

### 3.—OBSERVATIONS UPON FISHES AND FISH-CULTURE.

Materials of the kind included in this article have heretofore appeared in the report of the Division of Fish-Culture and have been published as a part of the Commissioner's Report. They are derived almost entirely from the reports of the superintendents of the stations and officers in charge of vessels of the Commission, and the language of the authors is preserved as nearly as possible. From the nature of the paper, arranged as it is by species in their zoölogical order, it would be difficult to indicate the authority for each item, but a list of the persons from whom information has been obtained is given below, together with the names of the stations or vessels furnishing the scene of their observations. The notes have been arranged for publication by the editor of the Commission, Dr. Tarleton H. Bean.

#### LIST OF PERSONS FROM WHOM NOTES HAVE BEEN OBTAINED.

A. C. Adams, schooner <i>Grampus</i> and Gloucester, Mass.	W. F. Hubbard, Clackamas, Oregon.
C. B. S. Adams, M. D., steamer <i>Fish Hawk</i> .	Fred Mather, Cold Spring Harbor, N. Y.
C. G. Atkins, Craigs Brook and Schoodic stations, Me.	John Maxwell, Woods Holl, Mass.
H. H. Buck, Green Lake, Me.	W. F. Page, Neosho, Mo.
Frank N. Clark, Alpena and Northville, Mich.	Robert Platt, lieutenant U. S. Navy, steamer <i>Fish Hawk</i> .
Richard Dana, Woods Holl, Mass.	W. de C. Ravenel, Battery station and Havre de Grace, Md.
Henry Douglass, Sandusky, Ohio.	H. M. Smith, M. D., Washington, D. C.
Vinal N. Edwards, Woods Holl, Mass.	Livingston Stone, Clackamas, Oregon.
John Gay, Gloucester, N. J.	Geo. B. Williams, jr., Baird, Cal.
Rudolph Hessel, Carp Ponds, Washington, D. C.	S. G. Worth, Central station, D. C., and Fort Washington, Md.

#### Sawfish (*Pristis pectinatus*).

A sawfish, measuring 15 feet 4 inches and weighing about 600 pounds, was taken at San Carlos Bay, Fla., by the steamer *Fish Hawk*, on March 22, 1889. The skin was prepared in a very skillful manner by the surgeon of the vessel, Dr. C. B. S. Adams, and was presented to the U. S. National Museum. A female was also surrounded by the seine, but escaped before the haul was landed. It was supposed that the pair had approached the shore for breeding purposes. The bottom upon which they were found was covered with fine white sand, intermingled sparsely with small shells, chiefly scallops.

**Carp** (*Cyprinus carpio*).

Spawning was in progress at the Carp Ponds from May 10 to 15, 1889. Mr. Hessel found the roots and even the entire surface of certain water plants covered with eggs. Some injury was caused by cold nights, and the superintendent restocked the ponds artificially with about 2,000,000 eggs on or about May 10. During May the carp grew to a length of 1 to 1½ inches.

**Goldfish** (*Carassius auratus*).

At the end of May, 1889, the Chinese and Japanese goldfish in the ponds at Washington had reached a length of about 1 inch.

**Tench** (*Tinca tinca*).

According to observations of Mr. Hessel, adults and young of this fish remain close to the bottom of the pond, both day and night.

**Golden Ide** (*Idus melanotus*).

Spawning began at the Carp Ponds, April 16, 1889, on a low temperature. Six days of warm weather followed and the eggs hatched on the fifth or sixth day. Early in May Mr. Hessel noticed among the young a school of the rare white variety, which did not mingle with the common yellow or red ones, but kept aloof, even when feeding.

**Shad** (*Clupea sapidissima*).

In the season of 1889, at Havre de Grace, Mr. Ravenel found that the fry hatched at Battery station seemed stronger and in better general condition than those at the auxiliary station at Havre de Grace. This he attributes to the better lighting of the Battery hatching house.

The variable and low temperature of the water in the early part of the season, (50° on May 4 and not reaching 70° until after May 8) made the first fry weak and unfit for long shipments, the period of incubation being so greatly protracted.

From the 15th to the 27th of May 1,713 gravid females furnished 57,809,000 eggs, an average of about 33,750 each.

On May 16, 1,575,000 eggs were placed on car No. 3 to be hatched en route to Albany, N. Y., for the Hudson River.

The first fish were hatched April 25, with the surface water at a temperature of 60°.

In 1890 the collection of eggs at Battery station, Md., began April 21 and ended May 20. From May 7 to May 20 the work was retarded by heavy rains, followed by muddy water. The temperature of the water varied from 52° to 70°. The number of eggs taken during the season was 32,405,000. The largest take in one day was 3,419,000, on April 24. The eggs were of excellent quality and the fry were remarkably vigorous. The number of females handled was 985, which yielded an average of nearly 33,000. The catch of shad at the head of the bay and in the Susquehanna and Northeast Rivers was very small, probably on account of the May freshet, which shortened the seasons.

On the Delaware eggs were collected from May 12 to May 28 and fry were distributed from May 20 to June 4, 1890.

During the egg-collecting season in the Potomac at Fort Washington, Md., the lowest mean temperature of the water was 52°, the highest 78°. The greatest number of shad eggs taken any one day was on May 6, when 8,368,000 were secured, the mean temperature of the water being 59°. April 24, 6,124,000; temperature, 63°. May 7,

6,311,000; temperature, 61°. With the temperature at 78° the largest yield was only 148,000.

April 29, 1889, Mr. W. A. Wilcox stated that the shad catch of the Sacramento was 56,471 pounds; June 22, 1889, he announced the occurrence of shad in the Columbia River; May 8, 1889, he again mentions shad in the Columbia River.

W. H. Woodcock, January 25, 1889, reported three shad caught in the Stikine River, Alaska, by salmon fishermen during the past season.

April 20, 1889, Prof. Charles H. Gilbert reported that there was no foundation for the statement of the capture of shad in the Colorado River.

In 1890 the collection of eggs for the *Fish Hawk* began April 30 (when 40,000 were obtained) and closed May 23. Nearly 34,000,000 eggs were collected during the season, from which were obtained 20,596,000 fry. Eggs were taken from 691 females, the average being about 49,000 to a female. The greater portion of the eggs were taken in the first half of May. The temperature of the surface water at 8 a. m. varied from 57° on May 1 to 64° on May 15.

At Fort Washington station, in 1890, the usual shad-hatching operations were conducted in April and May. Although shad were abundant in the wide waters and the lower river, they failed to reach the headwaters in sufficient numbers to furnish the usual quantities of eggs, and those that were obtained were secured in small lots. The seine belonging to the station took only 4,606 shad, while the annual average of four seasons preceding was 8,800. The abnormal conditions were expected as a consequence of the unusually open winter. The production of eggs was no earlier, but several schools of fingerling shad were surrounded by the Fish Commission seine and by the seine at Moxley's Point, an occurrence not previously observed by Superintendent Worth since the station was established. Associated with the shad were schools of fingerling herring. The smallest of the shad were only 5 inches long, a size not usually seen in rivers in the spring. Another unusual occurrence was the daily catching of young sturgeon. The whole number of shad eggs collected was 35,202,000. The collecting began April 15 and closed May 17. The greatest number taken in one day was 3,564,000, on May 5, 1890.

H. M. Smith, of the Fisheries Division of the Fish Commission, observed a peculiar habit of the shad in the town of Steuben, Maine. The fish arrive in June and are taken in brush weirs set for herring as late as October. At times they go into Dyers Bay at high tide and remain on the flats when the tide recedes. The fishermen do not think that the shad are stranded, but are inclined to believe that the habit is due to a dislike to return to salt water. It is observed that the fish make holes in the soft mud and sand, in which they remain until the water again covers the flats. From conversations with the fishermen it would appear that during some seasons large numbers of shad are seen at the head of the bay and are easily taken with the hand. The annual number reported to have been thus caught in 1888, 1889, and 1890 was between 150 and 200, although many more could no doubt be secured were the fishermen so disposed. This habit of the shad has not been reported elsewhere in Maine and appears to be unique.

#### California Salmon (*Oncorhynchus chouicha*).

This salmon came into the McCloud River, at Baird station, Cal., in two runs in 1888, the first beginning August 14 and ending September 24, the second beginning

October 29 and closing December 15. Owing probably to the high temperature of the water, which averaged 55.8° during the first run, the eggs hatched in 36 days. During the second run the temperature of the water averaged 46.8°, and the eggs were 64 days in hatching.

The seine hauls in August averaged from 18 to 20 fish, which were mostly small males. On August 18 a ripe female was taken. This is an unusually early spawning date. Owing to the high temperature the eye-spots appeared in the eggs on the fifteenth day and hatching began on the thirty-sixth day. The shortest incubation period heretofore was 40 days.

The observations of persons living on the McCloud led to the expectation of a large run of salmon at Baird station late in October, and it was determined to continue the taking of eggs during this late run. The salmon arrived late in October and continued to come during November. A large portion of the females caught October 28 were not ready for spawning.

In the first run 375 females yielded 1,439,100 eggs, averaging nearly 4,000 each. In the second run 830 females furnished 3,862,000 eggs, an average of nearly 4,700 each.

In 1889, salmon first appeared in McCloud River on August 14, when a ripe female was caught in the trap at Baird station. This was unusually early, and no more were taken until August 27, when very few salmon were in the river. The late run of salmon commenced October 7, and many ascended the river while the racks were removed by a storm. On October 16, when fishing was resumed, 40 salmon, fresh from the sea and none of them ripe, were caught in one haul. On November 18 the run of fish ceased.

Of the salmon taken from the first run 1,129 were males and 382 females, of which 253 were gravid. In the second run 94 males and 170 females were taken; of the females 112 were ripe. The average yield of eggs from each female of the first run was 4,385; of the second run, 5,075; the average from 371 females was 4,600.

At the rack on the Clackamas in July, 1888, thousands of salmon which were prevented from ascending to their spawning grounds remained all summer until the spawning season arrived, the great mass of them always within 30 rods of the rack, which was continually attacked by relays of fish for the purpose of breaking it down.

From 969 females at the Clackamas station were taken about 4,600,000 eggs, an average of nearly 4,750 each.

On August 24, 1888, a number of large males were caught, indicating a run of salmon. This run made its appearance, but was small.

It was expected at Clackamas that the salmon which arrived at the rack in March and April would spawn about the middle of July, as they would have done at the sources of the river naturally; but ripe eggs were not obtained until near the end of August, and Mr. Stone has reached the conclusion that "their eggs will not ripen until about the time for the regular spawning season to begin at that portion of the river where they happen to be at the time."

Mr. Stone also concluded "that the salmon can not deposit their spawn until the temperature of the water where they are has reached the degree of cold natural to the river at the time of the regular spawning season at that point; or, in other words, if the water is not cold enough the salmon can not deposit their spawn. It also appeared that if the salmon are kept too long in water not cold enough for them to spawn in they will die; and if in some exceptional instances loose and apparently ripe eggs are found in them the eggs are worthless." In consequence of this belief it was decided

not to put in the rack at the Clackamas in future until the first run has ascended to their natural spawning grounds.

Early in September, 1888, owing to some peculiarity of the water supply of the Clackamas hatchery, serious injury to the eggs and young fish was observed. Investigation showed that at the time the early eggs were placed in the hatchery Clear Creek was very low, little rain having fallen and the impurities and minute vegetable and animal growth, which had accumulated in the creek during the summer from natural causes and from the deposits of mills up stream, remained in it. It was believed also that the great variation between the temperature of the Clear Creek water during the twenty-four hours; a difference of  $10^{\circ}$  having been noted, was another important factor in the imperfect development and death of eggs and embryos.

Mr. Stone believed further that many of the eggs taken early in the season were spoiled inside of the fish before they were taken. He thinks that a large percentage of the breeding salmon that were spawned before and perhaps during the first week in September contained these worthless eggs.

The egg-collecting season on the Clackamas River, Oregon, extended from August 28 to November 6 in 1889. The largest number of eggs taken in one day was 208,000, on September 27; the least number was 4,000, on August 29; the daily average of eggs collected was 62,514. The females handled numbered 957; the average number of eggs to each was 4,507. Mr. Hubbard states that more males are taken always than females. He estimated that the fry produced in the hatchery equaled about 85 per cent of the number of eggs introduced into the building.

*Mode of capture.*—Four traps were built in Clackamas River for catching salmon, one on the rack and three below it on the shallow riffles. These traps were placed at the lower end of a riffle where the water is very swift and the bed of the river has a good deal of fall. They are built of poles or slats in such a way that the water runs into the mouth of the trap with a great deal of force and passes out through the bottom, leaving the fish that come into them on the floor. Wings extend from the mouth of the trap up the river, diverging until at the upper end they are as far apart and take in as much of the river as possible. The fish are driven into these traps by stretching a net across the river some distance above the trap and drawing it down stream, driving the fish before it into the trap. The ripe fish are then taken out and put into pens when ready for spawning, the unripe ones being returned to the river.

#### *Atlantic Salmon (Salmo salar).*

In 1888 a plant of 20,000 fry, from Cold Spring Harbor, N. Y., was made in the Nissequogue River, Long Island, and this was repeated in 1889. The growth of salmon in this stream is remarkable; a yearling, caught by Mr. L. D. Huntington, May 15, 1889, was  $7\frac{1}{2}$  inches long and  $1\frac{1}{2}$  inches in greatest depth. In 1889 the station received from the hatchery at Orland, Me., 700,000 eggs; of these 25,000 were sent to the Fulton Chain hatchery, New York, and 17,500 to the hatchery of the Bisby Club, in Herkimer County, N. Y. These waters empty into Lake Ontario at Sacketts Harbor. The remaining eggs furnished 20,000 fry for the Nissequogue, as above stated, and 618,188 for tributaries of the Hudson.

On September 19, 1888, Mr. Atkins found, at Craigs Brook, a parr  $6\frac{1}{2}$  inches long which gave milt.

The rearing operations at Craigs Brook, Me., during the summer of 1889 were

remarkably successful. Of the yearling Atlantic salmon 89 per cent were saved, and the eggs of this species yielded 83 per cent of fish at the time of distribution. Mr. Atkins believes that the losses of fish were less in the second year than during their first year. The winter losses were small. The rearing troughs, holding about 2,000 fry, are 8 inches deep, 12 $\frac{3}{4}$  inches wide, and about 10 feet long.

*Fish disease.*—At Craigs Brook station, in May, 1890, while the fish were in the yolk stage, they were attacked by a disease previously unknown at Craigs Brook, which during May and June destroyed nearly one-third of the entire stock. It first appeared among the Atlantic salmon, but it was most fatal to landlocked salmon, säbbling, and Swiss lake trout. Some lots of fish were not attacked and some were exterminated by it.

**Schoodic Salmon** (*Salmo salar*, landlocked).

At the Schoodic station from 457 females the average number of eggs taken was 2,100 each. Three small females yielded 2,300 eggs, an average of 767 each.

Of the 495 males examined, the average weight was 3 $\frac{1}{2}$  pounds, the heaviest 5 $\frac{1}{8}$ , the lightest 1 $\frac{3}{4}$ . The average length of males was 19 $\frac{1}{4}$  inches, the longest being 24 and the shortest 15 $\frac{1}{2}$  inches. 471 females were weighed and measured, the average weight being 3 $\frac{3}{4}$  pounds, the heaviest 6 $\frac{3}{4}$ , the lightest slightly more than 2 pounds. The average length was 19 $\frac{1}{2}$  inches, the greatest 24 inches, the shortest 16 $\frac{1}{2}$ .

During the egg-taking season (October 24 to November 24, 1888) the temperature of the river water ranged from 49.5° to 34°. The mean temperature for October was 52.5° and for November 42.3°. The mean temperature of the river water in December was 35.3° and in January 34.5°. This comparatively high temperature hastened the development of the eggs, bringing them to the shipping stage unusually early, the shipments beginning January 29, 1889, and continuing until February 5.

At Schoodic station, Maine, the fishing was begun October 25, 1889, and continued until November 24, during which time 871 salmon were handled, including 313 males, 557 females, and 1 of unknown sex. The average yield of 517 females was 2,350 eggs each. The proportion of males was much larger than last year, and the yield of eggs greater. The total weight of eggs was 471 pounds 5 ounces, amounting, after deducting losses, to 1,017,000. The largest fish of the season was a male, measuring 26 inches and weighing 6 pounds. The heaviest female weighed 5 $\frac{1}{2}$  pounds and measured 23 $\frac{1}{2}$  inches; and the longest female measured 24 inches and weighed 5 pounds 6 ounces. On liberating the fish at the end of the season almost every female yielded a few eggs. From them 33 pounds, or about 75,000 eggs, were obtained, which hatched as readily as any of the others.

In the operations of Green Lake station it was found that the first salmon in 1889 appeared on the night of October 14. Spawning operations began November 4 and continued until November 15. The number of male salmon handled was 50, and of females 75. The females yielded an average of nearly 4,000 eggs. Mr. Atkins found that the males averaged 22.3 inches in length and about 5 pounds in weight; the females 25.5 inches in length and 7.8 pounds in weight. Of the females, 69 retained all or nearly all of their eggs. The longest and heaviest male measured 31 inches and weighed 13 $\frac{5}{8}$  pounds. The heaviest female was 30 inches long and weighed 11 $\frac{1}{8}$  pounds. The water was very cold during the winter and the development of the eggs slow.

In the rearing operations in 1889 at Craigs Brook, Me., Mr. Atkins succeeded in saving 97 per cent of the fish reserved and the eggs yielded 68 per cent of fish. The losses in winter were small.

**Von Behr Trout** (*Salmo fario*).

At Cold Spring Harbor, N. Y., 2½-year-old fish gave an average of 303 eggs each; 3½-year-old trout yielded 942 each. After the second year the growth of the brown trout is rapid.

At Northville, Mich., this species endures the climate well, and grows faster than the brook trout. Mr. Clark places from 10,000 to 12,000 eggs first upon gravel in a space 12 by 15 inches for about 40 days, or until the eye-spots begin to appear, when they are transferred to trays for hatching.

The average number of eggs furnished by 314 females was 520 each. The season began October 21, 1889, and closed January 2, 1890.

**Loch Leven Trout** (*Salmo levenensis*).

In the season of 1889-90 the loss in hatching Loch Leven trout at Northville, Mich., was only about 4 per cent. In attempting to rear fry hatched there from 13,000 eggs obtained from Germany, in March, 1890, the young, after the absorption of the yolk sac, commenced dying from some unknown cause, and 75 per cent were lost.

The average yield of 357 females was about 800 eggs each.

**Rainbow Trout** (*Salmo irideus*).

Mr. Clark reports that Northville, Mich., appears to be an unfavorable locality for rainbow trout. Upward of 19,000 yearlings were distributed between September 17, 1889, and March 10, 1890. The average yield of 123 females in the season of 1890 was about 968 eggs. The spawning season began January 4 and closed April 16, 1890.

**Brook Trout** (*Salvelinus fontinalis*).

The spawning season of 1889 began at Northville, Mich., October 14, 1889, and closed January 6, 1890.

By the use of gravel boxes the loss in hatching was only 2 per cent. A large proportion of the eggs were obtained from fish 18 months old.

On January 16, 1890, there were received at Neosho, from Northville, 25,000 eggs in excellent condition. When the embryo sac was two-thirds absorbed, a white spot appeared in the sac and almost exterminated the fry.

**Whitefish** (*Coregonus clupeiformis*).

There was an early run of whitefish to the spawning grounds in Lake Erie in 1888, but nearly all of the many eggs taken were lost. On Detroit River the penned fish did not do well. The warm weather was supposed to be the cause of the want of success with the eggs; the same thing happened at Sandwich, Ontario. The river water registered 50°.

At Alpena, Mich., eggs were collected from December 2, 1889, and the season closed at Thompson, December 14, with what is called the late run. On account of the warm weather the eggs at Alpena commenced hatching 15 to 20 days earlier than in former seasons; the first fish appeared April 5, and the last May 5, 1890.

**The Vendace** (*Coregonus albula*).

On April 12, 1888, 51,000 fish of this species, one month old, were planted in Heart Pond, Me., by Mr. Atkins.

**Yellow Perch** (*Perca flavescens*).

In April, 1889, the eggs of the yellow perch were successfully hatched by Mr. Worth at Central station. Adults from the Potomac River spawned naturally in the aquaria, and their eggs were placed in the universal hatching jars and developed almost without loss. The eggs were an oblong mass of fleecy texture, several inches long and heavier than water. The fry were very small; they were retained at the station in a small pond, and kept under observation.

On February 7, 1890, Mr. S. G. Worth obtained 243 adult yellow perch from the Potomac River. These were kept in running water at Central station until they deposited and fertilized their eggs naturally. The eggs were hatched successfully, with very small loss, and 704,000 fry were liberated in the Potomac River, and 50,000 in a private pond.

**Pike Perch** (*Stizostedion vitreum*).

The eggs of the pike perch, writes Mr. Douglass, of the Sandusky station, are about one-half as large as whitefish eggs. They are strongly adhesive, and great loss is sustained in separating them. The young begin to devour each other when only ten days old, and must therefore be liberated as soon as hatched.

**Sea Bass** (*Serranus atrarius*).

From June 5 to 10 about 1,150,000 eggs were collected at Woods Holl, Mass.; of these, 1,025,000 were hatched and the fry planted between June 10 and 13, 1889.

The collection of eggs for the Woods Holl-station began May 23, 1890, and closed June 20. The number taken was upward of 4,250,000, of which 90 per cent were hatched in Chester jars and McDonald boxes. The shortest hatching period was 70 hours, with an average temperature of 64°; the longest period was 127 hours, when the temperature averaged 56°. The fish were liberated near the station.

**Black Bass** (*Micropterus salmoides*).

At Neosho, Mo., the black bass were expected to spawn in the ponds in the spring of 1890, but although they were tame and thrifty they deposited no eggs. In one pond they were attacked in the mouth by leeches and have not flourished.

**Sheepshead** (*Archosargus probatocephalus*).

On March 19, 1889, Lieut. Robert Platt, U. S. N., found sheepshead spawning at Boca Grand Pass, Fla., and collected 3,400,000 eggs. He then went to San Carlos Bay, about 30 miles distant, and found the fish abundant there and in spawning condition. He obtained in all 23,400,000 eggs, from which 14,000,000 healthy fry were developed, and 2,500,000 eggs were retained in the jars to be transported North. Lieut. Platt describes the eggs as follows:

The egg of the sheepshead is a floating one and transparent; very small, 50,000 to the fluid ounce. We placed in the hatching jars about 300,000; they came out in forty hours, and can be liberated when seventy-two or eighty hours old. The fry are very small, but active and strong, and will stand considerable rough usage. We found that it was labor in vain to seine for spawning fish during the morning or ebb tide. The proper time is just before sundown, just as the flood tide begins to



make. At that time we would collect all the spawn we could handle. The morning hauls of the seine included nothing but male fish. The sheepshead when in spawn swim in schools, but not near the surface. They seem to like to swim close along the sandy beach in about 6 or 7 feet of water. At times our seine would have so great a quantity of these fish in it that we could not get it to the shore, but would have to raise the lead line from the bottom and liberate a great many so that we could examine those remaining in the net.

The apparatus used in hatching these eggs was the Chester jar in the tidal box.

**Scup** (*Stenotomus chrysops*).

May 22, 1889, 50,000 scup eggs were collected; 30,000 of these were hatched and the fry planted in Woods Holl Harbor May 29.

On June 14 and 16, 1890, about 444,000 eggs of this species were obtained for the Woods Holl station. These were placed in a Chester jar and a McDonald box. The first lot hatched in 72 hours at an average temperature of  $61\frac{1}{2}^{\circ}$ , the second lot in 95 hours when the temperature averaged  $62\frac{1}{2}^{\circ}$ .

**Spotted weakfish** (*Cynoscion maculatum*).

On April 1, 1889, Lieutenant Platt collected 1,450,000 eggs of this species at San Carlos Bay, Florida. He found the fish in great quantities, and the spawning season just beginning. He states that the egg floats, and is equal in size to that of the sheepshead. Only about 350,000 fry were developed. The period of hatching is 40 hours.

**Squeteague** (*Cynoscion regale*).

On June 6, 1890, there were obtained at Woods Holl, Mass., 237,700 eggs, of which 95 per cent were hatched in the Chester jar. The time of incubation was 65 hours, and the temperature  $60^{\circ}$ .

**Pompano** (*Trachynotus* sp.).

At San Carlos Bay, Florida, Lieutenant Platt seined a pompano weighing  $18\frac{1}{2}$  pounds. In the stomach he found crushed scallop shells.

**Mackerel** (*Scomber scombrus*).

Vinal N. Edwards, on May 21 and 24, 1889, collected 215,000 mackerel eggs, from which 150,000 fry were hatched and planted in Vineyard Sound, May 29. On June 3 500,000 eggs were taken from fish which had been dead a few minutes; none of these eggs survived.

Eggs of the mackerel were collected for Woods Holl station on June 2, 6, 10, and 11, 1890. The total number obtained was nearly 3,000,000, and the percentage hatched from good eggs was 89. The shortest hatching period was 72 hours, at an average temperature of  $61^{\circ}$ , and the longest period was 103 hours, when the average temperature was  $59^{\circ}$ .

**Tautog** (*Tautoga onitis*).

Eggs of this species were taken at Woods Holl May 21, June 10, 21, and 24, 1890. The total number collected was 808,605, of which 90 per cent were hatched. The shortest hatching period was 66 hours, on an average temperature of  $64^{\circ}$  to  $64\frac{1}{2}^{\circ}$ ; and the longest period 144 hours, with a temperature of  $56^{\circ}$ . The Chester jars and the McDonald box were used.

**Cod** (*Gadus morrhua*).

At Gloucester, Mass., November, December, and January are the best months for collecting cod eggs. 161 female cod furnished on an average 279,000 eggs.

At Woods Holl, Mass., according to the report of the superintendent, the period of incubation in the McDonald tidal box averaged 18 days; in the Chester box, 20 days.

Mr. Richard Dana counts 18 cod eggs to 1 inch, from which basis he obtains:

In 1 quart .....	336, 798
In 1 pint.....	168, 399
In 1 gill.....	42, 099
In 1 ounce .....	10, 254
In 1 cubic inch.....	5, 832

In 1889 the first cod for breeding purposes were received at Woods Holl on October 27; by November 19, 3,403 had been received, sufficient for the season's work. The fish were placed in live cars except 700, which were confined in a basin wherein the tide ebbs and flows. In this basin the mortality was great, probably owing to the high temperature, 55°, and the want of shelter from the sun. The eyes of many of the fish protruded from their sockets, and the fish became blind in six or seven days after their receipt. Board floats were then placed in the basin, after which the condition of the fish improved. When the temperature of the water fell to 46° the mortality decreased.

The first ripe eggs were taken November 18, and from this time until February 18, 1890, the number of gravid females handled was 91, which furnished about 8,500,000 eggs. From these upward of 5,750,000 fry were produced, which were liberated in the harbor from three to six days after hatching. The percentage of eggs hatched was 68. On February 11, 1890, were received from the Gloucester station 2,374,200 eggs. About 23 per cent of those received alive were hatched, the injury in shipment having been very great. On April 14, 1890, another shipment of 621,600 eggs was received from Gloucester, and of the number received alive 66 per cent were hatched. The hatching apparatus consisted of 40 Chester tidal boxes with a capacity of 6 hatching jars, each holding from 150,000 to 200,000 eggs, besides 47 McDonald tidal boxes each having a capacity of 500,000 eggs.

The temperature of the water in the hatchery ranged from 47° to 33° with no sudden changes and with unusual immunity from slime and sediment. The small supply of eggs alone prevented a large output of fry. The experiment of keeping cod in aquaria after the sac was absorbed proved again unsuccessful. The cod fry were generally liberated on strong ebb tide in Buzzards Bay or Vineyard Sound, so that they might quickly be carried into deep water. The average yield of the female cod at this station was nearly 94,000 eggs. In fertilizing these eggs the milt of 102 males was used. The shortest hatching period was 107 hours, from eggs obtained November 18, 1889, which were hatched November 23. The longest period was 696 hours, from eggs taken January 27, 1890, and hatched February 14. The average temperature during the hatching of the first lot was 47°. The maximum temperature during the incubation of the second lot was 38°, the minimum 34°, and the average 36°.

While the *Grampus* was obtaining cod eggs in October, 1889, it was found that few ripe fish were taken with hand lines as compared with those caught with the nets and trawls.

Capt. Fred. W. Wilson, under date of February 12, 1889, stated that he has fished most of the time in winter off Gloucester, Mass., for fifteen years past. In the winter of 1887-88 and 1888-89 he saw an unusual number of small cod on hard bottom everywhere in the vicinity. They ranged from 5 to 10 inches in length, and toward the end of January he saw some that weighed about  $\frac{1}{2}$  pound. Captain Wilson says the cod are credited to the hatchery on Ten-Pound Island, and if one-half of the number taken on his vessel reach maturity the success of the work will be established. Capt. Isaac Joyce about the same time made a similar report; he believed that the young were more plentiful in the winter of 1888-89 than ever before; the smallest ones taken by him were about 8 inches long. Capt. Henry S. Jacobs, on February 11, 1889, wrote that more small cod were seen in the fall and winter of that year, from the range of Thatcher's Island to the range of Half-Way Rock, than during any other season in his experience. A large number of fish 9 inches long were among those taken. On three occasions 1,000 pounds of such cod were caught at one haul. He attributes the increase of cod to the work of the hatchery at Gloucester, Mass.

The difficulties experienced in keeping the cod eggs afloat at Gloucester, Mass., have already been mentioned, and also the fact that eggs which sink do not always fail to hatch. The difficulty with these eggs led Mr. W. H. Lynch, machinist, to the use of aquaria jars with water coming in from below and the top covered by cloth to retain the eggs. He suggested, also, placing a perforated  $\frac{3}{8}$ -inch composition pipe along the bottom of the hatching trays and connected by rubber tube with the supply pipe, producing an upward current which would float the eggs.

The egg collecting began October 23, 1889, and continued until May 6, 1890. January and February were the best months. The largest yield in one day was nearly 3,500,000 on February 1. The number from 242 females was about 47,500,000, an average of nearly 200,000 to each female.

*Hatching eggs in roily water.*—In hatching eggs of the cod, haddock, and pollock at Gloucester, Mass., great mortality was caused by roily water, the sediment adhering to the eggs and causing them to sink. This difficulty was partly overcome by the use of the automatic jet; for the bulk of the eggs it served the purpose admirably, but greater difficulty was experienced in keeping cod eggs in circulation; many of them (apparently fertilized) sank to the bottom, and most of them failed to develop. By increasing the circulation after storms, many eggs that had sunk were cleaned and again became buoyant and hatched, yielding a fair percentage of fry, and in some cases eggs that remained on the bottom were developed and the young fry appeared vigorous.

#### **Haddock** (*Melanogrammus aeglefinus*).

The receipts of haddock eggs at Gloucester, Mass., during the latter half of the season were very large, but the percentage hatched was very small, the methods now in use for developing these eggs not proving satisfactory. The first eggs were taken February 13, 1890, and the last May 7, 1890. The fry were liberated in the outer harbor from April 12 to May 8. The eggs were obtained from 240 females, the average yield for each being 126,000.

**Pollock** (*Pollachius virens*).

The spawning season for pollock at Gloucester, Mass., includes October, November, and a part of December.

The first eggs were taken October 30, 1888, and the last December 17, 1888.

The period of incubation varied from seven to twelve days.

During November 50 females furnished 20,256,300 eggs, an average of 405,125 each. From December 3 to 17, 39 females furnished 11,623,500 eggs, an average of nearly 300,000 each.

On October 30, when the first eggs were taken, the temperature of the water at noon was 48°, and its density 25. The temperature of the air at noon on the same date was 48°. During November the temperature of the water at noon ranged from 41° to 49°; the lowest temperature being observed from the 23d to the 26th, both inclusive.

The density of the water during this month was from 25 to 26.

The air temperature at noon during November varied from 24° to 59°, the lowest temperature having been reached on November 23. From December 3 to 17 the water temperature at noon ranged from 38° to 45°, and its density from 25 to 26°.

The eggs of the pollock are small and tender—much more so than those of the cod. They are adhesive after three days' time, and require very pure clear water, and no motion whatever. The eggs measure 22 to the lineal inch, and a quart contains 614,172. Some eggs were tried by liquid measure and numbered 19,216 to the ounce.

Pollock when hatched are transparent, and almost of the same color as the sac; they will burst from the shell in seven or eight days; they are weak and lifeless for a time, then they begin to dart from place to place like the cod, and stop quite suddenly as if entirely exhausted. The eye is not very distinct, and the fish appears blind unless closely observed. The spawning season is short compared with that of the cod.

The eggs of this species were circulated at Gloucester, Mass., without difficulty by means of the automatic jet. The first eggs were received October 18, 1889, and collections continued until December 20. The largest number obtained in one day was upward of 5,000,000, on November 7; about 40,000,000 were taken in all. The number of females furnishing these eggs was 181, and the average yield of each was nearly 222,000. Nearly 15,000,000 fry were developed, all of which were liberated at Gloucester; the first on October 27, obtained from eggs collected October 18, and the last on December 29, from eggs obtained December 20, 1889.

**Flatfish** (*Pseudopleuronectes americanus*).

At Woods Holl, from February 3 to April 24, 1890, the number of females handled was 87, which yielded 5,848,000 eggs. Over 4,000,000 fry were produced, which were liberated from 2 to 5 days after hatching. The average number of eggs to the female was 67,220. The period of incubation is about 20 days. The adults were caught in a fyke net. In severe cold spells the fish leave the harbor and go into the deep water of Vineyard Sound and Buzzards Bay, but return when the temperature rises so that the anchor frost disappears.

**Sole** (*Solea solea*).

On October 6, 1888, the Commissioner deposited in Vineyard Sound, near Quick's Hole, 28 soles which had been received from time to time at Wood's Holl from England.

**Lobster** (*Homarus americanus*).

On June 16, 1888, car No. 3 left Woods Holl with 610 lobsters for the Pacific coast; 282 died en route. The survivors were planted at Monterey, July 1, 2, 3, 4, 5 and 6. Out of 196,000 eggs taken with the adults, 92,000 were lost in transit.

The experiment of acclimating lobsters on the Pacific coast was renewed in 1889. An account of the shipment will be found in the Bulletin of the U. S. Fish Commission for 1888, pp. 453-472.

The attempt to rear young lobsters in large numbers at the Woods Holl station was again unsuccessful.

On March 28, 1890, there were 745 lobsters, measuring from 7 to 10 inches in length, shipped from Woods Holl in wooden crates, packed in seaweed, for the Gulf of Mexico, near Galveston, Tex. Of these 385 were females, 37 of which had their eggs fertilized, and 360 were males. On April 7 the eggs, numbering 250,000, were planted near Galveston. The fresh water of the bay proved fatal to the adults.

For the hatching operations at Woods Holl lobsters were obtained from the local fishermen. After the eggs were stripped off the females were marked and returned to the grounds from which they were caught, the object being to ascertain how often they deposited their eggs under natural conditions. Collecting began April 16, and by June 30, 1890, there were received 723 egg lobsters, varying in length from 9 to 14 inches. From these were obtained 8,317,600 eggs, which produced about 4,500,000 of fry. These were liberated in Vineyard Sound and Buzzards Bay, in the vicinity of Woods Holl, from two to four days after hatching. The percentage hatched was 54. The apparatus used were the McDonald improved hatching box, the Chester jar, and the McDonald universal hatching jar. The first two were operated by tidal motion, the latter by a continual current through the jar. The longest incubation period of eggs received here was 42 days and 3 hours. These eggs were taken April 22, 1890, when the water temperature was 45°, and the lobsters were well developed in the eggs at the time of collection. They did not hatch until the water reached a temperature of 59°. A lobster with eggs, said to be about to hatch, and in which the embryo was well developed, was brought in when the temperature was 36°, but no increase in development was noticed until May 18, after a period of 99 days, when the water reached 54°. A few fry were retained in the jar in which they were hatched, and in six weeks after hatching were transferred to an aquarium.

**Common Pacific crab** (*Cancer magister*).

In July, 1888, Prof. Leslie A. Lee and Mr. J. F. Ellis, collected live crabs (*Cancer magister*) at San Francisco, Cal., for transportation to the Atlantic coast on car No. 3 of the Commission. The entire shipment was lost by the wrecking of the car.