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REPORT

OF THE

COMMISSIONERS

ON

FISHERIES AND GAME

FOR THE

YEAR ENDING DECEMBER 31, 1910.

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The Commonwealth of Massachusetts.

To His Excellency the Governor and the Honorable Council.

The Commissioners on Fisheries and Game respectfully submit this their forty-fifth annual report.

General Considerations.

The conditions connected with the maintenance of the natural and normal number of animals which are of very great biological value for the health and wealth of mankind are peculiarly complicated in Massachusetts, apart even from the political and legislative steps which annually depart from pristine conditions. Among the most notable of the peculiar conditions is the very high theoretical density of population, when figured in terms of total population and total area, but, as a matter of fact, a rather sparse population over wide areas, and excessive congestion in numerous cities, particularly in the eastern section of the State. This has resulted in —

(1) A large permanent, though floating, cosmopolitan population, including most prominently Greeks, Italians, Portuguese and Poles, which is relatively unassimilated and which to a considerable extent from its urban bases makes quasi-piratical forays upon the wild birds and animals, and upon fish, food and bait mollusks. To these people the problems of "conservation of natural resources" have never come. The rights of "free fishing, fowling and boating" appeal to such with peculiar force, but mean little beyond a stimulus to appropriate as much as possible of such public property. To these conditions are attributable much uneconomic destruction, *e.g.*, quantities of fish beyond the market supply (smelt, herring, etc.); small mackerel, bluefish, lobster and other species which are most valuable when full grown, and which resort to our shores to breed; small birds, which are of little value as food but absolutely essential to checking insect pests.

(2) An exceedingly active market demand, *e.g.,* Boston is the trading center of at least 5,000,000 people within a radius of 150 miles, as well as a shipping point for all directions.

(3) A shore line practically completely taken up by cities, towns and summer residents. One of the prime attractions to the summer residents is the possibility of securing a fresh supply of sea food under sanitary conditions. This demand is supplemented by the great number of transients swarming to the seashores during the warm season.

These conditions are especially disastrous to wild birds of all species (excepting English sparrows), to all the useful mammals (excepting the cat and dog), to all edible species of fish, mollusks and crustaceans. We are convinced that the destruction of the nests and young of our game and insectivorous birds by cats, foxes and self-hunting dogs far exceeds the annual kill by sportsmen.

Against the general slaughter are the sportsmen as a class. Although the sportsmen include about 5 per cent. of the population, and the food-consuming public outnumbers the sportsmen 20 to 1, yet game must be given special consideration as an efficient and satisfactory source of one of the best types of sport; best in the sense that it clears the brain for better work, promotes sturdy health by driving the blood more rapidly, trains the eye, develops the motor nerve centers and makes the man. Game must be maintained, therefore, as a means of developing physical manhood, clear vision, honest respect for the rights of others and a truer outlook upon life, both in the abstract and in the concrete. For these reasons, among others, it is essential that dead wild game be kept as far from the market places as possible, since market demands have been and doubtless always will be the stimulus to undue and unwise depletion.

The problem, then, in one aspect, is the personal relation of the individual to public rights and public property. Massachusetts chances to be located geographically at the confluence of two important tracts of bird migration, with a territory almost uniquely accessible, through good roads, trolleys and railroads, with its relatively large acreage of great ponds, and perhaps an equal territory of artificially flowed areas, many broad and sluggish streams in the eastern section, with numerous bays, sounds and harbors where wild ducks naturally are wont to bed, with many points and islands favorable for shooting. It is, therefore, especially important that the relation of the people to the birds and to the shooting privileges should be worked out with the utmost care and a high degree of intelligence, in order that the natural assets of Massachusetts be not destroyed or even seriously impaired as a result of unwise demands, practices or laws.

To maintain the birds special attention must be given to extensive and intensive propagation work in all sections of the State upon species best adapted to each section. Most attention should be given to the native species — quail, ruffed grouse, heath hen — in special locations; the wild turkey, black, wood and mallard ducks, teal and Canada geese could be naturalized in suitable localities, and by their presence would attract migratory wild individuals to nest in the neighborhood, where bird reservations may be provided.

The 1,100 and more large lakes and ponds of the State, so long abused, can be so handled as to furnish a greatly increased annual crop of fish. In our recommendations for legislation we strongly urge increased facilities for propagating useful birds and fish, and wider provision for securing safe and attractive breeding places for wild birds within the State, both on land owned or leased by the State and on that of private owners.

The State has now been districted, and all the streams, ponds and posted lands specially favorable for bird covers and breeding places are being descriptively catalogued, so that intelligent and systematic attention may be given. This work, begun some years ago, is being extended as rapidly as our facilities permit. A systematic consideration of the sources of pollution of public waters is now under way.

We again direct your attention to the important fact that provision should be made for securing from the clam flats an annual crop as certain as that from the strawberry field. The strawberry has become one of the most satisfactory and profitable garden crops. We could not nowadays be satisfied either to depend upon the crop of wild strawberries for our market supply, or to pick the first few large berries and destroy all the others. Yet such is precisely the method pursued by the clammers. Planting is not encouraged. No one can be offered any degree of likelihood that he may be able to reap where he has sown. Indiscriminate digging destroys thousands of clams for every one marketed. Massachusetts is the only State where similar public assets have been placed in the control of the towns, thereby diverting from the State treasury a very considerable sum. (The Rhode Island State treasury received last year $117,555.72 from the leases of the oyster grounds alone.) Shore property adapted for rearing mollusks is very carefully gardened in France, Italy, Holland, Japan and other countries.

In this connection we quote the statement from our annual report of 1909, pages 10 and 11: —

Mollusk Fisheries. — In 1905 the Legislature ordered a biological survey of the coastal areas below high-water mark, in order to ascertain: —

(1) The present and past conditions of the mollusk fisheries.

(2) The possibilities of increasing the annual production by (*a*) increasing the annual yield per acre; (*b*) suitable methods of securing an annual yield from areas at present unproductive.

(3) Ascertaining definite methods of increasing production by study of: —

(*a*) Life histories of the economic mollusks, particularly the oyster, clam, quahaug and scallop.

(*b*) Methods of feeding and rate of growth.

(*c*) Effects of unfavorable conditions; *e.g.*, pollution.

(*d*) Methods of checking ravages of enemies; *e.g.*, starfish, "drills," "winkles," etc.

A report to the Legislature upon this work states, in general, that of upwards of 60,000 acres of shellfish ground only about 3,552 acres are to-day yielding anything approximating the natural yield, *i.e.*, from $100 to $800 profit per annum; while upwards of 40,000 acres are producing at least 90 per cent. less than normal production; and about 15,000 acres at present unsuitable could at an expense of $50 to $300 per acre be made to yield from $100 to $500 profit annually. Under such development and utilization employment would be furnished to about 20,000 skilled and unskilled laborers, as compared with 2,184 in 1907; and a total production valued in the hands of the producers at $6,000,000 annually, instead of $752,000 as in 1907.

The results from more than 300 experimental plots prove conclusively that clams (*Mya arenaria*) and quahaugs (*Venus mercenaria*) can by appropriate methods be as successfully cultivated as are oysters to-day, or as any farm crop; that the value of a quahaug crop upon arrival at a marketable size often exceeds $1,800 per acre; and that the annual profit should average not less than $200 per acre.

These fisheries are prosecuted upon what is now in the east the last remnant of the public domain, viz., between high and low tide marks. The titles to the uplands have been acquired by individuals, and are subject to individual control and responsibility; and the title of the riparian owner extends to mean low-water mark, or to 100 rods beyond the mean high-water mark in cases where more than 100 rods of tidal flats are exposed by the average tide, but the riparian owner does not have an exclusive control of the fishing, fowling and boating. He may participate in these only on equal terms with the public, and subject to the disposing right of the General Court. Similarly, State laws have been enacted by which areas below high-water mark may be leased for oyster cultivation, but the lease holder can claim as his property only the oysters grown thereon. Curiously enough, present laws permit the cultivation of oysters in the waters below low-tide mark, but not clams, or scallops, either below or above low-water mark. It would be quite as logical for the State to permit the farmer to grow only corn.

The fisheries (which include the mollusk fisheries) are still public, and subject to the disposing action of the Legislature. If the Legislature should by appropriate laws make possible intensive cultivation of shellfish, *e.g.*, the oyster, clam, quahaug, scallop and lobster, in the area below high-water mark, under proper safeguards devised to secure public and private rights, there would follow: —

(1) Increased opportunities for skilled and unskilled labor.

(2) Increased yield per acre above the natural productiveness.

(3) Increased daily profits in proportion to the time and labor of the fishermen.

(4) Increased definiteness of supply, thus permitting the fishermen to take advantage of market conditions.

(5) Increased income to town from taxable property on the shellfish beds.

(6) Increased subsidiary industries.

(7) Increased revenue to citizens, communities and State, from leases of public domain.

An extended discussion is to be found in a special report to the General Court upon the mollusk fisheries of Massachusetts.

State Ponds. — During the past year commercial interests have sought to acquire control of one of the State ponds. Certain evidence was adduced at the hearings which seemed to indicate a systematic attempt to minimize the value of this pond as a State asset, where the public might exercise the "rights of free fishing, fowling and boating." Without in any degree passing an opinion as to the value of the testimony given, we urge the Legislature to consider carefully the precedent which would be established by the alienation of the public rights in even such an undeveloped asset as Benson's Pond.

Stocking Public Waters with Food Fish. — The most notable advance this year has been to secure from the United States Bureau of Fisheries, for stocking the Charles River basin, specimens of the Potomac catfish (*Ameiurus catus*), which grows to a much greater size than our common horned pout. Whether this fish will thrive here is, of course, problematical, but the experiment is well worth the attempt. One of the most notable successes of the National Bureau of Fisheries has been the naturalization of the king or quinnat salmon of the Pacific coast in the waters of Lake Sunapee, N. H., where in three years the fry have grown to 6 and even to 14 pounds, many specimens having been taken on rod and reel last summer. Arrangements have been made for introducing this noble fish into Lake Quinsigamond, near Worcester, where the conditions appear promising, and where the abundance of landlocked smelts should furnish abundant food, and the cold, deep water meet the requirements necessary. The addition of another species to those which have already become landlocked, *e.g.*, the herring, white perch, smelt, Sebago salmon, is of very great economic importance.

Quail. — It may be of interest to know that Massachusetts is the first State to rear quail in captivity, and to liberate the artificially propagated birds for restocking the covers. This year 182 were liberated, chiefly upon State reservations. We believe that the methods used can be successfully duplicated elsewhere, and that persons who are sufficiently careful, persistent and methodical can rear quail as readily as chickens, and in larger numbers at less expense for feed. A normal population of quail upon our farm and wood lands would do much to control injurious insects, which now levy enormous taxes upon us all. Our annual output will be much greater if we are enabled to "put out" the quail, as soon as they are a month or six weeks old, in favorable localities, where they will be cared for by providing for them unharvested grain fields and protection, particularly from cats, dogs and foxes.

Pheasants. — We continue to propagate and liberate in larger numbers ringnecked pheasants, in the belief that their value as game birds and as insect destroyers far exceeds the occasional damage to early peas, corn, etc.

National Control of Migratory Birds and Fishes. — This highly desirable federal law is now before Congress. Prompt action should be urged by every citizen of Massachusetts.

Deer. — For the first time since 1898 the Legislature permitted deer to be hunted in the five western counties. While the natural increase of deer may be estimated at 75 per cent. a year, our observations indicated that in Massachusetts the annual increase has been about 40 per cent., the prominent checks upon the natural increase being deaths due to illegal hunting, wire fences, trolley and steam cars, dogs, and injury to crops. It was estimated that at the beginning of the open season there were about 8,000 deer in the State. They had become so numerous and tame that they no longer confined themselves to the wild lands, but did extensive damage to crops. To compensate these damages even partially the State has annually paid a substantial sum, as the following table shows: —

A Comparative Statement of Money paid by the State Treasurer for Damages by Wild Deer, from 1903 to 1910 inclusive (Chapter 407, Acts of 1903).

(From Reports of State Auditor.)

Counties.	1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.
Berkshire,	-	-	-	$143 00	$324 50	$278 00	$512 00	$452 40
Bristol,	-	-	-	-	20 00	35 00	85 00	124 75
Dukes,	-	-	-	15 00	-	-	-	-
Essex,	-	-	-	469 18	683 50	453 82	345 50	286 00
Franklin,	-	-	-	477 00	793 25	1,415 78	3,793 05	3,363 10
Hampden,	-	-	-	214 30	156 00	199 00	410 50	779 00
Hampshire,	-	-	-	295 25	263 90	326 00	746 75	585 90
Middlesex,	-	-	-	-	445 63	1,016 83	615 42	879 73
Norfolk,	-	-	-	-	15 00	-	20 00	9 80
Plymouth,	-	-	-	39 00	-	-	20 00	-
Worcester,	-	-	-	370 00	211 00	645 60	1,374 87	871 16
Total,	$237 30	$392 25	$1,117 05	$2,022 73	$2,912 78	$4,370 03	$7,923 09	$7,351 84

	1909.	1910.
Total number of claimants,	524	411
Average cost per claimant,	$15 12	$17 89
Smallest claimant, amount received,	50	1 00
Largest claimant, amount received,	175 00	140 00

During the year, from usual and various causes, 598 deer were killed. To this the record of the six days' open season added 1,413, or a total of 2,011 deer killed during 1910. Most of these were used as food, at an average market value of at least $25, or a total food value of $50,275. Against this the State has paid out a total of $26,327.07, and received at least $10,000 from hunting licenses from deer hunters. Looked at alone from one point of view the public received from this source during 1910 at least $50,000 worth of food, at a net cost to the State of $16,000.

It is true that many persons who suffered substantial damage did not seek reimbursement, and others received only partial recompense. On the other hand, many people found real pleasure in seeing the deer as a feature in the landscape. To a country where summer visitors resort, the æsthetic is a most valuable asset, and to this the wild deer are an important contribution. But however valuable in this way, the fact that the undue increase in numbers is certain to bring corresponding burdens upon land owners by destruction of crops renders imperative some efficient method of utilizing the surplus. The present method of wholesale, irresponsible slaughter is open to serious criticism. Thus far attempts to reconcile the wishes of (1) those who would exterminate the deer; (2) those who would permit none to be killed; (3) those who desire rational hunting by competent and responsible persons, have been futile. The most rational suggestion, viz., a special license for deer hunters, has thus far not prevailed against the argument of "special privilege," notwithstanding the fact that such a plan proves satisfactory in other States.

On account of the relatively large amount of traffic on our highways, trolleys and steam roads, the use of rifles would be extremely hazardous. The compactness of the territory hunted and the great number of hunters, while rendering the sole use of shot guns imperative, at the same time reduce the chance of escape of wounded deer to less than 2 per cent. In no other State, so far as we know, were 1,413 deer shot in six days without loss of human life or limb.

Expenditures. — The details of all expenditures are published in the annual report of the Auditor of the Commonwealth. In general, $4,024.19 was expended for the benefit of the sea and shore fisheries; $7,348.01 for maintenance of inland resources, by the purchase and propagation of trout, quail, grouse and pheasants; $35,757.99 for the enforcement cf the fish, game and bird laws on land and sea; $2,958.22 for the protection of adult female lobsters, by purchase of those caught when carrying eggs; $11,818.05 for the salaries of the commissioners, printing, postage, traveling expenses of the commissioners and for clerical and office expenses. The total amount of fines was $2,976; and all other additional moneys received and turned into the treasury of the Commonwealth, from the activities of this commission, amounted to $35,530.54.

Marine Fisheries.

The most important feature of the commercial marine fisheries is the development of comprehensive plans for improved facilities for handling the fresh fish brought to the Boston market. T wharf has long been inadequate and unsuitable for effective methods. Only the fact that the business is under the management of exceedingly keen, efficient and public-spirited business men has prevented unsanitary and other conditions which would seriously reflect upon the good name of the largest fresh fish market, with a single exception, in the world.

Now, fortunately, the present location on Atlantic Avenue is likely to be abandoned, and the place given up to other business for which it is more suitable. The location at South Boston is so far superior that the public are to be congratulated upon the wisdom of the Legislature and of the men who have carried the project to a successful termination. The early future thus promises not alone better trading facilities for the fishermen and dealers, but sanitary conditions superior to any in the world. From these the public will gain most largely through an increased supply of fish, put upon the market in better condition as a result of improved methods of handling and distribution. Further, assurances have been received that through the co-operation of the associated dealers with the national, State and city fisheries authorities, aided directly or indirectly by the departments of biology, chemistry and physics in the various colleges and technical schools, a beginning is to be made in what should develop into an adequate fisheries institute, the purpose of which would be to furnish the necessary information and facilities for training men, and for original researches for economically exploiting and conserving the natural advantages of Massachusetts as a fish market for the world. The work done by the Imperial Fisheries Institute of Japan well illustrates the great value of intelligent and concerted effort for improving methods of catching and preparation of fish for the market, and for providing markets for the products.

Sea and Shore Fisheries. — While the general catch of sea fish was rather unsatisfactory, the unusual market demands, resulting from abnormal conditions in the beef supply, coupled with constantly increasing endeavors to get the fish to market in the best possible condition, resulted in higher prices to the fishermen. The mackerel season was the poorest on record, while the catch of herring and cod was below normal.

As usual, the high liner of the entire Massachusetts fleet was the schooner "Mary C. Santos," Capt. Manuel C. Santos, with a gross stock of $50,000, and the high liner of the Gloucester shack-haddocking fleet was the schooner "Thos. S. Gorton," Capt. William H. Thermos, stocking $45,000. The share of each of the crew of 23 men was $960, and the cook's share was $1,300. The "Matchless," Capt. Frank Gaspe, the "Josie and Phebe," Capt. Lawrence Norris, the "Gladys and Nellie," Capt. Frank Watts, all exceeded $40,000 gross stock.

The salt trawl-codfishermen had an average year. The knockabout schooner "Arethusa," Capt. Clayton Morrissey, with 826,327 pounds of codfish, stocking $27,362.79, establishes a new record.

The handliners had a poor year. Of the dory handliners, schooner "Elsie" weighed off 286,800 pounds, stocking $10,400, the average share being $250, while the high-line share was $281.

The seining fleet met a poor year. Schooner "Oriole," Capt. Chas. Maguire, was high line, with a stock of $9,000.

The halibut fleet had a fair year; the schooners "John Hays Hammond," "Catharine Burke," "Juno," "Dictator" are said to have stocked about $30,000 each. The schooner "Juno," Capt. John Streams, stocking $5,000, with a crew share of $165.86 each, established the record for a single halibut trip. He landed 39,000 pounds of halibut and 25,000 pounds of other fish.

Of the halibut flitches, the schooner "Essex," Capt. Michael Wyse, weighed off 150,300 pounds and 75 barrels of fins, stocking $13,700, the crew share being $338 each; schooner "Grayling" weighed off 144,750 pounds and 66 barrels of fins, stocking $13,200, the crew share being $333 each.

Of the dory handliners, schooner "J. J. Flaherty," Capt. Fred LeBlanc, was high liner, stocking $17,067, shares being $400 each.

The swordfishing fleet met with poor success, ascribed to "scarcity of feed" and wildness of the fish. Schooner "Lafayette," Capt. Geo. Peeples, was high line; as a result of three trips, 191 swordfish were landed, stocking $5,000, the crew share being $365.

In general, the catch of herring, squeteague, bluefish, butterfish, bass, scup, salmon, shad, squid, menhaden and other species was light. There are many indications that the trap fishing is overdone, that fewer traps would meet the market requirements, with less cost and greater profit.

Breeding Places for Fish. — There is increasing evidence that specific areas of water which are the natural breeding ground of useful fishes must be set aside as reservations, where the taking of fish must be carefully regulated.

National Control of Migratory Fish. — The migratory fish which annually resort to particular bays, estuaries and rivers for purposes of spawning cannot be regarded as the peculiar property of the States through whose waters they may chance to pass on the way to their breeding grounds, nor yet of that State in which they may breed. They are a national asset, useful as food for inland as well as seacoast communities, and should not be exposed to undue perils when approaching their spawning places. The relatively small size of the States on the Atlantic coast results in much legal, though unwise, destruction of such fish in one State when approaching the natural special spawning grounds, just over the line of an adjacent State. Many flagrant abuses can be adjusted only by national standpoint. Ingersoll (8) gives an account of the fishery in 1880; Krause (5) made a preliminary outline report for the Rhode Island Commission of Inland Fisheries; and Kellogg (2) published in 1903, under the auspices of the Museum of the State of New York, the first report on the feeding habits and growth of the quahaug. Unfortunately, this important paper, in which the practical importance of quahaug culture was pointed out for the first time, is little known to the fishermen of Massachusetts. With the consent of Professor Kellogg his report was taken four years ago as a basis for this investigation, and the results here given are a continuation and an expansion of the work originally outlined by him in 1903.

Commercial Experiments. — Our aim has been to make the work thoroughly practical, and it has been undertaken scientifically because science offers the best means of approaching any practical problem. The essential aim has been to develop scientific methods for the extension of the commercial quahaug fishery.

General Results. — Four years of experiments have demonstrated with convincing force that the only method of permanently increasing the natural supply, which can be applied on a large scale, is artificial culture or quahaug farming. The quahaug grows with sufficient rapidity to warrant large returns from small capital. Many acres of unproductive flats can be turned into valuable quahaug gardens, and many men given employment by the institution, under proper legal regulations, of a system of individual leases for the planting of quahaugs. Aside from its remunerative possibilities such a system is the only means so far devised for permanently checking the decline of the natural beds.

The Quahaug Family. — The quahaug belongs to the class of mollusks called the *Lamellibranchia,* or, to use an older nomenclature, the *Pelecypoda.* According to the classification given by Pelseneer (6), in which lamellibranchs are classified by their gill structure, the quahaug is placed with the soft clam (*Mya*) and the sea clam (*Mactra*) in the class of the *Eulamellibranchia,* one of the four great orders of the lamellibranchs, which is characterized by the edges of the mantle being generally united by one or more sutures, the presence, as a rule, of two adductor muscles and the union of the gill filaments at regular intervals by vascular junctions. In addition to the many living species the subfamily to which the quahaug belongs is represented, according to Zittel (10), by many fossil forms, extending from the Jurassic to Recent.

On the New England coast, according to Gould (11), two species, *V. mercenaria* and *V. notata,* with possibly a third, *V. præparca,* more generally considered a variation of *V. notata,* are found. Of these forms, *V. mercenaria* is the most abundant, and the other two are often considered as local variations of this species.

Names. — The scientific name of *Venus mercenaria* is supposed to have arisen from the use of the shell as "black wampum" by the Indians, as the beautiful purple tinge on the inner side of the shell made it an object of exchange among that primitive people. The common name in the New England States is "quahaug," sometimes spelled "quohog" or "cohog," while in New York and the south, where the soft clam (*Mya arenaria*) is not abundant, it is known by the name of "clam," "hard clam" or "hard-shelled clam." The small quahaug goes by the commercial name of "little neck," probably to distinguish it from the long-necked clam, *Mya,* although the claim is put forward that it was originally a local name similar to the "Blue Point" with the oyster. Ingersoll (8) states that in New Jersey they call small quahaugs, only an inch or so in breadth, "tea" clams. The present names are probably derivations of the old Indian names, such as "Poquahock," as given by Roger Williams in "A Key to the Language of America." Occasionally the monosyllable "quog" is used. The pronunciation of the word quahaug varies with the localities.

Distribution. — The quahaug, while essentially a southern and warm-water form, is found along the Atlantic coast from the Gulf of St. Lawrence to the Gulf of Mexico, where it was reported by Kellogg (3) in the vicinity of the Chandeleur Islands in 1904. Attempts are now being made to develop the fishery in Louisiana, but there is small demand for this shellfish in the local market. *Venus mercenaria* is truly an American form, its natural habitat being the Atlantic seacoast, although a few are reported to have been found in the last few years on the Pacific coast, as the result of accidental transplanting with eastern oysters.

In Massachusetts the quahaug is confined to the region of Cape Cod and the southern waters of the Commonwealth, practically no specimens being found north of the Plymouth section. As can be seen from the distribution map (Fig. 30), few quahaugs are found in Massachusetts Bay except on the north side of Cape Cod. The same state of affairs exists along the Maine coast, except in a few sheltered bays, such as Quahaug Bay, where the warm water and favorable natural conditions are such as to preserve the remnant of a once great quahaug supply. There is also evidence that a few were formerly taken near Salem, Mass. Passing northward, the quahaug again becomes abundant, and is found, according to Gould (11), at Halifax, Sable Island, Prince Edward Island, on the fishing banks and in the Gulf of St. Lawrence. At the present time a considerable number of small quahaugs of peculiar color, shape and flavor are shipped from Prince Edward Island. The present distribution, the geological changes along the coast and the evidences of former abundance, such as Indian shell heaps, are evidence, submitted by Ingersoll (8), that years ago the quahaug was more widely distributed, and that possibly on account of a decrease in the temperature along the shore of Massachusetts Bay there occurred a corresponding decrease in the supply and distribution of this mollusk.

ANATOMY.

A description of the anatomy necessarily should be included in a report on the quahaug, as a knowledge of the general structure of the animal is essential for the proper understanding of its development and habits. Just as certain words not in everyday use by most people are found convenient to sailors, printers, mechanics and men in any occupation, so a biologist must make use of certain technical terms in his descriptions. Those used in this report, however, are not numerous and not hard to remember. They are as follows: anterior, posterior, dorsal and ventral. The two former correspond to the terms "fore" and "aft" as used by sailors. In a quahaug the anterior is the end in the direction of which he burrows, the end from which the foot protrudes. The posterior or rear end is that at which the siphon or "neck" is located. This seems a little odd, but is easily understood when we recall that the prefix "ante" means before and "post" means after. In a quahaug the dorsal side corresponds to the hinge, the ventral to the side on which the shell opens.

It is the belief of biologists of the present time that all animals of a similar kind are descended from common ancestors. Thus, the clam, oyster, quahaug, scallop, mussel, etc., are believed to have a common descent as their early development is strikingly similar. Of these forms there is reason to believe that the quahaug most closely resembles the common ancestor. The study of this typical shellfish is, therefore, especially interesting.

The Shell. — The quahaug shell is formed of two heavy valves, equal in size and curvature, which enclose the soft parts and may be drawn tightly together for protection. The two valves are joined together on the upper or dorsal side, the hinge line, by a dark elastic ligament surmounting on each side a row of teeth, which fit into corresponding depressions in the opposite valve. This ligament gives the shell a natural tendency to gape, which is offset by the action of the two adductor muscles in bringing the edges in close apposition. The shell of the adult quahaug measures slightly more in length than in width, the average dimensions being: length, 3 inches; width, 2⅜ inches; thickness, 1⅜ inches. All sizes, weights and forms can be found, depending upon age and environment. Owing to the thickness of the shell distortion is not as common as with the scallop and clam, and few deformed specimens are found. The largest quahaug known to the writer was taken in a scallop dredge off Harwichport, and measured 5¼ inches in length.

The most prominent features of the external surface are two swelling, the umbones, one on each valve, which are directed anteriorly and toward the hinge, forming the so-called beak. Many specimens show imperfect umbones, due to the wearing away of the lime. Just beneath the beak is a depression, the part on each valve having the shape of a half moon, called the lunule, which is characteristic of the quahaug. The surface of the shell is covered with numerous concentric lines of more or less prominence, forming thin, closely packed ridges at the anterior and posterior margins, and leaving the lateral portion of the shell smooth. These ridges are more prominent in the young and rapidly growing quahaugs than in the large specimens, but they appear too irregularly and too frequently (75 to 100 on an average specimen) to be of any value in determining the age of the quahaug. In old age these growth lines pile up, showing retrogressive development, so well illustrated in the case of "blunts," where growth consists merely in a thickening of the edges. The shell is naturally free from foreign growth, although old specimens are sometimes found with shells honeycombed by the boring sponge, and quahaugs which are out of the sand are often covered with Serpula, barnacles, silver shells, grasses, etc.

On examining the interior of a valve, one sees a rough, white surface dotted with small granules between two large oval impressions, which mark the attachment of the adductor muscles. The ventral borders of the adductor muscle scars are connected by a distinct line, the pallial line, which is formed by the attachment to the shell of the mantle, a large flap forming the outer part of the body of the quahaug, and separates the white granular portion from a narrow, smooth, shiny surface, sometimes of a purple color. The posterior end of this line is indented to form the pallial sinus in which lies the siphon or neck. Just above the attachment of the adductor muscles can be seen smaller impressions, to which the muscles for moving the foot are attached. Along the hinge line are two kinds of prominent teeth, — the anterior or cardinal, consisting of short elevations; and the posterior or lateral, which extend for some distance along the dorsal margin. These teeth fit into corresponding depressions in the opposite valve, interlocking to form a compact joint. On the margin of the valve are faint vertical elevations which give the inner side a milled effect, as on a coin.

The shell is made almost entirely of lime, in some specimens crumbling on pressure in the hand. When dry quahaugs are handled in numbers, as in the shipping houses, considerable dust arises from the fine particles of lime which are rubbed off the shells, and if these quahaugs are again placed in water a white color is imparted to the fluid. Quahaugs from different localities vary in the hardness, compactness and thickness of shell, evidently due to the different amount of lime in the water. There are three layers, a rough outer, a fine middle and a thin, smooth inner, the outer being formed by the edge of the mantle, the two inner by secretions from its sides. In external appearance the shell varies from a white to a blue gray, according to the soil in which the animal is found. The heavy shell, so well adapted for the protection of the animal from enemies, makes it an almost stationary form, although it undoubtedly has the power of locomotion.

The Mantle. — The inside of both valves is closely lined by thin, semitransparent mantle lobes, which enclose the body in a fleshy case when the shell is shut. The enclosed space is called the mantle chamber. These folds are united on the hinge line, and are attached to the upper part of the visceral mass, the gills and the adductor muscles. The free border of each lobe is thickened, of white or yellow color according to the age of the quahaug, and folded into a double row of delicate frills. It contains slender muscle fibers which are attached along the pallial line of the shell. The edge of the mantle possesses sensory or tactile organs, as is shown by the withdrawal of the mantle when touched by a foreign body. The consumer can determine whether he is partaking of live or dead shellfish, as only the living form will respond in this way.

The function of the mantle is sensory, protective, respiratory, and assists in feeding. It forms a reservoir for the blood, and secretes, by numerous gland cells on the outer side and edge, a sticky substance which becomes impregnated with lime to form the new shell layers. Other cells at the edge secrete the horny cuticle, which can sometimes be seen reflected over the outer edge of the shell.

The Siphons. — On the posterior border the lobes are joined together in the form of two tubes, which are known as the siphons, or more commonly as the neck. The siphon is longer and more prominent in the soft clam (*Mya*), and the smaller fleshy extension of the quahaug is not so noticeable. Water passes in at the larger or lower opening and leaves by the smaller or upper, in this way establishing a continual circulation of microscopic food. The muscles of the siphon are heavier than those of the other part of the mantle, and form a V-shaped attachment to the shell, the pallial sinus. The siphons are yellow in color, often tinged with pigment, and bear very minute tentacles upon the outer edge, especially on the incurrent. The waste products are extruded into the stream of water passing out the excurrent siphon.

The Foot. — The quahaug has a large muscular foot resembling a plowshare, or a boat's keel, which can be thrust outward between the folds of the mantle. Its action is controlled by retractor muscles, anterior and posterior, which are attached to the shell above the adductors, and by the distension of the foot with blood. Although the shape of the foot is suggestive of a crawling existence, the quahaug makes but little use of this habit. Occasionally a groove can be seen in the sand where the quahaug has traveled a short distance. For the most part the foot is used as a burrowing organ, possibly because the heavy shell renders traveling difficult.

The Gills. — The foot merges into the abdominal portion or visceral mass, on each side of which are two conspicuous folds, the inner and outer gills, which hang free in the mantle chamber as delicate curtains between the visceral mass and mantle. The outer gills are attached at their base to the inner, which in turn are attached to a part of the visceral mass and to the inner gills of the opposite side, dividing the mantle chamber into a larger ventral and a smaller dorsal portion, the branchial and cloacal chambers respectively. Through the gills water is passed into the cloaca, and is forced out of the upper or excurrent siphon, which is in direct connection with this chamber, while the incurrent siphon leads only into the lower apartment. The gills may be roughly compared to sieves, by which the solid particles, including the minute plants, on which the quahaug feeds, are strained from the water.

The general structure of a gill is excellently described by Kellogg (2): —

The gills are the most complicated organs in the bodies of lamellibranchs, and must be described here as briefly and as simply as possible, without mentioning their wonderful histological structure. Outer and inner gills are practically the same. Suppose that one of these is carefully removed from its line of attachment to the body, and studied by means of the microscope from the surface and in section; such an examination shows the gill to be not a solid flap or fold, but an exquisite minute, basket-like structure with an outer and inner wall inclosing a space between. These walls are made of extremely fine rods placed side by side. In order that these rods may retain their position, they are in many forms irregularly fused with each other by secondary lateral growths of tissue. The outer and inner walls of the gills are also held together by partitions which extend across the inner space between them. The gill is thus seen to be basket-like, the walls being made of rods between which are spaces, which put the interior chamber in communication with the mantle space in which the gills hang. These rods, or filaments, of which the gill is made, contain an interior space into which the blood flows. They were probably primarily developed in order that the blood of the body might be brought in close contact with the water, that, by diffusion, the carbon dioxide of the blood might pass outward through the thin walls, while, by the same process, oxygen, carried by the water, might pass into the blood. But, in addition to performing the function of breathing, the gills have taken on that of collecting minute organisms used for food.

The Digestive System. — Just behind the anterior adductor muscle on the anterior part of the body is a funnel-shaped opening leading into a more constricted tube, the œsophagus. The mouth is guarded by two pairs of delicate ciliated flaps, triangular in shape, tapering backward toward the anterior part of the gills. These organs are the labial palps, which perhaps may be likened to the lips of higher animals, the two outer uniting to form the upper lip, the two inner the under lip, and have the power of conducting the microscopic food to the mouth. The œsophagus leads back into a stomach situated close to the dorsal wall of the visceral mass and surrounded by the liver, a paired dark-brown gland, which secretes the digestive juices. The intestine leads from the stomach in the form of a narrow tube, which, after making several convolutions in the visceral mass, passes backward through the heart to end just over the posterior adductor muscle.

The Circulatory System. — The blood of the quahaug is a colorless liquid passing in definite channels over the whole body, bringing oxygen and nourishment to all the tissues, and removing the waste materials. The chief organ of circulation, the heart, is situated on the dorsal part of the body, posterior to the stomach, in a large triangular pericardial space. It consists of an anterior ventricle and two auricles, which have a filmy appearance. The intestine passes through the ventricle. Blood is pumped from the ventricle through two aortæ, anterior and posterior, to the various parts of the body, whence it is returned to the gills, and thence to the auricles, which open into the sides of the ventricle.

The Nervous System. — The principal nervous mechanism of the quahaug consists of three pairs of ganglia. The first pair, the cerebral, are little white round organs about the size of a pin head, situated on both sides of the mouth, just posterior to the anterior adductor muscle, and are connected by a thin commissure which passes anterior to the œsophagus. Two other commissures pass from each cerebral ganglion, one to join the visceral ganglion of the corresponding side, the other to the pedal ganglion. The visceral ganglia, pear-shaped bodies, lying just beneath the posterior adductor, are also connected by a short commissure, and supply nerves to the mantle, gill and adductor muscle. The pedal ganglia, also connected with each other and with the visceral and cerebral, are situated just dorsal to the muscular part of the foot.

The Excretory System. — The excretory organs, the nephridia, consist of dark colored tubes of glandular nature lying beneath the pericardial chamber, one on each side of the body. By one end these tubes open into the pericardium, by the other, outside the body at the base of the gills. Their function is essentially the same as the kidneys in higher animals, — the extraction of waste material from the body through the blood.

The Genital Organs. — In both sexes the light colored reproductive organs are situated in the visceral mass, just dorsal to the tough foot, where they surround the folds of the intestine, extending upward to cover part of the liver and downward into the cavities of the foot. Kellogg (1) says: "In Venus the generative gland penetrates into spaces between the uppermost bundles of the foot, as is usual in forms with a locomotor foot. The posterior part of the visceral mass has many scattered muscle bundles, generally transverse, running from one side to the other. The sexual gland pushes down among these muscles for a considerable distance." These organs open by small ducts, one on each side, which terminate close to the opening of the excretory system, beneath the free border of the inner gill. The ovaries and testes are usually white, but in older quahaugs, particularly "blunts," they have a somewhat reddish or yellow appearance.

THE EARLY LIFE HISTORY.

Ripening of the Reproductive Organs. — During the spring the ovaries or testes of the quahaug enlarge in preparation for spawning, and the visceral mass assumes a plump appearance, due to the accumulation of numerous eggs and spermatozoa. Just when the first formation of the sexual products takes place is not known, but presumably they are in process of development for several months previous to the time of spawning.

Method of determining the Sex of a Quahaug. — As described under anatomy, the sexes are separate, each quahaug probably remaining either male or female, such as it may be, all its life. During the spawning season the male can be distinguished from the female by an examination of the spawn without the microscope. As this process may be of interest to the fishermen, since it applies to all shellfish, it is here described. The quahaug is opened, the sexual organs sliced with a knife, and the spawn, after diluting with water, is spread in a thin layer on a piece of glass. If the animal is a female, this white fluid will be made up of a great number of minute specks, individually visible to the naked eye, — the eggs: if a male, the fluid will be of a uniform consistency, and will have a milky vibrant appearance, due to the invisible spermatozoa.

The Egg. — The mature egg (Fig. 1), when extruded into the water, is spherical in shape and surrounded, for protection, by a gelatinous membrane three times its diameter. The shape and size of the eggs vary somewhat, even in the same quahaug. Normally they are spherical, though occasionally one axis is slightly longer than the other; but when extruded in masses they possess irregular shapes, owing to the pressure within the ovary. This is especially noticeable in eggs cut from the ovary, and is exceptional in the natural course of spawning. Such eggs soon assume their normal shape in the water. The diameter of the average egg is 1/12.8 of a millimeter (1/325 of an inch). The color of the egg as seen by the naked eye, in mass or separately, is white. Under the microscope it has an opaque appearance, due to the yolk granules, which are packed closely in the cytoplasm. The egg is surrounded by a definite thin membrane, especially noticeable when the polar bodies are formed, differentiating it from the scallop egg.

The large gelatinous covering constitutes a distinguishing feature in differentiating the quahaug egg from other forms, as it forms a transparent film around the egg. Evidently it is formed of a substance which swells when coming in contact with water until it attains about the size of 1/102 of an inch, or 3.2 times the diameter of the egg. In observing through a microscope eggs which have been artificially fertilized by mixing with spermatozoa, a few eggs will be found free from the covering, the majority surrounded by it, and sometimes empty cases. Usually a single egg is found in a case, but occasionally two eggs may be found in the same covering. In such instances the eggs are separate and of unequal sizes. The spermatozoa can be seen in great numbers clinging to and wiggling about the transparent film. It is interesting to note that apparently no distinction is made between the gelatinous coverings containing eggs and those without, indicating that possibly the covering and not the egg proper has the power of attracting and retaining the spermatozoa. The only noticeable difference is the absence of an inner or more dense covering, which is differentiated from the outer, when the egg is contained, by the number of spermatozoa which work their way to this second barricade. The cases without the eggs do not have this second layer.

The capsular covering is also of use to the quahaug as a means of protecting the minute egg and of preventing its sinking to the bottom. Only when the eggs are discharged "en masse" do they sink. These floating bits of protoplasm, although more easily washed ashore in rough weather, are carried farther, and do not stand as great a chance of an early death by falling on poor soil, as, for instance, the scallop eggs.

The Spermatozoön. — The spermatozoön, or male cell (Fig. 2), is composed roughly of two parts, a wedge-shaped head, the longest diameter of which, the length, is about 1/12 that of the egg, and a long, whiplike tail, the motile part. Nature has so arranged in all life that the egg contains the yolk or nutriment, and is therefore the large stationary form, while the spermatozoön, as a specialized organ of locomotion for finding the egg, has thrown off all useless cell contents. The average size of the spermatozoön is: body, 1/150 of a millimeter by 1/600 of a millimeter (1/3,800 by 1/15,200 of an inch); tail, 1/20 of a millimeter (1/500 of an inch) in length. Often, variations, such as the reversed shape of the head, described by Kellogg (1), are found.

Spawning.

Spawning can best be defined as the discharge of eggs from the female or of spermatozoa from the male into the water, where fecundation takes place by their union. The sexual cells are extruded into the mantle chamber and are carried out the excurrent siphon in a fine stream, passing into the water by successive puffs. A female quahaug was observed to shoot a fine stream, not more than a millimeter in diameter, with such force as to carry it at least 2 inches from the end of the siphon before the eggs separated into a fine spray, like a jet of smoke, which held together for a time and then spread out in a cloud. This stream ended with the expulsion of stringy chunks of eggs and yellow tissue. Another quahaug shot a continuous jet of spawn for forty-four seconds. The amount of spawn extruded at any one time was variable. The quahaugs under observation in the laboratory showed a tendency to throw their spawn little by little, although there is reason to believe that in nature it may be possible to discharge all the season's spawn at once. In the laboratory the same lots spawned three different times during the season, indicating that the quahaug is similar in this respect to the scallop.

Methods of Work. — The spawning was followed during 1909 and 1910 by keeping various sizes in tanks freely supplied with running salt water, where they could be under continual observation. For this purpose different grades of quahaugs, as "sharps," "blunts," "mediums" and "little necks," were placed in small lots in different compartments, some in sand, their natural environment, others merely in the water. (A complete description is given under "Methods of Work in Hatching.")

The Spawning Season. — The usual methods of microscopical examination, larval counts by means of the plankton net and records of the appearance of the set were used to determine the spawning season. Results also were obtained from the spawning under artificial conditions in the laboratory aquaria in 1909 and 1910.

From observation of the set, and from the size of the small quahaugs in the fall, it at first appeared that the spawning season was later than with the scallop and oyster. Investigation proved that the spawning season practically corresponds in Massachusetts waters with that of the scallop, *i.e.*, from the middle of June to the middle of August, the small size of the young quahaugs being due to slower growth. This is natural, as the quahaug, like the scallop, is essentially a southern or warm-water form, and its habits are directly influenced by temperature. Quahaugs in the Wellfleet laboratory extruded spawn in 1909 between June 23 and July 13; in 1910 as late as July 29, which further narrows the spawning limits. In the 1909 case it must be remembered that this occurred in one year, in one locality, with certain quahaugs and under possibly unnatural conditions; all of which are variable factors in the determination of the spawning season. One fact was definitely settled. The season lasts but twenty days, or less than a month, for any special batch of quahaugs; but for Massachusetts waters in general nearly two months are consumed, the greater part of the spawning, however, taking place during the last of June and the first part of July.

Temperature and Spawning. — Temperature has great influence over the distribution of all marine animals. It affects mollusks in three important ways; (1) their growth, by regulating the food supply; (2) their distribution, according to the environment; and (3) their development, as determined by spawning, early life history, etc. The time of spawning is so regulated by nature that it takes place when conditions, chiefly temperature, are favorable for the development of the unprotected embryo, which is extremely susceptible to all adversities.

Thus, spawning does not take place until the water has attained a warmth suitable for the development of the offspring. For this reason, the spawning of the quahaug in the southern waters takes place earlier than on our coast, as the requisite temperature has been reached sooner. Whether or not northern quahaugs, by the process of selection, require as warm water for the development of their offspring, and consequently spawn at a lower temperature than the southern forms, is unknown, and can be determined only by a series of observations along the Atlantic coast.

During the spawning experiments at the Wellfleet laboratory, in 1909, the following notes were made: "The first lot of spawn was given off June 23 to 26, during a sudden rise in temperature following a period of extremely cold weather for that season. The temperature of the air in the laboratory between June 23 and 26 during the day averaged from 78° to 80° F., while the water in the aquaria remained at a uniform temperature of 76° F., corresponding with the temperature of the water at the part of the harbor where the laboratory was located. On July 13 spawning again took place, the water attaining a temperature of 77° F., during a warm spell in which the laboratory temperature was 80° F. Between June 26 and July 13 no spawning was observed. It is interesting to note that the water between these dates was only moderately warm, averaging 71° F., and that spawning occurred simultaneously with a rise in temperature of the water, in each case reaching about 76°, which appears to be the 'spawning temperature' for Wellfleet, although in other localities it may be different."

In the light of these experiments the act of spawning during the summer may be likened to the operation of an automatic thermostat, which, when a certain temperature is reached, allows the escape of the contents held under pressure in the distended sexual organs. All the writer's observations tend to prove that temperature is the controlling factor in the spawning of the quahaug, and that the variations, either for different years or in different localities, whether on the north or south side of Cape Cod, in Buzzard's Bay or in the States south of Massachusetts, are primarily due to differences in temperature.

Age and Spawning. — The average quahaug is capable of spawning when two years old, its third summer, as sexual products can be found at that age. The size of the average two-year-old quahaug is between 1¼ and 1½ inches. It is well to realize that size, not age, is of importance in considering sexual maturity, and that a rapidly growing mollusk reaches reproductive activity sooner than a slowly growing specimen. Observations at Wellfleet in 1909 indicate that the quahaug is of little value as a "spawner" until it has attained a size of 2½ inches. In the spawning tanks the quahaugs were separated into small lots, according to size. Practically uniform conditions existed as regards flow of water, temperature, etc. The large (3 to 3¾ inches) and the small "sharps" (2½ to 3 inches) were the only quahaugs to spawn. The "little necks" (under 2½ inches) and the "blunts" (old quahaugs) did not throw any eggs or spermatozoa. This fact, if universally true, has an important commercial bearing on the capture of "blunts," as it would tend to show the fallacy of reserving the old "blunts" for "spawners." Before definite conclusions can be drawn frequent tests should be made to verify this observation. Under the conditions in the Wellfleet laboratory the distinction in size, class and age was sharply marked at three different intervals, quahaugs of the same sizes being the only ones to spawn. If the above observations hold generally true, it means that the quahaug has a period of sexual maturity only during middle life. On the other hand, it is a fact that sexual products are found in varying abundance in both "little necks" and "blunts," when the sexual organs are opened, but no proof that they are discharged can be given.

Two peculiarities which may be mere chance were shown by the spawning in the laboratory tanks.

(1) The spawning occurred at night on June 23, 24, 26 and July 13, 1909. No spawning during the daytime was observed until July 29, 1910, when the quahaugs spawned at 5 P.M. The spawning on June 23 and 24 occurred toward morning, while on June 26 and July 13 it took place in the first part of the night; on July 13 beginning at 8 P.M. Although it is probably the result of coincidence that most all the spawning took place at night, it is barely possible that the quahaug, buried under the sand in the deep water, is not influenced, as the scallop, by sunlight, and that darkness is a factor in natural spawning.

(2) The quahaugs in the spawning tanks were divided into two classes: (*a*) those buried naturally in sand; (*b*) those lying on the bottom of the tank without sand. The second class alone furnished the spawn. Possibly their unusual position and environment made them more susceptible to changes in temperature, and therefore more responsive.

Natural Fecundation. — By the act of spawning the parent quahaug completes its duty to its offspring. But a new individual does not begin even to exist, and no development can take place until a union of the egg and spermatozoön takes place. The reason for the vast number of eggs is now disclosed. The chances of union are rendered more and more uncertain as the swift tides bear away the eggs and spermatozoa. No one can answer definitely what per cent. of the eggs are fertilized in nature, as conditions are constantly varying and fecundation depends almost wholly on chance. It is no wonder that the quahaug needs many millions of eggs, unprotected as they are, since they have to pass through a series of adverse conditions, the first of which is the element of chance in the union of egg and spermatozoön.

Between the egg and the spermatozoön is an attraction which scientists tell us is of a chemical nature, and the minute spermatozoön is drawn irresistibly toward the egg, its final goal. How far this attraction zone extends through the water is not known, but under the microscope eggs can be observed fairly covered by a circle of spermatozoa, as if held there by some centripetal force. But one of these can gain an entrance, as after the body of the spermatozoa has entered the egg to fuse with its nucleus (germinative part) an impenetrable membrane is formed around the egg, shutting out the others. This fusion of the male and female pronucleus gives life to the young quahaug, which now starts through the series of changes described under the heading "Embryology."

All through its early existence, until it is large enough to settle into the sand, the young embryo is subject to continual danger on all sides. Under natural conditions, if but one out of the millions of eggs laid by a single quahaug reaches maturity, it is sufficient to perpetuate the species. The young embryo is thus forced to lead a continual struggle for existence, with but meager chance of survival. If, favored by chance, the union of the egg and spermatozoön takes place, the new individual is from six to twelve days at the mercy of the natural elements. Sudden changes in temperature or in the salinity of the water, such as cold rains, diminish the number of larvæ; the waves and tides wash many ashore; polluted waters may destroy; all manner of sea animals devour them as food; and, finally, the greater part of the remainder fall on poor ground, where they soon perish. The few that fall on good ground are still subject to the attacks of predaceous animals until they attain a sufficient size to resist those enemies.

Hatching.

Although the young quahaugs, from the time of byssal attachment, had been studied since 1906 in the laboratory, successful fertilization was not achieved until 1909, when several lots of embryos were developed in the spawning tanks. This occasion furnished an opportunity to study the embryology and complete the work on the early life history.

The essential object in this work was to find, if possible, a method of artificial hatching which would make possible the raising of seed quahaugs on a commercial scale. The question of seed is of the greatest importance to the quahaug culturist, as the natural beds cannot, as in the case of the clam, furnish a sufficient quantity for an extensive industry. The results of the experimental work in this direction so far have been somewhat discouraging. Two methods of obtaining seed seem possible: (1) the catching of the set in spat boxes in a manner parallel to the catching of oyster seed; the work on this point will be discussed under the subject of "Spat Collecting," which has met with more or less success; (2) the artificial rearing of the quahaug from the egg through the larval stages to a size suitable for planting. By protecting the helpless larva from its enemies during the most critical period of its life, it may be possible to reduce the great infant mortality, and raise thousands artificially to nature's one. So far we have been able to raise only a few quahaugs to the veliger (shell) stage, the majority perishing for various reasons, chief among which seems to be the lack of food and space. Our experiments have been so designed that if successful on a small scale they could readily be enlarged to meet the requirements of a business enterprise. The work is discouraging from a commercial standpoint from the fact that the chief cause of failure is due to the crowding of the larvæ, whereas to give the young quahaugs a sufficient amount of space would so materially increase the expense of production as to prohibit hatching. However, there are many things to encourage continuation of experiments along this line with the hope of ultimate success.

At the present time it would seem that the liberation in large numbers of larvæ one day old would undoubtedly be of benefit. This could easily be done, as the embryos do not die rapidly, when confined, until the second day. Our experiments have shown that a small number can be raised in the laboratory, enough for the study of the early life history, but that when large numbers are tried the result is unsatisfactory.

Methods of Work in Hatching. — Attempts were first made to fertilize the eggs by abstracting the spawn from male and female quahaugs by artificial cutting, and mixing these in the water. No satisfactory results were obtained by this method, as the eggs would not develop normally. It was finally decided to keep adult quahaugs in tanks supplied by running salt water, and to remove the spawn to special rearing tanks as soon as it appeared.

No facilities for such work were available until the summer of 1909, when a small one-horse power gasoline engine and pump were installed at the Wellfleet laboratory, which is situated on a wharf over the water. At high tide water could be pumped to a large wooden tank at the top of the building, which served as a reservoir. From this tank water was conducted by a large pipe to different parts of the laboratory, where it was supplied to the hatching tanks by rubber hose.

For hatching purposes we used wooden tubs, made of large hogsheads cut in two in the middle, through which passed a continuous stream of water. In order that the flow of water might be maintained without loss of larvæ, the water was drained off through sand filters, fitted so that they could be readily cleaned. This arrangement was accomplished by fitting into the bottom of the tub several short pieces of 3-inch galvanized iron piping in a vertical position. Sand was held in the pipes by wire netting on the bottom and could be removed when desired. For the purpose of aëration the salt water was forced in fine streams into the tanks, keeping the young larvæ under uniform conditions as regarded temperature, food supply and flow of water.

At the beginning of the spawning season the quahaugs were kept in ordinary tanks. When spawn was discharged into the water it was transferred to the special tubs previously described, and efforts were made to rear the embryos under what seemed to all purposes natural conditions. Large glass aquaria and glass hatching jars were also utilized, the eggs in the latter being constantly kept in slow motion by means of a double inflow of water, one on the bottom furnishing the circulation, the other on the top aërating the water. All sorts of combinations, such as varying the amount of spawn, the rate of flow, the kind of jars, and selecting the more active larvæ by siphoning, were tried in vain, as the quahaug embryos perished in great numbers, only a few reaching the veliger stage.

Embryology.

The embryology of practically all the *Lamellibranchiata* is strikingly similar, the eggs passing through identically the same stages and differing but little in appearance. This similarity holds true until after the formation of the embryonic shell. During the first part of the veliger (embryonic shell) stage the predominating type of a straight-hinged veliger holds true; and it is only in the last part of this period that differentiation in structure and form between species can be noticed. In the report on the scallop the embryology has been described in detail, and in the following pages, owing to the great similarity of the quahaug and scallop larvæ, only a brief description of the general features will be given, emphasis being placed on the points of difference. For a more complete description the reader is referred to the life history of the scallop, published in a previous report.

The first distinction has been already mentioned, the gelatinous case which surrounds the quahaug egg, whereas the scallop egg is naked. The majority of eggs remain within this covering until they become ciliated embryos, when by the rotary action of the cilia they break from its folds. It was a frequent occurrence to observe through the microscope embryos rapidly revolving within the cases.

Polar Cells. — About twenty-five minutes after the egg is laid, two clear transparent bodies, apparently containing no yolk granules, are given off at the flattened animal pole (Fig. 3). The first body by its appearance clearly demonstrates the presence of a membrane about the egg, as it is formed beneath the membrane, which forms part of the adhering strands for the polar cells.

Yolk Lobe. — The appearance of the polar bodies is followed by the formation of a poorly developed yolk lobe (Fig. 3), by no means as conspicuous as in the case of the scallop. No constriction, such as is found with the scallop, is observed with the quahaug egg; but the nutritive material is confined to one end, which later becomes the large yolk cell (Fig. 4). Just previous to the first segmentation the egg elongates into a pear-like body, the yolk lobe constituting the broad end. The elongation takes place in a direction horizontal to the polar cells and not vertical, as with the scallop.

Cleavage. — The quahaug egg develops by the same process of unequal cell division as the scallop, although the time and form of the divisions are different. The difference in time is probably unimportant, as the warmth of the water has a great deal to do with the rapidity of development in mollusk larvæ. The first cleavage (Fig. 5) is noticed thirty-five minutes after fertilization, and at the end of fifty minutes the majority of the eggs are in the 2-cell stage. The actual time from the beginning to the completion of the first cleavage for individual eggs is about three minutes. The average time for the completion of each cleavage after fertilization for the majority of the eggs was as follows: 4 cells (Fig. 10), one hundred and ten minutes; 8 cells (Fig. 11), one hundred and forty-five minutes; 16 cells (Fig. 13), one hundred and eighty-five minutes; 32 cells (Fig. 14), two hundred minutes.

The principal difference between the cleavage of the quahaug and the scallop egg is found during the first segmentation, and is chiefly due to the elongation in opposite directions. In both cases the first division gives 2 cells, a large and a small; with the scallop the larger cell has an elongated form, due to the construction of the yolk lobe, while with the quahaug both cells are spherical.

The egg passes through the 16, 32, 64, etc., celled stages, until the primitive ovum has become a compact mass of small cells (Fig. 12) surrounding a group of large cells, containing the nutritive yolk. This is the blastula stage of the embryo, which soon becomes a true gastrula by an invagination which forms the primitive digestive tract. About the age of ten hours the surface cells acquire minute hair-like processes (Fig. 15) called cilia, which enable the animal to move. Up to this period the egg has developed inside the transparent case, but the lashing of the cilia soon tears apart the protective covering, and the animal escapes, as a swimming embryo, into the water.

Trochosphere Larvæ. — By the time the embryo is able to break forth from its case the random revolutions of its early ciliated stage have changed, and a new larva, more elongated in form, swims through the water with a definite spiral movement, rotating voluntarily around its longitudinal axis in either direction. The new type of embryo is called a trochosphere (Fig. 16), and reaches that stage at the age of twelve to fourteen hours. It is differentiated from the ciliated gastrula by having an elongated or top-like body; by having the cilia confined to the blunt anterior end; the formation of a primitive mouth; and the appearance of a shell gland opposite the mouth. The trochosphere stage of the quahaug and the scallop are identical in regard to (1) form of animal; (2) mouth; (3) shell gland; (4) methods of swimming. The only difference lies in the flagellum, or whip-like feeler, formed in the scallop larvæ by the elongation of certain cilia on the anterior end, but probably absent in the quahaug.

In the course of the next twenty-four hours a thin transparent shell (Fig. 17) creeps slowly over the animal, until it completely envelops the soft parts. During this period the animal can be observed swimming through the water with its organs partly covered by two thin valves. The shell is formed by the secretion from the shell gland, which becomes calcified at two points, forming the two valves. With the spreading of the shell various changes of more or less importance, both in the anatomy and habits of the young quahaug, have taken place, giving rise to a period in its development known as the veliger stage, perhaps the most critical and important period of its existence.

The Veliger. — The early veliger (Fig. 18), formed about thirty-six hours after fertilization, is a different appearing animal than the swimming larva of the early stages. When first formed it has a transparent shell with a straight hinge line, which is nearly always held open at an angle of 45°, whether the quahaug is resting on the bottom or in the act of swimming. The animal at this time is but little larger than the trochosphere larva, the empty space between the soft body of the animal and the shell constituting the only gain in size. The ciliated velum has no flagellum, the stomach is prominent, two adductor muscles are present, and teeth are apparently present on the hinge line. The animal swims by means of a velum which is not extruded from the shell. This is the description of an undeveloped quahaug veliger, which has not as yet attained full size, and has not become proficient in the art of swimming with its velum. In the course of a few hours it will have reached the normal size, and will have taken on the attributes of a true veliger.

The straight-hinged quahaug veliger, except for the absence of a flagellum, is similar in every way to the young scallop of this stage. In fact, the majority of lamellibranchs, except *Anomia* and a few others, pass through the period of the early veliger practically identical in form and habits, so much so that it is impossible to differentiate between species. The first traces of individuality are found in the late veliger, in which each species develops a shell peculiar to itself. For this reason the reader is referred, for a detailed description of the early veliger stage, to the report on the scallop (*Pecten irradians*), as only a summarized account is here given.

The veliger stage may aptly be compared to childhood, placed as it is between embryonic development and the attachment stage or youth. Not until this point in its life does any important increase in size occur. This period is divided into two parts, which are styled, for want of a better title, (1) the early and (2) the late veliger, as several anatomical changes differentiate the two. The veliger derives its name from the peculiar swimming organ or *velum*, which during the first part of this period is one of the most important organs of the animal. With the development of the foot, which takes place toward the last part of the veliger stage, the velum gradually disappears, while the foot, for a brief period, performs its work. The duration of the veliger period depends largely on the temperature of the water, ranging from six to twelve days, during which the veligers can be taken in numbers in the water by means of the plankton net. When swimming in the aquarium they are sensitive to a sudden jar which causes them to pull in the extended velum and settle to the bottom. This circumstance makes it possible to separate the veligers from other plankton forms. The act of swimming is accomplished by the extension of the velum or ciliated pad, the lashing of the cilia propelling the animal in any direction. The entire veliger stage is passed as a swimming larva in the water, occasionally settling to the bottom, where it runs the risk of destruction. It is only brought to an end by the increasing size of the animal, the loss of the swimming function of the foot, and the acquirement of alternate powers of attachment and crawling.

The chief characteristics of the early veliger are: (1) an equivalvular shell with a straight hinge line; (2) a velum or ciliated swimming organ; (3) a primitive mouth lined with cilia, leading into a cavity in the center of the body, the stomach, and an abbreviated intestine with posterior anal opening; (4) an inconspicuous mantle; (5) two adductor muscles. The late veliger is characterized by (1) a shell marked by prominent umbones, directed posteriorly; (2) a well-developed foot, with byssal gland, which has taken the place of a degenerate velum; (3) a more complex digestive tract, with palps and coiled intestine; (4) a conspicuous mantle; (5) two adductor muscles and several primitive gill bars.

The change in the transition between these two forms is quite pronounced as regards: —

(1) *Shell.* — The straight hinge line of the common ancestral form gives way to one of slight curvature by the bulging of the valves to form the umbones. Both valves are of equal curvature, and the embryonic shell has a homogeneous texture which differentiates it from the succeeding growths.

(2) *The Velum.* — The swimming organ, situated within the anterior part of the shell, consists of an elliptical pad, with a border of lashing cilia, capable of extension and contraction, whereby it can be thrust out of the shell or withdrawn quickly by means of muscle fibers attached near the hinge. When contracted the ciliated edges fold inward. The velum is a modification of the anterior ciliated portion of the trochosphere larva. During the middle and last part of the veliger period a degeneration of the velum, with a simultaneous development of the foot, takes place. The growth of a muscular foot seems gradually to obliterate the velum, which can be seen in different stages of

degeneration, the foot with ciliated tip finally assuming the swimming function of the velum.

(3) *Gills.* — Several ciliated V-shaped filaments, capable of extension and contraction, arise on each side of the foot, and eventually become the complicated gills of the quahaug. A thin mantle, closely lining the sides of the shell, similar to the mantle of the adult, is noticeable, while the digestive tract has enlarged in size and length, the straight intestine becoming coiled.

At the beginning of the veliger period we find an animal anatomically equipped to lead a free-swimming life in the water, as is evidenced by its size, shape, lightness of shell and large swimming organ. At the end of this state we find the animal on the verge of another great change. Its free-swimming days are over, and anatomical changes have taken place which fit it to enter upon a new existence, that of youth. The ciliated swimming organ has been replaced by a long muscular foot, which at first enables the animal to swim through the water, but soon loses that power. The shell has changed in size, form and weight, while the soft parts have enlarged to such an extent that further shell growth of a more substantial nature is required. In brief, its free-swimming existence is ended, and, following the invisible law of nature, the structure of the animal has become altered, in preparation for a change of life.

The Attachment Stage.

The attachment of the quahaug marks the end of its embryology and the beginning of its real life under practically the same conditions which surround the adult. The change is accomplished by the development in the foot of a byssal gland which secretes a fine, tough thread, anchoring the animal to any object, particularly sand grains. The method of attachment is described in detail under "The Habits." There is some reason to believe that a crawling stage intervenes between the free-swimming and the attachment periods. If so, it is of slight duration, as the functions of crawling and attachment are supplementary, the welfare of the young quahaug depending both on its resting and its migratory powers. At all events, the time of attachment marks the appearance of a new growth, comparable to the dissoconch shell of the scallop as opposed to the prodissoconch (embryonic shell), which forms the true shell of the adult.

From this time on the changes in anatomy and habits are very similar in the quahaug and the soft clam (*Mya arenaria*), as the environment of both is the same. The habits of the young quahaug are described later, and only the changes in structure will be given here. Specimens for study were obtained from spat collectors, in the form of boxes, which were lowered from a raft in the Powder Hole, Chatham, Mass.

The Shell. — The new growth is sharply separated from the embryonic shell by a definite growth line, and is distinguished by different shell formation, as regards texture, color and lines of growth. The embryonic shell has a smooth homogeneous structure, with fine concentric lines of growth, whereas the new growth is coarser, whiter and characterized by concentric ridges occurring at definite intervals. The color is evidently due to the greater amount of lime salts. The ridges (Fig. 28) are especially prominent in rapidly growing quahaugs less than 1 inch in size, and can be observed on well-preserved adult specimens, where the umbones have not worn away. They reach their maximum size when the quahaug is about ¾ of an inch in length, varying greatly in prominence on the same and different specimens. In quahaugs 1 millimeter in size as many as twelve distinct ridges could be found. No explanation for these prominent lines can be given. In quahaugs ¾ of an inch in size they appear at the rate of two to three a month during the summer, apparently at regular intervals, as the amount of space between ridges seems to depend upon the rapidity of growth. These ridges differentiate the very early stages from *Mya arenaria,* which at first has a round form, different from the elongated adult. Both valves are equal and have prominent umbones, back of which appear faint lunules, the heart-shaped structure so well marked on the adult quahaug. Unlike the young scallop, no byssal notch is present.

The Soft Parts. — At the beginning of the attachment stage the animal has all the organs characteristic of the adult in miniature form. The visceral mass and sexual organs are not conspicuous, the foot is more mobile and relatively larger than the plow-shaped structure in the adult, the byssal gland, absent in the adult, is a conspicuous appendage of the foot, and the other organs, differing in size, position and development, are but rudimentary. As the quahaug increases in size these organs take on adult characteristics, and by the end of the attachment period (size, 9 millimeters), they conform in practically every detail with the adult.

(1) *The Mantle.* — The mantle appears larger than that of *Mya* (soft clam), and is pressed into a series of folds at the free margin, which gives the appearance of a number of large knobs or tufts. In the young the margin is ciliated and sensitive to touch, but in form it differs little from the adult, which apparently has maintained the primitive lamellibranch mantle.

(2) *The Siphon.* — The mantle edges at the posterior end of the young quahaug, almost at the beginning of the attachment stage, are modified to form the excurrent and incurrent siphons, which constitute the "neck." The siphon is very similar to the same structure in the clam. The excurrent part has the same filmy telescopic attachment (Fig. 29) which draws in and out with a folding motion. When a stream of water is shot out, the transparent tube is cautiously unfolded and held as a hose to direct the flow. The average time of

expansion was found to be four seconds, the time of contraction varying from two to eleven seconds. In crawling, there appears to be a certain degree of unison between the outflow of water and action of the foot which may assist the progress. This excurrent attachment gradually disappears as the quahaug grows older, although in one-half or three-quarter inch quahaugs a remnant can be observed on the edge of the excurrent siphon. The edges of the siphons are lined with tentacles, as this is a most important sensory part of the mantle, the incurrent siphon having about three times as many as the excurrent. In a 1-millimeter quahaug twelve tentacles were counted on the incurrent and four on the excurrent siphon, a greater number than on a clam of the same size. These large tentacles are probably of greater use as sense organs to the young quahaug than to the old. Very little color is found on the mantle and siphon, except on the tentacles, which sometimes are strongly pigmented.

(3) *The Foot.* — The early foot is a muscular body, capable of an extension equal to two-thirds the length of the shell. At the tip the cilia are somewhat longer, possibly aiding in the strong grip which is exerted at this point, enabling the quahaug to crawl along a surface. On each side of the foot is a circular otocyst or balancing organ. On the ventral side of the foot projects a papilla with a deep cleft, the byssal gland. It is more prominent than the byssal gland of the scallop.

(4) *The Gills.* — The few simple filaments of the veliger stage increase in number, forming the inner gill, while new buds repeat the same process to form the outer. As the gills enlarge they become more complicated, taking on adult characteristics.

(5) *The Muscles.* — The two adductor muscles remain in the same position, enlarging in proportion to the amount of increased work.

(6) *The Reproductive Organs.* — The visceral mass is formed above the foot, and is not visible until toward the last of the attachment stage, when the foot becomes relatively smaller and less motile. In this body are the ovaries or testes, according to the sex of the quahaug.

(7) *The Digestive Tract.* — The liver, arising by two ducts from the side of the stomach, enlarges rapidly and takes on a dark brown color. The intestine increases in length by forming tortuous coils in the visceral mass, and after piercing the ventricle of the heart, terminates behind the anterior adductor muscle.

THE HABITS.

A study of the habits of any animal frequently leads to the discovery of facts which can be utilized for practical purposes. In the case of the quahaug at least three habits are directly related to artificial cultivation: (1) the method of attachment, which furnishes possibilities for spat collecting; (2) the non-migratory life, which makes planting possible without enclosures; (3) the method of feeding, which suggests the probability of increasing the rate of growth, fattening and even producing special flavors. In addition, notes upon other topics are presented, such as enemies and environment, which do not properly come under the definition of habits, but to a greater or less extent influence the life of the quahaug. As far as possible these subjects have been arranged in accordance with the development of the animal.

Attachment.

Attachment takes place at the end of the veliger or free-swimming stage, when the young quahaug fixes itself to various objects by means of a horny thread called the byssus (Fig. 28), secreted from a gland in the foot. The objects of attachment are sand grains, shells, boxes, eelgrass, sea lettuce, etc. The period of fixation marks the change from an active swimming existence to a more sedentary mode of life. The gland which secretes the byssus in most lamellibranchs is situated in the ventral side of the foot, and varies in size and appearance. Lining the sides of this gland, which has the appearance of a pore, are a number of little cells which furnish a mucus-like secretion which, when coming in contact with water, immediately hardens, forming tough threads of conchiolin, a complex chemical substance of horny nature.

The byssus in the different lamellibranchs has a variety of forms. In some it consists of a number of soft glossy threads bundled together, as in the young of *Pecten,* the scallop; in the mussel (*Mytilus*), where it is an important organ of the adult, there is a thick bundle of hair-like threads with disks at the ends which are attached to the object of support; *Anomia,* the silver or jingle shell, has a calcareous byssus which projects through the lower shell and strongly attaches to the animal; and in the young of the soft clam (*Mya arenaria*) it consists of a single translucent thread with several branches. In the mussel the byssus in the adult has no connection with the foot, but is situated behind it, forming an almost permanent attachment for the support of that mollusk. Nevertheless, the mussel is reported to be able to move along slowly by the formation of new threads and the destruction of the old strands (Williamson, 13). Certain lamellibranchs seem to have lost the byssus through disuse, some apparently never possessing this organ at any stage of their development. Another class retains the byssus for certain periods, *e.g.,* the clam, which makes use of the power of attachment until it reaches a size capable of burrowing deeply in the sand, and the scallop, which throughout its life retains the power of byssal fixation, but does not use it to any extent after the first year.

The adult quahaug possesses no byssus as it has no need for that organ. For a long time there has been considerable question as to whether the quahaug in its early life possessed such an organ. Ryder (12) in 1880 found that the young of the soft clam were attached by a single branching thread to seaweed and sea lettuce. This fact was clearly demonstrated by Kellogg (4) in his report on the "Life History of the Common Clam," in which he gave some excellent drawings of the byssal attachment, and proved that the attachment stage was a necessary part of the life of the young *Mya*. At this time it was surmised that the quahaug likewise had a byssus during the early part of its existence. Proof was first obtained September, 1906, when it was the good fortune of this department to record the attachment of young quahaugs (*Venus mercenaria*) in the spat boxes at Monomoy Point.

The byssus of the quahaug is in appearance so similar to the same organ in the soft clam that if it were detached a person could not tell the two apart. In use, structure and formation the two threads are exactly the same, so that, in describing the attachment of the quahaug, use is made of facts recorded for the clam by Kellogg (4). The byssus consists of a single thread, normally from ¼ to ½ an inch in length, but so elastic that it can be stretched to a length of 1½ inches without breaking. Several branches, usually not more than two or three, extend from the lower part of the thread, and at their distal ends divide into strands like the delta of a river, which spread out on the foreign object, fastening themselves apparently by little suckers or stickers. The thread is of uniform thickness, except at its distal end, where it is slightly finer. Under the microscope the thread has a translucent glossy appearance, similar to strands of prepared gelatine.

The quahaug first attaches itself at the close of the veliger or free-swimming stage, when a prominent byssal gland is formed on the ventral side of the foot. The quahaug retains the power of attachment until it has attained a size capable of burrowing firmly in the sand. The largest quahaug observed with a byssus measured 9 millimeters, and was found in a spat box at Monomoy Point, Oct. 13, 1906.

Many observations on the byssal attachment of the quahaug were made at Monomoy Point, where the quahaugs were obtained in spat boxes suspended from a raft. The attached quahaugs were observed here during August and September in 1906 and 1907, and in 1908 as early as July 24. The majority of these quahaugs were buried in the sand and attached to the sand grains by the byssal threads. Occasionally a quahaug was found attached to the sides of the box out of the sand. At Wellfleet small quahaugs were found attached to the shells put down for the capture of oyster spat, and many times quahaugs were raked up adhering to shells and other material. Likewise young quahaugs were frequently observed to attach themselves to the glass dishes in which they were kept for study in the laboratory. These observations show that, while the majority settle in the sand, the quahaug can "set" on objects such as shells, boxes, eelgrass and sea lettuce, and in the latter cases can be carried such distances as described for the soft clam by Kellogg (4). Thus, the quahaug is comparable with the clam, which "sets" both out of and in the sand. Practically all the quahaugs attached out of the sand were between

2 and 3 millimeters in size, no large ones being observed, which indicates that the quahaug "sets" but temporarily out of the sand.

The time of spinning a byssus is comparatively short. No direct observations have been made on this point; but it has been known to break the old and form a new one within a few hours. It is doubtless a much shorter time, as the young scallop has been seen to spin a similar byssus in three minutes.

The process of attachment has not been studied. In general the embryo, swimming with its foot, strikes a surface, presumably catches hold with its foot, and, after crawling to a suitable place, spins its byssus. In other cases it strikes some object, and closing the shell drops to the ground, where it passes through the same process, only attaching itself to the sand grains. The young quahaug has the power to cast off the byssal thread at will and spin another. The thread separates from the animal at the byssal gland and remains clinging to the object to which it is attached. This is probably of constant occurrence, especially with the smaller quahaugs, as they are quite active at this stage, and in traveling from one resting place to another must repeatedly break the thread and quickly spin another. At this period the animal alternately leads a traveling and a sedentary existence.

Unquestionably the byssus is of importance to the young quahaug, as otherwise this organ would have degenerated from disuse. Primarily the function is protective, as it enables the animal, though of small size, to remain in the sand, and prevents its being washed from its shallow burrow. Again, in the earlier stages the attachment to various objects keeps the young quahaug from being smothered in silt, or from being washed ashore to its destruction. Attachment is needed only until the quahaug obtains sufficient size to protect itself by burrowing more deeply in the sand. The slender thread though small is unusually strong, resisting a considerable pull before it parts, and can be considered as the anchor cable which moors the quahaug.

The "Set."

The time of "set" varies, as it depends upon the spawning season. Usually the young quahaugs are noticed slightly later than the young scallops. At Monomoy Point, in the raft spat boxes, small quahaugs have been observed by the naked eye as early as July 24, in 1908, while in other years they have not been recorded until the second week in August. The "set" is not abundant, as is the case with the clam, and no quantities of young quahaugs comparable to the heavy "sets" of small clams are found. The fact that the "set" is usually below the low-water mark perhaps explains the failure to find thickly "set" areas, as many beds escape the attention of the quahauger. As it is, but few localities of heavy "set" are known. At the present time the Acushnet River furnishes the greater part of the small quahaugs, though in some years the Mill Pond in Chatham; Tuckernuck Island, Nantucket; Katama Bay, Edgartown, have also contributed considerably. The Katama Bay region maintains the steadiest supply, owing to the protection of the quahaugs under 1½ inches by the town of Edgartown, while in the case of Chatham and Tuckernuck Island the supply is very erratic. The beds have been depleted, have remained barren for a time and have again received other heavy "sets."

When the first attachment has been made, either to shells or sea lettuce, there is a later migration to the sand, but usually the "set" comes directly on the soil. The nature of the bottom largely determines the future welfare of the "set," which will soon perish if the ground is unsuitable. An excess of silt, slimy mud, shifting sand, proves unsuitable for the existence of the young animal, showing that only portions of the sea bottom are favorable for the existence of the young quahaug.

The same causes which influence the "set" of the soft clam to a large extent determine the abundance of young quahaugs in any locality. Its nature depends largely upon the location in respect to the shores and current, and definite combinations are necessary. As with the soft clam, it has been noticed that the "set" often occurs in an eddy, or on the sides of a swift current. In the Mill Pond at Chatham the "set" is found on the bar reaching part way across the entrance to the upper part, over which the tide sweeps back and forth. A similar case is found at the tip of Jeremy's Point, Wellfleet, and on the gravel bar, over which the tide flows with great speed, large numbers of seed quahaugs can be obtained. In the latter case the bar is exposed at low water during the low running tides.

The quahaug over ½ inch in length is comparatively free from the enemies which attack other shellfish, as its hard shell renders it immune from all except the horse-winkle (*Fulgur caniculatus* and *carica*) and the common cockle (*Lunatia heros* and *duplicata*). Severe winters and other climatic changes affect the quahaug but slightly, except on the exposed flats between the tide lines. So we find in the quahaug an animal which for the greater part of its life is better protected from enemies than the other commercial shellfish. On the other hand, the female quahaug produces the same quantity of eggs as the other shellfish. Therefore, the struggle for existence must be exceptionally severe during its early life or free-swimming period, furnishing a possible explanation for the frequent failure of the quahaug "set."

Spat Collecting.

In the oyster industry the importance of spat collecting became apparent as soon as the natural beds ceased to yield a sufficient amount of seed for planting purposes. In considering quahaug culture the question naturally arises as to whether there are any artificial means of raising young quahaugs for planting. The importance of having a good supply of seed is apparent. We have previously stated that at present there is no practical method of raising the young quahaug from the egg, owing to its small size and delicate nature. The other possibility is the collection of the quahaug seed from the water by some method of spat collecting similar to that used for the oyster.

When the oyster "sets" at the end of the veliger period it attaches itself by a calcareous secretion to shells and rocks. The quahaug, on the other hand, attaches itself by a single-threaded byssus to sand grains or other clean objects. Attempts were made to catch the quahaug at this stage by spat boxes, — small dry goods boxes, partly filled with sand, — which were suspended from the raft at Monomoy Point. In these boxes quahaugs were obtained at the end of the spawning season in more or less abundance, for the study of the early life history and for the growth experiments. In all probability the young larvæ, when ready to "set," strike the sides of the box and settle in the sand, where they are held in by the sides of the box. Unfortunately, while these boxes proved useful in obtaining quahaugs for experimental purposes, the amount collected was insufficient for commercial purposes. The largest number ever found in one box was 75 per square foot of surface, and the majority of boxes yielded less. To make such a method commercially important it would be necessary to obtain several hundred quahaugs to the square foot of surface. For this reason, unless the essential principles of this method can be applied on a large scale with better success, it is hardly practical to obtain the seed in this way. A better solution would be to develop the places which are naturally suited for the catching of seed by the building of gravel bars, and by artificially directing tidal currents, in other words making nature supply the seed.

Locomotion.

The organ of locomotion for the adult quahaug is the foot, which is described as situated on the ventral surface of the visceral mass in the form of a keel-like projection. Its shape enables the foot to readily enter the sand in the same manner as a plow, so that the animal can turn over, burrow or even crawl through the sand. The foot is composed of comparatively tough muscle fibers, and its action is aided by retractor muscles, anterior and posterior, which are attached to the shell above the fixation of the adductors. As with the soft clam (*Mya arenaria*), the foot is distended by the influx of blood from other parts of the body. The movements of the adult are confined to two forms, (1) burrowing and (2) crawling, the former being the more common.

Burrowing is the act of forcing the shell of the quahaug into the sand below the surface, and is accomplished by the action of the foot. Usually this act is performed when the quahaug lies under the water, but it may be possible for the animal, like the sea clam, to enter the sand when exposed to the air. The soft clam requires to be covered by water before it can burrow properly. The quahaug, resting on the surface, cautiously extends the muscular foot through the slightly opened valves, working it down among the sand grains until a sufficient purchase is obtained to raise the shell on edge. The shell by a series of jerks is pulled down after the active foot, until the animal is entirely buried beneath the surface, the external openings of the short siphons remaining in view. The length of time depends upon three factors, (1) the size of the quahaug, (2) its activity and (3) the soil. The large quahaugs take longer to burrow, as they are less active, heavier and require more force to enter the sand. The foot is relatively larger in the small quahaugs than in the large, and naturally the young show greater activity in burrowing. Besides age, the activity of the quahaug depends upon the temperature of the water, as below 50° F. they burrow slowly, often lying for long periods on the surface. This is an important fact for the planter, as there is danger in winter planting, owing to the exposure from non-burrowing. The nature of the soil, whether compact or loose, hard or soft, determines to some extent the rapidity of burrowing. When conditions are favorable, burrowing is usually accomplished within a few minutes. Out of 1,500 quahaugs planted at Monomoy Point in sixteen different lots on June 4, 1906, and Oct. 10, 1905, when the water was about 62° and 55°, respectively, 92 per cent. had burrowed within twenty-four hours after planting. The quahaugs were small, less than 41 millimeters, and in good condition. The June beds gave 94 per cent., the October beds 85½ per cent., showing the effect of temperature.

The power of burrowing is necessary for the quahaug in the same way as for the soft clam. Whenever the animal is forced or torn from its burrow by natural or artificial agencies it can again resume its natural position in the soil.

The quahaug also possesses the power of crawling, as it is equipped with all the necessary organs for progress through the soil, but does not make use of this faculty to any great extent. The act of crawling is accomplished in much the same way as the burrowing, which is a modification of the original crawling habits of the young. After burrowing in the soil the animal works the extended foot forward, forming a way for the shell, which is pulled after the foot. The movement is anterior, *i.e.*, the siphonal end of the animal brings up the rear, the end of the shell projecting so that a winding trail is left on the surface of the sand, showing the course of the animal. Crawling is effected by the same conditions which influence burrowing, such as temperature, soil and size of the quahaug, the older animals moving very little, while the young forms are more active. In one instance a blunt quahaug between the tide lines was found to have crawled 7 inches in twenty-four hours. All movements in this bed were in the direction of the retreating tide. While crawling is more often observed between the tide flats, it also takes place in the natural habitat, below low-water mark. On wet flats the quahaug can possibly crawl without water over it; but most of the crawling is done under the water.

Various writers have referred to the quahaug as wandering between the tide lines, as if the animal were constantly moving from place to place. In reality the quahaug moves but little, and usually at a slow rate, as by force of habit it is a stationary animal. The writer several times has observed its wanderings, as shown by the marks on the tidal flats, but has never found evidence of its traveling any great distance. On the other hand, from general observations and from planted beds which were left for years, he has invariably found that the quahaugs remained in the same localities where placed. Even the smaller, active quahaugs, 3/4 of an inch, which are more prone to crawling, have been observed to remain where planted. Kellogg (2) in 1903 was the first to note that there was practically no migration of the quahaugs in his beds, which he found intact several months after planting. All our growth experiments substantiate Professor Kellogg's observations, as in no case was there any general migration. Therefore, it can be concluded that, while the quahaug has the power of moving, possessing as it does the necessary organs for crawling, it makes use of this habit but little, and when placed on satisfactory bottom will remain within a few feet of its original position. The importance of this fact to planters should not be overlooked, as otherwise the prospective culturist will be afraid that his planted crop may move. Such is not the case, and the culturist need never fear any appreciable loss through migration.

The proofs on which the above conclusion is founded are three: (1) observations on many growth experiments; (2) experiment on movement below low-water mark; (3) experiment on movement between the tide lines.

(1) The facts on this point have already been given. In all the growth experiments the quahaugs were found a year or more later in the immediate vicinity. In no case had there been any marked migration. In several beds, planted between the tide lines at Monomoy Point, which were taken up eleven months after planting, nearly all the quahaugs were found within 3 feet of the original beds. In one bed the quahaugs were of small size, measuring 17 millimeters in length, showing that even the young, active animals were not inclined to wander.

(2) A means of roughly determining the migratory powers of the quahaug was tried at Monomoy Point in 1906. Short stakes, in width and thickness 3 inches by 1 inch, were driven in the coarse sand in the Powder Hole in front of the laboratory, where there were 2 feet of water at low tide. Six quahaugs were placed in order around the stake, 1 at each end, 2 at each side, with the tips of their shells just

touching the wood, so that any movement could be readily determined. Four lots of 6 quahaugs each, measuring 28, 29, 40 and 41 millimeters, were placed in position Sept. 14, 1906, and examined three times, at intervals of three, fourteen and thirty-eight days, respectively, at each examination the quahaugs being left where found, so that the final observation recorded the total movement for the entire period. On the first examination after three days 5 quahaugs out of the 24 had moved from their original position, moving from ½ to 3 inches, on an average of 1 inch. In fourteen days 8 more, 13 in all, had moved, the average distance this time being 1.27 inches, the minimum distance traveled being ½ inch and the maximum 3 inches, while 1 quahaug was missing. After a period of thirty-eight days 4 were reported missing, 5 remained as originally placed and 14 had moved an average of 2.15 inches, with a minimum of ½ inch and a maximum of 6 inches. What became of the 4 missing quahaugs was not determined, and it is a matter of conjecture whether they crawled away or were washed out of their burrows in the sand. The distance covered by the 15 that moved is very slight and unimportant. If the quahaug were naturally a migratory form, as the sea clam, within thirty-eight days all would have traveled away; but considering the fact that 83 per cent. of the number remained within a few inches of their original position, it can be concluded that the quahaug leads practically a sedentary life. No difference was noticed in the movement of the 28-millimeter and the 41-millimeter quahaugs, as the number of large and small which moved were about the same, although the larger quahaugs covered about twice as much distance as the small. A parallel experiment with sea clams (*Mactra solidissima*) was conducted under the same conditions, with the result that all disappeared in the course of a few days after planting.

(3) A similar experiment was tried between the tide lines at Monomoy Point, on a sand clam flat. Five stakes were driven in the flat, and quahaugs were planted close to these on Sept. 18, 1906. One month later all but 1 out of 57 quahaugs were found within 6 inches of the posts, showing that, even between the tide lines, the so-called wandering zone, the quahaugs showed no tendency to migrate.

Movement of the Young Quahaugs.

(1) *Swimming.* — The swimming period of the quahaug's life lasts during its embryonic existence, ending soon after the completion of the veliger stage, although the footed larva has for a short period the power of swimming with its muscular foot. The embryo acquires the power of moving through the water at the age of ten hours, when the surface cells are equipped with minute hair-like processes, cilia. The early movements consist of random revolutions of a spiral nature. Two hours later, definite direction is established by the elongation of

the animal, which now swims with a spiral movement, rotating around the longitudinal axis. With the growth of the embryonic shell, about thirty-six hours after fertilization, the animal, now called the veliger, swims by means of the velum, a muscular pad covered with long cilia. The velum has been derived from the anterior ciliated area of the ciliated larva. The animal opens its shell, thrusts out the velum, and is propelled by the action of the cilia in any direction. During the summer spawning months the water is full of these small veligers, which can be taken by a plankton net of silk bolting cloth. When startled, as by a sudden jar, they cease swimming, pull in the velum, close the shell, and settle to the bottom. During the veliger stage occurs the loss of the velum and the appearance of the foot, which takes its place, at first as a swimming, later as a crawling organ. Swimming is accomplished through a kicking movement of the foot, which propels the animal through the water. A similar movement has been seen in adult razor clams, which have been observed to swim through the water for short distances by the kicking with the long foot.

(2) *Crawling.* — With the young quahaug crawling is somewhat different than with the adult, and is similar to the crawling of the young clam. Observations were made on quahaugs from 2 to 3 millimeters in size. At this age the flexible foot is elongate, and more like the blade of a knife than the keel-shaped foot of the adult. Two methods of crawling were observed.

(*a*) *The Forward or Following Movement.* — The forward movement is the common means of crawling, and is similar to the methods observed in the young clam and scallop. It consists of extending the foot and dragging the body after it, in the same manner as the adult quahaug moves through the sand. Fig. 20 shows the foot just appearing from the shell. The mantle and siphon are extended, while the angle between the shell and the foot is acute. This is the beginning of the movement. Fig. 21 shows the foot extended to its full length. It has made a twist so that the bottom part of the ciliated tip can get a firm hold. By straightening out this twist the shell is raised on edge to its natural position when in the sand. The usefulness of this movement is explained by the fact that the quahaug, when exposed, lies flat on the surface of the sand, and that the shell is thus raised on edge, so that it can enter the sand with a cutting edge. The next movement (Fig. 22) is what might be styled a "downward tip," as this action is likewise of use in entering the sand as a wedge. Then quickly follows an upward tip (Fig. 23). By these two tips the quahaug has withdrawn within the shell all but the extremity of the foot, and is now ready for another start. The distance covered is three-fourths the length of the foot. The two tips are caused by the retractor muscles of the foot. In the downward tip the anterior retractor pulls on the anterior portion of the foot, resulting in the downward tip to the anterior portion of the shell, and the second or upward tip is the result of a similar action of the posterior retractor. A 3-millimeter quahaug was observed to travel at the rate of an inch, over eight times its length, in two minutes, covering about 1/17 of an inch at each movement, the average time of each movement being about seven seconds.

(*b*) *Backward Movement.* — The young quahaugs make use of another method of crawling, though less frequently than the first. This movement resembles a kick, and sends the shell backwards or sidewise. In Fig. 24 the foot is turned under the shell until the tip finds a resting place. Then by a jerky motion the shell is raised from the bottom and hurled to the position of Fig. 25 by a direct backward thrust. The foot is then drawn in and the same performance repeated. Sometimes the shell rests on the same valve, sometimes it is turned over so that on the completion of the movement it rests on the opposite side (Figs. 26 and 27). There is a similarity between the forward and the backward movements as they both depend upon the contraction and the expansion of the foot, but they differ in the application of the force, the first being a pull and the second a thrust. The average of 12 cases observed gave six seconds as the time consumed from start to finish by this movement, as compared with seven seconds for the other. The longest time observed was ten seconds, the shortest, four.

It is interesting to note that while in the case of the scallop a direct relation can be noted between the expulsion of water from the siphonal region and locomotion, in the case of the quahaug such cannot be definitely established. Possibly there may be a slight aid during the forward movement, although the flow of water is not co-ordinated with the contraction of the foot, as with the scallop. In the backward movement there is no assistance whatever.

(3) *Rate of Crawling.* — The following observations were made on the distance traveled by small 2 and 3 millimeter quahaugs. Small round glass dishes 1⅝ inches in diameter, were partly filled with fine white sand. Two quahaugs 2 and 3 millimeters were put in the center of the dish, which was placed in the aquaria. On examination fifteen minutes later it was found that the 2-millimeter quahaug had traveled 32 millimeters, or sixteen times its own length, *i.e.*, the rate of 5 inches per hour. The first 23 millimeters were through the sand, the last 9 on the surface. On a second examination, one and one-half hours later, the quahaug had only traveled 10 millimeters more, this time under the sand. The 3-millimeter quahaug had not moved at all, remaining in the position originally placed in the sand.

Three other quahaugs, 2 millimeters, 3 millimeters and 3 millimeters in length, respectively, were placed in a dish 3 inches in diameter, filled with white sand. Examined six hours later, they had moved 11 millimeters, 26 millimeters and 100 millimeters, respectively.

Recovery from Injury.

In several cases the shells of the quahaugs have been broken in planting. Unless the break or crack is too large the wound will heal by the formation on the inside of a new layer of shell, the old crack never joining, but merely being held together by the new growth underneath. It is well for the quahaug culturist to know that slight breaks are not always fatal to the quahaug, and that, in planting, broken ones should not be discarded.

The Feeding Habits.

The food of the quahaug, as of all the lamellibranch mollusks, consists principally of diatoms, — minute plant forms which are found in all waters. These little plants vary greatly in size and shape, often the species of one family but faintly resembling each other. Their chief characteristic is a silicious case, which distinguishes them from other plankton forms. The marine diatomaceæ are somewhat different from the fresh-water forms, but maintain the same general family characteristics. They are abundant throughout the water, although the lighter and smaller forms are most numerous near the surface. These surface species are naturally of less food value than the large, deeper forms. On the various soils which constitute the bottom, the diatoms are constantly reproducing and adding to the supply in the water. It has been found that mud furnishes better breeding places than sand, and that the color of certain surface soils is often due to the kind of diatomaceous growth. An increase in the temperature of the water results in more rapid reproduction. Other minute forms of plankton life are ingested by the quahaug, unless they are too large, in which case, by a complicated mechanism of the ciliary tracts, they are discarded with silt and other foreign material. In this way the quahaug shows a selective power in feeding. Small crustaceans, larvæ of mollusks and crustaceans, protozoa, rotifers, bacteria, etc., constitute a part of the quahaug food, the quantity depending on the location and the season.

The following account is taken from the work of Prof. James L. Kellogg, who has ably described the feeding habits of the quahaug in his report upon "The Feeding Habits and Growth of *Venus mercenaria*." The subject-matter is presented in condensed form, as only the important features are given. From the previous description of the anatomy the reader will remember that just inside the shell lies the mantle, enclosing the body in a fleshy case. Posteriorly the mantle lobes are fused to form two tubes, the incurrent and excurrent siphons, through which a steady stream of water enters and leaves the mantle chamber. Suspended in the mantle chamber, on each side of the visceral mass, are two conspicuous folds, the inner and outer gills, which play an important part in the collection of the food. On each side of the mouth, which is on the median line behind the anterior adductor muscle, are the palps, which are similar in appearance to the gills and function in conducting food to the mouth.

We have seen that a constant stream of water entered the mantle or branchial chamber. What becomes of it? And what is it that causes the current? All of this water in the mantle chamber streams through the minute openings between the filaments of the gill and enters its interior space. It now rises to the base of the gill, and flows into a tube, the epibranchial chamber, through which it passes backward, leaving the body by the upper or exhalent siphon, which is directly continuous with the epibranchial chambers of the four gills. The currents which we first noticed, then, enter the mantle chamber by the lower siphon, pass into the interiors of the four gills, flow to their upper or attached edges, and are directed backward and out through the upper siphon tubes of the mantle.

The cause of these rapid currents is revealed by a microscopic examination of the rods or filaments of the gills. These are found to be covered on their outer surfaces, which face the water on both sides of the gill, with innumerable short, hairlike structures which project perpendicularly from the surface. These cilia are protrusions of the living protoplasm of the cells which form the walls of the filaments. Each possesses the power of movement, lashing in a definite direction, and recovering the original perpendicular position more slowly. This movement is so rapid that it cannot be seen till nearly stopped by inducing the gradual death of the protoplasm. It is very effective in causing strong currents in the surrounding water.

A microscopic examination, and direct experiment with minute, floating particles, will show that other cilia are present on the filaments than those which cause the water to enter the gills. The diagrammatic figure of the gill does not show why the minute food particles may not be taken into the interior of the gill by the entering stream of water, and finally out of the body through the broad water channels. This is prevented by long cilia arranged in bands, which project out laterally between contiguous filaments in such a way as to *strain* the water which enters the gill, thus preventing all floating matter from entering. These highly specialized cilia tracts of lamellibranch gills I have called the "straining lines." In some forms there is a single line, in others there are two. In some cases the lines are formed by a single row of cells; or a section across the line sometimes reveals several closely crowded cells bearing the greatly elongated straining cilia.

That foreign matter is really excluded as the current of water enters the gill, may be demonstrated by direct experiment on a living gill. Carmine may be ground into a fine powder, and suspended in water without becoming dissolved. If a small amount of this is allowed to fall on the surface of a living gill, it will be seen to lodge there. A wonderful thing now occurs. A myriad of separate minute grains, which may represent the food of the clam, are almost instantly cemented together with a sticky mucus which is secreted by many special gland cells in the filaments, and the whole mass, impelled by the oscillations of the cilia, begins to move with some velocity toward the lower or free edge of the gill. On this free margin is a groove into which the material collected on the faces of the gill is turned. This groove is also lined by ciliated cells, and the whole mass is swept swiftly forward in it toward the palps. The natural food of the clam, of course, is carried forward in the same way. It is evident that a large proportion of the organisms floating in the water which enters the mantle chamber must come in contact with the sides of the gills, and be carried forward to the mouth folds, to which they may be transferred. . . .

If we now examine the palps with a hand lens, we may notice that their inner surfaces — those nearest to the mouth — are covered by a set of very fine parallel ridges. They are capable of many movements. They may be bent and spirally twisted, lengthened or shortened, and, if their inner faces touch the edges of the gills, any material which is being brought to this region is transferred onto the ridges of the palp. This is accomplished by strong cilia which are developed on the ridges. These same cilia carry the foreign matter on across the ridges, and finally force it into the mouth.

Enemies.

The adult quahaug is well protected from enemies by its hard shell, while the young larva is at the mercy of both the natural enemies and adverse physical conditions, which make its existence most precarious. We can divide the enemies of the quahaug into two classes: (1) the enemies of the young; (2) the enemies of the adult.

Enemies of the Young. — Adverse natural conditions, rather than active enemies, destroy vast numbers of the quahaug larvæ. Up to the time of attachment the young quahaug is at the mercy of tide, wind, changes in temperature, cold rains, etc., which either wash it ashore or kill the delicate embryo by sudden changes. All manner of fish, crustacean and molluscan life feed on the larvæ, even the mother quahaug sucking down her own offspring. The young quahaug must "set" on good ground or perish. In this way nature has regulated the number of eggs in the individual quahaug so that the large number compensates for the great destruction. Even when the quahaug has "set" it is not free from enemies. It becomes the prey of ducks and other water fowl if it happens to settle in shallow water. While no actual instances have come to the notice of the writer of taking quahaugs from the crops of water birds, other small shellfish of a similar nature, although adults, have been found. If these mollusks were eaten, it is possible that the small quahaugs would also be taken. Such mollusks as *Lævicardium mortoni* and young razor clams (*Ensis directris*) have been found in the stomachs of flounders, and naturally small quahaugs could be taken in the same manner by bottom-feeding fish. Instances have been recorded where small quahaugs have perished by washing ashore in storms, showing that even when protected by a shell they are at the mercy of the elements. Starfish, particularly the young "star," probably prey upon the young form, and it is possible for the oyster drill to attack a small quahaug.

Enemies of the Adult. — The enemies of the adult can be grouped into two classes, — the active and the passive. The active enemies are given in order of their importance: (1) man; (2) the winkle or cockle (*Lunatia duplicata* and *heros*); (3) the conch (*Fulgur caniculatus* and *carica*); (4) the starfish. The passive enemies are those which feed on the same forms as the quahaug, in certain cases depriving it of its sustenance, in others hindering its growth. As such may be enumerated mussels, other shellfish of no economic value, seaweeds, etc.

(1) *Man.* — It is hardly necessary to more than mention man as the greatest enemy to the quahaug, because this report has shown in numerous ways, especially in the historical review of the fishery and the description of the quahaug beds, how man, through excessive digging, has gradually reduced the natural supply. It need scarcely be stated that, unless some method of culture is inaugurated within the next few years, the quahaug industry will become commercially extinct through overfishing by man. Man has overthrown the balances of nature both by ill-advised methods of overfishing and by changes in conditions through the pollution of the streams and waters. Man is and will be the greatest enemy of the quahaug unless he repair the damage already done and assist nature in renewing the supply.

(2) *The Winkle.* — The common bait winkle or cockle (*Lunatia heros* and *duplicata*) attacks the quahaug by perforating its shell in the region of the umbo by means of a rasping tongue armed with sharp teeth. The animal drills a clean countersunk hole from 1 to 6 millimeters in diameter, according to the size of the cockle. While the chief prey of the winkle is the sea clam, it will frequently attack both the quahaug, especially the "little neck," and the soft clam. Owing to the thick shell the quahaug is more immune than the sea clam, as it takes the winkle much longer to pierce the shell and suck out the contents. At Monomoy Point numbers of quahaugs were killed by the winkle in the experimental beds. In nearly every case, although variations have occurred, the perforation was made directly on the projecting umbo or beak of the quahaug. Although the winkle, with the exception of man, is considered the greatest active enemy of the quahaug, it can be readily prevented from injuring the quahaug beds by a little care on the part of the culturist. The cockle never appears on the quahaug grounds in such numbers that it is impossible to gather them, and owing to the high price of these snails for bait, $3 to $4 a bushel, it is highly profitable for the quahaug planter to capture them for the market, at the same time preventing damage to his quahaugs.

(3) *The Horse-winkle.* — The extent of the damage caused by this large gasteropod mollusk cannot be determined, and possibly may be

greater than the destruction by the cockle. The oystermen claim that large numbers of oysters and quahaugs are destroyed by the horse-winkle. The method of attack, which has not been studied by the writer, is aptly described by Colton (14), who states that quahaugs are eaten in from seven hours to three days; that the meals are far between, and that the winkles spend their time between meals buried in the sand. The method of attack is described as follows: —

The conch (*Fulgur perversa* or *F. carica*) grasps the *Venus* in the hollow of its foot, bringing the margin of the *Venus* shell against its own shell margin. By contracting the columellar muscle it forces the margins of the shell together, which results in a small fragment being chipped from the shell of *Venus*. This is repeated many times, and finally the crack between the valves is enlarged to a width of 3 millimeters or more.

The proboscis is normally about 5 millimeters to 8 millimeters in diameter. There are three ways in which it may get at the animal. First, it may flatten out its proboscis so that it will go through the crack; secondly, it may pour in a secretion between the valves which kills the clam; and thirdly, it may wedge its shell between the valves of the *Venus*, and by contracting the columellar muscle actually wedge the valves apart.

(4) *The Starfish.*— The starfish is the least effective of the four active enemies of the quahaug, as it is not able to readily attack the quahaug in its burrow. A large starfish, which was found in one of the experimental boxes at Monomoy Point, had eaten a number of the quahaugs which were buried under the sand. The starfish evidently was able to get at the animals by working its "arms" in the coarse sand until the quahaug was exposed, and then opening it in the same manner as the oyster, by the steady pressure of the tube feet on the two valves of the quahaug. Quahaugs lying outside the sand are rapidly devoured by the starfish, which, after forcing the valves apart, passes its everted stomach into the shell and digests the contents. Under natural conditions it is probable that little damage is accomplished by the starfish, owing to the difficulty of getting at the quahaugs.

QUAHAUG CULTURE.

The Decline.

For decades the tidal flats and waters of the seacoast have yielded valuable harvests of shellfish, and the free-fishing public have continued their campaign of spoliation under the impression that these fertile territories were inexhaustible. As the thickly bedded areas near the beaches were exhausted, the quahaug fishermen ventured into the deeper waters, which greatly increased the cost and difficulties of fishing. The deep-water beds which opened a new era of prosperity for the quahaug industry, are now beginning to show the effects of the severe systematic fishery which has prevailed for the past few years. There can be but one logical outcome to the present system, *i.e.*, the commercial extinction of the quahaug.

The serious nature of this decline has only recently been brought to the attention of the public, although many have noticed the increased cost of shellfish and at times have experienced difficulty in procuring a sufficient supply. At present there is a widespread awakening throughout the Commonwealth in regard to the cost of living, and considerable interest has been shown in matters relating to the shell-fisheries, with a view toward checking the decline by developing these important sources of public wealth.

The present quahaug industry is of comparatively recent growth. Although known as an article of food by the early settlers ever since the time of the Pilgrims, the quahaug did not attain universal popularity until within the last thirty years, when the opening of inland markets increased the demand. The resultant high prices naturally caused a large number of men to venture into the industry, stimulated by the hope of handsome profits. Soon there came a time when the natural increase of the fertile quahaug beds failed to equal the annual harvest, and a gradual decline set in, which has attained such magnitude as to threaten the extinction of a most important shore industry, assuming such serious proportions in many of our coast towns as to thoroughly alarm the citizens. In Buzzard's Bay, a natural habitat of the quahaug, the industry in at least half the towns has declined to the point of commercial extinction, and even in the communities where it still retains some foothold, its existence is due to the development of new areas in the deeper waters. Conditions in many localities on Cape Cod are scarcely better. Wellfleet, one of the leading towns of the Commonwealth in the production of quahaugs, presents a typical case of this kind. Practically the entire population, directly or indirectly, depends upon this industry for a livelihood. The quahaug fleet, comprising nearly a hundred boats of all sizes, which may be seen every fair summer day fishing in various parts of the bay, is fast depleting the large natural beds of this region, and already the inhabitants are becoming apprehensive of the exhaustion of these areas. Similar conditions prevail to a greater or less degree in most of the villages of Cape Cod, and serious complications would doubtless follow the destruction of the quahaug fishery.

Indications of Decline. — So universal has this decline become that it is hardly necessary to enumerate proofs of its existence. As already stated, the industry has been practically exterminated in many of the coast towns, while in others the natural supply is but a remnant of its former abundance, and there are but few localities where the yield of the natural beds has not decreased more or less. No one can question that the decline in the quahaug industry is general, and that its proper adjustment, as one of the great resources of the Commonwealth, is an important economic problem.

Rise in Price. — When the demand for any commodity increases, it is a law of economics that a rise in price will follow. We have seen how the demand for quahaugs has increased during the past twenty years. It was inevitable that there should be a rise in price. The development of the "little neck" (small quahaug) trade was the forerunner of the introduction of the larger quahaug. The increase in the price, while in part the result of an increasing demand, is also a sign of a decreasing supply. When the supply of a desirable commodity diminishes, the price advances, until a new equilibrium is established. Therefore, both supply and demand have combined to place the price of the quahaug at its present high figure.

Cause of the Decline. — In considering the present unsatisfactory conditions in the quahaug industry no one cause can be designated as having brought about this decline, but rather it has been the result of the combination of several important factors. The primary reason has undoubtedly been overfishing, a fact generally accepted throughout the fishing communities of the State. So long as the natural increase of the quahaug equals the amount taken from the flats it is clearly evident that the supply will not diminish. As soon, however, as the demand of the market necessitates a constantly greater annual production, the balance of nature is upset, and a diminution of the natural supply takes place. As we have already seen, the simultaneous decrease in the supply and increase in the demand caused a rise in the price, sufficient for a time to lure more men into the industry. This time of prosperity has already passed, and many men are leaving the fishery to seek a livelihood in other pursuits, as, in spite of the high prices, they are unable any longer to make a living. The discovery of large quahaug beds in the deep water was the only factor that prevented the destruction of the quahaug fishery long ago. These beds are now being overfished, and when they are depleted the disappearance of this great industry will be complete.

While the immediate cause of the decline is undoubtedly, and always has been, overfishing, the real cause lies in the conditions which tolerated such a system of spoliation, and allowed it to continue unchecked after its destructive features had long been apparent.

Under the old laws governing the fisheries of the Commonwealth, the State originally held possession of and exercised authority over all tidal waters as public property for every citizen. Later there arose a widespread feeling that the communities whose lands bordered on the ocean should have first right over these valuable territories. This feeling on account of the conditions of that time, met with little opposition, as transportation was slow and the people from the inland communities had not the same opportunities for utilizing the fishing privileges that the inhabitants of the coast towns possessed. Thus the rights of the Commonwealth over the shellfisheries came to be vested in the individual seacoast towns. According to the original act the selectmen of every coast town were given certain privileges of supervision over the shellfish interests within its borders. The Legislature, however, was careful to specify that every inhabitant of the Commonwealth could still continue to take shellfish for family use or three bushels for bait per day in any part of the coast, in this manner reserving an important privilege for the public.

As this privilege has never been exercised to any extent for market purposes, the towns have had absolute control of the shellfisheries for years. Their authority has been a direct trust from the Commonwealth, and if the decline of the shellfisheries has been attributable to improper legislation, or lack of legislation, this responsibility rests wholly upon the seacoast towns. Let us see in what manner these towns have improved the valuable privileges, and how they have guarded the sacred trust conferred upon them by the Commonwealth. The past record of the majority of the towns fails to show any consistent effort on their part to safeguard or develop these industries. A few communities have made certain short-lived attempts to foster or protect their native resources, but in every important instance these efforts have proved either wholly inadequate, or, if possessing the qualities of success, have been abandoned without sufficient trial. The usual type of reform attempted by the towns has been restrictive legislation, which has aimed in an illogical and ineffectual manner to check the exploitation of the natural beds rather than provide methods of increasing the supply. Legislation of this kind has never proved a success in any important instance. It has been unpopular, difficult to enforce and thoroughly unadapted to effect the intended reform. It is inherently a false or mistaken policy. The shellfisheries have needed laws of a constructive nature, designed to develop the industry. Restrictive legislation unless accompanied by constructive is never truly protective, and in the past has proved such an unqualified failure as to be abandoned by its former advocates. It is not the purpose of this paper to criticise harshly the evidently well-meant efforts of the towns to benefit the shellfisheries, but it is universally conceded that they have in most cases proved a failure. It is not necessary to go into detail in the investigation of the various attempts of the towns in this direction, as they have taken in almost all cases the form of a close season over some specified areas, and few attempts to build up the natural resources have ever been honestly attempted. In the case of the quahaug fishing, we find that the efforts of the towns to keep the supply from becoming depleted have never been more than the most half-hearted attempts, and we are forced to conclude that the towns have dealt badly with the trust reposed in them by the Commonwealth, and have neglected the great opportunities for improving and preserving the natural quahaug beds.

It is only fair to state that the system of town control is ill calculated to produce the best results. It is not reasonable to suppose that a number of municipalities, working independently, should be able to evolve a unified system. It is, however, just cause for surprise that the Commonwealth has so long allowed such mismanagement. It is certainly a most pressing need that this old, cumbersome policy should give place to a more unified and successful system.

Under the present system of free fishing no constructive legislation can be applied, as there is no incentive for individual effort. The fishermen who advocate cultural methods and conservation of the natural resources are powerless through the indifference of others, and consequently are forced, against their will, to join the campaign of spoliation under the argument that they may as well get their share as long as the supply lasts. In this way the present system puts a premium on personal greed and discourages individual effort. It is practically impossible for legislation to check lawless exploitation where valuable resources are thrown open to the public. The unreasoning element will inevitably abuse the privilege to the utmost limit, and the more thoughtful will be swept into tacit consent. Naturally it would be for the general welfare for every fisherman to do his best to better conditions, but under the present system this rule could not hold, as no man, no matter how much a philanthropist, will work hard for the betterment of conditions only to see the results of his work appropriated by another.

The Remedy.

We have pointed out that the attempts by which the towns endeavored to stop the decline of the quahaug supply were all of a restrictive nature, designed to check the demand rather than to increase the supply. The true remedy is to be found in legislation which will permit the application of cultural methods. There are only two methods by which constructive laws can operate: (1) seeding the public waters and flats at the expense of the towns or of the State; (2) the introduction of a system of private grants.

(1) While there has never been any effort on the part of the towns or of the State to seed extensive tracts of quahaug territory, there have been attempts in the case of the soft-shelled clam. Such communal clam culture has generally failed, as the planting was usually in the hands of men unaccustomed to such work and ignorant of the proper methods. While successful communal culture can be carried on, there will always remain the natural drawbacks to any altruistic scheme of this sort, such as expense, uncertainty and non-co-operation, which tend to make it impractical.

(2) The proposed remedy for preserving the native quahaug beds and developing the industry to its normal status is based upon a system of grants held and operated by individuals. Under this system an inhabitant of the Commonwealth would be permitted to lease a grant

of limited area from the State or town for a term of years, provisional upon the efficiency with which he improves his holding, and be guaranteed immunity from outside molestation. For this privilege he would pay a reasonable annual rental to the Commonwealth or town in addition to the taxes which would be levied by the town upon the value of his holdings. A system of this sort, which would allow a part of the waters in each town to become rented property, while the remainder, at least half the present area, should exist as public property, would so benefit the industry that the annual production for the rented part alone would doubtless exceed the present output for the whole under existing conditions. This proposed remedy has been the outgrowth of a long series of experiments on the part of the Massachusetts Department of Fisheries and Game. These experiments have aimed throughout to formulate a practical remedy for the prevailing evils. The experiments in question have shown conclusively that quahaug seed can be successfully transplanted from one locality to another, and that it can be made to grow to a marketable size with a small outlay of capital in a sufficient time to yield large returns. Not only have these experiments, conducted in varied environments in our coast waters, proved that this remedy contains the necessary elements of success, but a study of the industry as a whole has shown that it is the only remedy which can bring about the desired results. The proposed remedy is not a theory evolved on the spur of the moment, but is the outgrowth of several years of careful study of the prevailing conditions along our coast. It is a system based on the results of successful experiments, and has been placed on a practical, commercial basis with the oyster, both abroad and in the United States.

Benefits. — (1) It will save the declining industry by lessening the drain on the natural beds and by meeting the increasing demands of the market. Moreover, the "spawners" on the grants will in all probability suffice to abundantly seed all the public ground, at least to a greater degree than at present.

(2) It will increase the supply to more adequately meet the demands of the market. The quahaug has become a popular article of diet and there is no reason why it should not be a far more important item in the food supply of the Commonwealth than it is at present. In Massachusetts, where the population is so dense that it has to depend in great measure on other sections of the country for its supply of foodstuffs, any important article of food native to the Commonwealth should be well cared for.

(3) It would furnish more remunerative and steady work for the fishermen. This result would be accomplished in two ways: it would increase the supply of shellfish on the flats and tidal waters, held in common as already explained, thus increasing the catch of the average fisherman. But of greater value to the fisherman would be the privilege of holding a small piece of territory as his own property, which

should, under favorable circumstances, yield him a considerable annual income.

(4) It would be a benefit to the coast communities, where the shellfish industry furnishes the main income of the inhabitants. Under present conditions these communities depend for support on an uncertain industry, the revenue from which is extremely variable. Under these discouraging conditions many fishermen live literally from day to day, barely tiding over the severe winters with the money earned during the summer's fishing. The proposed system would do away in a great measure with this unsatisfactory state of affairs, as it would practically assure to every industrious quahauger a steady income.

(5) It would furnish a more abundant sea food for the public. Any undertaking which will result in increasing the supply is desirable from an economic standpoint. The quahaug as an article of diet has had a favorable reputation for some years. Its popularity is steadily growing, and anything which would tend to increase the supply must be considered a public benefit.

(6) It would utilize thousands of acres of barren land now lying idle and unproductive. It has been a wise policy of this country for many years, fostered by men who have the national interests at heart, to conserve the natural resources and bring them to their highest degree of usefulness. In Massachusetts, not primarily an agricultural State, large tracts of territory, which in the fertile western countries would never be touched, are nevertheless, by careful tillage, made to yield profitable returns. It seems poorly in accord with the prevailing methods of thrift that large areas along our shore, which are more valuable acre for acre than any upland, should be allowed to remain unproductive, when they could, with a comparatively slight expenditure of time and money, be made to yield substantial returns. It is inconceivable that such a misguided policy can much longer control the shellfisheries. Already the matter has attracted popular attention, and will soon be dealt with in the same progressive spirit which Massachusetts has ever shown in the management of her industries.

Quahaug Farming.

Under the proposed system of quahaug culture the available territory comprising the tidal flats and shallow waters of our coasts would be dotted with small areas under artificial cultivation. There would be a striking similarity in this arrangement to a tract of agricultural country where fertile gardens are interspersed with stretches of meadow and pasture land. There can be no question that the system which holds sway over the agricultural districts of our country is equally desirable for our extensive shore areas, which now produce but a portion of their normal yield. If these tracts could be divided, in part at least, into small plots of cultivated ground, nature would be greatly assisted in her efforts to render these territories productive.

That we may see to what degree the installation of such a system would affect the industry, let us take one of these proposed cultivated plots or grants to serve as a model. The average fisherman, an industrious family man, would take out one of these little grants. At first he would not depend very much on the income derived in this manner, but would probably continue to fish on the public grounds. Gradually, as he became accustomed to its management, he would come to look more and more to his own leased territory for a livelihood. He would be constantly on the outlook in his trips around the bays and coves of his home district for little "pocket" beds of small quahaugs, where he could procure seed for his grant. He would carry this seed carefully home with him, and experiment, with ever-increasing interest, in planting so as to insure the least loss and greatest gain. He would be ever anxious to see how his novel harvest was maturing, looking over his bed from time to time to note the growth of the seed, and to remove cockles and other enemies. If his little farm were located between tide lines he would be careful to have his seed planted early in the spring, and would in most cases harvest the entire crop late in the fall or early winter, before it suffered exposure to the ice. If his grant were situated just below mean low-water mark, where it would never be exposed, he could probably allow his seed to remain for two seasons, when it would yield a still better profit. But wherever situated, on soil at all suitable, he would possess in his little holding of an acre or more property of such value that he would be able, under normal conditions, to reap enough to support his family in very comfortable circumstances. He would be able to do this with far less expense of time and labor than enterprises of this sort usually require. While his grant would in every material respect be a miniature farm, and would probably be known as such, it would be entirely free from most of the labor involved in the care of the ordinary farm. No time would have to be devoted to the work of plowing, harrowing or weeding, which makes the life of the average farmer such a hard-working existence. There would be none of the expense and labor of fertilizing, so necessary for the success of upland gardening; there would be little or no time required in fighting the natural enemies of the growing crop which the upland farmer experiences. The quahaug has few enemies, and these do little damage, and are, besides, easy to fight. The fisherman-farmer would be free from anxiety on account of the weather, over which his more unfortunate neighbor of the upland so constantly worries. No drought, beating rain or early frost is likely to injure his growing crop. Practically the only labor required is that of seeding and harvesting, which are simpler and easier for the shellfish culturist than for the farmer. The ordinary farmer is frequently content to reap from his average acre of cultivated ground from $20 to $50. The quahaug planter on an equal territory could raise many times that amount as under favorable circumstances $750 net may be realized annually from one acre.

The comparison is strikingly in favor of the quahaug grant, and the benefit of such a system is sure to follow for all coast communities. The shellfisherman is raised from an uncertain livelihood to a position of secure and comfortable independence, the communities made more prosperous and a decadent industry revived.

History of Quahaug Farming. — Until within recent years few attempts at quahaug culture have been made in Massachusetts, although for some time oystermen in the States directly south have carried on successful planting. The demand for small seed has extended even to Massachusetts, and many thousand bushels have been shipped out of the State for planting purposes. Nantucket, Chatham, and finally New Bedford have taken their turn in this traffic, according to the abundance of small quahaugs. In 1909 one New York planter is authentically reported to have purchased nearly 5,000 bushels of seed from Massachusetts, paying $3 per bushel. During 1909 the shipment of seed from New Bedford and Fairhaven approximated 45,000 bushels. These small quahaugs are replanted in Long Island waters, and in one year's time, according to the results of growth experiments, probably netted the planter at least 4 bushels of marketable little necks for every bushel planted. Lately some of the Massachusetts oystermen have successfully raised quahaugs on their oyster grants, and are ready to engage in a more extensive way.

The first legislative act permitting the planting of quahaugs was passed for the Narragansett Bay section in 1874. This legislation permitted the giving of licenses for the planting of shellfish in the town bordering on Mount Hope Bay. Nothing was accomplished, however, as the law was repealed the following year. The second movement took the form of a special law permitting the bedding of quahaugs in Eastham, Orleans and Wellfleet in 1904, which in fact was a semi-license. Finally, in 1909 a general law was passed, which gave local option to the coast towns in the giving of grants. As yet these laws appear to be without result. The "bedding" act was utilized to some extent to hold quahaugs for market, and in a few cases for growing purposes. No town has as yet taken advantage of the general law. What culture has been carried on has been done secretly or on the oyster grants, where protection is given. Under these adverse conditions planting has proved remunerative, and there is every indication that, when absolute protection is guaranteed the culturist, a flourishing industry will be inaugurated.

Possibilities of Quahaug Farming. — While the subject of clam farming has received a great deal of attention, people have failed to see that the same cultural methods can be employed even to greater advantage with the quahaug. A quahaug farm, if properly tended, should yield more revenue, acre for acre, than any clam flat, and prove a much safer investment for the planter. If it were not for the scarcity of seed at the present time, quahaug culture, although confined to the southern waters of the Commonwealth, would become the greatest of the shellfish industries of Massachusetts.

The quahaug has a wide range; it is found in all depths of water, from the high-tide line to a depth of more than 50 feet, and in various kinds of bottom. This natural adaptability gives the quahaug a wider area than any other commercial shellfish, as it will live in almost any soil, although the rate of growth depends essentially upon its location in respect to current. Vast areas, over 25,000 acres, on the southern shores of Massachusetts, at present unproductive except for here and there small scattering beds, can be utilized for shellfish farms, which, when placed under cultural methods, should yield many times the present production and furnish a livelihood for thousands of men. Quahaugs will grow on such areas as the Common Flats of Chatham, if they are planted and properly cared for. Instance after instance can be cited where the territory is so extensive that if every inhabitant of that particular locality were allotted a grant of two or three acres, the leased portion would be but a small part of the whole area. It is conservation of our natural resources in the truest sense to make use of the great undeveloped possibilities of our shore waters.

Methods of operating a Quahaug Farm.

Selecting the Ground. — The planter should have two main ideas in mind in choosing the location of his grant: (1) facilities for work and marketing; (2) productive capacity. The ideal grant combines the two, where the work is easy and the growth rapid, while a near-by market furnishes high prices. Unfortunately, such delightful combinations are few, and the culturist will have to choose a grant with such qualifications as he thinks best suited to his needs. For this reason it is desirable to consider these points more in detail.

(1) Facilities for work comprise three things: (*a*) The accessibility of the grant to the home of the culturist, where he can get to it without loss of time and where he can have a protective oversight. The term "home" is used here in the sense of landing place, boat mooring or shellfish shanty, where the culturist keeps his equipment. (*b*) The depth of water over the bed, and the nature of the bottom, as raking in shallow water is much easier and less expensive as to time and implements than the deep-water quahauging, while the firmness of the bottom increases the work of raking. If, perchance, the grant is between the tide lines the labor of harvesting the quahaugs is less than if they were continually covered by water, but in such a case the working period is limited, and the quahaug culturist risks the destruction of his crop during the winter. (*c*) The ease of marketing is another

factor, as distance and poor transportation facilities add to the expense. The planter must consider the question of bringing his produce as cheaply as possible to the railroad.

(2) The most important factor in the selection of the ground is its productive capacity. The prime requisite of a grant is a rapid rate of growth, which, for a grant situated below mean low-water mark, depends upon two conditions, — the current or circulation of water and the nature of the soil. In the case of the few grants existing either permanently or temporarily between the tide lines, a third condition, exposure, demands attention, as the time of exposure at low tide reduces the feeding period of the quahaug. As the majority of the grants will be below low-water mark the other two conditions are more important.

(*a*) *Soil.* — The nature of the soil affects the quahaug in two ways: (1) if too shifting it buries the quahaug or washes it beyond the border of the grant; (2) soils in which organic acids, caused by the decay of plant life, are present, prove unsatisfactory for any catching of seed, interfere to a slight extent with the growth by destroying the shell, and worst of all, give the quahaug a poor, black appearance, unfavorable for immediate marketing. While the effect of soils on shell formation has never been worked out, and although the quahaug derives its material for its shell from the water, nevertheless, the nature of the soil in some indirect way determines the appearance, the composition and the weight of the shell, as observations on quahaugs from various soils in near-by localities indicate.

(*b*) *Current.* — The growth of the quahaug depends upon the circulation of water, as the current is the "food carrier," and therefore, within limits, the more current, the more food. Current also keeps the ground clean, and prevents contamination or disease from spreading. The most important point in choosing the ground is to locate the grant where there is a good current, as growth is directly proportional to the circulation of the water. It is possible, of course, for a place to have so rapid a current that it would cause a shifting of the bottom, and perhaps wash the quahaugs from their burrows, but such a current is found in but few localities in which one would think of planting.

There are several other factors which do not influence the growth directly but at the same time have more or less influence upon the productive qualities of the grant.

(*c*) *Pollution.* — It is hardly necessary to more than mention the danger to public health and the depreciation in the value of the marketed quahaugs when it is publicly known that the grant is situated in contaminated waters. For purely business reasons the planter should ascertain the purity of the water in the locality of his proposed grant, as in the future the public will demand the closure of all polluted waters and discountenance the sale of shellfish from such sources.

(*d*) The proximity of localities where seed quahaugs may be readily obtained should be considered, as the cost of obtaining the necessary stock is an important item. If the grant can be situated in the vicinity of a natural quahaug bar, where seed can be obtained from the natural set, it will prove advantageous. If a method of artificial hatching of the seed, either from the egg or by spat collecting, is successfully placed on a commercial basis, such a precaution will not be necessary, as the quahaug culturist, like the oysterman, will be able to raise his own seed.

(*e*) Closely connected with the study of the food of the quahaug comes the question of flavor of the meat, an important item in marketing. It is a well-known fact that quahaugs from various localities have different flavors, and in the future there will be a greater use of trade names and special brands, based on this fact. The flavor of a quahaug depends upon its environment, and, although it has not been absolutely proved, evidence points to the fact that the different flavors are due to the different kinds of plant food. In the future, when more practical knowledge is obtained about the food of these animals, it may be possible to supply special flavors by artificial cultures of food. Another factor determining the condition of the meats is the presence of oils, chemicals, etc., from factory wastes, which sometimes renders the shellfish unsavory. The soil and the silt in the water may also influence the flavor.

(*f*) The grant should be chosen in a well-protected locality. Natural conditions, such as loose sand, exposure to winds and choppy seas, increase both the loss of stock and difficulty of labor. Masses of floating eelgrass in some places are strewn over the bottom by storms, interfering with the growth and increasing the labor. Fortunately, the quahaug is hardy, and is not affected to any great extent by the elements, except when the grant is located between the tide lines. A grant between the tide lines or close to low-water mark is an uncertain investment, as there is always danger of destruction during a severe winter, either by the ice or frost. The danger is not so much in the freezing of the quahaug as it is in the sudden thawing. If frozen quahaugs are slowly thawed out they will assume normal functions, as if nothing had happened, but when thawed out quickly many perish. From observation it can be said that in a fairly protected locality, where the grant is not too high between the tide lines, the chances of loss from winter will not be more than one case out of seven.

In some localities there may occur a slight loss from the winkle, a natural enemy of the quahaug. The culturist can, by more or less labor, according to their abundance, keep them off his property. As the winkle is valuable for bait, the actual loss of time will be minimized, and even if unmolested the damage will be slight.

The rule for choosing a grant should be: bottom of a mixture of mud and sand (exact nature of soil not important); clear of eelgrass, especially thick eelgrass; water the depth of 3 feet or more at low tide; a *good current;* and such facilities for work as best suits the particular planter.

Obtaining the Seed. — Nature has not provided so abundant a means of stocking the quahaug farms as is the case with the clam. The set of quahaugs is more scattering and apparently less abundant. In nature this is not necessary, because the young quahaugs after once they have taken refuge in the sand, are more hardy than the young clams, which perish in great numbers. Occasionally natural sets will be found in limited localities, as Stony Bar, Wellfleet; Mill Pond, Chatham; Acushnet River, etc. From these places the seed must be obtained. At the present writing Acushnet River and Tuckernuck Island have large beds of seed, which the inhabitants are industriously shipping to planters outside the Commonwealth. As these beds vary, occurring in different sections in succeeding years, the natural seed must be purchased from the specially favored localities. Small quahaugs can also be obtained from Prince Edward Island, and probably from the southern States.

The planters might experiment in catching seed by simulating the natural conditions of the seed bars on their grants, and turn their grounds into spat collectors. By the combined efforts of interested planters it would not be many years before a practical method of spat collecting could be devised. As the object of most planters would be the production of "little necks," the size for planting would be under the maximum market "little neck."

Planting. — The grant needs little preparation for planting. After the bounds are marked according to the regulations, thick eelgrass, stones and other débris which would interfere with the raking, and enemies such as winkles, should be gradually removed, either before planting or in the work of harvesting. The planting of the small quahaugs is a simple matter. It should take place preferably before May 1, when the quahaug begins its summer growth, but as seed is scarce, the planter will probably plant whenever he can procure the young. The quahaugs should be scattered evenly from a boat by shovels such as the oyster planters use, or it can be done in any way most convenient for the culturist. Ordinarily the quahaugs will burrow in the sand in a short time after they settle to the bottom. As their activity depends to a great extent on the temperature of the water, it is not advisable to plant in cold weather, as the quahaugs, instead of burrowing, will lie exposed on the surface, where they are in danger of perishing. The amount of seed that can be planted on any given area depends upon the natural conditions, chiefly the current. As many as 20 to the square foot can be bedded when the circulation is good, while the number should be decreased or increased according to the speed of the current. The planter, after a year or two, will be able to determine the exact number he can plant on his grant to the best advantage.

Working the Grant. — The work of caring for the grant will entail but slight labor. No cultivation of the ground is required, as in the upland farm, and the quahaug is left undisturbed until it has attained marketable size. A certain amount of oversight will be necessary to keep off poachers, and time must be given to destroy enemies and clean away any dead seaweed that drifts upon the grant, but further precautions are unnecessary.

Harvesting. — The principal labor comes in the harvesting of the crop, which must be done by raking or tonging. The location and natural conditions of the grant make this a variable factor, as depth of water, hardness of bottom and exposure to rough weather increase the difficulty of raking. While a certain portion of the crop may be taken at any season, the greater part will be marketed in the fall, when the season of raking on the natural beds is nearing a close, in order to get the advantage of the full summer's growth and the better winter prices. The fall work will apply only to the more protected grants which permit work in rough weather. The planter will have his grant divided into sections according to the size of the planted seed, which will be assigned in lots according to size and length of time before marketing. By dividing the ground into three or more parts, planted with quahaugs of different sizes, the culturist will have a sort of rotation of crops, cleaning up and replanting one-third of his property each year. In this way the planter will be able to place a uniform size on the market and receive a proportionately better price for his goods. There will be less labor in culling, and the "little necks" can be shipped directly in barrels or bags to special customers.

The Value of a Quahaug Farm. — An acre of "little-neck" quahaugs has a high market value. A conservative estimate of 10 per square foot gives an annual yield of 600 bushels of 2½-inch quahaugs per acre. This assumes that 120 bushels of 1¾-inch quahaugs were planted to the acre. The price paid for the same, at the high price of $5 per bushel, would be $600. The price received for the same, at $3 per bushel, would be $1,800, or a return of $3 for every $1 invested. This is a conservative estimate on all sides. Quahaugs could be planted two or three times as thick, seed might be purchased for less money, more money might be received for private shipments, and faster growth can be obtained. Practically the only labor necessary is gathering the quahaugs for market. The quahaug farm requires no such care as the agricultural farm, and offers far more profit.

Perhaps the greatest advantage to the fisherman, next to the amount of quahaugs he can produce from his grant, is the fact that he is independent of the market. The value of the present quahaug industry lies chiefly in the production of "little necks," which could be made a specialty under a cultural system. The planter can market his quahaugs at whatever size and whatever time he desires, and is not forced to ship during periods of low prices, as he can leave his quahaugs bedded on his grant. At the present time the quahaugers, except in a few towns where there are "bedding rights," are forced to ship their catch as soon as taken, and receive often a low market price. In this way the planters could regulate, to a great extent, the market price for their own benefit.

Advantage of a Uniform Size. — At the present time there is much dissatisfaction among the quahaug fishermen who rake on the natural beds because they receive poor prices. From the fisherman's standpoint the dealer is to blame, as it is claimed that he is continually trying to increase the middleman's profits. From the point of view of the shellfish dealer the fault seems to be with the fisherman, who does not carefully select his stock for market. A dealer is bound to pay better prices for uniform and selected stock. The common practice is to ship as "little necks" quahaugs of all sizes from 1¼ to 3 inches, large and small promiscuously scattered through the barrel, or first a barrel of large, then small, with the result that in most cases the dealer knows not what to expect, and naturally gives a minimum price. Perhaps with more care on the part of the quahauger this circumstance might be improved to some extent; but the fault lies rather in the present method of fishing. The logical method of increasing the price is the steady shipment of uniform selected stock. This is entirely impossible under free-for-all fishing. Steady orders cannot be filled when raking is irregular; a uniform size cannot be shipped, owing to the varied yield of the natural beds; and the quahaugs, unless bedded as in Orleans, Wellfleet and Eastham, must be shipped for whatever price is offered. Quahaug culture with its grant system offers a remedy, and furnishes to the quahauger a means of controlling the market. In contrast to the free fishery, the yield from the quahaug farm is steady instead of irregular; only quahaugs of the maximum market size, necessarily uniform, need be shipped, and the best prices obtained for them, while the quahauger is not forced to ship at a low price, but can wait until the market reaches his figure. As an illustration of the difference in price between ordinary shipped "little necks" from the natural fishery and uniformly selected stock from leased area, the following case is cited: from a locality on Cape Cod in 1909 quahaugs were shipped to market, the selected stock bringing $18 a barrel to the planter at any season, the ordinary stock, ranging from 1½ to 3 inches, only $10. No other proof is needed to show the advantage of a uniformly selected stock, such as can be obtained only by quahaug farming.

THE INDUSTRY.

From the standpoint of the fisherman the methods of capture and preparation of the quahaug for the market need no explanation; but the average reader, perhaps unfamiliar with the practical side, may find the following pages of interest. In order to give a complete report upon the quahaug fishery, owing to the fact that such data may be of use in later years for comparative purposes, it has been necessary to include special parts of the mollusk report of 1909.

The Fishing Grounds.

The quahaug is essentially a southern or warm-water mollusk and Massachusetts practically marks the northern range of the fishery, although quahaugs are taken in the Gulf of St. Lawrence. As shown on the accompanying map (Fig. 30), only the southern waters of the Commonwealth are included in this fishery. For greater detail the reader is referred to the "Mollusk Report" of 1909.

The quahaug like the scallop territory can be arbitrarily separated into four main divisions: (1) the north side of Cape Cod; (2) the south side of Cape Cod; (3) Buzzard's Bay; (4) the Islands of Nantucket and Martha's Vineyard.

North Side of Cape Cod. — In this section Plymouth marks the northern range, as a few quahaugs are found in this harbor. Passing south, small beds are found in Barnstable harbor, while from Brewster north, in the waters of Orleans, Eastham and Wellfleet, the largest quahaug fishery of the Commonwealth is carried on. A few quahaugs are also found in Provincetown harbor and along the Truro shore. The chief characteristics of this section are: the great rise and fall of the tide, averaging about 10 feet, which leaves large areas of exposed flats; the swiftness of the tides, causing a shifting of the sand bars; and the great depth of the water over the quahaug beds.

Quahaugs are found both on the flats and in all depths of water, although the commercial fishery is carried on mostly in the deep water, with rakes ranging from 30 to 60 feet in length. The best beds are in the deep water, as the other localities have been fished out, the quahauging gradually extending to the deeper or the more exposed waters. Unfortunately, quahaugs can be taken only on moderate days, as rough water interferes with raking, and the quahauger who can average four working days a week is considered fortunate. In this section the basket rake shown in Fig. 59 is used. Quahaugs are taken also with ordinary clam or garden rakes on the flats at low water, especially in the harbors during the low course tides. About 8,000 acres are included in this section.

(*a*) *Barnstable Harbor.* — In Barnstable harbor, on the north side of the town, a few quahaugs are found in isolated patches, which are of small commercial importance. In the future the vast barren flats may be made productive of quahaugs as well as clams, although at present the total area of the quahauging grounds is hardly 5 acres.

(*b*) *Orleans and Brewster.* — The fishery is conducted in the deep water, with the basket rake. The area comprises about 1,000 acres in Cape Cod Bay, and about 500 in Pleasant Bay, on the east side of the two towns.

(*c*) *Eastham.* — The quahaug territory comprises about 4,000 acres, extending from the shore for a distance of nearly 3 miles. While scattering quahaugs, largely blunts, are found over the entire area, the fishery is conducted only at certain places. In 1910 a thickly set bed of quahaugs was discovered south of Billingsgate Island. The question of town jurisdiction over this bed has caused the towns of Wellfleet and Eastham much legal dispute, court expense and hard feeling — another instance of the inefficiency of the present method of town shellfish regulation.

(*d*) *Wellfleet.* — The quahaug territory of Wellfleet comprises about 2,500 acres, and approximately takes up all the harbor, wherever there are no oyster grants, running from the "Deep Hole," between Great Island and Indian Neck, southward to the Eastham line. Outside these limits a few quahaugs are found on the flats of Duck Creek and along the shore. They are more abundant on the north side of Egg Island, where they are taken in shallow water with ordinary hand rakes. The best quahauging is found in the channel, extending from an imaginary line between Lieutenant's Island and Great Beach Hill south to Billingsgate and beyond. Here the greatest depth at low tide is 4½ fathoms, with a general average of 3 fathoms. Raking is done with long-handled basket rakes.

(*e*) *Provincetown.* — No commercial fishery is carried on. A few quahaugs, chiefly little necks, are found in the tide pools among the thatch on the northwestern side of the harbor.

South Side of Cape Cod. — This section, comprising the towns on the south side of Cape Cod from Chatham to Falmouth, ranging in order, from east to west, Chatham, Harwich, Dennis, Yarmouth, Barnstable, Mashpee and Falmouth, has less territory, about 5,000 acres, and produces only one-fifth of the yield on the north side of the Cape. While this section is favorable for the scallop, quahaugs are not found in any great numbers on the exposed waters on the Sound side, and the grounds are mostly confined, except in the case of the Common Flats of Chatham, to the enclosed bays and harbors, such as Pleasant Bay, Lewis Bay, Osterville Bay, Waquoit Bay, etc. Natural conditions are somewhat different than on the north side, as the rise and fall of the tide is slight, about 2 feet, and, owing to the sheltered conditions, raking can be carried on at all times during the summer months. The shallow water permits easier raking and the use of shorter handled rakes. Basket, claw and garden rakes are used, although the greater part of the commercial fishery is conducted with the basket type.

(*a*) *Chatham.* — Chatham is favorably situated in regard to the quahaug fishery, as this shellfish is found in the waters on the north and south sides of the town. The grounds are extensive, covering about 2,000 acres, the greater part of which consists of the vast area south of the town, known as the Common Flats. The quahauging grounds are in four localities: (1) Pleasant Bay; (2) Mill Pond; (3) Stage harbor; (4) Common Flats.

(*b*) *Harwich.* — Harwich shares with Chatham and Orleans the quahaug fishery of Pleasant Bay, but has a more limited territory, as only a small portion of Pleasant Bay lies within the town limits. Practically all this territory, comprising 100 acres, is quahauging ground, though the commercial quahauging is prosecuted over an area of 10 acres only. Scattering quahaugs are found over an area of 100 acres. In the southern waters of the town, on the Sound side, scattering quahaugs are found in certain localities, but are not of any commercial importance. The most important of those localities are off Dean's Creek and in Herring River, where quahaugs are dug for home consumption.

(*c*) *Dennis and Yarmouth.* — The quahauging grounds, about 200 acres in area, are practically all in Bass River, where Dennis and Yarmouth have equal fishery rights.

(*d*) *Barnstable.* — The greater part of the quahaug industry is conducted on the south shore of the town, which is especially adapted, with its numerous inlets, for the growth of this shellfish. The principal fishery is in Cotuit harbor and West Bay, and is chiefly shared by the villages of Osterville, Marston's Mills and Cotuit, which lie on the east, north and west sides, respectively, of the bay. The principal area for quahauging is a flat along Oyster Island, comprising about 70 acres of sandy bottom, while directly west, in the center of the harbor, is a strip of 80 acres of mud and eelgrass where scallops and quahaugs abound. Scattering quahaugs are found in Osterville harbor, West Bay, Poponesset River and East Bay, comprising a total of 1,650 acres, of which part only is productive. At Hyannis the grounds are confined to Lewis Bay, where they cover an area of 800 acres. Quahaugs are found in scattered patches over this area, but in no place is quahauging especially good.

(*e*) *Mashpee.* — The best grounds are found in Peponesset Bay and river, where a territory of 200 acres includes several oyster grants, which are worked but little. On the east side of Waquoit Bay scattering quahaugs are found in Mashpee waters.

(*f*) *Falmouth.* — There is practically no quahaug industry in Falmouth. Hardly 100 bushels are dug annually, and those only for home consumption. A few quahaugs are perhaps shipped by the oystermen. Quahaugs are found mostly in scattering quantities over a large area in Waquoit Bay, and in small quantities on the north and west side of Great Pond, comprising a total of nearly 400 acres. Not all this ground is capable of producing quahaugs, but many parts could produce good harvests.

Buzzard's Bay. — The Buzzard's Bay section comprises the towns bordering on the bay, and includes the towns of Falmouth, Bourne, Wareham, Marion, Mattapoisett, Fairhaven and New Bedford, covering an area of about 8,000 acres of quahauging territory. This section is naturally well adapted for the quahaug, as conditions are especially favorable for its habitation. The numerous inlets and bays, the medium rise and fall of the tide, the influx of the water as it courses in and out of the little bays and estuaries, together with its warmth and the abundance of food forms, renders Buzzard's Bay extremely well situated for the growth and propagation of the quahaug. This section shows the greatest effects of overfishing, as part of the beds have been almost exhausted and the remainder are under a severe strain. The quahaug can never be exterminated completely, as when the supply becomes scarce the number of men engaged in the fishery diminish, but it is comparatively easy to ruin the commercial industry. The natural adaptability of Buzzard's Bay will never fully be utilized until a system of quahaug planting is inaugurated, whereby nature will be assisted in the restocking of the depleted areas. Fishing is carried on with a variety of rakes, from an ordinary garden to the large basket rake.

(*a*) *Falmouth.* — Small patches of good quahaugs are found at North Falmouth, Squeteague Pond, West Falmouth harbor on the southeast side, and a few in Hadley harbor, Naushon.

(*b*) *Bourne.* — Situated at the head of Buzzard's Bay, and separated from the adjacent town of Wareham by Cohasset Narrows, Bourne has many advantages for a profitable quahaug industry. It possesses nearly twice as much quahaug territory as Wareham, but, as most of this is unproductive, has a smaller annual output. The territory includes over 2,500 acres of ground, most of which consists of flats of mud, sand and eelgrass, covered with shallow water. It is very sparsely set with quahaugs. Outside the oyster grants practically the entire stretch of coast from Buttermilk Bay to Wing's Neck is quahauging territory. Other grounds lie between Basset's Island, Scraggy Neck and Handy's Point.

(*c*) *Wareham.* — Quahaugs are found over practically the entire territory, and comprise a total area of about 1,300 acres. Although much of this area is barren, the commercial fishery is maintained by small isolated beds which occur here and there. The two principal centers of the industry are in Wareham River and Onset Bay. At Onset the whole bay, except the oyster grants, as included between the southeast end of Mashnee Island and Peter's Neck, is used for quahauging. A few quahaugs are found in Broad Cove, and fair digging is obtained in Buttermilk Bay and Cohasset Narrows. The Wareham River, outside the oyster grants, and a narrow shore strip from Weweantit River to Tempe's Knob, comprise the rest of the territory. In Onset channel a fine bed exists in deep water, 2 to 4 fathoms, but the ground is so hard that not much digging is done.

(*d*) *Marion.* — The quahaug territory, comprising a total of 400 acres, is chiefly confined to Marion harbor, running in a narrow strip parallel to the shore from Aucoot Cove all along the coast to Planting Island. Almost all the head of the harbor and all of Blankenship's and Planting Island Cove is quahaug area. Small grounds are also found at Wing's Cove and in the Weweantit River.

(*e*) *Mattapoisett.* — Quahaugs are very unevenly distributed over 800 acres. The best quahaugs are found in Aucoot Cave and at Brants. In the main harbor scattering quahaugs are found.

(*f*) *Fairhaven.* — Some 3,000 acres are more or less bedded with quahaugs. Of this, probably not more than one-tenth is very productive. The best quahauging is in Acushnet River, where digging for market has been forbidden because of sewage pollution (see New Bedford), and in Priest's Cove as far as Sconticut Neck. In these grounds "little necks" are numerous. The grounds around West Island and Long Island, once very productive, are now largely dug out. Little Bay and the east coast of Sconticut Neck are fairly productive, while the west coast yields only a small amount. Most of the quahaugs dug for food come from the deep water west-southwest of Sconticut Neck.

(*g*) *New Bedford.* — Good beds of quahaugs, particularly "little necks," exist in Acushnet River and Clark's Cove, but can be taken only for bait. As several sewers run into the Acushnet River, and the public health was endangered by the consumption as food of the quahaugs taken from the river and the waters near its mouth, nearly 400 acres of quahaug territory were closed by the State Board of Health. What little available territory there is outside the proscribed area, off Clark's Point, is free to all.

The Islands of Nantucket and Martha's Vineyard. — This section comprises valuable territory, especially in the production of "little necks." The grounds, approximating 7,000 acres, are found principally in Katama Bay, Edgartown, Nantucket harbor and near the Island of Tuckernuck. Conditions here resemble closely the south side of Cape Cod, as regards exposure, rise and fall of the tide, and depth of water.

(*a*) *Nantucket.* — Nantucket is especially adapted for quahaugs, as Nantucket harbor, Maddequet harbor and the Island of Tuckernuck possess extensive territory. The quahauging territory of Nantucket is divided into three sections: (1) Nantucket harbor; (2) Maddequet harbor; and (3) Tuckernuck. In Nantucket harbor quahaugs are found over an area of 2,290 acres, both scattering and in thick patches. Maddequet harbor, on the western end of the island, has approximately 300 acres suitable for quahaugs, running from Broad Creek to Eel Point. On the eastern end of Tuckernuck Island is a bed of quahaugs covering about 200 acres; while on the west side, between Muskeget and Tuckernuck, is a large area of 2,500 acres which is more or less productive. The Tuckernuck fishery is largely "little necks," and it is from here that the shipment of small seed quahaugs has been made.

(*b*) *Edgartown.* — The finest "little neck" fishery in Massachusetts is found in Katama Bay, in the town of Edgartown. Two-fifths of the entire catch are "little necks." The most productive grounds are situated in the lower part of Katama Bay, while quahaugs are also found in Edgartown harbor and in Cape Poge Pond, the total area of these localities comprising 1,800 acres.

Industrial Practices.

Methods of Capture. — Several methods of taking quahaugs are in vogue in Massachusetts, some simple and primitive, others more advanced and complex, but all modifications of simple raking or digging. These methods have arisen with the development of the industry, and record the historical changes in the quahaug fishery, as each new fishery or separate locality demands some modification of the usual methods.

(*a*) "*Treading.*" — The early settlers in Massachusetts quickly learned from the Indians the primitive method of "treading" quahaugs, which required no implements except the hands and feet. The "treader" catches the quahaug by wading about in the water, feeling for them with his toes in the soft mud, and then picking them up by hand. Nowhere in Massachusetts is it used as a method of commercial fishery.

(*b*) *Tidal Flat Fishery.* — Often quahaugs are found on the exposed tidal flats, where they can sometimes be taken by hand, but more often with ordinary clam hoes or short rakes. Owing to the scarcity of quahaugs between the tide lines, this method does not pay for market fishing, and is resorted to only by people who dig for home consumption.

(*c*) *Tonging.* — In most parts of Buzzard's Bay and in a few places on Cape Cod quahaugs are taken with *oyster tongs*. This method is applicable only in water less than 12 feet deep, as the longest tongs measure but 16 feet. Four sizes of tongs are used, 8, 10, 12 and 16 feet in length. Tonging is carried on in the small coves and inlets, where there is little if any rough water. A muddy bottom is usually preferable, as a firm, hard soil increases the labor of manipulating the tongs, which are used in the same manner as in tonging oysters.

(*d*) *Raking.* — The most universal way of taking quahaugs is with rakes. This method is used in every quahaug locality in Massachusetts, each town having its special kind of rake. Four main types of rakes can be recognized: —

(1) *The Digger.* — In some localities, chiefly in Buzzard's Bay, the ordinary potato digger or rake, having four or five long, thin prongs, is used. Usually it has a back of wire netting, which holds the quahaugs when caught by the prongs. As the digger has a short handle of 5 feet, it can be used only in shallow water, where the quahauger, wading in the water, turns out the quahaugs with this narrow rake. This method yields but a scanty return, and is more often used for home consumption than for market.

(2) *The Garden Rake.* — The ordinary garden rake, equipped with a basket back of wire netting, is in more general use in shallow water, either by wading or from a boat, as it has the advantage of being wider than the potato digger.

(3) *The Claw Rake.* — This type of rake varies in size, width and length of handle. It is used chiefly at Nantucket. The usual style has a handle 6 feet long, while the iron part in the form of a claw or talon is 10 inches wide, with prongs 1 inch apart. Heavier rakes with longer handles are

sometimes used for deep water, but for shallow water the usual form is the short-claw rake.

(4) *The Basket Rake.* — The greater part of the quahaug production is taken from deep water, with the basket rake. These rakes have handles running from 23 to 65 feet in length, according to the depth of water over the beds. Where the water is of various depths, several detachable handles of various lengths are used. At the end of these long handles is a small cross-piece, similar to the cross-piece of a lawn mower; this enables the quahauger to obtain a strong pull when raking. The handles are made of strong wood, and are very thin and flexible, not exceeding 1½ inches in diameter. The price of these handles varies according to the length, but the average price is about $2. As the long handles break very easily, great care must be taken in raking.

Three forms of the basket rake are used in Massachusetts. These rakes vary greatly in form and size, and it is merely a question of opinion which variety is the best, as all are made on the same general principle, — a curved, basket-shaped body, the bottom edge of which is set with thin steel teeth.

The Wellfleet and Chatham rake is perhaps the most generally used for all deep-water quahauging on Cape Cod, and finds favor with all. It consists of an iron framework, forming a curved bowl, the under edge of which is set with thin steel teeth varying in length from 2 to 4 inches, though usually 2½-inch teeth are the favorite. Formerly these teeth were made of iron, but owing to the rapid wear it was found necessary to make them of steel. Over the bowl of this rake, which is strengthened by side and cross pieces of iron, is fitted a twine net, which, like the net of a scallop dredge, drags behind the framework. An average rake has from 19 to 21 teeth, and weighs from 15 to 20 pounds.

The basket rake used at Edgartown and Nantucket is lighter and somewhat smaller than the Wellfleet rake. The whole rake, except the teeth, is made of iron. No netting is required, as thin iron wires ⅓ inch apart encircle lengthwise the whole basket, preventing the escape of any marketable quahaug, and at the same time allowing the mud to wash out. This rake has 16 steel teeth, 1½ inches long, fitted at intervals of 1 inch in the bottom scraping bar, which is 16 inches long; the depth of the basket is about 8 inches. Shorter poles, not exceeding 30 feet in length, are used, and the whole rake is much lighter. The price of this rake is $7.50, while the poles cost $1.50.

The third form of a basket rake is a cross between the basket and claw rakes. This rake is used both at Nantucket and on Cape Cod, but is not so popular as the other types. The basket is formed by the curve of the prongs, which are held together by two long cross-bars at the top and bottom of the basket, while the ends are enclosed by short strips of iron. This rake exemplifies the transition stage between the claw and basket types, indicating that the basket form was derived from the former. Handles 20 to 30 feet long are generally used with these rakes.

Shallow v. *Deep Water Quahauging.* — Two kinds of quahauging are found in Massachusetts, — the deep and the shallow water fisheries. This arbitrary distinction also permits a division of localities in regard to the principal methods of fishing. Although in all localities there exists more or less shallow-water fishing, the main quahaug industry of several towns is the deep-water fishery. In all the Buzzard's Bay towns except Fairhaven and New Bedford the shallow-water fishery prevails; this is also true of the south side of Cape Cod. On the north side of Cape Cod the opposite is true, as the quahauging at Wellfleet, Eastham, Orleans and Brewster is practically all deep-water fishing. At Edgartown and Nantucket, although there is considerable shallow-water digging, the deep-water fishery is the more important.

The deep-water fishery is vastly more productive than the shallow-water industry, furnishing in 1907 118,500 bushels, compared to 23,227 bushels, or more than five times as much. The deep-water fishery, *i.e.*, the basket-rake fishery, is the main quahaug fishery of the State, and each year it is increasing, because of the opening of new beds. On the other hand, the shallow-water grounds are rapidly becoming barren from overfishing. The deep-water quahauging is harder work, requires considerable capital but has fewer working days. Naturally the earnings from this fishery should surpass those of the shallow-water industry. The deep-water quahauger averages from $5 to $8 for a working day, while the shallow-water fisherman earns only from $2 to $3 per day.

Both power and sail boats are used in deep-water quahauging, though power is gradually replacing the old method of sailing, because of its increased efficiency and saving of time. When the quahaug grounds are reached, the boat is anchored at both bow and stern, one continuous rope connecting both anchors, which are from 500 to 600 feet apart, in such a way that the bow of the boat is always headed against the tide. A sufficient amount of slack is required for the proper handling of the boat, which can be moved along this anchor "road" as on a cable, and a large territory raked. The rake is lowered from the bow of the boat, the length of the handle being regulated by the depth of the water, and the teeth worked into the sandy or muddy bottom. The quahauger then takes firm hold of the crosspiece at the end of the handle, and works the rake back to the stern of the boat, where it is hauled in and the contents dumped on the culling board or picked out of the net. In hauling in the net the rake is turned so that the opening is on top, and the mud or sand is washed out before it is taken on board. The long pole passes across the boat and extends into the water on the opposite side when the rake is hauled in. This process is repeated until the immediate locality becomes unprofitable, when the boat is shifted along the cable. The usual time for quahauging is from half ebb to half flood tide, thus avoiding the extra labor of high-water raking. Deep-water raking is especially hard labor, and six hours constitute a good day's work.

Boats. — Nearly all kinds of boats are utilized in the quahaug fishery, and are of all values, from the $10 second-hand skiff to the 38-foot power seine boat, which costs $1,500. The shallow-water industry requires but little invested capital. Dories and skiffs are the principal boats, costing from $10 to $25. Occasionally a sail or power boat may be used in this fishery. The deep-water industry requires larger and stronger boats. These are either power or sail boats, often auxiliary "cats," and their value runs anywhere from $150 to $1,500. The average price for the sail boats is $250, while the power boats are assessed at $350. At Orleans several large power seine boats, valued at about $1,500, are used in the quahaug fishery. These seine boats are 30 to 38 feet over all, have low double cabins, and are run by 8 to 12 horse-power gasolene engines. The ordinary power boats have gasolene engines from 2 to 6 horse-power. In this way each method of quahauging has its own boats, which are adopted for its needs.

Dredging. — So far as known, dredging is never used in quahauging in Massachusetts, although it is sometimes used on sea-clam beds. It has been tried, but without success, chiefly because of the uneven nature of the bottom. The invention of a suitable dredge is necessary, and there can be little doubt that in the future, if this difficulty is overcome, dredging will be used in the quahaug fishery. In 1879 Ingersoll (8) reports in Rhode Island the use of a quahaug dredge similar in structure to our rake. Evidently this form was never especially successful, possibly because these dredges could not be dragged by sail boats.

Outfit of a Quahauger. — The implements and boats used in quahauging have already been mentioned. The outfit of the average quahauger in each fishery is here summarized: —

Deep-water Quahauging.		*Shallow-water Quahauging.*	
Boat,	$300	Boat,	$20
2 rakes,	20	Tongs or rakes,	3
3 poles,	6	Baskets,	2
	$326		$25

Season. — The quahaug fishery is essentially a summer fishery, and little if any is done during the winter. The season in Massachusetts lasts for seven months, usually starting the last of March or the first of April, and ending about the first of November. The opening of the spring season varies several weeks, owing to the severity of the weather; and the same is true of the closing of the season.

As a rule, the Buzzard's Bay industry, where digging is done in the shallow waters of protected bays and coves, using short rakes and tongs, has a longer season than the quahaug industry of Cape Cod, where the fishery is carried on in deep and open waters. With the former, the cold work and hardship alone force the quahaugers to stop fishing, a long time after storms and rough weather have brought the latter industry to an end.

The actual working days of the deep-water quahauger number hardly over 100 per season, while those of the shallow-water fisherman easily outnumber 150. The deep-water quahauger's daily earnings are two or three times the daily wages of the shallow-water quahauger, but the additional number of working days in part makes up this difference.

The quahaug season can be divided arbitrarily into three parts: (1) spring; (2) summer; (3) fall. The spring season lasts from April 1 to June 15, the summer season from June 15 to September 15, and the fall season from September 15 to November 1. These seasons are marked by an increase in the number of quahaugers in the spring and fall. The men who do summer boating quahaug in the spring before the summer people arrive, and in the fall after the summer season is over. The opening of the scallop season, in towns that are fortunate enough to possess both industries, marks the closing of the quahaug season. These two industries join so well, scalloping in the winter and quahauging in the summer, that a shellfisherman has work practically all the year.

Marketing. — The principal markets for the sale of Massachusetts quahaugs are Boston and New York. In 1879 the Boston market, according to Ingersoll (8), sold comparatively few. At the present time the Boston market disposes of many thousand bushels annually, but nevertheless the greater part of the Massachusetts quahaugs are shipped to New York. This, again, is due to the better market prices offered by that city. Besides passing through these two main channels, quahaugs are shipped direct from the coast dealers to various parts of the country, especially the middle west. This last method seems to be on the increase, and the future may see a large portion of the quahaug trade carried on by direct inland shipments.

(*a*) *Shipment.* — Quahaugs are shipped either in second-hand sugar or flour-barrels or in bushel bags. The latter method is fast gaining popularity with the quahaugers and dealers, owing to its cheapness, and is now steadily used in some localities. When quahaugs are shipped in barrels, holes are made in the bottom and sides of the barrel, to allow free circulation of air and to let the water out, while burlap is used instead of wooden heads.

(*b*) *"Culls."* — Several culls are made for the market. These vary in number in different localities and with different firms, but essentially are modifications of the three "culls" made by the quahaugers: (1) "little necks;" (2) "sharps;" (3) "blunts." The divisions made by the firm of A. D. Davis & Co. of Wellfleet are as follows: (1) "little necks," small, 1½ to 2¼ inches; large, 2¼ to 3 inches; (2) medium "sharps," 3 to 3¾ inches; (3) large "sharps," 3¾ inches up; (4) small "blunts;" (5) large "blunts."

(*c*) *Price.* — The prices received by the quahaugers are small, compared with the retail prices. "Little necks" fetch from $2.50 to $4 per bushel, sharps and small blunts from $1.10 to $2, and large blunts from 80 cents to $1.50, according to the season, fall and spring prices necessarily being higher than in summer. The price depends wholly upon the supply in the market, and varies greatly, although the "little necks" are fairly constant, as the demand for these small quahaugs is very great. To what excess the demand for "little necks" has reached can best be illustrated by a comparison between the price of $3 paid to the quahauger per bushel, and the actual price, $50, paid for the same by the consumer in the hotel restaurants.

(*d*) *Bedding Quahaugs for Market.* — By town laws in Orleans, Eastham and Wellfleet, each quahauger may, upon application, secure from the selectmen a license, giving him not more than 75 feet square of tidal flat upon which to bed his catch of quahaugs. While no positive protection is guaranteed, public opinion recognizes the right of each man to his leased area, and this alone affords sufficient protection for the success of this communal effort, which is the first step by the people toward quahaug farming.

The quahauger needs only to spread his catch on the surface, and within two tides the quahaugs will have buried themselves in the sand. Here they will remain, with no danger of moving away, as the quahaug moves but little. The quahauger loses nothing by this replanting, as not only do the quahaugs remain in a healthy condition, but even grow in their new environment.

The result of this communal attempt at quahaug culture is beneficial. While the market price for "little necks" is almost always steady, the price of the larger quahaugs fluctuates considerably, and the market often becomes "glutted." This would naturally result in a severe loss to the quahauger if he were forced to keep shipping at a low price. As it is, the fortunate quahauger who possesses such a grant merely replants his daily catch until the market prices rise to their proper level. An additional advantage is gained by the quahauger, who at the end of the season has his grant well stocked, as higher prices are then offered. As many as 1,000 barrels are often held this way at the end of the season.

History of the Fishery. — Although reckoned inferior to the soft clam (*Mya arenaria*), the quahaug was dug for home consumption for years in Massachusetts, and but little attempt was made to put it on the market. The commercial quahaug fishery started on Cape Cod, about the first of the nineteenth century, growing in extent until about 1860. From 1860 to 1890 the production remained about constant. The production in 1879 for Massachusetts, as given by A. Howard Clark, totalled 11,050 bushels, valued at $5,525. It is only in the last fifteen to twenty years that the actual development of the quahaug fishery has taken place. The present production of Massachusetts is 144,044 bushels, valued at $194,687. To the popular demand for the "little neck" can be attributed the rapid development of the quahaug industry during the last ten years. This development has furnished employment for hundreds of men, and has given the quahaug an important value as a sea food. What it will lead to is easily seen. The maximum production was passed a few years ago, constant overfishing caused by an excessive demand is destroying the natural supply, and there will in a few years be practically no commercial fishery, unless measures are taken to increase the natural supply. Quahaug farming offers the best solution at the present time, and gives promise of permanent success.

Not only has there been an increase in production, but also an increase in price, which has more than doubled between 1888 and 1902, and has alone supported a declining fishery in many towns, making it still profitable for quahaugers to keep in the business, in spite of a much smaller catch. The advance in price is due both to the natural rise in the value of food products during the past twenty-five years and also to the popular demand for the "little neck," or small quahaug.

Statistics of the Quahaug Fishery. — In the following table the towns are arranged in alphabetical order, and the list includes only those towns which now possess a commercial quahaug fishery. In giving the number of men, both transient and regular quahaugers are included. In estimating the capital invested, the boats, implements, shanties and gear of the quahauger are alone considered, and personal apparel, such as oil-skins, boots, etc., are not taken into account. The value of the production for each town is based upon what the quahaugers receive for their quahaugs, and not the price they bring in the market. The area of quahaug territory given for each town includes all ground where quahaugs are found, both thick beds and scattering quahaugs.

Town.	Number of Men.	Capital invested.	Number of Boats.	Number of Dories and Skiffs.	1907 Production.		Area in Acres.	Value of Yield per Acre.
					Bushels.	Value.		
Barnstable,	25	$850	-	25	2,500	$3,700	950	$3 95
Bourne,	46	1,000	-	46	5,400	8,400	2,500	3 36
Chatham,	50	5,750	25	25	6,700	10,000	2,000	5 00
Dennis,	15	150	-	10	500	950	200	4 75
Eastham,	25	8,000	12	-	10,000	11,500	4,000	2 87
Edgartown,	70	12,000	42	18	20,000	32,000	1,800	17 77
Fairhaven,	115	5,000	11	100	15,000	16,500	3,000	5 50
Falmouth,	-	-	-	-	100	115	400	29
Harwich,	7	200	-	7	1,500	2,550	100	25 50
Marion,	19	250	-	19	800	1,500	400	3 75
Mashpee,	7	70	-	5	250	285	400	71
Mattapoisett,	28	500	-	28	800	1,500	750	2 00
Nantucket,	48	6,750	30	10	6,294	8,487	5,290	1 60
Orleans,	75	25,000	30	25	33,000	41,350	1,500	27 56
Wareham,	50	1,000	-	50	6,000	10,500	1,300	8 08
Wellfleet,	145	27,500	100	-	33,000	41,350	2,500	16 54
Yarmouth,	20	240	-	10	2,200	4,000	1,000	4 00
Totals,	745	$94,260	250	378	144,044	$194,687	28,090	$6 93 [1]

[1] Average.

The Laws.

In the past there has been a scarcity of quahaug legislation as there has been little demand for the protection of this mollusk; but within a few years the legal regulation of the quahaug fishery will become a most important part of the shellfish legislation of Massachusetts. The quahaug industry is entering upon a new phase of existence, the cultural stage, and the development of the industry along such lines will necessarily entail numerous laws governing the leasing, planting, pollution and sale of quahaugs. For this reason it may be well to consider what has already been done in a legislative way for the protection of the quahaug fishery.

Little direct quahaug legislation has been passed, as the quahaug usually has been included in general laws with other commercial shellfish. The reason for the lack of legislation is probably due to the recent growth of the quahaug fishery, which has only in the past fifteen years developed into an important industry.

Previous to 1904 the quahaug, with the clam, oyster and scallop, came in the general acts under the term shellfish. The general acts were of several kinds: (1) town regulation; (2) permits; (3) seizure in vessels; and (4) protection of the shellfisheries by limiting the catch, place and time of taking.

In 1874 occurs the first mention of the word quahaug in a legislative act "to regulate the shellfisheries in the waters of Mount Hope Bay and its tributaries," whereby the selectmen of the towns bordering on Mount Hope Bay were permitted to grant licenses for the cultivation of clams, quahaugs, scallops and other shellfish to any inhabitant. It seems strange that such an advanced and beneficial act should have been passed at that early period, since it was clearly before its time, as is shown by its repeal the following year. It is only within the last two years that similar legislation has been passed for the quahaug, as illustrated by the act of 1909, which permits the granting of leases for the growing of quahaugs by the selectmen provided the town meeting has voted to adopt the general law. The act of 1874, although it applied only to the Narragansett Bay section of Massachusetts, brings out clearly the fact that the cultivation of shellfish is no new project as it was considered of practical importance thirty-five years ago.

In 1880 the word quahaug again appears in the general act whereby the Commonwealth gave to the towns and cities their present oversight and power "to control and regulate the taking of eels, clams, quahaugs and scallops." This act was later amended by the Acts of 1889, but the general terms were not changed, and the present law differs but slightly. As the seacoast towns hold their control over the shellfisheries as a direct trust from the Commonwealth, it is their duty to preserve the fisheries, while the Commonwealth should see that the towns take the proper care of their natural shellfish resources. Certain towns should be deprived of the rights which they are abusing in neglecting one of the great resources of the public wealth, which belongs not only to the inhabitants of the seashore communities but to *every resident* of this Commonwealth. At the present time, owing to a certain self-satisfaction and fear of outside influence, the majority of fishermen prefer the present system of town control, no matter if the shellfisheries suffer, and until public opinion is favorable for the utilization of the quahaug fishery for every inhabitant of the Commonwealth, both fishermen and consumer, State control is not desirable.

In 1900 occurred the first special quahaug legislation, in the form of an act forbidding in the towns of Swansea and Somerset the capture of quahaugs less than 1½ inches across the widest part. Since that time five other laws relating to the quahaug fishery have been enacted, in all three town and three general. The following features are illustrated by these acts: —

Limiting the Size of Quahaugs captured. — The capture of quahaugs under 1½ inches across the widest part was forbidden by law in 1900 in the towns of Swansea and Somerset, in 1901 in Berkley, in 1903 in Edgartown, and in 1904 in Eastham, Orleans and Wellfleet. This law has also been adopted by other towns under the regulation of the selectmen, and is to be commended for the protection afforded to the home industries, as the gain for leaving the small quahaugs is many times the profits on the small seed. In this connection attention is again called to the shipment in the past of the small seed from Nantucket, Chatham and New Bedford to localities outside the State, where they are replanted, with a return, in one year's time, of about 5 bushels for every bushel planted.

Permits. — In Eastham, Orleans and Wellfleet the selectmen are empowered to issue permits for the capture of the quahaug, while in Edgartown, Berkley, Swansea and Somerset the permits are issued for shellfish in general. Often the towns are very slack about the enforcement of requiring permits, although Edgartown is to be highly commended for the excellent manner of regulating, by inspectors, her shellfish permits. These permits are given at the discretion of the selectmen, and are supposed to require six months' residence in the town. Different prices are charged for these permits: in Edgartown, $2; in Wellfleet, $1; in Berkley, although empowered by the Acts of 1901, no permits are given; in Somerset and Swansea only clam permits are given. The provisions of the Edgartown permit limit the catch to 4 bushels from sunrise to sunset, no more than 2 of which can be "little necks." The Wellfleet permits limit the daily catch to 4 barrels per man.

Bedding Quahaugs. — In Eastham, Orleans and Wellfleet the selectmen may give, for a period not over two years, under such conditions as they may deem proper, to any inhabitant of the respective towns, licenses to bed quahaugs in any waters, flats or creeks where there is no natural quahaug bed, not covering more than 75 feet square in area, and not impairing the private rights of any person or materially obstructing any navigable waters. The object of this law was to make possible the advantage of a favorable market, as the quahauger could bed his catch until the market brightened and the price went up, otherwise he would be compelled to ship at a low figure. Undoubtedly the originators of this act did not foresee that in this way they had taken the first step toward quahaug farming, as the success of bedding quahaugs has demonstrated to the quahaugers of this section the practical benefits which would be derived from quahaug culture.

Contaminated Waters. — One of the detrimental results of civilization has been the pollution of the public waters in Massachusetts, which appears to us most unfortunate, as in the light of present-day knowledge, such a state of affairs could be readily avoided. The tendency of the past has been to dispose of sewage, manufacturing wastes and other refuse by allowing it to flow into the nearest streams. In this way some of the finest rivers in the Commonwealth, the Merrimac, Connecticut, Taunton, Charles and Mystic, have had their fisheries ruined.

Pollution has not been confined to the fresh water alone, but has for commercial purposes ruined the shellfish beds of many salt-water harbors. In several cases, particularly at Boston, Lynn and New Bedford, certain parts of the harbors have been closed by the State Board of Health in the interest of the public health.

For years the relation of the oyster from infected beds to epidemics of typhoid fever has been known and definitely traced. The same is true of the clam and quahaug, particularly the "little neck," which is consumed raw. The quahaug, when feeding, acts as a living filter, since all the microscopic forms in the water, taken through the incurrent siphon, are strained out by the cilia on the gills. Thus, if the typhoid bacilli are present in the water, as is the case when sewage from the houses of typhoid patients empties near the shellfish beds, they are collected by the feeding quahaug. The person partaking of a raw quahaug from this locality would be ingesting a concentrated collection of germs, with perhaps serious results. Cooked quahaugs are more free from germs, and if thoroughly cooked are possibly wholesome, as a certain temperature is fatal to the bacillus. Unfortunately, cooking cannot always be relied upon to reach the requisite temperature.

In 1901 it was enacted that the Commissioners on Inland Fisheries and Game (now the Commissioners on Fisheries and Game), whenever so requested in writing by the State Board of Health, should prohibit the taking of oysters, clams, scallops and quahaugs from the tidal waters or flats of any part of the Commonwealth for such period of time as the board of health might determine. The penalty for violation was, for first offence not less than $5 and not more than $10, and not less than $50 nor more than $100 for each subsequent offence. Unfortunately the beneficial effect of this law, namely, the protection of the public health by the closing of sewage-polluted areas, was rendered void by the passage of a bill in 1907 permitting the taking of shellfish from these areas for bait, upon securing permits from the board of health. Although the law provides heavy penalties for buying and selling, experience has shown the impracticability of effective enforcement on account of the ease with which (1) proofs are destroyed by the violator, and (2) the difficulty of tracing any lot of polluted shellfish to prove that their ultimate destination, perhaps a week or two hence, is human food and not fish bait. Very few quahaugs are used for bait, and the absurdity of the situation is shown when in the case of the Acushnet river over 1,100 permits to take quahaugs for bait have been issued by the New Bedford Board of Health. In such cases as the Acushnet River, where seed quahaugs are abundant, a means should be found to permit the sale of the seed for planting purposes *within the Commonwealth* by the passage of a special act for the town of Fairhaven and city of New Bedford. But until the laws permit the planting of such quahaugs it is impossible to adequately solve the question of obtaining seed from the polluted areas. Transplanted to pure water these mollusks will readily purify themselves from all contamination.

Biological Investigation. — In 1905 the Commissioners on Fisheries and Game were empowered to make a biological investigation and report as to the best methods, conditions and localities for the propagation of quahaugs. The results of that investigation are embodied in this report.

Planting, Cultivation and Bedding of Quahaugs. — In 1909 the selectmen of towns or the mayor or aldermen of cities, provided the act is approved by the city council or by the voters of the town at an annual or special town meeting, are empowered to issue written licenses for the purpose of planting and cultivating quahaugs upon and in the flats and creeks below mean low-water mark, for a term of not more than ten and not less than five years. The important fact that up to the present time no town has taken advantage of this act, which permits practical quahaug culture being carried on, is another proof of the inability of the coast towns to properly adjust their point of view toward the practical means not only of preserving their natural supply from extinction but also of building up an extensive and profitable business for the inhabitants.

Date.	Kind.	Provisions.
1900, . .	Special town, . .	No quahaugs less than 1½ inches to be taken in Swansea and Somerset.
1901, . .	Special town, . .	No quahaugs less than 1½ inches to be taken in Berkley.
1901, . .	State, . . .	No quahaugs to be taken from the waters closed by the State Board of Health.
1903, . .	Special town, .	No quahaugs less than 1½ inches to be taken in Eastham, Orleans and Wellfleet. Selectmen of these towns empowered to grant permits for taking quahaugs. For bedding quahaugs, grants not exceeding 75 feet square, given on the flats and creeks.
1905, . .	State, . . .	Biological investigation of quahaug fishery by the Fish and Game Commission.
1909, . .	State, . . .	Planting, cultivation and bedding of quahaugs.

The Food Value.

The market value of the quahaug except in the case of "little necks," depends rather upon the quality of the meat than on the appearance of the shell. In the growth experiments the ratio of the meats to the shell, in other words, the "fattening," has been little considered. While an increase in shell naturally presupposes a corresponding increase in the soft parts, it does not always follow that the quality of the soft parts has improved. Oyster planters bed oysters to obtain rapid growth, and then transplant the stock to other waters to "fatten" for the market, because localities of rapid growth are not always suitable for fattening purposes. Naturally the ratio between shell and meat varies in the different localities, owing to the environment, food, amount of lime in the water, etc. The prospective quahaug culturist should therefore determine not only the growing property of his grant but also the quality of the product.

Owing to the heavy shell the actual amount of food is but a small per cent. of the total weight of the quahaug. To find the ratio between the meat and shell, a series of determinations on various sized quahaugs were made in three localities, Buzzard's Bay, the Islands and the north side of Cape Cod. For this purpose quahaugs were taken from Fairhaven, Nantucket and Wellfleet. Four sizes of "sharps," 10 each, measuring 55, 65, 75 and 85 millimeters, were taken for comparative purposes in each locality. Whenever possible the weight of "blunts" of similar sizes was also recorded for comparison with the "sharps." The method of work consisted in (1) obtaining the correct sizes from the fresh catch, care being taken to select no deformed specimens; (2) the determination of the total weight; (3) the removal of the meats and fluid; (4) determination of the weight of the meats; (5) records of the natural conditions of the beds where the quahaugs were taken; (6) determination of the volume of the different parts by water displacement to serve as a check on the weighing.

Chemical Composition. — As a food the quahaug ranks next to the scallop and ahead of the oyster in proteins, carbohydrates and minerals. The following figures are from the tables of Professor Atwater, rearranged by Langworthy (15). The food value of the quahaug in the shell, removed from the shell and canned is compared with the scallop, oyster and clam.

	Refuse, Bone, Skin, etc. (Per Cent.).	Salt (Per Cent.).	Water (Per Cent.).	Protein (Per Cent.).	Fat (Per Cent.).	Carbohydrates (Per Cent.).	Mineral Matter (Per Cent.).	Total Nutrients (Per Cent.).	Food Value per Pound (Per Cent.).
Oysters, solids,	–	–	88.3	6.1	1.4	3.3	.9	11.7	235
Oysters, in shell,	83.3	–	15.4	1.1	.2	.6	.4	2.3	40
Oysters, canned,	–	–	85.3	7.4	2.1	3.9	1.3	14.7	300
Scallops,	–	–	80.3	14.7	.2	3.4	1.4	19.7	345
Soft clams, in shell,	43.6	–	48.4	4.8	.6	1.1	1.5	8.0	135
Soft clams, canned,	–	–	84.5	9.0	1.3	2.9	2.3	15.5	275
Quahaugs, removed from shell,	–	–	80.8	10.6	1.1	5.2	2.3	19.2	340
Quahaugs, in shell,	68.3	–	27.3	2.1	.1	1.3	.9	4.4	65
Quahaugs, canned,	–	–	83.0	10.4	.8	3.0	2.8	17.0	[illegible]
Mussels,	49.3	–	42.7	4.4	.5	2.1	1.0	8.0	140
General average of mollusks (exclusive of canned).	60.2	–	34.0	3.2	.4	1.3	.9	5.8	100

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The Meat. — The entire solid contents of the quahaug is used for food, whereas with the scallop only the adductor muscle or "eye" is taken. The meat is either eaten raw, when the quahaugs are served as "little necks" on the half shell, or cooked in various ways.

With advancing age, as is shown by the increase in the weight of the meat of the "blunt" when compared with the same sized "sharp," the flesh becomes tough and of a yellow color, which renders it less edible than the tender "little neck."

Comparison by Localities. — In the following table the average quahaug of 70 millimeters (2¾ inches) for Wellfleet on Cape Cod, Nantucket on Vineyard Sound, and Fairhaven on Buzzard's Bay is shown. The per cent. by weight of the different parts was determined by the average of the four sizes, as described above. The important factor is the per cent. by weight of the solid contents.

The average gives the value for the 70-millimeter quahaug for the State. From 100 pounds of quahaugs by weight the consumer would obtain 13.57 pounds of meat.

Locality.	Total (Per Cent.).	Shell (Per Cent.).	Solid Contents (Per Cent.).	Fluid Contents (Per Cent.).
Wellfleet,	100	62.98	12.12	24.90
Nantucket,	100	63.09	13.53	23.38
Fairhaven,	100	61.33	15.07	23.60
Average,	100	62.47	13.57	23.96

The Food Value of the Quahaug and Scallop. — In comparing the food value of the scallop and quahaug by weight it is necessary to eliminate the fluid in the shell from consideration, as it is variable with the scallop. Again, only the adductor muscle is eaten in the scallop, while the entire solid contents of the quahaug is consumed. When the weight of the shell and the edible portion are considered, it is interesting to note that the amount of edible materal in both shellfish is practically the same in per cent. by weight, being 17.85 per cent. for the quahaug, and 17.77 per cent. for the scallop. Since the weight of the quahaug's shell is 82.15 per cent. and the scallop's but 49.43 per cent., the non-edible soft parts of the scallop amount to 32.80 per cent.

Shell. — The amount of lime in the water and age of the quahaug determine the weight of the shell, although the character of the soil appears to have an indirect effect upon the nature of the lime structure. Likewise, the rate of growth is important, as the slow-growing quahaugs apparently have thicker shells than those in more favorable localities. As the size of the quahaug increases from 55 to 85 millimeters the weight of the shell in per cent. of the total weight increases .06 per cent. for each millimeter gain in length, the meats .04 per cent., while the fluid contents decreases .1 per cent. The shell of a "blunt" weighs over one and one half times that of a "sharp" of the same size.

Unlike the scallop the quahaug is seldom put through the process of "soaking," as it is usually shipped to market in the shell. Occasionally when "shucked" the volume is increased by judicious "feeding" with fresh water. The small quahaugs are more responsive to "soaking" than the old tough specimens, but as they are generally served on the half shell this process is seldom used.

"Soaking" is accomplished by placing the quahaug meats in fresh water, thereby causing a swelling of the tissues, which increases the bulk about one-third. The principal change is attributed to osmosis, which distends the tissues. It was found that after twenty-four hours of soaking the tissues lost the water and gradually returned to their normal weight.

THE RATE OF GROWTH.

Object. — The experiments on growth were conducted with the following objects: (1) to ascertain the normal rate of growth; (2) to find the average length of life; (3) to determine the length of time necessary for the production of a marketable quahaug; (4) to discover practical methods of artificial culture and propagation in order to replenish the barren flats and to check the decline of the natural supply; (5) to obtain information of value to prospective quahaug culturists.

General Plan. — The principal results of these experiments have already been given in previous reports and this paper merely presents the work in detail showing the general method of obtaining the data. With the limited appropriation available $500 per year it was impossible to conduct the investigation in as extensive and comprehensive a manner as could have been desired. In order to obtain satisfactorily the general growth for Massachusetts and the effect of environment, such as soil, current, tide, depth of water, etc., it was necessary to have a large number of experimental plots. As means were limited, the greater part of these beds were of small size, less than 1/1000 of an acre, since it was considered advisable to plant a large number of small plots, covering a variety of conditions, rather than a few large costly beds, as small areas seem to furnish, for all practical purposes, a true index of growth in any locality. In accordance with this plan 187 small experimental beds were planted along the Massachusetts coast, and records of their growth were taken at stated intervals over a period of five years. By planting quahaugs which were five years old, as well as younger ones, at the beginning of the investigation the growth of the quahaug has been determined not only for the five years but for a much longer period. The growth experiments of Kellogg (2) were taken as a basis for this investigation, and the work carried out upon the lines indicated by that investigator. The experiments have been conducted on a practical commercial basis, as the main object was the increasing of the natural supply.

Methods of Work.

Localities. — Five places on the Massachusetts coast were chosen as representative localities: (1) the island of Nantucket; (2) Monument Beach on the shore of Buzzard's Bay; (3) Plymouth harbor, representing the northern commercial range of the quahaug; (4) Wellfleet harbor, the center of the greatest quahaug area in the Commonwealth; and (5) Monomoy Point, in the town of Chatham, as representing the south side of Cape Cod. As it seemed best to concentrate the work as much as possible, the greater part of the experiments were conducted in the last two localities, only a few beds being planted in the other three. These two places, Wellfleet and Monomoy, may be considered as fairly representative of the two great quahaug areas, — the north and south sides of Cape Cod.

Experimental Beds. — The first experimental plots were laid out in terms of the acre, 1/1000 of an acre being the usual size. The later beds were made even smaller, 1/4000 of an acre. The number of quahaugs corresponded to the size of the bed, and in most cases they were thinly planted as only in special instances was crowding necessary for experimental purposes. The planted quahaugs if they were fortunate enough to escape the raids of fishermen and summer residents, were measured annually, and the rate of growth recorded as long as the bed escaped destruction by man or nature. The beds were marked by stakes and protected by signs, which stated briefly that the enclosed plot was under control of the Commonwealth for experimental purposes, as provided by chapter 327, Acts of 1906. Less difficulty was found in protecting the quahaug experiments than similarly planted clam beds, which were often destroyed through human agency. The first beds were laid out in the form of pens, made by sinking boards in the soil so that they projected slightly above the surface. Owing to the difficulty of sinking the boards, the use of this type of bed was limited to shallow water. Later, when records of the migration of the quahaug were obtained, such precautions were found unnecessary, as the quahaug generally remains where planted.

The method of planting was extremely simple, the quahaugs being evenly distributed over the surface of the bed where, in a short time, according to the temperature of the water, they would burrow in the soil. In shallow-water beds and in special cases where greater accuracy was desired the quahaugs were buried by hand in the soil.

Owing to the impossibility of obtaining by raking all the quahaugs in beds such as above described, a factor which would make for inaccuracy, a method of planting was tried in which boxes of various sizes, filled with sand, were used with excellent results. The mollusks, placed in these boxes, could be lowered to any depth in the desired locality, in such a manner that they could readily be taken up and all the quahaugs obtained.

The beds were divided into two classes, below low-water mark and between the tide lines. Each bed was designed to illustrate a particular point in regard to conditions, favorable or unfavorable, which influence the growth of the quahaug, and for this reason different locations were tried. A record of each bed was kept, giving all facts about its natural location, records of growth, etc. By a comparison of these beds, the favorable and unfavorable conditions for quahaug culture could be ascertained. The beds were put in both good and poor places, on natural quahaug ground and on barren area, as often through the failure of a bed the cause may be discovered and a remedy suggested.

The Seed. — All sizes of quahaugs were planted in order to obtain data on the growth of the animal for a long period and to arrive at some conclusion as to the length of life. In general, the smallest obtainable were used, the usual size being 1 to 1½ inches. To satisfactorily obtain a complete record of the growth of this animal it was necessary to have quahaugs extremely small. Although "little necks" and even slightly smaller quahaugs could be procured at Edgartown, no quahaugs of small size could be obtained at the regular quahauging places in sufficient numbers for planting. This was due not so much to the lack of quahaug seed as to the impossibility of raking them in any great depth of water. This difficulty was encountered only at the start, as later the small quahaugs were caught in the spat boxes at Monomoy Point. In the fall of 1905, by a fortunate chance a place was found at Nantucket where quahaugs of extremely small size, running from 6 to 8 millimeters, could be obtained as late as November 1. The seed thus obtained furnished the nucleus for the growth experiments at Monomoy Point, and in 1906 another stock was obtained from the same place.

The following description of the locality at Nantucket where the small quahaugs were obtained in 1905 and 1906 is taken from notes made at that time :—

Coatou Point, consisting of a narrow strip of sandy beach, lies directly across the harbor from the village of Nantucket. On one side is a salt-water pond, connected with the harbor by a stream through which the tide flows into the pond. The stream has a bed of coarse sand and is protected by a sand bar at its mouth. The sand in the lower part of the stream, which extends for about 50 yards in a crooked course, is fine and clear white. Half way up there is a stretch of fine gravel and above this coarse sand. At the upper part of the stream, where it nears the pond, the sides rise abruptly in banks lined with heavy thatch, and are heavily set with the ribbed mussel (*Modiola plicatula*), while large bunches of the common mussel (*Mytilis edulis*) lie in the bed of the stream. In this part of the creek the quahaugs were abundant, and could be exposed by raking the surface of the sand. Many of these small quahaugs had a bit of green algæ attached to the beak of the shell, and were especially numerous in the clumps of mussels. Quahaugs could be obtained as large as 1¾ inches, but no larger, while the majority were small (6 to 8 millimeters). The locality is evidently one of slow growth, judging from the appearance of the quahaugs and from the fact that no increase in growth between August and the following spring could be noticed. The method of gathering these small quahaugs was by hand and by sifting the sand through fine mesh screens, a slow process, as only 200 could be gathered per hour by one person.

In the following year, 1906, the seed under 1½ inches was obtained at Edgartown in Katama Bay. The quahaugs were raked in the usual manner with a basket rake of the Edgartown type; but instead of washing the mud and sand from the rake when it was drawn to the surface of the water, as is customary, the contents were dumped at once on the culling board, where the small quahaugs, which otherwise would have slipped through the meshes of the rake, were separated from the débris.

Another method of obtaining seed was by means of the box spat collectors on the raft at Monomoy Point. The subject of spat collecting has already been discussed, and the method of obtaining the young quahaugs described. It was possible to obtain the desired sizes, even very small specimens. In this way a study of the early life history proved advantageous for the cultural experiments, as quahaugs could be hatched for planting purposes.

Measuring the Quahaugs. — For convenience the measurements were taken in the metric system. Three methods of measuring were used: (1) rule; (2) callipers and rule; (3) triangular measuring instrument, such as pictured in the report on the "Scallop Fishery," 1910. The first two were used only for a short time at the beginning of the work and soon gave place to the third method, which proved more satisfactory in speed and accuracy. This instrument consists of an inverted triangle, formed by two strips of metal welded together at the apex of the triangle and joined at the base by a short cross-piece. The whole structure is made of brass, except the braised joint, and can be made as light as desired, although there is danger of a heavy blow rendering a light instrument inaccurate. Several sizes are used in the work, the most convenient having a base measuring 3 inches. The sides of the triangle are scaled in the metric system on one face and in fractions of inches on the other, the divisions corresponding to the millimeter markings on the ordinary rule, being about 5 millimeters apart, thus enabling the operator to make easier and more accurate readings. When measuring, the triangle is held with the base away from the body, and the object is brought down the narrowing sides until it strikes, at which point the measurement is read.

Three measurements were made of each quahaug, *length,* along the anterior posterior axis; *width,* from the umbones to the edge of the shell, along the dorso-ventral axis; and *thickness,* from valve surface to valve surface, along the lateral axis. After a sufficient number of measurements were taken, a table was formulated by which the corresponding width and thickness for any given length might be calculated. The use of this table eliminated the necessity of taking more than the length measurements.

An easy method of recording the growth of the planted quahaugs consisted in notching the edges of the shell with a file. The mark thus made would remain permanently on the shell, showing the increase in growth. This efficient method was originally used by Dr. A. D. Mead of the Rhode Island Commission of Inland Fisheries in his experiments on the soft clam (*Mya*), and has proved very satisfactory in our quahaug experiments. It has been used not only as a check upon other measurements, but, in connection with the table of length and width, has provided a permanent record for successive yearly growths.

The simple statement of the gain in length does not adequately express the actual increase in the bulk of the quahaug, which should be indicated in terms of volume. A quahaug which grew in one year from a length of 1 inch to a length of 2 inches, a gain of 1 inch, does more than merely double in size, as the figures would seem to indicate. When the gain in volume is considered by comparing the water displacement of the two sizes, it is found that the volume of the 2-inch quahaug is over seven times that of the 1-inch, which gives the true increase. The quahaug shuts its shell closely enough to be water tight, and it is relatively an easy matter to accurately obtain its water displacement, a process impossible with the soft clam and scallop, which have more or less open shells. A table (see Table 3) of volume by water displacement and number per quart was made for each length from 1 to 88 millimeters, several hundred specimens being used for each size, except for the sizes under 6 millimeters. The individual quahaugs vary greatly, some being thick, others thin, some narrow, others wide. For this reason it was necessary to use a large number of quahaugs of each size, and after plotting the results on co-ordinate paper to form a uniform curve for the volume.

Monomoy Experiments.

During the period from 1905 to 1910 growth experiments were conducted in the Powder Hole, a sheltered harbor of salt water situated at Monomoy Point, Chatham, at the elbow of Cape Cod. In former years the Powder Hole was a spacious harbor where a hundred vessels could anchor, but the sand bars have so shifted that at the present time nothing remains but an almost enclosed body of water, of perhaps 3 acres, connected with the ocean on the bay side by a narrow opening through which a dory may enter at high tide. The opening changes constantly, owing to the shifting nature of the sand, and has successively worked from the south to the north side, closed and re-opened again at the south at intervals of one and a half years. A large part of the original harbor is now either dry land or salt marsh, while on the north and west side is a sand flat of 3 acres, which up to 1910 contained an abundant quantity of soft clams. The harbor itself is slowly diminishing in size, due to the encroachment of the sand, and will doubtless eventually become a small pond, not connected with the ocean. By referring to Fig. 31 the location of the flats and experiments can be seen.

The water on the north and west sides averaged from 15 to 18 feet in depth, gradually shoaling to the south and east. In the shallow water the soil was covered with an abundant growth of eelgrass. The rise and fall of the tide was about 1½ feet on the average, but extremely erratic, as the force and direction of the wind and the position of the opening were important in determining the amount of water passing through the narrow inlet. The location and depth of the opening made it possible for the clam flat to be constantly under water for weeks, while at other times several days might pass with the water barely covering the flats. At such times the water was over the flats for only a brief period, probably not averaging much over five hours out of the twenty-four. Naturally, the amount and frequency of the tidal flow affected the salinity of the water, which varied somewhat with the influx of the tide. The amount also varied with the high or low running tides, as a certain height had to be reached before water would flow through the inlet.

The Powder Hole, which was taken by the Commonwealth for experimental lobster hatching, proved an excellent locality for experiments on the life and growth of the quahaug, as it was a natural breeding ground. In addition to the quahaugs naturally bedded in this body of water, additional seed was planted for experimental purposes. A small laboratory was erected on the shore, and a raft 20 feet long by 10 feet wide (see report on the "Scallop Fishery," 1910) was securely moored in the deepest part of the harbor.

Box Experiments. — Two main classes of experiments were undertaken, (1) bed and (2) box, which differ only slightly, the box form being a more convenient modification of the experimental bed previously described. This form consisted of small grocery boxes filled with sand and supplied with rope handles, by which they could be let down in any depth of water, either suspended from the raft or placed on the bottom in any part of the Powder Hole, where they could be raised by a line or a long hooked pole whenever desired. The advantage of the experimental box over the bed lay first, in greater accuracy, as it permitted the operator to obtain each time the same number of quahaugs that he planted, a thing that it is almost impossible to do in a planted bed, where the quahaugs must be raked under water; secondly, it furnished a convenient means of handling; and thirdly, it permitted the planting of numerous small beds, equally as efficient from a practical standpoint, under a variety of natural conditions in the different parts of the Powder Hole.

The box experiments were divided into four classes: (*a*) rack boxes placed on posts; (*b*) boxes in the shallow water near the shore, at a depth of from 1 to 5 feet; (*c*) boxes in deep water, 10 to 18 feet; and (*d*) boxes suspended by ropes from the raft. In all cases, especially on the raft, the boxes were made as strong as possible to withstand the strain of lowering and taking up. The boxes could be used only one year, as the ship worms (Teredo) render the wood unfit for service.

The method of planting a box experiment is comparatively simple. Rope handles are stretched diagonally from end to end, the number of the experiment carved on the side of the box, and the box filled one-half to two-thirds full of clean sand from the shore. The dimensions of the box and the height of the sides above the sand are recorded. The quahaugs, which have previously been measured and notched by a file on the edge of the shell, are either placed on the surface of the sand and allowed to burrow when the box is under the water, or are placed in their natural position under the sand. The box is then lowered at the desired locality.

(1) *Rack Boxes.* — This group comprises the first box experiments, which were started in October, 1905, and continued until October, 1908. These experiments have been grouped together as they comprise all the box experiments of 1905. During the first ten months these boxes were not on the raft, but were located in a different part of the Powder Hole, under circumstances which will be briefly described as follows: —

Wooden boxes of the same length and as nearly as possible the same size were arranged so as to slide between two upright posts about 8 feet long driven firmly in the bottom in from 5 to 6 feet of water. At intervals on the posts were wooden pins, so adjusted that they could be withdrawn at will. These pins furnished a resting place and support for the boxes. Thus the boxes could be raised or lowered for examination at any time. The posts were driven down so that the tops were from 1½ to 2 feet below the surface of the water at low tide, to prevent their being carried away by the ice. To the ends of the boxes were attached galvanized iron handles 3 by 4 inches, which, passing over the posts, made the runners for the boxes. Considerable difficulty was encountered in putting down the posts in getting them the right distance apart, so the boxes would slide easily. One box was used to set the posts and the others lowered after the posts were in position. The boxes were placed in sets of two and three, the former being found more advantageous.

The natural conditions of the quahaugs which were planted in these boxes were especially favorable. The location was in the northeast end of the Powder Hole, as is shown in Fig. 31, at the edge of the deep water, or where the old channel once existed. The bottom was mud covered with thin eelgrass, while the depth of the water at low tide averaged 5½ feet. The sand in the boxes was taken from the exposed flats of the Powder Hole, and was coarse and firm. Raised as they were from the bottom at various heights, the quahaugs were entirely free from the influence of the dead eelgrass, and were able to get a better circulation of water than if resting on the bottom. The sand in the different boxes did not extend flush with the top, but varied from 1½ to 5 inches from the top of the box, leaving a projecting rim. When taken up the sand in the boxes had a muddy appearance at the surface, due to the settling of matter floating on the water. The depth of water over the boxes varied with their location, since all the racks were below low-water mark, and were never exposed. No means were at hand for obtaining the exact rate of current over these experiments, but the circulation was good, and while perhaps not as swift as at the raft was all that could be desired by the quahaug planter. The density varied with the influx of the tide from 1.021 to 1.025.

(2) *Shallow-water Boxes.* — The boxes were somewhat larger than the deep-water boxes, as they could be more easily handled. These boxes were located principally on the south and east sides of the Powder Hole, both on clear bottom and in eelgrass. It is interesting to note that the rate of growth in the boxes was more rapid than for quahaugs in the natural soil in the same locality.

(3) *Deep-water Boxes.* — These boxes were of small size, for convenience in raising. Two methods of raising them were tried. Where the water was sufficiently shallow to permit the box being seen, the pole with hook was used. In the deeper water a rope and small wooden buoy were attached to the box.

(4) *Raft Boxes.* — A raft, 20 feet long by 10 wide, was moored in the Powder Hole near the flat on the north side, where the deepest water and best circulation were obtained. It was provided with a central well and four trap-doors, by means of which the boxes could be lowered to any depth up to 18 feet. The raft was used only during the summer months, and was hauled on land for the winter, the box experiments being transferred for winter to water deep enough to escape the ice. During the winter of 1906 to 1907 a heavy rope frame on posts was placed under the water at a depth of 2½ feet from the surface. On this framework, primarily intended for wire scallop cages, were suspended a number of quahaug boxes, while others were placed on the ground in the same locality at a depth of 11 feet.

The natural conditions on the raft were especially favorable for quahaug growth, and extremely good results were obtained. The position of the raft was such as to receive the full benefit of the incoming tide as it passed through the opening over the flat, bringing with it the abundant diatomous food accumulated on the sand. In this way the circulation of the water in the vicinity of the raft was the best in the Powder Hole, and accounts for the better growth in the raft boxes.

In addition to the box experiments, quahaugs were also placed in wire cages or baskets, and their growth obtained out of the sand. These cages were made of various sized wire mesh, from 1/4 to 1 1/4 inch, according to the size of the quahaugs, and usually measured 1 1/2 by 1 by 1/2 feet. They were suspended from the raft in the same manner as the boxes. For the very small quahaugs a series of jars were suspended, a few quahaugs in each jar.

Experimental Beds. — The experimental beds can be divided into two classes, (1) between the tide lines, (2) below low-water mark. The tidal beds were located in the different parts of the clam flat in connection with clam experiments (Fig. 31). The first of these beds was put out in October, 1905, and the last taken up in 1910. The main results are shown by the comparison of growth between the tide lines only one-fifth of the time under water and on the raft under nearly the same conditions. The first of these beds were in the form of pens made by sinking boards into the sand, but the later ones were planted without bounds of any sort, as it was found that the quahaugs did not travel far.

The beds below low-water mark were mostly confined to the east and south side of the Powder Hole, in shallow water from 2 to 4 feet deep, both in clear spaces and on eelgrass bottom. The entire number, six, planted in 1905 and 1906, were in the form of pens, and varied in size from 1/1000 to 1/100 of an acre. In all these beds the rate of growth was slow.

The growth experiments at Monomoy, as already shown, were grouped into the raft and bed classes. The two kinds of experimental beds, between the tide lines and below low-water mark, were continued from 1905 to 1910. The raft experiments, however, were separated into two series, the first during the four years from 1905 to 1908, when the main laboratory was at Monomoy Point, and the second during 1909 and 1910. The object of the first series was to determine the average rate of growth and methods of planting; the second, the growth of old quahaugs and blunts.

Plymouth Experiments.

Three beds of quahaugs, Nos. 118, 186 and 187, were planted on the flats of Plymouth harbor in connection with experiments on the soft clam (*Mya arenaria*). The experimental beds, situated between the tide lines, were located on Grey's and Egobert's flats in the town of Kingston, on the western side of the harbor. Plymouth harbor presents a vast area of flats more or less covered with eelgrass, with a great variety of soils. Three towns, Duxbury, Kingston and Plymouth, share the fishing rights of this harbor. The general and natural conditions are: (1) large rise and fall of tide; (2) good circulation of water, due to the swift currents, except on the shore flats of the western side; (3) high flats with long exposure; (4) variety of soils from a shifting sand to a soft mud; (5) great area of eelgrass flats.

Egobert's, the larger of the two Kingston flats, has an area of about 275 acres, covered by thick eelgrass except for a triangular piece on the mid-southern section, which comprises about 80 acres of smooth, unshifting sand. The greater part of this section is barren, although a few clams are scattered along the edge near the channel. Grey's flat, situated to the west of Egobert's, is of an entirely different type. It is a long flat, with a uniform width of 100 yards. It runs throughout its length parallel to the shore, while on the east side it is separated from Egobert's by a 300-foot channel. Like Egobert's, it is covered for the most part by eelgrass, but is essentially different in the nature of its soil which is mud throughout. Although the total area of the flat is about 115 acres, an irregular section of mud on the southeastern section, comprising 30 acres, is the only available clam territory. This area is composed of soft mud on the north and the south, but the middle section contains several acres of hard mud. Bed No. 118 was planted on the southwest side of Grey's, in the soft mud; the other two on Egobert's, — No. 187 in the eelgrass, No. 186 on the clear sand, with seed obtained at Marion.

The results, as will be seen by reference to the general table, were briefly as follows: on Egobert's the bed in the eelgrass showed a slower growth than the bed on the bare sand, due to difference in circulation of water. The averages for Grey's and Egobert's flats were about the same, showing that, where the current is the same, the soil, whether soft mud or hard sand, makes little difference in the growth of the quahaug. Growth between the tide lines, with a good circulation of water, even when the feeding period is limited to ten hours out of the twenty-four, is often better than in beds constantly under water, where there is less circulation of water. Culture on these flats is advisable only through the summer months, a gain of 2.4 bushels for every bushel of inch quahaugs planted being recorded for these two flats, as the planter runs the risk of losing his quahaugs in a severe winter. There are places where quahaugs could be safely bedded in deeper water in Plymouth harbor and Duxbury Bay, and there is reason to look forward to a combination of quahaug and clam culture on these flats. Along the western shore of the harbor the growth would be so slow as to render any culture on those shore flats impracticable, but in other parts of the harbor growth may be faster. As the growth is accomplished only during the summer months, the planter should buy large seed in the spring and sell the "little necks" in the fall, thereby not risking a winter loss.

Wellfleet Experiments.

The harbor of Wellfleet Bay, some 4 miles long and nearly 2 miles wide, contains approximately 2,500 acres of quahauging ground. The greater part of this territory is under water, ranging from a few feet in depth to upwards of 5 fathoms at low tide. Particularly in the

the young from other small mollusks of similar shape. On a 1-millimeter quahaug as many as 12 of these ridges could be counted (Fig. 28). As the quahaug grows these ridges appear at regular periods, evidently intervals of time rather than growth, and, as the animal grows older, gradually disappear.

Growth of Old and Young. — As can be seen from Table 2, the actual increase in length as well as the relative increase in volume constantly diminishes as the quahaug increases in size. In other words, the older and larger a quahaug becomes the more slowly it grows. By placing a series of quahaugs from 1 to 95 millimeters in boxes suspended from the raft under similar conditions as regards sand, depth and current, sufficient data were obtained to plot a curve of the year's growth and formulate a table for each sized quahaug from 1 to 100 millimeters. It was found from this experiment that a 14-millimeter quahaug evidenced the greatest gain in length, and that above this size the yearly growth for the larger quahaugs steadily diminished with advancing age. When a 14-millimeter quahaug showed a yearly gain of 27.7 millimeters, a 20-millimeter would give 25.2 millimeters; a 30-millimeter, 20.8 millimeters; a 40-millimeter, 17 millimeters; a 50-millimeter, 13.9 millimeters; a 60-millimeter, 11 millimeters; a 70-millimeter, 8.1 millimeters; an 80-millimeter, 5.1 millimeters; a 90-millimeter, 2.5 millimeters; a 100-millimeter, .6 millimeters. After the quahaug reaches a certain age or size the gain in thickness of the shell surpasses that of increasing length and width, with the result that the old quahaug becomes what is known by the fishermen as a blunt.

Blunts. — Quahaugs with shells thickened at the edges or lips, a sort of retrogressive growth typical of old age, are often taken from the fishing grounds. The size alone does not always indicate the age, as the conditions of its environment may be such as to cause a small-sized quahaug to become a blunt. In many respects slow growth is similar to old age, and may cause a thickening of the edges. Retrogressive growth occurs by a gain in thickness of the shell without a corresponding advance at the edge. Evidently the soft parts of the animal have attained their full development, and therefore the mantle cannot secrete new material for the extension of the shell.

Our experiments did not substantiate the statement of many quahaugers that blunt quahaugs, when placed in a favorable condition will become sharps, *i.e.*, attain once more a thin lip. Blunts of various thicknesses and sizes were obtained at Wellfleet and placed in the raft boxes at Monomoy Point, where conditions were favorable for rapid growth. Control experiments of small quahaugs were conducted at the same time. Part of the same lot of quahaugs were planted near the shore, where the conditions were less favorable for rapid growth. The experiments lasted from May 17 to Sept. 14, 1909. The results were briefly as follows: in the raft boxes, five classes were arbitrarily made, the first two irrespective of length and width, the last three of thickness of lips. (1) Thick blunts; (2) thin blunts; (3) large blunts, 3¾ inches; (4) medium-sized, about 3 inches; (5) small, 2¾ inches.

(1) The thick blunts were divided between three boxes, containing, respectively, (*a*) broad blunts with ridge in center of edge; (*b*) square-edged blunts; (*c*) round-edged blunts. Box (*a*) showed an increase of 1.8 millimeters in width, as compared with a thickening of 3.22 millimeters, giving a ratio of 1.8 millimeters to 3.22 millimeters; box (*b*) 1.3 millimeters to 2.15 millimeters; and box (*c*) 1.5 millimeters to 2.35 millimeters, making an average ratio of 1.53 millimeters to 2.57 millimeters. None of the three boxes showed any definite indication of sharpening, although box (*b*) showed a thin raised edge of growth.

(2) The box of thin-lipped blunts showed a true blunting tendency, giving a typical rounded growth at the edge. These showed an increase in width of 1.6 millimeters, compared with a thickening of 4 millimeters.

(3) The large blunts were placed in three boxes, in classes of wide, medium and fine edges. The average of the three boxes gave a ratio of .7 millimeters to 2.55 millimeters, showing a slower growth for the large than the small and medium sized blunts. The large blunts with the thick lips showed the slowest gain.

(4) Two boxes of medium-sized blunts showed a ratio of 2.51 millimeters to 4.94 millimeters, one box showing a fairly good ring of growth, which might be considered an attempt at sharpening.

(5) The two boxes of small blunts showed a ratio of 1.7 millimeters to 3.6 millimeters, indicating that the shell thickened twice as fast as they increased in size.

The results in the shore experiments were as follows: the blunts placed under poor-growing conditions showed even slower growth, a gain of .22 millimeter in width, than on the raft boxes, and a correspondingly greater thickening. Also, the large blunts showed a slower growth than the small. Experiments were also tried in the opposite direction, *i.e.*, growing blunts from sharps. The sharps over 3 inches showed little gain and great thickening tendencies, but did not evidence any decided blunting. Twelve boxes were used on the raft and in the shore beds, the small sharps giving greater gain than the large.

Length of Life. — Owing to the impracticability of carrying on work for a sufficient period to determine the length of life of any particular set of quahaugs, any statements regarding the period of existence must necessarily be more or less of an estimate. Nevertheless, by means of Table 2 it is possible to give approximately close figures for the age of any given quahaug up to 4 inches in length. On the raft boxes at Monomoy Point, a very favorable place for growth, the following figures were obtained, starting with a 5-millimeter (⅕ inch) quahaug on January 1 at the age of six months. The size of 51.9 millimeters (slightly over 2 inches) was obtained in two and one-half years: 74.25 millimeters (slightly less than 3 inches) in four and one-half years; 89.5 millimeters (slightly over 3½ inches) in seven and one-half years; 96 millimeters (slightly over 3¾ inches) in ten and one-half years; and 101.3 millimeters (about 4 inches) in sixteen and one-half years. The growth during the last six years is more or less a matter of conjecture, but up to the tenth year is approximately correct. In this case the quahaug was under favorable growing conditions. There are places where the growth is four times as slow as in the raft boxes, which would place the age of a large quahaug over fifty years. Where the growth was slow, the quahaugs would probably show blunting before they reached the size of 4 inches. Blunts are older than sharps, and their age is still more a matter of guess work, a decided blunt ranging from twenty-five years to an indefinite age.

The Little Neck. — The culturist who desires to raise the most profitable shellfish will inquire the length of time necessary for producing a marketable quahaug. The following answer, while general, will not apply in every case, since the rate of growth varies according to current, tide and other conditions of environment. In favorable surroundings the quahaug will reach a size of 2 inches in two and one-half years after birth, and at the same rate of growth will attain over 2½ inches in three and one-half years. In exceptionally favorable situations the size of 2¼ inches may be obtained in two and one-half years, and that of 2¾ inches in three and one-half years; but such rapid growth is seldom found, and more often is less than that indicated by the first set of figures. In one of the unfavorably situated experiments, where thick eelgrass cut off the circulation of water, it would have taken four times as long to produce the same size quahaug.

The Growing Months. — The quahaug, like the scallop (*Pecten irradians*), increases in size only during the summer months, no shell formation taking place during the cold weather. Its annual life consists of a period of active growth in the summer and a period of winter rest, during which the animal lies practically dormant. As with the scallop, growth begins about May 1, when the temperature of the water has reached 49° F., varying with the seasonal changes of the different years, and ceases during November, when the temperature has fallen below 45°. For all practical purposes growth ceases about November 1, at a temperature of 49°, which is especially true of the exposed Wellfleet flats, but at Monomoy Point there is a slight November growth. The decrease in the microscopic food forms (diatoms) in the water about December 1 is not sufficient to explain the cessation of growth, which is due rather to the inactivity or sluggishness of the quahaug during the cold weather. By monthly measurements of the quahaugs in the raft boxes and in the shore beds at Monomoy Point, the comparative value of the different summer months was determined in terms of the gain per cent. as follows: considering the entire year as 100 per cent., May received 3.78 per cent.; June, 10.81 per cent.;

July, 19.02 per cent.; August, 25.56 per cent.; September, 26.24 per cent.; October, 12.85 per cent., and November, 1.74 per cent.

Growth on Barren Flats. — There are few areas, no matter how adverse the natural conditions, where quahaugs will not live, but their rate of growth will depend entirely upon the environment. There are many barren flats on which they will grow, if planted, but on which certain conditions prevent the natural set. In the future it will be possible to utilize such areas for quahaug culture and to make productive localities now practically worthless.

Comparison of Localities. — The growth experiments were conducted chiefly at Wellfleet and Monomoy Point, a few beds being planted at Plymouth, Nantucket and Monument Beach. Adult quahaugs were planted for spawning purposes in the Essex and Ipswich rivers, but no record of their growth was taken. These quahaugs, one year after planting, were in a thriving condition, but showed no evidence of propagation. Nevertheless, under the prevailing conditions of rapid growth in these rivers, in spite of the inability to obtain a natural set, it should pay to plant quahaugs. The following table gives a comparison of the growth in the various localities. From a practical standpoint only the Monomoy and Wellfleet comparisons are of interest, as the other beds are too few in number.

	Nantucket.	Plymouth.	Monument Beach.	Wellfleet.		Monomoy.			
				Beds.	Boxes.	Raft Boxes.	Shore Boxes.	Shore Beds.	Flat Beds.
Number of beds,	1	3	1	80	4	48	32	6	3
Annual growth,	8.48	9.41	10.15	9.69	28.62	24.02	12.60	11.16	7.63
Increase in volume (per cent.),	132	149	163	155	783	574	216	183	117

The Monomoy experiments afforded a comparison for the four years 1906 to 1910 in the raft boxes and in the shore beds. On the raft the standard growth was as follows: in 1906, 22.84 millimeters; in 1907, 24.21 millimeters; in 1908, 18.72 millimeters; in 1909, 24.92 millimeters. In the shore beds the growth was 5.06 millimeters in 1906; 13.27 millimeters in 1907; 10.01 millimeters in 1908, and 17.43 millimeters in 1909. The slow growth for the shore beds in 1906 is partly due to the effects of transplanting, in 1908 to the closure of the outlet, which for several months interfered with the circulation in the Powder Hole.

A comparison of the various parts of the Powder Hole gives the following figures for the average growth: raft boxes, 24.02 millimeters; edge of clam flat near raft, 19.38 millimeters; clam flat, 7.63 millimeters; eastern part, 17.53 millimeters; east side, 8.92 millimeters; south side, 12.15 millimeters.

Natural Conditions.

There is no more convincing illustration of the influence of environment upon the life of the quahaug than the effect of the surrounding conditions upon its growth. Chief among these natural agents may be enumerated current, tide, soil, depth and salinity of the water, arranged in order of individual importance, yet so closely interwoven that their separate actions cannot always be clearly demonstrated. Their various combinations form a favorable or unfavorable environment for the growth of the quahaug, and govern largely the rapidity of its development. A discussion of these conditions involves their separate treatment, but the reader should realize that there are few, if any, instances where the pure uncomplicated action of a single natural condition can be obtained.

Current. — The most essential condition for shellfish growth is a good current, not necessarily an exceedingly swift flow, but rather a fair circulation of water. Current performs a threefold service: (1) it determines the supply of food for the body and lime for the shell; (2) it governs the supply of oxygen for the gills; and (3) finally, it acts as a sanitary agent.

(1) The food of the quahaug, as already stated, consists of microscopic forms, chiefly diatoms, in the water. The growth of the quahaug, as with lower animals, is directly proportional to the amount of food, and the animal situated in a current naturally receives a greater supply than one in still water. For all practical purposes current means food, and, within limits, increase in current indicates increase in the amount of food, thus furnishing an index of the growth. The amount consumed likewise depends upon the quantity in the water, the feeding power or capacity of the quahaug, and the absence of silt or other material in the water, which would interfere with the mechanical feeding process of the animal. In a similar way, current aids shell formation by increasing the supply of available lime salts.

(2) Intimately associated with its value as a food carrier is the no less important service of affording a good supply of oxygen. The quahaug, like man, needs a definite amount of oxygen to perform the normal functions of life, — to transform food into body tissues and energy. Current supplies fresh oxygen, and a quahaug with a good circulation of water is able to assimilate more food and grow faster than one in the still water.

(3) The work of sanitary agent is performed by carrying away all products of decomposition, thus preventing contamination in thickly planted beds.

From the standpoint of the culturist, circulation of water is most important, and in choosing a grant selection should be based upon the current. Nearly all our growth experiments, directly or indirectly, indicate its value. A few cases are cited to show the direct experimental relation between current and growth.

A comparison of the growth in sand boxes at Monomoy Point was made in three parts of the Powder Hole: (*a*) the raft, which had a good circulation, gave an annual gain of 24.5 millimeters (612 per cent. gain in volume); (*b*) the south side, in front of the laboratory, where there was only a slight flow of water with the rise and fall of the tide, gave a gain of 16.18 millimeters (305 per cent. gain in volume); (*c*) the east side, where eelgrass cut off practically all circulation, showed a gain of 13.62 millimeters (241 per cent. gain in volume).

Wire mosquito netting was placed over part of the jars in which small quahaugs were suspended from the raft. A month later the quahaugs in the jars without netting showed a gain of 3.4 millimeters, compared with 1.21 millimeters for the netting jars, illustrating the effect on growth by restricting the circulation.

The channel connecting the Powder Hole and the ocean became blocked during the summer of 1908, with the result that there was a stagnation of water in the Powder Hole during part of the growing months. The shore beds showed a slow growth of 10.01 millimeters in 1908, as compared with 13.27 millimeters in 1907 and 17.43 millimeters in 1909.

In our experiments in Wellfleet Bay the greatest growth occurred in Herring River, Blackfish Creek and on Egg Island, which get both the backward and forward sweep of the tide. The various local groups of beds are here arranged in order of rapidity of growth: —

	Per Cent.		Per Cent.
Herring River,	100	West of Lieutenant's Island,	52
Egg Island,	75	Blackfish Creek (north side),	51
Blackfish Creek (south side),	72	Sow Rock bar,	33
Indian Neck,	68	South of Lieutenant's Island,	15
The Meadows,	55	East side of Great Island,	9

Tide. — Quahaugs are found between the tide lines, but in less abundance than beneath low-water mark, their natural habitat. This circumstance may be the result of exposure to severe winters, since the quahaug lies near the surface of the soil and not at a depth, as the soft clam. The principal effect of exposure, as demonstrated by experimental beds between the tide lines at Plymouth and Wellfleet, is the retardation in growth from loss of feeding time. The quahaug can feed only when covered with water, and exposure from four to twelve hours daily materially lessens the amount of food consumed, assuming that the quahaug feeds continually when under water. Experiments have demonstrated that the longer the exposure, the slower the growth. Eighty experimental beds between the tide lines at Wellfleet were classified as low, medium and high, according to the length of exposure (Fig. 36). The low beds, 32 in number, having a better circulation and longer feeding period, gave an annual growth of 12.5 millimeters (.49 of an inch); the 27 medium gave 7.82 millimeters (.31 of an inch); and the 21 high beds showed a gain of 7.17 millimeters (.28 of an inch). Considering the growth of the low beds as 100 per cent., the medium would show 61.53 per cent. and the high 57.39 per cent. While this evidence is open to the criticism that the faster growth of the low beds was due to a better circulation of water, it is confirmed by an experiment at Monomoy Point, where the annual growth was 24.02 millimeters in the raft boxes, as compared with 7.63 millimeters on the near-by clam flat under the same conditions, except for the exposure of the flat.

Planting between the tide lines entails considerable loss. Only 84 out of 154 beds were recovered at Wellfleet, over 50 of the remaining 70 having been washed away, buried or destroyed by cockles, the greatest loss occurring in the exposed portions of the bay, especially near Lieutenant's Island. After three months only 42 per cent. of the planted quahaugs were found in the 84 good beds. Life between the tide lines is a difficult existence for the quahaug, especially for the smaller animal, which is forced to maintain a continual struggle against adverse conditions.

Depth. — The depth of water over the grant is of practical interest to the culturist, who desires rapid growth and at the same time easy facilities for harvesting. Owing to the better circulation of water, the average growth in the deep water will exceed that in the shallow; but in localities where the current is approximately the same, any depth beyond 3 feet at low tide (for protection during the winter) gives no increased growth and affords a distinct disadvantage to the planter in taking up his crop. The quahaug appears to live equally well at any depth, and is occasionally raked in 50 feet of water on the north side of Cape Cod.

The relation of depth to growth could not be experimentally determined on a large scale owing to the cost and difficulty of planting in deep water. A few observations regarding the rate of growth at various depths were made from the raft at Monomoy Point, but these apply more to the study of circulating layers of water in the Powder Hole. In 1909, in 18 feet of water, boxes containing quahaugs of the same size were suspended from the raft at 5, 10 and 15 feet. The gain in these boxes in terms of the standard for four and one-half months was 536 per cent., 554 per cent. and 438 per cent., respectively. The maximum growth occurred between 5 and 10 feet, and is intimately associated with the circulation in the Powder Hole, only the upper layer of water, above 10 feet, being disturbed by the inflowing tide.

Soil. — The quahaug is found in nearly every kind of soil, — gravel, sand and mud all seem alike to this mollusk. It is found in hard soil, into which it is difficult to force a rake, and in soft mud, where the gatherer sinks ankle deep. The best soil, if such can be designated, is a mixture of sand and mud, sufficiently loose to permit easy raking. The important consideration is the effect of the various soils on the growth and condition of the quahaug, rather than whether the animal can live. Organic acids in certain soils affect the composition of the shell, and through their irritating influence retard the growth by increasing the repairing processes. The kind of soil also affects the composition and shape of the shell, coarse, gravelly soil, especially in the case of the soft clam, giving a heavy, rough shell, in contrast to the thin paper-shell variety of the fine sand clam. In one instance quahaugs on a soft mud bottom had developed an elongate shell. In general, the soil has little influence upon the growth of the quahaug, and acts only as a resting place. The popular idea that the quahaug procures its nourishment from the soil, like a vegetable, is entirely erroneous, as the animal obtains its food from the water. The nature of the soil indirectly modifies the food supply, as certain soils are more prolific breeding grounds of the microscopic forms which make up the food of the quahaug.

(1) *Growth in Wire Cages.* — Kellogg (2) first described the growth of quahaugs in wire racks out of sand. Our experiments along this line were made with the view of developing a method of keeping quahaugs for the market without bedding in the sand. Wire cages, 1½ by 1 by ¼ feet, of ¼ to 1¼ inch mesh, were suspended in 1906 and 1907 from the raft at Monomoy Point. The annual growth was 12.87 millimeters, as compared with 23.53 millimeters for quahaugs in the sand boxes under the same conditions. A greater difference was found in 1909 with larger quahaugs (69 millimeters), which showed one-fourth the gain of the quahaugs in the sand boxes. The slower growth in the wire cages was due to the unnatural environment, which interfered with the natural feeding habits, and to the encrusting of the shells with barnacles, Serpula, Anomia, Crepidula and oysters, which use the same food. The experiment demonstrates that soil has little effect on shell formation, the quahaug obtaining its food and mineral salts from the water; and that quahaug culture in wire cages is impracticable, because it yields poor returns and is an expensive method of holding the catch for market.

(2) *Mud v. Sand.* — A comparison of the growth in mud and sand under similar conditions was made at Monomoy Point by suspending quahaugs of the same size from the raft in two boxes, one containing a sticky, black mud, the other clean, coarse sand. The increase in volume for the mud was 342 per cent. and 424 per cent. for the sand, which shows that the actual type of soil is of little consequence.

(3) *Eelgrass.* — The soil exerts an indirect influence on growth by the abundance or scarcity of eelgrass, which if thick prevents the free circulation of water over the bed. In addition to the examples cited under "Current," a comparison of experiments Nos. 186 and 187 on Egobert's Flat, Plymouth harbor, gives an annual growth of 11.73 millimeters for the clear and 7.43 millimeters for the eelgrass, although both beds were near together. The presence of eelgrass is not necessarily an indication of slow growth, as it only becomes a detriment when thick enough to interfere with the circulation.

Salinity. — The amount of salts in solution, although it may influence the spawning, does not materially affect the growth of the quahaug. Experimental beds, located in densities from 1.009 (less than one-half the ordinary salt content) to 1.026 (fairly high salt content), have shown no appreciable effects. In the laboratory, quahaugs have been kept alive in tanks in which the water, by evaporation, reached a salinity of 1.035. They have also been found in rivers with a daily variation in density from 1.015 to 1.022. Salinity, however, indirectly affects growth by modifying the food supply, brackish waters being more productive of diatoms.

Dwarf Quahaugs. — Quahaugs, like the higher animals, vary in their individual growth. Occasionally a specimen exhibits a consistently slow growth, either from an unfavorable position or from impaired feeding power. In case of defective nutrition shell formation will be slow for a number of years, and even for life. In one experimental bed a dwarf quahaug showed an annual growth of 6 millimeters, compared with an average of 9.35 millimeters in 1907; 4 millimeters, with 8.33 millimeters in 1908; and 5 millimeters, with 7.83 millimeters in 1909, which was less than two-thirds its normal growth.

Growth under Adverse Conditions. — In localities where conditions are at all unfavorable, 30 to 40 millimeter quahaugs grow more rapidly than smaller sizes, in direct contrast to growth under favorable conditions, where the 15-millimeter quahaug exhibits the greatest growing power. In the shore beds at Monomoy Point, where the environment proved a hindrance to rapid growth, 1,700 measurements gave a gain of 3.93 millimeters for quahaugs between 24 and 30 millimeters, compared with 4.93 millimeters for quahaugs between 30 and 40 millimeters. This difference is best explained by the ability of the larger quahaugs to combat the adverse conditions.

Growth in Thickly Planted Beds. — Nature regulates thick sets of clams or quahaugs by the simple process of gradually forcing out the superfluous shellfish, and leaving only the maximum number per square foot that the soil will support. If the bed has a poor circulation of water an overpopulation may cause an insufficient food supply and slower growth than if less thickly planted. The number per square foot which will give the best growth in any locality can be determined only by experiment, the planter gradually increasing his stock until the maximum production is reached. In the boxes at Monomoy Point various numbers of 1½-inch quahaugs, from 7 to 90 per square foot, gave uniform results. The box containing 90 to the square foot, which was so crowded that several were forced out of the sand, showed about two-thirds the growth of the others. This experiment only illustrates the effect of crowding, and has no practical bearing on the maximum production of a large grant, which is entirely a question of the food supply.

Transplanting. — Transplanted quahaugs do not at first exhibit their usual rate of growth, as they take some time to become accustomed to their new environment. In planting between the tide lines at Wellfleet, where the quahaugs are exposed to the action of the waves and shifting sand, a sufficient time, about one month, is necessary for the regulation of the feeding habits. This fact should be borne in mind in determining the growth for any locality, as described under "Tables," and no less than two months be taken for the test. It is an advantage to plant in April, which affords an opportunity for the quahaugs to become accustomed to their surroundings before growth begins, May 1. The period of acclimatization is an extremely variable factor, depending on the size of the quahaugs, the date of planting (the period being longer in the fall), length of time out of water, and the change in environment. The decrease in growth from a complete change in environment and late planting is shown in the wire cages in 1906 and 1907. The quahaugs were placed in their new surroundings Sept. 18, 1906. The calculated rate of growth for 1906, 6.41 millimeters, was only one-half that of 1907, 12.87 millimeters, owing to the subnormal growth during September and October. Similarly, quahaugs transplanted from Nantucket to the raft boxes at Monomoy Point gave a calculated rate of 16.58 millimeters for 1906, as compared with 23.13 millimeters for 1907.

Growth in Boxes. — From a comparison of sand boxes and beds under the same condition it was found that growth was invariably faster in the boxes. The same results had been recorded in clam experiments on the Plymouth flats, where faster growth was obtained in boarded beds raised above the flat. Near Egg Island, Wellfleet, 3 box beds averaged an annual gain of 29.12 millimeters, compared with 12.06 millimeters for 13 ordinary beds. The idea that drainage was the cause was disproved by similar results being obtained below low-water mark at Monomoy Point. Boxes with sides of different heights were tried, to determine if these in some way aided the feeding, and boxes large and small, without sides, with and without bottoms, were used, but no appreciable difference was found; yet in every case growth was faster in the boxes than in the control beds. Also, the distance from the bottom, as demonstrated by a series of boxes arranged in the form of steps, made no difference. An explanation, which in part accounted for this curious result, arose from the situation of these beds. In all cases the beds at certain times were exposed to wave action, which caused a slight shifting of sand, presumably enough to interfere with the feeding. The quahaugs in the boxes were protected from this action and were given better opportunity for feeding.

TABLES.

The following tables, which were formulated during the investigation, are presented for the use of the quahaug culturist in determining the productivity of new ground. The last, Table V, gives the summarized results from 187 experimental beds.

The method of procedure in determining the growth on a prospective grant for a series of years by means of these tables is as follows: —

(1) The culturist must obtain the growth for a definite period of not less than two months by planting a small experimental bed with quahaugs of a known size. The simplest way is to notch the edges with a file and the new growth can readily be measured when the quahaugs are taken up. The reasons for having the growing period no less than two summer months is due to the slow growth immediately after transplanting, as described under "Transplanting." The planter then has at hand the following data: (1) size planted; (2) gain in length for a certain known time, *i.e.*, 40-millimeter quahaugs grew to 48.92 millimeters, a gain of 8.92 millimeters from July 1 to September 1.

(2) By means of Table I. (monthly values) we find that the growth during July and August is 44.58 per cent. of the total yearly growth, which is therefore 20 millimeters.

(3) Table II. reduces the gain of a 40-millimeter quahaug to that of a 25-millimeter, which is used as a uniform standard in the experiments of this department, by multiplying with the factor 1.353, and in this example the result will be 27.06 millimeters.

(4) By Table III. the gain in volume is obtained by dividing the water displacement or number per quart of a 52.06-millimeter quahaug by that of a 25-millimeter, which gives 709 per cent., or 8 quarts for every quart planted.

(5) By Table IV. the growth on the grant can be calculated to five and one-half years. In the case of a gain of 20 millimeters for a 25-millimeter quahaug, the figures would read ½ year 5 millimeters; 1½, 28.30 millimeters; 2½, 46.98 millimeters; 3½, 59.85 millimeters; 4½, 69.46 millimeters; 5½, 76.64 millimeters (25.4 millimeters equal 1 inch).

Value of the Different Months. — The quahaug only increases the size of the shell during the summer months, and at a variable rate, the months of August and September showing the fastest growth. The table is taken from the monthly measurements of quahaugs from the raft boxes and beds at Monomoy Point, and the value of the various months is presented in terms of the gain for a standard quahaug of 25 millimeters. Each month is given a number representing the gain in per cent., the entire year being considered as 100 per cent.

Table I.

Month.	Per Cent.	Month.	Per Cent.
January,	-	August,	25.56
February,	-	September,	26.24
March,	-	October,	12.85
April,	-	November,	1.74
May,	3.78	December,	-
June,	10.81		100.00
July,	19.02		

Size and Growth. — In recording the growth of a large number of various sized quahaugs under the same conditions in the raft boxes at Monomoy Point sufficient data were obtained to formulate a table giving the comparative annual increase in length for quahaugs from 1 to 100 millimeters in size. If, for example, a 25-millimeter quahaug, which is taken as a standard size in our experiments, gained 23 millimeters, a 50-millimeter quahaug would gain 13.9 millimeters, and a 75-millimeter quahaug 6.6 millimeters in the same time. From these measurements factors were obtained which by multiplication would transform the growth of any sized quahaug into terms of the standard 25-millimeter quahaug. This table was of great assistance in reducing the experimental data to uniform figures when it was impossible to obtain the standard size for planting.

According to the table the size of 14 millimeters gives the best growth, all larger sizes gradually decreasing. Theoretically, as shown in the table, the sizes below 14 millimeters reversely exhibit slower growth, but practically this is somewhat offset by the increase in velocity, as the quahaug grows toward 14 millimeters in size, *i.e.*, a 5-millimeter quahaug practically would gain 26.80 millimeters, although theoretically its initial growing power would only be 20.02 millimeters at the same rate according to the table.

Table II.

Size in Millimeters.	Factor.	Size in Millimeters.	Factor.	Size in Millimeters.	Factor.
1,	2.875	35,	1.223	69,	2.738
2,	1.840	36,	1.243	70,	2.840
3,	1.474	37,	1.271	71,	2.949
4,	1.278	38,	1.299	72,	3.067
5,	1.139	39,	1.329	73,	3.194
6,	1.046	40,	1.353	74,	3.333
7,	.979	41,	1.377	75,	3.485
8,	.931	42,	1.411	76,	3.651
9,	.895	43,	1.438	77,	3.833
10,	.868	44,	1.465	78,	4.035
11,	.849	45,	1.494	79,	4.259
12,	.836	46,	1.523	80,	4.510
13,	.830	47,	1.554	81,	4.792
14,	.830	48,	1.586	82,	5.055
15,	.833	49,	1.620	83,	5.349
16,	.849	50,	1.655	84,	5.679
17,	.865	51,	1.691	85,	6.053
18,	.881	52,	1.729	86,	6.479
19,	.895	53,	1.769	87,	6.970
20,	.913	54,	1.804	88,	7.541
21,	.927	55,	1.840	89,	8.215
22,	.947	56,	1.886	90,	9.200
23,	.962	57,	1.933	91,	10.000
24,	.979	58,	1.983	92,	10.952
25,	1.000	59,	2.035	93,	12.105
26,	1.022	60,	2.091	94,	13.143
27,	1.046	61,	2.140	95,	14.839
28,	1.065	62,	2.191	96,	16.788
29,	1.085	63,	2.289	97,	17.500
30,	1.106	64,	2.347	98,	23.000
31,	1.127	65,	2.421	99,	28.750
32,	1.150	66,	2.500	100,	38.333
33,	1.174	67,	2.570		
34,	1.198	68,	2.644		

Size and Volume. — The mere statement of the gain in length does not adequately express the actual increase, which should be stated in terms of volume. The tight shell of the quahaug makes easy the exact determination of the volume by water displacement. A quahaug 25 millimeters (about 1 inch in length) displaces 3 cubic centimeters of water, while 51 millimeters (about 2 inches in length) is not merely twice as large, as the measurements indicate, but, displacing 22.8 cubic centimeters, has a volume of 7.6 times the first, a true index of the actual increase. In preparing the following table the water displacements of a large number of quahaugs from 1 to 88 millimeters were taken. Owing to the variation in the individual quahaugs, several hundred were used to obtain the displacement for each size, except in the cases of the quahaugs below 10 millimeters, which were difficult to obtain. From this table the gain in volume for any size and growth can be readily determined.

Table III.

Size in Millimeters.	Volume in Cubic Centimeters.	Number per Quart.	Size in Millimeters.	Volume in Cubic Centimeters.	Number per Quart.
1,	.007	100,714	25,	3.000	235
2,	.013	54,231	26,	3.400	207
3,	.021	33,572	27,	3.820	185
4,	.032	22,031	28,	4.250	166
5,	.043	16,396	29,	4.700	150
6,	.056	12,589	30,	5.170	136
7,	.072	9,790	31,	5.670	124
8,	.091	7,747	32,	6.180	114
9,	.133	5,299	33,	6.700	105
10,	.191	3,691	34,	7.250	97.25
11,	.255	2,764	35,	7.800	90.35
12,	.313	2,252	36,	8.400	83.92
13,	.393	1,794	37,	9.050	77.90
14,	.490	1,439	38,	9.750	72.31
15,	.600	1,175	39,	10.500	67.14
16,	.718	982	40,	11.300	62.39
17,	.848	831	41,	12.000	58.75
18,	.998	706	42,	12.900	54.65
19,	1.210	583	43,	13.800	51.09
20,	1.440	489	44,	14.800	47.63
21,	1.680	420	45,	15.800	44.64
22,	1.970	358	46,	16.900	41.72
23,	2.270	310	47,	18.000	39.17
24,	2.600	271	48,	19.000	37.11

Table III. — Concluded.

Size in Millimeters.	Volume in Cubic Centimeters.	Number per Quart.	Size in Millimeters.	Volume in Cubic Centimeters.	Number per Quart.
49,	20.200	34.90	69,	55.200	12.77
50,	21.500	32.79	70,	57.700	12.22
51,	22.800	30.92	71,	60.100	11.73
52,	24.200	29.13	72,	63.000	11.19
53,	25.600	27.54	73,	65.700	10.73
54,	26.900	26.21	74,	68.400	10.31
55,	28.300	24.91	75,	71.100	9.92
56,	29.800	23.66	76,	74.200	9.50
57,	31.300	22.53	77,	77.300	9.12
58,	33.000	21.36	78,	80.400	8.77
59,	34.600	20.38	79,	83.900	8.40
60,	36.300	19.42	80,	87.300	8.08
61,	38.200	18.46	81,	90.900	7.76
62,	40.300	17.49	82,	95.000	7.42
63,	42.400	16.63	83,	99.500	7.09
64,	44.500	15.84	84,	104.200	6.77
65,	46.600	15.13	85,	109.000	6.47
66,	48.700	14.48	86,	114.000	6.18
67,	50.900	13.85	87,	118.700	5.94
68,	53.000	13.30	88,	123.000	5.73

Standard Growth. — The growth in millimeters up to five and one-half years is given for various annual rates of growth, from 1 to 30 millimeters, of a standard 25-millimeter quahaug. Knowing the annual growth for a 25-millimeter quahaug, the reader can determine the size at any period up to five and one-half years by referring to the other columns.

Table IV.

Annual Rates in Millimeters for a 25-Millimeter Quahaug.	Size in Millimeters at Various Ages.					
	½ Year.	1½ Years.	2½ Years.	3½ Years.	4½ Years.	5½ Years.
1,	5	5.89	6.84	7.85	8.92	10.03
2,	5	6.93	9.01	11.29	13.67	16.08
3,	5	8.13	11.49	15.08	18.68	22.05
4,	5	9.19	13.68	18.50	23.00	27.16

Table IV. — Concluded.

Annual Rates in Millimeters for a 25-Millimeter Quahaug.	Size in Millimeters at Various Ages.					
	½ Year.	1½ Years.	2½ Years.	3½ Years.	4½ Years.	5½ Years.
5, ...	5	10.39	16.34	22.21	27.47	32.21
6, ...	5	11.63	18.86	25.57	31.50	36.78
7, ...	5	12.90	21.33	28.78	35.26	40.96
8, ...	5	14.19	23.83	32.03	38.98	45.00
9, ...	5	15.48	26.19	34.96	42.32	48.66
10, ...	5	16.65	28.29	37.63	45.39	52.03
11, ...	5	17.82	30.35	40.23	48.32	55.20
12, ...	5	18.98	32.39	42.74	51.13	58.20
13, ...	5	20.14	34.35	45.11	53.80	61.03
14, ...	5	21.31	36.31	47.49	56.41	63.75
15, ...	5	22.48	38.19	49.68	58.80	66.21
16, ...	5	23.64	40.08	51.88	61.17	68.62
17, ...	5	24.81	41.88	54.07	63.47	70.81
18, ...	5	25.97	43.59	55.97	65.52	72.83
19, ...	5	27.14	45.27	57.92	67.52	74.80
20, ...	5	28.30	46.98	59.85	69.46	76.64
21, ...	5	29.47	48.65	61.76	71.40	78.41
22, ...	5	30.64	50.29	63.50	72.99	79.88
23, ...	5	31.80	51.88	65.22	74.44	81.21
24, ...	5	32.97	53.43	66.81	76.20	82.71
25, ...	5	34.13	54.94	68.54	77.81	84.07
26, ...	5	35.30	56.45	70.08	79.22	85.25
27, ...	5	36.46	57.95	71.58	80.52	86.31
28, ...	5	37.63	59.36	72.98	81.75	87.36
29, ...	5	38.79	60.72	74.36	82.92	88.40
30, ...	5	39.96	62.15	75.75	84.06	89.32

The Experimental Beds. — This table gives a summary of the experiments of this department. The current is represented by numbers from 1 to 5, according to its velocity, 1 indicating still water and 5 a rapid flow. The average annual growth and increase in volume is given in terms of a 25-millimeter quahaug, which has been taken as an arbitrary standard for the sake of comparison. The size, in terms of the length, at various ages is given in yearly intervals from one-half to five and one-half years, starting with the average length of 5 millimeters.

Table V.

No. of Experiment	Location.	Current.	Soil.	Depth of Water in Feet at Low Tide.	Salinity.	Annual Growth in Millimeters.	Gain Per Cent. in Volume.	Size in Millimeters at Various Ages.						Remarks.
								½ Yr.	1½ Yrs.	2½ Yrs.	3½ Yrs.	4½ Yrs.	5½ Yrs.	
1	Nantucket, Polyps harbor,	2	Compact mud, .	.3	1.009	8.48	132	5	14.81	24.96	33.44	40.58	46.76	
2	Monument Beach, . .	2	Mud, . .	2.0	1.022	10.15	163	5	16.83	28.75	38.15	45.93	52.59	
3	Monomoy, east side of Powder Hole.	1	Coarse sand, .	2.5	1.022	8.91	140	5	15.36	25.98	34.70	42.02	48.33	Bed near shore.
4	Monomoy, south side of Powder Hole.	2	Coarse sand, .	2.5	1.022	10.27	165	5	16.97	28.85	38.33	46.18	52.89	Bed near shore.
5	Monomoy, south side of Powder Hole.	2	Coarse sand, .	2.5	1.022	13.37	234	5	20.57	35.08	45.99	54.77	61.94	Bed near shore.
6	Monomoy, south side of Powder Hole.	2	Coarse sand, .	2.5	1.022	12.81	221	5	19.92	33.98	44.66	53.29	60.49	Bed near shore.
7	Monomoy, south side of Powder Hole.	2	Coarse sand, .	2.0	1.022	12.09	204	5	19.08	32.57	42.95	51.37	58.46	Bed near shore.
8	Monomoy, east side of Powder Hole.	2	Coarse sand, .	2.0	1.022	9.53	151	5	16.10	27.30	36.38	43.95	50.45	Bed near shore.
9	Monomoy, flat, . . .	2	Coarse sand, .	Exposed.	1.024	4.78	69	5	10.13	15.75	21.39	26.49	31.10	Shifting sand.
10	Monomoy, raft, . . .	4	Coarse sand, .	5.0	1.024	18.87	389	5	26.99	45.05	57.67	67.36	74.54	Sand box.
11	Monomoy, raft, . . .	4	Coarse sand, .	4.5	1.024	23.07	536	5	31.88	51.99	65.33	74.56	81.32	Sand box.
12	Monomoy, raft, . . .	4	Coarse sand, .	6.5	1.024	22.30	510	5	30.98	50.77	64.02	73.48	80.28	Sand box.
13	Monomoy, raft, . . .	4	Coarse sand, .	5.5	1.024	27.58	734	5	37.14	58.77	72.39	81.33	86.92	Sand box.
14	Monomoy, raft, . . .	4	Coarse sand, .	5.5	1.024	25.50	638	5	34.72	55.70	69.31	78.52	84.66	Sand box.
15	Monomoy, raft, . . .	4	Coarse sand, .	5.5	1.024	21.68	488	5	30.27	49.77	62.94	72.48	79.41	Sand box.
16	Monomoy, raft, . . .	4	Coarse sand, .	4.0	1.024	21.40	478	5	29.93	49.31	62.46	72.04	79.00	Sand box.
17	Monomoy, raft, . . .	4	Coarse sand, .	4.5	1.024	25.12	622	5	34.27	55.12	68.72	77.98	84.21	Sand box.
18	Monomoy, raft, . . .	4	Coarse sand, .	5.0	1.024	24.73	605	5	33.82	54.53	68.07	77.38	83.70	Sand box.

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19	Monomoy, raft, . . .	4	Coarse sand, .	3.5	1.024	25.00	617	5	34.13	54.94	68.54	77.81	84.07	Sand box.
20	Monomoy, raft, . . .	4	Coarse sand, .	5.0	1.024	20.37	440	5	28.73	47.60	60.56	70.18	77.29	Sand box.
21	Monomoy, raft, . . .	4	Coarse sand, .	4.5	1.024	25.08	620	5	34.22	55.06	68.66	77.92	84.16	Sand box.
22	Monomoy, middle of Powder Hole.	3	Coarse sand, .	11.0	1.024	13.98	250	5	21.29	36.27	47.45	56.36	63.70	Sand box.
23	Monomoy, raft, . . .	4	Coarse sand, .	4.0	1.024	26.09	664	5	35.40	56.59	70.22	79.34	85.35	Sand box.
24	Monomoy, south side of Powder Hole.	2	Coarse sand, .	.5	1.022	17.42	343	5	25.30	42.60	54.87	64.33	71.66	Sand box.
25	Monomoy, south side of Powder Hole.	2	Coarse sand, .	.5	1.022	14.26	257	5	21.61	36.80	48.06	57.05	64.40	Sand box.
26	Monomoy, raft, . .	4	Coarse sand, .	5.0	1.024	25.11	621	5	34.26	55.11	68.71	77.97	84.20	Sand box.
27	Monomoy, raft, . .	4	Coarse sand, .	9.0	1.024	21.81	493	5	30.42	49.98	63.17	72.68	79.60	Sand box.
28	Monomoy, raft, . .	4	Coarse sand, .	8.0	1.024	21.23	472	5	29.74	49.03	62.16	71.77	78.75	Sand box.
29	Monomoy, raft, . .	4	Coarse sand, .	11.0	1.024	24.31	587	5	33.33	53.90	67.35	76.70	83.13	Sand box.
30	Monomoy, raft, . .	4	Coarse sand, .	3.0	1.024	24.18	581	5	33.18	53.70	67.12	76.49	82.95	Sand box.
31	Monomoy, raft, . .	4	Coarse sand, .	8.0	1.024	24.66	602	5	33.74	54.43	67.95	77.26	83.61	Sand box.
32	Monomoy, middle of Powder Hole.	3	Coarse sand, .	11.0	1.024	14.78	271	5	22.21	37.77	49.19	58.27	65.70	Sand box.
33	Monomoy, raft, . .	4	Coarse sand, .	7.0	1.024	21.91	497	5	30.53	50.14	63.34	72.85	79.75	Sand box.
34	Monomoy, raft, . .	4	Coarse sand, .	3.5	1.024	21.41	478	5	29.95	49.32	62.47	72.05	79.01	Sand box.
35	Monomoy, edge of clam flat,	4	Coarse sand, .	1.0	1.024	19.76	419	5	28.02	46.57	59.39	68.99	76.20	Sand box.
36	Monomoy, raft, . .	4	Coarse sand, .	2.0	1.024	14.13	253	5	21.46	36.55	47.82	56.74	64.07	Sand box, planted late in the season.
37a	Monomoy, south side of Powder Hole.	2	Coarse sand, .	.8	1.022	7.51	115	5	13.55	22.61	30.44	37.16	43.02	Sand box.
37b	Monomoy, south side of Powder Hole.	2	Coarse sand, .	1.0	1.022	9.22	145	5	15.86	26.86	35.81	43.30	49.74	Sand box.
37c	Monomoy, south side of Powder Hole.	2	Coarse sand, .	1.3	1.022	1.14	15	5	6.04	7.14	8.33	9.59	10.88	
38a	Monomoy, south side of Powder Hole.	2	Coarse sand, .	1.0	1.022	7.31	111	5	13.30	22.11	29.79	36.41	42.21	Sand box.

Table V. — Continued.

No. of Experiment.	Location.	Current.	Soil.	Depth of Water in Feet at Low Tide.	Salinity.	Annual Growth in Millimeters.	Gain Per Cent. in Volume.	Size in Millimeters at Various Ages.						Remarks.
								½ Yr.	1½ Yrs.	2½ Yrs.	3½ Yrs.	4½ Yrs.	5½ Yrs.	
38b	Monomoy, south side of Powder Hole.	2	Coarse sand, .	1.0	1.022	6.58	99	5	12.37	20.29	27.43	33.68	39.20	Sand box.
38c	Monomoy, south side of Powder Hole.	2	Coarse sand, .	1.0	1.022	7.80	120	5	13.93	23.33	31.38	38.24	44.19	Sand box.
38d	Monomoy, south side of Powder Hole.	2	Coarse sand, .	1.0	1.022	7.20	109	5	13.16	21.83	29.43	36.00	41.77	Sand box.
39a	Monomoy, raft, . .	4	Coarse sand, .	7.0	1.024	11.03	181	5	17.85	30.41	40.31	48.41	55.29	Sand box, covered.
39b	Monomoy, raft, . .	4	Coarse sand, .	7.0	1.024	13.16	229	5	20.32	34.67	45.49	54.22	61.47	Sand box, uncovered.
40a	Monomoy, raft, . .	4	Coarse sand, .	6.0	1.024	22.07	502	5	30.72	50.40	63.62	73.09	79.97	Sand box, 90 quahaugs per square foot.
40b	Monomoy, raft, . .	4	Coarse sand, .	6.0	1.024	23.44	551	5	32.31	52.56	65.93	75.21	81.87	Sand box, 60 quahaugs per square foot.
40c	Monomoy, raft, . .	4	Coarse sand, .	6.0	1.024	25.01	617	5	34.14	54.96	68.56	77.82	84.08	Sand box, 45 quahaugs per square foot.
40d	Monomoy, raft, . .	4	Coarse sand, .	6.0	1.024	25.16	624	5	34.32	55.16	68.79	78.04	84.26	Sand box, 22 quahaugs per square foot.
40e	Monomoy, raft, . .	4	Coarse sand, .	6.0	1.024	21.10	467	5	29.59	48.81	61.93	71.56	78.56	Sand box, 7 quahaugs per square foot.
41a	Monomoy, south side of Powder Hole.	2	Coarse sand, .	1.0	1.022	7.73	119	5	13.84	23.15	31.15	37.98	43.91	Sand box, 60 quahaugs per square foot.
41b	Monomoy, south side of Powder Hole.	2	Coarse sand, .	1.0	1.022	10.08	162	5	16.74	28.45	37.83	45.62	52.28	Sand box, 43 quahaugs per square foot.
41c	Monomoy, south side of Powder Hole.	2	Coarse sand, .	1.0	1.022	8.38	130	5	14.68	24.73	33.14	40.25	46.39	Sand box, 22 quahaugs per square foot.
41d	Monomoy, south side of Powder Hole.	2	Coarse sand, .	1.0	1.022	6.08	90	5	11.73	19.06	25.83	31.80	37.11	Sand box, 7 quahaugs per square foot.
42	Monomoy, clam flat, .	4	Coarse sand, .	Exposed.	1.024	11.71	19	5	18.64	31.80	42.01	50.32	57.33	
43	Monomoy, clam flat, .	4	Coarse sand, .	Exposed.	1.024	6.39	96	5	12.13	19.82	26.82	32.97	38.41	
44	Monomoy, edge of clam flat,	4	Coarse sand, .	1.0	1.024	21.28	474	5	20.80	40.11	62.24	71.85	78.82	Sand box.
45	Monomoy, raft, . .	4	Coarse sand, .	5.0	1.024	23.45	551	5	32.33	52.58	66.04	75.28	81.89	Sand box.

46	Monomoy, raft, . .	4	Coarse sand, .	5.0	1.024	9.10	143	5	15.50	26.40	35.23	42.63	49.00	Wire cage.
47	Monomoy, raft, . .	4	Coarse sand, .	6.5	1.024	10.74	175	5	17.52	29.81	39.55	47.56	54.38	Wire cage.
48	Monomoy, raft, . .	4	Coarse sand, .	5.0	1.024	8.29	129	5	14.56	24.51	32.88	39.95	46.06	Wire cage.
49	Monomoy, south side of Powder Hole.	2	Coarse sand, .	.8	1.022	12.47	213	5	19.53	33.81	43.85	52.38	59.53	Sand box.
50a	Monomoy, raft, . .	4	Coarse sand, .	5.0	1.024	21.57	484	5	30.14	49.58	62.75	72.31	79.25	Sand box.
50b	Monomoy, east side of Powder Hole.	1	Coarse sand, .	2.0	1.022	9.87	158	5	16.50	28.02	37.28	44.99	51.59	Sand box.
50c	Monomoy, east side of Powder Hole.	1	Coarse sand, .	2.5	1.022	8.91	140	5	15.36	25.98	34.70	42.02	48.83	
51	Monomoy, south side of Powder Hole.	2	Coarse sand, .	1.0	1.022	19.13	397	5	27.29	45.96	58.52	68.05	75.82	Sand box.
52	Monomoy, south side of Powder Hole.	2	Coarse sand, .	1.0	1.022	21.16	469	5	29.66	48.91	62.04	71.65	78.65	Sand box.
53	Monomoy, south side of Powder Hole.	2	Coarse sand, .	1.0	1.022	19.91	424	5	28.20	46.83	59.68	69.29	76.47	Sand box.
54	Monomoy, south side of Powder Hole.	2	Coarse sand, .	1.0	1.022	17.91	357	5	25.87	43.44	55.80	65.34	72.65	Sand box.
55	Monomoy, south side of Powder Hole.	2	Coarse sand, .	2.0	1.022	18.42	374	5	26.46	44.30	56.79	66.36	73.66	
56	Monomoy, south side of Powder Hole.	2	Coarse sand, .	1.5	1.022	17.11	333	5	24.94	42.07	54.28	63.60	71.08	Sand box.
57	Monomoy, south side of Powder Hole.	2	Coarse sand, .	1.5	1.022	16.55	317	5	24.18	41.07	53.08	62.44	69.82	Sand box.
58	Monomoy, south side of Powder Hole.	2	Coarse sand, .	1.5	1.022	16.25	308	5	23.93	40.53	52.43	61.75	69.17	Sand box.
59	Monomoy, south side of Powder Hole.	2	Coarse sand, .	1.5	1.022	19.03	394	5	27.17	45.32	57.98	67.58	74.85	Sand box.
60	Monomoy, south side of Powder Hole.	2	Coarse sand, .	1.5	1.022	15.56	290	5	23.13	39.25	50.91	60.13	67.56	Sand box.
61	Monomoy, south side of Powder Hole.	2	Coarse sand, .	1.5	1.022	13.45	236	5	20.67	35.25	46.18	54.97	62.25	Sand box.
62	Monomoy, east side of Powder Hole.	1	Coarse sand, .	1.5	1.022	14.07	252	5	21.39	36.44	47.64	56.58	63.92	Sand box.
63	Monomoy, east side of Powder Hole.	1	Coarse sand, .	1.5	1.022	13.23	231	5	20.41	34.81	45.66	54.40	61.65	Sand box.
64	Monomoy, east side of Powder Hole.	1	Coarse sand, .	1.5	1.022	14.85	273	5	22.30	37.91	49.35	58.44	65.84	Sand box.
65	Monomoy, east side of Powder Hole.	1	Coarse sand, .	1.5	1.022	12.11	204	5	19.11	32.62	43.00	51.42	58.51	Sand box.

Table V. — Continued.

No. of Experiment.	Location.	Current.	Soil.	Depth of Water in Feet at Low Tide.	Salinity.	Annual Growth in Millimeters.	Gain Per Cent. in Volume.	Size in Millimeters at Various Ages.						Remarks.
								½ Yr.	1½ Yrs.	2½ Yrs.	3½ Yrs.	4½ Yrs.	5½ Yrs.	
66	Monomoy, east side of Powder Hole.	1	Coarse sand, .	1.5	1.022	12.63	216	5	19.71	33.62	44.23	52.81	59.98	Sand box.
67	Monomoy, edge of clam flat,	4	Coarse sand, .	1.5	1.024	10.95	179	5	17.76	30.25	40.10	48.17	55.04	Sand box.
68	Monomoy, edge of clam flat,	4	Coarse sand, .	1.5	1.024	8.83	139	5	15.26	25.79	34.46	41.75	48.04	Sand box.
69	Monomoy, edge of clam flat,	4	Coarse sand, .	1.5	1.024	11.60	193	5	18.52	31.57	41.74	50.01	57.00	Sand box.
70	Monomoy, edge of clam flat,	4	Coarse sand, .	1.5	1.024	12.61	216	5	19.69	33.59	44.19	52.76	59.93	Sand box.
71	Monomoy, edge of clam flat,	4	Coarse sand, .	1.5	1.024	15.28	283	5	23.78	40.30	52.14	61.44	68.88	Sand box.
72	Monomoy, raft, . .	4	Coarse sand, .	5.0	1.024	27.15	714	5	36.64	58.06	71.79	80.70	86.47	Sand box.
73	Monomoy, raft, . .	4	Coarse sand, .	5.0	1.024	25.66	645	5	34.90	55.14	69.56	78.74	84.85	Sand box.
74	Monomoy, raft, . .	4	Coarse sand, .	5.0	1.024	25.23	627	5	34.40	55.29	68.89	78.13	84.34	Sand box.
75	Monomoy, raft, . .	4	Coarse sand, .	5.0	1.024	25.94	657	5	35.23	56.36	69.99	79.14	85.18	Sand box.
76	Monomoy, raft, . .	4	Coarse sand, .	5.0	1.024	25.99	660	5	35.29	56.43	70.06	79.21	85.24	Sand box.
77	Monomoy, raft, . .	4	Coarse sand, .	5.0	1.024	24.16	580	5	33.16	53.67	67.09	76.46	82.93	Sand box.
78	Monomoy, raft, . .	4	Coarse sand, .	5.0	1.024	25.50	638	5	34.72	55.70	69.31	78.52	84.66	Sand box.
79	Monomoy, raft, . .	4	Coarse sand, .	5.0	1.024	25.68	646	5	34.93	55.97	69.59	78.77	84.87	Sand box.
80	Monomoy, raft, . .	4	Coarse sand, .	6.0	1.024	26.41	634	5	35.78	57.07	70.70	79.75	85.68	Sand box.
81	Monomoy, raft, . .	4	Coarse sand, .	6.0	1.024	26.21	670	5	35.55	56.77	70.40	79.49	85.47	Sand box.
82	Monomoy, raft, . .	4	Coarse sand, .	6.0	1.024	23.33	547	5	32.19	52.40	65.75	75.03	81.71	Sand box.
83	Monomoy, raft, . .	4	Coarse sand, .	6.0	1.024	25.25	628	5	34.43	55.32	68.93	78.17	84.37	Sand box.

84	Monomoy, raft, . .	4	Coarse sand, .	6.0	1.024	24.59	599	5	33.65	54.34	67.83	77.05	83.51	Sand box.
85	Monomoy, raft, . .	4	Coarse sand, .	6.0	1.024	26.12	666	5	35.44	56.63	70.26	79.38	85.38	Sand box.
86	Monomoy, raft, . .	4	Coarse sand, .	6.0	1.024	19.14	398	5	27.30	45.51	58.19	67.79	75.06	Sand box.
87	Monomoy, raft, . .	4	Coarse sand, .	6.0	1.024	20.38	441	5	28.74	47.61	60.58	70.20	77.81	Sand box.
88	Monomoy, raft, . .	4	Coarse sand, .	6.0	1.024	24.74	605	5	33.83	54.57	68.09	77.39	83.72	Sand box.
89	Monomoy, raft, . .	4	Coarse sand, .	6.0	1.024	20.42	442	5	28.79	47.68	60.65	70.27	77.38	Sand box.
90	Monomoy, raft, . .	4	Coarse sand, .	6.0	1.024	25.91	656	5	35.19	56.31	69.94	79.09	85.14	Sand box.
91	Monomoy, raft, . .	4	Coarse sand, .	6.0	1.024	25.80	651	5	35.07	56.15	69.77	78.94	85.01	Sand box.
92	Monomoy, raft, . .	4	Coarse sand, .	6.0	1.024	22.86	529	5	31.64	51.66	64.98	74.24	81.02	Sand box.
93	Monomoy, raft, . .	4	Coarse sand, .	6.0	1.024	21.91	497	5	30.53	50.14	63.34	72.85	79.75	Sand box.
94	Monomoy, raft, . .	4	Coarse sand, .	6.0	1.024	26.12	666	5	35.44	56.63	70.26	79.38	85.38	Sand box.
95	Monomoy, raft, . .	4	Coarse sand, .	15.0	1.024	21.36	477	5	29.89	49.24	62.39	71.98	78.94	Sand box.
96	Monomoy, raft, . .	4	Coarse sand, .	5.0	1.024	25.00	617	5	34.13	54.94	68.54	77.81	84.07	Sand box.
97	Monomoy, raft, . .	4	Coarse sand, .	10.0	1.024	23.76	564	5	32.69	53.06	66.43	75.78	82.35	Sand box.
98	Monomoy, raft, . .	4	Coarse sand, .	5.0	1.024	26.86	700	5	36.31	57.74	71.37	80.34	86.16	Sand box.
99	Monomoy, raft, . .	4	Coarse sand, .	5.0	1.024	26.23	671	5	35.57	56.80	70.43	79.52	85.49	Sand box.
100	Monomoy, raft, . .	4	Coarse sand, .	5.0	1.024	25.84	653	5	35.11	56.21	69.83	78.99	85.06	Sand box.
101	Wellfleet, north of Egg Island.	5	Coarse sand, .	Exposed.	1.024	27.21	716	5	36.71	58.25	71.88	80.78	86.53	Sand box.
102	Wellfleet, north of Egg Island.	5	Sand, . .	Exposed.	1.024	29.47	819	5	39.34	61.39	75.01	83.46	88.83	Sand box.
103	Wellfleet, north of Egg Island.	5	Sand, . .	Exposed.	1.024	31.09	903	5	41.23	63.69	77.08	84.16	89.58	Sand box.
104	Wellfleet, north of Egg Island,	5	Sand, . .	Exposed.	1.024	26.72	694	5	36.14	57.53	71.16	80.16	86.01	Sand box.
105	Wellfleet, north of Indian Neck.	5	Sand, . .	Exposed.	1.024	20.52	446	5	28.91	47.85	60.84	70.47	77.56	

Table V. — Continued.

No. of Experiment.	Location.	Current.	Soil.	Depth of Water in Feet at Low Tide.	Salinity.	Annual Growth in Millimeters.	Gain Per Cent. in Volume.	Size in Millimeters at Various Ages.						Remarks.
								½ Yr.	1½ Yrs.	2½ Yrs.	3½ Yrs.	4½ Yrs.	5½ Yrs.	
106	Wellfleet, north of Indian Neck.	4	Sandy mud, .	Exposed.	1.024	16.50	315	5	24.23	40.98	52.98	62.32	69.72	
107	Wellfleet, north of Indian Neck.	2	Sandy mud, .	Exposed.	1.024	3.88	55	5	9.06	13.42	18.09	22.48	26.55	Bed high, near shore.
108	Wellfleet, south side of Herring River.	5	Sandy mud, .	Exposed.	1.022	21.78	492	5	30.38	49.93	63.12	72.64	79.56	
109	Wellfleet, south side of Herring River.	5	Sandy mud, .	Exposed.	1.022	19.81	420	5	28.08	46.66	59.48	69.09	76.29	
110	Wellfleet, south side of Herring River.	2	Sandy mud, .	Exposed.	1.022	6.06	90	5	11.71	19.01	25.76	31.73	37.03	Bed high, near shore.
111	Wellfleet, south side of Herring River.	5	Sand, . .	Exposed.	1.022	27.92	750	5	37.54	59.25	72.87	81.65	86.28	
112	Wellfleet, south side of Herring River.	1	Soft mud,	Exposed.	1.022	1.83	25	5	6.75	8.64	10.71	12.86	15.05	Mud hole in thatch.
113	Wellfleet, south side of Blackfish Creek.	4	Coarse sand, .	Exposed.	1.024	9.09	144	5	15.59	26.38	35.20	42.60	48.96	
114	Wellfleet, south side of Blackfish Creek.	5	Coarse sand, .	Exposed.	1.024	13.32	233	5	20.51	33.03	45.87	54.64	61.90	
115	Wellfleet, north side of Blackfish Creek.	4	Sand, . .	Exposed.	1.024	8.32	129	5	14.60	24.59	32.97	40.05	46.17	
116	Wellfleet, west of Indian Neck.	4	Sand, . .	Exposed.	1.024	6.63	100	5	12.43	20.42	27.59	33.87	39.41	Exposed longer than No. 117.
117	Wellfleet, west of Indian Neck.	4	Sand, . .	Exposed.	1.024	13.32	233	5	20.51	35.03	45.87	54.64	61.90	
118	Plymouth harbor, Grey's Flat.	4	Mud, . .	Exposed.	1.021	9.07	143	5	15.56	26.34	35.15	42.53	48.90	
119	Wellfleet, west of Indian Neck.	4	Shifting sand, .	Exposed.	1.024	9.52	153	5	16.09	27.28	36.35	43.92	50.41	
120	Wellfleet, west of Indian Neck.	4	Sand, . .	Exposed.	1.024	8.25	128	5	14.51	24.42	32.77	39.82	45.92	Near shore.
121	Wellfleet, west of Indian Neck.	4	Sand, . .	Exposed.	1.024	12.34	210	5	19.37	33.06	43.55	52.04	59.16	
122	Wellfleet, north side of Blackfish Creek.	4	Sand, . .	Exposed.	1.024	10.86	177	5	17.66	30.06	39.87	47.91	54.76	
123	Wellfleet, north side of Blackfish Creek.	4	Sand, . .	Exposed.	1.024	7.97	123	5	14.15	23.75	31.93	38.87	44.88	

124	Wellfleet, north side of Blackfish Creek.	4	Sand, . .	Exposed.	1.024	9.38	150	5	15.92	26.99	35.97	43.49	49.93		
125	Wellfleet, north side of Blackfish Creek.	3	Sand, . .	Exposed.	1.024	3.88	55	5	9.06	13.42	18.09	22.48	26.55		High, near shore.
126	Wellfleet, north side of Blackfish Creek.	4	Sand, . .	Exposed.	1.024	6.49	98	5	12.26	20.07	27.15	33.34	38.83		
127	Wellfleet, north side of Blackfish Creek.	3	Sand, . .	Exposed.	1.024	5.15	75	5	10.58	16.73	22.71	28 07	32.90		
128	Wellfleet, north side of Blackfish Creek.	3	Sand, . .	Exposed.	1.024	2.19	30	5	7.16	9.48	12.01	14.62	17.21		
129	Wellfleet, north side of Blackfish Creek.	4	Sand, . .	Exposed.	1.024	13.18	230	5	20.35	34.71	45.56	56.27	61.53		
130	Wellfleet, west of Indian Neck.	2	Sand, . .	Exposed.	1.024	5.57	82	5	11.10	17.78	24.13	29.77	34.81		High bed.
131	Wellfleet, west of Lieutenant's Island.	4	Sand. . .	Exposed.	1.024	13.89	248	5	21.17	36.13	47.23	56.12	63.45		
132	Wellfleet, west of Lieutenant's Island.	4	Sand, . .	Exposed.	1.024	8.39	130	5	14.69	24.75	33.17	40.28	46.43		
133	Wellfleet, west of Lieutenant's Island.	4	Sand, . .	Exposed.	1.024	7.05	107	5	12.96	21.46	28.94	35.45	41.16		
134	Wellfleet, west of Lieutenant's Island.	4	Sand, . .	Exposed.	1.024	11.42	189	5	18.31	31.21	41.28	49.50	56.46		
135	Wellfleet, Egg Island, .	5	Coarse sand, .	Exposed.	1.024	10.58	172	5	17.33	29.48	39.14	47.69	53.87		
136	Wellfleet, Egg Island, .	5	Coarse sand, .	Exposed.	1.024	12.90	223	5	20.02	34.15	44.87	53.53	60.75		
137	Wellfleet, Egg Island, .	5	Coarse sand, .	Exposed.	1.024	15.93	298	5	23.56	39.95	51.73	61.00	68.45		
138	Wellfleet, Egg Island, .	5	Coarse sand, .	Exposed.	1.024	12.90	223	5	20.02	34.15	44.87	53.53	60.75		
139	Wellfleet, Egg Island, .	5	Coarse sand, .	Exposed.	1.024	14.95	275	5	22.42	38.10	49.57	58.68	66.09		
140	Wellfleet, Egg Island, .	5	Coarse sand, .	Exposed.	1.024	15.72	293	5	23.32	39.55	51.26	60.51	67.95		
141	Wellfleet, Egg Island, .	5	Coarse sand, .	Exposed.	1.024	12.13	205	5	19.13	32.64	43.05	51.48	58.57		
142	Wellfleet, Egg Island, .	5	Coarse sand, .	Exposed.	1.024	9.52	151	5	16.09	27.28	36.35	43.92	50.41		
143	Wellfleet, Egg Island, .	5	Coarse sand, .	Exposed.	1.024	14.95	275	5	22.42	38.10	49.57	58.68	66.09		
144	Wellfleet, Egg Island, .	5	Coarse sand, .	Exposed.	1.024	14.88	273	5	22.34	37.96	49.42	58.51	65.91		
145	Wellfleet, north of Egg Island.	5	Sand, . .	Exposed.	1.024	13.25	232	5	20.43	34.84	45.70	54.45	61.71		
146	Wellfleet, north of Egg Island.	3	Sand, . .	Exposed.	1.024	7.12	110	5	13.06	21.63	29.17	35.71	41.44		

Table V. — Concluded.

No. of Experiment.	Location.	Current.	Soil.	Depth of Water in Feet at Low Tide.	Salinity.	Annual Growth in Millimeters.	Gain Per Cent. in Volume.	Size in Millimeters at Various Ages.						Remarks.
								½ Yr.	1½ Yrs.	2½ Yrs.	3½ Yrs.	4½ Yrs.	5½ Yrs.	
147	Wellfleet, Great Island Meadows.	3	Sand, . .	Exposed.	1.024	10.93	179	5	17.74	30.21	40.05	48.11	49.98	
148	Wellfleet, Great Island Meadows.	3	Sand, . .	Exposed.	1.024	7.54	115	5	13.60	22.68	30.54	37.27	43.14	Near shore.
149	Wellfleet, Great Island Meadows.	3	Sand, . .	Exposed.	1.024	8.18	127	5	14.42	24.25	32.56	39.58	45.66	
150	Wellfleet, Great Island Meadows.	3	Sand, . .	Exposed.	1.024	9.59	152	5	16.17	27.43	36.54	44.13	50.65	
151	Wellfleet, Great Island Meadows.	3	Sand, . .	Exposed.	1.024	7.68	118	5	13.78	23.03	30.99	37.79	43.71	
152	Wellfleet, Great Island Meadows.	3	Sand, . .	Exposed.	1.024	3.74	55	5	8.91	13.11	17.61	21.88	25.83	High bed.
153	Wellfleet, Great Island Meadows.	3	Sand, . .	Exposed.	1.024	9.66	154	5	16.25	27.58	36.72	44.35	50.88	
154	Wellfleet, Great Island Meadows.	3	Sand, . .	Exposed.	1.024	10.50	170	5*	17.24	29.32	38.93	46.86	53.62	
155	Wellfleet, Great Island Meadows.	3	Sand, . .	Exposed.	1.024	7.97	123	5	14.15	23.75	31.93	38.87	44.88	
156	Wellfleet, Great Island Meadows.	3	Pebbles, . .	Exposed.	1.024	9.17	145	5	15.68	26.55	35.41	42.84	49.23	
157	Wellfleet, Great Island Meadows.	3	Sand, . .	Exposed.	1.024	5.64	83	5	11.18	17.95	24.36	30.05	35.13	
158	Wellfleet, Great Island Meadows.	3	Sand, . .	Exposed.	1.024	3.95	56	5	9.14	13.57	18.33	22.78	26.91	
159	Wellfleet, Great Island Meadows.	3	Sand, . .	Exposed.	1.024	5.92	88	5	11.53	18.66	25.30	31.18	36.41	
160	Wellfleet, Great Island Meadows.	3	Sand, . .	Exposed.	1.024	3.38	47	5	8.53	12.32	16.38	20.32	23.99	
161	Wellfleet, south of Lieutenant's Island.	2	Sand, . .	Exposed.	1.024	5.78	85	5	11.36	18.31	24.83	30.61	35.77	
162	Wellfleet, south of Lieutenant's Island.	2	Sand, . .	Exposed.	1.024	2.12	29	5	7.07	9.31	11.74	14.27	16.80	
163	Wellfleet, south of Lieutenant's Island.	2	Sand, . .	Exposed.	1.024	2.12	29	5	7.07	9.31	11.74	14.27	16.80	
164	Wellfleet, south of Lieutenant's Island.	2	Sand, . .	Exposed.	1.024	4.24	60	5	9.49	14.34	19.42	24.11	28.42	

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165	Wellfleet, north of Egg Island.	5	Sand, . .	Exposed.	1.024	14.59	266	5	22.00	37.42	48.78	57.82	65.20	
166	Wellfleet, north of Egg Island.	4	Sand, . .	Exposed.	1.024	7.68	118	5	13.78	23.03	30.99	37.79	43.71	
167	Wellfleet, Egg Island, .	5	Coarse sand, .	Exposed.	1.024	12.69	218	5	19.69	33.74	44.38	52.97	60.15	
168	Wellfleet, Egg Island, .	5	Coarse sand, .	Exposed.	1.024	12.06	203	5	19.05	32.51	42.88	51.29	58.37	
169	Wellfleet, Egg Island, .	5	Coarse sand, .	Exposed.	1.024	9.31	147	5	15.84	26.84	35.79	43.27	49.70	
170	Wellfleet, Egg Island, .	5	Coarse sand, .	Exposed.	1.024	11.07	182	5	17.90	30.49	40.41	48.52	55.41	
171	Wellfleet, Egg Island, .	5	Coarse sand, .	Exposed.	1.024	11.35	188	5	18.23	31.06	41.11	49.30	56.25	
172	Wellfleet, Egg Island, .	5	Coarse sand, .	Exposed.	1.024	9.38	150	5	15.92	26.99	35.97	43.49	49.93	
173	Wellfleet, Egg Island, .	5	Coarse sand, .	Exposed.	1.024	10.15	163	5	16.83	28.60	38.02	45.83	52.51	
174	Wellfleet, Egg Island, .	5	Coarse sand, .	Exposed.	1.024	11.91	200	5	18.88	32.21	42.51	50.88	57.93	
175	Wellfleet, Egg Island, .	5	Coarse sand, .	Exposed.	1.024	8.04	124	5	14.23	23.91	32.15	39.10	45.16	
176	Wellfleet, Sow Rock Bar, .	5	Coarse sand, .	Exposed.	1.024	5.15	75	5	10.58	16.73	22.71	28.07	32.90	High bed.
177	Monomoy, raft, . .	4	Coarse sand, .	5.0	1.024	19.95	422	5	28.24	46.89	59.75	69.36	76.55	Sand box.
178	Wellfleet, south of Lieutenant's Island.	2	Sandy mud, .	Exposed.	1.024	2.89	40	5	8.00	11.22	14.66	18.13	21.39	Eelgrass.
179	Wellfleet, south of Lieutenant's Island.	2	Sandy mud, .	Exposed.	1.024	2.54	35	5	7.58	10.35	13.34	16.38	19.30	
180	Wellfleet, south of Great Beach Hill.	1	Sand, . .	Exposed.	1.024	.85	11	5	5.76	6.57	7.42	8.33	9.27	High bed.
181	Wellfleet, south of Great Beach Hill.	1	Sand, . .	Exposed.	1.024	.99	13	5	5.88	6.83	7.84	8.91	10.02	High bed.
182	Wellfleet, south of Great Beach Hill.	1	Sand, . .	Exposed.	1.024	.21	3	5	5.19	5.39	5.60	5.81	6.04	High bed.
183	Wellfleet, south of Great Beach Hill.	1	Sand, . .	Exposed.	1.024	.56	7	5	5.50	6.03	6.59	7.19	7.71	High bed.
184	Wellfleet, east of Great Beach Hill.	3	Gravel, . .	Exposed.	1.024	2.54	35	5	7.58	10.35	13.34	16.38	19.30	Near shore.
185	Wellfleet, east of Great Beach Hill.	3	Sand, . .	Exposed.	1.024	2.75	38	5	7.83	10.87	14.14	17.42	20.55	Near shore.
186	Plymouth Harbor, Egobert's Flat.	4	Fine sand, .	Exposed.	1.021	11.73	197	5	18.67	31.84	42.06	50.37	57.39	
187	Plymouth Harbor, Egobert's Flat.	4	Fine sand, .	Exposed.	1.021	7.43	113	5	13.45	22.41	30.18	36.86	42.70	Eelgrass.

BIBLIOGRAPHY.

1. Kellogg, J. L. A Contribution to our Knowledge of the Morphology of Lamellibranchiate Mollusks. Bulletin United States Fish Commission, 1890.
2. Kellogg, J. L. Feeding Habits and Growth of *Venus mercenaria*. New York State Museum Bulletin No. 71, Zoölogy, 10, 1903.
3. Kellogg, J. L. Notes on the Marine Food Mollusks of Louisiana. Gulf Biological Station Bulletin No. 3, 1905.
4. Kellogg, J. L. Observation on the Life History of the Common Clam, *Mya arenaria*. Bulletin United States Fish Commission, 1899.
5. Krause, A. K. Preliminary Report on the Habits and Life History of the Quahaug. Rhode Island Commission of Inland Fisheries, 1903.
6. Pelseneer, P. A Treatise on Zoölogy, Part V., Mollusca. Edited by E. Ray Lankester, London, 1906.
7. Kellogg, J. L. Shellfish Industries, 1910. Henry Holt & Co.
8. Ingersoll, E. The Clam Fisheries. In the Fisheries and Fishing Industries of the United States, United States Fish Commission and Tenth Census, 1887.
9. Verrill, A. E. Report upon the Invertebrate Animals of Vineyard Sound. United States Fish Commission Report, 1871–72.
10. Von Zittel, K. A. Text-book of Palæontology, London, 1900.
11. Gould, A. A. Report on the Invertebrata of Massachusetts, 1870.
12. Ryder, J. A. The Byssus of the Young of the Common Clam (*Mya arenaria*, L.). American Naturalist, January, 1889.
13. Williamson, H. C. The Spawning, Growth and Movement of the Mussel. Twenty-fifth Annual Report of the Fishery Board for Scotland, 1906.
14. Colton, H. S. How Fulgur and Sycotypus eat Oysters, Mussels and Clams. Proceedings of the Academy of Natural Sciences of Philadelphia, 1908.
15. Langworthy, C. F. United States Department of Agriculture, Farmers' Bulletin 85, 1898.

During the past four years the investigations at Wellfleet were carried on to determine the practicability of securing a "catch of oyster spat" in Wellfleet Bay. The catching of spat is a very important advantage to the oyster industry.

The report of Mr. Belding follows: —

OBSERVATIONS ON THE SET OF OYSTER SPAT IN WELLFLEET BAY.

The future success of the Massachusetts oyster industry will depend not only upon producing oysters of good quality and accessible markets, but also upon the raising of seed oysters. At the present time the problem of obtaining small oysters is an important factor in the development of the industry, since the greater part of the seed is brought from Long Island Sound, the Massachusetts oysterman paying the added cost of transportation. By raising native seed other difficulties, such as the inability to obtain suitably small oysters for planting and the prohibitive prices in years of poor set in Long Island Sound, will be eliminated, and the oyster industry in the Commonwealth placed on a more substantial basis.

Owing to variable natural conditions the control of the oyster set, in spite of numerous investigations in this country and abroad, has proved a baffling problem, which, possibly, may never be satisfactorily solved. At the present time young oysters can be caught, with more or less uncertainty, by placing shells in the water during the spawning season, the planter having no means of foretelling whether he will get a good or a poor set. Except in Buzzard's Bay and the Taunton River, where there were once natural oyster beds, little attempt has been made to catch the natural set, the Cape Cod planters obtaining their seed outside the Commonwealth. The object of this paper is to present a few facts concerning spat collecting, with the hope that it may arouse renewed interest in the production of native oyster seed. The following observations in Wellfleet Bay, in spite of their limited scope, show that oyster spat can be collected artificially in localities commonly considered unproductive, and that similar results can be obtained in other sections where spat collecting has not been given a fair trial by the oystermen.

The following report consists of an introductory section, briefly dealing with the natural history of the oyster in as far as it relates to general spat collecting, a description of the conditions in Wellfleet Bay, and the results obtained from an investigation of the spawning season and from experiments with spat collectors. The methods of work are described under each topic.

Natural History.

Spawning. — The American oyster (*Ostrea virginica*) is unisexual, whereas the European species (*Ostrea edulis*) is hermaphroditic,, *i.e.,* both sexes occur in the same animal. The ripe generative organs (Fig. 62), in either sex, surround the liver and intestine, giving the appearance of branching veins filled with creamy white contents. The eggs or spermatozoa, during the act of spawning, are extruded from two main ducts, opening, one on each side, below the large adductor muscle, and are swept from the mantle chamber into the water, where they unite with the spawn from another oyster of the opposite sex. The oyster ready to spawn is popularly said to be "in milk," owing to the white, milky appearance of the reproductive organs. In Massachusetts waters the oyster begins to spawn at the age of two years, but its greatest activity does not take place before the fourth or fifth year.

Fecundation. — According to the late Prof. W. K. Brooks of Johns Hopkins University the average female oyster is capable of producing 16,000,000 eggs per season. The extruded eggs, about 1/400 of an inch in diameter, can be seen by the naked eye as tiny white specks, which under the microscope have a round opaque appearance, due to the yolk granules within the cell. The spawn of the male oyster has a uniform milky consistency, due to the great number of minute spermatozoa, which mainly consist of a nucleated body and long slender tail. In this way nature has provided a division of labor, since the egg is the inactive form, which contains the nutriment, while the spermatozoön is modified for swimming in search of the egg.

In order that the egg, which has been cast off from the parent oyster, shall develop into a new individual, it must unite with a spermatozoön, the act of fusion being known as fecundation or fertilization. In nature the meeting of these two is often a matter of chance, depending upon the simultaneous spawning of several oysters in the same locality, and probably numbers of eggs are never fertilized.

Early Life History. — With the completion of spawning the adult oysters have fulfilled their parental duties and the developing embryo is at the mercy of the natural elements. In order to overcome such adverse conditions as sudden changes in temperature, cold rains, storms, freshets, as well as the active enemies of the young larvæ, and in order to maintain the proper equilibrium in spite of this great destruction, nature has provided an enormous number of eggs for every female oyster.

During the first few hours, if the temperature of the water is not below 70° F., the embryo develops by the usual method of unequal cell division, and passes successively through 2, 4, 8, 16, 32, etc., celled stages, until it finally becomes a mass of small cells surrounding a few large cells, which are to form the primitive digestive tract. In the course of a few hours these surface cells throw out fine hair-like processes, cilia, which by their lashing enable the animal first to rotate and then to swim through the water. The body soon elongates; cilia are only visible on the front end; the primitive mouth is formed on the under surface; and the shell gland is developed opposite the mouth. Gradually a thin, transparent shell envelops the body, the cilia on the anterior end forming a thick pad, the velum or swimming organ, which permits the little shelled larva to lead a free-swimming existence.

The formation of a mouth, stomach, intestine and anus enable the young animal to digest minute organisms and to obtain its sustenance from the water. During this veliger period the oyster larvæ can readily be taken by towings with the plankton net.

Attachment. — About the sixth day, the length of the free-swimming period depending upon the temperature of the water, the embryo settles to the bottom, and, if fortunate, attaches itself to some hard clean surface by the edges of the mantle, a fleshy fold on the inside of the shell. This temporary attachment is soon replaced by a calcareous fixation which firmly fastens the oyster by its left or deep valve to the object of support. The attachment is caused by a sticky secretion from the mantle which becomes impregnated with lime salts. Several instances have been observed on the gravel bar in Herring River, Wellfleet, where yearling oysters had made a second attachment at the edge of the shell, leaving an interval between the two pebbles (Fig. 68: 16). This fact indicates that the oyster at the age of one year still retains its power of attachment.

Previous to the attachment the early straight-hinged veliger larva has changed in size and shape to an unequivalvular form, with prominent umbones pointing posteriorly, which is readily recognizable under the microscope. During the early attachment period the anterior adductor muscle disappears, the gill filaments increase in number, and a different shell formation takes place.

Spat Collecting.

The present system of spat collecting developed from a study of the attachment habit in the young oyster, the planters finding that they could aid nature during the spawning season by placing in the water suitable objects on which the larvæ would set. The oyster will fasten to any hard clean surface, often on unusual objects, as old shoes, rubber boots, tin cans, clay pipes, glass bottles, and many other articles which occasionally find their way into the water. At Monomoy Point a large lobster was captured with five oysters, two and one-half months old, attached to its shell.

In America various shells have been utilized for cultch. In Massachusetts the oyster shell, most popular in other States, is generally considered second to the scallop, which, of a more fragile nature, readily allows the breaking apart of the clustered oysters. The heavier oyster shell does not break as easily, and consequently, unless the clusters are separated by hand, the oysters either die or take on an elongate form from lateral pressure. Oyster shells are preferred for exposed waters, scallop for quiet localities where the light shells will not be washed away. Clam, mussel, razor clam, silver or jingle shells, as well as gravel and small stones, are occasionally used. In Europe intensive oyster culture demands more elaborate methods, and various combinations of brush, bamboo, rope, tile and cement are used to catch the spat.

In the United States spat is collected both in the deep water and beween the tide lines. The former method is used in Long Island Sound, where the cultch is planted in water as deep as 40 feet; the latter in Massachusetts, where the seed is taken mostly between the tide lines (Fig. 64). The waters at the head of Buzzard's Bay, formerly the site of several natural oyster beds, yield an abundant harvest from the planting of shells on the gravel bars in brackish water. Outside of Buzzard's Bay and Narragansett Bay little spat collecting is carried on in Massachusetts, the planters preferring to buy their seed outside the State.

In placing the spat collectors the planter should have in mind two things: first, the desirability of a hard bottom to support the shells; secondly, the danger of planting the shells too early. In certain cases it is profitable to artificially harden the bottom with stones or gravel before planting. After the shells have been in the water for a short time, they become covered with a slimy growth of microscopic plants, which renders impossible the attachment of the young oyster. For this reason, except in favored localities, where the growth of the slime is slow, the oysterman must needs wait until the spawning season is well under way before placing his shells in the water. Even then the conditions determining a set are so erratic that the oysterman does not average more than one good set in every three to four years.

In Massachusetts the oyster industry is regulated locally by the various coast towns, and spat collecting is permitted under the following conditions:—

> The mayor and aldermen of a city or selectmen of a town may, by writing under their hands, grant a license for a term not exceeding ten years to any inhabitant thereof . . . to plant oyster shells for the purpose of catching oyster seed, upon and in any waters, flats and creeks therein, at any place where there is no natural oyster bed; not, however, impairing the private rights of any person, nor materially obstructing any navigable waters. . . . The shore line of such licensed premises shall be . . . the line of high water for the planting of oyster shells, but the provisions of this section shall not authorize the placing of such shells upon the land of a riparian owner between high and low water mark without his written consent.

Conditions in Wellfleet Bay.

During the summer of 1908 a series of observations was made upon the oyster set in Wellfleet Bay. In this locality the planters, after a few unsuccessful attempts, had gradually reached the conviction that the capture of oyster spat in Wellfleet Bay was almost an impossibility. With the object of possibly discovering a remedy for this condition, the following plan of investigation was outlined: (1) a survey of the natural oyster set in the bay; (2) observations on the spawning and larvæ in the water; (3) experiments with spat collectors in the different parts of the Bay.

Wellfleet Bay. — Wellfleet Bay, an arm of Cape Cod Bay some 4 miles long and 2 miles wide, has an extensive area of flats, owing to the great rise and fall of the tide (10¾ feet). For this reason practically all the set is found between the tide lines, although spat is occasionally noticed on the oysters planted in the deep water. The flats vary in composition from gravel to soft mud, but for the most part consist of a dark coarse sand. The tide flows swiftly, causing a slight shifting of the flats, especially in the lower part of the bay, and forming numerous sand and gravel bars, such as Stony, Smalley's, Blackfish Creek and Herring River bars. At the head of the bay, on the east and west sides, are two inlets, Duck Creek and Herring River, while half way down on the east side is Blackfish Creek. At low tide little remains of these tributaries except streams in the channel bed. The two principal sand bars are Smalley's Bar, opposite Blackfish Creek, and Egg Island, at the northern end of the bay.

The Wellfleet Oyster Industry. — In any consideration of the set it is essential to know the amount of adult spawning oysters on the beds. In 1908, when the greater part of our observations were made, there were but 70,000 bushels of oysters planted in the bay. Of this number, 68,000 were three-year-old oysters, the remainder seed. Five and six-year-old oysters were found in scattering quantities near Indian Neck, in the northern part of the harbor. In spite of the small number and size of the spawning oysters a comparatively heavy set occurred in 1908, which indicates that favorable weather conditions during the spawning season are more important than the number of spawners. In 1909 approximately the same number of oysters were on the beds, but being older were capable of producing more spawn. In 1910 and 1911, owing to the development of the Wellfleet industry by new companies, a considerably larger number of oysters were planted.

Previous Attempts at Spat Collecting. — The first settlers in Wellfleet found a natural oyster bed in the vicinity of Hitchin's Creek or Silver Spring in 1644. In 1775 this natural bed was completely destroyed and was never replenished, owing to the lack of suitable objects on which the spat could catch. Until 1908 the only successful spat collecting had been in Herring River, where two set, the last in 1906, had been obtained by Mr. E. P. Cook of Wellfleet. Various attempts have been made in other parts of the bay by the oystermen, with indifferent success.

Preliminary Survey. — The main problem was to determine whether the prevailing opinion that unfavorable natural conditions rendered spat collecting impossible was true or whether it had arisen through lack of initiative and erroneous methods. The first step in the solution of this problem was a general survey of the oyster set of previous years in order to determine the most productive localities. For this purpose an examination of the rocks, gravel bars, wharf pilings, stakes, etc., was made for evidences of set.

The result of the survey indicated that artificial spat collecting could be carried on successfully, as was later substantiated by the experimental collectors. The observations were briefly as follows: —

(1) The greater part of the oyster set took place between the tide lines, which limited the area for placing the experimental spat collectors.

(2) Sufficient evidence was found of the natural abundance of larvæ in the water, as in the favorable localities whenever a clean surface was presented a few spat could be found attached, the chief difficulty being the lack of suitably raised collectors. The number of oysters from one to three years old, attached to the piling and stones under Commercial and Chequesset Inn wharves (Fig. 66), as well as the quantity of living and dead oysters on the stones, pebbles and large rocks in nearly every part of the bay, gave promise of an abundant natural production.

(3) The localities of the greatest natural set appeared to be Herring River, Blackfish Creek and the bar south of Jeremy's Point, locally known as Stony Bar.

The Plankton Net.

The importance of determining the spawning season and time of set in Wellfleet Bay was early evident, since such information not only would show the proper time to put down our spat collectors, but also, when continued through a series of years, would prove of value to the local oyster planters. For this reason the first step in our investigation was directed toward a study of the spawning habits of the oyster in this locality.

Methods of Investigation. — Beginning in May examinations were made at definite intervals to determine the condition of the spawn in the adult oysters on the grants. Information was also gathered from the oystermen as to when the oysters were "in milk," and at what times in previous years spat had been observed, a method which, although helpful, did not give as definite results as the plankton net, and which, after 1908, was used only for general reference.

The general usefulness of the plankton net, which has been used extensively in the study of microscopic life in the water, suggested that it might prove of value in determining the presence of the free-swimming oyster larvæ previous to the time of set. In the past little attention has been given to the shellfish larvæ in the veliger or free-swimming stage, and merely the abundance or scarcity of any year noted. An endeavor was made to make our work roughly quantitative by using stated distances, same period of tide and a uniform method of counting the larvæ with the microscope and Rafter cell.

The tow net was made of No. 11 silk bolting cloth, supported from a copper ring 12 inches in diameter by a fold of canvas. The net was towed behind a dory near the surface of the water at a uniform rate of speed, which permitted the water to filter through the fine meshes, leaving the plankton or floating organisms. A uniform speed was essential, as too rapid movement would result in the backing of water from the net, owing to the difficulty of filtering, and too slow a rate would allow the net to sink. The variation in current, tide and wind likewise rendered difficult the filtration of the same amount of water at each towing, so that the counting was only roughly comparable. Except in protected inlets any quantitative work with a simple net in sea water necessarily has to allow for these errors. As the same distance, a round trip of 600 feet off Chequesset Inn wharf, was taken for each towing, and only approximate results desired, the value of the work from a practical standpoint was little affected.

The second step was the separation of the oyster and other shellfish larvæ from the miscellaneous plankton forms in the towing, which had been washed into a small pail containing about 3 inches of water. The water was given a whirling motion with a small stick, which forced the larvæ by centripetal action to the center of the pail, where they could be easily taken out with a pipette. The operation was repeated several times to obtain all the larvæ. If, perchance, sand had been taken in the towing, it would also settle to the center with the lamellibranch and gasteropod larvæ, but the larger grains could be separated later by proper manipulation in small glass dishes. No satisfactory method of separating the fine sand grains or gasteropod larvæ from the lamellibranch veligers could be devised, except the laborious method of picking out the individuals with a fine pipette. However, their removal was not essential, since they did not materially interfere with the counting.

The method of counting is an adaptation of the Sedgwick-Rafter device for counting diatoms and algæ. The larvæ are spread evenly in a Rafter cell, consisting of a brass rectangle, 1 millimeter high, 20 millimeters wide and 50 millimeters long, fitted onto a glass slide and having a volume of 1,000 cubic millimeters, or 1 cubic centimeter. By means of a ruled square in the ocular of the microscope, covering 1 square millimeter of surface on the slide, the larvæ are counted from ten different areas and the result multiplied by 100 to give the entire number, which, if the distribution in the cell is even, proves a fair estimate.

Results.

The Oyster Larva. — The duration of the veliger or free-swimming period is variable, the temperature of the water having a great influence on the rapidity of larval development. During this stage certain anatomical changes occur which render the animal capable of forsaking the free-swimming existence and ready to lead a stationary life. It is difficult to distinguish the oyster from the other shellfish at this period, the early veligers of many lamellibranchs having the same flat hinge line. It is only during the last days of the veliger stage that the final characteristics which differentiate it from the quahaug, clam, scallop and other shellfish appear. The oyster just previous to the time of set has an equi-valvular shell with projecting umbones (beak) pointing posteriorly. The convex left valve is larger than the right and forms the greater part of the characteristic hump-like umbones.

The appearance in the towings of the larva with prominent umbones marks the time for immediately putting down the shell spat collectors. Recognition of the young oyster at this period by the plankton net and microscope should prove of value to the oyster planters, especially in the localities where the natural conditions, favorable for the growth of minute animal and vegetable life in the water, render a short submergence of the shells imperative. In Buzzard's Bay the oysterman considers it important to know the exact time of set in order to prevent his shells becoming covered with a slime, which would interfere with the attachment of the spat. In this respect conditions are more favorable at Wellfleet, the shells sliming but little. It is to be regretted that our method of determining the exact time of set, since it depends upon microscopical examination of the larval oysters, cannot become of popular use among the practical oystermen of the Commonwealth.

The Spawning Season. — In Wellfleet Bay the spawning season approximately extends from the middle of June to the middle of August; but the greater part of the spawn is liberated during the last week in June and the first two weeks in July. The actual spawning of the individual oyster is probably of brief duration, and the long season is best explained by the variation in the ripening of the different oysters. Observations of the spawning season for four years gave the following data: in 1908 microscopical examinations of the eggs showed that a few oysters had begun to spawn as early as June 12, but that the season practically did not start until June 23; by July 10 the majority of oysters in the upper part of the bay had ceased spawning, while the oysters in the lower part, where the water was cooler, were not so far advanced. In 1909 the main spawning took place between June 26 and July 10, followed by a second period between July 22 and July 31. In 1910 the first spawning occurred between June 24 and July 1, the second from July 13 to July 22, and scattering larvæ were found in the water from July 27 to August 12. In 1911 the first spawning came between June 28 and July 5, the second from July 19 to July 22, and scattering larvæ were found from July 26 to August 24. According to these records the principal spawning takes place during the last week in June and the first two weeks in July, with a slight variation for the different years. The subsequent spawning evidently depends upon variable temperature conditions, and exhibits no regularity.

Temperature and Spawning. — The temperature of the water was the chief factor regulating the spawning, which took place at 70° F. or over. The 1911 season was slightly later than 1909 and 1910, owing to the cold weather during June. The temperature of the water in the upper part of Wellfleet Bay followed closely the weather changes, the action of the sun on the flats exposed at low tide rapidly raising the temperature several degrees. The sudden bursts of spawning were invariably preceded by a high temperature of the water, brought on by the hot weather, the month of July, during which most of the spawning took place, averaging 3 degrees warmer than the month of August. In general, the time of spawning could be told from the condition of the weather and the temperature of the water, the observant oysterman invariably predicting an early or late season.

The Destruction of Larvæ. — The numerous offspring of the oyster maintain a continuous struggle for existence against the adverse forces of nature. In our study with the plankton net a few observations were made on the effect of cold rains upon the larval oyster and other shellfish. In most cases the rain either caused the destruction of the swimming larvæ or forced them to settle to the bottom. At Monomoy Point, Mass., during a long, cold rain, counts were made of the number of larvæ in a certain amount of water which passed through the plankton net: before the rain, 30,000; after nine hours, 15,000; after fifteen hours, 3,000. After the rain ceased the number of larvæ gradually increased, until it was the same as at the first counting.

The years of the best set have had little or no rain during the brief free-swimming period, thus affording no drawback to the development of the larva. The conditions causing set are varied, complex and constantly changing. A set is achieved by a happy combination of favorable conditions largely presided over by the element of chance, and for this reason will always remain a more or less baffling problem to the oysterman, who in his feeble way is unable to control the mighty forces of nature.

Spat-collecting Experiments.

In connection with the use of the plankton net small shell collectors were put down in order to determine the values of the different parts of the bay and to ascertain the natural conditions influencing spat collecting. Seventy-four collectors, consisting of ½ to 1 bushel of shells, were placed between the tide lines in the selected localities, and covered with galvanized wire netting, 1-inch mesh, securely fastened to the flat by four short stakes, in order to prevent the contents from washing away in the strong currents. The final result showed a little mound of shells, 6 to 8 inches high, covering perhaps 5 square feet. By this simple device it was possible at a small expense to test a large territory with more satisfactory results than by using a few large collectors. In studying any particularly favorable locality, such as a sand or gravel bar, a series of collectors were placed at definite intervals to determine the most favorable part.

Three difficulties which unfavorably influenced the results were encountered: (1) the shells were difficult to obtain and the greater part of the collectors consisted of razor clam shells, a form less suitable for catching spat than the scallop or the oyster shell; (2) the extreme lowness of the shell heaps, not over 8 inches above the surface of the flat, rendered the small collectors less efficient than larger heaps; (3) part of the collectors were planted late in the spawning season, July 11 to July 24, and possibly may have missed the heavier part of the set. They were taken up September 7 to October 14, the more important being taken up first. By this time the young oysters were of a readily discernible size.

Location of the Collectors. — Seventy-four collectors were placed between the tide lines around the bay, from Billingsgate Island on the west to the south side of Lieutenant's Island on the east, a distance of nearly 7 miles. In Herring River and Blackfish Creek were long, tongue-shaped bars over which the tide flows swiftly. On these a series of collectors from high to low water mark were set out to find at what depth of water the greatest abundance of set occurred. A second series at right angles to the first were placed across the bar in the direction of the tide flow, to determine whether the set took place on the outer edge, mid surface or inner edge of the bar. In the other parts of the bay the more isolated collectors were usually placed in pairs, one near high, the other near low water mark.

Results. — Of the 74 collectors, 26 were washed away, the greatest loss taking place in Blackfish Creek, near the Chequesset Inn and Egg Island, Jeremy's Point and Billingsgate Island. The condition of the remaining 48 can be classified as follows: (1) good, 14, mostly in Herring River and Blackfish Creek; (2) fair, 18; (3) poor, 16. Only in one place were the collectors a decided disappointment, on the north side of Blackfish Creek, where the entire bar shifted with the early autumn gales, either burying or washing away the small shell heaps.

When taken up only 18 collectors out of the 48 which were recovered had caught any spat. The following table gives location, the number of collectors, the percentage of shells found and the relative value of the locality in terms of the amount of spat. The collector with the greatest number of young oysters was taken as the standard and given 400 per cent. Since a collector which contained 10 per cent. of the original shells could not capture as much spat as one with 50 per cent., it was necessary, in determining the relative value of the locality, to allow for this difference by estimating the catch for the entire collector.

LOCATION.	Number of Collectors.	Per Cent. of Shells.	Value (Per Cent.).
East side of Great Island,	1	25	2.67
East side of Great Island,	2	25	5.33
Herring River,	3	33	6.00
Herring River,	4	25	400.00
Herring River,	5	25	266.67
Herring River,	6	25	8.00
Herring River,	7	25	5.33
Herring River,	8	25	10.67
Herring River,	9	25	2.67
Herring River,	10	25	5.33
Herring River,	11	10	33.33
Indian Neck,	12	10	6.67
Indian Neck,	13	10	6.67
Blackfish Creek,	14	10	6.67
Blackfish Creek,	15	40	5.00
Blackfish Creek,	16	40	6.67
Blackfish Creek,	17	40	41.67
Blackfish Creek,	18	10	13.33

(1) *At what Level between the Tide Lines does the Best Set occur.* — The greater part of the set in Wellfleet Bay occurred between the tide lines, which was due in some measure to the height of the tide, 10¾ feet, and the large area of exposed flats. To determine at what height the set of oysters was most likely to take place, three classifications of the collectors were made, (1) *high,* (2) *medium,* and (3) *low,* according to their situation in regard to low-water mark. Of 47 collectors, 17 were high, 9 low and 21 medium. Of the 18 collectors which caught set, 3 were high, 13 medium and 2 low, showing a per cent. of 72 for the medium in the productive collectors as compared with 45 of the total number. The strip of territory about half way between the tide lines in Wellfleet Bay was the most productive of oyster seed, and recognition of this fact should be taken by the local oyster planters in putting down shells for spat collecting.

(2) *Gravel Bars as Natural Spat Collectors.* — When a long bar projects from the land at the mouth or entrance of a bay, creek or river, it seems to act as a natural spat collector for shellfish, particularly oysters, if there are suitable objects, such as shells or pebbles, on which the set can fasten. The top or highest portion of the bar seems most suitable for the attachment of the young oyster, while the clams and quahaugs are deposited around the edges. It is especially noteworthy

that in Wellfleet Bay the best grounds for the oyster set are the raised bars swept by the tidal currents in Herring River and Blackfish Creek.

(3) *Artificial Bars.* — The preliminary survey showed that the chief difficulty in obtaining oyster set in Wellfleet Bay was due to a lack of raised places for catching the seed. The question then arose as to whether portions of the ordinary flats could not be modified in some manner to afford suitable collecting ground. The problem of raising the level of the chosen locality to make a firm foundation for the shells was considered, and in order to test the efficiency of this plan an unproductive flat of soft mud in Herring River was selected. Several loads of coarse gravel were dumped upon the soft mud until a solid raised platform was built. On this the shell collectors were placed. If the shells had been placed on the mud before it had been covered with the gravel they would soon have been covered with silt. A fair set was obtained on the shells, which proved that by proper means many places on the flats of Wellfleet Bay could be utilized in a similar manner.

The Survey.

About Dec. 1, 1908, a record was taken of the natural conditions in the localities of abundant set and a general survey was made for the purpose of determining the favorable locations of the set in the various parts of the bay, on the bars, flats and large rocks.

The West Side of the Bay. — Passing north from Billingsgate Island the first locality of set was the low gravel bar, locally known as Stony Bar, situated south of Jeremy's Point. The tide passed with great swiftness over the bar, which was exposed only at extremely low running tides, rendering this locality, in spite of its favorable location for an abundant oyster and quahaug set, unsuitable for artificial spat collectors. Here quantities of small oysters were found attached to the gravel and small stones.

The tidal flats on the bay shore of Great Island consisted mostly of yellow or dark colored sand, furnishing no foundation for the set except on the large rocks which were scattered along the shore. Occasionally stones or pebbles covered with small oysters averaging 19 millimeters (⅘ of an inch) in size were gathered. North of the "Meadows," a gravel bed, 40 by 30 feet was covered with a thick set, averaging 14.8 millimeters (⅗ of an inch). The scattering set from this locality to Herring River averaged slightly larger, about 22 millimeters (⅚ of an inch).

The North Side of the Bay. — With the exception of Herring River, which will be described later, the north side showed a similar condition, — a scattering set on the pebbles and stones; but, owing to the greater amount of suitable objects for fixation, the natural set was correspondingly greater. The average size along this shore was 22 millimeters (⅚ of an inch). The heaviest set was found on the wooden piles and rocks under the Chequesset Inn and Commercial wharves, which were literally covered with young oysters, averaging 20.48 millimeters. Likewise the stakes marking the quahaug beds proved miniature collectors, a single stick often holding as many as 50 spat.

The East Side of the Bay. — The same conditions held true along the entire east shore, a scattering set on all stones and shells exposed from the sand. The rocks on Indian Neck and the west side of Lieutenant's Island were well supplied with spat. On the south side of Blackfish Creek a gravel bar extending from the shore of Lieutenant's Island in a northerly direction proved one of the best situations in the bay for planting shells. The abundance of the natural set and the results from the experimental spat collectors showed that this region ranked next to Herring River in the production of seed oysters. The average size, 13 millimeters (½ inch), was less than in the upper part of the harbor.

The Rocks. — A number of rocks, varying in size from small stones to a circumference of 70 feet, were scattered over the flats along the eastern and western shores. These rocks often occurred in clusters or groups, as at Indian Neck or west of Lieutenant's Island; but occasionally solitary specimens rose abruptly from the sands. The larger of the rocks, known to the quahaug fishermen as Old Sow, Blue Rock, etc., furnished evidence of an abundant natural set, and indicated what might be accomplished, by proper spat collectors, since, with few exceptions, their sides, 2 feet above the sand, were thickly covered with oyster spat. In many instances the young oysters had attached to a previous set and could be readily scraped off the rocks.

On the western side of the bay records were taken of the oyster set on six rocks from 2 to 9 feet in diameter. The average number of oysters per square foot was 41, ranging from 28 to 80, and the average size 12.23 millimeters (½ inch).

Blue Rock, the largest in the bay, having a circumference of 70 feet and rising 12 feet above the sand flat west of Lieutenant's Island, had the heaviest set. The rock lies in a favorable location and is completely covered only during the high course tides. The 1908 set began 1 foot from the bottom, was thickest from 1 to 4 feet and gradually thinned from 4 to 6 feet. The different sides showed variations in the amount of set: the west side averaged 125 per square foot, size, 9.84 millimeters; the east side, 109, size, 6.96 millimeters; the south side, 125, size 10 millimeters; the north side, 53, size, 9.44 millimeters. The size of the set on the small rocks near by varied from 8 to 15.5 millimeters, according to location.

Herring River. — Herring River emptied into the northwest corner of the bay by a deep bend which almost separated Great Island from the main land. Formerly the incoming tide passed swiftly up the river to flood thousands of acres of salt marsh along its numerous branches; but in 1909 the passage of salt water above the first bend was prevented by the construction of a dike. The area concerned in the oyster set lay below the dike, and although the river currents were somewhat altered, the conditions governing the set in this territory remained unimpaired by the construction of the dike.

Scattering oysters were found on the stones, shells and sedge along the shores. In one instance the projecting sides of a gunning tub, buried in the sedge, had caught 75 spat 15 millimeters in size. Two principal localities of set were found: on the north side of the river were the remains of an old wharf, used in former days for the fishing schooners. Here the old piles and stones were covered with oysters; but owing to the absence of suitable objects for attachment outside the wharf little set was noticeable.

The second locality was a gravel bar on the south side of the river, which proved the best spat collecting territory in the bay. This bar, covering approximately 500 by 150 feet, ran in a northwesterly direction from a point on the north side of Great Island in such a manner that the incoming tide flowed over it diagonally. Between the outer side of the bar and the channel at low tide was an area of shifting sand, while on the south and west a sand and mud flat separated it from Great Island. A series of spat collectors on this bar gave excellent results. The scattering shells, placed on the gravel area by Mr. E. P. Cook of Wellfleet also received a good uniform set. Over this bar 6 shells, averaging per shell 11.5 spat, 18.5 millimeters in size, were found to the square foot.

The great abundance of the set is due to the location of the bar in reference to the natural conditions of current, tide and shore line. The bar presents (1) a peculiar shore formation, guiding the flow of the tidal currents; (2) a high raised surface; (3) heavy material, such as gravel and pebbles, which offer a suitable foundation for the shells as well as serving as spat collectors; (4) the direction and force of the current, which has full sweep over the bar, affording a chance for the floating larva at the proper time to come in contact with suitable objects for attachment.

Conclusions.

(1) The idea of the Wellfleet oystermen that the capture of seed in Wellfleet harbor was impossible has proved erroneous. Our experiments have demonstrated that spat can be successfully gathered if the oystermen will use intelligent perseverance.

(2) At present there is an abundance of natural spat in the waters, but a lack of suitable objects on which it can set. The heavy sets on the gravel bars, rocks and under the wharves are obvious evidence.

(3) The two localities where set is most certain at the present time are the gravel bars in Herring River and Blackfish Creek.

(4) Other localities, particularly on the north end of the bay, can be made productive of oyster set by the formation of artificially raised gravel bars on which to plant the shells.

(5) The set takes place between the tide lines, only a small part striking in the deep water. The heaviest set is about half tide line.

(6) The spawning season lasts from June 15 to August 15, but the principal spawning takes place during the last week in June and the first two weeks in July.

(7) A method of determining by microscopical examination the exact time of oyster set has been tried with success. This is important to the oysterman in deciding at what period he should put down his shells to prevent sliming.

(8) The shell collectors in Wellfleet Bay gather slime slowly, due in part to the long exposure of the flats to the sun and air. Ordinarily the Wellfleet oysterman should put down his shells during the first week in July.

Inland Fisheries.

It appeared to be the opinion of the Legislature that the commissioners should continue to lease the fishing privilege in Tisbury Great Pond to private parties, according to the provisions of Acts of 1910, chapter 529. We have so leased to F. Allen Look *et al.* for a period of three years. A copy of the lease is on file at this office. In view of this fact, the following report upon this pond by William Converse Kendall, assistant, United States Bureau of Fisheries, is of interest: —

An Account of Tisbury Great Pond, Martha's Vineyard, with a List of Fishes collected in October and November, 1906.

In October and November, 1906, Mr. Vinal N. Edwards of the United States Bureau of Fisheries Station at Woods Hole made a large collection of fishes in Tisbury Great Pond, Martha's Vineyard, and has kindly furnished data upon which is based the following account.

Tisbury Great Pond, the aboriginal name of which is said to have been Takisny, is situated on the south side of Martha's Vineyard in the town of Tisbury. Its long axis, lying about east and west, is 2 miles, and its transverse diameter about 1½ miles. From the shores, the bottom, of hard, eel-grass-covered sand, gradually slopes off to a depth of 12 feet near the middle of the pond. From four to five months of the year it is an enclosed pond with no outlet, but with five rather muddy affluent streams, the sources of which are among the hills at the northward. During the summer and early fall the pond is open to the ocean, but about the first of November, or with the first heavy southeast gale, the outlet is blocked with sand. The outlet once blocked would probably forever remain so were it not for the residents near the pond, who with horses drag or dredge out a channel sufficient to allow the water to flow. The surface of the pond is a little higher than the sea level, and the released waters soon cut through the loosened sand of the bar, making a channel from 100 to 200 feet wide and from 3 to 5 feet deep. Owing to the higher level of the pond the sea does not flow into it until about half tide.

The salinity of the pond water varies somewhat in different parts of the pond, and according to whether it is closed or open. The density, as observed by Mr. Edwards in October, during the open season, was 1.0223 to 1.0226 in the portion next to the sea, but in the coves near the inlets it was found to be only 1.008.

There is authentic history of the early importance of the fishery at this pond, particularly for striped bass, smelts and alewives. One record of the former abundance of striped bass is that in December, 1848, 18,000 of those fish were taken by one set of a long shore seine in one of the inflowing streams. They were carted to Vineyard Haven and shipped by two schooners to New York.

Mr. Allen Look, who helped make this famous catch, is still living. About 1870 the pond was leased to Mr. Look and his sons. In 1869 they had planted there 1,200 to 1,400 breeding white perch, which species did not previously exist there. Having wisely allowed them to rest practically undisturbed for about ten years, they began seining, and have taken some 200 barrels each season since. Each season yields also about 200 barrels of eels, all taken in eel pots.

It is said that up to 1875 smelts were very abundant there, and from 600 to 700 barrels were taken annually. Since then, however, there has been a steady decline in the fishery, so that now only 50 or 60 barrels are taken each season.

Large numbers of alewives enter the pond each year and ascend the streams to spawn. The fishery for this species is carried on with a shore seine near the outlet, so that but a comparatively small portion of those that enter the pond are caught. Yet the fishery yields annually about 300,000 alewives.

In the early annual reports of the Commissioners of Inland Fisheries of Massachusetts occur a few letters from Mr. Look regarding the condition of the fishery in the pond. Under date of Oct. 4, 1873, he writes: —

There have been no new kinds of fish put in the pond during the past year, but from the barrel of white perch that was put in on April 1, 1869, we caught last spring 25 barrels of large perch, besides large quantities of small ones, of all sizes. Out of the whole catch we killed and sold 10 barrels of the largest, suffering the rest to escape unharmed. These 10 barrels weighed some 2,000 pounds and gave us net proceeds of $200. This shows with what rapidity white perch will increase if they have a chance. If those we let go increase in proportion to the first barrel, there will be an enormous quantity of them in three years. I think it takes about that time for them to mature. I have seen three distinct sizes, apparently one, two and three years old.

We have been very careful about keeping the pond open to the sea at proper times for the fish to come and go out.

The herring [alewives] have increased very much since the lease was given; they come earlier and are larger.

Smelt fishing was not as good last spring as in former years, owing to the hard winter. Smelts usually come into our ponds in December and January, but the weather was very severe during these two months.

We have been particular in giving herring and smelts a good chance to spawn. We not only allow them the days the lease requires but give them the whole month of May, which is their best spawning month.

Again, under date of Nov. 20, 1874, Mr. Look reports as follows: —

We have not put any new kinds of fish in the pond since my last report. We have removed from the pond 12 barrels of white perch, some 200 barrels of herring and about 10 barrels of smelts. Net proceeds, $485.20; town's part $24.60.

You will perceive that the catch was smaller than last year, not owing, however, to the scarcity of fish. We selected out some 12 barrels of the largest perch and let them go as breeders; also released all the smallest sized fish, which were very numerous.

Herring [alewives] were very numerous, but in consequence of the dullness of the market we caught but a very small proportion of what were in the pond. I should say that there were certainly 600 barrels of herring left to spawn. They were about one-sixth larger than they were a few years ago.

Smelts were not very plenty and we fished but a very little for them. I noticed that there was an abundance of smelt spawn attached to the pebbles and grass in the streams, where they deposited their eggs during the month of April. I saw also a large number of smelts passing from the pond to the sea about the middle of April. I caught some of them and found that they had spawned.

On Oct. 18, 1875, Mr. Look wrote that the net proceeds of the fishery of the pond during the year were $1,015.31, of which the town's part was $50.71. He said: —

This amount was mostly for herring, which were very plenty.

There were no perch removed from the pond during the year; the lessees thought it better to let them spawn one year, although they are quite numerous.

Last spring, while seining for herring, we caught some 5,000 or 6,000 pounds of large white perch at one time; we picked out a few of the herring and tipped the seine and let the perch go. The pond seems to be well stocked with perch of all sizes.

Smelts were very numerous last spring, but owing to the hardness of the winter it was impossible to fish for them until the season for catching them was about up. We caught some 15 barrels. There was a swarm of smelts in the fresh streams during the spawning season, — more than has been seen for four years. The pebbles in the stream were covered with spawn.

The last report from Mr. Look appearing in the commissioners' report is a brief statement of the number of fish caught, dated Dec. 31, 1883:—

White perch, 5,800; alewives, 89,731; striped bass, 8; smelts, 126,800; tautog, 57.

Regarding shellfish, Mr. Edwards says that the "soft clam" (*Mya arenaria*) is fairly abundant. Hard clams, or "quahogs" (*Venus mercenaria*), apparently never existed there, as no old or dead shells have ever been seen. It is said that oysters abounded up to 1825. That year the pond remained closed throughout the season, and in August the water became hot and stagnant, killing all the oysters. Mr. Look and sons have planted some in the last few years, but they have not done well.

The number of species of fishes occurring in the pond varies with the seasons, as elsewhere, so that sometimes there are but few taken; the same may be said of the quantity of any kind. Such was the case in 1907 and 1908, according to Mr. Edwards, but the reverse obtained in 1906.

On October 5 and 6, and on the 16th to the 19th, both inclusive, Mr. Edwards made 10 hauls of the seine each day, or 60 hauls in all, at the upper end of the pond, taking on those days, respectively, 38, 34, 36, 35, 34 and 39 species. On the 20th he made 15 hauls near the outlet, taking 46 species, collecting in all 79 species. Eleven were recorded by Mr. Edwards as "numerous" or "many," all but 3 of which were found quite generally distributed, but varying greatly in numbers in the different seine hauls.

At the upper end of the pond 24 species were taken that he did not find at the lower end. Nine species were found exclusively at the lower end, but of 7 of these there was only 1 each and only 5 each of the other 2 species. While most of the 24 kinds found at the upper end of the pond were rather scarce, they usually exceeded in numbers those found only at the lower end. Three of them, *Lucania parva, Fundulus diaphanus* and *Menidia berylina cerea,* were among the most abundant fishes of the pond, and naturally occurred in the more brackish water.

Of the species listed some are adventitious forms already recorded by Dr. H. M. Smith from Woods Hole and vicinity, principally at Katama Bay, Martha's Vineyard, not far east from Tisbury Great Pond. But there were collected 3 species not previously recorded from localities so far north; these are *Gymnachirus nudus* Kaup, *Platophrys ocellatus* and *Gobius stigmaticus.*

A few hauls of the seine were again made on November 13 to 15, both inclusive, in which only 35 species were caught, but adding 6 to the pond list.

The following is a revised and annotated list of 85 species of fishes of Tisbury Great Pond, prepared from the list furnished by Mr. Edwards and arranged according to the order in Jordan & Evermann's "Fishes of North and Middle America:" —

1. *Mustelus canis* (Mitchill). "Smooth dogfish." Listed by Edwards without further data.
2. *Raja erinacea* (Mitchill). "Summer skate." But 4 taken, 2 at the upper end and 2 at the lower end of the pond.
3. *Anguilla chrisypa* (Rafinesque). Eel. Plentiful at both parts of the pond.
4. *Elops saurus* (Linnæus). "Big-eye herring." On the 16th 4 were taken at the upper end and on the 20th 1 at the lower end of the pond.
5. *Etrumeus teres* (DeKay). Round herring. Six collected on the 19th at the upper end of the pond.
6. *Clupea harengus* (Linnæus). Herring. Quite evenly distributed; 72 caught.
7. *Pomolobus pseudoharengus* (Wilson). Alewife; "herring." Pretty evenly distributed; more common than the glut herring; one of the abundant species.
8. *Pomolobus æstivalis* (Mitchill). Glut herring. Many were take in one haul and a few in another on October 19 at the upper end of the pond, but at no other time.
9. *Brevoortia tyrannus* (Latrobe). Menhaden. Young very numerous and commonly distributed in the pond; taken in both months.
10. *Anchovia brownii* (Gmelin). Striped anchovy. Only 3 taken, on the 5th at upper end of the pond.
11. *Anchovia mitchilli* (Cuvier & Valenciennes). Common anchovy. But 8 taken, on the 19th at upper end of the pond.
12. *Salvelinus fontinalis* (Mitchill). Brook trout. Listed by Edwards without further data.
13. *Osmerus mordax* (Mitchill). Smelt. Some smelts were taken every day at both ends of the pond; 215 in all.
14. *Synodus fœtens* (Linnæus). Lizard fish. One was taken near the outlet on the 20th.
15. *Fundulus majalis* (Walbaum). Killifish. This species seemed not to be very numerous; only 45 were collected, and all at the upper end of the pond.
16. *Fundulus heteroclitus* (Linnæus). Mummichog. Abundant everywhere.
17. *Fundulus diaphanus* (Le Sueur). "Spring minnow." Pretty numerous at the upper end of the pond, none taken at the lower end.
18. *Lucania parva* (Baird & Girard). "Rainwater fish." First recorded from the Woods Hole region by Dr. Smith in 1898. In this pond it was caught only at the upper end. It was very abundant in some hauls, scarce in others.
19. *Cyprinodon variegatus* (Lacépède). "Short minnow." Over 90 were taken at both ends of the pond, but they were somewhat more numerous at the lower end than at the upper end.
20. *Tylosurus marinus* (Walbaum). Garfish. Nineteen collected, all but 1 at the upper end of the pond.

21. *Hyporhamphus roberti* (Cuvier & Valenciennes). Halfbeak. Listed by Edwards without further data.
22. *Pungitius pungitius* (Linnæus). Nine-spined stickleback. Only 1 was taken in October, that at the upper end of the pond on the 19th; others were found in November.
23. *Gasterosteus aculeatus* (Linnæus). Three-spined stickleback. Only 16 taken, found at both ends of the pond.
24. *Apeltes quadracus* (Mitchill). Four-spined stickleback. Abundant at both ends of the pond.
25. *Fistularia tabaccaria* (Linnæus). Trumpet fish. Only 1 caught, at the upper end of the pond.
26. *Syngnathus fuscus* (Storer). Pipefish. Numerous everywhere.
27. *Menidia berylina cerea* Kendall. "Little silverside." Found common at the upper end of the pond; none observed at the lower end.
28. *Menidia menidia notata* (Mitchill). Silverside. Abundant everywhere; large individuals of this species are probably the "green smelt" of the fishermen of this locality.
29. *Mugil cephalus* (Linnæus). Striped mullet. Many everywhere; none mentioned in Mr. Edwards' November list.
30. *Mugil curema.* White mullet. Listed by Edwards without further data.
31. *Sphyræna borealis* (DeKay). Barracuda. Twenty were taken, 11 at the lower end of the pond in October; none in November.
32. *Ammodytes americanus* (DeKay). Sand eel. Collected only in November. Large ones listed as *A. dubius.*
33. *Scomber scombrus* (Linnæus). Mackerel. At the lower end of the pond 5 mackerel were taken on October 20, and others in November.
34. *Decapterus macarellus* (Cuvier & Valenciennes). Mackerel scad. Five taken at the lower end of the pond on October 20; none in November.
35. *Trachurops crumenophthalmus* (Bloch). Big-eye scad. There were 20 specimens collected, 14 in one day at the upper end of the pond; none found in November.
36. *Carangus hippos* (Linnæus). "Horse crevalle." Sixty-three collected at both ends of the pond.
37. *Carangus crysos* (Mitchill). Yellow crevalle. Only 16 caught, 11 at the lower end on October 20; none in November.
38. *Vomer setipinnis* (Mitchill). Horsefish. One collected on October 20 at the lower end of the pond.
39. *Selene vomer* (Linnæus). Look down. According to Dr. Smith this fish is rare in this region; first noticed in 1885; usually taken in September.
40. *Trachinotus falcatus* (Linnæus). Round pompano. In the upper end of the pond 12 were taken in October.
41. *Trachinotus carolinus* (Linnæus). Pompano. Only 8 taken, all at the upper end of the pond and 6 of them on the 19th of October; none in November.
42. *Pomatomus saltatrix* (Linnæus). Bluefish. All that were collected were found at the upper end of the pond; 84 were caught, 38 of which were taken on October 4 and 41 on the 5th.

43. *Poronotus triacanthus* (Peck). Butter fish. Four were caught in October, 1 of which was at the lower end of the pond; others were collected in November.
44. *Morone americana* (Gmelin). White perch. Very common; 208 taken, 74 in one day at the upper end of the pond.
45. *Epinephelus niveatus* (Cuvier & Valenciennes). Snowy grouper. But 1 taken, this near the outlet on October 20. This is one of the southern strays.
46. *Centropristes striatus* (Linnæus). Sea bass. Fifty-one were taken, probably all small, only 1 of which was at the lower end of the pond.
47. *Priacanthus arenatus* (Cuvier & Valenciennes). Short big-eye. Four specimens were secured, 2 on October 16 at the upper end and 2 on the 20th at the lower end of the pond.
48. *Lutianus griseus* (Linnæus). Gray snapper. First recorded by Dr. H. M. Smith in 1898; two specimens of young about 1½ inches long found here on October 17.
49. *Lutianus apodus* (Walbaum). Schoolmaster. First recorded by Smith in 1898; 2 found here on October 17 at the upper end of the pond.
50. *Stenotomus chrysops* (Linnæus). Scup. Forty-one collected; 26 in one day at the upper end of the pond; none taken in November.
51. *Lagodon rhomboides* (Linnæus). Sailor's choice. Reported by Smith as not very common, but they were very numerous in this pond; said by Edwards to be more common than the scup. At the upper end of the pond 117 were taken, 72 of which were on October 4 and 33 on the 5th; none at the lower end; others taken in November. Mr. Edwards said they were about 5 inches long; much brighter color than elsewhere in the region.
52. *Kyphosus sectatrix* (Linnæus). "Rudderfish." One specimen only was taken, at the lower end of the pond on October 20.
53. *Cynoscion regalis* (Bloch & Schneider). "Squeteague." All taken at the upper end of the pond, 11 of the 16 on October 18; none in November.
54. *Leiostomus xanthurus* (Lacépède). Spot. Only 4 taken, 1 on each day from October 17 to 20 inclusive.
55. *Menticirrhus saxatilis* (Bloch & Schneider). "Kingfish." Only 7 kingfish, all at the upper end of the pond.
56. *Tautogolabrus adspersus* (Walbaum). Cunner. Small cunners were found everywhere; 169 taken in all, from 24 to 31 each day.
57. *Tautoga onitis* (Linnæus). "Tautog." The tautog seemed to be pretty common; 142 in all were collected, from 16 to 31 each day, most at the lower end of the pond.
58. *Chætodipterus faber* (Broussonet). "Angelfish." Smith says that this species is a very rare straggler, first taken in 1889, since when only 3 have been observed; all taken at Menemsha Bight, Martha's Vineyard. One specimen about 2$\frac{5}{16}$ inches long was taken on October 4 in this pond near the upper end.
59. *Chætodon ocellatus* (Bloch). Butterfly fish. Four specimens were taken, 3 at the upper end and 1 at the lower end of the pond.

60. *Monacanthus hispidus* (Mitchill). "Filefish." First recorded by Smith in 1898. Found here quite plentiful; 83 were secured in October and still others in November.
61. *Alutera schœpfii* (Walbaum). "Foolfish." Seven specimens were taken at the upper end of the pond.
62. *Sphæroides maculatus* (Bloch & Schneider). "Puffer." Eight were obtained, found at both ends of the pond.
63. *Chilomycterus schœpfi* (Walbaum). "Porcupine fish." Said by Smith to be rare and irregular of occurrence. It was taken in this pond only in November.
64. *Myoxocephalus æneus* (Mitchill). "Little sculpin." Nineteen specimens were collected in October, the most at the upper end of the pond; others were taken in November.
65. *Myoxocephalus octodecimspinosus* (Mitchill). Sculpin. This species occurs only in Edwards' November list.
66. *Gobiosoma bosci* (Lacépède). Naked goby. Listed by Edwards without further data.
67. *Gobius stigmaticus* (Poey). According to Jordan & Evermann the recorded range of this species is coast of North Carolina, the West Indies and northward to Rio Janeiro. One specimen about 1¼ inches long was taken in this pond on October 20. This is the first record of this fish known to the writer north of North Carolina.
68. *Opsanus tau* (Linnæus). Toadfish. This species seems to be common; 142 were collected in October, taken in all parts of the pond; also taken in November.
69. *Pholis gunnellus* (Linnæus). Rock eel. Only 6 specimens taken, at the upper end of the pond.
70. *Prionotus carolinus* (Linnæus). Sea robin. Eight were taken, occurring at both ends of the pond.
71. *Prionotus strigatus* (Cuvier). Striped sea robin. Thirteen were collected, all at the upper end of the pond, of which 11 were taken on October 4.
72. *Zoarces anguillaris* (Peck). Mutton fish. One was taken near the outlet on October 20.
73. *Merluccius bilinearis* (Mitchill). "Whiting." This species was taken only in November.
74. *Pollachius virens* (Linnæus). Pollack. Taken only in November by Edwards.
75. *Microgadus tomcod* (Walbaum). Tomcod. This species was pretty common in all parts of the pond, but the most were taken near the outlet on October 20.
76. *Gadus callarias* (Linnæus). Cod. Recorded by Edwards only in November.
77. *Urophycis tenuis* (Mitchill). Hake. Reported only in November by Edwards.
78. *Urophycis chuss* (Walbaum). Squirrel hake. Mr. Edwards reported 16 of this species taken in various parts of the pond in October, but none in November.

79. *Paralichthys dentatus* (Linnæus). "Summer flounder." Only 6 of this species taken in October, all at the upper end of the pond; again listed in November.
80. *Paralichthys oblongus* (Mitchill). Four-spot flounder. Apparently not numerous.
81. *Pseudopleuronectes americanus* (Walbaum). "Winter flounder;" "flat fish." Abundant everywhere both in October and November.
82. *Lophopsetta maculata* (Mitchill). "Sand dab." In October 60 were taken, 35 of which we caught at the outlet on the 20th; others were obtained in November.
83. *Platophrys ocellatus* (Agassiz). Specimens about 2½ inches long were caught on October 4 at the upper end of the pond; others were taken October 16 and 20. Jordan & Evermann give the range of this species, "Western Atlantic from Long Island to Rio Janeiro, on sandy shores." The only other record of its occurrence north of Florida seems to be that of Bean, who collected 2 small examples at Fire Island Inlet Beach, Great South Bay, Long Island, Sept. 30, 1890.
84. *Achirus fasciatus* (Lacépède). Hog choker. Only 9 of this species taken, all on October 5 at the upper end of the pond.
85. *Gymnachirus nudus* (Kaup). Naked sole. One specimen taken on October 20 near the outlet. The only previous record of this species is the original one of Kaup,[1] who, in 1858, under the name *Gymnachirus nudus,* described a scaleless sole from Bahia, Brazil, making it the type of a new genus.

The report of Arthur Merrill, superintendent of the Sutton hatchery, follows: —

To the Commissioners on Fisheries and Game.

I herewith submit a report on fish-cultural work and general improvements at the Sutton hatchery.

At the end of 1909 the collection of eggs for hatching the present year was very satisfactory, the number being nearly 900,000, — the largest amount ever secured here. They were of superior quality, fertilization being unusually good. There was no loss traceable to diseased ovaries, which sometimes has a noticeable effect on the quality of the eggs.

There were 610,000 eggs taken from the adult trout in the large pond, — only a moderate number for the stock of fish in the pond, owing to an excess of males; 150,000 eggs were collected from yearling fish, a smaller number than usual because of the smaller spawners. The brown trout yielded 130,000 eggs, an increase over 57,000 taken the previous year, made possible by using the pool below the dam to increase the

[1] Uebersicht der Soleinæ der vierten subfamilie der Pleuronectidæ (Weigenmann Archiv für Naturgeschichte, I, p. 101, 1858).

stock of breeders. The brown trout in this pool do not yield as heavily as the plumper ones in the pond, but their eggs are fully as good.

At the end of the spawning season the surplus males were sorted out, and nearly 1,100 were liberated in suitable lakes and rivers. The yearling spawners were wintered in the upper pond, and were put in the main pond the next spring, when two years old, but being small the loss from cannibalism was rather heavy. This loss has been an annual experience, but it seems unavoidable when it is necessary to mix two-year-old fish with larger ones, although when the runway system below the dam is completed it may be possible to grade the fish so that the loss will be much reduced.

No eggs were sent away during the winter, and the increased number taken made the number for hatching nearly twice what is usually retained, while the water supply remained the same, and at the time of greatest need, when the embryos were developing, just previous to hatching, was only 1 gallon per minute for 200,000 eggs. The normal flow sought for in hatchery construction is 1 gallon per minute for 25,000 eggs.

As the eggs developed and required an increasing supply of oxygen, the effect of this scanty flow was to partially suffocate them, in the lower troughs even to kill them outright, large numbers showing the dead trunk of the embryo in the otherwise normal appearing egg, diagnostic of suffocation. The loss of fertilized eggs was very heavy up to the time of hatching, after which, while the fry subsisted on the yolk sac, which is the easiest period of their existence, nothing unusual happened except an outbreak of gill inflammation, which was easily checked by the use of salt. But at the beginning of the period of feeding and growth there was a widespread development of "weakness," and in all the ponds and troughs, without exception, heavy losses followed, ultimately reducing by 50 per cent. the stock of fingerlings reared from the number the year before. The rearing troughs, which normally carry an excess of fry to restock the ponds and distribute advanced fry in June, were so depleted that the use of half of them was discontinued.

No such widely extended loss of fry ever occurred before, and it can only be assumed that it was brought on by an overcrowded hatchery.

An account of the development of this hatchery and its water supply has been given before, and the deficiencies that make it dangerous and unsatisfactory were pointed out, with recommendations for improvement. These recommendations, which are repeated, are, in effect, that the present building be given up, as it is in such a state of decay that repairs to keep it in existence would be wholly disproportionate to any value that it can have. It is unsafe for hatching, as in every year of its operation incipient cases of fry disease have appeared. —

several times causing heavy losses, — which might at any time lead to an extensive epidemic.

Brown trout fry to the number of 60,000 were distributed in rivers suitable for them, and 400,000 brook trout fry were put in brooks. The rest of the brook trout were reserved for rearing, and under normal conditions would have been sufficient for filling all the ponds and distributing 50,000 to 75,000 advanced fry in addition, but this expected distribution was not carried out, owing to the loss of the fry intended for it. The brown trout fry did better than the brook trout fry in the upper rearing troughs, but in such cold water they never make a satisfactory growth. In the lower ponds, where the brook trout cannot live, the results with brown trout were comparable to the results with brook trout in the spring-fed ponds.

The health and growth of all the trout were very satisfactory after the feeble ones had been eliminated, the only further loss occurring in the west ponds, where the same trouble often happens, and in this case was due to long-delayed distribution. The number of fingerlings raised and distributed was 76,000, — 12,000 brown trout and 64,000 brook trout.

Some work of improvement was accomplished, being limited to what could be done permanently. On the brook the work of concreting was extended up by the hatchery, the whole forming a very useful runway for the yearling spawners. As a harder bottom was reached the newer part was of solid concrete instead of concrete slabs. At the point where the change was made a concrete arch bridge was built across the brook. The continuation of this work was planned so as to replace the decayed wooden pens that extend up to the dam, and in the other way, with a concrete channel that would also serve as a runway where the waste water from the dam flows down.

For the purpose of developing a new water supply that could be used in the present building or in the new hatchery, the area to the south of the brook, in the large hare pen, containing a great number of small springs, was ditched, the mud thrown into banks and covered with gravel, 400 feet of field tile laid, the joints covered with screened pebbles, and the whole graded over with gravel. The water was conducted into a concrete settling tank, with underdrain for cleaning, and a 4-inch vitrified pipe, with cemented joints, laid to the old hatchery pipe at the quail pens. This pipe will be laid through the pens, when they can be emptied of birds for the purpose of doing the work, to the site for the new hatchery. At the upper end of the collecting drain a connection was made with the brook, which here receives its main supply from near-by springs, and an additional supply provided for in seasons of low water.

The barn was raised 16 inches and brick underpinning laid on three sides, wood and concrete being used on the fourth. This work increased the head room, which before was insufficient for any person to stand erect, so that the whole could be used for work or storage, and made it practicable to make a concrete manure pit and floor, so that the last difficult hiding place of rats was destroyed.

Some attention has been given to the grounds each year in making general improvements, and this was continued, including considerable tree and brush cutting, grading where work was done on the ponds, seeding and propagating beds for shrubs desired in bird work, and blowing out stumps and grubbing to get more open ground. Large quantities of loam used in bird pens were utilized in grading the brooder ground along the road at the barn, and on the terraces at the pond.

To the recommendation made for improvements for hatching, needed on account of the unfitness of the present building for that work, it might be added that proper facilities for handling, sorting and penning up fish, incidental to the work of spawning and shipping, are also needed. At present this is done without any conveniences planned for the work, and from lack of protection in inclement weather is subject to interruptions and serious delays.

These improvements, if carried out as suggested, would provide that all this work would be done at one place, with equipment adapted for the work. In addition, the opportunity would be given to carry on some desirable experimental work, also to co-operate most advantageously in studies of fish and fish diseases.

The recommendation for a road owned and controlled or fenced by the State, that has been made several times, is repeated, for the need of this improvement seems more urgent than ever to end a condition which is not very creditable. Passage to or from the grounds is inconvenient on account of obstructions and detours, dangerous at times on account of the cattle and sometimes bulls, and unduly expensive in the time spent in keeping a clear passage through the field when this is necessary.

The plank pens below the dam, seven in number, are in various stages of decay, some being so nearly rotted out that they are of little further use and of such small value that they might well be discontinued; but those lying below, and receiving the overflow from the dam, are useful for rearing, and very necessary for handling the spawners that are run into it when the pond is drawn off. Concrete could be easily put in as there is an ample filling of stone and gravel to build on. Building narrower pens in pairs, getting six in place of the present three, would give more useful pens, and the extra ones would replace the three north of the hatchery, that could be filled in instead of being rebuilt. The work of rebuilding these pens would include the enlarging and concreting of the pool below the dam, that is so useful for holding the breeding brown trout. For the channel to carry the waste water and serve as a runway for yearlings, the concrete slabs that are in use, with entire satisfaction, farther down the brook are recommended, with a heavier slab to cover and hold them in place, instead of the chestnut frame used down the brook.

The water supply for the house is at present very uncertain, because the hydraulic ram pumping it is worn out and gives a small and interrupted supply. The supply was never satisfactory because, being drawn from the pond after being used for fingerling and brood fish rearing, it was unfit for culinary purposes and for drinking. The expense of maintenance has always been excessive because the water carries, as a heavy sediment, the mud of the ponds stirred up by the fish, and this by constantly clogging the pipes and deranging the working of the ram required frequent cleaning and repairs. With the improvement in the hatchery carried out, an opportunity would be given to replace the ram with a pumping engine or motor, and substitute the water used in the hatchery for the unfit pond water.

A cook house, for use both in fish and bird work, is very desirable, as with it changes in the details of feeding could be carried out that would make possible the use of less expensive material, and substitute cooked for the less safe raw food. Such a house appears to be an inseparable part of the equipment where any extensive bird work is carried on, and is a valuable aid in preparing food for fish, especially in seasons when there is a scarcity of meat.

Except for the permanent improvements on the buildings, ponds and grounds, the relative importance of the work on fish or birds, as measured by the cost of supplies and attention given, indicates that the operation of the fish hatchery requires not more than two-fifths of the whole, which for the present year was about $4,600. The cost of the improvements is estimated at $900, the most important items being $80 for the refrigerator, $115 for the work on the barn, $135 for the new water supply, and $270 for the concrete work along the brook. The labor and miscellaneous supplies cannot be exactly apportioned, but while it is known that the greater part of the teaming and carting was on fish account, the greater part of the labor, lumber, hardware, oil and food was for the birds, amounting, for the food alone, to $500 for grain and meat for the birds and $250 for fish meat.

A division of labor cost is more difficult, for hardly two days are alike, but the hours generally run with an excess given to the birds, especially in the season of the greatest amount of work.

The estimate of three-fifths of the expense for bird work, which is approximately correct, would, if applied to the cost of routine work, make the cost of rearing birds $2,400, and the cost of fish $1,600, excepting only the principal items of permanent work.

The cost of labor is increased by the eight-hour day law, and, as has been reported before, this is greater than the difference between ten and eight, for the day's work cannot be compressed into eight hours, running, as it does, through a considerable part of the year to ten, twelve or fifteen hours, and the supply of labor sufficient to accomplish what is needed to be done cannot be economically spread over a day of that length, even if it can be furnished.

Changing conditions have increased the average cost of labor to 24 cents per hour, and it is still necessary to do with temporary day labor much of the work that will only yield the best results when done with a considerable degree of skill and intelligence.

With the increase of the present work that is expected, and the added problem of doing experimental work in breeding ducks and the European gray partridge, it is an opportune time to seek a class of assistants who will regard highly the privilege of study and observation that goes with the work, and will work with the aim of contributing all they can to the success of the undertaking.

Respectfully submitted,

ARTHUR MERRILL.

Distribution of Fish and Eggs during 1910.

Fry distributed,	925,000
Fingerlings distributed,	133,500
Adult fish put out (white perch),	1,717
Brooks stocked with fry,	151
Applications filled for fry,	163
Brooks stocked with fingerlings,	217
Applications filled for fingerlings,	317
Great ponds stocked during the year,	16
Rivers stocked during the year,	1

Hatchery Expenses.

Adams,	$316 20
Hadley,[1]	371 20
Sutton,[2]	5,930 67
	$6,618 07

GAME BIRDS.

Some of the important facts elicited by our biological experiments and observations incidental to rearing and liberating bob-white may perhaps throw some light upon some causes of disappointing results in the numerous attempts made by sportsmen's associations and individuals to restock depleted covers.

[1] Includes purchase of 200,000 trout eggs at 50 cents per thousand, $100.

[2] Includes purchase of 60,000 trout fingerlings at $15 per thousand, $900, and cost of rearing pheasants and quail.

The most significant cause of ill success appears to be due to lack of knowledge of the importance of the family ties in this species. The family flocks keep together until the approach of the breeding season. We have repeatedly observed that a bird from another flock was received into full membership in the family only after much strife, in some cases resulting in the death of the stranger. In cases where, for example, two flocks were put into the same box for transportation to the place of liberation, the flocks quickly assort themselves when freed, and seek separate feeding grounds. Birds from different flocks usually do not unite into one flock, but wander apart, seeking their old covey companions.

Apply these facts to conditions which obtain in cases where quail are purchased for liberation in large quantities. Ordinarily they are trapped by boys or negroes in the south, a small number being taken from different flocks. These are then taken to the country store, where they are confined with birds similarly taken in different parts of the country. The original flocks are hopelessly mixed. They are taken north and liberated, either in the autumn or long before the mating season. The birds, then, thus liberated, wander off, each seeking its original flock companions. The chances of these birds uniting into coveys of reasonable size are very remote. If they do not so unite the chances with enemies are exceedingly small. We have noted that in instances where a covey was harassed by a cat or a fox the neighborhood of the roosting place was changed nightly, whereas if they were undisturbed they chose the same roosting place repeatedly. The peculiar and well-known manner in which the bob-whites arrange themselves is a great safeguard against prowling enemies, and the safety of any one individual is enormously increased in proportion to the increased size of the flock.

A further complication arises as a result of the temporary confinement of the birds in old chicken coops. Here they are exposed to infection from the parasites, both animal and vegetable, so frequent in domestic poultry, but to the effects of which domestic poultry is relatively immune. Then follow the diseases peculiarly fatal to bob-white, and known under various names, coccidiosis, "blackhead," white diarrhœa, Alabama quail disease, etc. As a result of long confinement may follow lung diseases (either inflammatory or fungoid), digestive or excretory derangements.

The obvious remedy for these untoward conditions is artificial propagation, with the necessary precautions to grow healthy stock and prevent the spread of infectious diseases.

The report of Superintendent Merrill of the Sutton hatchery follows: —

To the Commissioners on Fisheries and Game.

GENTLEMEN: — I herewith submit a report on rearing game birds at the Sutton hatchery for 1910.

This work, which has been carried on with an increasing degree of success, was continued on the same lines as was followed the previous year. We have improved methods where opportunity offered, but are experimenting for the purpose of finding a way to do a far more extended work, with the proper methods so far worked out that the waste in time and expense will be the least possible.

The season's work has shown a most marked advance in the details that have been previously open to question. For some troublesome difficulties, as is the case in all pioneering work, easy solutions have been found; others must be left for future work, with the weight of added experience in favor of a practical solution. Some details of a local nature, relating to the mating, care or hatching of the birds, and constructing coops, have been changed and improved; for others, relating to the scope of the work, more definite recommendations for changes and improvements can be made. On the whole, the results, while quite satisfactory from a practical point of view, are much more valuable in the application of the experience gained in doing more effective work in the future.

A lesson of the season of 1909, near the end of the year, emphasized a difficulty in working with quail that was not fully appreciated before, but which is of such importance that its solution is probably the key to the domestication of the quail. The growth of the young in confinement was very encouraging, but they did not develop the vigor to carry them through to maturity, and when, as in the case of the late summer lots, cold weather overtook them when not fully grown, they became rather easy victims to organic or functional diseases, and even the older lots did not possess strength to carry them through the winter without some loss from lung congestion and nephritis ("bird gout").

The conditions that caused this winter loss undoubtedly affected the breeding lots during the following summer, causing much more loss during the season that they were in breeding pens, and interfering with the gain in prolificness expected from domestication.

The average number of eggs laid was about the same to each bird, a little above 50, but the largest number to a bird was only 84, as compared with 102 last year and 100 the year before. However, several of the most promising layers were lost by death or escape before the season was over.

In the matings the descendants of the hen that in 1908 laid 100 eggs, and the other that in 1909 laid 102 eggs, predominated, largely for the reason that the birds so descended did not suffer the winter losses that the others did, either because they hatched earlier or possessed a greater degree of inherited vigor. The better-laying hens come from these lots and from the old hens left over, but no particular distinction could be noted in the fertilization. In a series of four pens, the birds on both sides being the second generation from the 100-egg bird of 1908, the earlier broods showed exceptional vigor, and the succeeding ones were hatched and reared separately, each comparing favorably with the other lots hatched at the same time, and especially with those that were of more mixed blood or had an infusion of wild blood.

This strain of birds, the longest grown and maintained, was of noticeable tameness, and this was secured without effort to a degree that had been found impossible in the earlier years. In contrast with these the progeny of 4 birds with wild mates were most difficult to tame. Though grown under the same conditions, and given close attention to tame and better fit them for pen breeding, as they were desired for future brood stock, their inherited wildness was manifest, however handled.

The wild birds, though supposed to be of native stock, did not differ materially in size or markings from the pen-grown stock of southern or western extraction. Three of the 4 were hens, and proved fine examples of the adaptability of quail to breeding in captivity. The full number of eggs laid by each could not be credited, owing to the raids of squirrels, they taking some eggs from all the pens, but pen 33 yielded 25 eggs; pen 34, 45 eggs; pen 35, 34 eggs. In all the pens they attempted incubation, but this could not be allowed, as their situation was quite hopeless for rearing young. In pen 34 the hen first attempted to incubate 11 eggs; these were taken away, and in nineteen days she laid and started to incubate 13 more. The wild male was mated with a bird that laid 67 eggs, 65 fertile.

Only 1 female failed to lay, and this failure was probably due to an enfeebled condition, as she died during the summer, much emaciated. Two females died in extruding their first eggs, the only cases of this kind in bird work here.

Fertilization was uniformly good, with one exception, viz., lot 9. Because of some abnormal condition only 33 of the 40 eggs were fertile.

Incubators were used only to finish eggs partly incubated by bantams, but, as several lots so hatched were defective, it seemed doubtful if it was of any advantage to continue, and the most of the later lots were hatched by bantams.

In the report of last year a feeble development of the embryos, causing loss in the shell or soon after hatching, was noted, and measures taken to ascertain the cause. So far as investigated, the cause seemed due in part to the influence of the setting hen on the embryos, and in part, as was shown very clearly in some cases, to the parent bird.

At the beginning of the present season a greater loss indicated that this would be a more serious problem, and some very erratic hatching, the incubation varying from twenty-two and one half to twenty-eight days, in the lots that suffered heaviest loss, rather closely connected this loss with the bantams, either in the manner of incubating or some departure from the proper temperature, airing or cooling. These matters had been under investigation, but no information resulted as to whether any methods used were at fault; and a marked variation in the body temperature of the bantam did not coincide with the varying results in the hatch; but assuming that the irregularities noted in one might in some way be connected with the other, a corrective was tried by constant and frequent changes of the bantams on the nests. They were placed in groups of 3 to 6, and daily each was taken from one nest and shifted to the next. After this was tried few lots varied from the normal time of hatching, twenty-three and one-half days, and better hatching resulted.

Another source of weakness in embryonic development was noted late in the hatching season the previous year, and to quite the same extent this year. This was determined by the record of the hatch under individual bantams, the nest being made up with eggs from two or more quail pens. It was frequently seen that in the same nest the eggs laid by one bird would hatch normally, while the eggs laid by another would all fail. This is well shown in two lots that hatched August 21. In lot 48, 7 eggs had fully developed dead embryos; these eggs came from pen 13; the other eggs, coming from pens 10 and 30, hatched strong chicks that grew up. In lot 50, 10 eggs from pen 32 failed in the same way; the eggs from pens 33, 34 and 35 hatched a lot of normal chicks.

In the case of lots 48 and 50, and others where there has been such a case of similar failure in the product of one bird, the records, so far as they are sufficient, have shown a tendency to weakness through all her progeny.

In the statement of eggs laid and infertile ones tested out, given below, the number of hens that laid the full season is 23, these laying an average of 54 eggs. The others were interrupted, in pens 22, 26 and 31, by the death of the hen before completing laying; in pen 20 the hen was killed by the male. In pens 1 and 7 the hens escaped quite early in the season. Pens 2, 3, 7, 30, 32, 33, 34 and 35 lost eggs through squirrel raids. The pens were numbered when laying began, but six have no records. In pens 4 and 6 the hens died laying their first egg. In pens 5, 23 and 25 they died early, without laying; in pen 24 they died late in the summer, without laying.

The first nest building was started by the old females in March; the first egg was laid in pen 5 by a young hen; the last eggs were laid early in September. In pen 11 the hen ceased laying in June, the earliest noted in any season.

The whole number of eggs laid was 1,384; broken in collecting, marking and handling, 15; sent away, 23; infertile, 131; broken or missing under hens, 115; fertile, but failed to hatch, 187; dead chicks under bantams or killed by them, 77; hatched apparently in normal condition and put in rearing boxes or brooders, 837.

About 140 of these chicks were deficient in strength at the time of hatching, and all quickly perished. Of the 700 that hatched in normal condition, 400 grew to the age suitable for liberation, *i.e.*, one month or over; and 171, varying in age from five weeks to five months, were liberated on reservations or land closed to hunting, where they would be cared for; 11 were liberated on the hatchery grounds, and 6 that escaped were permitted to remain with them.

The loss of birds over the age of one month was more general throughout the season, and more from incidental causes than the specific diseases that previously caused the heaviest losses. The bacillary infection accounted for the loss of 39 and nephritis (or "bird gout") for about 60, but this last loss did not parallel the loss from the same disease last year, for it came later in the season and from younger birds, — some September-hatched lots that did splendidly for the first four to six weeks, but had not sufficient hardiness to withstand the cold weather that came later.

Pen Number.[1]	Eggs laid.	Tested out, Infertile.	Pen Number.[1]	Eggs laid.	Tested out, Infertile.
1, ...	5	5	19, ...	48	9
2, ...	66	14	20, ...	29	2
3, ...	52	1	21, ...	42	-
7, ...	12	-	22, ...	45	7
8, ...	12	4	26, ...	28	-
9, ...	40	33	27, ...	45	5
10, ...	49	3	28, ...	83	-
11, ...	31	3	29, ...	37	7
12, ...	72	7	30, ...	71	2
13, ...	69	4	31, ...	33	2
14, ...	47	2	32, ...	67	2
15, ...	70	1	33, ...	25	3
16, ...	79	8	34, ...	45	3
17, ...	59	2	35, ...	34	1
18, ...	29	1		1,324	131

[1] One pair in each pen.

Fixed methods in rearing were not considered as established by any previous work, but not much change was made this year, as the data for anything radically different were not sufficient, and it was recognized that the experimental work necessary to determine finally the maximum results that could be secured with a practical equipment and supply of labor was a greater undertaking than could be carried out with the present means; but by such incidental tests as were possible the routine was simplified, and much information gained bearing on the difficulties and failures.

Brooders were used to less than the usual extent, as early in the season less favorable results were obtained, and it was possible that the brooder was responsible; but as the season advanced and it was found that some loss apparently due to brooder troubles was actually due to more remote causes, incubators were used more successfully. The success, however, did not equal that from using bantams. These reared the best lots, and, indeed, the only ones where all the chicks hatched were brought to maturity.

This was the third year in which bantams surpassed artificial incubation, and they were used to such greater extent as to bring out some of their defects as quail rearers. Viciousness, extending to the slaughter of the quail as fast as they hatched, appeared to some extent, but the loss was kept down to a minimum by constant inspection. The attitude of the bantam was often shown before the first chick would leave the shell, the shell being torn open to kill it. In such cases the eggs could be taken away and hatched in an incubator. In two instances the chicks were accepted at first and killed later, and in another the bantam was very solicitous in hovering her chicks, only to eat them one by one at her leisure. Several cases of serious injury that seemed not to be mere viciousness, but acquired habits or tastes, resulted from feather eating. Not less than six lots, all promising, were injured, the one suffering most severely having the wing feathers torn out. The most of the others had their body feathers stripped, but their wings were untouched. In a very exceptional case the chicks, quite young, had their wings torn off. A considerable loss followed, even after the chicks were taken from the hens. Efforts made to check the practice by diverting the hen's attention were not successful, possibly because of the type of coop and shelter box used; these, although generally successful, compel the chicks to enter and leave in front of the hen, through a slatted gate that would not permit the hen to leave, and it appeared in some cases as though the habit originated in the hen's anxiety to assist the chicks to enter by seizing them by the feathers and drawing them in.

Feeding has at various times included practically all kinds of food likely to nourish young birds, but items have been eliminated until it is practically certain that a diet only sufficient in variety for a proper rotation, and not at all difficult to procure, is all that is required. The practice of last year was continued, the food consisting mainly of maggots, sour milk, with shredded wheat, custard, and grain when they desired it. Before the end of the season the custard was discontinued, with no appreciable change in the growth or condition of the birds so fed. At times the maggots or sour milk were omitted, with no noticeable effect; and the same was true whether fed with or without fruit. These trials were not considered sufficient on which to base conclusions, as it was not possible to fully take into account the various influences that might affect the results, but they are of some value as indicating that if carried out thoroughly they would place bird rearing on a more practical basis so far as relates to procuring a proper food supply.

In the work here maggots have been regarded as the most valuable food, and with the arrangements for growing them the supply has been dependable and easily produced. In a noticeable number of cases where maggots were fed so freely that they constituted the main item of the feed, the birds thrived without any check, and it was also noted that the periods of greatest loss from bowel troubles did not coincide with feeding maggots abundantly.

The system of maggot rearing followed is to place fly-blown meat in inclined barrels, and as the maggots hatch and consume the meat to add a fresh supply, putting in dry sandy loam as freely as is required to absorb moisture and keep them covered. If the number of maggots is not large they will grow in the barrel until ready for use, when they will crawl out and drop into a box underneath. If they are crowded they will crawl out before they are grown, and can be fed in the box below. If crowded in hot weather they will heat, sometimes enough to kill them, and when hot they sweat freely, which enables them to crawl up vertical surfaces and escape. At such times dust should be used freely. When grown they are screened into another box and given a liberal supply of fresh sand for scouring, which they do by squirming unceasingly until they change into the pupa stage. It is very necessary to reserve a liberal number of maggots to change into breeding flies, and this is rendered difficult at times by the activity of the agencies that keep flies in check. At times there is an abnormal increase of a small ichneumon fly, a parasite on the meat fly, that destroys them in the pupa stage. The maggots reserved for flies must be covered up to protect them from this fly.

About midsummer a great number of black carrion bugs appear and devour the maggots. These must be guarded against by screening. Late in the summer collecting flyblows is rendered difficult by the appearance of a spotted beetle which eats them, and they are also sought by the yellow jackets which become abundant then. White-faced hornets kill and carry off many flies.

Custard, as prepared for the birds, is about in the proportion of two eggs to a pint of milk and a shredded wheat biscuit, or an equal amount of pheasant meal or bread crumbs. This is a useful food because it is easily prepared, and it is reasonably safe if used moderately. Probably under some conditions it leads to trouble, more especially in birds of weak digestion. It is safer to use it alternately with sour milk curd, which is an excellent food, and appears, when fed, to correct the ill effects from the other foods. Sour milk mixed with shredded wheat so carefully that the shreds of the wheat are not broken is excellent for starting young birds; the two combined make the best possible food, and the birds readily eat the worm-like shreds.

As the birds (quail) grow they show more preference for hard foods, and are little inclined to eat the soft, although at any age they are fond of maggots. Grain then becomes their chief food, and should be supplemented largely by weed seed. The birds can be supplied with green food best by moving them about in portable coops, but with the approach of freezing weather the green food disappears, and with the appearance of ice and snow they have only a bleak and frozen pen, where they spend their time in inactivity, and eat what food is daily supplied them. It is difficult to keep them supplied with dust and chaff, as with the first storm this is wet and frozen, and wet chaff soon becomes a danger. It has been recognized from the first that conditions for wintering are not good, not because of the need of more warmth or protection from the weather, but because of the difficulties in feeding the birds, and the lack of any incentive to exercise. For bettering these conditions large quantities of hay, chaff and cured weeds were collected, and light portable pens constructed, closed in except a part of the sunny side, and filled with chaff and dust. Concealment was supplied by hanging loosely tied bundles of weeds in the corners, as even the tamest birds are in danger of being put in a panic by some prowling enemy or incautious visitor, and knowing a hiding place they will seek it, when without it they would dash wildly about the pen.

In wintering, the large open pens have been but little better than the smaller open ones, so it can be assumed that the pens now under trial, and very promising so far, will be much less expensive, and more easily kept in repair, than the large ones first built. Feeding will be under control, and no excess will spoil through wetting, to do future harm, while exercise can at any time be forced upon the birds by making them scratch for their food.

The diseases to which quail are susceptible were less prevalent, but not wholly avoidable, this year, owing to the continued necessity of using a very restricted area. The outlook, however, is very encouraging for raising quail with a minimum of loss from this source, and it is believed now that the much feared infectious diseases are of less consequence than organic diseases and lung or digestive troubles, the first causing considerable loss among grown or partly grown birds, the last causing the chief loss among young birds.

In 1909 a disease believed to be identical with the so-called Alabama quail disease was very destructive for a period, but its spread was checked, and the ground occupied by the infected lots treated with lime and fire. During the present season this ground was heavily coated with unused loam when a coop was placed on it, an apparently effective measure, for the appearance of the disease this year was in a different locality. First a lot of 15 birds a month old, out by the west gate, was destroyed; next, the same number of half-grown birds on the terraces by the pond. These were the only appearances of the disease west of the pond, where it was prevalent the year before.

Much later in the season, the last of September, the lot of birds reared by the male in pen 29 became infected with this disease, and was soon destroyed. Later, a lot of old birds that had been kept in breeding pens on the same ground became diseased, and died in one of the large pens, to which they had been removed for the winter, making it appear very probable that the disease in both lots had a common origin, and that in the older lot its action was much slower, or that the infection was dormant for a period.

It appears from pathological findings that this disease is the Alabama quail disease, described in Bulletin No. 109 of the United States Bureau of Animal Industry, and it is as rapid and fatal as the disease described there, for in all the lots infected not one bird has survived. The disease has spread through and destroyed a lot in less than a week, and the death of a bird usually follows in about a day from the time that its droopiness denotes that it is sick. This is particularly the case with young birds; those nearly grown and adults may live in a droopy condition two or three days. The adult birds that died in the large pen had a profuse white diarrhœa; this in the other birds was very moderate, and in the youngest very slight. In the young birds all the organs appear normal except where the intestines show the lesions characteristic of the disease, the progress of the disease being too rapid for any discoloration; but this appears in the old birds, and in them the lesions are much more numerous, appearing also on the liver, which is not generally the case with the young. There is no noticeable loss of appetite except in the case of birds that are sick the longest period, and only a moderate emaciation in these; the youngest appear as plump as when growing vigorously.

This disease is undoubtedly a poultry disease, and here evidently originates from poultry, but indirectly. In three years it has appeared in fourteen lots of birds, only five of which lots were raised under hens, and in these lots the birds were from four to seven weeks old, leading to the presumption that if the hens carried the disease it was dormant for a considerable period, or that the chicks were immune for the early weeks of their lives.

It is reasonable to expect a steadily lessening chance of outbreak of this disease with the measures taken against it, such as disinfecting the ground with lime and fire, and abandoning the use of such places as cannot be covered with fresh loam.

The kidney disease — bird gout, which was first recognized in 1909 — has been less prevalent this year, and has been mostly confined to the younger birds hatched in September. These late lots have always been the most difficult to carry through the winter, the use of heat bringing on a chronic bowel trouble and the lack of heat resulting in much loss from lung congestion. The most successful lots were wintered in window cages, — a box with chaff inside and a roomy airing coop outside. The advantages of this arrangement, it is hoped, can be secured in the winter coops under trial.

Several lots of the older birds were moved about and brought into good condition when they showed a tendency to this disease, for its symptoms can be readily noted before there is much damage. The loss of appetite is very pronounced, and the birds move about with a characteristic stiffness which increases until they have no inclination to move, and are then found dead in an attitude of repose. The progress of the disease from the time the symptoms are noted is rather rapid, and although for a time they do not eat much, there is no noticeable loss of flesh. The kidneys vary from their normal color to reddish or yellowish brown, but are more often lighter to grayish, and frequently are quite enlarged. The ureters are filled with a chalk-like material, largely urates normally secreted by the kidneys. These urates are deposited more or less in the tissues, through the body cavity, sometimes to the extent that all the organs are covered, giving them a frosted appearance.

The conditions that would generally be approved for rearing young birds — clean quarters, a proper ration and ample exercise — are necessary to keep this disease in check. Such conditions are easily met in summer, with enough room for work, but in bad or wintry weather the matter is difficult. Here is one of the real problems in quail breeding, to which the utmost attention is being given.

The underlying consideration for producing birds that will cope with the hardships incidental to growing in close confinement is to grow them with a reserve of vigor that will carry them through any difficult period, like an enforced stay in a crowded coop, a bad storm or cold wave, a long period of wintry weather, or the trying changes of early spring. Under the most favorable conditions possible captive-grown birds must compare unfavorably with wild birds, and the deficiency of stamina makes them harder to keep than is often the case with wild birds. This deficiency is manifested in the frequent recurrence of digestive, lung and kidney troubles, a progressive increase of which is a very marked feature in the later hatched lots. The early or mid-summer lots always produce the best wintering birds, the late summer or fall lots the ones most subject to the diseases mentioned, probably in part because the increasing cold of fall retards their development.

It seems very likely that, to carry these late birds through the winter, closed and partially warmed coops will be required, but there is ample reason to believe that they can be grown running free in open ground in the same way that young pheasants are reared, and, as in the case with pheasants, grow more rapidly and stronger. Fed regularly they could be depended on to seek their feeding place in bad weather, and could be recaptured if necessary. Two lots of young birds that seemed at the age of a month to be in a hopeless condition were liberated on the grounds and made a pronounced gain in vigor. They wandered out into the fields, but were back with fair regularity at their feeding places.

Some additional experience with the coccidial or amœbic disease still leaves this infection in relation to bird rearing an unsettled matter. It is certainly very fatal to grouse, producing a disease that in its spread and fatal ending is nearly as rapid as the bacillary infection in quail. In quail we have as yet no case which from post-mortem appearances, confirmed by pathological examination, could be considered to be this infection; or that has caused more than an incidental loss, taking a part of a flock, not being of the nature of an epidemic.

Among many hundred quail reared under bantams, the commonly recognized source of infection, only in four lots was the cause of death found to be the inflammation characteristic of this disease. These four lots were watched very carefully, and the highest loss in any one was 3 birds. All four were kept under observation for many weeks after the losses, and continued in the pens with all evidence of good health.

The importance of infectious diseases, as compared with other agencies, in causing loss of very young birds has never been properly estimated, being a more technical problem than could be worked out here, unless with the aid of a skilled pathologist; but among the young of the ages that have contributed most largely to the death list, no case of infection has been revealed in those submitted for pathological examination. Many died from known causes, but this is not the case of the greater number of small ones.

The character of some of the earliest losses leads to the belief that it results from causes ante-dating hatching. For the early loss is sometimes immediately after hatching, sometimes in a day or two, but is foreshadowed by the weak and stumbling movements of the birds, an abnormal number of cripples, or, as has been noted before, many dead embryos.

In one unusual case a lot of 15 birds died before they were two days old, but all became crippled immediately after hatching. Much of this loss comes before the birds take any food.

Occasionally a lot grows up with no loss; more often there is no loss after the first few weak ones, but rather frequently there is an incidental loss for which no cause has been assigned, but which appears, from such examination as can be given here, to be an intestinal disturbance, as though it were a digestive trouble, and this loss runs most heavily in what would be called unthrifty lots. The use of lime water has been recommended and tried for this, apparently with good effect. In the case of some lots of pheasant the effect was certainly very pronounced.

Loss of the same character, and to considerable extent, is regularly met with in young pheasants reared under hens or in brooders, even when the brooders are most thoroughly sterilized, but it is far less where the chicks have unrestricted range when growing. Where this cannot be followed, improved methods, more careful attention and timely treatment, when proper treatment is known, must be looked to for lessening this loss. To know more thoroughly the extent and effect of the more important infectious and organic diseases is the most necessary step to take.

Many incidents in quail life are interesting as bearing on their domestication, and some of the difficulties encountered in their care are well worth noting.

In pen 20, after the hen had laid 29 eggs, she was found dead, with the marks characteristic of violence done by one quail to another; her head and neck behind were stripped of skin and flesh to the bone. The birds had mated and the eggs were well fertilized, 27 out of 29 being fertile, and nothing had occurred to disturb the relations of the birds except taking the eggs away. While this is believed to have excited the male to attempt incubation himself several times, no case has occurred where it has been suspected of exciting him to violence. In three other cases where the hen has been killed it was done soon after the birds were put together, and seemed to be on account of the disinclination of the hen to mate. Many more cases have occurred where a strange bird has been put in with a flock. The desire to join a flock is very strong in a lone bird, but he is not always well received, and is in much danger unless the pen is large enough for him to keep apart and establish acquaintanceship by degrees. So far it has seemed entirely safe to unite flocks of nearly equal strength; this has been tried repeatedly and no inclination to quarrel shown.

In nine instances, with a total of 102 eggs, one-fourteenth of the whole, the parent birds attempted incubation, although the opportunity was given them to incubate the greater number. In several instances they abandoned well-filled nests, the eggs left to tempt them to set, and started others. A nest with 20 eggs was so well concealed that it was not found until 14 were laid in another nest. The grass roots were attached to the oldest of the 20, and some must have lain over forty days, but only 1 was infertile and none of the fertile failed to hatch.

One female in the large pens hatched 8 very active chicks, but kept them only a few days. As in many other similar cases they quickly disappeared, this being the invariable ending when they have been allowed the care of the young in the large pens, while they have been always successful in their care when kept in the brooder pens and the chicks fed the same as the brooder and hen reared chicks.

In four pens the eggs were taken from the parent hen when it was plainly unsafe to allow them to attempt rearing where they were kept.

Two cocks successfully incubated eggs, and in neither case was the hen seen to set on the nest. One continued to lay until the cock was covering 17 eggs, which he did very well, but after hatching his brood he escaped while being transferred, and she reared them. The cock remained about for several weeks and successively adopted several half-grown young that escaped from the pens. In the other pen the hen also continued to lay, but as the cock would not allow her near the nest, she dropped her eggs as near as she dared, and he rolled them in. His objections to her presence in the pen seemed so likely to result in violence that she was removed for safety. He hatched 11 chicks and reared all but 1 to nearly full size. This one came from one of the laid-in eggs, four days after the others.

In pen 2 a pair made an unsuccessful hatch, probably for the reason that, although the nest was in grass near the middle of the pen, it was badly infested with mites or spider lice. Both birds were removed to small brooder coops, and each given a brood of bantam-hatched chicks, which were adopted and successfully reared.

The constant menace of rats about the pens has made it necessary to wage an unceasing warfare against them. The damage that they have done has never been great, but has been such that it was seen that little could be accomplished without keeping them down, and the real burden of their presence has been in the cost of fighting them, and in the restrictions that their presence has placed upon handling the birds. Last year they killed 8 young and 15 grown birds, but took no eggs, as the breeding pens were remote from their haunts. This year no damage was done, as the warfare against them during the winter was so effective that only three were known to survive the winter.

Several years' work about the buildings and ponds in putting in concrete rat-proofing had so restricted their hiding places that those not killed by shooting, traps and poison, were killed or dislodged by the use of carbon bisulphide. At one place where their extensive runs under the pheasant pens and maple trees east of the hatchery made this ineffective, and they were disinclined to take poison, they were forced to take this by putting it in their holes and sealing the entrances with frozen mud. Others appeared in the spring, but did not become numerous or bold, or do any damage except where a lone one went to some distant pheasant coops and killed some young birds.

Early in the laying season the lessening yield of eggs, and the presence of some shells indicating that something was destroying them, led to setting traps, and in three widely separate places where eggs had been missed squirrels were captured, — red squirrels at one place and chipmunks at all three, about a dozen in all. The loss ceased, and the yield continued at the same rate as before the interruption. Assuming that it would have been the same the whole time, the number taken must have exceeded 40.

No case of destroying eggs or young birds has been proved against mice or shrews, but they are regarded as a serious pest, as, under the protection of the pens, they multiply enormously, disturbing the birds and eating great quantities of their food. Where coops are placed on ground possibly infected, and filled with loam to safeguard the birds from this infection, the precaution is sometimes defeated by the extensive tunneling operations of the mice, where the under soil is brought to the surface.

Traps have never given satisfaction, but poison is usually quite effective, as the mice will eat it freely, even where other food is about, and they seem to have little of the caution of the rat. One peck of grain, a pint of molasses and one-eighth of an ounce of strychnine, with enough hot water for mixing, make a satisfactory mixture, and, dried after mixing, will keep to be used at convenience. For mice this is placed in dishes in any concealed place where the mice will find it, but for any open place, where safe concealment is not possible, it can be used with safety in a rainproof box in a dish or compartment in one corner, the entrance for the mice being an inch auger hole in the other corner, with many obstructions to prevent a direct passage across the box. These boxes are useful for protecting shrubbery and trees during the winter, without danger to seed-eating birds, when bird work through the summer has caused an abnormal increase of mice.

While some open-top rearing coops were being tried, a loss, small but unaccountable, was noted, when a blue jay was seen carrying off a young bird; later he took another one, and being followed was seen to eat it. Traps baited with dead birds were robbed repeatedly by him before he was finally caught.

As for the details of breeding and rearing, no specific recommendations need be made, as changes and improvements must be worked out by experience, and the best methods determined by a longer test of practice. It is suggested that these details might be quicker settled and regarded as more nearly fixed if they could be made the subject of a scientific study, with approximately the thoroughness of experiment station work.

For the expected extension of the work it is believed that nothing will prove more practical than to do it on a much larger area, where the methods of the game farm can be used; namely, to rear the birds in open ground, depending on widely extended work and use of fresh fields to secure immunity from disease. This would, of course, invite constant loss from predatory enemies, and the measure of success would depend very largely on faithfulness in guarding, but with this reasonably well done the loss would hardly exceed that loss which seems inseparable from the exclusive use of pens.

The use of a small area and portable pens seems capable of accomplishing a great deal more than was hoped for in the beginning of the work. The experience of three seasons is most decidedly in favor of the small pen for breeding, and the one most likely to promote successful rearing by the parents. These small pens are very satisfactory in getting the birds to a suitable age for liberation, but beyond that the pens require an excessive amount of labor to shift and fill with loam and seed, — when it is necessary to do this, and if this is not done, disease and feebleness are invited.

If the birds are liberated young some measure of control over them should be exercised, so that care can be given if needed, and it is suggested that in addition to using public reservations, sanctuaries could readily be established in many of the deputy districts by the voluntary posting of a group of farms, so located that they would include good quail country and be under the observation of the deputy in that district, who could supervise guarding and feeding the birds when this was necessary. In whatever way this work may be provided for, it is not less important than successful rearing, and is very necessary to supplement and make that work effective.

In comparing quail rearing with other bird work, it is found that so far as it has progressed the results with quail are superior at every important point to similar work that has been done with grouse. Quail can be mated and bred far more easily, they lay more and better fertilized eggs, and their chicks have greater resisting power to the diseases to which both are subject.

Against the long-established work of pheasant breeding, only limited experience with quail can be offered, but in the two years that a fair comparison can be made, the results with both are very nearly the same.

In 1909 the pheasants averaged 60 eggs, the quail 55; in 1910 the pheasants 50 eggs, the quail 54. The percentage hatched in 1909 was slightly less than 50 per cent for both; in 1910 55 per cent for pheasants and above 60 per cent for quail. To the age of one month, very soon after which either bird can be liberated, each hundred eggs yielded 22 pheasants and 25 quail in 1909; this was increased in 1910 to 27 pheasants and 30 quail from each hundred eggs.

While it is known from the work of other years that the results with pheasants can be improved, no improvement with them can be conceived that cannot readily be equalled with quail.

Experimental work was continued with grouse, confirming to some extent the conclusions previously reached, that while they can be bred and reared in captivity quite readily under certain conditions, limitations on this work, arising from their nature and susceptibility to disease, make it seem improbable that they can ever be the subject of any extensive breeding and rearing operations.

Two lots of birds from broken-up nests arrived so chilled and weak that they died almost immediately after being received. Another lot, from a nest where the old bird was killed by a dog, and a lot of eggs hatching 13 chicks from 13 eggs, gave two fine flocks that were easily grown to the age of six weeks on a diet of maggots, custard and sour milk, and at that time were in such vigor that the growth of all to maturity was more than probable.

They were brooder grown, with the usual precautions taken in sterilizing brooders and coops, and in the use of soil in the coops unexposed to infection, but being grown in proximity to other birds they became infected and quickly died from the amœbic disease. Continued success with quail lots on the same ground and in the same brooders followed, indicating that the problem with grouse, already shown to be easy in regard to food and care, should, in consideration of the danger from disease, be done wholly apart from any other bird work.

The breeding of the mature birds on hand, 1 male and 3 females, was undertaken in the quail-breeding pens without success, none of them showing any inclination to mate. The presence of the male put the females in a state of fright that they did not get over during the time they could be watched, although he was not as savage as any previously used. He was wholly indifferent to them at first, but after a time showed an inclination to attack them. Finally, when it seemed unlikely that mating would be accomplished in the small pens, all 4 birds were put in the large pen of two acres, where in a brief time 2 were found nesting. The third female remained in hiding most of the time, but if she nested her nest could not be found.

Twelve eggs in one nest failed to hatch, as all were infertile. In the other, 4 were fertile and hatched, 5 were infertile. The chicks were left to the old bird to rear, but she was not very successful, as the last one was found drowned when three weeks old. The eggs were somewhat smaller than those from wild birds, and the chicks were possibly deficient in strength, as the chick found drowned was much smaller and thinner than those of the same age in the pen-grown lots.

The work with pheasants gave about the same results as were obtained last year. The brood stock was reduced from 75 to 63 laying hens, and the eggs were proportionately less, numbering 3,300. Some obtained by exchange increased the number set to 3,650. The hatching was better, about the same number of chicks being obtained from a lesser number of eggs, the improved results being due, in part, to the more limited use of brooders. The number distributed was 696, a moderate increase over the number put out the year before, but the brood stock was largely increased in anticipation of an extension of the work, making the total number reared 770. This increase is partly owing to sending the birds away at a younger age, but does not include a considerable number that escaped when well grown and were not recaptured.

The work was necessarily done on the same ground, with nearly the same methods, brooders being used as they could be spared from other work. The majority were reared by the open-ground method with hens.

The results varied. The variation followed the season somewhat, as in most of the previous years, the early lots suffering more from cold weather. During the period through June to the middle of July the best results were obtained, because of most favorable weather conditions; following this there was an increase of digestive troubles, with additional loss because of the various enemies that were attracted by and preyed upon the young birds.

Excellent results were obtained from lots put out in the sprout land to the west, where the trees were small and scattered, the underbrush thick and the soil dry and sandy. About 500 poults were put out here, and all the successive lots grew very satisfactorily until the oldest were nearly ready to put out, when they were discovered by hawks, and it was so difficult to guard them that they were brought in. Several lots were put in the garden and shrubbery, and here the best results were obtained, for they could be easily guarded until ready for liberation, and the number kept there was not so large that they were crowded. Of several lots placed for special purposes, one lot kept a considerable area in corn free from weeds, and seemed to find the best shelter possible under the growing corn. Another lot, in a shrubbery bed, was very well sheltered under the shrubs and roses, and found an abundance of tender green food in the weeds growing in the shade, when all the fields were dry and bare. On a plot of ground not previously used for birds, on account of receiving the cleanings from the henhouses for several years, a lot was placed and given lime water freely, they also having the benefit of a rank growth of garden vegetation; this lot was in health and growth far above the average of the birds at that time. Two lots were placed in the sprout growth on the south boundary, but did not thrive, largely on account of being on a northerly slope and getting little sun, the weather being cool and cloudy when they were first put out. Here, as in the sprout land to the west, hawks gave trouble. Working under the low growth, and rarely beeing seen, they carried off many birds. To control them in such a situation some one should be on the ground practically all the time, and pole traps set about in large numbers.

All of these lots did well or fairly, none could be considered poor, and the poorest results came from being placed in a faulty situation. The watering and feeding required three to five brief visits a day; extra time was needed to treat them for lice or to watch for hawks, and occasionally to shift the coops. As compared with brooder work the labor was decidedly less, and while the percentage reared might average less, the birds were of better quality.

On account of the well-known disadvantages of working on a restricted plot of land, and the incidental injury to the other bird work done on the same ground, it is urged that it would be practicable to do the pheasant rearing in the way that these detached lots have been cared for, but wholly in large colonies outside, and in such a scale that it would be profitable to keep an attendant constantly with the main colony, with lesser colonies within easy guarding and working distance. The season for this work would cover a period of less than four months, and the equipment required would be light and easily moved to another place for the next year's work.

The production of eggs on a large scale can be carried on with reasonable certainty of getting a stated number of good quality, and this number can easily be made to exceed the capacity of a considerable tract of land for rearing. As applied here it might be said that, without materially interfering with the largest amount of rearing that could safely be done, a surplus of many thousand eggs could be produced. These, distributed among interested parties to be hatched, reared and liberated, would largely extend the work, with a very moderate increase of equipment, while affording people who most strongly desire to have their neighboring covers stocked an opportunity to assist in the work. It does not require more than ordinary care to raise a fair percentage of pheasants, and while to do as well as this is to some extent dependent on opportunity or conditions, aptitude for the work is of most importance, and where this is shown in working with pheasants, it will be available for the more important and popular work with quail.

If the place selected for this work is free from preying enemies, or can be guarded with guns or traps, small coops to house the hen and poults for the first few days are all that are required. After the chicks learn the call of the hen they can be allowed a free run, with no danger of straying away and slight chance of any serious epidemic. Where coops are used, and they are grown in confinement, the danger from disease is far greater, and it is of the utmost importance to work on ground not used by poultry; but where this is impossible there is no more practicable way than to use a filling of untainted loam each time the coop is used.

In the present uncertain state of pheasant rearing it might not be appropriate to recommend any extension requiring costly equipment which might soon become useless for that or any other work. But if it is continued, even temporarily, and done with proper effectiveness and economy, more breeding pens must be provided to secure the desired increase of eggs and to improve their quality.

As some of the most useful quail pens were built and formerly used for pheasants, there seems to be no reason why the pens desired for pheasants cannot be built with the intention of ultimately using them for other birds.

There is a probable advantage to be gained in pens of different types, one of which, the movable, would be most useful in adapting to other work, and is the best in many respects for breeding pheasants; another, built to cover more ground, but with open top, and used only in the breeding season for birds with clipped wings, would give the required room with less expense, and could occupy ground too rough to be used in any other way.

Besides the larger production which it will give, more pen room will make it possible to handle the birds more effectively in many ways. This year a persistent egg-eating habit reduced by many hundreds the number of eggs collected. It was corrected by putting the birds practicing it in movable coops on grass, and as a rule they quickly ceased. Feather eating, leading to the killing of several birds, was stopped in the same way. This experience and the evidence before obtained have shown that, besides saving this waste, an increased yield and better quality of eggs have resulted when the birds were given room, fresh ground to scratch and green vegetation to eat.

Respectfully submitted,

ARTHUR MERRILL.

Birds distributed during 1910.

Pheasants distributed,	696
Applications filled,	72
Quail distributed,	182

ENFORCEMENT OF LAW.

It is unfortunate that there are many people who feel that the various State boards and commissions are bound to serve exclusively the particular classes with which each comes most closely in contact. On the contrary, every commissioner, if he seeks to deal conscientiously with each problem which comes before him for consideration and decision, must primarily seek the interest of the whole State, to the complete exclusion of every special interest, geographical section or group of individuals. Too frequently membership in a secret order is used upon the commissioners or their deputies as a lever to secure special privileges or exemptions.

So far as concerns the work of this commission in its relation to the sportsmen, the conditions are peculiar. There are exceedingly wide variations between the sportsman of the best type and the opposite. The one is a conservative conservationist, the latter is a vandal in nature's temple, "a sworn foe to sense and law," whose creed is to selfishly appropriate to his own uses the fish and game to which future generations have a just claim.

Several of our laws, notably those relating to the sale of game and to the killing of "short lobsters," are impossible of enforcement in the present conditions of public sentiment. Not until actual extinction is really imminent will the persons most interested realize that the various species have not gone to some other section, to return "next year" in its former abundance, but that new conditions introduced by man (*e.g.*, forest fires, destruction and cutting of the forests, excessive killing) and new enemies (*e.g.*, cats and dogs) have been responsible in largest measure for the passing of some of our most valued species of birds, while unwise methods of capture, excessive fishing, destruction of breeding grounds and pollution of public waters have contributed to the decrease of certain fish and shellfish.

In connection with the increased number of deputies, our records indicate that there has been a decreased number of violations of the fish and game laws. Knowledge that the chances of detection are multiplied has exercised a restraining influence upon would-be violators.

Deer. — Deer have become a real problem. Economically we have large uninhabited areas well suited for producing an annual crop of these valuable food mammals; indeed, such land can produce little else. However, the utilization of this crop is a knotty problem. The average citizen doubtless would be gratified at the opportunity of an occasional glimpse of the beautiful animals. Unfortunately, however, the deer is no respector of property rights, and while many landowners cheerfully permit the destruction of crops, fruit trees, nursery stock, etc., in exchange for the æsthetic and sentimental pleasure afforded by the presence of the deer, this pleasure proves to be a luxury too expensive for the generality of landowners and farmers. It has become a serious problem how best to reconcile the varied interests of the citizen of leisure, the farmer who must needs protect his crops and the hunter who seeks recreation in the hunt, and yet at the same time to protect from lawbreakers a valuable asset of the State. (It has been estimated that there are about 8,000 deer in the State, valued as food and hide at $25, or a total of $200,000.) Under the present law, which permits killing deer in the five western counties except on posted land, and enables the landowner who so desires to kill deer at any time when in the act of damaging crops, about 2,000 deer were killed, or approximately 25 per cent. of the estimated total number. Under most favorable conditions the annual increase is considered to be 75 per cent. per year. Our observations indicate that the actual average rate of increase in Massachusetts has been about 40 per cent. per year. It seems, therefore, that the present law reasonably meets the conditions by providing for protection of property, for giving the landowner opportunity to indulge his tastes, by protecting the deer by posting lands, checking the undue increase of the deer, keeping them more closely confined to the wild lands, giving a limited opportunity for hunting, and safeguarding human life by prohibiting the use of rifles. The deplorable circumstances, such as permitting young children to kill, or unsportsmanlike practices which result in unnecessary suffering, can perhaps be adjusted by other means. In succeeding years we do not expect the delirious rush which characterized the first open season for twelve years. On the other hand, the excessive numbers of hunters in the rather small district insured relatively few wounded deer left at the close of the open season, and at the same time instilled a spirit of wholesome caution among the hunters. That no human lives were sacrificed in killing 1,200 deer is abundant cause for congratulation when compared with the results in Maine, Michigan and elsewhere, where rifles were legally used. Some data relative to deer in Massachusetts are included in the report of Chief Deputy Nixon.

That branch of our duties which includes the enforcement of law has been under the direct charge of our efficient chief deputy, W. W. Nixon, whose report follows: —

BOSTON, MASS., Jan. 1, 1911.

Commissioners on Fisheries and Game, State House, Boston, Mass.

GENTLEMEN: — I hereby submit my annual report for the year ending Dec. 31, 1910. I have devoted almost my entire time to office work, where I have worked early and late in my endeavors to keep in touch with the deputies of this department and to better the service.

During the year I have also collected many egg lobsters, details of which appear elsewhere in this report.

When not attending to the work of the office, mostly Saturday afternoons, Sundays and holidays, I have been about looking for illegal feathers in millinery stores, infractions of law relative to game birds, or out in the woods and covers looking for violators of the law.

The office of deputy is a difficult one to fill, and it is the duty of all good citizens to lend every assistance and encouragement. Much good has resulted from moral influence in prevention of violations, and in an educator. Much wanton destruction of fish and game can be stopped deputy who realizes the responsibility of his position can do much to bring fish and game protection into popular favor. He must become an educator. Much wanton destruction of fish and game can be stopped as well as violations of law prevented. The public are easily educated in matters of this kind, if it is put to them in the right light, and if the deputy knows the laws as he should. He should study carefully all new laws in order that he may not only understand the provisions himself, but be able to interpret the meaning to the general public. The proper observance of the fish and game laws depends almost entirely upon the vigilance and good judgment of the deputies of this department. The enforcement of the fish and game laws, however, in regard to the foreign element is about as serious a one as the deputies have to meet. This class is the most persistent and determined not only in violating the law, but in resisting arrest and attempting to evade punishment.

During the year 215 complaints have been received at the office, personally, by telephone and by letter, all of which have been referred to the deputy in whose district the violations occurred. Many arrests and convictions resulted.

A sort of census taken of the hunters on the hunting ground is a new and interesting feature in connection with the work of the deputies. This work has been carried on only a short time, but promises development. Each deputy has been furnished with cards from this office, and has been instructed, when meeting a hunter in the covers, to get his name, the number of his hunting license and the amount and kind of game in his possession, the cards to be returned to this office weekly. This information will be of marked value to the commission, as in this way the commission can keep fairly well informed of the amount and kind of game in different parts of the State, and can intelligently recommend necessary legislation, in addition to furnishing valuable statistics as to the annual production of game. The number of hunters seen on the hunting grounds, and looked over by the deputies of this department for illegal game, was 2,397. The following game was found in the possession of hunters during the open season: —

Deer,	69	Geese,	13
Coons,	2	Woodcock,	41
Monkey,	1	Squirrels,	79
Ducks,	426	Skunk,	1
Quail,	46	Teal,	1
Rabbits,	392	Partridge,	145
Wildcat,	1	Snipe,	1
Fox,	6		

I am of the opinion that the license law should be changed so as to allow nonresidents and aliens who pay for hunting licenses to shoot birds and animals of all kinds in their proper seasons, including deer, as these classes of sportsmen bear their share of the expense for fish and game protection. Also, if nonresidents are allowed to hunt deer in this Commonwealth, it would be the means of bringing in, to our rural population, a large amount of money from sportsmen of other States for teams, camp lodgings, etc.

There will always be individuals who, for their own selfish ends, will risk even heavy fines in their endeavors to violate the fish and game laws, and there are men who still regard game laws as interfering with their own peculiar ideas of freedom in a free country; still, the cause of fish and game protection goes steadily forward, and its friends have good reason to rejoice.

The commission has endeavored, by every means possible, to keep the sporting public and farmers informed as to the law regarding deer. Circular letters have been sent to all newspapers and to each nonresident holding a Massachusetts hunting license and to others interested in the new deer law.

The commission has always found the reporters and newspapers ready and willing at all times to publish matters of interest regarding the fish and game laws, and the thanks of the commission and of the general public are extended to them for the good work they have accomplished.

Bag Limit. — The bag limit should be in the interest of *bona fide* sport, and the limit of game should not be in a season but in a day, as it would be almost impossible to enforce the season limit, whereas a day limit would be relatively easy. The best hunters and all true sportsmen should be in favor of such a law, as it would be in the interest of legitimate sport.

Herring. — Numerous complaints have been made to this office of the taking of herring illegally by Italian fishermen, and many arrests have been made, convictions secured and heavy fines imposed and paid, with no let up on the part of the violators, who make their living by taking herring both outside and inside of the restricted districts. These men work hard for what small amount of money they earn, and will take the chances of arrest for a few herring.

The taking of herring for bait along the shores, and in the harbors and rivers of this State, should be given careful attention, and laws enacted that would be as just as possible to the smelt fishermen, herring fishermen and buyers. The law as it is to-day is not satisfactory to any one.

The seiners or netters, who use large seines for taking herring, sometimes catch more than their boats will hold, with the result that the surplus has to be thrown away, sometimes hundreds of barrels. If allowed to take herring by the torching method, when their boat is loaded they start for the market, and do not take more than they can handle, as they do when seining.

Assaults on Deputies. — During the year three assaults have been committed on deputies of the department, while in the performance of their duties, the most serious of which took place in Fayville, in Southborough, on July 3, at 5.30 A.M., and came near costing Deputy Bemis his life in his endeavors to arrest three Italians who were hunting on the Lord's day in violation of law. While attempting to put the handcuffs on one of the violators he was shot in the face and body by one of the others, with a charge of bird shot, some of which entered both eyes and blinded him. He was able to grope his way out of the woods to the nearest house, about a mile distant, when assistance was summoned. Every effort was made to apprehend the violators, but to no purpose. After a relentless search of ten days and nights, the matter was dropped for a time, since when no clue has been found which could be used to any purpose.

Fortunately the effects were not as serious as at first supposed, Deputy Bemis being strong and rugged, in good physical condition and used to roughing it. After careful attendance in the hospital for six weeks he is able to take up his duties again.

The assault on Deputy David, on October 7, was committed by one of two Italians whom he was arresting for violation of the game laws, and was not of so serious a nature. After being assaulted by one of the Italians and having three ribs fractured, he used force enough to land his man, who, being held in the lower court, was given nine months in jail at the Superor Court, and is now serving his time.

The case of Deputy Tribou was of minor importance. While with two other deputies, arresting a violator of the lobster law, he was held and prevented from offering any assistance to them, but the violator was arrested and fined. The party assaulting Deputy Tribou was put into court also, but was discharged.

Below is given a record of the law enforcement work of the deputies of this department, covering the past ten years. This record shows the number of arrests and amount of the fines; number of permanent and special deputies employed throughout each year; number of aliens arrested for hunting without licenses since the passage of chapter 317 of the Acts of 1905; number of nonresidents arrested since the passage of chapter 198 of the Acts of 1907; and number of residents arrested for hunting without registration certificates since the passage of chapter 484 of the Acts of 1908. Also note the arrests for hunting on the Lord's day.

Year.	Arrests.	Fines.	Regular Deputies.	Special Deputies.			Sunday Hunting.
				Number.	Salary.	Service.	
1900, ...	185	$2,163 00	1	22	$20-$50	1-8 months	44
1901, ...	156	1,588 16	6	7	20- 60	1 month	51
1902, ...	157	1,772 00	10	10	20- 60	6 weeks	57
1903, ...	169	2,452 00	9	3	50- 60	4-6 months	41
1904, ...	265	4,297 00	10	14	40- 60	1-9 months	55
1905, ...	319	4,112 13	14	8	60	2-6 months	78
1906, ...	327	3,311 55	16	9	50- 60	2 months	88
1907, ...	390	3,599 20	14	17	60	2-6 months	69
1908, ...	474	7,353 75	21	18	60	1-6 months	45
1909, ...	421	5,774 50	23	16	10- 60	- -	52
1910, ...	357	3,740 00	30	14	50- 60	1 week-3 months	29

Alien arrested for hunting without license: 1905, 22; 1906, 29; 1907, 42; 1908, 30; 1909, 31; 1910, 29.
Nonresident arrested for hunting without license: 1907, 4; 1908, 1; 1909, 7; 1910, 5.
Residents of Massachusetts hunting without license: 1909, 27; 1910, 37.

Deer. — Chapter 307, Acts of 1907, allowed the farmer to shoot with a shotgun deer doing damage on cultivated land. During 1907 16 deer were shot by farmers. Under this same law, as amended in 1908, chapter 377, 17 deer were shot by farmers. This act provided that the carcass of the deer should be sold by the city or town clerk, and the proceeds forwarded to the Commissioners on Fisheries and Game.

Under this same law, as amended in 1909, chapter 396, which repealed that part of the act regarding the disposing of the carcass, since which time the farmer has retained the carcass, 198 deer were shot by farmers.

Under this same law, as amended in 1910, chapter 545, which allowed deer doing damage to be killed in any manner, 327 deer have been killed by the farmers. These figures speak plainer than words of the effect of this part of the deer law.

Below is given a summary by counties of the number of deer shot, amount of damage claimed by owner, and deputies' estimate: —

County.	Number killed.	Owners' Estimate.	Deputies' Estimate.
Barnstable,	1	$15 00	$15 00
Berkshire,	27	215 00	153 50
Bristol,	-	-	-
Dukes,	-	-	-
Essex,	2	25 00	-
Franklin,	124	1,282 40	859 15
Hampshire,	57	489 50	322 75
Hampden,	45	360 60	172 28
Middlesex,	9	51 00	12 00
Nantucket,	-	-	-
Norfolk,	8	90 00	30 00
Plymouth,	-	-	-
Suffolk,	-	-	-
Worcester,	54	289 00	124 50
	327	$2,817 50	$1,689 18

The largest number of deer doing damage shot by or under the orders of any one person was in the towns of Deerfield, Rowe, Templeton, Amherst, 6 each.

The largest number of deer shot by one person was 10, at Rowe, 6 on his own land and 4 while working for other parties.

The largest number shot in one town was Charlemont 13, Deerfield 12.

Five cases were put into court in connection with the shooting of deer doing damage, as follows: —

One case for using rifle instead of shotgun, chapter 396, Acts of 1909. Convicted; case filed.

One case for not being owner of land. Convicted; fined $25; paid.

One case where no damage was shown. Convicted; case filed.

One case of failure to notify the commission of the shooting. Convicted; fined $20; paid.

One case of not being owner of the land. Case pending, owing to illness of deputy.

Returns of the Open Season on Deer in Massachusetts, Nov. 21–26, 1910, inclusive.

Berkshire County.

	Total.	Buck.	Doe.	Wounded.
Adams,	2	1	-	-
Alford,	6	5	1	1
Becket,	20	10	8	1
Cheshire,	6	3	2	-
Dalton,	1	-	-	-
Egremont,	2	2	-	-
Florida,	14	6	6	1
Great Barrington,	6	3	3	-
Hancock,	11	7	4	-
Hinsdale,	4	3	-	-
Lanesborough,	2	2	-	-
Lee,	3	1	2	-
Lenox,	10	7	2	-
Monterey,	10	8	2	2
Mount Washington,	1	-	-	-
New Ashford,	6	5	1	-
New Marlborough,	6	3	2	-
North Adams,	5	2	3	1
Otis,	6	2	1	1
Peru,	1	-	-	-
Pittsfield,	10	6	4	-
Richmond,	5	5	-	1
Sandisfield,	10	7	1	-
Savoy,	13	6	3	-
Sheffield,	15	6	4	-
Stockbridge,	3	-	-	-
Tyringham,	3	2	-	1
Washington,	12	6	4	2
West Stockbridge,	2	1	-	-
Williamstown,	22	13	7	-
Windsor,	8	6	1	-
	225	128	61	11

Returns of the Open Season on Deer in Massachusetts, Nov. 21–26, 1910, inclusive — Continued.

Franklin County.

	Total.	Buck.	Doe.	Wounded.
Ashfield,	15	7	1	5
Bernardston,	9	8	-	1
Buckland,	23	8	5	1
Charlemont,	9	6	1	-
Colrain,	10	6	4	1
Conway,	15	6	4	-
Deerfield,	18	11	7	1
Erving,	11	5	6	1
Gill,	5	5	-	-
Greenfield,	15	10	1	-
Hawley,	8	5	2	-
Heath,	4	1	1	-
Leverett,	19	11	2	3
Leyden,	7	1	4	-
Monroe,	4	1	3	-
Montague,	19	9	5	-
New Salem,	4	1	-	-
Northfield,	16	8	5	4
Rowe,	18	12	4	2
Orange,	5	4	-	-
Shelburne,	14	7	4	-
Shutesbury,	5	2	1	-
Sunderland,	7	3	3	1
Warwick,	10	4	4	1
Wendell,	13	6	4	1
Whately,	7	2	4	-
	290	149	75	22

Hampden County.

	Total.	Buck.	Doe.	Wounded.
Blandford,	15	11	5	-
Brimfield,	12	11	1	-
Chester,	33	17	11	4
Chicopee,	7	3	3	1
Granville,	17	6	4	-
Hampden,	5	4	1	-

Returns of the Open Season on Deer in Massachusetts, Nov. 21–26, 1910, inclusive—Continued.

Hampden County—Concluded.

	Total.	Buck.	Doe.	Wounded.
Holland,	2	2	-	-
Holyoke,	2	2	-	-
Longmeadow,	5	3	2	1
Ludlow,	21	13	7	2
Monson,	11	6	4	-
Montgomery,	10	3	6	1
Palmer,	24	15	8	2
Russell,	8	3	-	-
Southwick,	17	11	4	2
Springfield,	3	2	1	-
Tolland,	2	-	1	-
Wales,	2	1	1	-
Wilbraham,	24	12	11	2
Westfield,	11	6	2	-
	231	131	72	15

Hampshire County.

Amherst,	5	2	3	-
Belchertown,	16	6	8	1
Cummington,	12	4	4	3
Chesterfield,	9	3	-	-
Enfield,	10	3	6	1
Goshen,	4	3	-	-
Granby,	7	5	-	-
Greenwich,	8	4	3	2
Hadley,	5	2	1	-
Hatfield,	8	5	1	1
Huntington,	20	10	3	1
Middlefield,	17	9	2	-
Northampton,	4	2	-	-
Pelham,	5	1	-	1
Plainfield,	6	5	1	1
Prescott,	7	2	2	3
Southampton,	9	5	4	-
Ware,	21	10	6	3

Returns of the Open Season on Deer in Massachusetts, Nov. 21-26, 1910, inclusive — Continued.

Hampshire County — Concluded.

	Total.	Buck.	Doe.	Wounded.
Westhampton,	11	7	1	2
Williamsburg,	6	1	2	1
Worthington,	10	6	3	-
	200	95	50	20

Worcester County.

	Total.	Buck.	Doe.	Wounded.
Ashburnham,	3	1	1	1
Athol,	17	12	3	2
Barre,	26	12	8	1
Berlin,	1	-	1	-
Blackstone,	3	2	-	2
Bolton,	8	4	2	-
Boylston,	5	1	2	3
Brookfield,	14	5	6	1
Charlton,	10	3	3	-
Clinton,	3	1	-	-
Dana,	10	8	-	-
Douglas,	7	3	1	3
Dudley,	2	-	-	-
Gardner,	2	-	-	-
Grafton,	16	6	7	3
Hardwick,	20	10	5	1
Harvard,	43	23	13	2
Holland,	4	-	-	-
Holden,	10	7	2	1
Hubbardston,	10	7	3	-
Lancaster,	20	12	6	1
Leicester,	1	1	-	-
Leominster,	6	3	2	1
Lunenburg,	21	11	7	2
Mendon,	2	1	1	-
Millbury,	1	-	-	-
Milford,	3	2	1	-
Northborough,	3	1	-	-
Northbridge,	2	1	1	-

Returns of the Open Season on Deer in Massachusetts, Nov. 21–26, 1910, inclusive — Concluded.

Worcester County — Concluded.

	Total.	Buck.	Doe.	Wounded.
Oakham,	6	2	2	-
Oxford,	2	-	-	-
Paxton,	3	2	1	-
Petersham,	8	4	4	-
Phillipston,	9	6	1	2
Princeton,	6	5	1	-
Royalston,	6	4	2	-
Rutland,	11	5	4	-
Southborough,	6	4	1	-
Southbridge,	2	-	-	1
Spencer,	24	12	5	4
Sterling,	12	2	2	-
Sturbridge,	6	3	1	1
Sutton,	5	1	-	-
Templeton,	12	6	6	-
Upton,	1	-	1	-
Uxbridge,	7	5	2	1
Warren,	8	1	1	-
Webster,	2	-	-	-
Westborough,	5	3	1	-
Westminster,	10	6	3	-
Winchendon,	12	6	2	-
	436	214	115	33

In addition, there are 8 deer which I am unable to place, owing to the fact that in their excitement some of the hunters failed to sign their names or to give town or date of killing.

Circular letters were sent to all paid deputies before the open season requesting them to keep a careful record of all deer shot and send same to the office. Much valuable information was secured and many complicated cases straightened out.

The youngest persons to report the shooting of deer were boys, one twelve years and seven months old and the other thirteen years old. Both of these boys shot bucks.

The largest buck reported was shot at Blandford by a Springfield sportsman, and weighed 450 pounds. The largest doe was shot by a Pittsfield sportsman in Hancock, and weighed 300 pounds.

There have been 16 dead deer found by the hunters and deputies since the season closed, which were probably wounded during the open season. Seven deer have been found wounded; these were killed by deputies of this department since the close of the open season.

Summary.

Total killed in open season, on record,	1,281
Total wounded in open season, on record,	101
Total killed, not placed on record,	8
Found dead, probably shot in open season,	16
Found wounded and shot by deputies,	7
Grand total,	1,413
Total number of reports received,	1,413

The passage of chapter 138 of the Acts of 1901 gave the Commissioners on Fisheries and Game and their deputies authority to arrest persons for taking shellfish in contaminated waters, when so requested by the State Board of Health. This act was first applied to the local waters of New Bedford and Fairhaven in 1904. The following is a record of the numbers of arrests and fines: —

1904, 28 arrests; all cases filed.
1905, 50 arrests; fines, $215; cases filed, 11.
1906, 49 arrests; fines, $265; cases filed, 4.
1907, 54 arrests; fines, $720; defaulted, 2.
1908, 66 arrests; fines, $750; filed, 2; discharged, 2.
1909, 37 arrests; fines, $380; filed, 3.
1910, 54 arrests; fines, $560; filed, 4.

In 1907 this same act was applied to Boston and Quincy waters. The following is a record of the number of arrests and fines: —

1907, 20 arrests; fines, $65; filed, 10.
1908, 11 arrests; fines, $75; filed, 2.
1909, 19 arrests; fines, $140; filed, none.
1910, 19 arrests; fines, $115; discharged, 2; defaulted, 1.

In 1909 this act was applied to Lynn, Revere and Saugus waters. The following is a record of the number of arrests and fines: —

1909, 21 arrests; fines, $175; filed, 3.
1910, 8 arrests; fines, $30; filed, 3; discharged, 1.

Lobsters collected. — During the year just closed the deputies of the department have collected egg-bearing lobsters as follows: —

Bourne, 61 lobsters in count; expenses, $0.50.
Lowe, 24 lobsters in count; expenses, $0.40.
Mecarta, 1,563 lobsters in count; expenses, $103.06.
Holmes, 488 lobsters in count; salary and expenses, $572.63.
Nixon, 1,950 lobsters in count; expenses, $56.23.
Nixon sold to United States hatchery, Gloucester, 532 lobsters, count.
Nixon sold to United States hatchery Woods Hole 151 lobsters count.
Nixon liberated 1,267 lobsters, count.
Total expenses of collecting, shipping and liberating 4,086 lobsters, $732.82.

This table shows the expense contracted in this work, outside of the price paid for the lobsters. The prices paid range from 14 to 30 cents per pound during the year, following the market.

We believe that the expense necessary to carry out the provisions of chapter 408 of the Acts of 1904, under which the above work is done, exceeds the good results shown. Since the majority of the lobster fishermen and dealers are unable to realize that the work is carried on primarily for their benefit, and appear to be unwilling to co-operate, we suggest the repeal of that part of the law which permits the egg lobsters to be purchased.

Following is the record of arrests and convictions for the year ending Dec. 31, 1910: —

Number of persons arrested,	337
Number of complaints,	356
Number of offences,	39
Most arrests for one offence was for taking shellfish in contaminated water,	81
Next largest was for hunting without a license,	37

Classification of Arrests during the Year 1910.

Violation of: —	
Acts of 1904, chapter 329, relative to pickerel,	2
Acts of 1910, chapter 469, relative to trout,	10
Acts of 1907, chapter 306, relative to closed ponds,	13
Acts of 1904, chapter 308, relative to fishing with more than ten hooks,	1
Acts of 1907, chapter 285, relative to shellfish in contaminated waters,	78
Acts of 1906, chapter 477, relative to shellfish in the town of Dartmouth,	2
Acts of 1909, chapter 291, relative to torching,	15
Revised Laws, chapter 91, section 133, as amended by Acts of 1903, chapter 246, relative to poison in brook,	1
Acts of 1855, chapter 401, relative to seining,	1
Acts of 1908, chapter 492, relative to illegal apparatus,	9
Revised Laws, chapter 91, section 85, relative to taking clams without permit,	1
Revised Laws, chapter 91, section 85, relative to taking eels without permit,	1

Acts of 1910, chapter 177, relative to seed scallops,	2
Revised Laws, chapter 91, sections 71 and 74, relative to smelts,	7
Revised Laws, chapter 91, section 70, relative to bass,	3
Revised Laws, chapter 91, section 86, relative to lobsters,	3
Revised Laws, chapter 91, section 88, relative to lobsters,	11
Revised Laws, chapter 92, section 14, relative to posted land,	2
Revised Laws, chapter 91, section 52, relative to seining,	1
Revised Laws, chapter 91, section 122, relative to gill nets,	1
Revised Laws, chapter 91, section 85, relative to quahaugs,	3
Assault on deputy,	2
Acts of 1904, chapter 176, relative to hunting on the Lord's day,	29
Acts of 1910, chapter 365, relative to partridge,	3
Acts of 1909, chapter 309, relative to pheasants,	6
Acts of 1907, chapter 250, relative to song and insectivorous birds,	12
Acts of 1903, chapter 244, relative to heron,	2
Acts of 1903, chapter 244, relative to bittern,	1
Acts of 1910, chapter 472, relative to terns,	1
Acts of 1909, chapter 421, relative to ducks,	1
Acts of 1903, chapter 329, relative to use of feathers for millinery purposes,	7
Acts of 1908, chapter 402, relative to alien license,	28
Acts of 1909, chapter 262, relative to non-resident licensee,	3
Acts of 1909, chapter 325, relative to registration of hunters,	42
Acts of 1909, chapter 396, and Acts of 1910, chapter 545, relative to deer,	21
Acts of 1905, chapter 245, relative to dogs chasing deer,	7
Acts of 1910, chapter 564, relative to squirrels,	10
Acts of 1909, chapter 328, relative to snaring,	4
Acts of 1910, chapter 355, relative to ferrets,	7
Acts of 1907, chapter 299, relative to forest fires,	2
Number of hunters' licenses revoked for violation of game laws,	39

Comparative Table of Law Enforcement for the Years 1907–10.

Items.	1907.	1908.	1909.	1910.
Total fines imposed,	$3,470 20	$7,097 50	$5,804 50	$3,740 00
Fines from arrests by paid deputies,	$1,921 20	$6,348 50	$5,400 50	$3,604 00
Fines from arrests by unpaid deputies,	$1,549 00	$759 00	$404 00	$136 00
Total counts taken to court,	390	472	417	355
Total number of persons arrested,	358	455	383	333
Convictions,	327	424	397	322
Cases filed,	63	77	59	55
Cases discharged,	56	45	19	31
Cases defaulted,	7	2	1	2
Costs paid when cases were filed,	-	-	$54 90	$102 69

One lobster case, with fine of $45, still pending.

Two cases appealed from 1908, of which one paid $20 fine, the other paid $53 fine, not included in above table.

Forest Fires. — The number of forest fires discovered by deputies of the department, who rendered assistance in extinguishing the same, were as follows: —

Deputy Burney,	3	Deputy Ruberg,	1
Deputy Brown,	1	Deputy Tribou,	4
Deputy Converse,	5	Deputy Stratton,	2
Deputy Hatch,	1	Deputy Scudder,	1
Deputy Keniston,	1	Deputy Osborne,	4
Deputy Leonard,	10		
Deputy Mills,	5		38

In narrative report ending Dec. 11, 1910, Deputy Albert L. Stratton says: —

December 7, left home at 9 A.M. Went to Orange by street car. On foot to Partridgeville and Eagleville ponds. While at Partridgeville heard shouting; lady calling for help; house was on fire. Was the first one there. Helped move out furniture. House burned down.

In accordance with chapter 272, Acts of 1909, and chapter 421, Acts of 1909, I have sealed up at the various cold storage warehouses during the year 1910, 113 packages containing the following: —

Black ducks,	1,093	Brant,	8
Widgeons,	666	Teal,	74
Mallards,	169	Quail,	46
Red-heads,	153	Grass birds,	54
Canvas-backs,	69	Peeps,	178
Butterballs,	54	Miscellaneous,	13
Miscellaneous ducks,	118		
Wild geese,	82		2,777

To show the interest which the public take in the fish and game laws, I would say that 67 bills were introduced in the Legislature during the session of 1910 relating to these matters. This does not include 21 recommendations made by the commissioners.

Respectfully submitted,

W. W. NIXON,
Chief Deputy.

Money turned into the Treasury of the Commonwealth as the Result of the Activities of the Commission during the Year 1910.

Total net receipts from all forms of hunting licenses,	$34,666 75
Sale of egg-bearing lobsters,	838 79
Fines from prosecutions by deputies,	3,720 00
Received for heath-hen fund (from Anawan Club),	25 00
	$38,506 54

There have been no applications for the inspection of fish under the Acts of 1902, chapter 138, and no fees have been received.

Recommendations for Legislation.

The Commissioners on Fisheries and Game respectfully recommend the passage of laws designed to accomplish the following purposes: —

1. Inasmuch as experience has shown that it is impossible to depend upon commercial sources for fish for stocking public waters, and the hatcheries at present owned by the State are entirely inadequate to meet the requirements (*e.g.*, not less than 5,000,000 fry and 1,000,000 fingerling trout, together with white perch and other desirable species, are demanded), the commissioners should be authorized to lease, purchase or construct one or more suitable fish hatcheries.

2. Special investigations should be made to determine how those birds which feed upon gypsy moth, brown-tail moths, leopard moths, cut worms and other noxious insects can be increased or colonized within the infested regions or in special locations.

3. On account of the alarming decrease in the number of useful birds, and the consequent damage from insect pests to shade trees, garden and farm crops, some provision for rearing game and insectivorous birds should be made. We therefore urge that the commissioners be authorized to lease, purchase and construct increased facilities for rearing useful, insectivorous and game birds.

4. That the commission should have authority to purchase, lease or receive as gifts, areas to be used as bird reservations, *i.e.*, specially protected breeding places for birds. Property thus acquired should be administered by the Commissioners on Fisheries and Game for the purpose of securing the utmost possible population of useful birds. Whenever necessary to confirm titles, power of eminent domain should be given similar to that in chapter 504, Acts of 1907; and part of that money received by the Commonwealth for hunters' licenses should annually be expended for the purpose of acquiring land for such purposes.

5. That investigation be made of the infectious diseases of native birds and foreign birds introduced into the State, with

a report including expert opinions upon the probability of such diseases spreading among our native birds, and, so far as possible, suggesting remedies and methods for preventing such infection; and that for these purposes money be appropriated from money received by the Commonwealth for hunting licenses.

6. Relative to the introduction of fish into State waters.

7. Amendments perfecting the laws relative to ruffed grouse, quail and woodcock.

8. On petition of the mayor and aldermen of a city, or of the selectmen of a town within which a great pond or any portion thereof is situated, the Commissioners on Fisheries and Game may prescribe and extend such reasonable regulations relative to the fishing in such ponds and their tributaries, with such penalties, as they deem to be for the public interest, and shall cause such regulations to be enforced.

9. Also, under Acts of 1908, chapter 484, relative to registration of hunters, the persons applying for a license should be required to establish their identity; and, for the purpose of permitting effective enforcement, the requirements for license or registration should be extended to all persons hunting for any species of bird or mammal, and should further require that the license or certificate of registration should be carried on the person when hunting. Minors under sixteen years of age making application for registration should be obliged to have the consent of their parents or guardian in writing. Upon conviction of violation of game laws, persons holding licenses should be instructed by the court convicting them to surrender such license to the court.

10. Also, for such amendment of the laws as to ensure the development of the mollusk fisheries below high-water mark in such a manner as to permit increase in the economic yield of food material; to furnish wider opportunities for remunerative employment of skilled and unskilled labor.

11. Protection of gray, European or Hungarian partridge.

12. Protection of wood or summer duck.

13. Chapter 285, Acts of 1907, which permits the taking of clams and quahaugs from contaminated waters, should be repealed, or other necessary action taken.

14. Dogs should not be allowed to hunt at large habitually unaccompanied by owner during the breeding season of birds in areas frequented by them, from March 1 to October 1.

15. The deputies of this commission should be authorized to arrest hunters whom they find in the act of violating the provisions of section 91 of chapter 208 of the Revised Laws relative to wilfully pulling down stone walls or fences.

16. Protection of property injured by gray squirrels.

17. A perfecting amendment relative to protection and sale of hares and rabbits.

18. A perfecting amendment relative to protection of game birds and water fowl.

19. A perfecting amendment to section 1, chapter 317, Acts of 1905, relative to the carrying of firearms by unnaturalized foreign-born persons.

Courtesies.

Permits to hold egg-bearing lobsters in confinement, for collection by the agents of this commission, according to chapter 408, Acts of 1904, were issued to 607 fishermen and dealers.

Permits for taking birds and eggs, under section 9, chapter 92, Revised Laws, as amended by chapter 287, Acts of 1903, were issued to the following-named persons: —

Frank B. Webster, Hyde Park.
Albert H. Tuttle, Cambridge.
Clarence Birdseye, Amherst.
Chester S. Day, West Roxbury.
Chester A. Reed, Worcester.
Fred B. McKechnie, Boston.
Wm. Brewster, Cambridge.
Charles R. Lamb, Boston.
Edward R. Adams, Canton.
Henry P. Burt, New Bedford.
R. H. Carr, Brockton.
B. G. Willard, Millis.
Geo. M. Gray, Woods Hole.
A. C. Bent, Taunton.
Nathan F. Stone, Shrewsbury.
Robert O. Morris, Springfield.
Haynes H. Chilson, Northampton.
F. A. Binford, Hyannis.
Frederic H. Kennard, Boston.
F. H. Carpenter, Taunton.
J. A. Barton, Fitchburg.
William Dearden, Springfield.
Owen Durfee, Fall River.
Frank S. Akin, Fall River.
John H. Hardy, Jr., Boston.
James R. Mann, Arlington Heights.
Thos. M. Douthart, Woods Hole.
A. M. Wilcox, Wellesley.
Fred P. Hersom, Chelsea.
E. H. Forbush, Boston.

Permits to have wild ducks in possession, for purposes of propagation, were issued to: —

Seth A. Borden, Fall River.
Spencer Borden, Fall River.
Clark Chase, Jr., Fall River.
Alfred V. Freeman, South Duxbury.
Guilford C. Hathaway and Benjamin Brown, Fall River.
Allan Keniston, Edgartown.
A. D. Kingsbury, Medfield.
H. S. Little, Newbury.
Miss E. W. Magee, Holliston.
Frederick E. Mosher, New Bedford.
John C. Phillips, Wenham.
William A. Read, New Bedford.
James E. Rothwell, Brookline.
William H. Thurston, Chiltonville.
R. E. Warren, Sharon.
Frank E. White, Saundersville.

Permits to have wild geese in possession, for purposes of propagation, were issued to: —

A. D. Kingsbury, Medfield.
H. S. Little, Newbury.
Frederick E. Mosher, New Bedford.
James E. Rothwell, Brookline.

Permits to have ruffed grouse in possession, for purposes of propagation, were issued to: —

Mrs. Oakes Ames, Sharon.
Miss Lorna H. Leland, Templeton.
Herbert Parker, Lancaster.
James E. Rothwell, Brookline.

Permits to have quail in possession, for purposes of propagation, were issued to: —

Spencer Borden, Fall River.
John Goulding, South Sudbury.
C. F. Hodge, Worcester.
Wm. H. Leonard, East Foxborough.
Wm. A. Read, New Bedford.
James E. Rothwell, Brookline.

Permit to take birds and animals protected by law, for scientific purposes, was issued to: —

Gardner C. Basset, Worcester.

Permit to take sea birds, for scientific purposes, was issued to: —

Vinal N. Edwards, Woods Hole.

Permit to have native insectivorous birds in possession, to be used in connection with experiments and observations upon the use of birds for destroying certain flies in greenhouses, was issued to: —

Seth A. Borden, Fall River.

Permit to have native insectivorous birds in possession, for purposes of propagation, was issued to: —

James E. Rothwell, Brookline.

Permit to trap gray squirrels, for transfer to other parts of the State, was issued to: —

Frederick D. Woods, Wellesley.

Permit to collect and have in possession the nests of wild birds, after they have been vacated, was issued to: —

Arthur A. Osborne, Peabody.

Permit to have swans in possession, for purposes of propagation, was issued to: —

George H. Walker, Needham.

Permits to bring into the Commonwealth during the close season not exceeding fifty birds known as Anatidæ, in accordance with the provisions of section 2, chapter 421, Acts of 1909, were issued to: —

R. L. Agassiz, Boston.
Ingersoll Amory, Boston.
James W. Austin, Boston.
Charles F. Ayer, Boston.
Thomas Barbour, Brookline.
Decim Beebee, Boston.
John N. Beebee, Boston.
Frank B. Bemis, Boston.
Henry B. Bigelow, Cambridge.
G. F. Blake, Weston.
F. J. Bradlee, Boston.
Gorham Brooks, Boston.
Henry B. Chapin, Boston.
James M. Codman, Brookline.
C. P. Curtis, Boston.
F. W. Curtis, Boston.
Daniel Dewey, Boston.
William B. Emmons, Boston.
H. B. Endicott, Boston.
H. Wendell Endicott, Dedham.
Henry H. Fay, Jr., Boston.
Norman F. Greeley, Boston.
Samuel Hammond, Nahant.
J. Hurd Hutchins, Boston.
Eben D. Jordan, Boston.
Robert Jordan, Boston.
Wilton Lockwood, Boston.
Arthur Lyman, Waltham.
George H. Lyman, Boston.
Theodore Lyman, Cambridge.
F. S. Mead, Brookline.
Charles Merriam, Weston.
Arthur N. Milliken, Boston.
S. J. Mixter, Boston.
William Jason Mixter, Boston.
James C. Neeley, Brookline.
Albert L. Nickerson, Boston.
J. H. North, Boston.
Eben C. Norton, Norwood.
Charles J. Paine, Jr., Weston.

John B. Paine, Weston.
William A. Patterson, Boston.
Dudley L. Pickman, Boston.
C. A. Porter, Boston.
J. L. Saltonstall, Boston.
Richard Saltonstall, Boston.
Thomas Silsbee, Boston.
William H. Slocum, Boston.
Bayard Thayer, Lancaster.
William G. Titcomb, Boston.
C. N. Tyler, Boston.
J. D. Upton, Boston.
Benjamin Vaughan, Boston.
Henry G. Vaughan, Boston.
B. Vincent, Boston.
Arthur Wainwright, Boston.
Roger S. Warner, Boston.
Moses Williams, Boston.
Paul Winsor, Weston.

Permits to bring into the Commonwealth during the close season not exceeding fifty birds known as Limicolæ, in accordance with the provisions of chapter 508, Acts of 1909, were issued to: —

Charles J. Paine, Jr., Weston.
B. Vincent, Boston.

Permits to rear and sell pheasants, in accordance with the provisions of chapter 309, Acts of 1909, were issued to: —

Howard E. Newton, Foxborough.
Thos. R. Sherburne, Lexington.
Frederick W. Fisher, Newton.
Albert L. Brown, Cohasset.
Andrew S. Coyle, Taunton.
Minnie Blagden, Rowley.
H. S. Little, Newbury.
Austin L. Millett, Rowley.
Milan A. Brayton, Fall River.
Grenville L. Winthrop, Lenox.
Charles M. Emerson, Taunton.
Edward C. Alden, Taunton.
C. L. Converse, Stoneham.
Elmer A. Macker, North Grafton.
James Ashton, Fall River.
A. N. Reynolds, Westwood.
Chester H. Keyes, Middleborough.
E. H. Allen, Stoneham.
S. B. S. Keyes, Middleborough.
Frank R. Boston, Beverly.
G. Marston Whitin, Whitinsville.
John Clark, Brockton.
J. Goulding, South Sudbury.
Geo. M. Ballard, Danvers.
Charles F. Berry, Needham Heights.
Bayard Thayer, Lancaster.
E. P. Wilbur, South Framingham.
Seth A. Borden, Fall River.
John C. Phillips, Boston.
M. J. McQuaid, Clinton.
Spencer Borden, Fall River.
Frederick E. Mosher, New Bedford.
James E. Rothwell, Brookline.
Irene Pettis, Mill River.
Frank A. Lemmer, Easthampton.
W. H. Palmer, Beverly.
Allan Keniston, Edgartown.
Thos. Barry, Marblehead.
Annie E. Freeman, Provincetown.
A. D. Kingsbury, Medfield.
J. H. Hathaway, New Bedford.
Oscar D. Young, North Beverly.
Axel Klinglof, Worcester.
Harry C. Ashby, Topsfield.
Edward B. Woodbury, Topsfield.
Thomas Mallery, Natick.
Edward Herbert, Fall River.
Robert Montgomery, Natick.
Frank P. Hewins, South Framingham.
Robert W. Harwood, Natick.
William A. Read, New Bedford.

W. R. Morrill, South Framingham.
L. W. Prouty, South Framingham.
George D. Flynn, Fall River.
Theodore K. Grimsby, Essex.
C. A. Osgood, Arlington.
Bert Meek, Lexington.
J. Raymond Adams, Newbury.
Ferdinand B. Sage, South Sudbury.
Isaac U. Wood, Fall River.
Frank E. White, Saundersville.
Albert A. Hall, Lowell.
Leander F. Herrick, Worcester.
William Sim, Cliftondale.
Joseph Gardella, Haverhill.
Mrs. Alexander Gilmore, Fayville.
W. S. Allison, Merrimacport.
E. F. Parmlee, Boston.
George McNeil, Winthrop.
Clarence C. Puffer, Brockton.
Charles Whittemore, Newton.

Permit to have in possession lobsters of any size, for scientific investigation, issued to: —

Marine Biological Laboratory, Woods Hole.

Permit to take lamprey eels, for scientific purposes, was issued to: —

Geo. M. Gray, Curator of the Marine Biological Laboratory, Woods Hole.

Permits to take sand eels for bait, under chapter 164, Acts of 1902, were issued to: —

James Crooks, Newburyport.
A. P. Hilton, Newburyport.
George E. Pettingill, Newburyport.

Permit to operate a pound net in Buzzards Bay was issued to: —

Marine Biological Laboratory, Woods Hole.

Permit to transfer fish from one stream to another was issued to: —

Louis E. Vose, East Walpole.

Permit to use a seine in any of the ponds in Barnstable County, to secure spawning white perch, was issued to: —

Everett B. Mecarta, Harwich.

Permits to have small trout in possession, for purposes of study, were issued to: —

W. Hewins Thayer, New Bedford.
W. C. Phillips, New Bedford.

Permit to take fish of any species, for scientific investigation, was issued to: —

L. W. Tilden, Fairhaven.

Permits to buy and sell or have in possession trout artificially propagated and maintained, in accordance with the provisions of chapter 377, Acts of 1909, were issued to: —

Sandwich Trout Company, Sandwich.
A. B. Savery, Wareham.
Jacob Diegel, Agawam.
N. F. Hoxie, Plymouth.
Wm. A. Gaston, Barre.
Chas. R. Doten, Plymouth.
Prior & Townsend, Boston.
Michael J. Welch, Boston.
H. A. Baker, Sharon.
Shattuck & Jones, Boston.
S. Atwood & Co., Boston.
Lane Bros., Silver Lake.
Geo. L. Guptill, Berkley.
F. H. Johnson & Co., Boston.
Gove & Mollins, Boston.
C. M. Bassett, New Bedford.
Rich & Matthews, Boston.
W. S. Nickerson, Kingston.
G. W. Shultis, Hartsville.
G. W. Randall, Plympton.
Watson Bros., New Bedford.
Atlantic Fish Market (Long & Hanitsch), Campello.
L. W. Tilden, Fairhaven.

GEORGE W. FIELD.
GEORGE H. GARFIELD.
GEORGE H. GRAHAM.

APPENDICES.

[A.]

Deputy Fish and Game Commissioners, with the Number of their Districts, Residences and Telephone Numbers.

William W. Nixon, *Chief Deputy*, Central Office, State House. Telephone, Hay. 2700; residence telephone, 466–2 Cambridge.

Assigned to District —	Name.	Residence.	Telephone Number.
1	William H. Jones,	Nantucket,	24–32
2	Charles L. Savery,	West Tisbury,	-
	Allan Keniston,	Edgartown,	6–21
3	Everett B. Mecarta,	Harwich,	36–4
4	Samuel J. Lowe,	New Bedford,	761–2
5	Allen A. David,	Taunton,	966–1
6	Nathan W. Pratt,	Middleborough,	153–4
7	Charles E. Tribou,	Brockton,	2101
8	William Day,	Marshfield,	50
9	William H. Leonard,	East Foxborough,	Foxborough 9–4
10	James E. Bemis,	South Framingham,	564–J
11	William W. Nixon, *Chief Deputy*,	Cambridge,	2248–W
	Frederick W. Goodwin,	East Boston,	515–2
12	- -	- -	-
13	Walter A. Larkin,	Andover,	172–5
14	Thomas L. Burney,	Lynn,	1613–13
15	James I. Mills,	Ayer,	51–2
16	George H. Brown,	Millbury,	26–13
17	A. D. Putnam,	Spencer,	75–4 or 75–6
18	Irving O. Converse,	Fitchburg,	269–1
19	Albert L. Stratton,	Athol,	24–O
20	Dennis F. Shea,	Ware,	132
21	John F. Luman,	Palmer,	17–5
22	James P. Hatch,	Springfield,	2458–1
23	Charles H. Gehle,	Westfield,	843 or 920
24	William W. Sargood,	Northampton,	-
25	Lyman E. Ruberg,	Greenfield,	585–
26	Arthur M. Nichols,	North Adams,	537–2
27	Fred R. Zeigler,	Pittsfield,	362–11
28	DeWitt Smith,	Great Barrington,	72–6

The following were employed as special paid deputies: —

Name.	Residence.	Term of Service (1919).
John M. Dineen,	Easthampton,	Nov. 1–Nov. 30.
Albert H. Eldredge,	Ware,	Sept. 20–Nov. 30.
Gilbert A. Gildrie,	Pittsfield,	Nov. 22–Nov. 28.
Warren A. Goff,	Dighton,	Oct. 10–Nov. 30.
Chester H. Hall,	Princeton,	Nov. 23–Nov. 28.
Wm. E. Holland,	West Brimfield,	Nov. 24–Nov. 30.
Charles L. Houghton,	Westfield,	Nov. 12–Dec. 31.
Harry L. Lyford,	Spencer,	Oct. 1–Nov. 30.
Geo. C. Paradise,	Fall River,	Sept. 6–Dec. 31.
Geo. W. Piper,	Andover,	Oct. 22–Nov. 30.
Wm. N. Prentiss,	Milford,	Sept. 6–Nov. 30.
Michael S. Ryan,	Oakdale,	Nov. 19–Nov. 28.
Lindsey G. Smith,	Dwight,	Nov. 19–Nov. 28.
Patrick J. Woods,	New Bedford,	Oct. 7–Nov. 30.
Geo. W. Williams,	Worcester,	Nov. 3–Dec. 31.

Cities and Towns alphabetically arranged, with the Number of the District in which Each is included.

8 Abington.
15 Acton.
4 Acushnet.
26 Adams.
23 Agawam.
28 Alford.
12 Amesbury.
22 Amherst.
13 Andover.
11 Arlington.
18 Ashburnham.
18 Ashby.
25 Ashfield.
10 Ashland.
19 Athol.
5 Attleborough.
17 Auburn.
8 Avon.
15 Ayer.
3 Barnstable.
20 Barre.
27 Becket.
14 Bedford.
20 Belchertown.
9 Bellingham.
11 Belmont.
5 Berkley.
10 Berlin.
25 Bernardston.
13 Beverly.
14 Billerica.
16 Blackstone.
23 Blandford.
15 Bolton.
11 Boston.
3 Bourne.
15 Boxborough.
13 Boxford.
17 Boylston.
8 Braintree.
3 Brewster.
7 Bridgewater.
21 Brimfield.
7 Brockton.
17 Brookfield.
11 Brookline.
25 Buckland.
14 Burlington.
11 Cambridge.
8 Canton.
15 Carlisle.
6 Carver.
25 Charlemont.
21 Charlton.
3 Chatham.
14 Chelmsford.
11 Chelsea.
26 Cheshire.
23 Chester.
24 Chesterfield.
22 Chicopee.
2 Chilmark.
26 Clarksburg.
17 Clinton.
8 Cohasset.
25 Colrain.
15 Concord.
25 Conway.
24 Cummington.
27 Dalton.
20 Dana.
13 Danvers.
4 Dartmouth.
11 Dedham.
25 Deerfield.
3 Dennis.
5 Dighton.
16 Douglas.
10 Dover.
14 Dracut.
21 Dudley.
15 Dunstable.
7 Duxbury.
7 East Bridgewater.
22 East Longmeadow.
3 Eastham.
24 Easthampton.
7 Easton.
2 Edgartown.
28 Egremont.
20 Enfield.
19 Erving.
12 Essex.
11 Everett.
4 Fairhaven.
5 Fall River.
2 Falmouth.
18 Fitchburg.
26 Florida.
9 Foxborough.
10 Framingham.
9 Franklin.
4 Freetown.
18 Gardner.
2 Gay Head.
12 Georgetown.
25 Gill.
12 Gloucester.
24 Goshen.
2 Gosnold.
16 Grafton.
22 Granby.
23 Granville.
28 Great Barrington.
25 Greenfield.
20 Greenwich.
15 Groton.
12 Groveland.
22 Hadley.
7 Halifax.
12 Hamilton.
22 Hampden.
26 Hancock.
8 Hanover.
7 Hanson.
20 Hardwick.
15 Harvard.
3 Harwich.
24 Hatfield.
13 Haverhill.
25 Hawley.
25 Heath.
8 Hingham.
27 Hinsdale.
8 Holbrook.
17 Holden.
21 Holland.
10 Holliston.
24 Holyoke.
16 Hopedale.
10 Hopkinton.
20 Hubbardston.
10 Hudson.
8 Hull.
23 Huntington.
11 Hyde Park.
12 Ipswich.
7 Kingston.
6 Lakeville.
18 Lancaster.
26 Lanesborough.
13 Lawrence.
27 Lee.
17 Leicester.
27 Lenox.
18 Leominster.
22 Leverett.
14 Lexington.
25 Leyden.
10 Lincoln.
15 Littleton.
22 Longmeadow.
14 Lowell.
22 Ludlow.
18 Lunenburg.
14 Lynn.
13 Lynnfield.
14 Malden.
12 Manchester.
9 Mansfield.
13 Marblehead.
4 Marion.
10 Marlborough.
8 Marshfield.
3 Mashpee.
4 Mattapoisett.
15 Maynard.

Cities and Towns alphabetically arranged, with the Number of the District in which Each is included — Concluded.

9 Medfield.
14 Medford.
9 Medway.
14 Melrose.
16 Mendon.
12 Merrimac.
13 Methuen.
6 Middleborough.
27 Middlefield.
13 Middleton.
10 Milford.
16 Millbury.
9 Millis.
11 Milton.
26 Monroe.
21 Monson.
19 Montague.
28 Monterey.
23 Montgomery.
28 Mount Washington.
14 Nahant.
1 Nantucket.
10 Natick.
11 Needham.
26 New Ashford.
4 New Bedford.
17 New Braintree.
28 New Marlborough.
20 New Salem.
12 Newbury.
12 Newburyport.
11 Newton.
9 Norfolk.
26 North Adams.
13 North Andover.
9 North Attleborough.
17 North Brookfield.
13 North Reading.
24 Northampton.
16 Northborough.
16 Northbridge.
19 Northfield.
5 Norton.
8 Norwell.
9 Norwood.
2 Oak Bluffs.
17 Oakham.
19 Orange.
3 Orleans.
28 Otis.
16 Oxford.
21 Palmer.
17 Paxton.
14 Peabody.
22 Pelham.
7 Pembroke.
15 Pepperell.
27 Peru.
20 Petersham.
19 Phillipston.
27 Pittsfield.
25 Plainfield.
9 Plainville.
6 Plymouth.
7 Plympton.
20 Prescott.
18 Princeton.
3 Provincetown.
8 Quincy.
8 Randolph.
7 Raynham.
13 Reading.
5 Rehoboth.
14 Revere.
27 Richmond.
4 Rochester.
8 Rockland.
12 Rockport.
26 Rowe.
12 Rowley.
19 Royalston.
23 Russell.
17 Rutland.
13 Salem.
12 Salisbury.
28 Sandisfield.
3 Sandwich.
14 Saugus.
26 Savoy.
8 Scituate.
5 Seekonk.
9 Sharon.
28 Sheffield.
25 Shelburne.
10 Sherborn.
15 Shirley.
16 Shrewsbury.
22 Shutesbury.
5 Somerset.
11 Somerville.
22 South Hadley.
24 Southampton.
10 Southborough.
21 Southbridge.
23 Southwick.
17 Spencer.
22 Springfield.
18 Sterling.
27 Stockbridge.
14 Stoneham.
8 Stoughton.
15 Stow.
21 Sturbridge.
10 Sudbury.
22 Sunderland.
16 Sutton.
14 Swampscott.
5 Swansea.
5 Taunton.
19 Templeton.
14 Tewksbury.
2 Tisbury.
23 Tolland.
13 Topsfield.
18 Townsend.
3 Truro.
15 Tyngsborough.
28 Tyringham.
16 Upton.
16 Uxbridge.
14 Wakefield.
21 Wales.
9 Walpole.
10 Waltham.
20 Ware.
6 Wareham.
21 Warren.
19 Warwick.
27 Washington.
11 Watertown.
10 Wayland.
16 Webster.
10 Wellesley.
3 Wellfleet.
19 Wendell.
13 Wenham.
17 West Boylston.
7 West Bridgewater.
21 West Brookfield.
12 West Newbury.
23 West Springfield.
27 West Stockbridge.
2 West Tisbury.
16 Westborough.
23 Westfield.
15 Westford.
24 Westhampton.
18 Westminster.
10 Weston.
4 Westport.
9 Westwood.
8 Weymouth.
24 Whately.
7 Whitman.
22 Wilbraham.
24 Williamsburg.
26 Williamstown.
14 Wilmington.
19 Winchendon.
14 Winchester.
26 Windsor.
11 Winthrop.
14 Woburn.
17 Worcester.
24 Worthington.
9 Wrentham.
3 Yarmouth.

List of Cities and Towns included in Each District assigned to Deputy Fish and Game Commissioners.

DISTRICT NO. 1.

Deputy WILLIAM H. JONES, Nantucket.

Telephone, 24–32.

Nantucket.

DISTRICT NO. 2.

Deputy CHARLES L. SAVERY, West Tisbury.

Deputy ALLAN KENISTON, Edgartown.

Telephone, 6–21.

Chilmark.
Edgartown.
Falmouth.
Gay Head.
Gosnold.
Oak Bluffs.
Tisbury.
West Tisbury.

DISTRICT NO. 3.

Deputy EVERETT B. MECARTA, Harwich.

Telephone, 36–4.

Barnstable.
Bourne.
Brewster.
Chatham.
Dennis.
Eastham.
Harwich.
Mashpee.
Orleans.
Provincetown.
Sandwich.
Truro.
Wellfleet.
Yarmouth.

DISTRICT NO. 4.

Deputy SAMUEL J. LOWE, New Bedford.

Telephone, 761-2.

Acushnet.
Dartmouth.
Fairhaven.
Freetown.
New Bedford.
Mattapoisett.
Marion.
Rochester.
Westport.

DISTRICT NO. 5.

Deputy ALLEN A. DAVID, Taunton.

Telephone, 966–1.

Attleborough.
Berkley.
Dighton.
Fall River.
Norton.
Rehoboth.
Seekonk.
Swansea.
Somerset.
Taunton.

DISTRICT NO. 6.

Deputy NATHAN W. PRATT, Middleborough.

Telephone, 153–4.

Carver.
Lakeville.
Middleborough.
Plymouth.
Wareham.

District No. 7.

Deputy Charles E. Tribou, Brockton.

Telephone, 2101.

Bridgewater.
Brockton.
Duxbury.
East Bridgewater.
Easton.
Halifax.
Hanson.
Kingston.
Pembroke.
Plympton.
Raynham.
West Bridgewater.
Whitman.

District No. 8.

Deputy William Day, Marshfield.

Telephone, 50.

Abington.
Avon.
Braintree.
Canton.
Cohasset.
Hanover.
Hingham.
Holbrook.
Hull.
Marshfield.
Norwell.
Quincy.
Randolph.
Rockland.
Scituate.
Stoughton.
Weymouth.

District No. 9.

Deputy William H. Leonard, East Foxborough.

Telephone, Foxborough 9-4.

Bellingham.
Foxborough.
Franklin.
Mansfield.
Medfield.
Medway.
Millis.
Norfolk.
North Attleborough.
Norwood.
Plainville.
Sharon.
Walpole.
Westwood.
Wrentham.

District No. 10.

Deputy James E. Bemis, South Framingham.

Telephone, 226-J.

Ashland.
Berlin.
Dover.
Framingham.
Holliston.
Hopkinton.
Hudson.
Lincoln.
Marlborough.
Milford.
Natick.
Sherborn.
Sudbury.
Southborough.
Waltham.
Wayland.
Wellesley.
Weston.

District No. 11.

Deputy Frederick W. Goodwin, East Boston.

Telephone, East Boston, 515-2.

Arlington.
Belmont.
Boston.
Brookline.
Cambridge.
Chelsea.
Dedham.
Everett.
Hyde Park.
Milton.
Needham.
Newton.
Somerville.
Watertown.
Winthrop.

DISTRICT No. 12.

Deputy CARL E. GRANT, Essex.

Telephone, Essex 1-3.

Amesbury.
Essex.
Georgetown.
Gloucester.
Groveland.
Hamilton.
Ipswich.
Manchester.
Merrimac.
Newbury.
Newburyport.
Rockport.
Rowley.
Salisbury.
West Newbury.

DISTRICT No. 13.

Deputy WALTER A. LARKIN, Andover.

Telephone, Andover 31-12.

Andover.
Beverly.
Boxford.
Danvers.
Haverhill.
Lawrence.
Lynnfield.
Marblehead.
Methuen.
Middleton.
North Andover.
North Reading.
Reading.
Salem.
Topsfield.
Wenham.

DISTRICT No. 14.

Deputy THOMAS L. BURNEY, Lynn.

Telephone, 1613-13.

Bedford.
Billerica.
Burlington.
Chelmsford.
Dracut.
Lexington.
Lowell.
Lynn.
Malden.
Medford.
Melrose.
Nahant.
Peabody.
Revere.
Saugus.
Stoneham.
Swampscott.
Tewksbury.
Wakefield.
Wilmington.
Winchester.
Woburn.

DISTRICT No. 15.

Deputy JAMES I. MILLS, Ayer.

Telephone, 51-2.

Acton.
Ayer.
Bolton.
Boxborough.
Carlisle.
Concord.
Dunstable.
Groton.
Harvard.
Littleton.
Maynard.
Pepperell.
Shirley.
Stow.
Tyngsborough.
Westford.

DISTRICT No. 16.

Deputy GEORGE H. BROWN, Millbury.

Telephone, 26-13.

Blackstone.
Douglas.
Grafton.
Hopedale.
Mendon.
Millbury.
Northborough.
Northbridge.
Oxford.
Shrewsbury.
Sutton.
Upton.
Uxbridge.
Webster.
Westborough.

DISTRICT No. 17.

Deputy A. D. PUTNAM, Spencer.

Telephone, 75-4 or 75-6.

Auburn.
Boylston.
Brookfield.
Clinton.
Holden.
Leicester.
New Braintree.
North Brookfield.
Oakham.
Paxton.
Rutland.
Spencer.
West Boylston.
Worcester.

DISTRICT No. 18.

Deputy IRVING O. CONVERSE, Fitchburg.

Telephone, 269-1.

Ashby.
Ashburnham.
Fitchburg.
Gardner.
Lancaster.
Leominster.
Lunenburg.
Princeton.
Sterling.
Townsend.
Westminster.

DISTRICT No. 19.

Deputy ALBERT L. STRATTON, Athol.

Telephone, 24-O.

Athol.
Erving.
Montague.
Northfield.
Orange.
Phillipston.
Royalston.
Templeton.
Warwick.
Wendell.
Winchendon.

DISTRICT No. 20.

Deputy DENNIS F. SHEA, Ware.

Telephone, 132.

Barre.
Belchertown.
Dana.
Enfield.
Greenwich.
Hardwick.
Hubbardston.
New Salem.
Petersham.
Prescott.
Ware.

DISTRICT No. 21.

Deputy JOHN F. LUMAN, Palmer.

Telephone, 17-5.

Brimfield.
Charlton.
Dudley.
Holland.
Monson.
Palmer.
Southbridge.
Sturbridge.
Wales.
Warren.
West Brookfield.

DISTRICT No. 22.

Deputy JAMES P. HATCH, Springfield.

Telephone, 2571-3.

Amherst.
Chicopee.
East Longmeadow.
Granby.
Hadley.
Hampden.
Leverett.
Longmeadow.
Ludlow.
Pelham.
Shutesbury.
South Hadley.
Springfield.
Sunderland.
Wilbraham.

DISTRICT No. 23.

Deputy CHARLES H. GEHLE, Westfield.

Telephone, 843 or 920.

Agawam.
Blandford.
Chester.
Granville.
Huntington.
Montgomery.
Russell.
Southwick.
Tolland.
Westfield.
West Springfield.

DISTRICT No. 24.

Deputy WILLIAM W. SARGOOD, Northampton.

Chesterfield.
Cummington.
Easthampton.
Hatfield.
Goshen.
Holyoke.
Northampton.
Southampton.
Westhampton.
Whately.
Williamsburg.
Worthington.

DISTRICT No. 25.

Deputy LYMAN E. RUBERG, Greenfield.

Telephone, 376-R.

Ashfield.
Bernardston.
Buckland.
Deerfield.
Gill.
Greenfield.
Hawley.
Charlemont.
Colrain.
Conway.
Heath.
Leyden.
Plainfield.
Shelburne.

DISTRICT No. 26.

Deputy ARTHUR M. NICHOLS, North Adams.

Telephone, 391-12.

Adams.
Cheshire.
Clarksburg.
Florida.
Hancock.
Lanesborough.
Monroe.
New Ashford.
North Adams.
Rowe.
Savoy.
Williamstown.
Windsor.

DISTRICT No. 27.

Deputy FRED R. ZEIGLER, Pittsfield.

Telephone, 362-11.

Becket.
Dalton.
Hinsdale.
Lee.
Lenox.
Middlefield.
Peru.
Pittsfield.
Richmond.
Stockbridge.
Washington.
West Stockbridge.

DISTRICT No. 28.

Deputy DEWITT SMITH, Great Barrington.

Telephone, 72-6.

Alford.
Egremont.
Great Barrington.
Monterey.
Mount Washington.
New Marlborough.
Otis.
Sandisfield.
Sheffield.
Tyringham.

[B.]

List of Commissioners.

United States Bureau of Fisheries, Washington, D. C.

George M. Bowers, Commissioner.
Hugh M. Smith, Deputy Commissioner.
Irving H. Dunlap, Chief Clerk.
R. S. Johnson, Assistant in Charge of Division of Fish Culture.
Barton W. Everman, Assistant in Charge of Division of Inquiry Respecting Food Fishes.
A. B. Alexander, Assistant in Charge of Division of Statistics and Methods of the Fisheries.
Hector Von Bayer, Architect and Engineer.

Superintendents of United States Fisheries Stations.

E. E. Race, Green Lake, Me.
Charles G. Atkins, Craig Brook, East Orland, Me.
E. E. Hahn, Boothbay Harbor, Me.
W. F. Hubbard, Nashua, N. H.
E. N. Carter, St. Johnsbury, Vt.
C. G. Corliss, Gloucester, Mass.
E. F. Locke, Woods Hole, Mass.
Chester K. Green, Cape Vincent, N. Y.
L. G. Harron, Washington, D. C.
George A. Seagle, Wytheville, Va.
R. K. Robinson, White Sulphur Springs, W. Va.
H. D. Aller, Beaufort, N. C.
J. J. Stranahan, Cold Springs, Bullochville, Ga.
James A. Henshall, Tupelo, Miss.
W. E. Morgan, Edenton, N. C.
A. G. Keesecker, Fishery, Tenn.
S. W. Downing, Put-in-Bay, O.
S. P. Wires, Duluth, Minn.
S. P. Bartlett, Quincy, Ill.
M. F. Stapleton, Manchester, Ia.
G. W. U. Brown, Homer, Minn.
W. O. Buck, Neosho, Mo.
J. L. Leary, San Marcos, Tex.

G. G. Ainsworth, Leadville, Col.
D. C. Booth, Spearfish, S. D.
H. D. Dean, Bozeman, Mont.
G. H. Lambson, Baird, Cal.
Henry O'Malley, Clackamas, Ore.
A. H. Dinsmore, Baker Lake, Wash.
W. K. Hancock, Yes Bay, Alaska.
S. G. Worth, Mammoth Spring, Ark.
C. P. Henkle, Afognak, Alaska.
R. E. Coker, Fairport, Ia.

Alabama.

Game and Fish Commissioner.

John H. Wallace, Jr.,	Montgomery.

Arizona.

Fish and Game.

W. L. Pinney, Secretary,	Phœnix.
V. V. Merino,	Flagstaff.
Theo. T. Swift,	Safford.

California.

Fish and Game Commission, San Francisco.

M. J. Connell, President,	Los Angeles.
David Starr Jordan,	Stanford.
F. G. Sanborn,	San Francisco.
John P. Babcock, Chief Deputy,	San Francisco.

Colorado.

State Game and Fish Commission.

Thomas J. Holland, Commissioner,	Denver.
R. L. Spargur, Chief Clerk,	Denver.
W. E. Patrick, Superintendent Fish Hatcheries,	Denver.
James A. Shinn, Deputy Commissioner,	Denver.

Connecticut.

George T. Mathewson, President,	Thompsonville.
E. Hart Geer, Secretary,	Hadlyme.
E. Hart Fenn,	Wethersfield.

Delaware.

Game Protective Association.

A. D. Poole, President,	Wilmington.
E. G. Bradford, Jr., Secretary and Treasurer,	Wilmington.

Florida.

Honorary Fish Commissioner.

John Y. Detwiler, ... New Smyrna.

Georgia.

Fish Commissioner.

A. T. Dallis, ... LaGrange.

Idaho.

Fish and Game Department.

William N. Stephens, State Game Warden, . . . Boise.
B. T. Livingston, Chief Deputy, ... Boise.

Illinois.

State Game Commissioner.

John A. Wheeler, ... Springfield.

Board of Fish Commissioners.

Nat H. Cohen, President, ... Urbana.
S. P. Bartlett, Secretary, ... Quincy.
Henry Kleine, ... Chicago.

Indiana.

George W. Miles, Commissioner, ... Indianapolis.
R. D. Fleming, Chief Deputy, North, ... Fort Wayne.
Jacob Sottong, Chief Deputy, South, ... Brookville.

Iowa.

State Fish and Game Warden.

George A. Lincoln, 234 Granby Block, ... Cedar Rapids.

Kansas.

L. L. Dyche, ... Pratt.

Louisiana.

Board of Commissioners for the Protection of Birds, Game and Fish.

Frank M. Miller, President, ... New Orleans.
Fred J. Grace, Register of State Land Office, . . . Baton Rouge.
Prof. W. R. Dodson, Director, State Experiment Stations, ... Baton Rouge.

MAINE.

Inland Fisheries and Game.

J. W. Brackett, Chairman, ... Phillips.
Blaine S. Viles, ... Augusta.
Edgar F. Ring, ... Orono.

Sea and Shore Fisheries.

James Donahue, Commissioner, ... Rockland.

MARYLAND.

Board of Shellfish Commissioners.

Walter J. Mitchell, Chairman, ... La Plata.
Benjamin K. Green, Treasurer, ... Westover.
Dr. Caswell Grave, Secretary, ... Baltimore.

State Fishery Force.

T. C. B. Howard, Commander, ... Annapolis.

State Game Warden.

Horace F. Harmonson, ... Berlin.

Fish Commissioners.

Samuel J. Twilley, ... Pocomoke City.
John H. Wade, ... Boonsborough.

MASSACHUSETTS.

Commissioners on Fisheries and Game.

George W. Field, Chairman, ... Boston.
John W. Delano, ... Marion.
George H. Garfield, ... Brockton.

MICHIGAN.

Fish Commissioners.

Charles D. Joslyn, President, ... Detroit.
Delbert H. Power, Vice-President, ... Sutton's Bay.
Fred Postal, ... Detroit.

State Game, Fish and Forestry Warden.

Charles S. Pierce, ... Lansing.
Charles N. Smith, Chief Deputy, ... Petoskey.

Minnesota.

Game and Fish Commissioners.

Robert Hannah, President,	Fergus Falls.
George J. Bradley, First Vice-President,	Norwood.
O. J. Johnson, Second Vice-President,	Glenwood.
Joseph A. Wessel, Secretary,	Crookston.
H. A. Rider, Executive Agent,	Little Falls.

Missouri.

Fish Commissioners.

L. A. Geserich, President,	St. Louis.
Ed. Lee,	St. Louis.
W. S. Willard, Secretary,	St. Joseph.
Ed. Willoughby,	Windsor.
Richard Porter,	Paris.

State Game and Fish Commissioner.

Jesse A. Tolerton,	Jefferson City.

Montana.

State Game and Fish Warden.

Henry Avare,	Helena.
D. H. Morgan, Chief Deputy,	Helena.

Nebraska.

Game and Fish Commission.

A. P. Shallenberger, Governor, and ex officio Game and Fish Commissioner,	Lincoln.
Dan Geilus, Chief Deputy Game and Fish Commissioner,	Lincoln.
W. J. O'Brien, Superintendent of Hatcheries,	Gretna.
Joe Benkler, Deputy Warden,	Lincoln.
Isaac King, Deputy Warden,	Superior.
John E. Donovan, Deputy Game Warden,	Lincoln.

Nevada.

Fish Commission.

George T. Mills,	Carson.
E. B. Yerington,	Carson.
James Clark,	Reno.

New Hampshire.

Nathaniel Wentworth, Chairman,	Hudson Centre.
Charles B. Clarke,	Concord.
Frank P. Brown,	Whitefield.

New Jersey.

Fish and Game Commissioners.

B. C. Kuser, President,	Trenton.
William A. Logue, Treasurer,	Bridgeton.
Percival Chrystie,	High Bridge.
Ernest Napier,	East Orange.
Walter H. Fell, Secretary,	Trenton.

New Mexico.

Game and Fish Warden.

Thomas P. Gable, Territorial Game and Fish Warden,	Santa Fé.
Willi G. Fischer, Chief Deputy Game and Fish Warden,	Santa Fé.

New York.

Forest, Fish and Game Commission.

Thomas S. Osborne, Commissioner.
John B. Burnham, Deputy Commissioner.
John D. Whish, Secretary.
Llewellyn Legge, Chief Game Protector.
Office, State Capitol, Albany, N. Y.

Bureau of Marine Fisheries.

Clinton S. Dixon, Deputy State Superintendent of Marine Fisheries.
Charles Wyeth, Engineer and Surveyor.
Office, 1 Madison Avenue, New York City.

North Carolina.

Dr. R. H. Lewis,	Raleigh.
T. Gilbert Pearson,	Greensboro.

North Dakota.

Game and Fish Board of Control.

Herman Winterer, President, ... Valley City.
J. L. Killion, Vice-President, ... Towner.
D. I. Armstrong, Secretary, ... Willow City.
J. B. Eaton, ... Fargo.
Thomas Griffiths, ... Grand Forks.
W. N. Smith, Chief Game Warden, District No. 1, . Grafton.
Olaf Bjorke, Chief Game Warden, District No. 2, . Abercrombie.

Ohio.

Commissioners of Fish and Game.

Paul North, President, ... Cleveland.
Thomas B. Paxton, ... Cincinnati.
J. F. Rankin, ... South Charleston.
D. W. Greene, ... Dayton.
George W. McCook, ... Steubenville.
George C. Blanckner, Secretary, ... Columbus.
J. C. Speaks, Chief Warden, ... Columbus.

Oklahoma.

State Game and Fish Warden.

Lon Frame, ... Ardmore.

Oregon.

Department of Fisheries.

R. E. Clanton, Master Fish Warden, ... Salem.

State Game and Forestry Warden.

R. O. Stevenson, ... Forest Grove.

Pennsylvania.

Department of Fisheries.

W. E. Meehan, Commissioner of Fisheries, ... Harrisburg.

Board of Fishery Commission.

John Hamberger, ... Erie.
Henry C. Cox, ... Wellsboro.
Andrew R. Whitaker, ... Phœnixville.
W. A. Leisenring, ... Mauch Chunk.

Game Commissioners.

Dr. Charles B. Penrose, President,	Philadelphia.
C. K. Sober,	Lewisburg.
John M. Phillips,	Pittsburg.
Arthur Chapman,	Doylestown.
William B. McCaleb,	Harrisburg.
Lanning Harvey,	Wilkes-Barre.
Dr. Joseph Kalbfus, Secretary,	Harrisburg.

RHODE ISLAND.

Commissioners of Inland Fisheries.

Charles W. Willard, President,	Westerly.
William H. Boardman, Vice-President,	Central Falls.
Adelbert H. Roberts, Auditor,	Woonsocket.
Isaac H. Clarke, Treasurer,	Jamestown.
Daniel B. Fearing,	Newport.
William P. Morton, Secretary,	Providence.

Commissioners of Shellfisheries.

Philip H. Wilbour, Chairman,	Little Compton.
John H. Northup,	Apponaug.
Edward Atchison,	Slatersville.
Samuel F. Bowden,	Barrington.
John G. Wilcox,	Westerly.

Commissioners of Birds.

C. E. Pierce, Chairman,	East Providence.
W. Gordon Reed, 2d,	Providence.
Edwin R. Lewis, M.D.,	Westerly.
W. H. Thayer,	Bristol.
C. M. Hughes,	Newport.

TENNESSEE.

State Warden.

Joseph H. Acklen,	Nashville.

TEXAS.

Game, Fish and Oyster Commission.

R. H. Wood,	Rockport.

UTAH.

Fred W. Chambers,	Salt Lake City.

Vermont.

John W. Titcomb, ... Lyndonville.

Virginia.

Commission of Fisheries.

W. McDonald Lee, Commissioner, ... Irvington.
S. Wilkins Matthews, Secretary, ... Oak Hall.
George B. Keezell, ... Keezeltown.
Bland Massie, ... Tyro.
J. M. Hooker, ... Stuart.
Edward L. C. Scott, Clerk, ... Richmond.

Washington.

Fish Commissioner and Game Warden Ex Officio.

John L. Riseland, ... Bellingham.

West Virginia.

Forest, Game and Fish Warden.

J. A. Viquesney, Warden, ... Belington.
W. B. Rector, Chief Deputy, ... Belington.
H. M. Lockridge, Chief Deputy, ... Belington.

Wisconsin.

Fish and Game Warden Department.

George W. Rickeman, State Fish and Game Warden, . Madison.
J. F. Sugden, Chief Deputy, ... Madison.

Commissioners of Fisheries.

The Governor, ex officio.
Jabe Alford, President, ... Madison.
George B. Hudnall, Vice-President, ... Superior.
E. A. Birge, ... Madison.
James J. Hogan, ... LaCrosse.
William J. Starr, ... Eau Claire.
A. A. Dye, ... Madison.
A. L. Osborn, ... Oshkosh.
James Nevin, Superintendent of Fisheries, . . . Madison.

Wyoming.

State Game Warden.

D. C. Nowlin, ... Lander.

[C.]

Distribution of Food Fish.

Trout Fry.

Distribution of Trout Fry from the Adams Hatchery during April and May, 1910.

Applicant.	Town.	Name of Brook.	Number.
Chester E. Gleason,	Pittsfield,	Sackett,	5,000
Stacy Oliver,	Pittsfield,	Schoolhouse,	5,000
Frank W. Rice,	Lanesborough,	Hancock,	5,000
William H. Newton,	Lanesborough,	Hancock,	5,000
C. R. St. James,	Lanesborough,	Allen,	5,000
Henry A. Root,	Hancock,	Hancock,	5,000
O. C. Bidwell,	Monterey,	Old Carter,	5,000
Samuel Newell,	Great Barrington,	Tributary to Alford,	5,000
John M. Maloney,	Great Barrington,	Green,	5,000
Henry W. Scott,	Great Barrington,	Green,	5,000
Homer E. Foote,	Great Barrington,	Seekonk,	5,000
Orlando S. Fish,	Pittsfield,	Rice,	5,000
James M. Seavey,	Pittsfield,	Sachem,	5,000
Joseph L. White,	Lanesborough,	Town,	5,000
H. J. Couch,	Lanesborough,	Rice,	5,000
James M. Downes,	Hancock,	Hancock,	5,000
W. E. Foster,	-	-	5,000
Walter G. Wood,	Huntington,	Woodruff,	5,000
H. J. Coughlin,	North Adams,	Sherman, Tunnell,	15,000
H. J. Coughlin,	Clarksburg,	North Branch,	
Harry J Sheldon,	Adams,	Bassett,	10,000
J. E. Morgan,	Adams,	Tophet,	5,000
John McCormick,	Windsor,	Tyler,	5,000
Harry J. Stetson,	Plainfield,	Stetson,	5,000
Robert Groves,	Savoy,	Bear,	5,000
D. E. Burnett,	Savoy,	Perkins,	5,000
James G. Bennett,	Cheshire,	Pettibone,	5,000
George McAuley,	Cheshire,	Mason,	5,000
Bradley C. Newell,	Rowe,	Newell Farm,	5,000
L. I. Brown,	Rowe,	Brown,	5,000
Ide Brown,	Rowe,	Hunt,	5,000
Arthur M Nichols,	North Adams,	Tunnell,	5,000
Arthur M. Nichols,	Clarksburg,	North Branch,	
Pittsfield Fish and Game Association,	Pittsfield,	Angler's Club Pond,	25,000
			195,000

Fry distributed from the Hadley Hatchery during March and April, 1910.

Herbert W. Gould,	Athol,	Newton,	5,000
Harry A. Bancroft,	Athol,	Newton,	5,000
Arthur W. Stevens,	Athol,	Ellinwood,	5,000
W. S. Ellinwood,	Athol,	Ellinwood,	5,000

Fry distributed from the Hadley Hatchery, etc. — Concluded.

Applicant.	Town.	Name of Brook.	Number.
James W. Boutell,	Athol,	Riceville,	5,000
H. S. Weston,	Athol,	Ellinwood,	5,000
Foster A. Caples,	Athol,	- - - -	5,000
E. B. Newton,	Athol,	Popple Camp,	5,000
Anson R. Tolman,	Phillipston,	Newton,	5,000
Claude R. Edgerly,	Athol,	Collar,	5,000
Joseph Hamel,	Boylston,	Greeley,	5,000
Oakley Whitney,	Petersham,	Popple Camp,	5,000
George W. Boutell,	Athol,	Newton,	5,000
W. L. Pitcher,	Westhampton,	Manhan River,	5,000
D. Scott Low,	Westhampton,	Manhan River (north branch),	5,000
J. A. Miller,	Easthampton,	Parsons,	5,000
Edw. L. Schmidt,	Belchertown,	Jabish,	5,000
M. W. Smith,	Goshen,	Rogers,	5,000
John Doherty,	Goshen,	Highland,	5,000
W. A. Smith,	Goshen,	Highland,	5,000
F. E. Hawks,	Goshen,	Packard,	5,000
John N. Moore,	Orange,	Cheney,	5,000
W. H. Gale,	Orange,	Goddard,	5,000
William Boyle,	Shelburne Falls,	Catamount,	5,000
E. M. Gould,	Shelburne Falls,	Long,	5,000
Arthur B. Harlow,	Easthampton,	Bassett,	5,000
Leon N. Baldwin,	Easthampton,	Hannum's,	5,000
Wilfred Laro,	Easthampton,	Hannum's,	5,000
Henry C. Davis,	Ware,	Bonn,	5,000
Stedman W. Coe,	Hardwick,	Newton,	5,000
E. L. Parker,	Coldbrook,	Coldbrook Stream,	5,000
Herbert E. Tyler,	Kendal Green,	Hobbs,	5,000
Winfield F. Rowe,	Weston,	Devil's Den,	5,000
George E. Warren, Jr.,	Waltham,	Pequod,	5,000
Elvin J. Hoffses,	Wayland,	Schoolhouse,	5,000
Charles F. Mills,	Wayland,	Pequod,	5,000
Dennis F. Shea,	Ware,	Flat,	5,000
			185,000

Fry distributed from the Sutton Hatchery during April and May, 1910.

William T. Sweet, E. L. Douglass, C. A. Kilburne, Frank Grant, W. S. Marsh, L. H. Bowers, R. C. Hollister, C. F. Bowers, John M. Sauter,	Westfield,	Powder Mill, Jack's,	45,000
A. W. Pratt,	Gardner,	Mosquito,	5,000
W. A. Streeter,	Gardner,	Hosmer,	5,000
E. L. Knowlton,	Gardner,	Poor Farm,	5,000
S. W. Rogers,	Phillipston,	Brigham,	5,000
H. L. Curtis,	Gardner,	Bailey,	5,000
C. Fred Morse,	Gardner,	Wilder,	5,000
H. G. Howard,	Ashburnham,	Cooper,	5,000
F. A. Gravlin,	Ashburnham,	Black,	5,000
John Gibson, Archie McKean,	Lancaster,	Slate Rock, Burke's, Shoeshank,	10,000
Horace H. Ramsey,	Orange,	Swift River,	5,000
A. P. Morin,	North Brookfield,	Rothwell, Mad, Snow,	15,000
Elmer A. Macker,	North Grafton,	Sheehan, Carroll, Bummit,	15,000
C. L. Allen,	Worcester,	Barber,	5,000
Henry E. Dean,	Worcester,	Lincoln,	5,000
Henry W. Carter,	Millbury,	Sutton,	5,000
W. F. Durgin,	Mendon,	Muddy,	5,000
J. S. Hubbard,	Fiskdale,	Clay,	5,000
Henry H. Hallock,	Hubbardston,	Prentice,	5,000
Charles C. Kinch,	Chelmsford,	Golden Cove,	5,000
Charles E. Blaisdell,	Lowell,	Flag Meadow,	5,000
Willis S. Holt,	West Andover,	Hardy's,	5,000
Fred E. Jones,	Tyngsborough,	Flint,	5,000

Fry distributed from the Sutton Hatchery, etc. — Concluded.

Applicant.	Town.	Name of Brook.	Number.
S. J. Bigelow,	North Chelmsford,	Swan's,	5,000
George W. Alcott,	Chelmsford,	Black,	5,000
John H. Seifer,	Westford,	Vine,	5,000
Henri E. Richardson,	Westford,	Snake Meadow,	5,000
H. A. MacDonald,	Beverly Farms,	Onion,	5,000
C. A. Currier,	Lexington,	Concord Avenue,	5,000
N. J. Hardy,	- -	- - -	5,000
O. W. Whittemore,	- -	- - -	5,000
Walter Baker,	Woburn,	Hall's,	5,000
C. E. Taylor,	- -	- - -	5,000
R. H. Magee,	- -	- - -	5,000
D. F. McIntosh,	- -	- - -	5,000
David G. Whelton,	Danvers,	Turnpike,	5,000
George M. Sinclair,	Middleton,	Blind,	5,000
F. S. Burke,	Danvers,	Nichols, Frost,	5,000
Richard L. Everit,	Wellesley Farms,	Indian Spring,	5,000
Nathan B. Everett,	Assonet,	Ledge,	5,000
Joseph Rudolph,	Norton,	Birch,	5,000
Dana C. Everett,	Assonet,	Ledge,	5,000
J. J. Kennedy,	Stoughton,	Dead Meadow,	5,000
Jefferson Jones,	Stoughton,	Cedar,	5,000
William H. Brown,	Royalston,	Whitney,	5,000
Marcus A. Young,	Royalston,	Loud,	5,000
Arthur L. Brown,	Royalston,	Stockwell,	5,000
Archie C. Towne,	Royalston,	Stockwell,	5,000
Charles T. Brown,	Royalston,	Loud,	5,000
Fitchburg Sportsmen's Club,	Fitchburg,	Ashburnham,	10,000
	Townsend,	Lord,	15,000
Daniel H. Rice,	Barre,	Tansey Meadow,	10,000
Fred Field,	Montague,	Cold,	5,000
R. L. Clapp,	Montague,	Pond,	10,000
O. E. Bradway,	Monson,	Bates and Conant,	10,000
Frank R. Sutcliffe,	Monson,	Sykes and Sutcliffe,	10,000
W. M. Baker,	New Salem,	Holden,	5,000
W. M. Baker,	Warwick,	Darling,	5,000
R. T. Shumway,	New Salem,	Porters,	10,000
A. T. Mitten,	- -	- - -	10,000
George S. Baker,[1]	Rehoboth,	Upper branch Palmer River,	10,000
R. W. Briggs,	Merrimac,	Attitash,	10,000
F. W. Read,	Middleborough,	Josie, Ford, Fall,	15,000
Brockton Fish and Game Association,	Bridgewater,	Sturtevant's,	15,000
Leominster Sportsmen's Association,	Leominster-Shirley,	Heywood, Tophet,	15,000
Fred Field,	Montague,	Cold,	5,000
W. E. Smith,[1]	North Chester,	Middle branch Westfield River,	20,000
James E. Bemis,[1]	Wellesley,	Fuller,	15,000
James E. Bemis,[1]	Needham,	Trim,	15,000
James E. Bemis,[1]	Newton,	Farm,	150,000
			545,000

Fingerling Trout Plants during Fall of 1910.

Edw. L. Knowlton,	Gardner,	Poor Farm,	500
S. W. Rogers,	Gardner,	Brigham,	500
A. W. Pratt,	Gardner,	Bailey,	500
H. L. Curtis,	Gardner,	Bailey,	500
Myron R. Goddard,	Gardner,	Hubbardston,	500
H. O. Bateman,	- -	- - -	500
Charles T. Brown,	Winchendon,	Belknap,	500
Levi F. Martin,	Winchendon,	Beaman,	500
W. H. Perry,	Winchendon,	Bailey,	500
Levi P. Ball,	Winchendon,	Beals,	500
H. A. Haywood,	Royalston,	Stockwell,	500
Marcus A. Young,	Winchendon,	Stockwell,	500
Archie C. Towne,	Winchendon,	Stockwell,	500
William H. Brown,	Winchendon,	Beaman,	500
A. L. Brown,	Winchendon,	Stockwell,	500
H. L. Howard,	Ashburnham,	Cooper,	500

[1] Obtained brown trout fry.

Fingerling Trout Plants during Fall of 1910 — Continued.

Applicant.	Town.	Name of Brook.	Number
Frank A. Gravlin,	Ashburnham,	Black,	500
William P. Wharton,	Groton,	Hunkerty,	1,000
F. J. Piper,	Townsend,	Stickney,	500
F. J. Knight,	Townsend,	Stickney,	500
F. L. Hager,	Baldwinville,	Brigham, Bourn and Hadley,	500
F. L. Newton,	Baldwinville,	Trout,	500
J. D. Mason,	Baldwinville,	Fenno,	500
M. H. Gleason,	Baldwinville,	Norcross,	500
J. H. Whitcomb,	Littleton,	Beaver,	500
Albert H. Sherman,	Harvard,	Hell Pond,	500
Edward S. Cook,	Norfolk,	Mann,	500
F. P. Searle,	Norfolk,	Cress,	500
J. N. Blanchard,	Franklin,	Paine's Pond,	500
H. A. Besse,	Franklin,	Cress,	500
Leominster Sportsmen's Association, Charles F. McCarthy, Francis W. Leary,	Lunenburg,	Lunenburg, Fort Meadow,	3,000
James H. McGarry, George A. Greene, Andrew L. Morgan,	Marlborough,	Flag, Bartlett,	2,500
Sutton Hatchery,	– –	– – –	2,000
Silas Hatch,	Falmouth,	Child's River,	1,000
Charles S. Baker,	Falmouth,	Coonamessitt,	1,000
James Heyes,	Westport,	Kirby,	1,000
Joseph Rudolph,	Taunton,	Bird, Segreganset,	1,000
James Burke,	South Westport,	Cornell,	1,000
Thomas Taylor,	Westport,	Bread and Cheese,	1,000
Frank W. Read,	Middleborough,	Fall, Josie Meadow,	1,000
Roland M. Keith,	Bridgewater,	Mill,	1,000
J. H. Tower,	Rockland,	Plyer and Molly,	1,000
W. Scott Edson,	Scituate,	Tack Factory, Spring,	1,000
F. M. Draper,	Norton,	Doris, Tucker,	1,000
R. W. Leonard,	Foxborough,	McAvoy,	1,000
Alton S. Brown,	Foxborough,	Rumford River,	1,000
John T. Robinson,	Hyde Park,	Pine Tree,	1,000
Charles L. McMahon,	Randolph,	Blue Hill,	1,000
J. J. Kennedy,	Stoughton,	Dead Meadow,	1,000
Reymund E. Warren,	– –	– – –	1,000
Frank B. Twitchell,	Natick,	Nobscot, Brackett's,	1,000
Charles N. Hargraves,	Framingham,	Rattlesnake, Sucker, Angelica,	1,000
Edward Babson,	Rockport,	Stony,	1,000
W. H. Gee,	Rockport,	Wine,	1,000
R. W. Briggs,	Amesbury,	Attitash,	1,000
Charles H. Preston,	Topsfield,	Elliott,	1,000
Herman A. MacDonald,	Beverly Farms,	Onion River,	1,000
D. G. Whelton,	Salem,	Poor,	1,000
Edgar P. Sellew,	Billerica,	Webb,	1,000
C. A. Currier,	Lexington,	Dunn's,	1,000
Charles F. Nourse,	Lexington,	Shawsheen,	1,000
O. W. Whittemore,	– –	– – –	1,000
N. J. Hardy,	– –	– – –	1,000
E. J. Hoffses,	Weston,	Cherry,	500
A. Grip,	Weston,	Allen,	500
Bernard W. Stanley,	Weston,	Allen,	500
Thomas H. Bruce,	Weston,	Cherry,	500
Henry H. Watson,	Weston,	Allen,	500
Frank H. Haron,	Weston,	Cherry,	500
Gardiner H. Fiske,	Weston,	Cherry,	500
John A. Barton,	Ashby-Townsend,	Pearl Hill,	3,000
Greenfield Sportsmen's Association,	Greenfield,	Green River,	2,000
Fred E. Field,	Montague,	Cold Brook,	400
R. L. Clapp,	Montague,	Pond,	400
Charles H. Sawyer,	Hatfield,	Roaring,	400
N. P. Farwell,	Turners Falls,	Fall River,	400
Frederick Spencer, Louis Vici, A. Schempp, John Conners,	Buckland,	Deerfield River,	1,600
W. C. Thompson,	Buckland,	Avery,	400
D. E. Benjamin,	– –	– – –	400
J. Phelps,	– –	– – –	400
A. G. Moody,	– –	– – –	400

Fingerling Trout Plants during Fall of 1910 — Continued.

Applicant.	Town.	Name of Brook.	Number.
Bradley C. Newell,	Rowe,	Newell Farm,	400
E. A. Pike,	Rowe,	Hunt,	400
J. N. Moore,	Orange,	Cheney,	400
W. H. Gale,	Orange,	Jones,	400
R. T. Shumway,	New Salem,	Poole River,	400
H. H. Ramsey,	New Salem and Warwick,	Gale and Cheney,	400
W. M. Baker,	Warwick,	Darling,	400
J. W. Boutell,	Athol,	Riceville,	200
A. W. Stevens,	– –	– – –	200
E. B. Newton,	– –	– – –	200
W. S. Ellinwood,	Athol,	Ellinwood,	200
B. W. Streeter, Jr.,	Athol,	West,	200
Joseph Hamel,	Royalston,	Nancy Whipple,	200
C. R. Edgerly,	Athol,	Greeley,	200
J. L. Pelkey,	– –	– – –	400
A. P. Rice,	Athol,	Nelson,	200
G. A. Caples,	– –	– – –	200
J. L. Powers,	– –	– – –	400
Louis H. Ruggles,	Furnace,	Moose,	400
W. E. Davis,	Winchendon,	Priest,	400
H. H. Hallock,	Hubbardston,	Prentiss,	400
W. M. Tourtelott,	Prescott,	West branch Swift River,	400
H. E. Brown,	North Dana,	Powers,	400
G. W. Durkee,	Dana,	Blackmer,	400
J. E. Sweetland, E. J. Brannigan,	Dana,	Blackmer,	400
B. W. Buckley, J. H. Neff,	Ware,	Muddy, Flat,	1,200
A. T. Mitten,	– –	– – –	400
John Corsa,	– –	– – –	400
A. H. Dakin,	– –	– – –	400
J. F. Page,	– –	– – –	400
J. O. Thompson,	– –	– – –	400
N. E. Augur,	– –	– – –	400
D. S. Low,	Easthampton,	Bassett,	400
W. L. Pitcher,	Easthampton,	Bassett, Sawyer,	400
J. A. Miller,	Easthampton,	Manhan,	400
E. R. Alvord,	Easthampton,	Pomeroy,	400
Northampton Rod and Gun Club,	Easthampton, Hatfield, Northampton,	Parsons, Broad, Running Gutter,	2,000
A. J. Polmatin,	Williamsburg,	Mill River,	400
M. S. Howes,	Cummington,	Willcutt,	400
W. E. Pillinger,	Williamsburg,	Ashfield,	400
F. L. Bisbee,	Williamsburg,	North branch Mill River,	400
F. A. Shumway,	Williamsburg,	Bradford,	400
M. E. Story,	– –	– – –	400
E. A. Woodward,	– –	– – –	400
H. A. Buzzell,	Longmeadow,	Pecowsie,	400
A. D. Prouty,	– –	– – –	400
R. L. Smith,	Hampden,	Scantic River,	400
Ira J. Humes,	Holyoke,	Batchelor,	800
J. M. Eddy,	Enfield,	Sunk,	400
Stevens Rod and Gun Club,	Chicopee Falls,	Cooley, Williams,	1,000
Westfield Fish and Game Club,	Westfield,	Sandy Mill,	2,000
A. D. Norcross,	Monson,	Conant,	400
H. T. Moulton,	Wales,	Conant,	400
W. M. Peck,	Wales,	Conant,	400
S. D. Sherwood,	Wales,	Conant,	400
North Brookfield Fish and Game Association,	North Brookfield,	Webb, Harrington,	1,000
J. F. Stone,	Sturbridge,	Walker Pond,	400
F. T. Bullard,	Sturbridge,	Great,	400
W. E. Holland,	Brimfield,	Quoboag River,	1,200
G. H. Wilson,	Spencer,	New Pond,	400
Dr. A. E. Snow,	Spencer,	Wilson,	400
H. S. Tripp,	Spencer,	Thompson,	400
C. E. Bill,	West Brookfield,	Sucker,	200
W. E. Sibley,	West Brookfield,	Tanney, Bassett,	200
N. C. Capen,	Spencer,	Meadow,	400
A. D. Putnam,	– –	– – –	400

Fingerling Trout Plants during Fall of 1910 — Concluded.

Applicant.	Town.	Name of Brook.	Number.
C. C. Dodge,	Shrewsbury,	Bullard,	400
H. E. Dean,	Worcester,	Lincoln,	400
George P. King,	- -	- - -	400
R. E. Howard,	- -	- - -	400
Norton Company,	Worcester,	Barber,	400
Clinton Rod and Gun Club,	Clinton,	Collins, Clamshell,	1,000
A. G. Chickering,	Bolton,	Hillside,	400
L. F. Cobb,	- -	- - -	400
W. F. Hosmer,	South Sudbury,	Chub,	400
H. M. Plimpton,	Sutton,	Mill,	400
G. A. Moo,	- -	- - -	400
H. W. Carter,	Millbury,	No Name,	400
E. A. Macker,	North Grafton,	Summit, Shahan,	1,200
E. C. Traver,	- -	- - -	400
H. D. Aldrich,	- -	- - -	400
I. P. Taft,	- -	- - -	400
B. E. Aldrich,	Milford,	Braggville,	400
Dr. P. E. Joslin,	Hopedale,	Muddy Pond,	400
W. F. Durgin,	Mendon,	Muddy,	400
A. F. Johnson,	- -	- - -	400
C. A. Reynolds,	Sutton,	Stevens,	400
W. R. Wallis,	East Douglas,	Centerville,	400
E. P. Heath,	East Douglas,	Centerville, Howell,	400
P. S. Callahan,	Fiskdale,	Hyland,	400
J. P. Siddall,	Sturbridge,	Hinman,	400
C. R. Kelley,	Sturbridge,	Hobbs,	400
Fred Quinn,	Fiskdale,	Cooper,	400
E. D. Atkins,	Uxbridge,	Cold Spring,	400
C. B. Adams,	Webster,	Sucker, Brown,	1,200
H. P. Coughlin,	- -	- - -	2,000
W. P. Martin,	Adams,	Bassett,	400
R. A. Roehm,	Adams,	Dean,	400
W. N. Nye,	- -	- - -	400
P. E. Powers,	Adams,	Miller,	400
H. H. Fitzroy,	Savoy Center,	Town Hall,	400
Michael Clancy,	- -	- - -	400
P. H. Callahan,	Cheshire,	Needham,	400
Francis O'Neill,	Cheshire,	Kitchen, McDonald,	400
Pittsfield Anglers' Club,	Pittsfield,	Yokum, Sackett,	2,000
Dr. A. L. Boudreau,	Becket,	Cole,	400
J. N. Pelkey,	Middlefield,	Coldbrook,	400
George F. Blood,	West Stockbridge,	Mack,	400
A. Silvernail,	West Stockbridge,	Mack,	400
J. L. Hover,	West Stockbridge,	Flat,	400
Thomas S. Clarke,	Lenox,	Farm,	1,000
H. E. Foote,	Great Barrington,	Green River,	400
J. A. Verchot,	New Boston,	Balch, Thorp,	400
H. S. Manley,	Montville,	Morley, Reservoir,	400
J. G. Stevens,	Great Barrington,	Stevens,	400
George W. Greene,	New Marlborough,	Konkapot,	400
Samuel Newell,	Great Barrington,	Alford,	400
C. M. Gibbs,	Great Barrington,	Green River,	400
			123,500

Ponds stocked and closed in Accordance with Chapter 91, Section 19, Revised Laws, as amended by Chapter 274, Acts of 1903, and further amended by Chapter 306, Acts of 1907.

Name of Pond.	Town.	Brown Trout Fingerlings.	White Perch.
Muddy,	Kingston,	1,000	-
White,	Athol,	1,000	-
Russell,	Russell,	1,000	-
Fresh,	Dennis,	-	121
Attitash,	Amesbury,	1,000	-
Pelham,	Wayland,	1,000	-
Little Chauncy,	Northborough,	1,000	-
Little Herring,	Plymouth,	1,000	-
Scaddings,	Taunton,	1,000	-
Indian Head,	Pembroke,	1,000	-
		9,000	121

Waters stocked without Further Action during 1910.

Name of Waters.	Town.	White Perch.	Brown Trout Fingerlings.
Whalom Lake,	Lunenburg,	432	-
Long Pond,	Lakeville,	242	-
Shawsheen River,	Billerica,	301	-
Nabnasset,	Westford,	281	-
Harris,	Methuen,	186	-
Jamaica,	Boston,	154	-
Scargo Lake,	Dennis,	-	1,000
		1,596	1,000

[D.]

Distribution of Pheasants.

Applicant.	Town.	Number.
Sigmund Klaiber,	Turners Falls,	12
Dennis E. Farley,	Farley,	12
North Brookfield Fish and Game Association.	North Brookfield,	12
M. C. Needham,	Oakham,	12
John W. Jackson,	Belchertown,	12
Waldo H. Pierce,	Prescott,	12
Charles E. Gee,	North Dana,	12
George W. Alcott,	Lowell,	12
Henry Boynton,	Lowell,	12
C. W. Prescott,	Concord,	12
James P. Stearns,	Brookline,	12
George W. Randall,	Plympton,	12
William J. Wright,	Duxbury,	12
Edw. E. Whiting,	West Upton,	12
Roland M. Keith,	Bridgewater,	12
George R. Sampson,	Middleton,	12
J. A. Barton,	Fitchburg,	12
Homer E. Foote,	Great Barrington,	12
J. G. Stevens,	Great Barrington,	12
Frank W. Rice,	Pittsfield,	12
W. E. Foster,	Lanesborough,	12
Rufus W. Page,	Newburyport,	12
Basil E. Aldrich,	Milford,	12
Arthur LeB. Treen,	West Medway,	12
Walter F. Durgin,	Hopedale,	12
Willis L. Colson,	Boston,	12
P. S. Callahan,	Fiskdale,	12
E. D. Atkins,	Uxbridge,	12
W. R. Wallis,	East Douglas,	12
A. L. Nickerson,	Dedham,	12
E. W. Grew,	Boston,	12
George H. Doty,	Waltham,	12
S. G. Tenney,	Williamstown,	12
Humphrey J. Coughlin,	North Adams,	12
H. H. Whitcomb,	Littleton,	12
Frank J. Knight,	Townsend,	12
Charles F. Cooper,	Springfield,	12
Frank S. Eaton,	Springfield,	12
George Brimicomb,	Shrewsbury,	12

Distribution of Pheasants — Concluded.

Applicant.	Town.	Number.
Thomas W. Lynch,	Sterling,	12
Henry E. Dean,	Worcester,	12
Dennis F. Shea,	Ware,	12
Albert W. Lewis,	Fall River,	12
Melville Anderson,	Fall River,	12
Harrison G. Blake,	Woburn,	12
S. H. Sinclair,	Salem,	12
Ernest J. Varrell,	Marblehead,	12
William C. Bradley,	Rockport,	12
John C. Spring,	West Gloucester,	12
Robert K. Lufkin,	Gloucester,	12
W. Prentiss Parker,	Ipswich,	12
John E. Gibson,	Merrimac,	12
Robert W. Adams,	Chelmsford,	12
Travers D. Carman,	Tolland,	12
C. F. Gifford,	Westport Factory,	4
Joel P. Bradford,	New Bedford,	4
Albert C. Aiken,	Fairhaven,	4
John J. Kennedy,	Stoughton,	4
F. M. Draper,	East Norton,	4
Melvin S. Nash,	Hanson,	4
William P. Melcher,	Waquoit,	4
Howard Marston,	Boston,	4
Leon P. Nourse,	Westborough,	4
John M. Eddy,	Smith's,	4
Raymond S. Smith,	Hampden,	4
J. C. Crombie,	Methuen,	4
		696

[E.]

Distribution of Quail.

Applicant.	Town.	Number.
G. W. Field,	Sharon,	26
E. M. Brastow,	Wrentham,	26
F. O. Long,	North Grafton,	25
H. M. Blackstone, superintendent,	Bridgewater,	26
Everett W. Needham,	Westminster,	26
F. J. Dutcher,	Hopedale,	26
Forest Park,	Springfield,	16
State Hatchery Grounds,	Wilkinsonville,	11
		182

[F.]

Arrests and Convictions.

Report upon Convictions, Fines, etc., for Violations of the Fish and Game Laws.

State v. —	Town or City.	Offence.	Court Decision.	Fine.	Remarks.
Mike Konstantynowicz,	New Bedford,	Taking shellfish in violation of section 114, chapter 91, Revised Laws, as amended by chapter 285, Acts of 1907; also chapter 403, Acts of 1909, and chapter 177, Acts of 1910,	Convicted,	$10 00	
Augustine Cabral,	New Bedford,		Convicted,	10 00	
Manuel Soares,	New Bedford,		Convicted,	10 00	
Charles H. Davis,	Chatham,		Convicted,	5 00	
Manuel Perry,	New Bedford,		Convicted,	10 00	
Odelon Leblanc,	New Bedford,		Convicted,	10 00	
Walter Latoper,	New Bedford,		Convicted,	10 00	Failed to pay; went to jail.
William Walsh, Jr.,	East Boston,		Convicted,	5 00	
William Walsh, Sr.,	East Boston,		Convicted,	10 00	
John Souza,	New Bedford,		Convicted,	10 00	
Edward Delair,	New Bedford,		Convicted,	10 00	
Frank England,	New Bedford,		Convicted,	10 00	
Elisha Clark,	New Bedford,		Convicted,	10 00	
Manuel Sylvia,	New Bedford,		Convicted,	10 00	
Antone Sylvia,	New Bedford,		Convicted,	10 00	
James Medeiros,	Dartmouth,		Convicted,	10 00	
Manuel Souza,	Dartmouth,		Convicted,	10 00	
Salvador Souza,	Dartmouth,		Convicted,	10 00	
Antone Gaper,	New Bedford,		Convicted,	10 00	
Joseph Gleason,	Dorchester,		Convicted,	5 00	
Alfonso Marino,	Boston,		Convicted,	5 00	
Cologero Marino,	Boston,		Convicted,	5 00	
Wilfred Breault,	New Bedford,		Convicted,	10 00	
Manuel Morris,	New Bedford,		Convicted,	15 00	

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Report upon Convictions, Fines, etc., for Violations of the Fish and Game Laws — Continued.

STATE v. —	Town or City.	Offence.	Court Decision.	Fine.	Remarks.
Dennis McGee,	Quincy,	Taking shellfish in violation of section 114, chapter 91, Revised Laws, as amended by chapter 285, Acts of 1907; also chapter 403, Acts of 1909, and chapter 177, Acts of 1910.	Convicted,	$5 00	
Michael Walsh,	Quincy,		Convicted,	5 00	
Edmund Bergeron, Jr.,	New Bedford,		Convicted,	10 00	Failed to pay; went to jail.
William H. Lawler,	Beachmont,		Convicted,	–	Filed.
William J. Powers,	Beachmont,		Convicted,	–	Filed.
David A. Ross,	Beachmont,		Convicted,	–	Filed.
George Phillips,	Revere,		Discharged,	–	
Alonzo Cook,	Revere,		Convicted,	5 00	
John Campiano,	Dorchester,		Convicted,	5 00	
Carlo Ferretti,	Lynn,		Convicted,	5 00	
Peter Rodgers,	New Bedford,		Convicted,	15 00	
Alphonse Parent,	New Bedford,		Convicted,	15 00	
Joseph Millo,	New Bedford,		Convicted,	15 00	
Joseph Arsenault,	New Bedford,		Convicted,	15 00	
John V. DeCosta,	Fairhaven,		Convicted,	15 00	
Manuel Cruz,	New Bedford,		Convicted,	15 00	
John Millo,	New Bedford,		Convicted,	15 00	
John Gomes,	New Bedford,		Convicted,	15 00	
John Correia,	Fairhaven,		Convicted,	15 00	
Manuel DeCoste,	New Bedford,		Convicted,	15 00	
John Newman,	Hull,		Convicted,	10 00	
Nelson Neilson,	Hull,		Convicted,	10 00	
Peter Lawson,	Hull,		Convicted,	10 00	
James Neilson,	Hull,		Convicted,	10 00	
John Johnson,	Hull,		Convicted,	10 00	
Maurice Neilson,	Hull,		Convicted,	10 00	
Maurice Morrissey,	Hull,		Convicted,	10 00	
Daniel Daly,	Hull,		–	–	Defaulted; second offence.
Michael Giroward,	New Bedford,		Convicted,	15 00	
Maurice Neilson,	Hull,		Discharged,	–	
J. Tinlson,	Chelsea,		Convicted,	10 00	
Arthur Cabana,	New Bedford,		Convicted,	15 00	Failed to pay; went to jail.
Manuel Mellor,	New Bedford,		Convicted,	15 00	Failed to pay; went to jail.
Joseph Dion,	New Bedford,		Convicted,	15 00	
Charles Cyr,	Fairhaven,		Convicted,	–	Filed.
Manuel Gomes,	New Bedford,		Convicted,	15 00	
Manuel Avila,	New Bedford,		Convicted,	15 00	
William Breault,	New Bedford,		Convicted,	15 00	
Loring M. Austin,	New Bedford,		Convicted,	15 00	

Joseph Mowiez,	New Bedford,	Taking shellfish in violation of section 114, chapter 91, Revised Laws, as amended by chapter 285, Acts of 1907; also chapter 403, Acts of 1909, and chapter 177, Acts of 1910,	Convicted,	15 00	
Alfred Antoni,	New Bedford,		Convicted,	-	Filed.
Manuel Ferreira,	New Bedford,		Convicted,	15 00	
Alexander Cormier,	New Bedford,		Convicted,	15 00	
Oliver Cormier,	New Bedford,		Convicted,	15 00	
Antone Souza,	New Bedford,		Convicted,	15 00	
John Carson,	New Bedford,		Convicted,	-	Filed.
Frank Coons,	New Bedford,		Convicted,	15 00	
John Teres,	New Bedford,		Convicted,	15 00	
William Lacharette, Jr.,	New Bedford,		Convicted,	-	Filed.
William Lacharette, Sr.,	New Bedford,		Convicted,	-	Filed.
Manuel Brown,	Fairhaven,		Convicted,	15 00	
William S. Staples,	Fairhaven,		Convicted,	15 00	
William D. Westgate,	Fairhaven,		Convicted,	15 00	
Clovics Gammon,	New Bedford,		Convicted,	10 00	
Manuel Damello,	New Bedford,		Convicted,	10 00	
John Carey,	New Bedford,		Convicted,	20 00	
Alex Lapirre,	New Bedford,		Convicted,	20 00	
Clovis Leblanc,	New Bedford,		Convicted,	20 00	
Manuel Perry,	Berkley,	Residents hunting without certificate of registration in violation of chapter 484, Acts of 1908, as amended by chapter 325, Acts of 1909,	Convicted,	10 00	
William A. Walker,	Westport,		Convicted,	-	Filed.
Antonio Prone,	Lawrence,		Convicted,	-	Sentence suspended.
Walter H. Jones,	Worcester,		Convicted,	10 00	
Bernard E. Page,	Walpole,		Convicted,	10 00	
David P. Allen,	Framingham,		Convicted,	10 00	
Carl S. Church,	Arlington,		Convicted,	10 00	
Donald H. Church,	Arlington,		Convicted,	10 00	
George S. Taylor,	West Yarmouth,		Convicted,	10 00	
Charles A. Fulton,	Boston,		Convicted,	-	Filed.
Ellis B. West,	Revere,		Convicted,	10 00	
Guy P. Arienti,	Great Barrington,		Convicted,	3 00	
Peter Arienti,	Great Barrington,		Convicted,	5 00	
George K. Tuttle,	South Acton,		Discharged,	-	
Andrew Tucker,	Middleborough,		Convicted,	-	Filed.
William Heiser,	Readville,		Convicted,	5 00	
William F. Osgood,	Reading,		Convicted,	10 00	
Charles H. King,	Mansfield,		Convicted,	10 00	
Walter Johnson,	Lynn,		Convicted,	10 00	
James McDonald,	Harvard,		Convicted,	-	Filed.
Eugene Lindsey,	Russell,		Convicted,	10 00	
Arthur Delorey,	Lynn,		Convicted,	10 00	
Harry Smith,	Peabody,		Convicted,	10 00	
Charles Dudley,	Athol,		Convicted,	10 00	
Jugas Thomassunas,	Athol,		Convicted,	10 00	

Report upon Convictions, Fines, etc., for Violations of the Fish and Game Laws — Continued.

STATE *v.* —	Town or City.	Offence.	Court Decision.	Fine.	Remarks.
Eugene Battiston,	Leverett,	Residents hunting without certificate of registration in violation of chapter 484, Acts of 1908, as amended by chapter 325, Acts of 1909,	Convicted,	$10 00	
Peter Lucy,	Leverett,		Convicted,	10 00	
Alton C. Tuckerman,	Tisbury,		Convicted,	10 00	
Arthur J. Gould,	Middleton,		Convicted,	10 00	
Louis Ouilette,	Taunton,		Convicted,	–	Filed.
Daniel Hawley,	Arlington,		Convicted,	10 00	
Myron L. Newton,	Charlemont,		Convicted,	10 00	
Daniel Debieu,	Holyoke,		Convicted,	–	Filed.
Charles H. Chase,	Mansfield,		Convicted,	–	Filed; paid costs of court, $2.35.
David Palmer,	Adams,		Convicted,	10 00	
Albert Farren,	Hawley,		Discharged,	–	
Michael Murphy,	Ware,		Convicted,	10 00	
Steven C. Webster,	Scituate,		Convicted,	10 00	
Joseph Sullivan,	Milford,		Convicted,	–	Filed.
Albert Bishop,	– –		– –	–	Defaulted.
Alfred Butler,	North Brookfield,		Discharged,	–	Paid costs of court, $4.41.
Charles H. Goodell,	Worcester,		Discharged,	–	
Paul Martino,	Northampton,	Aliens hunting without license in violation of chapter 317, Acts of 1905, as amended by chapter 402, Acts of 1908, and further amended by chapter 614, Acts of 1910,	Convicted,	12 00	
Felix Sanfanelli,	Springfield,		Discharged,	–	
Andriel Seibelli,	Springfield,		Convicted,	10 00	
Waldo Biancout,	Springfield,		Convicted,	10 00	
Antone Sylvia,	Oak Bluffs,		Convicted,	10 00	
James Mauvisk,	Lowell,		Convicted,	10 00	
Ambrose Newell,	Douglas,		Convicted,	15 00	
Stephen Gozzleo,	North Adams,		Convicted,	10 00	
Philip Mongini,	Sheffield,		Convicted,	–	Continued subject to good conduct.
Andy McCollum,	Topsfield,		Convicted,	10 00	
Ortanlolio Ojinlajio,	Sharon,		Convicted,	10 00	
Primo Guletti,	Springfield,		Convicted,	10 00	
Michael Grilli,	Boston,		Convicted,	10 00	
Patrick Rocco,	Boston,		Convicted,	10 00	
Joseph Ceumto,	Richmond,		Convicted,	10 00	
Natale Amici,	Lee,		Convicted,	15 00	
Angelo Bortelli,	Lee,		Convicted,	15 00	
George Guarini,	Monroe,		Convicted,	15 00	
Bernardo Dominico,	North Attleborough,		Convicted,	10 00	Sent to jail for assault, etc.; 9 months.
Volastyslaw Wynyski,	Norwood,		Convicted,	10 00	
Joseph Antolini,	Lynn,		Convicted,	15 00	

Samuel Bonner,	Brookfield,		Convicted,	15 00	Appealed; paid in superior court.
Fred Bonner,	Brookfield,		Convicted,	15 00	Appealed; paid in superior court.
Napoleon Desrosiers,	Athol,	Aliens hunting without license in violation of chapter 317, Acts of 1905, as amended by chapter 402, Acts of 1908, and further amended by chapter 614, Acts of 1910,	Convicted,	10 00	
Pietro Dinicolo,	Fitchburg,		Convicted,	10 00	
Nicolo Castronomo,	Lynn,		Convicted,	10 00	
Ambrose Newell,	East Douglas,		Convicted,	10 00	
Umberto Songani,	Hudson,		Convicted,	10 00	
Endor Carroll,	New Bedford,		Convicted,	10 00	
Vito Margiotta,	Wakefield,		Convicted,	10 00	
George Guarini,	Monroe,		Convicted,	10 00	
Robert J. Coleman,	Lynn,		Convicted,	10 00	
John Taglioferri,	Athol,	Killing song or insectivorous birds in violation of section 7, chapter 92, Revised Laws, as amended by chapter 250, Acts of 1907,	Convicted,	10 00	
William F. Flynn,	Belchertown,		Convicted,	10 00	
Charles F. Michael,	Gloucester,		Convicted,	10 00	
John J. Ellis,	Gloucester,		Convicted,	10 00	
John Piscol,	Chicopee,		Convicted,	10 00	
Lawrence Gallagher,	New Bedford,		Convicted,	–	Filed.
Fred Varone,	East Brookfield,		Convicted,	–	Filed.
John Kier,	Palmer,		Convicted,	50 00	
John Simonds,	Palmer,		Discharged,	–	
Thomas Cook,	Lee,		Convicted,	20 00	
James Wilson, Jr.,	West Stockbridge,		Convicted,	10 00	
Charles Healy,	Montgomery,		Convicted,	–	Filed.
Gilbert Adkins,	Montgomery,		Convicted,	–	Filed.
George Rounds,	Williamstown,		Discharged,	–	
Everett W. Donalson,	Sutton,		Convicted,	–	Filed; paid costs of court, $12.
Edward L. Cosgrove,	Northfield,	Killing or hunting deer in violation of chapter 396, Acts of 1909, and section 1, chapter 545, Acts of 1910,	Convicted,	75 00	Appealed; discharged in superior court.
Walter F. Gould,	Ipswich,		Convicted,	–	Filed.
Donald Powell,	Wilbraham,		Convicted,	25 00	
Robert J. Hartness,	Grafton,		Discharged,	–	
John A. Lucas,	Sharon,		Discharged,	–	
Sydney A. Weston,	Sharon,		Discharged,	–	
William R. Snow,	Sharon,		Discharged,	–	
Benjamin A. Lucas,	Sharon,		Convicted,	50 00	Appealed.
William Parker,	Sharon,		Discharged,	–	
Robert G. Morse,	Sharon,		Discharged,	–	
Clarence E. Heath,	Dedham,		Discharged,	–	
John S. Nichols,	Hartford, Conn.,	Nonresidents hunting without license in violation of chapter 198, Acts of 1907, as amended by chapter 262, Acts of 1909,	Convicted,	15 00	
Thomas R. Brown,	Montclair, N. J.,		Convicted,	10 00	
William H. Kent,	Providence, R. I.,		Convicted,	5 00	
Emil Johnson,	Boylston,		Convicted,	–	Probation for six months.
William P. Brigham,	West Boylston,	Hunting on Lord's day in violation of chapter 176, Acts of 1904,	Convicted,	10 00	Appealed; paid in superior court.
George S. Taylor,	West Yarmouth,		Convicted,	10 00	
Morris I. Johnson,	West Yarmouth,		Convicted,	10 00	

Report upon Convictions, Fines, etc., for Violations of the Fish and Game Laws — Continued.

STATE *v.* —	Town or City.	Offence.	Court Decision.	Fine.	Remarks.
Stephen Gozzleo,	North Adams,	Hunting on Lord's day in violation of chapter 176, Acts of 1904,	Convicted,	-	Filed.
Harry Smith,	Lawrence,		Convicted,	$10 00	Also costs of court, $1.90.
Michael Grilli,	Boston,		Convicted,	10 00	Gun confiscated.
Patrick Rocco,	Boston,		Convicted,	10 00	
Charles Barrett,	North Andover,		Convicted,	10 00	Also costs of court, $4.38.
Joseph Censato,	Richmond,		Convicted,	10 00	
Arthur Flebotte,	Indian Orchard,		Convicted,	5 00	
Adelino Castignetti,	Framingham,		Convicted,	15 00	
William F. Flynn,	Belchertown,		Convicted,	10 00	
Joseph Brusti,	Chicopee,		Convicted,	15 00	
Daniel Sentry,	South Weymouth,		Convicted,	-	Filed; costs of court, $3.
Ralph H. Proctor,	South Weymouth,		Convicted,	-	Filed; costs of court, $3.
Henry Eaton,	Berkley,		Discharged,	-	
Ralph Dembroder,	Harvard,		Discharged,	-	
James McDonald,	Harvard,		Convicted,	10 00	
Joseph Fraser,	Fall River,		Convicted,	-	Filed.
Charles F. Carlton,	Halifax,		Convicted,	10 00	
George Seidel,	Adams,		Convicted,	-	Filed.
David Palmer,	Adams,		Convicted,	-	Filed.
Edward Fencler,	Lynnfield,		Convicted,	10 00	
Konstantz Yackewicz,	Cambridge,		Convicted,	5 00	
Joseph Chevator,	Cambridge,		Convicted,	5 00	
Ardino Andrizzi,	Natick,		Convicted,	10 00	
Giuseppe Pangini,	Natick,		Convicted,	10 00	
Stanislaw Bursee,	Worcester,		Convicted,	-	Filed; costs of court, $5.
Walter H. Jones,	Worcester,		Convicted,	20 00	
Frederick G. Smith,	Worcester,		Convicted,	20 00	
David Palmer,	Adams,	Hunting with ferret in violation of section 11, chapter 92, Revised Laws, as amended by chapter 328, Acts of 1909; also chapter 533, Acts of 1910,	Convicted,	10 00	
George Seidel,	Adams,		Convicted,	10 00	
John L. Doyle,	North Oxford,		Convicted,	25 00	
James J. Rice,	North Oxford,		Convicted,	25 00	
John White,	North Oxford,		Convicted,	25 00	
Theo. Mathels,	Cohasset,	Setting snares, traps, etc., in violation of chapter 328, Acts of 1909,	Convicted,	15 00	
Philip Mongini,	Sheffield,		Convicted,	20 00	
George Simpson,	Medfield,		Convicted,	20 00	
Charles Winslow,	Fall River,	Setting seine in violation of section 4, chapter 401, Acts of 1885,	Convicted,	20 00	
Elbridge Dam,	Weymouth,	Netting smelts in violation of section 74, chapter 91, Revised Laws,	Convicted,	50 00	
Carl Wheblo,	Weymouth,		Discharged,	-	

William Wall,	Braintree,	Possession of smelts in close season in violation of section 71, chapter 91, Revised Laws,	Convicted,	5 00	
William White,	Braintree,		Convicted,	5 00	
Frank McCue,	Braintree,		Convicted,	25 00	Failed to pay; went to jail.
William E. Crossman,	Weymouth,		Convicted,	5 00	
Carl Whebb,	Weymouth,		Convicted,	15 00	
Joseph Allen,	Fall River,	Taking fish which frequent fresh water in violation of section 132, chapter 91, Revised Laws, as amended by chapter 498, Acts of 1908,	Convicted,	20 00	
Charles Winslow,	Fall River,		Convicted,	30 00	Appealed; paid $20 in superior court.
William McNorton,	Fall River,		Convicted,	–	Filed; paid costs, $7.50.
Phillip H. Negus,	Fall River,		Convicted,	–	Filed; paid costs, $7.50.
Waldo Sherman,	Freetown,		Convicted,	–	Filed; paid costs, $7.50.
John Van Valkenburgh,	Sheffield,		Convicted,	5 00	
Dennis Shea,	Holyoke,		Convicted,	10 00	
Salvatore Colona,	Norton,		Convicted,	15 00	
Angelo Malomtonio,	Norton,		Convicted,	15 00	
N. E. Booth,	**Fall River,**	Possession of live song or insectivorous birds in violation of section 7, chapter 92, Revised Laws, as amended by section 1, chapter 250, Acts of 1907,	Convicted,	–	Filed; paid costs, $1.55.
Henry Strom,	**Montague,**	Possession of trout in close season in violation of chapter 377, Acts of 1909,	Convicted,	10 00	
Wyatt H. Hathaway,	**Palmer,**	Killing deer with rifle in violation of section 17, chapter 92, Revised Laws, as amended by chapter 396, Acts of 1909,	Convicted,	–	Filed.
Leonard Bartlett,	Walpole,	Having trout under 6 inches in possession in violation of chapter 377, Acts of 1909; also chapter 469, Acts of 1910,	Convicted,	1 00	
Walter Turner,	Hawley,		Convicted,	20 00	Also costs of court, $4.
Joseph Monto,	Pittsfield,		Convicted,	25 00	
William L. Neilson,	Worcester,		Convicted,	5 00	
Arthur Smith,	Barre,		Convicted,	5 00	
O. V. White,	Worcester,		Convicted,	5 00	
Henry Forpelle,	Springfield,		Convicted,	20 00	
Henry Walker,	Worcester,		Convicted,	10 00	
Howard Gibson,	Boston,	Fishing in closed ponds in violation of section 19, chapter 91, Revised Laws, as amended by chapter 306, Acts of 1907,	Convicted,	20 00	
Henry Peach,	Malden,		Convicted,	20 00	
Alfred Turner,	Lawrence,		Convicted,	–	Filed.
Nathan B. McLeod,	Dorchester,		Convicted,	10 00	
Edwin E. Farnham,	Belmont,		Convicted,	–	Filed.
F. L. Johnson,	Waltham,		Convicted,	–	Filed.
Harry A. Wilson,	Waltham,		Convicted,	–	Filed.
William A. Graham,	Waltham,		Convicted,	5 00	
Frank Churchill,	Hanson,		Convicted,	–	Filed.
Joseph Semond,	Hanson,		Convicted,	–	Filed.
John H. Southworth,	Brockton,		Convicted,	–	Filed.
Charles B. Southworth,	Hanson,		Convicted,	–	Filed.
Edward Darrington,	Westfield,		Convicted,	5 00	

Report upon Convictions, Fines, etc., for Violations of the Fish and Game Laws — Continued.

State *v.* —	Town or City.	Offence.	Court Decision.	Fine.	Remarks.
Albert P. Fields,	Taunton,	Dogs chasing deer in violation of section 18, chapter 92, Revised Laws, as amended by chapter 245, Acts of 1905,	Convicted,	–	
Howard Hathaway,	Dighton,		Discharged,	–	Filed; costs of court, $4.10.
John Carlson,	Rutland,		Convicted,	$10 00	Also costs of court, $9.
Thomas A. Joyce,	Lynn,		Convicted,	–	Filed; costs of court, $1.30.
James O'Brien,	Westford,		Convicted,	5 00	
John A. Lucas,	Sharon,		Convicted,	10 00	Appealed.
William Parker,	Sharon,		Convicted,	10 00	Appealed.
Elizabeth Poirier,	New Bedford,	Possession of prohibited birds, etc., for millinery in violation of chapters 244 and 329, Acts of 1903,	Convicted,	10 00	
Annie F. Riley,	New Bedford,		Convicted,	10 00	
Walter H. Brown,	Fall River,		Convicted,	10 00	
Katherine A. Burns,	Fall River,		Convicted,	10 00	
Louise Tilman,	Fall River,		Convicted,	10 00	
George L. Bump,	Fall River,		Convicted,	10 00	
Fred E. Bagley,	New Bedford,		Convicted,	10 00	
Arthur Boisclair,	New Bedford,		Convicted,	10 00	
Fred C. Munch,	Hull,	Having in possession lobsters under the legal length in violation of chapter 303, Acts of 1907,	Convicted,	55 00	
Cortas Theodore,	New Bedford,		Convicted,	15 00	
Louis Corayer,	Hull,		Convicted,	10 00	
Charles Davis,	Plymouth,		Convicted,	17 00	
Nelson S. Bartlett,	Barnstable,		Convicted,	5 00	
Manuel Salvatore,	Cohasset,		Convicted,	16 00	
William V. Corinha,	Winthrop,		Discharged,	–	
Fred Fredericks,	Nahant,		Convicted,	3 00	
Charles Roberts,	Nahant,		Convicted,	20 00	
Antoni Fanarlari,	Nahant,		Convicted,	10 00	
Foster G. Sherman,	Fall River,	Intent to sell egg-bearing lobsters in violation of section 86, chapter 91, Revised Laws,	Convicted,	20 00	
Oscar F. Gibbs,	Dennis,		Convicted,	10 00	
Maurice A. Hayden,	Bridgewater,		Convicted,	10 00	
Ignatius Bullock,	Templeton,	Possession of wild duck in close season in violation of chapter 421, Acts of 1909,	Convicted,	–	Filed; costs of court, $2.45.
Tony Ferriara,	Hull,	Interfering with and assault on deputy,	Discharged,	–	
Frederick C. Davis,	Bourne,	Potting eels without permit in violation of section 85, chapter 91, Revised Laws,	Convicted,	5 00	
Andrew F. Stolberg,	Worcester,	Having in possession pickerel under 10 inches in length in violation of section 67, chapter 91, Revised Laws, as amended by chapter 329, Acts of 1904,	Convicted,	6 00	
Charles Tobin,	Holyoke,		Convicted,	1 00	

George Smith,	Fall River,	Having in possession short bass in violation of section 70, chapter 91, Revised Laws,	Convicted,	10 00	
Arthur B. Lloyd,	Forest Hills,		Convicted,	10 00	
Riley Barber,	Westfield,		Convicted,	10 00	
Arthur Roy,	New Bedford,	Setting and drawing gill net in Buzzards Bay in violation of section 122, chapter 91, Revised Laws,	Convicted,	20 00	
Joseph LeBlanc,	Springfield,	Snaring trout in violation of section 1, chapter 377, Acts of 1909,	Convicted,	20 00	
Albert Donovan,	Boston,	Killing gray squirrels in violation of chapter 564, Acts of 1910,	Convicted,	10 00	
Leigard Robsham,	Framingham,		Convicted,	–	Filed.
Henry Parlee,	Chelmsford,		Convicted,	–	Filed.
James McDonald,	Harvard,		Convicted,	–	Filed.
Robert J. Hartness,	Grafton,		Convicted,	10 00	
E. Chauncey Gilmore,	Hopedale,		Convicted,	10 00	
Guiseppe Pangini,	Natick,		Convicted,	10 00	
Edwin Smith,	Boxborough,		Convicted,	–	Filed.
Arthur A. Pritchard,	Worcester,		Discharged,	–	
Frank O. Howard,	Worcester,		Discharged,	–	
Salvatore Aloudi,	Boston,	Torching herring in violation of chapter 291, Acts of 1909,	Convicted,	–	Filed.
Tony Ramponi,	Boston,		Convicted,	–	Filed.
Joseph Samarto,	Boston,		Convicted,	100 00	
Joseph Marino,	Boston,		Convicted,	–	Filed.
Kolor Meters,	Boston,		Convicted,	50 00	
Frank Spinola,	Boston,		Convicted,	50 00	
Jio Bello,	Boston,		Convicted,	50 00	
Tony Busslack,	Boston,		Convicted,	50 00	
Carlo Moricer,	Boston,		Convicted,	50 00	
Vincenzo Senagro,	Boston,		Convicted,	50 00	
Massao Shiulla,	Boston,		Discharged,	–	
Antonio Shiulla,	Boston,		Convicted,	50 00	Sentence suspended.
Antonio Briano,	Boston,		Convicted,	50 00	Sentence suspended.
Vincenzo Fishia,	Boston,		Convicted,	50 00	
Vincenzo Lomea,	Boston,		Convicted,	50 00	Sentence suspended.
William Savory,	Chelsea,	Selling clams from polluted areas in violation of chapter 285, Acts of 1907,	Convicted,	15 00	
Christopher Neilson,	Hull,		Discharged,	–	
William G. Walsh,	Boston,		Discharged,	–	
Michael H. McDonough,	Lee,	Killing fish by pollution in violation of section 133, chapter 91, Revised Laws, as amended by chapter 246, Acts of 1903,	Convicted,	10 00	
Fred A. Kehoe,	Rutland,	Shooting a bittern or heron in violation of chapter 244, Acts of 1903,	Convicted,	–	Filed.
Lincoln Greeley,	Rockland,		Convicted,	–	Filed.
George A. Wolfe,	Dorchester,		Convicted,	6 00	Also costs of court, $2.90.

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Report upon Convictions, Fines, etc., for Violations of the Fish and Game Laws — Concluded.

STATE v. —	Town or City.	Offence.	Court Decision.	Fine.	Remarks.
Frank A. Sampson,	New Salem,	Failure to notify Commissioner on Fisheries and Game of deer shot while damaging crops in violation of chapter 545, Acts of 1910,	Convicted,	$20 00	
Bernardo Dominico,	North Attleborough,	Assault with dangerous weapon,	Convicted,	–	Nine months in jail; costs, $2.50.
Elmer Larson,	Milford,	Killing pheasants in violation of chapter 309, Acts of 1909,	Convicted,	10 00	
Ernesto Rarmelli,	Lynn,		Convicted,	25 00	
Cherubino Roberts,	Lynn,		Convicted,	25 00	
James L. Kelso,	Winthrop,		Convicted,	5 00	
William Francis,	Concord,		Convicted,	10 00	
Leon E. Mayo,	Medfield,		Convicted,	10 00	
Christopher Stone,	Ashland,	Snaring ruffed grouse in violation of chapter 533, Acts of 1910,	Convicted,	5 00	
Christopher Stone,	Ashland,	Possession of ruffed grouse in close season in violation of chapter 365, Acts of 1910,	Convicted,	20 00	
George H. Holmes,	Boston,		Convicted,	–	Continued to December 17, for sentence.
William M. Taylor,	Lynn,	Killing tern in violation of chapter 472, Acts of 1910,	Convicted,	20 00	
Lewis G. Doten,	Plymouth,	Using sweep seine in violation of section 52, chapter 91, Revised Laws,	Discharged,	–	
Joseph Bugsbee,	– – –	Selling game birds in violation of chapter 441, Acts of 1908, as amended by chapter 272, Acts of 1909,	Discharged,	–	
Wendal Eldridge,	Harwich,	Possession of illegal scallops in violation of section 1, chapter 177, Acts of 1910,	Convicted,	–	Filed.
E. Chauncey Gilmore,	Hopedale,	Hunting on posted land in violation of section 14, chapter 92, Revised Laws,	Convicted,	5 00	
George L. Sprague,	Milford,		Convicted,	5 00	
John Jacobson,	East Douglas,	Using over ten hooks for fishing in violation of section 26, chapter 91, Revised Laws, as amended by chapter 308, Acts of 1904,	Convicted,	20 00	
Arthur A. Pritchard,	Worcester,	Setting forest fires in violation of chapter 299, Acts of 1907,	Discharged,	–	Costs of court, $6.35.
Frank O. Howard,	Worcester,		Discharged,	–	

[G.]

RETURNS FROM THE SHORE POUND AND NET FISHERIES FOR THE YEAR 1910.

Apparatus employed.

PROPRIETOR.	Town.	Number of Men.	Number of Boats.	Value.	Pounds.	Value.	Nets.	Value.
Frank C. Hodgkins, Preston J. Marchant,	Annisquam,	12	7	$3,058 00	-	-	5	$900 00
Ensign C. Jerauld,	Barnstable,	9	4	1,100 00	2	$2,500 00	-	-
Harry C. Howell, C. F. Wentworth,	Beverly,	1	2	135 00	-	-	1	3 00
J. Eldridge & Son, Gilbert E. Ellis, A. S. Hall,	Brewster,	5	4	50 00	7	2,200 00	-	-
Fred W. Baker, George N. Bearse, J. D. Bloomer, Walter C. Bloomer, William A. Bloomer, Geo. W. Crowell & Co., Samuel Dill, Roscoe H. Gould, Seymour Patterson, E. C. Flanders & Co.,	Chatham,	13	10	1,605 00	5	4,200 00	129	1,321 00
James Look, George W. Manter, Daniel W. West,	Chilmark,	20	19	1,435 00	12	7,800 00	1	10 00
Joseph Boutin, George A. Finney, agent,	Chiltonville,	3	3	280 00	1	1,000 00	7	40 00
John F. Cornell, Irwin C. Hall, Russell W. Hotch, Frank B. Veeder,	Cuttyhunk,	6	9	1,681 00	1	1,000 00	57	500 00

Apparatus employed — Concluded.

Proprietor.	Town.	Number of Men.	Number of Boats.	Value.	Pounds.	Value.	Nets.	Value.
Zenas H. Baker,	Dennis,	4	4	$1,008 00	3	$2,100 00	-	-
Benjamin Walker,								
Charles Gardner,	Dighton,	19	12	520 00	1	50 00	8	$570 00
E. D. Perry,								
Albertis F. Simmons,								
Harry E. Hunt,	Duxbury,	4	5	2,050 00	2	3,500 00	21	700 00
E. R. Dunham,	Edgartown,	4	5	80 00	2	450 00	-	-
David B. Pease & Allen Mayhew,								
William A. Read,	Fall River,	1	-	-	-	-	-	-
D. D. Diamond & Co.,	Gay Head,	20	21	1,655 00	16	6,500 00	1	25 00
Linus S. Jeffers & Co.,								
A. H. Vanderhoop & Co.,								
L. L. Vanderhoop & Co.,								
Fuller A. Andrews,	Gloucester,	19	17	4,660 00	3	2,750 00	13	1,750 00
George W. Douglas,								
Thomas Douglas,								
Joseph Douglas,								
Henry W. Nelson,								
Alexander Sargent,								
F. A. & C. W. Tarr,								
Orin Crosby,	Hyannis,	9	5	1,950 00	-	-	91	850 00
Clinton A. Sturges,								
Ansel Taylor,								
Alfred W. Riley,	Lanesville,	-	-	-	-	-	4	26 50
Edw. W. Heath,	Manchester,	3	6	461 00	1	1,000 00	-	-
H. D. Powell (F. H. Johnson and others),	Nahant,	12	7	1,400 00	4	6,000 00	-	-
Avard L. Smith (R. A. Atwood and others),								
Arthur J. Barrett & Co.,	Nantucket,	22	24	7,115 00	8	3,100 00	207	3,209 00
Nelson Clark,								
Edward I. Fisher,								
George H. Hamblin,								
Arthur McCleave,								
John S. Watkins,								
George M. Winslow,								
Joseph A. Nickerson,	New Bedford,	2	2	825 00	-	-	-	-
Victorino Perry,								
C. A. Caswell & Co.,	Newburyport,	10	10	3,870 00	-	-	93	1,875 00
George H. Short,								
Otis E. Burt,	North Tisbury,	1	4	185 00	2	500 00	-	-

Fred C. Rich,	North Truro,	12	10	3,680 00	–	10,000 00	–	2,000 00
Allen R. Norton,	Oak Bluffs,	–	–	–	–	–	–	–
Maurice S. Hayden,	Orleans,	–	–	–	–	–	–	–
H. E. Knowlton,								
A. L. Daggett,	Provincetown,	44	48	16,414 00	6	5,000 00	613	5,885 00
James W. Fuller,								
John Johnson,								
James E. Kelley,								
Thomas J. Lewis,								
William B. Lewis,								
A. P. Lewis & Manuel James,								
Alfred A. Mayo,								
H. L. Mayo,								
Martin Nelson,								
Frank I. Sears,								
Edwin W. Smith,								
John R. Swarts,								
Manuel P. Vera,								
J. R. Williams,								
Edwin Williams,	Raynham,	21	4	200 00	–	–	–	300 00
Antone Vieiro,	Robinson Hole,	–	–	–	–	–	–	–
Charles P. R. Fellows,	Salem,	1	1	7 00	–	–	–	–
John Elvander,	Sandwich,	2	4	565 00	1	1,100 00	4	40 00
Eugene W. Haines,								
A. N. Goff,	Segregansett,	21	5	175 00	–	–	4	400 00
J. H. Miller,	Somerset,	10	2	100 00	–	–	1	150 00
Obed S. Daggett,	Tisbury,	14	20	1,730 00	17	5,200 00	1	40 00
George H. Luce,								
H. Nelson Luce,								
J. A. Mayhew & Co.,								
W. L. & G. F. Tilton,								
John R. Walker,								
Otis B. Luce,	Vineyard Haven,	2	7	1,425 00	6	2,800 00	–	–
James R. Tilton,								
F. D. Grinnell,	Westport,	2	1	20 00	–	–	1	30 00
John J. Veeder (Marine Biological Laboratory),	Woods Hole,	3	5	5,085 00	1	600 00	–	–
Shirley D. Lovell,	Yarmouth,	2	2	20 00	1	250 00	21	195 00
Hiram E. Baker,								

Number of Pounds of Fish taken

Town.	Alewives.	Bluefish.	Flounders.	Mackerel.	Menhaden.	Pollock.	Scup.	Sea Bass.
Allerton,	-	-	-	-	-	-	-	-
Annisquam,	-	-	-	-	9,200	585,105	-	-
Barnstable,	-	-	-	23,200	-	21,500	-	-
Bay View,	-	-	-	-	-	-	-	-
Beachmont,	-	-	-	-	-	-	-	-
Beverly,	-	-	401	-	-	-	-	-
Boston,	-	-	-	-	-	-	-	-
Bournedale,	-	-	-	-	-	-	-	-
Brant Rock,	-	-	-	-	-	-	-	-
Brewster,	23,108	237	9,346	150	-	-	-	-
Chatham,	5,300	1,587	59,250	8,624	7,700	-	32,740	-
Chilmark,	100	65	32,930	9,948	-	125	5,625	3,340
Chiltonville,	-	-	-	575	-	1,000	-	-
Cohasset,	-	-	-	-	-	-	-	-
Cuttyhunk,	-	-	70,400	8,339	-	9,000	80,000	-
Dennis,	8,250	-	16,335	51	27,200	-	6,000	-
Dighton,	268,550	-	-	-	-	-	-	-
Duxbury,	-	-	-	3,200	-	36,000	-	-
Eastham,	-	-	-	-	-	-	-	-
East Mattapoisett,	-	-	-	-	-	-	-	-
Edgartown,	100	5	1,200	1,150	-	-	2,550	-
Fall River,	8,700	-	-	-	-	-	-	-
Gay Head,	52,725	-	9,600	5,050	-	100	16,900	1,175
Gloucester,	20,975	5	1,530	10,273	7,800	199,017	4	-
Green Harbor,	-	-	-	-	-	-	-	-
Hull,	-	-	-	-	-	-	-	-
Hyannis,	4,000	4,505	129,400	2,796	1,200	400	-	-
Kingston,	-	-	-	-	-	-	-	-
Lanesville,	-	-	-	-	-	-	-	-
Magnolia,	-	-	-	-	-	-	-	-
Manchester,	5,101	-	-	1,479	300	33,120	4,181	-
Manomet,	-	-	-	-	-	-	-	-
Marblehead,	-	-	-	-	-	-	-	-
Minot,	-	-	-	-	-	-	-	-
Nahant,	-	182	-	1,750	-	1,740	-	-

in Nets, Pounds, Traps, etc.

Sea Herring.	Shad.	Squeteague.	Striped Bass.	Squid.	Tautog.	Other Edible or Bait Species.	Lobsters.	Total.	Value.
-	-	-	-	-	-	-	488	488	$90 00
22,200	13,800	-	-	-	-	89,774	-	720,079	6,051 91
-	-	-	-	5,000	1,200	26,000	1,390	78,290	4,826 95
-	-	-	-	-	-	-	620	620	82 60
-	-	-	-	-	-	-	6,462	6,462	1,179 00
-	-	-	-	-	-	1,200	29,427	31,028	3,759 95
-	-	-	-	-	-	-	8,741	8,741	1,000 42
-	-	-	-	-	-	-	19,946	19,946	1,870 78
-	-	-	-	-	-	-	14,459	14,459	1,799 76
66,500	-	17	54	16,925	2,293	25,457	-	144,087	2,596 00
40,681	304	10,556	100	76,965	1,955	52,398	22,844	321,004	13,476 55
-	-	23,221	-	2,350	20	180	29,733	107,637	7,403 26
700	-	-	-	-	375	1,800	31,063	35,513	3,144 74
-	-	-	-	-	-	-	92,871	92,871	12,831 24
-	-	1,800	-	-	-	-	131,997	301,536	18,630 81
13,325	32	900	-	141,800	7,285	26,125	4,172	251,475	5,275 62
-	3,637	-	-	-	-	5,175	-	277,362	2,925 46
216,200	-	-	-	-	-	141,600	19,676	416,676	8,181 85
-	-	-	-	-	-	-	756	756	279 21
-	-	-	-	-	-	-	3,137	3,137	351 33
-	20	374	-	6,500	-	4,950	98	16,947	513 46
-	4	-	-	-	55	2	-	8,761	90 40
-	75	5,620	-	2,200	1,775	1,505	17,784	114,509	4,316 34
63,482	468	-	-	6,810	134	554,122	68,799	933,419	15,420 57
-	-	-	-	-	-	-	129,170	129,170	13,442 54
-	-	-	-	-	-	-	31,394	31,394	4,350 75
-	-	450	32	-	-	-	2,036	144,819	3,007 20
-	-	-	-	-	-	-	6,629	6,629	864 93
1,340	-	-	-	-	-	-	12,654	13,994	3,436 59
-	-	-	-	-	-	-	1,802	1,802	185 35
19,000	285	-	-	1,800	626	308,876	8,057	382,825	3,027 06
-	-	-	-	-	-	-	139,067	139,067	12,754 09
-	-	-	-	-	-	-	136,680	136,680	17,875 56
-	-	-	-	-	-	-	12,270	12,270	1,066 70
277,180	-	-	-	9,700	-	387,648	25,031	703,231	8,078 96

Number of Pounds of Fish taken

Town.	Alewives.	Bluefish.	Flounders.	Mackerel.	Menhaden.	Pollock.	Scup.	Sea Bass.
Nantasket,	-	-	-	-	-	-	-	-
Nantucket,	200	18,291	3,410	66,882	-	1,580	10,550	-
New Bedford,	-	-	12,357	-	-	-	1,300	-
Newburyport,	-	-	-	400	-	410,927	-	-
North Tisbury,	6,000	-	1,450	-	-	3,000	1,400	100
North Truro,	-	-	15,921	10,424	19,200	4,500	-	-
Oak Bluffs,	-	-	-	-	-	-	-	-
Onset,	-	-	-	-	-	-	-	-
Orleans,	-	-	120	-	-	20	-	-
Pembroke,	-	-	-	-	-	-	-	-
Plymouth,	-	-	-	-	-	-	-	-
Provincetown,	-	-	897,710	157,839	-	23,400	-	-
Quincy,	-	-	-	-	-	-	-	-
Raynham,	368,800	-	-	-	-	-	-	-
Robinson Hole,	-	-	-	-	-	-	2,000	-
Rockport,	-	-	-	-	-	-	-	-
Sagamore,	-	-	-	-	-	-	-	-
Salem,	-	-	7,700	-	-	-	-	-
Sandwich,	-	-	1,000	2,658	387	38	-	-
Scituate,	-	-	-	-	-	-	-	-
Segregansett,	455,000	-	-	-	-	-	-	-
Somerset,	170,000	-	-	-	-	-	-	-
Swampscott,	-	-	-	-	-	-	-	-
Tisbury,	800	462	22,050	4,230	-	1,450	11,800	528
Vineyard Haven,	16,000	6	2,158	152	-	550	12,546	414
West Falmouth,	-	-	-	-	-	-	-	-
Westport,	1,500	-	-	-	-	-	100	-
West Tisbury,	-	-	-	-	-	-	-	-
Weymouth,	-	-	-	-	-	-	-	-
Whitman,	-	-	-	-	-	-	-	-
Winthrop,	-	-	-	-	-	-	-	-
Woods Hole,	-	45	-	896	204,100	-	28,120	-
Yarmouth,	37,600	-	600	-	-	-	-	-
Totals,	1,452,809	25,390	1,294,868	320,066	277,087	1,332,572	215,816	5,557

in Nets, Pounds, Traps, etc. — Concluded.

Sea Herring.	Shad.	Squeteague.	Striped Bass.	Squid.	Tautog.	Other Edible or Bait Species.	Lobsters.	Total.	Value.
-	-	-	-	-	-	-	33,870	33,870	$4,465 05
14,600	70	9,077	-	-	-	53,051	6,333	184,044	13,513 93
-	-	-	-	-	400	-	18,546	32,603	2,558 57
71,156	68,200	-	-	-	-	188,660	-	739,343	7,289 10
-	-	3,000	-	2,500	-	-	1,313	18,763	787 00
241,300	50	890	-	540,200	405	764,117	-	1,597,007	15,660 31
-	-	-	-	-	-	200	-	200	25 00
-	-	-	-	-	-	-	7,272	7,272	594 00
-	-	-	-	-	-	100	2,030	2,270	469 74
-	-	-	-	-	-	-	1,287	1,287	102 96
-	-	-	-	-	-	-	86,819	86,819	10,251 30
342,475	2,400	-	-	570,430	-	333,600	2,972	2,330,826	51,598 32
-	-	-	-	-	-	-	131	131	28 95
-	2,132	-	-	-	-	-	-	370,932	1,449 60
-	-	-	-	-	1,100	-	5,916	9,016	904 00
-	-	-	-	-	-	-	55,550	55,550	5,799 91
-	-	-	-	-	-	-	2,522	2,522	256 55
-	-	-	-	-	-	-	48,785	56,485	7,206 38
2,200	240	-	-	39,400	-	43,421	6,733	96,077	2,324 51
-	-	-	-	-	-	-	26,930	26,930	2,309 67
-	3,850	-	-	-	-	100	-	458,950	2,445 00
-	125	-	-	-	-	-	-	170,125	1,409 00
-	-	-	-	-	-	-	9,989	9,989	1,271 57
-	10	105,343	118	9,950	2,475	1,350	-	160,566	5,257 14
-	5	12,677	-	15,800	-	4,455	3,717	68,480	2,386 96
-	-	-	-	-	-	-	1,401	1,401	413 60
-	-	-	-	-	3,900	6,600	24,479	36,579	3,750 42
-	-	-	-	-	-	-	29,592	29,592	3,101 21
-	-	-	-	-	-	-	20,004	20,004	3,169 26
-	-	-	-	-	-	-	1,482	1,482	186 97
-	-	-	-	-	-	-	9,336	9,336	1,623 80
1,950	-	10,430	-	23,445	370	20,275	22,293	311,924	4,238 60
-	-	-	-	-	-	22,345	1,511	62,056	1,430 00
1,394,289	95,707	184,355	304	1,471,775	24,368	3,065,086	1,440,066	12,600,115	$342,466 32

Returns from the Lobster Fisheries.

Proprietor.	Town.	Number of Men.	Number of Boats.	Value.	Number of Pots.	Value.	Number of Lobsters.	Value.	Number of Egg-bearing Lobsters.
M. W. Springer,	Allerton,	1	1	$25 00	18	$20 00	325	$90 00	-
Clarence Chase,	Barnstable,	2	2	250 00	40	50 00	893	126 95	-
Daniel S. Burnham,	Bay View,	1	1	15 00	50	50 00	413	82 60	-
Charles Neil,	Beachmont,	1	1	400 00	150	450 00	4,308	1,179 00	41
John Anderson, C. W. Foster and Warren Hersey, Albion Frye, Harry C. Howell, Wallace C. Kenney, Nelson A. Southwick, C. F. Wentworth,	Beverly,	12	16	2,580 00	906	1,506 00	19,618	3,663 18	105
Joaquin Perry, Joseph Serrilla, Manuel Serrilla,	Boston,	3	8	995 00	330	330 00	5,827	1,000 42	-
A. J. Chandler, Frank C. Leonard, Percy H. Marsh, Albert A. Nightingale,	Bournedale,	4	6	515 00	204	250 00	13,297	1,870 78	107
C. C. Cady, J. Thomas Doten, Fred L. Ford, Clifford G. Harris, M. H. Hewins, Wm. A. Pool, J. E. White,	Brant Rock,	8	8	330 00	347	489 00	9,639	1,799 76	-
B. R. Baker, Fred W. Baker, Anson C. Bloomer, Bradford N. Bloomer, Jos. D. Bloomer, Walter C. Bloomer, Wm. A. Bloomer, Samuel Dill, Walter N. Eldredge,	Chatham,	19	33	5,635 00	1,096	1,468 00	15,229	5,570 40	1,452

Walter W. Eldredge,									
Chas. G. Hamilton,									
T. W. Holway,									
Edson F. Olson,									
Seymour Patterson,									
B. F. Rich,									
Chas. E. Smith,									
N. W. Hamilton,									
E. J. Dean,									
Roy E. Cottle,									
Jerry Look,									
Benj. C. Mayhew,									
Wm. S. Mayhew,	Chilmark,	12	18	3,890 00	611	1,112 00	19,822	2,722 75	146
Everett A. Poole,									
Austin E. Smith,									
J. D. and F. P. Tilton,									
Onslow Stuart,									
Joseph Boutin,									
John E. Finney,									
Ernest Johns,									
Albert F. Pierce,	Chiltonville,	12	18	1,150 00	462	652 00	20,675	2,834 74	82
Chas. H. Pierce,									
H. S. Sampson,									
R. F. Swift,									
Levi S. Thurston,									
Geo. T. Ainslie,									
Joseph Bandura,									
Levi Cadose,									
John Eltman,									
Antoine S. Figueiredo,									
Anton Grassie,									
Patrick Grassie,									
Manuel Oliver,	Cohasset,	15	25	4,787 00	1,925	3,005 00	61,914	12,831 24	160
Andrew Peterson,									
Orne Peterson,									
Antone Sidney,									
Antoine L. Silvia,									
Joseph A. Silvia,									
Manuel L. Trombas,									
Frank Veira,									

Returns from the Lobster Fisheries — Continued.

Proprietor.	Town.	Number of Men.	Number of Boats.	Value.	Number of Pots.	Value.	Number of Lobsters.	Value.	Number of Egg-bearing Lobsters.
D. N. Bosworth,									
Joseph Comara,									
John Cornell,									
Harold F. Deane,									
Thomas B. Dowling,									
Isaac Gregory,									
Irwin C. Hall,									
Sam'l E. Jackson & Co.,									
Geo. C. King,									
Walter Loveridge,	Cuttyhunk,	25	36	$10,859 00	1,935	$2,147 50	87,998	$13,310 38	907
Frank Peters,									
Louis J. Ramos,									
Russell W. Rotch,									
Roland S. Snow,									
Oscar H. Stetson,									
Chester F. and Frank B. Veeder,									
Ernest G. Veeder,									
Harold S. Veeder,									
Oscar F. Gibbs,									
Austin F. Howes,	Dennis,	4	8	406 00	190	100 00	2,781	573 19	92
A. P. Howes,									
Benj. Walker,									
Sam'l P. Burgess,									
Chester N. Morse,									
Wm. K. Bartlett,	Duxbury,	8	12	700 00	325	520 00	13,117	2,269 85	140
Frank E. Wadsworth,									
Sam'l G. L. Wadsworth,									
Henry E. Knowles,	Eastham,	2	2	310 00	50	138 00	504	279 21	32
Joshua L. Macomber,	East Mattapoisett,	2	4	580 00	100	64 00	2,091	351 33	-
N. P. Nye,									
Manuel Deloura,	Edgartown,	1	2	615 00	6	6 00	65	13 00	-
Benj. J. Attaquin,									
Granville M. Belain,									
M. P. Cooper,	Gay Head,	8	19	1,592 00	360	365 00	11,856	1,508 96	171
J. A. Mayhew & Co.,									
Harry G. Reed,									
Chas. H. Ryan,									

Edward L. Ashley, Henry H. Ashley, Frank B. Brewer, C. A. Dixon, Nelson F. King, Peter Knutson, Walter E. Marchant, D. E. Mehlman, Joseph S. Moniz, Albert and Howard Parsons, Edwin F. Parsons, Elbridge D. Rust, Everett L. Small, Arthur Stevens, Joseph Douglass, Melvin Parsons,	Gloucester,	17	22	1,698 00	1,067	1,307 00	45,866	8,099 86	156
Robert Brown, Wm. M. Cushing, George Delano, W. M. Englestead, Geo. W. Gardner, Wilfred Keene, C. E. Peterson, Chas. R. Peterson, Lyman Sears, A. I. Shaw, Herbert P. Tolman, Wm. H. Tolman,	Green Harbor,	13	34	11,777 00	1,406	2,573 25	86,113	13,442 54	469
Walter F. Kelley, Ambrose B. Mitchell, F. C. Munch,	Hull,	4	8	807 00	415	550 00	20,896	4,350 75	30
Orin Crosby, Clinton A. Sturges,	Hyannis,	-	-	-	82	32 00	1,357	278 00	55
Allen R. Gorham, H. S. West,	Kingston,	2	2	750 00	95	136 25	4,419	864 93	22
Chas. W. Lucas, Edward M. Poland, Alfred W. Riley, Addison H. Woodbury, Geo. H. Woodbury,	Lanesville,	7	7	95 00	235	255 00	9,436	3,398 83	40
John B. Knowlton,	Magnolia,	1	2	14 00	34	50 00	1,201	185 35	12
Augustus Ferreiro, David C. Jones,	Manchester,	3	1	400 00	135	165 00	5,371	820 87	15

Returns from the Lobster Fisheries — Continued.

Proprietor.	Town.	Number of Men.	Number of Boats.	Value.	Number of Pots.	Value.	Number of Lobsters.	Value.	Number of Egg-bearing Lobsters.
H. S. Arnold, C. D. Bacon, A. R. Barney, E. H. Bartlett, Sam'l H. Benson, G. L. Binney, Laban B. Briggs, Jr., James E. Burke, H. D. Cleveland, Geo. D. Cook, Chas. A. Dixon, Comfort H. Dixon, Archie Fenton, Geo. W. Holmes, Ralph B. Holmes, Geo. A. Manter, W. J. Nightingale, Frank R. Peterson, Jack Platt, Chas. W. Raymond, J. E. Raymond, Robert Richardson, Rodmond D. Rogers, Laban B. Briggs, Clinton Adams, Wm. F. Allen, Harvey L. Bailey, Chas. O. Briggs, J. E. Brown, Ernest Cronk, W. F. Dennis, Peter J. Farry, Arthur D. Frost, Fred A. Fuller, Wm. F. Gardner,	Manomet,	28	42	$3,648 00	1,605	$2,602 00	92,711	$12,754 09	226

Thos. P. Gilbert, Everett S. Hamson, Geo. K. Hamson, Jr., David P. Howe, John G. Howe, Patrick H. Keenan, Thos. P. Lyons, John W. Mace, James H. Magee, Jonathan B. Mason, Wm. F. Merritt, Harry A. Oliver, Everett P. Peach, Joseph S. Phillips, Augustus K. Roundy, Stephen Q. Smith, Wm. T. Smith, Chas. H. Smithurst, Clarence K. Stone, Samuel Stone, John F. Trefry, Wm. H. Tutt, J. S. Withum,	Marblehead,	38	50	7,408 00	1,698	2,315 00	91,120	17,875 56	492
C. H. Pratt, Eugene Pratt, Danforth P. Sylvester,	Minot,	5	7	360 00	275	275 00	8,180	1,066 70	38
Chas. DeCoste, E. H. Crowell, Gilbert G. Hunt, G. H. Lamphier, Herbert E. Potter, Wm. A. Smith, Chas. W. Taylor,	Nahant,	7	11	1,035 00	370	407 50	16,687	3,112 00	112
Joseph B. Tibbets, Harry C. Bates, R. F. Gardner, Frank Lean, Sam'l McDonald, Ephraim Onderkirk, Geo. L. Hatch, Henry E. Hatch,	Nantasket,	7	6	720 00	444	570 00	22,580	4,465 05	149

Returns from the Lobster Fisheries — Continued.

PROPRIETOR.	Town.	Number of Men.	Number of Boats.	Value.	Number of Pots.	Value.	Number of Lobsters.	Value.	Number of Egg-bearing Lobsters.
Walter Jewett, Joseph Mayo, Arthur McCleare, Joseph H. Ray, Adolph A. Robdin, Manuel Thomas, John S. Watkins,	Nantucket,	8	8	$385 00	276	$286 75	4,222	$1,328 99	113
Geo. M. McLain, J. A. Nickerson, Victorino Perry, Bartholomew Sylvia, Geo. B. Taber, Manuel Cambra,	New Bedford,	9	7	1,783 00	370	465 00	12,364	2,003 49	200
Otis E. Burt,	North Tisbury,	–	–	–	30	50 00	875	150 00	25
J. Alton Harrison, Wm. Thompson,	Onset,	2	5	1,355 00	130	145 00	4,848	594 00	32
Frank Freeman, Caleb Hayden, Maurice S. Hayden,	Orleans,	3	3	185 00	72	157 00	1,353	459 44	100
Edmund E. Crossley,	Pembroke,	1	2	210 00	50	50 00	858	102 96	–
George Atwell, Jas. H. Bagnall, Chas. A. Briggs, H. J. Caswell, Chas. H. Davis, John R. Harlow, Benj. F. Hodges, Whitman Nickerson, Wm. L. Peterson, Preston Ray, A. P. Sylvester, Joseph P. Thurston,	Plymouth,	12	22	4,322 00	748	1,219 35	57,879	10,251 30	147
Cushing H. Emery, Martin Nelson, Joseph S. Perry, John W. Savage, W. C. Snow, Chas. Williams, Jr.,	Provincetown,	5	5	64 00	241	203 50	1,981	727 16	78

John I. Bennett,	Quincy,	1	1	300 00	16	20 00	87	28 95	-
Manuel Marshall,	Robinson Hole,	3	4	938 00	175	150 00	3,944	766 00	9
Antone Vieiro,									
Wm. Garrow,									
Chester W. Gott,									
Chas. F. Green,									
W. I. Jones,									
Arthur Rich,	Rockport,	9	11	1,525 00	695	985 00	37,033	5,799 91	223
Wm. E. Norwood,									
Geo. E. Wendell,									
Arthur Norwood,									
S. Thurston,									
Arthur Gibbs,	Sagamore,	1	3	50 00	90	75 00	1,681	256 55	26
Geo. F. Ball,									
Chas. H. Berry,									
Chas. S. Brown,									
John A. Dunn,									
Chas. P. R. Fellows,	Salem,	10	12	1,589 00	785	1,007 25	32,523	7,047 88	182
Thos. F. Hogan,									
Louis N. Letourneau,									
Chas. L. Wales,									
Geo. H. Whelpley,									
Geo. W. Dunn,									
John Elvander,									
John F. Mahoney,	Sandwich,	2	3	250 00	82	115 00	4,485	807 76	99
E. W. Haines,									
Oscar Anderson,									
Thomas Dwyer,									
Geo. F. Edson,	Scituate,	5	9	740 00	346	525 00	17,953	2,309 67	7
Thos. S. Turner,									
Daniel Ward,									
Walter M. Boyden,	Swampscott,	2	2	500 00	150	225 00	6,659	1,271 57	-
A. B. Lewis,									
Edward W. Cleveland,									
L. E. Smith,	Vineyard Haven,	5	7	677 00	178	215 00	2,478	430 27	73
Jas. R. Tilton,									
Geo. E. Whitney,									
Geo. A. Gifford,									
Wm. A. Hammond,									
Geo. W. Hart,									
Wm. S. Head,	Westport Point,	10	11	2,420 00	460	542 50	16,319	2,811 42	226
Fred W. Palmer,									
H. G. Sowle,									
Wm. B. Whalon,									

Returns from the Lobster Fisheries — Concluded.

Proprietor.	Town.	Number of Men.	Number of Boats.	Value.	Number of Pots.	Value.	Number of Lobsters.	Value.	Number of Egg-bearing Lobsters.
Alvin F. Bourne, F. J. Densmore,	West Falmouth,	2	3	$215 00	38	$76 00	934	$413 60	-
A. L. Adams, Lester D. Mayhew, F. H. Reed & Co., Lewis A. Rogers, David T. Butler, Lindley W. Mayhew,	West Tisbury,	8	14	2,090 00	509	687 50	19,728	3,101 21	126
Francis J. Cain, Edwin J. Culley,	Weymouth,	2	2	450 00	250	340 00	13,336	3,169 26	45
N. G. Hatch, Geo. M. Wadsworth,	Whitman,	2	4	300 00	61	90 00	988	186 97	1
Hartley L. Wells, D. H. Fullerton,	Winthrop,	2	4	415 00	55	55 00	6,224	1,623 80	-
W. C. Baker, James F. Cook, Robert A. Gaffin, Chas. R. Grinnell, Oscar R. Hilton, Patrick J. Larkin, Alfred Nickerson, W. E. Nickerson, Frank I. Peterson, Jas. K. P. Purdum, Prince M. Stuart, A. H. Vedeler, Robt. N. Veeder, Audbrey D. Wilde,	Woods Hole,	14	18	1,978 00	336	411 00	14,862	1,950 55	216
Shirley D. Lovell,	Yarmouth,	2	4	1,040 00	75	100 00	1,007	300 00	34
		392	576	$88,127 00	23,174	$32,156 35	960,930	$170,684 98	7,213

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ILLUSTRATIONS

Fig. 1. — Mature egg ready for union with male cell. Magnified 385 diameters.

Fig. 2. — Spermatozoa (male cells). Note length of tail and shape of head. No attempts were made to study the minute anatomy. Magnified 385 diameters.

Fig. 3. — Egg, twenty-five minutes after fecundation, showing the two polar cells (pc) and the faintly developed yolk lobe. Magnified 385 diameters.

Fig. 4. — Egg just previous to the first cleavage, showing large yolk lobe. Magnified 385 diameters.

Fig. 5. — The two-celled stage at the completion of the first cleavage, fifty minutes after fecundation. The larger cell contains the yolk lobe. Magnified 385 diameters.

Figs. 6, 7, 8, 9. — This series illustrates the process of cleavage in the egg during the change from the two-celled to the four-celled stage. Magnified 385 diameters.

Fig. 10. — The four-celled stage, one hundred and ten minutes after fecundation. Side view. Magnified 385 diameters.

Figs. 11, 12. — The eight-celled stage, one hundred and forty-five minutes after fecundation. Magnified 385 diameters.

Fig. 13. — The sixteen-celled stage, one hundred and eighty-five minutes after fecundation. Side view. Magnified 385 diameters.

Fig. 14. — The thirty-two-celled stage, two hundred minutes after fecundation. Side view. Note large yolk cell. Magnified 385 diameters.

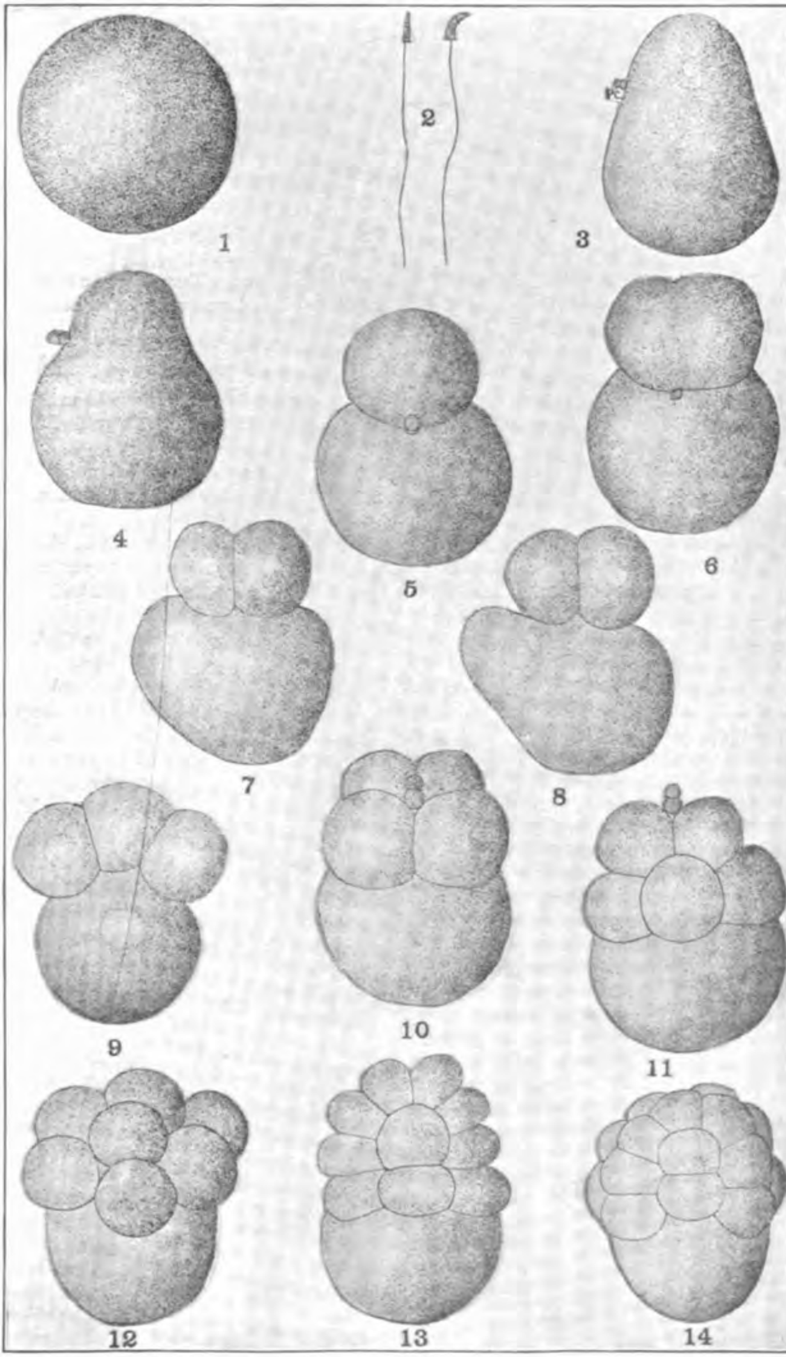

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Fig. 15. — Ciliated gastrula, ten hours after fecundation. The embryo can now swim through the water by means of hairlike cilia. The larger cells have become invaginated. Magnified 385 diameters.

Fig. 16. — Trochosphere stage, twelve to fourteen hours after fecundation. The body has elongated and the cilia are now confined to the front end. The opening of the primitive mouth (pm) can be seen on the lower side, while above is a slight indentation corresponding to the beginning of the shell gland (sg). Magnified 385 diameters.

Fig. 17. — Formation of the shell, which arises at two symmetrical points of calcification, right and left of the median line, and gradually envelops the animal. Magnified 385 diameters.

Fig. 18. — Early veliger swimming with velum extended from the shell, about thirty-six hours after fecundation. aa, anterior adductor muscle, pa, posterior adductor muscle, s, stomach, a, anus, mt, mouth, v, velum. Magnified 385 diameters.

Fig. 19. — Veliger slightly older than shown in Fig. 18. The intestine (i) has elongated, and the liver (l) is more prominent.

Figs. 20-27. — Figs. 20–24 illustrate the ordinary method of crawling of the small 2 to 3 millimeter quahaugs. It consists of extending the foot and dragging the body in a forward direction. Fig. 20 shows the foot just appearing from the shell; the mantle and siphon are extended, while the angle between the shell and the foot is acute. Fig. 21 shows the foot extended to its full length. It has made a twist so that the bottom part of the ciliated tip can get a firm hold, and thus raise the animal on edge so that the shell can enter the sand with a cutting edge. In Fig. 22 the shell has taken a downward tip, the foot being partly withdrawn into the shell. Fig. 23 shows the animal at the completion of an upward tip, caused by the further withdrawal of the foot, which has straightened the shell into its original position. Figs. 24 and 27 show another method of crawling, the quahaug being forced backward by a forceful movement of the foot. In Figs. 24 and 26 the foot is turned under the shell until the tip finds a resting place; then by a jerky motion the shell is raised from the bottom and thrust either to the position of Fig. 25 on the same side or turned over on the opposite side (Fig. 27).

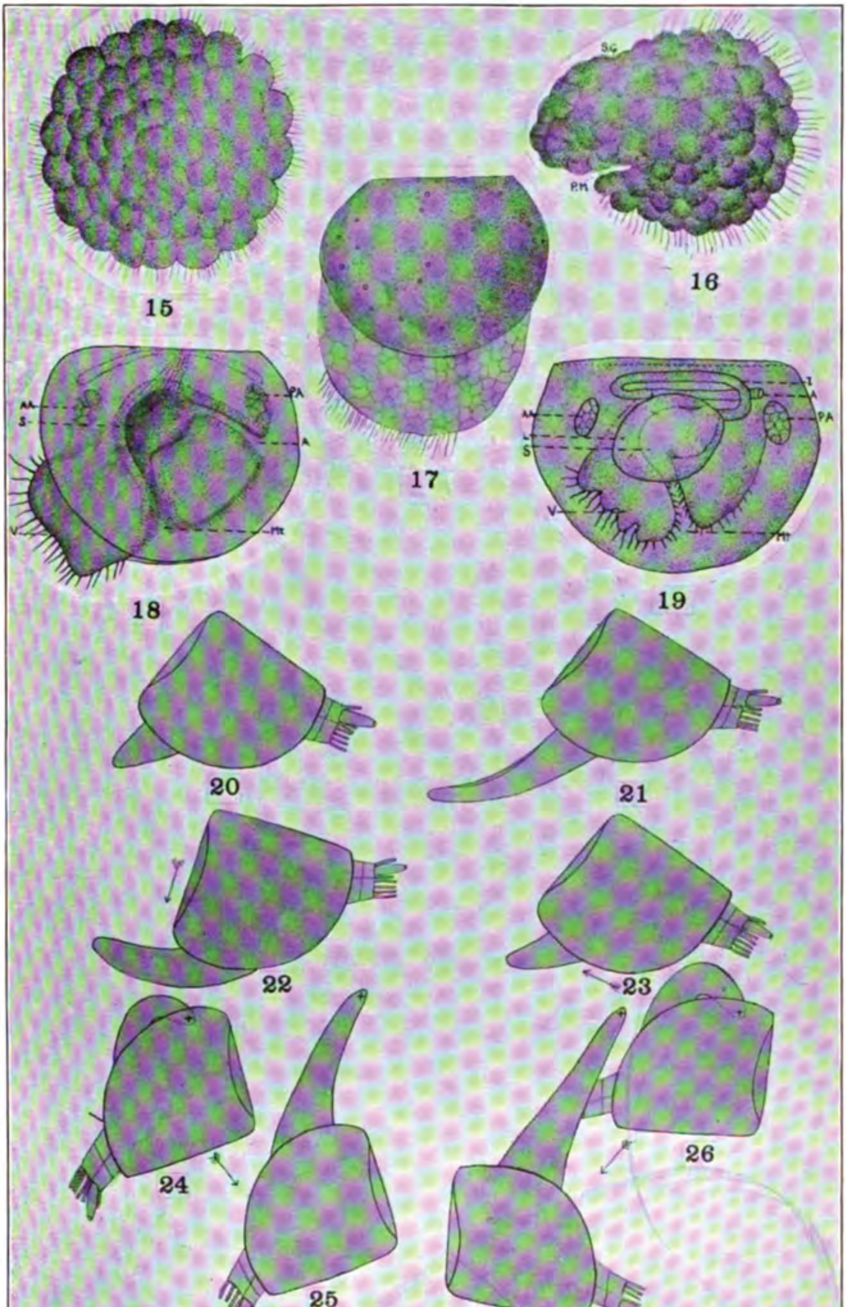

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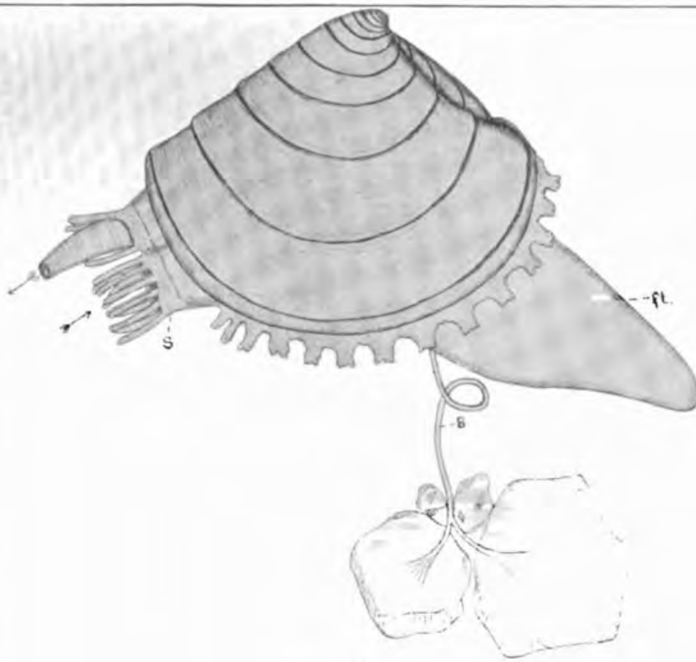
Fig. 28. — Young quahaug, 1 millimeter ($\frac{1}{25}$ inch) in length, attached to sand grains by the byssus (b). The siphon (s) consists of two parts, an incurrent encircled by twelve tentacles, through which the water enters the mantle chamber of the animal, and an excurrent with four tentacles and filmy telescopic tube, through which the water passes out of the mantle cavity. The byssus arises from a gland on the under side of the foot (ft).

Fig. 29. — Young quahaug, 1 millimeter in size, half buried in the sand. The animal is feeding, water passing in and out of the extended siphon, as shown by the arrows.



28

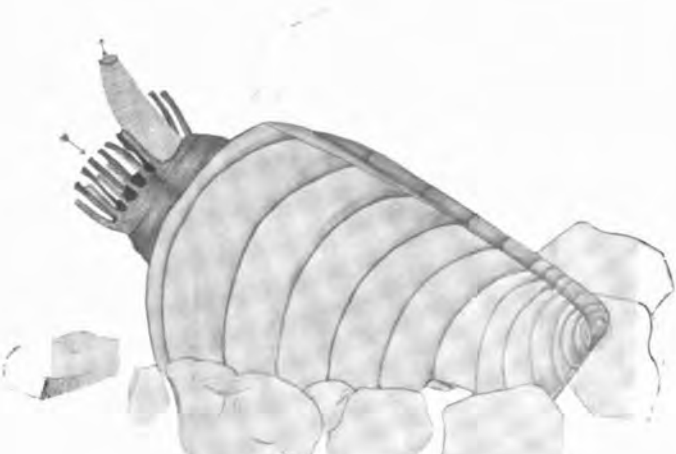


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Fig. 30. — Map showing the distribution of the quahaug in Massachusetts. The black areas indicate ground where quahaugs are found.

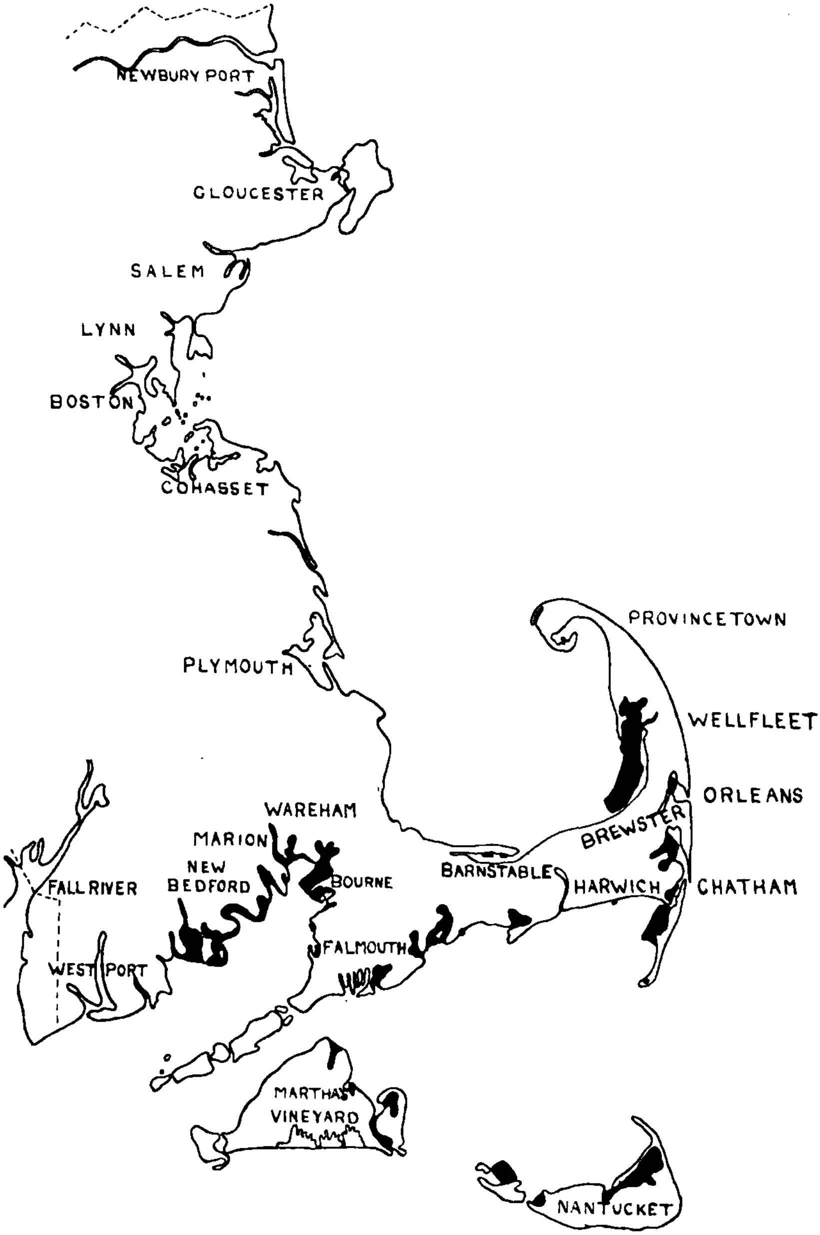
NEWBURY PORT
GLOUCESTER
SALEM
LYNN
BOSTON
COHASSET
PLYMOUTH
PROVINCETOWN
WELLFLEET
ORLEANS
BREWSTER
CHATHAM
HARWICH
BARNSTABLE
WAREHAM
MARION
NEW BEDFORD
BOURNE
FALL RIVER
FALMOUTH
WEST PORT
MARTHAS VINEYARD
NANTUCKET

Fig. 31. — Plan of the Powder Hole, Monomoy Point, Mass., showing the shellfish experiments and laboratory of the Massachusetts Department of Fisheries and Game. The harbor, represented by the dotted lines, is bounded on the north and west by a clam flat of coarse sand. The channel connecting the Powder Hole with the ocean passes across this flat. The deepest water, 18 feet, is found near the clam flat, while in the eastern and southern parts of the harbor the shallow water is filled with a thick growth of eelgrass. (1) Raft; (2) car in which egg lobsters were confined for hatching purposes; (3) scallop pen; (4) scallop pen; (5) scallop pen; (6) winter rack for suspending scallop baskets and quahaug boxes under water as a protection from the ice; (7) quahaug bed No. 3; (8) quahaug bed No. 5; (9) quahaug bed No. 7; (10) quahaug bed No. 6; (11) quahaug bed No. 8; (12) clam bed No. 19; (13) sea clam bed; (14) clam bed No. 18; (15) clam bed No. 3; (16) clam bed No. 2; (17) clam bed No. 99; (18) clam bed No. 100; (19) clam bed No. 20; (20) clam bed No. 1; (21) laboratory.

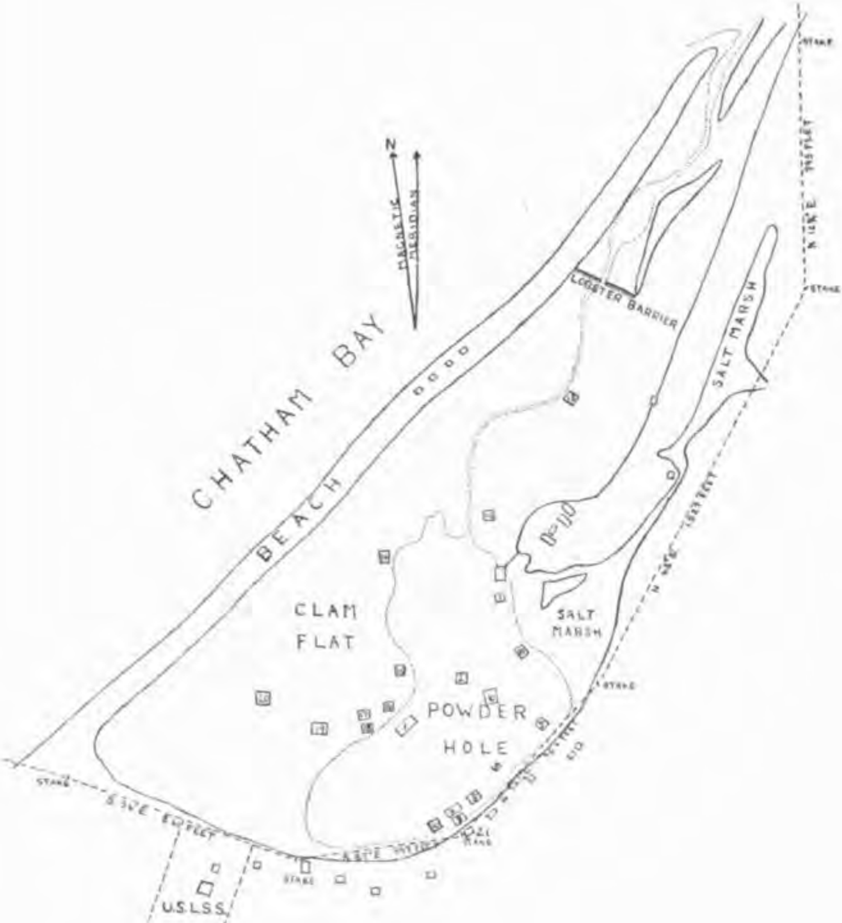

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Fig. 32. — Map of Wellfleet Bay showing the location between the tide lines of quahaug growth experiments 101 to 185. Many acres of flats are exposed, owing to the large rise and fall of the tide, which is about 10¾ feet. The average increase in volume for 84 beds in one year was 185 per cent., or over 2¾ bushels for every bushel planted.

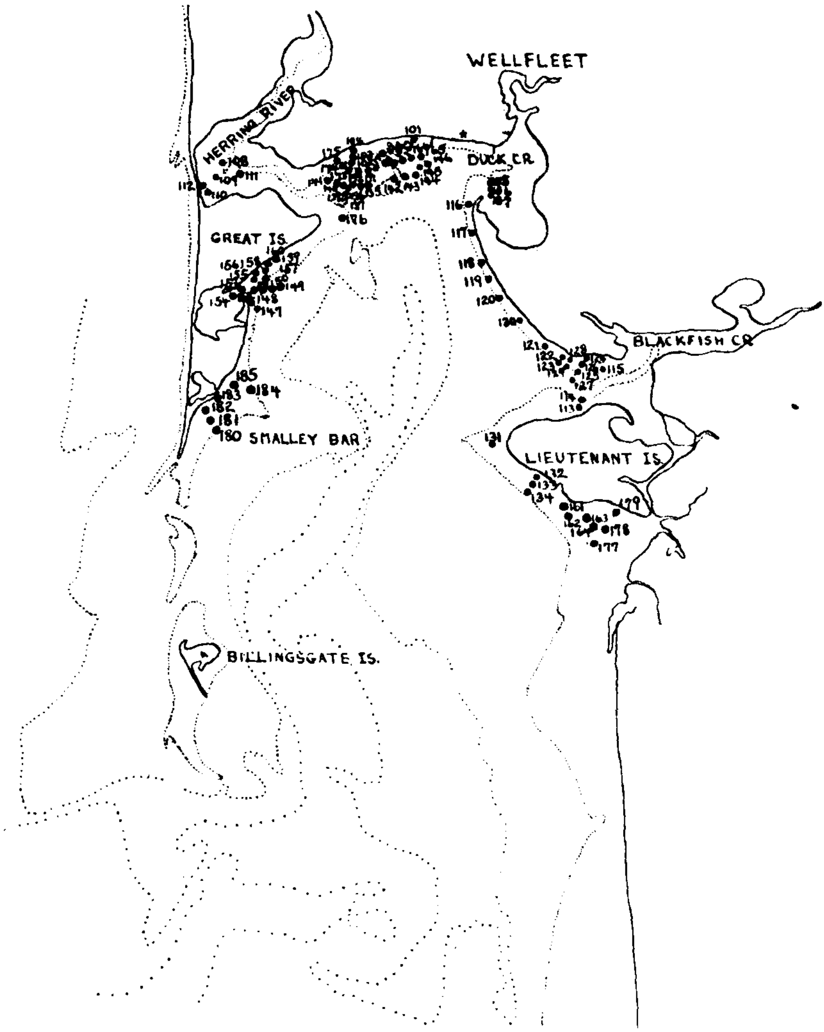
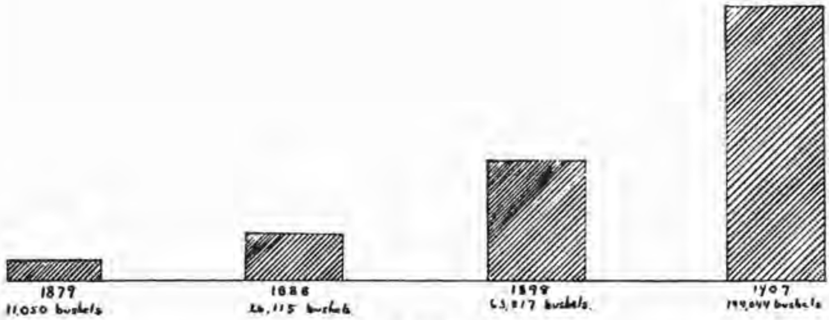

WELLFLEET
HERRING RIVER
DUCK CR.
GREAT IS.
BLACKFISH CR.
SMALLEY BAR
LIEUTENANT IS.
BILLINGSGATE IS.

Fig. 33. — The increase in quahaug production for Massachusetts from 1879 to 1907 is represented by a series of columns, corresponding to the annual yield for 1879, 1888, 1898 and 1907. The figures for the first three years are taken from the reports of the United States Bureau of Fisheries.

Fig. 34. — The increase in value for the annual production of these years is similarly represented.

Fig. 35. — The rise in price per bushel for these years illustrates that the increased demand and high cost of living have made quahauging a remunerative business, in spite of the fact that the daily yield of the individual quahauger has become less.



Production

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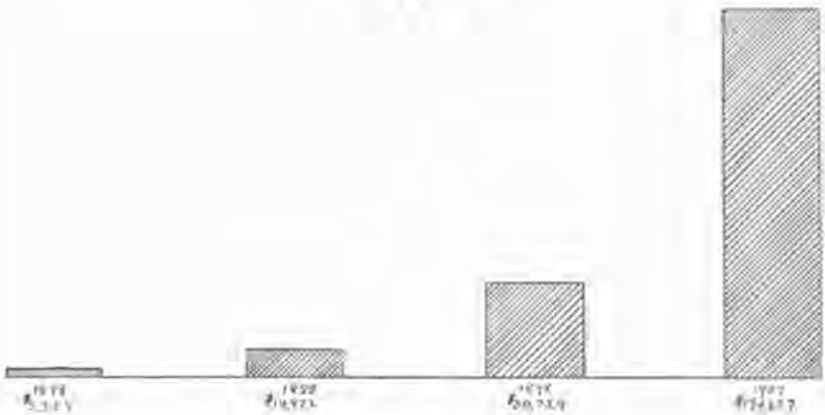

Value of Production

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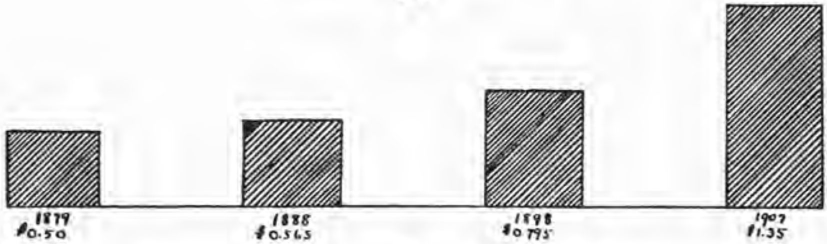

Rise in Price per Bushel

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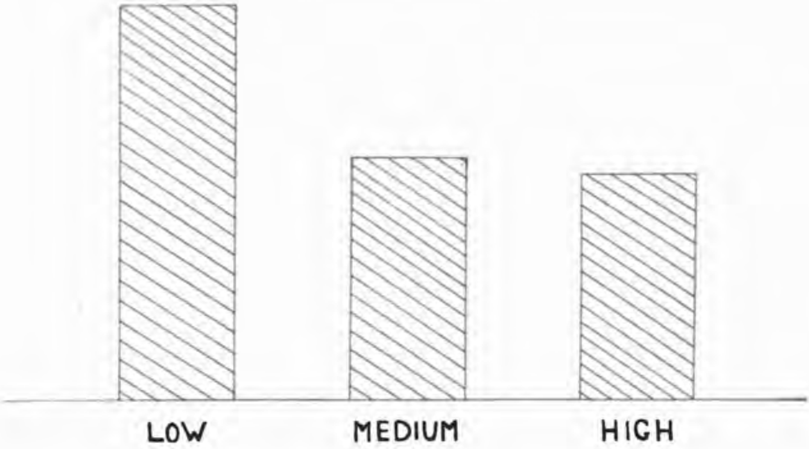
Fig. 36. — Growth between the Tide Lines. — Eighty beds, planted between the tide lines at Wellfleet, were classified as *low*, *medium* and *high*, according to the length of time exposed. The *low* beds, 32 in number, having a better circulation and longer feeding period, gave a growth of 12.5 millimeters (.49 inch) in one year; the 27 *medium* beds gave 7.82 millimeters (.31 inch); and the 21 *high* beds showed a gain of 7.17 millimeters (.28 inch). Considering the growth of the *low* beds as 100 per cent., the *medium* would show 61.53 per cent., and the *high* 57.39 per cent.

Fig. 37. — Age and Growth. — With age the rate of growth both in actual increase and gain in volume becomes less. The three columns represent the comparative annual increase in length of 21.2 millimeters (.83 inch), 10.5 millimeters (.41 inch) and 5 millimeters (.20 inch) for quahaugs one and one-half, three and one-half, and five and one-half years old, planted in boxes suspended from a raft at Monomoy Point.

Fig. 38. — Current and Growth. — The three columns represent the comparative increase in length during 1909 for small quahaugs planted in three sections of the Powder Hole. The highest column shows the average growth 27.23 millimeters (1.07 inches), in the raft boxes, where the circulation of water was good; the second column shows a growth of 19.44 millimeters (.77 inch) in boxes near the south shore of the Powder Hole, in front of the laboratory, where there is a slight current; the third column shows a growth of 14.94 millimeters (.59 inch) in boxes near the southeast shore, where there was practically no circulation, owing to the thick eelgrass.



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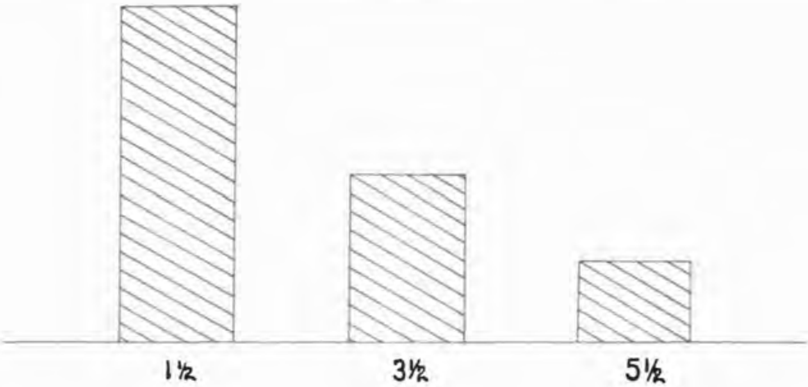

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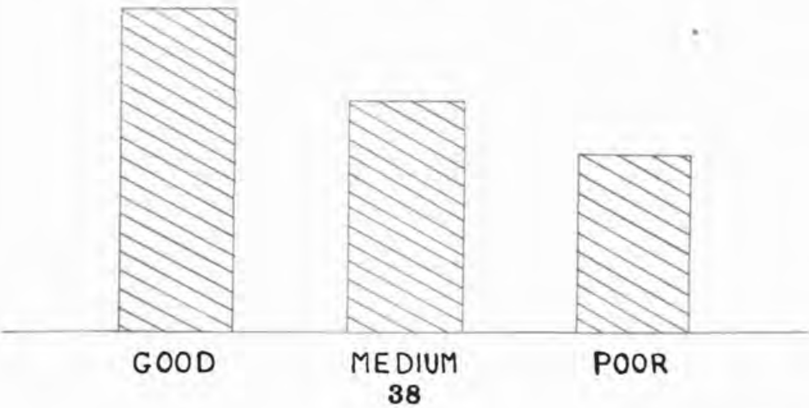

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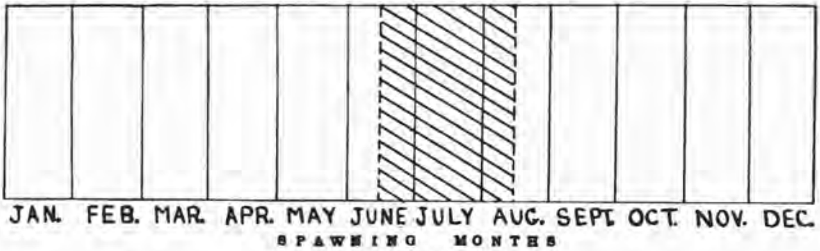
Fig. 39. — The Spawning Months. — The spawning season lasts from the middle of June to the middle of August. This period is represented by the shaded portion.

Fig. 40. — The Growing Months. — The quahaug increases in size of shell only during the summer months, growth ceasing during the cold weather. The shaded portion represents the period of growth.

Fig. 41. — The Relative Value of the Growing Months. — The quahaug does not increase with equal rapidity during the seven months of growth. The relative value of these months is represented in terms of the increase during each month for a standard quahaug. Considering the total annual growth as 100 per cent., the following are the values for the individual months: May, 3.78 per cent.; June, 10.81 per cent.; July, 19.02 per cent.; August, 25.56 per cent.; September, 26.24 per cent.; October, 12.85 per cent.; November, 1.74 per cent.

Fig. 42. — The Food Value. — The relative proportion, by weight, of the various parts of an average quahaug of 70 millimeters (2.75 inches) is represented by a series of columns. (1) Total weight, 100 per cent.; (2) shell, 62.47 per cent. (3) meat, 13.57 per cent.; (4) fluid, 23.96 per cent.



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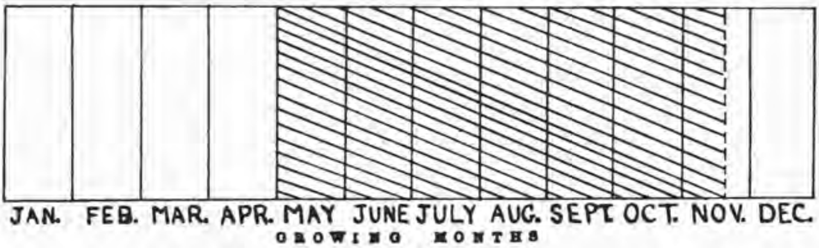

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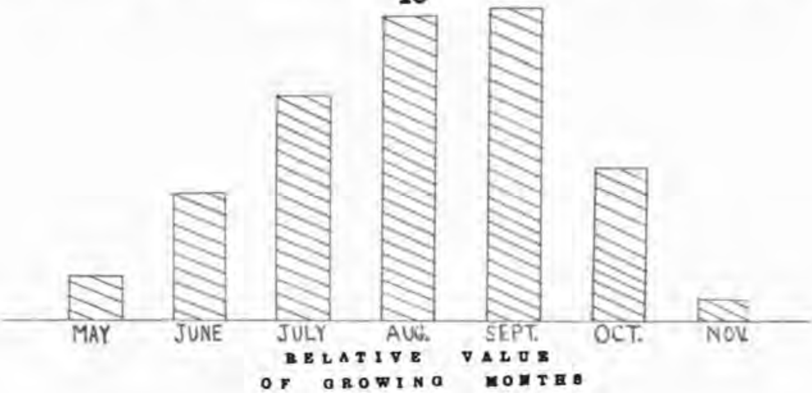

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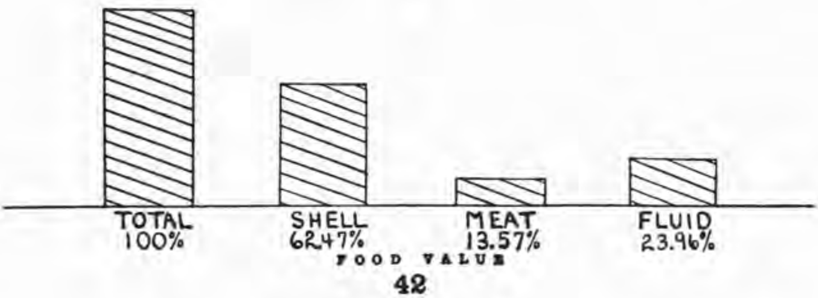

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Fig. 43. — Growth of a standard 25 millimeters (1 inch) quahaug for fourteen months, showing the cessation of growth during cold weather: —

	Millimeters.		Millimeters.
May 1,	25.00	January 1,	47.00
June 1,	26.00	February 1,	47.00
July 1,	28.80	March 1,	47.00
August 1,	33.50	April 1,	47.00
September 1,	39.20	May 1,	47.00
October 1,	44.40	June 1,	47.65
November 1,	46.70	July 1,	49.47
December 1,	47.00		

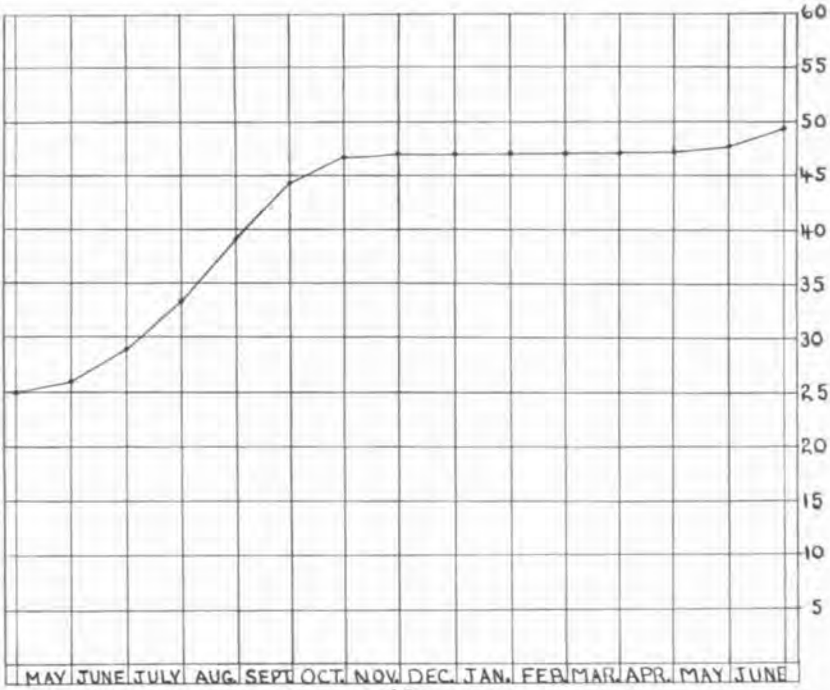
Fig. 44. — **Growth for Four Years.** — The growth of the average quahaug from two series of experimental beds is here given for a period of four years, starting with a quahaug of 5 millimeters (⅕ inch) at the age of one-half year. Note the difference between the rapid growth at Monomoy Point and the slower Wellfleet beds, also the decrease in the rate of growth as the quahaug increases in size.

Growth in the Raft Boxes at Monomoy Point (Millimeters).

Month.	First Year.	Second Year.	Third Year.	Fourth Year.
January 1,	5.00	28.73	49.11	62.66
February 1,	5.00	28.73	49.11	62.66
March 1,	5.00	28.73	49.11	62.66
April 1,	5.00	28.73	49.11	62.66
May 1,	5.00	28.73	49.11	62.66
June 1,	5.73	29.50	49.62	63.03
July 1,	7.93	31.70	51.08	64.10
August 1,	12.42	35.58	53.66	65.98
September 1,	19.17	40.79	57.12	68.51
October 1,	25.59	46.14	60.68	71.11
November 1,	28.38	48.76	62.42	72.38
December 1,	28.73	49.11	62.66	72.55
Annual gain,	23.73	20.38	13.55	9.89

Growth between the Tide Lines in Wellfleet Harbor (Millimeters).

Month.	First Year.	Second Year.	Third Year.	Fourth Year.
January 1,	5.00	16.21	27.48	36.69
February 1,	5.00	16.21	27.48	36.69
March 1,	5.00	16.21	27.48	36.69
April 1,	5.00	16.21	27.48	36.69
May 1,	5.00	16.21	27.48	36.69
June 1,	5.51	16.72	27.90	37.04
July 1,	6.94	18.16	29.07	38.01
August 1,	9.33	20.57	31.04	39.64
September 1,	12.23	23.49	33.42	41.61
October 1,	14.89	26.15	35.60	43.41
November 1,	16.06	27.33	36.56	44.21
December 1,	16.21	27.48	36.69	44.31
Annual gain,	11.21	11.27	9.21	7.62



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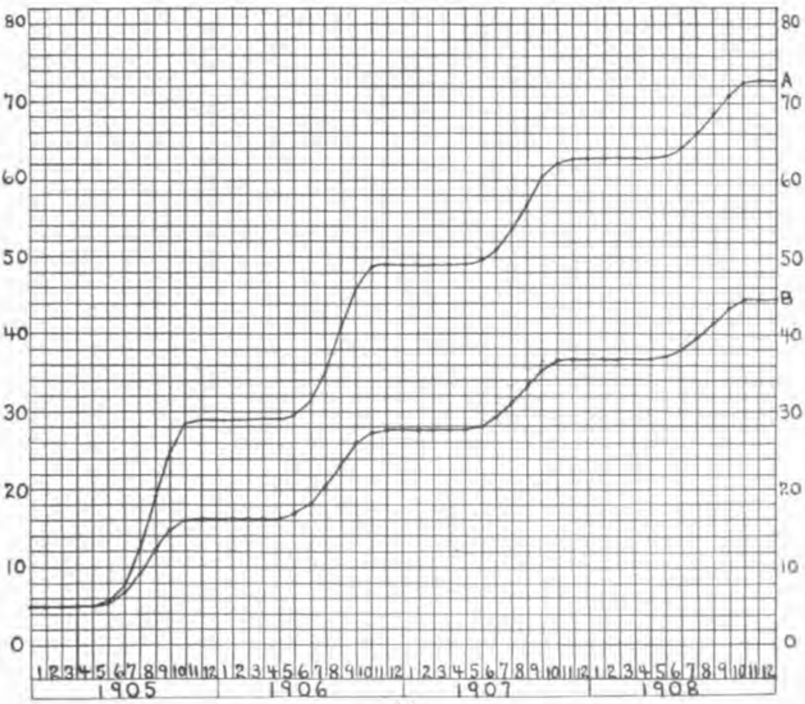

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Fig. 45. — The growth of a quahaug in the raft boxes, Monomoy Point, from one and one-half to five and one-half years old, is shown with the corresponding increase in volume. Starting with 1 bushel of one and one-half-year-old quahaugs there would result at the age of five and one-half years approximately 19 bushels. The figures on the left give the size of the quahaug (reduced one-half); those on the right represent the volume in bushels corresponding to the various years.

Age (Years).	Size.		Volume (Bushels).
	Millimeters.	Inches.	
One and one-half,	28.73	1.13	1.00
Two and one-half,	49.11	1.93	4.44
Three and one-half,	62.66	2.47	9.10
Four and one-half,	72.55	2.86	14.04
Five and one-half,	79.90	3.18	18.96

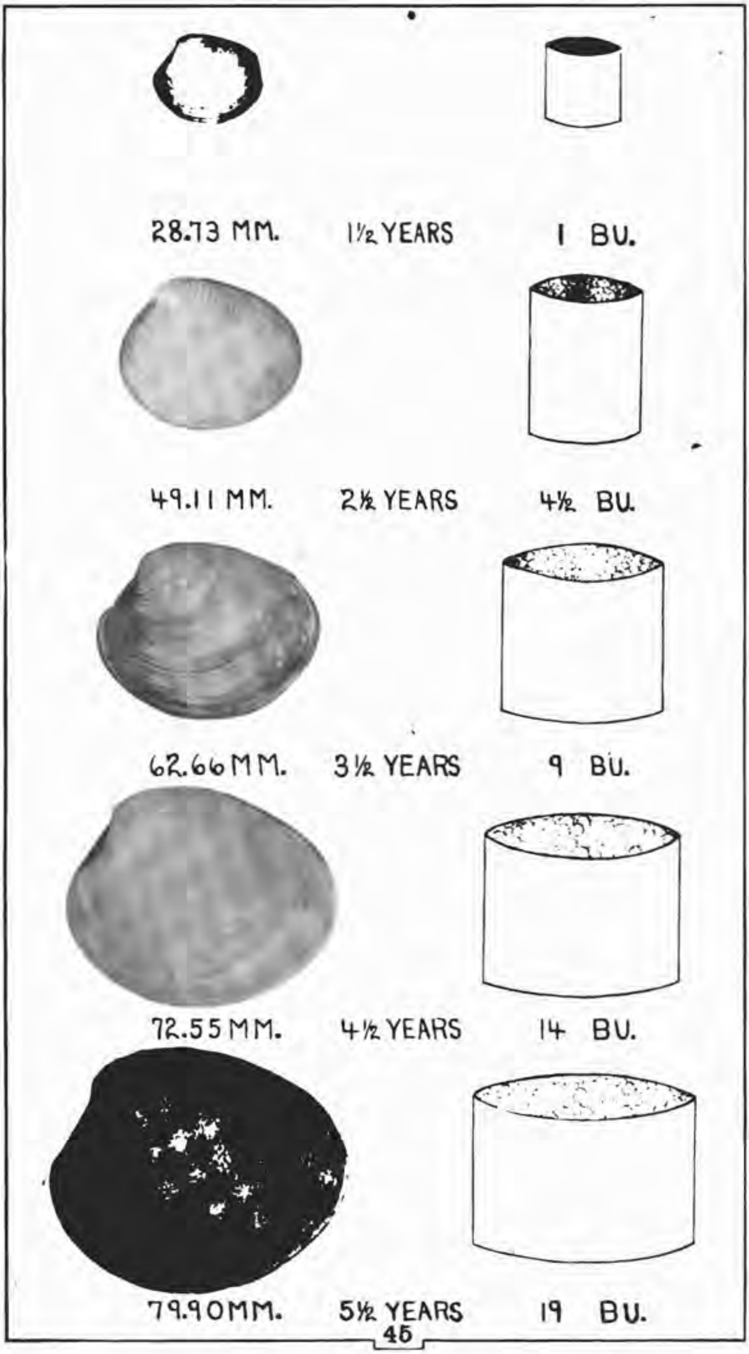
28.73 MM.
1½ YEARS
1 BU.
49.11 MM.
2½ YEARS
4½ BU.
62.66 MM.
3½ YEARS
9 BU.
72.55 MM.
4½ YEARS
14 BU.
79.90 MM.
5½ YEARS
19 BU.

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Fig. 46. — Diagram of the method used in experimental hatching of quahaug eggs and rearing of the young larvæ at the Wellfleet laboratory. It represents a cross-section of the laboratory, showing a small 1½ horse power gasolene engine (B), connected by a belt with a pump (C), by which salt water is forced from below into a tank (A) situated near the roof. The laboratory is located on a wharf over the water, which enables salt water to be obtained directly from beneath the floor. The inlet of the pump is guarded by a strainer (H), which prevents seaweed entering the pipe. From the tank the salt water is conducted through the laboratory by a large pipe set with small petcocks. From these petcocks pieces of rubber tubing (F) lead to the hatching tubs (E), which consist of half barrels fitted with sand filters (D). The tubs are placed over a sink (G) which carries off the filtered water. By this arrangement a continuous flow of water is established through the hatching tanks.

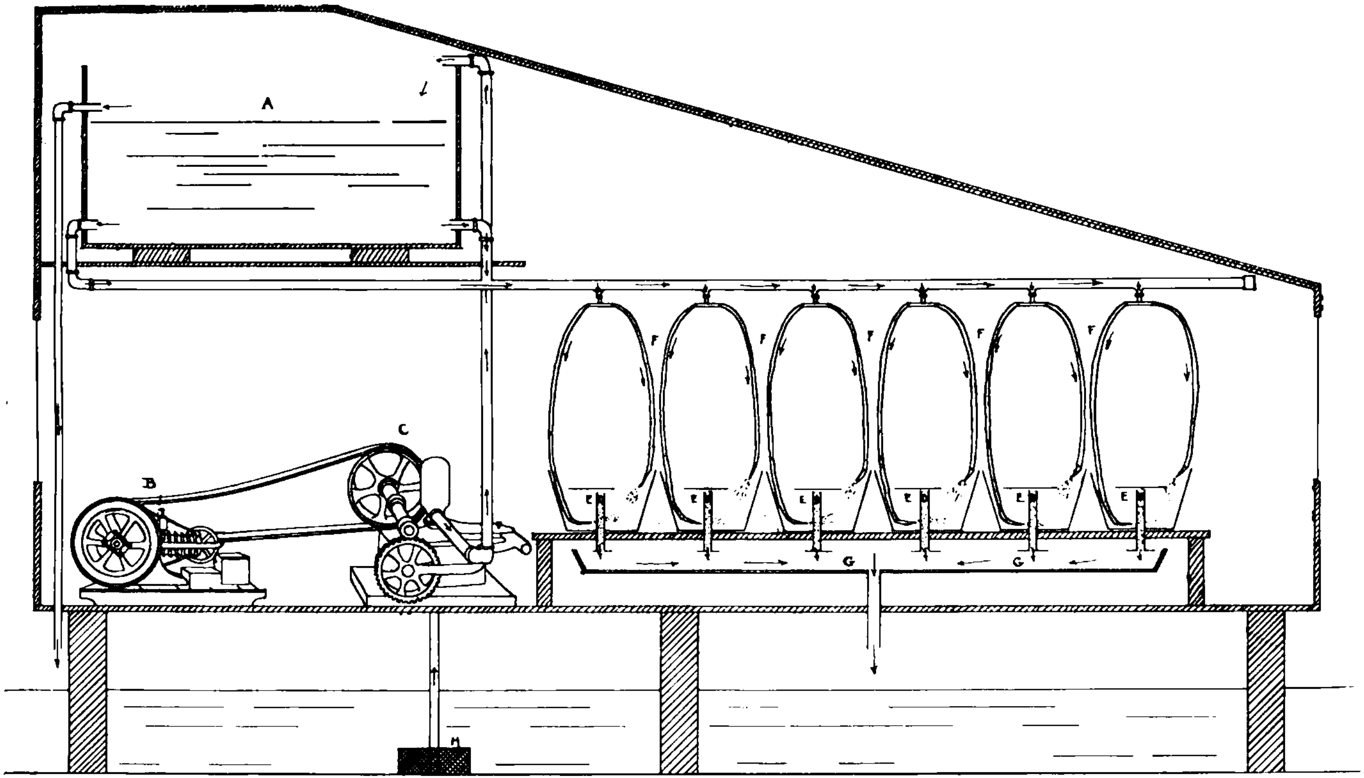

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Fig. 47. — Photograph taken from a model in the Museum of Natural History in New York. The different portions of the anatomy are indicated by the labels. The symbol A. A. and P. A. refer to the anterior and posterior adductor muscles. which hold the two valves of the shell together. The posterior part of the animal is represented by the siphon, which consists of two parts, an incurrent and an excurrent, through which the water enters and leaves the quahaug in the directions indicated by the arrows. In the mantle chamber the food is filtered from the water by the gills, which are here shown cut off near their base.

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Fig. 48. — The exterior of the laboratory at Wellfleet, showing the hatching tubs. This building, formerly an oyster house situated on the Chequesset Inn wharf, was provided in 1908 for the use of the department by Mr. L. D. Baker of Wellfleet. One large room, 20 by 30 feet, is used for the laboratory, while two small rooms adjoining are utilized for sleeping quarters. The situation over the water affords satisfactory facilities for experimental work on sea forms.

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Fig. 49. — The quahaug farm of Z. A. Howes at Wellfleet. Several hundred bushels of seed quahaugs are planted between the tide lines. The boundaries of the grant are marked with stakes, made of slender saplings topped with brush. The man in the foreground is examining the growth of the quahaugs.

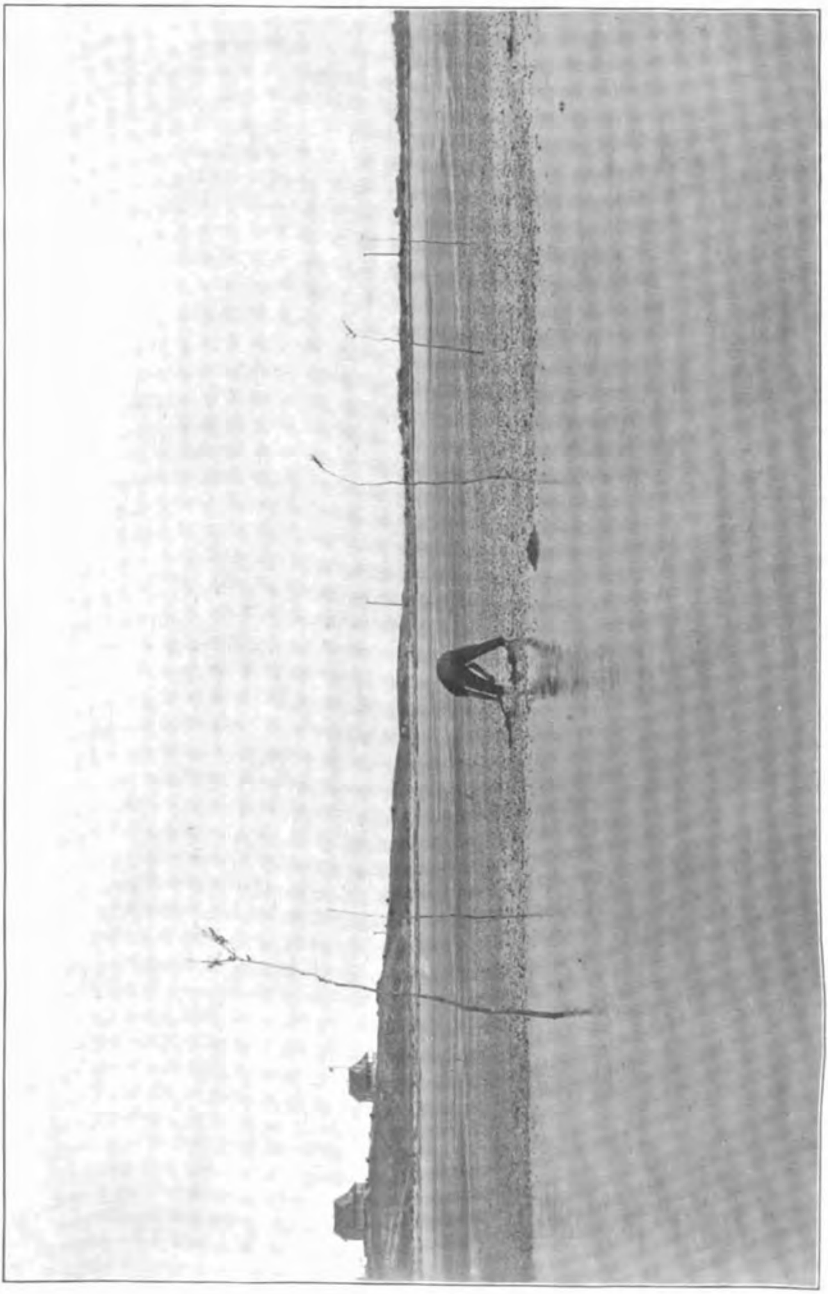

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Fig. 50. — Small grants for the bedding of the catch at Wellfleet. Under the Acts of 1904 the inhabitants of Eastham, Orleans and Wellfleet have the privilege of staking off not over 75 feet square of flat for bedding the catch, when the prices are low. During dull seasons many bushels of "blunts" are planted until the price becomes satisfactory. This may be termed the first step toward quahaug culture. Note the quahaugs in the center, which are still uncovered.

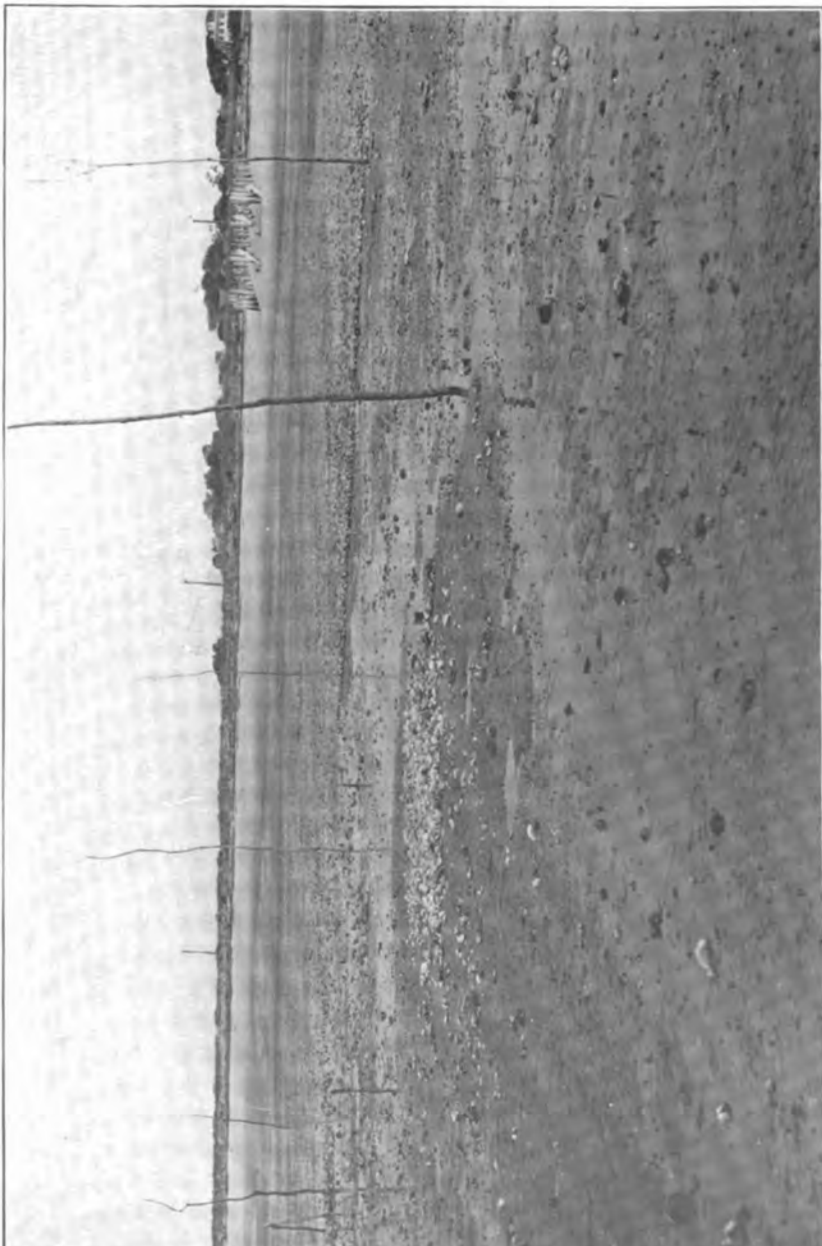

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Fig. 51. — One of the boxes suspended from the raft at Monomoy Point when taken up at the end of the summer. The quahaugs which have been growing in the box are shown in front. On careful examination the notches in the shell. marking growth for three years, can be seen. The box and rope are covered with barnacles and silver shells (*Anomia*), while the wood has been perforated by a boring mollusk, the shipworm (*Toredo*). This illustrates an easy method of obtaining the rate of growth of the quahaug.

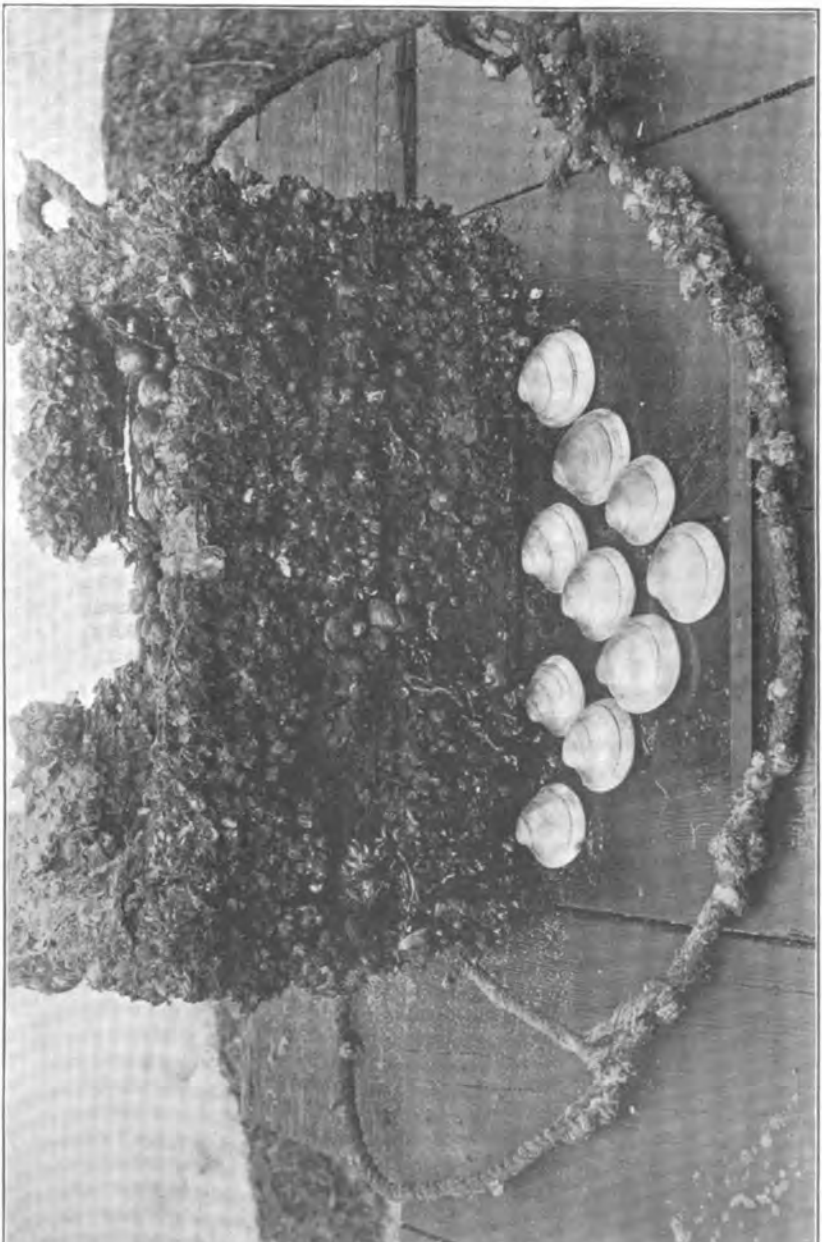

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Fig. 52. — These two sizes illustrate the stimulating effect on growth of current, which acts as a food carrier. In each bed quahaugs of the same size were planted and allowed to remain for three years. The larger quahaugs were planted in a box on the raft, where the circulation of water was good; the smaller in the south-eastern corner of the Powder Hole, not 75 yards from the raft, in shallow water among thick eelgrass, which shut off all circulation.

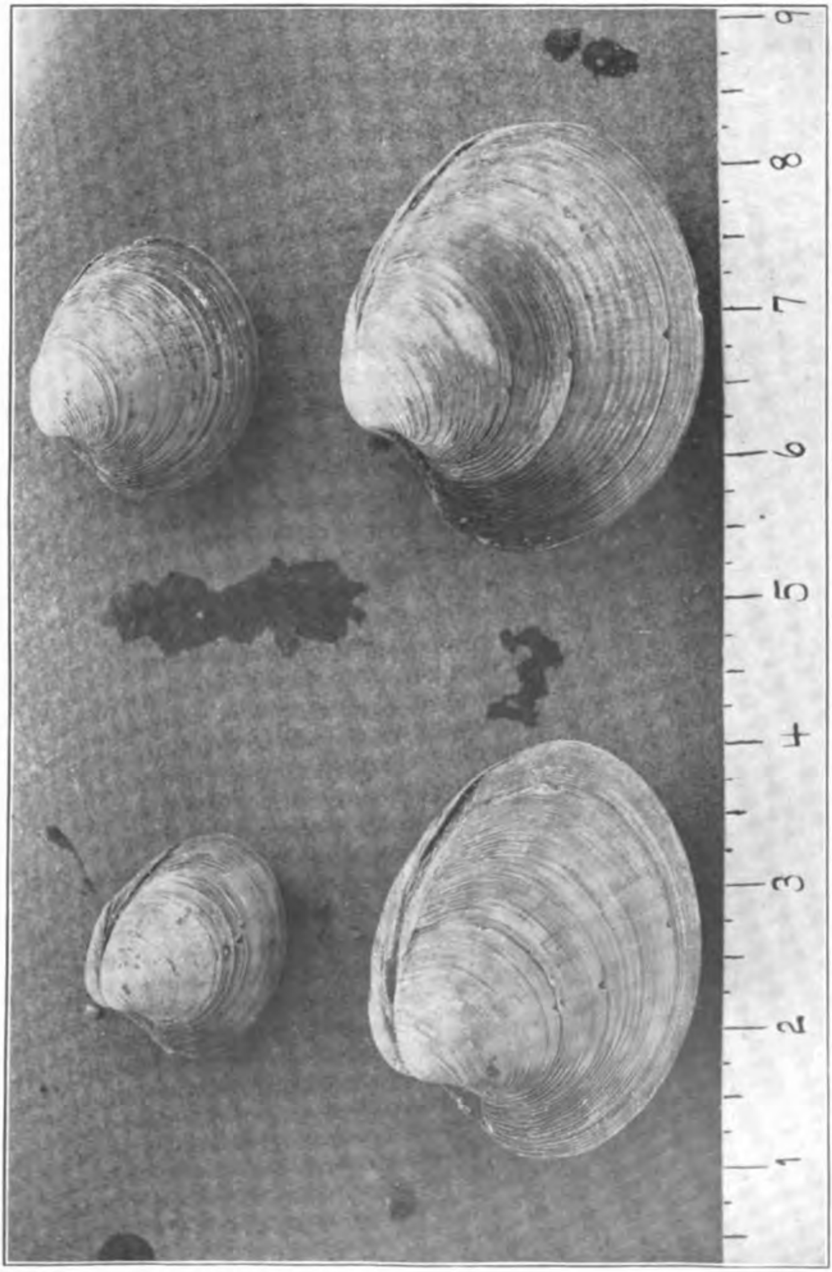

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Fig. 53. — Quahaugs from an experimental bed at Monomoy Point, showing two years' growth. The two notches or file marks on the shells indicate the growth per year. The photograph is two-thirds life size. These quahaugs show rapid growth, having gained nearly 1 inch in length per year.

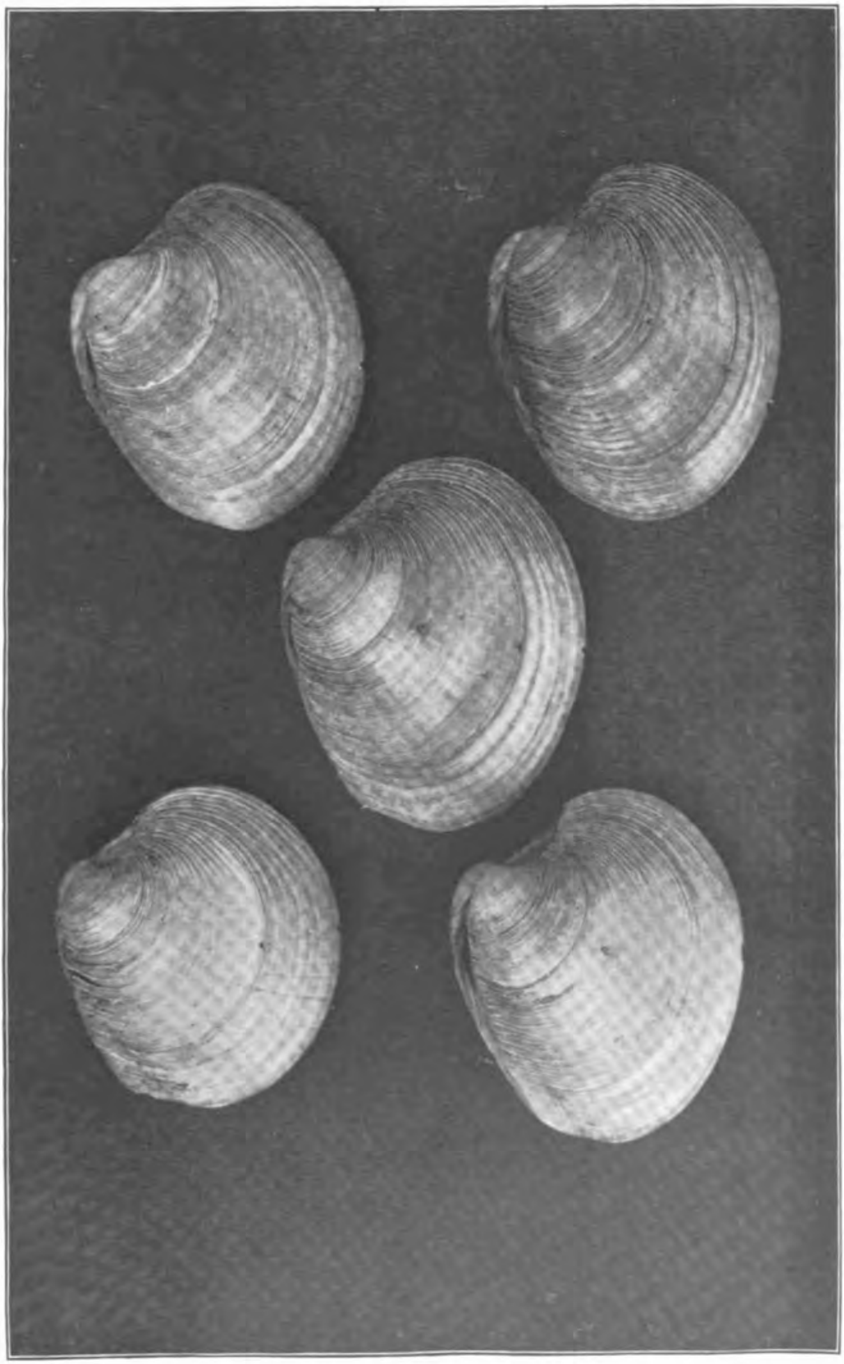

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Fig. 54. — The principal enemy of the adult quahaug is the common winkle or cockle (*Lunatia duplicata* or *heros*), pictured at the right and left in the illustration. In the corners are quahaug shells, through which a clean countersunk hole has been bored by this mollusk at the umbo. In the center is a starfish, the great pest of the oyster beds, and on rare occasions an enemy of the quahaugs.

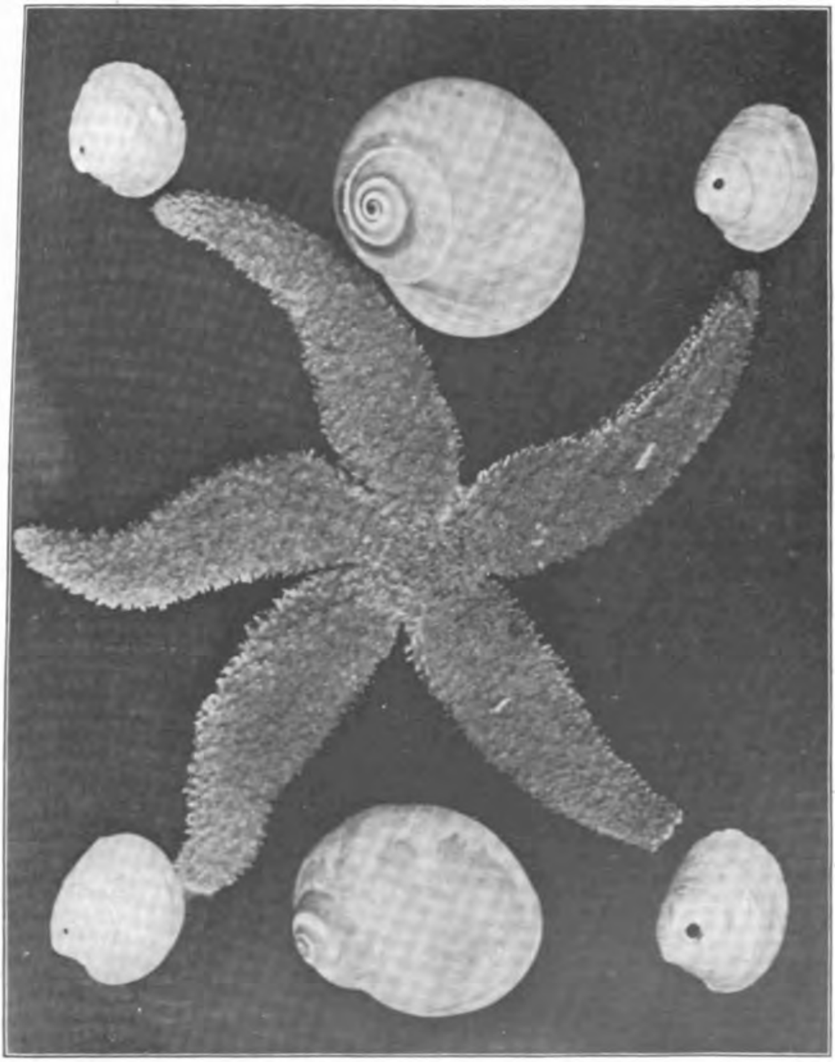

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Fig. 55. — Scene along the river front at Fairhaven, showing a quahaug shanty and several skiffs, which are used in raking the small seed quahaugs from the Acushnet River. Owing to the pollution within the restricted area, quahaugs can only be taken from this river for transplanting purposes. Since writing this report an act was passed in 1911 whereby the city of New Bedford and the town of Fairhaven by a common board govern the taking of quahaugs from this section by licenses and by restrictions as to selling and transplanting.

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Fig. 56. — The quahaug house of the firm of A. D. Davis & Co. at Wellfleet in 1907, one of the receiving agencies for the Wellfleet fishermen. A typical quahauging boat of Wellfleet is shown, waiting to unload its cargo of quahaugs. The long handles of the rakes can be seen on the deck of the boat.

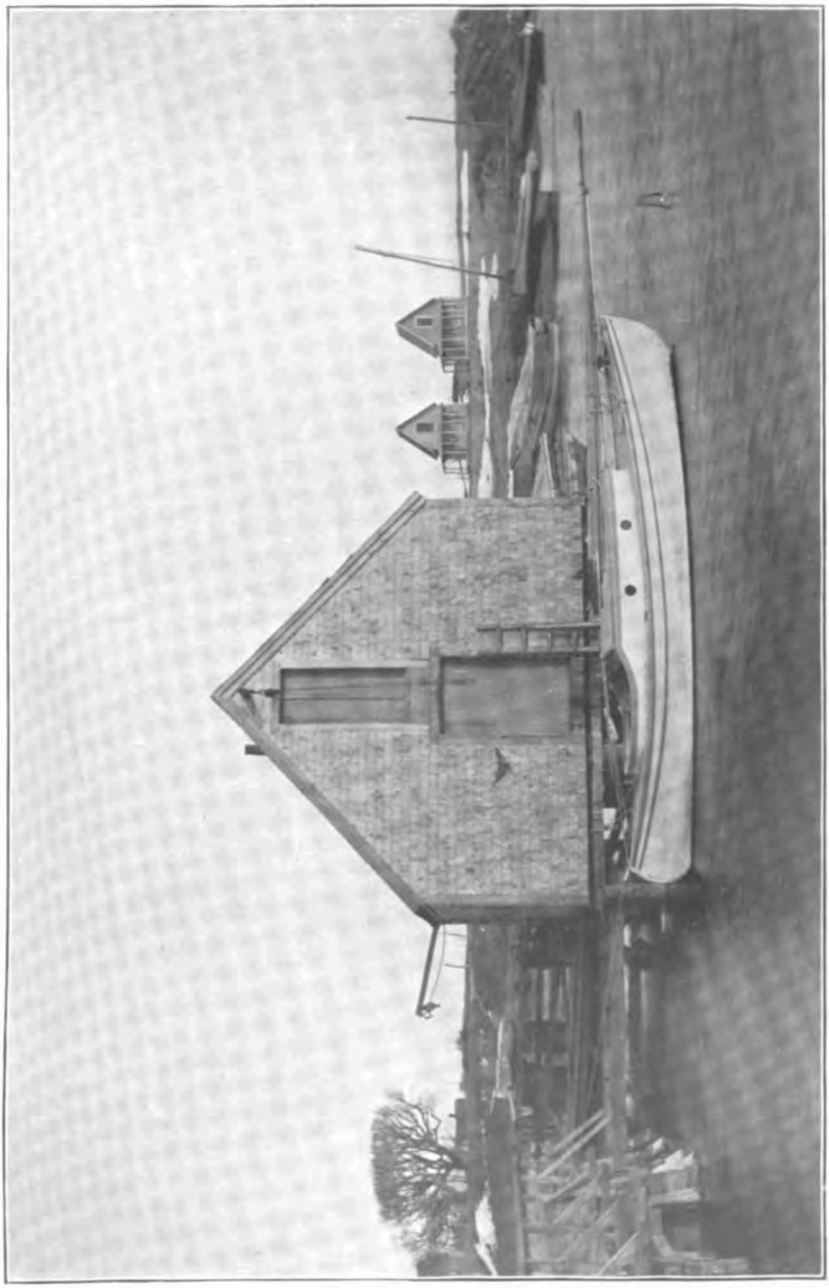

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Fig. 57. — The Wellfleet quahauging fleet at their moorings in Duck Creek. Practically all these boats are equipped with gasolene engines, a common type being power cat boats without masts.

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Fig. 58. — Basket rake covered with fine meshed wire netting, used at New Bedford and Fairhaven in the capture of the small seed quahaugs in the Acushnet River.

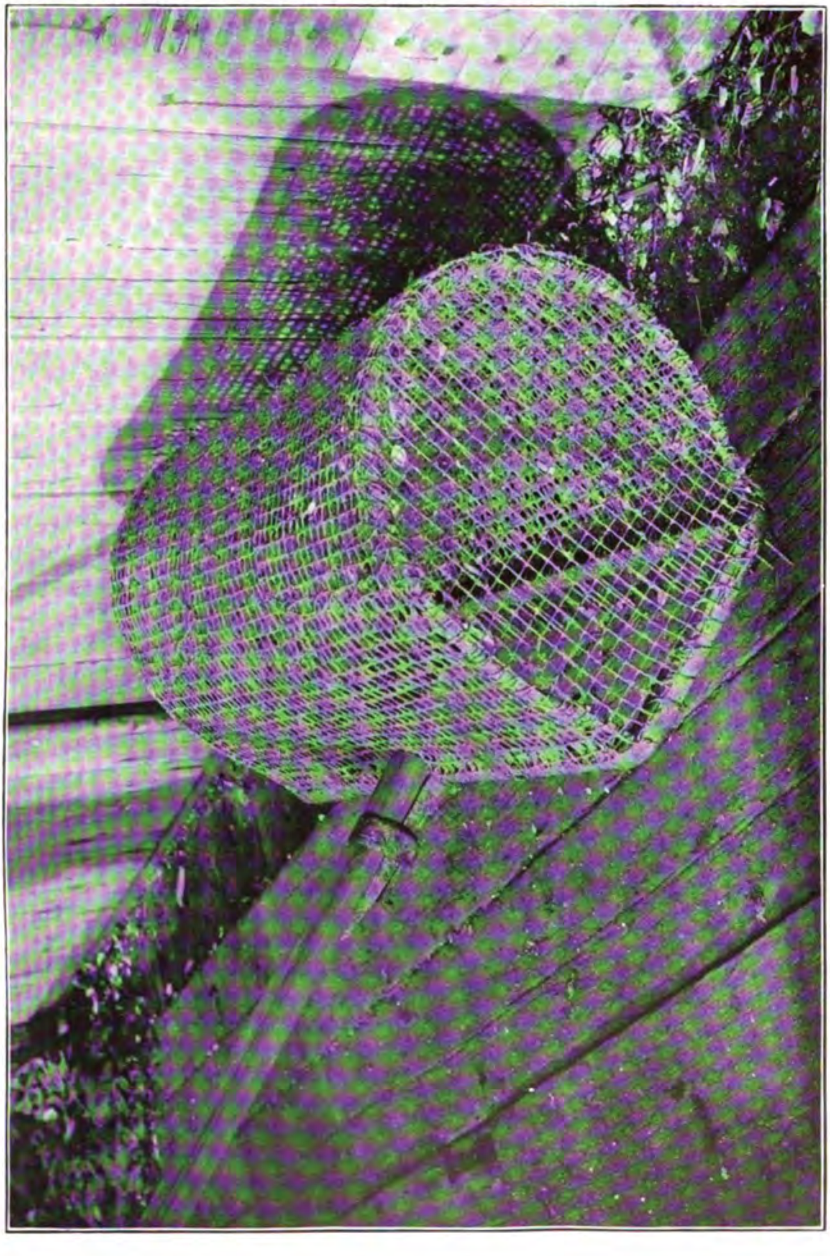

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Fig. 59. — The type of basket rake used for deep water quahauging on Cape Cod. It consists of an iron framework, forming a curved bowl, the under edge of which is set with thin steel teeth varying in length from 2 to 4 inches, though usually 2½ inch teeth are preferred. Over the bowl of this rake, which is strengthened by side and cross pieces of iron, is fitted a twine net, which, like the net of a scallop dredge, drags behind the framework. An average rake has from 19 to 21 teeth and weighs from 15 to 20 pounds.

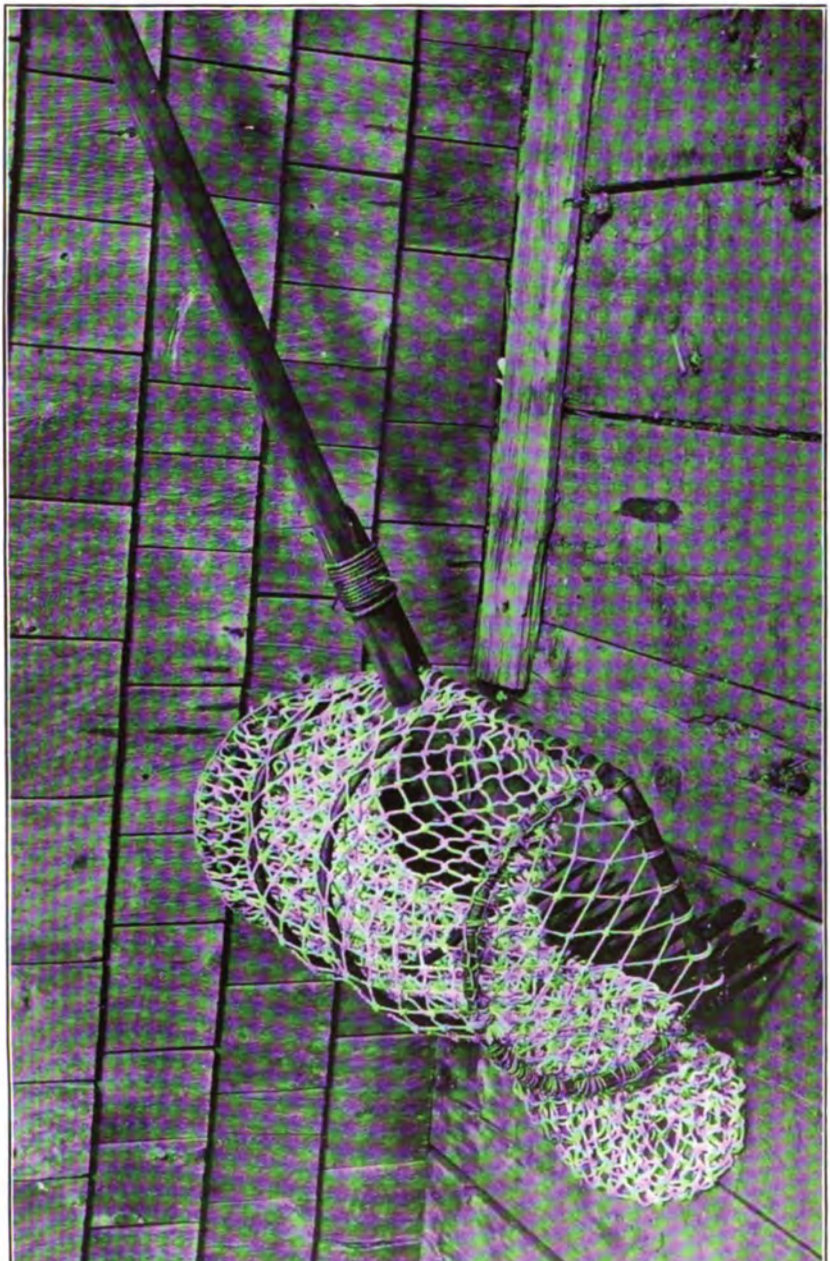

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Fig. 60. — The Claw Quahaug Rake. — This rake varies greatly in size and length. Its use is chiefly confined to Nantucket. The general style has a handle 6 feet long, while the iron part, in the form of a claw or talon, with prongs 1 inch apart, is 10 inches wide. A heavier rake, as here shown, is sometimes used in the deeper water.

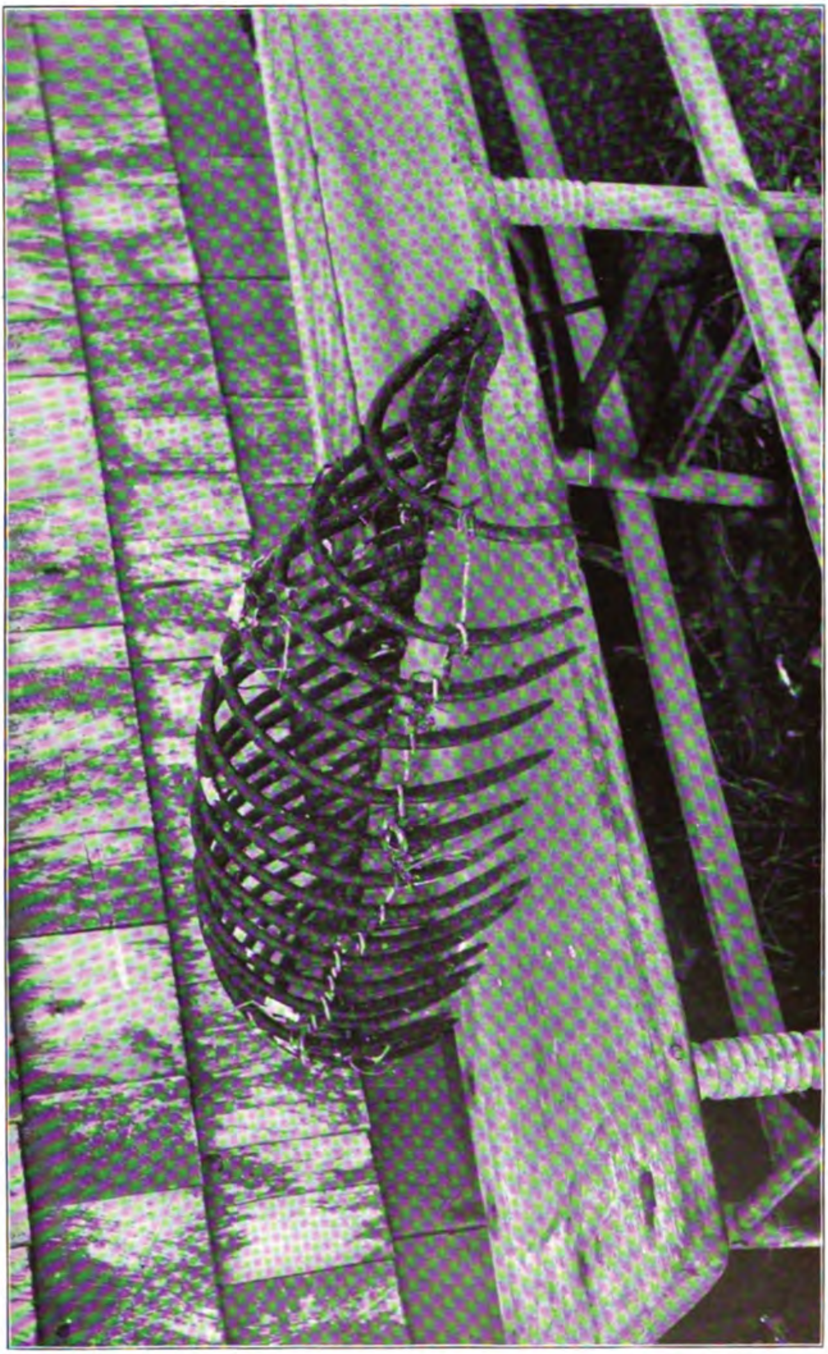

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Fig. 61. — This style of basket rake is used at Edgartown and Nantucket. The whole rake is made of iron, no netting being required, as thin iron wires ¾ of an inch apart encircle lengthwise the entire basket, preventing the escape of any marketable quahaugs, while at the same time allowing mud and sand to wash out. This rake has 16 steel teeth, 1½ inches long, fitted at intervals of 1 inch on the scraping bar. The depth of the basket is about 8 inches. Short poles not exceeding 30 feet in length are used, as the raking is carried on in water which does not exceed 25 feet in depth. Only the iron framework of the rake is shown.

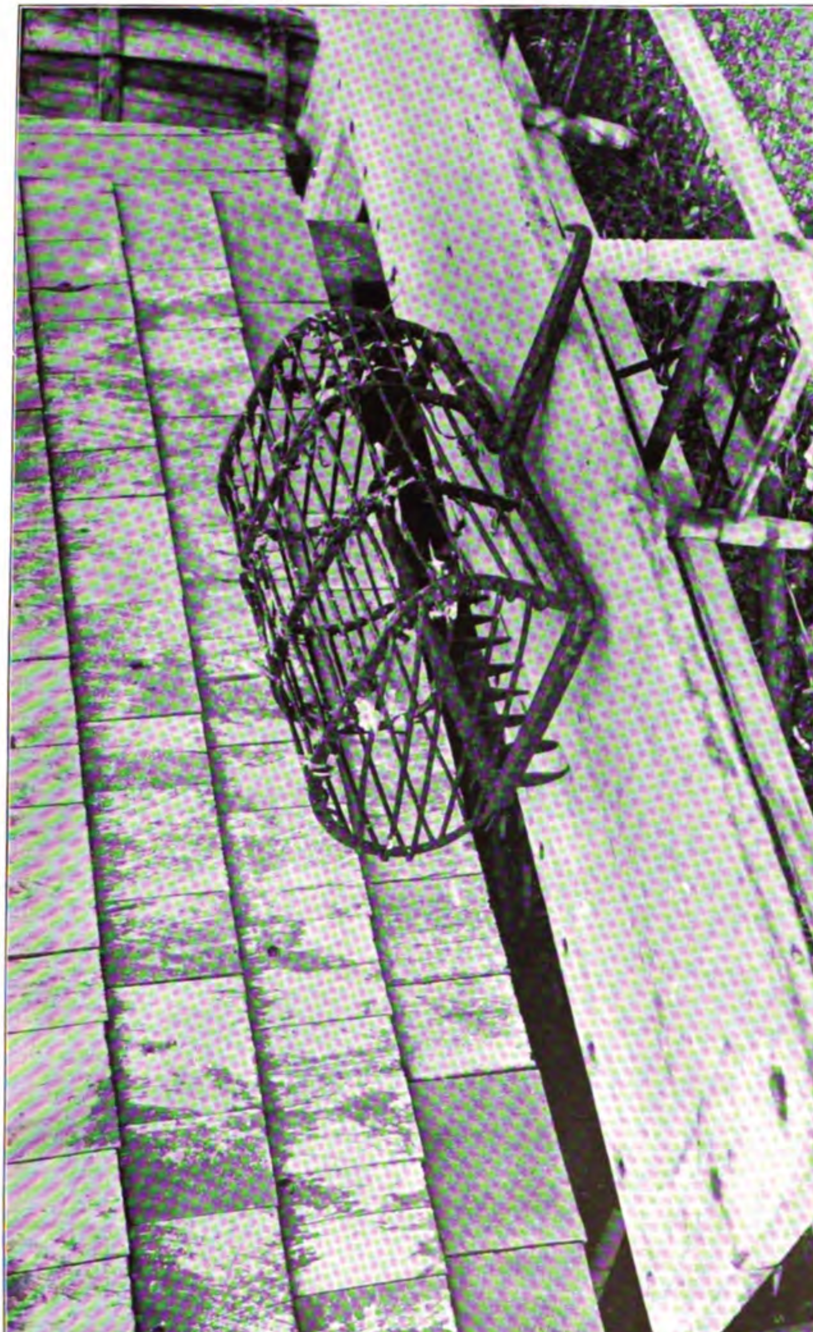

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Fig. 62. — Anatomy of the Oyster. — From a model in the American Museum of Natural History. The right valve and mantle have been removed to show the internal organs. The oyster may roughly be likened to a book, the valves of the shell representing the cover, the fleshy mantle closely lining the shell the first and last leaves, and the gills, running lengthwise beneath the large adductor muscle, the inner pages. Between the muscle and the hinge lies the heart, and above the gills the visceral mass, consisting of the cream-colored reproductive organs, which are here pictured as round white masses, and the dark-colored digestive organs. Between the anterior end of the gills and the hinge are the palps, four fleshy flaps, similar in appearance to the gills. The microscopic plants which form the food of the oyster are filtered out by the hairlike cilia of the gills, transferred to the palps, and passed into the mouth. A short œsophagus leads into the stomach, which is surrounded by a dark-green gland, the liver. The intestine passes backward, then folds on itself just below the adductor muscle, passes forward to form a second coil, before it again leads backward, to end above the heart and adductor muscle.

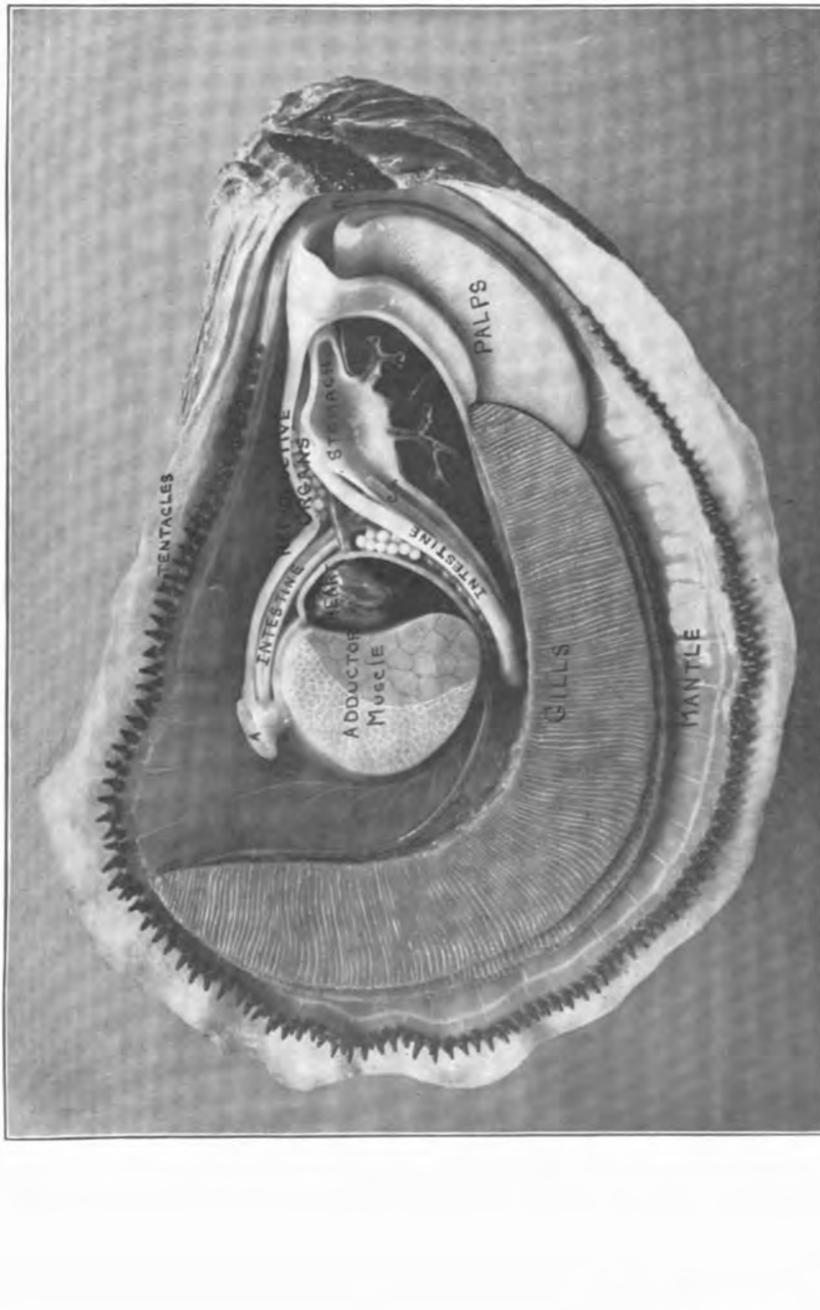

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Fig. 63. — The buildings of the Sea Coast Oyster Company at Wellfleet in 1910. The two boats lying at the wharf are typical gasolene oyster dredgers, by means of which the shells are put down for the capture of spat, the grounds are cleared, the seed is planted and the oysters gathered for market.

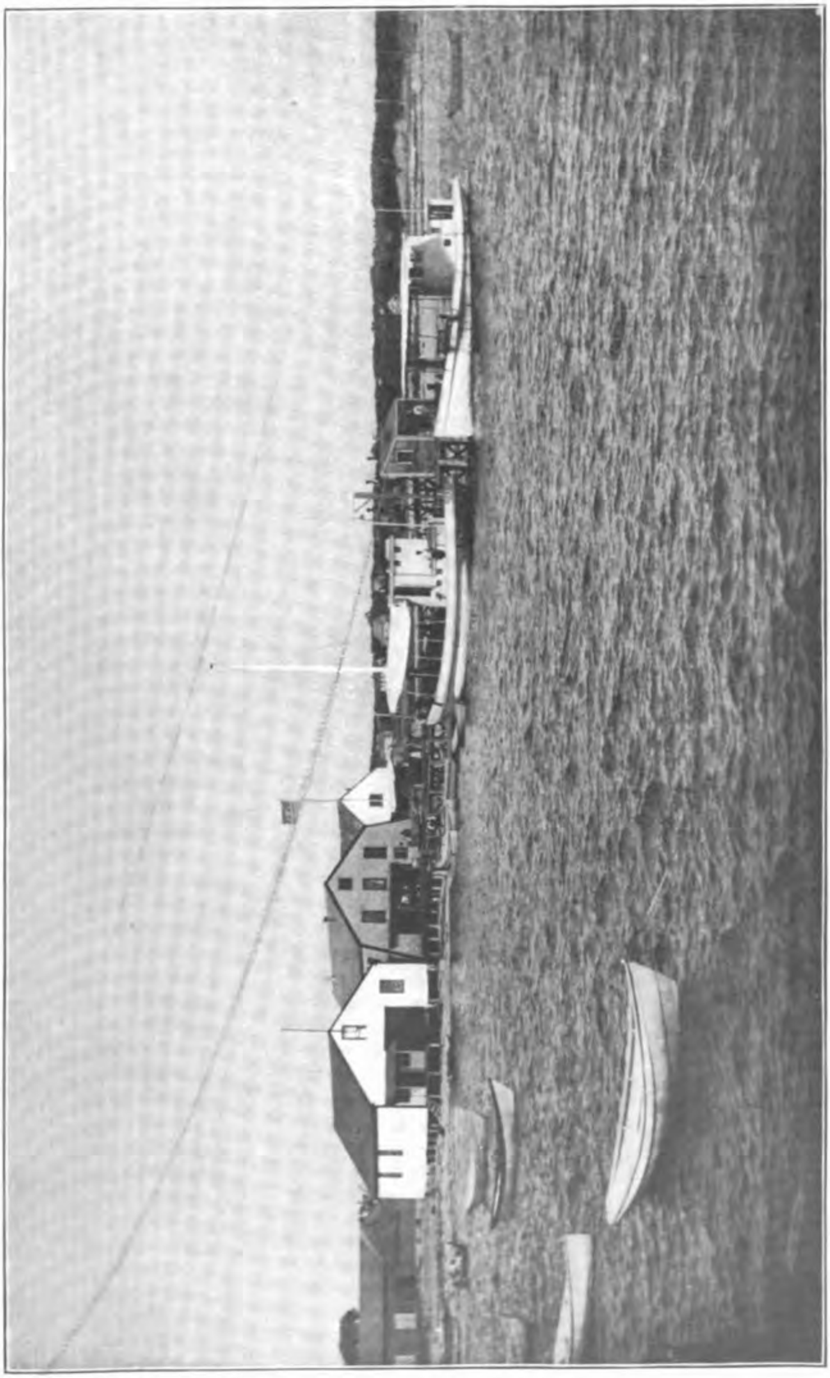

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Fig. 64. — Herring River, Wellfleet, at low water, showing the shells planted for the capture of seed oysters in 1908 on the gravel bar north of Great Island. The shells and pebbles are covered with spat.

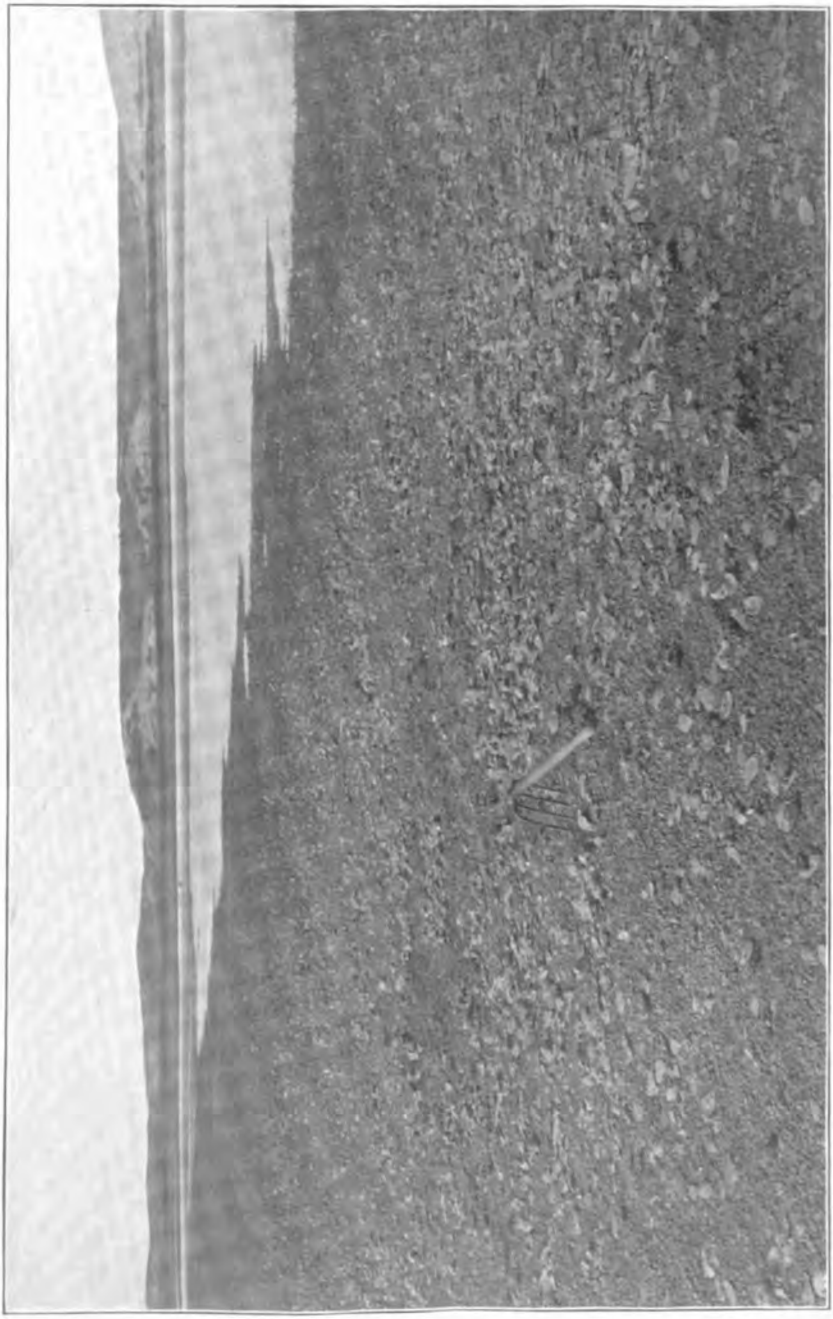

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Fig. 65. — Near view of oyster shells on the gravel bar in Herring River. The set is about three months old. Notice the clean appearance of the shells.

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Fig. 66. — Oyster seed, mostly two-year olds, attached to the wooden piles and the stones beneath Chequesset Inn wharf, Wellfleet, Mass. The abundance of the natural set on such objects indicates that successful spat collecting can be carried on in this locality. During severe winters the mortality is heavy, owing to the exposure between the tide lines; but these oysters have weathered two ordinary winters.

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Fig. 67. — Oyster spat, one month old, on the shells of the experimental spat collectors located in Wellfleet Bay, 1908. Various shells, such as oyster, scallop, razor clam, clam, quahaug, silver or jingle shells can be utilized for spat collecting.

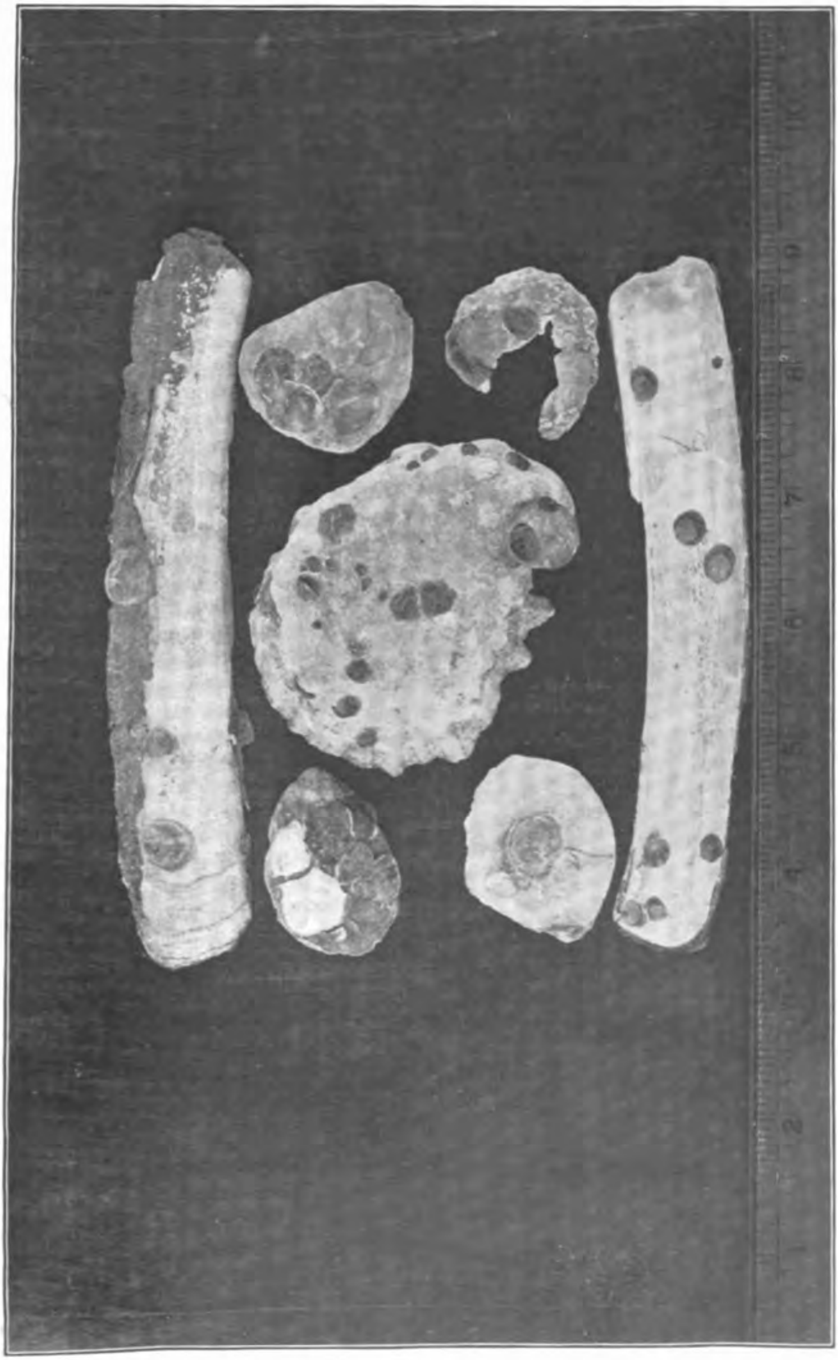

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Fig. 68. — Figs. 1–20 illustrate the growth of the seed oysters caught on small stones. Figs. 1–10 show three-month-old oysters attached to living snails (*Littorina littorea*). Figs. 11–14 show the oysters of the same age attached to small stones. Figs. 15–18 show oysters one and one-half years old attached to small pebbles, while Figs. 19 and 20 show two and one-quarter-year-old oysters attached in the same fashion. Fig. 16 gives a peculiar illustration of the method of attachment. The young oyster has formed an attachment to a second pebble towards its free end at some distance from the first, indicating that the mantle, even at the age of one year, retains the power of secreting a fixative.

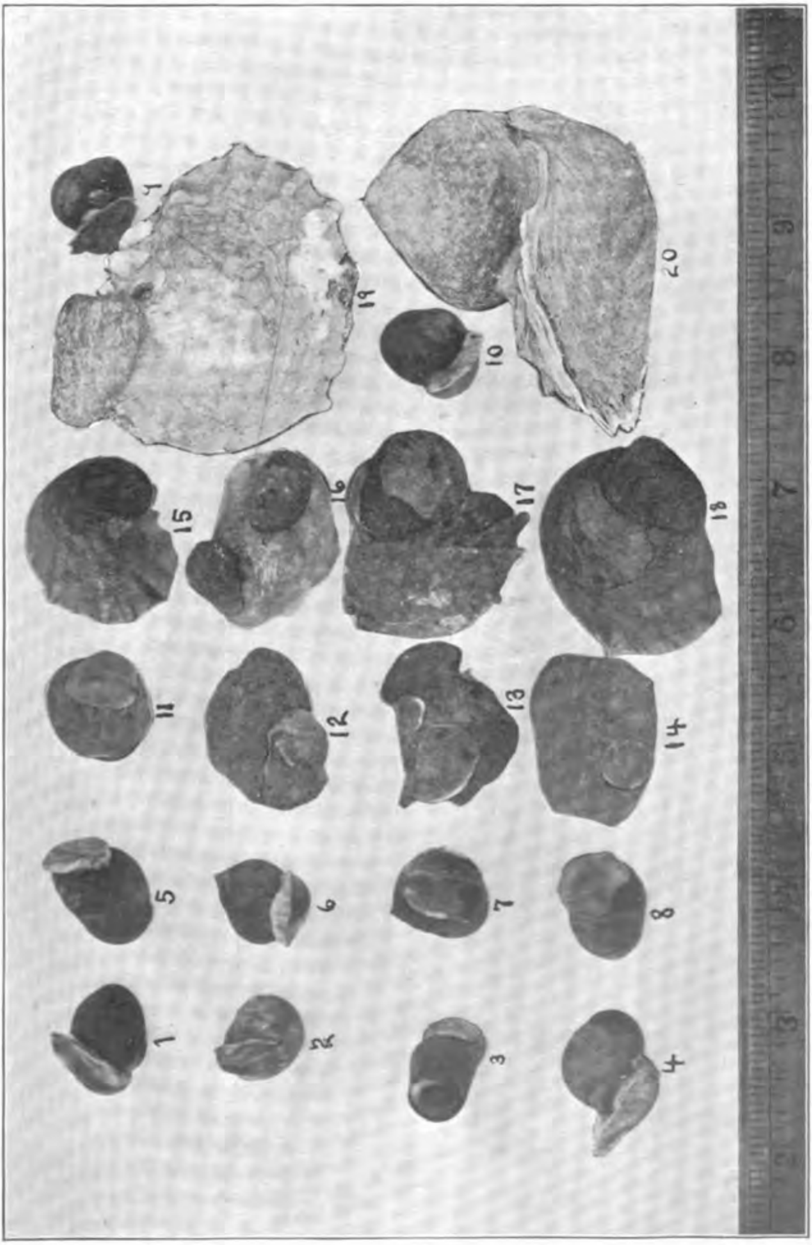

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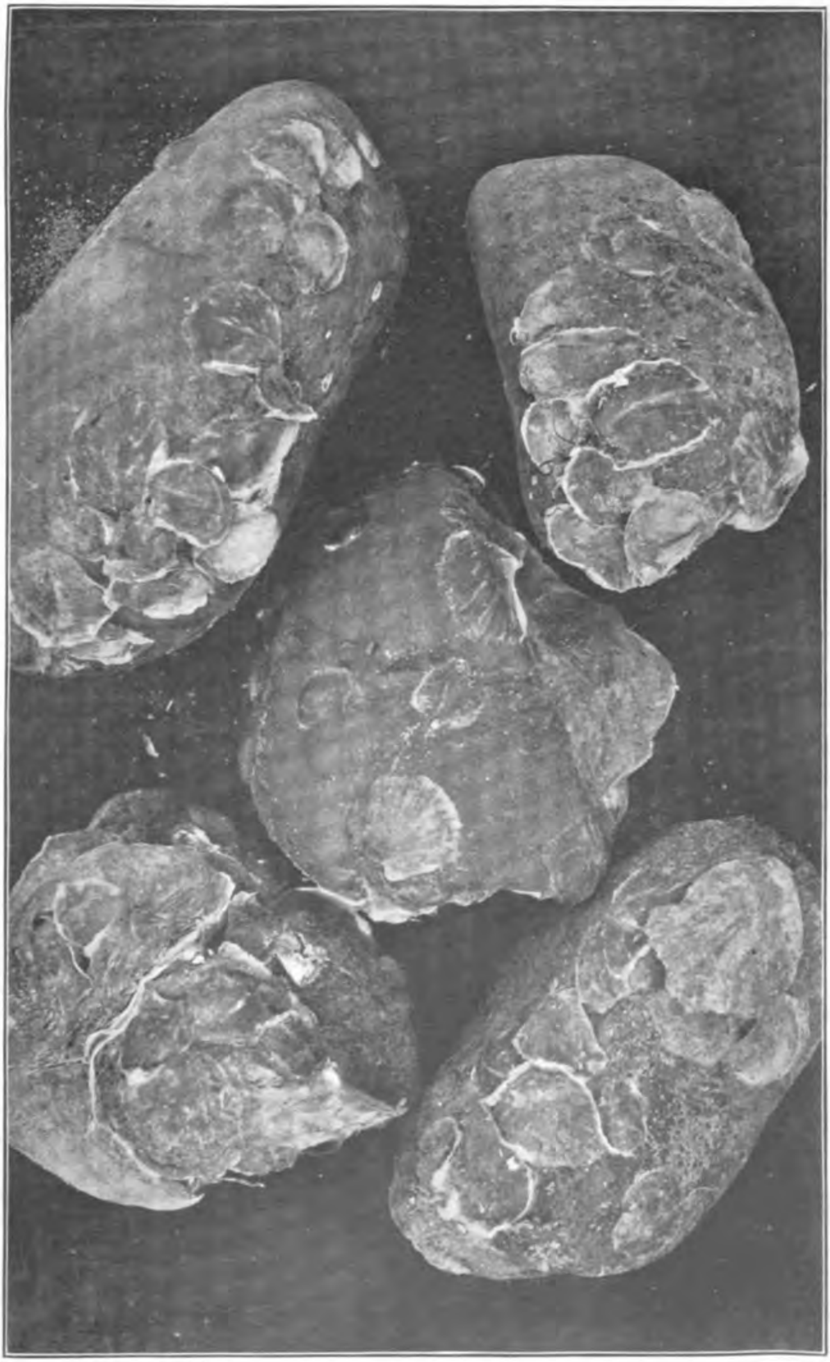
Fig. 69. — Three-month-old spat upon stones, which were gathered beneath Chequesset Inn wharf, Wellfleet.



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