one and the same herring could spawn more than once a year, and that therefore one and the same race of herrings had two distinct spawning-seasons.³⁰ No con-

²⁶ "*Trangrums-Acten*," Stockholm, 1784, pp. 76, 77, 78.—G. C. CEDERSTRÖM, "*Fisködling och Sveriges fiskerier*," Stockholm, 1857, p. 215.—*Kgl. Vet. Akads. handl.*, 1817, pp. 35, 44.—*Handl. rör sillf.*, pp. 64, 66, 90, 117, 120, 126.—*Nya handl. rör sillf.*, I, p. ix, x.—*Oefvers. af Kgl. Vet. Akads. Förhandl.*, I, 1844, p. 120. C. N. EKSTRÖM, "*Praktisk afhandling om lämpligaste sättet att fiska sill, torsk, långa, makrile, hummer och ostron*," Stockholm, 1845, p. 8.—A. W. MALM, "*Göteborgs och Bohusläns Kgl. Hushållnings-Sällskaps handlingar*," 1856, pp. 9-10; 1857, p. 21.

²⁷ See my "*Preliminär berättelse, 1873-'74*," pp. 19-21, where all the conflicting opinions regarding the spawning-time of the so-called "old herring" are for the first time given in a collected form.

²⁸ NILSSON, "*Handl. rör sillf.*," p. 55.—*Skandinavisk Fauna*, iv, p. 508.

²⁹ See my "*Preliminär berättelse*" for 1873-'74, pp. 29-32.

³⁰ M. E. BLOCH, "*Oeconomische Naturgeschichte*," i, p. 192.—B. G. E. DE LA CEFÈDE, "*Histoire naturelle des poissons*," v, Paris, 1803, p. 434.—*Handlingar rörande sillfisket*, p. 56.—R. PARNELL, "*Memoirs of the Wernerian Natural History Society*," vii, Edinburgh, 1838, p. 319.—*Evidence on the operation of the acts relating to trawling for herring on the coasts of Scotland*, Edinburgh, 1863, p. 30.—A. RUSSEL, "*The salmon*," Edinburgh, 1864, p. 86.—See also, KRÖYER, "*Danmarks Fiske*," iii, p. 170.—This whole question has already been discussed more than two centuries ago, as may be seen from NEUCRANTZ, "*De harengo exercitatio medica*," Lubecæ, 1654, pp. 18, 19.

vincing proof, however, has been brought forward for these suppositions, which must rather be considered as unsuccessful attempts to explain the fact that herrings which spawn at different seasons of the year occur on the same coast, without having recourse to the supposition that two different races of herrings live in the same water, exposed to entirely similar influences.

Another opinion has also been advanced, viz, that the herrings only spawn every other year. Although it will be difficult to deny the possibility of such an occurrence, even merely as an exception from the common rule, or owing to special circumstances, and although it must be acknowledged that such a supposition affords a very convenient explanation of the relationship and occurrence of the so-called migratory herring (*stråksillen*),³¹ it must, on the other hand, not be forgotten that there is not sufficient proof for the absolute correctness of the supposition, and that it brings in its train numerous other difficulties. Nothing of the kind has ever been noticed in other closely-related species of fish, and it seems perfectly clear that we should not look for any such characteristic in a species of animals whose only shield in the battle for existence is its fecundity.

In the same way it has also been asserted, in order to prove the occasionally quite frequent occurrence of so-called "migratory herrings," that the herrings grow so old that through old age they lose the faculty of propagating the species.³² But no convincing proof of this assertion has so far been brought forward, although it ought to have been comparatively easy to obtain such proof. It is not known how often the herring can spawn—in other words, how long it retains and uses its propagating faculty. A Scotch fishery commission has, however, expressed the opinion that the herring does not live longer than the time occupied by two to three propagation periods.³³

Some time before spawning commences the herrings which have hitherto lived rather scattered, begin to gather in large masses, which, with the principal races of herrings, assume gigantic proportions, and form so-called "herring-mountains," which gradually approach the places

³¹ BOECK, "*Om Silden og Sildefiskerierne*," p. 24.—G. O. SÆRS, "*Morgenbladet*," Christiania, January 4, 1872, No. 3.—*Indberetning om det Aarene 1870-'73, anstillede praktisk-videnskabelige Undersøgelser*." Christiania, 1874, p. 59.—Compare, also, LÖBERG's entirely different explanation in "*Norges Fiskerier*," pp. 23-24, and my explanation in my "*Preliminær Berättelse*" for 1874-'75, p. 11.—Although it is natural to suppose that those herrings which finish their first spawning very early are so much weakened by it that they need an extra year to gain sufficient strength for another spawning—an explanation which agrees well with the circumstance that the "migratory herring" is smaller than the large spawning herring—we must, as long as this supposition lacks sufficient proof, and as long as the phenomena which shall be explained by it can be explained in a much less doubtful manner, nevertheless, reject it.

³² C. U. EKSTRÖM, *Oefvers. af Kgl. Vet. Akads. Förhandl.* i, 1844, p. 26. *Praktisk afhandling*, p. 8.—A. W. MALM, "*Göteborgs och Bohusläns Kgl. Hushållnings-Sällskaps handlingar*," 1867, p. 20.—*Läsning för Fiskare i Bohuslän, Göteborg*, 1861, p. 17.

³³ Report of the Royal Commission on the operation of the acts relating to trawling for herring on the coasts of Scotland, Edinburgh, 1863, p. 28.

where they are going to spawn. Occasionally, however, the herrings arrive at the spawning-places some time before spawning commences; during a portion of the great fishing-periods, this seems to have been the rule, but generally this is not the case, although it happens that at the beginning of the fisheries herrings are caught which are far from being ready to spawn. The various individuals composing a school of herrings do not all get ready for spawning at one and the same time, so that the spawning-season of one school generally extends over nearly a quarter of a year; the number of spawning fish is small at the beginning and at the end, and greatest about the middle of the spawning-season. It is therefore an old experience, gained during the great herring-fisheries in the western portion of the North Sea, that in the beginning the fishermen catch more fat herrings, fewer spawning herrings, and scarcely any herrings which have done spawning; that the number of fat herrings decreases in proportion as the spawning herrings become more frequent, and that towards the end of the fisheries nearly exclusively such herrings are caught which have done spawning, together with a few spawning herrings, but no fat herrings at all. This last-mentioned kind seems to give way before the spawning herring—does therefore not go along to the spawning-place, and is not found there whilst spawning is going on.

The herring generally takes no food during spawning and immediately previous to it, and as the sexual organs develop at the expense of fat, the fish are very lean after spawning. During the spawning-season we therefore find, at least with the sea-herring, only very inconsiderable and entirely indeterminable traces of food in its stomach or entrails. This is not so much the case with the coast-herring, which finds sufficient food even near the spawning places, and which seems to continue to take food farther into the spawning-season.

The approach of the herrings to the spawning-places may certainly be delayed or interrupted by unfavorable weather, but when spawning has once commenced the herring blindly rushes forward towards its object without being deterred or hindered by anything; for instance, the attacks of fish of prey, &c.

It has also been observed that when the herrings begin to approach the spawning-places the overwhelming majority are female fish, while the very reverse is the case towards the end of their visit to the coast; and a predominance of male fish is said to be a sure sign that the fisheries are approaching their end.³⁴ A short time before the beginning of the spawning-season small quantities of fish composed exclusively of male fish are caught.

The herrings generally approach the spawning-place at the beginning of night and leave it early in the morning immediately after having spawned; but during the great fisheries it also happens that the her-

³⁴BOECK, "Om Silden og Sildefiskerierne," p. 26; *Tidsskrift for Fiskeri*, VII, p. 24.

rings come to the spawning-places during daytime, and this is said to take place particularly towards the end of their visit to the coast.³⁵

Concerning the spawning-process itself, opinions are divided as to whether it continues uninterruptedly till finished, or (as with the carp) goes on at intervals, the contents of the sexual organs being emptied gradually. The latter opinion is advocated by *Axel Boeck*, who mentions a number of very plausible reasons in its favor, which, however, are not altogether convincing. He even goes so far as to speak of the importance which this gradual spawning process ought to have for the fishermen.³⁶ According to information received from experienced fishermen, two to three weeks would elapse before a school of herrings had by repeated emissions ejected all the spawn and roe contained in their sexual organs; but this does by no means prove that every individual fish spawns at intervals. The fact that the nets sometimes contain fish whose sexual organs are only half emptied is not a sufficient proof that such fish, if left alone, would have retained the products of their sexual organs till they could find another chance to emit them. It is quite probable that miscarriages take place under violent shocks or when death is threatened. It must also be remembered that by no means all those herrings which at one and the same time approach a spawning-place also spawn together, but that a greater or smaller number come near the coast which are not quite ready for spawning. This circumstance may have led to erroneous or exaggerated versions of actual facts. As far as known the spawning process of the great schools of herrings is one continuous act. It is certain that the herring, when free, does not begin to spawn until the entire contents of the sexual organs are so loose that the least pressure will make them flow out; ³⁷ and even if there are intervals in the spawning process these intervals must be very short.

During the spawning process the herrings are packed in a dense mass, are in constant and violent motion, move their tails rapidly, press and rub against each other or against the bottom, press against the nets, &c., all with the obvious intention to facilitate the emptying of the sexual organs.³⁸ It has been observed that during the emission of the milt the sea-water assumes a whitish color, that a peculiar odor becomes perceptible, and that many scales which have become loose during the process rise to the surface. In net-fishing it has also been observed that the

³⁵ BOECK "Om Silden og Sildefiskerierne," p. 59.

³⁶ *Om Silden og Sildefiskerierne*, pp. 26, 27.

³⁷ The products of the sexual organs begin to get loose, especially in the male fish, long before spawning commences. With a practical view *Dr. Heincke* has given an excellent table of the gradual development of the sexual organs in the "*Jahresbericht der deutschen Commission zur wissenschaftlichen Untersuchung der deutschen Meere*," IV-VI, pp. 68, 69.

³⁸ Professor HENSEN, who has observed the spawning of the herring in the Sli-fjord (Duchy of Schleswig), says that the roe is freely emitted by the female fish while hurrying to and fro over the spawning-place. (*Jahresbericht*, IV-VI, p. 26.)

female fish generally go nearer the bottom than the male fish.³⁹ After the spawning process is finished the herring hasten back to the open sea, but according to observations made in Scotland, they first gather for a while near the surface in the spawning-place.⁴⁰ Together with the roe a sticky slime is emitted, which soon becomes hard in the water, and by means of which the roe, when it sinks to the bottom, is fastened to rocks, stones, and aquatic plants; sometimes the roe even forms large compact cakes.

As the Skagerack herring spawns during the night, and during the dark and cold season of the year, the Bohuslän coast offers but few opportunities for observing the spawning process. This is probably also the cause of the characteristic ignorance of the spawning process of the herring displayed by the Bohuslän fishermen. The remarks which we propose to make on the phenomena accompanying the spawning of the herrings are, therefore, principally based on observations made by fishermen in more favorable localities. For comparison's sake, we will, however, reproduce here the excellent description of the spawning process of the herring given by *Gisler*, which in some respects must still be considered the best of the kind. In his "*Beskrifning om Strömmings-Fiskets beskaffenhet, Norrbotten*" (Description of the Herring-Fisheries in Norrbotten), he thus describes the spawning process of the herring:⁴¹ "When the herrings approach the coast in large numbers and emit both roe and milt, giving a whitish color to the water, the fishermen say that the herrings 'are shining.' When this takes place the following may be observed: The herrings which have halted, say about one-eighth of a mile from the coast, approach the land in large masses, both male and female, and emit milt and roe. Packed closely together they press forward towards the land, beat their tails against each other, and cause such violent commotion that many scales are torn off and float near the surface of the water; a strong and rank odor (*odor aphrodisiacus*) fills the air, and may be perceived at a great distance. During this time the fish do not heed seines or nets but press against them. In a few moments, about sunrise, the roe and milt will give the water a whitish-gray color, extending far out towards the deep; as soon as the fish have commenced spawning they will go out to sea, seeking those places where several currents meet, ejecting roe and milt all the time, till, when they have reached the deep, they have grown quite light and empty; they scarcely return to the coast that same summer. The roe when emitted is surrounded with a gluey juice, by which it is fastened to rocks, stones, plants, and fishing apparatus; lines which have been left in the water near the bottom are often covered with roe to the thickness of an inch, and it is quite difficult to scrape it off. With regard to its spawning process, the herring

³⁹ *Nordisk Tidsskrift for Fiskeri*, I, p. 38.

⁴⁰ HUGH MILLER, according to W. BRABAZON: "The deep sea and coast fisheries of Ireland. Dublin, 1848, p. 31.—J. G. BERTRAM: "The harvest of the sea." London, 1873, p. 170.

⁴¹ *Kyl. Svenska Vetenskaps Academiens Handlingar för 1748*, IX, p. 113-115.

bears a strong resemblance to other small fish; bream, perch, crucian, &c., which also press close against each other and cause a great commotion in the water when they spawn. For some days in the beginning of spring only milters are caught, but as soon as spawning commences milters and spawners are caught containing loose milt and roe. When spawning is over, both milters and spawners seek the deep."

After the eggs of the herring have been laid and have become impregnated, some time elapses before they are hatched; this time varies according to the temperature of the spawning-place. The somewhat conflicting observations on this subject seem to point to a varying incubation-season for the different races. *C. J. Sundevall's* opinion is probably correct, that "fish do not have a regular hatching-time for their eggs like birds."⁴² This conscientious observer says that on the coast of Stockholmlän, the eggs of those herrings which spawn there, are generally hatched in about 14 days or a little more, but may, when the temperature of the water is higher (say upwards of 68° F.), be even hatched in 3 days.⁴³ *Ekström* reports that on the coast of Mörkö hatching takes about 14 days.⁴⁴ From the Sli-fjord, which has been examined by the German Fishery commission, it is reported that the hatching of the herring-eggs during spring-time, when the temperature was, comparatively speaking, high (18 to 20° C. = 64.4°-68° F.) took only about 8 to 10 days.⁴⁵ The same observation has been made by *Krøyer* regarding the herrings on the coast of Denmark.⁴⁶

⁴²*Stockholms läns Kgl. Hushållnings-Sällskaps handlingar*, VI, Stockholm, 1855, p. 158.

⁴³*Kgl. Svenska Vetenskaps Academiens handlingar*, I, 1, 1855, p. 17.—See *Stockholms läns Kgl. Hushållnings-Sällskaps handlingar*, VI, p. 195, where it says: "The development of the eggs progresses rapidly. During August they are often hatched in 3, or at most 5-6 days. With a water temperature of 14-15° = 57°-59° F., the eggs have been hatched in 6-8 days. During May it took 6-8 days to hatch them." These observations have been repeated by *WIDEGREN* in his treatise "*Några ord om sillfiske samt om sillens eller Strömmingens rätta beredning till handelevara*" (*Kgl. Landbruks Academiens Tidskrift*, X, Stockholm, 1871.—*Tidskrift för Fiskeri*, VI, p. 68.—*Circulars des deutschen Fischerie Vereins*, 1872, IV, p. 106.—United States Commission of Fish and Fisheries. Report for 1873-74 and 1874-75, Washington, 1876, p. 186.—Report on the herring fisheries of Scotland. London, 1878, p. 182.)

⁴⁴*Die Fische in den Scheeren von Mörkö*. Berlin, 1835, p. 221.

⁴⁵*Circulars des deutschen Fischerie-Vereins*, 1874, p. 268. Later Professor *KUPFER* has given the following results of the above-mentioned commission: "The roe of the autumn-herring, with a lower temperature (48.2°-51.8°F.) and a saltness of about 2 per cent., develops in exactly the same time and shows the same phenomena as the Sli-spring herring with a higher temperature (57.2°-68°F.) and a saltness of only 0.5 per cent.; the development of the eggs in the Western Baltic goes on independent of the temperature of the water and its saltness in about 7 days, counting from the time of impregnation; the majority of the eggs are hatched in 7 days, some of them even in 6 days, although the hatching of an indeterminable percentage of eggs may be delayed a few days." (*Jahresbericht*, IV-VI, p. 31-32).—Dr. H. A. MEYER adds the following information, based on more recent and complete observations: "that with a temperature of 38.3°F. the development of the egg takes about 40 days, with a temperature of 44.6°-46.4°F. about 15, and with a temperature of 50°-51.8°F. about 11 days; but that the influence of the temperature on the roe of the spring-herring does not differ from its influence on the roe of the autumn-herring."—*Jahresbericht*, IV-VI, p. 240.)

⁴⁶*Danmarks Fiske*, III, p. 170.

On the southern coast of Bohuslän A. W. Malm made observations during April, 1856, which showed that it took the spring-herrings spawning in that region about 24 days for the development of the roe;⁴⁷ and from Norway we have Axel Boeck's observations, which fully agree with this.⁴⁸ In Scotland the views seem to differ somewhat from ours; thus Allman says, that the development of the roe of the winter-spawning herring occupies 25 to 30 days,⁴⁹ whilst the fishermen say that it generally takes the roe of the summer-herring 2 to 3 weeks and that of the winter-herring 4 to 8 weeks to develop;⁵⁰ Bertram, however, computes the period necessary for developing the egg at 10 weeks.⁵¹

The newly-hatched young herrings vary somewhat in size according to the size of their progenitors, those on the coast of Stockholm measuring only 7 millimeters,⁵² whilst those on the west coast of Norway reach a length of 10 millimeters.⁵³

The newly-born herring with its long and narrow body bears very little similarity to its progenitors, and therefore has to undergo considerable changes in size and shape until it becomes a genuine herring.⁵⁴ The tender young herring grows very rapidly; higher temperature and the larger quantity of food consequent upon it will accelerate its development.

Prof. C. J. Sundevall therefore feels justified, on the ground of his own and Baron C. J. Cederström's observations, in stating that the young herring on the coast of Stockholm reach a length of 25 millimeters in about two months, 36 millimeters in three months, 50 millimeters in four months, 75 millimeters in one and 125 to 150 millimeters in two years.⁵⁵ Elkström says that the young herrings on the coast of Mörkö

⁴⁷ *Göteborgs och Bohusläns Kgl. Hushållnings-Sällskaps handlingar*, 1856, p. 10, 11.—*Göteborgs och Bohusläns fauna* (vertebrates). Göteborg, 1877, p. 579.

⁴⁸ *Om Silden og Sildefiskerierne*, p. 12-13.

⁴⁹ Report of the Royal Commission on the operation of the acts relating to trawling for herring on the coast of Scotland. Edinburgh, 1863, p. 24.

⁵⁰ Evidence of the Royal Commission on the operation of the acts relating to trawling for herring, p. 21, 33, 34.—MITCHELL, "The herring," p. 340.—BERTRAM, "The Harvest of the Sea." London, 1873, p. 168.

⁵¹ The Harvest of the Sea, p. 171.—BUCKLAND finally mentions observations from Scotland by Captain McDONALD, according to which the roe of the herring is hatched in about 18 days. (Report on the herring-fisheries of Scotland. London, 1878, p. 162.)

⁵² C. J. SUNDEVALL, "*Stockholms läns Kgl. Hushålln. Sällsk. handl.*," VI, p. 195.—*Kgl. Svenska Vetensk. Acad. handl.*, I, 1, 1855, p. 18.—The same observation is found in A. W. MALM, "*Göteborg's och Bohusläns fauna*," p. 579.

⁵³ BOECK, "*Om Silden og Sildefiskerierne*," p. 13.—According to the observations of the German Fishery Commission, the length of the newly-hatched herring varies from 5.2-8.8 millimeters. (*Jahresbericht*, IV-VI, p. 32, 33, 240-248.)

⁵⁴ C. J. SUNDEVALL, "*Stockholms läns Kgl. Hush. Sällsk. handl.*," VI, p. 196-197. *Kgl. Sv. Vet. Ak. handl.*, I, 1, 1855, p. 18-19, 21-22., Plate IV. (*Jahresbericht der Commission zur wissenschaftlichen Untersuchung der deutschen Meere*, IV-VI, p. 74, 79, 98, 121, 127, 130, 243.)

The overlooking of these facts has doubtless been the cause of several mistakes in distinguishing young herring from young small herring.

⁵⁵ *Stockholms läns Kgl. Hushålln. Sällsk. handl.*, VI, p. 105, 196-197. *Kgl. Sv. Vet. Akad. handl.*, I, 1, 1855, p. 18-19.

reach a length of 25 millimeters in one month, 50 millimeters in about three months, and 100 millimeters in one year.⁵⁶

Professor *Münter*, who has observed the life of the herring on the coast of Pommerania, thinks that young herrings caught on that coast measuring 56.7 millimeters were two to three months old.⁵⁷ The data furnished by Professor *Krøyer* regarding the growth of the young herrings on the Danish coasts agree entirely with *Ekström's* observations from the coast of Södermanland.⁵⁸ Professor *Nilsson* says that the young of the autumn-spawning herring reach a length of 75 millimeters in May, but that near the mouth of the Laga River young fish are found at the same season which were larger and were, therefore, presumably a year older,⁵⁹ and that on the coast of Bohuslän, according to assurances given by the fishermen, the herrings have reached a length of 25 millimeters towards the end of May, 50 millimeters in August (about the middle of the month), and next autumn, when the herrings are one and a half years old, 75 to 100 millimeters; ⁶⁰ which observation has later been somewhat modified, the young herring reaching a length of 75 millimeters during the first summer, and those small herrings which measured about 100 millimeters being called "last year's young ones."⁶¹

Young herring begin to appear on the coast of Bohuslän already in the beginning of May, and with the increasing warmth grow quite rapidly, measuring 65 to 90 millimeters⁶² from the point of the lower jaw to the root of the tail (a total length, therefore, of 80 to 110 millimeters).

⁵⁶ *Die Fische in den Scheeren von Mörkö*, p. 221-222.

⁵⁷ *Archiv für Naturgeschichte*, XXIX, p. 303.

⁵⁸ *Danmarks Fiske*, III, p. 170-171.

⁵⁹ *Handlingar rörande sillfisket*, p. 59.—Professor NILSSON seems to have forgotten the spring-spawning race of herrings (*Clupea majalis*, Nilss.), whose occurrence in this region cannot have been unknown to him.

The observations of the German Fishery Commission on the young of the autumn-spawning herring in the western part of the Baltic seem to prove that those fish which are hatched in autumn reach the same or perhaps even a greater length in one year's time than those fish which are hatched in spring. (*Jahresbericht*, IV-VI, p. 248.)

⁶⁰ *Handlingar rörande sillfisket*, p. 45.

⁶¹ *Handlingar rörande sillfisket*, p. 130.

See, also, EKSTRÖM, "Praktisk afhandling," p. 10, where he says that "in November or December the young fish, then nearly a year old, have reached a length of 75-100 millimeters."

⁶² During the latter part of November, 1873, I measured a great many young herring, which had about that time been caught on our northern coast, and found that the total length of one-year-old fish varied from 78 to 109.5 millimeters. Very numerous and accurate measurements of young herrings, made in the bay of Kiel by the German Fishery Commission, from November 14, 1876, to May, 1877, gave the following minimum of total length, viz: November 14, 84 millimeters; end of November, 90 millimeters; end of December, 100 millimeters; end of January, 110 millimeters; of February, 114 millimeters; of March, 135 millimeters; and of April, 138 millimeters. (*Jahresbericht*, IV-VI, p. 245.)

Young herring having a total length of 85 to 95 millimeters are, by A. W. MALM, considered to be almost two years old. (*Göteborgs och Bohusläns fauna* [vertebrates], Göteborg, 1877, p. 581.)

By measuring a large number of herrings caught on the coast of Bohuslän during the latter part of spring, I have found that the majority of herrings in that region may, according to their size, be divided into three groups, namely, 1, those measuring 100 millimeters (total length 120 millimeters), which must be considered as one-year-old-fish;⁶³ 2, those measuring 145 to 150 millimeters (total length 170 to 175 millimeters), which must be considered as two-year-old-fish; and 3, those measuring 175 millimeters (total length 200 to 210 millimeters), which are presumably three years old, and have fully-developed sexual organs. Occasionally I found a fish measuring only 160 millimeters (total length 185 millimeters) which had loose roe,⁶⁴ as well as a fish measuring 160 to 170 millimeters (total length 185 to 200 millimeters), which could not possibly have become ready for spawning that same year. Larger fish, measuring about 200 millimeters (total length 23½ centimeters), are probably four years old.⁶⁵ As a considerable portion of the food which the herring eats and assimilates is directly or indirectly used for the formation of the milt and roe, the growth of the herring in size is, of course, a slow process.⁶⁶ The circumstance that the spawning season of our coast-herrings extends over a period of at least several months, causing a considerable difference of age among the young fish, and a difference in their ability to seek and obtain food, with other accidental circumstances, must be considered as the cause why in one and the same net fish of every possible size may be caught.⁶⁷

The Bohuslän coast herring seems to spawn for the first time when it is three years old, although this must by no means be understood as if all fish born in one and the same year must spawn at that particular

⁶³ According to the extensive investigations of the German Fishery Commission, the growth of the young herrings in the southwestern portion of the Baltic is more rapid during spring than my observations on the coast of Bohuslän have shown it to be. In the above-mentioned part of the Baltic the herring are said to reach a total length of 130 to 140 millimeters during the first year, i. e. 10 to 20 millimeters more than my observations showed. (*Jahresbericht*, IV-VI, p. 246.)

⁶⁴ In reproducing my observations (*Preliminär berättelse*, 1873-74, p. 35) in the "*Jahresbericht der commission zur wissenschaftlichen Untersuchung der deutschen Meere in Kiel*" (IV-VI, p. 247), the circumstance seems to have been overlooked that my measurements do not include the caudal fin, which of course increases the length considerably. I have in doing so followed the custom of other writers, amongst the rest AXEL BOECK, who does not count in the caudal fin. Modern writers, as well as some of the older ones, have followed a different course in this respect. Desirable as uniformity in this matter would be, the choice must be left to individual opinions; only for the sake of avoiding mistakes it should always be mentioned what length is meant, and this has, unfortunately, not always been done.

⁶⁵ A. W. MALM's observations agree with this, as he says that fish having a total length of 190 to 220 millimeters "are presumably in their fourth year," and that fish measuring 300 millimeters (total length) "are probably upwards of 6 years old" (*Fauna*, pp. 573, 577).

⁶⁶ Judging from the observations of the German Fishery Commission, the later growth of the herring is not quite so slow as I have mentioned above.

⁶⁷ See "*Preliminär berättelse*," p. 156.

age, for some do not seem to get ready for spawning till they are four years old.

Opinions have been very much divided, both among naturalists and persons engaged in the herring fisheries, as to *the age at which the herring spawns for the first time*. Professor *Nilsson*, on the authority of "intelligent fishermen," supposed that "no kind of fish spawns in its second year," and that "the herring does not spawn till it is five or six years old."⁶⁸ *Ekström*, on the other hand, thinks that those herring which measure about six inches ("counted from the point of the nose to the caudal fin") are two years old, and that those measuring 10 to 12 inches are about 4 to 5 years old; and also says that the herrings on the coast of Bohuslän do not spawn until they have reached a length 7 to 8 inches (total length).⁶⁹ Prof. *C. J. Sundevall*, who has observed the growth of the herring on the coast of Stockholm län, thinks that they are ready to spawn when three or three to four years old, when they have reached a total length of about 8 inches or 200 millimeters.⁷⁰ *Axel Boeck* is inclined to believe that "the youngest herring which spawns can scarcely be less than three, and certainly not more than four years old," although he is not able to give sufficiently strong reasons for his opinion;⁷¹ he also says that persons who have long been occupied in fishing have informed him that the herring, when spawning must be six or six to eight years old.⁷² Prof. *G. O. Sars* seems to have followed Professor *Nilsson* in trusting the authorities mentioned by him, and at first fixed the age when the herring spawns for the first time at four to five, and more recently at five to six years;⁷³ although he grants that some favored individuals which have just reached the age of four years (that is, "Christiania herring" of the preceding summer) may, in exceptional cases, be ready for spawning whilst of the five-year-old herrings (the "middle-herring" of the preceding summer) a much larger number have reached maturity.⁷⁴

Of foreign naturalists who have given attention to this question we

⁶⁸ *Handlingar rörande sillfisket*, pp. 45, 47, 51, 71.—See, also, the same work, pp. 59 and 60, where it says "when the herring begins to spawn for the first time, it is at least 5 to 6 years old."

⁶⁹ *Praktisk afhandling*, pp. 10, 11.—See, also, the same, p. 5.

⁷⁰ *Stockholms läns Kgl. Hush. Sällsk. handl.*, VI, pp. 105, 151, 161, 162.

⁷¹ *Om Silden og Sildefiskerierne*, pp. 36, 37.—*Tidsskrift for Fiskeri*, VII, p. 21.

⁷² *Om Silden og Sildefiskerierne*, pp. 36, 37.—*Tidsskrift for Fiskeri*, VII, pp. 20, 21.—In the "*Christiania Morgenbladet*" of November 5 and November 20, 1872, *Boeck* gives a full account of the six years' development of the herring furnished him by a man by the name of *Dahl*. According to this authority, herrings are on the west coast of Norway called "*Musse*" when 1 year old; "*Bladsild*" (leaf herring), when 2 years old; "*Christiania sild*" (Christiania herring), when 3 years old; "*Middelsild*" (medium herring), when 4 years old; "*Kjøbmandsild*" (merchant's herring), when 5 years old; and "*Vaarsild*" (spring herring), when 6 years old; distinctions which seem to be of very ancient date in Norway.

⁷³ *Indberetning om de i Aarene, 1870-73, anstillede praktisk-videnskabelige Undersøgelser*, pp. 38, 39, 40.—Recently COLLETT has expressed the same opinion (*Norges Fiske*, Christiania, 1875, pp. 191, 192).

⁷⁴ *Indberetning, 1870-73*, p. 39.

must mention *A. van Leuvenholk*, who thinks that herring spawn when only one year old,⁷⁵ and *Yarrell*, who, in accordance with observations made by himself, maintains that during the first year herrings do not develop sufficiently to have mature milt or roe.⁷⁶ We must also mention the British Commission for examining the Scotch legislation regarding the herring seine-fisheries (*Playfair, Huxley and Maxwell*), which has shown that opinions vary much among Scotch fishermen, some supposing that one, others that three, and others that even seven years must elapse before the herring is ready to spawn. The report of the commission says: "No sufficient proof can be brought forward against the assertion that the herring reaches its maturity when one year old." "There is good reason to suppose that the eggs are hatched in at most two to three weeks after spawning, and that six to seven weeks later (that is, at most ten weeks after spawning) the young fish have reached a length of 3 inches." "Since it is well known that young salmon can leave a river and return to it after twelve months eight to ten times larger than when they left, and since the herring lives on nearly the same food as the young salmon, it seems quite possible that it can also grow in the same rapid proportion." "Under these circumstances nine months ought to be a sufficiently long time to increase the length of the herring from 3 to 10 or 11 inches." "It may well be objected, however, that one cannot draw absolutely certain conclusions regarding the growth of fish by means of analogy, and it will perhaps be best to leave it an open question whether the herring has reached its maturity at the age of 12, 15, or 18 months, and consider the last mentioned figure as the maximum."⁷⁷ In North America naturalists seem inclined to the opinion that the herring, like most other migratory fish, does not reach its maturity till it is three years old.⁷⁸

⁷⁵ *Scaede vervolg der brieven, Delft, 1697, sid. 336-337.*

⁷⁶ *British Fishes, 3d edition, I, London, 1859, p. 107.*

⁷⁷ Report of the Royal Commission on the operation of the acts relating to trawling for herring on the coasts of Scotland. Edinburgh, 1863, p. 27.—Evidence of the Royal Commission on the operation of the acts relating to trawling for herring on the coasts of Scotland, pp. 8, 9, 17, 23, 33, 34.—*Mitchell, The Herring*, pp. 30, 340.—*Bertram, The Harvest of the Sea*, pp. 169, 170.

⁷⁸ *M. H. Perley, Reports on the Sea and River Fisheries of New Brunswick. Fredericton, 1852, p. 290.*—Fourth Annual Report of the Department of Marine and Fisheries. Ottawa, 1872, Appendices of the fisheries branch, p. 131.

The work of the German Fishery Commission has led to still another view of this question, according to which the herring reaches its maturity when two years old. Since it has been ascertained that at the age of one year the herring has a total length of 130-140 millimeters, and that fully-matured herrings have been caught in the western portion of the Baltic, having a total length of 160-200 millimeters, Dr. *H. A. Meyer* felt justified in supposing that the growth of the 60-70 millimeters which were lacking to bring the length to the last mentioned figure and the full development of the sexual organs would not require more than one year. (*Jahresbericht, IV-VI, p. 247.*)

If, however, further investigations should confirm this supposition, which is by no means impossible, I believe, for my part, that such investigations ought to prove that such is the case only with *some* of the fish born during one and the same spawning-season, but that by far the larger number of these fish only reach their maturity at the age of three, and perhaps even four, years.

According to unanimous testimony, the herring continues to grow (though slower) long after it has reached maturity, or the faculty of propagating the species; but the assertion that the herring, as well as other fish, know no other limit of growth but death is probably not well founded.⁷⁹ It is not known how old the herring is when it ceases to grow; but it is reasonable to suppose that it has reached its full growth at eight years of age.

It is not known to what age the herring can live, but it is not probable that it reaches a very high age. Nor has the assertion been proved that the herring lives so long that it loses its propagating faculty from old age. Interesting attempts have been made to ascertain the age of herrings and other fish from the layers composing the scales⁸⁰ or from the number of vertebræ in the backbone,⁸¹ and future histological investigations will doubtless throw more light on this subject. It must finally be mentioned that the above-mentioned Scotch Commission is of opinion that, owing to the violent persecutions to which the herring is exposed, it will scarcely be possible for it to reach a higher age than three to four years and live through two to three propagating epochs.⁸²

The Bohuslän coast herring occasionally reaches a length of more than 300 millimeters; but even specimens measuring upwards of 250 millimeters are comparatively rare, especially on the southern part of the coast, probably owing to the fact that fishing is there carried on more vigorously. The largest specimen which I obtained measured 322 millimeters (370 including the caudal fin), a length which corresponds with that given by *Ekström* as the maximum length of the Bohuslän herring,⁸³ and which exceeds that mentioned by later authors. *Collett* mentions that the largest herring which he could obtain from the boundary waters between Norway and Bohuslän had a total length of 364 millimeters;⁸⁴ and *Lundberg*, in his treatise on the herring, containing numerous measurements of the herrings in the Royal Swedish Museum, says he could not find any specimen longer than 344 millimeters; this was one sent from Strömstad by Baron *C. Cederström*.⁸⁵ No large specimens, such as are occasionally found in the northern portion of the North Sea, near the northern coast of Norway, Iceland, or Northeastern North America, are, as far as known, ever caught in the Skagerack. *Buckland* gives 17 inches

⁷⁹ A. V. LEUWENHOEK, "*Epistola physiologica.*" Delphis, 1719, p. 218.

⁸⁰ A. V. LEUWENHOEK, "*Epistola physiologica.*" pp. 401, 402.—According to these accounts the herring can reach an age of at least twelve years.

⁸¹ H. HEDERSTRÖM, "*Rön om fiskars ålder*" (Rgl. Vet. Acads. handl., 1759, XX, pp. 222, 329).

⁸² Report of the Royal Commission on the operation of the acts relating to trawling for herring, p. 28.

⁸³ *Praktisk afhandling*, pp. 5, 10.—During the rich herring fisheries in the beginning of 1878, I observed several herrings having a total length of 375 millimeters, and a maximum height of 75-85 millimeters.

⁸⁴ *Norges Fiske*. Christiania, 1875, p. 192.

⁸⁵ *Bidrag till Rännedommen om strömmingen i Stockholms skärgård*. Stockholm, 1875, pp. 20, 21.

as the length of the largest herring which, to his knowledge, has ever been caught on the coasts of Great Britain;⁸⁶ and from Holland it is reported that the crew of the vessel *De Dankbaarheid*, Captain *Klaas Dorlandt*, in 57° 23' N. L., on the 23d October, 1863, caught a herring measuring 485 millimeters in length.⁸⁷

For the sake of comparison we will here, after *H. Baars*, give the average size of herring caught on the coast of Norway. The average length of the "great herring" is 350 millimeters; of the "spring-herring," 300-320; of the "merchants' herring," 250; of the "medium-herring," 235; of the great "Christiania herring," 200; and of the little "Christiania herring," 180.⁸⁸ According to *Collett*, however, the average length of the "great herring" is 330-340 millimeters, and that of the "spring-herring" about 330, whilst three to four year old "summer-herring," which have not yet spawned, often reach a total length of 270 to 280, and "half-grown two-year-old fish" 170 to 190. The largest specimen of the "great-herring" kind in the Christiania Museum has a total length of 378 millimeters.⁸⁹

Regarding the propagation and development of the *small herring*, I have not been able to find any information in old writers, and my own observations are still so far from complete that I deem it best to defer their publication. This I offer in excuse of the brevity of the following account:

The fishermen, at least in that part of the coast of Bohuslän where herring-fisheries are carried on during spring and summer, are well acquainted with the fact that the "small-herring" has fully developed roe and milt in spring and during the early part of summer, and some fishermen have even observed their young some time after spawning. The spawning of the "small-herring" may be somewhat delayed or accelerated by the weather, but seems as a general rule not to have undergone any change with regard to the time when it takes place. In the reports of *P. Clancey*, superintendent of herring-fisheries to the Royal Board of Trade, we find the following notice, that on the 11th March 1811, small-herring containing both milt and roe were caught,⁹⁰ indicating that spawning would begin at most 3-4 months later. From this circumstance we may safely draw the conclusion that it is not necessary to suppose an advance in time of the spawning-season of the "small-herring," in order to explain the statements of *Nilsson*, *Wilhelm von Wright*, *Ekström*, *A. W. Malm*, *E. Ugglä*, as well as the opposing statement of *G. von Yhlen*, probably derived from *M. E. Bloch's* ichthyology, or from the supposition that the spawning-season was always contemporaneous with the fishing-season. The above-mentioned writers take *autumn* to

⁸⁶ Familiar history of British Fishes. London, 1873, p. 122.

⁸⁷ *Verslag van den Staat der Nederlandsche Zeevisserijen over 1860*, p. 15.

⁸⁸ *Die Fischeri-Industrie Norwegens*. Bergen, 1873, pp. 50, 51, 54.

⁸⁹ *Norges Fiske*, p. 192.

⁹⁰ G. C. CEDERSTRÖM, "*Fiskodling och Sveriges Fiskerier*," Stockholm, 1857, p. 215.

be the spawning-season of the small herring.⁹¹ Mr. G. von Yhlen, superintendent of fisheries, who at first gave the *latter part of autumn* as the spawning-season of the small herring has done so in accordance with the experience of old fishermen, although it is my opinion that there is no reason why he should admit the spawning during autumn merely as an exception.⁹²

Prof. C. J. Sundevall has ascertained that the small-herring on the coast of Stockholmlän spawn towards the end of June and in July,⁹³ therefore somewhat later than on the coast of Bohuslän. Kröyer reports of his *Olupea sprattus*, that "they generally spawn in August, but begin during the latter half of June, and sometimes continue till September."⁹⁴ and of *Olupea Schoneveldi*, that "in spawners which were caught early in spring he found the milt strongly developed,"⁹⁵ which indicates an earlier spawning-season for this last-mentioned variety.

The small herring found on the northern coast of Germany (Pommern, Holstein, East Friesland) is said to spawn in autumn.⁹⁶ On the eastern and southern coasts of Great Britain the small herring are reported to spawn twice a year, viz: during summer⁹⁷ and during winter immediately after new year.⁹⁸ The small herring found on the coast of Iceland spawns during spring.⁹⁹

My own observations regarding the spawning-season of the small-herring show that on the middle coast it begins towards the end of May or early in June. It is probable that the spawning-season begins a little earlier on the northern and a little later on the southern coast.¹⁰⁰ The small-herring which are caught in autumn and the beginning of winter have never very strongly developed milt and roe (a circumstance which can be fully and extensively proved by the preparation of so-called

⁹¹ NILSSON, "*Prodromus ichthyologiae Scandinavicae*, Lunda, 1832, p. 22. *Skandinavisk Fauna* IV, p. 521.—W. v. WRIGHT, "*Handlingar rörande sillfisket*," pp. 167, 175.—EKSTRÖM, "*Praktisk afhandling*," pp. 9, 103.—*Oefvers. af Kgl. Vet. Akad's. Förhandl.*, I, 1844, p. 26.—A. W. MALM, "*Göteborgs och Bohusläns Kgl. Hushålln. Sällsk. handl.*" for 1856, p. 10. *Läsning för Fiskare i Bohuslän*, p. 15.—E. UGGLA, "*Göteborgs och Bohusläns Kgl. Hushålln. Sällsk. Quartalskrift*, July 1867, pp. 51, 52, April 1868, p. 45.

⁹² G. VON YHLEN, "*Göteborgs och Bohusläns Kgl. Hushålln. Sällsk. Quartalskrift*," July 1871, p. 52, July 1872, p. 50. *Nya Handlingar rörande sillfisket*, I, p. 19. Recently Dr. A. W. MALM has communicated observations from the years 1864 and 1865 which correct his above-mentioned older observations (*Fauna*, pp. 582, 583).

⁹³ *Stockholms läns Kgl. Hushålln. Sällsk. Handl.*, vi, pp. 109, 185-187.

⁹⁴ *Danmarks Fiske*, iii, p. 191.

⁹⁵ *Danmarks Fiske*, iii, p. 201. I have observed similar cases on the coast of Bohuslän.

⁹⁶ BLOCH, "*Oeconomische Naturgeschichte*," i, p. 207.—L. WITTMACK, *Circulare des deutschen Fischerei-Vereins*, 1875, p. 119.

⁹⁷ YARRELL, "*British Fishes*," 3d ed., i, p. 116.—J. COUCH, "*A History of the Fishes of the British Islands*," IV, London, 1865, p. 110.—E. HOLDSWORTH, "*Deep-sea fishing and fishing-boats*," London, 1874, pp. 133-135.

⁹⁸ HOLDSWORTH, "*Deep-sea fishing and fishing-boats*," pp. 133-135.

⁹⁹ F. FABER, "*Naturgeschichte der Fische Islands*," Frankfurt-am-Main, 1829, p. 180.

¹⁰⁰ NILSSON, "*Skandinavisk Fauna*," iv, p. 521.

"skinless and boneless anchovies"), but are nevertheless not very thin, which shows that they cannot have spawned previous to the beginning of the autumn fisheries. The larger small herring which are caught during spring and summer are generally thinner and in a poorer condition.¹⁰¹

Regarding the spawning of the small herring it ought also to be mentioned that Mr. *Holdsworth*, who is thoroughly versed in all questions relating to the British fisheries, in his well known work "Deep-sea fishery and Fishing-boats" has expressed the supposition that the small herring, like the codfish, the mackerel, and (according to *Couch*) the pilchard¹⁰² and other salt-water fish emit their roe on the surface of the water during summer generally in the open sea and during winter nearer the coast.¹⁰³

The young of the small herring are said to appear on the northernmost part of the coast about midsummer or the beginning of July. No information can be found in any writers on the subject as to how fast the small herring grows, and how old it is when it spawns for the first time,¹⁰⁴ and my own observations are not sufficiently advanced to draw any certain conclusion from them. But as on the 18th of March, 1874, I received from Kalfsund several small herrings measuring 96-97 millimeters (from the point of the lower jaw to the root of the tail) which had strongly developed sexual organs, and as the majority of those which I received from Tjörn during the latter part of spring, measured only 100-110 millimeters, it does not seem impossible that the small herring spawns for the first time when two years old, although this will probably only occur with some of the descendants of one and the same spawning-season. It is on the whole more probable that the small herring, like the herring, does not become capable of spawning till it is three years old.

The largest small herring which I ever obtained on the coast of Bohuslän measured 149 (counting in the caudal fin, 172.3) millimeters in length; but even specimens measuring 140 millimeters are rare.

For comparison's sake I will, in conclusion, give a few facts concerning the spawning and growth of some fish which are closely related to the herring.

The most important of these, the American herring (*Alosa præstabilis* or *sapidissima*, the shad), spawns like the salmon, high up the rivers, and

¹⁰¹LÖBERG, "*Norgea Fiskerier*," p. 97.

¹⁰²Fishes of the British Islands, iv, p. 81.—*Holdsworth*, "Deep-sea fishing and fishing-boats," pp. 31, 132.

¹⁰³"Deep-sea fishing and fishing-boats," p. 135.

¹⁰⁴A little more than a year ago Dr. *A. W. Malm* gave some information on this point, to the effect that young fish measuring 20-34 millimeters (total length), and obtained between July 5th and August 15th, are said to be young ones of that same year, whilst young fish measuring 42-57 millimeters (total length) and obtained towards the end of July or the middle of August, are said to be a little over a year old. (Fauna, pp. 583-585.) According to Dr. *Malm's* opinion, the small herring, which is only half the size, may reach about the same length during its first year as the herring which is twice as large, and whose young measuring 46-49 millimeters are said to be a year old. (Fauna, pp. 580-581.)

its spawning is thus described: "Gathered in dense schools, the spawners and milters move slowly in a circle, the dorsal fins often protruding above the surface of the water. Suddenly, as if struck by an electric shock, they dart off, and immediately roe and milt are expelled in the water. Wherever there is only one couple they slowly swim in a circle, the milter holding his head close to the pectoral fin of the spawner."¹⁰⁵ Although the roe is not loose, it is only a little heavier than the water of the river, so that by artificial impregnation it can be kept floating in the current; it also differs from the roe of the herring by being entirely free from any sticky substance, by which it could be fastened to any object either at the bottom or near the surface. With a water temperature of 24° C. (75.2° F.) it is hatched in about 60–70 hours, but when the temperature is lower it takes longer, requiring about seven days with a temperature of 62.6°–64° F.¹⁰⁶ For a spawning-place the shad prefers either coarse sand or a bottom with a rich vegetation.¹⁰⁷ The *Alosa præstabilis* does not reach its maturity until it is 3–4 years old, although milters which are only 2 years old are said to be able to propagate the species.¹⁰⁸ When five years old they are considered fully grown.¹⁰⁹

The American river-herring (*Pomolobus pseudoharengus*—"the alewife") seems to reach maturity at the same age as the *Alosa præstabilis*¹¹⁰, but its roe when ejected is like that of the herring, accompanied by a sticky slime, by means of which it adheres to any objects found in the spawning-place; it is hatched at the usual temperature in about 70–74 hours.¹¹¹

Our common *Alosa finta* also spawns up rivers and streams, where it empties its sexual organs with violent muscular exertions, beating the water with its tail, so that during quiet evenings or nights the noise of the spawning may be heard at some distance from the spawning-place.¹¹²

¹⁰⁵ Report of the Commissioners of Fisheries of Massachusetts, for 1869, p. 17.—*Slack*, United States Commission Fish and Fisheries, II, report for 1872 and 1873, p. 460.

¹⁰⁶ Report of the Commissioners of Fisheries of Massachusetts, for 1867, p. 36.—United States Commission, Fish and Fisheries, II, pp. 425, 430.

¹⁰⁷ *Slack*, United States Commission, Fish and Fisheries, II, p. 460.

¹⁰⁸ Report of the Commissioners of Fisheries of Massachusetts, for 1867, pp. 23, 40; for 1869, p. 18; for 1870, p. 5; for 1871, p. 12; for 1873, p. 13; for 1875, pp. 5, 52.

¹⁰⁹ Report of the Commissioners of Fisheries, of Massachusetts, for 1869, p. 21.

¹¹⁰ Report of the Commissioners of Fisheries of Massachusetts, for 1868, pp. 7, 8, 9, 23; for 1869, pp. 5, 6, 21; for 1874, p. 8; for 1875, p. 52.—United States Commission of Fish and Fisheries, II, pp. LIX–LXI.

¹¹¹ Report of the Commissioners on Inland Fisheries of Massachusetts, for 1873, pp. 8, 9.

¹¹² YARRELL, "British Fishes," 3d ed., I, p. 130.—KRÖYER, "*Danmark's Fiske*," III, pp. 317, 318.

