

Shellfish Farming

Shellfish is a culinary and fisheries term for exoskeleton-bearing aquatic invertebrates used as food, including various species of molluscs, crustaceans, and echinoderms. Although most kinds of shellfish are harvested from saltwater environments, some kinds are found in freshwater.

Despite the name, shellfish are not a kind of fish, but are simply water-dwelling animals. Many varieties of shellfish (crustaceans in particular) are actually closely related to insects and arachnids, making up one of the main classes of the phylum Arthropoda.

Familiar marine molluscs enjoyed as a food source by humans include many species of clams, mussels, oysters, winkles, and scallops. Some crustaceans commonly eaten are shrimp, lobster, crayfish, and crabs. Echinoderms are not as frequently harvested for food as molluscs and crustaceans; however, sea urchin roe is quite popular in many parts of the world.

History

Oyster farming was practiced by the ancient Romans as early as the 1st century BC on the Italian peninsula. With the Barbarian invasions the oyster farming in the Mediterranean and the Atlantic came to an end.

In 1852 Monsieur de Bon started to re-seed the oyster beds by collecting the oyster spawn using makeshift catchers. An important step to the modern oyster farming was the oyster farm built by Hyacinthe Boeuf in the Ile de Ré. After obtaining the rights to a part of the coast he built a wall to make a reservoir and to break the strength of the current. Some time later the wall was covered with spat coming spontaneously from the sea which gave 2000 baby oysters per square metre.

Oyster farming is an aquaculture (or mariculture) practice in which oysters are raised for human consumption. Oyster farming was practiced by the ancient Romans as early as the 1st century BC on the Italian peninsula and later in Britain for export to Rome. The French oyster industry has relied on aquacultured oysters since the late 18th century.

Varieties of farmed oysters: Commonly farmed food oysters include the Eastern oyster *Crassostrea virginica*, the Pacific oyster *Crassostrea gigas*, Belon oyster *Ostrea*

edulis, the Sydney rock oyster *Saccostrea glomerata*, and the Southern mud oyster *Ostrea angasi*.

Cultivation

Oysters naturally grow in estuarine bodies of brackish water. When farmed, the temperature and salinity of the water are controlled (or at least monitored), so as to induce spawning and fertilization, as well as to speed the rate of maturation – which can take several years.

Three methods of cultivation are commonly used. In each case oysters are cultivated to the size of "spat," the point at which they attach themselves to a substrate. The substrate is known as a "cultch" (also spelled "cutch" or "culch").^[5] The loose spat may be allowed to mature further to form "seed" oysters with small shells. In either case (spat or seed stage), they are then set out to mature. The maturation technique is where the cultivation method choice is made.

In one method the spat or seed oysters are distributed over existing oyster beds and left to mature naturally. Such oysters will then be collected using the methods for fishing wild oysters, such as dredging.

In the second method the spat or seed may be put in racks, bags, or cages (or they may be glued in threes to vertical ropes) which are held above the bottom. Oysters cultivated in this manner may be harvested by lifting the bags or racks to the surface and removing mature oysters, or simply retrieving the larger oysters when the enclosure is exposed at low tide. The latter method may avoid losses to some predators, but is more expensive.

In the third method the spat or seed are placed in a cultch within an artificial maturation tank. The maturation tank may be fed with water that has been especially prepared for the purpose of accelerating the growth rate of the oysters. In particular the temperature and salinity of the water may be altered somewhat from nearby ocean water. The carbonate minerals calcite and aragonite in the water may help oysters develop their shells faster and may also be included in the water processing prior to introduction to the tanks. This latter cultivation technique may be the least susceptible to predators and poaching, but is the most expensive to build and to operate. The Pacific oyster *C. gigas* is the species most commonly used with this type of farming.

Types

True oysters

True oysters are members of the family Ostreidae. This family includes the edible oysters, which mainly belong to the genera *Ostrea*, *Crassostrea*, *Ostreola*, and *Saccostrea*. Examples include the Belon oyster, eastern oyster, Olympia oyster, Pacific oyster, and the Sydney rock oyster.

Pearl oysters

Almost all shell-bearing mollusks can secrete pearls, yet most are not very valuable.

Pearl oysters are not closely related to true oysters, being members of a distinct family, the feathered oysters (Pteriidae). Both cultured pearls and natural pearls can be extracted from pearl oysters, though other molluscs, such as the freshwater mussels, also yield pearls of commercial value.

Other types of oysters

A number of bivalve molluscs (other than true oysters and pearl oysters) also have common names that include the word "oyster", usually because they either taste like or look somewhat like true oysters, or because they yield noticeable pearls. Examples include:

- Thorny oysters in the genus *Spondylus*
- Pilgrim oyster, another term for a scallop, in reference to the scallop shell of St. James
- Saddle oysters, members of the Anomiidae family also known as jingle shells
- Dimydarian oysters, members of the family Dimyidae
- Windowpane oysters

Fishing from the wild

Oysters are harvested by simply gathering them from their beds. In very shallow waters, they can be gathered by hand or with small rakes. In somewhat deeper water, long-handled rakes or oyster tongs are used to reach the beds. Patent tongs can be lowered on a line to reach beds that are too deep to reach directly. In all cases, the task is the same: the oysterman scrapes oysters into a pile, and then scoops them up with the rake or tongs.

In some areas, a scallop dredge is used. This is a toothed bar attached to a chain bag. The dredge is towed through an oyster bed by a boat, picking up the oysters in its path.

While dredges collect oysters more quickly, they heavily damage the beds, and their use is highly restricted. Until 1965, Maryland limited dredging to sailboats, and even since then motor boats can be used only on certain days of the week. These regulations prompted the development of specialized sailboats (the bugeye and later the skipjack) for dredging.

Oysters can also be collected by divers.

In any case, when the oysters are collected, they are sorted to eliminate dead animals, bycatch (unwanted catch), and debris. Then they are taken to market, where they are either canned or sold live.

Cultivating oysters

Oysters have been cultured for well over a century. The Pacific oyster (*Crassostrea gigas*) is presently the most widely grown bivalve around the world. Two methods are commonly used, release and bagging. In both cases, oysters are cultivated onshore to the size of spat, when they can attach themselves to a substrate. They may be allowed to mature further to form 'seed oysters'. In either case, they are then placed in the water to mature. The release technique involves distributing the spat throughout existing oyster beds, allowing them to mature naturally to be collected like wild oysters. Bagging has the cultivator putting spat in racks or bags and keeping them above the bottom. Harvesting involves simply lifting the bags or rack to the surface and removing the mature oysters. The latter method prevents losses to some predators, but is more expensive.^[34]

The Pacific or Japanese oyster, *Crassostrea gigas*, has been grown in the outflow of mariculture ponds. When fish or prawns are grown in ponds, it takes typically 10 kg (22 lb) of feed to produce 1 kg (2.2 lb) of product (dry-dry basis). The other 9 kg (20 lb) goes into the pond and after mineralization, provides food for phytoplankton, which in turn feeds the oyster.

To prevent spawning, sterile oysters are now cultured by crossbreeding tetraploid and diploid oysters. The resulting triploid oyster cannot propagate, which prevents introduced oysters from spreading into unwanted habitats.

Restoration and recovery

In many areas, non-native oysters have been introduced in attempts to prop up failing harvests of native varieties. For example, the eastern oyster (*Crassostrea virginica*) was

introduced to California waters in 1875, while the Pacific oyster was introduced there in 1929.^[1] Proposals for further such introductions remain controversial.

The Pacific oyster prospered in Pendrell Sound, where the surface water is typically warm enough for spawning in the summer. Over the following years, spat spread out sporadically and populated adjacent areas. Eventually, possibly following adaptation to the local conditions, the Pacific oyster spread up and down the coast and now is the basis of the North American west coast oyster industry. Pendrell Sound is now a reserve that supplies spat for cultivation.^[37] Near the mouth of the Great Wicomico River in the Chesapeake Bay, five-year-old artificial reefs now harbor more than 180 million native *Crassostrea virginica*. That is far lower than in the late 1880s, when the bay's population was in the billions, and watermen harvested about 910,000 m³ (25,000,000 imp bsh) annually. The 2009 harvest was less than 7,300 m³ (200,000 imp bsh). Researchers claim the keys to the project were:

- using waste oyster shells to elevate the reef floor 25–45 cm (9.8–17.7 in) to keep the spat free of bottom sediments
- building larger reefs, ranging up to 8.1 ha (20 acres) in size
- disease-resistant broodstock

The "oyster-tecture" movement promotes the use of oyster reefs for water purification and wave attenuation. An oyster-tecture project has been implemented at Withers Estuary, Withers Swash, South Carolina, by Neil Chambers-led volunteers, at a site where pollution was affecting beach tourism. Currently, for the installation cost of \$3000, roughly 4.8 million liters of water are being filtered daily. In New Jersey, however, the Department of Environmental Protection refused to allow oysters as a filtering system in Sandy Hook Bay and the Raritan Bay, citing worries that commercial shellfish growers would be at risk and that members of the public might disregard warnings and consume tainted oysters. New Jersey Baykeepers responded by changing their strategy for utilizing oysters to clean up the waterway, by partnering with Naval Weapons Station Earle. The Navy station is under 24/7 security and therefore eliminates any poaching and associated human health risk.^[40] Oyster-tecture projects have been proposed to protect coastal cities, such as New York, from the threat of rising sea levels due to climate change.^[41]

Depuration

Depuration of oysters is to remove fecal contamination in seafood before being sold to end consumers.

Oyster depuration begins after the harvest of oysters from farmed locations. The oysters are transported and placed into tanks pumped with clean water for periods of 48 to 72 hours. The holding temperatures and salinity vary according to species.

Economic importance of Oysters

Oysters as food

Jonathan Swift is quoted as having said, "He was a bold man that first ate an oyster" but evidence of oyster consumption goes back into prehistory, evidenced by oyster middens found worldwide. Oysters were an important food source in all coastal areas where they could be found, and oyster fisheries were an important industry where they were plentiful. Overfishing and pressure from diseases and pollution have sharply reduced supplies, but they remain a popular treat celebrated in oyster festivals in many cities and towns.

It was once assumed that oysters were only safe to eat in months with the letter 'r' in their English and French names. This myth is based in truth, in that in the Northern Hemisphere, oysters are much more likely to spoil in May, June, July, and August. In recent years, pathogens such as *Vibrio parahaemolyticus* have caused outbreaks in several harvesting areas of the eastern United States during the summer months, lending further credence to this belief.

Nutrition

Oysters are an excellent source of zinc, iron, calcium, and selenium, as well as vitamin A and vitamin B₁₂. Oysters are low in food energy; one dozen raw oysters contains 110 kilocalories (460 kJ). They are rich in protein (approximately 9g in 100g of pacific oysters).

Traditionally, oysters are considered to be an aphrodisiac, partially because they resemble female sex organs. A team of American and Italian researchers analyzed bivalves and found they were rich in amino acids that trigger increased levels of sex hormones. Their high zinc content aids the production of testosterone.

Selection, preparation and storage

Unlike most shellfish, oysters can have a fairly long shelf life of up to four weeks. However, their taste becomes less pleasant as they age. Oysters should be refrigerated

out of water, not frozen, and in 100% humidity. Oysters stored in water under refrigeration will open, consume available oxygen, and die.

Oysters must be eaten alive, or cooked alive. The shells of live oysters are normally tightly closed or snap shut given a slight tap. If the shell is open, the oyster is dead, and cannot be eaten safely. Cooking oysters in the shell kills the oysters and causes them to open by themselves. Traditionally, oysters that do not open have been assumed to be dead before cooking and therefore unsafe. However, according to at least one marine biologist, Nick Ruello, this advice may have arisen from an old, poorly researched cookbook's advice regarding mussels, which has now become an assumed truism for all shellfish. Ruello found 11.5% of all mussels failed to open during cooking, but when forced open, 100% were "both adequately cooked and safe to eat."

Oysters can be eaten on the half shell, raw, smoked, boiled, baked, fried, roasted, stewed, canned, pickled, steamed, or broiled, or used in a variety of drinks. Eating can be as simple as opening the shell and eating the contents, including juice. Butter and salt are often added.

Oysters can contain harmful bacteria. Oysters are filter feeders, so will naturally concentrate anything present in the surrounding water. Oysters from the Gulf Coast of the United States, for example, contain high bacterial loads of human pathogens in the warm months, most notably *Vibrio vulnificus* and *Vibrio parahaemolyticus*. In these cases, the main danger is for immunocompromised individuals, who are unable to fight off infection and can succumb to septicemia, leading to death. *Vibrio vulnificus* is the most deadly seafood-borne pathogen.