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Scallops and Their Utilization

Calico scallops dredged off Florida's east coast. Photograph by the Florida State News Bureau, Tallahassee.

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INTRODUCTION

This paper brings together pertinent information on the history, biology, harvesting, and utilization of the various species of scallops of commercial importance in the United States. The information is contained in almost 200 papers covering a span of about 100 years.

HISTORY

There are currently four species of scallops of commercial importance in the United States: Sea scallops (*Placopecten magellanicus*), bay scallops (*Aequipecten irradians*), calico scallops (*Argopecten gibbus*), and the Pacific sea or weathervane scallop (*Patinopecten caurinus*).

Sea Scallops

The sea scallop fishery began on a small scale about 1880 when some of the inshore beds along the New England coast were fished. By 1900, landings were about 400,000 pounds (180,000 kg) of meats with the largest volume being landed in Maine ports. Then, in the early 1920's, scallop beds were discovered off along Long Island and the fishery shifted to that area. With the discovery of sea scallops on Georges Bank, the major activity shifted north with New Bedford evolving as the major scallop port in the United States, a position it has held ever since.

A relative lack of abundance of scallops on Georges Bank in 1965 led to the exploitation of sea scallop populations from Hudson Canyon off New Jersey south to Cape Hatteras. This bonanza was short lived, and mid-Atlantic landings returned in a few years to somewhat less than their previous levels. At the same time, landings in Virginia ports increased greatly from 194,000 pounds (88,000 kg) of meats in 1964 to 2.8 million pounds (1.3 million kg) in 1965. Regional trends in sea scallop landings from 1960 to 1974 are presented in Figure 1.

In 1976, total landings of sea scallop meats were 20,000,000 pounds (9,000,000 kg) worth $35,000,000 to the fishermen or $1.77/pound ($3.90/kg) making the sea scallop the tenth most valuable fishery product in the United States and the second most valuable bivalve, with oysters ranking first (O'Brien, 1961; Bourne, 1964; Robinson, 1977).

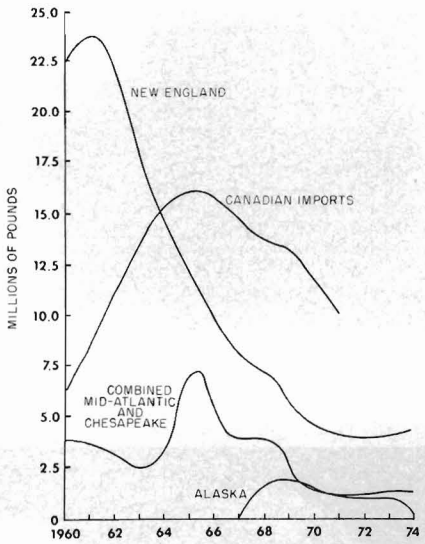

Figure 1.—Sea scallop landings, imports, in various regions. Source: Fisheries of the United States, Curr. Fish. Stat., Natl. Mar. Fish. Serv., NOAA, various numbers and years.

Bay Scallops

Bay scallops have been harvested since colonial times when settlers on Cape Cod picked them up by hand at low tide (Belding, 1910). Landings of bay scallops fluctuate widely from year to year reflecting the relative success or failure of a particular year class. As bay scallops live somewhat less than 2 years, spawning success is reflected very quickly in the catch rate (characteristic of all short-lived species). For

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instance, in 1968, landings of bay scallop meats in New England were less than 500,000 pounds (227,000 kg). According to Hanks (1971), landings had jumped to over 2,000,000 pounds (900,000 kg) in 1971, but then they dropped equally rapidly to about 550,000 pounds (250,000 kg) in 1974; and, in 1976, total United States landings of bay scallop meats were again over 2,000,000 pounds (900,000 kg).

Calico Scallops

Calico scallops have been harvested only since 1960 when the Bureau of Commercial Fisheries (now the National Marine Fisheries Service) discovered the beds off Cape Kennedy, Fla. Landings from these beds and from those off North Carolina and northwestern Florida have fluctuated widely as is common with short-lived species. In recent years, landings went from a low of 558,000 pounds (250,000 kg) worth $356,000 in 1973 to over 2 million pounds (900,000 kg) worth about $1.4 million in 1976. The most consistent production has been from the Cape Kennedy beds with very little recent production from off North Carolina and none from northwest Florida (Robinson, 1977; Allen and Costello, 1972; and Cummins, 1971).

Figure 2.—The sea scallop, *Placopecten magellanicus*.

Pacific Sea Scallops

For serveral years in the 1960's, there was considerable interest in developing a fishery for the Pacific sea (weathervane) scallop. Several New Bedford vessels went to the west coast to help establish the fishery. However, problems with production, processing, and marketing somewhat dimmed the initial enthusiasm which had led to an article in the trade press entitled "U.S. Scallop Fishery—Switching Coasts?" (Anonymous, 1968). As of 1974, landings of scallop meats in Alaska amounted to about 7 percent of the volume and 7 percent of the value of all scallops landed in the United States. For statistical purposes, the landings data are included in the landings of *Placopecten magellanicus* (Anonymous, 1968; Bell and Fitzgibbon, 1977).

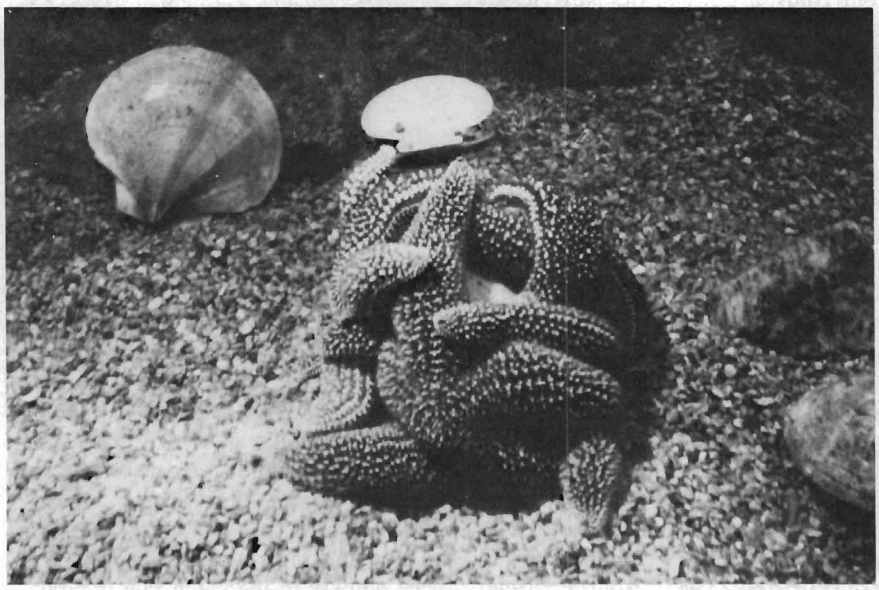


Figure 3.—Sea scallop engulfed by starfish; other sea scallops nearby.

BIOLOGY

Biologically speaking, scallops are benthic marine pelecypod mollusks of the family Pectinidae.

Sea Scallops

The sea scallop (Fig. 2, 3) is one of the largest of the family Pectinidae in the United States. It commonly grows to 6-7 inches (150-175 mm) in diameter, and individuals as large as 9 inches (200 mm) are not uncommon. The bottom shell is fairly flat and usually white in color; whereas, the upper is somewhat convex and reddish brown. A striking feature of all scallops is the rows of functioning bright blue eyes along the edges of the mantle. Another unique feature of the scallops is their ability to swim which is maintained throughout their life. The swimming ability varies with species, with sea and bay scallops being particularly adept.

The scallops swim by jet propulsion. Water is taken into the mantle cavity and then forcefully expelled in several ways which make it possible for the animal to move in any one of several directions. By expelling the water through openings on either side of the hinge, the scallop moves with eyes front. Water can also be expelled at the forward edge of the shell driving the scallop backward (hinge first). Finally, either of the two hinge jets may be used to provide a spinning motion.

The sexes of the sea scallop are usually separate, but hermaphrodites are found occasionally. Spawning occurs in late summer or early fall. Exact time varies from one year to the next and from one area to another. What triggers spawning is not known precisely, but it probably is temperature related. The fertilized eggs remain on the bottom for the first stages of life. They soon become free swimming but still tend to stay close to the bottom. The free swimming stage lasts about 2 weeks, varying with water temperature. When they settle to the bottom, the scallops attach themselves to various substrates by means of byssal threads. The ani-

mals can (and frequently do) sever their thread connection and swim in apparently random directions for considerable distances—well over 100 feet (30 m) is apparently not uncommon. At a shell diameter of about 3 inches (75 mm), the scallops lose the habit of byssal attachment but still retain, to a lesser degree, their swimming ability.

Sea scallops require about 4½ years to reach the 3¾-inch (95-mm) size recommended by the International Commission for the Northwest Atlantic Fisheries and proposed as a regulation by the National Marine Fisheries Service as the minimum that should be harvested to insure a sustainable yield (Bourne, 1964; Posgay, 1950, 1953).

Bay Scallops

Bay scallops occur from New England to the Gulf Coast of Florida. In contrast to the sea scallops, they are small, rarely exceeding 3 inches (75 mm) in height with the maximum being 3½ inches (90 mm) (Fig. 4). The shells are equally curved and prominently ridged. They are thin in proportion to size so the bay scallop remains an active swimmer during its short life span.

Bay scallops are hermaphroditic (both male and female sex organs are found in each individual), but usually only one kind of sex cell is cast out at any one time. Spawning occurs from mid-June to mid-August when the scallops are about 1 year old; very few spawn twice. The young are free swimming for about 12 days at which time they attach themselves by means of their byssal threads to various substrates. The bay scallop maintains its attaching ability throughout its 20-26 month life span.

During the winter, bay scallops grow only very slowly; as a result, a fairly thick ridge or line appears on the shell. It is the presence of this ridge that unfailingly distinguishes the adult from the juvenile. In most areas, it is forbidden to harvest bay scallops lacking the ridge. Also, in many areas, harvesting is prohibited entirely from a few months before to a few months after the peak spawning period. In general, the "open season" is from 1 October to 1 April (Belding, 1910; Gutsell, 1931).

Figure 4.—Bay scallop meats.

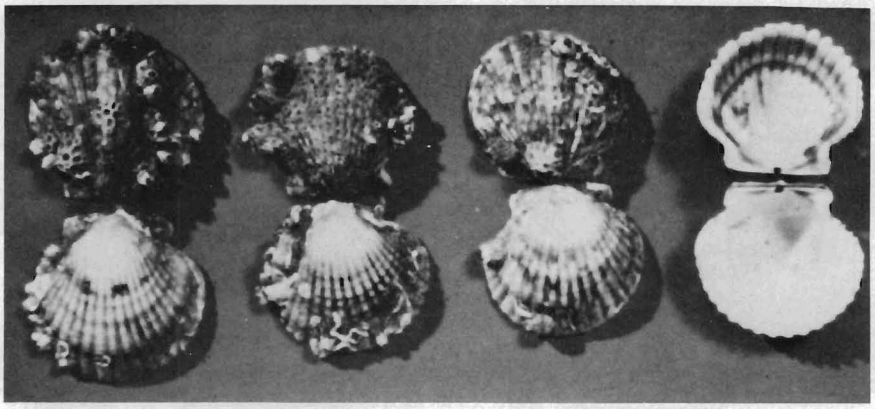


Figure 5.—Calico scallops.

Calico Scallops

The calico scallop is found from Cape Hatteras along the shores of the Gulf of Mexico, throughout the Greater Antilles, and around Bermuda. They are somewhat smaller than the bay scallop, generally growing to 1½-2¼ inches (40-60 mm) with the maximum about 3⅛ inches (80 mm) (Fig. 5). The shells are about equally convex, deeply ridged, and are mottled with red to brownish-red bands on a light background. The shells are considerably thicker than those of the bay scallop which accounts for the fact that, although smaller, the calico scallop is less motile.

Like the bay scallop, the calico scallop is hermaphroditic. In the laboratory, it has been observed that when spawning, the sperm is ejected first followed by the eggs. Spawning of the calico scallops is related to age rather than size; that is, all calico scallops 10-12 months old will spawn regardless of the size they may have reached.

Spawning is, as with other species, probably triggered by rising water temperatures as it begins about the first of March and continues to June and occasionally longer. A drop in temperature during spawning will cause it to terminate.

The larvae are planktonic and may be found anywhere from the surface to the bottom. The small calico scallops, like the bay scallops, attach themselves by byssal threads to various objects, such as any shell material, pieces of tile, rope, etc. Although the attaching is greatest in the young scallops, of less than 1 inch (25 mm), the ability is maintained but rarely used for the life span of the species.

The duration of the plankton stage from fertilization to settling on the bottom is about 2 weeks. At this time, the young are only 0.01 inch (0.25 mm) in shell height; but, in 10 weeks, they have grown to over 1 inch (25 mm); and it is estimated that in 24 months, the maximum age, the scallops average slightly over 2 inches (54 mm) (Allen and Costello, 1972).

Pacific Sea Scallop

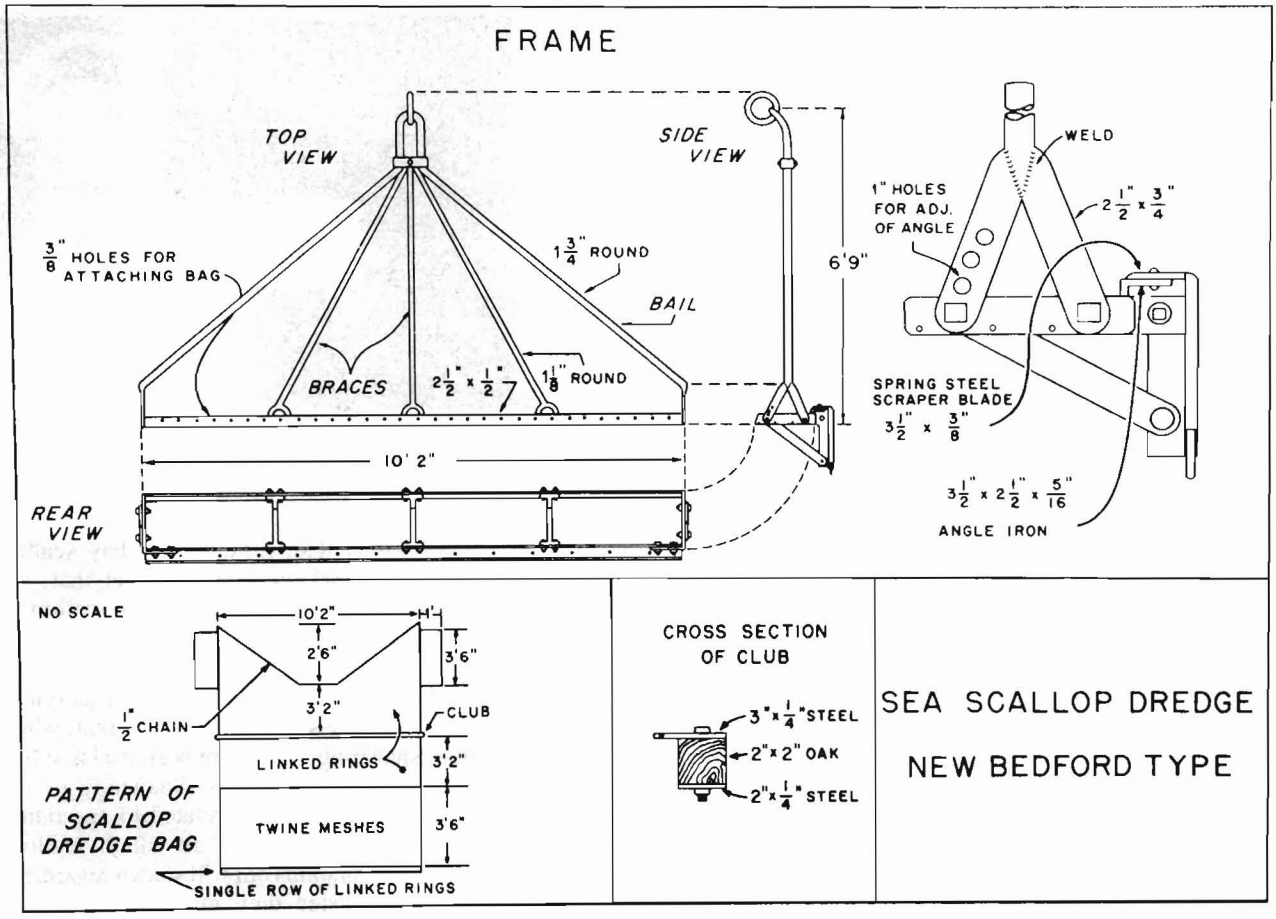
Information on the spawning, growth, and reproduction of the Pacific sea scallop is very fragmentary. However, spawning appears to occur during the summer. Growth rate varies greatly with area, being 1.5 times greater on some beds than on others. In most respects, the Pacific sea scallop seems to be very similar to the east coast sea scallop (Haynes and Hitz, 1971).

HARVESTING

Sea Scallops

Until recently, sea scallops have been caught almost entirely by dredges (Fig. 6). Vessels up to about 100 feet (30 m) tow two dredges simultaneously, one from each side of the vessel. The dredges may be as much as 14 feet (4.25 m) wide, but 11-12 feet (3.35-3.7 m) is more common. In the last few years, however, there has been a trend toward using conventional otter trawls modified by adding sweep chains and chafing gear to protect the net from the bottom. The otter trawls are used primarily on the smooth hard bottom found in the scallop beds off the mid- and South Atlantic areas. In the first half of 1976, about half the scallops

Figure 6.—New Bedford-type sea scallop dredge.



landed in Virginia were caught by otter trawl. Most of Georges Bank, however, is too rough for otter trawls. (Kelly, 1976[1]).

The sea scallop dredge consists essentially of a rectangular frame 11-14 feet (3.35 -4.25 m) wide by about 1.5 feet (0.5 m) high. The lower frame assembly is a spring steel scraper blade which serves to scoop the scallops up and into the linked ring bag. The steel rings which make up all of the bottom and about half of the top are usually 3 inches (75 mm) in inside diameter made from $^{5}/_{16}$-inch (9½-mm) stock held together with dredge clips. The forward half of the top is made up of $^{5}/_{16}$-inch (9½-mm) cord fastened into 6-inch (150-mm) stretched mesh netting by means of cord clips (Bourne, 1964; Royce, 1947; Posgay, 1957).

[1]William Kelly, Supervisory Fishery Reporting Specialist, Statistics Branch, National Marine Fisheries Service, NOAA, Brittingham Bldg., 55-57 W. Queen Street, P.O. Box 447, Hampton, VA 23669. Pers. commun.

Bay Scallops

Bay scallops are usually caught with small dredges towed by outboard motor boats. In shallow waters, they may also be taken with dip nets, rakes, or even picked up by hand.

The bay scallop dredge is only about 3 feet (1 m) wide. The bag is made up of 2-inch (50-mm) inside diameter rings on the bottom and 2-inch (50-mm) mesh netting of heavy twine on top (Schwind, 1976).

Calico Scallops

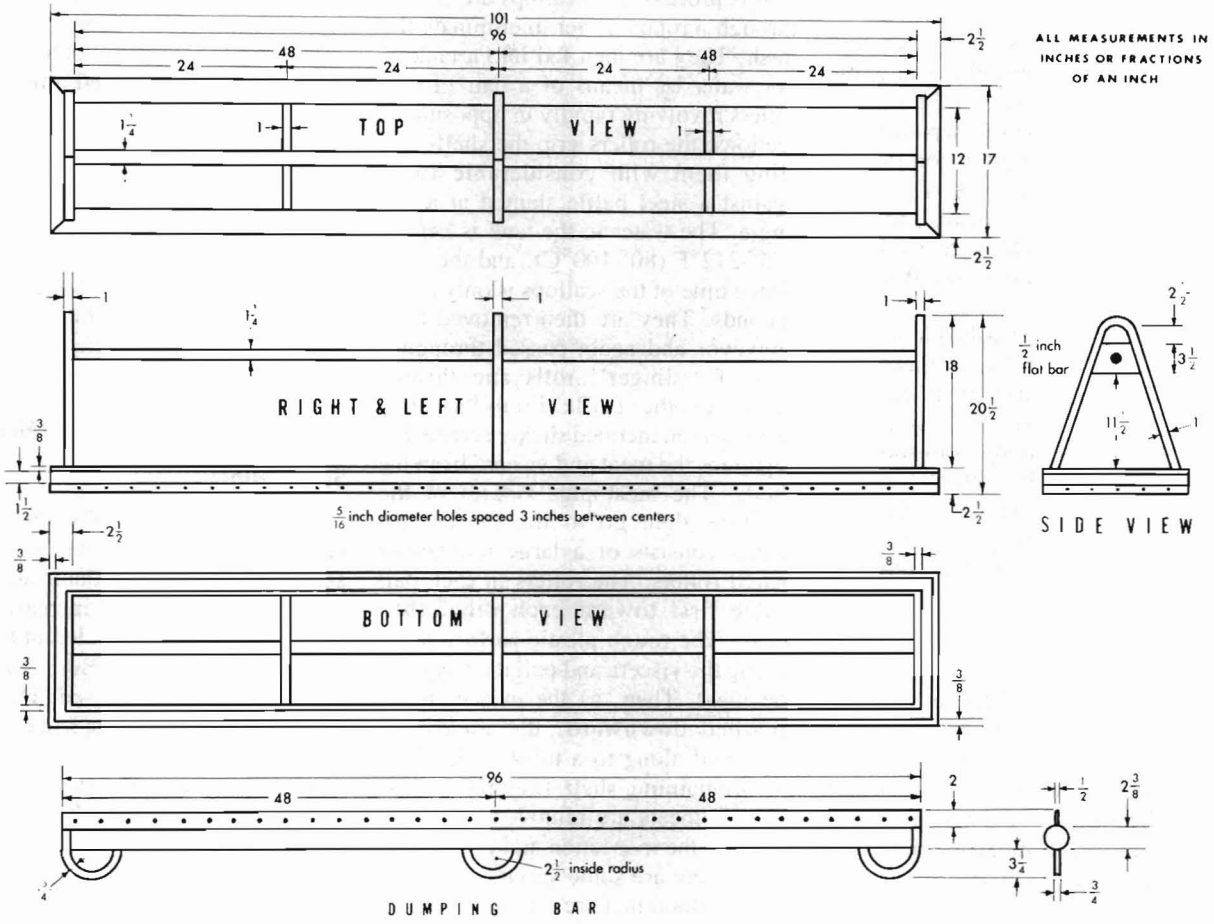
This species is caught either by tumbler dredge (which will fish either side up) or by modified otter trawls. The type of bottom dictates the gear to be used.

The calico scallop dredge (Fig. 7) has a rectangular frame opening identical on top and bottom edges, the bag is made up of 2-inch (50-mm) inside diameter rings held together with clips (Rivers, 1962; Bullis and Cummins, 1961).

PROCESSING

Primary processing (removing the meat from the shell) may be done at sea or ashore. Historically, the vast majority of sea scallops was shucked aboard the vessel. Recently, there has been a

Figure 7.—Calico scallop dredge.



trend toward shucking ashore. Bay scallops are almost always shucked ashore, and calico scallops have been shucked both aboard (Fig. 8) and ashore.

The yields of meats obtained vary with location of the beds and the time of year, being less after spawning. Average yields per U.S. standard bushel, which weighs from about 70 to occasionally as high as 80 pounds (32 to 36 kg), are reported as: 6 pounds (2.7 kg) for sea and bay scallops and 2.7-3.5 pounds (1.2-1.4 kg) for calico scallops. Details of the primary processing methods are given below.

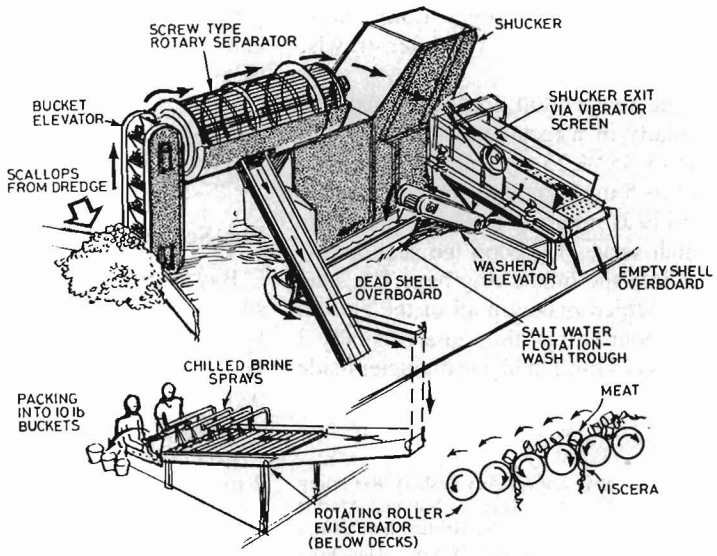


Figure 8.—Shipboard shucking machine for calico scallops. Illustration courtesy of *World Fishing*, Dorset House, Stamford St., London, England.

Sea Scallops

The procedures for shucking sea scallops aboard the vessel are essentially as follows. When the dredges are hauled back and dumped on deck, considerable trash ranging from undersized scallops, empty shells, and unmarketable species of fish up to very large boulders must be disposed of before shucking can begin. After sorting, the shell stock is dumped into the shucking boxes which line the rail of the vessel. A special knife is used to separate the shells and cut free the adductor muscle (the only part saved by U.S. fishermen). In Europe, the gonads are also saved as these are highly esteemed as a delicacy, more desirable even than the adductor muscle.

The meats are then washed in seawater and put in muslin bags which hold 35-40 pounds of meats. The filled bags are carefully iced in storage pens in the hold to keep the scallops from spoiling (Bourne, 1964; Peters, 1974).

If the scallops are to be landed whole, the trash is sorted out and the shell stock lowered into the hold and iced in the pens.

Calico and Bay Scallops

The small size of these scallops makes it almost impossible economically to shuck them by hand aboard the vessel. However, machines using a "shock-heat-shock" method have been developed, and some were installed aboard the larger vessels fishing for calico scallops off Florida's east coast. In this process, the scallops are passed through a rotary sorter to eliminate the trash. They are then fed into a tank of hot water by means of a pair of soft rollers revolving rapidly in opposite directions; the rollers grip the shells and sling them with considerable force against a steel baffle slanted at a 45° angle. The water in the tank is kept at 175°-212°F (80°-100°C), and the residence time of the scallops is only a few seconds. They are then removed by a conveyor and again passed through a pair of "slinger" rolls and thrown against another baffle. From this, they drop onto an inclined shaker screen that separates the meat and viscera from the shells. The meat plus viscera of the scallops then go to the eviscerator which consists of a large number of paired rollers. The rollers in each pair rotate first toward each other then away. The rough plastic surface tends to grip the viscera and pull it away from the meat. Then, as the eviscerator is inclined downward, the meats are propelled along to a brine tank where any remaining shell fragments sink, and the meats are removed by a conveyor to the inspection and packing tables. There are some variations on this basic method that are (or have been) in use: 1) Entrance slinger rolls only, 2) exit slinger rolls only, and 3) no slinger rolls. An early variation of this method of historical interest used a free fall of considerable height (30-40 feet) (9-12 m) onto a solid slab to provide the initial shock (Cummins, 1971).

The seagoing machines were removed from the vessels after a few years and the reasons given vary: i.e., the machine made the vessel unstable, the meats were poor in quality, the crews were unhappy, etc.

PROCESSING ASHORE

Sea Scallops

With the recent exploitation of sea scallop beds off the coasts of New Jersey and the Delmarva Peninsula, there has been a significant increase in the amounts of scallops landed in the shell and shucked ashore. Both hand and machine shucking are used. The procedures are essentially the same as those described above. On the west coast, a machine was developed and patented by the NMFS Seattle Technological Laboratory (now the Pacific Utilization Research Division, Northwest and Alaska Fisheries Center, NMFS,

An 8-foot New Bedford-type scallop dredge.

A 10-foot Georges Bank-type scallop dredge with a catch of calico scallops.

NOAA, Seattle, Wash.). This machine uses oxyacetylene flames to loosen the adductor muscle from its attachment to the shell. The shells are removed mechanically and the viscera separated from the meat by suction (Nelson, 1970).

After shucking or after landing the shucked meats, the meats are washed; large sea scallops are cut by hand into smaller "bite-size" pieces. They are then either packaged in 1-, 5-, or 10-pound (0.5-, 2.25-, or 4.5-kg) packages and frozen in a plate freezer, or they are first frozen in liquid nitrogen, liquid carbon dioxide, or liquid refrigerant-12 and then packaged. The individually quick freezing methods provide very rapid freezing and a product that is of excellent appearance and convenient to use both for the housewife and for the restaurant chef.

With the increase in landings of shell stock, there has been an increase in the problems associated with disposal of the waste products—viscera and shell. Presently, the viscera are being used as an additive to animal feeds (primarily for hogs). The shells are sometimes used as fill in land reclaiming projects, crushed and added to concrete, or spread over oyster beds as cultch.

Bay Scallops

Very often, bay scallops are shucked by a family group (i.e., a cottage industry) either in a separate building or in a wing of the family home especially laid out and equipped to meet the local and state sanitation requirements. Or, the shell stock may be sold by the fisherman to a processor who then takes care of the shucking, packaging, freezing (if necessary), and distribution.

Calico Scallops

Early in this fishery, landings were quite heavy in the Cartaret County area of North Carolina, and processing was very much a cottage industry. Trucks would drop off the day's catch of shell

stock at various homes where it would be shucked the next day by the housewives and, perhaps, children. The shucked meats would be picked up that evening when the next batch of shell stock was delivered. At present, calico scallop shell stock is processed in modern sanitary plants or aboard ships where quality control can be maintained much more easily and uniformly than in the cottage industry situation (Fig. 7) (Thomas[2]).

QUALITY PROBLEMS

Most of the problems that have been identified are for sea scallops. Regulations regarding sanitation in the shucking process aboard the vessel vary from state to state. In general, it is required that stainless steel or plastic containers, wash boxes, and sometimes shucking benches be used, so it will be possible to easily sanitize the equipment (O'Brien, 1961).

When the shuckers aboard the vessel fill their pails with meats, they dump them in the wash box where they may soak in seawater for as long as 6 hours. In summer, the temperature of the wash water may be 70°F (21°C) or even higher. When the bags of scallop meats are iced down in the hold, the meat temperature begins to drop slowly, the filled bags contain 3½-4 gallons (13-15 liters) and measure about 16-18 inches (400-450 mm) high by 6-8 inches (150-200 mm) thick; to cool this bulk in melting ice (which is about the most efficient chilling agent known) takes many hours. It could be as short as 8 hours, but it could also be as long as 36 hours. The time depends on meat temperature and thoroughness of icing. And as quality loss in iced products is directly related to time at a specific temperature, it is very important that temperatures be lowered as close to ice temperature as possible and in as short a time as possible. It has been found that the quality of sea scallop meats on landing was greatly improved by rapid chilling in refrigerated seawater (RSW) prior to bagging. In these tests, the RSW was held at 30°-32°F (−1°-0°C), and the equipment was capable of cooling 300 pounds (136 kg) of scallop meats from 70°F (21°C) to 32°F (0°C) in 1 hour. The increase in quality was equal to an increase of iced storage time of 2-9 days as compared with meats not prechilled in RSW. Ordinarily, 10-12 days is considered the maximum storage period for iced sea scallop meats (Varga and Blackwood, 1969).

At present, no vessels are equipped for freezing scallop meats on board. In some preliminary tests, it was found that even poor freezing methods gave better results than when iced scallop meats are frozen ashore. As an example, scallop meats packed in 5-pound (2.25-kg) cartons and slowly frozen aboard the vessel (approximately 24 hours to reach 5°F (−15°C)) were of superior quality during a storage period of 12 months at 0°F (−18°C) to scallop meats held on ice for 2 days in the usual cotton bags, then packaged and plate frozen ashore (Peters, et al.[3], 1959). Research done in Canada also shows that the quality of scallop meats frozen prerigor is significantly better than that of scallops frozen ashore (Dyer and Hiltz, 1974).

The frozen storage life of scallop meats conventionally iced, frozen, and stored at 0°F (−18°C) is considered to be about 12 months. However, no work has been done to determine the influence of length of iced storage on the quality of scallop meats during subsequent frozen storage.

The landing of sea scallops in the shell from the offshore banks is relatively new. The problems involved with this procedure are not yet fully known or properly evaluated. Some processors have found that some vessels are not icing the shell stock as well as they should; but, at present, there are no guidelines available to show the vessel captains the best procedures for stowage.

There is also a difference of opinion about the effect on quality of machine shucking as compared with hand shucking. A processor who uses hand shucking claims that even the very brief exposure of the meats to hot water, as experienced in machine shucking, causes significant cooking of the meats that makes them unacceptable to his customers. A proponent of machine shucking, however, says he has no problem at all in selling his sea scallop meats.

A possible problem area results from the fact that sea scallops cannot close their shells tightly and, thus, die quite rapidly when taken out of the water; and when they die, the shells tend to gape open. The gaping exposes the interior of the scallop to the melt-water from the ice used to cool the product. The melt-water will contain various amounts of mud washed from the shells as it flows over them. It is very difficult (if not impossible) to get the shell stock clean before icing in the hold. To do a really good job would require equipment specially designed and constructed for shipboard installation. A brief rinsing with the deck hose will not do the job.

It is very doubtful that bacteria of public health significance are present in the offshore waters, but there is no guarantee that the scallop meats do not pick these up during subsequent handling. Only strict observance of the fundamental rules of sanitation will insure a completely wholesome product.

Paralytic shellfish poisoning (PSP) is not a problem with scallops. Occasionally, the livers and mantles have measurable toxicity, but PSP has never been found in the adductor muscle and only in very minor amounts in the roe (Bourne, 1965).

AQUACULTURE

A possible solution to the problems of steadily declining catch of sea scallops and the great fluctuations in landings of bay and calico scallops might be found in the application of aquaculture to these species.

Sea Scallops

Surprisingly little work has been reported on the growth of sea scallop lar-

[2]Frank B. Thomas, North Carolina State University, P.O. Box 5592, Raleigh, NC 27607. Pers. commun.

[3]Peters, J. A., D. T. McLane, D. M. Lukshin, and J. W. Slavin. 1959. Tests on the freezing and storage of scallop meats. U.S. Fish Wildl. Serv., Technological Laboratory, East Boston, Mass. Unpubl. manuscr.

vae under laboratory conditions. Early reports indicated little success in raising sea scallop larvae (Posgay, 1953). One researcher, however, recently succeeded in raising sea scallops to maturity in the laboratory and considers this species to be a prime subject for commercial aquaculture (Culliney, 1974). On the other hand, other workers consider that there are more unfavorable characteristics than favorable. Among these are the fact that sea scallops are slow growing requiring 3-4 years to reach marketable size as compared with 1 year for the bay scallop. Also, growth rate cannot be increased by increasing the water temperature. Sea scallop growth is greatest at 50°F (10°C) and declines rapidly above this temperature, ceases entirely at about 68°F (20°C), and the animals die at about 73°F (23°C) (Gates and Mathiessen, 1971; Posgay, 1953).

Bay Scallops

Several scientists have successfully grown bay scallops under controlled conditions, and one of them reports that they will reach marketable size in 5 to 7 months; however, the procedure is, at present, very labor intensive (Castagna, 1975).

Calico Scallops

Very little has been published on raising calico scallops under controlled conditions. Spawning can be induced fairly easily, but this author has found no reports of successful rearing to marketable size.

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