PROPAGATION AND DISTRIBUTION OF FOOD FISHES, 1921.

REPORT OF THE DIVISION OF FISH CULTURE FOR THE FISCAL YEAR 1921.[1]

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CONTENTS.

[1] Appendix IX to the Report of the United States Commissioner of Fisheries for 1921. B. F. Doc. No. 912.

INTRODUCTION.

In considering the value of any branch of governmental work it is clearly just to take cognizance of the progress made, as evidenced by an increased volume of work, but improved methods and lower costs of producing and distributing the output are, in the case of fish culture, of more importance, as indicating efficiency and sustained interest in the work.

For a number of years there has been no increase in the funds provided for the propagation and distribution of food fishes, and only the very inadequate increase in compensation of faithful employees as provided by the so-called bonus of $240 per annum. In the face of this condition and the fact that the cost of all commodities, labor, and railroad rates increased many fold during the period of the World War, it is particularly gratifying to note that the bureau maintained its fish-cultural establishment, if not intact, still at a point of efficiency where it handled an increased volume of work without material increase in the cost of production or distribution.

The value of modern fish culture is so generally accepted by those having knowledge of the facts as to need no defense and is shown by the action of many States in providing funds for such work, by the numbers of fish-cultural plants financed by commercial interests, and by individuals who are interested only in maintaining the fish supply in a given locality.

The bureau's fish-cultural division is probably more completely organized and equipped than any similar institution in the world. It has been built up through a long period of years and represents the thoughtful and painstaking effort of many persons. It has reached a point in its history where its movement must either advance or retrograde. To longer maintain the present magnitude of the work with the funds provided is manifestly impracticable. On the other hand, the opportunities for its continued enlargement and extension are restricted only by the facilities available.

During the fiscal year ended June 30, 1921, 62 per cent of the appropriation provided by Congress for the propagation and distribution of food fishes was expended in the maintenance and development of the commercial fisheries.[2] The remaining portion of the fund was devoted to the equally important, though less extensive, work of producing and disseminating in the interior waters of the country various species of trout and the so-called warm-water fishes, including the black basses, crappies, and sunfish. The widely extended and rapidly increasing use of the automobile has opened to tourists and sportsmen numerous trout and bass waters which were formerly inaccessible, with the result that interior streams and lakes in all parts of the country have been heavily overfished. Of all fishermen concerned automobilists as a class are perhaps the most law-abiding, but their rapidly increasing numbers and their habit of camping near a promising body of water and fishing it for an extended period—sometimes for several days—has constituted a drain which it will not be easy to make good. A most serious aspect of the situation is that it threatens the resources of waters which have never heretofore required any appreciable effort on the part of either Federal or State agencies to maintain. The greatest danger in this respect lies in the Western mountain States, in New England, and in other parts of the country which abound in natural scenic beauty.

The situation is a grave one, and if not given proper and immediate attention by the States concerned and by the Federal Government there is imminent danger of the total depletion of fish life in many valuable waters which have heretofore yielded an abundant supply. The advantages of keeping the interior waters of the country well stocked with the game and food fishes adapted to them are many and obvious. By such means a cheap and very desirable food supply is afforded to a certain class of people who would otherwise be unable to enjoy it. Vast numbers of people are inspired by the lure of good fishing to seek the great out-of-doors, with very beneficial results to their health, aside from the recreation afforded. Certain of the State authorities who are not able to cope with the difficulty have applied to the Bureau of Fisheries for aid, but in most instances it could not be given, the bureau's resources having been already greatly overtaxed in the effort to maintain the scope of its work along previously established lines.

The bureau's efforts in fish culture are directed chiefly toward the maintenance of the existing fisheries of the country and toward the development of new and profitable sources of fish supply by extending its operations over a wider territory in fields contiguous to the present stations. Five important functions are involved in this work, namely, the collections of eggs from various species of fish of economic value, the incubation of the eggs in properly equipped hatcheries, the rearing and feeding of the young of certain species, the rescue of stranded fishes from overflow waters in the Mississippi Valley, and the distribution of fish and fish eggs in suitable waters.

[2] The expenditures involved in distributing the output of the hatcheries represents approximately 17 per cent of the total appropriation, and 30 per cent of this amount represents the expenditures in connection with the commercial species.

Part 1.—FISH PROPAGATION AND RESCUE.

Summary of Operations.

SPECIES OF FISHES HANDLED.

During the fiscal year ended June 30, 1921, the bureau propagated and distributed some 48 species of fishes, as shown in the following list. Fishes rescued from overflowed lands in the Mississippi Basin and restored to original waters or distributed in other sections of the United States are included.

LIST OF SPECIES HANDLED.

THE CATFISHES (SILURIDÆ):
- Horned pout, bullhead (*Ameiurus nebulosus*).
- Marbled catfish (*Ameiurus nebulosus marmoratus*).
- Mississippi catfish (*Ameiurus lacustris*).
- Spotted catfish, channel catfish (*Ictalurus punctatus*).
- Yellow catfish (*Leptops olivaris*).

THE SUCKERS (CATOSTOMIDÆ):
- Mongrel buffalofish (*Ictiobus urus*).
- Common buffalofish (*Ictiobus cyprinella*).
- Smallmouth buffalofish (*Ictiobus bubalus*).

THE CARPS (CYPRINIDÆ):
- Asiatic carp (*Cyprinus carpio*).

THE SHADS AND HERRINGS (CLUPEIDÆ):
- Shad (*Alosa sapidissima*).
- Glut herring (*Pomolobus aestivalis*).
- Skipjack (*Pomolubus chrysochloris*).

THE SALMONS, TROUTS, WHITEFISHES, ETC. (SALMONIDÆ):
- Common whitefishes (*Coregonus albus* and *C. clupeaformis*).
- Cisco (chiefly *Leucichthys artedi*).
- Chinook salmon, king salmon, quinnat salmon (*Oncorhynchus tschawytscha*).
- Chum salmon, dog salmon (*Oncorhynchus keta*).
- Humpback salmon, pink salmon (*Oncorhynchus gorbuscha*).
- Silver salmon, coho salmon (*Oncorhynchus kisutch*).
- Sockeye salmon, blueback salmon, redfish (*Oncorhynchus nerka*).
- Steelhead salmon (*Salmo gairdneri*).
- Atlantic salmon (*Salmo salar*).
- Landlocked salmon (*Salmo sebago*).
- Rainbow trout (*Salmo shasta*).
- Blackspotted trout, redthroat trout (*Salmo lewisi*).
- Loch Leven trout (*Salmo levenensis*).
- Lake trout, Mackinaw trout (*Cristivomer namaycush*).
- Brook trout (*Salvelinus fontinalis*).

THE GRAYLINGS (THYMALLIDÆ):
- Montana grayling (*Thymallus montanus*).

THE SMELTS (OSMERIDÆ):
- Smelt (*Osmerus mordax*).

THE PIKES (LUCIDÆ):
- Little pickerel (*Lucius vermiculatus*).
- Common pickerel (*Lucius lucius*).

THE SUNFISHES, BLACK BASSES, AND CRAPPIES (CENTRARCHIDÆ):
- Crappies (*Pomoxis annularis* and *P. sparoides*).
- Largemouth black bass (*Micropterus salmoides*).
- Smallmouth black bass (*Micropterus dolomieu*).
- Rock bass (*Ambloplites rupestris*).
- Warmouth bass, goggle-eye (*Chænobryttus gulosus*).
- Bluegill sunfish (*Lepomis pallidus*).
- Common sunfish (*Eupomotis gibbosus*).

THE PERCHES (PERCIDÆ):
- Pike perch (*Stizostedion vitreum*).
- Yellow perch (*Perca flavescens*).

THE BASSES (SERRANIDÆ):
Striped bass, rockfish (*Roccus lineatus*).
White bass (*Roccus chrysops*).
White perch (*Morone americana*).
THE DRUMS (SCIAENIDÆ):
Fresh-water drum, lake sheepshead (*Aplodinotus grunniens*).
THE CODS (GADIDÆ):
Cod (*Gadus callarias*).
Haddock (*Melanogrammus æglefinus*).
Pollock (*Pollachius virens*).
THE FLOUNDERS (PLEURONECTIDÆ):
Winter flounder, American flatfish (*Pseudopleuronectes americanus*).
Pole flounder (*Glyptocephalus cynoglossus*).

SUMMARY OF OUTPUT.

During the fiscal year 1921 the bureau's efforts in fish propagation and rescue of stranded fishes resulted in a gross output of 4,962,583,555 fish and fish eggs for distribution, 93 per cent of which was made up of the important commercial species and 7 per cent of the species used in stocking interior waters. Losses due to transportation amounted to 94,150, making a net product of fish and fish eggs actually distributed of 4,962,489,405. A summary of this net output, shown by species, is given in the following table:

SUMMARY, BY SPECIES, OF NET OUTPUT OF FISH AND FISH EGGS, FISCAL YEAR 1921.

Species.	Eggs.	Fry.	Fingerlings.	Total.
Catfish			35,257,070	35,257,070
Buffalofish		108,307,000	1,645,835	109,952,835
Carp		106,043,000	8,918,580	109,961,580
Shad		32,792,275		32,792,275
Glut herring		43,815,000		43,815,000
Whitefish	181,650,000	238,800,000		420,450,000
Cisco	186,510,000	89,800,000		276,310,000
Chinook salmon	6,780,000		32,780,765	39,560,765
Chum salmon		7,000,000	19,436,400	26,436,400
Silver salmon		600,000	6,486,150	7,086,150
Sockeye salmon	350,000	38,778,500	30,434,500	69,563,000
Steelhead salmon	493,000	38,810	2,928,915	3,460,725
Atlantic salmon		1,387,000	280	1,387,280
Landlocked salmon	575,000	208,115	124,250	907,365
Rainbow trout	2,553,240	414,100	3,872,225	6,839,565
Blackspotted trout	820,000	3,899,100	1,000,300	5,719,400
Loch Leven trout			64,000	64,000
Lake trout	2,824,000	16,563,300	208,500	19,595,800
Brook trout	856,890	3,642,330	7,559,625	12,058,845
Grayling		1,400,000		1,400,000
Smelt	600,000	7,000,000		7,600,000
Pike and pickerel			540,510	540,510
Crappie			37,303,900	37,303,900
Largemouth black bass		585,050	1,221,905	1,806,955
Smallmouth black bass		303,700	54,590	358,290
Rock bass			108,305	108,305
Warmouth bass			100	100
Sunfish			30,371,475	30,371,475
Pike perch	296,475,000	57,385,000	108,515	353,968,515
Yellow perch	12,000,000	176,369,450	6,166,435	194,535,885
Striped bass		20,184,000		20,184,000
White bass			27,170	27,170
Freshwater drum			34,080	34,080
Cod	208,800,000	175,341,000		384,141,000
Haddock	188,940,000	271,880,000		460,820,000
Pollock		455,066,000		455,066,000
Winter flounder		1,768,660,000		1,768,660,000
Pole flounder	19,410,000			19,410,000
Miscellaneous fishes			4,935,165	4,935,165
Total	1,109,637,130	3,626,262,730	226,589,545	4,962,489,405

SUMMARY OF EGG COLLECTIONS.

Eggs are obtained by several methods, but the principal source of supply is the commercial fisheries, where, were it not for the bureau's

activities, vast numbers of eggs would be sent to market in the fish and become a total loss. In the case of certain species, notably but not exclusively the salmons of the Pacific coast, where commercial fishing does not extend to or is not permitted on the spawning areas, employees of the bureau capture the spawning fish either in seines or in traps and artificially incubate in its hatcheries the eggs thus obtained. The object of this work is to bring about a higher percentage of fertility in the eggs than is possible in natural reproduction and to afford the eggs and the resulting young fish protection from their natural enemies. Eggs in appreciable numbers are also obtained from domesticated fish, which are maintained in ponds at fish-cultural stations from year to year under more or less artificial conditions.

A decrease of approximately 121,000,000 in the aggregate egg collections occurred this season as compared with last year, as is indicated by the accompanying table, and the same causes that were operative to the detriment of the work then were again in evidence. However, in any line of enterprise where results are dependent to a large extent upon weather conditions, as is the case in all of our egg-collecting fields, a comparison of one season's work with that of another will indicate a considerable fluctuation in total results, and it is only by comparing the results over a period of years that the actual trend of the work may be traced with any degree of accuracy.

The most noticeable variations in the egg collections of 1921 as compared with 1920 are increased collections of eggs of chum salmon, cisco, rainbow trout, blackspotted trout, whitefish, pike perch, yellow perch, striped bass, carp, haddock, and glut herring, and decreased collections of eggs of the chinook, silver, sockeye, humpback, and steelhead salmon, landlocked salmon, lake and brook trout, shad, buffalofish, cod, pollock, and other species of less importance. It is to be noted that while a decrease occurred in the number of eggs collected during 1921, as compared with the previous year, there was an increase of approximately 179,000,000 in the aggregate output of the stations in eggs, fry, and fingerlings. This apparent discrepancy in figures is accounted for by the better quality of the eggs handled during the year and the higher percentage of fry produced; also to an increase in the numbers of eggs fertilized and planted on the spawning grounds.

COMPARISON OF EGG COLLECTIONS, 1920 AND 1921.

Species.	Fiscal year 1920	Fiscal year 1921.	Species.	Fiscal year 1920.	Fiscal year 1921.
Buffalo fish	236,400,000	163,267,000	Blackspotted trout	2,617,600	5,993,600
Carp	47,250,000	117,218,000	Loch Leven trout	85,000	94,220
Shad	65,667,000	37,549,000	Lake trout	53,753,000	44,247,500
Glut herring		55,130,000	Brook trout	19,947,900	16,110,810
Alewife	130,000		Grayling	700,000	
Whitefish	422,769,000	540,776,000	Smelt		8,000,000
Cisco	181,150,000	317,200,000	Pike perch	416,100,000	508,942,000
Chinook salmon	51,793,000	43,829,820	Yellow perch	175,398,000	218,333,750
Chum salmon	15,417,000	28,182,000	Striped bass	19,358,000	24,600,000
Humpback salmon	579,300		Cod	912,417,000	482,012,000
Silver salmon	10,079 000	8,273,000	Haddock	406,235,000	635,950,000
Sockeye salmon	108,115,000	76,012,500	Pollock	954,800,000	650,850,000
Steelhead salmon	4,006,609	1,603,000	Winter flounder	1,805,167,000	1,980,291,000
Atlantic salmon	797,000	911,720	Pole flounder		19,410,000
Landlocked salmon	2,026,800	1,063,200			
Rainbow trout	9,631,200	10,994,750	Total	6,121,390,009	5,990,844,870

SUMMARY OF FISH-RESCUE WORK.

That part of the net output for the fiscal year 1921 derived from the rescue of stranded fishes is shown in the following table, which gives for each point from which the rescue work was conducted the total number of each species salvaged, the portion of that total restored to the original waters and the portion deliverd to applicants; and for each species the total number rescued, the portion of that total restored to the original waters, and the portion delivered to applicants.

For a discussion of the rescue operations and suggestions for the enlargement of their scope, see page 78.

NUMBER AND DISPOSITION OF FISH RESCUED FROM OVERFLOWED LANDS, FISCAL YEAR 1921.

Station.	Species.	Delivered to applicants.	Restored to original waters.	Total.
Bellevue, Iowa	Buffalofish	150	313,865	314,015
	Carp	434	138,325	138,759
	Catfish	64,390	2,147,350	2,211,740
	Crappie	7,565	4,780,935	4,788,500
	Drum		2,295	2,295
	Largemouth black bass	30,510	27,400	57,910
	Pike and pickerel	410	19,185	19,595
	Pike perch		250	250
	Sunfish	35,120	3,595,630	3,630,750
	White bass	175	9,410	9,585
	Yellow perch	5,900	5,100	11,000
	Miscellaneous		2,698,600	2,698,600
Total		144,654	13,738,345	13,882,999
Cairo, Ill	Buffalofish		107,350	107,350
	Carp		44,715	44,715
	Catfish		670,800	670,800
	Crappie		170,800	170,800
	Largemouth black bass		2,600	2,600
	Pike and pickerel		4,900	4,900
	Sunfish		55,250	55,250
	White bass		800	800
Total			1,057,215	1,057,215
Fairport (Iowa) and auxiliaries.	Buffalofish		104,473	104,473
	Carp		53,757	53,757
	Catfish		1,013,826	1,013,826
	Crappie	4,000	166,827	170,827
	Drum		420	420
	Largemouth black bass	1,450	4,838	6,288
	Pike and pickerel	150	321	471
	Sunfish	8,300	71,711	80,011
	White bass		3,176	3,176
	Miscellaneous		5,872	5,872
Total		13,900	1,425,221	1,439,121
Homer, Minn	Buffalofish		30,165	30,165
	Carp	57	1,190,303	1,190,360
	Catfish	42,178	10,727,650	10,769,828
	Crappie	39,835	15,919,625	15,959,460
	Drum		19,405	19,405
	Largemouth black bass	30,770	139,045	169,815
	Pike and pickerel		175,040	175,040
	Pike perch		108,265	108,265
	Sunfish	39,135	11,716,580	11,755,715
	White bass		6,990	6,990
	Yellow perch	12,635	4,980,187	4,992,822
	Miscellaneous		527,080	527,080
Total		164,610	45,540,335	45,704,945

NUMBER AND DISPOSITION OF FISH RESCUED FROM OVERFLOWED LANDS, ETC.—Con.

Station.	Species.	Delivered to applicants.	Restored to original waters.	Total.
La Crosse, Wis.	Buffalofish	1,020	799,510	800,530
	Carp	25	2,059,164	2,059,189
	Catfish	33,300	18,560,800	18,594,100
	Crappie	16,625	14,455,540	14,472,165
	Drum		11,960	11,960
	Largemouth black bass	132,180	103,985	236,165
	Pike and pickerel		322,130	322,130
	Sunfish	15,050	12,678,660	12,693,710
	White bass		6,620	6,620
	Yellow perch	1,805	1,011,000	1,012,805
	Miscellaneous		904,110	904,110
Total		200,005	50,913,479	51,113,484
Marquette, Iowa	Buffalofish		243,000	243,000
	Carp	85	340,515	340,600
	Catfish	19,650	1,098,350	1,118,000
	Crappie	5,650	1,620,250	1,625,900
	Largemouth black bass	33,940	5,990	39,930
	Pike and pickerel		18,375	18,375
	Rock bass	75		75
	Sunfish	11,800	1,627,100	1,638,900
	Yellow perch	5,800	211,625	217,425
	Miscellaneous		788,500	788,500
Total		77,000	5,953,705	6,030,705
Quincy, Ill.	Buffalofish		46,300	46,300
	Carp		91,200	91,200
	Catfish	14,975	785,200	800,175
	Crappie	400	92,900	93,300
	Largemouth black bass	35,790	1,800	37,590
	Sunfish	5,740	139,560	145,300
	Yellow perch	150	50	200
	Miscellaneous		11,000	11,000
Total		57,055	1,168,010	1,225,065
San Marcos, Tex.	Catfish		70,000	70,000
	Largemouth black bass	2,886	60,000	62,886
	Sunfish		70,000	70,000
Total		2,886	200,000	202,886
Total of all stations	Buffalofish	1,170	1,644,663	1,645,833
	Carp	601	3,917,979	3,918,580
	Catfish	174,493	35,073,976	35,248,469
	Crappie	74,075	37,206,877	37,280,952
	Drum		34,080	34,080
	Largemouth black bass	267,526	345,658	613,184
	Pike and pickerel	560	539,951	540,511
	Pike perch		108,515	108,515
	Rock bass	75		75
	Sunfish	115,145	29,954,491	30,069,636
	White bass	175	26,996	27,171
	Yellow perch	26,290	6,207,962	6,234,252
	Miscellaneous		4,935,162	4,935,162
Grand total		660,110	119,996,310	120,656,420

STATIONS AND SUBSTATIONS OPERATED AND OUTPUT OF EACH.

During the fiscal year 1921 fish-cultural work was conducted from 37 main stations, 32 substations, and approximately 60 egg-collecting or auxiliary stations. The following table gives the main fish-cultural stations, in alphabetical order, and the substations operative during the year, the period of operation of each, and the number of fish and eggs, by species, furnished for distribution by each station through propagation, through collections from auxiliary stations, and through rescue of fish from overflowed lands of the Mississippi Basin. It will be noted that transfers of fish and eggs from station to station are frequent. (For table of egg transfers, see p. 15.) Such transfers are made in the interest of economy and convenience

where the shipments consist of eggs and give advantageous distribution centers in the case of young fish.

STATIONS AND SUBSTATIONS OPERATED, AND OUTPUT OF EACH, FISCAL YEAR 1921.

[Asterisk (*) denotes transfer of eggs. See table, p. 15.]

Station and period of operation.	Species.	Eggs.	Fry.	Fingerlings, yearlings, and adults.	Total.
Afognak, Alaska: *					
Entire year	Sockeye salmon	(*)	30,211,000	17,597,000	47,808,000
Baird, Calif.:					
Entire year	Chinook salmon			1,465,000	1,465,000
Battle Creek, Calif.*—					
Entire year	do	(*)		1,781,000	1,781,000
Mill Creek, Calif.—					
Entire year	do	3,000,000		1,347,400	4,347,400
Baker Lake, Wash.:					
Entire year	Sockeye salmon		7,050,000		7,050,000
Birdsview, Wash.*—					
Entire year	Blackspotted trout		23,700		23,700
	Chinook salmon			973,865	973,865
	Chum salmon			1,536,000	1,536,000
	Silver salmon		600,000	2,176,000	2,776,000
	Sockeye salmon	(*)		9,000	9,000
	Steelhead salmon	* 85,000		128,250	213,250
Brinnon, Wash.—					
November-June	Chum salmon		1,500,000	575,000	2,075,000
	Steelhead salmon	100,000			100,000
Duckabush, Wash.—					
Entire year	Chum salmon		5,500,000	5,682,000	11,182,000
	Silver salmon			50,000	50,000
	Steelhead salmon			1,095,000	1,095,000
Quilcene, Wash.—					
Entire year	Chum salmon			6,575,500	6,575,500
	Silver salmon			470,800	470,800
	Steelhead salmon	85,000		303,500	388,500
Quinault, Wash.—					
Entire year	Chinook salmon			24,800	24,800
	Silver salmon			1,398,000	1,398,000
	Sockeye salmon		950,000	3,448,000	4,398,000
Sultan, Wash.—					
Entire year	Chinook salmon			303,300	303,300
	Silver salmon			1,974,300	1,974,300
	Steelhead salmon			76,800	76,800
Berkshire, Mass.:					
Entire year	Brook trout			296,825	296,825
	Rainbow trout			41,900	41,900
Boothbay Harbor, Me.:					
Entire year	Flounder		841,235,000		841,235,000
	Pollock		11,906,000		11,906,000
Bozeman, Mont.: *					
Entire year	Blackspotted trout		912,500	152,500	1,065,000
	Brook trout			546,950	546,950
	Rainbow trout	* 325,000	[1] 250,000	798,000	1,373,000
Glacier Park, Mont.—					
March-June	Blackspotted trout			420,000	420,000
	Brook trout			30,000	30,000
	Grayling		1,400,000		1,400,000
	Rainbow trout			185,000	185,000
Yellowstone, Wyo.*—					
July-September	Blackspotted trout	* 820,000	2,012,400		2,832,400
Cape Vincent, N. Y.:*					
Entire year	Brook trout		397,000		397,000
	Cisco	* 186,510,000	89,400,000		275,910,000
	Lake trout	39,000	450,000		489,000
	Pike perch		7,970,000		7,970,000
	Rainbow trout		66,100		66,100
	Whitefish	* 89,650,000	40,300,000		129,950,000
	Yellow perch		11,000,000	2,150	11,002,150
Central Station, Washington, D. C.:					
Entire year	Brook trout			36,200	36,200
	Chinook salmon			12,500	12,500
	Cisco		400,000		400,000
	Pike perch		1,500,000		1,500,000
	Rainbow trout			20,400	20,400
	Shad		800,000		800,000
	Whitefish		800,000		800,000
	Yellow perch		500,000		500,000
Bryans Point, Md.—					
February-May	Shad		13,639,175		13,639,175
	Yellow perch		158,819,450		158,819,450

[1] Fry produced at Meadow Creek auxiliary station.

STATIONS AND SUBSTATIONS OPERATED, AND OUTPUT OF EACH, FISCAL YEAR 1921—Continued.

[Asterisk (*) denotes transfer of eggs. See table, p. 15.]

Station and period of operation.	Species.	Eggs.	Fry.	Fingerlings, yearlings, and adults.	Total.
Clackamas, Oreg.:					
Entire year	Blackspotted trout			95,000	95,000
	Brook trout			4,000	4,000
	Chinook salmon	130,000		4,362,000	4,492,000
Applegate, Oreg.—					
Entire year	do			77,400	77,400
	Silver salmon			35,150	35,150
	Steelhead salmon			450,000	450,000
Big White Salmon, Wash.—					
Entire year	Chinook salmon			4,000,000	4,000,000
Little White Salmon, Wash.—					
Entire year	do	950,000		12,190,000	13,140,000
	Chum salmon			5,067,900	5,067,900
Rogue River, Oreg.—					
Entire year	Blackspotted trout			47,500	47,500
	Chinook salmon			4,308,000	4,308,000
	Rainbow trout			189,500	189,500
	Silver salmon			381,900	381,900
	Steelhead salmon			866,000	866,000
Salmon, Idaho—					
July-September	Chinook salmon	2,700,000			2,700,000
Upper Clackamas, Oreg.—					
Entire year	do			1,935,500	1,935,500
Washougal, Wash.—					
April-June	Steelhead salmon	223,000	15,000		238,000
Willamette, Oreg.—					
July-June	Shad		2,347,100		2,347,100
Cold Springs, Ga.:					
Entire year	Catfish			4,120	4,120
	Crappie			1,550	1,550
	Largemouth black bass		144,750	67,805	212,555
	Sunfish			61,350	61,350
	Warmouth bass			100	100
Craig Brook, Me.:					
Entire year	Atlantic salmon		1,387,000	280	1,387,280
	Brook trout		1,085,000	23,625	1,108,625
	Landlocked salmon		8,395	35,150	43,545
	Sockeye salmon		17,500		17,500
Duluth, Minn.: *					
Entire year	Brook trout			110,000	110,000
	Lake trout	*100,000	6,057,000	147,500	6,304,500
	Pike perch		8,500,000		8,500,000
	Rainbow trout			20,500	20,500
	Whitefish		9,600,000		9,600,000
Edenton, N. C.:					
Entire year	Glut herring		43,815,000		43,815,000
	Largemouth black bass.			23,085	23,085
	Shad		16,006,000		16,006,000
	Sunfish			9,905	9,905
Weldon, N. C.—					
April-May	Striped bass		20,184,000		20,184,000
Erwin, Tenn.:					
Entire year	Brook trout			300,435	300,435
	Crappie			400	400
	Largemouth black bass.		33,000	32,980	65,980
	Rainbow trout	55,000		700,100	755,100
	Rock bass			17,200	17,200
	Smallmouth black bass.			5,165	5,165
	Sunfish			20,350	20,350
Fairport, Iowa, and substations:					
Entire year	Buffalofish			104,473	104,473
	Carp			53,757	53,757
	Catfish			1,013,826	1,013,826
	Crappie			170,827	170,827
	Drum			420	420
	Largemouth black bass.			6,288	6,288
	Pike and pickerel			471	471
	Sunfish			80,011	80,011
	White bass			3,176	3,176
	Miscellaneous			5,872	5,872

STATIONS AND SUBSTATIONS OPERATED, AND OUTPUT OF EACH, FISCAL YEAR 1921—Continued.

[Asterisk (*) denotes transfer of eggs. See table, p. 15.]

Station and period of operation.	Species.	Eggs.	Fry.	Fingerlings, yearlings, and adults.	Total.
Gloucester, Mass.: *					
Entire year	Cod	[1] 208,800,000	50,900,000		259,700,000
	Flounder (pole)	19,410,000			19,410,000
	Flounder (winter)		132,070,000		132,070,000
	Haddock	188,940,000	271,880,000		460,820,000
	Pollock	(*)	443,160,000		443,160,000
Green Lake, Me.:					
Entire year	Brook trout		608,050		608,050
	Landlocked salmon	495,000	144,720		639,720
	Rainbow trout		26,000		26,000
	Smelt	600,000	7,000,000		7,600,000
Grand Lake Stream, Me.*—					
Entire year	Brook trout		47,880		47,880
	Landlocked salmon	* 80,000	55,000	79,100	214,100
Homer, Minn.:					
Entire year	Buffalofish			30,165	30,165
	Carp			1,190,360	1,190,360
	Catfish			10,769,828	10,769,828
	Crappie			15,959,460	15,959,460
	Drum			19,405	19,405
	Largemouth black bass			169,815	169,815
	Pike and pickerel			175,040	175,040
	Pike perch			108,265	108,265
	Rock bass			3,300	3,300
	Sunfish			11,755,715	11,755,715
	White bass			6,990	6,990
	Yellow perch			4,992,822	4,992,822
	Miscellaneous			527,080	527,080
Atchafalaya, La.—					
February-April	Buffalofish		40,040,000		40,040,000
Bellevue, Iowa—					
July-November	Buffalofish		68,267,000	314,015	68,581,015
	Carp		42,718,000	138,759	42,856,759
	Catfish			2,211,740	2,211,740
	Crappie			4,788,500	4,788,500
	Drum			2,295	2,295
	Largemouth black bass			57,910	57,910
	Pike and pickerel			19,595	19,595
	Pike perch			250	250
	Sunfish			3,630,750	3,630,750
	White bass			9,585	9,585
	Yellow perch			11,000	11,000
	Miscellaneous			2,698,605	2,698,605
La Crosse, Wis.—					
Entire year	Brook trout		107,000	316,050	423,050
	Buffalofish			800,530	800,530
	Carp			2,059,189	2,059,189
	Catfish			18,594,100	18,594,100
	Crappie			14,472,165	14,472,165
	Drum			11,960	11,960
	Largemouth black bass			236,165	236,165
	Pike and pickerel			322,130	322,130
	Rainbow trout		30,000	23,690	53,690
	Sunfish			12,693,710	12,693,710
	White bass			6,620	6,620
	Yellow perch			1,012,805	1,012,805
	Miscellaneous			904,110	904,110
Marquette, Iowa—July-November	Buffalofish			243,000	243,000
	Carp			340,600	340,600
	Catfish			1,118,000	1,118,000
	Crappie			1,625,900	1,625,900
	Largemouth black bass			39,930	39,930
	Pike and pickerel			18,375	18,375
	Rock bass			75	75
	Sunfish			1,638,900	1,638,900
	Yellow perch			217,425	217,425
	Miscellaneous			788,500	788,500
Meredosia, Ill.—					
July-November	Buffalofish			46,300	46,300
	Carp			91,200	91,200
	Catfish			800,175	800,175
	Crappie			93,300	93,300
	Largemouth black bass			37,590	37,590
	Sunfish			145,300	145,300
	Yellow perch			200	200
	Miscellaneous			11,000	11,000

[1] Represents eggs fertilized and planted on spawning grounds.

STATIONS AND SUBSTATIONS OPERATED, AND OUTPUT OF EACH, FISCAL YEAR 1921—Continued.

[Asterisk (*) denotes transfer of eggs. See table, p. 15.]

Station and period of operation.	Species.	Eggs.	Fry.	Fingerlings, yearlings, and adults.	Total.
Leadville, Colo.:*					
Entire year	Blackspotted trout		950,500		950,500
	Brook trout	*500,000		2,706,000	3,206,000
	Lake trout			24,000	24,000
	Loch Leven trout			34,000	34,000
	Rainbow trout			99,500	99,500
Louisville, Ky.:					
Entire year	Largemouth black bass		32,000	1,100	33,100
	Rock bass			4,500	4,500
	Smallmouth black bass		146,000	10,700	156,700
	Sunfish			76,150	76,150
	Yellow perch		750,000		750,000
Cairo, Ill.—					
July-October	Buffalofish			107,350	107,350
	Carp			44,715	44,715
	Catfish			670,800	670,800
	Crappie			170,800	170,800
	Largemouth black bass			2,600	2,600
	Pike and pickerel			4,900	4,900
	Sunfish			55,250	55,250
	White bass			800	800
Mammoth Spring, Ark.:					
Entire year	Largemouth black bass			1,400	1,400
	Rock bass			4,725	4,725
	Smallmouth black bass		24,000	2,200	26,200
Manchester, Iowa:*					
Entire year	Brook trout			466,225	466,225
	Rainbow trout	*65,500		155,950	221,450
	Rock bass			53,910	53,910
	Smallmouth black bass			2,500	2,500
Nashua, N. H.:					
Entire year	Brook trout			735,600	735,600
	Pike perch		1,175,000		1,175,000
	Rainbow trout			42,000	42,000
	Smallmouth black bass		31,700		31,700
Neosho, Mo.:*					
Entire year	Catfish			3,000	3,000
	Crappie			13,222	13,222
	Largemouth black bass			20,175	20,175
	Rainbow trout	*100,000		167,965	267,965
	Rock bass			10,040	10,040
	Smallmouth black bass		1,500	2,701	4,201
	Sunfish			31,680	31,680
	Yellow perch			58	58
Northville, Mich.:					
Entire year	Brook trout		321,000	148,225	469,225
	Rainbow trout		42,000	51,575	93,575
	Smallmouth black bass			31,200	31,200
Bay City, Mich.—					
April-May	Pike perch	277,250,000	7,040,000		284,290,000
Charlevoix, Mich.*—					
Entire year	Lake trout	*2,685,000	10,000,000		12,685,000
	Steelhead salmon		23,810		23,810
	Whitefish	15,000,000	20,000,000		35,000,000
Orangeburg, S. C.:					
Entire year	Crappie			300	300
	Largemouth black bass			204,675	204,675
	Rock bass			500	500
	Sunfish			14,200	14,200
Put in Bay, Ohio:*					
Entire year	Carp		63,325,000		63,325,000
	Pike perch		12,600,000		12,600,000
	Whitefish	*77,000,000	167,500,000		244,500,000
St. Johnsbury, Vt.:					
Entire year	Brook trout	256,890	931,900	85,800	1,274,590
	Lake trout		37,000		37,000
	Landlocked salmon			10,000	10,000
	Steelhead salmon			5,875	5,875
Holden, Vt.—					
Entire year	Brook trout		144,500	29,200	173,700
	Lake trout		19,300	12,350	31,650
	Rainbow trout			400	400
	Steelhead salmon			3,490	3,490
Swanton, Vt.*—					
March-May	Pike perch	*19,225,000	18,100,000		37,325,000
	Yellow perch	12,000,000	5,300,000		17,300,000

STATIONS AND SUBSTATIONS OPERATED, AND OUTPUT OF EACH, FISCAL YEAR 1921—Continued.

[Asterisk (*) denotes transfer of eggs. See table, p.15.]

Station and period of operation.	Species.	Eggs.	Fry.	Fingerlings, yearlings, and adults.	Total.
San Marcos, Tex.:					
Entire year	Black bass			257,715	257,715
	Catfish			70,000	70,000
	Crappie			5,904	5,904
	Rock bass			320	320
	Sunfish			74,872	74,872
Saratoga, Wyo.:*					
Entire year	Blackspotted trout			194,000	194,000
	Brook trout	100,000		129,000	229,000
	Rainbow trout	*1,297,740		145,000	1,442,740
Spearfish, S. Dak.:					
Entire year	Brook trout			530,000	530,000
	Lake trout			29,900	29,900
	Loch Leven trout			34,000	34,000
	Rainbow trout			126,945	126,945
Springville, Utah:*					
Entire year	Blackspotted trout			91,300	91,300
	Brook trout	(*)		200,300	200,300
	Catfish			2,000	2,000
	Rainbow trout	*350,000		172,000	522,000
Paris, Idaho—					
March-April	Whitefish		600,000		600,000
Tupelo, Miss.:					
Entire year	Crappie			1,280	1,280
	Largemouth black bass.		351,000	54,500	405,500
	Sunfish			73,005	73,005
White Sulphur Springs, W. Va.:*					
Entire year	Brook trout			857,400	857,400
	Crappie			550	550
	Largemouth black bass.		25,800	600	26,400
	Rainbow trout	*250,000		663,151	913,151
	Rock bass			175	175
	Smallmouth black bass.		100,500	125	100,625
Woods Hole, Mass.:*					
Entire year	Cod	(*)	124,441,000		124,441,000
	Flounder		795,355,000		795,355,000
Wytheville, Va.:*					
Entire year	Brook trout			40,900	40,900
	Crappie			160	160
	Largemouth black bass.			9,423	9,423
	Pike perch		500,000		500,000
	Rainbow trout	*110,000		315,550	425,550
	Rock bass			14,060	14,060
	Smallmouth black bass.			100	100
	Sunfish			10,325	10,325
Yes Bay, Alaska:					
Entire year	Sockeye salmon	350,000	550,000	9,380,500	10,280,500
Gross output		1,109,637,130	3,626,264,230	226,682,195	4,962,583,555
Loss in transit			1,500	92,650	94,150
Net output		1,109,637,130	3,626,262,730	226,589,545	4,962,489,405

EGG-COLLECTING OR AUXILIARY STATIONS.

The eggs hatched at the main stations and substations listed in the foregoing table are in many cases obtained from auxiliary sources, usually temporary stations occupied during the season only or, in some instances, mere camps, which are shifted from year to year. In the Great Lakes and off the New England coast collections are made by the bureau's vessels or boats in favorable localities. The following stations and egg-collecting points, operative for the periods indicated, furnished eggs of the given species for the main hatcheries during 1921.

EGG-COLLECTING STATIONS AND SPECIES HANDLED, FISCAL YEAR 1921.

Stations.	Period of operation.	Species handled.
Bozeman, Mont.:		
Meadow Creek, Mont	April to June	Rainbow trout.
Yellowstone Park, Wyo	July to September	Blackspotted trout.
Clear Creek	do	Do.
Columbine Creek	do	Do.
Cub Creek	do	Do.
Thumb Creek	do	Do.
Cape Vincent, N. Y.:		
Bygotts Point, N. Y	November	Cisco, whitefish.
Chaumont Bay, N. Y	November and December	Do.
Deseronte, Canada	do	Do.
Fair Haven Bay, N. Y	do	Do.
Grass Bay, N. Y	May	Yellow perch.
Pigeon Island, Canada	October and November	Lake trout.
Sodus Bay, N. Y	November and December	Cisco.
South Bay, Canada	do	Whitefish.
Stony Island, N. Y	October and November	Lake trout.
Duluth, Minn.:		
Boy River, Minn	April	Pike perch.
Briesburg, Minn	do	Do.
Grand Marais, Mich	October and November	Lake trout.
Keystone, Mich	do	Do.
Lac La Belle, Mich	do	Do.
Manitou Island, Mich	do	Do.
Marquette, Mich	do	Do.
Munising, Mich	do	Do.
Ontonagon, Mich	do	Do.
Portage, Mich	do	Do.
Washington Harbor, Mich	do	Do.
Green Lake, Me.: Fish River Lake, Me	November	Landlocked salmon.
Leadville, Colo.:		
Carroll Lake, Colo	October and November	Brook trout.
Crystal Lake, Colo	do	Do.
Engelbrecht Lake, Colo	do	Do.
Evergreen Lake, Colo	do	Do.
Hen and Ford Lakes, Colo	do	Do.
Musgrove Lake, Colo	do	Do.
Northfield, Colo	do	Do.
Turquoise Lake, Colo	do	Brook and Loch Leven trouts.
Northville, Mich:		
Alpena, Mich	November	Lake trout, white fish.
Cheboygan, Mich	do	Do.
Detour, Mich	do	Do.
Frankfort, Mich	do	Do.
Leland, Mich	do	Do.
Manistique, Mich	do	Do.
Northport, Mich	do	Do.
St. Ignace, Mich	do	Do.
St. James, Mich	do	Do.
St. Joseph, Mich	do	Do.
Scotts Point, Mich	do	Whitefish.
Put in Bay, Ohio:		
Catawba Island, Ohio	November and December	Do.
Isle St. George, Ohio	do	Do.
Port Clinton, Ohio	November and December, April to June.	Whitefish, carp, pike perch.
Toledo, Ohio	November and December, April.	Whitefish, pike, perch.
St. Johnsbury, Vt.:		
Darling Pond, Vt	September to December	Brook trout.
Lake Mitchell, Vt	September to November	Do.
Margalloway River, Me	do	Do.
Saratoga, Wyo.:		
Canon Creek, Wyo	April to June	Rainbow trout.
Lost Creek, Wyo	do	Do.
Sage Creek, Wyo	do	Do.
Spearfish, S. Dak.:		
Crow Creek, S. Dak	October to December	Brook and Loch Leven trouts.
Schmid Ponds, S. Dak	do	Do.
Springville, Utah: Fish Lake, Utah	October and November, April and May.	Brook and rainbow trouts.
Woods Hole, Mass.:		
Quissett, Mass	February and March	Winter flounder.
Waquoit, Mass	do	Do.
Wickford, R. I	March	Do.

TRANSFERS OF EGGS.

For the convenient reference of persons interested in the results of the frequent interchange of fish eggs between the various stations of the bureau this table is prepared, indicating all such transfers of eggs during the fiscal year 1921. It is the intention to include a similar table in all future reports.

TRANSFERS OF EGGS, FISCAL YEAR 1921.

Species.	Number of eggs.	From—	To—	Final disposition of fry or fingerlings.
Blackspotted trout.[2]	50,000	Yellowstone Park.	Birdsview, Wash...	Washington waters.
	25,000	.....do.....	Clackamas, Oreg....	Oregon waters.
	1,000,000	.....do.....	Leadville, Colo.....	Colorado waters.
	200,000	.....do.....	Saratoga, Wyo.....	Wyoming waters.
Brook trout[2]...	800,000	Leadville, Colo....	Bozeman, Mont.....	Two Medicine Lake and Grinnel Creek, Glacier Park, and other Montana waters.
	350,000	Springville, Utah.	.....do.....	Do.
	200,000	.....do.....	Clackamas, Oreg....	Oregon waters.
	452,800	.....do.....	Saratoga, Wyo.....	Wyoming waters.
	200,000	.....do.....	Spearfish, S. Dak...	South Dakota waters.
Chinook salmon	[1] 20,000	Battle Creek, Calif.	Central station, Washington, D. C.	Pennsylvania waters.
Cisco.....	1,000,000	Cape Vincent, N.Y.	.....do.....	Cayuga Lake, N. Y.
Cod.....	8,700,000	Woods Hole, Mass.	Gloucester, Mass....	Atlantic Ocean.
Lake trout.....	25,000	Charlevoix, Mich..	Leadville, Colo.....	Twin Lakes, Colo.
	25,000	.....do.....	St. Johnsbury, Vt...	Averill Lakes and Lowell Lake, Vt.; Silver Lake, Taylors Pond, and Winnesquam Lake, N. H.
	25,000	Duluth, Minn.....	Spearfish, S. Dak...	Reclamation Reservoir, S. Dak.; Big Wind River, Wyo.
Landlocked salmon.[2]	10,000	Grand Lake Stream, Me.	Craig Brook, Me....	Pleasant Lake and Toddy Pond, Me.
	[illegible]0	.....do.....	St. Johnsbury, Vt...	Lake St. Catherine, Vt.; Lake George, N. Y.
Pike perch.....	8,000,000	Swanton, Vt.....	Cape Vincent, N. Y.	Lake Ontario, N. Y.
	2,025,000	.....do.....	Central station, Washington, D. C.	Perkiomen Creek, Lake Sheridan, Paupack River, and other Pennsylvania waters.
	2,000,000	.....do.....	Nashua, N. H.....	Merrimack River and tributaries, N. H.
	500,000	.....do.....	Wytheville, Va.....	New River, Va.
Pollock.....	24,350,000	Gloucester, Mass..	Boothbay Harbor, Me.	Boothbay Harbor, Me.
Rainbow trout.	[3] 50,000	Bozeman: Meadow Creek, Mont.	Duluth, Minn.....	Clearwater River, tributary of, Minn.
	[3] 25,000	.....do.....	Manchester, Iowa...	Reserved for brood stock.
	[3] 50,000	.....do.....	Spearfish, S. Dak...	Spearfish Creek and tributaries, S. Dak.
	[3] 60,000	Manchester, Iowa.	La Crosse, Wis.....	Spring Valley Creek and tributaries, and other Wisconsin waters.
	[3] 98,991	Neosho, Mo.....	Erwin, Tenn.....	Pigeon River and North Indian Creek, Tenn.
	[3] 105,000	Saratoga: Sage Creek, Wyo.	Leadville, Colo.....	Platte River, Rifle Creek, and other Colorado waters.
	[3] 100,000	Springville: Fish Lake, Utah.	Clackamas, Oreg....	Alder Creek and Clackamas and Molalla Rivers, Oreg.
	[3] 50,000	.....do.....	Duluth, Minn.....	French and Sucker Rivers, Minn.
	[3] 25,000	.....do.....	Leadville, Colo.....	Platte River, Rifle Creek, and other Colorado waters.
	[3] 100,000	.....do.....	Spearfish, S. Dak...	Bear Butte, Horse, and Castle Creeks, S. Dak.
	[3] 50,000	White Sulphur Springs, W. Va.	Berkshire: Hartsville, Mass.	Housatonic and Westfield Rivers, Mass.
	[3] 25,000	.....do.....	Central station, Washington, D. C.	Potomac and Beaverdam Rivers, Md.
	[3] 57,000	.....do.....	Northville, Mich....	Au Sable and Pere Marquette Rivers, Mich.
	[3] 50,000	.....do.....	St. Johnsbury, Vt...	Crescent Pond, N. Y.
	[3] 150,000	Wytheville, Va...	Cape Vincent, N. Y.	Horseshoe Pond, Salmon Creek, and Neversink River, N. Y.
	[3] 20,000	.....do.....	Central station, Washington, D. C.	Potomac and Beaverdam Rivers, Md.
	[3] 50,000	.....do.....	Green Lake, Me.....	Great Brook and Beaver Pond, Me.
	[3] 50,000	.....do.....	Nashua, N. H.....	Cold and Nashua Rivers, N. H.
	[3] 100,000	.....do.....	White Sulphur Springs, W. Va.	Cheat and Cranberry Rivers and tributaries and other West Virginia waters.

TRANSFERS OF EGGS, FISCAL YEAR 1921—Continued.

Species.	Number of eggs.	From—	To—	Final disposition of fry or fingerlings.
Sockeye salmon	8,000,000	Afognak, Alaska..	Quinault, Wash.....	Quinault Lake, Wash.
	5,000,000	.....do.....	Yes Bay, Alaska....	McDonald Lake, Alaska.
	30,000	Birdsview, Wash .	Clackamas, Oreg....	Columbia River, Oreg.
	[4] 20,000	.....do.....	Craig Brook, Me....	Pleasant River, Me.
Steelhead salmon.[3]	25,000	.....do.....	Charlevoix, Mich....	Hortons Creek, Mich.
	10,000	.....do.....	Erwin, Tenn.....	Reserved for brood stock.
	25,500	.....do.....	Manchester, Iowa...	Do.
	58,000	.....do.....	St. Johnsbury, Vt...	Lake Tarleton, N. H.; Cayuga Lake, N. Y.; and Peacham Pond, Vt.
Whitefish.....	750,000	Cape Vincent, N. Y.	Central station, Washington, D.C.	Cayuga Lake, N. Y
	750,000	Put in Bay, Ohio .	.....do.....	Do.
	59,120,000	.....do.....	Charlevoix, Mich....	Lake Michigan.
	10,000,000	.....do.....	Duluth, Minn.....	Lake Superior.

[1] For exhibit—fingerlings delivered to Pennsylvania Fish and Game Commission.
[2] Eggs from wild stock.
[3] Eggs from domesticated stock.
[4] This transfer was due to a misunderstanding of orders.

Propagation of Commercial Fishes.

The more important commercial fishes propagated by the bureau are the salmons of the Pacific coast, the whitefish, cisco (lake herring), lake trout, pike perch, and yellow perch of the Great Lakes, the yellow perch of the Potomac, the carp in the Portage River section of Ohio, the marine species—including the cod, haddock, pollock, winter and pole flounders—the buffalofish in Louisiana, and the anadromous fishes of the Atlantic coast—the shad, glut herring, alewife, striped bass, and Atlantic salmon. A discussion of the propagation of these fishes at the various stations during the fiscal year 1921 follows. Data concerning the spawning seasons for the species at the different stations are assembled in the table on page 72, and the amount and cost of fish food used at the Pacific salmon stations are given in the table on page 75.

PACIFIC SALMON CULTURE.

With the recent increase in the cost of all labor and materials the bureau has found it impossible to maintain the former magnitude of its Pacific salmon operations or to keep pace with the work done along that line by the various State commissions. The Yes Bay (Alaska) station was temporarily closed in order that its allotment of funds might be used to rebuild the water-supply line and make repairs to the hatchery and its equipment, such action being essential to prevent complete deterioration of valuable Government property. In the following pages is given a brief review of the work of the hatcheries on the Pacific coast.

AFOGNAK (ALASKA) STATION.

[EDWIN WENTWORTH, Superintendent.]

There was another excellent run of sockeye salmon in Letnik Lake, and during the active spawning season, extending from July 31 to September 24, 62,300,000 eggs were laid down in the hatchery. This

is the fourth consecutive year that the egg collections have exceeded 50,000,000, and it would seem to indicate the permanency of the reestablished run, which was practically destroyed by the volcanic eruption of 1912. In none of these years do the egg collections afford an accurate index to the numbers of fish entering the lake, as it is the exceptional season when conditions are such as to permit active fishing throughout the spawning season. Thus, many of the fish annually escape to perform the spawning function under natural conditions. During the fiscal year 1920 upward of 79,000,000 eggs were taken, after which the racks were removed from the spawning streams. It was estimated that not more than 50 per cent of the spawning salmon entering the lake were used. During the season of 1921 the egg collections did not fill the hatchery, as floods during August prevented successful fishing.

Of the eggs collected 10,000,000 were transferred to other points, 5,000,000 going to the Yes Bay (Alaska) station, 2,000,000 to Quinault, Wash., and 3,000,000 to the State fish hatchery at Bonneville, Oreg., in continuance of an effort to restock the Columbia River with the species. The eggs retained at the station were incubated with a loss of 6½ per cent. In view of the excellent run of sockeye salmon that has entered Letnik River during the past four years, it may not be amiss to consider the opening of Letnik Bay to commercial fishing for the species after it has been ascertained that a sufficient number of fish has entered the lake to insure a satisfactory number of eggs for artificial incubation. This would involve the installation of a rack, making it possible to count the salmon passing through. It is believed the same rack would be useful in excluding Dolly Varden trout and silver salmon from the lake should this be considered advisable. The water temperature at the beginning of the spawning period registered 52° F.; at its close, 40°.

YES BAY (ALASKA) STATION.

[C. H. VAN ATTA, Superintendent.]

Fish-cultural work at this station was confined to the incubation of the sockeye-salmon eggs transferred from the Afognak station, 4,025,000 fingerlings resulting from the 5,000,000 eggs received. During December 350,000 of the eyed eggs were planted in three local lakes, which have been designated as Cannery Lake, Round Lake, and Lake No. 2. These bodies of water do not at present support a run of salmon, though they appear to be suited to the purpose. A rather casual inspection of the lakes on May 17 disclosed several schools of sockeye-salmon fingerlings from 1 to 1½ inches long. Each school was estimated to contain from 25 to 75 fish.

In view of the extensive repair work in hand it was not possible to take up fish-cultural operations on the usual scale. The repairs were essential to prevent complete deterioration of valuable property and were made from the funds usually allotted for propagation, the special appropriation requested by Congress for the purpose having been refused. The main features of the work consisted in the installation of a new water supply and extensive repairs to the hatchery building, including new foundation piling, new floors, and a complete set of 240 hatching troughs. The water supply required

approximately 4,000 feet of 18-inch and 16-inch wood stave pipe, which was carried on a trestle from 1 foot to 24 feet high, and 1,250 feet of 6-inch pipe to provide water for domestic use and for fire protection. The trestle is made to accommodate a tramcar and makes available for station use an excellent supply of firewood and lumber, also, after the station has been equipped with a sawmill. The work also included repairs to other station buildings and the construction of a new launch. The station is now on an operating basis again, and fish-cultural work will be resumed during 1922.

During the fiscal year 1920 a system of feeding young salmon that had been in successful operation in the Washington field for some time was tried at the Yes Bay station. An arm of McDonald Lake, locally known as McDonald Slough, was temporarily screened, and a considerable number of young sockeye salmon were placed therein. The fish were fed regularly on salted salmon and made a very excellent growth. The results of the experiment were so satisfactory that piling has been driven to make the feeding inclosure a permanent feature of the station's work.

BAKER LAKE (WASH.) STATION AND SUBSTATIONS.

[J. R. RUSSELL, Superintendent.]

Necessity for economy has compelled the suspension of fish-cultural operations at three of the field stations in the Washington group in the past two years, and this has tended to reduce the output in that region. The combined output of the Washington stations for the fiscal year 1921, exclusive of Quinault, is 36,873,015, against 33,086,750 for the preceding year, 20,393,315 of the 1921 figures representing fingerlings, as opposed to a production of 9,842,350 fingerlings in 1921.

BAKER LAKE (WASH.) STATION.

Of particular interest in connection with the fish-cultural work in this field was the excellent run of sockeye salmon at Baker Lake. The run began on July 1, when 115 adult fish were taken, and continued to August 13, the peak of the run occurring between July 20 and 24. A total of 7,850 spawning fish were taken. The spawning period extended from October 10 to November 30. About 46 per cent of the total brood stock, or 3,645 fish, proved to be gravid females and yielded 11,750,000 eggs. This is the largest collection of sockeye-salmon eggs obtained at Baker Lake, exceeding last year's record collection by 600,000. The incubation period was unusually protracted, the first fry appearing on April 1, nearly three months later than in the preceding year, and hatching operations were not completed until May 31. The long incubation season was attributable to low water temperatures, brought about by cold spring weather and late snowstorms in the mountains. Apparently there were no ill effects to either eggs or fry, as the loss of eggs amounted to only 3.6 per cent, while the fry hatched seemed to possess the usual vigor.

Though it has not been possible to replace all equipment destroyed by the fire of last year, all of the fry produced were retained in the hatchery troughs to the end of the sac stage, this being effected through the use of the stacked-tray system. There remained on hand

at the close of the fiscal year 4,000,000 of these young salmon, which will be reared to a larger size before liberating. In connection with its rearing operations the bureau is indebted to the fish and game authorities of the State of Washington, which furnished without charge 1,000 cases of canned salmon "do-overs" to be utilized as food for the fish.

The improved run of sockeye salmon in Baker Lake seems especially noteworthy from the fact that for more than 20 years the maintenance of the run of this species has depended almost exclusively on artificial propagation. It has been the custom at this point to trap all fish as they enter Baker Lake from the river and transfer them to an inclosure near the head of the lake, where they are held until ready to spawn. Thus, only the comparatively few fish which occasionally escape the trap during high-water periods spawn naturally in the lake.

In addition to the sockeye-salmon operations 700,000 silver-salmon eggs were taken between November 17 and December 15. In pursuance of the adopted policy of reserving Baker Lake so far as possible for the propagation of sockeye salmon, these eggs were transferred to the Birdsview hatchery immediately after being eyed.

BIRDSVIEW (WASH.) SUBSTATION.

The work of the Birdsview substation, on the Skagit River, was also successful. Its output of chinook salmon was larger than in any previous year, and the collections of silver and steelhead salmon eggs were above the average. This substation is now dependent on the fish that enter Grandy Creek for its egg collections. The trap in Phinney Creek, formerly a valuable egg-producing stream, was destroyed by floods two years ago, and since that time funds for its replacement have not been available. The success of the work at this point is attributed largely to the favorable water stages which prevailed throughout the spawning season. The streams in this locality are subject to sudden and violent fluctuation, and not infrequently at the spawning season the water is at such a low stage as to make the ascent of fish difficult, if not impossible. Of passing interest is the collection of 13,500 sockeye-salmon eggs from fish taken in Grandy Creek, the result, apparently, of plants of that species made by the bureau in Grandy Lake.

BRINNON, DUCKABUSH, AND QUILCENE (WASH.) SUBSTATIONS.

The propagation of chum salmon at the three substations on Hood Canal—Brinnon, Duckabush, and Quilcene—was unusually successful from the standpoint of egg collections and numbers of fry produced. Thirteen million eggs of this species, taken in Walcotts Slough, at the Brinnon substation, represented the largest number of eggs taken in that region. The egg collections do not accurately represent the numbers of spawning fish in the streams, since many escaped during the high-water stages, which were frequent during the spawning period and adversely affected the work at all points on the canal.

There are two distinct runs of chum salmon in the tributaries of Hood Canal. The spawning of the first, or summer run, occurs

in September, while the late or winter run spawns from early November to well into January. A peculiarity of this species is that the fish in most instances are in spawning condition when they leave salt water to enter the streams, and most of the eggs collected in the Washington field are obtained in tidewaters. The increased collections of chum-salmon eggs within the past two years may be attributed to the lessened activity of commercial fishermen, the low prices prevailing offering but little inducement to fish.

There was a satisfactory run of silver salmon at the Hood Canal substations, though egg collections fell below those of the preceding year because the run occurred at a time when floods prevented the successful operation of traps or seines, a condition that continued to prevail throughout the spring spawning season of the steelhead salmon.

QUINAULT (WASH.) SUBSTATION.

[PHILO B. HAWLEY, Foreman in Charge.]

The fish-cultural work at this substation during the year was less successful than usual, the aggregate output amounting to only 5,820,800 as compared with 15,908,600 in 1920. Eggs at this point are obtained from fish taken in traps or by other means in the tributaries of Quinault Lake, which, like most streams in a mountainous country, react quickly to climatic conditions, a heavy rain producing flood conditions almost immediately. The waters rapidly subside on the cessation of rain, while even a short period of dry weather causes low water stages at all points. Fishing operations are conducted in the streams at some distance from the hatchery, the eggs being transported by canoe. Every season there are times when the water stages in the upper Quinault and Big Creek, the principal spawning streams, are so low that it is difficult to operate a canoe, while at other times the water is so high that all traps are submerged to a depth of 1 to 5 feet.

As it is characteristic of salmon to ascend the streams in the greatest numbers during high-water stages, it is not surprising that the egg collections should be subject to material fluctuation from year to year. Thus, the number of eggs of any species taken is not necessarily a just criterion of the number of salmon available at spawning time. The remedy for this situation, from a fish-cultural standpoint, is the construction of a trap at the lake outlet similar to the one used at the Baker Lake station, whereby all the fish are taken as they enter and are held in an inclosure until they are ready to spawn.

The first sockeye-salmon eggs were taken November 3, and between that date and November 20 the entire egg collections for the season, amounting to 1,750,000, were obtained. From November 20 to the time that efforts at spawn taking were abandoned, on December 15, high-water stages precluded all possibility of seining or fishing by other methods. Local collections of this species were augmented by the receipt of 2,000,000 eggs from the Afognak station. The run of silver salmon appeared to be larger than usual, and during the spawning season of that species, which is coincident with that of the sockeye, 1,565,000 eggs were secured. A small number of chinook-salmon eggs was also taken. The run of chinooks, which was apparently not large, was earlier than usual.

The output consisted of 950,000 fry and 3,448,000 fingerlings of the sockeye salmon, including 1,500,000 fingerlings carried over from the preceding year, 1,398,000 silver salmon, and 24,800 chinook fingerlings, with 1,000,000 sockeyes remaining on hand at the close of the fiscal year.

From time to time there has been some criticism regarding the bureau's work at Quinault, particularly on the part of the Quinault Indians. The substation is located on the Quinault Indian Reservation, and salmon fishing is the principal means of support for the Indians. Following the passage of regulations that had the effect of restricting salmon fishing to some extent in the Quinault River, a petition was submitted to the Commissioner of Indian Affairs, expressing the belief of the petitioners that the work of the hatchery had been detrimental rather than beneficial to the fishery of the river. The statement appeared to be founded on prejudice rather than on fact. The results of artificial propagation at other points do not bear out the contention, and in Quinault waters the fish taken for artificial propagation represent but a small part of the fish reaching the spawning grounds, probably not more than 10 per cent in any season. Furthermore, for several years considerable numbers of sockeye-salmon eggs transferred from the Alaska stations have been incubated in the Quinault hatchery and the resulting fingerlings planted in Quinault Lake or its tributaries.

Notwithstanding these facts, it was decided to try an experiment, which it was hoped would furnish reasonably reliable data on the results of artificial propagation as compared with natural reproduction. The plan suggesting itself was to take an accurate census of the sockeye salmon entering Quinault River and Quinault Lake for a period of years and by checking the returns from each year involved to secure at the proper time the desired figures for comparison. During the first two years of this period no artificial propagation of the sockeye salmon was to be conducted, and all fish of that species entering the lake were to be permitted to seek their natural spawning grounds for natural reproduction, this period to be followed by two years of artificial propagation.

Conditions in Quinault Lake and Quinault River are particularly favorable for the conduct of an experiment of this character. A fairly accurate record of the number of fish taken by the Indians as a commercial venture each season is available, and it remained only to obtain a count of the fish escaping the fishing operations in the river as they entered the lake on their way to the spawning grounds. To accomplish this a row of piling was driven across the outlet of the lake, approximately 700 feet at the site selected. Four-inch mesh cotton webbing was attached to the piling in such a manner as to prevent the fish from entering the lake except by way of a 16-foot entrance provided in the weir at the point of deepest water. This entrance was so arranged that the fish were forced to pass near the surface of the water over a strip of white canvas, making them plainly visible to the attendant located in a small building on the piling above. Provison was also made for closing the entrance at times when the observer was not present. The first count was made on April 14, when three sockeyes passed over the counting entrance, and was continued to June 10. The results of the census are indicated in the following table:

Date.[1]	Number of fish.	Date.[1]	Number of fish.
April 14	3	May 16	118
15	1	17	405
16	16	18	30
17	1	19	19
18	3	20	255
19	3	21	11
20	23	22	788
21	0	23	103
22	9	24	65
23	2	25	171
24	23	26	129
26	3	27	228
27	2	28	902
28	1	29	299
29	44	30	606
May 1	4	31	610
2	51	June 1	649
5	96	2	1,685
6	1	3	563
7	20	4	208
8	151	5	13
9	18	6	853
10	11	7	186
11	246	8	826
12	421	9	164
13	230	10	90
14	82		
15	286	Total	11,788

[1] No count made on dates omitted.

The count was discontinued and the webbing removed from the piling on June 10 because of the increasing numbers of fish that "gilled" in the 4-inch mesh. This trouble was not anticipated, as the webbing was of the same quality and mesh as that used at the Baker Lake station for a long period of years with entire success, and the 4-inch mesh is in general use for fish traps on Puget Sound. An estimate of the fish entering the lake after the removal of the webbing placed the number at 8,000, or a total of approximately 20,000 for the season. Inasmuch as it was not possible to obtain a complete and accurate record, it was decided to postpone the experiment for another season and proceed with artificial propagation as usual. With slight changes the weir constructed for the purpose described will be of value in connection with fish-cultural work should it be found desirable to continue such work after the conclusion of the experiment. The number of sockeye salmon taken in the commercial fisheries conducted by the Indians in Quinault River during this period amounted to 28,608.

SULTAN (WASH.) SUBSTATION.

At the Sultan substation, on Elwell Creek, there was a falling off in the egg collections of all species as compared with those of the preceding year. This creek is a tributary of the Skykomish River, which joins the Snohomish River at tidewater, some 20 miles from its mouth. This 20-mile stretch of the Snohomish River is subjected to intensive gill-net fishing operations each year, and it is extremely doubtful if the fish which are able to escape the nets during the fishing season, together with those that are given free ascent of the stream during the closed season, are sufficient in number to maintain the run in the watershed.

CLACKAMAS (OREG.) STATION AND SUBSTATIONS.

[H. C. MITCHELL, Superintendent.]

Under this heading are included the four Federal fish-cultural stations in the State of Oregon, two located on the Washington side of the Columbia River, with one egg-collecting station on the Washougal River, also in the State of Washington, and another on the Snake River, near Salmon, Idaho. The aggregate egg collections during the fiscal year 1921 were 42,912,320, and though the chinook salmon predominates in the work all species of the Pacific salmons excepting the sockeye and including the steelhead are represented. The shad is also propagated at Willamette Falls, Oreg., and the output is further augmented by the incubation of eggs of other species obtained by transfer from various points, and the distribution of the resulting fish in Oregon, Washington, and Idaho waters. The species thus transferred consist of brook trout, rainbow trout, blackspotted trout, and sockeye salmon.

In line with the very general belief, which appears to be well substantiated by reliable investigators, that much greater returns may be expected from the planting of larger-sized fingerling fish, particularly in the case of the chinook salmon, it has been the policy to develop facilities as rapidly as possible for this purpose. The stations in the Oregon field have an excellent record in this respect. During the fiscal years 1919–20 and 1920–21, an aggregate of approximately 83,500,000 fish from 2 to 3½ inches long have been planted in suitable waters of the State. These consist largely of the chinook salmon, though, as mentioned before, smaller numbers of brook, rainbow, and blackspotted trouts and steelhead salmon are included.

In contrast with the conditions that obtained during the previous spawning season of the salmon, when low-water stages at all points handicapped the work, floods prevailed in most of the streams during the season covered by this report. While it was not possible to state with accuracy to what extent the operations were curtailed by the floods, there is reason to believe that with more nearly normal weather conditions the aggregate collection of eggs would have exceeded that of any preceding year and that at some points the eggs available would have been in excess of hatchery capacity.

CLACKAMAS (OREG.) STATION.

Though the racks installed in the Clackamas River in connection with operations at Clackamas station were of unusually substantial construction and remained intact through two severe freshets they were carried away on October 3, and the egg-collecting season ended on that date. Though a very fair number of chinook and silver salmon had collected between the racks prior to their destruction, conditions in the river were such as to render the laying out and operation of a seine impossible. Consequently, the egg collections were reduced very considerably, totaling only 360,000 of the chinook salmon. Shad culture at Willamette Falls during July resulted in the collection of 2,119,000 eggs of that species. Transfers of eggs from other points were made as follows: 3,166,000 chinook salmon from Snake River (Idaho) station, 100,000 chinook salmon

from Little White Salmon (Wash.) station, 100,000 blackspotted trout from Montana Fish and Game Commission, 25,000 blackspotted trout from Yellowstone Park, and 197,000 brook trout and 96,000 rainbow trout from Springville (Utah) station.

UPPER CLACKAMAS (OREG.) SUBSTATION.

The spring run of chinook salmon in the Clackamas River was the largest for a number of years, and egg collections of that species at the Upper Clackamas substation exceeded the previous season's record collection by nearly 800,000. Racks were installed early in July and fishing operations continued until September 16, when high water permitted the escape of all remaining fish, probably two-thirds of all the fish intercepted by the racks getting away at this time. There has been a most decided improvement in the annual run of spring chinooks in this stream, and the station, though small, is of importance to the fisheries of the Clackamas River. Because of its exceptionally attractive and convenient location and its well-kept condition it is a point much favored by visitors. Unfortunately, the Clackamas River is difficult to protect against the poacher, and illegal fishing is prevalent.

LITTLE WHITE SALMON AND BIG WHITE SALMON (WASH.) SUBSTATIONS.

There was a lighter fall run of chinook salmon in the Columbia River in the fall of 1920 than has occurred for several previous years. To offset this there were not the intensive fishing operations witnessed throughout the period of the war, and the demand for chum and silver salmon was particularly light. As at all points in the Oregon field, the persistent high-water stages throughout the spawning period rendered the work of the spawn-taking crews difficult and hazardous, and at times the streams were quite beyond control. The run of chum salmon was of fair proportions, but it occurred at a time when it was possible to obtain only a limited number of eggs, and only a small proportion of the fish were obtained for propagation. During the run of silver salmon the floods were so severe as to make fishing impossible; therefore no eggs of this species were recorded.

The collections of fish eggs at the Little White Salmon substation for the year consisted of 16,950,000 chinook salmon (of which 2,000,000 were sent to the Big White Salmon substation and 1,100,000 to the Clackamas station) and 5,162,000 chum-salmon eggs. This substation also handled 30,000 sockeye-salmon eggs transferred from the Washington field. At the Big White Salmon substation 5,005,000 chinook-salmon eggs represent the total egg collections.

ROGUE RIVER (OREG.) SUBSTATION.

Operations at the Rogue River substation suffered less from the prevalent floods than at any other point in the field, and 4,438,000 chinook salmon, 506,000 silver salmon, and 121,500 steelhead salmon eggs were secured. There were on hand at the beginning of the year 49,500 blackspotted trout, 886,000 steelhead salmon, and 197,000 rainbow trout fry, all of which entered into the distribution from the station later in the year.

APPLEGATE (OREG.) SUBSTATION.

At the other substation in southern Oregon, on Applegate Creek, the rainfall was excessive, and while higher water stages are frequently witnessed in the stream than occurred at any time during the season of 1921 still the amount of water carried during the year was unusually large. Placer mining at points on the creek above the station has resulted in large deposits of gravel at the fish barrier which will necessitate some changes before the next spawning season. Egg collections were unusually light, as most of the spawning fish escaped over the racks. The results of the season's egg collections were 80,000 chinook salmon, 36,000 silver salmon, and 55,000 steelhead salmon.

WASHOUGAL RIVER (WASH.) SUBSTATION.

The substation on Washougal River was opened on April 15, and 359,000 eggs of the steelhead salmon were obtained. High water and the lumber work on the river were both sources of trouble and interfered with the egg-collecting work. From the collections shipments of eyed eggs were made to the New York Conservation Commission, to the Clarke County Game Commission at Vancouver, Wash., and to the Montana Fish and Game Commisison in exchange for blackspotted trout eggs.

Some unusual features have been observed in connection with the work at this point. Last season it was noted that the fish remained quietly in the pools below the dam, showing but little inclination to ascend the river. Furthermore, the eggs secured were of poor quality, only 29 per cent of them producing fry. It is doubted if eggs of first quality were obtained from any of the female fish handled. The cause of this unsatisfactory condition was not ascertained, but the theory was advanced that the newly erected dam which stops the fish many miles below their wonted spawning grounds was responsible. In view of the excellent quality of the steelhead eggs taken at other points under very similar conditions, this theory is not altogether tenable. During the season of 1921 the quality of the eggs obtained was much better, though a considerable number of fish were taken in which small undeveloped eggs were distinguishable. There was nothing in the appearance of the fish to lead one to suppose they would spawn during that season. It is a condition not previously observed at any point, and it is more or less perplexing. It may be analogous to recorded instances of Atlantic salmon seeking their spawning grounds in fresh-water streams a full year in advance of the time they were ready to perform the spawning function and remaining there until that purpose was accomplished.

SALMON (IDAHO) SUBSTATION.

The results of the season's work on the Snake River were very satisfactory. The racks were installed in Lemhi Creek before the end of the fiscal year 1920, and a good run of fish appeared early in July. Spawning began on August 14, and between that date and September 1, 6,000,000 eggs were secured, filling all available space in the eyeing station troughs. Immediately after this the racks were removed, and the fish remaining in the stream were permitted

to ascend to their natural spawning grounds. It is probable that the numbers of fish thus released for natural spawning exceeded those involved in the egg collections. This substation is located within 10 miles of the "top" of the Rocky Mountains, in the State of Idaho, and to reach this mountain stream for the accomplishment of their supreme mission in life the salmon travel approximately 1,500 miles without food after entering the Columbia River at Astoria, Oreg. The conditions which were observed here in regard to the splendid spring run of chinook salmon were not confined to the Snake River. Similar conditions were observed in all tributaries of the Columbia River frequented by the so-called spring-run fish.

Very excellent results in the rearing of young salmon have been obtained from the use of a comparatively new article of fish food. This is the immature spawn of the salmon taken by the commercial fishermen. The spawn is purchased at a comparatively low cost and held in cold storage until needed. In commenting on its value in his annual report for 1920 the superintendent of the station states:

> The salmon fry fed on salmon spawn and beef spleen produced remarkably fine fingerlings. It is by far the most satisfactory food that has ever been used in this field. No trouble was experienced with the fish at any point where its use was adopted. They were uniformly sturdy and readily accepted it throughout the year.

While the expense involved in feeding fish on an extensive scale is considerable, in view of the quite general belief that the future supply of salmon in the Columbia and other rivers of the State is dependent very largely on the numbers of fingerling fish released from the hatcheries, the work is considered of first importance. Because of the long period during which so little is known of the life of the salmon—from the time of the seaward migration as a fingerling or yearling until its return for the reproduction of its kind—it is difficult to effect any positive check on the actual results of hatchery work. Nevertheless, the evidence in favor of the work at certain points, notably in the Columbia, Clackamas, and Rogue Rivers, is of a convincing nature, and it appears to fully warrant the expense necessary to continue the feeding and intelligent planting of fingerlings. Upward of 68,000 pounds of fish food was used at the stations in the Oregon field during the fiscal year 1921. The details are given in the table of fish food on page 75.

BAIRD (CALIF.) STATION AND SUBSTATIONS.

[W. K. HANCOCK, Superintendent.]

In this field are to be recorded a number of untoward circumstances resulting in a serious curtailment of the fish-cultural work. From the fall run of fish the aggregate egg collections for the entire field amounted to 7,910,000, as compared with 11,785,000 the preceding year, which included 1,349,700 eggs of the spring run chinook salmon taken in the McCloud River at Baird.

Racks were again installed in the McCloud River in time to intercept the spring run of chinooks, but no fish appeared. This is directly attributable to the dam erected in the Sacramento River at Redding for irrigation purposes. This dam had the effect of diverting into the irrigation ditches most of the water in the river during periods of low-water stages, and though an opening was left in the

dam to permit the passage of fish it was never effective. The matter of providing a suitable fishway was taken up with the California Fish and Game Commission, and at the close of the year the case was pending in the courts.

There was a very large run of fall chinooks in the Sacramento River, and while the early fall was marked by low-water stages it was estimated on November 15 that there were enough fish impounded at the Battle Creek substation to yield not less than 15,000,000 eggs. At Mill Creek the run was even larger, and the egg collections for that substation were estimated at not less than 30,000,000. Beginning November 20 several days of heavy rains occurred, bringing about flood conditions of unusual severity. Many miles of territory, including railroads and highways, were under water. The retaining racks at all points were destroyed and spawning operations abruptly brought to a close.

At the Battle Creek substation 2,450,000 eggs were taken, of which 504,000 were transferred to Baird for incubation and 20,000 shipped to central station, Washington, D. C., for exhibition. The remainder were hatched successfully, and 1,781,000 fingerling fish were planted in Battle Creek. At the Mill Creek substation 5,460,000 eggs were secured, of which 1,000,000 were shipped to Baird and 3,000,000 to the State hatchery at Sisson. From the remainder 1,347,400 fingerling fish were produced at the station.

INVESTIGATIONS AND EXPERIMENTS.

FERTILIZATION OF SALMON EGGS IN NATURAL SPAWNING.

At many points on the Pacific coast certain species of salmon, notably the humpback and chum, spawn at or near the mouths of streams in tidewater. A rather general belief has existed that the results of such natural spawning were negative, and in order to obtain information on the subject the field superintendent in charge of the Pacific coast stations and the superintendent of the Baker Lake (Wash.) station were detailed to investigate these conditions in Puget Sound. The report of their findings follows:

In conformity with instructions relative to securing information on the percentage of fertilization of salmon eggs in natural spawning, with special reference to the eggs deposited in places over which the tide ebbs and flows, an investigation was made of Walcott Slough, at Brinnon, Wash., on March 5, 1920.

Walcott Slough runs through extensive tide flats, which at flood tide are completely covered with salt water. During ebb tide a good flow of fresh water, estimated at about 3,000 gallons per minute, passes through the slough, its source being spring seepage at the slough head. The fish—chum salmon with a few silver salmon—enter this slough to spawn, the entire slough bottom being composed of gravel suitable for the purpose. The bureau has a rack and trap installed at a favorable point in the slough, about 500 yards from salt water, where fish are captured for propagation. Below the rack some natural spawning occurs, and this occupied our attention. Several nests were investigated, all but two of which contained eggs. These two might possibly have been made last year, though they had the appearance of being used quite recently. Eight nests were examined, beginning with No. 1 (see table, p. 28) just below the trap, about 500 yards from salt water at low tide, and ending with No. 8, about 200 yards from the same water stage. During flood-tide periods salt water covered the nests from three to six and three-fourths hours to a depth of 1½ to 5½ feet. This will vary somewhat with higher or lower runs of tide.

The condition and character of the bottom wherever nests were found would indicate that the fish chose points where spring seepage occurs through

gravel from 1 to 4 inches in diameter. Here the eggs were buried from approximately 8 to 16 inches deep. When the eggs were reached, the gravel was found to be absolutely clean, more especially where the good eggs were secured, with a coating of fine sediment on top, indicating a circulation of fresh spring seepage water at all times. Anticipating this condition, a common trough was installed in the slough, with a circulation of fresh water assured at a low tide, but which at flood periods would be covered from 1½ to 4 feet with salt water without any circulation. The trough was filled with gravel, through which about 25,000 eggs were carefully mixed. A tight cover was then fastened on the top, with sufficient space left at both ends for proper circulation. The eggs were placed in the gravel on December 18, 1919, immediately after being fertilized, and on examination, on March 5, 1920, they were found to have hatched with an estimated loss of about 30 per cent. The fry appeared to be extremely active and healthy. The bad eggs were nearly all decayed and broken but had the appearance of having been fertilized and the embryo partially developed.

This would lead us to believe that an entire salt-water supply, with as low a density as 1.010 for an extended period, is injurious but not absolutely fatal, and it strengthened our belief that where fish spawn naturally within tidewater area the eggs are deposited where they receive a circulation of fresh water, as before stated. Samples of eggs were taken from each nest, and, contrary to Mr. Robertson's theory and observations in hatching eggs in gravel, the infertile eggs were chalky white when first observed in the gravel. The alternating salt and fresh water may be a contributing cause, though where a continuous circulation of fresh water seeps through the gravel it would appear difficult for salt water to penetrate sufficiently to have much influence on the eggs.

Our observations led us to believe that the infertile eggs might be accounted for largely by a scarcity of male salmon. However, there is a possibility that spawning might have occurred wholly in salt water, which may prevent the action of the eggs necessary to proper fecundation. As all but a few of the fish entering the slough were taken in the trap, and as the males are usually the first to ascend, it is not improbable that most of the males entered the trap, thus reducing the possibility of successful natural spawning at the points where observations were made. The table would indicate enormous losses through natural spawning, but as conditions were not absolutely normal, we would not care to be too emphatic from this meager survey.

To obtain full information relative to the foregoing it would be necessary to extend observations over the entire spawning season. Each nest should be marked and accurate data produced as to the number of fish depositing in each nest, together with all natural and unusual occurrences noted.

RESULTS OF EXAMINATIONS OF FISH NESTS, WALCOTT SLOUGH, BRINNON, WASH., MARCH 5, 1920.

Nests.	Distance from salt water at mean low tide.	Height of tide over nest at mean high water.		Water density, high tide.	Vertical rise of tide on reaching nest.		Length of time tide covers nest.	Estimated number of eggs per nest.	Condition of eggs.	Remarks.
	Yds.	*Ft.*	*In.*		*Ft.*	*In.*	*Hrs.*			
No. 0 box [1]	550	1	7	1.018	7	8	3	[2] 25,000	Hatched...	Estimate 70 per cent hatched.
No. 1 [1, 3]...	500	2	5	1.022	6	8	6	46	Good.....	41 good; 5 dead.
No. 2 [1, 3]...	450	2	1	1.022	7	0	4¾	100	Total loss.	Unfertile.
No. 3 [1, 3]...	450	2	1	1.022	7	0	4¾	151	Perfect....	1 dead, but all fertile.
No. 4 [4].....	420	3	1	.....	6	0	6¼	500	Total loss.	Unfertile.
No. 5 [4].....	410	3	1	.....	6	0	6¼	200	...do.....	Do.
No. 6 [4].....	300	4	7	.....	5	6	6¾	402	Very poor.	400 dead; 2 good (bad, unfertile).
No. 7 [4].....	250	4	7	.....	5	6	6¾	.....	.....	Nest looked good, but contained no eggs.
No. 8 [4].....	200	5	7	.....	3	6	8	.....	.....	Do.

[1] The salt water density was tested by pumping water from bottom over nests at flood tide and ranged from 1.018 at box location to 1.022 at nests Nos. 1, 2, and 3, and 1.025 natural sea water in Hood Canal.
[2] Planted.
[3] Nests 5 feet apart.
[4] Current swift and water badly discolored; numbers estimated from those seen in the water and caught in net and baskets set below the nests on the riffles when disturbing eggs; good eggs are not as buoyant as dead ones, and therefore some may have escaped our notice.

HATCHING EGGS IN GRAVEL.

At the Afognak (Alaska) station an experiment in hatching eggs in gravel after the so-called Robertson method was undertaken during the season of 1920. Eggs to the number of 5,500,000 were placed in two old hatching troughs, mixed thoroughly with gravel, and bedded in the bottom of the creek. The troughs were fitted with a cover and water was introduced through a 1-inch pipe leading from a small dam, so that there would be a gradual flow through each trough. The intake of this pipe was carefully protected by a screen.

On opening the troughs in the spring it was found that very few of the eggs had hatched. Though the winter was a mild one it is probable that the eggs had been frozen, as there had been a very light fall of snow, leaving the creek unprotected, and frost may have penetrated to a greater depth than in seasons of lower temperature. Eggs placed in gravel boxes patterned after the Robertson plan and held in the hatchery developed nicely, and the majority of the fry remained in the gravel until the yolk sac was absorbed.

SUGGESTIONS FOR POSSIBLE IMPROVEMENT AND ENLARGEMENT OF WORK.

Further extension of the feeding operations at all stations where chinook, sockeye, and silver salmons are handled is desirable. This would necessitate an increased allotment for the Pacific coast work, since at the present time there is not sufficient capacity or funds to feed all stock resulting from the eggs collected. In fact, it has been necessary to close certain substations and curtail expansion in all fields. The extension of operations in other fields is essential if the work is to be kept at its highest efficiency. The take of eggs at many of our stations has been reduced through extensive commercial fishing operations during the period of the war, when heavy demands were made for this class of food, and it will take many years to restore the streams to their former productiveness.

The small statutory salaries provided for the lower grades of the bureau's service and the consequent inability to maintain a trained and efficient personnel have been important factors in the declining output. Because of these conditions it has been necessary to employ and train new men at most points every season, and as competent men could not be secured or retained at the statutory wage provided station allotments have been drawn upon in many instances for the employment of temporary help at the prevailing high wages, thus greatly reducing the funds available for actual propagation work.

The returns from the marking of young salmon on the Columbia River and at other points have not been wholly satisfactory. One reason for the small returns from these experiments may be the fact that it has been the custom to hold the fish intended for marking for several months beyond the natural spring migration, and this may have had a serious effect on the life of the fish involved. The thought has occurred that better results might be secured if the fish used in the marking experiments are held over one year, or until the migration of the following spring. The results of the marking experiments also suggest the desirability of a more thorough study of the early life of the salmon, with the view of correcting any possible weaknesses in present methods of propagation and distribution. This is a phase of the work that is respectfully referred to the division of scientific inquiry.

One of the greatest needs in connection with Pacific salmon propagation is more adequate protection for the fisheries through the enactment and rigid enforcement of restrictive legislation. The regulations should provide (1) for the return to the waters uninjured of all immature fish that may be taken in nets or other fishing devices; (2) for a weekly closed season, thus assuring ascent to the natural spawning grounds of a certain proportion of the unripe fish; (3) for cessation of fishing operations after the canneries have put up a fixed number of cases, the limit of the pack to be determined by investigations in each locality, which must be such as will permit the escapement of a sufficient number of fish to insure continuation of the run in each locality; (4) for systematic destruction of Dolly Varden trout in salmon streams, these fish having been found to be among the greatest enemies of young salmon; (5) for setting aside natural lakes for use as salmon-rearing reservoirs; (6) for seeding of eyed salmon eggs in the more inaccessible lakes, in order that the young may pass the early stages of their existence in waters which are comparatively free from natural enemies. During periods of flood the fish in these lakes would pass from them over slight falls and through the intervening rapids, entailing little loss. In certain barren lakes the application of such a plan would necessitate the provision of a food supply. Work of this character has already been undertaken in a limited way in the vicinity of the Yes Bay (Alaska) station.

The tray system recently introduced in connection with the propagation of salmon at the western stations is proving a very important factor in the work. The eggs are carried in the regular baskets until within two or three weeks of the hatching period, when they are transferred to 14 by 16 inch trays, made of 1 by 1½ inch lumber and covered with wire cloth 14 to 16 meshes to the inch. From 3,500 to 4,000 sockeye-salmon eggs are placed on one of these trays. The trays are stacked from 6 to 8 deep in a trough compartment, thus increasing the holding capacity of a 16-foot trough from six to eight times and permitting the safe development of 300,000 to 400,000 fry in a space which was formerly required for 50,000. The fry are carried in dark, deep pockets, with the view of providing, so far as possible, the seclusion afforded in natural hatching, as it is believed they will develop under such conditions all the characteristics of gravel-hatched fry.

Another favorable feature is the more compact arrangement of the hatching apparatus, which permits of a much better control of the fry than under the basket and open-trough system. While it is entirely practicable to spread the green eggs on the trays directly and continue using them throughout the incubation period and up to the time the fry are ready to be fed, it has been found more satisfactory to carry the eggs in the baskets to the point of hatching and then transfer them to the trays, as such an arrangement permits of a thorough cleaning of all apparatus involved. Writing in regard to the use of this system, C. H. Van Atta, superintendent of the Yes Bay (Alaska) station, states:

Sixty thousand sockeye-salmon fry were placed on 12 trays, each 13½ by 25 inches in dimensions. The trays were stacked in one regular basket com-

partment of the hatching trough and held thus from March 12 until the yolk sac had been completely absorbed, on June 7. The total loss of fry during this period was 180.

Without the trays only about 50,000 salmon fry can be safely carried in a standard 16-foot hatching trough through the sac stage. It would therefore appear that by the use of this system the fry capacity of each trough is increased by approximately 200 per cent. J. R. Russell, superintendent of the Baker Lake station and its auxiliaries, in the State of Washington, writes:

> The stacked tray system for holding fry during the sac stage was tested this year for the first time, 1,000 of the trays being in use at the Baker Lake hatchery, with 11,000 fry to a tray and 4 trays in each basket compartment, making a total of 264,000 fry per trough. The system proved an entire success. The loss was small. The danger from smothering, which sometimes occurs when large numbers of fry are held on the trough bottoms, appeared to be entirely eliminated, and the "paddling" of the fry, which is essential in the trough, is rendered unnecessary.

From this statement the trough capacity appears to be even greater than was indicated by the experiment at the Yes Bay station. During a period of water scarcity at the Baird (Calif.) station the trays were successfully used to economize in space and water.

PROPAGATION OF FISHES OF THE GREAT LAKES.

The bureau's work in the propagation of the commercial species indigenous to the Great Lakes extends from the Rainy Lake region, in Minnesota, to Lake Champlain, in Vermont. Under existing conditions the work in this field fails of its fullest efficiency through a lack of adequate facilities. An example of this condition is suggested in the possibilities that exist in the propagation of pike perch. In the Rainy Lake field, where pike-perch propagation has been tried in a tentative way, arrangements may be concluded with the Minnesota Fish and Game Commission for the establishment of a small inexpensive hatchery, to be operated jointly by the bureau and the State as an adjunct of the Mississippi Valley work.

Another important pike-perch field awaiting development is in Saginaw Bay, Mich., this region offering greater returns for a given expenditure of funds than any other of which the bureau has knowledge. With an inexpensive but well-equipped hatchery, located in the lower section of the bay, the bureau would be in a position to save the immense numbers of eggs—estimated to be over a billion a year—which are now being sent to market in the fish and lost.

At the pike-perch substation located near the head of Lake Champlain, at Swanton, Vt., large numbers of pike-perch eggs are lost every spring because of inadequate facilities. Before any appreciable improvement can be expected at this station it will be necessary to provide an efficient penning system, so that the large numbers of partially ripe fish taken by commercial fishermen may be held under favorable conditions awaiting the full development of their eggs.

So far as the propagation of whitefish, lake trout, and cisco (lake herring) is concerned, there has been no notable change in recent years either in methods pursued or the fields occupied. Probably the greatest improvement in this branch of the work, both as regards

equipment and extent of territory covered, has been in connection with the operations at the Cape Vincent (N. Y.) station. Within the past year the capacity of the hatchery at that point has been increased approximately 150 per cent without increasing the floor space, this being made possible by the construction of a new and compact type of battery for the glass jars used in the incubation of these eggs. A cut of the battery showing the placing of jars and other details is shown herewith in Figure 1. The scope of the station's field operations has been materially enlarged through close cooperation with the New York Conservation Commission and the Dominion and Provincial fisheries authorities of Canada. At the present time the most prolific field occupied is in the vicinity of the Bay of Quinte, on the Canadian side of Lake Ontario.

The great need in all branches of fish conservation is effective, stringently enforced protective legislation. Simple, easily understood, and easily remembered fishery laws are always desirable, but in the Great Lakes regions the fault probably lies not so much in the character or wording of present laws as in the lax enforcement of legislation now on the statute books. A close season, varying in length to meet local conditions, should be established for all species in the Great Lakes region, and no commercial fishing should be permitted until 40 per cent of the fish on the fishing grounds are in spawning condition, this fact to be determined by the use of set nets operated under supervision. The State laws should provide that commercial fishermen operating during the spawning period be required to turn over free of charge to designated agents of the bureau or the State the ripe eggs of all fish taken. In the framing of the laws more stress should be laid upon the legal size of fish than upon the size of the mesh of seines or nets, and a moderate percentage of small fish should be allowed. In connection with this feature of the work the importance of uniform laws governing all persons alike in a given locality is not to be overlooked. In order to bring about the greatest good, such laws must in their application be not only interstate but international.

The aggregate output of this group of stations, including the hatchery on Lake Champlain, where pike perch and yellow perch are propagated, amounted in round numbers to approximately 1,158,000,000 eggs, fry, and fingerlings, as against 886,000,000 in the preceding year. The increase may be attributed largely to more favorable weather conditions prevailing throughout the spawning seasons of the species handled. By way of contrast in climatic conditions as they affect fish culture, the work in the Great Lakes region during the spawning season of 1920 suffered generally from severe cold and violent storms. During the spawning season of 1921, while stormy weather was encountered at certain points, the work was interfered with principally by unseasonably warm weather, resulting in water temperatures too high for the best results in artificial incubation.

This branch of fish culture has for many years received the heartiest support of the interests most directly benefited by the work, and that these interests still have faith in the efficacy of artificial propagation is evidenced by the many letters received from them, commending the work and urging its extension. While the figures given for the output of the Great Lakes represent largely such commercial

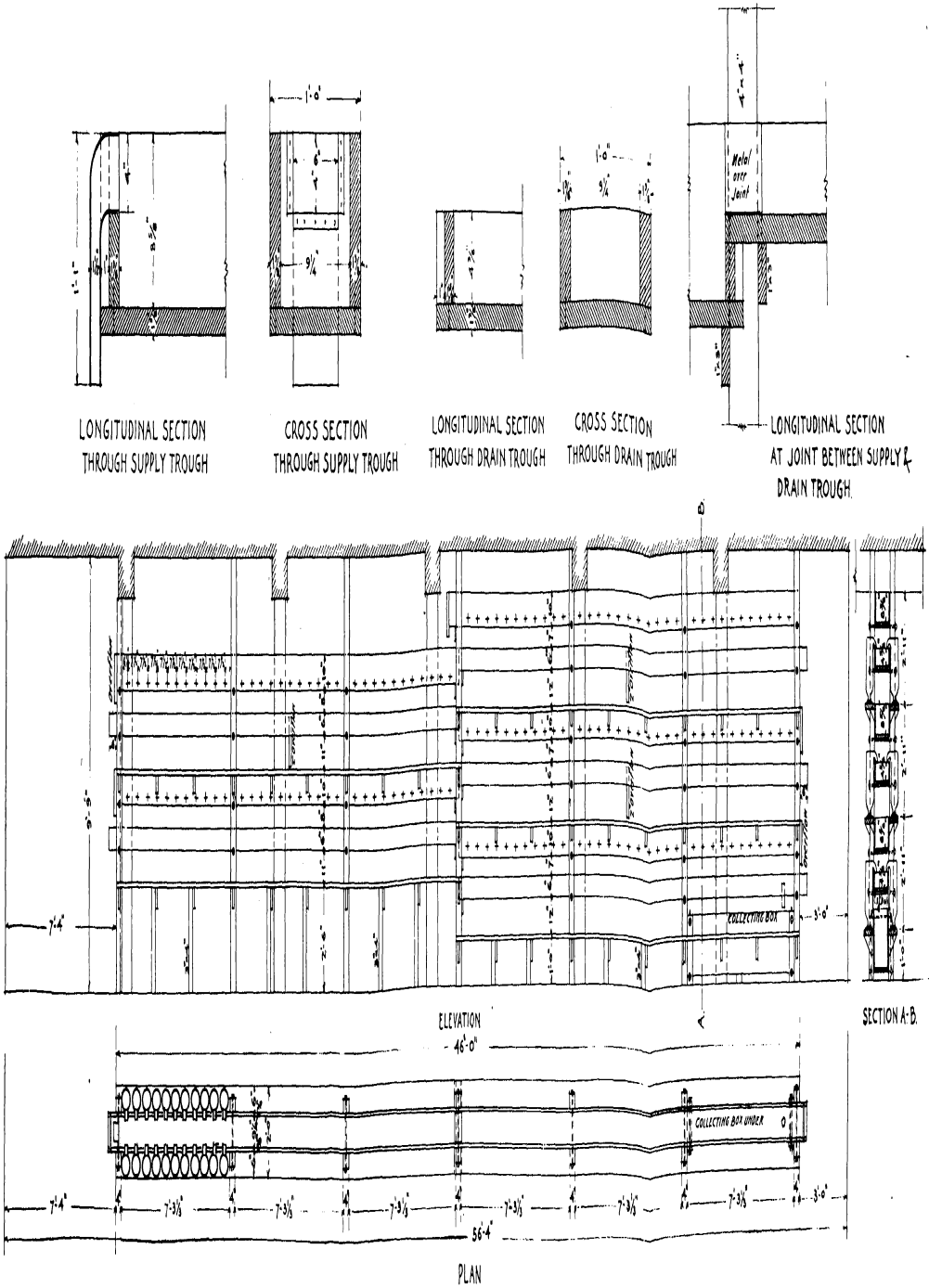


FIG. 1.—Plan of hatching battery in use at the Cape Vincent (N. Y.) station for the incubation of whitefish and cisco eggs. (Designed by J. P. Snyder.)

[OVER---- (Page p. 32.)

species as the whitefish, lake trout, cisco, pike perch, and yellow perch, they also include brook trout, rainbow trout, and smallmouth black bass, which species are produced in limited numbers at several of these stations.

DULUTH (MINN.) STATION.

[S. P. WIRES, Superintendent.]

The spawning season of the lake trout in Lake Superior fields, on which the Duluth hatchery depends for its stock of eggs, began about four days later than usual at nearly all points, the bulk of the eggs being taken between October 17 and November 1, though in the vicinity of Isle Royale, Mich., small lots were secured at intervals from the last week in September to about the middle of November. The run of fish was irregular and the egg collections light, the total aggregating only 12,726,500, or little more than half the take of an average season. On account of unseasonable weather and water conditions, poor transportation facilities, and a lack of ice at some of the more isolated fisheries, the quality of the eggs obtained was so impaired as to cut down the output of lake trout from this station to a total of 6,379,500, of which 175,000 were eyed eggs, shipped on assignment to other hatcheries, 6,057,000 fry, and 147,500 fingerling fish.

In the course of the lake-trout spawning season 940,000 whitefish eggs were collected in the Isle Royale field, and on January 6 this number was augmented by the receipt of 10,000,000 eyed eggs of very good quality from the Put in Bay (Ohio) hatchery. The combined stock yielded an output of 9,600,000 fry, all of which were planted in good condition, in various parts of Lake Superior. The station also distributed the product of 150,000 brook-trout eggs received from a commercial hatchery in New England and two consignments of rainbow-trout eggs, aggregating in the neighborhood of 100,000, the latter being transferred to the station from western hatcheries of the bureau.

In cooperation with the Minnesota fisheries authorities the force of the Duluth station established and operated two field stations for the collection of pike-perch eggs during the spring—one on the Rat Root River and the other on Boy River, a tributary of Leech Lake. The bureau's share in the proceeds of these operations amounted to 13,680,000 eggs. At Boy River the work was not altogether successful, as more than 98 per cent of the fish taken had deposited their eggs previous to capture. This may have been due to the unusually low water stages that obtained in the early part of the season, the fish not being attracted to the streams and spawning in the shallow waters of Leech Lake.

NORTHVILLE (MICH.) STATION AND SUBSTATIONS.

[W. W. THAYER, Superintendent.]

There was a further decrease in the number of whitefish and lake-trout eggs secured from Lakes Michigan and Huron, two causes for which are assigned—the State laws and inexperienced and unreliable spawn-takers. Under the present laws fishermen are permitted to use an unlimited number of nets during the fishing season and are not required to make any provision for the salvage of ripe eggs taken.

The effect of this is that so many nets are operated by the fishermen that they are not able to lift them at proper intervals, and the fish taken are either dead or the quality of their eggs impaired. During the spawning season in the fiscal year 1921 there was a good catch of fish and weather conditions were generally favorable, but for the reasons stated the egg collections were unsatisfactory, both as to quantity and quality. This applies to both the lake trout and the whitefish. The egg collections amounted to 30,876,000 of the lake trout and 12,080,000 of the whitefish, and all of them were incubated at the Charlevoix hatchery. The loss on the former amounted to 59 per cent and on the latter to 51 per cent. The output of the station was augmented by the transfer of 59,120,000 whitefish eggs from the Put in Bay station and 25,000 steelhead eggs from the Birdsview (Wash.) field, the fry from both lots entering into the general distribution.

The pike-perch work on Saginaw Bay was fairly successful, but it does not represent by any means the potential value of this region as an egg-collecting field. The spawning season extended from March 26 to April 16, during which period 284,290,000 eggs were taken. Of this number 54,050,000 were deposited on the spawning grounds after being fertilized and 223,200,000 were sent to the Detroit hatchery of the Michigan Fish Commission for incubation. The importance of the work in this field has been mentioned on several occasions and funds should be forthcoming to place hatchery facilities in this field for the full development of the work.

From the Northville station there were distributed 475,000 brook-trout fry and fingerlings, resulting from eggs purchased of commercial fish-culturists, and 90,500 rainbow trout were produced from eggs transferred from the West Virginia and Missouri stations of the bureau. Approximately 31,200 smallmouth black bass reared from the Northville station brood stock were also distributed, and at the close of the year there remained in the station ponds about 75,000 bass and 2,000 rainbow-trout fry.

PUT IN BAY (OHIO) STATION.

[S. W. DOWNING, Superintendent.]

Owing to quite generally favorable weather conditions in Lake Erie and to the close cooperation of the commercial fishermen, the whitefish work of the Put in Bay station resulted very satisfactorily, though the spawning season was unusually late. Between November 20 and December 12 eggs to the number of 376,500,000 were collected from fishermen operating in the various fields and placed in the Put in Bay hatchery. Of these, 141,060,000 were secured in the vicinity of Port Clinton, Ohio; 93,840,000 at Isle St. George; and smaller numbers from the fisheries around Toledo, Middle Bass Island, and Catawba Island. In the former prolific whitefish field near Monroe Piers, Mich., no eggs whatever were obtained, as fishing operations were brought to a close very early in the spawning season by a heavy and protracted wind and rain storm which came on just as preparations had been completed for the penning of the partially ripe fish. Shipments of green and eyed eggs aggregating 139,870,000 were forwarded to various State and Federal hatcheries and 7,000,000 fer-

tilized eggs were deposited on the reefs where taken. The remaining stock produced 167,500,000 fry, which were liberated on the spawning grounds in the lake, care being taken to scatter them over as wide an area as possible. The incubation period was shortened by the unusually mild winter, averaging only 119 days, in a mean temperature of 38¾° F.

The high-water temperatures prevailing during most of the winter brought on a run of pike perch in March, and some of the commercial fishermen reaped very good returns during the latter part of that month. No spawning fish were in evidence in March, however, and the run throughout the entire season was characterized by the very small number of spawners included in it. Egg-collecting operations extended from April 5 to April 24, but the number of eggs taken was proportionately small. Despite the fact that the fishermen were willing and anxious to act on any suggestion with a view to obtaining good eggs, the quality of the eggs was uniformly poor, being about the poorest, in fact, ever noted in eggs handled at the station. The total of 111,600,000 laid down in the hatchery yielded only 12,600,000 fry. These were strong and active, however, and the entire output was liberated in good condition on the spawning grounds in the lake.

Soon after the middle of May the carp propagation work, inaugurated two seasons ago in connection with the Port Clinton fisheries, was taken up, a small hatching battery for the purpose being set up in one of the fish houses at that point. During the egg-collecting period, extending from May 23 to June 11, spawn takers made daily visits to the fishing grounds to take eggs from the ripe fish landed in the seines, liberating at the same time the fry hatched from earlier lots. The catch of carp was below that of a normal season, but the egg collections were considerably larger than in either of the two previous seasons, the total amounting to 74,325,000. From this stock 63,325,000 fry were hatched and planted on the spawning grounds in the Portage River, between Port Clinton and Oak Harbor.

During the fall, arrangements were made with local fishermen on Lake Erie to save all smallmouth black bass taken in their seines and hold them in live boxes until a sufficient number could be secured to warrant a shipment. By this means 805 adult fish of that species were collected during October and forwarded to various pond fish-cultural stations of the bureau to serve as a brood stock.

CAPE VINCENT (N. Y.) STATION.

[J. P. SNYDER, Superintendent.]

During the first half of November lake-trout eggs to the number of 549,000 were taken at points on Stony Island, N. Y., and Pigeon Island, on the Canadian side of Lake Ontario. As is usual at that time of the year, stormy weather was encountered and all of the eggs were obtained during but four days of weather suitable for fishing. Thirty-nine thousand eggs were shipped to applicants, and of the 450,000 fry hatched from the remainder 80,000 were furnished for stocking interior waters in the State of New York and 370,000 were returned to Lake Ontario waters. Collections of whitefish eggs from Lake Ontario amounted to 150,200,000.

The collecting operations for both lake trout and whitefish were conducted in American and Canadian waters under the same cooperative agreement that was effective last season. In Canadian waters the work was handicapped by lack of a suitable boat, making it necessary to plant on the spawning grounds immediately after fertilization 29,650,000 of the eggs taken at Deseronto and Big Island. Canadian hatcheries received 30,000,000 of the eggs obtained, in accordance with the terms of the agreement; 29,300,000 were turned over to hatcheries of the New York Conservation Commission and 1,000,000 were diverted to the Washington exhibit. The remainder were incubated at the Cape Vincent station and the resulting fry planted in Lake Ontario waters. Egg collections of cisco (lake herring) from Ontario waters totaled 317,200,000, of which 73,200,000 were obtained in Canadian waters at Deseronto and Bygotts Point. The fisheries authorities of Pennsylvania and New York received 104,410,000 and 65,000,000, respectively; 17,100,000 fertilized eggs were planted on the spawning grounds, and the fry hatched from the remainder were returned to Lake Ontario waters.

During the spring a small number of brood yellow perch were obtained from trap nets set in the St. Lawrence River, and from the 15,000,000 eggs thus secured 11,000,000 fry were hatched and returned to the St. Lawrence River. A consignment of 8,000,000 eyed pike-perch eggs received from the Lake Champlain hatchery yielded for distribution 7,970,000 fry of excellent quality, an usually high percentage. In addition to the commercial species enumerated 150,000 rainbow-trout eggs from the bureau's Virginia station and approximately 450,000 brook-trout eggs from commercial dealers were incubated and the fry distributed to applicants in New York State.

A boat suited to the needs of the station was obtained by transfer from the Navy, but because of the time consumed in making needed repairs to motors was not available for service during the past season. When fully equipped, this boat will add much to the productivity of the station, being particularly valuable in connection with the whitefish and cisco work in Canadian waters.

SWANTON (VT.) SUBSTATION.

[A. H. DINSMORE, Superintendent.]

The work at this point is conducted cooperatively with the State of Vermont. During the operating season of 1921, extending from March 2 to May 10, pike-perch eggs to the number of 112,312,500, also 43,950,000 yellow-perch eggs, were secured for incubation. The winter being unusually mild, the Missisquoi River was open at an early date. Nets were set during the first part of March and hauled at frequent intervals at the various points to anticipate the presence of fish. The first pike perch were taken at Sandy Point March 25 and at Campbell's on April 4. Three trap nets were in operation at the mouth of the river, but the results from their use would not appear to warrant their continuance. All fish taken were immediately transferred to the inclosure for ripening, but because of low water stages, resulting in an improper circulation of water through the inclosure, the mortality was high, and all brood fish on hand were released on

April 20. A cold spell in April, following the warm weather of March, caused a protracted incubation period for the pike-perch eggs. In this connection it is interesting to note that while the egg collections were made during the period from April 6 to 20 there was very little difference in the dates on which any lot of eggs reached the eyed stage or completed incubation. The eggs were of extremely poor quality, the loss during incubation being in excess of 77 per cent.

Collections of yellow-perch eggs were in progress from April 21 to April 23. Of the 43,950,000 taken 12,000,000 were delivered to the State hatchery at Burlington, Vt. The remainder were incubated with but slight loss. Upward of 33,000,000 of the pike-perch eggs were shipped to applicants, 14,700,000 going to hatcheries in the State of Vermont.

PROPAGATION OF YELLOW PERCH, BRYANS POINT (MD.) STATION.

[L. G. HARRON, Superintendent.]

Fish-cultural operations were undertaken at this point on March 1, the work being addressed to the propagation of the yellow perch. Between the 3d and the 10th of March 18,226 brood fish were taken. Spawning occurred between the 10th and the 23d of March, resulting in a total collection of 172,630,000 eggs of excellent quality. Of these 2,600,000 were shipped to Washington, where they served as an exhibit during incubation, the fry being used to supply applicants in Virginia. The remaining eggs were incubated in the hatchery, producing 158,819,450 fry, which were planted on the spawning grounds.

MARINE FISH CULTURE.

The season's work in this field may be considered satisfactory, the output of eggs and fry comparing favorably with that of the year previous. While there was a falling off of nearly 50 per cent in the output of cod as compared with last year, this is compensated for by satisfactory increases in the production of other species, notably the haddock. The work during the past season was extended to include the pole flounder (*Glyptocephalus cynoglossus*), a species not previously propagated. This fish, locally known as the "gray sole," has only recently been introduced in the markets of New England. Its existence in these waters has long been known, but previous to the use of the otter trawl in the shore fisheries it was not generally known to fishermen. Because of its small, weak mouth it was not taken on the trawl lines. It has since proved to be a popular fish, commands a high price in the markets, and a fishery of importance is being built up in connection with it.

Inadequate funds have prevented the development of possibilities for valuable work in the conservation of the large number of eggs of the marine fishes that are annually lost in connection with commercial fishing. Such work has now been undertaken on a limited scale by placing spawn takers on the fishing vessels operating in the offshore fisheries, to strip the mature eggs from the fish taken, fertilize, and return them immediately to the water. The work is considered of special value, since it deals with the conservation of vast quantities of eggs of the cod and haddock which have heretofore been annually destroyed.

BOOTHBAY HARBOR (ME.) STATION.

[E. E. HAHN, Superintendent.]

Fish-cultural work at this station during the year was addressed to the winter flounder and the pollock and resulted in an output of 841,235,000 and 11,906,000 of the respective species. The pollock fry were produced from eggs collected in the Gloucester fields and represent the first really successful attempt to make long-distance shipments of pollock eggs. Collection of flatfish eggs was commenced February 23 and continued to April 22. A total of 6,298 female brood fish were handled during the season and yielded 906,696,000 eggs. Though weather conditions favored the work, the spawning season ended earlier than usual, and because of this circumstance the take of brood fish was smaller than had been anticipated. On the other hand, the female fish taken were above the average in size and yielded a correspondingly large number of eggs. Some experiments in the rearing of the fry were conducted but without marked results.

A careful watch of the local fishing grounds where a limited number of boats engage in a spring fishery for cod and haddock was maintained with the view of obtaining eggs. The results were negative, however, as has been the case for several seasons, no fish in spawning condition being taken. Similar results followed a continuation of an effort to locate spawning areas of the alewife in the Damariscotta River and other points in the vicinity of Boothbay Harbor.

The steamer *Gannet* has been connected with the work of this station and has rendered valuable assistance in fish-cultural operations, particularly in the flatfish work, also in transporting men and supplies in connection with the repairs that have been made to the lobster pound at Pemaquid, Me.

GLOUCESTER (MASS.) STATION.

[C. G. CORLISS, Superintendent.]

In this field the output of pollock fry has for a number of years been larger than that of any other species propagated. With the general adoption of the gill net for taking pollock in the shore fishery and the prevailing high prices, this fish, which was formerly of minor importance, has come into high favor. During the calendar year 1920 more than 4,000,000 pounds of pollock, valued at $118,502, were landed fresh at Gloucester, Mass., approximately 3,745,000 pounds of this amount having been taken in the shore fishery. In 1921, the pollock spawning season extended from November 15 to January 21, and the egg collections aggregated 650,850,000 as compared to 954,800,000 the preceding year. In the course of the fishing season there was a rather sharp decline in the market price of pollock, which resulted in the withdrawal of many boats from this line of work. The weather throughout the spawning period was exceptionally good, and to this fact the higher quality of the eggs obtained is attributed. Twenty-four million of the eggs were transferred to the Boothbay Harbor (Me.) station, and the remainder produced 443,160,000 fry, which were distributed on the pollock spawning grounds.

A rather unusual occurrence connected with the pollock work is the fact that the fish apparently sought new spawning grounds during the season. Heretofore practically all of the spawning fish have been taken in Massachusetts Bay, and all fish taken from spawning grounds to the eastward of Cape Ann have been barren of eggs. This year, however, large numbers of eggs were obtained from fish caught on the grounds lying from 20 to 30 miles eastward of Cape Ann.

The season's collection of cod eggs fell considerably below last year's established record collection of 570,704,000. Two reasons are ascribed for the falling off, (1) the comparatively small run of fish on the shore spawning grounds, and (2) the low market price for cod. Eggs were taken between January 15 and April 29, the total amounting to 210,040,000. Of these 151,530,000 were planted on the spawning grounds immediately after being fertilized, this method being resorted to at times during the spring months, when the low density of the sea water does not permit of making transfers to the hatchery. In addition to the local collections cod eggs to the number of 8,700,000 were transferred to Gloucester from the Woods Hole hatchery. The fry distribution from the station amounted to 50,900,000.

Propagation of the haddock at the Gloucester station was eminently successful and is represented by a record collection of eggs of that species. The causes contributing to this result were favorable weather, an abundance of fish on the spawning grounds throughout the season, and the comparatively high market price for haddock. The price was an important factor in attracting to this fishery a large number of fishermen who ordinarily follow the cod or other lines of fishing. The spawning period extended from January 22 to April 25, and 629,120,000 eggs were taken. Of these, 182,120,000 were deposited on the spawning grounds for the reason stated above.

Since the mild winter suggested the probability of an early spawning season for flatfish, nets were set as early as February 2 for the capture of a brood stock, but no fish were secured until March 14. During the first week of the season the take of adult fish was unusually large, giving promise of a fine egg collection. With the beginning of active commercial fishing, however, the collection of fish for propagation work fell off rapidly, and the season's operations resulted in obtaining only 154,740,000 eggs. From this stock 132,070,000 fry were hatched and distributed.

Because of the prominence the pole flounder has attained in the New England markets in recent years and the constantly increasing number of fishermen engaged in its capture, an investigation of the spawning habits of the fish was made with the view of undertaking its artificial propagation in the event that course seemed advisable. At the present time commercial fishing for the pole flounder begins in midwinter some 15 miles off Cape Ann. The fish appear to work slowly inshore, and by July fishing for them is in progress in the shoal waters of Ipswich Bay. The average daily catch per boat is from 8,000 to 12,000 pounds.

Large numbers of the fish were examined in April, but no ripe spawn was found until May 22. From that date until June 30, when the work was brought to a close, 19,410,000 eggs were taken,

fertilized, and planted on the spawning grounds. The eggs of the pole flounder are about one-twentieth of an inch in diameter, a liquid quart containing approximately 426,000. They are semi-buoyant and nonadhesive. It is probable that spawning continues throughout the summer months. It would appear that the species is worth the attention of fish culture, and that considerable numbers of eggs for artificial propagation are obtainable in the commercial fishery at comparatively small expense.

WOODS HOLE (MASS.) STATION.

[W. H. THOMAS, Superintendent.]

At the approach of the cod spawning season at this station negotiations were entered into with fishermen operating vessels equipped for carrying live fish to supply brood cod for the propagation work, but as only one suitable vessel was available the number of fish secured was smaller than was desirable. The first consignment of 485 fish was delivered on November 15. Five further consignments delivered between that date and December 6 brought the total brood stock up to 2,441 fish, all of which were placed in the spawning cistern. Stormy weather prevented any further deliveries. The fish were an exceptionally fine lot, a large percentage being females. For several seasons heretofore cod propagation at the Woods Hole station has been reduced to almost negligible proportions because of the very large percentage of barren fish among the brood stock. It is impossible to assign an entirely satisfactory reason for this condition, but it may have been due partly to the undersize of the fish and also to the fact that they were taken in places not usually frequented by spawning fish. The fish secured this season were of good size and were taken on fishing grounds located some distance offshore. The egg returns from them were very satisfactory, the total amounting to 214,702,000. Of this stock, 8,700,000 green eggs were transferred to the Gloucester station and 124,441,000 fry were hatched.

On account of more favorable weather conditions the results of the season's flatfish work were larger than those of the previous year, though the egg collections were not equal to that of the record year of 1918. Operations in local fields began on January 12 and resulted in a collection of 803,567,000 eggs. A very satisfactory increase in the number of fish obtained at Quisset Harbor is to be recorded. The collecting station at Wickford was opened March 18 and was in operation until March 28, when high-water temperatures made it impracticable to continue the work. The egg collections at this point amounted to 112,228,000, or less than half of last year's. From the total of 915,855,000 eggs obtained from all points fry to the number of 795,355,000 were hatched and deposited in local waters.

During March, 1920, the three-story frame building connected with the Woods Hole station, the first floor of which was occupied as a machine shop while the two upper stories furnished storage space for fish-cultural and scientific equipment, was destroyed by fire. A special appropriation of $65,000 for rebuilding and replacing equipment was provided by Congress, becoming available June 5, 1920.

Advantage was taken of this opportunity in reconstruction to make certain changes in building and equipment that will add much to the

convenience and efficiency of the operations and also effect an economy. The new building, of fireproof construction, provides for a machine shop, boiler and pump room, garage, and ample storage space. The old boiler and pump room, of frame construction, constituting a further fire menace, has been removed. The new boiler space is adjacent to and connected with the coal shed by a covered passage, thus eliminating a long and expensive haul of coal from the storage to the boiler.

Another important change was the construction of a sand filter, with a capacity of 300 gallons of water per minute. The arrangements are such that the water from the cod-spawning cistern enters the filter by gravity. From the filter it is returned to the storage tanks by the pumps. "Make-up" water will be added each day in sufficient quantities to keep the supply in good condition. This will add to the efficiency of the fish-cultural work by eliminating from the hatchery the sediment that is carried in the water taken direct from the harbor and which has been particularly detrimental to the eggs under incubation during periods when the harbor water is agitated by high winds. The arrangement will be further effective in a saving of fuel, since it is found expedient to raise the temperature of the hatchery water supply from 8 to 10 degrees during the winter months. The new system will permit of the water that has been warmed being kept in circulation throughout the entire system. Modern heating apparatus, with automatic thermo controls and an electrically operated pump, for use during the summer when but comparatively small quantities of water are used, will effect a further saving in fuel consumption.

PROPAGATION OF BUFFALOFISH, ATCHAFALAYA (LA.) SUBSTATION.

[C. F. CULLER, in Charge.]

The propagation of buffalofish in the Atchafalaya River district of Louisiana is meeting with success, dependent to a large extent on the regulations recently established by the Louisiana Conservation Commission. Under existing arrangements no fisherman is allowed to operate nets during the spawning season without first securing from the State authorities a permit, which is revocable in the event that the eggs of all ripe fish taken are not delivered without charge to collecting agents of the bureau. It is considered that permission to fish during the closed season, with the right to retain the fish captured after stripping, is sufficient compensation for the eggs turned over to the bureau.

This work was inaugurated in the spring of 1918 to meet the large and increasing market demands for buffalofish, and while the water stages in the river during the spawning season are not uniformly favorable the experience gained has demonstrated that, with the local cooperative assistance at present afforded, there is no reason why hatching operations should not be continued on an extensive and profitable basis. Thus far the fishermen have willingly complied with the terms of the regulations, and the cooperation rendered by them has contributed largely to the success of the work.

In the season of 1921 the substation was opened on January 23 and, in order to free the hatchery water supply of the large amount of sediment contained in it, a filter was installed in the water-supply

line. No sand being available for the purpose, cinders were substituted, and to the presence of this material is attributed the loss of approximately 46,000,000 of the first eggs received. The removal of the cinders and the refilling of the filter with sand and gravel corrected the situation, though the output of the substation was considerably reduced.

The first eggs were taken on February 27, and during the spawning season, which ended on March 25, a total of 96,440,000 eggs were taken. Of these, 1,440,000 were planted on the spawning grounds after being fertilized and 38,600,000 fry were developed at the hatchery. The conditions were unusual, inasmuch as the Atchafalaya River was at a low stage until late in January, whereas a rise occurs in the late fall in more normal years, its effects continuing into the spring months. To this condition may be attributed the short season and the small numbers of fish on the customary spawning grounds. The water temperatures during the egg-collecting period ranged from 60 to 76° F. The incubation period was 10 days in a mean water temperature of 60°. The eye spots in the egg are visible to the unaided eye in from four to five days, and the fry have absorbed the umbilical sac in from four to five days after hatching.

Further counts and measurements to ascertain the correct number of eggs to a liquid quart were made and a standard of 120,000 was established as a result. Observations were made at several points to determine the percentage of fertilization that is attained in eggs deposited under natural conditions. The results varied from zero in certain places to as high as 40 per cent at others, with an average of 10 per cent at all points considered. Efforts were also made to secure information relative to the spawning of the paddlefish, but nothing of a reliable nature was gained.

Buffalofish propagation conducted on an experimental scale at Clarendon, Ark., has been permanently discontinued, it having been found that very few of the local fishermen are inclined to lend their cooperation.

PROPAGATION OF ANADROMOUS FISHES OF ATLANTIC COASTAL STREAMS.

Included under this head are the shad, glut herring, alewife, striped bass or rockfish, and the Atlantic salmon.

PROPAGATION OF SHAD, BRYANS POINT (MD.) AND EDENTON (N. C.) STATIONS.

The work addressed to the shad is conducted at only two hatcheries, Bryans Point, on the Potomac River in Maryland, and Edenton, on Albemarle Sound in North Carolina. It is interesting to note that the run of shad is being maintained in these regions, notwithstanding the failure to put into effect the greatly needed regulatory measures for which the bureau has worked. During the 12-year period from 1910 to 1921, both fiscal years inclusive, the Maryland hatchery distributed a total of 448,799,000 shad fry, an average annual output of 37,399,000. The total output of shad from the North Carolina hatchery during the same period amounted to

409,683,000, or an average annual ouput of 34,140,250. Practically all of these fry in each instance were distributed on local spawning grounds. In view of the conditions that exist in other shad streams where artificial propagation is not conducted, it seems but just to assume that the hatcheries have been a factor in maintaining the shad fisheries in their vicinity.

The bureau is frequently importuned by State officials and others to render assistance in restocking depleted shad streams by planting therein a portion of the output of its two hatcheries. In their efforts to obtain this assistance the illogical argument has been advanced that the shad hatcheries, being the property of the Federal Government and supported by public funds, should apportion their output in accordance with public demands and without regard to the source of supply. Were the bureau to be influenced by such reasoning it would result in dividing the comparatively small output of its two hatcheries among various States along the Atlantic seaboard. The numbers allotted in any instance would be negligible, and such a course would inevitably result disastrously to the fisheries in the waters in which hatchery operations are now conducted.

For many years the bureau followed the policy of making systematic plants of shad fry in the principal shad rivers and tributary streams along the Atlantic seaboard, but the results did not justify a continuance of such efforts, because the States concerned did little or nothing for the protection of the species, and with the rapid and constant increase in fishing operations and fishing devices the run constantly lessened. Finally, in order to maintain the dwindling supply in home waters the bureau found it necessary to discontinue shipments to outside points and return to the local spawning grounds the entire product of its shad hatcheries.

The status of the shad fisheries at the present time is precarious in the extreme, fully warranting the adoption of drastic measures if they are to be saved from total and early extinction. In spite of the discouraging situation, however, the States most nearly concerned have thus far appeared loath to take any decidedly aggressive action toward safeguarding or increasing the run.

While the falling off of the shad run in many Atlantic coastal rivers and their total disappearance in others are due to several causes, the chief factor involved would seem to be a total lack of protection during the spawning season. As a result of the extensive fishing operations near the mouths of such streams and in the salt and brackish waters below very few shad are able to reach their spawning grounds. The considerable amount of trade waste entering the streams has also had a deleterious effect.

The collection of shad eggs in the Potomac, at the Bryans Point (Md.) station, fell considerably below that of a normal season, amounting to only 15,620,000. During February and March the weather was unusually mild, with high water temperatures, the maximum in March being 64° F., with a mean temperature of 52° F. As a result, spawning shad were taken unusually early, and 316,000 eggs were secured during that month. Weather conditions in April were a reversal of those in March, with equally unfavorable results to the work, and the season was brought to an early close on May 9. Approximately 1,110,000 of the eggs secured were sent to central

station for an exhibit, and the resulting fry were returned to the Potomac River. The eggs retained for incubation at the hatchery produced 13,639,175 fry, all of which were deposited on local spawning grounds.

The conditions during the season were especially favorable to pound-net operations. The high water temperatures in March appeared to cause the shad in their upstream migration to leave the deep-water channels, which are unobstructed by nets, and seek the shallower water of the flats, thus coming in contact with the pound nets set to intercept them. In 1915 similar conditions prevailed, and that season and the one under discussion represent the only marked variations in the collections of shad eggs at this station in a long period of years.

Another factor bearing on the shad work in the Potomac River is the apparent increasing indifference of certain fishermen to the necessity for cooperating with the bureau by saving for propagation the eggs from the spawning fish taken by them. Most of the fishermen render this service willingly, realizing its value to them and to their industry, but the high prices paid for shad in recent years have evidently created among a certain class of fishermen a feeling that the only important consideration is to get the largest number of shad to market in the shortest possible time. This attitude has undoubtedly resulted in the loss of a very considerable number of eggs, and if it continues it may become advisable to invoke the aid of the Maryland and Virginia authorities. Since the shad fishermen are licensed by the State in which they operate, it would seem that a regulation might be put into effect that would require all fishermen taking shad on the spawning grounds within certain areas and in working distance of the hatchery to assist employees of the bureau in conserving the ripe eggs under penalty of a revoked license for failure to comply.

The first shad eggs for the Edenton (N. C.) hatchery were secured on March 28, and on May 5 the season ended with a total collection of 21,710,000 eggs. As at Bryans Point, climatic conditions were unfavorable for the best results, the fluctuating water temperatures being particularly annoying. A considerable reduction in the expense of collecting eggs was effected during the season by closer cooperative relations with the fishermen, a situation that the bureau has constantly endeavored to foster. One of the difficulties in obtaining shad eggs in this region is the large number of pound nets used. As such nets are lifted at infrequent intervals, the eggs of fish taken in them are seldom fit for incubation. Eggs of the shad appear to be at their best when taken from fish caught between sundown and midnight. For this reason gill nets, which are set on the ebb tide and lifted at half-hour intervals, constitute the most dependable source of egg supply for the Edenton hatchery.

The Edenton station also propagates pond fishes, mention of which is made on page 63.

PROPAGATION OF GLUT HERRING, EDENTON (N. C.) STATION.

The propagation of glut herring was taken up last season for the first time at Edenton, and the results obtained may warrant a continuance of the work. Some opposition was made by local fisher-

men on the ground that the stripping of the fish reduced their market value, an objection which is not altogether well founded. While it is true that the appearance of the female may be affected by the stripping process, the roe at spawning time has no market value. The spawning season of this species coincides with that of the shad, and for that reason the egg collections were limited, the hatching capacity permitting of a total collection of 56,130,000.

PROPAGATION OF ALEWIFE, BOOTHBAY HARBOR (ME.) STATION.

For the past two seasons attempts have been made to secure eggs of the alewife for artificial propagation at the Boothbay Harbor (Me.) station. The Damariscotta River supports a run of the species, and there is a fishery of some importance at Damariscotta Mills. An examination of the fish taken at this fishery in tidewater very soon disclosed that no fish with mature spawn were obtainable from this source. The efforts made to hold the fish in an inclosure, awaiting the maturity of the eggs, were not successful, and attempts to secure eggs from the fish after their entrance into fresh-water ponds above the falls were equally unsuccessful. Seines, pound nets, and fyke nets were employed at Damariscotta Mills and at West Boothbay Harbor in ponds where the alewife is known to spawn, but the results were negative in every instance in so far as they pertained to eggs for propagation, though considerable numbers of fish with immature eggs and also of spent fish were taken. No satisfactory explanation of this unusual situation is at hand, since alewives in spawning condition are taken in various forms of nets at other points.

PROPAGATION OF STRIPED BASS, WELDON (N. C.) SUBSTATION.

The bureau propagates the striped bass or rockfish at a single substation, located on the Roanoke River at Weldon, N. C., where a yearly average of about 12,500,000 fry is hatched and returned to the spawning grounds in the river. The work is greatly handicapped by the floods usually encountered and also by the difficulty experienced in securing ripe fish of the two sexes at the same time. During the height of the run this latter condition is less pronounced than it is earlier or later in the season. Contrasted with the output of some of the commercial species, the work at this hatchery is not large, but it is showing a steady and gratifying increase, as is evidenced by a comparison of the results of the past 10 years. The production of striped bass fry at Weldon rose from 5,256,000 in 1912 to 20,184,000 in 1921, an increase of nearly 400 per cent.

PROPAGATION OF ATLANTIC SALMON, CRAIG BROOK (ME.) STATION.

[J. D. De Rochbr, Superintendent.]

For many years it has been the practice of the bureau to purchase in May and June practically all the salmon captured by the Penobscot River fishermen, estimating the average weight at 12½ pounds, and paying the prevailing market prices for them, together with a bonus of 60 cents per fish for careful handling. The fish have been held in a large lake or inclosure until their eggs were mature,

and after having been stripped they have been released in the river. Operations along these lines have resulted in the purchase of almost the entire catch and paying for the fish at a seemingly exorbitant price, this amounting in effect to the maintenance of the run for the sole purpose of furnishing employment to a few river fishermen.

After thoroughly canvassing the situation the bureau recently decided to curtail its expenditures in this direction, with the view of ascertaining if equally good results could not be brought about by less expensive methods. Taking all related facts into consideration, it would seem that the State of Maine should interest itself in providing efficient fishways over the dams which at present obstruct the passage of the salmon to their natural spawning grounds.

At the beginning of the fiscal year there were on hand 316 brood salmon, obtained by purchase from local fishermen in June. At the spawning season in October these fish yielded 911,720 eggs, from which 821,240 fry were hatched. On March 12, 1921, 600,000 eggs of this species were received from the New Brunswick hatcheries of the Canadian Government in exchange for eggs of the brook, rainbow, and blackspotted trouts. These were successfully incubated, producing 565,760 fry, all of which entered into the general distributions in Maine waters.

Propagation of Fishes of Interior Waters.

The serious inroads that have been made in the public waters of the interior as a result of the extensive and rapidly increasing use of the touring automobile are making it exceedingly difficult to maintain the fish supply in such waters. Recognizing the necessity for heavier stocking of their waters, many of the States have called upon the bureau for assistance, which, in view of its greatly overtaxed resources, it has not always been possible to extend. One of the greatest demands is for brook trout. The bureau does not produce its brook-trout eggs, but of necessity relies upon commercial fish-culturists for a large portion of its supply. In many instances such eggs can not be considered as more than a by-product of the commercial plants. They are, as a rule, taken from 2-year-old and 3-year-old fish and for that reason do not have the stamina that might be expected from the progeny of older fish. In view of this situation, Congress has been asked for sufficient funds to establish a plant for the production of the brook-trout eggs needed to fill the bureau's hatcheries. After placing it on an operative basis such a plant could be made to produce eggs of superior quality in numbers sufficient to meet the bureau's requirements and at a smaller cost than is now involved in the purchase of a poor grade of eggs.

The demand for smallmouth black bass can not be met by the hatcheries, the principal handicaps in the work with this species being unfavorable weather and insufficient pond space. Means for increasing the production of bass and other so-called warm-water fishes are again mentioned as being one of the most important requirements of the service. During a long period of time the output of such fishes has not kept pace with the demand, and to meet the deficiency the bureau has found it necessary to utilize for general

distribution a small percentage of the fishes rescued from the Mississippi River overflows. In recent years the demand for bass has increased, but funds have not been provided for increasing the production of the species at the fish-cultural stations. This has resulted in a tendency to draw more heavily on the rescue work to meet the demands, until the number of bass so diverted in the fiscal year 1921 amounted to approximately 43 per cent of the total number rescued. Any increased diversion of bass from this source is not advisable, and unless other means are found for an increased production of the fish-cultural stations a large number of applications must of necessity remain unhonored.

Of interest in connection with the fish-cultural work is the development in recent years of fish and game protective associations in practically all parts of the country. Composed as they are of the leading citizens of the communities in which they reside, their influence for the protection and conservation of the natural resources is of great benefit. Such organizations endeavor to obtain the services of men experienced in stocking local streams with fish life, and in many instances they maintain ponds at their own expense for the purpose of rearing young fish obtained from State or Federal hatcheries to a larger size than would be otherwise possible before planting them in public waters. The intelligent cooperation resulting from this movement is marked and is worthy of encouragement. Another favorable influence exerted by organizations of this character is an increased respect on the part of the general public for the State fish and game laws. It is the policy of nearly all such organizations to favor better protective laws, to demand of their members a strict observance thereof, and to urge the same line of conduct on all others with whom they come in contact.

Among the more important species propagated for the stocking of interior waters are the catfish; rainbow, blackspotted, and brook trout; crappies; largemouth and smallmouth black bass; rock bass; and sunfish. The results accomplished with these species by the various stations during the fiscal year 1921 are reviewed in the following discussion. Data concerning the spawning seasons are given on pages 73 and 74, and a tabulation of the amount and cost of fish food used occurs on page 76.

NEW ENGLAND SALMON AND TROUT STATIONS.

BERKSHIRE (MASS.) STATION.

[WILLIAM A. CASLER, Superintendent.]

Fish-cultural work at this station, which is located near the town of Hartsville, Mass., was confined to operations with the brook and rainbow trout. Between October 20 and November 10 brook-trout eggs to the number of 133,500 were collected from brood fish in the station ponds, and two lots of eggs, aggregating 322,500, were acquired by purchase from commercial hatcheries. As the station fish were old and somewhat imperfect through interbreeding, the quality of their eggs was poor and heavy losses resulted, both during the incubation period and at the time the fry were ready to take food. A heavy loss was also sustained on one lot of the commercial eggs

from the disease known as "bluesac." In each case, however, after culling out the defective stock no further trouble was experienced, and the distributions of young fish from the three lots of eggs comprised 296,825 healthy No. 1 and 2 fingerlings, with 34,000 fingerlings on hand at the close of the year.

From two lots of rainbow-trout eggs—one of 50,000 transferred from the White Sulphur Springs hatchery and another of 6,920 taken from the station fish—43,900 thrifty fingerlings were produced, of which 2,000 remained on hand at the end of the year. The spawning season of the rainbow trout at this station extended from December 22 to January 20.

CRAIG BROOK (ME.) STATION.

[J. D. De Rocher, Superintendent.]

In addition to the propagation of the Atlantic salmon, for which purpose this station was primarily established, it has an annual output of brook trout from eggs purchased of commercial fish-culturists. The distribution of this species for the fiscal year 1921 amounted to 1,085,000 fry and 23,625 fingerling fish. The year's distributions also included landlocked salmon fry and fingerlings to the number of 43,545, these fish being the product of eggs transferred from Grand Lake Stream. A detailed account of the work with the Atlantic salmon is contained in the section devoted to the anadromous fishes, page 45.

Having an abundant water supply of excellent quality, this station possesses opportunities for development as a trout-rearing center. At comparatively small cost its capacity may be increased to the point where it will alone adequately meet the requirements of that section of the country.

GREEN LAKE (ME.) STATION AND SUBSTATION.

[John A. Story, Superintendent.]

Perhaps the most important part of the work of this station is the propagation of the landlocked salmon. Operations addressed to this species are conducted at the main station, a substation at Grand Lake Stream, and an egg-collecting station on Fish River Lakes, the work at the latter point being done on a cooperative basis with the Maine Commission of Inland Fisheries and Game. At Fish River Lakes egg collections were made from Cross, Eagle, and Square Lakes Thoroughfares, aggregating 525,000. These were all delivered at the State hatchery for eyeing. Under the agreement 250,000 of them were reserved for planting in parent waters, while the remainder were divided equally between the bureau and the State hatcheries after being eyed. The lakes were at high level prior to the spawning season, with but little rain during that period. Under these conditions there was but little and a constantly decreasing current over the usual spawning areas. This is thought to have been a factor in the reduced egg collections, though whether or not it was the most important one it is hardly possible to say. A total of 336 male and 260 female fish were handled during the season, the first being taken on October 24 and the last on November 9.

The number of landlocked salmon eggs taken from Green Lake represents an average season. Pound nets were set at the mouth of Great Brook as usual, and 87 female and 49 male fish were taken, the first fish entering the trap on October 14 and the last on November 19. Eggs to the number of 220,300 were secured, of which 70,000 were shipped to applicants. From the remainder 122,120 fry were hatched and distributed.

Of the 317,200 eggs obtained at Grand Lake Stream 115,000 were shipped to other points and 184,400 were retained for parent waters. To the unseasonably warm weather, which continued through the late fall, and the consequent high-water temperatures the delayed and prolonged run of spawning salmon is attributed. Spawning fish were still being taken in small numbers daily, when a sudden temperature change, with danger from ice, made it necessary to discontinue operations. The adult fish taken this season were of a larger average size than is usual at this point. Several specimens weighing 6 and 7 pounds were taken, yielding an average of 1,600 eggs per fish. During July and August 79,000 fingerling salmon carried over from the previous year were liberated in Grand and Dobsis Lakes.

The work addressed to the propagation of smelt met with a fair degree of success. From the 8,000,000 eggs obtained 7,000,000 fry were hatched and liberated in local waters and 600,000 eyed eggs were shipped to applicants. Practically all of the eggs were obtained this season from natural spawning, the adult fish being confined in troughs until this function was performed, after which they were liberated and the eggs transferred to hatching jars. Comparative tests of this method of obtaining eggs as against artificial stripping seems to prove the superiority of the former method. Of 150,000 eggs taken by artificial stripping only about 15 per cent produced fry, while the percentage of hatch obtained from natural spawning was 95. It was noted, however, that the best results were obtained from fish that were about ready to spawn when taken. When held in confinement for more than 36 hours prior to spawning, eggs of a poor quality resulted. In one instance a trough in which approximately 500,000 eggs had been deposited was left undisturbed for observation after the removal of the adult fish. On the fourth day the eggs showed the effects of smothering, this condition, which is well known to fish-culturists, being brought about by improper aeration of the water. The dam at the outlet end of the trough was raised, thus subjecting the eggs to a more rapid flow of water and relieving the dangerous symptoms. These eggs completed incubation in 14 days, with a mean water temperature of 55.5° F., as against 20 to 27 days for the eggs incubated in Downing jars, with a mean water temperature of 46°.

In addition to the species already mentioned, brook-trout eggs to the number of 788,860 acquired by purchase from commercial dealers and 50,000 rainbow-trout eggs transferred from the bureau's Virginia station were received during the year. Fifty thousand of the brook-trout eggs were reshipped to the Grand Lake Stream substation. From the eggs of that species retained at Green Lake 608,050 fry were distributed. The rainbow-trout eggs underwent a rather heavy loss during incubation and produced only 26,000 fry.

The distributions from the Grand Lake substation consisted of 47,880 brook-trout fry, 115,000 eyed eggs of the landlocked salmon, 55,000 landlocked-salmon fry, and 79,100 landlocked-salmon fingerlings, with approximately 74,000 fingerlings of that species on hand at the end of the year.

NASHUA (N. H.) STATION.

[WALDO F. HUBBARD, Superintendent.]

The work at this station was concerned with the brook and rainbow trouts, pike perch, and smallmouth black bass. A few brook-trout eggs were obtained from brood fish at the station, but most of the eggs of this species were acquired by purchase. The rainbow eggs, with the exception of 16,638 taken from fish in the hatchery ponds, were transferred from the Wytheville (Va.) station, and the pike-perch operations consisted in the incubation of 2,000,000 eyed eggs shipped from Swanton, Vt. During the spawning season of the smallmouth black bass in Lake Sunapee, extending from June 2 to June 17, collections of fry of that species to the number of 31,700 were made and shipped to applicants. The work with the various species was conducted without unusual incident, and the output of fish for distribution is shown in the table on page 12.

ST. JOHNSBURY (VT.) STATION.

[A. H. DINSMORE, Superintendent.]

From this station as a center the usual field stations for the collection of brook-trout eggs were operated at Lake Mitchell and Darling Pond. Largely because of climatic conditions, the results of the work at both points were rather unsatisfactory. The egg collections amounted to 214,148 and 411,777, respectively, all of which were of the usual high quality.

During the summer of 1920 an investigation was made of the fish-cultural possibilities existing at points on the Big Margalloway and Little Margalloway Rivers and Parmacheence Lake, in northern Maine. As the field gave promise of satisfactory returns, a tentative plan was formulated for undertaking work in cooperation with the Northern Oxford Guides Association. The first eggs were taken October 13, and the collections, which extended to October 27, aggregated 300,000. As the main objects of the work were to build up the supply of trout in the local waters and to encourage the local organization in their fish-cultural activities, the bureau claimed only 50,000 of the eggs secured. The others were successfully incubated in the log hatchery put up by the association, and the resulting fry were planted, with but slight loss, in local waters. While the work was not particularly successful from a fish-cultural standpoint, the information gained will be useful in connection with any future work that may be attempted in that field.

At Lake Dunmore, Vt., a new field station was established for the collection of lake-trout eggs and was operated jointly by Federal and State employees. Eggs to the number of 130,000 were collected and sent to the Holden hatchery, another subsidiary of the St. Johnsbury station, to be eyed. After reaching the eyed stage half of them were turned over to the State fisheries authorities.

In accordance with past custom a considerable number of brook-trout eggs was purchased, and as usual they were greatly inferior to the eggs obtained from wild stock. Such purchases amounted to 877,800, and 56,000 eggs in addition were turned over to St. Johnsbury station by a Massachusetts dealer, with the understanding that half the resulting fry were to be placed at his disposal for sale to persons desiring fish for stocking private waters, the other half to be the property of the bureau. Two shipments of steelhead-salmon eggs, aggregating 58,000, were received from one of the Puget Sound (Wash.) stations, and a consignment of 25,000 landlocked-salmon eggs was forwarded from the Grand Lake Stream (Me.) hatchery.

Following the custom of past years, collections of smallmouth black bass fry were undertaken at Lake Tarleton, and though started some 10 days earlier than ever before they did not precede the unusually early spawning of the bass. High winds interfered with the work, making difficult the placing of screens and the dipping of the fish, and in some instances the screens were destroyed. Approximately 54,000 fry were obtained from this source and placed in ponds at the St. Johnsbury station for later distribution. This work at Lake Tarleton enables the bureau to secure limited numbers of bass for distribution in the Vermont field and at the same time assists in keeping down their numbers in the lake, where they are considered objectionable.

At the Holden substation approximately 350,000 brook-trout eggs were received, some from the field stations and some from commercial hatcheries, and the distributions of fry and fingerling fish from this lot amounted to 173,700, with 47,380 fingerlings on hand at the end of the year. The rather serious losses made evident by these figures are attributed mainly to an accident occurring on April 15, when the spring water supply to the hatchery was cut off. A more extensive system of aeration had been installed to overcome the losses occurring in recent years through defective aeration of the water. The new system promises good results, but because of this accident the evidence in its favor can not yet be considered conclusive. This substation also handled and distributed the product of approximately 145,000 lake-trout eggs collected at Lake Dunmore, Vt., 25,000 of the same species transferred from the Charlevoix (Mich.) field, and 50,000 rainbow-trout eggs received from the West Virginia hatchery of the bureau.

Work looking to the development of the York Pond (N. H.) site as a station for the production of brook-trout eggs was carried forward as expeditiously as the limited funds available for the purpose would allow. During the summer the small bottom west of the pond and the extensive flat below it were cleared and a small log cabin to house the employees was constructed. Officers of the Forest Service have rendered valuable aid in the work of developing this station. Through their efforts the camp has been provided with telephone connections, and they are planning for the construction of a wagon road to the site. They have also rendered assistance in running levels, with the view of turning the flow of one or more of the adjacent brooks into the pond system.

ROCKY MOUNTAIN TROUT STATIONS.

BOZEMAN (MONT.) STATION AND SUBSTATIONS.

[W. T. THOMPSON, Superintendent.]

Although the cold, stormy weather of winter was unduly protracted, interfering with fish-cultural work into the late spring months, a satisfactory season is to be recorded in this field. With Bozeman station as headquarters an auxiliary station is operated at Meadow Creek, in the Madison Valley, and substations in the Glacier National Park and the Yellowstone Park.

BOZEMAN (MONT.) STATION.

Fish-cultural work at the Bozeman station was confined to the incubation of eggs transferred from other points, these transfers amounting to 1,357,200 rainbow-trout eggs from Meadow Creek, 1,236,400 blackspotted-trout eggs from Yellowstone Park, and brook-trout eggs from the Springville and Leadville stations in the numbers of 350,000 and 782,000, respectively. Part of the rainbow-trout eggs were shipped to applicants and other stations; the remainder were hatched and distributed as fry and fingerlings to fill the demands for them in Montana, Wyoming, Idaho, Washington, and Oregon. Approximately 800,000 fry of the rainbow trout and blackspotted trout remained on hand at the close of the fiscal year.

MEADOW CREEK (MONT.) AUXILIARY STATION.

The Meadow Creek egg-collecting or auxiliary station was opened on April 9. The weather throughout the spring was cold and stormy, and there was no clearly defined run of fish, as is the case under more favorable conditions. The first rainbow trout appeared at the rack early in April, and the run continued at intervals up to June 10, during which period 2,273,000 eggs were taken. Of this number 1,357,200 were sent to the Bozeman station. The eggs taken during the latter half of the spawning season were of poorer quality than usual, probably because of the turbid water, which was materially affected by the storm conditions. The results of hatching were therefore disappointing, and of those retained for stocking home waters only 300,000 fry were realized. Near the close of the fiscal year 500,000 blackspotted-trout eggs were received at the Meadow Creek hatchery from the State hatchery at Anaconda, and these, with 30,000 rainbow-trout fry, were on hand June 30.

Mixed in with the rainbow-trout run were a limited number of grayling, though not sufficient to warrant spawn taking. The fish appeared to have been driven into the lake by the soft ice in the stream shortly after their appearance at the racks, the grayling evidently being very susceptible to influences of this kind. In recent years grayling have deserted the Meadow Creek spawning grounds, to which they formerly ascended in considerable numbers every spring. Whether or not the successful establishment of the rainbow trout therein is responsible for the abandonment of the stream by the grayling is conjectural, but the present spawning grounds of the fish in the region are unknown, though several attempts have been made to locate them.

YELLOWSTONE PARK (WYO.) SUBSTATION.

The spawning season of the blackspotted trout in the Yellowstone Park involves portions of two fiscal years. At the beginning of the fiscal year 1921 there were on hand in the hatchery 850,000 eggs which had been collected in June, and this number, added to the total obtained in July, gave an aggregate collection of 6,430,400 for the season. During the spring of 1921 the season was late, as at the Meadow Creek auxiliary station, and ice was still in Yellowstone Lake at the arrival of the spawning crews on June 10. The first eggs were taken at Fish Lake, near Soda Butte, on June 19, and at the close of the fiscal year the total egg collection numbered 1,747,500, of which 829,600 were obtained from Fish Lake and the remainder at different points on Yellowstone Lake. All eggs taken during the year were of excellent quality. The usual limited numbers were assigned to various State fish and game commissions, and smaller numbers were diverted for stocking the waters of the Glacier National Park. The remaining eggs were incubated at the lake hatchery, and fry to the number of 2,012,400 were distributed in Yellowstone Park waters, the park superintendent cooperating in the distribution.

GLACIER PARK (MONT.) SUBSTATION.

From the Glacier Park hatchery, which was in operation for a period extending from June 13 to September 17, 1921, there were distributed in park waters 2,035,000 fry and fingerling grayling, brook, rainbow, and blackspotted trout, with approximately 445,000 grayling and rainbow-trout fry on hand at the close of the fiscal year. The rainbow trout were derived from the Madison Valley egg collections and the blackspotted trout from the Yellowstone Park. For the grayling and the brook trout the bureau is indebted to the Montana Fish and Game Commission, and grateful acknowledgment of this cooperative assistance is hereby made. As in the Yellowstone Park distributions, officers of the national park service rendered valuable assistance in transporting the fish to suitable points for planting.

LEADVILLE (COLO.) STATION.

[CHARLES B. GRATER, Superintendent.

The output of fry and fingerling fish from this station was smaller than usual because of certain conditions affecting the egg collections at two important sources. Low water at Turquoise Lake exposed the customary spawning beds of the trout, and attempts to take the fish by seines and fyke nets at other probable spawning points were not altogether successful. Similar conditions existed at Engelbrecht Lake, where further difficulties were experienced also in the matter of transportation. The aggregate total of brook-trout eggs obtained from the collecting fields occupied was 4,305,400. This station also handled 1,209,000 blackspotted-trout eggs transferred from the Yellowstone Park field, 130,000 rainbow-trout eggs from the stations in Wyoming and Utah, and 25,000 lake-trout eggs shipped from Michigan.

The Leadville station has for a number of years been able to successfully operate field stations at a number of privately owned lakes

and reservoirs, obtaining from them considerable numbers of brook-trout eggs for distribution in the form of fry and fingerling fish to applicants throughout Colorado and New Mexico and at the same time maintain unimpaired the original sources of supply. In recent years this work has suffered from the frequent labor changes occasioned by the low rate of compensation offered, and in certain instances the lake owners have refused to permit the continuance of fish-cultural work under the direction of the inexperienced men whom the bureau has been forced to place in charge. The time is at hand when a more definite policy with reference to this field of operations will have to be adopted if the work is not to seriously deteriorate.

SARATOGA (WYO.) STATION.

[O. N. BALDWIN, Superintendent.]

As has been mentioned in several previous reports, this field remains practically undeveloped because of lack of funds. Every year the station employees, at the expenditure of much time and labor, secure limited numbers of eggs at field stations where, with proper equipment and means for eying eggs intended for transfer and for the complete incubation of those needed for the maintenance of the local run of fish, the egg collections might be very greatly increased, the loss of eggs incident to their transfer in the green state obviated, operating expenses reduced, and the general efficiency of the work greatly improved. During the spring of 1921, with the primitive means available, the Sage Creek collecting field yielded 1,185,295 rainbow-trout eggs, Lost Creek, 982,185, and Canyon Creek—occupied for the first time—351,850, a total of 2,519,330. The station brood stock also produced 140,000 eyed eggs of this species.

Brook-trout eggs to the number of 1,132,400 were handled during the year. Of these 134,000 were taken from the station brood stock, 448,000 were received from Springville (Utah) station, and the remainder were taken at a new and promising field station located at Big Creek Lake, in North Park, Colo. This field is about 100 miles from the Saratoga station, well up on the Continental Divide. Incubation of the brook-trout eggs was completed a full month earlier than usual, with the result that most of the fry were taking food early in the winter.

Incidental to the other fish-cultural work, there are taken each season small numbers of Loch Leven-trout eggs, this species appearing to thrive in the streams of the region. With the more complete development of fields contiguous to the station it is probable that very successful work can be accomplished with the Loch Leven. Besides the species already mentioned, 200,000 blackspotted-trout eggs were received from Yellowstone Park collections and were incubated with a loss of only 6,000. The resulting fry and fingerlings entered into the general distribution. With improved roads and better transportation facilities there is reason to believe that the blackspotted trout will also eventually bear a conspicuous part in the operations of the Saratoga station. There remained on hand at the close of the year upward of 1,000,000 eggs, fry, and fingerling fish.

SPEARFISH (S. DAK.) STATION.

[D. C. BOOTH, Superintendent.]

There was a decrease in the output of this station during the fiscal year 1921 as compared with previous years, this condition resulting from the very limited water supply available. For a number of years the spring that has furnished the station with water has been decreasing in volume, until during the season of 1920 its flow did not exceed 25 gallons per minute. Quite opportunely, the city of Spearfish found it necessary to augment the city supply by constructing a new reservoir, and the bureau was able to effect an arrangement whereby it obtains the surplus water for its fish-cultural work. The expense involved in installing the new system made it necessary to greatly curtail all other expenditures during the year.

From the brood fish on hand 222,500 brook-trout eggs, 37,600 Loch Leven-trout eggs, and 79,000 rainbow-trout eggs were obtained These collections were supplemented by the transfer of 150,000 rainbow-trout eggs from the Bozeman and Springville stations and 200,000 of that species from a commercial fish-culturist in Pennsylvania in exchange for an equal number of brook-trout eggs furnished from the bureau's Leadville station. Some 46,000 green brook-trout eggs were purchased from a local source, and 25,000 lake-trout eggs were received from the Duluth station. The fry and fingerlings resulting from all of this stock entered into the general distributions.

SPRINGVILLE (UTAH) STATION AND SUBSTATION.

[CLAUDIUS WALLICH, Superintendent.]

Fish-cultural work in this field during the year resulted in the distribution to applicants or in local waters from which egg collections were made of 463,600 No. 2 to No. 5 fingerling brook, blackspotted, and rainbow trouts, 250,000 eyed rainbow-trout eggs, 2,000 fingerling catfish, and 600,000 fry of the Bonneville whitefish from the Paris (Idaho) substation. In addition to the above approximately 700,000 fry and fingerlings of the various species of trout handled remained on hand at the close of the year and a total of 1,202,000 eyed brook-trout eggs were shipped, being consigned to the Bozeman, Saratoga, Spearfish, and Clackamas stations. These eggs do not enter into the records as an output of the Springville station.

Eggs to the number of 51,400 were obtained from the brood stock of brook trout at their first spawning. Because of inadequate facilities for handling the spawning fish there was a loss of eggs from natural spawning. The eggs taken were of a quality equal to that from wild fish. Spawning continued throughout the month of December. The brood stock of blackspotted trout yielded 107,800 eggs, the spawning season extending from March 20 to May 20. An overflow of muddy water through the pond system during the spawning season interfered with the most efficient conduct of the spawn-taking work, hence the quality of the eggs was somewhat impaired. Spawning of the rainbow trout continued from December 30 to March 19, during which period 179,000 eggs were taken. In contrast to the brook trout the rainbows have continued in a healthy and

growing condition and successful results from the brood stock of that species are anticipated.

From the collecting stations located on Fish Lake, which are operating jointly by the bureau and the State of Utah, 1,901,400 brook-trout eggs and 1,734,800 rainbow-trout eggs were obtained as the bureau's share of the work. Employees of the bureau occupied the station at Twin Creeks from October 30 to November 14, after which the field was left to employees of the State. It is encouraging to note that the run of brook trout at this point has increased since the bureau's operations were undertaken, and it has been reported from reliable sources that a noticeable increase in the average size of the fish has occurred during the past two seasans, though this has not been verified by actual measurements or weight. The abundance of immature fish in the creek and along the shores of the lake appears to be a further indication of the success of the liberal planting of large-sized fingerlings.

During the course of the brook-trout egg collections it was noted that the adult rainbow trout were dying in considerable numbers, a condition that had existed for several months from information brought out on inquiry. The cause of the mortality could not be ascertained. The rainbow-trout spawning season at Twin Creeks occurred between May 1 and June 4, and at this time there was no indication of the mortality noticed in the previous fall.

There are several promising opportunities for extending the trout work of this station, among which may be mentioned the Kayune Reservoir, which is the property of the U. S. Fuel Co. This reservoir has been offered to the bureau exclusively for fish-cultural work, and the reports received from the plants of brook trout and rainbow trout made in it are most encouraging. There are very good prospects for early railroad communication with the Strawberry Reservoir, of the Reclamation Service, which is at present inaccessible during the spawning season of the rainbow trout. A recent investigation of Jorgensen Creek, a tributary of Fish Lake, about 4 miles from the present camp on Twin Creeks, indicates that a field station might profitably be established at that point. At the time the place was visited 46 large fish which had been beheaded by coyotes were noted.

The substation established for the propagation of the Bear Lake whitefish at Paris, Idaho, was opened on November 22 and operated until April 10. The usual difficulties encountered during the egg-collecting season—severe cold, violent winds, and snowstorms—prevailed without abatement. Eggs to the number of 1,056,000 were taken, from which 600,000 fry were hatched and planted, 500,000 being deposited on the spawning grounds in Bear Lake and 100,000 in Utah Lake.

COMBINATION TROUT AND POND FISH-CULTURAL STATIONS.

The stations possessing the greatest attractions for the general public are, perhaps, those located in sections of the country where the natural conditions make it possible to propagate both the Salmonidæ and the pond fishes. At such stations a brood stock of the

various species handled is maintained at all times and work of a strictly fish-cultural nature is under way throughout the year, whereas the fish-cultural work at certain of the hatcheries, especially those handling the commercial species, is seasonal in its character. The "combination" stations operated by the bureau are located at Erwin, Tenn.; Manchester, Iowa; Neosho, Mo.; White Sulphur Springs, W. Va.; and Wytheville, Va. Following is the aggregate output, by species, of this group of stations for 1921:

Brook trout	1,064,950	Smallmouth black bass	112,591
Crappie	14,332	Sunfish	62,355
Largemouth black bass	121,978	Yellow perch	58
Pike perch	500,000		
Rainbow trout	2,583,244	Total	5,154,893
Rock bass	95,385		

ERWIN (TENN.) STATION.

[A. G. KEESECKER, Superintendent.]

The aggregate output of this station shows an increase of about 30 per cent over that of the previous year. The spawning season of the rainbow trout began on November 8 and continued to January 27, the total egg collection amounting to 936,000, of which 822,000 were eyed. With the exception of 55,000 eyed eggs supplied to the State hatchery at Elkmont, Tenn., the entire lot was incubated in the Erwin hatchery. The losses were merely nominal, and the output of this species for the year amounted to 755,100, this number including 59,926 fingerlings derived from eggs transferred from the Neosho (Mo.) station. As an addition to the brood stock 10,000 steelhead eggs transferred from the Birdsview (Wash.) station were incubated, producing 9,300 fry. The year's work with the rainbow trout indicates a very satisfactory improvement, both with regard to the productivity of the brood fish and the quality of the eggs secured. No brood stock of brook trout is maintained at this station, all eggs of that species handled being acquired by purchase from commercial dealers. During the year the 439,300 eggs thus acquired resulted in an output of 300,435 fingerlings.

The spawning season of the smallmouth black bass began on April 13 and continued to May 28. Twelve nests were occupied, and 10 of them were productive, though the percentage of fry hatched in each nest was small. The distribution of this species amounted to 5,165 fingerlings, and it was estimated that upward of 3,000 were on hand at the close of the year. The outcome of the operations with the largemouth black bass was better, 65,980 of these being available for distribution, with approximately 10,000 on hand at the end of June. During the spawning period, extending from April 13 to June 1, the warm weather during the spring was followed by colder weather, and this was an important factor in reducing the output of both species of black bass. The year's distribution also included 17,200 rock bass, 400 strawberry bass, and 20,350 sunfish, all fingerlings.

MANCHESTER (IOWA) STATION.

[FRANK E. HARE, Superintendent.]

The output of this station consists of 125,500 eyed eggs of the rainbow trout and 678,585 fry and fingerling fish of the different species propagated. The rainbow-trout brood stock did not yield an altogether satisfactory return, there being only 378,600 eggs taken. With the maturity of plans now being formulated a very decided improvement in this direction is confidently expected. During the spring 25,000 eggs taken from wild rainbow trout were transferred to Manchester from the bureau's Montana station with the view of infusing new blood in the brood stock, and the product of an equal number of steelhead eggs shipped from the Birdsview (Wash.) station will also be reared with that end in view. The adult brook trout, consisting of 625 2-year-old fish and 35 fish 3 years old and over, yielded 58,000 eggs. These fish were again affected by a gill disease just prior to the spawning season and suffered a heavy mortality. Brook-trout eggs to the number of 550,000 were obtained from commercial dealers in Massachusetts and incubated with satisfactory results. The cold weather of the late spring reduced the output of largemouth black bass to 2,500 fingerlings, but better success attended the culture of the rock bass, the distribution of that species amounting to 53,910 No. 1½ fingerlings.

NEOSHO (MO.) STATION.

[FRED J. FOSTER, Superintendent.]

There was a very satisfactory increase in the output of rainbow trout from this station for the fiscal year 1921. The records indicate that the egg shipments were increased over those of the preceding year by 48 per cent, while the increase in the number of fingerling fish distributed was as high as 117 per cent. The improvement was not confined solely to the increased number of fish and eggs produced but has been extended to the quality of the product and a betterment of the condition of the brood stock.

For a number of years the station has been supplied with water from two sources—the Hearell Spring and the McMahon Reservoir. Observations made by the superintendent led to the belief that the eggs of fish held in ponds supplied from the spring were not equal, either in numbers or quality, to those taken from fish in ponds supplied from the reservoir. For the purpose of testing the soundness of this theory the following experiment was conducted: A number of 3-year-old rainbow trout from the same hatch, which up to the time of the experiment had been held in the same pond, were divided into two equal lots. One lot was placed in pond No. 18, supplied entirely with water from the McMahon Reservoir, and the other was placed in Pond F, supplied largely from Hearell Spring. The eggs obtained from fish held in the McMahon water proved 82 per cent

fertile, while the rate of fertility of the other lot was only 67. This and further experiments along the same lines gave these results:

Pond.	McMahon water.	Hearell water.	Fertile eggs.	Pond.	McMahon water.	Hearell water.	Fertile eggs.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
No. 18	100	0	82	No. 5	50	50	77
No. 15	70	30	80	No. F	30	70	67

It is unfortunate that more complete data on these experiments are not available, and perhaps the data at hand can not be accepted as conclusive. Nevertheless, the evidence seemed sufficiently strong to warrant the construction of two new ponds supplied entirely with the McMahon water and the alteration of present lines to admit of a further elimination of the Hearell water from the stock ponds. During the coming year the brood stock of rainbow trout will be held exclusively in ponds supplied with the McMahon water. The nature of the apparent ill effects of the water from Hearell Spring on the adult fish has never been ascertained, but an ovarian affection appears to prevail among the fish that have been retained in that water for any considerable period.

Another item of possible interest in trout culture at the Neosho station was the occurrence of a disease among the fingerling trout, both at the main station and at the Roaring River substation, resulting in some loss. The trouble first appeared as a discoloration of the gills from cream to brown in color, sometimes one and sometimes both gills being affected. This was followed by an apparent disintegration of the tissues and finally by a peculiar sloughing off of the gill. The trouble manifested itself only in the newly constructed ponds or in ponds supplied with water from recently constructed reservoirs. On being removed to surroundings entirely remote from new concrete work the fish recovered rapidly, even in advanced cases where the gill seemed to have been destroyed. After being treated with a 1 to 1,000 solution of copper sulphate these affected ponds were allowed to remain idle for several months, and no trouble in connection with their use has since developed.

The output of pond fishes also shows an improvement over the recent past, the aggregate having been exceeded only in two previous seasons. Further improvement in this line of effort involves some interesting problems. The ovarian trouble of the rainbow trout may be present among the pond fishes held in water from Hearell Spring, and investigations looking toward the solution of this phase of the subject are already under way. The station ponds devoted to the production of the warm-water species are well supplied with natural food for their young, and were fingerling fish produced to the extent of the natural food available the station's output would be materially increased. The warm-water species propagated are largemouth and smallmouth black basses, rock bass, sunfish, crappie, and yellow perch. Artificial nests were tried in connection with the spawning of the largemouth black bass, with results that led the superintendent to recommend their general use. The output of the station by species is indicated in the tabular statement showing the production of fish by stations on page 12.

WHITE SULPHUR SPRINGS (W. VA.) STATION.

[DELL BROWN, Superintendent.]

Work at this station during the year was conducted along the usual lines. The results from trout propagation, both the brook and the rainbow, were of a satisfactory nature, but, on the other hand, the spawning of the two species of the pond fishes turned out to be an almost total failure.

The brood stock of approximately 2,700 female rainbow trout 2 years old and older produced 1,058,900 eggs, or more than a half million in excess of the previous season's collection. Only 68 per cent of them hatched, however, and the cause of this heavy mortality can not be explained. On reaching the eyed stage 447,000 were supplied to applicants and transferred to other stations of the bureau. The remainder were incubated at the station, together with a consignment of 100,000 received from the Wytheville (Va.) hatchery. The brood stock of brook trout, consisting of about 150 3-year-old fish and 350 2-year-old fish, yielded 80,000 eggs, which number was supplemented by the purchase of a million eggs from commercial dealers in New England. The so-called "white-spot" disease caused some mortality among the fry of this species just prior to the feeding stage, and a gill affection was prevalent later among the fingerlings. Eggs to the number of 22,000 were taken from 150 3-year-old albino brook trout. The males of this lot appeared to be lacking in virility, and some difficulty was experienced in obtaining the necessary fertilizing medium. Nine thousand fingerlings resulted from these albino aggs, 1,000 of which were furnished to applicants, leaving 8,000 on hand at the close of the year.

A consignment of adult smallmouth black bass obtained from Lake Erie waters for a brood stock survived the winter without undue loss, numbering 115 at spawning time. During the spring 46 nests of this species were noted in the ponds, and the output of fry amounted to 100,500. The 23 largemouth black bass on hand produced 25,800 fry and 600 fingerling fish. The results from the rock bass and sunfish were negligible. This condition was attributed in part to lack of proper nourishment, it having never been the custom to feed the brood-pond fishes at this station. Steps have now been taken to feed them on beef heart, and the results will be carefully noted.

WYTHEVILLE (VA.) STATION.

[GEORGE A. SEAGLE, Superintendent.]

During the spawning season of the rainbow trout the 2,960 adult females on hand yielded 870,352 eggs, of which shipments totaling 480,000 were transferred in the eyed state to applicants and to other hatcheries of the bureau. The spawning season was unusually protracted, extending from October 10, 1920, to March 15, 1921, the wild fish recently introduced into the brood stock probably being the later spawners.

At the beginning of the spawning season 695 2-year-old fish were turned over to a representative of the scientific division for experiment. From these fish 30,500 eyed eggs and 19,000 fry were returned to the hatchery stock at the end of the season's investigations, and

they are included in the station's output. The experimental work connected with the spawning of the rainbow trout will be continued over a series of years, the operations next year to be conducted at Erwin, Tenn. With this end in view 416 of the adult fish involved in last season's work have been transferred to Erwin.

The output of brook trout from the station was reduced to negligible proportions by an apparently infectious disease which attacked the fry shortly after incubation was completed. Eggs from commercial hatcheries to the number of 274,000 were received, but because of this trouble only 30,900 fry were available for distribution. The output of this species also included 1,900 No. 4 fingerlings carried over from last year's hatch.

The largemouth black bass, usually prolific at this station, produced very few young. The brood stock consisted of 194 fish, and during April 60 nests were counted in one pond. A sudden drop in temperature had the effect of destroying all the eggs deposited, and the few fry produced were the result of a later spawning. The distribution of rock bass consisted of 14,060 fingerling fish Nos. 2 and 3 produced from 230 brood fish, while 10,325 sunfish comprised the output from a stock of 200 breeders of that species. Adult crappie to the number of 47 were carried through the year, but so far as could be ascertained the fish did not spawn, nor have they been known to take food. Of the 20 catfish transferred from the Cold Springs (Ga.) station last year only 5 remained at the end of June, 1921. Because of the rather dense growth of vegetation in the pond in which they were carried nothing could be learned as to any possible spawning activities. A consignment of 500,000 pike-perch eggs received from the Swanton (Vt.) hatchery was successfully incubated, and the resulting fry were planted in New River, Va.

With the view of increasing the efficiency of the work at the Wytheville station, particularly in connection with trout propagation, further repairs and improvements were made in addition to the new water-supply system installed last year. The more important features of this improvement were the demolition of the old wooden building used as a nursery and the construction of a new two-story building 56 by 36 feet. The building is of concrete to the window sills of the second story and of frame construction above that. It will contain 60 standard troughs—20 on the first floor supplied with brook water and 40 on the second level—which may use either brook or spring water, or a mixture of both as may be desirable. An enlarged settling tank and filter are also in process of construction for the correction of the turbid condition to which the spring water is subject for long intervals after heavy rains.

WORK OF POND FISH-CULTURAL STATIONS.

Climatic conditions play an important part in all branches of fish culture, but the success or failure of a season's work at a pond-cultural station is peculiarly susceptible to temperature changes in the spring. If the weather in the early spring is warm, the spawning activities of the fish, particularly the basses, are hastened. Should this condition be followed by a period of falling temperatures, it inevitably results in the desertion of the nests by the adult fish and the loss of practically all the eggs produced.

Future work looking to an increase in the output of the pond fishes must lie along the line of more intensive cultural methods. The proper steps to be taken in this direction are as yet more or less of an unsolved problem, but such studies as have been made would indicate that the problems are subject to satisfactory and practical solution. To the practical fish-culturist the deductions formed by observation of the results obtained from a certain pond giving most excellent results are sometimes seemingly contradicted by the results from another pond where conditions, from the generally accepted theories, are more favorable. Further investigations and studies of these interesting and important problems are urged as being absolutely essential.

Another point in connection with the operation of the pond stations is to determine the most suitable and effective way to distribute the output. The very young fry can not be successfully handled. Even the transfer of such fry to rearing ponds usually meets with a very heavy mortality. On the other hand, if they are retained in the spawning ponds with the adults the first fry appearing are sure to prey to a large extent on the progeny of the later spawners and will themselves fall a prey to the adults. The loss of young fish from cannibalism is large in an artificial pond under the best of conditions. Perhaps the most suitable time to effect the transfer to rearing ponds or to distribute the fish in them is in the advanced fry or No. 1 fingerling stage. At this time they are hardy enough to withstand careful handling, and, being still under the guardianship of the male parent, may easily be taken in a net as they school along the shores of the pond.

SUMMARY OF OUTPUT.

The output of the stations devoted to the culture of the so-called warm-water or pond fishes during the fiscal year 1921 aggregated 2,473,711, as opposed to a production of 1,837,598 the preceding year. The seven stations included in the pond fish-cultural group are given in the table below, with the figures of the aggregate output of each for the fiscal years 1920 and 1921. The Edenton (N. C.) station, though listed with the pond fish-cultural stations, also does important work with the shad and glut herring, mention of which is made on pages 42 and 44 in this report.

OUTPUT OF POND FISH-CULTURAL STATIONS, FISCAL YEARS 1920 AND 1921.

Station.	Output.		Station.	Output.	
	1920	1921		1920	1921
Cold Springs, Ga.	226,833	279,675	San Marcos, Tex.	376,500	408,811
Edenton, N. C.	42,560	32,990	Tupelo, Miss.	472,420	479,875
Louisville, Ky.	404,475	1,020,450			
Mammoth Spring, Ark.	39,895	32,325	Total.	1,837,598	2,473,711
Orangeburg, S. C.	274,915	219,675			

COLD SPRINGS (GA.) STATION.

[CHARLES W. BULLOCK, Superintendent.]

Five spawning and two rearing ponds were completed during the year at this station, and it was hoped the additional facilities provided would permit of a material increase in output. As at other points in the Southern States, the weather during the bass spawning season was not propitious. There was a heavy spawning during an unusually warm period in March, permitting of the shipment of more than 100,000 advanced fry in April, whereas the distribution does not usually begin before May 1. A sudden cold spell in April caused a drop of 20 degrees in the water temperature. This resulted in destroying what had appeared to be bright prospects for a remarkably successful season. During the cold weather many of the schools disappeared, and the fish hatched later were small and their rate of growth slow. The few stragglers surviving from the schools destroyed preyed freely on the weaker fish. Perhaps not of the least importance in contributing to the disappointing results was the almost total disappearance from the ponds of the cladocerans, copepods, and chironomids that had been observed in abundance during the early spring. While the numbers of bass produced for distribution represent a very fair average for the station, in view of the promising outlook in the early spring the results are disappointing.

At the Harris Ponds substation catfish and bluegills are reared in the same ponds. In certain respects the bluegills can be more satisfactorily handled than the bass, as they take readily to artificial feeding. It is never possible to anticipate results in the propagation of catfish. In certain seasons the output will be ample for all needs, while the next season, under apparently identical conditions, only small numbers of young are produced. During the past season only 5,000 fingerlings were obtained from 60 adults. In the course of the spring one of the ponds were stocked with 50 adult catfish in addition to the bluegills. Later in the season a heavy mortality occurred as a result of a parasitic affection.

Attempts to propagate crappie at this station have not been particularly successful. Two ponds devoted to the species produced 1,750 fingerlings. Two hundred of these were reserved for brood fish, but as they are very shy and nervous, refusing to take artificial food, it is doubted if they will be of much value in that connection.

The station water supply is lacking in lime or other mineral substance, excepting for a trace of silica. The presence of lime in solution has always been considered desirable in pond fish culture. By way of experiment the water supply to one of the ponds was arranged to pass over a cask of lime, and the results are being noted.

The output of the station for the fiscal year consisted of 212,555 largemouth black bass, 4,120 catfish, 1,550 crappie, 61,350 sunfish, and 100 warmouth bass. Approximately 145,000 of the bass were fry, while the others were all of the fingerling size.

EDENTON (N. C.) STATION.

[EDW. M. HAYNES, Superintendent.]

Five ponds at this station are devoted to the production of the pond fishes, and their output for the year consisted of 23,085 large-

mouth black bass and 9,904 sunfish, all of the fingerling 2½ size. Thirty adult crappie, obtained during the season for use as brood fish, failed to reproduce, the fluctuating air and water temperatures during the spawning season having a decidedly unfavorable influence on these fish, as it also did on the bass. No recent changes have occurred in the method of conducting the work at this point.

LOUISVILLE (KY.) STATION.

[CHARLES W. BURNHAM, Superintendent.]

The fiscal year 1921 marks the most successful season in the history of the station in the production of fish. The output aggregated 1,020,450 fry and fingerlings, divided, by species, as follows: Largemouth black bass, 33,100; rock bass, 4,500; smallmouth black bass, 156,700; sunfish, 76,150; and yellow perch, 750,000. These fish were distributed to applicants in Kentucky, Indiana, and Ohio, and liberal plants of sunfish were made in local waters.

The brood stock of smallmouth black bass was increased during the year by the purchase of 277 adults from Lake Erie fishermen. Of this number 52 died shortly after being received. The remainder were placed in a spawning pond, but failed entirely to spawn. It is difficult to assign a reason for this, as the fish appeared to be in a healthy condition throughout. A number of those that died from the effects of transportation were examined and found to be carrying eggs, and the 125 older fish at the station produced very excellent results under similar conditions.

It is perhaps worthy of mention here that of the 200 adult smallmouth black bass sent to the Mammoth Spring (Ark.) station from Lake Erie none survived the winter. In connection with the propagation of the basses, it is interesting to note that the young smallmouth black bass grow much more rapidly than the young of the largemouth black species.

Yellow-perch propagation at Louisville was successful this season, the 750,000 fry distributed being the progeny of 300 brood fish. It may be possible to considerably extend this branch of the work by increasing the number of breeders carried in the ponds.

MAMMOTH SPRING (ARK.) STATION.

[WILLIAM S. VINCENT, Superintendent.]

A considerable amount of work looking to the improvement of the pond system was accomplished at this station during the year. Such work in the main has consisted in the installation of concrete "kettles" and outlets in many of the ponds, comprising what is believed to be an innovation in pond construction. (See Fig. 3, opp. p. 68.) Improvements were also made in the drainage system. Four small rearing ponds were converted into one large one, and work was done for the improvement and increased fertility of the bottoms of the ponds.

In an effort to build up the brood stock a number of adult fish of the various species propagated were obtained from local waters during the late summer and early fall. In October 200 adult smallmouth black bass were transferred from Lake Erie. Most of these were unable to survive the winter, and all had perished prior to the

spawning season. Hence, the total number of brood fish of this species on hand at that period did not exceed 200. The smallmouth black bass were first observed to be spawning on March 28, when 12 nests were noted, and 38 nests had been occupied by April 8. By the end of the third day fungus had entirely destroyed the eggs on the first 12 nests, and only a negligible number of fry was produced from the remainder of the first spawning. Spawning was resumed on May 6 and 7, when 12 more nests were occupied. From this spawning the total output of smallmouth black bass, amounting to 26,500 fry and fingerling fish, was obtained. No satisfactory explanation for the failure of the early spawning is at hand. The long interval between the spawning periods observed this season is unusual. In previous years it has rarely exceeded one week. In addition to the smallmouth black bass, smaller numbers of the largemouth black bass and rock bass were distributed.

ORANGEBURG (S. C.) STATION.

[GEORGE W. N. BROWN, Superintendent.]

At this station a new pond, approximately 1 acre in area and supplied with water from springs at the head of the small cove in which it is built, was completed and stocked with bass. The output consisted of 204,675 largemouth black bass, 300 crappie, 500 rock bass, and 14,200 sunfish (bluegills), all of fingerling size. A small number of sunfish carried over from the previous year were distributed in connection with the current season's hatch. The station has also a small stock of the spotted catfish (*Ictalurus punctatus*), and it was estimated that approximately 1,000 young of the species were on hand at the close of the year.

SAN MARCOS (TEX.) STATION.

[MARK RILEY, Superintendent.]

The distributions from this station for the year 1921 included the following species: Largemouth black bass, 257,715; catfish, 70,000; crappie, 5,904; rock bass, 320; sunfish, 74,872. The San Marcos station has for a number of years been successful in producing goodly numbers of fish for distribution at a cost that compares favorably with that at any other station. Local conditions seem particularly suited to the purpose, and, unlike the conditions at all other stations, it is not necessary to supply artificial food for either the young or the adult fish. The output for the year 1921 was curtailed by fluctuating water temperatures during the spring and, further, by the ponds overflowing on two occasions, an occurrence that is caused by the unsatisfactory method of street drainage. To augment the production of fish beyond the capacity of the station ponds it has been customary to stock privately owned ponds or "tanks" with fish, with the understanding that the bureau shall have the privilege of taking a reasonable number of the progeny for distribution. Very satisfactory results have been obtained by this method, particularly with the crappie.

TUPELO (MISS.) STATION.

[DAVID DAVIES, Superintendent.]

The output of this station for the year consisted of 405,500 largemouth black bass, 73,005 sunfish, and 1,280 crappie, and the distribution was extended to approximately 310 applicants, located in Mississippi, Alabama, Tennessee, Arkansas, Louisiana, and Kentucky. The station output was also supplemented by a carload shipment of miscellaneous fishes from the rescue field on the upper Mississippi River, consisting of crappie, catfish, rock bass, buffalofish, carp, and yellow perch, all of which entered into the general distributions.

Of possible interest in connection with pond fish culture was the unusually late spawning of the largemouth black bass this year. On August 19, 1921, a lot of 3,000 advanced largemouth black-bass fry were taken from one of the station ponds, and again, on September 28, another lot of the same species and size was obtained.

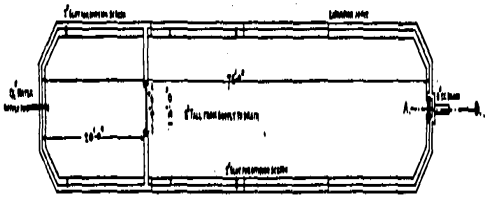
PRACTICAL DEVICES FOR USE IN POND FISH CULTURE.

A PRACTICAL SYSTEM OF CLEANING FISHPONDS.

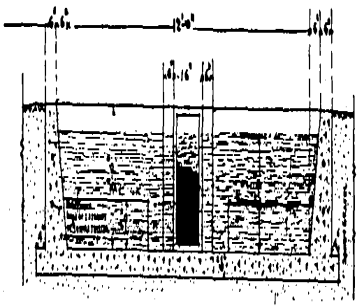
The necessity for the frequent cleaning of ponds in which fish are retained under artificial conditions is well known. If the ponds are of cement or lumber construction, the usual method of cleaning is to lower the water level and scrub the sides and bottom of the pond with a suitable brush. During the cleaning process the water in the pond becomes turbid and polluted from stirring up the accumulated sediment and filth from the bottom of the pond. The fish are forced to endure this unnatural condition until the pond is scrubbed, the accumulation of sediment flushed out through the outlet, and the pond again filled with clear water. In addition to this unfavorable condition to which the fish are exposed they are subject to further possible injury by bruises from contact with the brushes used in the scrubbing process. These conditions are entirely unavoidable under the system of cleaning in general use.

At the Manchester (Iowa) station a system of cleaning ponds that successfully overcomes both these difficulties has been adopted. (See Fig. 2.) At this station there are eight stock ponds of cement construction. They are approximately 80 by 13 feet and are 3 feet deep at the outlet, the bottom sloping upward toward the inlet, where the depth is 2½ feet.

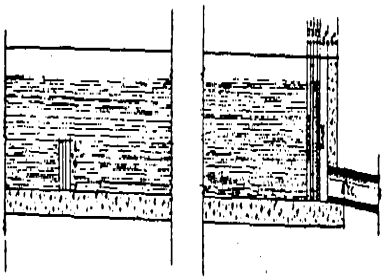
For the proper cleaning of the ponds a cement wall or dam, extending into the pond 4½ feet from each side, is installed, leaving a 4-foot opening in the middle. This dam is placed 20 feet from the inlet end of the pond and is 1 foot high. The open ends are grooved to accommodate a dam board 2 inches in thickness. In cleaning the pond the water level is lowered until that portion of the pond bottom between the inlet and the division wall is just covered. The pond being deeper at the outlet end, there is still sufficient water to hold the fish safely while the other section of the pond is being cleaned and flushed. After cleaning the first section the water is permitted to rise until the division wall is about submerged. The fish are then driven through the 4-foot opening in the wall into the clean section of the pond by the use of a "push screen." A board



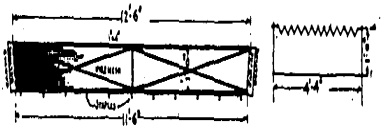
PLAN



CROSS SECTION C-D.

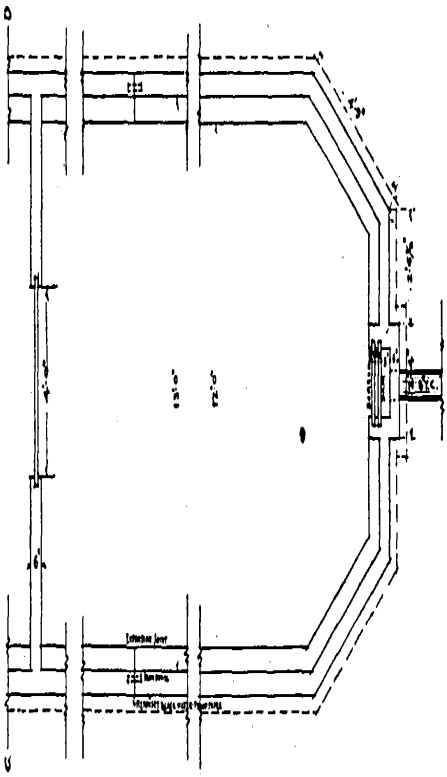


LONGITUDINAL SECTION A-B.



DAM BOARD

PUSH SCREEN



DETAIL PLAN

FIG. 2.—Plan of dam and "push screen" for convenient cleaning of stock fishponds. (Designed by F. E. Hare.)

2 inches thick, 1 foot wide, and 4 feet long is inserted in the grooves in the ends of the division wall to retain the fish, while the remaining portion of the pond is being cleaned. The dam board has a saw tooth edge permitting the overflow water to pass but preventing the escape of the fish.

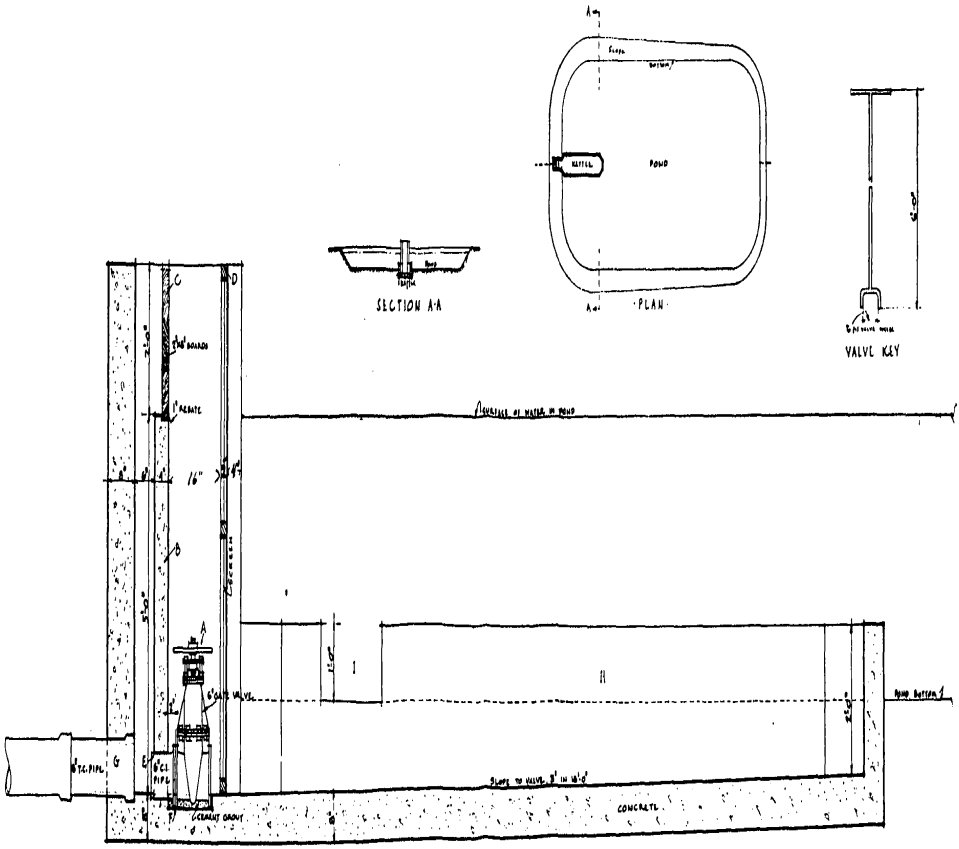
The "push screen" consists of a frame made of 1 by 4 inch lumber, to which is attached poultry netting of 1-inch mesh or smaller if the size of the fish requires. The smaller dimension of the lumber forms the face of the screen, to offer but slight resistance when being pushed through the water. Its shape conforms to the shape of the ponds. At Manchester the sides flare outward. In size it is somewhat shorter than the width of the pond for convenient handling, and to prevent the escape of fish around the ends strips of heavy duck or canvas belting are attached to each end of the screen. Iron staples driven into the bottom board at suitable intervals and slightly protruding will serve to keep the board from dragging on the bottom of the pond and facilitate the easy movement of the screen through the pond.

POND OUTLET AND "KETTLE."

As being of possible interest and value to persons interested in the subject a drawing of the pond outlet and "kettle" previously mentioned (p. 64), with descriptive text and specifications for construction, are given (Fig. 3).

In referring to the cut of the pond outlet and "kettle" it will be noted that it contains features not embodied in other constructions of a similar character. The drain box is made in about the same manner as those now in use at many stations, but in place of the wooden dam boards it has a cement dam *B*, the height of which is determined by the water level when the pond is filled. If it is desired to raise the water level of the pond, the wooden dam boards can be dropped in the slot *C*. The screen *D* is the same as those now in use. To draw down the water in the pond, a gate valve *A* is so placed at the bottom that all of it can be drawn through the kettle. To make this removable, a flanged valve of the standard low-pressure type is used. A short nipple with a flange on one end is placed in the forms when making the drain box. Later a rubber gasket is cut to size and the gate valve is bolted into place. It is not necessary to bolt the valve around the bottom, since it may be desirable at some time to remove it, and it would be a difficult matter to get at bolts so located. A 6-inch gate valve as described above measures approximately 10½ inches from face to face of flanges. Therefore, a standard valve should be used in place of the medium or heavy service valves. It will be necessary to place the flange of the nipple as close to the cement dam *B* as possible. Therefore, the bolts should be put in place before cementing.

Another feature of the plan is the construction of a cement "kettle" in front of the drain box. It will be noted that the side walls of this kettle extend approximately 12 inches above the earth floor of the pond, so that in drawing down the water in the pond when it drops below this point it must then enter at the sluice gates *I*. The small fish will be drawn down through these gates and will immediately seek the more quiet water at the upper end of the kettle.



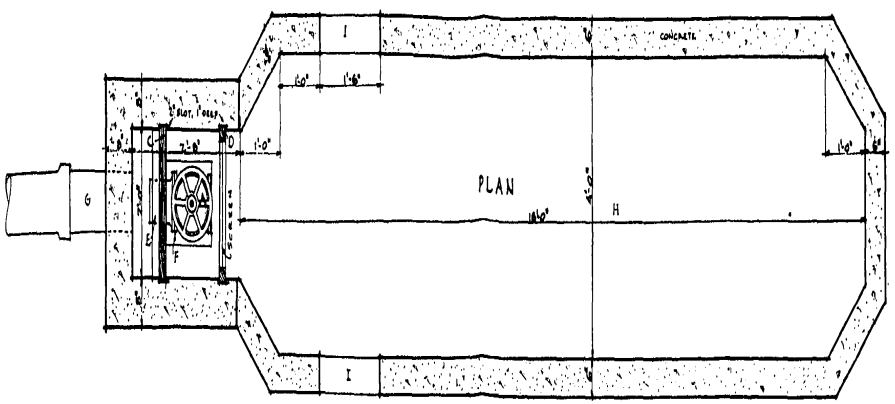


FIG. 3.—Plan of pond outlet and kettle for fishponds. (Designed by G. C. Leach.) 100267°—22. (Face p. 68.)

The water in this portion of the kettle is more or less clear. If only a few fish are desired, they can sometimes be dipped out with the ordinary hand dip net. In some instances it has been found advisable to put a cement walk around the outside of the kettle. This enables the fish-culturist to dip the fish out with greater ease and without agitating the mud on the earth bottom of the pond.

When it is desired to draw the water entirely off the pond, it is first lowered to about one-half its depth and the mud on the bottom of the kettle is stirred with a long-handled spade or broom until it is well agitated, when the gate valve *A* is opened wide and it is flushed out. After this the pond may be drawn down slowly and the fish drawn into the kettle. When the earth bottom of the pond is bare, there will be 1 foot of water in the kettle.

A 6-inch gate valve is sufficiently large for a pond one-half acre or less in area, an 8-inch valve for a three-fourths acre pond, and a 10-inch valve for a 1-acre pond.

SPECIFICATIONS.

Gate valve *A* is flanged and bolted to companion flanges *F* on nipple *E*, which passes through the center of cement dam *B*. The height of dam *B* is to correspond with the desired water level in the pond. Should it be necessary to raise the water level, wooden dam boards may be dropped in the slot *C*. *D* is the screen made in one or two sections, with a mesh in accordance with the size of fish to be carried. The gate valve should be set low enough for the water to drain out of the kettle *H*. Kettle *H* is constructed with end and side walls 12 inches higher than the earth bottom of the pond.

Preparatory to drawing down the pond for the removal of the fish the water is lowered by opening the gate valve with extension rod *J* to a point where it is possible to clean the bottom of the kettle with a long-handled brush. The mud and roily water is flushed out by opening the gate valve wide.

In drawing down the pond after the water level drops below the top wall of the kettle all water from the pond must enter at the side sluices *I*. This leaves the water comparatively quiet in the upper end of the kettle. The small fish seek that portion of the kettle and may easily be removed with a hand dip net.

Material in drain box.

Sides 8 inches, bottom 6 inches; total amount concrete, 50 cubic feet.

Cement	bags	12	1–2–4 mixture. Sand and broken stone or screened gravel.
Sand	cubic feet	22.5	
Stone and gravel	do	45	

Sides 6 inches, bottom 6 inches; total amount concrete, 38 cubic feet.

Cement	bags	9	1–2–4 mixture.
Sand	cubic feet	17	
Stone or gravel	do	34	

Fittings for drain box.

6-inch standard flanged gate valve.
6-inch companion flange.
6-inch nipple 6 inches long,

Reinforcement for dam.

Galvanized stock fence wire, 24-inch width preferred.

Material for kettle.

Walls 6 inches, bottom 6 inches; total amount concrete, 80 cubic feet.

Cement	bags	20	1–2–4 mixture.
Sand	cubic feet	38	
Stone or gravel	do	75	

MODIFIED FORM OF POND OUTLET.

Figure 4 on page 71 shows a modified form of the outlet just described, Figure 3.

In this outlet terra-cotta pipe has been substituted for iron, and the bell end of the terra-cotta ell, closed by the wooden disk, replaces the gate valve, while the cement dam, screen, removable wooden dam boards, and other features remain the same. When the pond is full, the ell opening is closed by the wooden disk, made tight by the use of clay. The wooden dam boards need not be used unless it is desired to raise the water level above the height of the permanent cement dam. To drain the pond, the wooden dam boards are fitted into their proper place and the wooden disk closing the ell opening in the terra-cotta dam pipe is removed by means of the iron rod to which it is attached. The depth of water at any stage of the operation may be controlled by proper manipulation of the wooden dam boards.

Each of the outlets described here, as well as the one described in a previous publication of the bureau,[3] has distinctive points of advantage and have been developed in meeting the varied conditions encountered in fishpond construction. It remains for the prospective pond builder to select the type best suited to his needs. The types described here are considered particularly desirable in ponds of comparatively large area or where the amount of water to be carried requires the use of correspondingly large pipe. The convenience of the valve in controlling the flow of water in drawing the pond, Figure 3, is easily recognized, but practically the same results are obtainable with the simpler installation shown in Figure 4, and the cost of fittings for this type will be somewhat less.

Work of Central Station, Washington, D. C.

[L. G. HARRON, Superintendent.]

Beginning with rainbow-trout eggs in December, 1920, and closing with pike-perch eggs in May, 1921, there were incubated in the hatchery apparatus maintained in the fisheries building at Washington for public display 7,717,000 fish eggs, representing eight species of fish—chinook salmon, rainbow and brook trouts, whitefish, cisco yellow perch, pike perch, and shad—from which 6,400,327 fry and fingerlings were distributed to applicants in Maryland, Virginia, West Virginia, Delaware, Pennsylvania, and New York.

[3] Coker, R. E.: Progress in Biological Inquiries, 1921. Report of the Division of Scientific Inquiry for the Fiscal Year 1921. Appendix VIII, Report, U. S. Commissioner of Fisheries for 1921, 38 pp., 2 figs. (A new Form of Pond Outlet, pp. 21–24, Figs. 1 and 2.) Washington, 1922.

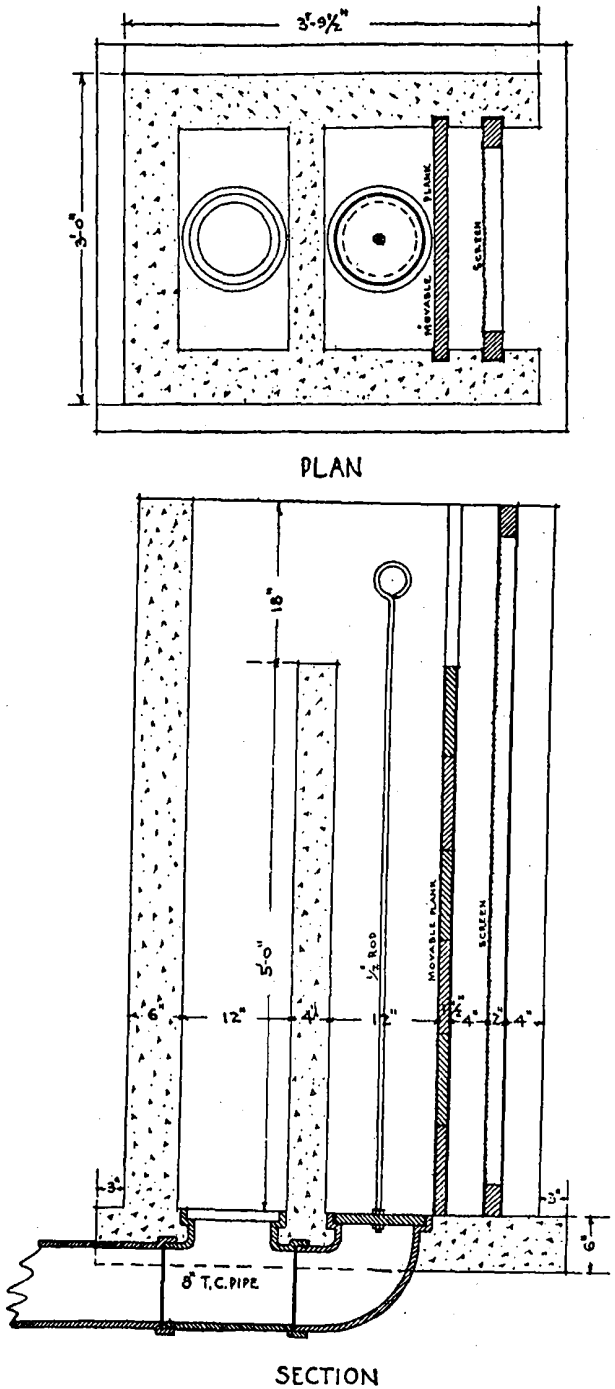


FIG. 4.—Plan of a simple and inexpensive outlet for fishponds. (Designed by G. C. Leach.)

In addition to the hatchery exhibit a display of adult fresh-water fishes was maintained in the aquaria throughout the year. The total number of fish exhibited was 2,614, representing 45 species. Collections for restocking were made from time to time from the Potomac River at Bryans Point, Md. Other sources of supply were the bureau's stations at White Sulphur Springs, W. Va.; Bellevue, Iowa; Bozeman, Mont.; the New York Aquarium, and the New York Conservation Commission hatchery at Caledonia, N. Y.

The health of the aquaria fishes throughout the year was generally good, with the exception of a short period during May and June, when a number of the fish were attacked by the parasite Ichthyophthirius, causing a considerable loss, particularly among the warm-water fishes. It has recently been found that this parasite may be destroyed by treating the fishes infected with a saturated solution of bicarbonate of soda. The solution is conveniently applied directly to the fish when held in shallow water with a small paintbrush. The treatment removes the mucous coating from the fish and destroys the parasite with no injury to the fish.

Spawning Seasons of Fishes Handled at Stations.

Records of the spawning seasons of the various species of fishes handled at the bureau's stations during the fiscal year 1921, together with the water temperatures at the beginning and end of such periods, are given in the following table, in which the stations are grouped and arranged as in the preceding discussion of the propagations of the commercial species and the species for stocking the interior waters; that is, Pacific salmon, Great Lakes, Marine, New England salmon and trout, Rocky Mountain trout, combination trout and pond fish-cultural, and pond fish-cultural stations.

SPAWNING SEASONS OF FISHES HANDLED AT STATIONS, WITH WATER TEMPERATURES AT BEGINNING AND END OF PERIODS, FISCAL YEAR 1921.

PACIFIC SALMON STATIONS.

Station.	Species.	Spawning season.	Water temperatures, °F.	
			Beginning of season.	End of season.
Afognak, Alaska	Sockeye salmon	July 31 to Sept. 24	52	40
Baker Lake, Wash	Silver salmon	Nov. 17 to Dec. 15	40.5	35.5
	Sockeye salmon	Oct. 10 to Nov. 30	46	39
Birdsview	Chinook salmon	Sept. 20 to Oct. 25	43	41
	Silver salmon	Nov. 20 to Feb. 11	43	41
	Steelhead salmon	Mar. 26 to May 21	44	47
Brinnon	Chum salmon	Nov. 15 to Jan. 6	50	48
	Steelhead salmon	Apr. 15 to May 11	42	52
Duckabush	Chum salmon	Aug. 28 to Sept. 12	49	49
	Silver salmon	Nov. 27 to Mar. 1	46	44
	Steelhead salmon	Apr. 11 to May 27	46	48
Quilcene	Chum salmon, early	Aug. 23 to Oct. 6	51	50
	Chum salmon, late	Nov. 4 to Jan. 3	45	45
	Silver salmon	Oct. 20 to Jan. 20	47	43
	Steelhead salmon	Mar. 22 to June 1	45	49
Quinault	Chinook salmon	Oct. 1 to Nov. 15	47	40
	Silver salmon	Nov. 3 to Dec. 15	42	40
	Sockeye salmon	....do	42	40
Sultan	Chinook salmon	Sept. 13 to Oct. 15	51	47
	Silver salmon	Oct. 8 to Feb. 2	49	42
	Steelhead salmon	Mar. 10 to May 28	42	45

SPAWNING SEASONS OF FISHES HANDLED AT STATIONS, ETC.—Continued.

PACIFIC SALMON STATIONS—Continued.

Station.	Species.	Spawning season.	Water temperatures, °F.	
			Beginning of season.	End of season.
Clackamas, Oreg.	Chinook salmon	Sept. 19 to Nov. 15	50	48
Upper Clackamas	Chinook salmon, spring run.	Aug. 25 to Sept. 24	59	60
Little White Salmon	Chinook salmon	Sept. 19 to Oct. 14	47	46
	Chum salmon	Oct. 28 to Dec. 2	42	39
	Silver salmon	Nov. 26 to Dec. 2	41	39
Big White Salmon	Chinook salmon	Sept. 19 to Oct. 15	47	47
Rogue River	Blackspotted trout	Mar. 29 to May 12	40	46
	Chinook salmon, spring run.	Aug. 11 to Oct. 15	56	40
	Silver salmon	Oct. 10 to Nov. 25	45	40
	Steelhead salmon	Feb. 26 to May 10	40	46
Applegate Creek	Chinook salmon	Nov. 1 to Dec. 1	42	40
	Silver salmon	Nov. 18 to Mar. 1	40	40
	Steelhead salmon	Jan. 5 to May 19	37	50
Washougal River	do	May 10 to June 2	48	62
Salmon, Idaho	Chinook salmon, spring run.	Aug. 14 to Sept. 15	63	60
Baird, Calif.:				
Battle Creek	Chinook salmon	Oct. 19 to Nov. 14	48	49
Mill Creek	do	Oct. 26 to Nov. 18	54	52
GREAT LAKES STATIONS.				
Duluth, Minn: Marquette, Mich.	Lake trout	Oct. 10 to Nov. 10		
Northville, Mich.: Charlevoix.	do	Nov. 12 to 26	48	45
Put in Bay, Ohio:				
Catawba Island	Whitefish	Nov. 13 to 29	40	41
North Bass Island	do	Nov. 10 to 29	43	41
Port Clinton	Carp	May 23 to June 13	68	75
	Pike perch	Apr. 5 to 24	48	49
	Whitefish	Nov. 13 to 29	40	41
Toledo	Pike perch	Apr. 8 to 24	48	49
Cape Vincent, N. Y.:				
Bygotts Point	Cisco	Nov. 22 to Dec. 1	35	32
	Whitefish	Nov. 10 to 23	43	34
Pigeon Island	Lake trout	Nov. 1 to 15	50	48
St. Lawrence River	Yellow perch	May 15 to June 15	46	50
BRYANS POINT (MD.) STATION.				
Bryans Point, Md.	Yellow perch	Mar. 10 to 23	53	57
	Shad	Apr. 22 to May 9	56.5	57
MARINE STATIONS.				
Boothbay Harbor, Me.	Flatfish	Mar. 10 to Apr. 22	36	45
Gloucester, Mass.	Cod	Jan. 15 to Apr. 29	38	48
	Haddock	Jan. 22 to Apr. 25	36	46
	Pole flounder	May 22 to end of summer, probably.	56	
	Pollock	Nov. 15 to Jan. 21	46	36
	Winter flounder	Mar. 18 to Apr. 22	40	46
Woods Hole, Mass.	Cod	Nov. 26 to Feb. 4	45	34
	Winter flounder	Jan. 16 to Mar. 30	38	43
NEW ENGLAND SALMON AND TROUT STATIONS.				
Berkshire, Mass.	Brook trout	Oct. 21 to Nov. 10	44	44
	Rainbow trout	Dec. 22 to Jan. 20	44	40
Craig Brook, Me.	Atlantic salmon	Oct. 20 to Nov. 12	55	46
Green Lake, Me.	Landlocked salmon	Nov. 10 to Dec. 1	48	37
	Smelt	Apr. 20 to 22	51	51
Grand Lake Stream	Landlocked salmon	Oct. 31 to Nov. 28	54	38
Nashua, N. H.	Brook trout	Nov. 3 to Dec. 20	48	47
	Rainbow trout	Nov. 3 to Dec. 23	48	46
St. Johnsbury, Vt.	Brook trout	Oct. 15 to Nov. 1	54	43
	Lake trout	do	54	43

SPAWNING SEASONS OF FISHES HANDLED AT STATIONS, ETC.—Continued.

ROCKY MOUNTAIN TROUT STATIONS.

Station.	Species.	Spawning season.	Water temperatures, °F.	
			Beginning of season.	End of season.
Bozeman, Mont.:				
Meadow Creek, Mont.	Rainbow trout	Apr. 15 to June 10	43	54
Yellowstone Park, Wyo.	Blackspotted trout	June 13 to July 22	40	55
Leadville, Colo.	Brook trout	Oct. 10 to Dec. 7	40	32
Saratoga, Wyo.	do	October and November	51	41
	Rainbow trout	April and May	48	54
	Loch Leven trout	October and November	51	41
Spearfish, S. Dak.	Brook trout, brood stock	Oct. 25 to Jan. 14	46	44
	Loch Leven trout, wild fish.	Oct. 16 to Dec. 12	46	45
	Rainbow trout, brood stock.	Jan. 18 to Mar. 20	44	39
Springville, Utah:				
Fish Lake	Brook trout	Nov. 1 to 14	42	42
	Rainbow trout	May 1 to June 4	42	42

COMBINATION TROUT AND POND FISH-CULTURAL STATIONS.

Erwin, Tenn.	Brook trout	Oct. 1 to Jan. 1	54	53
	Carp	May 1 to July 1	54	54
	Catfish	June 1 to Oct. 20	54	54
	Largemouth black bass	Apr. 15 to June 1	54	55
	Rainbow trout	Nov. 1 to Jan. 15	53	53
	Rock bass	May 1 to Sept. 1	54	54
	Smallmouth black bass	Apr. 15 to June 1	54	55
	Sunfish	May 1 to Sept. 1	54	54
	Yellow perch	Mar. 1 to Apr. 30	54	54
Manchester, Iowa	Brook trout	Nov. 4 to Dec. 17	50	50
	Largemouth black bass	May 15 to June 1	50	50
	Rainbow trout	Dec. 22 to Apr. 19	50	50
	Rock bass	May 15 to June 1	50	50
Neosho, Mo.	Crappie	April and May	57	57
	Largemouth black bass	Apr. 8 to June 20	57	58
	Rainbow trout	November to February	57	57
	Rock bass	Apr. 21 to July 18	57	58
	Smallmouth black bass	Apr. 22 to June 10	57	58
	Sunfish	May 10 to Sept. 1	57	58
	Yellow perch	Apr. 8 to 20	57	57
White Sulphur Springs, W. Va.	Brook trout	Nov. 15 to Dec. 13	53	50
	Largemouth black bass	May 1 to 25	64	73
	Rainbow trout	Nov. 11 to Jan. 31	53	49
	Rock bass	May 1 to June 15	67	75
	Smallmouth black bass	May 1 to 25	64	73
	Sunfish	May 1 to June 15	67	75
Wytheville, Va.	Largemouth black bass	Apr. 15 to June 20	60	60
	Rainbow trout	Oct. 10 to Mar. 15	54	54
	Rock bass	May to July	60	60
	Smallmouth black bass	Apr. 15 to June 20	60	60
	Sunfish	May to July	60	60

POND FISH-CULTURAL STATIONS.

Cold Springs, Ga.	Catfish	May 1 to June 30	64	80
	Crappie	Apr. 1 to June 30	61	80
	Largemouth black bsss	Mar. 15 to July 15	64	72
	Sunfish	Apr. 1 to July 31	61	72
Edenton, N. C.	Largemouth black bass	Mar. 20 to June 15	64	80
	Sunfish	June 1 to July 15	74	80
Louisville, Ky.	Largemouth black bass	Apr. 7 to 24	60	64
	Rock bass	Apr. 24 to June 15	64	76
	Smallmouth black bass	Apr. 14 to May 2	60	61
	Sunfish	Apr. 25 to June 30	68	85
	Yellow perch	Mar. 26 to Apr. 7	58	58
Mammoth Spring, Ark.	Rock bass	May 1 to June 1	59	60
	Smallmouth black bass	Mar. 28 to May 7	67	64

SPAWNING SEASONS OF FISHES HANDLED AT STATIONS, ETC.—Continued.

POND FISH-CULTURAL STATIONS—Continued.

Stations.	Species.	Spawning season.	Water temperatures, °F.	
			Beginning of season.	End of season.
Orangeburg, S. C.	Catfish	Apr. 25 to June 30	74	78
	Crappie	Apr. 10 to June 30	70	78
	Smallmouth black bass	Mar. 15 to June 1	63	70
	Sunfish	Apr. 5 to June 30	68	78
San Marcos, Tex.	Crappie	March through June, mainly.		
	Largemouth black bass	Whole year, but mainly March through May.		
	Sunfish	Whole year		
Tupelo, Miss.	Crappie	Apr. 5 to May 20	68	77
	Largemouth black bass	Mar. 15 to June 1	69	82
	Sunfish	Apr. 14 to June 20	63	83

Fish Food Used at Fish-Cultural Stations.

AMOUNT AND COST OF FISH FOOD USED.

The ideal condition sought by all fish-culturists is a water area so arranged that a natural food supply is available when needed, but from our present knowledge the ideal is impossible of attainment in most cases and artificial feeding must be resorted to. In the rearing of fish under artificial environment, therefore, the problem of a satisfactory food supply at a reasonably low cost is ever present.

The following table gives for the fiscal year 1921 the number of pounds and the cost per pound of artificial fish food used at the various fish-cultural stations during the fiscal year 1921:

POUNDS AND COST PER POUND OF FISH FOOD USED, FISCAL YEAR 1921.

PACIFIC SALMON STATIONS.

Station.	Salted salmon.		Canned salmon.		Frozen salmon eggs.		Beef liver.	
	Lbs.	*Cost.*	*Lbs.*	*Cost.*	*Lbs.*	*Cost.*	*Lbs.*	*Cost.*
Afognak, Alaska	860	$0.015						
Yes Bay, Alaska	600	.03						
Baker Lake and substations, Wash.	1,215	.03					114	$0.15
Quinault, Wash.	3,000	.015						
Clackamas, Oreg., and substations	43,200	.03	9,000	$0.001	9,440	$0.04		
Baird, Calif., and substations	8,000	.01					880	.11
Total	56,875		9,000		9,440		994	

Station.	Beef spleen.		Pork liver.		Milk.		Wheat middling.	
	Lbs.	*Cost.*	*Lbs.*	*Cost.*	*Gals.*	*Cost.*	*Lbs.*	*Cost.*
Afognak, Alaska								
Yes Bay, Alaska								
Baker Lake and substations, Wash.	2,886	$0.05			176	$0.25		
Quinault, Wash.			2,230	$0.07				
Clackamas, Oreg., and substations	10,395	.045						
Baird, Calif., and substations							760	$0.03
Total	13,281		2,230		176		760	

POUNDS AND COST PER POUND OF FISH FOOD USED, FISCAL YEAR 1921—Continued.

NEW ENGLAND SALMON AND TROUT STATIONS.

Station.	Beef liver.		Beef hearts.		Beef spleen.		Sheep liver.		Pork liver.		Fishotine.	
	Lbs.	Cost.	Lbs.	Cost.	Lbs.	Cost.	Lbs.	Cost.	Lbs.	Cost.	Lbs.	Cost.
Berkshire trout hatchery, Mass.	1,336¾	$0.13	.....	.....	4,100	$0.05	372	$0.05	347	$0.07	.....	.....
Craig Brook, Me.	192	.12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Green Lake, Me.	352	.10	.....	.....	.....	.....	80	.07	170	.05½	.....	.....
Nashua, N. H.	1,263	.08	215	$0.05	.....	.....	1,337	.04¾	512	.06	.....	.....
St. Johnsbury, Vt.	758½	[1].08	.....	.....	.....	.....	.....	.....	.....	.....	57	$0.09
Total	3,892¼	.....	215	.....	4,100	.....	1,789	.....	1,029	.....	57	.....

ROCKY MOUNTAIN TROUT STATIONS.

Station.	Beef liver.		Beef hearts.		Beef spleen.		Sheep liver.		Wheat chop.	
	Lbs.	Cost.	Lbs.	Cost.	Lbs.	Cost.	Lbs.	Cost.	Lbs.	Cost.
Bozeman, Mont.	9,649	$0.09	.....	.....	.....	.....	.....	.....	.....	.....
Leadville, Colo.	32	.12½	2,711	$0.08½	.....	.....	.....	.....	.....	.....
Spearfish, S. Dak.	922	.12	1,280	.12	.....	.....	2,680	$0.07½	.....	.....
Springville, Utah.	4,234	.07	1,018	.07	1,770	$0.05	8,064	.06	4,000	$0.03½
Saratoga, Wyo.	3,997	[1].08	.....	.....	.....	.....	835	.04	.....	.....
Total	18,834	.....	5,009	.....	1,770	.....	11,579	.....	4,000	.....

COMBINED TROUT AND POND FISH-CULTURAL STATIONS.

Station.	Beef liver.		Beef hearts.		Sheep liver.		Sheep hearts.	
	Lbs.	Cost.	Lbs.	Cost.	Lbs.	Cost.	Lbs.	Cost.
Erwin, Tenn.	.....	.....	2,896	$0.08½	6,431	$0.06½	.....	.....
Manchester, Iowa.	.....	.....	2,637	.06½	13,997	.03½	.....	.....
Neosho, Mo.	.....	.....	385	.06½	10,919	.04	.....	.....
White Sulphur Springs, W. Va.	74	$0.09	2,903	.06½	21,387½	.04	8,275	$0.04½
Wytheville, Va.	.....	.....	2,705	.08¾	6,882	.06	.....	.....
Total	74	.....	11,526	.....	59,316½	.....	8,275	.....

Station.	Canned herring milt.		Meatein.		Azotine.		Shorts.	
	Lbs.	Cost.	Lbs.	Cost.	Lbs.	Cost.	Lbs.	Cost.
Erwin, Tenn.	96	$0.14	200	$0.08	.....	.....	5,300	$0.04½
Manchester, Iowa.	.....	.....	.....	.....	.....	.....	200	.03¾
Neosho, Mo.	.....	.....	.....	.....	.....	.....	4,000	.03
White Sulphur Springs, W. Va.	96	.14	.....	.....	.....	.....	.....	.....
Wytheville, Va.	.....	.....	.....	.....	250	$0.07¼	5,825	.03½
Total	192	.....	200	.....	250	.....	15,325	.....

POND FISH-CULTURAL STATIONS.[2]

Station.	Beef liver.		Beef hearts.		Fresh fish.		Fishotine.		Shorts.	
	Lbs.	Cost.	Lbs.	Cost.	Lbs.	Cost.	Lbs.	Cost.	Lbs.	Cost.
Cold Springs, Ga.	.....	.....	285¾	$0.08¾	5,154	$0.16½	400	$0.09½	400	$0.04
Edenton, N. C.	56¾	$0.20	.....	.....	269¼	.15½	.....	.....	.....	.....
Louisville, Ky.	.....	.....	289	.15	.....	.....	.....	.....	.....	.....
Mammoth Spring, Ark.	.....	.....	446½	.12	.....	.....	.....	.....	.....	.....
Orangeburg, S. C.	.....	.....	971	.12½	.....	.....	.....	.....	.....	.....
Tupelo, Miss.	.....	.....	1,908	.11	.....	.....	.....	.....	.....	.....
Total	56¾	.....	3,900½	.....	5,423¼	.....	400	.....	400	.....

[1] Beef liver and hearts combined.
[2] No artificial foods used at the San Marcos (Tex.) station.

FOOD FOR BASS.

One of the principal problems encountered at most of the pond fish-cultural stations pertains to a suitable food supply for both young and adult bass. At the Cold Springs (Ga.) station fresh mullet was for a number of years the staple food for the bass, but this material has not given entire satisfaction, and recently the price has been prohibitive. Beef hearts and groupers have been tried, but the fish show some reluctance in accepting either of these materials. More recently pork hearts have been tried with very satisfactory results.

TESTS WITH HERRING MILT AS FOOD FOR RAINBOW TROUT.

During the past year the bureau has purchased several cases of canned herring milt for the purpose of testing its value as a food for young rainbow trout. It has been tried at several hatcheries, and while the results of the tests made in comparison with other foods in more general use are not necessarily conclusive they seem to indicate that canned herring milt when used alone is not a satisfactory article of diet for young trout, though when used in combination with a meat product it may perhaps be considered a desirable article for the fish-culturists to keep on hand as an emergency food. It has the advantage of being easily prepared, does not "smoke" or discolor the water, and will keep for a long period.

A noticeable feature in connection with this experiment is that for a short period—ranging from 10 to 17 days—the fish receiving herring milt exclusively appeared to thrive equally as well as those receiving a meat diet and the mortality was not greater, but beyond that time the death rate increased so rapidly that in most cases the experiments were discontinued, as it appeared that none of the fish would survive under the treatment. A change to the usual foods appears to have restored normal conditions among the fish.

The tabulated statement of the results of these tests in feeding may be of interest. Rainbow trout were involved exclusively, and in each instance the fish had not previously received artificial food.

RESULTS OF TESTS WITH HERRING MILT AS FOOD FOR RAINBOW TROUT.

ERWIN (TENN.) STATION.

[Test continued for 16 days—2,500 fish per trough.]

Trough number.	Food used.	Weight per 1,000 fish—			Loss per 1,000 fish during test.
		At beginning of test.	At end of test.	Gained during test.	
		Ounces.	*Ounces.*	*Ounces.*	*Per cent.*
1	Beef heart	6	8	2	7½
2	Canned herring milt	6	7	1	21½

RESULTS OF TESTS WITH HERRING MILT AS FOOD FOR RAINBOW TROUT—Contd.

NEOSHO (MO.) STATION.

[Test continued for 30 days—2,000 fish per trough.]

Trough number.	Food used.	Weight per 1,000 fish.			Loss per 1,000 fish during test.
		At beginning of test.	At end of test.	Gained during test.	
		Ounces.	*Ounces.*	*Ounces.*	*Per cent.*
1	Canned herring milt 3 days, beef hearts 3 days, alternately	6	12½	6½	1⅛
2	Canned herring milt 3 days, sheep liver 3 days, alternately	6	11½	5½	5⅛
3	Beef heart	6	19¾	13¾	1⅛
4	Sheep liver	6	12	6	4⅛

WHITE SULPHUR SPRINGS (W. VA.) STATION.

[Test continued for 20 days—10,000 fish per trough.]

1	Canned herring milt	4½	8½	4	12⅛
2	Sheep liver	4½	9½	5	1⅛
3	Canned herring milt 10 days, sheep liver 10 days, alternately	4½	9	·5	1⅛

WYTHEVILLE (VA.) STATION.

[Test continued for 10 days—13,000 fish per trough.]

1	Canned herring milt	4½	5	½	7⅛
2	Beef heart	4½	6½	1½	3⅛

Rescue Operations.

[C. F. CULLER, in Charge.]

OUTLINE OF POSSIBLE EXTENSION.

So much has already been said regarding the importance of the rescue operations conducted in the Mississippi Basin, their value, simplicity, practical returns, and comparatively low cost that these phases of the work should be familiar to all interested persons. A brief outline of the possibilities of extending the work, with suggestions as to its requirements, may not be out of place, in view of the bill now pending before Congress to provide funds for enlarging its scope. Almost unlimited possibilities exist for the further extension of the work. In the bureau's greatest effort during the fiscal year 1920, when approximately 160,000,000 of fishes were saved, not more than 40 per cent of the available territory was covered. There are many miles of unbroken stretches of river lowlands where floods annually result in the destruction of millions of fish, while the major tributaries of the Mississippi afford a field of unknown possibilities. For the economical and efficient conduct of the work it would be desirable to establish headquarters near the central point of the more important operations, with a personnel available for its prosecution at all times. Under present arrangements the personnel for the rescue work is drawn from four of the regularly established

fish-cultural stations. This diversion is apt to result in a comparative lack of interest in the work of the home stations, and not infrequently it curtails their operations. Moreover, men drawn from other lines of activities can not be expected to be as familiar or as efficient in the prosecution of the rescue work as will men who can devote all their time to it. The work has grown to such proportions that men drawn from the fish-cultural stations can no longer handle it to the fullest advantage under such conditions.

The rescue field would afford profitable employment for such a force throughout the year, the line of operations to be something as follows: Rescue of fishes along the upper reaches of the river would occupy the attention of the men from July to December, during which time a crew of five men could save from 8,000,000 to 10,000,000 fish, at a total approximate cost of $2,000. That number of fish purchased from commercial fish-culturists would cost the bureau from $25,000 to $30,000 and to citizens of the Mississippi Valley would represent a food value of $1,000,000 to $1,500,000 when placed on the market three years after being rescued. These figures are very conservative when compared with the results attained at the bureau's regularly established fish-cultural stations. At the close of the rescue season important work in the salvage of eggs in connection with the commercial fisheries in Louisiana would consume practically all the time of the men from February to April. From Louisiana the crew would work northward to the confluence of the Ohio and the Mississippi Rivers, where important fields are open in the three adjoining States. The Illinois River overflows its dikes during the spring freshets, and in May or early June large pumps are operated to remove the water from the land. Many millions of young fish are thus left in the fields to perish or are passed through the pumps and destroyed. During the comparatively short periods when active rescue work is not under way the time could be profitably employed in repair and maintenance of the equipment used.

In addition to a personnel provided especially for the rescue work there should be two or three additional holding stations, these being essential for the "hardening" of the fish required for distribution. A part of the rescued fish are held in tanks of clear water and "hardened" for several days to enable them to withstand transportation. They are then shipped in the bureau's specially equipped distribution cars and planted in suitable tributary waters. Experience has shown that greater results can be attained in this way than by returning all fish rescued to the main river. The wider distribution also gives to people living in various parts of the Mississippi Valley a better opportunity to obtain fresh fish.

In addition to the requirements outlined above, houseboats with living quarters for a crew of five or six men should be provided. These boats would be placed in certain sections of the river, and when the pools at one point had been cleaned up they would be moved downstream to other fields. Launches will be needed to transport the crews to and from the fields of operation, to carry supplies, and to distribute fish. It has been found more economical to own launches than to rent them. Boats for hire are seldom in good running condition, and much valuable time is lost in repairs before the men can be placed in the field. There will be necessity for a boathouse and

storeroom at a central point for the proper housing of boats and equipment; also for two dwelling houses to serve as quarters for the men in immediate charge of the work.

Since the Mississippi River is largely a boundary water, most of the States regard the rescue operations as a work belonging to the Federal Government rather than to the States. Most of the States have rendered excellent cooperation; but in many cases their appropriations for rescue and fish-cultural work have been more or less sporadic, hence the work could not be well organized nor efficiently handled. Moreover, most of the States have a problem in maintaining the fish in their interior waters.

Citizens throughout the Mississippi Valley have urged the bureau to extend this valuable work, arguing that they are entitled to fresh fish as a food, and that it should not be necessary for them to depend upon the Pacific coast, the Atlantic coast, or the Great Lakes for their supply. They can not understand why an earnest effort should not be made to save the millions of fish that are dying in pools along the river.

METHODS EMPLOYED IN RESCUING FISH.

A rescue crew usually consists of five men and a foreman. A launch is employed in going to and from the field of operations, and the equipment for each field comprises two seines of one-fourth-inch mesh, from 50 to 75 feet long and 5 feet deep; six galvanized-iron tubs of 1½-bushel capacity; small dip nets; two tin dippers; and a small flat-bottomed boat, the latter being used in ponds too deep for wading.

After making a haul the fish are assorted into tubs by species and size. The number per tub is ascertained by noting the water displacement, one or more rings having been made on the inside of each tub, and the number established by actual count. The count is verified several times during the season, as the fish in some instances are subject to rapid growth.

When first taken from the warm water the fish will not safely stand a long railway journey. Therefore those intended for distribution are taken to the nearest holding station and hardened by being held for several days in cool running water. While the number of fish diverted for supplying applicants at a distance may seem large in the aggregate, it represents less than 1 per cent of the total collections. Such diversions during the fiscal year 1921 amounted to 660,110 fish of miscellaneous species.

REVIEW OF THE WORK.

The aggregate number of fish rescued during the fiscal year 1921 amounted to 120,656,420, a decrease of almost 36,000,000 as compared with the record of the previous year. Two causes contributed to this result. Labor conditions were unsatisfactory, making it difficult to obtain efficient crews at all points at the rate of compensation offered. The river remained at a high stage for a longer period than usual, thus permitting large numbers of fish bred in the overflow waters to return to the river unaided. This appears to have been particularly true with reference to such species as the carp, buffalofish, and catfish.

The work began at Prescott, Wis., on August 12 and was brought to a close at Bellevue, Iowa, on November 10, these dates indicating an unusually short season on account of the natural conditions mentioned. The work was conducted in the following fields:

One crew, with house boat, from Prescott, Wis., to Red Wing, Minn.; thence to Genoa, Wis.
Two crews on house boats from Wabash to Winona, Minn.; thence to Dakota and Dresshack, Minn.
Two crews from Homer, Minn.
One crew from La Crosse, Wis.
One crew from Genoa, Wis.
One crew from Ferryville, Wis.
Two crews from Lynxville, Wis.
One crew from Marquette, Iowa.
One crew with house boat from Dubuque to Bellevue, Iowa.
One crew from Bellevue, Iowa.

In addition to the regular rescue work collections of eggs from carp and buffalofish taken by commercial fishermen were made at Bellevue and Lynxville. The eggs were taken, fertilized, and planted on the natural spawning grounds. Such work was done from May 9 to 25 and resulted in the fertilization of 68,287,000 buffalofish and 42,718,000 carp eggs. Had these eggs not been thus handled they would have been sent to the markets in the fish and lost. While the planting of fertilized eggs is not considered as efficient as incubating them in a well-equipped hatchery, it is believed that under certain conditions it is expedient and results in much good if properly done.

In addition to the operations on the upper Mississippi rescue work was conducted from the Fairport (Iowa) biological station; also on the Illinois River at Meredosia and Cairo, Ill., and at San Marcos, Tex. The operations from Fairport and substations were in conjunction with the propagation of the fresh-water mussel, large numbers of the rescued fish being inoculated with the mussel glochidia before being liberated. Owing to unfavorable water stages the active season at Cairo was very short, extending only from October 1 to 19. In this field one seining crew working under the direction of the superintendent of the Louisville (Ky.) station salvaged a total of 1,057,215 fish of miscellaneous species at a total cost of $582.07, or at the rate of 55 cents per thousand fish handled. In the vicinity of the San Marcos (Tex.) station 202,886 black bass, catfish, and sunfish were removed from the bed of a stream, which almost entirely evaporated during a protracted hot spell, and were deposited in living waters. Reference to the table on page 7 will show the points from which rescue work was prosecuted during the season, the number of fishes salvaged at each and restored to the original waters, and the number delivered to applicants.

Part 2.—DISTRIBUTION OF FISH AND FISH EGGS.

Extent and Character of the Work.

[E. C. Fearnow, Superintendent of Fish Distribution.]

BRIEF REVIEW OF THE WORK.

The 4,962,489,405 fish and fish eggs (see table, p. 5) representing the net product of the hatcheries and rescue stations of the bureau for

the fiscal year 1921 were widely disseminated, the distribution reaching practically every State in the Union and the Territories of Alaska and Hawaii. Consignments of fish eggs were also shipped to the Governments of Canada, France, and Switzerland, and an allotment of fish was forwarded to an applicant in Mexico.

Fully 93 per cent of the output is represented by important commercial species—the salmons, shad, whitefish, pike perch, yellow perch, lake trout, cod, pollock, haddock, flounder, buffalofish, and carp. All of such fishes are planted on or adjacent to the spawning areas where the eggs originate, or the eggs are consigned to State commissions for incubation and distribution in nonproductive waters where conditions appear to favor the development of new fisheries. (See p. 87.) Included under the head of the commercial fishes are the large numbers of food fish annually salvaged from the overflowed territory along the Mississippi River and at other points (see pp. 7 and 78), a branch of the work that has become one of the most popular, practical, and beneficial of the bureau's activities.

Among the more important species propagated for the stocking of interior waters are the brook, rainbow, and blackspotted trouts, the largemouth and smallmouth black basses, rock bass, sunfish, crappies, and catfish. While the numbers of such fishes are by comparison small, representing only 7 per cent of the aggregate output, the importance of this work is not to be underestimated. It is this branch of its work which brings the bureau in close contact with the general public, as is evidenced by the large number of applications received each year, and the interest thus aroused in the fisheries can not be other than beneficial. The economic value of the work is large. In most instances the reports received from applicants regarding the results obtained from planting fish furnished by the bureau are of a highly satisfactory nature. (See p. 88.)

SUMMARY OF DISTRIBUTION TO ALL APPLICANTS.

The following table shows in summarized form how many and what species of fish and fish eggs out of the net product of the hatcheries and rescue stations for the fiscal year 1921 were delivered to all applicants, both in the United States and Territories and in foreign countries. Only a small percentage of the immense numbers of fish rescued from overflowed lands was delivered to applicants, the great bulk having been returned to the original waters, as is shown in the table on page 7.

SUMMARY, BY SPECIES, OF DISTRIBUTION OF FISH AND EGGS TO ALL APPLICANTS, FISCAL YEAR 1921.

[Asterisk (*) denotes eggs; dagger (†), fry; all others are fingerlings or yearlings.]

UNITED STATES AND TERRITORIES.

State and species.	Number.
Alabama:	
Carp	45
Catfish	2,240
Crappie	1,900
Largemouth black bass	†153,550
	46,585
Rock bass	4,000
Sunfish	45,300
Alaska: Sockeye salmon	*350,000
	†30,761,000
	26,977,500
Arizona:	
Brook trout	73,000
Catfish	1,200
Crappie	2,775
Rainbow trout	37,000
Rock bass	200
Sunfish	1,000
Yellow perch	300
Arkansas:	
Catfish	5,620
Crappie	6,520
Largemouth black bass	†39,000
	24,461
Rainbow trout	49,061
Rock bass	10,140
Smallmouth black bass	†25,500
	2,639
Sunfish	20,120
Yellow perch	1,000
California:	
Chinook salmon	*3,000,000
	4,593,400
Rainbow trout	*25,000
Steelhead salmon	*20,000
Colorado:	
Blackspotted trout	†868,500
Brook trout	†27,000
	2,004,050
Lake trout	24,000
Largemouth black bass	9,725
Loch Leven trout	34,000
Rainbow trout	*200,000
	62,500
Sunfish	600
Connecticut:	
Brook trout	135,600
Catfish	2,400
Largemouth black bass	2,380
Pike perch	†150,000
Rainbow trout	13,000
Delaware: Pike perch	†500,000
District of Columbia:	
Rainbow trout	13,500
Shad	†800,000
Florida:	
Largemouth black bass	2,450
Sunfish	400
Georgia:	
Brook trout	38,000
Catfish	3,060
Crappie	300
Largemouth black bass	†82,500
	45,405
Rainbow trout	70,000
Rock bass	100
Sunfish	37,250
Warmouth bass	100
Hawaii: Rainbow trout	*25,000
Idaho:	
Blackspotted trout	*50,000
	23,000
Brook trout	29,275
Landlocked salmon	*15,000
Rainbow trout	*128,000
	27,000
Whitefish	*500,000
	†500,000

State and species.	Number.
Illinois:	
Brook trout	500
Buffalofish	141,653
Carp	125,211
Catfish	1,546,730
Crappie	148,204
Drum	175
Lake trout	*10,000
Largemouth black bass	8,741
Pike and pickerel	410
Pike perch	250
Rainbow trout	*1,000
Rock bass	900
Sunfish	208,350
White bass	2,510
Whitefish	*2,000,000
Yellow perch	100
Miscellaneous fishes	16,390
Indiana:	
Brook trout	†24,000
	22,500
Carp	25
Catfish	1,980
Crappie	1,040
Largemouth black bass	†12,000
	8,775
Rainbow trout	18,500
Rock bass	600
Smallmouth black bass	12,900
Sunfish	2,760
Yellow perch	2,275
Iowa:	
Brook trout	11,775
Buffalofish	†68,267,000
	557,590
Carp	†42,718,000
	528,902
Catfish	3,272,437
Crappie	6,405,468
Drum	2,120
Lake trout	*50,000
Largemouth black bass	44,797
Pike perch	37,560
Rainbow trout	*64,500
	5,500
Rock bass	47,000
Smallmouth black bass	1,500
Sunfish	5,230,707
White bass	9,410
Yellow perch	223,175
Miscellaneous fishes	3,487,105
Kansas:	
Catfish	250
Largemouth black bass	240
Rainbow trout	1,625
Sunfish	200
Yellow perch	800
Kentucky:	
Buffalofish	107,350
Carp	44,715
Catfish	673,400
Crappie	172,400
Largemouth black bass	†20,000
	6,675
Pike perch	4,900
Rainbow trout	500
Rock bass	4,775
Smallmouth black bass	†146,000
	2,500
Sunfish	131,750
White bass	800
Yellow perch	†450,000
	1,200
Louisiana: Buffalofish	†40,040,000
	150
Catfish	600
Crappie	530
Largemouth black bass	150

SUMMARY, BY SPECIES, OF DISTRIBUTION OF FISH AND EGGS, ETC.—Continued.

[Asterisk (*) denotes eggs: dagger (†), fry; all others are fingerlings or yearlings.]

UNITED STATES AND TERRITORIES—Continued.

State and species.	Number.
Maine:	
Atlantic salmon	†1,387,000
	280
Brook trout	*256,890
	†1,730,930
Flounder (winter)	†841,235,000
Lake trout	*50,000
Landlocked salmon	*375,000
	†208,115
	108,400
Pollock	†11,906,000
Rainbow trout	†26,000
Smelt	†7,000,000
Sockeye salmon	†17,500
Maryland:	
Brook trout	18,700
Catfish	1,500
Chinook salmon	2,500
Cisco	*300,000
Crappie	2,180
Lake trout	*4,000
Largemouth black bass	4,350
Pike perch	*1,000,000
Rainbow trout	*150,000
	37,750
Rock bass	360
Shad	†7,436,250
Sunfish	4,260
Whitefish	*100,000
Yellow perch	†85,205,850
	300
Massachusetts:	
Brook trout	257,525
Carp	100
Catfish	7,400
Cod	*208,800,000
	†175,341,000
Flounder (pole)	*19,410,000
Flounder (winter)	†848,993,000
Haddock	*188,940,000
	†271,880,000
Largemouth black bass	550
Pike perch	†725,000
Pollock	†443,160,000
Rainbow trout	*50,000
	29,600
Smallmouth black bass	†12,000
Sunfish	180
Michigan:	
Blackspotted trout	*10,000
Brook trout	†264,000
	500,375
Carp	200
Catfish	6,950
Crappie	640
Lake trout	*1,000,000
	†14,875,000
Landlocked salmon	*10,000
Largemouth black bass	16,400
Pike perch	*277,250,000
	†8,040,000
Rainbow trout	†34,000
	64,975
Rock bass	600
Smallmouth black bass	19,351
Smelt	*400,000
Steelhead salmon	†23,810
Sunfish	1,675
Whitefish	*20,000,000
	†29,500,000
Yellow perch	1,200
Minnesota:	
Brook trout	78,820
Buffalofish	30,175
Carp	1,190,320
Catfish	10,746,580

State and species.	Number.
Minnesota—Continued.	
Crappie	15,929,225
Drum	19,405
Lake trout	†670,000
	20,000
Largemouth black bass	153,765
Pike and pickerel	175,040
Pike perch	†2,500,000
Rainbow trout	56,400
Smallmouth black bass	1,000
Steelhead salmon	*70,000
Sunfish	11,727,380
White bass	6,990
Whitefish	†100,000
Yellow perch	4,912,812
Miscellaneous fishes	527,080
Mississippi:	
Carp	84
Catfish	2,460
Crappie	1,344
Largemouth black bass	†165,500
	37,640
Rainbow trout	5,000
Rock bass	300
Sunfish	49,030
Yellow perch	100
Missouri:	
Buffalofish	8,395
Carp	19,684
Catfish	269,638
Crappie	130,570
Drum	420
Largemouth black bass	21,361
Pike perch	470
Rainbow trout	59,329
Rock bass	4,125
Smallmouth black bass	2,260
Sunfish	51,680
White bass	840
Yellow perch	768
Miscellaneous fishes	480
Montana:	
Blackspotted trout	*350,000
	†854,000
	522,500
Brook trout	*200,000
	436,175
Catfish	1,600
Grayling	†1,400,000
Largemouth black bass	1,350
Rainbow trout	*225,000
	†250,000
	758,000
Steelhead salmon	*75,000
Nebraska:	
Brook trout	†32,900
	39,000
Largemouth black bass	1,000
Rainbow trout	43,000
Nevada: Rainbow trout	*50,000
	23,000
New Hampshire:	
Brook trout	†381,000
	519,500
Catfish	4,600
Lake trout	*25,000
	†12,000
	1,400
Landlocked salmon	*20,000
	5,850
Pike perch	*2,000,000
	†500,000
Rainbow trout	33,000
Smallmouth black bass	†14,200
Steelhead salmon	545
Whitefish	*250,000

SUMMARY, BY SPECIES, OF DISTRIBUTION OF FISH AND EGGS, ETC.—Continued.

[Asterisk (*) denotes eggs; dagger (†), fry; all others are fingerlings or yearlings].

UNITED STATES AND TERRITORIES—Continued.

State and species.	Number.
New Jersey:	
Brook trout	7,400
Catfish	600
Crappie	400
Largemouth black bass	4,040
Pike perch	*1,000,000
	†1,050,000
Rainbow trout	4,000
Sunfish	4,800
Yellow perch	100
New Mexico:	
Blackspotted trout	†73,500
Brook trout	492,000
Catfish	3,600
Crappie	3,755
Largemouth black bass	900
Rock bass	1,400
Sunfish	1,400
Yellow perch	100
New York:	
Blackspotted trout	*10,000
Brook trout	†446,000
	42,000
Carp	100
Catfish	7,200
Cisco	*121,210,000
	†89,800,000
Crappie	750
Lake trout	*1,510,000
	†456,000
	5,550
Landlocked salmon	*125,000
	4,000
Largemouth black bass	12,490
Pike perch	*525,000
	†10,495,800
Rainbow trout	*10,000
	†65,100
	1,900
Steelhead salmon	*199,000
	2,500
Whitefish	*59,300,000
	†41,100,000
Yellow perch	†13,700,000
	3,700
North Carolina:	
Brook trout	253,500
Crappie	950
Glut herring	†43,815,000
	†5,500
Largemouth black bass	102,580
Rainbow trout	453,100
Rock bass	11,200
Shad	†15,756,000
Smallmouth black bass	1,635
Striped bass	†20,184,000
Sunfish	27,520
North Dakota:	
Carp	5
Catfish	800
Crappie	500
Largemouth black bass	6,380
Rock bass	400
Ohio:	
Brook trout	†33,000
Buffalofish	1,000
Carp	†63,325,000
Catfish	6,375
Crappie	1,800
Largemouth black bass	14,380
Pike perch	†12,600,000
Rainbow trout	†10,000
Rock bass	600
Smallmouth black bass	6,300
Sunfish	10,570
Whitefish	*30,640,000
	†167,500,000

State and species.	Number.
Ohio—Continued.	
Yellow perch	†300,000
	800
Oklahoma:	
Catfish	2,250
Crappie	4,350
Largemouth black bass	2,720
Rainbow trout	*100,000
	56,400
Rock bass	1,350
Sunfish	2,000
Yellow perch	2,200
Oregon:	
Black-spotted trout	101,500
Brook trout	4,000
Chinook salmon	*3,650,000
	10,682,900
Rainbow trout	*604,940
	189,500
Shad	†2,347,100
Silver salmon	417,050
Steelhead salmon	1,316,000
Pennsylvania:	
Brook trout	†3,000
	613,475
Carp	85
Catfish	11,600
Chinook salmon	10,000
Cisco	*65,000,000
Crappie	3,050
Lake trout	*50,000
Landlocked salmon	*10,000
Largemouth black bass	24,870
Pike perch	†2,174,200
Rainbow trout	396,701
Rock bass	200
Smallmouth black bass	125
Steelhead salmon	*55,000
Sunfish	11,800
Whitefish	*10,000,000
Yellow perch	1,175
Rhode Island:	
Brook trout	23,000
Flounder (winter)	†78,432,000
Largemouth black bass	150
Smallmouth black bass	†5,500
South Carolina:	
Crappie	300
Largemouth black bass	117,875
Rainbow trout	16,000
Sunfish	5,000
South Dakota:	
Brook trout	379,100
Catfish	400
Crappie	375
Loch Leven trout	2,000
Lake trout	5,000
Largemouth black bass	3,850
Rainbow trout	84,110
Sunfish	500
Tennessee:	
Brook trout	13,935
Catfish	5,100
Crappie	4,050
Largemouth black bass	†86,000
	23,955
Rainbow trout	*55,000
	171,000
Rock bass	8,900
Smallmouth black bass	3,530
Sunfish	15,200
Yellow perch	900
Texas:	
Catfish	70,350
Crappie	5,904
Largemouth black bass	257,370
Rock bass	320
Sunfish	74,872

SUMMARY, BY SPECIES, OF DISTRIBUTION OF FISH AND EGGS, ETC.—Continued.

[Asterisk (*) denotes eggs; dagger (†), fry; all others are fingerlings or yearlings.]

UNITED STATES AND TERRITORIES—Continued.

State and species.	Number.
Utah:	
Blackspotted trout	91,300
Brook trout	188,300
Catfish	2,250
Lake trout	*50,000
Rainbow trout	161,000
Whitefish	†100,000
Vermont:	
Brook trout	†591,400
	89,200
	*25,000
Lake trout	†38,300
	4,900
Landlocked salmon	*20,000
	6,000
Pike perch	*14,700,000
	†13,150,000
Rainbow trout	7,200
Steelhead salmon	*25,000
	6,320
Yellow perch	*12,000,000
	†2,600,000
Virginia:	
Brook trout	118,350
Catfish	1,300
Crappie	100
Largemouth black bass	†15,000
	24,003
Pike perch	†500,000
Rainbow trout	279,600
Rock bass	10,660
Shad	†6,452,925
Smallmouth black bass	†88,500
	100
Sunfish	8,225
Yellow perch	†74,113,600
	300
Washington:	
	*100,000
Blackspotted trout	†9,000
	79,700
Brook trout	*300,000
Chinook salmon	*130,000
	17,491,965
Chum salmon	†7,000,000
	19,436,400
Rainbow trout	*75,000
	3,000
Silver salmon	†600,000
	6,069,100

State and species.	Number.
Washington—Continued.	
Sockeye salmon	†8,000,000
	3,457,000
	*49,000
Steelhead salmon	†15,000
	1,603,550
West Virginia:	
Brook trout	212,815
Catfish	8,100
Crappie	2,700
Largemouth black bass	†6,000
	8,212
Rainbow trout	181,100
Rock bass	175
Smallmouth black bass	†12,000
	750
Sunfish	3,400
Yellow perch	800
Wisconsin:	
Brook trout	†103,000
	655,355
Buffalofish	799,520
Carp	2,009,104
Catfish	18,580,500
Crappie	14,470,840
Drum	11,960
Lake trout	†512,000
	15,000
Largemouth black bass	171,990
Pike and pickerel	322,130
Pike perch	†5,000,000
Rainbow trout	†29,000
	150,190
Sunfish	12,687,546
White bass	6,620
Whitefish	*28,760,000
Yellow perch	1,012,230
Miscellaneous fishes	904,110
Wyoming:	
	*100,000
Blackspotted trout	†2,044,900
	182,300
Brook trout	*100,000
	302,400
Catfish	5,900
Lake trout	20,150
Largemouth black bass	8,660
Loch Leven trout	28,000
Rainbow trout	*309,800
	327,000
Smelt	*200,000

FOREIGN COUNTRIES.

Country and species.	Number.
Canada: [1]	
Blackspotted trout	*200,000
Rainbow trout	*280,000
Whitefish	*30,000,000
France: Rainbow trout	*150,000
Mexico:	
Largemouth black bass	600
Yellow perch	500
Switzerland:	
Lake trout	*50,000
Rainbow trout	*50,000

[1] In exchange for trout eggs 600,000 Atlantic salmon eggs were received from Canada.

ASSIGNMENTS TO STATE FISH COMMISSIONS.

The following table shows the States in which the State fish commissions, as applicants, received part of the distribution shown in

the preceding table and gives the species and numbers of fish and fish eggs assigned to each such commission:

ASSIGNMENTS OF FISH AND FISH EGGS TO STATE FISH COMMISSIONS, FISCAL YEAR 1921.

[NOTE.—Asterisk (*) denotes eggs; dagger (†), fry; all others are fingerlings.]

State and species.	Number.
California: Chinook salmon	*3,000,000
Colorado: Rainbow trout	*50,000
Connecticut: Brook trout	52,000
Idaho:	
Blackspotted trout	*50,000
Landlocked salmon	*15,000
Rainbow trout	*50,000 7,000
Whitefish	*500,000
Illinois:	
Catfish	25,300
Crappie	5,800
Drum	175
Largemouth black bass	200
Pickerel	410
Pike perch	250
Rock bass	500
Sunfish	26,325
White bass	175
Whitefish	*500,000
Iowa:	
Lake trout	*50,000
Rainbow trout	*62,000
Maine:	
Lake trout	*50,000
Landlocked salmon	*475,000
Maryland:	
Cisco	*300,000
Lake trout	*4,000
Pike perch	*1,000,000
Rainbow trout	*150,000
Whitefish	*100,000
Massachusetts: Rainbow trout	*50,000
Michigan:	
Lake trout	*1,000,000
Landlocked salmon	*10,000
Pike perch	*223,200,000
Smelt	*200,000
Whitefish	*20,000,000
Minnesota:	
Catfish	6,800
Crappie	5,200
Largemouth black bass	9,340
Steelhead salmon	*70,000
Sunfish	5,200
Yellow perch	2,250
Missouri:	
Rainbow trout	100
Sunfish	100
Montana:	
Blackspotted trout	*350,000
Rainbow trout	*150,000
Steelhead salmon	*75,000
Nebraska:	
Brook trout	32,000
Rainbow trout	30,000
Nevada: Rainbow trout	*50,000
New Hampshire:	
Lake trout	*25,000
Landlocked salmon	*20,000
Pike perch	*2,000,000
Whitefish	*250,000
New Jersey: Pike perch	*1,000,000
New York:	
Cisco	*104,410,000
Lake trout	*1,500,000
Landlocked salmon	*100,000
Steelhead salmon	*199,000
Whitefish	*29,200,000
Ohio: Whitefish	*23,640,000
Oklahoma:	
Rainbow trout	*100,000 †41,000 8,000
Rock bass	100
Oregon:	
Chinook salmon	*3,650,000
Rainbow trout	*604,940
Pennsylvania:	
Chinook salmon	10,000
Cisco	*65,000,000
Lake trout	*50,000
Steelhead salmon	*30,000
Whitefish	*10,000,000
South Dakota:	
Brook trout	2,100
Rainbow trout	3,000
Tennessee: Rainbow trout	*55,000
Utah: Lake trout	*50,000
Vermont:	
Lake trout	*25,000
Landlocked salmon	*20,000
Pike perch	*14,700,000
Steelhead salmon	*25,000
Yellow perch	*12,000,000
Washington:	
Blackspotted trout	*75,000
Rainbow trout	*75,000
Steelhead salmon	*49,000
Wyoming:	
Blackspotted trout	*100,000
Brook trout	*100,000
Catfish	1,200
Largemouth black bass	2,150
Rainbow trout	*309,800
Total	*483,914,740 †41,000 236,575

CONSIDERATIONS IN DISTRIBUTION OF COMMERCIAL FISHES.

The output of the bureau's hatcheries handling the commercial species is planted in local waters on the natural spawning grounds in so far as this may be desirable or practicable. This course is obviously necessary for the maintenance of the fishery involved, particularly where commercial fishing is aggressively prosecuted or where, as in the case of the anadromous fishes, commercial activities are coincident with the spawning season of the fish. It has been ably argued that the bureau's hatcheries belong to the people and that the output should be distributed more widely in neighbor-

ing States. If such a course were to be generally followed, the results would most certainly be disastrous. If a hatchery addressed to the propagation of a commercial species is successful in maintaining the fishery against the inroads of market fishing in the region covered by its activities, it may be fairly classed as efficient. If its annual output is only just sufficient to accomplish this purpose, it would be suicidal to divert any portion of it to other waters. Most of the States object, and with justice, through their fisheries authorities to the shipment outside their boundaries of eggs taken in their waters or the fry produced from such eggs.

The attitude of the fishermen is also a consideration. In most cases the bureau is to a large extent dependent on them for its egg collections. Speaking generally, the fishermen are deeply interested and render hearty cooperation. They watch the work with jealous interest, and any large or unwarranted diversion of eggs or fry would meet with strong opposition from them, and if persisted in would certainly result in refusal of the fishermen to deliver their eggs to the hatcheries. While the bureau's hatcheries are operated for the general good and the public is benefited by the increased food supply, the local fishermen are perhaps most intimately interested, and they should render every possible assistance to the hatcheries. Certain States now have laws whereby fishermen are given permits to fish during the closed season, with the restriction that all mature eggs shall be delivered to an agent of the bureau or the State for propagation. As the fishes are the property of the State, such a requirement is held to be just.

On the other hand, if a hatchery of the bureau succeeds in obtaining large numbers of eggs, more than are required for local waters, an intelligent distribution of the output to other waters is then permissible and even desirable. Under the most favorable conditions the results of natural spawning can not be expected to equal from 75 to 80 per cent of the numbers of young fishes put out by an efficient hatchery. Nature undoubtedly provides for a rather wide distribution of young fishes from natural reproduction. It is therefore not always advisable to limit the distribution of the output of a hatchery beyond reasonable restrictions, because if more young fishes are placed in a limited area than the waters can support they can not be expected to produce proportionate returns in marketable fish.

The following are among the points to be considered in connection with the distribution of the commercial species in new waters: (1) Do the waters under consideration support a commercial fishery? (2) Are the laws adequate for the protection of the fishes? (3) What are the conditions regarding dams or other barriers and pollution from trade or other forms of waste? (4) What is the attitude of local fishermen, and will they be willing to cooperate in the collection of eggs for the work of artificial propagation?

RESULTS OF PLANTING FISHES IN INTERIOR WATERS.

By E. C. Fearnow,
Superintendent of Fish Distribution.

The question has frequently been asked whether the bureau's work in stocking streams and ponds in the interior States is producing satisfactory results. While the numerous letters received from ap-

plicants from time to time are favorable in character, no effort has heretofore been made to condense such information into a tabular form to indicate the general effects of the work.

The system of card-indexing applications, inaugurated in 1917, will in course of time give such information. However, it is believed that a table classifying the results accomplished during several years would be very useful in giving the bureau and the general public a concrete idea as to the value of the work that is being done in the interior States. A table of this character would also be invaluable when making assignments of fishes, as it would show what species are most productive in a given region.

The following is an explanation of the grades used in classifying the results: "Excellent" means that the fish increased in size and multiplied. "Good" is used where the applicant was satisfied, the fish attaining a large size, the number of fish apparently on the increase. "Fair" means that the results are only ordinary, many of the applicants merely use this word to express the results of the plants. "Overflow" is used where the dam of the pond broke and the fish escaped. This does not mean a loss of the fish, as in many instances the statement is made that certain streams were stocked by the breaking of dams. "Uncertain" is used where the applicant is undecided as to results. Most of the reports classified under this heading cover plants of fish made in large streams and lakes, where it was found difficult to determine whether the fish furnished by the bureau had actually produced results, owing to the waters being previously stocked with the same species. "Poor" covers reports which indicate that the plants were a failure. Failures are attributed to a number of causes as follows: Not adapted to the waters; fish received in poor condition; destroyed by snakes and other noxious animals. Many failures are attributed to the severe winter of 1916 and 1917, when ponds froze to an unprecedented depth. In some instances the fish were stolen.

The following table shows the general results of planting fishes during the fiscal year 1917:

GENERAL RESULTS, BY SPECIES, OF FISH PLANTINGS, FISCAL YEAR 1917.

Species.	Number of reports.	Increase and growth.					
		Excellent.	Good.	Fair.	Overflow.	Uncertain.	Poor.
Catfish	127	34	47	25	2	8	11
Buffalofish	2	1	1				
Shad	1					1	
Whitefish	4	2	2				
Steelhead salmon	20	3	6	2		8	1
Landlocked salmon	28	8	15	3		1	1
Rainbow trout	589	157	234	98	7	50	53
Blackspotted trout	288	101	151	26		6	4
Loch Leven trout	6	2	3			1	
Brown trout	1	1					
Lake trout	21	4	9	2		3	3
Brook trout	1,514	532	717	124	6	45	90
Grayling	9	5	2	1		1	
Smelt	3		3				
Crappie	235	59	77	49	9	20	21
Largemouth black bass	927	270	415	108	32	52	50
Smallmouth black bass	326	101	131	41	5	29	19
Rock bass	76	14	21	19	4	9	9
Sunfish	280	57	88	59	25	18	33
Pike perch	97	43	19	11	1	14	9
Yellow perch	32	10	8	4		4	6
White perch	11		2	1		7	1
Total	4,597	1,402	1,943	574	92	277	309

Of the 4,597 reports received 30.5 per cent showed excellent results, 42.2 per cent good, 12.4 per cent fair, a little over 2 per cent overflow, over 6 per cent uncertain, and 6.5 per cent poor.

Black bass and sunfish appear to produce highly satisfactory results in most of the States, though many applicants have been dissatisfied with the sunfish on account of its small size, the growth attained not being as large as with some species. The stock of sunfish at most of the bureau's hatcheries has been improved in recent years, and it is believed that from now on this fish will give perfect satisfaction.

The rainbow trout appears to be especially well adapted to the waters of California, Colorado, New Mexico, Montana, North Carolina, and Wisconsin, while on the other hand a large percentage of failures or of only fairly good returns have been reported with that species in Arizona, Massachusetts, Ohio, New York, and Pennsylvania. This tends to accentuate the frequently expressed opinion that the rainbow trout is not as a rule adapted to eastern waters. It is true that the rainbow trout appears to have been very successfully established in West Virginia and in certain sections of Tennessee and North Carolina, but the data at hand would indicate that for eastern waters in general the conditions are better adapted to the brook trout. Numerous reports have been received to the effect that no rainbow trout were ever seen in waters where they had been planted. Mention of this failure of the rainbow trout to establish itself in certain sections of the country is very prominent in the reports.

DISTRIBUTION COSTS AND EQUIPMENT.

COST OF DISTRIBUTION.

As in all other lines of activity, the cost of distributing the output of the bureau's hatcheries has increased very considerably in recent years. The net increase in distribution costs since 1916 has amounted to approximately 150 per cent. The distribution of an output not appreciably decreased during this period, with no increase in funds provided for the conduct of the work, has been accomplished only by exercising the most rigid economy at every point. Unless additional funds for the propagation and distribution of food fishes is forthcoming, it may be necessary to inaugurate decided changes in the distribution methods to meet the increasing demands for fish.

During the fiscal year 1921 the cars of the bureau traveled 85,060 miles, while detached messengers in charge of live fishes traveled 385,988 miles, honoring approximately 10,000 applications for fish. The total cost of making this distribution, including maintenance and repairs to five distribution cars, amounted to $69,600.

DISTRIBUTION CARS.

The two steel cars added to the distribution service during the spring of 1920 have fully demonstrated their superiority over the cars of wood construction. Their increased carrying capacity, together with lower cost for maintenance and repair, make them in every respect a high-class investment. It is recommended that the

two wooden cars still in use be replaced with cars of steel at an early date. In addition to the advantages already cited, it is frequently necessary to accept second-class service in the movement of the wooden cars, as many railroads refuse to move them in their first-class trains.

POCKET THERMOMETER FOR USE IN CARRYING LIVE FISH.

An improved device of interest in connection with the distribution of live fish is a pocket thermometer designed especially for the convenience of messengers in making shipments of fish or fish eggs. The column of mercury is protected by a hard rubber jacket, provided with a pocket clip and a ring, to which a cord may be attached. The advantages claimed for it over the type of thermometer previously used are its lighter weight and its greater convenience when in actual use. It is also less subject to breakage than the metal-jacketed thermometer.

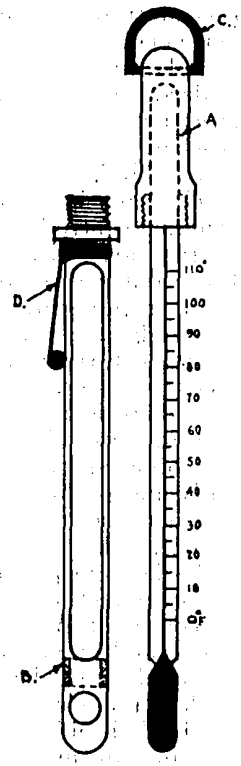


FIG. 5.—Pocket thermometer designed particularly for use in connection with the distribution of living fishes. (Designed by E. C. Fearnow.)

Procedure in Assignments of Fishes to Applicants.

APPLICATION BLANKS.

On receipt of a request for fish the bureau supplies a blank calling for a complete description of the waters to be stocked. When the blank is properly executed and returned with the indorsement of a Member of Congress, the bureau endeavors to assign a suitable species of fish thereon, and the delivery is made at the earliest practicable date, at the applicant's railroad station, without cost to him. As the information requested on the application blank is used as a basis for determining the species to be assigned and to some extent the number of fish that will be furnished, the applicant should endeavor to have it as complete and accurate as possible.

SELECTION OF SPECIES.

One of the most perplexing problems confronting the division of fish culture is how to distribute the product of its hatcheries in a manner which will bring about the best results and at the same time be just and equitable to the large number of persons who every year apply to the bureau for fishes for stocking waters, both public and private.

Many persons who are familiar with some particular species of fish insist on its introduction into waters in which they may be interested. In one case an applicant who has recently moved to a new section of the country wants his favorite fish in the local waters, while in another case an applicant applies for a certain species on

the recommendation of a friend or because the species has afforded him pleasure in another region. The importance of making a careful survey of the waters to be stocked, with the view of determining the species best adapted thereto, is often not recognized. It has been proved beyond a doubt that in nearly every case it is advisable to plant a species which is native to the locality, and in specifying his choice of fish the applicant should bear this in mind. Nonindigenous species should not be introduced unless it can be clearly shown that the native species, because of changed conditions, have failed to maintain themselves. There are many notable examples of the successful transplanting of fishes where the results have been highly beneficial. However, there is always an element of uncertainty in the planting of nonindigenous fishes in any region, and it should be undertaken only after a careful consideration of all phases of the situation, because if promiscuous plantings were to be permitted the work of fish culture might easily become a curse instead of a blessing to mankind.

The carp is an appropriate example of the results of the indiscriminate introduction of a foreign species. This fish was popular in the early history of fish culture in America, largely, perhaps, because it was a favorite with European fish-culturists and because of its rapid growth and ready adaptability to new surroundings. Through carelessness and indifference the carp became widely distributed in the waters of the country, with the result that in many sections a stigma will always apply to this sturdy fish. Nevertheless, there is a place in the piscatorial world for the carp, and for certain waters it fills a demand that can not be adequately met by any other species. It frequently happens that carp can be successfully and profitably propagated in waters that are quite unsuited to the finer species; and, under proper restrictions, this idea should be encouraged.

Aside from possible injury to indigenous species that may follow the introduction of foreign fishes, there are other important points to consider: Will the new inhabitants find a suitable temperature range and other conditions congenial to their reproduction? Will the food supply be of a suitable character and ample for their needs? Unless these essentials are present an introduced species can not establish itself in a new environment on a self-maintaining basis. Not infrequently species of fishes that are possessed of the highest food and game qualities in their natural habitat will, when transplanted in less favorable surroundings, degenerate to a point where they have no attractions either from a food or a game standpoint. Even the planting together of the same species of fish taken from different sections of the country or from different streams in the same section may be inadvisable. Certain investigators have expressed the belief that such plantings may lead, or in certain instances may have already led, to a form of hybridization which may result in seriously impairing the virility of the progeny.

Many of the more progressive State fish and game commissions have requested that all applications for certain species of nonindigenous or predacious fishes be submitted to them for approval. The bureau commends this policy, and all such applications, including those for carp, are referred before acceptance for the proper State

authorities to pass upon. Even with the State's indorsement the bureau reserves the right to exercise its judgment.

In connection with this matter, it appears expedient to continue the policy of refusing to supply the spiny-rayed fishes to applicants in the Pacific coast watershed. This step is essential for the protection of the important salmon and trout fisheries. The planting of the spiny-rayed fishes in the streams of the west coast might result in destroying millions of young salmon inhabiting such waters. The bureau maintains that the interests of the commercial fisheries are paramount to those of the sportsmen.

Eggs of certain species are furnished to State hatcheries where such a course appears to be to the interest of the work and, on rare occasions, to applicants having hatching facilities in cases where the eggs can be delivered more economically than the young fish.

SIZE OF ALLOTMENTS.

In determining the size of allotments of fishes on applications, the bureau is governed by the number and size of the requested species available for distribution in connection with the number of applications received for it, by the extent of water area to be stocked, and by the distance to which the fishes must be transported. It aims in every case to supply only a sufficient number of young fish for a brood stock, and the recipient is expected to provide for their protection until they have had time to mature and stock the waters through natural reproduction. The importance of adequate protection for fish furnished for stocking any body of water is so obvious that the bureau has seriously considered the advisability of curtailing or entirely discontinued the distribution of fish in localities where such protection is not afforded.

It is recognized that the larger bodies of water should receive the larger number of fishes for stocking purposes, but it does not appear judicious to honor applications for such waters to the exclusion of the smaller, though perhaps no less important, bodies of water. It is the policy of the bureau to apportion the output of its hatcheries in such a manner as will permit of filling all applications, so far as such a course may be practicable. Applications are frequently received from persons in sections remote from a fish-cultural station and in a part of the country where it is known that the waters are already abundantly stocked with desirable species. In such instances the bureau does not consider it wise to incur the expense of sending small numbers of artificially reared fishes to a considerable distance, and the applicants are so notified.

TIME AND METHOD OF DELIVERY.

Certain species, notably the brook trout and the rainbow trout, are planted whenever possible during the fingerling stage; but, as the rearing facilities are limited, the stock must be reduced in the early spring to prevent overcrowding. Thus, a part of the output is annually shipped in the fry stage. The distribution of the basses and other pond fishes begins about three weeks after they are hatched and extends over a period of several months, the last lots of fishes sent out ranging from 2 to 4 inches in length. The basses, sunfishes,

crappies, yellow perch, and other fishes rescued from landlocked ponds and pools in the Mississippi River Valley are from 3 to 6 inches long when distributed.

It is the policy of the bureau to fill applications in the order of their receipt and to deliver fishes assigned as soon thereafter as possible, but there are certain conditions connected with the distribution work which should be thoroughly understood by prospective applicants.

The cost involved in making shipments of fishes compels the bureau to exercise the utmost economy in arranging its distribution work. The delivery of special consignments and those intended for distant points must be delayed until a sufficient number of applications from the same section of the country have been received to warrant the expense of a messenger shipment. The bureau can not carry a stock of fish for delivery on demand, and when the supply of one year is exhausted no more are available until the crop of the succeeding year is ready to be sent out. The shipment of trout from the bureau's eastern stations begins early in March, and all applications received after that time are carried over until the following year. Trout distributions from stations in the Rocky Mountain regions are made between May and October, and, in order to insure early attention, applications from that part of the country should be in the Washington office of the bureau not later than May 1. The so-called warm-water fishes, including black basses, sunfish, and crappies, are shipped between May and December, and requests for them should be submitted prior to May 1.

The fishes are shipped in railroad cars especially designed for the purpose or in baggage cars accompanied by a messenger, and the delivery is made at the applicant's railroad station without expense to him. When an application for fish is received by the bureau the person submitting it is immediately notified of the species assigned thereon and the approximate time when delivery may be expected. Full directions for the reception and care of the fish are also sent to him. Prior to the shipment a second notice is sent, usually a telegram, specifying the exact time when the assignment will arrive at his railroad station. If for some unforeseen reason it becomes necessary to postpone the delivery, the applicant is notified accordingly.

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