REPORT ON THE SOFT-SHELL CLAM INDUSTRY ON THE EAST COAST OF THE UNITED STATES

(A report to be presented to the Special Committee of Clam Technicians sponsored by the Atlantic States Marine Fisheries Commission.)
May 17, 1948

By Harry J. Turner, Jr., Biologist
Woods Hole Oceanographic Institution

Introduction

The purpose of this report is to bring together as much information as is available about the soft shell clam and the clam industry so that the Committee of Clam Technicians may have a concrete basis for discussion of problems affecting that industry. Present knowledge of the biology of the clam, summarized in the first chapter, is based on literature cited in the bibliography at the end of the report. Production and price statistics were furnished by the United States Fish and Wildlife Service. These data are supplemented by additional information obtained from the conservation departments of the coastal states extending from Maine through New Jersey.

Economic aspects of the clam industry are discussed at the production level only. The basic problems of the clam resources could best be attacked at this level. Investigation into the economics of processing and distribution of clams are beyond the scope of this report.

Contact was made with authorities from each of the coastal states either in person or by mail. Valuable information on geographical problems was secured in this manner. It was also possible to gain a considerable insight on different attitudes toward the clam industry as they prevail in different sections of the coast. Further information on shellfish improvement programs of several Massachusetts towns was obtained by Mr. Charles Wheeler who interviewed local officials and studied their statements in town reports.

Appreciation is expressed to Dr. J. Carl Medcof of the Atlantic Biological Station, St. Andrews, N. B. for his cooperation in making available data derived from his experimental program sponsored by the Dominion of Canada. Part of the expenses incurred in collecting of the data and compilation of this report were borne by the State of Maine Department of Sea and Shore Fisheries.

CHAPTER I

Biology of the Clam

Range

The soft clam, Mya arenaria, occurs on the east coast of North America from the Arctic Ocean south to Cape Hatteras. It is found in abundance as far south as New Jersey but occurs in such small numbers from New Jersey to Cape Hatteras that no significant industry has been developed there.

The bulk of the clam crop comes from the intertidal zone. In some localities clams are secured by special methods in water as deep as five feet at low tide, and small quantities occasionally are taken by dredge fishermen as an incidental part of the catch. Verrill gives the seaward range as being from the half-tide mark to 40 fathoms. All specimens he took in deep water were young. The upper limit with respect to tide has not been determined with certainty.

The greater part of the commercial clam crop is produced north of Cape Cod where a tide range of eight feet and more exposes extensive flats at low water and facilitates digging. South of Cape Cod there is less exposed area at low water due to a smaller range of tide and shellfish must often be dug under water. Here the fishermen find it more profitable to limit their underwater digging activities to the hard clam which lives nearer the surface of the bottom and may be harvested with rakes and tongs.

Life History

Spawning. The sexes are separate. Spawning occurs during the late spring, summer, and early fall. A two-and-one-half inch female spawns approximately three million eggs, and a male of that size produces sperm which number in the billions. Males and females extrude their sex products into the water where the motile sperm swim toward and unite with the eggs. The fertilized egg develops in a few hours into a larva which can swim.

Temperature is believed to determine the season of breeding. In New Jersey the first spawning occurs in May. As one passes northward along the coast, the spawning begins progressively later in the year. The duration of the breeding season is not exactly known, but there is evidence that it may extend well into the fall. Sets of clams are often found in the early spring which are so small that they can have had little time to grow before winter set in.

The stimulus which sets off the act of spawning has not been determined. Mature clams which contain ripe eggs or sperm may be induced to spawn experimentally by placing them in water a few degrees warmer than that to which they have been accustomed. More extensive work on the mussel has shown that the presence of reproductive products of the opposite sex acts as a stimulus to spawning. If this is also true of the clam, it is evident that in well populated beds the spawning of a single individual may set off a burst of spawning among the others. This will insure a high percentage of fertilization since large numbers of eggs and sperm will be in the water at the same time.

<u>The free swimming period.</u> As soon as the larva has developed swimming organs, it swims freely in the water feeding on suspended material. This probably consists of bacteria and small animals and plant cells. Its powers of locomotion are not great enough to much more than keep it afloat. Dispersal occurs as a result of water currents. While swimming about in the water, the larva passes through a series of developmental stages.

The duration of the free swimming period depends on the temperature of the water. Warmer waters favor more rapid development so that the larval period may be as short as twelve days in Massachusetts while in Maine it may be extended to three weeks.

<u>Setting.</u> By the end of the free-swimming period the larva has acquired most of the organs characteristic of the adult. It is still too small to be distinguished with the unaided eye and under the microscope looks somewhat like a small quahaug. At this stage the swimming organ begins to degenerate and the larva settles to the bottom where it crawls about with its foot. It then attaches to some object by means of a thread or byssus similar to that found in the adult mussel. It may attach to sand grains, seaweed, rocks, thatch-grass, or other objects. The power of attachment remains until the young clam has grown to a length of $\frac{1}{4}$ inch.

After attachment the young clam feeds and grows. At first growth is more rapid in the anterior-posterior direction so that by the time the clam can be seen by the naked eye it has the general shape of the adult. It may detach at any time and crawl short distances in search of a more favorable locality. Finally if it comes to rest on a bottom with favorable characteristics, the young clam burrows in and attaches itself to sand grains in the sides of the burrow. If washed out it will burrow in again, and if conditions are not suitable, it may dig its way out and migrate short distances by crawling with its foot. As a rule, the young clam is permanently established in its burrow before it is an inch long. It retains its power to dig for some time in the event that scouring frees it from its burrow. However this ability becomes less with increasing size so that clams over 2 inches long seldom bury themselves when exposed.

The effect of the type of soil on setting and growth is not well understood. It has been demonstrated that the soil acts mainly as a support since food is supplied from the water above. The physical nature of the soil has been shown to have some influence on clam production. Loose shifting soils do not catch sets and often kill adults by filling the siphons with sand. Firm mixtures of sand and mud or soils compacted and cemented by algal growth appear to be the best.

The chemical nature of the soil is believed to be of little significance, although recent studies have indicated that there may be unknown substances in certain soils which cause mortality. In general, however, it is considered that the only unfavorable soils are those which cause decalcification of the shell by acid substances resulting from the decomposition of organic matter.

The soft-clam lives in water containing 8 to 28 parts of salt per thousand. Thus clams occur in harbors and estuaries where sea water may be diluted with as much as three times its volume of fresh water. The distribution of the better clam beds indicates that setting and growth may actually be favored by waters containing somewhat less salt than is found in normal sea water.

<u>Feeding and growth.</u> The food of the adult clam consists of material floating in the water. For some time it was believed to consist mainly of living microscopic plants such as diatoms and other algae, but recent studies of related species indicate that organic detritus may form the bulk of the food of molluscs. Organic detritus is a term given to material consisting of the dead bodies of small plants and animals, clumps of bacteria, and decomposing fragments of larger organisms.

The rate of growth of the young clam is influenced by a variety of conditions including temperature, time of submergence, availability of food, current, degree of crowding, and probably several others. To a certain degree warm water favors rapid growth but excessively high temperatures are detrimental. Clams which live near the low tide level grow faster than those at higher levels because they have more time to feed during each tidal cycle. A strong current serves both to bring in new supplies of food and also to remove detrimental waste products. Under crowded conditions competition for food as well as accumulation of waste products may seriously inhibit growth.

<u>Spawning Age.</u> From Massachusetts south where growth is rapid, most clams probably spawn when one year old. There are some indications that clams which set in the early summer in these localities may spawn in the fall of the same year but the numbers of eggs produced by them is probably small. Nothing is known concerning the spawning age of clams in the regions north of Massachusetts.

As the adult clam continues to grow the yearly production of eggs or sperm becomes greater. However in clams of great age the reproductive organs degenerate and result in the familiar "waterbellies" which are useless for propagation and low in meat yield. The life span of the clam is estimated to be about ten to twelve years in Massachusetts and may be longer in the northern localities where growth is slower.

Production and Growth

The rate of growth of the clam has been recorded for Rhode Island, Massachusetts, and New Brunswick. Graph Figure 1 shows average rates in these localities.

The difference in the growth rate has been shown to depend on the temperature. Investigations made in Massachusetts have determined that clams stop feeding when the temperature drops below 37°F, thus restricting the growing season to the warmer months of the year. In the more northern regions where winters are longer the growing season is reduced accordingly.

Commercial clams, which are generally at least two inches long, may be produced in one year in Rhode Island, two to two and ½ in Massachusetts, and 4½ to five years in New Brunswick. One acre of land populated with 25 two inch clams to the square foot will contain 540 bushels. The wet weight of the meats which may be shucked from this quantity equals 8100 pounds or a little over four tons. Some particularly favorable localities sometimes support as many as 50 clams per square foot and double the production. As the length of clams is increased, their volume and weight go up in an exponential manner. The following table shows the product of one acre containing 25 clams per square foot at different lengths.

Length	Bushels per acre	Pounds of Meat per acre	Age R.I.	Age Mass.	Age N.B.
2 in.	540	8100	1	2-2 1/2	4 1/2-5
2 1/4 "	735	11025	1 1/3	3	6
2 1/2 "	1063	15945	2	3 1/2	7
2 3/4 "	1356	20340	2 1/2	4 1/2	

Enemies and Diseases

Predators. In the free swimming stage clam larvae are probably attacked by all kinds of animals which feed on plankton. Considering the numbers of eggs that are spawned each season, the mortality at this stage must be very great. As soon as setting has occurred three groups of bottom-living animals may further reduce their numbers. These enemies are crabs and crab-like organisms, boring snails, and starfish.

The lady crab and the blue crab dislodge young clams by agitating the sand and eat them after crushing the shells with their claws. Their destructive influence is limited to small clams in soft sand. Greater destruction is caused by the horseshoe crab which burrows through the flats devouring young clams in large numbers.

Among the boring snails, the oyster drill may cause considerable destruction to small clams after they have set. The drill bores a hole through the shell with its rasp-like tongue and sucks out the contents. Greater destruction is caused by the cockle Polynices which can burrow down a considerable distance into the soil and attack clams of a larger size. This snail operates in essentially the same manner as the oyster drill but its larger size and burrowing ability makes it a serious pest. It is estimated that a two inch cockle can destroy 26 clams per month.

The starfish, which is one of the most serious pests to the oyster industry, has only a limited destructive influence on clams. It operates by attaching the sucker-like appendages on its arms to both shells of the clam and exerting a steady outward pull until the shells open. It then protrudes its stomach and digests the contents. Small starfish sometimes eat small clams which have not yet burrowed but the destruction of larger clams is limited to those washed out of the sand by scouring. Other preditors include shore birds and bottom feeding fish but their importance has not been determined.

The clam-worm, Nereis, which is often found in large numbers in clam beds, has been thought by some to prey upon live clams. However, careful studies have shown that this worm is a scavenger and does not harm live clams. Its presence in the shells of dead clams is due to its habit of feeding on the bodies of clams which have died from other causes. Ecological studies have shown that clam worms are often found in association with clams and it is possible that their presence in certain soils indicate evnironmental conditions favorable for clam growth.

A tubeworm, Clymenella, is sometimes found in flats where conditions do not favor clam growth. This worm does not directly affect the clams but indicates that the conditions are unfavorable and must be changed in some manner before the beds may be made productive.

Methods of control. Some communities which carry on planting operations employ men to police the beds and pick up cockles and crabs. Aside from this no methods of controlling predators have been developed.

Competitors. The soft clam sometimes occurs in localities where conditions are favorable for other species as well. Clam beds located where conditions favor the growth of the blue mussel are often overgrown by this species. When this occurs the beds become carpeted with mussels and as a result setting of clams is discouraged and growth is inhibited.

The thatch-grass, *Spartina*, is believed to overgrow clam producing areas when sedimentation has built the beds up to a point high enough above low tide so that the grass can survive. However, the growth of thatch islands usually results in marginal extensions of the flats as a result of sedimentation. Clumps of thatch-grass may be beneficial in acting as natural spat collectors, and it is often observed that the best digging occurs around such clumps.

Diseases. From time to time whole populations of clams die out simultaneously leaving the individuals rotting in their shells. Nothing is known as to what causes this. It has been suggested that pollution spreading from a few dead individuals to others may be the cause, but this has not been established. Various worm parasites have been observed but their incidence is low.

CHAPTER II

Geographical Aspects of the Clam Industry

The east coast of the United States may be roughly divided into three sections as far as the clam industry is concerned. From Cape Ann north and east the soft clam is the predominant species of shellfish and is dug largely for commercial purposes. Here the tide range of eight feet and more exposes extensive flats which are generally protected from the open sea, thus providing ideal conditions for clam growth. The small size of the coastal communities where employment may be seasonal or occasional leads the inhabitants to depend heavily on the sea for at least part of their income.

Between Cape Ann and Cape Cod similar conditions exist in many localities. Where clams are plentiful, particularly in small communities, clamming may be performed mainly for commercial purposes. In this section digging for recreation and home consumption takes on some importance. Permanent employment in manufacturing and industrial plants reduce the necessity for dependence on sea products, and as a result coastal inhabitants tend to consider shellfish resources as a means of supplementing their own diets rather than their income.

South of Cape Cod the oyster and quahaug supplant the clam commercially. The small tide range and difficulty of clamming in submerged beds make commercial exploitation of other species more profitable. The soft clam, however, plays a very important part in this section where inhabitants of heavily populated communities find it profitable to supplement their diet, particularly when there is considerable unemployment. It is estimated for example that 90% of the clams dug in Rhode Island are consumed either by the families of the diggers or by local inhabitants who purchase them direct from the diggers or through small dealers. The presence of clams also adds to the attractiveness of summer resorts. Tourists and vacationers expect sea food and the pleasure of catching it themselves.

Maine leads in commercial clam production with a yearly average of over six million pounds of meats. Massachusetts is second, averaging about three million pounds per year of which the greater part comes from the Ipswich and Essex region. In New Hampshire contamination of the Great Bay area has eliminated the most productive digging so that practically no clams are dug for commercial purposes. Rhode Island, in spite of its small commercial crop probably ranks third in total production. Since 90% of this is for home consumption, it is apparent that clams must form an important item in the food budget of the inhabitants of that state. Contamination and unsuitable coast line generally limit commercial clamming in Connecticut, New York, and New Jersey.

CHAPTER III

Economic Aspects of the Clam Industry

It is very difficult to evaluate the importance of the clam industry in the economy of coastal communities because few records are available which show how much individual clam diggers actually earn. In most states the shellfish resources are controlled by individual towns, each of which has its own system of licensing and restrictions with no obligation to make reports to a centralized authority.

In Maine however, new legal measures have recently been instituted which require that commercial clam diggers obtain a state license as well as local permits. This promises to facilitate the evaluation of the industry in the future. The Maine Department of Sea and Shore Fisheries has also maintained a competent staff of field workers who have kept in close contact with the clam industry for some time and have been able to make fairly accurate estimates on the number of active commercial diggers.

Information supplied by this department shows that clam digging at best can be considered only a part time occupation. The average earnings are given in the following table.

Year	Estimated No. of licenses	Average yearly earnings per license
1942	1,100	$ 427
1943	1,250	476
1944	1,500	276
1945	1,500	518
1946	1,875	968
1947	no information	
1948	1,947 applied for in the first three weeks of the year	

It must be understood however that the term "average yearly earnings" is derived by dividing the value of the crop by the number of license holders. It is highly probable that some diggers take advantage of their licenses only occasionally to supplement their incomes or food supplies when other occupations are unavailable or unattractive. However these average earnings are so small that few diggers make a living wage by clamming alone.

Information derived from two towns on Cape Cod indicates that a similar situation exists in that part of Massachusetts. Average yearly incomes for persons in the towns of Barnstable and Chatham who hold commercial licenses for the taking of all types of shellfish are given in Table I.

A typical picture of the economics of clam digging has been obtained from the activities of industrious commercial diggers who depend on clamming for the greater part of their incomes. The writer has had the opportunity to observe two men digging in Barnstable harbor during the summer and fall of 1947. These two men, who were the only regular diggers out of several commercial license holders of the town, were out on the flats each day the weather permitted. Both were able to secure the two hods (1 1/5 bushels) limit allowed by the town regulations in spite of the extreme scarcity of clams. For their day's labor they were able to shuck out about two gallons apiece which were sold to local restaurants for about six dollars a gallon. They were able to work a total of about half the year, which would give each an income of nearly $2000 from clamming alone. This was supplemented by scalloping in the late fall and winter, but no observations were made on this activity.

The meager data presented above shows that clamming is generally an occasional occupation and in spite of present high prices, the most industrious diggers can hope for only a relatively small income.

The seed clam industry of Massachusetts is of special interest because it utilizes contaminated stocks which would otherwise go to waste or be bootlegged into food channels. Bonded master diggers are licensed by the Department of Conservation to employ diggers who may work over contaminated areas to supply seed clams for state shellfish aid and for sale to private grant holders. In 1947 master diggers in the Boston area were delivering seed in 20 barrel lots for $7 a barrel. (At this time the Boston fish markets were paying $18 a barrel for clean clams.) Diggers were paid $5 a barrel by the master diggers and were able to dig about two barrels a tide. Most diggers made at least $10 a day when they worked, and the master diggers made $40 a load minus the costs of transportation. This occupation however, cannot be depended upon to provide year round employment since the demand for seed clams is governed by the activities of the State Conservation department and of a few private grant holders.

The overall value of the clam industry is difficult to evaluate. Besides the diggers, there are also involved the shuckers, canners, distributors, and restaurant owners. The Commissioner of Sea and Shore Fisheries in Maine has stated that he estimates the total yearly value of the clam industry in that state to be about seven million dollars. No other such estimates have come to the attention of the writer.

The value of the industry in Massachusetts is indicated by the imports of six of the largest dealers in the first 11 months of 1947. These dealers reported to the Massachusetts Special Legislative Commission for the Study of Shellfish that they had imported from Maine and Canada 1,800,000 gallons of shucked clams valued at $9,000,000.

In addition to the industrial value in the strict sense, the availability of clams for clam bakes, in seafood restaurants, and for recreative digging provides an added attraction in resort communities and thus has a definite but indirect effect on their prosperity.

CHAPTER IV

Trends in Clam Abundance

A unanimous opinion pervades among the coastal inhabitants that clams have been sharply declining in abundance for a number of years. Reports of Kellogg, Mead, and Belding written in the early part of this century show that this opinion was held even at that early date. Actual trends in clam abundance are difficult to demonstrate because of the questionable reliability of the available statistics and lack of data on digging effort. The occasional nature of clamming as an occupation further complicates the picture. When prices are high there may be a greater tendency for coastal inhabitants to go clamming. When clam prices are low other employment may be more attractive even when clams are abundant.

The yearly production figures for Maine, shown in figures 2 and 2a do not in themselves indicate a downward trend in clam abundance. During the last 20 years, for which the data are most complete, cyclic fluctuations show a general downward trend with a low point in 1944, but this is balanced by a consistantly high level of production during the three subsequent years. It is probable that this increase resulted from intensified digging effort stimulated by the high prices as shown in figure 3. Maine clam diggers today claim that they are digging in areas where clams are so scattered that formerly they would not even have been considered. If such is the case it is likely that Maine clam resources are in grave danger of over-exploitation, and production may drop within the next few years as the stocks are reduced.

In Massachusetts clam abundance has clearly reached an all time low. In figure 6, it may be seen that between 1935 and 1940 the yearly crop nearly tripled and from then on a steady decline took place even though prices were climbing to greater heights than ever before. (See figure 7) It is possible that this is a case of over-exploitation of the clam stocks. At the same time diggers licensed to work in contaminated areas which are relatively undisturbed find it profitable to supply seed stock for less than half the market value of clean clams.

In states south of Massachusetts little can be learned from the catch and price statistics. See figures 8 through 15. The industry is small in these states and unreported digging for local consumption is so extensive that it is impossible to determine abundance trends with any accuracy.

CHAPTER V

Attempts at Shellfish Improvement

Experimental Plantings

The first records of experimental plantings were published between 1901 and 1904 by Mead who performed a series of experiments under the auspices of the Rhode Island Fish Commission. A number of tidal flats were closed by act of legislature for the purpose of making experiments on clam culture. Because of interference by poachers only one of several experiments was carried to conclusion.

Seven bushels of seed clams less than ½ inch long obtained from locations where heavy sets had occurred, were planted by scattering on a plot about 2/5 acres in area at a rate of 17½ bushels per acre. This area was then closed for two years. At the end of this time the clams had grown to between two and three inches in length and the area was opened to the public. Careful samplings of small areas by the investigators indicated that the plot should contain about 3000 bushels per acre. However, estimates made on what was actually obtained from the plot by the public was about 1500 bushels per acre.

Town Plantings

During the depression years several towns in Massachusetts took advantage of federal funds to plant seed clams on their depleted flats. This gave employment to needy persons and rehabilitated their shellfish resources at the same time. A number of such projects which were started in 1934 were so successful that they were continued even after federal subsidizations were discontinued. See Table II.

Although records of these operations are not readily available, a great deal of valuable information has been obtained from town reports and personal interviews. The data presented may be questionable in connection with the return derived from each project since there is no way of checking the accuracy of the various estimates. The cost of plantings was often partially subsidized by federal and state grants, in amounts which seldom appear in town reports.

The general procedure is as follows. Seed stock averaging 1¼ inches is dug in contaminated areas by men licensed by the Conservation Department. Digging is often done on a morning tide and the seed is shipped by truck in $\frac{1}{2}$ bushel bags to the town the same day. Some sort of supervision is required to prevent diversion of this contaminated material into food channels. Care in handling after delivery depends on the town shellfish officer who then transports the seed bags by boat to the flats and if the tides are unfavorable, sinks the bags at high tide near the location where the planting operations are to be carried out. At low tide planting is accomplished by plowing in. As a rule one man plows a furrow with a hand plow and the seed is distributed by two others as in planting potatoes. A second furrow is then made covering the seed in the first furrow. This process is continued until the seed is all planted.

The efficiency of such operations is as follows. The quality of the seed is variable and is usually accompanied by a high percentage of shell and debris. Samples taken from deliveries at Barnstable in 1947 showed that as much as 40% by volume may be useless. Some of this is broken seed which results from crushing in bottom layers of bags which may be piled too high in the delivery trucks.

After planting, the beds are often tended by deputy shellfish officers who collect and destroy such enemies as are obvious. Boring snails and their eggs, and small crabs are usually collected in pails and deposited on town disposal grounds. Large horseshoe crabs are pierced several times with a clam hoe and the shells broken. Part of the cost of control of clam enemies is borne by the state Conservation Department which allocates special funds for this purpose.

The data given in Table II suggest that cultivation of clams can be a highly profitable venture. These operations are often successfully carried out on flats which never or very seldom become populated by natural sets. This demonstrates conclusively that barren areas may be made productive merely by utilizing seed from contaminated areas which would otherwise go to waste.

It is also apparent from the tables that operations are usually carried out on a very small scale. Towns which possess many acres of barren flats seldom cultivate more than a very small proportion of the available area, largely due to the cost. In Massachusetts town money is appropriated from town funds for expenditures on shellfish propagation. Since the income from clammers' licenses and dealers' permits does not make up a significant fraction of a year's expenditure, the expense is borne by all the taxpayers of the town. When the clams are ready for digging, the profit is made only by the licensed diggers, who have contributed at most a few dollars in permits and taxes.

It would appear logical that if the industry is to be expanded to its fullest capacity, license fees should be adjusted to cover the principle costs of the plantings.

It was noticed when this information was being collected that a number of failures which may have occurred in town plantings were not recorded since shellfish officers were reluctant to report poor results in town reports. Present knowledge is sufficient to make it possible to recognize certain flats as unsuitable. Wave swept beaches of coarse sand are too shifting and clams planted in them may be either washed out or smothered. Accumulations of very fine silt have been reported as unfavorable in some sections in Maine. Investigations now in progress by the New York State Conservation Department indicate that certain soils cause death of clams possibly because of an unknown substance.

However, it is possible to check a locality for its ability to support clam growth. A few small experimental plantings may be made at small cost and will show whether the locality will support clams and what sort of production may be expected. If done in the spring useful information will be obtained by the end of the summer.

Spat Collecting

It is a matter of general knowledge that intense sets of clams often occur in certain isolated localities leaving large tracts either entirely barren or very sparsely populated. It has also been noted that such sets do not necessarily occur in the same place in successive years. Several investigators have studied the conditions which influence setting.

One of the first studies on the conditions influencing the set was made by Kellogg in 1899. He observed a heavy set in the West Falmouth Harbor in a locality which later proved unsuitable for growth. After studying various environmental factors he concluded that the set was caused by the action of the tidal currents. Water rich in clam larvae rushed through the narrow harbor mouth then slowed down as the inlet widened. The current velocity also decreased from the center of the stream toward the shore so that larvae carried in by the rising tide were concentrated in the quieter waters where they could settle to the bottom.

Belding reported a heavy set which occurred in 1906 on Rowley Reef, Plum Island Sound where a horseshoe shaped sand bar obstructed a swift current and formed an eddy. The bottom encompassed by this eddy which was about 50,000 square feet in area contains small clams averaging nearly 2,000 per square foot in number.

In 1902, Mead observed that in the Rhode Island waters, setting was patchy although larvae seemed to be abundant in the water at all times during the spawning season. After observing under the microscope that clam larvae would stop swimming and settle whenever they struck an object, he devised a spat collector which consisted of a box partially filled with sand and covered with a coarse wire screen. He reasoned that larvae would strike the screen and fall through into the box. This device was reported as being very successful even in localities where sets did not occur around the outside of the box.

Resurfacing unproductive flats has been observed to induce setting although the mechanism is not understood. Belding reported a heavy set occurring on flats formed from the dredgings of the Annisquam River in Gloucester, Massachusetts in 1905 and a similar occurrence in Yarmouth in 1920.

The operations of Marcus Howes of Barnstable are of special interest although he published no records. Mr. Howes resurfaced a portion of a ten acre grant with thatch sods and fine sediments taken from nearby thatch islands in 1911. He claims to have obtained successive heavy sets on this treated area and that sales grossed approximately $20,000 per year. One man who dug for Mr. Howes testified that he was able to dig as much as eight barrels per day, and that the producing area was sharply deliniated by the boundaries of Mr. Howes' grant. In 1926 renewal of the grant was refused by the town officials. At the present time, opinion is divided as to whether this area was made productive by treatment or was favorably situated for natural seeding.

It may be concluded that heavy sets occur to some extent where mechanical agencies in the aquatic environment concentrate larvae and allow them to settle. Whether setting is induced on resurfaced areas by a chemical stimulus or whether the physical nature of the sediments is responsible is not known.

CHAPTER VI

Control of Clam Resources

The fundamental principle upon which the shellfish laws of most states are based is the free fishing right of the public in all marine waters below the high tide mark. As a consequence of this principle, there has been a tendency in all the New England states except Rhode Island to delegate control of intertidal shellfish resources to the various local communities. However, within the last few years when sanitation and conservation problems became more important, some state authorities have begun to assume more control.

Regulations pertaining to sanitation are fairly uniform in all the clam producing states and are based on standards laid down by the U. S. Public Health Service. These regulations define contaminated areas, minimum sanitary standards for processing plants, and transportation conditions. In each state a department or bureau competent to deal with the problems involved, is the authority. In effect such regulations remove the contaminated areas from local jurisdiction.

Conservation regulations are also commonly administrated by state authorities. A two inch minimum-length law is in effect in Maine, New Hampshire, and Massachusetts while Connecticut maintains a $1\frac{1}{2}$ inch limit.

In addition, Maine and Connecticut have incorporated many of the town laws into state departmental regulations so that state conservation officers may be empowered to assist the local authorities in law enforcement.

Maine has recently adopted legislation requiring state-issued licenses of persons engaged in all aspects of the clam industry. The income from the license fees finances clam conservation programs and the records obtained promise to provide considerably more information about the industry that has hitherto been obtained in any state. The practice of state licensing of diggers was also enacted in New Hampshire with supervision of the clam flats delegated to the conservation officer in 1941, but was repealed in 1944 because of a clause which required a residency of five years and thus deprived summer residents of the privilege.

Local regulations are generally concerned with conservation as it pertains to the local situation. Daily limits are common in all coastal communities where a scarcity exists. In Connecticut many towns have increased the minimum length to two or two and one quarter inches. Closed seasons are also common. In addition, many communities issue regulations designed to restrict the benefits derived from their shellfish resources to local interests. Some towns limit digging to their own residents. Others with a profitable resort trade restrict or prohibit exportation of shellfish in order to maintain a supply for local consumption. This is carried to extremes in the four eastern Maine counties where exportation of the clams beyond the limit of the state or into any of the western coastal counties during the summer is prohibited. Since clam canning is restricted during this period because of the post spawning drop in meat yield, this law is presumably designed to prevent depletion of the flats during the summer when the demand for fresh clams is great and thus preserve an adequate supply of clams for canning in the winter and spring when the meat yield is high.

Regulations which provide for individual initiative in clam culture are in existence in Maine, Massachusetts, New York, and New Jersey. In Main residents may acquire intertidal land for shellfish culture from either the town or state. Towns are prohibited from granting more than ¼ the area of the available flats and the state may grant ½ acre. Preference is given to the riparian owners of the adjacent properties and public hearings are required before grants are made. Opposition of the general public has prevented much development of individual shellfish culture. In Massachusetts the authority to make intertidal shellfish grants is vested in the selectmen of the coastal towns who may grant as much as five acres of barren flats to town residents for clam culture. The term "barren" is defined as flats which have not produced an appreciable shellfish crop in the two years previous to the time of granting. Public hearings are required before action is taken on applications for grants. Here also there is considerable public opposition although a recent reversal of public policy in the town of Barnstable has made it possible for 18 residents to acquire grants of 5 acres each. The Massachusetts law requires that grantholders develop their areas to contain $25 worth of clams per acre within two years. Thus riparian owners of shore front properties are prevented from acquiring clam grants merely for the purpose of preventing trespassing on their intertidal beaches.

In New York, the ownership of intertidal land varies according to the charter of the individual community. In some towns, the low tide mark is the seaward boundary of private property. In others the intertidal zone is controlled by the town. Certain of the flats of the Long Island bays come under state jurisdiction. Consequently individuals wishing to obtain clam grants must approach whatever authority maintains control. The few instances of attempts at clam culture have not met with success because of unsuitable grounds.

The reluctance of legislative bodies to deprive the public of its fishing rights by closing intertidal flats has even restricted state development bureaus and commissions from carrying out research. Special legislation was required in Rhode Island in 1901 to permit the commissioners of fisheries to occupy flats for the performance of experiments on clam culture and the area was limited to three acres. In Maine the Sea and Shore Fisheries Department is limited to two acres in any one location but larger conservation areas may be established by agreement with the towns. The Massachusetts laws permit the director of Marine Fisheries to control "not exceeding ten ponds and estuaries, creeks or other arms of the sea-----" for purposes of scientific investigation of all fish.

CHAPTER VII

Pollution Problems

The soft clam producing area of the east coast has probably been more seriously affected by domestic and industrial pollution than by any other factor. Within the past 40 years during which minimum sanitary standards have become standardized, the clam industry has been completely eliminated from some areas.

The discharge of industrial wastes into rivers, estuaries and harbors may render the waters unsuitable for the growth of marine invertebrates and thus prevent setting and growth of clams on flats which might otherwise be productive. Domestic pollution on the other hand, may actually provide better conditions for clam growth by increasing the food supply. However, the danger of epidemics of gasto-intestinal diseases such as typhoid, dysentery, and others has caused the public health services in every state to adopt the recommendations of the U. S. Public Health Service and prohibit digging in all areas where the incidence of pollution is too high.

The index of pollution generally accepted is the most probable number of human intestinal bacteria found in 100 milliliters (approximately 0.1 quarts) of clam meat. The U. S. Public Health Service recommends that shellfish whose scores exceed 2,400 intestinal bacteria be considered unfit for human consumption. It must be understood that these bacteria are not in themselves pathogenic except in rare circumstances, but their presence in large numbers indicates that clams are accumulating large quantities of human intestinal wastes in which there is danger that disease causing bacteria may be found. For this reason many coastal inhabitants have eaten clams from polluted areas for years and have suffered no ill effects when none of the contamination was discharged from the homes of carriers of typhoid or dysentery. These people are inclined to resent the closure of their digging grounds since they do not realize what the consequences would be if persons carrying intestinal disease should move into their areas.

Close approximations as to the effect of pollution on the clam industry are available only for New Hampshire and Massachusetts. The Great Bay area of New Hampshire which has become progressively more contaminated by the Piscatequa river was entirely closed to digging by 1940. A drastic drop in production in the two other clam producing areas in the state for reasons other than pollution has rendered the industry practically non-existant.

More detailed information is available for Massachusetts. Fortunately a complete survey of the clam producing areas was conducted in 1907 and grossly contaminated areas where coliform counts exceed 24,000. The method has one drawback however. Uncontaminated sea water is usually not readily available in regions where cleansing plants might best serve and shipment of contaminated clams to distant plants would add to the cost of the operation. Consequently investigations are now being carried on to test the efficiency of using water which is first sterilized with chlorine and later has the chlorine removed chemically.

CHAPTER VIII

Present Programs

Investigations

At the present time, investigations on various clam problems are being conducted in Canada, Maine, and Massachusetts.

In Canada the Atlantic Biological Station is conducting intensive studies in Passamoquoddy Bay. These include the effect of population density on growth rates, utilization of stunted stocks, and the effect of different methods of digging. The biology of certain clam enemies is also receiving attention.

Preliminary results on growth rates have shown that five years or more are required in the Passamaquoddy Bay region before clams reach commercial size and thus it is questionable that clam farming on a commercial scale would be profitable. Growth rates have also been found to show an inverse ratio with population density. Experiments on digging methods are not complete but there is some evidence that loosening of the soil with subsequent reburrowing by the clams causes measurable acceleration of growth.

Studies of two boring snails *Polynices heros* and *Polynices triseriata* have shown that the former is less numerous and probably less destructive than the latter. Predations of *Polynices triseriata* may be sufficient to destroy 90% or more of the clam spat on badly infested areas. While *Polynices heros* has a free swimming larva, *Polynices triseriata* emerges directly from the egg case without a free swimming larva, which suggests that in this species control by removing egg cases may be possible to some extent. However, trial collections of adult snails on experimental plots have shown that infestations of *Polynices* are not significantly reduced by this method of frequent collecting.

In Maine an ambitious program of investigation is being conducted by personnel of the Department of Sea and Shore Fisheries. By agreement with the town of Scarboro, seven conservation areas have been established and seeding arrangements have been made. The town has set a license fee of $25 with a remittance of $20 to each digger who brings in three barrels of seed clams for use on the conservation areas. The available seed includes newly set stocks which occur in too great concentrations for optimum growth and also stunted material which is found at levels too high above the low tide mark. A somewhat similar program is under way at Harpswell. In addition numerous similar programs are being contemplated as agreements with various towns can be reached.

Substitute for Page 22 Paragraphs 1-4

CHAPTER VIII

Present Programs

Investigations. At the present time, investigations on various clam problems are being conducted in Canada, Maine, and Massachusetts.

In Canada, the Atlantic Biological Station is conducting studies to show how the growths and survival of transplanted seed stock are affected by density of crowding and by different methods of handling and planting; how the yield, year after year, in bushels per acre of naturally populated areas is affected by various methods of harvesting; how the yield of meats in pounds per bushel is influenced by season, environmental factors and by various commercial handling methods. The usefulness of stunted stocks for seeding barren areas is being tested and the biology of certain clam enemies is also receiving attention.

Preliminary results on growth rates in this region have shown that in most of the producing areas five years or more are required before clams reach commercial size and therefore it is doubtful whether clam farming on a commercial scale would be profitable except in those inlets where the most favorable conditions obtain.

Growth rates of transferred stock have been shown to be less at high than at low levels on the beach, less for stunted than for "normal" seed clams, less in sheltered parts of inlets than where water circulation is active and, in certain soils, less when the soil is undisturbed than when it is periodically loosened by digging.

Annual natural mortalities of planted stocks which survive planting in good growing areas vary greatly, being sometimes as low as 2% in sandy soils and as high as 15% in clayey soils. Stunted stock appears to survive just as well as normal. Digging for large clams may destroy a high percentage of the small young clams that are left in the soil by burial and smothering at depths that are too great to permit them to recover their normal position near the surface. This mortality is highest in clayey soils where it may involve 60% of the one- and two-year old clams.

The yield of meats per bushel of shell stock improves when the soil in areas that have been undisturbed for long periods is loosened by digging. It increases towards the mouths of inlets, towards the lower inter-tidal levels, as the density of crowding decreases, as the size of commercial clams decreases and when the period between digging and shucking is reduced. It is highest just before spawning and lowest in the immediate post-spawning period and it changes little during the winter months.

Studies of two boring snails *Polynices heros* and *Polynices triseriata* have shown that the former is less numerous and probably less destructive than the latter. *P. heros* has been shown to have a free swimming larva while *P. triseriata* emerges directly from the egg case without a free swimming larva.

This suggests that partial control of the latter species by removing egg cases may be possible. Predations of this species may be so great as to destroy 90% or more of the clam spat on badly infested areas. Attempts to reduce the infestations of Polynices in experimental plots by collection of adult snails have shown that this is not effective as a control measure.

The study of the efficiency of various methods of harvesting natural populations and the effects these methods have on sustained yield per acre is still incomplete.

The salvaging of stunted clams which occur in large numbers is also receiving attention. Studies of shell - meat ratios are being made in cooperation with commercial canning firms. The legal aspects of taking undersized stunted stocks is under consideration.

The Department of Sea and Shore Fisheries has also made cooperative agreements with other state departments which will make personnel and equipment available for a topographic and geological survey of the intertidal lands between Bath and Friendship this coming summer. If this information shows promise in interpreting factors affecting clam growth, the survey may be expanded to include the entire coast of Maine.

Flats now closed because of pollution are examined from time to time to determine the clam population and also the likelihood of reduction of contamination. Such examinations have made possible the shifting of pollution lines and the opening of good clamming areas for winter digging.

In addition, new legislation has been instituted which provides the central authority with funds and more control. Provision is made for more accurate statistical studies by which the entire industry may be better evaluated.

In Massachusetts an intensive program of investigations is being conducted in Barnstable harbor by personnel of the Woods Hole Oceanographic Institution. Methods of planting seed are being studied, and factors which may induce setting are being investigated. Several private individuals have secured grants of five acres each and their operations are being conducted in close cooperation with the investigators. Investigations of the waters, soils, and other environmental conditions are also being conducted.

Conservation Programs

The maintainence and management of conservation areas in Scarboro, Maine are part of a conservation program as well as one of investigation. These areas will ultimately be opened for public digging and will benefit the diggers of the town.

A similar conservation program has been under way in Massachusetts for some time. The Department of Conservation is empowered to supply seed clams to such coastal towns as defray half the cost. Many towns have taken advantage of this opportunity including those mentioned in a previous section. In addition the Conservation Department has funds with which to assist coastal towns in management of the beds and elimination of clam enemies.

CHAPTER IX

Discussion

Present clam situation

Biological knowledge. The present knowledge of the biology of the clam is based almost wholly on the works of Kellogg, Mead, and Belding. These investigators have given a rather complete picture of the life history and have made several preliminary contributions to our knowledge of the ecology and physiology of the clam. However, the precise conditions which influence spawning, setting, and survival are in need of more intensive investigation. The role of soil types, enemies, and epidemic mortality on clam populations has never been clearly determined nor have methods of control been properly evaluated.

Shellfish officers and interested persons have acquired a considerable fund of practical information which pertains to various local situations. This sort of information deals with methods of transplantation, care of beds, and predator control. In general, this knowledge is not available through publications, and considerable difficulty may be experienced in obtaining the information because of the absence of exact records. Procedures used by local authorities are also the "rule of thumb" variety which have been developed by trial and error without exhaustive scientific testing.

Extent of the clam resources

There is probably less known as to the extent of the clam resources of the northeastern states than any other resource of similar value. There is no published material which contains records of the areas of the producing and potentially producing flats or even of the areas closed because of contamination. For purposes of this report the potential area of Massachusetts has been calculated from a recent sanitary survey combined with a shellfish survey which was completed in 1907. The resulting figure of 5,000 potentially productive acres is based on the assumption that no changes have occurred since 1907. A considerable body of local opinion holds that natural causes have reduced the productive area in some regions. If this is true the foregoing assumption is not valid.

Trends in clam populations are also subject to considerable controversy. Personnel involved in the industry are in nearly unanimous agreement that the clam resources have been dwindling and that depletion from overdigging and natural causes has reduced the present populations to low levels. However, production statistics do not generally demonstrate this for any state except Massachusetts. Maine's yearly production fluctuates violently from year to year but the general trend has remained relatively constant since 1889. In the Middle Atlantic and Southern New England States where the majority of the clams dug are believed to be diverted into small businesses and home consumption, neither of which contribute to commercial statistics, it is impossible to demonstrate trends in abundance.

The available evidence suggests that current digging effort stimulated by high prices is of sufficient intensity to harvest each generation of clams as soon as they grow to legal size. This can produce an apparent depletion even though the total numbers of each generation may be as great as they ever were. Unfortunately statistics from which digging effort may be calculated have never been collected.

Public opinion and the present legal situation

Current legal measures affecting clams and the clam industry are somewhat chaotic. The trend toward centralization and unification of the shellfish laws in Maine shows definite progress. Here greater jurisdiction is being assumed by the Department of Sea and Shore Fisheries which is an agency sympathetic with problems of the industry and is also one which holds the confidence of the fishermen.

In Massachusetts control of the shellfish resources is now distributed to the towns. Here the character of the coastline is so complex and the problems of the shellfish industry so diversified that unified regulations may not be advantageous to the industry.

For many years the shellfish resources have been considered as public property and a definite negative attitude toward any kind of conservative management prevailed. As shellfish products become more in demand and it is becoming apparent that the supply is not unlimited, public opinion appears to be changing gradually in favor of positive action to conserve the resource. As a result, community shellfish improvement programs have been instituted in certain Maine towns, and on Cape Cod interest in improving barren areas by public and private effort has developed. Accompanying the awakening to the need for definite programs, has come the relization that there is insufficient knowledge of the biology of the clam to provide a concrete basis for intelligent improvement programs. Consequently measures to provide for investigations have been initiated by popular demand in the legislative bodies of Maine, Massachusetts, and the Federal Government.

Present needs

It has been shown that under the free fishing system the shellfish producing areas are unable to provide enough soft shell clams to satisfy the ever growing demand. It is apparent therefore that there is a definite need to increase the productive areas. At the present time there is evidence that the following measures would each contribute to their end:

1. Planting seed clams where sets do not normally occur. On the Massachusetts coastline this would nearly triple the productive area. Presumably this ratio prevails all along the New England Coast.

2. Creating new seeding areas by treatment of the surface. Evidence is accumulating that this method is practicable in certain localities.

3. Reduction of polluted areas. Over half the clam flats of Massachusetts are closed because of pollution. In many places the value of the shellfish crop would offset materially the cost of pollution abatement.

4. Utilization of clams from polluted areas by purification and as sources of seed. This has been carried out profitably on a limited scale in Massachusetts for some time.

5. Management of present productive areas for the greatest economic benefit. It is possible that existing clam beds may be made to provide a greater sustained yield if managed properly. In some localities greater benefit may be derived by reserving beds for digging for home consumption or as an attraction for summer vacationists rather than for commercial purposes.

Bibliography

Belding, David L., 1909: A Report upon the Mollusk Fisheries of Massachusetts, Boston.

Belding, David L., 1916: Report on the clam fishery. Comm. Fish and Game, Mass., 50th Ann. Report, pp. 93-234.

Belding, David L., 1930: The Soft-shelled Clam Fishery of Massachusetts. Commonwealth of Mass., Dept. of Conservation, Div. Fish & Game, Marine Fisheries section, Marine Fisheries Series, No. 1.

Coe, Wesley R. and Turner, Harry J., Jr., 1938: Development of the gonads and gametes in the soft-shell clam (Mya arenaria). Jour. Morph., V. 62, No. 1, Jan. 1, 1938, pp. 91-111.

Coe, Wesley, R., 1947: Nutrition, growth and sexuality of the Pismo clam (Tivela stultorum). Jour. Exp. Zoöl., Vol. 194, No. 1., Feb. 1947, pp. 1-24.

Culture of Soft Clams: U. S. Dept. of Interior, Fish & Wildlife Ser., Fisheries Leaflet #73.

Dexter, R. W., 1944: Annual fluctuations of abundance of some marine mollusks, Nautilus, V. 58, pp. 18-24, 1944.

Dexter, R. W., 1945: Zonation of the Intertidal Marine Mollusks at Cape Ann, Mass. Nautilus, V. 58, (4), 135-142, 1945, 9 tables.

Dexter, R. W., 1947: The marine communities of a tidal inlet at Cape Ann, Mass. Ecological Monographs, July 1947, pp. 261-294.

Field, I. A., 1922: Biology and economic value of the sea mussel, Mytilus edulis. Bull. Bur. Fish. 38: 127-259, figs 99-230. Also Doc. No. 922.

Kellogg, J. L., 1901: The clam problem and clam culture. Bull. U. S. Fish Comm. for 1899, pp. 39-44.

Kellogg, J. L., 1901: Observations on the life history of the common clam (Mya arenaria). Bull. U. S. Fish Comm. for 1899, pp. 193-202.

Kellogg, J. L., 1903: Conditions governing the existence and growth of the soft-shelled clam, Mya arenaria. Report U. S. Comm. Fish & Fisheries for 1903, pp. 195-224.

Kellogg, J. L., 1910: Shellfish Industries. Henry Holt & Co., 1910, 361 pp.

Marston, Alice T., 1931: Preliminary experiments on the effect of temperature upon the ingestion of bacteria by the clam (mya arenaria). Commonwealth of Mass., Dept. of Conservation, Div. Fish & Game, Marine Fisheries section, Marine Fisheries Series, No. 4

Mead, A. D. and Barnes, E. W., 1900-1904: 5 papers. Observations on the soft-shell clam. Ann. Reports, Comm. Inland Fish, Rhode Island.

Needler, A. W. H. and Ingalls, R. A., 1944: Experiments in the production of soft-shelled clams (Mya). Fish Res. Bd. Canada Prgr. Repts, 35: pp. 3-8, 1944.

Nelson, T. C., 1928: Pelagic dissoconchs of the common mussel, Mytilus edulis, with observations on the behavior of the larvae of allied genera., Biol. Bull., 55: pp. 180-192.

Newcombe, C. L., 1932: An ecological study of the soft-shelled clam (Mya arenaria L.). Rept. Biol. Board Canada, 1932.

Newcombe, C. L., 1935: Growth of Mya arenaria in the Bay of Fundy region. Canadian Jour. Res. Sec. D., Zoöl. Sci. 13, (6), 97-137, 8 figs, 1935.

Newcombe, C. L., 1936: A comparative study of the abundance and the rate of growth of Mya arenaria L. in the Gulf of St. Lawrence and Bay of Fundy regions. Ecology, Vol. 17, 1936.

Newcombe, C. L. and Kessler, Herman, 1936: Variations in growth indices of Mya arenaria L. on the Atlantic coast of North America. Ecology, Vol. 17, No. 3, July 1936.

Ryder, J. A.: Byssus of the young of the common clam. American Naturalist, Jan. 1889.

Verrill, A. E. and Smith, S. I., 1873: Report on the invertebrate animals of Vineyard Sound and adjacent waters, with an account of the physical characters of that region. Ann. Rep. Comm. Fish and Fisheries for 1871-1872; 295-778. (Authors' private issue of reprints dated 1874.)

Wilson, P. T., 1926: A brief study of the succession of clams on a marine terrace. Publ. Puget Sound, Biol. Sta., Vol. 5, pp. 137-148.

Wilton, Margaret H. and Helen I., 1929: Conditions affecting the growth of the soft-shelled clam (Mya arenaria L.). Contr. Can. Biol. 4: 81-93, 1929.

Yonge, C. M., 1923: Studies on the comparative physiology of digestion. I. The mechanism of feeding, digestion and assimilation in the lamellibranch Mya. Brit. Jour. Experimental Biol. 1., 1923.

Young, R. T., 1945: Stimulation of spawning in the mussel (Mytilus califoranianus). Ecology, Vol. 26, No. 1, pp. 58-69.

Minutes of the meeting of the special committee of clam technicians held at Hotel Lafayette, Portland, Maine, September 23, 1947 (unpublished).

Report of the special commission established for the purpose of making an investigation and study relative to edible shellfish, the propagation thereof and their reclamation from contaminated areas by means of purification plants. Commonwealth of Massachusetts, 1948.

FIGURES

Figure 1. Average rates of growth of the soft-shell clam in Rhode Island, Massachusetts, and New Brunswick. These rates are based on the investigations of Mead (Rhode Island), Belding (Massachusetts), and Newcombe (New Brunswick).

Figure 2. Yearly production of soft-shell clam meats for Maine as reported by the U. S. Bureau of Fisheries and the U. S. Fish and Wildlife Service.

Figure 2A. Yearly production of clam meats for Maine as reported by the Maine Department of Sea and Shore Fisheries. Note the drastic increase in 1907. It is suggested that the reports for 1907 to 1914 refer to clams in the shell.

Figure 3. Prices paid to the diggers in Maine as reported by the U. S. Bureau of Fisheries and the U. S. Fish and Wildlife Service.

Figure 4. Yearly production of clam meats for New Hampshire as reported by the U. S. Bureau of Fisheries and the U. S. Fish and Wildlife Service. Since 1943 clam production has dropped to an insignificant figure according to Professor C. W. Jackson.

Figure 5. Prices paid to diggers in New Hampshire as reported by the U. S. Bureau of Fisheries and the U. S. Fish and Wildlife Service.

Figure 6. Yearly production of clam meats for Massachusetts as reported by the U. S. Bureau of Fisheries, the U. S. Fish and Wildlife Service, and the Massachusetts Department of Conservation.

Figure 7. Prices paid to the diggers in Massachusetts as reported by the U. S. Bureau of Fisheries, U. S. Fish and Wildlife Service, and the Massachusetts Department of Conservation.

Figure 8. Yearly production of clam meats for Rhode Island as reported by the U. S. Buearu of Fisheries and the U. S. Fish and Wildlife Service. These data represent about ten percent of the total production according to the Rhode Island Department of Agriculture and Conservation.

Figure 9. Prices paid to the diggers in Rhode Island as reported by the U. S. Bureau of Fisheries and the U. S. Fish and Wildlife Service.

Figure 10. Yearly production of clam meats for Connecticut as reported by the U. S. Bureau of Fisheries and the U. S. Fish and Wildlife Service.

Figure 11. Prices paid to the diggers in Connecticut as reported by the U. S. Bureau of Fisheries and the U. S. Fish and Wildlife Service.

Figure 12. Yearly production of clam meats for New York as reported by the U. S. Bureau of Fisheries and the U. S. Fish and Wildlife Service.

Figure 13. Prices paid to the diggers in New York as reported by the U. S. Bureau of Fisheries and the U. S. Fish and Wildlife service.

Figure 14. Yearly production of clam meats for New Jersey as reported by the U. S. Bureau of Fisheries and the U. S. Fish and Wildlife Service.

Figure 15. Prices paid to the diggers in New Jersey as reported by the U. S. Bureau of Fisheries and the U. S. Fish and Wildlife Service.

TABLES

TABLE I

BARNSTABLE SHELLFISH INCOME — 1935-1944

Year	Number of Licenses	Shellfish Income	Shellfish Income per man
1935	396	$ 37,050	$ 93.56
1936	154	62,050	402.92
1937	320	107,900	337.18
1938	337	53,650	159.19
1939	263	64,050	243.53
1940	277	54,100	195.30
1941	59	54,900	930.50
1942	108	81,000	750.00
1943	130	140,200	1078.46
1944	129	129,500	1003.85
	2,173	$ 784,400	

Average per man in 10 yrs. $ 360.97 per year

CHATHAM SHELLFISH INCOME 1942, 1944, 1945, 1946, 1947

Year	Number of Licenses	Shellfish Income	Shellfish Income per man
1942	318	$ 38,235	$ 120.23
1944	134	30,557	228.03
1945	114	22,134	194.15
1946	105	22,146	210.91
1947	146	17,008	116.49
	817	$130,080	

Average per man in 10 yrs. $ 159.21 per year

TABLE II

BARNSTABLE CLAM PLANTING STATISTICS

Date	Cost of Planting	Amount Planted	Date dug	Amount dug	Return
1934	$1500.00	500 barrels	1935-36	1665 barrels	$6825.00
June 1935		36 "	" "	85 "	425.00
June-July 1935		57 "	1936	75 "	379.00
July-Aug. 1935	$ 20.00 ERA	43 "	1938		1000.00
		242 "	1936 up to Apr. 1	522 "	2050.00
June-July 1936	$ 656.00	394.5 "	1938		2724.00
May-June 1938	$ 300.00 ERA	104 "	1939		489.00
			March 1942		2119.71

ORLEANS CLAM PLANTING STATISTICS

1940	$ 46.69		Aug. 1941		450.00
summer 1941	185.00		Nov. 1943		715.00
1942-1943	474.89	260 bushels	Area opened Nov. 1945	1934 bushels	3363.61*

*Quahaug planting

EASTHAM CLAM PLANTING STATISTICS

	$ 400.00		1937		1880.00

TABLE III

TOWN	1907 Production	1907 Productive Area	1907 Possibly Productive Area	% of 1907 Productive Area Closed by Pollution	1947 Productive Area	1947 Possibly Productive Area
Salisbury	15,000 bu	250 acres	—	100	—	—
Newburyport	55,500 "	1,080 "	—	100	—	—
Newbury	300 "	100 "	260 acres	50	50 acres	130 acres
Rowley	2,000 "	100 "	300 "	—	100 "	300 "
Ipswich	25,000 "	820 "	125 "	25	615 "	100 "
Essex	15,000 "	300 "	325 "	—	300 "	325 "
Gloucester	6,000 "	175 "	275 "	25	130 "	50 "
Manchester	100 "	5 "	10 "	100	—	—
Beverly	100 "	10 "	30 "	—	10 "	30 "
Salem	200 "	15 "	70 "	100	—	—
Lynn	1,000 "	40 "	160 "	100	—	—
Saugus	1,000 "	50 "	100 "	100	—	—
Nahant	300 "	50 "	150 "	100	—	—
Boston	7,500 "	1,280 "	1,000 "	100	—	—
Cohasset	200 "	10 "	40 "	25	7 "	10 "
Scituate	200 "	20 "	40 "	—	20 "	40 "
Marshfield	200 "	30 "	30 "	—	30 "	30 "
Duxbury	700 "	15 "	800 "	—	15 "	800 "
Kingston	500 "	10 "	150 "	50	5 "	50 "
Plymouth	3,000 "	60 "	440 "	50	30 "	100 "
Barnstable	700 "	20 "	330 "	—	20 "	330 "
Yarmouth	600 "	15 "	25 "	—	15 "	25 "
Orleans	3,000 "	75 "	75 "	—	75 "	75 "
Eastham	4,000 "	75 "	100 "	—	75 "	100 "
Wellfleet	800 "	15 "	250 "	—	15 "	250 "
Truro	50 "	3 "	47 "	—	3 "	47 "
Provincetown	400 "	6 "	200 "	50	3 "	100 "
Chatham	1,500 "	60 "	300 "	50	30 "	200 "

Continued

TOWN	1907 Production	1907 Productive Area	1907 Possibly Productive Area	% of 1907 Productive Area Closed by Pollution	1947 Productive Area	1947 Possibly Productive Area
Harwich	100 bu	6 acres	10 acres	—	6 acres	10 acres
Dennis	50 "	5 "	30 "	—	5 "	30 "
Mashpee	50 "	10 "	30 "	—	10 "	30 "
Falmouth	200 "	10 "	40 "	50	5 "	10 "
Bourne	100 "	30 "	—	—	30 "	—
Wareham	800 "	50 "	—	10	40 "	—
Marion	100 "	10 "	—	—	10 "	—
Mattapoisett	100 "	10 "	—	20	8 "	—
Fairhaven	100 "	25 "	25 "	25	19 "	20 "
New Bedford	300 "	15 "	—	100	—	—
Dartmouth	200 "	15 "	—	10	14 "	—
Swansea	5,000 "	50 "	100 "	100	—	—
Somerset	50 "	10 "	20 "	100	—	—
Dighton	40 "	2 "	8 "	100	—	—
Berkley	25 "	4 "	6 "	100	—	—
Freetown	100 "	15 "	—	100	—	—
Fall River	100 "	10 "	15 "	100	—	—
Nantucket	400 "	20 "	130 "	—	20 "	100 "
Edgartown	1,200 "	120 "	50 "	—	120 "	50 "
Totals	153,865 bu	5,111 acres	6,096 acres		1,835 acres	3,342 acres

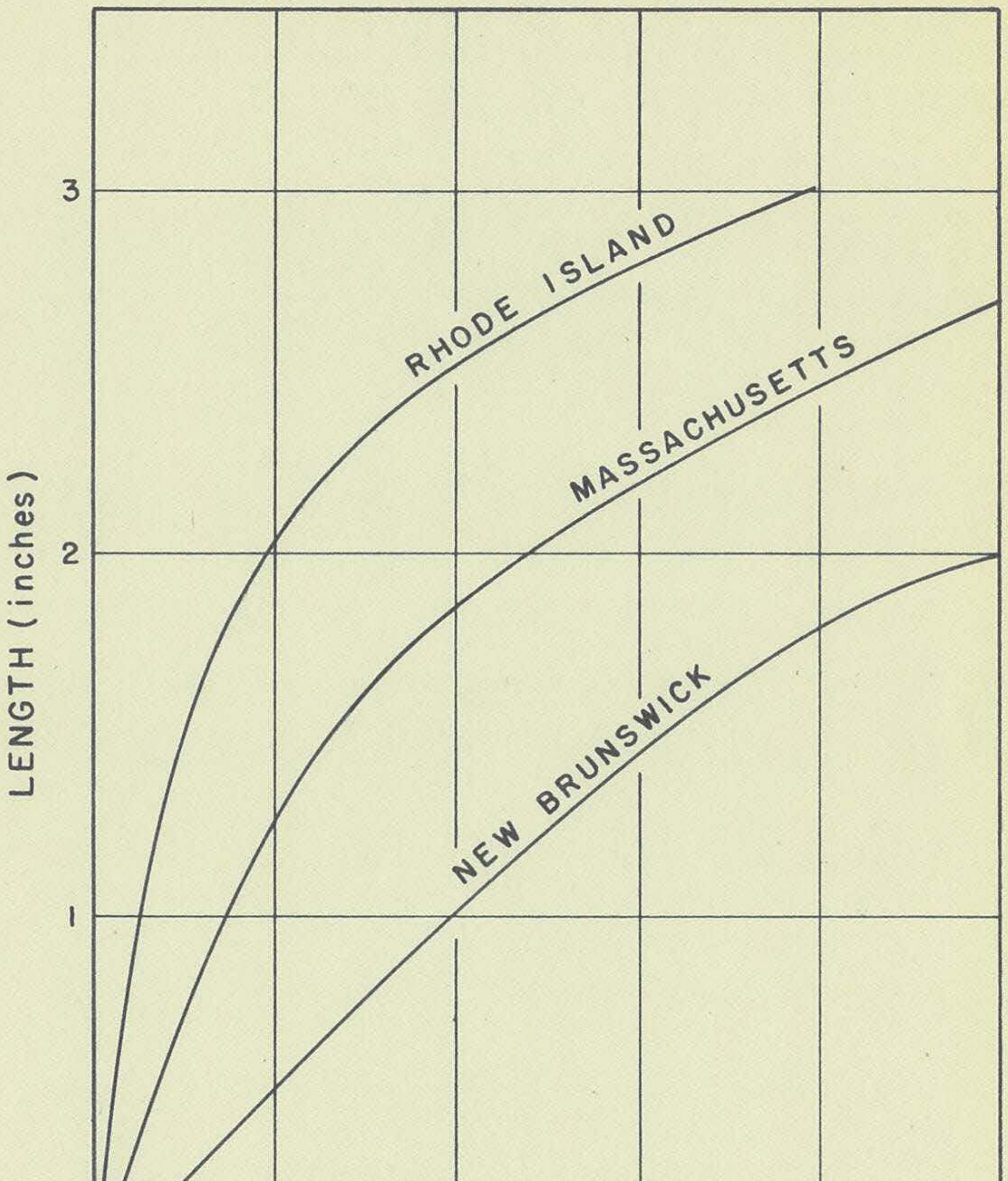

LENGTH (inches)
3
2
1
RHODE ISLAND
MASSACHUSETTS
NEW BRUNSWICK
0
1
2
3
4
5
YEARS

FIGURE 1

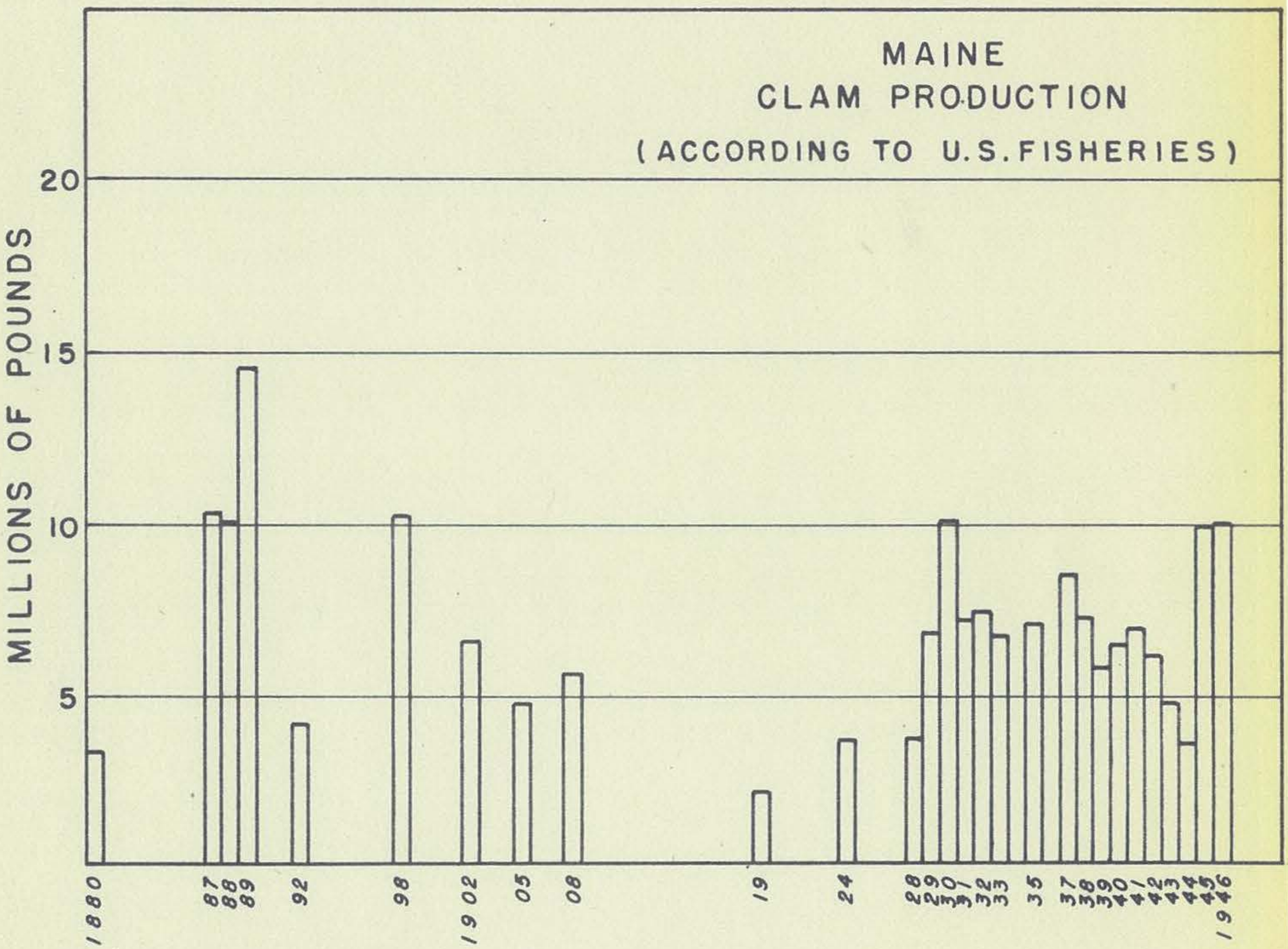
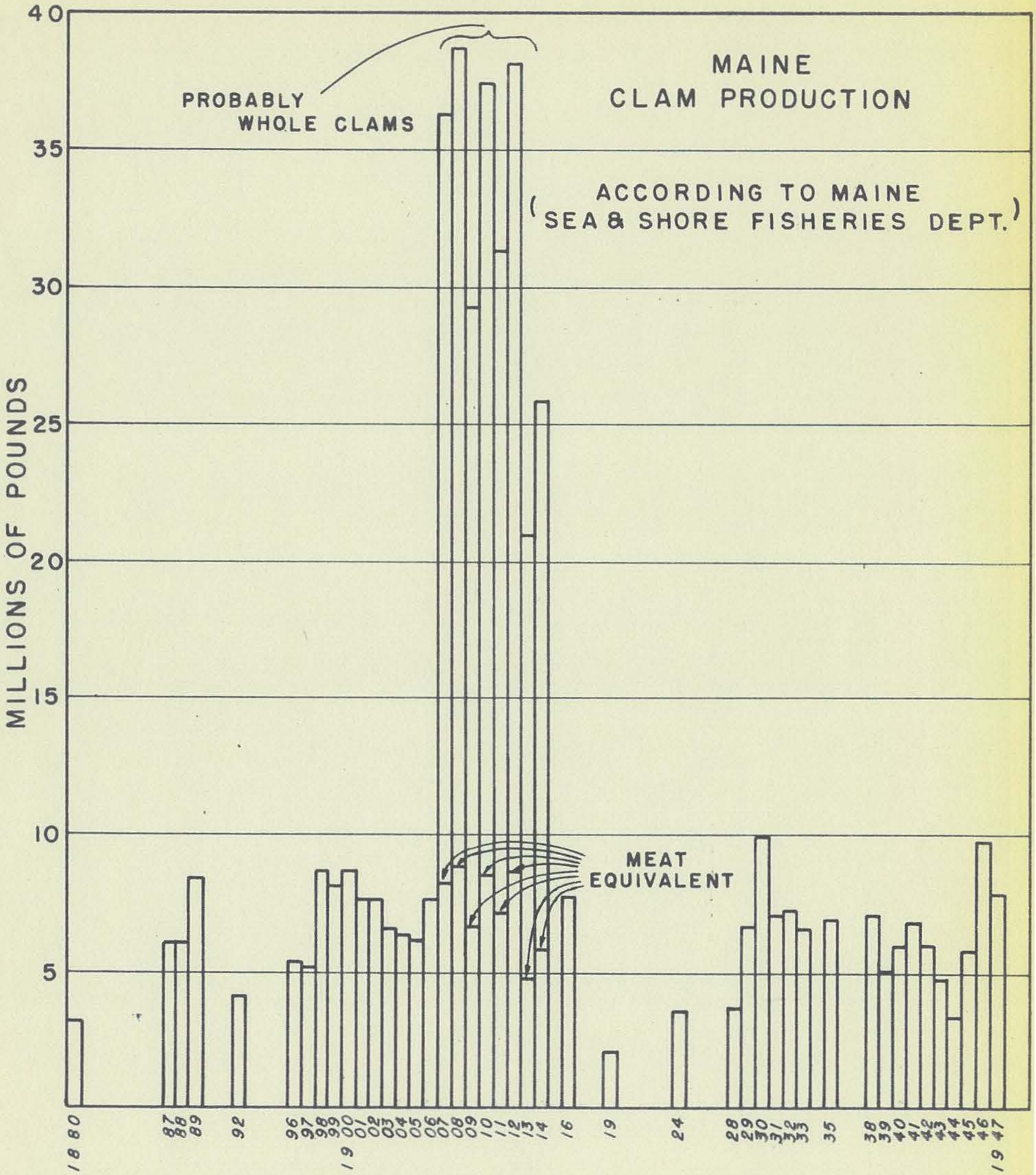

MAINE
CLAM PRODUCTION
(ACCORDING TO U.S. FISHERIES)
MILLIONS OF POUNDS
20
15
10
5
1880
87
88
89
92
98
1902
05
08
19
24
28
29
30
31
32
33
35
37
38
39
40
41
42
43
44
45
1946

FIGURE 2



MAINE
CLAM PRODUCTION
(ACCORDING TO MAINE SEA & SHORE FISHERIES DEPT.)
PROBABLY WHOLE CLAMS
MEAT EQUIVALENT
MILLIONS OF POUNDS
40
35
30
25
20
15
10
5
1880
87
88
89
92
96
97
98
99
1900
01
02
03
04
05
06
07
08
09
10
11
12
13
14
16
19
24
28
29
30
31
32
33
35
38
39
40
41
42
43
44
45
46
1947

FIGURE 2A

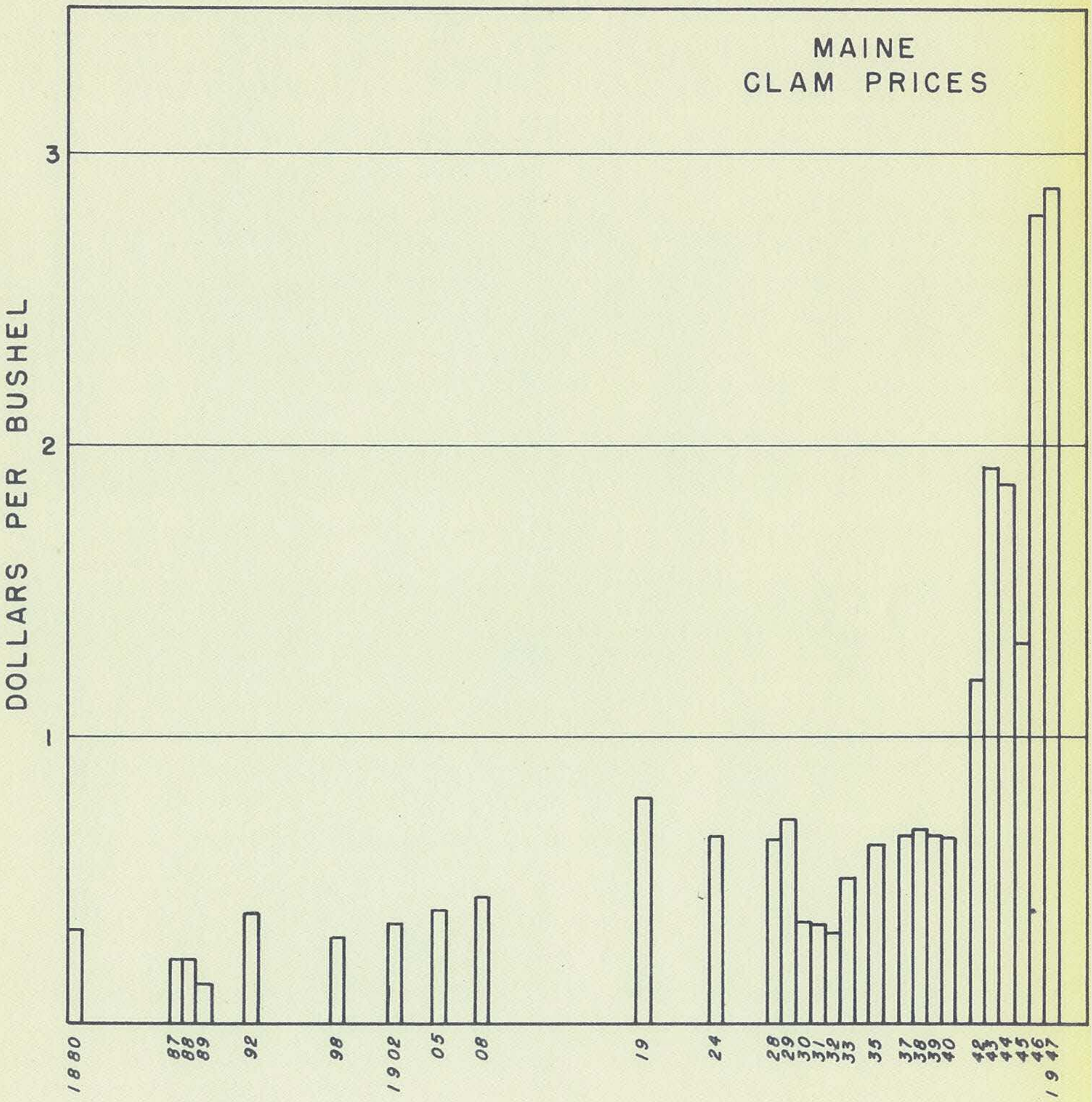

MAINE
CLAM PRICES
DOLLARS PER BUSHEL
3
2
1
1880
87
88
89
92
98
1902
05
08
19
24
28
29
30
31
32
33
35
37
38
39
40
42
43
44
45
46
1947

FIGURE 3

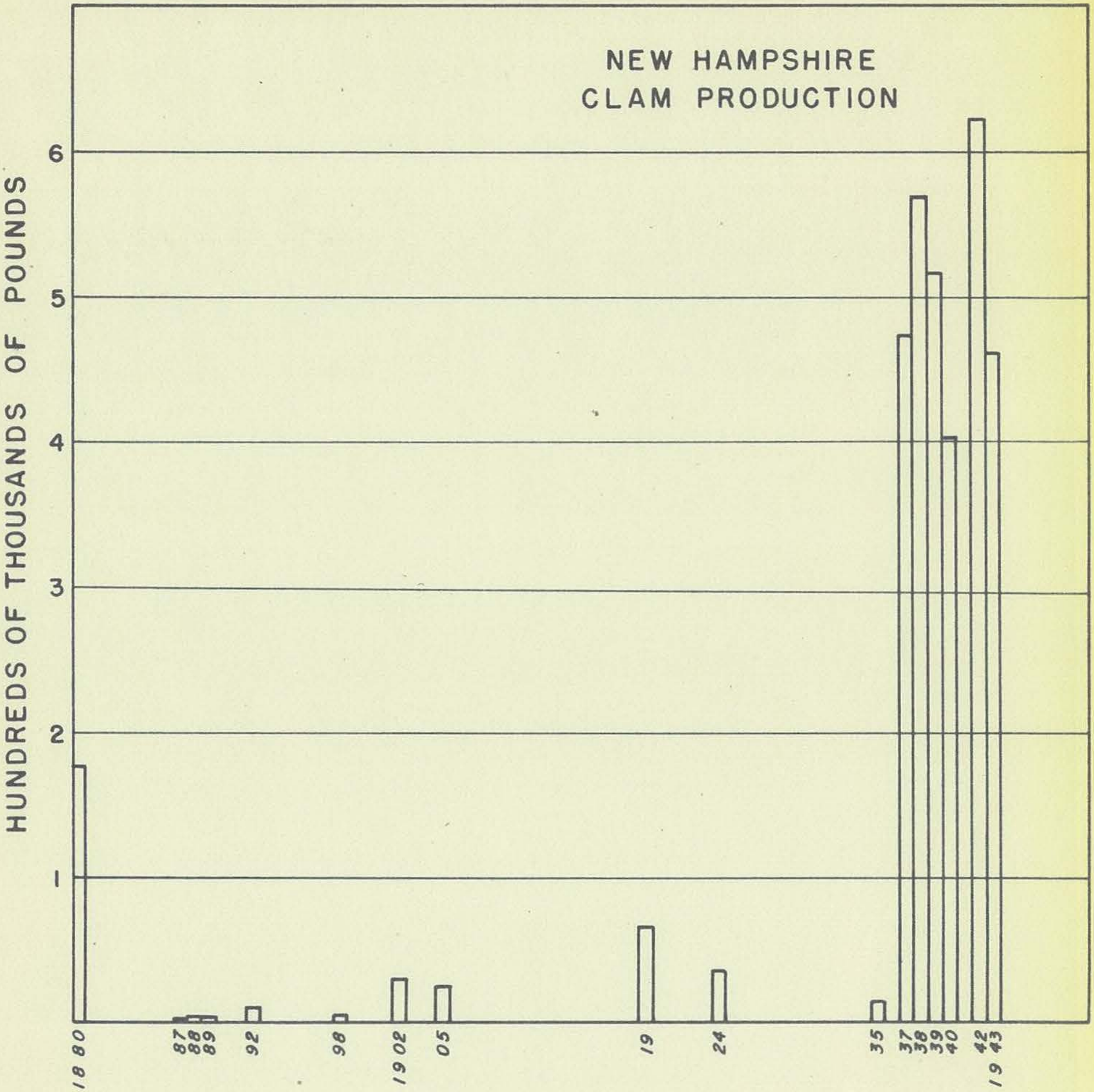

NEW HAMPSHIRE
CLAM PRODUCTION
HUNDREDS OF THOUSANDS OF POUNDS
6
5
4
3
2
1
1880
87
88
89
92
98
1902
05
19
24
35
37
38
39
40
42
1943

FIGURE 4

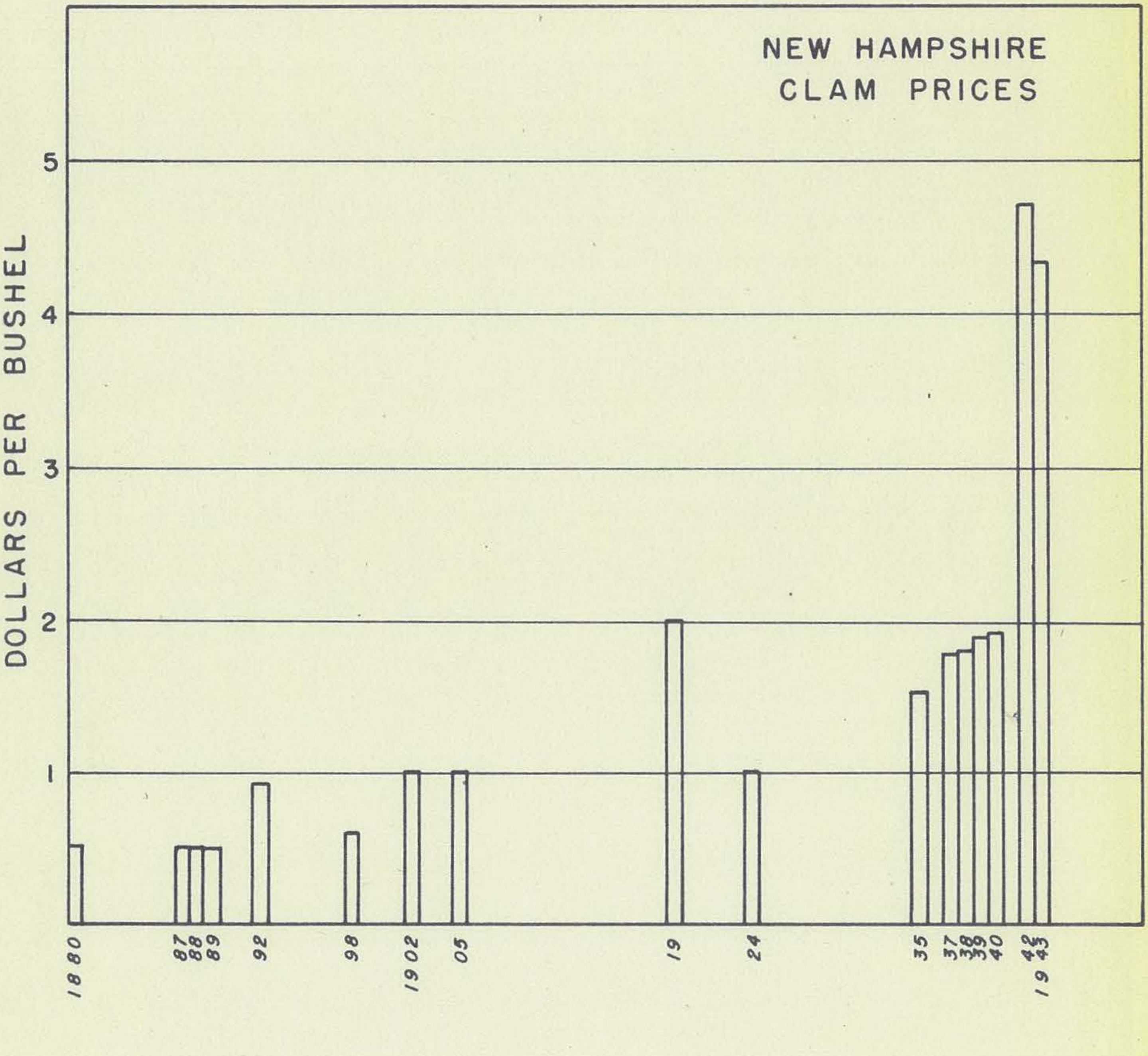

NEW HAMPSHIRE
CLAM PRICES
DOLLARS PER BUSHEL
5
4
3
2
1
1880
87
88
89
92
98
1902
05
19
24
35
37
38
39
40
42
1943

FIGURE 5

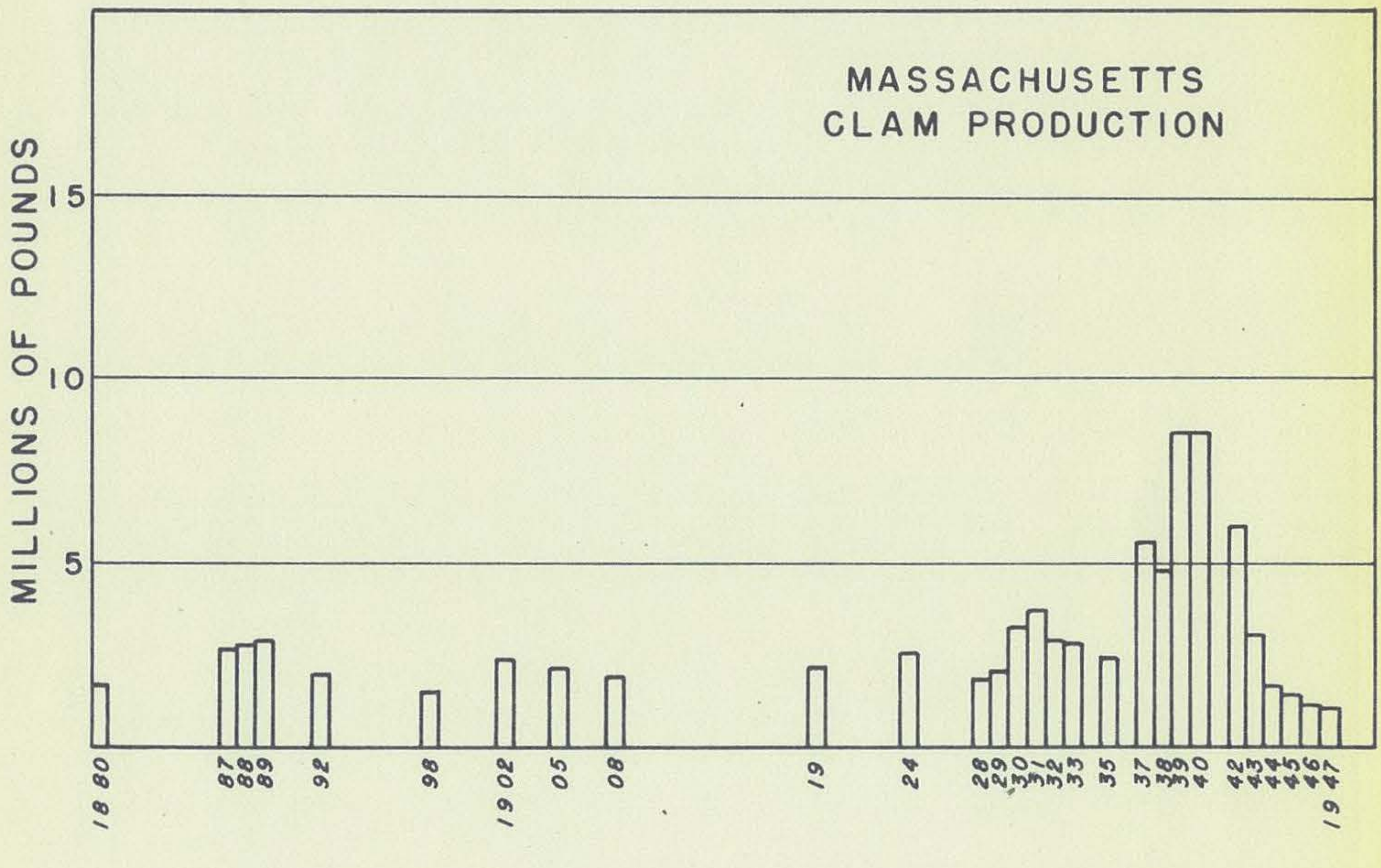
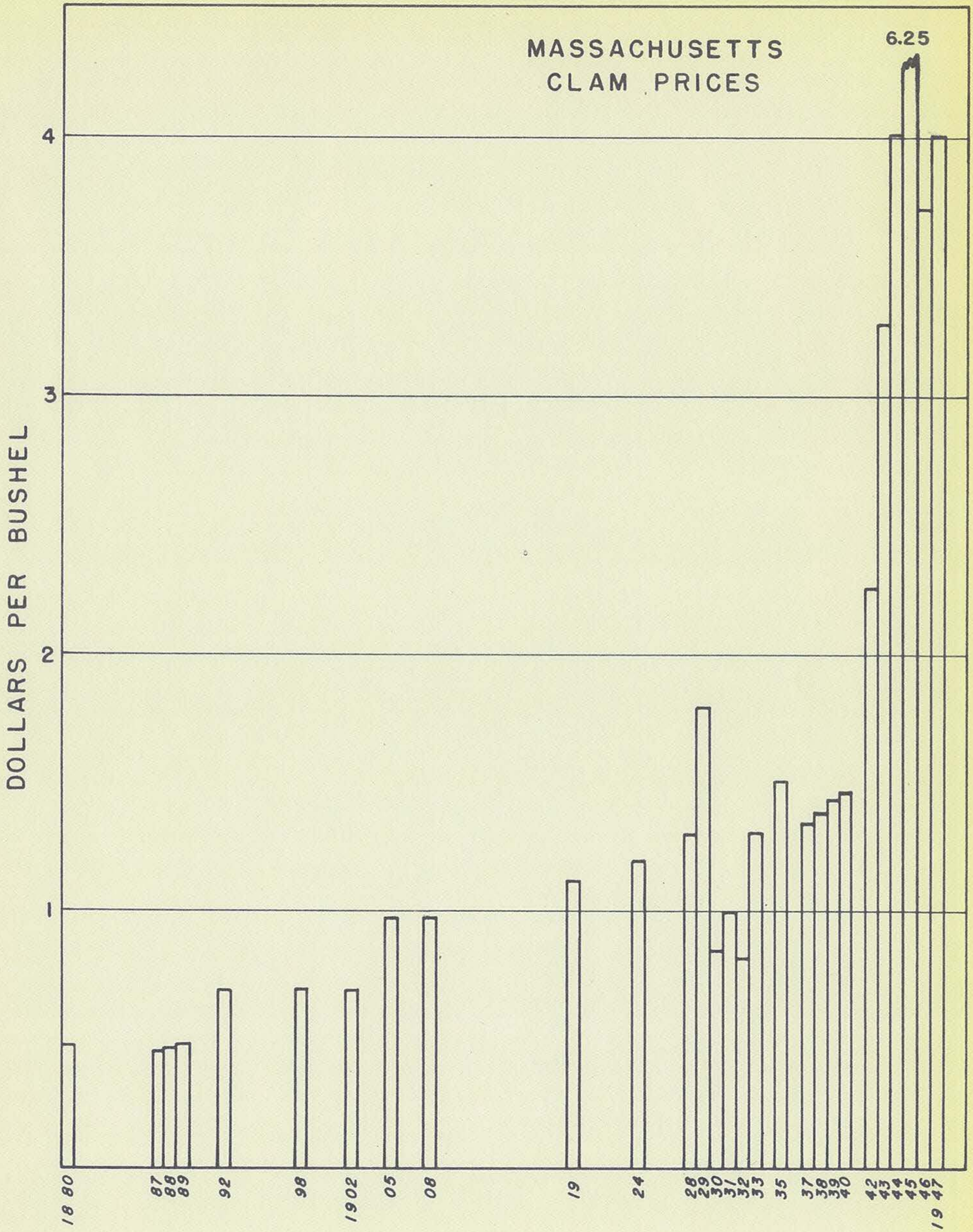

MASSACHUSETTS
CLAM PRODUCTION
MILLIONS OF POUNDS
15
10
5
1880
87
88
89
92
98
1902
05
08
19
24
28
29
30
31
32
33
35
37
38
39
40
42
43
44
45
46
1947

FIGURE 6



MASSACHUSETTS
CLAM PRICES
6.25
DOLLARS PER BUSHEL
4
3
2
1
18 80
87
88
89
92
98
1902
05
08
19
24
28
29
30
31
32
33
35
37
38
39
40
42
43
44
45
46
19 47

FIGURE 7

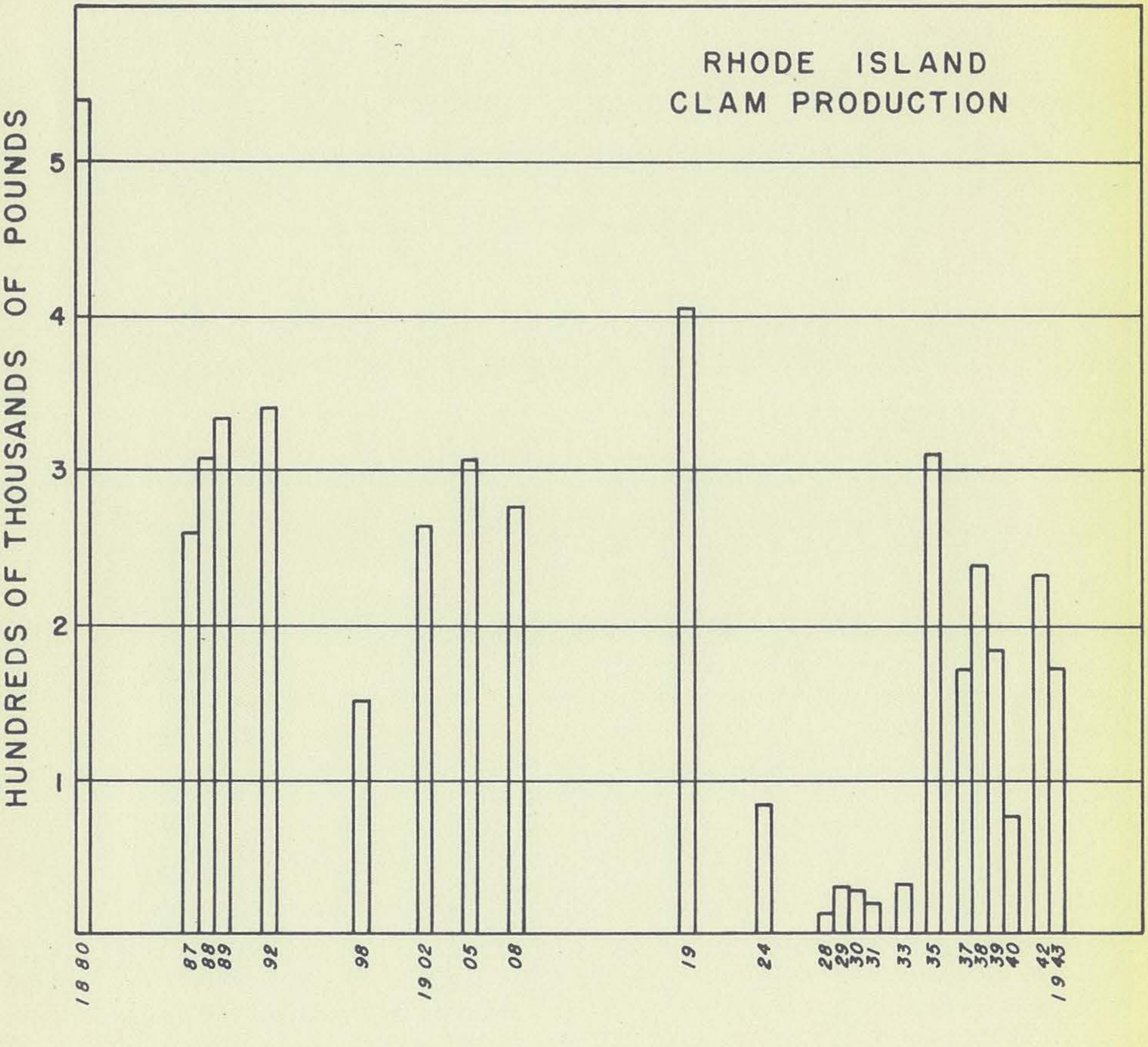

RHODE ISLAND
CLAM PRODUCTION
HUNDREDS OF THOUSANDS OF POUNDS
1
2
3
4
5
1880
87
88
89
92
98
1902
05
08
19
24
28
29
30
31
33
35
37
38
39
40
42
1943

FIGURE 8

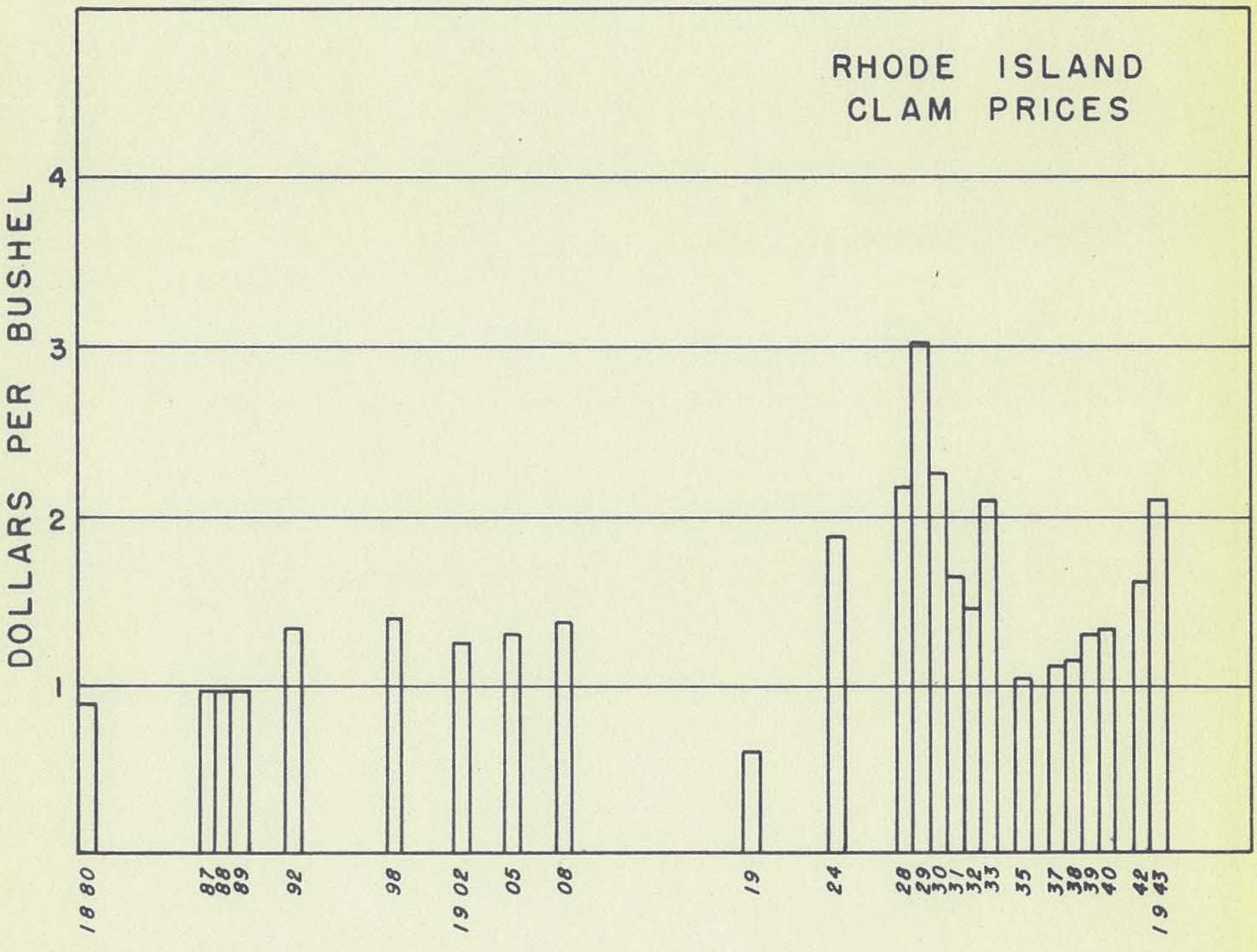
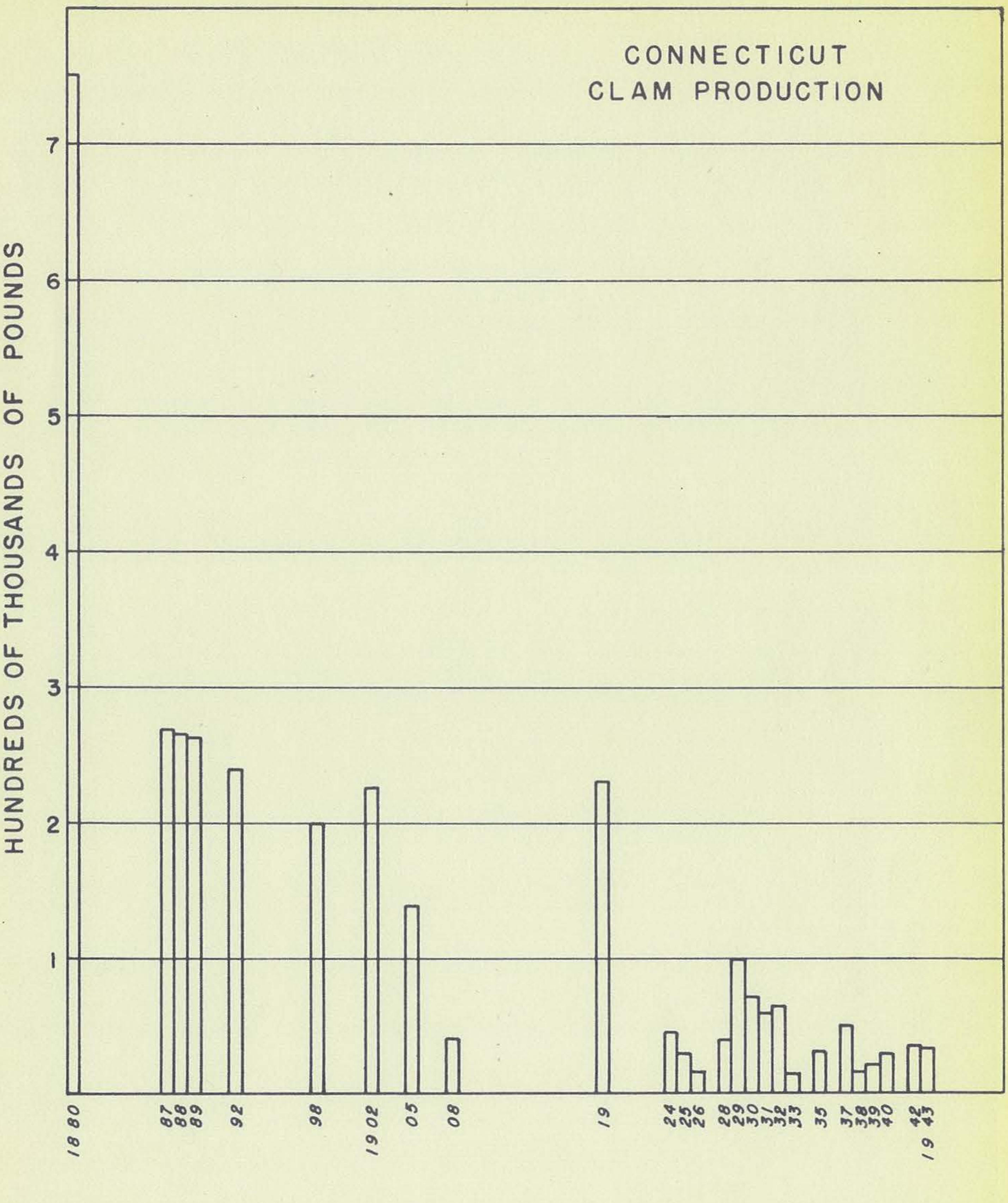

RHODE ISLAND
CLAM PRICES
DOLLARS PER BUSHEL
4
3
2
1
1880
87
88
89
92
98
1902
05
08
19
24
28
29
30
31
32
33
35
37
38
39
40
42
1943

FIGURE 9



CONNECTICUT
CLAM PRODUCTION
HUNDREDS OF THOUSANDS OF POUNDS
1
2
3
4
5
6
7
1880
87
88
89
92
98
1902
05
08
19
24
25
26
28
29
30
31
32
33
35
37
38
39
40
42
1943

FIGURE 10

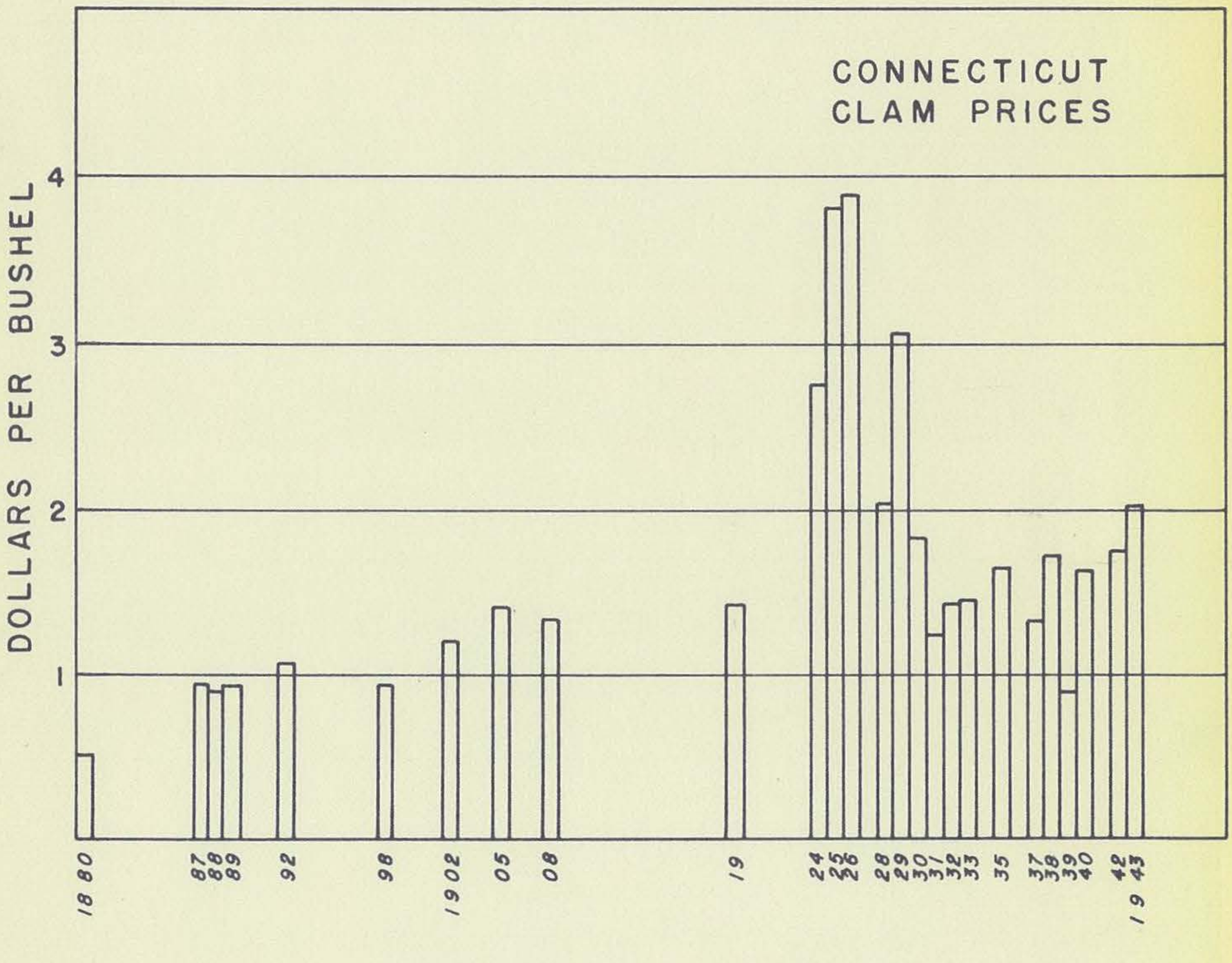

CONNECTICUT
CLAM PRICES
DOLLARS PER BUSHEL
1
2
3
4
1880
87
88
89
92
98
1902
05
08
19
24
25
26
28
29
30
31
32
33
35
37
38
39
40
42
1943

FIGURE 11

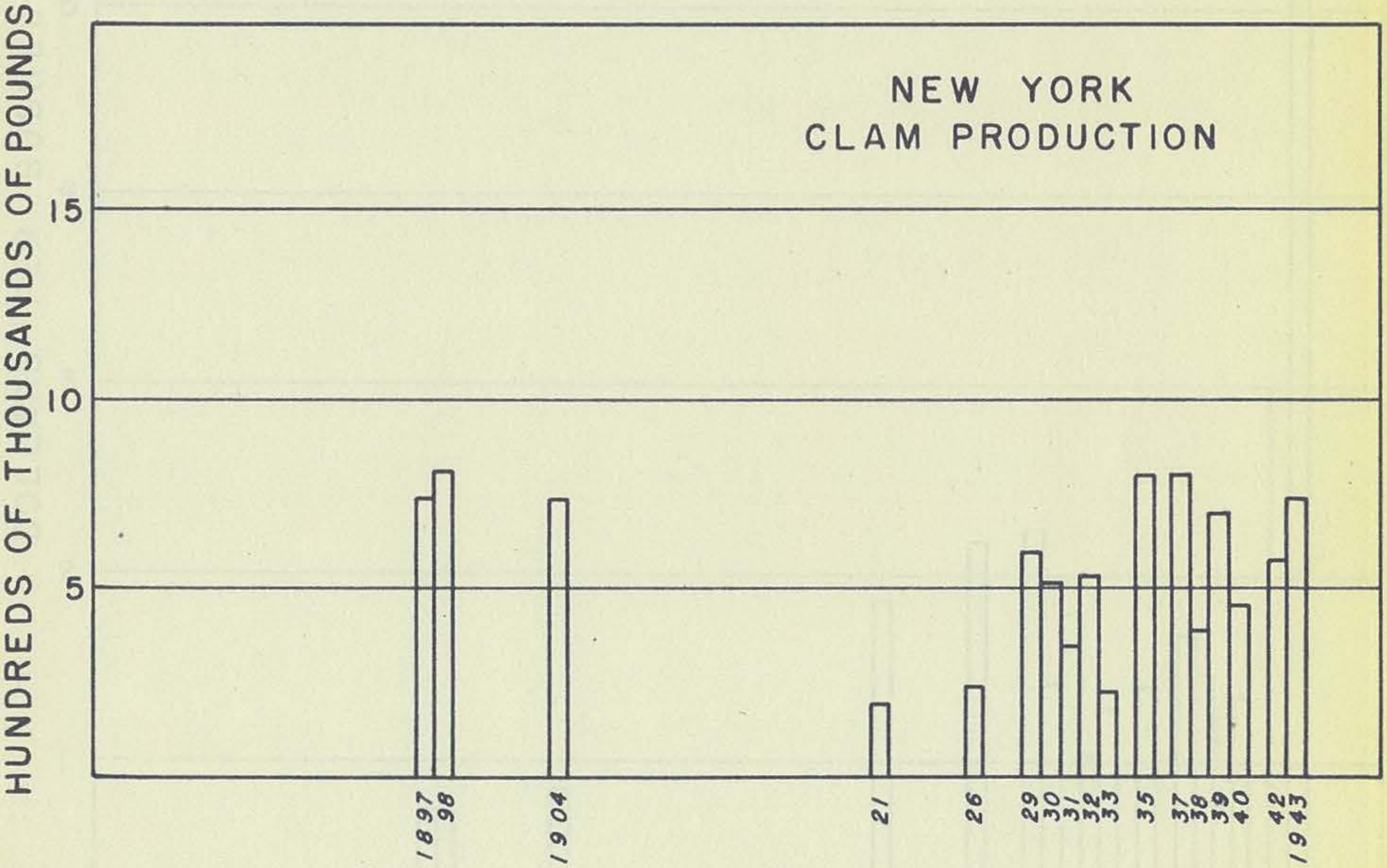
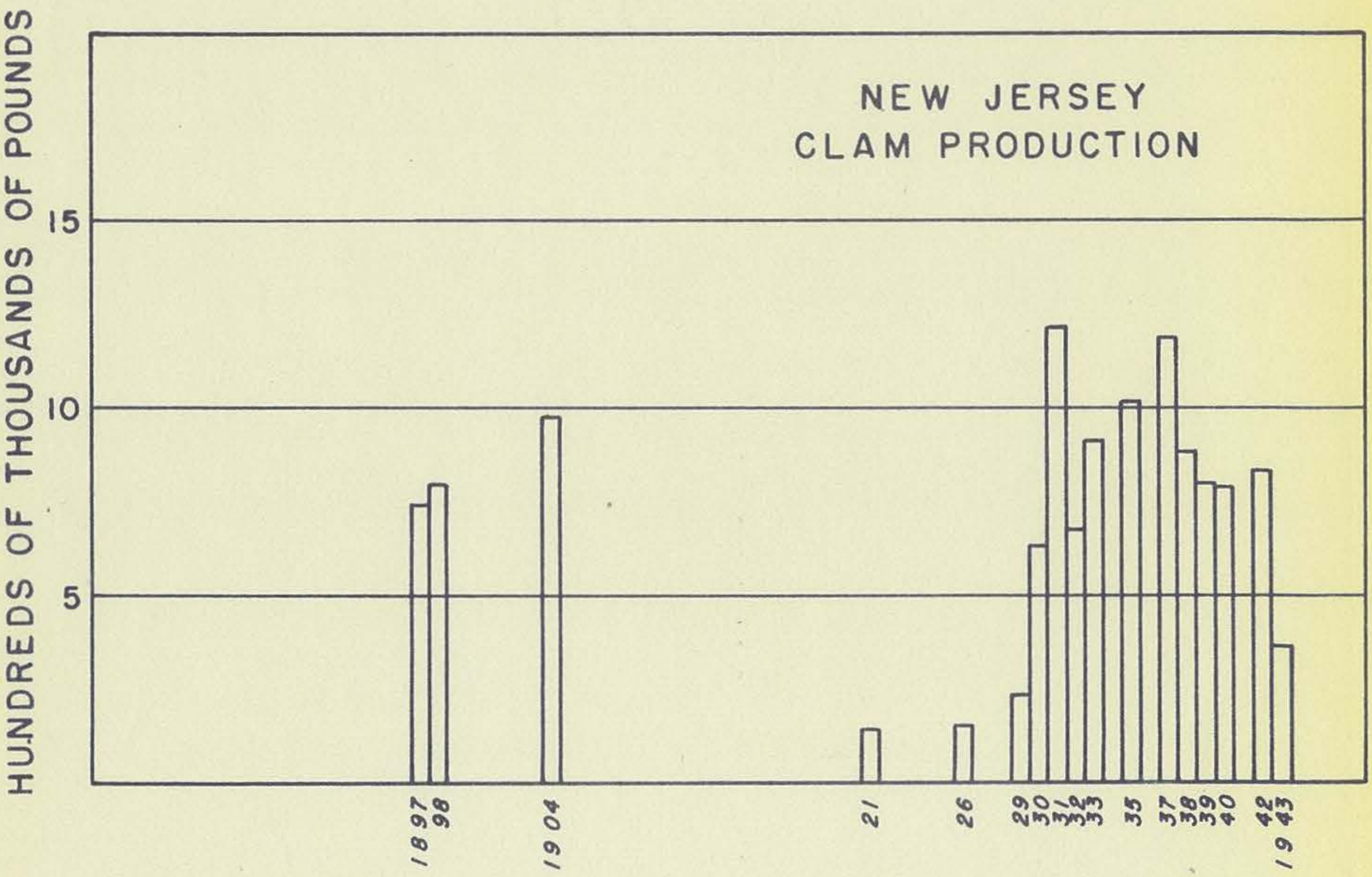

NEW YORK
CLAM PRODUCTION
HUNDREDS OF THOUSANDS OF POUNDS
15
10
5
1897
98
1904
21
26
29
30
31
32
33
35
37
38
39
40
42
1943

FIGURE 12



NEW JERSEY
CLAM PRODUCTION
HUNDREDS OF THOUSANDS OF POUNDS
15
10
5
1897
98
1904
21
26
29
30
31
32
33
35
37
38
39
40
42
1943

FIGURE 14

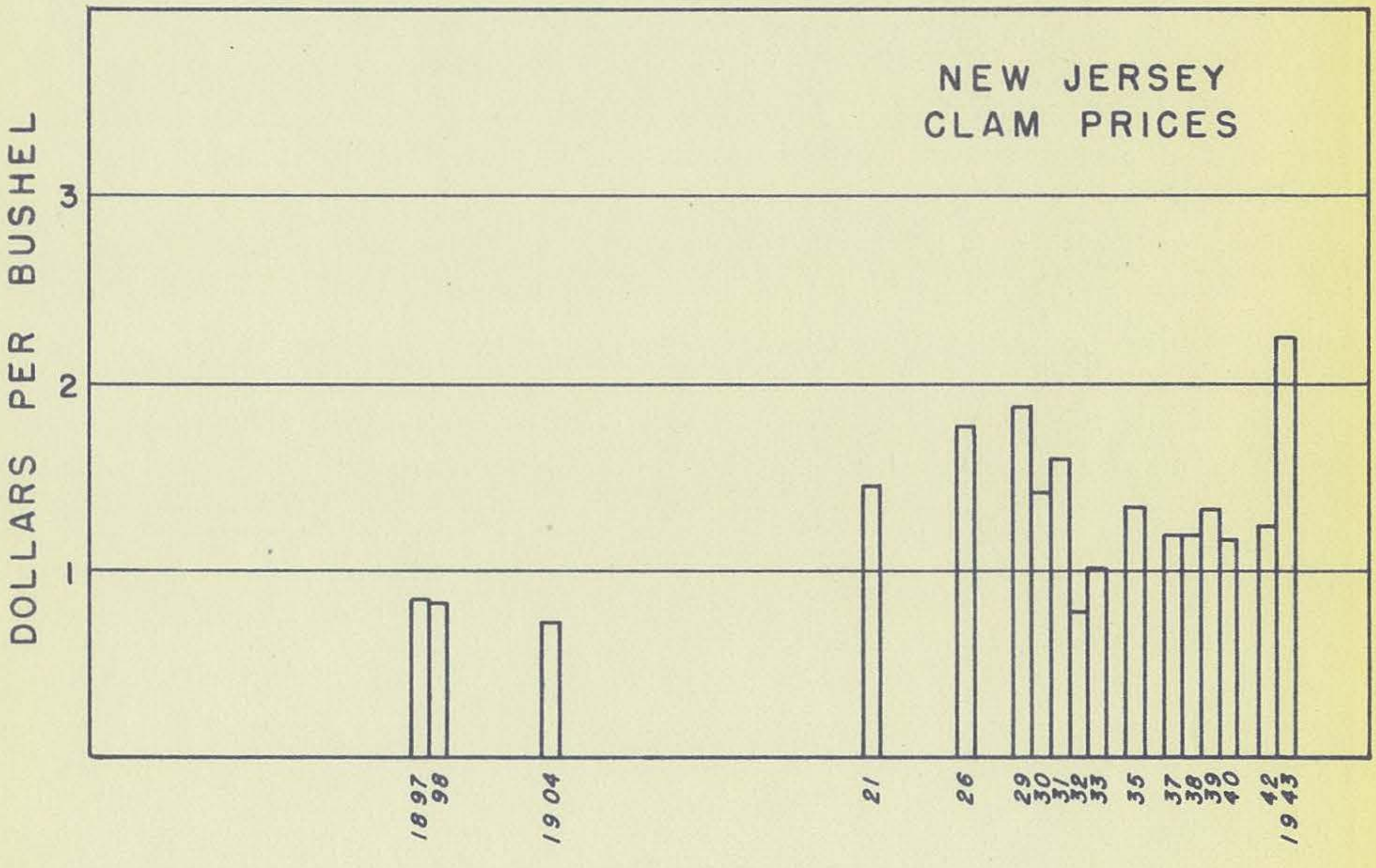

NEW JERSEY
CLAM PRICES
DOLLARS PER BUSHEL
3
2
1
1897
98
1904
21
26
29
30
31
32
33
35
37
38
39
40
42
1943

FIGURE 15