# THE STATUS OF COMMERCIAL MARINE AQUACULTURE IN CALIFORNIA

**Draft Report to the**
**California Fish and Game Commission**

**California Department of Fish and Wildlife**
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# 1 INTRODUCTION

Aquaculture is a form of agriculture devoted to the propagation, cultivation, maintenance, and harvesting of aquatic plants and animals in marine, brackish, and fresh water. Public Resources Code [PRC] Section 828 defines aquaculture as the culture and husbandry of aquatic organisms, including, but not limited to, fish, shellfish, mollusks, crustaceans, kelp, and algae. Aquaculture does not include species of ornamental marine or freshwater plants and animals not used for human consumption or bait purposes that are maintained in closed systems for personal, pet industry, or hobby purposes (California Food and Agriculture Code Section 25.5, Fish and Game Code [FGC] Section 17).

This report focuses on the current status of commercial marine aquaculture in California and environmental conditions within state waters and does not include federally administered waters beyond three nautical miles (nm) offshore. Artificial propagation, rearing, and stocking projects for the purpose of recovery, restoration, or enhancement of native fish stocks carried out under a valid Scientific Collecting Permit issued by the California Department of Fish and Wildlife (CDFW), or the Ocean Resources Enhancement and Hatchery Program (OREHP) are not included here; these types of activities are addressed through separate regulatory programs. Although there are a small number of land-based hatchery and production facilities, commercial marine aquaculture currently occurs primarily in sheltered and protected bays and estuaries, and, to a lesser extent, in the nearshore and offshore environment in California state waters.

A California marine aquaculture program, or framework, can be broadly conceptualized to include all the policy, management, and regulatory components spread throughout multiple agencies, at all levels of local, state, and federal government, having roles in managing marine aquaculture in the state. CDFW and the California Fish and Game Commission (Commission) are the principal state government entities responsible for the management, protection, and conservation of the state’s fish and wildlife resources. As part of that responsibility, the Commission has the authority to regulate certain aspects of commercial marine aquaculture on state lands or in state waters, while CDFW has management responsibility.

This report is intended to serve as a foundation to build a common understanding of existing California commercial marine aquaculture activities and identify areas that need further refinement and consideration. This information will be used to inform a Statewide Aquaculture Action Plan (Action Plan) to guide sustainable marine aquaculture development in California (see further discussion in Chapter 5).

# 2 DESCRIPTION OF COMMERCIAL MARINE AQUACULTURE OPERATIONS IN CALIFORNIA

The following chapter provides a summary of the status of current marine aquaculture operations in California and includes a description of the primary species and culture methods.

## Overview

Marine aquaculture of shellfish and seaweed occurs throughout the state of California in both coastal waters and private land-based facilities (Figure 2-1 and Table 2-1). Although the majority of operations are within coastal waters, there are three active land-based facilities growing shellfish and/or seaweed for commercial sale and consumption, with a fourth long-standing operation in Cayucos closing business in early 2020. A total of 4,960 acres of California public tidelands are utilized for marine aquaculture, which are leased out by the Commission via a state water bottom lease, unless the tidelands are previously granted or privately owned by other entities.


Figure 2-1. Locations of commercial marine aquaculture facilities in California. Open circles show locations with facilities in state waters and closed circles show land-based facilities. Many facilities within state waters also have associated land-based facilities.

| Location | Total Number of Operators | Total Acreage of Operations | Acreage in Use (estimated) | Tideland Manager | Primary Species | Culture Methods |
|---|---|---|---|---|---|---|
| Humboldt Bay | 7 | 4045 | 386 | Humboldt Bay Harbor, Recreation, and Conservation District; City of Arcata; City of Eureka | Pacific and Kumamoto Oysters, Mediterranean Mussels, Algae, Manila Clams | Intertidal longlines, stakes, hanging baskets, rack-and-bag, and floating-upweller system (FLUPSY) |
| Tomales Bay | 7 | 520 | 152 | Fish and Game Commission (State Water Bottom leases) | Pacific, Kumamoto, Eastern, and European Flat Oysters; Manila Clams; Mediterranean, California Sea, and Bay Mussels | Bags on groundline, rack-and-bag, rack-and-tray, intertidal longlines, stakes and wires, rafts, floating longlines, and in-ground culture with net cover |
| Monterey Bay | 1 | 2 | 1 | City of Monterey | Red Abalone | Cages on rafts and cages under pier |
| Morro Bay | 2 | 290 | 90 | Fish and Game Commission (State Water Bottom leases) | Pacific Oysters and Manila Clams | Longlines, barge, bottom bags, and stakes |
| Santa Barbara | 2 | 97 | 25 | Fish and Game Commission (State Water Bottom leases) | Mediterranean Mussels and Pacific Oysters | Subtidal longlines |
| Agua Hedionda Lagoon | 1 | 5 | 5 | Private | Pacific, Kumamoto, and Olympia Oysters, Green Abalone, Calico and Rock Scallops, Algae, Manila Clams and Mediterranean Mussels | Subtidal longlines, FLUPSY |
| San Diego Bay | 2 | <1 | <1 | San Diego Unified Port District | Seaweed and shellfish seed | Subtidal longlines and FLUPSY |

Table 2-1. Current Marine Aquaculture Activity in California Waters (from north to south).

As of early 2020, the Commission manages 17 active state water bottom leases for marine aquaculture totaling 907 acres, of which 267 acres are currently used (Table 2-2). At the time of publication, the Commission has received and is considering three applications for additional state water bottom leases in California state waters. Existing leases range in size from 5 to 156 acres, with an average size of 53 acres. State water bottom leases managed by the Commission are located within Tomales Bay, Morro Bay and the Santa Barbara Channel. The greatest number of state water bottom leases are held in Tomales Bay with a total of 12 leases, operated by 7 different businesses. Out of a total of 520 acres leased in Tomales Bay, only 152 acres are currently used. In Morro Bay, two operators occupy three leases in the area, utilizing 90 of their total leased acreage of 290. Two leases in Santa Barbara run by two operators account for 97 acres of leased tidelands, of which only 25 acres are currently used.

Table 2-2. Active state water bottom leases by lessee, location and lease acreage.

| Lease Number | Lessee | Location | Number of Acres |
|---|---|---|---|
| M-430-02 | Marin Oyster Company | Tomales Bay | 5 |
| M-430-04 | Charles Friend Oyster Company | Tomales Bay | 62 |
| M-430-05 | Tomales Bay Oyster Company | Tomales Bay | 156 |
| M-430-06 | Cove Mussel Company | Tomales Bay | 10 |
| M-430-10 | Hog Island Oyster Company | Tomales Bay | 5 |
| M-430-11 | Hog Island Oyster Company | Tomales Bay | 5 |
| M-430-12 | Hog Island Oyster Company | Tomales Bay | 30 |
| M-430-13 | Point Reyes Oyster Company | Tomales Bay | 25 |
| M-430-14 | Point Reyes Oyster Company | Tomales Bay | 5 |
| M-430-15 | Hog Island Oyster Company | Tomales Bay | 128 |
| M-430-17 | Point Reyes Oyster Company | Tomales Bay | 62 |
| M-430-19 | Marin Oyster Company | Tomales Bay | 25 |
| M-614-01, parcel 1 | Grassy Bar Oyster Company | Morro Bay | 143 |
| M-614-01, parcel 2 | Morro Bay Oyster Company | Morro Bay | 134 |
| M-614-02 | Grassy Bar Oyster Company | Morro Bay | 15 |
| M-653-02 | Santa Barbara Mariculture | Santa Barbara | 72 |
| M-654-03, parcels 1 & 2 | PharmerSea LLC | Santa Barbara | 25 |

Aquaculture facilities without state water bottom leases include operations within Humboldt Bay, Monterey Bay, Agua Hedionda Lagoon, and San Diego Bay. These facilities account for an additional 4,053 acres set aside for marine aquaculture in California waters. In Humboldt Bay, leases are granted to the operators by the Humboldt Bay Harbor, Recreation, and Conservation District; the City of Arcata; or the City of Eureka. These tidelands are held in the public trust by these lessors. Coast Seafoods Company (recently purchased by Pacific Shellfish) leases over 1,000 acres but farms approximately one third of its lease. Other companies hold smaller leases ranging from approximately 10 to 350 acres. In Monterey Bay, one operator uses one acre of the two acres leased from the City of Monterey. In San Diego County, five acres of private tidelands are leased to one aquaculture operator in Agua Hedionda Lagoon and less than one acre is split by two operators in San Diego Bay.

Total shellfish production reported to CDFW[1] in 2018 (January through December) was 495.2 metric tons (mt) all species combined (Figure 2-2). This resulted in a value of $15.3 million[2]. Shellfish production has been on the decline since peaking between 2010 and 2014. The decrease in statewide production after this time period is the result of the Drakes Bay Oyster Company (DBOC) ending their operations within Drakes Estero in late 2014. Historically, DBOC accounted for approximately one-third of the shellfish production in the state. Production in 2018 is similar to levels seen prior to 2010. The culture of Pacific Oysters represented the largest production for the industry, resulting in 57% of total shellfish production, and 53% of the total value in 2018. By location, Humboldt Bay produced 50% of the oysters in California in 2018, followed by Tomales Bay which made up 43% of oyster production. Four and three percent came from Morro Bay and Agua Hedionda Lagoon, respectively. In mussel production, 59% came out of Agua Hedionda Lagoon, followed by 34% from Santa Barbara and 6% from Tomales Bay. In 2018, clams were only reported from Tomales Bay, which produced a half ton of clams and $5,120 in revenue. No information on abalone production in 2018 was received. Production amounts for seaweed cultivated in California for commercial sale and consumption are unknown but presumed to be de minimis

1 Production reports are required as a condition of state water bottom leases. Production reports from facilities outside of state water bottom leases is voluntary to CDFW and not always provided. However, in 2013, the California Department of Public Health (CDPH) implemented mandatory reporting of harvest amounts for all non-state leases to CDPH in addition to the already required reporting for state water bottom leases. Thus, historically, production amounts are likely underestimates; however, beginning in 2013 have been complete.

2 Oyster value based on an average retail/wholesale price per shell for the state ($0.65). Clam value based on $5 per pound. Mussel value based on $3 per pound.

at this time. Harvests of wild kelp and edible seaweeds are regulated separately and are not within the scope of this report.

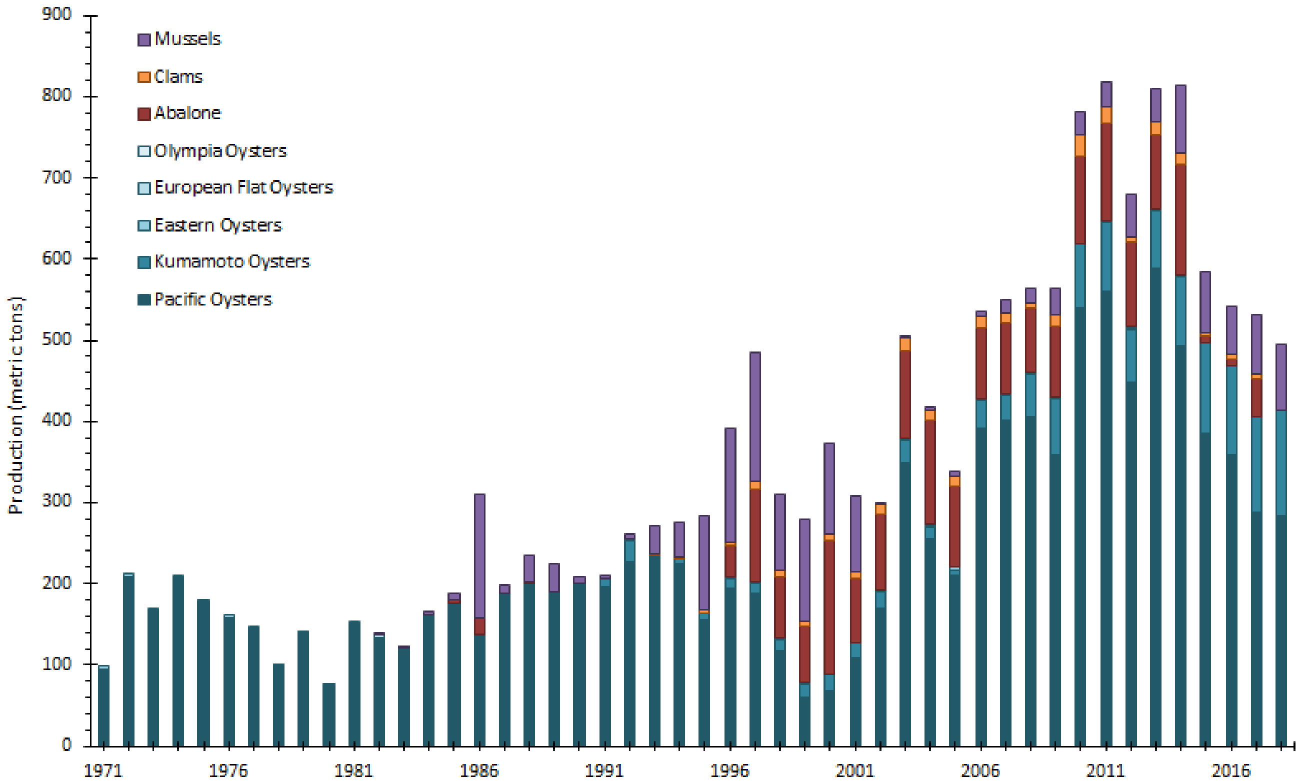


Figure 2-2. California commercial production of mussels, Manila Clams, Red Abalone, Kumamoto Oysters, Pacific Oysters, Olympia Oysters, European Flat Oysters, Eastern Oysters from 1971-2018. The following rates were used to convert reported numbers of oysters into gallons before converting into metric tons: 170 Pacific Oysters/gallon, 300 Kumamoto Oysters/gallon, 300 Eastern Oysters/gallon, 140 European Flat Oysters/gallon.

## Cultivated species

California's commercial marine aquaculture industry consists of the production of oysters, mussels, clams, abalone and seaweed. Operators are restricted to growing the species that are approved on their lease. Additionally, each aquaculture facility must register the species they wish to culture in an annual aquaculture registration with CDFW. The species approved for culture by CDFW in 2019 are shown in Table 2-3.

Table 2-3. Number of registered aquaculture facilities for each marine species cultivated in California in 2019.

| Species | Number of Registered Aquaculture Facilities |
|---|---|
| Pacific Oyster (Crassostrea gigas) | 17 |
| Kumamoto Oyster (Crassostrea sikamea) | 11 |
| Olympia Oyster (Ostrea lurida) | 4 |
| Eastern Oyster (Crassostrea virginica) | 3 |
| European Flat Oyster (Ostrea edulis) | 3 |
| Manila Clams (Venerupis philippinarum) | 11 |
| Mediterranean Mussel (Mytilus galloprovincialis) | 10 |
| Bay Mussel (Mytilus trossilus) | 2 |
| California Sea Mussel (Mytilus californianus) | 1 |
| Red Abalone (Haliotis rufescens) | 5 |
| Green Abalone (Haliotis fulgens) | 1 |
| Ogo (Gracilaria spp.) | 5 |
| Sea Lettuce (Ulva spp.) | 5 |
| Dulse (Palmaria palmata) | 2 |
| Giant Kelp (Macrocystis pyrifera) | 2 |
| Bladderwrack (Fucus spp.) | 1 |
| Nori (Porphyra spp.) | 1 |
| Kombu (Laminaria farlowii) | 1 |
| Turkish Towel (Chondracanthus exasperatus) | 1 |

## *Shellfish*

Generally, the term shellfish refers to marine invertebrates including many species of mollusks, crustaceans, and echinoderms that are used as food and have hard exoskeletons. The dominant cultured species for commercial marine aquaculture production in California are shellfish including several species of oysters, mussels, clams, and abalone. Shellfish operations occur primarily in estuarine and intertidal state waters, although some production also occurs in land-based facilities. Further, most shellfish culture operations have some land-based facilities that can be used for hatching, early rearing, and processing of shellfish. As shown in Figure 2-1 and Table 2-1, most shellfish operations in California are located in Humboldt Bay, Tomales Bay, and Morro Bay.

There has been some debate about naturalized populations of nonnative shellfish cultured in California and the question of whether they are invasive. U.S. Presidential Executive Order 13112 (Clinton 1999) defines an invasive species as “an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health.” The National Invasive Species Council describes invasive species as “a non-native species whose introduction does or is likely to cause economic or environmental harm or harm to human, animal, or plant health” (ISAC 2006). The National Invasive Species Management Plan (NISMP) further indicates that the National Invasive Species Council will focus on “non-native organisms known to cause or likely to cause negative impacts and that do not provide an equivalent or greater benefit to society.” The NISMP provides further policy guidance and notes that many established nonnative species “are non-invasive and support human livelihoods or a preferred quality of life.”

Determining relative impacts resulting from naturalized populations of nonnative species is often a subjective, value-driven decision, and impacts can vary from one region to another and over time, particularly under changing ocean conditions. Some nonnative species are considered harmful and therefore invasive by some, while others consider them beneficial. This typifies the discussion of naturalized shellfish populations in California. Various nonnative shellfish species have been approved for cultivation and importation into California, through registrations, permits, and lease conditions that are subject to ongoing adaptive management over time. In this report, the term “nonnative” is used.

### Oysters

Five oyster species are cultured in the California shellfish industry. Four of the five species grown are nonnative species. The Pacific Oyster (*Crassostrea gigas*), originally from Japan, is the principal species on the U.S. Pacific coast. The Kumamoto Oyster (*Crassostrea sikamea*), also from Japan, is the second most grown oyster species in California estuaries. The Eastern Oyster (*Crassostrea virginica*), grown on the Atlantic and Gulf coasts, accounts for most U.S. oyster landings but is just a small percentage of the oyster production in California. Two brooding oyster species are cultivated to a lesser extent: the European Flat Oyster (*Ostrea edulis*) and the Olympia Oyster (*Ostrea lurida*), the latter of which is native to the Pacific coast. Figure 2-3 below shows most of the cultured oyster species in California.

Figure 2-3. Species of oysters grown in California. Left, Pacific Oyster; center, Eastern Oyster; upper right, Kumamoto Oyster; lower right, Olympia Oyster (Photo: CDFW).

The first commercial oyster beds were established in San Francisco Bay in about 1851 when mature native (Olympia) oysters were shipped form Shoalwater Bay, Washington (Willapa Bay) and later from other bays in the U.S. Pacific Northwest and Mexico. Market demand for a larger half-shell product stimulated experiments in transporting the Eastern Oyster from the Atlantic states to the Pacific coast. Cool summer water temperatures, however, prevented successful natural reproduction of the Eastern Oyster. Soon after completion of the transcontinental railroad in 1869, shipments of Eastern Oyster seed were made and transplanted in San Francisco Bay for further growth, marking the beginning of actual oyster raising in California. However, with California's population and industrial growth came a degradation of water quality in San Francisco Bay, and by 1939 the last of the San Francisco Bay oysters were commercially harvested (Barrett 1963).

The commercial oyster industry and CDFW began conducting earlier experimental plantings using the Pacific Oyster in Tomales Bay, Elkhorn Slough, Drakes Estero, Bodega Lagoon, and Morro, Newport, and San Francisco bays during the 1930s. Several Pacific Oyster plantings proved successful, demonstrating that imported Pacific Oyster seed could be grown commercially in California. Commercial oyster culture is now centered on five major growing areas: Humboldt Bay, Tomales Bay, Morro Bay, Santa Barbara Channel, and Agua Hedionda

Lagoon. The highest production of commercial oysters occurs in Humboldt Bay, followed by Tomales Bay, Morro Bay, Agua Hedionda Lagoon and the Santa Barbara Channel respectively. The primary methods of oyster culture employed by California growers are intertidal and subtidal longline culture, stakes, rack-and-bag, and bottom bags.

### Mussels

There are three primary species of wild mussels along the California coast, the Mediterranean Mussel (*Mytilus galloprovincialis*), the California Mussel (*Mytilus caifornianus*) and the Bay Mussel (*Mytilus trossulus*). Experiments in the 1980s culturing wild mussel seed stock and in developing hatchery and growout methods have greatly increased the importance of commercial mussel production, particularly the Mediterranean Mussel, which occurs primarily in southern and south-central California. A related species, the Bay Mussel, occurs in northern California and hybrids of the two species are commonly found between Cape Mendocino and Monterey Bay.

Most mussel production in California comes from naturally set Mediterranean Mussel or Bay Mussel seed. However, some growers acquire Mediterranean Mussel seed from U.S. Pacific coast hatcheries, the same species that is cultured in Spain and most of Europe. Currently, several operations within California actively culture and harvest mussels (primarily Bay and Mediterranean Mussels). The primary methods of mussel culture employed by these growers are submerged longlines and bag culture. Agua Hedionda Lagoon, Santa Barbara Channel, and Tomales Bay are the primary growing areas of mussels in California. Agua Hedionda produced 47.80 mt, $316,167, Santa Barbara produced 27.78 mt, $183,753 and Tomales Bay produced 5.22 mt, $34,545 in 2018.

### Clams

Currently, the Manila Clam (*Venerupis philippinarum*) is the only clam species grown commercially in California. The Manila Clam is a nonnative clam introduced to the U.S. Pacific coast, including California, from Japan with Pacific Oysters in the 1930s (Talley et al. 2015). While locally abundant in protected-water areas of California from Elkhorn Slough north (Frey 1971), no commercial fishery exists on local stocks. The commercial culture of clams in California began in 1981, but production levels were relatively low until the mid-1990s. Commercial growers purchase artificially reared clam seed for grow out. Because of its preferred distribution in the upper tidal zone, it is not believed to have displaced any native species (Bourne 1982). The Manila Clam often occurs with Pacific Littleneck Clam (*Protothaca staminea*), Soft Shell Clam (*Mya arenaria*), *Macoma* spp. clams, and other estuarine infauna (NOAA 1989).

Currently, approximately half of the registered shellfish operations in California are actively culturing and harvesting clams. The areas with the highest clam production are Tomales Bay, and Humboldt Bay. The primary methods of clam culture employed by these growers has historically been direct-seeding to the substrate under protective netting, tethered bags on groundlines, and seed culture in trays hung from floating rafts. Tomales Bay produced 0.46 mt, $5,120 in 2018 with no other bays reporting production.

### Abalone

Currently, there are three remaining commercial facilities in California raising abalone for sale locally and abroad, while some additional facilities are engaged in research. Abalone are primarily cultured in land-based tanks, but one operation cultures abalone in California waters using cages suspended from floating rafts and under a wharf. The primary species cultured is Red Abalone (*Haliotis rufescens*) and, to a much lesser extent, Green (*Haliotis fulgens*) and Pink Abalone (*Haliotis corrugata*). The White (*Haliotis sorenseni*) and Black Abalone (*Haliotis cracherodii*), federally listed as endangered, are the object of research and/or recovery activities.

Pioneering efforts to mass cultivate abalone in California began about 45 years ago, with a peak in abalone production in 1997. Participation in the industry has declined since that time, which was due in part to disease impacts. However, interest in abalone aquaculture remains high, prompted in part by the closure of the commercial abalone fishery in 1997. Presently, the commercial culture of Red Abalone occurs in four main coastal areas: the Santa Cruz area, Monterey Bay, and Santa Barbara. As of early 2020, a long-standing abalone farm in San Luis Obispo is in the process of closing operations.

## *Seaweed*

While California has a long history of wild harvest of seaweed (also called macroalgae, or large marine algae), interest in seaweed aquaculture has been a more recent development. Early cultivation of seaweeds was done in land-based tanks to support abalone aquaculture operations, though in recent years abalone farmers have started selling the cultivated seaweed to meet a growing market for edible seaweed. In the last few years, the first land-based aquaculture facility devoted entirely to edible seaweed cultivation began operating in Moss Landing. There are currently no operating commercial seaweed aquaculture farms in California waters, although two farms are in the process of starting operations in the Santa Barbara Channel and San Diego Bay. However, several existing aquaculture farms sell seaweed opportunistically harvested from their shellfish cultivation gear, where regulations allow. There is growing interest in culturing a variety of seaweeds in intertidal and offshore waters, and several small scale or research and development projects focused on seaweed aquaculture are in progress.

Currently grown or proposed species include Ogo (*Gracilaria spp.*), Sea Lettuce (*Ulva spp.*), Dulse (*Palmaria palmata*), Giant Kelp (*Macrocystis pyrifera*), Bladder Wrack (*Fucus spp.*), Nori

(*Porphyra lanceolata*), Kombu (*Laminaria farlowii, Laminaria setchelii*), and Turkish Towel (*Chondracanthus exasperatus*).

Microalgae, or microscopic algae, are raised primarily as feed for hatchery operations and other market applications (e.g., pharmaceutical, bioenergy). Microalgae cultivation primarily occurs on land in contained vessels, tanks, or ponds and is not included within the scope of this report.

### *Finfish*

Currently, there is no commercial aquaculture of marine finfish in California. The only related finfish activity is limited to the OREHP's land-based hatchery and intertidal nursery cage operations that are research oriented and in support of stock enhancement.

## Cultivation methods

Aquaculture in California consists of both land-based operations and operations within coastal waters. Land-based facilities can include tanks, raceways, or ponds and related administrative or support structures. Water used for land-based facilities can be municipally supplied and discharged to sanitary sewers or can be drawn from and discharged to the marine environment. Certain marine species may be cultured in inland locations, in full-strength seawater, brackish water, or nearly freshwater. Additionally, land-based facilities may house nursery or hatchery operations which supply grow-out facilities in coastal waters or depuration tanks for removing contaminants or physical impurities.

Aquaculture facilities within state waters utilize a variety of culture methods depending on species, environmental conditions, and logistical considerations. Individual farms will often use several methods and grow several species simultaneously. Culture techniques have evolved over time; many culture methods that were more environmentally harmful have been phased out in favor of methods that are more compatible with resource protection goals. Now, most culture methods used in California place species off the bottom using containers or by suspending them in the water column to avoid additional substrate disturbance. New and innovative techniques continue to be developed to grow species in a wide range of depths and conditions, ranging from shallow estuarine to deeper offshore environments.

### *Bottom Containers*

**Methods Included:** Bag-on-bottom (aka bags, bottom bags), bags on groundline, cage-on-bottom, tray-on-bottom
**Species Cultured:** Oysters

**Description:** Shellfish are placed into a fabricated container which is then placed on the seafloor (Figure 2-4). Most commonly this container is a bag made of Vexar polyurethane mesh. Bottom containers may be either tethered or untethered in place. Tethered containers are typically attached with hooks to a long rope (groundline) anchored at either end with screw anchors. Hooks are usually made of coated wire, halibut hooks, or another custom design. Untethered containers rely on their larger size and weight to remain in place. Long parallel rows of bottom containers are separated by spaces to walk between lines and to periodically flip bags over to the other side of the line to reduce fouling of the bag, prevent burial, and tumble the shellfish. There are two common spatial designs: one-sided design where bags are all laid on one side, and double-sided design where bags are laid on both sides of the line in an alternating, checkerboard pattern.

This culture method dominates oyster production in California due to its suitability to the extensive intertidal areas in most leases and its low-cost relative to culture methods which require more structural components. Oysters grow well, are relatively easy to handle, allow boats to pass over easily during high tide, and can be walked through relatively easily during low tide.

Figure 2-4. Bags on bottom attached to staked lines; bags are attached to lines using coated wire and closed using zip ties (Photos: CDFW).

## *Embedded Clam Culture*

**Methods Included:** In-ground culture, clam bags, clam roll
**Species Cultured:** Manila Clams
**Description:** Because clams are infaunal species, living in the sediment, special techniques are used to keep clams in the mud but still harvestable. Clams are grown either inside containers or directly seeded into the sediment, the latter of which is a method that is being phased out. Clam bags (typically Vexar mesh bags) are filled with pea gravel and clams and are then buried in rows flush with the sediment surface (Figure 2-5). In-ground culture seeds clams directly in the sediment with predator-exclusion netting affixed to the surface. After

several years of grow-out time, the bags are removed from the mud and gently shaken to remove sediment. To harvest clams that are directly seeded into the sediment, rakes or hydraulic dredges must be used. Only one company in California still uses in-ground clam culture. Because of the increased substrate disturbance caused by harvesting with the hydraulic rake, this method will be phased out in the next few years.


Figure 2-5. Left: Embedded bottom bags used for clam culture (Photo: CDFW). Right: Clams seeded into the mud are covered with mesh netting until they can be raked out at harvest time (Photo: California Coastal Commission).

## *Rack Culture*

**Methods Included:** Rack-and-bag, rack-and-tray, rack-and-cage
**Species Cultured:** Oysters
**Description:** Shellfish are placed into a fabricated container (e.g. mesh bag) designed to protect and hold organisms during the grow-out phase of production. Containers are then placed atop and may be attached to constructed racks in the intertidal zone, effectively lifting the containers 1-2 feet off the seafloor. Containers alternate between being submerged at high tide and exposed during low tide. Racks are commonly organized in parallel rows with space between rows to walk. Alternative designs of bag placement on the racks may be used, such as slightly overlapping bags to withstand greater wave energy (Figure 2-6). As with bottom containers, aquaculturists will manually flip, move or adjust the containers during low tide to prevent biofouling and influence the shell shape and strength.

Figure 2-6. Rebar racks and Vexar mesh oyster bags, suspended above substrate using PVC. Bags may be arranged in an overlapping fashion to absorb wave energy more effectively (Photos: CDFW).

This method is commonly used in California for several reasons. Logistically, the raised containers can be accessed by boat and may be easier to handle than bottom containers. In addition, the rack structure allows containers to be placed off-bottom in softer sediments where the bottom container method is not an option due to a high burial risk.

### *Intertidal Longline*

**Methods Included:** Tumble culture, tip bags
**Species Cultured:** Oysters
**Description:** In the intertidal, ropes or wrapped steel cables (longlines) are hung between anchors made with hinged/flange PVC stakes or wire tension supports, with supporting posts of rebar or PVC pipe evenly spaced throughout to keep the line taut. Containers (e.g. bags, baskets) of shellfish are then attached with stainless steel wire gauge, coated wire, or halibut hooks to these lines so that they are suspended approximately 1-4 feet above the seafloor. Optionally, floats may be attached to the unattached end of the containers so that they will rotate up and down, or “tip”, as the water level changes with the tides (Figure 2-7). This replaces the need to manually flip the bags as in bottom container culture and rack culture. Shellfish will be exposed to air during low tide and, if floats are attached, will float at the surface during high tide. During low tide, if the containers are not hung high enough above the seafloor, they may touch the bottom.

Figure 2-7. Intertidally suspended lines with floating bags (top, left and right) and hanging non-floating baskets (bottom) (Photos: Michael Toussaint, Marin Oyster Company).

## *Subtidal Longline*

**Methods Included:** Floating longline, submerged buoyed longline, mussel longline
**Species Cultured:** Oysters, mussels, seaweed (in development)
**Description:** Subtidal longlines are similar to intertidal longlines, but they are used in deeper areas of bays or nearshore waters where the seafloor is always submerged. The longlines are anchored at each end to the seafloor and are suspended near the water surface with a series of buoys. Containers such as baskets, trays, cages, or bags are filled with shellfish and attached to the floating longline (Figures 2-8 and 2-9). There are many variations and designs related to this culture method. To keep culture species floating at the surface, floats may be attached to individual containers. Alternatively, the containers may be suspended in the water column and never exposed to air. This submerged longline variation can include the

suspension of stacked trays or cages of shellfish that hang vertically beneath the longline (Figure 2-10). A variation of this method is used for mussels, which utilizes a specialized “fuzzy mussel rope” with a higher surface area for mussel settling and culturing. Fuzzy rope containing cultured mussels is hung in long repeating loops suspended from evenly spaced attachment points to the submerged longline. The submerged longline can be maintained at a constant water depth, approaching 30 feet deep in some nearshore farms, using a series of submerged floats and counterweights.

Figure 2-8. Subtidal longlines using bags with floats attached to keep the bags at the surface (Photos: CDFW).

Figure 2-9. View of subtidal longlines from a distance (left photo: California Coastal Commission; right photo: CDFW).

Figure 2-10. Submerged longline variations: mussel longline (left photo: CDFW) and stacked cages hanging from a submerged longline (right photo: CDFW).

## *Raft Culture*

**Methods Include:** Barges, floating upwelling raft system (FLUPSY)
**Species Cultured:** Oysters, mussels, clams
**Description:** Another method of subtidal culture includes suspending a variety of species and containers from floating barges or rafts (Figure 2-11). Rafts consist of two large floats at either end covered in a plywood decking with a series of poles making up the center of the raft and are anchored to the seafloor. From the poles, containers such as baskets, stacks of trays, or mussel rope can be suspended. Rafts offer a secure structure from which shellfish culture can operate; attachment of containers is reliable and generally holds up well under storm conditions. Rafts allow for operational ease, and large volumes of product can be processed readily with the use of winches and other machinery which lift containers from the water. Interest is growing in this method for growers who are already maximizing use of the intertidal portions of their lease(s) or do not have access to intertidal areas.

Figure 2-11. View of rafts at a distance (left) and up close (right) (Photos: CDFW).

A popular modification of this method, the floating upwelling raft system (FLUPSY), is used to grow shellfish seed quickly to the appropriate size for planting. On a FLUPSY, a series of upwelling containers hold small oyster seed while an underwater paddle wheel circulates algae and nutrient-rich waters through the screened bottoms of each container (Figure 2-12). Floating rafts support the upwelling containers and keep the shellfish several feet below the water surface. FLUPSYs are typically installed adjacent to piers and held in place using mooring lines and chain as well as anchored to the seafloor.

Figure 2-12. Raft modification: floating upwelling raft system. Upwelling containers hang in compartments on floating rafts (left) with a large paddle wheel directing nutrient rich water through containers (right) (Photos: CDFW).

# 3 Description of Habitats and Interactions with Aquaculture

A sustainable aquaculture industry depends on the ability to operate within the environmental framework and philosophy of natural resource management. 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 is essential that aquaculture technology not have significant impacts upon the health of the ecosystem on which it also depends.

## Physical Setting and Wildlife Habitats

The following sections provide brief descriptions of the types of marine habitats in California and the types of species that inhabit them, oceanographic conditions, and the effects of climate change on the aquaculture industry.

### *California Coastal Habitat*

The coast of California is composed of sandy beaches, rocky headlands, sea cliffs, and lagoons in the intertidal and nearshore environment. Generally, the coastline north of Point Conception is rugged, with prominent headlands, stretches or sea cliffs, and small sandy beaches. South of Point Conception, the shoreline is typically adjacent to coastal plains and marine terraces; and long sandy beaches are common. Tidal flats, sandy or muddy expanses that become exposed at low tides and are associated with coastal rivers as well as bays and estuaries, are distributed along the California coast. Beds of mussels (*Mytilus* spp.), seagrass beds, and algal assemblages from turfs (e.g., *Endocladia muricata*) to low canopies of leathery kelp and stalked algae species (e.g., *Pterygophora californica*, *Postelsia palmaeformis*) are distributed in patches throughout rocky shoreline habitat along the coast.

Estuarine and wetland habitats encompass soft-sediment habitats, including tidal mudflats, eelgrass beds and areas of open water. Habitat formed by eelgrass and other plants plays an important functional role as foraging and nursery areas for a diverse range of fish and invertebrate species, many of which inhabit estuaries as juveniles before moving to kelp and other offshore habitats as adults. Estuaries, coastal bays and beaches are also an important part of the Pacific Flyway and host thousands of migrating shorebirds, as well as provide important foraging and nesting area for resident bird populations (CDFW 2009).

Seagrass habitats support an abundant and biologically diverse assemblage of aquatic wildlife species. The most common type of seagrass in estuaries and sheltered coastal bays in California is Common Eelgrass (*Zostera marina*). A second variety of eelgrass, *Zostera pacifica*, is found along the open coast of southern California. Eelgrass beds provide refuge, foraging, breeding, or nursery areas for a variety of invertebrates, fish and birds. The most common type of seagrass along the open coast of California is Surfgrass (*Phyllospadix* spp.), which forms beds that fringe nearly all the rocky coastline at the zero-tide level down to several meters below the zero-tide level.

Other key habitats in the open coast of California include kelp forests, rocky reef habitats at various depths, nearshore pelagic habitat, and soft bottom habitats at various depths. Kelp forests are an important component of California's marine ecosystems that provide shelter for both juvenile and adult species of fish, provide important nursery habitat for Southern Sea Otters (*Enhydra lutris nereis*), offer vertical and horizontal substrate for a variety of marine organisms, and account for a large portion of the primary productivity in the nearshore communities. In California, there are two primary canopy-forming kelp species: Giant Kelp (*Macrocystis pyrifera*) and Bull Kelp (*Nereocystis luetkeana*). In addition, intertidal boulders, platforms and cliffs, as well as tidepools, are home to many species of snails, barnacles, anemones, crabs, sea stars, and fishes. Kelp forests grow along rocky coastlines and typically remain nearshore in subtidal communities.

Many offshore rocks and islets are present along California’s rocky coastlines, which provide habitat for many species of pinnipeds (i.e., seals and sea lions) and seabirds. Many seabird species occur and nest in colonies on these features along the California coast. In addition, many marine mammal species, which are protected under the federal Marine Mammal Protection Act (MMPA), are known to occur within the nearshore environment along the California coast.

### *California Nearshore Pelagic Habitat*

The nearshore pelagic habitat supports planktonic organisms that float or swim in the water, as well as fish, marine birds, and marine mammals. The pelagic community is composed of microorganisms such as phytoplankton (e.g., diatoms, dinoflagellates) and zooplankton (e.g., protozoans, radiolarians, copepods, amphipods), and other organisms like worms, mollusks and jellyfish. Many pelagic fish species, seabirds, cetaceans, and sea turtle species occur off the coast of California or are associated with nearshore habitat.

### *Wildlife Corridors and Nurseries*

The marine environment provides migration corridors for many wildlife species, and the spatial and temporal scales of these migrations vary based on the specific marine environment (e.g., nearshore, pelagic). Wildlife movement within the marine environment includes nearshore migration of Gray Whales between Baja California and the Bering Sea, seasonal movements of juvenile salmon out of rivers and along the shoreline, and daily movements of pinnipeds between haul-outs and foraging grounds. Larval dispersal from marine invertebrate and fish species occurs over long distances and is important when considering connectivity of populations. The Pacific Flyway extends along the Pacific Coast from Mexico north to Alaska and into Siberia, Russia. Migratory birds use this major migratory route because of its unique biological characteristics.

Important wildlife nursery sites along the California coast include pinniped rookeries (e.g., offshore rocks, mudflats, sandy beaches), seabird breeding colonies (e.g., offshore rocks), and shorebird breeding areas (e.g., beaches, mudflats).

### *California Benthic Habitat*

Benthic (seafloor) habitat in California varies geographically but is typically characterized by either hard (rocky or reef) substrate or soft (sand or mud) substrate. The locations of each benthic substrate type vary within each biogeographic region based on several factors, including the geology of the shoreline. Both substrates provide habitat for numerous invertebrate and fish species. Rocky areas provide hard substratum to which kelp and other algae attach in waters up to approximately 100 feet deep, while in deeper water, hard substratum provides attachment substrate for many species of deep-water invertebrates. In addition to attached organisms, the structural complexity of rocky areas provides habitat and protection for mobile invertebrates and fishes.

Soft-bottom environments range from flat expanses to slopes and basin areas. Soft-bottom habitats lack the complex, three-dimensional structure of hard-bottom substrata, and are somewhat less diverse in species assemblages than rocky reefs, depending on the compositional sediment type. Soft bottom species are generally bottom-dwelling invertebrates and fishes, and many have special adaptations for the habitat such as flattened bodies and concealing coloration (Allen et al. 2006). Soft-bottom habitats can be highly dynamic in nature as sediments shift due to wave action, bottom currents, and geological processes. Shallow, sandy, soft-bottom benthic habitat is found in areas along the coast that are subject to constant tide, wave, and shoreline processes, resulting in a highly changing and low-productivity region. Sandy benthic habitat generally extends to water depths of approximately 300 feet. Muddy sediment bottoms are typically found in water depths greater than 300 feet along the shelf but also occur in estuaries and lagoons.

Submarine canyons are submerged steep-sided valleys that cut through the continental slope and occasionally extend close to shore. These features exhibit bathymetric complexity, support unique deep-water communities, and affect local and regional circulation patterns. Canyons provide habitat for young rockfish and flatfish that settle in nearshore waters to grow and move offshore as adults. Canyons also attract concentrations of prey species and provide important foraging opportunities for seabirds and marine mammals (Yen et al. 2004).

## California Current System

The California Current is part of the North Pacific Gyre, which swirls clockwise within the northern basin of the Pacific Ocean. The California Current is made up of southward-flowing surface waters extending more than a hundred miles offshore; these waters are cooler than the waters farther offshore. This cold water results in upwelling, which brings nutrient-rich sediments to the ocean surfaces and produces highly productive conditions for wildlife such as whales, seabirds, and fish. Two large countercurrents also influence conditions along the California coastline, including the northward-flowing subsurface Davidson Countercurrent and Southern California Countercurrent. During the winter, the California Current tends to “move” offshore, allowing the inshore countercurrents to dominate in the nearshore surface waters (Reid et al. 1958).

Oceanographic patterns create pelagic habitats that differ from one another with respect to temperature, salinity, chlorophyll content, contaminant loads and planktonic biological assemblages. Oceanographic patterns also strongly influence growth, fecundity and survivorship of many species, and well as dispersal and recruitment patterns of sedentary species that have planktonic phases. Oceanographic conditions such as currents, water masses, and temperature strongly influence marine biodiversity. Variations in oceanographic factors determine areas of productivity where krill, squid, anchovy, seabirds, and marine mammals congregate in the pelagic ecosystem (Yen et al. 2004). Features such as eddies, upwelling plumes, currents, recirculation cells and river outflow plumes can be associated with high marine biodiversity, and transport patterns created by these features can significantly affect recruitment patterns of fish and invertebrates in intertidal nearshore communities (Farrell et al. 1991, Wing et al. 1995, Mace and Morgan 2006).

Two large-scale atmospheric processes also influence the California Current system: El Niño-Southern Oscillation (ENSO) events and Pacific Decadal Oscillations (PDO). ENSO events generally reduce upwelling of cold, nutrient-rich waters, increase onshore and northward flows, and increase sea surface temperatures. ENSO events typically occur every several years, and generally result in declines of zooplankton and reductions in productivity that can affect fish, seabird, and marine mammal populations. PDO events occur over much longer timescales (20–30 years) and have large-scale impacts on zooplankton and fish productivity throughout the North Pacific.

## *Oceanography*

The California coast represents a tectonically active continental margin, dominated by processes such as uplift, erosion, and seismic activity, much of which is associated with transform plate movement along the San Andreas Fault. Consequently, the coast in most areas drops quickly into deep water. Generally, the continental shelf is only a few miles wide, although in some parts of the Southern California Bight south of Point Conception it becomes substantially wider. Ocean circulation along the whole coast is dominated by the California Current, an ocean current that sweeps south along the entire west coast of North America from southern British Columbia to southern Baja California (Hickey and Banas 2003).

North of Point Conception, the California Current sweeps slowly south along the shoreline, and the cool, low-salinity waters of the current are responsible for the cold water temperatures and frequent coastal fogs that characterize this part of the California coast. Also, the prevailing northwesterly winds drive surface water to the right of the wind flow (offshore), and this phenomenon drives coastal upwelling. Upwelling brings cold, nutrient-rich bottom water to the surface where the abundant nutrients support high plankton productivity and, by extension, much of the marine food web, from anchovies to whales. This productivity is at the root of California's commercial ocean fisheries and shellfish industries, and potentially could support a substantial aquaculture industry. However, the upwelling process is highly variable on both seasonal and inter-annual timescales. When the California Current is slowed or disrupted, as happens during the winter months and during El Niño years (and sometimes at other times), this results in reduced upwelling rates and a sharp decline in plankton production (Hickey and Banas 2003). Consequences include failed or reduced fisheries, and sharp declines in seabird and marine mammal populations as breeding decreases and animals starve or migrate elsewhere to find food.

South of Point Conception, in the waters of the Bight, the shoreline cuts sharply eastward and the California Current moves offshore of the Channel Islands. A counter-clockwise countercurrent is generated, moving generally from south to north along the shoreline from northern Baja California to Point Conception, and producing a very large eddy within the Bight. The Southern California Countercurrent (SCC) is also variable over time, being strongest in summer and fall and weakest in winter and spring. Upwelling is usually a minor process in the Bight, but strong offshore winds can result in nearshore upwelling and a sharp drop in water temperatures. Water movement through the eddy carries upwelling waters and plankton as well as pollutants and sediments from terrestrial rivers into the Bight. Compared with the coastline north of Point Conception, the waters along the coastlines around the Bight have fewer nutrients, warmer water, and are mixed less with waters of the open ocean. Mixing within the Bight typically results in efficient dispersion of suspended particles, however smaller eddies and wakes formed around islands can temporarily isolate some areas (Mitarai et al. 2008). The coastal waters of the Bight, specifically within 3 nm of the shore, are also relatively sheltered from the prevailing northwest winds by Point Conception and the Channel Islands. This location results in substantial reductions in wave height and energy compared to the coast north of Point Conception (Hickey and Banas 2003).

### *Effects of Climate Change on the Environment*

According to the Intergovernmental Panel on Climate Change, which was established in 1988 by the World Meteorological Organization and the United Nations Environment Programme, global average temperature is expected to increase by 3–7 degrees Fahrenheit (°F) by the end of the century, depending on future GHG emission scenarios (IPCC 2014). According to California's Fourth Climate Change Assessment, temperatures in California are projected to increase by 5.6 to 8.8°F by 2100 (OPR et al. 2018a).

Water resource–related vulnerabilities also include potential degradation of watersheds, alteration of ecosystems and loss of habitat, impacts on coastal areas, and ocean acidification (CNRA 2018a). The ocean absorbs approximately one-third of the CO2 released into the atmosphere every year from industrial and agricultural activities, changing the chemistry of the ocean by decreasing the pH of seawater. Ocean acidification affects many shell-forming species, including oysters, mussels, abalone, crabs, and the microscopic plankton that form the base of the oceanic food chain (Kroeker et al. 2010, 2013). In addition, significant changes in the behavior and physiology of fish and invertebrates attributable to rising CO2 and increased acidity have already been documented (OPR et al. 2018a).

California's ocean supports a vast diversity of marine life, as well as fishing communities that depend on fish and shellfish for their livelihoods and that provide a diverse supply of seafood to the state and for export. In the last few years, California has experienced an unprecedented marine heat wave, resulting in closures of fisheries and a significant loss of northern kelp forests. There is increasing evidence that sea-level rise, ocean acidification, and ocean warming associated with climate change are transforming and degrading California's coastal and marine ecosystems (OPR et al. 2018b).

## Potential Impacts of Commercial Aquaculture Development

The following potential issues and areas of concern have been identified regarding commercial marine aquaculture development:

- Escape of cultured organisms and subsequent genetic, disease transmission, and competition effects, including past and present impacts and ecosystem-level impacts;
- Impacts associated with a potential increase in disease vectors;
- Impacts of predator control activities and devices on nontargeted species;

- Pathway for aquatic nuisance species;
- Impacts of cultured species on protected and sensitive species;
- Water quality concerns, including pollution and eutrophication from aquaculture operations;
- Impacts to the ecological carrying capacity;
- Modification of local water circulation patterns and current speeds from aquaculture infrastructure;
- Marine debris resulting from aquaculture gear loss;
- Physical impacts from aquaculture activities on the seafloor and substrate affecting biological resources, such as sensitive marine habitats and species;
- Ecosystem and public health impacts related to the use of fish meal and fish oils and aquaculture discharges into the water;
- Hazardous materials concerns related to the use of chemicals;
- Impacts to coastal aesthetic values;
- Impacts to tribal and/or cultural resources;
- Conflict with existing uses and navigation, including fishing grounds, recreation areas, public access, consumptive and non-consumptive uses, and natural preserves; and
- Contribution of anthropogenic impacts to global climate change.

## Impact Mitigation and Avoidance

Many of the potential impacts to biological resources can be minimized and/or avoided through the establishment of siting criteria, best management practices, and adaptive management. For example, potential impacts to tribal cultural resources, land use, aesthetics, recreation, and navigation or traffic may be reduced and/or avoided following discretionary review processes that would require projects be consistent with applicable policies, regulations, and local plans. Chapter 5 provides a brief overview of potential siting, best management practices, and adaptive management measure for current and potentially future marine aquaculture operations and activities that may occur within state waters.

# 4 MANAGEMENT CONTEXT

This chapter provides a brief overview of current primary national and state policies and management authorities for current marine aquaculture operations and activities that may occur within state waters.

## Policies, Management Authorities

### *National Policy*

In the National Aquaculture Act of 1980, the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) stated, “It is, therefore, in the national interest, and it is the national policy, to encourage the development of aquaculture in the United States.” U.S. aquaculture is governed by environmental laws such as the MMPA, Clean Water Act (CWA), Endangered Species Act (ESA), and Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act).

A primary objective of federal aquaculture policy is to develop more efficient permitting processes to promote industry development while setting standards for environmentally safe operations. Federal support, engagement and authorities span several agencies: the U.S. Food and Drug Administration (FDA), U.S. Environmental Protection Agency, U.S. Army Corps of Engineers (USACE), U.S. Fish and Wildlife Service (USFWS), and U.S. Department of Agriculture. Interagency collaboration and cooperation can help promote the development of new technologies that improve sustainability as well as improve the efficiency of the permitting pathways.

### *State Policies*

California has a long history of marine legislation, policy, management, and regulatory measures (CDFW 2016). With respect to marine aquaculture in California more specifically, the Aquaculture Development Act (PRC Sec. 825 et seq.) provides state policy direction encouraging the practice of aquaculture; augmented food supplies; expanded employment and economic opportunities; increased native fish stocks, enhance commercial and recreational fishing, and protect and better use the land and water resources of the state. Further, FGC Section 1700 declares a statewide policy to encourage the conservation, maintenance and utilization of the ocean and waters under the jurisdiction of the state for the benefit of the state citizenry and development of fisheries, including commercial aquaculture. In providing oversight of marine aquaculture development, the state is also directed to provide regulatory and administrative efficiency and effectiveness (Assembly Joint Resolution 43 (2014 Chesbro); FGC Sections 15100, 15702; and Government Code 65920 et seq.).

CDFW and the Commission are the principal state government entities responsible for the management, protection, and conservation of the state's fish and wildlife resources. As part of that responsibility, the Commission has the authority to regulate certain aspects of commercial marine aquaculture on state lands or in state waters, while CDFW has management responsibility. Specifically, the FGC provides CDFW and the Commission the authority to regulate marine aquaculture in four ways:

- registration of aquaculture facilities and species cultured within the state;
- lease of state water bottoms and water column for the purpose of aquaculture;
- permitting and licensing of various aquaculture-related activities, including stocking, broodstock collection, and importation; and
- detection, control, and eradication of disease in aquaculture facilities.

### California Fish and Game Code Sections 15000–15703—Aquaculture

FGC Sections 15000 through 15703 (Division 12) provide a framework for regulation of aquaculture operations in California. The Code includes regulations for brood stock acquisition, leasing of state water bottoms, disease control, and importation of shellfish and finfish. Pursuant to FGC Section 15400, the commission may lease state water bottoms or the water column to any person for aquaculture, including, but not limited to, marine finfish aquaculture. No state leases shall be issued, unless the commission determines that the lease is in the public interest in a public hearing conducted in a fair and transparent manner, with notice and comment, in accordance with commission procedures. In addition, pursuant to Section 15411 lessees may not unreasonably impede public access to state waters for purpose of fishing, navigation, commerce, or recreation. The lessee may, however, limit public access to the extent necessary to avoid damage to the leasehold and the aquatic life culture therein.

### Title 14, California Code of Regulations

Title 14 of the California Code of Regulations (CCR) provides implementing regulations under this authority. In addition, 14 CCR Section 15386 identifies CDFW as a trustee agency which has jurisdiction by law over natural resources affected by a project that are held in trust for the people of the State of California.

### Senate Bill 201 and the Marine Aquaculture Programmatic Environmental Impact Report

The abovementioned authorities to regulate marine aquaculture were modified when the California Legislature passed the Sustainable Oceans Act, also known as SB 201, in 2006. This act added FGC Sections 54.5 and 15008 and amended FGC Section 15400 and PRC

Section 30411. As amended by SB 201, leases and regulations adopted by the Commission for marine finfish aquaculture shall meet, but are not limited to, the standards pursuant to FGC Section 15400(b). This law has three major implications:

- It provides that "the commission may lease state water bottoms or the water column to any person for aquaculture, including, but not limited to, marine finfish aquaculture" (FGC Section 15400) under certain conditions and with certain restrictions (see Chapter 5: SB 201 factors).
- It requires that "the department [CDFW] shall, in consultation with the Aquaculture Development Committee, prepare programmatic environmental impact reports for existing and potential commercial aquaculture operations in both coastal and inland areas of the state" (FGC Section 15008[a]) if funds are appropriated to CDFW and matching funds are provided by the aquaculture industry.
- If a final programmatic EIR (PEIR) is completed, it "shall provide a framework for managing marine finfish aquaculture in an environmentally sustainable manner" (FGC Section 15008[b]) "so as to avoid adverse environmental impacts, and to minimize any unavoidable impacts" (FGC Section 15008[b][10]).

For over thirteen years, CDFW has attempted to reconcile the rigid California Environmental Quality Act (CEQA) framework and substantive considerations mandated by SB 201 with the delivery of a draft PEIR that addresses a new marine aquaculture management framework that is in accord with stakeholders throughout the state. Rather than engaging in this important policy and planning effort within the constraints of a CEQA document as a starting point, CDFW is coordinating steps with the Commission (with guidance and support from the California Ocean Protection Council) toward the development of a refined management framework through an Action Plan for marine aquaculture development in California (see further discussion in Chapter 5).

### CDFW Tribal Consultation Policy

The CDFW Tribal Communications and Consultation Policy provides the foundation for CDFW to work cooperatively, communicate effectively, and consult with Tribes. Pursuant to this policy, CDFW seeks to establish and maintain respectful and effective communications and consultation with Tribes with respect to current and proposed future aquaculture activities.

## Regulatory Overview

There are numerous other federal, State, and local agencies that also provide approvals or permits for aquaculture activities in the state. Depending upon the location and the nature of the activity, regulatory approvals or permits may be required from the agencies listed in Table 4-1. Each of these agencies and its general regulatory authority is discussed briefly below.

Table 4-1. Federal, State, and Local Involvement in State Waters.

| Agency | Jurisdiction | Permit or Statutory Authority | Subject |
|---|---|---|---|
| U.S. Army Corps of Engineers (USACE) | Waters of the United States | Section 404, Clean Water Act<br>Nationwide Permit 48, Existing Commercial Shellfish Aquaculture Activities | Placement of dredge or fill material, including structures, in jurisdictional waters of the United States |
| USACE | Waters of the United States | Section 10, Rivers and Harbors Act | Placement of materials in navigable waters |
| USACE | Federally listed wildlife and plant species | Federal Endangered Species Act (ESA) | Section 7 consultation regarding harm to or take of listed wildlife and plant species, including certain marine species |
| NOAA National Marine Fisheries Service (NMFS) | Federally listed marine and anadromous fish, sea turtles and marine mammals | ESA | Section 7 consultation regarding harm to or take of listed species |
| NMFS | Federally listed marine and anadromous fish, sea turtles and marine mammals | Marine Mammal Protection Act | Incidental harassment authorization or letter of authorization regarding harm of marine mammals |
| NMFS) | Federally listed marine and anadromous fish, sea turtles and marine mammals | Magnuson-Stevens Fishery Conservation and Management Act | Designates and protects Essential Fish Habitat via a requirement for interagency consultation.<br><br>Issue exempted fishing permit or other authorization to grow federally managed species in the exclusive economic zone. |
| NOAA National Ocean Service | National marine sanctuaries | National Marine Sanctuaries Act | Consultation requirement (similar to ESA Section 7) regarding management and trust responsibilities for National Marine Sanctuaries |

Table 4-1. Federal, State, and Local Involvement in State Waters.

| Agency | Jurisdiction | Permit or Statutory Authority | Subject |
|---|---|---|---|
| U.S. Coast Guard | Navigable waters of the United States | Private Aids to Navigation Permit | Responsible for obstructions or aids to navigation in waters of the United States, including requiring aquaculture-related structures located in navigable waters be marked with lights and signals to ensure navigational safety |
| California Fish and Wildlife Commission | State water bottoms | Lease of State Water Bottom, Fish and Game Code | Use of State-owned tidelands (Sovereign Lands) |
| California Department of Fish and Wildlife (CDFW) | Fish and wildlife | Aquaculture Registration, Fish and Game Code | Registration of aquaculture facilities |
| CDFW | State-listed fish and wildlife species | California Endangered Species Act (CESA) | Take of State-listed species |
| CDFW | Fish and wildlife | Letter of Authorization | Placing or planting of any live fish, fresh or saltwater animal, or aquatic plant within a water of the state |
| CDFW | Fish and wildlife | Standard Live Importation Permit | Importation of most live aquatic species |
| CDFW | Fish and Wildlife | Long-Term Live Importation Permits | Importation of aquatic species on an ongoing basis that do not represent a significant concern for potential impacts on state wildlife resources<br><br>Importation of aquatic species |
| CDFW | Fish and wildlife | Health Certificate by appropriate out-of-state agency | Generally required for aquaculture products stocked in the state, except for sales between aquaculturists registered with CDFW for the species in question |
| CDFW | Fish and wildlife | Wild Broodstock Collection Permit | Permission to collect wild stock for use in developing a domestic broodstock |

Table 4-1. Federal, State, and Local Involvement in State Waters.

| Agency | Jurisdiction | Permit or Statutory Authority | Subject |
|---|---|---|---|
| CDFW | Fish and wildlife | Restricted Species Permit | Certain species identified in FGC Section 2118 that are not established in California or listed as detrimental |
| CDFW | Fish and wildlife | Addition of species to individual certificates of registration | Adding species to current registration list |
| CDFW | Fish and wildlife | Aquarium Dealers Permit | Aquarium dealers wishing to sell certain species of fish; must be obtained from registered aquaculturists and sold as pets |
| CDFW | Fish and wildlife | Marine Life Protection Act | Designates Marine Protected Areas; develops plans for their management; reviews proposed developments for consistency |
| California Coastal Commission (CCC) | Coastal zone | Coastal Development Permit (CDP), California Coastal Act | Development activities within the California coastal zone |
| CCC | Federal waters beyond coastal zone | Coastal Zone Management Act, federal consistency determination or certification (in the case of a federal activity) | Development activities beyond the coastal zone |
| Regional Water Quality Control Boards (RWQCBs) and California State Water Resources Control Board (SWRCB) | Waters of the state | Section 401 Water Quality Certification, Clean Water Act (CWA) | As part of Section 404 permit process, ensure that project would meet State water quality standards |
| RWQCBs and SWRCB | Waters of the state | Section 402 National Pollutant Discharge Elimination System (NPDES) Permit, CWA | Discharges to waters of the United States |
| RWQCBs and SWRCB | Waters of the state | Waste Discharge Requirements, Porter-Cologne Water Quality Control Act | Discharges to waters of the state |

Table 4-1. Federal, State, and Local Involvement in State Waters.

| Agency | Jurisdiction | Permit or Statutory Authority | Subject |
|---|---|---|---|
| RWQCBs and SWRCB | Waters of the state | Approvals specific to Areas of Special Biological Significance | Areas of Special Biological Significance are 34 ocean areas monitored and maintained for water quality by SWRCB. Within these areas, NDPES permits are not issued unless the RWQCB grants a special exemption. |
| California Department of Health Services | Health of California residents | Certification of Growing Water | All shellfish harvested commercially for human consumption |
| | | Shellfish Handling and Marketing Certificate | Shellfish dealers |
| California Department of Food and Agriculture | Agricultural operations | Weighmaster Registration | Those selling aquaculture products by weight |
| California State Lands Commission (CSLC) | State-owned submerged tidelands | Review of CDFW leases | Ensure lands leased by CDFW for aquaculture are not otherwise used |
| California State Historic Preservation Office | Historic structures | Compliance with Section 106 of National Historic Preservation Act (NHPA) as part of USACE Section 404 permit | As part of Section 404 permit process, ensure that project would not adversely affect historic properties |
| Cities, Counties, Special Districts | Project area | Land Use Permit and/or CEQA review | Compliance with local regulations and State environmental review requirements<br><br>Type of approval varies by planning area |

# 5 LOOKING AHEAD

This report is designed to build a common understanding of existing marine aquaculture and its management framework, pointing to areas that need further consideration for potential future marine aquaculture development. Building on the management context review in Chapter 4, this section discusses known unresolved issues to facilitate future discussions with the objectives, principles, and concepts underlying sustainable future development of marine aquaculture in California.

In general, it is difficult to predict how commercial-scale marine aquaculture could evolve along California's coast in the future. A myriad of factors may influence the number, location, type, and size of aquaculture operations, including federal, State, and local regulations; environmental conditions; markets; technology and husbandry techniques; economics; and competition for space. Expansion of marine aquaculture would also include associated land-based and dock-side infrastructure and support facilities.

While the majority of existing shellfish operations within the state are located within intertidal areas, there is a potential for future shellfish, seaweed, and/or finfish aquaculture facilities in offshore areas. Offshore operations would require floating or submerged gear technology, tethered in some way to the bottom and sited in accordance with a variety of considerations. Support facilities, such as offices, feed storage and hatcheries on land (where applicable), as well as docks and boats, would enable the operators to conduct offshore aquaculture production. Operational visits to offshore facilities would need to be conducted in cooperation with other offshore activities to ensure safe and efficient marine transport.

Marine aquaculture expansion on land would likely occur on private property or granted state lands (e.g., often administered by ports and special harbor districts) and would not require a lease from the Commission. The lead regulatory authority for land-based aquaculture expansion is anticipated to be the CCC, either directly or through local coastal programs administered by counties after approval by the CCC, and RWQCBs with regard to discharge permitting.

Of note and per FGC Section 15007, the spawning, incubation, or cultivation of any finfish species of the family Salmonidae, transgenic fish species, or any exotic species of finfish is unlawful in waters of the Pacific Ocean that are regulated by this state. Other (non-prohibited) species of finfish may not be cultured in ocean waters of the State's jurisdiction without a lease from the Commission. Regulations defining a management framework that governs the issuance and conditions for operating such a lease in an environmentally sustainable manner have not yet been promulgated, but must, at a minimum, consider ten factors enumerated in FGC Sec.15400(b).

## Siting Analysis, Best Management Practices, and Adaptive Management

Sound management of marine aquaculture in public waters relies on a foundation of appropriate siting of operations. Some criteria for suitable siting of marine aquaculture operations originate in the existing local, State, and federal regulatory framework and the public trust doctrine; other criteria are provided by the legislative mandate of SB 201 explicitly; and still other criteria may arise from stakeholder or environmental impact concerns.

The following section describes some examples of potential mitigation or avoidance measures that may be adopted to reduce certain environmental impacts from commercial marine aquaculture facilities and may be used during consideration of their approval or denial of an application or renewal. For example, potential criteria for siting aquaculture facilities include requirements to reduce and/or avoid or minimize impacts to resources and may include:

- minimum depth requirements;
- minimum and/or maximum current speeds or water circulation patterns;
- minimum distances from sensitive habitats such as essential fish habitat, seagrass, kelp, rocky reefs, marine protected areas, and other management areas such as areas of special biological significance or national marine sanctuaries;
- minimization of impacts to the seafloor, substrate, and sensitive species and habitats;
- avoidance of areas with harmful algal blooms;
- minimum distances from other aquaculture facilities or maximum density of facilities;
- avoidance of the range or habitat of wild populations of the same species being cultured;
- avoidance of the range or habitat of one or more special-status species; and/or
- avoidance of waste discharge points or areas that are otherwise unsafe to harvest finfish, shellfish, or seaweed for human consumption.

The use of best management practices to avoid and minimize adverse effects on wildlife might include specifications for gear, lighting, noise levels and duration (both above and underwater), and vessel speed limits. Best management practices for the commercial aquaculture industry could also include specifications on the types of monitoring, recordkeeping, and reporting requirements. For example, a Hazard Analysis and Critical Control Point Plan could outline methods to prevent the introduction and spread of aquatic invasive species and implementation measures should prevention efforts fail. A Shellfish and Finfish Disease Prevention and Response Plan could identify the methods for disease prevention and response should disease outbreaks occur. Recordkeeping, biosecurity measures, use of antibiotics, vaccines or other therapeutants may all be covered in this plan.

Environmental impact models now allow potential lessees and regulators to assess the suitability of sites, understand the potential risks and benefits of proposed operations, and estimate the limits of acceptable farm biomass before they are permitted. The National Centers for Coastal Ocean Science website provides a portal to easily access coastal planning tools designed to assist the planning of sustainable aquaculture development. For example, models such as Depomod or AquaModel may be used to examine near and far field effects of farms in the coastal shelf where nearshore or open-ocean aquaculture may develop (NCCOS 2017).. Modeling tools are useful during the initial screening of potential sites, but they do not replace the need for actual site surveys and should not be a regulatory requirement without further testing, sensitivity analyses, and validation studies.

Adaptive management is a systematic, decision-based approach for improving resource management by learning over time from management outcomes. A rapidly growing body of data, engineering, and management experience have been accumulating globally and form the foundation of the impact analyses and components of new aquaculture management frameworks (DeCew et al 2012, Price and Morris 2013, Rust et al. 2014). The adaptive management approach can reduce reactionary responses and strengthen the management, viability, and sustainability of marine aquaculture (IUCN 2007). It is also defined and directed by Fish and Game Code.[3]

## *Path Forward – Action Plan*

This report is intended to serve as a foundation to build a common understanding of existing California commercial marine aquaculture activities and identify areas that need further refinement and consideration for future marine aquaculture development. This report and ensuing discussions will inform the development of an Action Plan that identifies areas of opportunity and avoidance to minimize impacts to habitat, biodiversity and wild fisheries. The

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[3] FGC §13.5: “Adaptive management,” unless otherwise specified in this code, means management that improves the management of biological resources over time by using new information gathered through monitoring, evaluation, and other credible sources as they become available, and adjusts management strategies and practices to assist in meeting conservation and management goals. Under adaptive management, program actions are viewed as tools for learning to inform future actions.

FGC § 703.3: It is the policy of the state that the department and commission use ecosystem-based management informed by credible science in all resource management decisions to the extent feasible. It is further the policy of the state that scientific professionals at the department and commission, and all resource management decisions of the department and commission, be governed by a scientific quality assurance and integrity policy, and follow well-established standard protocols of the scientific profession, including, but not limited to, the use of peer review, publication, and science review panels where appropriate. Resource management decisions of the department and commission should also incorporate adaptive management to the extent possible.

goal of the Action Plan will be to support the development and piloting of innovative tools and approaches to inform sustainable aquaculture management in California (OPC 2020).

Looking forward, the Action Plan should, at a minimum, address the following:

- measures to minimize impacts through permit conditions and regulatory tools that already exist;
- regulatory gaps that may require legislative or regulation changes;
- gaps in scientific understanding or technological innovation that may point to needed research & development;
- best practices for eliminating detrimental impacts;
- siting criteria or zones where marine aquaculture might develop that minimize user conflicts and resource impacts and enhance economic opportunity within the state; and
- administrative capacity, funding and expertise.

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