altogether against the unprotected iron, which is electro-positive to magnetic oxide.

It appears, however, that the neighborhood of copper or its compounds in sea-water would probably be destructive to a surface of magnetic oxide, as was the case in the experiment noted. Whatever galvanic action occurs in such a couple must necessarily be at the expense of the magnetic oxide. The presence of zinc, tin, or lead would probably be protective to the iron.

In conclusion I may say that this examination indicates that the magnetic oxide is an effective protection against the ordinary processes of iron rust; that the kind of galvanic action which occurs between iron and its magnetic oxide in presence of sea-water is altogether at the expense of the former; that the neighborhood of copper, nickel, silver, or other metal electro-negative to the magnetic oxide of iron in presence of sea-water will lead to the speedy destruction of the magnetic oxide; and, finally, that the specimens thus far examined appear to have been exposed to the protective process for too short a time to insure full security under the conditions presented by the requirements of the Fish Commission.

SMITHSONIAN INSTITUTION,
Washington, D. C., February 23, 1885.

33.—REPORT OF OPERATIONS AT THE HATCHING ESTABLISHMENT FOR MARINE FISHES, ARENDAL, 1884.*

By G. M. DANNEVIG.

To the Management of the Arendal and Omegn branch of the Society for the Promotion of the Norwegian fisheries:

I have the honor to submit to the board of managers the following report of the operations of the hatching establishment during the year 1884:

COD.—On account of the easily foreseen difficulties in procuring the necessary number of parent fish, the purchase of these was commenced at the beginning of the year and continued without interruption until about the middle of the month of April. The fish obtained were, however, very small, and yielded in consequence little spawn, which will, to some extent, explain the comparatively small result which the establishment has to show for the present year. It will be evident also, from the detailed report given below, that there were other causes which operated strongly in the same direction. Besides, we should not leave out of consideration the fact that, as director of the establishment, I had to confront an entirely new experiment, and that, in addition to theoretical knowledge, there is required also a practical acquaintance

**Beretning over Virksomheden ved Udklækningsanstalten for Saltvandsfisk.* Arendal, 1884. Translated from the Norwegian by TARLETON H. BEAN.

with the subject, which can be acquired only after considerable experience. The actual hatching operations begun on February 19th and continued until April 29th, when the last fry were liberated.

Table showing the extent of cod-hatching from February 19 to April 27, 1884.

Date.	Number of eggs fertilized.	Total number of fertilized eggs.	Eggs rejected.	Net stock in the apparatus.	Fry liberated.	Water at 8 a m.		Remarks.
						Specific gravity.	Temperature Fahr.	
Feb. 19	525,000	525,000	.....	525,000	.....	.....	.....	
22	60,000	585,000	200,000	385,000	.....	.....	.....	
25	450,000	1,035,000	.....	835,000	.....	.....	.....	
26	75,000	1,110,000	75,000	835,000	.....	.....	.....	No eggs were rejected from February 26 to March 7, because all of them were so fouled by impure water that it was impossible to separate them.
27	300,000	1,410,000	.....	1,135,000	.....	.....	.....	
28	800,000	2,210,000	.....	1,935,000	.....	.....	.....	
29	150,000	2,360,000	.....	2,085,000	.....	.....	.....	
March 1	300,000	2,660,000	.....	2,385,000	.....	.....	.....	
3	250,000	2,910,000	.....	2,635,000	.....	.....	.....	
4	150,000	3,060,000	.....	2,785,000	.....	1.020	.....	
6	350,000	3,410,000	.....	3,135,000	.....	1.022	.....	
7	175,000	3,585,000	500,000	2,810,000	.....	1.024	.....	
8	125,000	3,710,000	.....	2,935,000	.....	1.022	.....	
12	625,000	4,335,000	.....	3,560,000	.....	1.019	36.50	
14	100,000	4,435,000	.....	3,665,000	.....	1.019	36.95	
17	480,000	4,915,000	275,000	3,815,000	50,000	1.018	37.62	
18	.....	4,915,000	400,000	3,410,000	5,000	1.018	36.05	
20	250,000	5,165,000	800,000	2,860,000	.....	1.024	38.75	
21	.....	5,165,000	1,100,000	1,760,000	.....	1.025	39.42	
22	40,000	5,205,000	.....	1,800,000	.....	1.024	38.75	
23	175,000	5,380,000	.....	1,915,000	60,000	1.022	38.75	
24	1,000,000	6,380,000	600,000	2,205,000	110,000	1.020	37.62	
25	500,000	6,880,000	150,000	2,555,000	.....	1.019	37.62	
26	375,000	7,255,000	100,000	2,830,000	.....	1.022	38.07	
27	500,000	7,755,000	200,000	3,090,000	40,000	1.021	37.85	
28	.....	7,755,000	125,000	2,915,000	50,000	1.024	38.97	
29	850,000	8,605,000	95,000	3,663,000	10,000	1.025	39.20	
30	150,000	8,755,000	.....	3,785,000	25,000	1.024	39.20	
31	500,000	9,255,000	575,000	3,615,000	95,000	1.025	39.87	
April 1	650,000	9,905,000	785,000	3,345,000	135,000	1.019	38.97	
2	450,000	10,355,000	.....	3,795,000	.....	1.023	38.97	
3	450,000	10,805,000	.....	4,245,000	.....	1.027	41.45	
4	750,000	11,555,000	.....	4,995,000	.....	1.027	41.00	
5	220,000	11,775,000	.....	5,215,000	.....	1.025	39.87	
6	.....	11,775,000	.....	5,215,000	.....	1.020	39.20	
7	.....	11,775,000	.....	5,215,000	.....	1.021	39.65	
8	600,000	12,375,000	440,000	5,375,000	.....	1.020	40.55	
9	.....	12,375,000	300,000	4,995,000	80,000	1.020	41.00	
12	.....	12,375,000	530,000	4,425,000	40,000	1,020	40.32	
13	.....	12,375,000	.....	4,405,000	20,000	1.019	41.45	
14	.....	12,375,000	.....	4,385,000	20,000	1.020	41.00	
15	.....	12,375,000	.....	4,375,000	10,000	1.025	40.55	
16	.....	12,375,000	.....	4,120,000	255,000	1.017	43.25	
17	.....	12,375,000	.....	3,700,000	420,000	1.018	42.12	Liberated at Hovekilen.
19	.....	12,375,000	.....	2,700,000	1,000,000	1.025	41.67	
20	.....	12,375,000	230,000	2,450,000	20,000	1.020	41.00	
22	.....	12,375,000	.....	1,990,000	460,000	1.020	42.35	
23	.....	12,375,000	.....	1,490,000	500,000	1.021	41.67	Liberated at Langevig.
24	200,000	12,575,000	.....	1,290,000	400,000	1.021	41.45	
25	.....	12,575,000	.....	1,040,000	250,000	1.024	41.45	
26	.....	12,575,000	.....	440,000	600,000	1.023	41.67	
27	.....	12,575,000	.....	.....	440,000	.....	.....	Eggs and young.
	.....	*12,575,000	7,480,000	.....	5,095,000	.....	.....	

* Maximum daily number of eggs.

From the above table it will be seen that upwards of 12,500,000 cod eggs were fertilized, and that 5,000,000 young fish, or 40½ per cent., were obtained from these. It will be observed also that the largest stock of eggs possessed at one time was somewhat over 5,000,000, which was merely one-eighth of the capacity of the establishment. Since it is not difficult, with an abundant supply of parent fish, to hatch out two broods in a year, the yield might be increased to about 80,000,000.

When I heard the American fish-culturists, at the London Fisheries Exposition last year, lament about the muddy water which they had to use, I stated somewhat freely that the sea-water on the Norwegian coast would be sufficiently clean for hatching purposes without filtering, and, as a result of my opinion, I had it pumped directly into a reservoir, from which it was afterwards conducted through wooden pipes and rubber tubes to the apparatus. It was quickly apparent that this was a great mistake, and that even very carefully constructed filters are necessary for successful hatching. It is unquestionable that the sea-water here is tolerably clear, but if we consider the fact that about 15,000 liters of water daily flow through each apparatus, and that the bottom of the box is covered with wire gauze so fine that neither eggs nor young fish can escape through it, we must realize that this gauze will arrest all the dirt contained in the water and soon become so clogged that the circulation will be greatly retarded. Moreover, if some of the eggs, which float freely in the box during the process of development, should from time to time come into contact with the bottom, these also will soon be coated with mud and will sink to the bottom and be destroyed usually within a few hours. The loss occasioned in this way was at first considerable, but after the water became cleaner through the use of filtering-frames, and I, besides, had learned by experience how to handle the eggs more carefully, there was an improvement, and, towards the last as high as 50 per cent. of young fish were obtained. This may indeed be regarded as very gratifying, especially when we consider the fact that the Americans, who had all possible expedients at their command, after a whole winter's work obtained a considerably smaller average.

The next difficulty which presented itself, and which caused a considerable loss of eggs, was the circumstance that the sea-water sometimes contained so little salt that its specific gravity was less than that of the eggs, which may be placed, with little variation, at 1.023. In consequence of this the eggs fell to the bottom, and were securely held there by the current, which has a downward movement as well as a rotary motion. It was possible, of course, to increase the saltness of the water, but not without considerable expense, and to move the whole establishment farther out to sea, to obtain salter water, was naturally not to be thought of, at least until other means had been tried to get rid, if possible, more easily of this drawback, which for a long time remained so serious that I even began to doubt the result. Naturally

there was nothing to be done but to direct all my attention to the apparatus, with a view of improving it if possible.

I must state here that the Americans, in their attempt to develop cod eggs in 1879, used many of the older forms of apparatus, but first obtained satisfactory results after the construction of an entirely new appliance. This, which was called from its inventor the Chester rotating apparatus, was, however, also encumbered with various drawbacks, and I determined, therefore, to experiment not only with the last named but also with one of the older forms, and I selected the so called Clark's, which appeared to me to be the most successful. The experiments with this were, to be sure, unsuccessful in America, but when I based my calculation upon cleaner water I believed that it would prove effective in our country. The result showed that so far I was right; but now the fatal circumstance interfered—the salinity of the water at certain times was too low—and a new difficulty also intervened, which was not, and, without somewhat extensive preliminary experiments, could not have been foreseen. The difficulty was that the cod eggs, which are naturally developed at the surface, remained lying on the bottom, and that in an apparatus in which there is a descending current.

By accident I made the discovery that the greater or lesser inclination of the apparatus had considerable influence on the direction of the current, and after having made some experiments I had the Clark's apparatus set up in such a way as to secure a fall of 8 inches in 8 feet, instead of 1 inch in the same distance, as proposed by an American fish-culturist, Mr. R. E. Earll. By way of explanation allow me to give a short description of the structure of this apparatus. It consists simply of a water-tight box, 8 feet long, 2 feet wide, and 1 foot deep. It is divided lengthwise into two equal parts, and each of these again into five smaller compartments, by means of partitions.

As a result the box contains ten compartments of equal size, besides a smaller one in each end, which serve for the inflow and exit of the water. In each partition there is a depression containing a tin spout, through which the water flows from one compartment to another. Now, when the water is brought into the uppermost compartment this will be filled to within about one inch from the top, whereupon it will flow into the next division, and so on until all the compartments are filled. From the last an exit-pipe extends through the floor. In each of the ten compartments there is a wooden box, furnished with a wire-gauze bottom, and somewhat smaller than the space wherein it is contained. This wooden box has one of its edges pressed under the tin spout through which the water comes, and then it is naturally elevated at the opposite side in such a way that it rests somewhat obliquely.

In these small boxes, then, the eggs are placed, and, since the fine openings in the bottom furnish the only escape for the water, it is clear that the principal current must be descending. Now, by giving the box a greater inclination, as directed above, the water obtains, in leaving

the tin spout to enter the next compartment, a vertical fall of about three-fourths of an inch. The downward movement which the water hereby acquires changes its course so that, instead of flowing right off along the surface as before, it now proceeds towards the bottom, thence along the upward-inclined surface of the box, and then farther upward—in brief, it receives a whirling movement in a vertical, instead of, as heretofore, a horizontal direction. The eggs cannot now longer remain on the bottom, but must go with the current and be kept thereby in continual motion. The number of eggs injured in this way was very large; however, the loss was not total, since they could, to some extent, collect in the "eddies" of the hatching-box opposite the tin spout, also along the sides of the box, which is movable. In order to secure motion in the mass of eggs there is needed merely a brief pressure on the edge of the box, which pressure also forces the water up through the bottom, and I have determined to utilize this circumstance. Consequently I have had constructed an appliance which, by communication with a steam-engine, will furnish a uniform upward and downward movement to the egg-boxes. This apparatus, however, was finished too late to be tested during the more unfavorable condition of a too low salinity of the water.

It is essential, however, in this case, as well as under the former condition, to keep the apparatus absolutely clean, and to remove the dead eggs immediately. When there is a stock of 40,000,000 to 50,000,000 eggs in the establishment this will involve considerable labor, of course; but, on the other hand, there is reason to believe that careful filtering of the water before introducing it into the boxes will diminish the labor to a considerable extent.

FLOUNDERS.—As gravid flounders, chiefly *Skrubbe*,* were rather easily procured, and the greater portion of the apparatus stood idle for want of eggs, I resolved to make an experiment with these fishes also, and so much the more because no attempt of this kind had previously been made. The following table furnishes a synopsis of the results accomplished in this direction:

Table showing the extent of flounder-hatching from March 6 to April 28, 1884.

Date.	Eggs fertilized.	Total number of fertilized eggs.	Rejected eggs.	Net stock of fertilized eggs.	Young liberated.	Remarks.
March 6	100,000	100,000	.....	100,000	.....	
11	300,000	400,000	.....	400,000	.....	
19	750,000	1,150,000	150,000	1,000,000	.....	
24	.....	1,150,000	.....	955,000	45,000	
25	600,000	1,750,000	.....	1,555,000	.....	
26	200,000	1,950,000	.....	1,705,000	50,000	
27	200,000	2,150,000	.....	1,905,000	.....	
29	250,000	2,400,000	.....	2,010,000	145,000	
31	400,000	2,800,000	300,000	2,110,000	.....	
April 1	.....	2,800,000	400,000	1,710,000	.....	
4	.....	2,800,000	.....	1,560,000	150,000	
5	.....	2,800,000	.....	1,360,000	200,000	
7	500,000	3,300,000	.....	1,860,000	.....	

Pleuronectes flesus.

Table showing the extent of flounder-hatching from March 6 to April 28, 1884—Continued.

Date.	Eggs fertilized.	Total number of fertilized eggs.	Rejected eggs.	Net stock of fertilized eggs.	Young liberated.	Remarks.
April 8	350,000	3,650,000	.....	2,210,000	.....	
9	.....	3,650,000	300,000	1,660,000	250,000	
14	.....	3,650,000	.....	1,655,000	5,000	
16	.....	3,650,000	250,000	1,195,000	210,000	
17	.....	3,650,000	.....	995,000	200,000	
19	.....	3,650,000	300,000	595,000	100,000	
21	.....	3,650,000	.....	495,000	100,000	
22	.....	3,650,000	300,000	.....	195,000	
23	200,000	3,850,000	.....	200,000	.....	
28	.....	3,850,000	.....	.....	200,000	Fertilized eggs.
	.....	3,850,000	2,000,000	.....	1,850,000	

From 3,850,000 eggs were obtained 1,850,000 young fish, or 48 per cent., which was a somewhat better result than that secured with the cod. Flounder eggs are a little heavier than those of the cod, their specific gravity reaching 1.026, and we might suppose that they were more difficult to manage, especially when the water was too brackish. This, however, did not prove to be true, as they are more hardy than cod eggs and are not so easily destroyed by resting for a while on the bottom. An experiment with *Slette** and *Tungeflyndre*† conducted at the same time was equally successful. The period of incubation was from twelve to seventeen days, according to the temperature of the water. There are about 2,400 *Skrubbe* eggs in a gram, but the number varies considerably with the size of the parent fish.

LOBSTERS.—With a view of testing the possibility of developing lobster spawn after it was shed, I procured, on the 21st of June, some lobsters, which were kept in a box in the hatching-house after a portion of their eggs had been deposited.

The eggs, however, were placed in a specially constructed apparatus, which received a uniform water supply from the large reservoir of the establishment, which was pumped full every morning and evening, and during warm weather at noon also. After a space of about fourteen days the shells began to burst, and the young then appeared, surrounded only by the thin internal covering, which is not shed until they are able to swim, or after the first shedding of the skin. Beyond this stage, however, I was unable to rear a single young lobster out of the whole mass of eggs; they all died, without exception, within four days after they had escaped from the external shell, and before they were capable of swimming.

I had observed, though, that the temperature of the water exercised great influence on the longevity of the lobsters, and that this was increased proportionally as the water became cooler, whereas during very warm days they usually died within twenty-four hours.

After I had placed a new lot of eggs in the apparatus, on the 1st of August, I attempted to reduce the temperature by the use of ice; but

* *Pleuronectes limanda.* † *Pleuronectes solea, fide* Molbeck.—T. H. B.

as this was unsuccessful, on account of the warm weather and the heat radiated from the boiler, I had the pumping continued, with short intervals, from 6 a. m. to 10 p. m., and during the last week through the night also. In this way the water in the reservoir, as well as in the apparatus, was kept cooler, because it was not exposed so long to the warm air.

Now there was an improvement. On the 7th of August the first fully hatched young lobsters made their appearance in the boxes, and from that time until August 21, when the work ceased, some hatched out, as a rule, every day. The young were lively and disported themselves freely in the water, but seldom lived longer than a few days. I do not know what was the cause of this, but I believe it was want of food, since the water was filtered before it was introduced into the apparatus.

FLÖDEVIG HATCHING ESTABLISHMENT,
September 4, 1884.

POSTSCRIPT.—After my report of operations of the hatching establishment during the present year was delivered, I had an opportunity of informing myself more fully about a circumstance which is intimately connected with the same, and which I cannot omit to mention, since it furnishes rather satisfactory proof that the results of hatching are already beginning to appear.

On the 9th of September the fishermen living here set a so-called mat-net (fine-meshed net) to catch young herring for bait. When this was hauled I examined the catch, to discover if possible young cod of the year, and found therein, to my great delight, a score of these fish, measuring 2½ to 4 inches in length. Afterwards I examined the bottom alongshore with a water telescope, and saw plenty of young cod of the above-named size, a phenomenon which I had not observed before, although I have lived in the place eighteen years. In order to increase my knowledge of the matter, I inquired of the fishermen to what extent they had previously observed young cod in the catch of the mat-nets, but obtained the uniform answer that this was the first occurrence of the kind to their knowledge. A very old fisherman stated, however, that he had often seen such young cod "in the olden days," which is not surprising, because the number of cod along the coast at that time was considerable.

The young flounders, which were seen in large numbers previously during the summer, have within the last four to six weeks entirely disappeared. Probably they now frequent the bottom in sand areas, where it is difficult to discover them. I shall, however, direct attention to them also after the autumn, in order to obtain, if possible, more definite information concerning their development and their habits during the first year of their existence.

FLÖDEVIG, *September* 15, 1884.