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DANIEL C. ROPER, Secretary
BUREAU OF FISHERIES
HENRY O'MALLEY, Commissioner

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AQUATIC SHELL INDUSTRIES[1]

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INTRODUCTION

Our domestic marine shells of commercial importance are usually accumulated as by-products of food industries and from deposits of dead shells, while fresh-water mussel shells and imported marine shells are obtained principally for their manufacture into pearl buttons. This paper concerns itself with the sources of raw materials, the making available of such raw material, its manufacture into useful commodities, and something of the marketing practices of the shell utilization industries which in 1932 yielded products in this country valued at nearly $8,000,000. The fresh-water mussel fishery and the pearl-button industry are discussed rather cursorily in this report since it has been well described in previous literature of this Bureau.[2]

HISTORY

The early Indians of North America made beads from the shells of clams, fresh-water mussels, and abalone, and used the same beads or "wampum" as a medium of exchange. Aquatic shells were recognized as a raw material of commerce by the colonists, who depended entirely upon oyster shells for their supply of lime. The supply of shells in these early years came not only from shells resulting from the accumulation of current shucking, but also from old heaps of shells deposited through hundreds of years by the Indians. By 1880, we find that the principal use of shells was for building up boglands for wharves, railway beds, etc., and that next to this use the larger part of the supply was converted into lime. At that time it was said that quantities were [illegible] the water at ebb tide for collection of

spat in the development and renewal of oyster beds; quantities were used as ballast for vessels; as a component of mixed fertilizers; as a base for hydraulic cement; for building of roads; and one of the minor uses was as a food for poultry. It is interesting to note the development of this latter use from one of casual comment 50 years ago to one of major importance at the present time.

The more recent growth of the oyster-shell industry has been largely caused by the extensive utilization of the supply of reef shell in southern coastal waters.

Buttons have been made in this country from marine shells since 1855 and from fresh-water mussel shells since 1891. There are reports of such novelty jewelry as cuff links being carved from the latter shells more than 100 years ago in the mussel-bearing regions of the Ohio River.

SOURCES OF RAW MATERIAL

Oyster shells.—The greater number of the plants uses as a raw material the shells accumulating currently at oyster shucking houses. The supply of shells from this source is usually limited, and frequently operation might be extended if greater supplies of raw material were available. Plants using such oyster shells are located along the Atlantic coast from Rhode Island to Florida and westward to Texas and on the Pacific coast. Only recently there has been increased interest and actual installation of equipment for manufacture in the utilization of the Japanese oyster shell for poultry feed in the State of Washington. Since these oysters can be grown only from imported seed, the shells have no utility to growers of Japanese oysters for cultch as in the case with growers of native oysters.

During the year 1931, the production of market oysters in the United States was about 12,000,000 bushels. This represents a similar quantity of shell which either was returned to the water as cultch, or was available for manufacture.

Reef shells, which are deposits of shells resulting probably from centuries of accumulation, furnish the raw material for but little less of the annual production of crushed oyster-shell products than those shells of all other sources combined. The presence of these deposits or reefs on our Gulf coast has been explained as the result of years of growth when the water was clean and salty; then death as freshets from inland streams have changed the water from salt to fresh and may have piled layers of mud on them. Reef deposits are present along the east coast of Florida, on the Gulf, and on the Pacific coast. Many of these deposits are now under long-term lease to the several operating companies by the various States. The comparatively slight inroads made into the known deposits by activities to date indicate that the supply yet available is sufficient for exploitation for many years.

Fossil deposits of sea life of another era are frequently exposed from the sides of mountains and hills of California. At points where oyster shells predominate, these deposits are exploited as a source of poultry feed.

Marine-clam shells.—Marine-clam shells used in poultry-feed manufacture are obtained from reef deposits in California and British Columbia, and to a lesser extent from shells accumulated at canneries in the Puget Sound area which use hard clams. The utilized deposits

in California, although consisting principally of clam shells, also include shells of scallops and oysters while those in British Columbia are said to be composed mainly of the shells of butter clams and little-neck clams.

Fresh-water mussel shells.—Fresh-water mussels are taken commercially in the Mississippi River and its tributaries. In 1931, the catch of these mollusks amounted to 37,254,697 pounds in terms of the weight of the shell, of which it is estimated that in excess of 90 percent is a waste product of button manufacture and is available for by-products. In 1931, the fresh-water mussel producing States, in order of their importance with respect to the volume of their production, were: Arkansas, Illinois, Indiana, Iowa, Tennessee, Alabama, Kentucky, Wisconsin, Minnesota, Kansas, Ohio, Missouri, and Louisiana.

Marine-pearl shells.—The only domestic marine shells, other than those of the oyster and clam, known to be used in domestic manufacture are the abalone of California which is used for manufacture into novelties; the clam shell used in the north Pacific for poultry feed and lime; and the conch and several small sea shells used in novelty manufacture.

Several marine shells of foreign source are imported into this country largely from Australia for manufacture into pearl buttons and novelties. Imports of shells and buttons of pearl or shell as reported by the Bureau of Foreign and Domestic Commerce for the years 1929 to 1932 appear in table 1.

TABLE 1.—*Imports for consumption of shells and buttons of pearl or shell, 1929–32*

Item	1929		1930		1931		1932	
	Quantity	*Value*	*Quantity*	*Value*	*Quantity*	*Value*	*Quantity*	*Value*
Shells not manufactured:								
Green snail shell ... pounds	189,665	$56,263	313,896	$47,239	111,521	[illegible]	109,456	$8,115
Mother-of-pearl ... do	8,924,262	2,574,526	[illegible]	[illegible]	[illegible]	[illegible]	3,974,903	909,167
Shells, not specially provided for[1] ... pounds	8,579,352	306,490	3,061,098	73,016	2,719,310	71,234	4,794,724	22,568
Shells and mother-of-pearl, engraved, cut, ornamented, or manufactured		60,433		42,713		27,206		26,363
Shell pearl buttons:								
Fresh-water ... gross	1,765	1,057	3,264	1,463				
Ocean ... do	804,677	418,582	947,373	435,414	980,552	440,548	930,034	325,486
Total		3,397,328		2,703,462		1,846,522		1,291,609

[1] These are believed to consist principally of clam shells imported from British Columbia for manufacture into poultry feed.

PRODUCTION OF RAW MATERIAL

Oyster and marine-clam shells.—Dredges and tongs are used in the taking of 95 percent of the domestic catch of oysters, with such other devices as grabs, rakes, and forks used to a more limited extent.

The dredge consists essentially of two triangular iron frames which are joined at the apexes. To the base of the lower frame are welded iron teeth which have the function of tearing the oysters loose from the bottom. Between the two triangles a bag is attached to collect the oysters. The dredges, usually two in number, are dragged behind the boat and raised at intervals by hand or power to [illegible] catch. These dredges vary in size [illegible] from 2 or 3 bushels to as many [illegible]

The common oyster tong consists of two long handles which are bolted together some 4½ feet from the shorter end, scissors fashion, the longer ends forming the handles. To the short ends are attached at right angles light iron bars about 3½ feet long which are equipped with teeth pointed inward, and parallel to this bar and above are other lighter iron bars attached to the first with wires. When closed, these form a basket-like device. The handles vary in length according to the general depth of the water in which fished. The gathering of the oysters is accomplished by dropping the toothed portion of the tongs to the bottom and operating the handles back and forth until the oysters are broken loose and collected in the basket; then they are hauled on board the boat. The fishing boats either transport their fare direct to shucking houses and canneries located along the waterfront or sell to "run boats" or "buy boats" which transport the catch to market.

At the shucking houses the shells are usually conveyed from the shucking table by means of an endless belt in a trough which carries them outside, where they are piled awaiting further disposition.

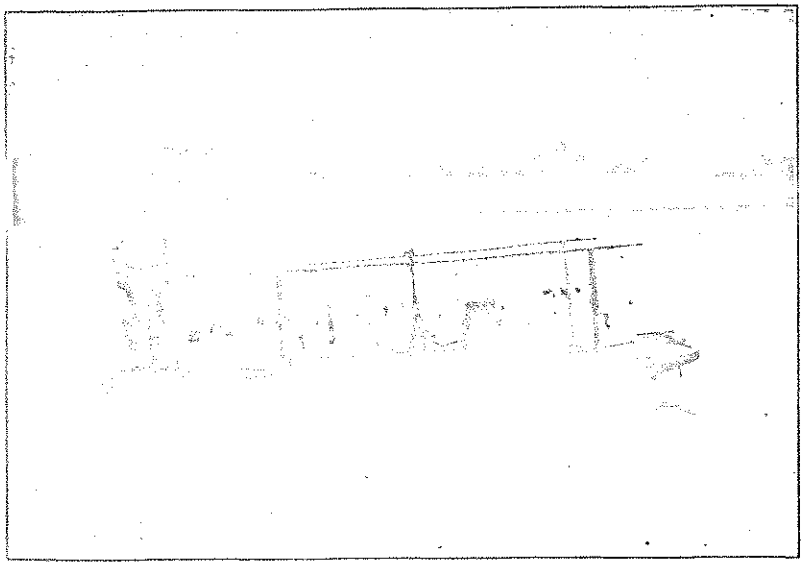

FIGURE 1.—Boat equipped with crowfoot bar used in fresh-water mussel shell fishery.

In the case of oyster and marine-clam shell reefs an electric suction dredge is usually used to raise the submerged shell. These dredges are equipped with revolving cutter heads to loosen the shells, which are then drawn up by suction through a pipe line to be washed free of sand and mud in a rotary washer located to the rear of the upper deck of the dredge. Upon being washed, the shells are dumped into lighters which are towed to the crushing plants.

Fossil shells are usually dislodged from their deposits by power-operated shovels, while the hard clams of Puget Sound are taken by hand-operated shovels.

Fresh-water mussel shells.—Fresh-water mussels are taken principally by crowfoot bars, and mussel dredges, with rakes, tongs, and forks used to a lesser extent.

The crowfoot bar consists of a bar to which are attached many short lines having four-pronged wire hooks arranged at intervals. The bar is towed behind the craft above the mussel beds with the hooks dragging on the bottom. As the hooks touch the gaping mussels lying on the bottom, the mussel closes tightly on the hooks. At intervals the bar and hooks are raised to the deck and the mussels removed.

The dip-net drag, familiarly known as a dredge, consists of a long-handled dip net with a flat surface at the extreme submerged end of the hoop. To this flat surface are usually attached teeth. In operation the net is towed from a power boat by ropes attached to either side of the hoop of the net while an operator forces the flat bottom down into the mud. The net is lifted frequently to discharge the catch.

Marine pearl shells.—The raw material represented by foreign marine shells imported for button manufacture are taken principally by divers, who may either dive naked or employ diving suits. Dredges are used to some extent where bottom conditions are favorable. The domestic abalone are taken by divers, and the conchs are taken by hooks.

MANUFACTURE

Oyster shells.—Oyster shells, as the most abundant of our aquatic shell raw materials, provide the greatest volume of manufactured shell products. The most important of these is crushed shell for use in poultry feeding.

We shall first consider a process typical of the handling of reef shells in manufacture. Upon receipt at the plant in the lighters, the shells are hoisted by an electric crane which operates on a track, to a pile of shells which rises above the crushing machine. These shells feed by gravity into a pit from which extends a chain of buckets for raising the shells to the crusher. A man stands at this pit and throws aside any rocks or refuse which may be mixed with the shells. From the crusher the shells are elevated to a washer where smaller particles are washed out and conveyed to a pile of such material in the yard. Screening is also effected at this time, and the larger particles of shells are returned to the crusher for a second crushing. The crushed shells, most of which are now suitable for poultry feed, are next moved on a belt conveyor to an immense stock pile near the main plant. Here they are allowed to air dry and bleach for several days at least, before being moved by the same crane which unloads the lighters to a pile immediately next to the building where they can feed easily into the drier. This drier is of the direct-heat rotary type, similar to those used in menhaden reduction plants. The temperature applied to the shells varies according to the dampness and condition of the shells and can be determined only by experience. As soon as the shells have passed through the drier they receive a screening which eliminates the large particles not suitable for the commercial sizes. That part of the shell which passes through the screen is conveyed to a higher level, where it is graded by means of diagonal, horizontal, or cylindrical screens into the various products, which range from the consistency of powder to coarse products suitable for turkeys, geese, and even ostriches. These various products fall into hoppers and with the exception of that part intended for [illegible] flour are bagged, weighed, and conveyed on an endless belt [illegible]

the railway spur, where laborers wheel the sacks by hand truck into freight cars.

The accumulation of fine particles or dust to be used as agricultural lime is frequently insufficient for market needs, in which case some one or more of the other products receives a further processing to reduce the size. The product eliminated in the first screening operation before the shells enter the drier also is sold for agricultural use and at a price considerably less than the final lime product.

There is some variation in the operation of the plants utilizing reef shells which were visited. The arrangement and construction of the cranes varied, there was some variation in the order of some of the operating functions, and the number of products varied; but in general the above describes their procedure. The plants operate with great efficiency, electric power being utilized in nearly every function which minimizes the item of labor.

The capacity of plants utilizing reef shells reach several hundred tons per day's operation.

The plants using the oyster shells accumulating from current shucking operations follow much the same procedure as those using reef

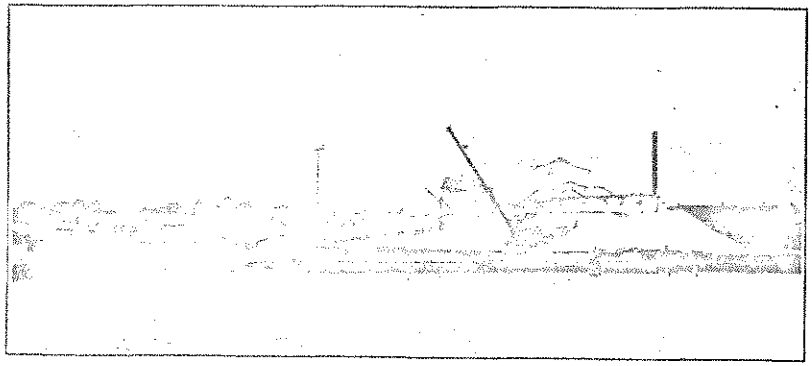

FIGURE 2.—Oyster-shell crushing plant, utilizing reef shell. Photograph by Spattswood, Jacksonville, Fla.

shells. Some of these plants however eliminate certain of the operating functions. Washing of the shells is frequently dispensed with where they are already free from foreign substances. In all cases the shells are allowed to dry in the sun which has the effect of bleaching them. The crushing, heat drying, screening, and other functions vary little from those already described above, except that the smaller plants may vary in the extent to which mechanical means may be utilized.

The capacity of plants using shells from current shucking varies from less than 10 tons per day's operation to probably as much as 100 tons.

Some plants using oyster shells operate exclusively in the production of "burned" lime. These firms, which are located in Virginia, burn the shells in pot kilns for as much as 24 hours to produce calcium oxide. To this they may add potash, plaster, or other ingredients, to increase the value of the product for use as a fertilizer.

Marine-clam shells.—In those plants utilizing marine-clam shells for which data are available there was found to be little variation in [illegible] those producing poultry feed from [illegible] shells.

Fresh-water mussel shells.—The primary product of the fresh-water mussel shell is the pearl button. Upon receipt at the button factory or cutting plant, the shells are sorted by hand according to species and quality and are classified as to size by mechanical means. They are then soaked in water for a week or more as a means of softening the shells. After softening, blanks are cut from the shells by tubular saws made from specially hardened steel rotating at high speed. Blank cutting plants are frequently operated near the mussel producing centers, while the finishing plants are concentrated principally at Muscatine, Iowa, with scattered factories elsewhere. When the blanks have been accumulated at the finishing plants, they are first classified according to thickness, then placed in tumblers, which are barrels containing water and pumice stone which cleans the blanks and removes the rough edges. The blanks are next submitted to the

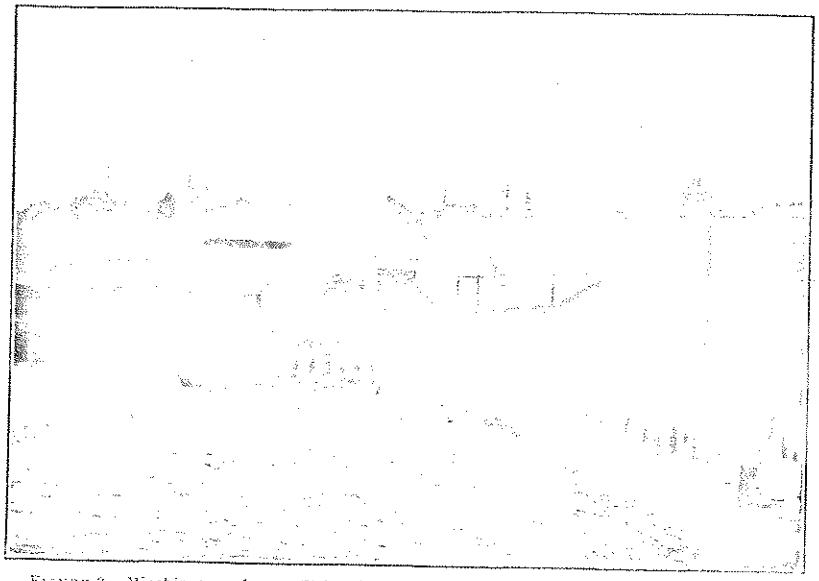

FIGURE 3.—Washington plant utilizing Japanese oyster shells. Cannery in the background.

grinder, which is a machine equipped with an emery wheel which removes the horny back and reduces the blanks to a uniform thickness. Again the blanks are soaked in water and are softened for the finishing machine—an ingenious device which rounds the edges of the blank, carves out the center, and drills 2 or 4 holes in it. The buttons are now tumbled in water and pumice to remove rough edges and clean them preparatory to polishing. This last operation consists of tumbling in which sulphuric or other acid and steam are used. They are then dried in sawdust and submitted to a treatment in a combined tumbler and shaker with sawdust and washing powder, which gives the buttons their final luster, after which they are sorted, carded, and packed ready for sale. Some of the buttons may be dyed, and discolored buttons bleached.

As has already been explained, a large portion of the total weight of mussel shells used in button manufacture are [illegible] able for byproducts. As a result, a [illegible]

oped in the utilization of this refuse for poultry feed, lime, chips, and colored shells.

The production methods for poultry feed and lime are almost identical with those employed in oyster shells. The chips consist of small pieces of shells which are polished by tumblers similar to those used in button manufacture. These may be dyed into some one of a half dozen or more colors. The smaller shells, not suitable for button manufacture, are also frequently polished and dyed.

Marine pearl shell.—Marine shells of foreign source are used especially in the manufacture of buttons with a considerable quantity of novelties being also manufactured. Even the very small pieces of shell are utilized by employing them in button manufacture, inlays, etc. The uses of domestic marine shells such as abalone, conchs, and miscellaneous shells, are confined almost entirely to novelty articles.

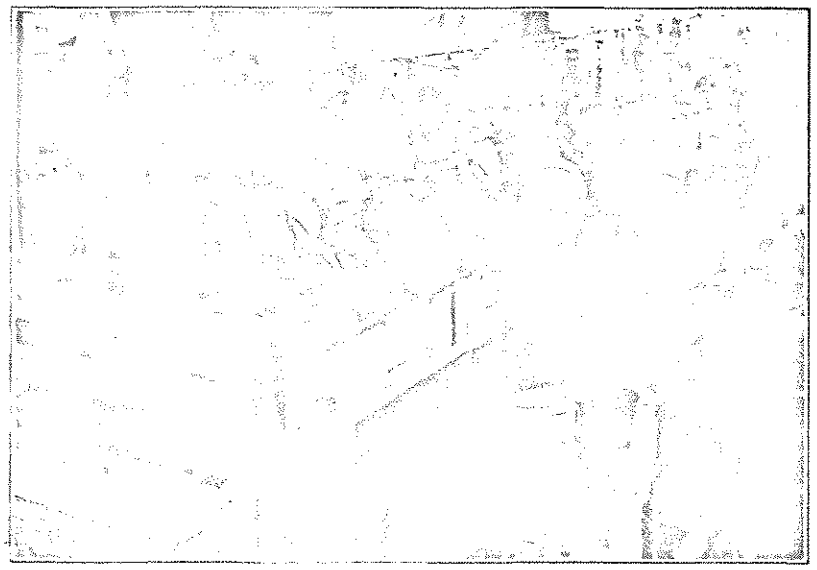

FIGURE 4.—Cutting button blanks from fresh-water mussel shells.

PRODUCTION STATISTICS

Oyster and marine clam shell products.—In 1932 there were 56 plants in the United States engaged in the manufacture of poultry feed and agricultural lime from oyster shells. These were distributed geographically as follows: 2 in Rhode Island, 5 in New Jersey, 5 in Pennsylvania, 1 in Delaware, 6 in Maryland, 8 in Virginia, 3 in North Carolina, 4 in South Carolina, 3 in Florida, 2 in Alabama, 6 in Mississippi, 4 in Louisiana, 2 in Texas, and 5 in California. Marine clam shell products were produced at 4 plants in Washington and 1 in California.

The production of crushed oyster shell for poultry feed in 1932 amounted to 256,725 tons, valued at $1,326,029. This figure includes a small amount of crushed marine clam shells for poultry feed produced in California. In addition there were 1,640 tons of poultry feed valued at $4,561 produced from marine clam shells in Washington.

During the past 12 years the 1932 production was exceeded only in 1929 and 1930 when but little more was produced than in 1932; however, the value of the production in 1932 was exceeded in each of the preceding 11 years.

The production in the North and Middle Atlantic areas while small has remained fairly constant throughout the 12-year period, but that in the Chesapeake region has consistently declined from a peak of nearly 120,000 tons in 1922 to less than 45,000 tons in 1932. The South Atlantic States, not including Florida, reached a peak of 16,200 tons in 1927 and decreased to 10,400 tons in 1932. The position of the Gulf States including the Florida east coast in oyster shell utilization has increased rapidly in the past 12 years with the exploitation of the vast supplies of reef shells. In the years from 1927 to 1930 inclusive, Louisiana alone accounted for annual outputs exceeding 100,000 tons with some recession during the past 2 years. In Florida there has been increased activity in reef shell manufacture in recent years and in 1932 the production in this State exceeded 61,000 tons of poultry feed.

Table 2 includes statistics of the production of crushed oyster shell for poultry feed from 1921 to 1932 inclusive.

The domestic production of crushed oyster shells for agricultural lime has varied from a peak of 93,168 tons, valued at $431,213 in 1922, to 49,281 tons, valued at $124,471 in 1932.

Fresh-water mussel shell products.—There were 16 plants in the United States in 1932 utilizing fresh-water mussel shells in button manufacture. Of these, 3 were located in New York, 1 each in New Jersey, Wisconsin, and Missouri, and 10 in Iowa. Most of the Iowa plants are located at Muscatine on the Mississippi River. Byproducts of mussel shells were prepared at 2 plants in New York, 2 in Wisconsin, 1 in Missouri, 1 in Illinois, 1 in Kentucky, and 8 in Iowa—a total of 15 byproducts plants. Mussel-shell novelties were prepared at 2 plants in Iowa. There were 25 plants utilizing mussel shells in manufacture. Some of the concerns were active in the production of more than one of the above products or groups of products.

The production of buttons from fresh-water mussel shells in the United States in 1899 was valued at $2,766,053 and in 1904, $4,370,241, according to statistics collected by the Bureau of the Census. The value of the production in 1912 and 1922 amounted to $6,173,486 and $4,725,242, respectively, according to surveys made by the Bureau of Fisheries. Byproducts in 1912 were valued at $187,607 and in 1922 they were valued at $204,104. Data on the production of buttons, novelties, and byproducts have been collected annually since 1929 and are presented in table 4.

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TABLE 2.—*Production of crushed oyster shells for poultry feed in the United States, 1921–32*

States	1921		1922		1923		1924	
	Tons	*Value*	*Tons*	*Value*	*Tons*	*Value*	*Tons*	*Value*
Rhode Island, Connecticut, New York, New Jersey, and Delaware	15,230	$157,372	20,493	$200,831	18,063	$211,982	12,634	$158,044
Pennsylvania								
Maryland	51,408	492,978	90,249	803,388	81,862	726,226	70,961	708,042
Virginia	26,150	325,125	26,173	230,115	19,682	201,488	22,619	226,126
North Carolina, South Carolina, and Georgia	2,957	20,630	6,740	56,165	5,818	61,218	6,472	72,698
Florida, Alabama, and California [1]	48,855	292,340	20,954	153,387	19,693	165,272	16,565	141,155
Texas	40,863	384,606	4,082	35,139	47,076	342,032	4,006	36,654
Louisiana			34,684	274,941			56,288	419,785
Mississippi			32,646	251,872	32,789	278,031	30,266	257,920
Total	185,474	1,759,120	236,021	2,005,838	224,983	1,986,249	219,211	2,019,254

States	1925		1926		1927		1928	
	Tons	*Value*	*Tons*	*Value*	*Tons*	*Value*	*Tons*	*Value*
Rhode Island, Connecticut, New York, New Jersey, and Delaware	11,364	$136,253	10,921	$125,945	12,178	$131,540	14,225	$143,510
Pennsylvania								
Maryland	63,709	643,889	68,973	678,606	50,734	501,216	43,755	375,466
Virginia	24,872	264,705	21,883	226,552	12,515	130,846	17,784	169,272
North Carolina, South Carolina, and Georgia	7,307	79,763	7,100	86,000	16,100	180,139	7,561	82,186
Florida, Alabama, and California [1]	11,752	97,593	8,294	69,127	8,438	70,730	12,053	102,424
Texas	4,300	37,175	3,790	31,554	(2)	(2)	(2)	(2)
Louisiana	71,884	526,834	98,283	886,528	123,183	1,082,125	123,354	1,126,619
Mississippi	32,283	288,845	31,922	273,028	[3] 20,712	[3] 235,169	[3] 18,573	[3] 156,508
Total	226,971	2,075,017	251,166	2,379,141	249,959	2,332,065	237,305	2,155,985

States	1929		1930		1931		1932 [4]	
	Tons	*Value*	*Tons*	*Value*	*Tons*	*Value*	*Tons*	*Value*
Rhode Island, Connecticut, New York, New Jersey, and Delaware	15,020	$149,053	7,702	$75,254	6,700	$69,270	5,372	$51,649
			5,738	61,091	4,123	44,822	3,152	31,370
Pennsylvania								
Maryland	41,908	319,901	40,706	312,847	34,045	235,024	28,271	187,838
Virginia								
North Carolina, South Carolina, and Georgia	28,427	266,173	18,519	166,441	19,941	175,669	18,508	113,322
			14,390	116,890	7,263	66,196	10,415	57,903
Florida, Alabama, and California [2]	[5] 149,207	[5] 1,286,191	[5] 36,320	[5] 293,610	[5] 55,028	[5] 301,333	[5] 91,101	[5] 411,767
Texas	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Louisiana	(2)	(2)	115,880	1,012,767	93,729	654,027	79,775	359,563
Mississippi	27,970	202,132	38,998	270,641	32,801	224,200	23,181	132,317
Total	262,232	2,223,453	279,118	2,309,544	253,630	1,770,538	256,725	1,326,029

[1] Statistics for California include a small amount of poultry feed produced from clam shells. In addition there were 1,800 tons of poultry feed, valued at $14,400 produced in Washington from clam shells in 1932.
[2] Statistics of the production in California were not obtained prior to 1929.
[3] The production in Texas is included with that of Mississippi in 1927 and 1928.
[4] The production in Texas and Louisiana is included with that of Florida, Alabama, and California in 1929.
[5] The production in Texas is included with that of Florida, Alabama, and California in 1930, 1931, and 1932.

TABLE 3.—*Production of crushed oyster shell lime in the United States, 1921–32* [1]

States	1921		1922		1923		1924	
	Tons	*Value*	*Tons*	*Value*	*Tons*	*Value*	*Tons*	*Value*
Rhode Island, Connecticut, New York, New Jersey, and Delaware	5,241	$29,084	7,799	$31,873	5,402	$20,026	3,645	$14,438
Pennsylvania								
Maryland	26,859	148,624	38,211	155,119	36,319	95,664	28,899	88,518
Virginia	33,478	206,645	27,415	182,680	31,341	215,209	28,908	205,663
North Carolina, South Carolina, and Georgia	1,555	9,535	1,815	9,075	5,200	30,500	3,131	17,625
Florida, Alabama, and California [2]	3,045	4,810	622	1,768	999	3,775	603	1,408
Texas			540	2,700			585	1,733
Louisiana	3,586	3,936	15,956	47,218	2,162	4,500	3,478	6,251
Mississippi			780	780	2,285	2,285	1,400	750
Total	73,704	502,634	93,168	431,213	83,808	372,286	70,269	336,384

States	1925		1926		1927		1928	
	Tons	*Value*	*Tons*	*Value*	*Tons*	*Value*	*Tons*	*Value*
Rhode Island, Connecticut, New York, New Jersey, and Delaware	3,708	$17,461	4,107	$17,861	3,235	$11,773	3,439	$15,014
Pennsylvania								
Maryland	27,488	76,747	25,410	65,246	25,662	68,544	21,092	57,758
Virginia	27,134	188,475	21,315	109,734	22,976	101,423	28,357	180,588
North Carolina, South Carolina, and Georgia	1,565	10,305	1,350	9,250	2,375	16,588	2,017	13,589
Florida, Alabama, and California [2]	1,730	2,078	1,225	1,862	2,150	2,088	2,425	8,425
Texas	500	1,350	350	1,400	(3)	(3)	(3)	(3)
Louisiana	4,145	5,670	2,675	3,746	2,667	5,175	10,130	17,302
Mississippi	1,548	1,172	800	1,100	[3] 2,095	[3] 3,394	[3] 1,248	[3] 1,873
Total	67,818	303,261	57,232	207,619	60,560	295,985	68,708	303,439

States	1929		1930		1931		1932	
	Tons	*Value*	*Tons*	*Value*	*Tons*	*Value*	*Tons*	*Value*
Rhode Island, Connecticut, New York, New Jersey, and Delaware	4,248	$18,752	1,952	$9,255	1,760	$7,620	1,686	$7,013
			1,752	8,629	1,453	6,166	822	3,274
Pennsylvania								
Maryland	20,217	54,444	20,080	53,722	15,593	32,608	15,289	24,455
Virginia								
North Carolina, South Carolina, and Georgia	25,378	179,184	120,615	151,476	23,702	119,370	13,926	62,733
			2,675	14,650	525	2,670	910	4,137
Florida, Alabama, and California [2]	[3] 18,173	[3] 43,848	[3] 3,727	[3] 13,853	[3] 3,200	[3] 5,791	[3] 13,180	[3] 20,755
Texas	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
Louisiana	(3)	(3)	9,374	28,907	4,421	13,198	1,885	1,312
Mississippi	4,518	4,418	7,733	5,126	1,855	1,000	2,073	757
Total	72,534	300,646	67,938	285,708	52,509	221,486	49,281	124,471

[1] Includes both burned and unburned shell intended for agricultural use. The production of burned lime was confined to Virginia. The production in 1928 was 15,971 tons, valued at $126,541; in 1929, 13,545 tons, valued at $115,474; in 1930, 9,150 tons, valued at $85,959; in 1931, 11,207 tons, valued at $85,851; and in 1932, 7,626 tons, valued at $44,688.
[2] Statistics of the production in California were not obtained prior to 1929.
[3] The production in Texas is included with that of Florida, Alabama, and California in 1929.
[4] The production in Texas and Louisiana is included with that of Florida, Alabama, and California in 1929.
[5] The production in Texas is included with that of Florida, Alabama, and California in 1930, 1931, and 1932.

TABLE 4.—*Production of fresh-water mussel shell products in the United States, 1929–32*

Product and State	1929		1930		1931		1932	
	Quantity	*Value*	*Quantity*	*Value*	*Quantity*	*Value*	*Quantity*	*Value*
Pearl buttons:								
Iowa..........gross..	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	$3,356,426	10,501,702	$2,325,071
Other States..do....	6,645,070	1,096,705	4,184,729	1,444,948	5,569,515	1,384,388	4,682,770	1,053,852
Total......do....	20,205,073	5,795,863	15,433,941	4,785,881	16,658,496	4,740,814	15,184,472	3,378,923
Crushed shell for poultry feed:								
Iowa..........tons..	11,329	127,227	8,349	71,803	9,871	90,661	6,788	53,274
Other States.do....	443	3,330	344	1,758	305	2,353	490	2,790
Total......do....	11,772	130,557	8,693	73,561	10,176	93,014	7,278	56,064
Agricultural lime:								
Iowa..........tons..	1,362	1,951	1,252	1,914	9,091	9,091	1,081	1,081
Other States.do....	195	550	261	563	267	486	104	337
Total......do....	1,557	2,501	1,513	2.477	9,358	9,577	1,185	1,418
Other products:[1]								
All States..........	....	215,594	....	145,500	....	126,835	....	119,855
Grand total......	....	6,144,515	....	5,007,419	....	4,970,240	....	3,556,260

[1] Includes stucco, colored and natural color shell chips, and pearl novelties.

Marine pearl-shell products.—Marine-shell buttons in 1932 were produced in 1 plant in Maine, 1 in Massachusetts, 6 in Connecticut, 7 in New York, 21 in New Jersey, 2 in Pennsylvania, and 1 in Maryland—a total of 39 plants. Marine-shell novelties were manufactured at 2 plants in Massachusetts, 3 in Rhode Island, 1 in Connecticut, 5 in New York, 11 in New Jersey, 1 in Pennsylvania, 1 in Maryland, 3 in Florida, and 3 in California—a total of 30 plants. Since frequently the same plants were engaged both in the manufacture of buttons and novelties, marine-shell manufacturing plants were only 53 in number.

Data on the production of buttons and novelties have been collected annually since 1930 and are presented in table 5.

TABLE 5.—*Production of marine pearl-shell products in the United States, 1930–32* [1]

Product and State	1930		1931		1932	
	Quantity	*Value*	*Quantity*	*Value*	*Quantity*	*Value*
Pearl buttons:						
Maine, Massachusetts, and Connecticut..........gross..	1,418,803	$1,052,584	1,328,513	$954,520	1,132,032	$780,014
New York..........do....	748,718	628,871	98,764	100,295	393,720	225,794
New Jersey..........do....	936,265	1,148,665	1,310,556	1,017,334	609,523	536,541
Delaware, Pennsylvania, and Maryland..........gross..	1,418,007	871,190	1,741,650	801,515	1,644,018	952,954
Total..........do....	[illegible]	[illegible]	4,470,463	2,853,064	3,829,293	2,504,303
Novelties:						
Massachusetts and Connecticut	....	102,350	....	103,845	....	90,700
Rhode Island	....	19,454	....	18,067	....	18,091
New York	....	134,484	....	37,848	....	22,350
New Jersey	....	343,244	....	322,329	....	114,300
Pennsylvania, Maryland, and Florida	....	120,102	....	148,777	....	82,665
California	....	25,000	....	35,373	....	31,760
Total	....	844,834	....	665,239	....	359,716
Grand total	....	4,544,147	....	3,518,303	....	2,864,019

[1] [illegible]

AQUATIC SHELL PRODUCTS AND THEIR USES

Oyster and marine-clam shells.—Various oyster shell tests have shown as high as 97, 98, and even in excess of 99 percent calcium carbonate content. This makes the product a valuable digestible source of calcium for laying hens.

Egg shells are almost pure calcium carbonate and about 10 percent of the weight of an egg is in the shell. A hen which lays 12 dozen eggs averaging 24 ounces to the dozen in a year's time lays 18 pounds of eggs or nearly 2 pounds of pure calcium.

The position of oyster shell in the diet of laying hens is well brought out by Hendricks, Lee, and Godfrey[3] in their review of earlier investigations in this connection. They state:

> As early as 1892 a bulletin of the New York State Agricultural Experiment Station reported the results of a feeding experiment in which a grit consisting of ground oyster shells was compared with one consisting of ground glass. The hens receiving oyster shell produced more eggs, and the eggs had better shells. In 1919, Wheeler found that a deficiency of inorganic calcium depresses egg production in hens and ducks. The results of extensive investigations relating to the calcium metabolism of laying hens reported by Buckner, Martin, and associates at the Kentucky station show that the feeding of calcium carbonate results in increased egg production, larger eggs, heavier shells, increased hatchability of the eggs, and greater size and vigor of the chicks hatched. Halpin found that feeding oyster shell increases the thickness of the egg shell. Robertson and Baskett have recently reported that feeding minerals increases egg production and egg size and improves the general health of the birds.
>
> Oyster shell either is a source of easily available mineral or contains a small amount of some factor which is present in cod-liver oil.

Growing chicks also require calcium as a bone-building mineral. This can be obtained in easily digestible form from chick sizes of crushed oyster shells.

No data are available on the comparative feeding values of domestic marine clam and oyster shell poultry feeds. The former product has been marketed almost entirely on the Pacific coast. The product is said to be high in calcium content. A study made by Voelcker[4] (1931) points out that the cockle shell native of England is of practically equal value as a source of lime and of virtually the same feeding value as compared with oyster shell both in respect to the health of the birds and the nature of the eggs. His analyses showed that cockle shell contains 96.40 percent carbonate of lime and oyster shell, 96.91 percent. At the present time oyster shell of American production is used in England.

The term "agricultural lime" is usually loosely used to include not only calcium and magnesium oxides but also carbonate forms. The domestic production of agricultural lime from oyster shells is marketed by producers as "burned" lime (calcium oxide) and pulverized shell or "dust" (calcium carbonate), either one of which may be mixed with potash or other ingredients before application to the soil. In 1931 the sales, excluding oyster shells, of agricultural lime and other liming materials by producers in the United States according to data published by the Bureau of Mines were as follows: Quicklime, from limestone, 78,392 tons, valued at $422,107; hydrated lime from limestone, 218,920 tons, valued at $1,502,042; pulverized lime [illegible] tons, valued at $2,117,141; and calcareous marl [illegible]

[3] Effects of cod-liver oil and [illegible] by Walter A. Hendricks, [illegible] Agr. [illegible] vol. 43, no. 6, Sept. 15 [illegible]
[4] [illegible]

$65,635. The domestic production of burned agricultural lime from oyster shells in the same year amounted to 11,207 tons, valued at $55,884, and unburned agricultural lime, 41,392 tons, valued at $59,092. There was also a production of 9,358 tons of unburned agricultural lime, valued at $9,577, from fresh-water mussel shells; and a small amount was made from marine clam shells.

Table 6 presents data on the efficacy of various liming materials.

TABLE 6.—*Available lime oxide content of various liming materials per ton*

Material	Minimum	Maximum
[illegible]	1,400	1,700
[illegible] lime	1,400	1,960
[illegible]	1,200	1,600
[illegible] oyster shells, and marl	800	1,100
[illegible] residues	400	700
[illegible] materials	350	600

NOTE.—Data taken from "Lime in Agriculture", Bulletin no. 190, published by the National Lime [illegible], 1930.

In addition to the manufacture of crushed oyster shell for poultry feed and agricultural lime many tons are used for ballast, highway building material, a base for cement, shell flour for use in mixed feeds

FIGURE 5.—Oyster-shell road under construction.

[illegible]ical lime. An outlet for shell lime is found in the oil refining [illegible] where it is employed for prevention of corrosion, for reducing [illegible], and for other uses.

Fresh-water mussel and marine pearl shells.—Fresh-water mussel shells furnish the most important source of domestic-made buttons [illegible] marine pearl shells are second in importance as a raw material. The principal materials competitive to aquatic shells in button manufacture, in order of their importance, as follows: Vegetable ivory, [illegible] porcelain, galalith (casein plastic), composition, and horn.

In addition to buttons certain aquatic shells are an important raw material in the production of many novelty articles, such as knife handles, plates for revolver handles, cuff buttons, brooches, buckles, stick pins, fancy buttons, chains, inlaid work, colored shells, and pieces of shell and small shells for gardens and aquaria, etc.

SEASONS OF MANUFACTURE

The manufacture of oyster-shell products is seasonal only to the extent that raw material, especially in those crushing plants utilizing shells from current shucking operations, may be limited to a period approximating the oyster season. Where there is a sufficient supply of raw material, operations are conducted throughout the year, providing of course that there is an adequate demand for the products. The reef-shell plants are fortunate in having a continuous supply of raw material.

The manufacture of mussel- and marine-shell products likewise depends for its continuous operation on the supply of shell and the demand for their products; but in normal times they may be considered year-around industries.

DISTRIBUTION OF SHELL PRODUCTS

A survey of somewhat more than one half of the domestic producers of crushed oyster shells for poultry shows a distribution of this product which follows very closely the areas of concentration of poultry raisers. Thus, large quantities find market in California, in the Middle Western States, in the Middle Atlantic area, and in the Southwest. The supply of poultry feed from marine-clam shells finds its outlet almost entirely in the Pacific Coast States.

There is understood to be but little foreign production of crushed shell although France produces a limited supply. Because of this fact nearly one fifth of the domestic production of crushed oyster shell for poultry feed enters foreign markets. The United Kingdom is our principal foreign customer, followed in order by Canada and Belgium. There were 11 other countries receiving smaller shipments of crushed oyster shell in 1932.

Table 7 includes statistics of the domestic exports of oyster shell, by countries of destination, from 1929 to 1932, inclusive.

Shipments of crushed oyster shell in 1932 from ports in the Florida Customs District exceeded the shipments from all other customs districts. During the preceding 3 years the New Orleans Customs District had exceeded Florida. It should be noted that with increased exploitation of her reef deposits Florida's export trade has increased from 956 tons in 1929 to 27,293 tons in 1932.

Table 8 shows statistics of the domestic exports of oyster shells by customs districts from 1929 to 1932.

The survey of domestic producers indicated very limited distribution of agricultural shell lime. Most of the firms market lime only within their own States or immediately surrounding States. Only negligible quantities are exported.

Several foreign countries produce large quantities of pearl-shell buttons. The principal ones of these are Japan, Germany, Czechoslovakia, Italy, France, Austria, and England.

TABLE 7.—*Domestic exports of oyster shells, by countries, 1929–32* [1]

Country	1929		1930		1931		1932	
	Tons	*Value*	*Tons*	*Value*	*Tons*	*Value*	*Tons*	*Value*
Azores and Madeira Islands							100	$614
Belgium	2,051	$21,409	1,560	$14,539	4,308	$38,852	3,986	26,776
Canada	80	884	45	280				
Finland			116	1,209	10	75	30	142
France	14	141						
Germany	975	11,189	1,594	16,113	1,350	11,446	626	4,527
Irish Free State	143	1,326	126	1,315	40	393	73	546
Italy	127	1,378	65	698	54	516	129	893
Malta, Gozo, and Cyprus	5	56						
Netherlands	1,587	15,897	1,037	10,268	1,227	10,520	205	1,328
Norway	25	280	160	1,792	75	748		
Spain	33	375	50	560	124	1,039	175	1,133
Sweden	101	1,120			113	1,011	110	750
United Kingdom	24,702	262,525	33,455	337,206	35,702	350,209	34,425	252,947
Canada	12,729	122,040	11,308	110,359	9,915	94,034	10,561	89,213
Bermuda			1	9				
Bahamas	1	25	1	15				
Newfoundland and Labrador			3	62	3	70		
Trinidad and Tobago			1	15			2	20
Other British West Indies	1	46	12	146	1	16		
Cuba	29	325	43	424	5	54		
Dominican Republic			1	10				
Venezuela					1	10	1	17
Philippine Islands							5	40
Australia			10	112				
Union of South Africa	103	1,173	50	560	201	1,688		
Egypt			10	110				
Total	42,749	443,789	49,553	496,302	53,189	510,741	50,425	378,946

[1] While these products are classified as "oyster shells" in foreign trade statistics it is believed that they are almost entirely crushed shell for poultry feed.

Source: Bureau of Foreign and Domestic Commerce.

TABLE 8.—*Domestic exports of oyster shells, by customs districts, 1929–32* [1]

Customs district	1929		1930		1931		1932	
	Tons	*Value*	*Tons*	*Value*	*Tons*	*Value*	*Tons*	*Value*
Maine and New Hampshire	23	$228			5	$75		
Vermont	787	7,333	739	$7,438	586	5,936	274	$2,651
Massachusetts							10	110
Rhode Island	1,884	17,737	1,609	17,227	1,845	17,686	1,197	10,847
Connecticut	4,357	42,617	4,211	42,218	2,973	29,818	2,520	22,856
New York	6	110	5	110	3	70	1	10
Philadelphia	91	1,116	22	260	49	536	3	30
Maryland	4,760	47,048	1,385	15,060	1,065	10,906	1,091	8,220
Virginia	3,120	42,343	589	10,165	1,892	26,800	118	1,579
North Carolina	309	4,755	1,725	35,353	685	9,742		
Florida	3,062	38,814	4,717	51,615	5,125	58,280	4,097	37,469
Louisiana	959	8,735	10,571	60,292	13,512	115,584	27,293	178,716
Texas	5,853	48,603	8,347	82,345	6,089	58,462	3,933	38,456
New Orleans	13,122	130,428	12,014	121,594	15,891	145,739	5,764	42,082
Alaska					894	8,031	1,602	15,780
San Francisco			89	1,490			41	254
Oregon	2,007	20,626	937	8,588	722	5,985	537	4,386
Washington and Idaho	25	241	47	351	47	424		
Hawaii and Pacific Islands	1,845	17,127	1,687	14,567	1,069	9,682	918	7,837
Puerto Rico	485	4,576	301	2,805	91	858	54	484
Virgin Islands	587	5,892	313	4,969	682	5,767	1,035	7,479
Total	42,749	443,789	49,553	496,302	53,189	510,741	50,425	378,945

[1] While these products are classified as "oyster shells" in foreign trade statistics, it is believed that they are almost entirely crushed shell for poultry feed.

Source: Bureau of Foreign and Domestic Commerce.

Button manufacturers rely chiefly for a domestic outlet of their products on garment manufacturers and wholesale dry goods firms located in and near larger cities. Considerable quantities also are exported. Table 9 shows statistics of the exports of pearl or shell buttons for the years 1928 to 1932.

TABLE 9.—*Domestic exports of pearl or shell buttons*

Year	Gross	Value	Year	Gross	Value
1928	454,529	$135,504	1931	95,683	$27,306
1929	242,399	82,915	1932	140,953	19,219
1930	216,794	55,970			

Source: Bureau of Foreign and Domestic Commerce.

Most of the crushed oyster shell plants have both rail and water facilities for transportation. Spurs usually bring cars to points adjoining their plants where the finished products can be loaded with little labor, and since nearly all the plants have their own docks they are not only convenient to incoming raw material but also in a position to frequently take advantage of transportation at rates on finished products considerably less than could be otherwise obtained. Trucks are used to some extent in transportation.

SELLING PRACTICES

The survey to which previous reference has been made shows the producers of crushed shell for poultry feed place great dependence in the broker as a sales medium, with the wholesale dealer in feeds occupying but little less importance in their plan of sales. A number of the plants sold large portions of their production direct to retail dealers in poultry supplies and a small amount was marketed direct to poultry raisers.

Since producers of agricultural lime market their production within limited areas, the principal outlet is direct to consumers. A small number of sales are made to wholesalers and sales through brokers are negligible.

Crushed-shell producers follow several advertising methods. Most of the firms distribute literature through the mails and also represent their commodities by salesmen, while several of the firms advertise in national as well as local newspapers.

For sale by the Superintendent of Documents, Washington, D.C. - Price 5 cents