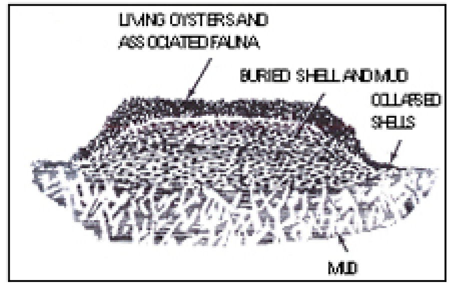
Value of Oysters

Ecological importance

Structure of oyster reefs



Cross section of oyster reef. Image credit: Modified from Bahr and Lanier, 1981.

Oyster reef ecosystem functions are inextricably linked to the reef's unique shell structure. Oyster reefs are created by the constant adhesion of new larvae to existing shells. As the new oysters grow, available settlement space accretes above the substrate, allowing for the attachment of other organisms and more oysters. The structure is not solid, but forms a matrix of interstitial spaces that are critical to habitation by oysters and other organisms (click here to see oyster community).

Some researchers have likened oyster reefs to islands in a sea of soft sediment. In subtidal areas, a mound of shell is formed that grows vertically and laterally, and the top of the bed or reef eventually flattens out, forming a platform (Bahr and Lanier 1981). A similar process occurs in intertidal areas, but the height is limited by the tidal elevation of the bed and the ability of oysters to withstand desiccation and temperature extremes. Structurally, the bed is composed of a base of mud, overlain with a mixture of buried shell and mud, with a veneer of living oysters and associated organisms. The shape of the oysters is influenced by density and the amount of siltation. Crowded conditions may result in oysters being elongated and sometimes watery because of competition for algae and detritus particles in the water. Silt deposition rates great enough to bury the oysters may also lead to elongated shells, as the oysters typically respond with increased shell growth in length.

Ecological community

The number of species found on any given oyster reef varies according to location, temperature, and salinity, but all oyster reefs have a diversity of species on, within, and around them. In one detailed study (Wells 1961), more than 300 invertebrate species were identified from local reefs near Beaufort, North Carolina. Most species associated with oysters and shells are fouling or encrusting organisms that attach directly to the shells - e.g., sponges, hydroids, bryozoans, barnacles, mussels, limpets, and some kinds of clams (e.g., ark shells, which have byssus threads) and other bivalves, in addition to the oysters themselves.

Some of the remaining animals live among the sessile ones and depend on them, or the algae growing on or between them, for food (e.g., small crustaceans, worms of various types, gastropods, and some fish). The shell matrices or crevices provide refuge from predation for many species, including small clams, grass shrimp, crabs, and worms.

In addition to these species, others, such as boring sponges and bivalves, are pests that burrow into the shell and may affect the health of the oysters. The soft-bodied "pea" crab (*Pinnotheres ostreum*) is a commensal organism that enters and remains in the mantle cavity of the oyster. One ectoparasite, the gastropod Boonea impressa, stays at the shell edge of the oyster, attaches to the oyster's mantle with its proboscis, and sucks out body fluids; as many as 100 of these parasites have been observed on a single oyster.

Many predators of oysters and other mollusks are found on oyster reefs, such as the gastropods called "oyster drills" (e.g., *Thais* sp., *Murex* sp., *Eupleura caudate*), various species of starfish, crabs (e.g., blue crabs and mud crabs) and even flatworms (*Stylochus* sp.). The substrate between or beneath oysters also contains many polychaete worms and clams that serve as food for other predators.

Some species of fish - e.g., gobies, skillet fish, blennies, oyster toadfish, and pipe fish - use oyster reefs as nesting sites. The fish attach their eggs in clean, articulated oyster shells, and this provides a measure of protection for them until they hatch. Other fish may forage on the reef and prey on the eggs or larvae.

Nutrient cycling

Because they are filter feeders, oysters can greatly influence nutrient cycling in estuarine systems and maintain the stability of the ecosystem. Oysters filter large amounts of phytoplankton and detritus (small organic particles) from the water column. As grazers of phytoplankton and other particles, these filter feeders couple, or join, the reef to the water column. The organic components resulting from metabolism are returned, or "remineralized" to the water in the form of feces, pseudofeces (see Biology Section) or excreted as urea, ammonium, nitrogen, phosphorus, and other inorganic nutrients. This flux or cycling of carbon and other essential materials is vital for the continuity and stability of any living system and acts to keep the system in balance.

On oyster reefs, the nutrients are moved from the water column to the benthos and back via the pumping action of oysters and other bivalves. In this process, suspended particles are aggregated in the oysters' guts and, when excreted, are used for food by deposit feeders and other organisms living in the sediment. Organic matter contained in the particles filtered by the oysters is used for growth, resulting in increased biomass, and some of the oysters are consumed by predators or degraded by bacteria and other organisms when they die, cycling the nutrients once more (Dame 1996). The resulting inorganic nutrients (e.g., dissolved carbon, nitrogen, and phosphorus) excreted by the bivalves, predators, and other reef and benthic organisms back into the water column is used by primary producers (phytoplankton), recycling these components through the system (Dame 1996; Dame et al 1984).

In systems with high ratios of oyster biomass to water volume, the removal of suspended organic particles by the bivalves controls nutrient flow in an estuary, and therefore the amount of phytoplankton, zooplankton, and other components of the ecosystem. For example, Chesapeake Bay was once dominated by oyster reefs and bivalve filter feeders, and the loss of these reefs has resulted in the Bay's shift from a benthic-pelagic system to a planktonic system.

Water quality

Oysters and some other bivalves (e.g., mussels) are suspension feeders that remove particles from the water column by passing it over their gills and either using it for food or binding it into larger segments, to be discharged from the gills and mantle cavity. Oysters are particularly efficient at filtering water and may have significant effects on phytoplankton biomass in an area. This is especially true if the oyster reef is dense and covers a relatively large area. Mussels, which also attach to oyster reefs, augment the filtration rates carried out on the reefs. Filtration activity is defined in terms of clearance rate - i.e., the volume of water cleared of particles per time unit. Clearance rates for *Crassostrea virginica* in Chesapeake Bay have been estimated at 163 liters per gram (of oyster tissue) per day. The time needed for oyster reefs to filter water depends on the biomass of the oysters, the concentration of phytoplankton, retention time of water in the bay, and many other factors. Using historical densities of oysters in Chesapeake Bay, one researcher estimated that the oyster population there in pre-colonial times could filter all of the water in Chesapeake Bay in 3.3 days, but now, because of depletion of the reefs, it would take 325 days (Newell 1988).

Encrusting, or fouling, organisms (e.g., tunicates, bryozoans, sponges, barnacles, and some polychaete worms) on oyster reefs and in the surrounding benthos are also suspension feeders and contribute to the overall filtering capacity of a reef. Because more oysters and associated animals can live where the structure of reefs is three-dimensional (e.g., pyramid-shaped) rather than flat, reef construction should reflect this consideration, especially if water quality is an important goal of the project.

Oyster Reefs and Submerged Aquatic Vegetation

Submerged aquatic vegetation (SAV), or sea grasses, constitute another key habitat in most estuaries and provide food, habitat, and nursery areas for many species. However, the density and areal extent of sea grass beds depend heavily on clear, relatively calm water. Pollution and sedimentation from unprecedented development in most coastal areas, along with increasing boat traffic, pose serious threats by diminishing water clarity and eroding shoreline areas.

To help restore SAV, some restoration projects combine oyster reef construction with sea grass plantings behind the reefs or within the shells to help establish SAV beds. The oyster reefs filter the water, increasing water clarity and, therefore, photosynthesis in the sea grasses, and also serve to protect the plants against erosion of substrate. Research is also under way in Chesapeake Bay to develop a predictive model using oyster biomass, water clarity, grass density, and other variables for evaluating potential SAV restoration project sites.

Economic importance

Oyster fishery and infrastructure

Despite declines in oyster landings, the value of the oyster industry to regional economies remains significant. Annual dockside value was around $30 million in the mid-1900s, and reached highs of more than $90 million per year in the 1990s. The full economic value of oysters goes well beyond dockside value; in addition to primary sales of the raw, unshucked product, there are economic benefits from secondary products and services (e.g., shucking and packing houses, transport, manufacture of prepared oyster products, and retail sales). For example, oysters worth $1 million in dockside value in Chesapeake Bay generate an estimated $36.4 million in total sales, $21.8 million in income, and 932 person- years of employment (Kirkley 2004).

Why have the patterns of production for this time-honored culinary delight, cultural icon, and valuable economic commodity changed so dramatically? Changes in regional production are the result of many interacting factors: local oyster abundance, local and national market forces, fishery management, and fishing industry dynamics (e.g., Gulf fishermen switching from shrimping to oystering).

Understanding these factors requires a closer look within key regions, at oysters themselves, their ecological habitats, and the fisheries based on them.

Atlantic Coast

The Atlantic coast includes several regions: New England, Middle Atlantic, Chesapeake, and South Atlantic. The oyster species native to all these regions is the American or Eastern oyster, *Crassostrea virginica*, which ranges from the Gulf of St. Lawrence to Florida and into the Gulf of Mexico. This oyster has been the mainstay of the U.S. oyster industry.

Oyster fisheries along the Atlantic coast are traditionally based on harvest from public and leased bottom. The proportion varies greatly among states, with some states favoring a public fishery and others encouraging private investment on leaseholds. Oyster production is limited by available substrate (shell material) for larvae to settle upon and grow. Some states subsidize their public fishery by planting shell and using aquaculture to grow oysters, then distributing the young spat to known oyster beds. Private growers carry out similar activities to cultivate their leased grounds. Other techniques, such as off-bottom aquaculture (e.g., oysters grown in bags hanging from floating surface structures), have been developed in some locations, but use of oyster beds remains the predominant production method.

Atlantic production is currently at such low levels that the industry infrastructure has all but collapsed. Total value of all oysters harvested in 2003 was less than $15 million, compared to a high of about $59 million in 1992. The average price of $6 per pound (all species combined) reflects the scarcity of oysters on the Atlantic coast. Some once-booming oyster ports are now ghost towns. In Chesapeake Bay, local harvests are insufficient to supply the few shucking houses that remain, so they are now processing Louisiana oysters. Oyster business owners wonder how long they will be able to keep their doors open.

Gulf Coast

Eastern oyster populations in the Gulf did not experience the severe historic declines from overfishing that occurred in the Chesapeake and Middle Atlantic regions. Still, Gulf oyster reefs are greatly diminished and suffer from many of the same modern problems, including pollution, habitat degradation, disease, and harvest pressure. However, production has remained fairly steady, and total value of Gulf oysters reached an all-time high of $61 million in value in 2003.

Like the Atlantic region, the Gulf oyster fishery includes both public and leased grounds. Much of the stability in Gulf oyster production can be attributed to the many private bottom leases, particularly in Louisiana, which growers assiduously maintain via cultch planting and seed-oyster transplanting. One of the techniques for increasing spat set and production on leases is to use dredges to resurface buried and silted shell so it is clean and available to oyster larvae.

Oyster growers assiduously maintain the bottom habitat on their leaseholds, ensuring that a constant supply of clean shell substrate is available to oyster larvae for settlement. Shell planting also occurs on public grounds. Off-bottom and pond-based aquaculture are being developed, but are not yet widely practiced. A major issue for the Gulf oyster industry is the human health risk associated with eating raw oysters tainted with the bacteria (e.g., *Vibrio* sp.) that cause cholera and other illnesses. State agencies monitor water quality and periodically close oyster beds to harvest, especially when heavy rains input high bacterial loads from the land. The industry is working to increase safety by using post-harvest treatments to reduce bacteria.

Pacific Coast

Olympia oyster populations were overharvested along the Pacific coast in the 1800s and further declined due to poor water quality in the early 1900s. Subsequent efforts to sustain a viable oyster industry in the Northwest led to establishment of a significant hatchery-based aquaculture industry. This industry primarily cultivates the non-native Pacific or Japanese oyster (*Crassostrea gigas*), which was first imported in the early 20th century. The Eastern oyster and a variety of other non-native species (e.g., Kumamoto oyster and European flat oyster) are also cultivated in smaller numbers as specialty items for the half-shell market. Production of oysters on the Pacific coast, primarily in Washington State, has remained at about 10 million pounds annually for the past several years, with values of $25 to $30 million from 2000 to 2003. It is notable that the value of Olympia oysters has averaged about $25 per pound from 1993 to 2003.

The non-native Pacific oyster is now the most important commercial oyster species in the region, constituting 99 percent of all West Coast oyster production. The vast majority of Pacific oysters come from Washington State, which has the largest concentration of oyster farms in the nation.

Oyster reefs as habitat for other commercial species

No other habitat type is itself a commercial edible species and also serves as refuge and food for other commercial species. Oyster reefs do this and much more. Because of the many species associated with oyster reefs, several commercial species use reefs at some time in their life cycles and prey upon the oysters and other associated fauna. A few of the commercial species observed in different studies include flounder, menhaden, herring, anchovies, spadefish, striped bass, cobia, croaker, silver perch, spot, speckled trout, Spanish mackerel, pinfish, butter fish, harvest fish, blue crab, stone crab, penaeid shrimp, black drum, and several species of mullet.

The importance of restoring oyster reefs cannot be overemphasized. Few habitats are as ecologically and economically important.