

NOTES ON THE TAGGING OF FOUR THOUSAND ADULT COD AT WOODS HOLE, MASSACHUSETTS.

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HISTORY AND OBJECTS OF THE EXPERIMENT.

Taking advantage of the annual release of a large number of adult cod at the fish-cultural station of the United States Fish Commission at Woods Hole, Massachusetts, the writer suggested that it might be possible to secure some useful information concerning the natural history of the cod by marking or tagging the fish just before their liberation. Accordingly, in the winter of 1897-98, and in the three succeeding years, the available fish were tagged so that they might be recognized if recaptured.

The cod which were thus treated had been caught in October and November of each year on Nantucket Shoals and brought to the Woods Hole station in the wells of fishing vessels. The fish weighed from 2½ to 20 pounds, and were what the fishermen call the "shore cod," as distinguished from the "bank cod." Few of them weighed less than 3 pounds or more than 10 pounds, and the average weight when caught was probably not far from 6 pounds, although when released after tagging the average weight was only 5 pounds. The larger part of the supply was obtained by the Fish Commission schooner *Grampus*, Capt. E. E. Hahn in command.

The fish were caught with hand lines, and only those in which the hook wounds were trivial were retained. On arriving at the station they were transferred to large floating cars, in which they were held pending the ripening of their eggs. The egg-taking season is from the middle of November to the last of January or first of February, and the maturation of the eggs of individual fish often extends over a period of several weeks, during which time the fish are handled two or three times a week. As soon as a fish has been finally stripped it is set at liberty, either in Vineyard Sound or Buzzards Bay.

Owing to the captivity and to the rather rough handling to which the brood cod are necessarily subjected in taking their spawn and milt, in addition to the loss of vitality incident to the spawning process, they

become much emaciated and some of them succumb, notwithstanding clams and fish are fed to them.

The tags were cut from sheet copper, as this metal is cheap and withstands the action of salt water for a long time. A few tags made of pure sheet tin were used, but they proved to be unsatisfactory. The copper tags were from five-sixteenths to three-fourths of an inch long, and one-fourth of an inch wide. A small hole was punched in one end, through which a fine copper wire was passed, attaching the tag to the fish. The average weight of the tags, with wire, was 0.65 gram, or about one-fourth that of a 10-cent silver piece.

The places of attachment were the bases of the three dorsal fins, the bases of the anal fins, and the upper and lower caudal lobes. Most of the tags were fastened to the upper part of the caudal fin, near its junction with the peduncle, where the rays are toughest and the tags are least liable to be torn out. To facilitate the passage of the wire through the fin an aneurism needle was used. After the weight, length, and sex of the fish were determined and recorded, and the tag was attached, they were towed into the sound or bay in live-cars and turned loose.

The record kept for each tagged fish comprised the following items: Tag number, position of the tag, date when released, where released, the weight, length, sex, and spawning condition (whether spent or immature).

In order to acquaint fishermen and fish-dealers with the purposes of the tagging, and to encourage the preservation and return of the tags, a circular was printed and distributed in the fishing towns in November, 1897. The circular contained a cut of a cod showing the position of the tags, and asked that any person coming into possession of a cod having such a tag forward the latter by mail to the U. S. Fish Commission, Washington, D. C., or to the U. S. Fish Commission station, Woods Hole, Massachusetts, together with the following information concerning the fish: The date when caught; on what grounds taken; weight before being dressed; total length measured from end of nose to end of tail; sex; and whether milt or eggs were ripe, large but not ripe, or immature.

Additional publicity was given to the experiment by a number of timely articles in the newspapers of New York, Boston, and other large cities, as well as in the press of the fishing towns. The novelty of the scheme excited unusual interest and the hearty cooperation of the fishermen was secured, as shown by the large number of tags recovered and the filing of full data regarding the captured fish.

The tagging began each winter about the 1st of December and continued for 2 or 2½ months. The work was usually brought to a close by the formation of anchor ice and the consequent killing of all the fish that remained in the cars.

The number of fish tagged during the four winters covered by the experiment was 4,019, divided as follows among the different years:

1897-1898.....	562
1898-1899.....	593
1899-1900.....	1,421
1900-1901.....	1,443

Among the subjects on which it was expected the tagging might throw light and thus prove of practical interest, were the rate of growth of the cod, the frequency of its spawning, the extent to which the individual fish migrate, the rate of movement, etc.

Although it is probable that other tagged fish may hereafter be captured, it is thought that sufficient time has elapsed and enough tags have been recovered to warrant the present summary of the outcome of the experiment.

NUMBER OF TAGGED FISH CAPTURED.

From the accompanying table it will be seen that of the 4,019 fish tagged and released 140 were subsequently captured by commercial fishermen up to December 31, 1901. The number taken during each of the four seasons covered by the experiment was as follows:

1897-1898.....	35
1898-1899.....	30
1899-1900.....	22
1900-1901.....	53

In addition to the foregoing there were quite a number of tagged fish taken for which records are unobtainable, the fishermen having lost or mislaid the tags or failed to report the captures. In New Jersey, New York, and Rhode Island fully 20 tagged fish are known to have been caught, but the tag numbers are unknown and hence the captures can not be taken into consideration. Some of the fishermen in Narragansett Bay, Rhode Island, took a number of cod which they liberated alive on discovering the tags without noting the tag numbers. In some cases fishermen are known to have unreported tags in their possession which they are keeping as curiosities. In a few instances fishermen have failed to report the catching of tagged cod through fear that there was some penalty attached to the killing of such fish.

Several reports of the capture of tagged cod on the coasts of Maine and Nova Scotia could not be verified.

In a number of instances the tags have not been observed at the time the fish were caught, but have been discovered by the wholesale dealers to whom the fish were sold. Occasionally tags have been forwarded by consumers. When fish were salted on the grounds, tags have sometimes been recovered months afterwards in the houses of salt-fish dealers or the skinning lofts of preparers of boneless cod. In at least one case a tag was overlooked by the man who caught the fish, by the men who cleaned, split, and salted it, by the man who unloaded it from the vessel, by those who handled it on shore, by the wholesale dealer, and by the retail dealer; it was eventually found by a consumer remote from the shore and forwarded to the Commission.

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Record of the tagged cod released at Woods Hole and subsequently captured by commercial fishermen, 1897-1901.

Tag No.	When released.	Where released.	When caught.	Where caught.
135	Feb. 14, 1898	Mouth of Woods Hole Harbor.	Mar. 22, 1898	Off Block Id., R. I.
210	Dec. 27, 1897	2 miles SW. bell buoy, Quicks Hole.	May 3, 1898	3 1/4 miles SSW. Chatham, Mass.
261	Jan. 8, 1898	Buzzards Bay, 1 m. NE. Robinsons Hole.	Apr. 9, 1898	1 1/4 miles E. Sankaty Head L. H., Mass.
265	.....do.....	.....do.....	May —, 1898	Off Brenton Reef, R. I.
315	Jan. 15, 1898	3 miles N. Gay Head light-house.	May 20, 1898	Off Chatham, Mass.
317	.....do.....	.....do.....	May 28, 1898	In trap at Monomoy, Mass.
320	.....do.....	.....do.....	Sept. 5, 1898	Nantucket Shoals.
324	.....do.....	.....do.....	May 18, 1898	SE. Brenton Reef L. S., R. I.
332	Jan. 18, 1898	3 miles W. Gay Head light-house.	July 7, 1898	South Channel.
337	.....do.....	.....do.....	Feb. 19, 1898	SW. of Block, Id., R. I.
339	.....do.....	.....do.....	May 8, 1898	1/2 mile off Sankaty Head L. H., Mass.
360	Jan. 22, 1898	2 miles NW. Gay Head light-house.	Feb. 4, 1898	Off West Hampton Beach, N. Y.
361	.....do.....	.....do.....	Mar. 14, 1898	Off Pt. Pleasant, N. J.
371	.....do.....	.....do.....	Apr. 18, 1898	2 miles from Brenton Reef L. S., R. I.
375	.....do.....	.....do.....	Mar. 22, 1898	2 miles ESE. Green Hill, R. I.
376	.....do.....	.....do.....	July 23, 1898	Off Chatham, Mass.
400	Jan. 25, 1898	4 miles SW. Tarpaulin Cove light-house.	Apr. 12, 1898	Off Block Id., R. I.
418	.....do.....	.....do.....	May 2, 1898	Nantucket Shoals, off Sankaty Head L. H.
438	Jan. 31, 1898	2 1/4 miles NE. Robinsons Hole.	Apr. 26, 1898	In pound net 10 miles E. Westerly, R. I.
448	.....do.....	.....do.....	Feb. 18, 1898	Off Napeague Beach, N. Y.
453	.....do.....	.....do.....	Apr. 5, 1898	Off NE. shore Gardiner Id., N. Y.
458	.....do.....	.....do.....	Nov. 15, 1898	Off Newport, R. I.
469	.....do.....	.....do.....	May 20, 1898	1 mile SE. Coggeshall Ledge, off Newport, R. I.
483	.....do.....	.....do.....	Mar. —, 1898	Near Green Hill, R. I.
488	.....do.....	.....do.....	Feb. 18, 1898	Off West Hampton Beach, N. Y.
489	.....do.....	.....do.....	May —, 1898	Off Newport, R. I.
495	Feb. 10, 1898	Mouth of Woods Hole Harbor.	May 11, 1898	In trap at Watch Hill, R. I.
511	.....do.....	.....do.....	Mar. 27, 1898	Nantucket Shoals, off Siasconset.
512	.....do.....	.....do.....	May 24, 1898	Nantucket Shoals, near Stone Horse Rip.
517	.....do.....	.....do.....	May 1, 1898	In trap near Wickford L. H., R. I.
533	.....do.....	.....do.....	Mar. 23, 1898	S. by E. Fisher Id., N. Y.
548	.....do.....	.....do.....	May 21, 1898	Off Rogers shoal, near Monomoy Pt., Mass.
550	.....do.....	.....do.....	Apr. 4, 1898	Off Block Id., R. I.
555	.....do.....	.....do.....	Aug. 1, 1898	Nantucket Shoals, 18 miles E. Sankaty Head.
561	.....do.....	.....do.....	Mar. —, 1898	Nantucket Shoals.
820	Dec. 24, 1898	3 m. SSE. Tarpaulin Cove light-house.	Dec. 26, 1898	4 miles S. Newport, R. I.
826	.....do.....	.....do.....	Mar. 3, 1899	5 miles off Wainscott, N. Y.
851	Dec. 30, 1898	Buzzards Bay, 1 1/4 miles NE. Robinsons Hole.	May 20, 1899	6 miles S. Block Id., R. I.
863	.....do.....	.....do.....	Apr. 17, 1899	2 miles SW. Pt. Judith, R. I.
868	.....do.....	.....do.....	Jan. 24, 1899	6 miles off Amagansett, N. Y.
880	.....do.....	.....do.....	Nov. 1, 1899	Nantucket Shoals, 2 miles SE. Sankaty Head L. H.
888	.....do.....	.....do.....	Jan. 19, 1899	8 miles off Amagansett, N. Y.
889	.....do.....	.....do.....	Mar. 20, 1899	Georges Bank in 33 fathoms.
921	Dec. 31, 1898	Off Jobs Neck	July 23, 1899	Nantucket Shoals, 12 miles E. Round Shoal L. S.
922	.....do.....	.....do.....	Feb. 6, 1899	17 miles W. Montauk Pt., off Amagansett, N. Y.
927	.....do.....	.....do.....	Aug 10, 1899	7 miles SE. Chatham Lights, Mass.
980	Jan. 17, 1899	2 miles S. Quicks Hole.	Jan. 27, 1899	Mecox Inlet, N. Y.
987	.....do.....	.....do.....	Jan. 28, 1899	5 miles off Amagansett, N. Y.
A 25	Jan. 18, 1899	1 1/4 miles S. Cuttyhunk.	Apr. 24, 1899	Nantucket Shoals, off Sankaty Head.
A 87	.....do.....	.....do.....	Jan. 24, 1899	Mussel Bed, off Pt. Judith, R. I.
A 139	Jan. 1, 1901	Mouth of Lackeys Bay	Mar. 29, 1901	3 miles SE. Fisher Id., N. Y.
A 141	.....do.....	.....do.....	Jan. 9, 1901	SE. Squibnocket Head, Marthas Vineyard.
A 165	.....do.....	.....do.....	June 14, 1901	Nantucket Shoals 5 miles off Siasconset.
A 235	Jan. 7, 1901	Mouth of Woods Hole Harbor.	May —, 1901	2 miles N. Block Id., R. I.
A 252	.....do.....	.....do.....	Apr 12, 1901	10 miles off Atlantic City, N. J.
A 296	.....do.....	.....do.....	May 24, 1901	1 mile SE. Chatham L. S. S., Mass.
A 298	.....do.....	.....do.....	May 4, 1901	Nantucket Shoals, 2 miles SE. Sankaty Head.
A 309	Jan 8, 1901	2 miles SE. Nobska	May 2, 1901	Near S end Dutch Id., Narragansett Bay, R. I.
A 389	.....do.....	.....do.....	Mar. 17, 1901	Off Narragansett Beach, R. I.
A 421	.....do.....	Mouth of Woods Hole Harbor.	June 14, 1901	Nantucket Shoals, 5 miles off Siasconset.

Record of the tagged cod released at Woods Hole and subsequently captured by commercial fishermen, 1897-1901—Continued.

Tag. No.	When released.	Where released.	When caught.	Where caught.
A 431	Jan. 8, 1901	Mouth of Woods Hole Harbor.	Jan. 30, 1901	2½ miles SE. Squibnocket Head, Martha Vineyard.
A 472	.....do.....	.....do.....	Mar. 20, 1901	Between Beaver Tail and Whale Rock, Narragansett Bay, R. I.
A 522	Jan. 10, 1901	Off can buoy, mouth of Woods Hole Harbor.	May 3, 1901	Nantucket Shoals, 2 miles NNE. Sankaty Head.
A 523	.....do.....	.....do.....	June 14, 1901	Nantucket Shoals, 5 miles off Siasconset.
A 530	.....do.....	.....do.....	Apr. 28, 1901	Nantucket Shoals, 3 miles NNE. Sankaty Head.
A 573	.....do.....	.....do.....	Apr. 10, 1901	3 miles N. by E. Montauk Pt., N. Y.
A 606	Jan. 15, 1901	½ mile S. Tarpaulin Cove.	Jan. 30, 1901	3 miles off Amagansett, N. Y.
A 643	.....do.....	.....do.....	Feb. 12, 1901	Off Watch Hill, R. I.
A 663	.....do.....	.....do.....	July 15, 1901	Nantucket Shoals, 4 miles S. Gt. Rd. Sh. Whistling Buoy.
A 666	.....do.....	.....do.....	Apr. 9, 1901	Off N. end Rose Id., Narragansett Bay, R. I.
A 684	.....do.....	.....do.....	June 1, 1901	Off SW. Ledge, Block Id., R. I.
A 709	.....do.....	Off mouth of Woods Hole Harbor.	May 8, 1901	1 mile NE. Muskeget Id., Mass.
A 721	.....do.....	.....do.....	Jan. 28, 1901	2 miles off Southampton, N. Y., in 60 ft. of water.
A 722	.....do.....	.....do.....	May 8, 1901	1 mile NE. Muskeget Id., Mass.
A 723	.....do.....	.....do.....	Sept. 1, 1901	Not known.
A 744	Jan. 16, 1901	.....do.....	Apr. 6, 1901	Off Rose Id., Narragansett Bay, R. I.
A 747	.....do.....	.....do.....	Mar. 8, 1901	Narragansett Bay, near Rose Id., R. I.
A 758	.....do.....	.....do.....	May —, 1901	Nantucket Shoals, 2 miles SE. Sankaty Head.
A 818	Jan. 18, 1901	1½ miles SE. Jobs Neck.	May —, 1901	6 miles off Block Id., R. I.
A 819	.....do.....	.....do.....	July 12, 1901	Nantucket Shoals, off N. end Fishing Rip Shoal.
A 824	.....do.....	.....do.....	June 29, 1901	Nantucket Shoals, 15 miles E. by S. Sankaty Head L. H.
A 870	.....do.....	.....do.....	Dec. —, 1901	Off Nomans Land.
A 876	.....do.....	½ mile SE. Jobs Neck.	May 15, 1901	In trap on W. side Block Id., R. I.
A 896	.....do.....	.....do.....	May 10, 1901	1 mile NW. Muskeget L. S. S., Mass.
A 944	Jan. 28, 1901	½ mile SE. can buoy off Woods Hole Harbor.	Apr. 9, 1901	3 miles N. by E. of Montauk Pt., N. Y.
B 8	Jan. 18, 1899	1½ miles S. Cuttyhunk.	June 19, 1899	12 miles SE. Chatham, Mass.
B 53	Jan. 24, 1899	3 miles NW. Cedar Tree Neck.	June 20, 1899	Nantucket Shoals, on Fishing Rip.
B 89	.....do.....	.....do.....	Mar. 27, 1899	Off Surfside, S. side Nantucket Id.
C 23	Jan. 23, 1899	Buzzards Bay, 2 miles N. Robinsons Hole.	June 10, 1899	3 miles SW. Block Id., R. I.
C 46	.....do.....	.....do.....	Aug. 1, 1899	10 miles ESE. Chatham, Mass.
C 51	.....do.....	.....do.....	May 2, 1899	In pound net off Narragansett Beach, R. I.
C 69	Jan. 26, 1899	.....do.....	May 17, 1899	Off Newport, R. I.
C 95	Feb. 3, 1899	3 miles NE. Gay Head.	May 9, 1900	On Round Hill Ledge, 5½ to 6 miles W. Pt. Judith, R. I.
C 98	.....do.....	.....do.....	June 26, 1899	Outer edge Cox's Ledge.
D 2	.....do.....	.....do.....	May 5, 1899	1½ miles S. Block Id., R. I.
D 3	.....do.....	.....do.....	May 23, 1899	Nantucket Shoals, 1 mile off Sankaty Head L. H.
D 41	.....do.....	.....do.....	Apr. 18, 1899	Nantucket Shoals, off Sankaty Head.
D 61	.....do.....	.....do.....	Aug. 25, 1899	Nantucket Shoals, 15 miles off Sankaty Head.
D 81	Feb. 4, 1899	2 miles S. Quicks Hole.	Mar. 10, 1899	Off Fire Id., N. Y.
D 82	.....do.....	.....do.....	Apr. 10, 1899	2 mi. SW. Pt. Judith, R. I.
E 46	Dec. 7, 1899	1 mile S. Tarpaulin Cove.	Apr. 16, 1900	Nantucket Shoals, 2 miles SE. Sankaty Head L. H.
G 35	Dec. 22, 1899	1 mile E. Quicks Hole bell buoy.	Apr. 9, 1900	½ mile off Seagirt, N. J.
H 64	Dec. 28, 1899	2 miles SE. Tarpaulin Cove.	June 8, 1900	10 miles SE. Chatham, Mass.
I 55	Jan. 6, 1900	2½ miles NE. Gay Head light-house.	Apr. 30, 1900	About 3 miles S. Brenton Reef L. S. S., R. I.
K 2	.....do.....	.....do.....	Apr. 17, 1900	Nantucket Shoals, 3 miles E. Sankaty Head.
K 55	.....do.....	2½ miles E. Job's Neck.	Apr. 19, 1900	Nantucket Shoals, 2 miles SE. Sankaty Head L. H.
L 70	Jan. 15, 1900	½ mile SW. Nobska light-house.	Apr. 18, 1900	Do.
M 35	Jan. 16, 1900	1 mile SE. Job's Neck.	Apr. —, 1900	Nantucket Shoals, off Siasconset.
M 64	Jan. 17, 1900	1 mile S. Nobska light-house.	Apr. 27, 1900	Nantucket Shoals, off E. end Nantucket.
M 81do.....do.....	Apr. 19, 1900	Nantucket Shoals, 2 miles SE. Sankaty Head L. H.
N 8do.....do.....	Apr. 28, 1900	Do.
N 25do.....do.....	Apr. 29, 1900	Do.

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Record of the tagged cod released at Woods Hole and subsequently captured by commercial fishermen, 1897-1901—Continued.

Tag No.	When released.	Where released.	When caught.	Where caught.
N 41	Jan. 19, 1900	1½ miles SSE, Tarpaulin Cove light-house.	May 25, 1900	Clinton, Conn., in lobster-pot.
N 91	.....do.....	.....do.....	Apr. 20, 1900	2 miles S. of E. end Fisher Id., N. Y.
O 36	.....do.....	Off can buoy, mouth of Woods Hole Harbor.	Feb. 7, 1900	5 miles E. Mantoloking, N. J.
P 76	Jan. 23, 1900	3 miles SE, Tarpaulin Cove light-house.	May 14, 1900	¼ mile off Siasconset, Nantucket.
P 96	.....do.....	.....do.....	July 14, 1900	15 miles SE, Chatham Lights, Mass.
R 55	Jan. 24, 1900	1 mile S. Nobska light-house.	Apr. 14, 1900	Nantucket Shoals, 2 miles E. Sankaty Head.
S 10	Jan. 25, 1900	1 mile SW, can buoy, mouth of Woods Hole Harbor.	Feb. 12, 1900	3 miles off Amagansett, N. Y.
S 43	.....do.....	.....do.....	Feb. 7, 1900	2 miles off Amagansett, N. Y.
S 98	.....do.....	.....do.....	Apr. 24, 1900	Nantucket Shoals, off Siasconset, Nantucket.
T 32	Jan. 26, 1900	1 mile E. Job's Neck..	Apr. 10, 1900	Nantucket Shoals, 1½ miles S. by E. Sankaty Head.
T 92	Dec. 19, 1900	1 mile S. Tarpaulin Cove.	Feb. 19, 1901	Off West Hampton Beach, N. Y.
U 23	Dec. 20, 1900	Off can buoy, mouth of Woods Hole Harbor.	Apr. 7, 1901	5½ miles off Block Id., R. I.
U 28	.....do.....	.....do.....	Apr. 20, 1901	Off Atlantic City, N. J.
U 36	.....do.....	.....do.....	Dec. 27, 1900	3 miles SW. Saconnet L. H., R. I.
U 76	.....do.....	.....do.....	May 15, 1901	Nantucket Shoals, 3 miles SE. Nantucket Id.
V 1	Dec. 21, 1900	Near bell buoy, off Nobska.	Jan. 12, 1901	¾ mile off Southampton, N. Y.
V 32	.....do.....	.....do.....	May 8, 1901	Nantucket Shoals, about 2 miles NNE. Sankaty Head.
V 40	.....do.....	.....do.....	July 4, 1901	Nantucket Shoals, off Great Round Shoal.
V 68	.....do.....	.....do.....	Jan. 14, 1901	Off northern coast of N. J.
V 75	.....do.....	.....do.....	Jan. 30, 1901	10 miles off Atlantic City, N. J.
W 6	Dec. 29, 1900	Off can buoy, mouth of Woods Hole Harbor.	Jan. 8, 1901	1½ miles off Southampton, N. Y.
W 48	.....do.....	.....do.....	Jan. 17, 1901	Off Squibnocket Head, Marthas Vineyard
W 81	.....do.....	.....do.....	Feb. 23, 1901	Off Southampton, N. Y.
W 83	.....do.....	.....do.....	Jan. 2, 1901	Off Squibnocket Head, Marthas Vineyard.
W 89	.....do.....	.....do.....	Mar. 15, 1901	10 miles off Atlantic City, N. J.
X 87	Dec. 31, 1900	3 miles SE, Tarpaulin Cove light-house.	Apr. 18, 1901	Beaver Tail Ledge, 1 mile W. by S. Brenton Reef L. S., R. I.
X 40	.....do.....	.....do.....	Jan. 14, 1901	Off Squibnocket Head, Marthas Vineyard.
X 60	.....do.....	.....do.....	Apr. 30, 1901	1 mile E. West Chop L. H., Mass.

Unless otherwise stated, all localities where tagged fish were released are in Vineyard Sound.

DISPERSAL AND MOVEMENTS OF THE TAGGED FISH.

The appended classified table shows the localities in which the tagged cod were caught and the months in which they were taken in each locality. The following points relative to the movements of the tagged fish have been developed by the experiments:

(1) The tagged cod have been found in the coastal waters of the middle Atlantic region throughout the year, but in largest numbers in April and May, when nearly 50 per cent were taken. Comparatively few have been captured any year between July and December.

(2) The range of the tagged cod, as judged by those caught, is from Georges Bank to Atlantic City, New Jersey. The localities mostly frequented were the south shore of Long Island, Narragansett Bay and the adjacent shores, and Nantucket Shoals.

(3) Shortly or immediately after their release, there was a well-marked southerly and westerly movement to the shores of New York and New Jersey, where they remained during the first four months of the year.

A feature of the fishing season of 1900-1901 was the taking of tagged fish farther south than in any of the other years, in the vicinity of Atlantic City, which is about the southern limit of the cod fishery.

On January 31, 1901, Capt. D. C. Clark wrote:

When fishing for cod about 12 miles south of Absecon Light, abreast of Atlantic City, yesterday, we discovered, while gutting fish, a cod with tag V 75. It weighed about 4 pounds and was in poor condition. It had no spawn in it, and looked as if it had been spawned out some time. We caught it in about $10\frac{1}{2}$ fathoms of water, about 10 miles offshore, with 300 or 400 other fish. There have been thousands of cod caught here this fall and winter, but this is the first one with a tag that has been taken.

On March 15, April 12, and April 15 Captain Clark caught cod bearing tags, and two other tagged fish were taken in the same locality by other fishermen about March 1.

(4) During March, April, and May the fish sought Narragansett Bay and the shores of Rhode Island, where a few were also found in January, February, June, November, and December.

(5) The largest number of fish were caught off Nantucket, on Nantucket Shoals, in April and May; in this region a few were also taken in March and the summer months. In October and November, however—the months when the fish were first caught on these grounds—only one of the tagged fish has as yet been taken, notwithstanding active fishing at that season by the commercial fishermen. The Fish Commission schooner *Grampus*, which during the years in question has caught from 4,000 to 6,000 cod annually on the Nantucket Shoals in October and November, has never taken a tagged fish.

This circumstance suggests (1) that the fish which frequent the Nantucket Shoals in the spring and summer months represent a different body or run from those caught in the same locality in fall, and (2) that the tagged fish which have frequented the shoals leave on the approach of the time when they were first taken and go to grounds at present unknown—perhaps to New York and New Jersey.

(6) The fish showed but a slight tendency to go to the eastward of Cape Cod or of Nantucket Shoals. A few were taken between May and August, southeast of Chatham, but only one was reported from South Channel and one from Georges Bank. The latter (No. 889) was caught by a Gloucester fishing schooner on March 27, 1899, at a depth of 33 fathoms.

(7) None of the tagged fish has been taken north of Cape Cod. If the schools with which the tagged fish mingled on Nantucket Shoals and elsewhere behaved as did the tagged fish, it is evident that the cod inhabiting the grounds off southern New England, New York, and New Jersey belong to a distinct body, and are not simply a part of the vast shoals found in Massachusetts Bay and on the coast of Maine.

The very active shore cod fishing carried on with boats and vessels between Cape Cod and the Bay of Fundy would almost inevitably have disclosed the presence of tagged fish had any been in those waters. There is but one report of anything like a definite character regarding the taking of a tagged cod in this region. This was communicated by Mr. F. G. Conley, mate of the *Grampus*, and related to a fish said to have been caught off Jonesport, Me., in the winter of 1897-98, but repeated efforts failed to verify the capture.

(8) The conclusion seems legitimate that the cod which resort to the shores of New York and New Jersey in winter do not represent an independent body of fish which have come from some offshore grounds at this season, but are a part of the great schools of shore cod which also frequent the southern New England coast.

(9) The month when the fish were released (that is, whether in December, January, or February) seemed to have no relation to the direction in which they moved, although it may be noted that none of the fish released as late as February was taken as far west and south as New Jersey, and that of the captured fish released in December a large percentage were from the shores of New Jersey and New York.

(10) The particular place where the fish were released—whether at the northern end, southern end, or the intermediate part of Vineyard Sound, or in Buzzards Bay—had no determining influence on their movements as evidenced by the localities in which caught.

(11) Some fish released side by side became widely separated in a short time, while other lots appeared to keep together for several months. Some were moved by individual instincts, others seemed to act en masse. The following references will illustrate the different behavior of particular lots of cod:

Of 55 cod released in Vineyard Sound 2 miles northwest of Gay Head light on January 22, 1898, 5 were recaptured, as follows: February 4, off Westhampton Beach, Long Island; March 14, off Point Pleasant, N. J.; March 22, off Greenhill, R. I.; April 18, off Brenton Reef lightship, Rhode Island; July 23, off Chatham, Mass.

Of 79 fish liberated in Vineyard Sound 1 mile south of Nobska light on January 17, 1900, 4 were recaptured, as follows: April 16, 2 miles southeast Sankaty light, Nantucket; April 27, off east end of Nantucket; April 28, 2 miles southeast Sankaty Light, Nantucket; April 29, 2 miles southeast Sankaty light, Nantucket.

(12) Of some lots of released fish, a comparatively large percentage was recaptured, while of others none was taken. This is illustrated by the following references: (1) Of 54 fish released January 31, 1898, in Vineyard Sound $2\frac{1}{2}$ miles northeast of Robinsons Hole, 9, or nearly 17 per cent, were recaptured; (2) of 71 fish released February 10, 1898, at the mouth of Woods Hole Harbor, 7, or nearly 10 per cent, were recaptured; (3) of 50 fish released December 30, 1898, in Buzzards Bay near Robinsons Hole, 6, or 12 per cent, were recaptured.

On the other hand, none of the following lots was recaptured: 53 fish released January 11, 1898, 3 miles west of Gay Head light; 96 fish released December 13, 1899, 4 miles southwest of Nobska light; 79 fish released December 23, 1899, in the latter place.

Summary, by months, of the regions in which tagged cod were caught, 1897-1901.

Regions.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Off New Jersey	2	1	2	3									8
Off New York	8	8	4	4									24
Off Connecticut					1								1
Rhode Island shores	1	1	5	8	10						1	2	28
Off Block Island		1	1	3	5	2							12
Off Marthas Vineyard	5			1								1	7
Nantucket Shoals			3	17	9	5	4	2	1		1		42
On Cox's Ledge						1							1
Off Muskeget Island					3								3
Monomoy Point					2								2
Off Chatham					3	2	2	2					9
South Channel							1						1
Georges Bank			1										1
Miscellaneous									1				1
Total	16	11	16	36	33	10	7	4	2		2	3	140

NOTES ON THE RATE OF TRAVEL.

Observations on this point are obviously unsatisfactory and unreliable. While the times and places of release and of capture of given fish may be accurately determined, it can not be stated in any case what route the fish has taken or how long it may have been in a locality before it was caught. Without laying undue stress on this subject, the records of a few cod which were caught a short time after their release may be examined. It is evident that the sooner a fish was captured and the less time it thus had to roam, the more accurate was the basis afforded for determining how fast it moved.

Some fish appear to have moved rapidly away as soon as released, while others remained in the vicinity and, when caught, had traveled only a few miles.

The tagged cod recaptured in the shortest time after liberation (No. 820) was released in Vineyard Sound, 3 miles SSE. of Tarpaulin Cove light, on December 24, 1898, and was caught 4 miles south of Newport, R. I., on December 26, 1898. The distance between these two points, by the most direct water route, is 33 miles.

Quite a number of fish each season were taken on the shores of Long Island within a comparatively short time after being liberated. Thus, No. 360, released January 22, 1898, 2 miles NW. of Gay Head light, was caught February 4, 1898, off Westhampton Beach, New York; time, 13 days; distance, 131 miles. No. S 10, released January 25, 1900, 1 mile SW. mouth of Woods Hole Harbor, caught February 12, 1900, 3 miles off Amagansett, New York; time, 18 days; distance, 88½ miles. No. S 43, released on the same day as the preceding, caught February 7, 1900, 2 miles off the same place; time, 13 days;

distance, 89 miles. No. W 6, released December 29, 1900, 2 miles SW. mouth Woods Hole Harbor, caught January 8, 1901, $1\frac{1}{2}$ miles off Southampton, New York; time, 10 days; distance, 107 miles. No. A 606, released January 15, 1901, one-half mile south of Tarpaulin Cove, Vineyard Sound, caught January 30, 1901, 3 miles off Amagansett, New York; time, 15 days; distance, 81 miles. No. A 721, released January 15, 1901, off the mouth of Great Harbor, Woods Hole, caught January 28, 1901, 2 miles off Southampton, New York; time, 13 days; distance, 102 miles. No. 980, released January 17, 1899, 2 miles south of Quicks Hole, Vineyard Sound, caught January 27, at Mecox Inlet, New York; time, 10 days; distance, 86 miles. No. 987, released at the same time and place, caught January 28, 1899, 5 miles off Amagansett, New York; time, 11 days; distance, 76 miles.

No. A 87 was released January 18, 1899, $1\frac{1}{2}$ miles south of Cuttyhunk, and caught January 24, 1899, off Point Judith, Rhode Island; time, 6 days; distance, 30 miles; and No. O 36 was released January 19, 1900, off mouth of Great Harbor, Woods Hole, and caught February 7, 1900, 5 miles east of Mantoloking, New Jersey; time, 19 days; distance, 150 miles.

In contrast with the foregoing are the following fish liberated near Woods Hole Harbor and captured off Squibnocket Head, on the outer side of Marthas Vineyard, the distance by the most direct route being about 24 miles: No. A 141, released January 9, 1901, caught January 30, 1901; No. W 48, released December 29, 1900, caught January 17, 1901; No. X 40, released December 31, 1900, caught January 14, 1901.

CHANGES IN WEIGHT AND SIZE OF TAGGED COD.

In the comparatively short time elapsing between the release and the capture of the tagged fish, but little opportunity has been afforded for obtaining data of much value on the rate of growth of the species. The records show a great irregularity in the changes in weight, some fish increasing inordinately, some but little, and some not at all.

The tagged fish recaptured were at liberty from 2 days to 15 months, the average time being 4 or 5 months. The number at large 6 months or more was 11. Only 3 fish were taken in the fall or winter succeeding release; one of these (No. 458), liberated January 31, 1898, was caught November 15, 1898; another (No. 880), liberated December 30, 1898, was caught November 1, 1899, and the third (No. A 870), released January 18, 1901, was caught in December, 1901. Only 1 fish was taken more than a year after release; this (No. C 95) was released February 3, 1899, and caught May 9, 1900.

In the case of the weight the basis for comparison is diminished in value by the poor condition of the fish at the time of release (owing to the loss of weight incident to captivity and the spawning condition) and by the questionable accuracy of the figures as submitted by the

fishermen. In many cases only the dressed weights of the fish have been reported, and in others the weights have simply been estimated or given in round numbers. In a small percentage of the fish the weights have been recorded with sufficient accuracy (sometimes by employees of the Fish Commission) to warrant the following comparisons, which must be considered in the light of the limitations referred to. In this table are given data for 40 specimens whose weight when captured is known or thought to have been stated with reasonable accuracy.

Among the most striking cases of increase in weight was that of the fish longest at liberty. It was a spent male, whose weight when released was 4 pounds, and when captured 15 months later was 7 pounds 8 ounces. Another noteworthy increase was that of an immature male weighing 3 pounds 8 ounces when released and 7 pounds when caught after 64 days.

Tag No.	Days at liberty.	Sex.	Weight when released.	Weight when re-captured.
			Lbs. Oz.	Lbs. Oz.
315	125	Female, barren	4	7
320	233	Male, barren	4	6
400	77	Male, spent	4 8	5
438	85	do	3 8	4 8
448	18	Female, spent	4	4 8
463	64	Female, barren	3 8	7
495	90	do	5	5 8
511	46	Male, barren	4	7 3
512	103	do	4 8	5 12
538	41	do	4	4 13
863	108	Female, spent	5 8	6
868	25	Male, spent	5	6
888	20	Female, spent	4 8	6 8
921	204	Female, barren	4	7
927	222	do	5 8	6 12
A 235	?128	Male, barren	5	7
A 296	137	Female, spent	4 8	4 12
A 721	13	Male, barren	5	5 4
B 8	122	Female, barren	5	7
B 39	62	do	5	6
C 51	96	Female, spent	5 4	7
C 69	111	Male, barren	5	6 8
C 95	460	Male, spent	4	7 8
C 98	143	do	7	8
D 3	109	do	5 4	6 10
D 61	203	Male, barren	5 4	7
D 82	65	do	4 8	5 8
G 85	108	Female, barren	3	4
H 64	162	Male, barren	3 8	4 12
I 55	114	Male, spent	4	4 12
M 64	100	Female, barren	6	8
M 81	92	Male, barren	4 6	6
N 26	102	Female, barren	6	8 4
O 36	19	Male, barren	6 9	8
S 10	18	do	4 9	5 12
S 43	13	do	4 9	5 4
S 98	89	Female, barren	4 6	5 4
T 32	74	Male, barren	6	7
V 32	138	Male, spent	4 8	5
W 81	25	Female, spent	3 8	3 9

NOTE.—The term "barren" is employed at the hatchery to designate fish which for any reason yielded no eggs or milt during the period of their captivity.

In forwarding tags a number of fishermen have referred to the condition of the fish, using such expressions as "a nice, plump fish," "fish in fine condition," "fish plump and healthy, tag has caused no sore," etc. On the other hand, many fish have been reported as "not healthy," "sore and thin," "rather thin," "in poor condition," "very thin fish,"

"poor and chafed," etc.; and there is undoubted evidence that in some cases the fish lost weight for a time after being released, and in other cases remained about stationary in this respect.

The following tabulation contains the record of 15 specimens illustrating these points:

Tag No.	Days at liberty.	Sex.	Weight when released.		Weight when recaptured.
			Lbs.	Oz.	Lbs. Oz.
* 261	91	Female, spent.....	4	8	4 2
337	32	Female, barren.....	5		4
† 339	110	.....do.....	5		7
360	13	.....do.....	8		8
361	51	Male, barren.....	5	8	4 8
† 371	86	.....do.....	4	8	4
469	109	.....do.....	4	8	4
‡ 483	43	Female, barren.....	5		5
‡ 551	141	Male, spent.....	6		6
‡ 822	37	Male, barren.....	6		5 12
987	11	Female, barren.....	4	8	4 8
A 606	15	Male, spent.....	6		5 4
D 41	74	Male, barren.....	5		4 10
* L 70	93	Female, spent.....	5		4
* V 40	185	Male, spent.....	5		5

* Fish reported as in poor condition.
 † Fish reported as in good condition.

‡ Fish reported as sore and thin.
 § Fish reported as rather thin.

The following meager comparisons of length comprise about all the data obtained relating to this topic. The figures represent the length from end of snout to middle of posterior edge of caudal fin. The fish longest at liberty (C 95) increased 2½ inches in length, at the same time that it increased 3½ pounds in weight. In most cases the recorded increase, if any, was so small that it might have arisen from a different method of measuring.

Tag No.	Days at liberty.	Length when released.		Length when recaptured.		Increase in weight.
		Ft.	In.	Ft.	In.	
339	110	2	↓	2	1	No.
360	13	2	7	2	7	No.
438	85	2	1	2	1	Yes.
469	109	2	↓	2	↓	No.
496	90	2	2	2	3	Yes.
512	103	2	1	2	5½	Yes.
533	41	2	1	2	2	Yes.
861	141	2	3	2	3	No.
C 95	460	2	1½	2	4	Yes.
G 35	108	1	10	1	10½	Yes.
M 64	100	2	2	2	3½	Yes.

SIGNIFICANCE OF FAILURE TO CATCH TAGGED FISH IN SECOND, THIRD, AND FOURTH SEASONS AFTER RELEASE.

As has previously been shown, only a few cod were recaptured in the season following their release, and only one was taken more than a year after liberation. The failure to obtain information regarding the whereabouts of the tagged fish after the first season is one of the most interesting developments of the experiment.

Almost the first suggestion that occurs to one to account for this circumstance is the loss of the tags, either by erosion of the wire or tag, or by tearing loose from the fins. Reference has been made to

the unsatisfactory use of tags made of block tin—a substance employed in the first year of the tagging experiments. Of over 150 tin tags employed, only one was recovered, and it was so much worn by the action of the salt water that it would undoubtedly have fallen off or been completely eroded within a very short time. In the case of copper tags, however, there is not the slightest evidence that chemical action was sufficiently rapid or active to cause their loss. Tags recovered months after attachment had undergone practically no change except a slight diminution in luster, their edges being as clean and the figures as sharp as when first put in the water; and in no instances was there observable any general or irregular thinning of the copper wire by which the tags were made fast.

While it is probable that some tags have been lost by the gradual tearing of that part of the fin through which the wire passed, the available evidence fails to show that many tags could have been lost in this way. A considerable number of tags have been returned to the Commission either with the entire fish or with the fins to which they were attached. In none of these cases has there been any indication that the tag was in danger of being lost through tearing of the fin. Sometimes the fin was entirely healed around the wire, and sometimes a small slit in the interradiial tissue had been formed by the movement of the tag. Very exceptionally a raw surface existed around the wire, and the fishermen occasionally reported that the wire had made a small sore in the fin.

It is clearly evident that the explanation of the point under consideration lies not in the tags but with the fish themselves, although what the real explanation is can only be surmised.

Mention has been made of the curious absence of tagged fish from the Nantucket Shoals in fall and winter, at a time when very active fishing is going on, and when the tagged fish were originally caught on these same grounds. It is possible that when the Nantucket Shoals cod have attained a certain age they cease to resort there, at least in fall and winter, and seek other grounds at that season, perhaps going to the offshore banks, where, becoming more widely dispersed and mixing with a larger body of fish, they are less likely to be caught than in the shore waters. This supposition carries with it the suggestion that the cod frequenting the Nantucket Shoals each fall and winter go there for the purpose of spawning, and represent new schools of fish that have perhaps come in from the offshore grounds.

The data on which to base deductions are obviously too meager.

THE LARGE PERCENTAGE OF TAGGED FISH CAUGHT.

The fact that about 4 per cent of the fish tagged and released were subsequently captured by the commercial fishermen raises several important questions. It must be conceded that this is an unexpectedly large proportion, when the abundance of cod on our shores and the wide

extent of the region involved are considered. There is little doubt, furthermore, that the fish retaken represented even more than 4 per cent of the available supply of tagged fish, because it is regarded as reasonably certain that some of the released specimens must, shortly after liberation, have necessarily succumbed to the effects of prolonged captivity; and, as has been shown, nearly 4 per cent of the tags used were such that their loss through natural agencies was likely.

The question naturally arises, Were there any reasons why these tagged fish should be taken in relatively larger numbers than wild, untagged fish? And to this question an affirmative answer can probably be made with safety.

When released, the tagged fish were for the most part thin and hungry, owing to captivity, spawning, and deficiency of food. It is therefore not unreasonable to expect that at first they fed with less caution than is normally exercised. But the acute hunger of a fish in a region of plenty is quickly appeased; and too large a percentage of the tagged fish were caught long after their liberation to warrant the belief that mere inordinate hunger resulting from their captivity could have been an important factor.

A more probable factor in their capture was the partial domestication arising from 2 to 4 months of captivity with artificial feeding, and the lowered vitality resulting from captivity, handling, spawning, and unaccustomed food. These conditions would undoubtedly have resulted in a loss of acumen in avoiding danger and in capturing natural food, and would have made the tagged fish less cautious in taking the bait offered by the fishermen.

While the known facts are entirely too meager to warrant sweeping conclusions on any of the points involved, it may not be uninteresting or altogether unprofitable to speculate as to the available cod supply in the region frequented by the tagged fish.

Excluding the extensive fishing done on Georges Bank and in the South Channel, where only two of the tag-bearing cod were captured, it appears from the official statistics that the average annual catch of cod between southern Massachusetts and southern New Jersey is about 20,000,000 pounds. The weight of the tagged fish released during four years was nearly 20,000 pounds, or about 5,000 pounds annually; and the aggregate weight of the tagged fish caught was approximately 805 pounds, or 200 pounds each year. From the foregoing data it appears that if the same proportion prevailed for the entire catch of wild fish as for the tagged fish, the available annual supply of cod on the grounds in question is 500,000,000 pounds, thus:

$$\begin{array}{l}
 5,000 \text{ (the available quantity of tagged fish)} : \left\{ \begin{array}{l} x \\ \text{(the available supply of wild fish)} \end{array} \right\} = \left\{ \begin{array}{l} 200 \text{ (the annual catch of tagged fish)} \\ \text{fish} \end{array} \right\} : \left\{ \begin{array}{l} 20,000,000 \text{ (the annual catch of wild fish)} \\ \text{fish} \end{array} \right\} \\
 x = 500,000,000.
 \end{array}$$

For the reasons stated it is probable that a smaller percentage of wild fish than of tagged fish is taken, and consequently the foregoing amount does not adequately represent the real abundance of cod on our shores.

MISCELLANEOUS INFORMATION AFFORDED BY THE EXPERIMENTS.

Among a mass of voluntary information furnished by cod fishermen in connection with the return of tags, some notes have been received which are not without interest.

From a number of sources it has been reported that the shore cod, which, on account of their small size, abundance in the inshore waters, and occurrence on grounds not formerly resorted to, the fishermen have come to look on as artificially-hatched fish, have at certain seasons been found to be feeding to a considerable extent on small lobsters. It was not possible to verify all of these reports, but in a few cases some of the young lobsters ejected by the cod when caught have been examined by the agents of the Commission. Writing from Nantucket under date of November 21, 1900, Mr. R. C. Small, who has taken great interest in the tagging experiments and forwarded many tags from Nantucket, said:

The school of cod off here are destroying a great many small lobsters. I have sent some of the lobsters taken from the pokes of the fish. I have found as many as four 3-inch lobsters in one cod. The fish throw them out after being taken into the boat.

The following interesting notes on the abundance and food of cod at the extreme southern limit of the cod fishery have been communicated by Capt. D. C. Clark, of Atlantic City, N. J.:

January 31, 1901.—We are catching cod with herring (i. e., alewives) and menhaden in them partly digested.

February 15, 1901.—Cod have been quite plentiful off these grounds this fall and winter up to about New Year's, when, as usual, they leave here and do not return till March, when apparently the same run of fish comes back. I am under the impression that they go south or away offshore, because we have gone 25 miles straight offshore from Absecon Light and have found no more or larger fish than inshore, say from 10 to 12 miles. So if they move offshore they must go a considerable distance, otherwise they must go south; and I am inclined to the latter view, as once in March I took as many as five croakers out of a large cod, two or three of them almost digested and the rest partly digested. One of them was but very little changed; it looked to me as if it might have been swallowed about three or four hours. We do not catch croakers here till late in the spring, say May or June. Now, the cod must travel very fast or the croakers must be nearer than we know. At this time of the year the cod we catch here are full of silversides and sand crabs; occasionally a small flounder or black-fish is to be found in them, but lately they have been unusually full of silversides. I think cod are no more abundant this winter than formerly. Of course, there are times when they are more plentiful than others, and some winters they are scarcer than others, but on the whole I think they are about the same this winter as they were last winter.

Haddock have been more plentiful here this winter than ever they were before. We have also caught more pollock than ever before, having taken some dozen or more. Previous to this time we never caught more than one or two in a season.

Cod fishing has been done here for the last 15 or 20 years to a certain extent, and for the last 4 or 5 years there have been from 30 to 100 men engaged all winter through, with from 15 to 25 boats of all descriptions, some having 3 men and some 7. They all quit about the middle of March, with the exception of myself and one or two more. We find occasional herring and menhaden in cod all the winter through.

To give you some idea of the number of fish running along here at the different times of the year, from November to Christmas a boat with 5 men fishing 5,000 hooks a day will catch from 600 to 1,200 fish. The same rig from Christmas to March will catch from 100 to 500 fish. After that time they become quite plentiful again, but the dog sharks are so thick that you can not do much.

April 14, 1901.—Cod have been rather scarce this spring on the Jersey coast. Dog sharks have commenced to be quite numerous, and this will about end the cod fishing. We are catching quite a number of cod with large roe about ready to be thrown off, and we find an occasional menhaden in them.

June 10, 1901.—None of the tagged fish we caught had any spawn in them. In fact, after Christmas only an occasional cod, perhaps a dozen in 200 or 300, will have spawn, while before Christmas half of them will be spawn fish.

Mr. R. C. Small reported from Nantucket in November, 1900, that—

The fishermen have not seen a single tag during this season's fishing, nor did they in 1899 after the spring catch. Of course, they fish here until late in December, and if anything turns up I will inform you at once. The cod are running rather small, that is, there are a great many 2 and 2½ feet, but they seem to school by themselves, and the fishermen shift from time to time to get better size.

While most of the tagged fish were taken on lines, quite a number were caught in fixed appliances. Perhaps a dozen were secured in trap or pound nets in New Jersey, Rhode Island, and Massachusetts, and one was caught in a lobster pot in Connecticut. A fish taken in a pound net off Seagirt, N. J., contained an alewife 8½ inches long and four cockles (*Lunatia*).

In April, 1901, a remarkable piebald cod, taken off Race Point, Massachusetts, was sent to the Commission. It weighed 10 pounds, and was apparently normal in all respects except as to color. The usual greenish-brown ground color and brown spots were lacking over nearly the entire body, and irregular blotches of creamy white and bright orange predominated on body and head. The fins were marked by white, orange, dull red, and greenish-black streaks, for the most part parallel with the rays. The iris was dark.