

Culture of Oysters

History

California's oyster fishery and oyster aquaculture industry have had a rich and colorful tradition. American Indians harvested the oyster resource for thousands of years before Spanish, Tsarist Russian, and European settlers occupied the West Coast. A substantial commercial oyster fishery began in the 1850s, when settlers from the East Coast attracted to California by the prospect of gold and new opportunities created larger markets for oysters. The increased population and market pressure for oysters had an immediate impact on the state's shellfish resources. The only available oyster was the Native oyster (*Ostreola conchaphila*; previously *O. lurida*; also called Olympia oyster in the Pacific Northwest), which was intensively fished, causing a rapid decline in the natural population. In response, Native oysters were transported from Shoalwater Bay, Washington (Willapa Bay), and later from other bays in the Pacific Northwest and Mexico, representing the initial attempts at oyster culture on the West Coast. Oysters were transplanted into San Francisco Bay, where they were maintained on oyster beds and then marketed throughout central California. The Shoalwater Bay trade of Olympia oysters dominated the California market from 1850 through 1869. Market demand for a larger, half-shell product stimulated experiments in transporting the Eastern oyster (*Crassostrea virginica*) from the Atlantic states to the West Coast. Several failed attempts were made to establish transport of the Eastern oyster to

California by sailing ships. Successful transport of oysters was achieved only after the completion of the transcontinental railroad in 1869. Shipments of juvenile and market-sized oysters were transported by rail in barrels of sawdust and ice and transplanted into San Francisco Bay. Cool summer water temperatures, however, prevented successful natural reproduction of the Eastern oyster.

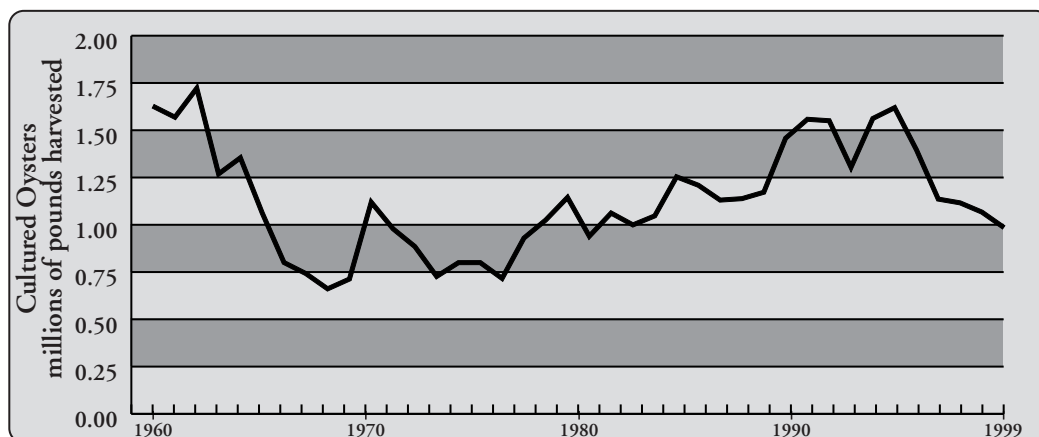
Transcontinental trade for Eastern oyster seed was fully established by 1875. Small, one-inch seed was transplanted in San Francisco Bay for further growth. The Shoalwater Bay trade for Olympia oysters was gradually terminated, and from 1872 until the early 1900s California's San Francisco Bay Eastern oyster industry was the largest oyster industry on the West Coast. Maximum production was reached in 1899 with an estimated 2.5 million pounds of oyster meat.

With California's population and industrial growth came a degradation of water quality in San Francisco Bay. By 1908, Eastern oyster production had fallen by 50 percent. By 1921, oyster meat quality declined to the extent that shipments of seed from the East Coast were terminated, and by 1939 the last of the San Francisco Bay oysters were commercially harvested. Oysters were still transported and held in Tomales Bay until they could be marketed in San Francisco, but the industry based on the Eastern oyster did not recover. The industry and state began re-examining earlier experimental plantings using the Pacific oyster (*Crassostrea gigas*), which originated in Japan. The California Department of Fish and Game (DFG) and commercial growers conducted experimental plantings of Pacific oysters in Tomales Bay and Elkhorn Slough in 1929. Experimental plantings continued in a number of bays, including Drakes Estero, Bodega Lagoon, and Morro, Newport, and San Francisco bays, throughout the 1930s. Humboldt Bay was excluded from plantings while the DFG tried to re-establish natural populations of Native oysters. Several Pacific oyster plantings proved successful, demonstrating that imported Pacific oyster seed could be grown commercially in California. Shipments of seed from Japan were made through the 1930s, suspended from 1940 through 1946, and increased significantly in 1947. The imported seed was inspected in Japan by both DFG personnel and commercial producers prior to shipment. DFG personnel examined the shell for organisms considered harmful if introduced into state waters.

Boxes containing oyster shell with attached young oysters (spat) were transported by ship in wooden crates kept moist with seawater. With the influx of seed oysters, the industry began its recovery in California and on the West Coast. The DFG lifted its restriction on Pacific oyster seed in Humboldt Bay in 1953, and in the next 30 years, the California industry showed rapid growth with production



Growing Oysters in Tomales Bay
Credit: Fred Conte



Commercial Harvest* 1960-1999, Cultured Oysters

Annual pounds of cultivated oysters harvested by State aquaculture producers. Data Source: California State Tax records (royalties reports) and DFG Aquaculture Harvest Survey Database.

* Packed weight is estimated to be 15.5 percent of live weight for *C. gigas* and 10.9 percent for *C. virginica*. Shucked gallons are calculated as 8.6 pounds/gallon for *C. gigas* and 8.5 pounds/gallon

for *C. virginica*. Cultchless oysters, *C. sikamea* and a large portion of *C. gigas* are sold as shellstock.

centered in Humboldt Bay, Drakes Estero, Tomales Bay, Elkhorn Slough, and Morro Bay.

The West Coast oyster industry initiated other significant changes in the early 1980s, which have had a significant impact on the industry nationally. These changes include the development of U.S. based shellfish hatcheries for the domestic production of Pacific oyster seed, and the ability to ship advanced hatchery-produced oyster larvae (swimming stage) to growout sites where the larvae are placed in tanks containing cleaned shell and heated seawater for spat production. In this process called remote setting, the larvae settle on clean oyster or scallop shell, called mother shell or cultch, attach and metamorphose into the more familiar flat young oyster called spat. Spatted cultch ultimately results in about nine to 13 market-sized oysters clustered on remnants of the old mother shell.

Another hatchery product is cultchless oyster seed that are grown out as individual oysters exclusively for the half shell market. Cultchless seed are produced by setting the larvae on sand or finely crushed oyster shell, resulting in unattached, individual oysters. Many California growers purchase cultchless seed from California-based advanced seed producers. These producers receive 3.0 to 5.0 mm cultchless seed from a hatchery, then use floating upweller systems (FUS) to hold the seed in flow-through containers receiving bay water containing algae. The oyster seed increases in size and is more easily handled in mesh bags used by the end producer. Individual growers are also adopting and expanding their own land-based FUS and downwellers to cut the cost of seed and assume the responsibility of early seed growth. All oysters grown in California currently are produced from hatcheries located in Washington, Oregon and Hawaii.

The hatchery systems primarily produce two species of Pacific oysters; the Pacific oyster (*C. gigas*) and the Kumamoto oyster (*C. sikamea*) which also originated in Japan and does not reproduce in California's cooler summertime

water. Other less prominent species produced by hatcheries have included the European oyster (*O. edulis*) and some Eastern oyster (*C. virginica*). The ability to ship oyster larvae long distances and set the spat at the growout areas has significantly reduced the cost of seed. The last shipment of Japanese seed to California was in 1989.

The level of oyster production within the various bays has fluctuated throughout the years, primarily because of water quality, the bay's ability to produce good standing crops of algae on which oysters feed, the adequacy of selected sites, and the financial viability of the various oyster operations. All growing areas are classified and certified by the California Department of Health Services (CDHS) based on health-related water quality standards established and regulated by the Interstate Shellfish Sanitation Conference (ISSC) and the National Shellfish Sanitation Program (NSSP). Water-bottom and offshore growout areas are leased from the state through the Fish and Game Commission, harbor and recreation districts, or belong to private corporations.

The industry uses a variety of oyster culture methods depending on the targeted market, the physical characteristics of the production bay and the need to protect the younger oysters from predators such as bat rays, rock crabs, and drills (snails). Culture methods are also influenced by factors such as substrate type, current velocity, tidal range, and phytoplankton productivity. California oysters are grown from spat to market size in about 13 to 18 months, depending on the bay and the culture method used.

California oyster production is currently centered in four areas, Arcata Bay located in the North Humboldt Bay complex, Drakes Estero, Tomales Bay and Morro Bay. Morro Bay oyster production has declined in recent years, but techniques have included bottom, rack-and-bag, and stake culture. Shellfish producers in the Santa Barbara Channel

have used a system of longlines with attached bags of European oysters suspended from offshore rafts in the deep waters, but have discontinued production in recent years. Shellfish producers also cultured cultchless oysters in Agua Hedionda Lagoon, located north of San Diego, but have switched to mussel production which was considered more suitable to the area.

Humboldt Bay growers use a variety of oyster culture methods, but the predominate method has been bottom culture of Pacific oysters. In bottom culture, cultch with attached spat is spread over leased areas in the bay, the oysters are grown to about four inches and are then harvested by hand picking and hydraulic dredge. Most of California's shucked oyster product is from bottom culture in Humboldt Bay. Because of environmental concerns and the impact of hydraulic dredging on eelgrass, growers are currently changing about 85 percent of their bottom culture production over a period of about three years to off-bottom, longline culture of the Kumamoto oyster. The Kumamoto oyster derives a higher market price as non-shucked shellstock, and the remaining bottom culture will be targeted for the peak shucked-oyster market in November and December. Environmental and economical studies are being conducted to determine the impacts of these changes on both the health of the bay and the economic health of the industry.

Longline culture primarily consists of a series of notched PVC pipe set in the substrate with twisted line stretched over the apex of the poles. Spatted cultch is inserted at intervals between the strands of the line which hold the growing oysters above the substrate. The lines containing the clustered oysters are harvested on a flood tide, thereby reducing disturbance to the substrate or associated eelgrass. Other forms of culture are off-bottom techniques, including bags of cultchless oysters supported by low racks and floating oyster bags attached to longlines.

Drakes Estero has one of the largest off-bottom, rack culture systems in the west. Like all off-bottom culture, the method is used primarily to avoid predators, use more of the water column, and avoid siltation that occurs when the oysters rest on the substrate. The rack culture system uses spatted mother shells strung on short lines with a tube spacer separating each mother shell. The short lines are hung in an inverted u-shape over the horizontal rails of wooden racks set in the bay.

Tomales Bay growers also use a variety of off-bottom techniques including rack-and-bag, stick and bag, and bag and longline culture. Rack-and-bag culture uses cultchless seed that is first grown in trays, upwellers and downwellers, or floating, rotating, mesh cylinders. After initial growth, the small oysters are transferred to a series of different sized mesh bags positioned on low racks in the bay. Bag and longline culture use cultchless seed in mesh bags attached

to an anchored line which suspends the bags vertically in the water or secures the bags on a stable, hard bottom, intertidal area. Bags can also be maintained horizontally at the surface using floats. To maintain the prime oyster shape for the half shell market, the bags must be moved frequently to prevent the individual oysters from growing together and resulting in an irregular shape.

Total annual oyster production for California has fluctuated throughout the industry's history, reflecting cyclic shellfish mortalities ("Summer Mortality Syndrome", SMS), availability of seed oysters, economic conditions, and the financial stability of individual companies. With the advent of hatchery technology and remote setting of oyster seed, the industry demonstrated significant growth from the mid-1980s to a second post-1960s peak in the mid-1990s. Reduced production after 1994 directly reflects several industry setbacks, which include financial restructuring after the 1990s recession, extended bay harvest closures due to sanitary degradation and oil spills, and recurrence of cyclic SMS. Several of these factors have been resolved, and production increases are expected. The data represents a conversion of all oyster products to a common denominator of shucked pounds of oysters expressed as packed weight. Total production in recent years is primarily Pacific and Kumamoto oysters. Annual Eastern oyster production has been 20 pounds or less for the past three years.

Oyster products are marketed as shucked meat in gallons and 10-oz jars, and as shellstock for the half-shell and barbecue markets. The shucked product is marketed as small (200/gallon), medium (140/gallon), and large (100/gallon). Shellstock is marketed as small (2.5-3.5 inches), medium (3.5-4.5 inches), large (4.5+ inches) sold by the dozen, and clusters (attached, mixed). The demand for oyster products far exceeds the state's production level, and the majority of shellfish products consumed in the state are imported from the Pacific Northwest and the Atlantic and Gulf states. California's product is considered prime, and its production areas are among the best in the country.

The CDHS has regulatory responsibility over shellfish product safety and periodically conducts sanitary surveys with the Federal Food and Drug Administration under worst-case scenarios such as heavy rain to determine growing area water quality and sanitation conditions. Two essential programs are the monitoring of the bays for indications of contamination, including human sewage, and for the occurrence of natural biotoxins such as paralytic shellfish poison produced by toxic phytoplankton. The programs are designed to provide a safe product for the consumer and an early warning system for people sport-harvesting shellfish in noncommercial areas. The water and meat quality monitoring programs conducted by the CDHS also provide an assessment of the biological condition of the

bays, which is essential information used by all agencies to prevent a reoccurrence of events which led to the contamination of San Francisco Bay.

Status of Biological Knowledge

Oysters are bivalve mollusks that exhibit a variety of sizes, shapes, shell textures and colors, and vary in their mode of reproduction and sexual expression. These biological and physical features influence where they grow and how they reproduce, which in turn influence commercial aspects such as culture practices and marketing strategy. The depth of the shell cup and the shape of the oyster influence market price of shellstock. Individual oysters conform to the shape of the substrate to which they are attached and are therefore highly variable in shape. In addition, shell shape, texture, and color are all influenced by the oyster's genetics and physical environment such as salinity, attachment substrate, crowding by other oysters and food. They feed on phytoplankton and nutrient-bearing detritus by pumping water over their gills, filtering the food material and passing it into the mouth.

All oysters have a typical molluscan trochophore larva that develops into a veliger larvae capable of filtering food, swimming, and selecting a suitable substrate for attachment. The microscopic veliger settles, cements its left valve to the substrate, and undergoes metamorphosis into an oyster spat. For the rest of its life the attached spat will compete for space and nutrients and, if it survives, will grow into the adult form. The five oysters now found in California belong to the family Ostreidae. They represent two groups characterized by biological variations, including different modes of sexual expression, reproduction, and dispersal of young. The exact temperature at which the oysters will spawn and the rate of larval development and growth depend on a variety of factors, including species, genetics and latitude of the breeding population. Natural spawning is also influenced by lunar periodicity and tides.

The Native and European oysters are rhythmical consecutive hermaphrodites; they can change sex either annually or at closer intervals. In their first year, they are strongly protandric; the first expression of sex at maturity is male. They may become female in the same year or in the following year if environmental conditions are good and food is plentiful. They are also larviparous (brooders); fertilization of eggs is internal, and the larvae are held for a period of time before release. Mature, egg-carrying females spawn at about 59-63° F. The eggs are released into the female's own mantle cavity and are fertilized as she takes in water containing the male's sperm. When the eggs hatch, the veliger larvae are held by the gill-

blades and incubate for about 10 days before release. Once expelled, the advanced larvae swim freely and feed on phytoplankton before settlement and metamorphosis (Native, 14-18 days; European, 10-14 days).

The Pacific, Kumamoto and Eastern oysters are alternative hermaphrodites; sex change occurs, but its timing is erratic. They have a tendency for protandry in their first year, but the tendency is not as strong as that of Native and European oysters. They are oviparous (broadcast spawners); the eggs are immediately released and fertilization takes place in the environment. Mature, egg-carrying females spawn at about 63-77° F, depending on the species, variety, and latitude. Water temperatures required to establish a natural population are higher than those consistently found in California. Since natural spawning and successful reproduction rarely take place in California, the oysters are spawned and reared in shellfish hatcheries at about 77° F. The eggs hatch into free-swimming trochophores, then become veliger larvae. Within three to five days these larvae settle, attach to a substrate, and metamorphose to spat.

The Native oyster is California's only indigenous oyster species and occurs along the Pacific coast from Sitka, Alaska to Cape San Lucas, Baja California. The largest concentrations occur in the Pacific Northwest along the coast of Washington's Puget Sound and in Willapa Bay. Although still grown commercially in Washington in specially constructed beds, natural concentrations are not abundant enough to support commercial endeavors. Populations of the Native oyster are still relatively low in California. Some protection of existing populations is provided by sport fishing regulations, which allow a daily harvest of 35 native oysters under the general invertebrate bag limit. The adult is about one to three inches in length and more often irregular in shape. Shell textures vary from smooth to rough with concentric growth lines, and the exterior has purple-brown to brown axial bands. The two shell valves are symmetrical; their interior is shades of olive-green and can have a metallic sheen. The internal shell's muscle scar in adults is usually centrally located and unpigmented.

The Native oyster is found in many of California's coastal inlets, especially mudflats and gravel bars located near the mouth of small rivers and streams. It cannot withstand high temperatures or frost when exposed, and does not survive low salinity or turbid water. The natural beds are invariably located in the low intertidal and subtidal zone of bays, where the oyster is better protected from both prolonged hot summer surface water temperatures and extreme cold winter water conditions. The oysters are often found clinging to rocky outcroppings or other structures that offer protection from rays and other predatory fish.

Adult European oysters are about three to four inches in length, with a poorly developed beak that gives the valves an oval to round shape. The left or attachment valve is larger and more deeply cupped than the right valve, with 20 to 30 ribs and irregular, concentric lamellae. The upper, smaller valve is flat, with numerous concentric lamellae but no ribs. The hinge ligament consists of three parts: a middle, flat part on the left valve and two projections on the right. The internal valves are white, and the muscle scar is eccentrically positioned and unpigmented.

Adult Eastern oysters may vary in length from two to six inches. The shells are asymmetrical, highly variable in texture and shape, and greatly influenced by environmental conditions. The external shell is usually a shade of gray, and the internal valves white with a variable-colored muscle scar, usually deep purple. The left valve is longer than the right, not deeply cupped, and the beak is usually elongated and strongly curved. The shell margins are usually straight or only slightly undulating, and the inner margins of the valves are smooth.

The adult Pacific oyster ranges from about four to six inches in length. The shell is coarse, with widely spaced concentric lamella and ridges. The shell is thinner than that of Eastern oysters yet more deeply cupped. The Kumamoto oyster is smaller but is prized for its deeper cup. It spawns in the fall in nature and grows more slowly than the Pacific. The Miyagi is the principal variety of Pacific oyster grown on the West Coast. The Pacific oyster's shape may be highly variable and greatly influenced by environmental conditions. The upper, flat, right valve is smaller than the left, and the inner surface of the valves is white with a faint purple hue over the muscle scar.

Oyster disease and shellfish pests are a major concern to the state resource agencies and the oyster industry. Because the West Coast industry depends on the movement of animals across state lines, the industry is subject to regulations established through cooperative agreements between resource agencies. All oyster seed and shellstock not destined for a terminal market that cross state lines are examined for the presence of disease and exotic "hitchhikers" (pests) which could be harmful to natural resources and commercial interests. Seed and shellstock that do not pass certification are destroyed through cooperative agreements with the state and the industry. The various state natural resource agencies have a cooperative program which regulates the interstate movement of shellfish seed and seedstock.

Oyster diseases on the West Coast most frequently occur in hatcheries, but a few significant oyster diseases have been reported from the field. Hatchery conditions are artificial environments which can stress oysters and render them susceptible to an array of infections. Hatchery-asso-

ciated oyster diseases are usually confined within the hatchery. When identified, the stocks are destroyed and systems disinfected. This is a protective measure for the natural resource and considered the most economically practical approach by the industry.

Field-associated oyster diseases are not common, but they do occur. Two examples of the most significant of these diseases for the West Coast are "Summer Mortality Syndrome" (SMS) of Pacific oysters, and "Bonamiasis" of European oysters. Summer mortality of Pacific oysters was first reported in the 1960s with mortality levels as high as 65 percent of adult Pacific oysters. Oyster losses attributed to SMS have fluctuated over the years, and studies have addressed the initiating agent as possible unknown pathogens, environmental factors and impacts, and stressors such as the combination of depleted energy reserves and attempted gonadal maturation. SMS was researched for decades without resolving the cause. In 1993 and 1994, summer mortalities of Pacific oyster seed in Tomales Bay reached 52 and 63 percent respectively, and were associated with elevated water temperatures above 20°C and a dinoflagellate bloom. Pathological examination and histology suggested that these mortalities were related to environmental causes and not an infectious agent. SMS appears to be cyclic, may be related to decadal cycles, and is the most significant mortality-related event experienced on the West Coast of the United States. In addition, as the losses are a "syndrome" and are not caused by a specific pathogen, multiple etiologies may result in oyster deaths during the summer. The type of stress that results in losses may also fluctuate over time, making diagnosis of the cause(s) and management of losses difficult. Growers are attempting to circumvent the problem by not planting Pacific oyster seed during the warmer months from May to October. However, seed availability during the cooler months has been a problem. Growers report that cooler bay water temperatures in 1999 appear to have moderated the mortality rate from that experienced previously.

Bonamiasis of the European oyster, caused by a parasite, has impacted the oyster industry to the same extent as SMS, as it has contributed to the inability to establish European oyster culture in California. The parasite infects the oyster's blood cells, destroys its immune system, and impacts other physiological processes.

Of recent concern is the 1980s discovery in California of a haplosporidium similar to that which causes MSX or Delaware Bay Disease on the East Coast. West Coast producers have not experienced the cyclic, catastrophic haplosporidia diseases that have occurred on the East Coast, despite movement of Eastern oysters between the coasts. It has been confirmed that the organism is the causative agent of MSX of Eastern oysters. The organism is found among Pacific oysters in one bay in California

but is not associated with significant mortalities. Morphologically similar haplosporidians have also been reported from Washington state. Recent studies suggest a common ancestry for the organism on both coasts and that the haplosporidian was not endemic to the East Coast but originated in Pacific oysters from Japan. Hypotheses for the introduction of the disease to Eastern oysters include importation of infected Pacific oysters to the East Coast, ballast water containing the infective agent, or introduction of an unknown intermediate host. In any event, the ultimate result has been catastrophic for the Eastern oyster and the East and Gulf coast industries. The result of these studies demonstrates the first molecular confirmation of the introduction of an exotic marine pathogen and emphasizes the need to adhere to strict importation guidelines as established by the International Council for the Exploration of the Seas (ICES).

Shellfish and the Environment

One of the more significant challenges to aquaculture in the next decade will be the industry's ability to position itself within the environmental framework and philosophy of natural resource management. Environmental issues are a concern nationally and are paramount in California.

Immediate environmental concerns relative to shellfish culture are the potential biological and physical impacts of culture technology on sensitive components of the marine ecosystem. These sensitive components include eelgrass as essential habitat for salmonid and other finfish, and the invertebrate assemblage present on and within the substrate that is essential to the food web of birds and other marine species. Also included are the impacts on the life habits of birds and marine mammals and on the physical structure of the bay. It will be essential that shellfish technology not have significant impact upon the health of the ecosystem on which it also depends. Shellfish culture and our living marine resources depend upon excellent water quality and a healthy environment and, therefore, these concepts are not mutually exclusive.

In response to these concerns, long-term federal and state supported regional research has been initiated to study shellfish culture impacts. This research is being conducted by university and state research agency personnel, focuses on the industry in California, Washington, and Oregon, and is monitored continuously to identify areas that may need immediate alteration. In addition, federal and state funding, coupled with industry resources, is being directed toward the development of industry best management practices to guide the industry in its present and future development.

Future Trends

Oyster hatchery and production seed technology has rapidly expanded in the past ten years. This has included application of remote setting of oyster seed as an industry standard, and the production and use of triploid (3n) oysters containing an extra set of chromosomes. The 3n condition prevents the onset of maturation and results in oysters characterized by year-round production of high quality meat. Although triploid production was a positive technical breakthrough, the sterile 3n oyster does not reproduce and therefore can not be improved through genetics. To overcome this, the industry now applies high pressure following fertilization to retard both polar bodies. The resultant tetraploids (4n) are then artificially crossed with diploids (2n), thereby producing sterile triploids (3n) that are used as production oysters while maintaining a viable genetic line in the diploid broodstock. This technology, coupled with the more recent establishment of broodstock genetic programs, will be a major industry thrust.

Oyster genomic research is an industry priority and a regional cooperative effort involving university and industry geneticists and oyster hatchery managers.

The establishment of a national Molluscan Broodstock Program (MBP) and the Molluscan Broodstock Center on the West Coast mark the true beginning of an oyster genetics program which fosters cutting edge genetics research. Using a mix of regional and national grants, geneticists are utilizing cooperative regional research to develop genetically marked family lines that are tested and selected for high yield and survival. Scientists are exploring the alternative strategy of crossbreeding and have demonstrated at the larval and market sizes that hybrid Pacific oysters have dramatically higher yield and superior metabolic performance than their inbred parents. This striking hybrid vigor or heterosis suggests that crossbreeding, in addition to traditional selection as practiced by the MBP, could improve oyster yield dramatically and quickly. Technology is also being developed to measure and more readily define "future performance" at the larval stage, thereby avoiding costly growout trials and stock maintenance.

Current and future trends of the oyster industry are reflected throughout the West Coast and the Pacific Rim because of the industry's regional infrastructure and markets. Industry shellfish hatcheries which were concentrated in the Pacific Northwest have opened in Hawaii, thereby taking advantage of stable water quality and consistent solar radiance used in energy-efficient algal culture. The primary markets for seed are West Coast producers who will expand into more international markets. The industry is rapidly expanding Kumamoto oyster production because of its higher value and half-shell market

demand, and greater market attention will be given to value-added shellfish products such as flash-frozen half-shell products for international Pacific Rim markets.

The oyster industry will concentrate on developing more efficient methods of off-bottom culture and culture techniques that are less intrusive and result in fewer environmental impacts. The greater adaptation of off-bottom culture, coupled with the higher valued half-shell Kumamoto oyster, is a potential that may offset the loss of shucked product produced in bottom culture. The development and adaptation of more environmentally sound practices will remain an industry priority.

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