Appendix E:

Biological Resources Technical Report

Biological Resources Impact Analysis for Coast Seafoods Company, Humboldt Bay Shellfish Aquaculture: Permit Renewal and Expansion Project

Prepared for:

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TABLE OF CONTENTS

Figures

Tables

Appendices

BIOLOGICAL RESOURCES IMPACT ANALYSIS FOR COAST SEAFOODS COMPANY, HUMBOLDT BAY SHELLFISH AQUACULTURE: PERMIT RENEWAL AND EXPANSION PROJECT

1.0 SUMMARY

This technical report discusses the effects of Coast Seafoods Company's (Coast), Humboldt Bay Shellfish Aquaculture: Permit Renewal and Expansion Project (Project) on biological resources in Humboldt Bay, including aquatic habitat, invertebrates, fish, and marine mammals. The information in this report is summarized in the Draft Environmental Impact Report (DEIR) for the Project. The information presented in this technical report includes:

- **Project Description** – background information.
- **Existing Conditions** – habitat types in Humboldt Bay, pertinent laws and regulations, special-status species, and use of Humboldt Bay by fish and marine mammals.
- **Impact Metrics and Definition of Significance** – metrics used for calculating impacts and threshold of significance.
- **Impact Analysis of the Proposed Project** – direct and indirect impacts to habitat, the benthic community, fish, and marine mammals.
- **Cumulative Impacts** – cumulative impacts of like activities in Humboldt Bay.
- **Determination of Significance** – whether the Project exceeds the established threshold of significance for impacts to biological resources.

Coast is proposing to continue shellfish aquaculture operations within 294.5 acres and expand operations into 622 acres of Arcata Bay (North Bay) in Humboldt Bay, California. Both the current and proposed expansion area is within the approximately 4,308 acres that Coast owns or leases in Humboldt Bay. All areas proposed for cultivation have had some level of shellfish aquaculture since the 1950s. The proposed expansion would include a maximum of 522 acres (or 86%) of cultch-on-longline culture methods and a maximum of 100 acres (or 16%) of basket-on-longline/rack-and-bag culture methods. Overall, the Project would result in a total of 916.5 cultured acres, which is equivalent to approximately 21 percent of the area leased or owned by Coast.

Both Pacific oysters (*Crassostrea gigas*) and Kumamoto oysters (*C. sikamea*) would be grown using the two longline culture methods. Cultch-on-longline would be placed at intervals of one line every 5 feet

(ft) and basket-on-longline would be placed at intervals of 3 lines spaced 5 ft apart with a 20 ft gap between groups of 3 lines. Oysters are currently grown at tidal elevations ranging from +3.0 ft to -2.0 ft mean lower low water (MLLW), although the proposed expansion area would include a lower elevation range (+1.5 ft to -2.0 ft MLLW). Comparatively, the mean tidal elevation of eelgrass in North Bay ranges from +1.4 ft to -3.1 ft MLLW. Therefore, eelgrass is growing in most of Coast's existing owned or leased land and at elevations that overlap spatially with the preferred elevations for oyster cultivation.

1.1 Overwater Structure

The only overwater structure added to Humboldt Bay from the Project is associated with changes to the FLUPSY, which would add a total of 72 square feet of additional surface area. The major concern associated with the addition of overwater structure is the potential to increase predation from ambush predators. The existing literature related to impacts from docks and pilings does not support a conclusion of increased predation risk. Further, a study conducted at Coast's clam rafts in Humboldt Bay collected seven species of fish. All species are native to Northern California and none were deemed likely predators on salmonids or longfin smelt.

1.2 Unstructured Habitat

Unstructured habitat is a very important resource within a mosaic of habitats because it provides edges or transitional zones between habitat types. Habitat transitions often represent areas with increased biological diversity because they provide habitat for larger species that likely use edge habitat (or near channel habitat, as described below) for foraging. There is a total overlap of 15.5 acres of unstructured intertidal habitat within the expansion area, including areas with macroalgae species present. Approximately 39 percent (or 6 acres) of this area overlaps with unstructured habitat that is within 100 meters (m) of a main channel. The addition of structure (e.g., PVC pipes, rack-and-bag structures, basket-on-longlines) will displace habitat and change the community structure associated with these areas.

There are certain species (e.g., California halibut (*Paralichthys californicus*) and black brant (*Branta bernicla nigr*)) that tend to avoid structure and other species (e.g., families Cottidae and Embiotocidae) that tend to be structure-oriented species. The existing literature on off-bottom culture that would be similar to the proposed activity does not support the conclusion that shellfish aquaculture adversely impacts fish and wildlife. The majority of literature indicates that changes to fish are often neutral or positive. Adding structure to mudflat habitat in North Bay can provide an increase in prey resources along the near channel habitat where many species appear to forage. Researchers have shown that oyster reefs provide more interstitial spaces for predator refugia and increased fitness due to the presence of suitable prey items. While there will be changes, and certain species that benefit more than others, the amount of unstructured habitat affected is a small portion of the unstructured near channel habitat available in North Bay.

1.3 Eelgrass Habitat

The three interactions that can potentially result in a direct loss of eelgrass include: (1) gear and shellfish products, (2) working practices, and (3) sediment scouring and accumulation. In addition, the analysis considers resilience of the ecological system, duration of impacts, and cumulative impacts. While the analysis identified a reduction in eelgrass turion density directly under the longlines, the projected loss in density is not anticipated to exceed the identified thresholds of significance. Because the analysis of potential impacts is based on empirical observations of loss directly under the longlines and between the lines, impacts associated with shading, mechanical abrasion, trampling, and desiccation of eelgrass blades are intrinsically incorporated into the analysis.

In terms of the expansion area, the existing data, field observations, and analyses do not indicate a loss of areal extent of eelgrass (i.e., eelgrass bed area) from the placement of cultch-on-longline and basket-on-longline aquaculture at 5 ft spacing. Impacts were estimated to be a 5 percent reduction in eelgrass density in the culture area and 1.7 percent reduction in eelgrass density when considering the larger eelgrass bed area (i.e., the shellfish culture and the contiguous eelgrass beds surrounding the expansion areas). Neither of these results exceed the threshold of significance established for this Project (please refer to Appendix D of the DEIR for a more detailed discussion). Despite this conclusion, Coast is proposing habitat improvements to ensure that the project has an overall beneficial ecological impact in Humboldt Bay.

Other potential impacts (e.g., fragmentation or disruption of floating eelgrass rafts and wrack) were also analyzed. While fragmentation is an accepted concept for impacts associated with the terrestrial environment, efforts to evaluate patch size and eelgrass density have found no consistent relationship between patch characteristics and species use, abundance, or diversity. The existing literature for aquatic systems support the concept that edge habitat is extremely productive, and as long as a habitat mosaic is provided, species use of an estuary would not be significantly altered. In terms of floating eelgrass rafts and wrack, a reduction in eelgrass density from the addition of longline culture could contribute to a reduction of these habitats. However, the projected amount of eelgrass density reduction is well within the natural variation and resiliency of eelgrass habitat within North Bay. Further, floating rafts and wrack are not known to be limited in North Bay. Given that eelgrass biomass has essentially doubled in the last 50 years, and because eelgrass habitat is at or near carrying capacity, a minor reduction in density from the Project will not significantly affect these processes.

1.4 Other Habitat Concerns

Other habitat concerns addressed in this document include: (1) sediment distribution and tidal circulation, (2) water quality, and (3) sediment quality. Shellfish aquaculture has both potential positive and negative impacts to these habitat conditions. There can be greater sediment deposition directly under shellfish aquaculture gear compared to control areas, although the levels reported were within the typical detection limit for this type of study. Further, even estimates as high as three times the rate in adjacent control sites under rack-and-bag culture showed no significant changes to sediment accretion. Effects to seabed topography would be further reduced with the incorporation of the proposed 5 ft spacing regime between longlines.

Two potential effects were analyzed for water quality: nutrients and turbidity, and contaminants. The ability for shellfish to filter water can potentially provide a benefit to the system, especially in terms of sequestration of excess nitrogen and phosphorous in tissue and shell. The amount of benefit that filtration provides depends on the physical mixing of nutrient sources, residence time in the estuary, and grazing pressure of farmed shellfish. The physical conditions of West Coast estuaries indicate that, while this may be a benefit, it is likely small in comparison to some of the estimates produced from the East Coast. However, some authors suggest that filtration by oysters can be considered a "safety net" to reduce anthropogenic inputs of nutrients to an estuarine system. In terms of the potential to introduce contaminants (e.g., accidental discharge of fuel, lubricants, or hydraulic fluids), the Project incorporates a number of Conservation Measures to minimize this potential impact. Coast regularly cleans and maintains its equipment, and is highly motivated to avoid contaminants due to the sensitive nature of oysters in terms of growth and taste.

Sediment quality is the final habitat concern addressed in this report. The process of benthic-pelagic coupling can have both negative and positive benefits to a system, depending on scale of the aquaculture operation and physical conditions of the system (e.g., flushing rate and circulation). The deposition of biodeposits within a shellfish farm will increase the organics in the sediment and can potentially change sediment quality. In general, the area of the seabed that is affected is typically restricted to immediately beneath or adjacent to the cultivation area, and the density of culture and circulation in Humboldt Bay would reduce this potential effect to be less than significant under the California Environmental Quality Act (CEQA). Other studies indicate that shellfish aquaculture may provide additional nutrients to the sediment that would promote the growth of seagrasses, but studies related to sediment "fertilization" on the West Coast indicate that eelgrass is not nutrient limited and this benefit is, therefore, likely negligible.

1.5 Potential Impacts to Benthic Communities

Benthic communities, both invertebrate resources and fish distribution, were analyzed for four potential impacts: (1) changes to species composition, (2) trampling effects, (3) introduction of non-indigenous species (NIS) and fouling organisms, and (4) establishment of non-native bivalves. Changes to species composition of benthic communities can affect prey resources for fish and wildlife, and the two main drivers for this change include changes to sediment quality (as discussed above) and addition of structured habitat. The majority of studies related to benthic community changes from increased biodeposition are from rack-and-bag culture in areas where culture well exceeds what is proposed by Coast. However, even at these extreme densities of culture operations, the literature suggests that oyster culture has a small impact on the stability of the ecosystem or that the ecosystem has adapted to oyster culture in the systems studied. Overall, changes from increased organics to the system were shown to result in a positive impact on the food supply for birds and fishes. Studies related to the addition of structure came to similar conclusions, with an increase in prey resources associated with shellfish aquaculture gear. The higher fish abundance associated with oyster longline culture in North

Bay that was sampled in 2003 to 2005 may have been a result of an increase in epibenthic species that fish using these structures were targeting as forage.

Studies related to benthic community changes from trampling are generally from locations that have a plant species that respond slowly to disturbance (e.g., turtle grass) and involve recreational areas that have a much higher incidence of potential disturbance than would result from the proposed Project. Native eelgrass responds very quickly to disturbance through either rhizome extension or seed dispersal. In terms of potential disturbance events, cultch-on-longline (which is the majority of proposed culture methods) activity occurs about 2 days per acre every 1.5- to 3-years for planting and harvesting and 4 hours per 10-acre area once each month for maintenance. Frequency and intensity for basket-on-longline is about 12 days per acre for planting and harvesting with the same line in rotation about every 4 months. Aside from the low frequency of access for longlines, a portion of the access is conducted when the beds are inundated (approximately 44% for cultch-on-longline and 80% for basket-on-longline/rack-and-bag). The most intensive culture method proposed, in terms of trampling potential, is rack-and-bag. This culture method is proposed in 4 acres of unstructured habitat outside of eelgrass, and would require daily activity for maintanence . The main reason that Coast has transitioned to longline methods is to reduce its ecological footprint in the bay. Longlines (both cultch-on-longline and basket-on-longline) require less maintenance than rack-and-bag culture and allow the site to be accessed when the plots are inundated. However, even with the higher level of activity associated with rack-and-bag culture, sites can only be accessed an average of 11 percent of the year, when the plots are exposed during a low tide, which naturally reduces trampling potential associated with shellfish aquaculture operations.

The final concerns associated with benthic communities are related to the introduction of NIS and establishment of non-native bivalves. Legacy introduction of NIS into Humboldt Bay occurred from over 100 years of shipping traffic into Humboldt Harbor and Bay and oyster operations. Current operations involve a number of stringent management measures to avoid introduction. Coast is a participant in a disease prevention program called the "Shellfish High Health Program" sponsored by the Pacific Coast Shellfish Growers Association (PCSGA). This program involves examination of oysters imported into California by a US Department of Agriculture (USDA)-certified Shellfish Pathologist and maintenance of a California Department of Fish and Wildlife (CDFW) permit to import oyster seed from out-of-state or out-of-country hatcheries. These management measures will control the introduction of NIS and disease into Humboldt Bay. In addition, there is a low potential for cultured shellfish to spread and persist in Humboldt Bay. Factors limiting oyster naturalization include water temperature, the high flushing rate of Humboldt Bay, and lack of suitable structured habitat for settlement. For these reasons, the risk of non-native oysters establishing in Humboldt Bay is low.

1.6 Special-Status Species and Commercially Important Species

Potential Project impacts to seven species or species groups were analyzed (Dungeness crab, Pacific lamprey, sturgeon, salmonids, forage fish, groundfish, and marine mammals). The main metrics used to analyze impacts included spatial overlap and human presence. The thresholds of significance were based on Section 15065 of the CEQA Guidelines. Potential Project impacts were discussed for each species or species groups in terms of four impacts: (1) human disturbance, (2) habitat degradation or alteration, (3) reduction in prey resources, and (4) obstructions to access or migration corridors.

Based on general Conservation Measures (e.g., boat operations, design and placement of aquaculture gear), eelgrass Conservation Measures (e.g., spacing longlines 5 ft apart), and the potential spatial overlap and frequency of human presence, no significant impacts were identified for the species or species groups analyzed with the possible exception of Pacific herring and marine mammals. Mitigation Measures were proposed for herring and marine mammals, including conducting a visual inspection of gear and shellfish products during the months of December through March for herring eggs and then to avoid those areas if spawn is observed until the eggs have hatched (Mitigation Measure BIO-1), and not conducting activity within 100 m of the Sand Island harbor seal haul-out location (Mitigation Measure BIO-2). These Mitigation Measures were considered sufficient to reduce the potential impact to these species to a level that is considered less than signfiicant.

2.0 PROJECT DESCRIPTION

The following provides a description of the Project focused on the characteristics of the proposed expansion area. A more thorough description of existing culture is provided in the DEIR.

2.1 Project Background

Coast has been culturing shellfish in Humboldt Bay, California since the early 1950's, and before that oysters have been cultured in Humboldt Bay since the early 1900s. Historically, Coast cultured as much as 1,000 acres of tidelands for oyster culture within its owned and leased footprint. Coast traditionally cultured shellfish using bottom culture methods, which entailed growing oysters directly on the bay bottom and harvesting them with an oyster dredge. In the mid to late 1990s, in response to requests from regulatory agencies, Coast began to transition its operations to more environmentally sustainable off-bottom culture methods.

In 2006, Coast reduced its operational farm footprint to approximately 300 acres within North and Central bays using exclusively off-bottom culture methods to cultivate Pacific and Kumamoto oysters[1] (Figure 1). The cultivated footprint has not changed since its 2006 approvals, although a new off-bottom culture method (e.g., basket-on-longline) was added in 2013.

2.2 Project Characteristics

The Project proposes to continue operations within 294.5 acres of Coast's existing culture area and expand operations into 622 acres (expansion area) of North Bay. Coast is also proposing to increase the capacity of its already-permitted Floating Upwelling System (FLUPSY). Project characteristics include:

1 Coast's current 300 acre footprint includes its FLUPSY, intertidal nurseries, wet storage floats and clam rafts.

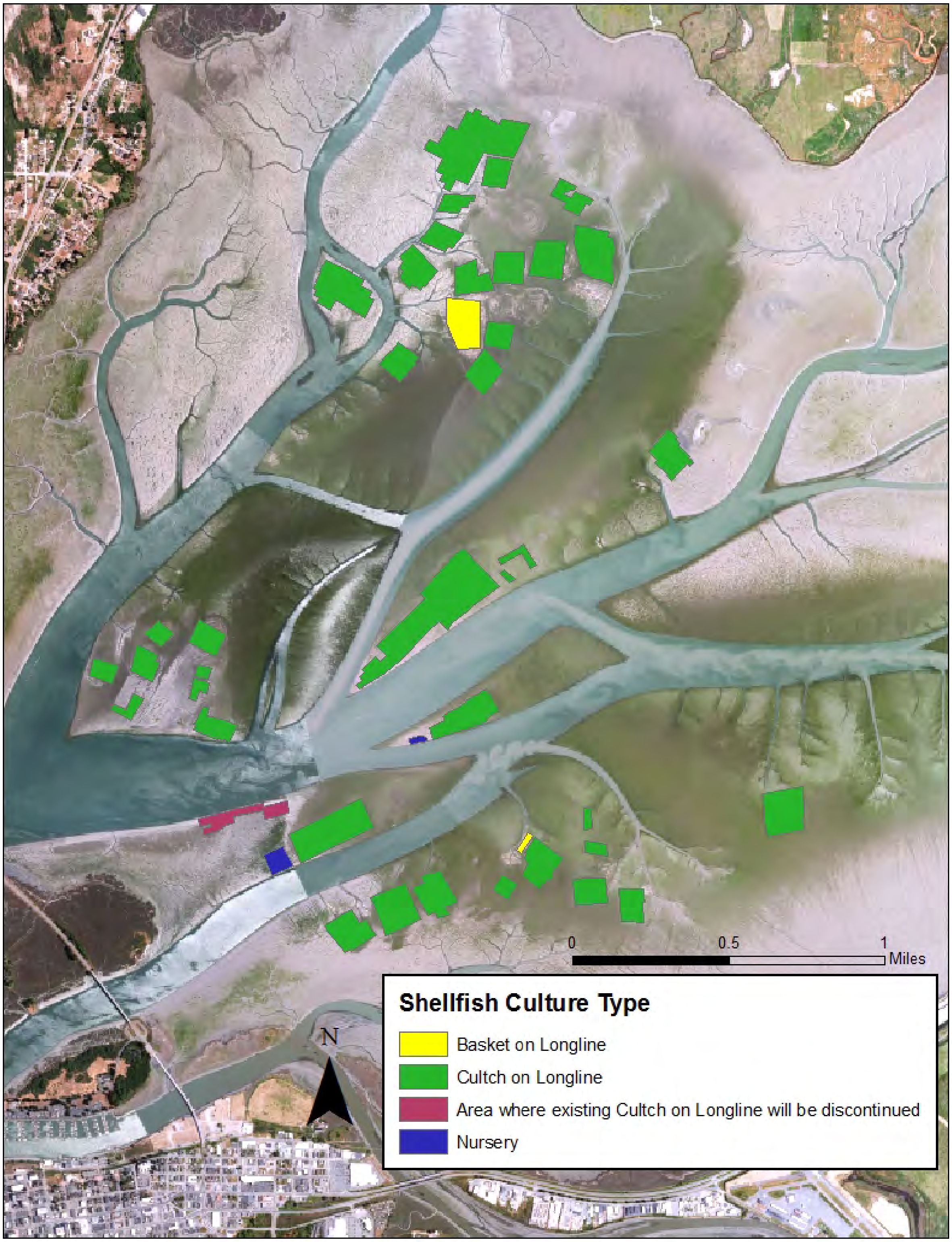

Figure 1 Existing Shellfish Aquaculture Footprint and Methods

Source: GIS layers provided by Wagschal, pers. comm., 2015

Note: includes a 5.5 acre area where existing culture will be discontinued.

- Extending regulatory approvals for the existing 300 acres of shellfish culture, with the exception of approximately 5.5 acres where farming will be discontinued (Figure 2).
- Increasing shellfish culture within an already permitted FLUPSY by adding eight culture bins.
- Permitting an additional 622 acres of intertidal oyster culture area (Figure 2).
  - Within a maximum of 522 acres, the cultch-on-longline culture method would be used.
  - Within a maximum of 100 acres, the basket-on-longline and/or rack-and-bag culture method would be used. Basket-on-longline culture would be used in up to 96 acres. Rack-and-bag culture would be used on a maximum of 4 acres. Rack-and-bag culture would not be placed within 10 ft of existing eelgrass beds[2], per the CEMP definition.

The Project only involves culturing the same species that Coast currently cultures (i.e., Kumamoto oyster, Pacific oyster, and Manila clam).

2.3 Project Alternatives

The Project is the Preferred Alternative, and will be what is discussed throughout the impacts section. In addition, the EIR considers four project alternatives, as follows:

- **Alternative 1:** 10-Foot Spacing Alternative – Coast would renew regulatory approval for its existing 300 cultivated acres and would expand its shellfish aquaculture operation by 955 intertidal acres using 10-ft spacing between longlines. This would allow for an increase in shellfish production equivalent to that provided by the Preferred Alternative but, due to the increased spacing between longlines, would result in a larger operational footprint.
- **Alternative 2:** Reduced-Acreage Alternative – Coast would renew regulatory approvals for its existing 300 cultivated acres and would expand its shellfish aquaculture operation by 300 intertidal acres (rather than 622 acres) using 5-ft spacing between shellfish longlines.
- **Alternative 3:** Existing Footprint Alternative – Coast would renew regulatory approval for its existing 300 cultivated acres but would not expand its operational footprint.
- **Alternative 4:** No Action Alternative – Coast would cease all shellfish aquaculture operations in Humboldt Bay and remove all associated equipment.

According to the DEIR, effects to eelgrass and other biological resources that use eelgrass habitat was the primary screening criteria for the scope of the alternatives. Because the primary change is associated with eelgrass habitat, the discussion of Alternatives in relation to biological resources is discussed in the Technical Analysis of eelgrass impacts included as Appendix D of the DEIR (Eelgrass Technical Report) and within the DEIR itself. Please refer to those documents for additional detail.

2 For the purposes of this Conservation Measure, an eelgrass bed is defined as "areas of vegetated eelgrass cover (any eelgrass within 1 m^2 quadrat and within 1 m of another shoot) bounded by a 5-m-wide perimeter of unvegetated area" (NOAA 2014).

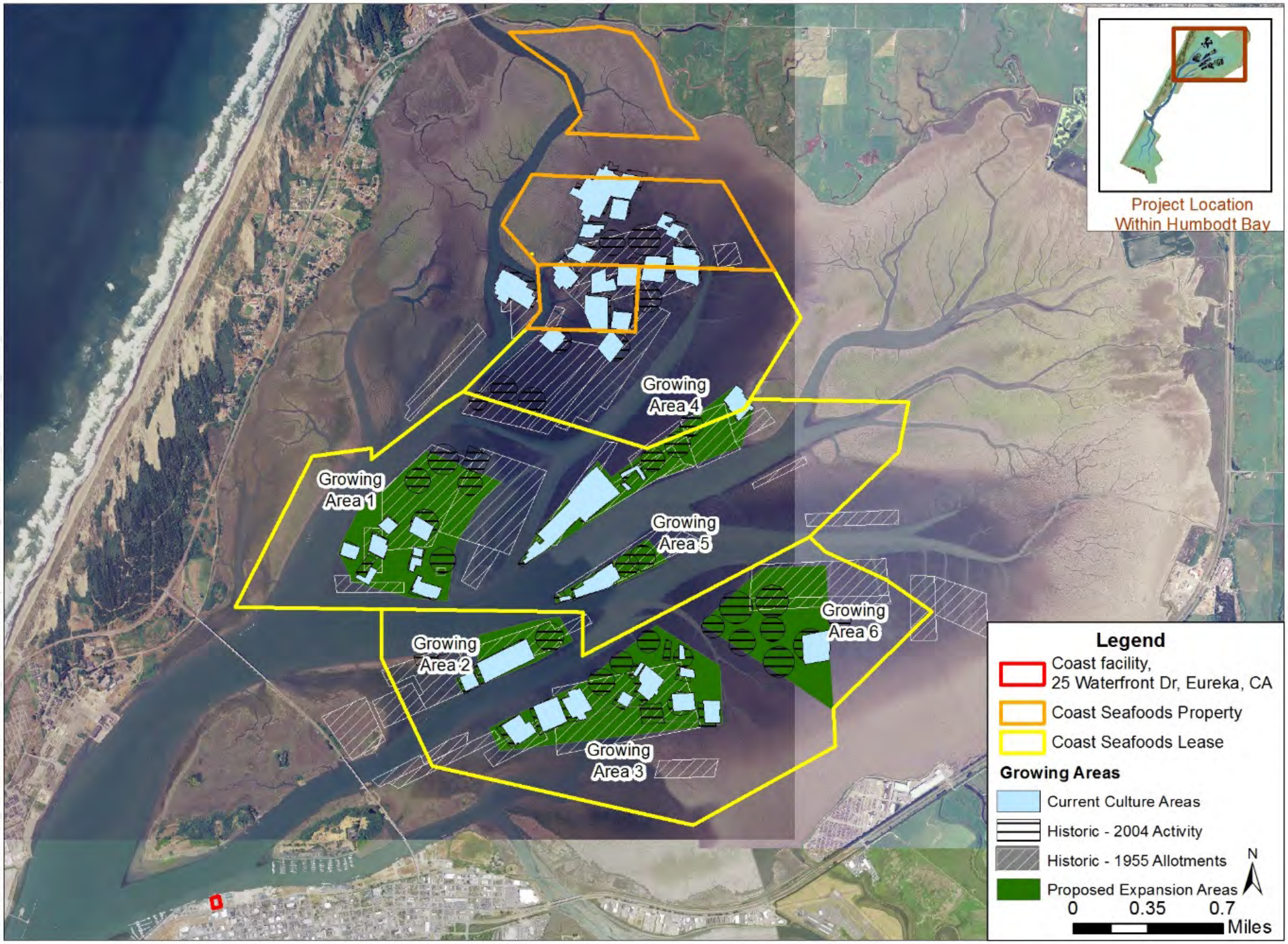

Figure 2 Areas Proposed for Continued and Expanded Shellfish Culture Overlaid on Historical Growing Areas.[3]

Source: GIS layers provided by Wagschal, pers. comm., 2015.

Note: Lease boundaries are approximate based on a review of the legal description and do not represent surveyed locations.

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3 A portion of Coast's existing culture footprint is located in areas currently owned by private property owners. Coast is currently in the process of finalizing leases from those tideland property owners. Figure 2 depicts Coast's currently leased area.

2.4 Culture Methods

Existing culture methods used by Coast include cultch-on-longline, basket-on-longline, and floating culture. The proposed aquaculture expansion area would include similar methods as used in the existing culture areas. However, spacing between individual longlines would be increased to 5 ft between individual lines for cultch-on-longline and 5 ft between groups of three baskets with a 20 ft gap between groups of three baskets. Rack-and-bag would use standard spacing methods and would not be sited within 10 ft of an existing eelgrass bed. The DEIR provides a description of the existing and proposed culture methods.

3.0 EXISTING CONDITIONS

The following information discusses the environmental setting of Humboldt Bay, focusing on conditions related to eelgrass habitat and other biological resources in North Bay that could be affected by the proposed Project. The information includes the following: (1) general habitat conditions in Humboldt Bay, (2) North Bay habitats, (3) ecological communities, (4) pertinent laws and regulations, and (5) special status species and commercially important species.

3.1 General Habitat Conditions in Humboldt Bay

Humboldt Bay is located approximately 260 miles north of San Francisco and is California's second largest estuary. The bay is 14 miles long, 4.5 miles wide at its widest point, and approximately 25 square miles in size (excluding its tributaries and sloughs). Humboldt Bay comprises three distinct sub-basins: (1) North Bay, (2) Entrance Bay, and (3) South Bay (Figure 3). Both the north and south segments are extremely shallow with large, mostly vegetated, mudflats exposed during minus tides. Habitat within each of these sub-basins is a mixture of unconsolidated sediment (or mudflats), eelgrass beds (both continuous and patchy[4]), coastal marsh habitat, macroalgae, and subtidal habitat in channels that drain the bay.

Overall, Humboldt Bay contains the most eelgrass coverage of any embayment in California based on the total size of the bay compared to eelgrass habitat. There are approximately 5,600 acres of eelgrass in Humboldt Bay, which is equivalent to about 31 percent of the total bay area. The majority of eelgrass is distributed between the two main sub-basins of the bay. Eelgrass covers about 84 percent of available habitat in South Bay (Gilkerson 2008). In comparison, eelgrass in North Bay covers a smaller portion (about 39%) of the available habitat area. This difference between the two sub-basins is likely caused by a combination of factors affecting eelgrass distribution. For example, South Bay is more sheltered from wind and wave action caused by a storm track that is predominately from the southwest. North Bay is surrounded by greater population density, which likely results in anthropogenic inputs of nutrients. Additionally, two of the four main freshwater inputs to Humboldt Bay occur in North Bay: Jacoby Creek and Freshwater Creek. The Elk River is part of Entrance Bay and Salmon Creek is part of South Bay. Freshwater inputs can result in increased turbidity and lower light levels. The major controlling factors for eelgrass in North Bay are discussed below.

Because the proposed expansion area is located primarily in North Bay (the proposed FLUPSY expansion is in Entrance Bay), the evaluation of biological impacts will focus on this portion of Humboldt Bay. The Project is not expected to affect other portions of Humboldt Bay.

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4 This report uses the definitions of eelgrass beds provided by Schlosser and Eicher (2012):

- Patchy eelgrass beds: >10% and <85% cover by eelgrass and larger than 0.01 ha (0.025 acres).
- Continuous eelgrass beds: >85% to 100% cover by eelgrass; variable density. An unvegetated area or patch of macroalgae (<0.01 ha within an eelgrass bed) was considered part of the continuous bed.

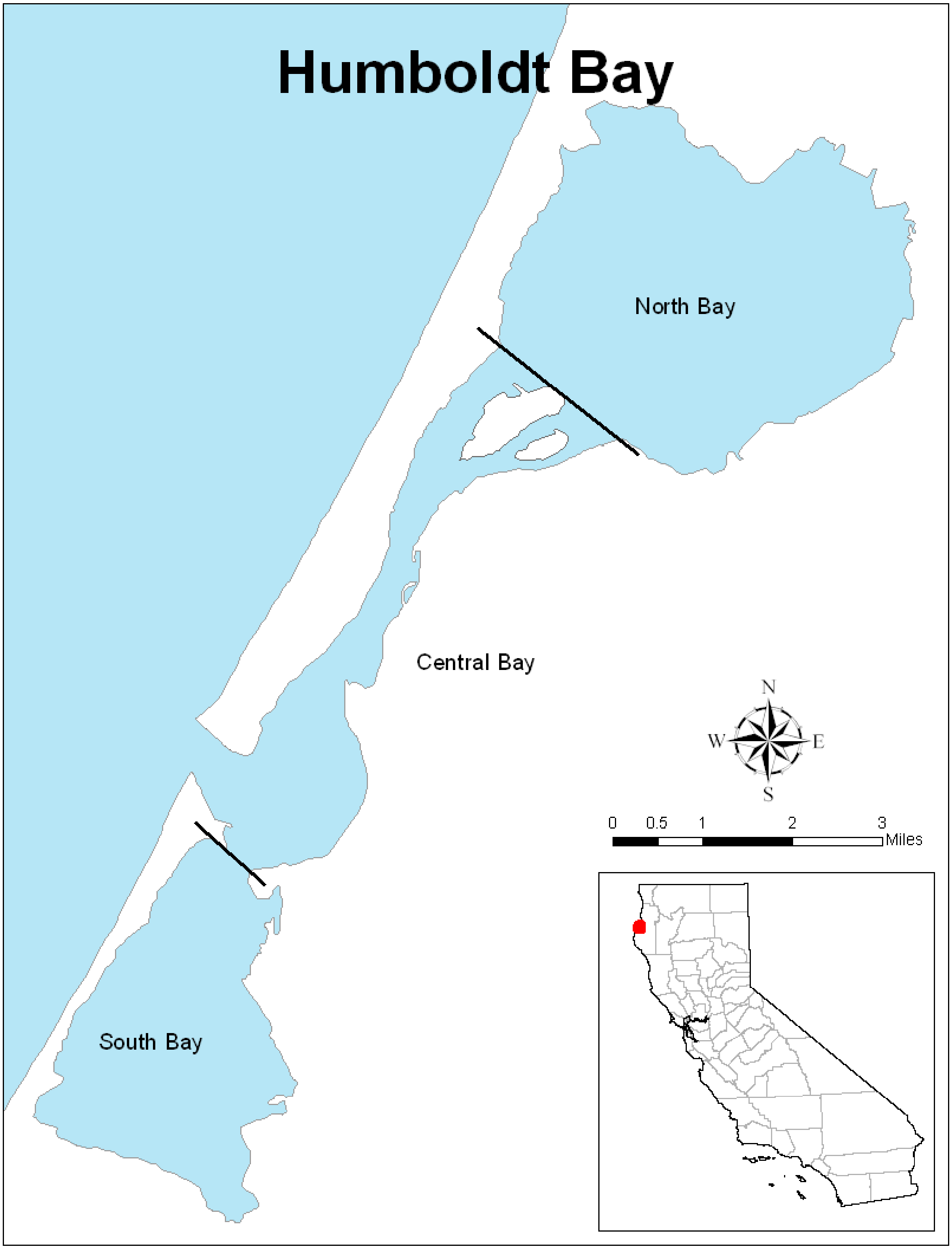

Figure 3 Sub-Basins of Humboldt Bay, California.
Source: Pinnix et al. (2005)

3.2 North Bay Habitats

Humboldt Bay habitats were recently mapped by NOAA (2012) using the emerging Coastal and Marine Ecological Classification Standard (CMECS). This effort provides a valuable baseline for evaluating future changes in habitat. Figure 4 includes the CMECS classifications for North Bay.

Native eelgrass (*Zostera marina*) is the dominant habitat of North Bay. The major controlling factors for eelgrass include: (1) light, (2) temperature, (3) energy, and (4) nutrients (Opler 1992, Tennant 2006, Gilkerson 2008, Swanson et al. 2012, CeNCOOS 2014, Shaughnessy and Hurst 2014). Eelgrass areal extent and shoot density in North Bay show a significant amount of natural variability (see Appendix D of the DEIR). It also appears that eelgrass is occupying most, if not all, available suitable habitat and may be at, or near, carrying capacity (Gilkerson 2008). A more detailed analysis of existing eelgrass resources in North Bay is provided in the Eelgrass Technical Report (Appendix D of the DEIR).

While eelgrass is an important habitat in Humboldt Bay, there are also large amounts of coastal marsh, macroalgae, and subtidal habitats in the bay. A smaller, but significant, amount of habitat is currently used for shellfish culture. In considering the role of each of these habitats, species utilization and changes to the system should be considered. As an example, the diking and filling of salt marsh habitat from the 1880s to the 1980s resulted in significant impacts, including channel confinement, gradient increase, and ongoing erosion of residual salt marsh habitat (Schlosser and Eicher 2012). It is important to also take into account the ecological value of a habitat mosaic on species diversity, connectivity between habitats (e.g., freshwater to estuarine), and resilience to natural and anthropogenic changes.

3.3 Ecological Communities[5]

The ecological communities in North Bay include two main types of habitats: subtidal and intertidal.

3.3.1 Subtidal Community

The subtidal community in Humboldt Bay includes plant and animal species that are always inundated by water. Due to the numerous aquatic species that occur in the bay and estuaries, "functionally related" species groups have been defined (HBMP 2007). Special status fish in this community include Pacific lamprey (*Entosphenus tridentatus*), green sturgeon (*Acipenser medirostris*), white sturgeon (*A. transmontanus*), coho salmon (*Oncorhynchus kisutch*), Chinook salmon (*O. tshawytscha*), steelhead (*O. mykiss*), coastal cutthroat trout (*O. clarki*), eulachon (*Thaleichthys pacificus*), and longfin smelt (*Spirinchus thaleichthys*). Commercially and recreationally important species that use subtidal areas include Dungeness crab (*Cancer magister*), Pacific herring (*Clupea pallasii*), rockfish (*Sebastes* spp.), and California halibut (*Paralichthys californicus*). Numerous bird and marine mammal species also use subtidal areas.

5 Language in this section is informed by work prepared by the Harbor District for the District's Mariculture Pre-Permitting Project.

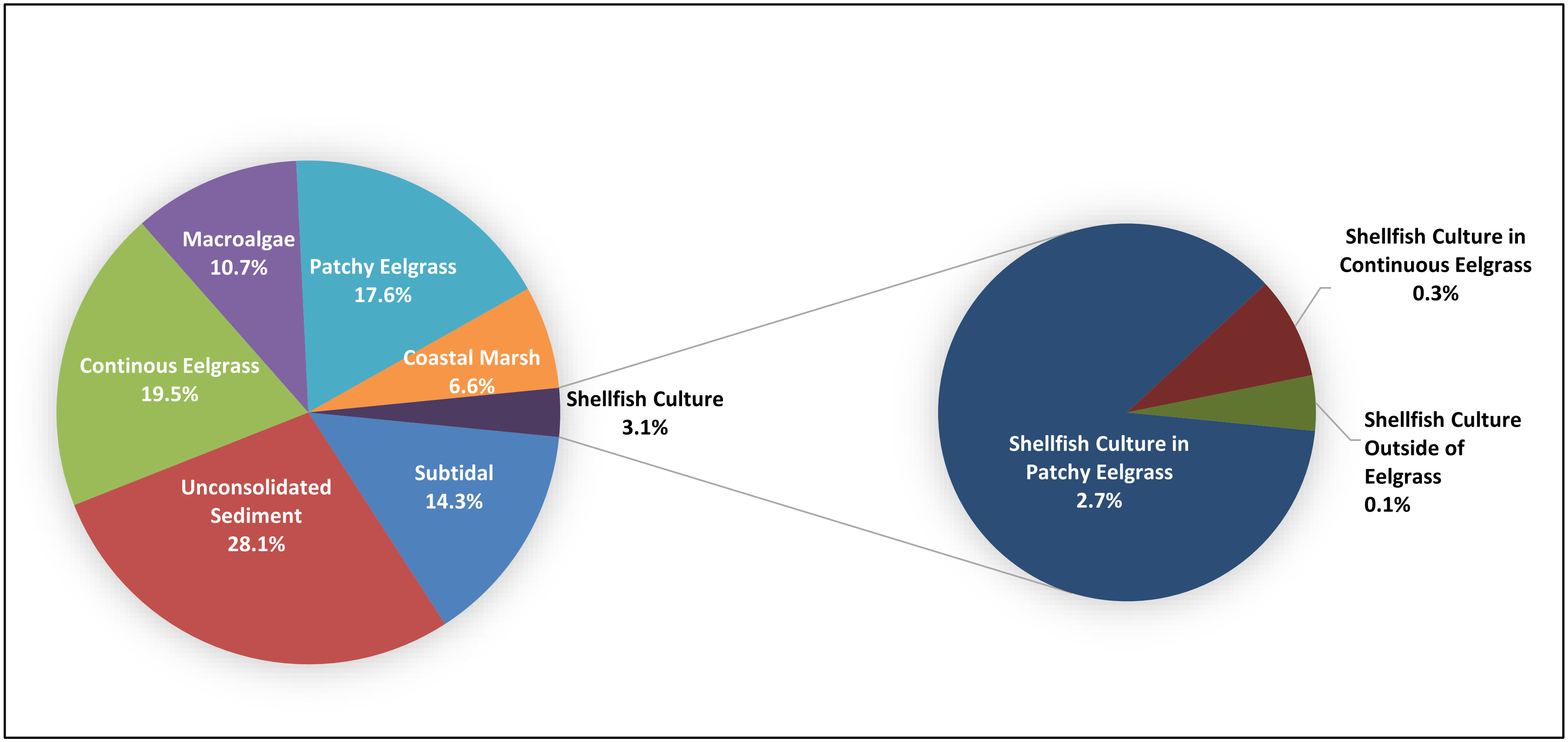

Figure 4 Habitats in North Bay Classified under the Coastal and Marine Ecological Classification Standard.
Source: Wagschal, pers. comm., 2015; Notes: Habitat areas based on data from NOAA (2012).

3.3.2 Intertidal Community

Intertidal mudflats are exposed during lower tides and submerged during higher tides. The tidal range in North Bay is approximately -2.0 ft to +8.5 ft MLLW. There are six major channels in North Bay that cut across the mudflats (Figure 5). In some areas, eelgrass forms dense beds, and, in other areas, eelgrass is sparsely distributed or absent. Species of marine algae also occur on the mudflats, including red algae (e.g., *Polysiphonia* sp., *Porphyra* sp., and *Ceramium* sp.), rockweed (*Fucus* sp.), and sea lettuce (*Ulva* sp.).

During high tides, fish can use the mudflats as foraging and nursery habitat. According to Schlosser and Eicher (2012), "In summer, large numbers of flatfish, rockfish, sculpins and other juvenile fishes move over flats at high tide to feed on mobile epifauna, sedentary infauna and protruding siphons and tentacles. These demersal fish are opportunistic predators and their prey choice will reflect the infaunal species distribution of the area." Various invertebrate species, including the commercially and recreationally important Dungeness crab, can occur on mudflats during high tides and low tides. Bird and marine mammal species also use intertidal areas. These species are discussed throughout this document.

3.4 Pertinent Laws and Regulations[6]

In the vicinity of the Project, numerous riparian habitats and other sensitive natural communities have been identified by city governments, CDFW, and the U.S. Fish and Wildlife Service (USFWS). These natural communities provide habitat for year-round and migrant species. Specific areas managed by local, state, or federal entities protecting riparian habitats and other sensitive natural communities include:

- The Humboldt Bay National Wildlife Refuge Complex, owned and managed by the USFWS.
- The Arcata Marsh and Wildlife Sanctuary, owned and managed by the City of Arcata.
- CDFW Wildlife Areas (WA), at the following locations: South Spit WA, Eel River WA, Fay Slough WA, Mad River Slough WA, Elk River WA.

Plans protecting biological resources in the vicinity of the Project include Local Coastal Plans, the Open Space Element of the County General Plan (CGP), Habitat Conservation Plans (HCPs), and recovery plans for listed species that are likely to occur within the Management Area.

6 Language in this section is informed by work prepared by the Harbor District for the District's Mariculture Pre-Permitting Project.

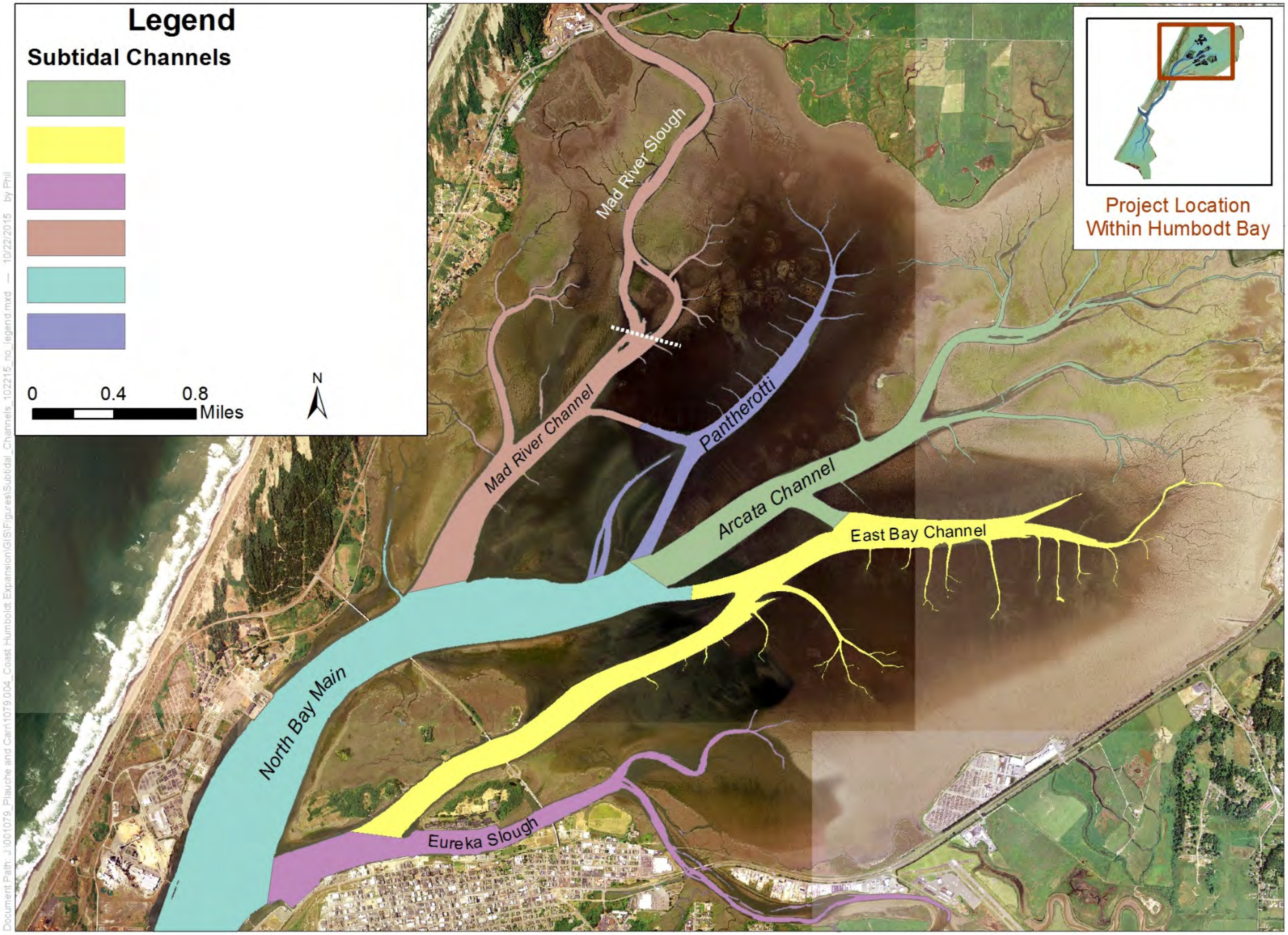

Figure 5 **Major Channels in North Humboldt Bay**
Source: modified from Pinnix et al. (2005); Dale, pers. comm., 2015.

Local Coastal Plans and other relevant documents include:

- City of Arcata Certified Local Coastal Program (LCP).
- Humboldt Bay Area Plan of the Humboldt County LCP.
- Eel River Area Plan of the Humboldt County LCP.
- Local Coastal Plan Issue Identification Report.
- Humboldt Bay National Wildlife Refuge Comprehensive Conservation Plan.
- Humboldt Bay Management Plan (HBMP).

Humboldt County's coastal plan policies call for providing maximum public access and recreational use of the coast; protecting wetlands, rare and endangered habitats, environmentally sensitive areas, tidepools, and stream channels; maintaining productive coastal agricultural lands; directing new development to already urbanized areas; protecting scenic beauty, and locating coastal energy facilities such that they have the least impact (County of Humboldt 2003).

The CGP is currently being updated (County of Humboldt 2012). The Biological Resources section of the Conservation and Open Space Elements describes the policies for preservation of natural resources, production of resources, outdoor recreation, and public health and safety.

In the general vicinity of the Project, HCPs and candidate conservation agreement and assurances plans have been written, but none geographicallty overlap the expansion area.

The HBMP (2007) provides guidance to the District regarding management of the bay. Preferred uses in North Bay identified by the plan include (1) continued or heightened protection of North Bay's environmental resources, (2) continued use for aquaculture or mariculture, and (3) the continuance and enhancement of recreational opportunities. Overall, the plan expresses a need to balance mariculture activities with other legitimate uses of the bay.

3.5 Special Status Species and Commercially Important Species

This technical report focuses on plant and animal species that are:

- Likely to occur within or adjacent to the Project sites and potentially be affected by the Project.
- Listed under the Endangered Species Act (ESA) or California Endangered Species Act (CESA).
- Listed as a Species of Special Concern or Fully Protected Species by the CDFW.
- Marine mammals protected under the Marine Mammal Protection Act (MMPA).
- Commercially important animal species that are potentially affected by the Project.

These species are referred to as "special status species" and "commercially important animal species." Table 1 provides a list of species for which the discussion of potential impacts to biological resources will focus. Note that black brant (*Branta bernicla*) and other birds are discussed within Appendix F of the

DEIR (Avian Resources Technical Report). Table 2 provides an indication of use by month for the species included in this report.

Table 1 Special Status and Commercially Important Animal Species Potentially Affected by the Project

Common Name	Scientific Name	Status
Invertebrates		
Dungeness crab	*Cancer magister*	Commercially important
ESA Listed Fish		
Green sturgeon – Southern DPS	*Acipenser medirostris*	FT, SSC
Coho salmon – Southern OR-Northern CA ESU	*Oncorhynchus kisutch*	FT, ST, SSC
Steelhead – Northern California DPS	*O. mykiss*	FT
Chinook salmon – California coastal ESU	*O. tshawytscha*	FT
Eulachon – Southern DPS	*Thaleichthys pacificus*	FT, SSC
Other Fish		
Pacific lamprey	*Entosphenus tridentatus*	SSC
White sturgeon	*Acipenser transmontanus*	SSC
Coastal cutthroat trout	*O. clarki*	SSC
Longfin smelt	*Spirinchus thaleichthys*	ST, SSC
Pacific herring	*Clupea pallasii*	Commercially important
Rockfish	*Sebastes* sp.	Commercially important
California halibut	*Paralichthys californicus*	Commercially important
Marine Mammals		
California sea lions	*Zalophus californianus*	Protected under the MMPA
Harbor seal	*Phoca vitulina*	Protected under the MMPA
Harbor porpoise	*Phocaena phocaena*	Protected under the MMPA

Sources: CDFW 2015a, CDFW 2015b, NMFS 2015a

DPS = Distinct Population Segment; ESU = Evolutionary Significant Unit; FT = Federally Threatened; SE = State Endangered; ST = State Threatened; SSC = CDFW Species of Special Concern; MMPA = Marine Mammal Protection Act

Notes:

1. *Birds are addressed in Appendix F of the DEIR (Avian ResourcesTechnical Report).*
2. *Tidewater goby (*Eucyclogobius newberryi*) was not included in this analysis, even though they are federally endangered, because they occur in "brackish (somewhat salty) water in shallow lagoons and lower stream reaches where water is fairly still by not stagnant" (USFWS 2015). This type of habitat will not be affected by the Project.*

Table 2 Timing of Species Use in Humboldt Bay

Species	Life Stage	Timing											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Invertebrates													
Dungeness crab	Adult												
	Juvenile												
ESA Listed Fish													
Green sturgeon	Adult/sub-adult												
Coho salmon	Adult												
	Juvenile												
Steelhead	Adult												
	Juvenile												
Chinook salmon	Adult												
	Juvenile												
Eulachon	Adult												
Other Fish													
Pacific lamprey	Adult (upstream)												
	Adult (downstream)												
White sturgeon	Adult/sub-adult												
Coastal cutthroat	Adult												
	Juvenile												
Longfin smelt	Adult												
	Juvenile												
Pacific herring*	Adult												
	Juvenile												
Rockfish	Adult												
	Juvenile												
California halibut	Adult												
	Juvenile												
Marine Mammals													
California sea lion	Adult												
Harbor seal	Adult												
	Pups												
Harbor porpoise	Adult												

Based on limited description
Based on clear timing description

Sources: Goetz 1983, Kucas and Hassler. 1986, Cole 2004, HBWAC and RCAA 2005, Pinnix et al. 2005, Fodrie and Mendoza 2006, Williamson 2006, Mello 2007, Wallace and Allen 2007, Burns 2008, Lowry et al. 2008, Israel et al. 2009, Studebaker and Mulligan 2009, Gustafson et al. 2010, Schlosser and Eicher 2012, Ricker et al. 2014, CDFW 2015b, Pinnix, pers. comm, 2015, Wallace and Allen 2015

3.5.1 Dungeness Crab

Following the closure of the salmon fishery and reduction of the groundfish fleet, the Dungeness crab fishery provided one of the most profitable fisheries in California (Hackett et al. 2009). The commercial fishery is managed by CDFW and the recreational fishery is managed by the California Fish and Game Commission. Sport catch is estimated to be 1 percent of the commercial catch (CDFW 2013). Dungeness crab landings in California have averaged 10.3 million pounds over the past 50 seasons, rising to 16.0 million pounds over the 10 seasons leading to 2011. Adults are rare in Humboldt Bay (Emmett et al. 1991), and the majority of landings occur in the open ocean off the coast in the vicinity of Humboldt Bay.

Dungeness crabs are highly mobile, living in sandy to sand-mud substrates of bays, estuaries, and the open ocean at depths less than 750 ft as adults (CDFW 2013). Mating occurs between February and June when pre-molt females are located by adult males. Fertilized eggs are released between October and December. Eggs transition through five stages between November and February of each year, with pelagic larvae consuming zooplankton and phytoplankton. Larvae are found offshore (i.e., outside of Humboldt Bay) until they develop into the final larval stage. Larval stages range in length from approximately 2.5 millimeters (mm) to 11.0 mm (Poole 1966). After 25 to 30 days, larvae settle into the benthic environment and metamorphose into juvenile crabs. Juvenile Dungeness crabs are found in bays and estuaries from March to July (Wild and Tasto 1983).

Habitat use for crabs depends primarily on life stage and size. For example, Williamson (2006) reported that juvenile crabs (mean sizes from 12.2 mm to 35.0 mm) in South Bay were positively correlated with dense eelgrass, areas with less variability in shoot length, and closer proximity to the channel. This study collected juvenile crabs in eelgrass ranging from 212 to 1,016 shoots/m^2 and distances ranging from 4 m to 75 m from a channel. Small crabs were more prevalent in habitat characterized by higher shoot density than larger crabs. Small juvenile crabs may be associated with high density eelgrass as a predator avoidance mechanism (Fernandez et al. 1993). Similarly, in Willapa Bay, adult Dungeness crabs primarily used unstructured muddy areas to feed, adult rock crabs (*Cancer productus*) used oyster aquaculture areas, and juvenile crabs of both species preferred shell deposits and oyster aquaculture areas over eelgrass and unstructured habitat (Dumbauld et al. 2000, Holsman et al. 2006).

3.5.2 Pacific Lamprey

The Pacific lamprey is a CDFW Species of Special Concern (CDFW 2015b). It is the largest lamprey in California, and adults can be up to 40 centimeters (cm) long. Pacific lamprey are widely distributed throughout the coast of California (e.g., Klamath and Eel rivers) and inland to watersheds in the Central Valley (e.g., San Joaquin River and Putah Creek). Similar to salmon, lamprey populations may be anadromous or resident and have a number of distinct runs. For example, Anglin (1994 *as cited in* CDFW 2015b) indicated that the Klamath River may have a spring-run of adults that spawn immediately after upstream migration and a fall-run that wait to spawn until the following spring. According to CDFW (2015b), "the general run trend is low numbers of migrants in October and November and higher numbers in the spring."

Adult migrations through Humboldt Bay and into tributary streams have been documented in the spring, but there is no information about potential fall migrations. In 2011 to 2013, upstream Pacific lamprey migrants were collected by CDFW in the Freshwater Creek fish weir between February and June, and downstream migrants were observed between March and July (Ricker et al. 2014). There was no indication whether these lamprey were spring-run adults that spawned and immediately migrated back to the ocean or whether they had remained in the freshwater for a longer period of time. According to CDFW (2015b), most upstream movements occur at night.

Lamprey spawning sites are typically low-gradient riffles where a nest is built in the gravel (CDFW 2015b). Juvenile lamprey (ammocoetes) burrow in the sediment and feed in streams with low velocities. After about 5 to 7 years in freshwater, the lamprey undergo physiological changes ("smolting") into adults and migrate to the ocean where they live for about 4 years. Downstream smolt migration typically occurs with high flow events in the winter and spring, with most movement ocurring at night. Adult lamprey are predators who attach to larger fish and feed on their body fluids, although adults do not feed during spawning migrations (Beamish 1980). Predation when lamprey are not migrating is typically confined to larger fish and marine mammals that occupy estuaries and nearshore coastal areas. Estuaries may be as important to lamprey as they are to salmonids for foraging, holding, and transition from freshwater to saltwater (and vice versa).

3.5.3 Green Sturgeon and White Sturgeon (Sturgeon)

Green sturgeon is a long-lived, slow-growing fish species, which is listed as threatened under the Federal ESA (NMFS 2015a) and as a CDFW species of special concern (CDFW 2015b). Mature males range from 4.5 ft to 6.5 ft and they do not reach sexual maturity until about 15 years, while mature females range from 5 ft to 7 ft and do not mature until they are 20 to 25 years for females (Kelly et al. 2007). Maximum ages of adult green sturgeon can range from 60 to 70 years. The southern distinct population segment (DPS) green sturgeon generally occur from Graves Harbor, Alaska to Monterey, California (Moser and Lindley 2007).

The life history of green sturgeon is typical of anadromous fish. They spend most of their lives in nearshore oceanic waters, bays (including Humboldt Bay), and estuaries. Spawning occurs in deep pools in "large, turbulent, freshwater river mainstems" (NMFS 2015a). In California, spawning is believed to occur in the Klamath River basin, Sacramento River, and South Fork of the Trinity River. There is also evidence that spawning may be resuming in the Eel River (CDFW 2015b).

Green sturgeon are considered the most marine-oriented of all the sturgeon species in North America (Moser and Lindley 2007). Juveniles enter bays and estuaries after only a year in freshwater and remain in marine waters until they return as adults to spawn. While green sturgeon are not expected to spawn in any of the Humboldt Bay tributaries, adults and sub-adults use the bay for foraging habitat. Green sturgeon typically access non-spawning estuaries in the summer and early fall months, and sturgeon have been documented in Humboldt Bay between April and October (Pinnix, pers. comm., 2015). Adults and sub-adults are regularly observed in deeper channels of Humboldt Bay, channel margins and mudflats when the tideflats are inundated during high tide, and around Sand Island in North Bay. While they have been observed in mudflats and along eelgrass margins (Pinnix, pers. comm., 2015), green sturgeon do not typically frequent shallow habitat where shellfish aquaculture is located.

Individual green sturgeon can be wide ranging in their migration patterns, and have been shown to move up and down the West Coast. For example, two fish tagged in Willapa Bay, Washington were later documented on a spawning migration up the Klamath and Sacramento rivers; a journey of more than 1,000 km (Moser and Lindley 2007). Similarly, green sturgeon recorded in Humboldt Bay from 2006 to 2008 were tagged in various locations, including Willapa Bay (Washington), Grays Harbor (Washington), the Rogue River (Oregon), San Pablo Bay (California), and the Sacramento River (Pinnix, pers. comm., 2015). It is likely that sturgeon are using bays, like Humboldt and Willapa, in the summer for foraging on invertebrates, particularly burrowing shrimp (Moser and Lindley 2007).

Like the green sturgeon, white sturgeon is a long-lived, slow-growing anadromous fish species. It is a CDFW species of special concern (CDFW 2015b). Mature males range from 2.5 ft to 3.5 ft and they do not reach sexual maturity until about 10 to 12 years, while mature females range from 3 ft to 4.5 ft and do not sexually mature until they are 12 to 16 years (CDFW 2015b). Maximum ages of adult white sturgeon have been known to be nearly 100 years, although more commonly, fish collected in California are no more than 27 years (CDFW 2015b). White sturgeon generally occur from Cook Inlet, Alaska to Ensenada, Mexico (PSMFC 1996).

White sturgeon spend most of their lives in nearshore oceanic waters, bays (including Humboldt Bay), and estuaries, although they prefer estuaries of large rivers (PSFMC 1996). The only known self-sustaining spawning population in California is in the Sacramento River, and spawning is believed to occur in the San Joaquin, Klamath, and Eel rivers (Israel et al. 2009). While white sturgeon are not expected to spawn in any of the Humboldt Bay tributaries, adults and sub-adults likely use the bay for foraging habitat. Young-of-the-year (YOY) white sturgeon have been shown to prefer water greater than 12.5 m in the Columbia River (McCabe and Tracy 1994). Juvenile and adult white sturgeon prefer deeper water, although they are occasionally found foraging in shallower habitats (Israel et al. 2009, CDFW 2015b).

3.5.4 Coho and Chinook Salmon, Steelhead Trout, and Coastal Cutthroat Trout (Salmonids)

Humboldt Bay supports three salmonid species that are listed as threatened under the Federal ESA (NMFS 2015a): coho salmon Southern Oregon-Northern Coastal California (SONCC) evolutionary significant unit (ESU), the Northern California steelhead trout DPS, and the California coastal Chinook salmon ESU. The coho salmon SONCC ESU is also listed as threatened under CESA. Additionally, Humboldt Bay supports coastal cutthroat trout, a CDFW species of special concern (CDFW 2015b).

Salmonid life history is characterized by periods of adult upstream migration, spawning and egg development, fry and juvenile development, smolt outmigration, and stream-estuary ecotone rearing. Channels within marsh habitats may be of particular importance to YOY salmonids because of the high insect and invertebrate prey resources and potential refuge from predators (Bottom et al. 2005). There is significant use of the tidal portions of Humboldt Bay tributaries, including Freshwater Creek, Elk River, and Salmon Creek by juvenile salmonids (Wallace 2006, Wallace and Allen 2007, Wallace and Allen 2015). CDFW estimated 40 percent of coho smolts and 80 to 90 percent of large steelhead trout smolts originated from the stream-estuary ecotone of Freshwater Creek in 2007 and 2008 (Ricker and Anderson 2011 *as cited in* Wallace and Allen 2015). While this stream-estuary ecotone is very important for salmonid survival, most of the Humboldt Bay sloughs are contained between levees and the adjacent marshes were converted to pasture lands over the last 150 years.

Sampling efforts in eelgrass beds of Humboldt Bay have not resulted in the capture of juvenile salmonids. For example, Pinnix et al. (2005) sampled over a two-year period (August 2003 to August 2005) using fyke nets, shrimp trawls, beach seines, purse seines, cast nets, and minnow traps. The authors identified a diverse and abundant fish community using the mud flats, oyster culture, and eelgrass meadows in Humboldt Bay, including a total of 49 species from 22 families of fishes. However, over the two years of sampling, no salmonid species were captured in any of the six different types of sampling gear employed in these studies. Another long-term study was conducted from June 1994 through August 1995 and then again from May 2003 through May 2006 in a small eelgrass bed adjacent to the main channel near the mouth of Entrance Bay (Garwood et al. 2013). The study collected 43 species representing 20 families of fishes, but only one juvenile steelhead and no other salmonids were collected throughout the six-year study.

Based on a sampling effort from May to September (Hunt et al. 1999), important prey items for juvenile Chinook salmon off the northern coast of California showed some seasonal trends. In May and June, the dominant prey included euphausiids, crab larvae, Pacific herring, and squid. In August and September, the dominant prey included Pacific sandlance, surf smelt, northern anchovy, and euphausiids. Dungeness crab larvae are also common prey items throughout the California coast and may be an important factor in seasonal migration. For example, Wild and Tasto (1983) reported that the spring arrival of Dungeness crab larvae in nearshore ocean waters coincided with the northward migration of salmonids.

There are two basic life history strategies for juvenile coho salmon in Humboldt Bay tributaries (Wallace and Allen 2007). The first were coho that rear in the upper estuary[7] (near salt marsh habitat) for the summer and migrate back upstream to over-winter, and the second were coho that rear in the estuary and then migrate to the ocean. A recent study in Humboldt Bay, California by Pinnix et al. (2013) used acoustic transmitters that were surgically implanted into out-migrating coho salmon smolts that exhibited this second life history strategy. Coho smolts spent more time in the stream-estuary ecotone compared to the lower estuary (e.g., intertidal habitat of Humboldt Bay). During their residency in Humboldt Bay (the lower estuary), coho smolts primarily used deep channels and channel margins and lasted an average of 10 to 12 days. They were also detected near floating eelgrass mats adjacent to the channels, but not over eelgrass beds. The results from this study emphasize the importance of edge

7 The study defined an estuary as "the portion of the stream under tidal influence during low stream flow in the summer. NSA [Natural Stocks Assessment Project] observed tidal influence approximately 9 km upstream of the mouth of Freshwater Creek Slough and about 6 km upstream of the mouth of Elk River."

habitat and the need for structural heterogeneity during salmonid residency and migration through Humboldt Bay.

3.5.5 Southern Eulachon, Longfin Smelt, and Pacific Herring (Forage Fish)

The eulachon is a small, anadromous fish that ranges from the Bering Sea, Alaska to Humboldt Bay, California. Eulachon supported Native American subsistence dip net fisheries and an inland recreational dip net fishery in the Klamath River Basin (Duran 2008). Due to a 20-yr decline in eulachon spawning runs, the National Marine Fisheries Service (NMFS) listed the Southern DPS as threatened under ESA in March 2010 (CDFW 2015b). The DPS includes populations in Washington, Oregon, and California. Critical habitat was designated in October 2011 and includes the Klamath River, Redwood Creek, and Mad River in California, which is the known southern extent of the southern DPS population (76 FR 65323). While the critical habitat for southern eulachon extends to just north of Humboldt Bay (i.e., Mad River), there were past occurrences of eulachon in Humboldt Bay tributaries (Jennings 1996) and they are thought to be infrequent visitors in the bay (Gustafson et al. 2010).

Eulachon spend 3 to 5 years (or 95% of their lives) at sea before returning to freshwater to spawn, which typically start as early as December and peaks in March and April in the Klamath River (Duran 2008). Eulachon have been documented in Humboldt Bay and nearby coastal rivers (Duran 2008). In 1996, the Yurok tribe supported a eulachon sampling effort on the Klamath River of over 110 surveying hours from early February to early May. No eulachon were observed. Considering the low abundance for over 20 years, CDFW considers the fish to be "nearly extirpated from California" (Duran 2008).

Longfin smelt are small, pelagic fish listed as threatened under the CESA and as a CDFW species of special concern (CDFW 2015b). Longfin smelt are known to occur in Humboldt Bay, but little is known regarding their distribution, abundance, or life history. The longfin smelt is a short-lived (generally 2 years) species. Adults spawn in low salinity or freshwater areas within the lower reaches of coastal rivers and the buoyant larvae are swept into more brackish waters where they rear and then move to marine waters. Spawning is believed to occur in tributary watersheds to Humboldt Bay between November and April when water temperatures are below 16°C.

Pacific herring are also small, pelagic fish. Herring use Humboldt Bay primarily for spawning and larval nursery habitat. According to Ray (pers. comm., 2015), herring are present along the coast and make some exploratory excursions into Entrance Bay until they are ready to spawn. This is similar to the pattern of the San Francisco Bay herring stock (Moser and Hsieh 1992, Bollens and Sanders 2004). Herring enter California bays and estuaries from October to April (peak from December to February), remain for 1 to 3 weeks without feeding, spawn, and then leave within days (Moser and Hsieh 1992, Bollens and Sanders 2004, CDFG 2006). Adults will hold in deep channels of bays to ripen for up to two weeks and then move to shallow areas to spawn (Ray, pers. comm., 2015). As observed by Bollens and Sanders (2004), larval herring abundance in San Francisco Bay peaks in February or March, and juvenile fish use the bay for rearing until about August when they migrate out to nearshore coastal waters. Pacific herring were collected as part of the mid-water assemblage in North Bay between 2003 and

2005. The general trend of herring abundance included low numbers in March, peak abundance from April through June, and then low numbers again from August to October (Pinnix, pers. comm., 2015). Overall, there are not many deep areas in Humboldt Bay for adult herring to remain long-term, but the bay is used extensively for nursery habitat of larval and juvenile fish.

Rabin and Barnhart (1986) reported that Pacific herring spawn in both North and South bays, but most spawning occurs in the northern end of the bay. The authors indicated that this is possibly due to an interaction between herring and freshwater inflows where low-salinity conditions may stimulate herring spawning. Although eelgrass is the principal substrate used for spawning in Humboldt Bay, the densest beds did not have spawn deposition during the most recent surveys (Mello 2007, Ray, pers. comm., 2015). A typical spawning event involves the deposition of herring eggs on approximately 300 acres of eelgrass in North Bay (Mello and Ramsay 2004). This represents less than 10 percent of available eelgrass used in each spawning event. This is similar to reports from Puget Sound where a large proportion of herring spawning habitat remains unused each year (Shelton et al. 2014). All of this information provides an indication that Pacific herring are not limited by spawning substrates in Humboldt Bay.

3.5.6 Rockfish and California Halibut (Groundfish)

Both rockfish and California halibut in Humboldt Bay are a commercially- and recreationally-important species (Warner 1982). Some rockfish species (e.g., yelloweye rockfish and bocaccio) are considered to be part of the deepwater assemblage and primarily use rocky substrates at depths greater than 151 ft, whereas other species (e.g., copper, brown, and black rockfish) are part of the nearshore sedentary assemblage that live in close association with rocky habitats at depths less than 120 ft (Schlosser and Bloeser 2006, Bargmann et al. 2011). The juvenile life stage of certain species (e.g., black and copper rockfish) are more common within shallower depths and non-rocky substrates such as sand, mud, and areas with kelp or eelgrass (Schlosser and Bloeser 2006, Studebaker and Mulligan 2009, Garwood et al. 2013). The larvae are pelagic and found in the upper mixed zone of the ocean before metamorphosing into juveniles and moving closer to shore (Larson et al. 1994 *as cited in* Parker et al. 2000). Humboldt Bay is primarily habitat for juvenile rockfish (i.e., it does not support much suitable adult habitat), and juvenile rockfish are present in eelgrass and nearshore habitats primarily from May to October (Studebaker and Mulligan 2009).

A study by Schlosser and Bloeser (2006) was conducted in bays and nearshore sites in California and Oregon, including Humboldt Bay, in June 2003 through December 2005. One of the main goals of the study was to "identify habitat associations of juvenile rockfish, cabezon and kelp greenling." The study results indicated that the most common species (in order of abundance) included black, copper, grass, and blue rockfish, which accounted for 91 percent of the 1,814 rockfish collected. The most highly used habitat types by juvenile rockfish in Humboldt Bay included mud associated with drift algae and pilings. Mud (or sediment with clay or silt) is a prominent habitat in North Bay (Figure 6).

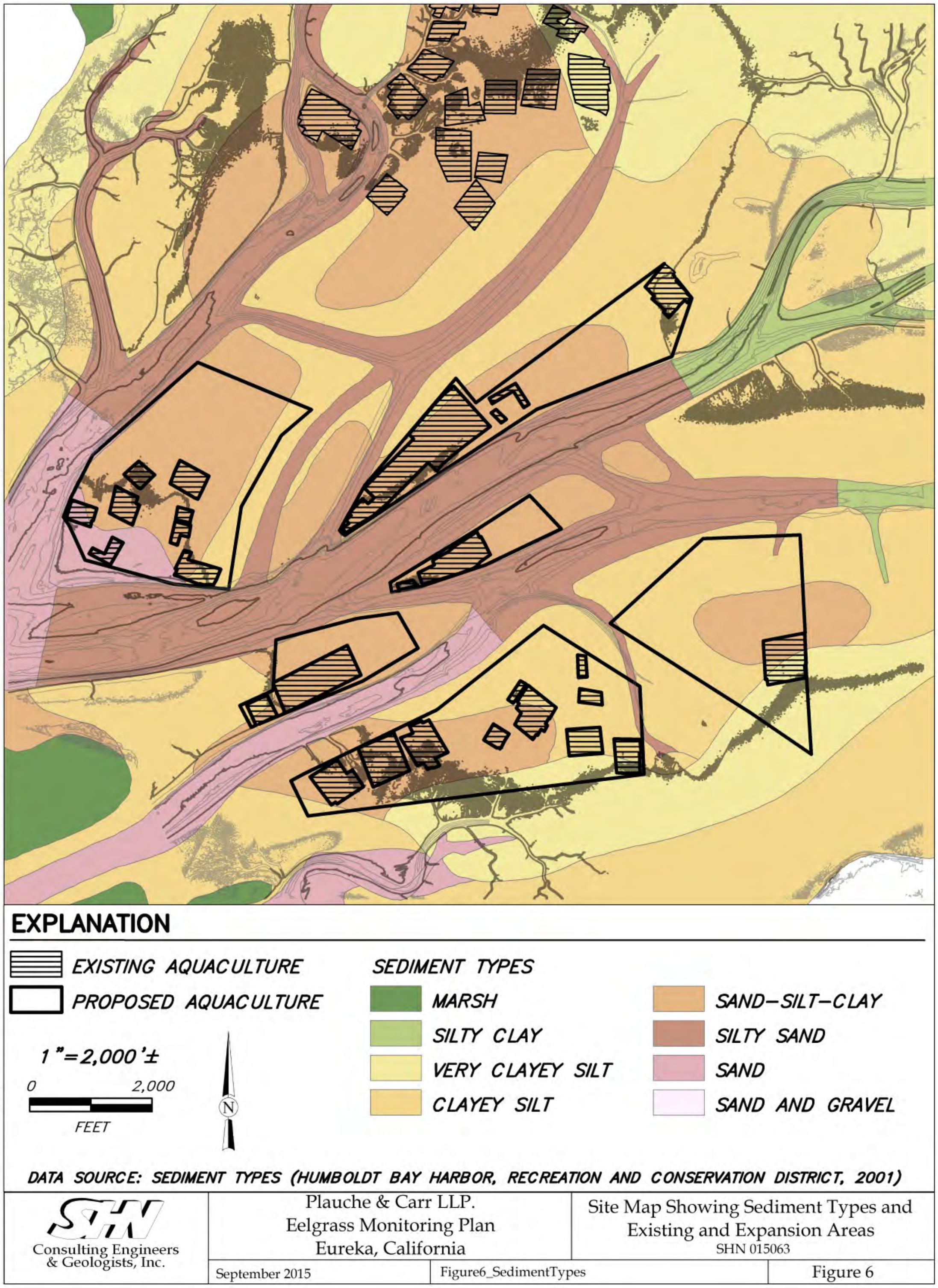

Figure 6 Sediment Types within the Existing Culture and Proposed Expansion Areas.

Source: SHN (2015)

Notes: Black outlines represent proposed expansion areas; hatched areas represent current culture areas.

A study on the feeding habits of YOY black and copper rockfish in eelgrass habitats of Humboldt Bay (Studebaker and Mulligan 2009) reported that gammarid amphipods and copepods were the dominant prey items. This is in general agreement with other studies that indicate rockfish feed predominantly on planktonic and epifaunal crustaceans (see references *as cited in* Studebaker and Mulligan 2009). In addition, there was a diet shift in copper rockfish over the course of the study from small planktonic crustaceans to larger epifaunal caprellid amphipods as the fish grew larger, whereas black rockfish showed no preference in diet over time.

Adult California halibut live in nearshore waters ranging from 1 to 100 m deep (Kramer and Sunada 1992 *as cited in* Fodrie and Mendoza 2006). Spawning occurs in pulses throughout the year, but peaks typically occur in February, July, and October. Larvae are planktonic for 3 to 4 weeks and settlement occurs in shallow coastal habitats. Fodrie and Mendoza (2006) conducted an analysis of the availability, usage, and contribution of potential nursery habitats for the California halibut in San Diego County. The authors indicated that there is approximately a 50/50 relationship of halibut that use protected embayments for nursery habitat compared to exposed coasts. Densities of fish in protected embayments (similar to Humboldt Bay) were highest at depths less than 2 m. In addition, fish densities were significantly different between vegetated and unvegetated bottoms, where juveniles (smaller than 250 mm) avoided areas covered by kelp forest, understory algae, or surfgrass. This is in agreement with other work that indicates that California halibut is one of the few fishes whose abundance was much higher in unvegetated areas compared to eelgrass beds (Valle et al. 1999, Bloeser 2000). Drawbridge (1990 *as cited in* Valle et al. 1999) reported that juvenile California halibut (smaller than 63 mm) prefer bare sand over eelgrass in the laboratory because they use the sand to partially bury themselves to avoid predation.

3.5.7 California Sea Lions, Harbor Seals, and Harbor Porpoises (Marine Mammals)

California sea lions are restricted to middle latitudes of the eastern North Pacific. There are three recognized management stocks: (1) U.S. stock from Canada to Mexico, (2) western Baja California stock, and (3) Gulf of California stock (Lowry et al. 2008, Carretta et al. 2009). Breeding colonies only occur on islands off southern California, along the western side of Baja California, and in the Gulf of California (Heath and Perrin 2008). California sea lions feed on fish and cephalopods, some of which are commercially important species such as salmonids, Pacific sardines (*Sardinops sagax*), northern anchovy (*Engraulis mordax*), Pacific mackerel (*Scomber japonicus*), Pacific whiting (*Merluccius productus*), rockfish, and market squid (*Loligo opalescens*) (Lowry et al. 1991, Lowry and Carretta 1999, Weise 2000, Lowry and Forney 2005). California sea lions do not breed along the Humboldt County coast. However, non-breeding or migrating adults may occur in Humboldt Bay year-round.

Harbor seals are widely distributed throughout the northern Atlantic and Pacific oceans. They occur along coastal waters, river mouths, and bays (Burns 2008, Lowry et al. 2008). Harbor seals consume a variety of prey, but small fishes predominate in their diet (Tallman and Sullivan 2004). In Northern California, pupping peaks in June and lasts about two weeks; pups are weaned in four weeks (Burns 2008). Foraging occurs in a variety of habitats, from streams to bays to the open ocean, and harbor seals can dive to depths of almost 500 m (Eguchi and Harvey 2005). Harbor seals breed along the Humboldt County coast and inhabit the area throughout the year (Sullivan 1980). Harbor seals use Humboldt Bay as a pupping and haul-out area; other nearby haul-out sites are located in Trinidad Bay and the mouths of the Mad and Eel rivers. The main pupping locations for harbor seals in Humboldt Bay are in South Bay (Laughlin 1974).

Harbor porpoises are distributed throughout the coastal waters of the North Atlantic, North Pacific Oceans, and the Black Sea. In the North Pacific, they range from Point Conception, California, to as far north as Barrow, Alaska, and west to Russia and Japan (Gaskin 1984, Angliss and Allen 2009, Carretta et al. 2009). Harbor porpoises from California to the inland waters of Washington have been divided into six stocks (Carretta et al. 2009), with three additional stocks occurring in Alaskan waters (Angliss and Allen 2009). Porpoises from Humboldt County are included in the SONCC stock that extends from Point Arena, California, to Lincoln City, Oregon (Carretta et al. 2009). Harbor porpoises have been observed throughout the year at the entrance to and within Humboldt Bay, usually as single individuals but sometimes in groups, with a maximum size of 12 animals (Goetz 1983). Abundance peaks between May and October, and porpoises are most abundant in Humboldt Bay during the flooding tide.

4.0 IMPACT METRICS AND DEFINITION OF SIGNIFICANCE

Aquaculture has the ability to affect biological resources in both negative and positive ways, with effects having the capacity to influence primary and secondary productivity and community structure (Simenstad and Fresh 1995). Manipulation of estuarine habitats to support aquaculture can disturb endemic communities (Pillay 1992). However, disturbances associated with shellfish aquaculture are typically infrequent and low intensity, which allows organisms to recover from or adapt to the changes associated with aquaculture activities.

4.1 *Impact Metrics*

There are four key ways in which potential Project impacts could affect biological resources: (1) human disturbance, (2) habitat degradation or alteration, (3) reduction in prey resources, and (4) obstructions to access or migration corridors.

Two main metrics are used in order to understand how these potential impacts will affect biological resources. The first metric is spatial overlap between different habitat types present in North Bay and the proposed Project (Table 3). It is important to understand that spatial overlap between habitats is not a quantification of impact because impacts may occur in discrete portions of a culture area and during limited times and for limited durations. In addition, species do not use different types of habitat to the same degree. For example, near channel habitat, or habitat within 100 m of a channel, is one of the primary habitat types used in Humboldt Bay by fish and wildlife (e.g., Williamson 2006, Garwood et al. 2013, Pinnix et al. 2013).

Table 3 Spatial Overlap of the Project with Habitats in North Bay

Area	Subtidal Channel Habitat	Near Channel Habitat			Intertidal Habitat		
		Non Eelgrass	Patchy Eelgrass	Continuous Eelgrass	Non Eelgrass	Patchy Eelgrass	Continuous Eelgrass
Existing Culture							
North Bay (acre)	2,110	1,736	657	1,134	3,035	1,301	827
Culture Area (acre)*	1	8	93	15	5	167	12
Area of Influence (%)	0.05%	0.5%	14.1%	1.3%	0.2%	12.8%	1.4%
Expansion Area							
North Bay (acre)	2,110	1,736	657	1,134	3,035	1,301	827
Culture Area (acre)	[6.5]**	6	31	204	9.5	77	288
Area of Influence (%)	0.0%	0.4%	4.7%	18.0%	0.3%	5.9%	34.8%

Sources: NOAA 2012

**Area calculations include the 5.5 acres that will be removed.*

***Subtidal habitat calculations are limited to spatial overlap with floating culture, which is an increase of 0.01 acres of FLUPSY bins. Although subtidal channel habitat overlaps with 6.5 acres of the proposed expansion areas as represented by planting polygons in Figure 2, intertidal planting is not proposed for these habitats. Since no culture would be planted in subtidal channels (Conservation Measure BIO-10), including a 10-ft buffer, the area of influence is shown as 0.0%.*

The second metric is frequency of human presence. This metric is relevant for both potential impacts to eelgrass habitat and the potential to disturb fish and wildlife. Frequency of human presence depends on the type of culture method present and the timing of operations (Table 4).

Table 4 Frequency of Activity by Culture Method

Culture Method	Type of Visit	Frequency and Rate
Cultch-on-Longline	Harvesting/Planting	2 days per acre (each acre every 1.5-3 years)
	Maintenance and Inspection	0.4 hours per acre (each acre once every month)
Basket-on-Longline	Harvesting/Planting	12 days per acre (each acre every 4 months)
	Maintenance and Inspection	While harvesting/planting; sometimes more frequently
Rack-and-Bag	Harvesting/Planting	12 days per acre (each acre every 4 months)
	Maintenance and Inspection	1 day per acre (each area every day)
FLUPSY	Maintenance and Inspection	Daily

Sources: Dale, pers. comm., 2015; DEIR Section 4, Project Description

Total human presence in Humboldt Bay for the Project can be measured by the number of trips and crew hours anticipated for the existing culture area and proposed expansion area (Table 5). As shown in the annual hours per acre for the entire Project, economies of scale will lead to a decrease in the average number of hours spent per acre of operation because most of the proposed activities (e.g., oyster longlines) will increase the activity in small increments over large areas. In other words, the majority of proposed activities occur infrequently and are of short duration and intensity. Hours per acre of operation are a measure of the frequency and intensity of operations, and suggest that for each acre of mariculture, work crews are anticipated to be present approximately 0.2 percent of the year (i.e., an average of 100 hours per acre). In terms of boat use in Humboldt Bay, the Project would result in an increase of approximately 18 trips per week throughout the bay (see also Table 4.1 of the EIR and Section 6.12, Noise).

Table 5 Frequency of Human Presence for Existing and Proposed Activities

Culture	Trips/Week	Hours/Week	# of Crew	Annual Crew Hours	Annual Hours/Acre
Existing Culture	57	218	40	51,584	171.9
Proposed Culture	75	292	64	90,896	98.6
Percent Change	+32%	+34%	+60%	+76%	-43%

Source: Dale, pers. comm., 2015
** includes up to 4 acres of rack-and-bag culture*

4.2 Thresholds of Significance

The CEQA Guidelines provide direction in evaluating Project impacts and determining which impacts are significant (Remy et al. 1999). CEQA defines significant effects as "a substantial adverse change in the physical conditions which exist in the area affected by the proposed project." Under CEQA Guidelines Section 15065 (Mandatory Findings of Significance), effects on aquatic biological resources are deemed significant where the Project would:

- Substantially reduce the habitat of a fish or wildlife species;
- Cause a fish or wildlife population to drop below self-sustaining levels;
- Threaten to eliminate a plant or animal community; or
- Reduce the number or restrict the range of an endangered, threatened, or rare species.

In addition to the Section 15065 criteria that trigger mandatory findings of significance, Appendix G of the CEQA Guidelines provides a checklist of other potential impacts to consider when analyzing the significance of project effects. The impacts for consideration when determining significance include whether the Project would:

- Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by CDFW or USFWS.
- Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act through direct removal, filling, hydrological interruption, or other means.
- Have a substantial adverse effect on coastal wetlands as defined by the CalCA.
- Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites.
- Conflict with any local policies or ordinances protecting biological resources.
- Conflict with the provisions of an adopted HCP, Natural Community Conservation Planning (NCCP), or other approved local, regional, or state HCP.

5.0 IMPACT ANALYSIS OF THE PROPOSED PROJECT

Direct and indirect impacts for aquatic biological resources are discussed in this section. A summary of eelgrass impacts is presented, but a more detailed analysis is provided in the Eelgrass Technical Report (Appendix D of the DEIR). Conservation Measures used in this analysis are discussed first, followed by a discussion of potential impacts.

5.1 *Conservation Measures*

Avoidance of potential impacts, where possible, is the first priority. Avoidance included project siting, longline spacing, and culture practices, which are discussed in more detail in the Eelgrass Technical Report. The following Conservation Measures will be used in the Project to avoid or minimize direct and indirect impacts for each of the following types of activities: (1) general/maintenance, (2) planting, and (3) harvest (Table 6).

Table 6 Conservation Measures used to Avoid or Minimize Direct and Indirect Impacts of the Project to Aquatic Biological Resources

#	Conservation Measure	Activity		
		General	Planting	Harvest
Hazardous Materials (HAZ)				
HAZ-1	Coast will not discharge any feed, pesticides, or chemicals (including antibiotics and hormones) into Humboldt Bay waters.	✓	✓	✓
HAZ-2	Coast will implement an equipment maintenance program for all vessels used in mariculture activities in order to limit the likelihood of release of fuels, lubricants, paints, solvents, or other potentially toxic materials associated with vessels as a result of accident, upset, or other unplanned events.	✓	✓	✓
HAZ-3	Coast will continue to fuel boats at commercial fuel dock facilities, carry oil spill absorption pads and seal wash decks or isolate fuel areas prior to fueling so as to prevent contaminants from entering the water.	✓	✓	✓
Biological (BIO)[1]				
BIO-1	Coast will not cause the intentional deposition of shells or any other material on the seafloor.	✓	✓	
BIO-2	Longline spacing for new shellfish culture plots would occur at 5-ft intervals.		✓	
BIO-3	Coast will implement in-kind and out-of-kind habitat restoration.[2]	✓	✓	✓
BIO-4	Monthly inspection of aquaculture plots to ensure that gear is properly maintained.	✓		
BIO-5	New rack-and-bag culture methods would not be planted within 10 ft of an existing eelgrass bed.		✓	
BIO-6	No anchoring the longline harvester* would be done so as to shade the same area of eelgrass for a period exceeding twelve hours.			✓
BIO-7	Larger work boats would be anchored in the channel outside of eelgrass beds and smaller skiffs would be used to access longlines where eelgrass is present when the area is inundated.	✓	✓	✓

#	Conservation Measure	Activity		
		General	Planting	Harvest
BIO-8	Boats will be operated in such a way as to minimize the degree of sediment mobilization and avoid propeller scaring in areas of eelgrass.	✓	✓	✓
BIO-9	No dredging, hydraulic harvesting, "bed cleaning," or any other activities with a hydraulic harvester would occur.			✓
BIO-10	New shellfish culture plots will not be planted within 10 feet of a subtidal channel.		✓	
BIO-11	Coast will not conduct any activity when a marine mammal is observed hauled out in or near a culture area ready for planting, scheduled maintenance, or harvesting until the mammal has left on its own and without provocation from Coast.	✓	✓	✓

***The longline harvester is a system that pulls individual longlines onto a scow at high tide, either by hand or with a hydraulically operated roller.**

Notes:

1. ***Birds are discussed in the Avian Technical Report (Appendix F of the DEIR).***
2. ***Conservation Measure BIO-3, regarding salt marsh and eelgrass restoration, is discussed in the Eelgrass Technical Report (Appendix D of the DEIR).***

5.2 Potential Impacts to Habitat

The following section discusses impacts to habitats or habitat characteristics, including: (1) overwater strcutures, (2) unstructured habitat, (3) eelgrass habitat, (4) sediment distribution and tidal circulation, (5) water quality, and (6) sediment quality.

5.2.1 Overwater Structures

The only overwater structured added to Humboldt Bay from the Project is associated with changes to the FLUPSY. There will be an increase of 8 bins in the FLUPSYs located within Entrance Bay, which is equivalent to an increase of approximately 72 square feet of additional surface area. While structure can provide increased prey resources (discussed below) and refugia from predation, it can also increase the number of predatory fish associated with the added structure and result in direct impacts from the consumption of fish eggs and larvae (literature *as cited in* Forrest et al. 2009).

Most of the scientific literature on the potential to increase predation pressure in marine systems is in relation to docks and pilings. There are obvious differences between these larger structures and shellfish aquaculture gear, but there are some relevant observations that can be used to determine potential impacts. Typically, when structure is discussed in the literature, the benefit is reported as higher for smaller fish that can use the structure as refugia rather than as predator ambush sites.

Cardwell and Fresh (1979) analyzed the stomach contents of maturing Chinook salmon, copper rockfish, and staghorn sculpin and reported that only staghorn sculpin stomachs contained juvenile salmonids and the presence of juvenile salmonids in the stomach contents did not change in relation to added structure. Ratté and Salo (1985) found no indication that predatory fish aggregated under piers.

Instead, predators were actually less abundant in shaded habitat. Salo et al. (1980) found that juvenile salmon comprised less than 4% of piscivorous fish diet in association with pier habitat.

In a study designed to determine if floating clam rafts resulted in increased predator density, or increased salmonid/longfin smelt predation rates, Kalson and Kramer (2015) surveyed fish species under and around floating clam rafts in Humboldt Bay. Seven species of fish were collected. All species are native to Northern California. None of the collected specimens were deemed likely predators on salmonids or longfin smelt.

Further, the proposed expansion is a modest expansion of an existing FLUPSY and is not likely to result in any additional impacts associated with the small increase in square footage. Impacts associated with overwater structures are considered less than significant under CEQA.

5.2.2 Unstructured Habitat

Optimal foraging/movement and fitness strategies depend on a mosaic of different habitats. Edges or transitional zones between two habitat types often represent areas with increased biological diversity (Holt et al. 1983, Orth et al. 1984, Boström et al. 2006). Because of the importance of edges, presence of unstructured habitat can be just as important as structured habitat. Additionally, the majority of fish and mammal species reviewed in this section (e.g., green sturgeon, rockfish, salmonids, harbor seals) are located primarily in the main channels, and likely use the edges of mudflats and eelgrass habitat for foraging. Most of these larger, mobile species are not known to use the dense interiors of eelgrass beds, especially in areas that would result in a risk of becoming stranded when the tide recedes.

The Project overlaps with 15.5 acres of unstructured habitat in the expansion area. Approximately 39 percent (or 6 acres) of this area is within 100 m of a main channel. That means that in 6 acres of nearshore unstructured channel habitat, cultch-on-longlines would be placed every 5 ft (Conservation Measure BIO-2), basket-on-longlines would be placed every 5 ft with 20 ft spaces between a group of three baskets, and rack-and-bag culture would be placed at 3 ft spacing with 5 ft between groups of three racks. In addition, there would be no intentional deposition of shell or other materials on the seafloor to make it more amenable to culture operations (Conservation Measure BIO-1). Aquaculture gear would increase the amount of structured habitat present in these areas, resulting in two potential impacts: alteration of species composition and increase in predation pressure.

There are certain species (e.g., California halibut and black brant) that tend to avoid structure and prefer open sand- or mudflat habitat[8] and others that are structure-oriented (e.g., fish in the families Cottidae and Embiotocidae). Forrest et al. (2009), which is a review of over 200 papers associated with off-bottom shellfish aquaculture, indicated that effects to fish are often neutral or positive. For example, Laffargue et al. (2006) demonstrated that the common sole (*Solea solea*) displayed a strong affinity for oyster-rearing structures when resting or seeking refuge during the day. Looking at it from

8 Note that black brant is also a species that tends to avoid structure. Impacts to brant are discussed more thoroughly in the Avian Resources Technical (Appendix F of the DEIR).

the opposite perspective, removal of oyster racks, Lin et al. (2009) reported that there would likely be a large decline in the biomass of zooplanktivorous and piscivorous reef fish post-removal because the oyster racks benefited reef fish by reducing predation or enhancing food sources. Pinnix et al. (2005) reported a slight change in species composition when comparing cultch-on-longline to eelgrass and mudflat habitat, but did not indicate that this would result in negative effects to the species that use Humboldt Bay.

Studies related to oyster reef habitats and shellfish aquaculture gear indicate an increase in prey resources associated with these habitats. For example, Coen et al. (2007) reported that oyster reefs provided more interstitial spaces for predator refugia and increased fitness due to the presence of suitable prey items. Dealteris et al. (2004) reported that shellfish gear supported native species of recreationally and commercially important fish and invertebrates in their early life history stages. Food-web modeling of intertidal oyster culture at much higher densities than is proposed for the Project (e.g., Leguerrier et al. 2004) also support the conclusion that off-bottom culture could benefit fish due to an enhanced food supply (discussed in more detail below). Finally, Castel et al. (1989) indicated that the presence of oysters on rack-and-bag structures augmented meiofauna biomass. The authors also reported a reduction in macrofaunal abundance associated with the racks, but indicated that this may have been a product of increased predation, which benefited the slightly larger organisms (e.g., fish and birds) rather than the benthic invertebrates present in the sediment.

While there will likely be changes, the amount of unstructured habitat affected within important transition zones from channels is a small portion of the unstructured nearshore habitat available in North Bay. Essentially, the addition of structure in these habitats slightly extends the type of structured habitat provided by eelgrass or provides a transition between unstructured and structured habitat for fish and crabs, especially for the early life history stages. The species that may be restricted from these areas are not limited by food availability (discussed within individual species sections below), and the potential to increase food resources along the margins of nearshore channel habitat may be a benefit to the majority of higher trophic organisms using North Bay. Therefore, this impact is less than significant under CEQA.

5.2.3 Eelgrass Habitat

Potential impacts to eelgrass habitat are reviewed in more detail in the Eelgrass Technical Report (Appendix D of the DEIR). The following is a summary of the analysis presented in that document. The information is presented in six main topics: (1) eelgrass density reduction, (2) natural variation and eelgrass resiliency, (3) trampling, (4) fragmentation, (5) floating eelgrass and wrack, and (6) summary of eelgrass impacts. Note that trampling is the only working practice that is discussed below. Propeller scaring, anchoring and boat wakes, considered to be less than significant impacts, are discussed in Appendix D of the DEIR.

Eelgrass Density Reduction

Aquaculture gear (e.g., baskets, PVC tubes, floats), shellfish products (e.g., cultch), and aquaculture activities can lead to shading, desiccation, and mechanical abrasion, which may affect the spatial extent and density of eelgrass beds in the immediate vicinity of culture. The type and concentration of gear can influence the level of this effect. Based on the best available scientific research, such as the Western Regional Aquaculture Center (WRAC) study by Rumrill and Poulton (2004), it is apparent that oyster longlines at 5 ft spacing (Conservation Measure BIO-2) can reduce eelgrass turion density directly under the lines themselves while the space between longlines does not show a reduction in density. These observations are consistent with additional recently collected data (SHN 2015) that indicates there is no change to areal extent with longlines spaced at 5 ft apart, but there is a density reduction under the longlines.

Two key sets of empirical data were used to estimate density reduction of eelgrass directly under the longlines (e.g., Rumrill 2015 and SHN 2015). This reduction was estimated within a "width of effect" area directly under the longlines. For example, shading from macroalgae is a factor incorporated in the empirical data used to estimate density reduction (see Figure 7).

Figure 7 **Depiction of Width of Effect Directly under Oyster Longlines.**
Source: modified from Dale, pers. comm., 2015

The width of effect is the extent to which a reduction in eelgrass density would occur under the longlines. This metric was calculated differently for cultch-on-longline compared to basket-on-longline. For cultch-on-longline, the width was based on the amount or length of cultch per line, average width of cultch (weighted by species cultured), growth of oysters, number of floats and posts, and width of fouling organisms attached to the cutch. For basket-on-longline, the width was based on the length of baskets per line, width of baskets, width of floats and posts, and width of fouling organisms attached to the baskets.

Using the values estimated from the empirical data cited above, a density reduction of 47 percent was estimated within the area described as width of effect under cultch-on-longline areas and 70 percent under basket-on-longline areas. This reduction was applied along the entire length of a longline (100 ft) and within an average width of effect of 0.5 ft for cultch-on-longline culture and 0.9 ft for basket-on-longline culture. Based on this width of effect and the reduction in density directly under the longlines, there would be an approximately 5.0 percent reduction in eelgrass density within the shellfish aquaculture expansion area and 1.7 percent when considering the larger eelgrass bed area (i.e., the shellfish culture and the contiguous eelgrass beds surrounding the expansion areas). While this analysis identified a reduction in eelgrass directly under the longlines, the projected reduction is not anticipated to exceed CEQA thresholds identified in Section 6.5 of the EIR when evaluated within the culture areas or within eelgrass beds. Finally, the analysis of potential impacts is based on empirical observations of loss directly under the longlines and between the lines, which inherently incorporates shading, desiccation, mechanical abrasion, and other working practices that potentially affect eelgrass.

The existing culture operations are part of the environmental baseline under CEQA, and so density reduction under the existing culture was not calculated. Further, according to Coast's southwest operations manager (Dale, pers. comm., 2015), many longlines that were originally planted in areas adjacent to eelgrass were later colonized by eelgrass. While no monitoring was associated with the earlier aquaculture activities, the data from NOAA (2012) shows eelgrass and existing shellfish culture in the same areas, potentially supporting the observations that eelgrass has expanded into aquaculture areas

Natural Variation and Eelgrass Resiliency

Bay-wide mapping has occurred to some degree between 1959 and 2009 (Schlosser and Eicher 2012). In North Bay, the areal extent of eelgrass ranged from a minimum of 840 acres in 1959 to a maximum of 3,577 acres in 2009. However, areal extent of eelgrass may be difficult to compare between years due to mapping methods. A review of the data suggests that eelgrass is extensive and relatively stable in Humboldt Bay (Judd 2006, Gilkerson 2008, Schlosser and Eicher 2012). Compiled data for the summer growing season in North Bay indicates that the standard deviation in shoot density can range between 34 percent and 77 percent of the mean within the same sampling year. Individual measurements that make up mean shoot density within the same area can range from a low of 48 turions/m^2 to a high of 272 turions/m^2 with no discernable factor controlling this variability. Finally, there can be high temporal variability, with percent change in density ranging between -41 percent and +45 percent between years. Overall, shoot density has high natural variability within North Bay. Comparatively, the predicted eelgrass density reduction under the longlines is expected to be approximately 5 percent of eelgrass within the oyster plots. The actual changes associated with the Project will be verified through a robust eelgrass monitoring plan (Appendix H of the DEIR), which will be compared to natural variability within adjacent control plots.

The Project, with oyster longlines spaced at 5-ft intervals, results in a relatively passive use of eelgrass habitat, especially compared to historical shellfish operations and other anthropogenic activities. Eelgrass distribution and density in Humboldt Bay has exhibited a high degree of variability in aerial extent and shoot density during the last 50+ years. This variability is from both natural and anthropogenic factors. For example, changes in water clarity due to runoff associated with upland watershed activities (e.g., silviculture and agriculture) have historically degraded conditions for eelgrass. Increased nutrients from agricultural use of fertilizers or animal waste runoff and municipal sewage discharges have also affected eelgrass distribution. Throughout these disturbances, eelgrass abundance has remained relatively high and no species populations were identified as limited based on a lack of eelgrass abundance and distribution in Humboldt Bay (see Schlosser et al. 2009).

Unlike other locations around the world where population declines are correlated with habitat loss (e.g., Dulvy et al. 2003), populations of species in Humboldt Bay that are highly associated with eelgrass habitat have not exhibited declines that are directly correlated with changes in eelgrass abundance and distribution (see Section 5.8 below on Pacific herring spawning). The species utilizing eelgrass in Humboldt Bay are adapted to the variability in abundance and distribution of eelgrass, and the changes to eelgrass density associated with the Project are well below the variability in eelgrass density typically seen in any given year or decade. Given that many of the anthropogenic stressors within the watershed have been reduced or modified (e.g., better agricultural practices, high treatment standards for municipal outfalls, reduced timber harvest and improved management), and that species present in Humboldt Bay are adapted to high variability in eelgrass distribution and abundance, the limited Project effects to eelgrass density will not result in measurable or appreciable changes to species populations in the bay. Stated another way, based on available data, current shellfish aquaculture operations are within the resilience of Humboldt Bay eelgrass, and potential impacts from the Project also are within the natural variation of the system. Despite this conclusion, Coast is proposing habitat improvements (Conservation Measure BIO-3) to ensure that the Project has an overall beneficial ecological impact in Humboldt Bay.

Trampling

Although trampling is included in the empirical data discussed above, it is a primary concern in terms of potential effects to eelgrass habitat. Eckrich and Holmquist (2000) studied trampling effects at three intensities on turtle grass in Puerto Rico. The study found that trampling (20 events/month) resulted in reduced seagrass cover and rhizome biomass. The effects were the greatest in areas with softer substrates. The sediment types within the proposed expansion area are primarily clayey silt, sand-silt-clay, or sand (see Figure 6 above), which fall into the category of "softer substrates." However, turtle grass is known to have slower recovery times compared to eelgrass because it recovers primarily by rhizome extension rather than seed dispersal (Zieman 1976). A more accurate comparison of potential effects from trampling would be for shoal grass (*Halodule beaudettei*). According to Zieman (1976), impacts to shoal grass from recreational activity are not likely to be a problem because the "plant does not have a well-developed deep rhizome system, grows well from seed, and is capable of colonizing a damaged area in a short time." These characteristics are similar to eelgrass (Ruesink et al. 2012).

More importantly, the potential trampling activity within Coast aquaculture plots is much lower than trampling activity studied by Eckrich and Holmquist (2000). Crew access to plots depends on the culture type (*see* Table 4), although all culture has be visited at least once per month to ensure that aquaculture gear is properly maintained (Conservation Measure BIO-4). Although cultch-on-longline requires the least amount of human activity, harvest activities would occasionally include the placement of bushel tubs, which are connected to floats and would be collected during the next high tide up to 12 hours later. Basket-on-longlines and rack-and-bag are visited more frequently than cultch-on-longline. Basket-on-longline plots are visited on an almost daily basis, but crews are not in the same parts of the bed each day; instead, they work through a bed such that an individual line is visited on average every 4 months (average rate of 12 days per acre). Rack-and-bag culture requires daily visits, to inspect, monitor, and repair bags, but rack-and-bag culture would not be placed in eelgrass (Conservation Measure BIO-5). Apart from planting and harvest, most activity is simply a visual inspection of culture equipment where staff can survey large amounts of equipment without physically accessing all parts of the plot.

In general, disturbance events associated with aquaculture operations in eelgrass are considered infrequent and of short duration within any one location relative to the time that the beds remain submerged. Therefore, trampling effects to eelgrass are considered less than significant under CEQA.

Fragmentation

The development of longline aquaculture (i.e., basket-on-longline and cultch-on-longline) within patchy and continuous eelgrass beds is not expected to contribute to habitat fragmentation. Although shading and other processes associated with lines may reduce eelgrass density within existing eelgrass beds, this reduction is not expected to be large enough to change how fish use the habitat or to affect the ability of the bed to persist from year to year. Prey organisms in the sediment tend to be more closely linked to sediment characteristics than to other habitat features (Frost et al. 1999, Bowden et al. 2001). Furthermore, if habitat fragmentation were to occur, the relationship between species survival and patch characteristics are neither unidirectional nor universal. For example, hard clam survival may improve in continuous eelgrass (Irlandi 1997), while juvenile crab survival may improve in smaller patches (Hovel and Lipcius 2001). The majority of literature related to aquatic habitat indicates that edge habitat is extremely productive (Holt et al. 1983, Orth et al. 1984, Boström et al. 2006), and as long as a habitat mosaic is provided, species use of an estuary would not be significantly altered (Hosack et al. 2006).

Anchoring and operating boats in eelgrass also has the potential to result in habitat fragmentation. The smaller skiffs and longline harvester used to access plots during high tide use small anchors (e.g., 10 lbs. Danforth anchors with 2 meters (m) of chain). Based on a study by Milazzo et al. (2004), small boats had a temporary effect to Neptune grass in the Mediterranean Sea, which is a slower growing seagrass that does not have the same recovery potential as eelgrass. In addition, Coast will not anchor the longline harvester so as to shade the same area of eelgrass for a period extending 12 hours (Conservation Measure BIO-6). The main study on boat anchoring that did result in fragmentation of seagrass beds was correlated with moderate anchoring pressure (0.9 boats/day/2500 m^2) from large boats that used

12 kg Brittany-type anchors (Francour et al. 1999). In comparison, the anchoring pressure from Coast operations is currently 8 boats/day for 300 acres (or 0.02 boats/day/2500 m^2), and the larger work boats are not anchored in eelgrass (Conservation Measure BIO-7). Finally, Coast will operate in such a way as to minimize the degree of sediment mobilization and avoid propeller scarring in areas of eelgrass (Conservation Measure BIO-8). Aerial photography in Humboldt Bay does not indicate that the eelgrass beds are being damaged by anchors or propellers, so it appears that no significant loss in biomass is occurring or likely would occur from boat use.

There is no identified impact associated with the Project that is likely to result in habitat fragmentation of eelgrass. Therefore, fragmentation effects to eelgrass from the Project are considered less than significant under CEQA.

Floating Eelgrass Rafts and Wrack

Eelgrass provides habitat structure both within rooted eelgrass beds and in areas where fragments and blades of eelgrass form floating rafts or wrack along the shoreline. Floating eelgrass may provide habitat that facilitates the movements and provides predator refugia for larval and post-larval fish (e.g., Worcester 1994, Pinnix et al. 2013), and can promote the long distance dispersal of eelgrass seeds (e.g., Källström et al. 2008). The break-down of floating rafts can also contribute to nutrient cycling and, through detritivores, the addition of nutrients can contribute to the food web (e.g., Heck et al. 2008). Eelgrass wrack along shorelines provides a food resource for amphipods and isopods, which in turn are preyed upon by birds and fish. The production of floating rafts and wrack is likely proportional to overall eelgrass abundance, with some estimating that approximately 50 percent of eelgrass biomass produced each year contributes to detrital food webs (Mateo et al. 2003).

A reduction in eelgrass biomass from the addition of longline culture could contribute to reductions of floating rafts and wrack. The presence of aquaculture infrastructure within the water column could also detain or affect the formation of floating rafts of detached eelgrass. The presence of longlines could affect the movement of floating materials and cause some material to become entangled in lines or transition from floating to submerged detached eelgrass. However, it is anticipated that most eelgrass material will be detained temporarily and will continue to travel to the areas where material is either concentrated into rafts by surface currents or becomes a component of beach wrack. Oyster longlines spaced 5 ft apart should provide similar circulation in the system to allow for movement of material as is already experienced within an eelgrass bed. More importantly, the reduction in eelgrass density appears to be well within the natural variability of North Bay and the species that use these habitats are adapted to this level of variability in the system, which indicates that a minor reduction in eelgrass density will not significantly affect the processes associated with, or habitats provided by, floating rafts and wrack. Because eelgrass habitat is at or near carrying capacity, a minor reduction in density from the Project will not significantly affect these processes. Therefore, effects to floating eelgrass rafts and the creation of wrack are considered less than significant under CEQA.

Summary of Eelgrass Impacts

In terms of the expansion area, the existing data, field observations, and analyses do not indicate a loss of areal extent from the placement of longline aquaculture at 5 ft spacing. Eelgrass density reduction directly under the longlines is estimated to be 5.0 percent of eelgrass in the culture area and 1.7 percent when considering the larger eelgrass bed area (i.e., the shellfish culture and the contiguous eelgrass beds surrounding the expansion areas). Trampling effects, while included in the empirical data used to calculate potential reduction in eelgrass density, is further explored. Based on the low frequency of access to individual plots, and short duration of activities, trampling is a less than significant impact to eelgrass under CEQA. Similarly, effects to fragmentation, floating eelgrass rafts, and wrack were considered to be less than significant because the projected amount of eelgrass density reduction is well within the natural variation and resiliency of eelgrass habitat within North Bay. Potential changes to eelgrass habitat would be monitored through a robust sampling plan (Appendix H of DEIR), and culture could be modified through adaptive management. Therefore, potential impacts to eelgrass habitat were considered less than significant.[9]

5.2.4 Sediment Distribution and Tidal Circulation

The largest alteration of sediment distribution and dynamics in Humboldt Bay continues to be the dredging of channels for navigational purposes. Volumes dredged in the main shipping channels average 143,000 cubic yards (cy) per year, with 113,000 cy on average occurring in Eureka Channel (Corps 2012). Historically, oyster harvesting practices (oyster dredging) may have also caused changes in sediment distribution (Barnhart et al. 1992). Oyster dredging is no longer utilized as a method for harvesting oysters in Humboldt Bay (Conservation Measure BIO-9).

Shellfish aquaculture is located in North Bay, which is dominated by intertidal bars (or intertidal mud and sandflats). Intertidal bars tend to be dynamic over time at small scales with mounds and depressions appearing and disappearing as sediment erodes and deposits in different locations (Hannam and Mouskal 2015). Studies of suspended mussel culture longlines have shown that gear may alter hydrodynamics and reduce flow rates at the farm scale. For example, a study in southern Norway suggested that flow velocities may be reduced by up to 30 percent in areas of longline mussel aquaculture (Strohmeier et al. 2005). However, Gambi et al. (1990) reported that eelgrass beds also reduced flows between 14.7 percent and 40.6 percent as compared to values up drift (or up current). Therefore, placing longlines in eelgrass is not likely to significantly change sediment dynamics beyond the natural conditions exhibited in eelgrass beds.

In areas of unstructured habitat, rack-and-bag and longlines could alter sediment distribution and tidal circulation more significantly than culture placed in eelgrass habitat. In a study of a 24 hectare (ha) (59 acre) intertidal rack-and-bag oyster farm in Mahurangi Harbour in northern New Zealand, Forrest and

9 While impacts to eelgrass are considered less than significant under CEQA, Coast has nevertheless proposed several habitat Conservation Measures to compensate for the reduction in eelgrass turion density and improve critical habitat for listed and threatened species in Humboldt Bay. See the Eelgrass Technical Report (Appendix D of the DEIR) for additional details regarding potential eelgrass impacts and habitat conservation measures.

Creese (2006) measured a mean sedimentation rate under the racks that was almost three times greater than adjacent control sites. However, the authors indicated that, despite this increased rate, no significant sediment accretion was evident. The seabed elevation was no more than 50 mm greater under the racks compared to between the racks, and there was not a change in the overall farm elevation that was significantly different from a normal shore profile.

Forrest et al. (2009) commented that effects on seabed topography can occur at sites where cultivation structures are in high density or aligned perpendicular to tidal currents. The goal of gear placement for existing culture has been to align gear to minimize sediment accumulation or scouring. This may include gear being placed parallel to tidal currents, to the extent practicable, although currents change seasonally (Dale, pers. Comm., 2015). Overall, it appears that gear placement measures have resulted in very few changes to the seabed of Humboldt Bay where shellfish culture occurs. For example, Rumrill and Poulton (2004) reported a deposition of fine sediments in 5-ft spaced longlines in May (up to 95 mm) that was eroded by July (down to 51 mm). The authors gave no indication whether this was a significant change or if this change persisted. The change observed by Rumrill and Poulton (2004) is minor and within the typical detection limit for this type of study (80 mm) (Hannam and Mouskal 2015). It is anticipated that basket-on-longline areas will have similar effects, although they would potentially be an intermediate effect between cultch-on-longline and rack-and-bag (discussed above). Regardless, studies in locations with active transport do not indicate that changes to sediment distribution and tidal circulation from the proposed types of shellfish aquaculture result in significant changes to the seabed topography.

The proposed Project, with 5 ft spacing between cultch-on-longlines, 5 ft spacing between groups of three basket-on-longlines and then a 20 ft space, and low density of rack-and-bag structures, is not expected to significantly affect sediment deposition or tidal circulation patterns in North Bay. For the majority of proposed culture, which would be placed in eelgrass, oyster longlines will be similar to conditions exhibited in eelgrass beds. Overall, the effect of the Project on these habitat variables is considered less than significant under CEQA.

5.2.5 Water Quality

Water quality indicators include: nutrient status, dissolved oxygen, temperature regime, turbidity and its effects on light, and contaminants. Of these indicators, oyster aquaculture activities have the potential to affect: (1) nutrients and turbidity (and effects on light), and (2) contaminants.

Nutrients and Turbidity

Development around North Bay results in nutrient input from a variety of anthropogenic sources. These include sewage treatment plants, septic systems, highway and parking lot run-off, domestic animal waste and lawn fertilizers. Turbidity is likely due to a combination of natural and human-exacerbated factors. These include seasonally high phytoplankton concentrations and sediment resuspension by wind-generated currents and particulates in runoff (Gilkerson 2008, Swanson et al. 2012, Shaughnessy and Hurst 2014), especially following rainfall events that are periodically exacerbated by human activities such as timber harvest and development.

Oysters remove nutrients from the water column and reduce turbidity through filter feeding on phytoplankton and other particulate matter (Figure 8). The amount of benefit that filtration provides depends on the physical mixing of nutrient sources (e.g., oceanic vs. riverine), residence time in the estuary, and grazing pressure of farmed shellfish (Dumbauld et al. 2009). Although not currently recognized as a direct benefit on the West Coast, bivalve filtration may become more valuable as nutrient input increases within coastal communities (Shumway et al. 2003, Burkholder and Shumway 2011, Kellogg et al. 2013).

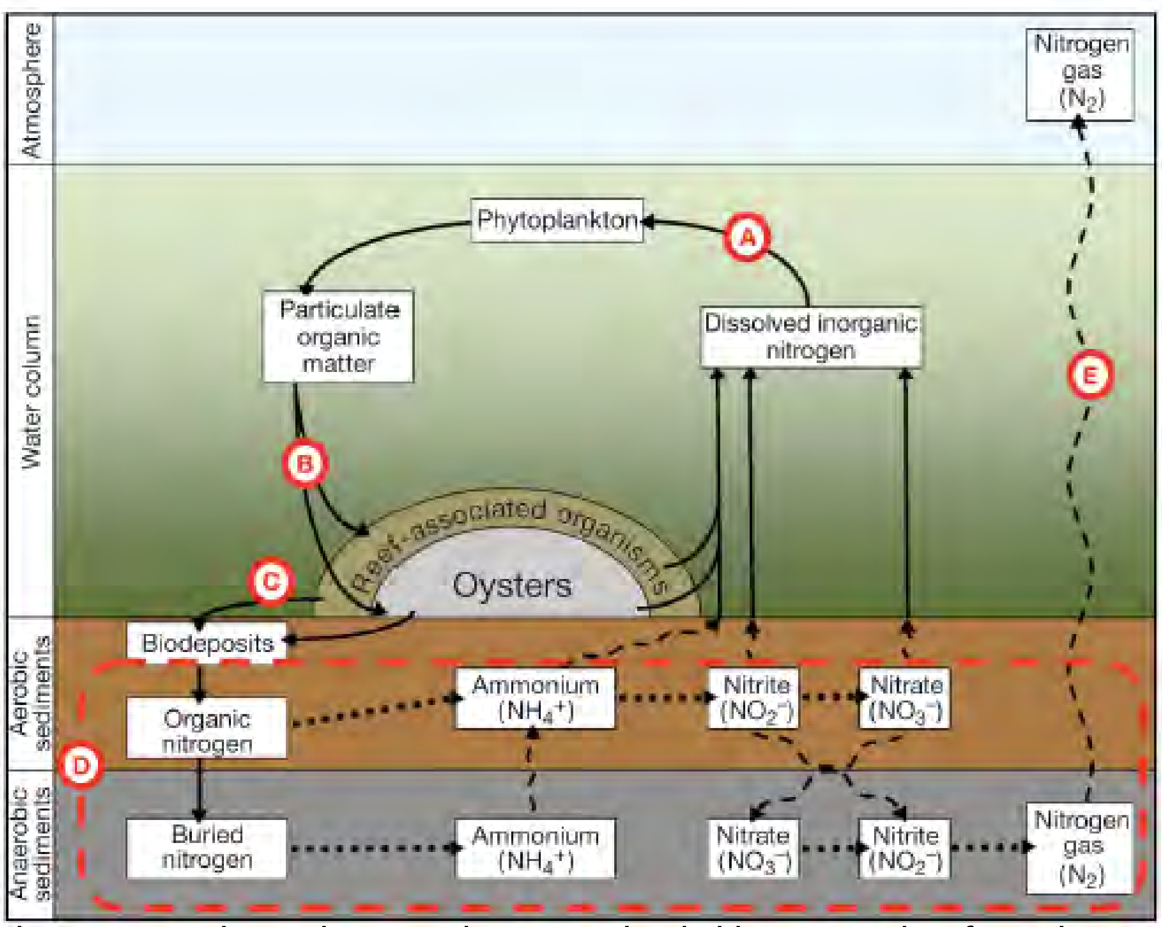

Figure 8 Primary Nitrogen Pathways Associated with Oysters and Reef Organisms

Source: Kellogg et al. (2013)

Notes: Phytoplankton use dissolved inorganic nitrogen for their growth (A), oysters and other reef-associated organisms filter phytoplankton and other particulate organic matter from the water column (B), some of the associated nitrogen is incorporated into organisms and some is deposited on the surface of the sediments (C), and, given the right conditions, a portion of the nitrogen in these biodeposits is transformed into nitrogen gas (D) which diffuses out of the sediments back to the atmosphere (E) where it is no longer available to phytoplankton for growth (diagram adapted from Newell et al. 2005).

As an example of the potential benefits offered by shellfish filtration and nutrient sequestration, Kellogg et al. (2013) partially quantified the removal of nutrients from the water column at a subtidal oyster reef restoration site compared to an adjacent control site in the Choptank River within Chesapeake Bay, Maryland. The authors indicated that denitrification rates at the oyster reef in August were "among the highest ever recorded for an aquatic system." In addition, a significant portion (47 and 48 percent of total standing stock) of the available nitrogen and phosphorous were sequestered in the shells of live oysters and mussels. An ancillary benefit of the shellfish reef structure, which is also true for shellfish aquaculture gear and shellfish, was that the structure and faunal composition provide ample microhabitats for communities of nitrifying microbes. One of the conclusions by Kellogg et al. (2013) was that oyster reef restoration could be considered a "safety net" to reduce additional downstream impacts to water quality. Because shellfish aquaculture provides many of the same benefits, with the added benefit of the total removal of nutrients at harvest, the shellfish aquaculture can be considered a net benefit to water quality ecosystem functions (albeit small).

The studies described above confirm the importance of cultured and natural shellfish assemblages in maintenance of ecosystem stability in many marine estuaries, including the maintenance of eelgrass ecosystems. Relating these observations to Humboldt Bay, it is clear that filter feeding shellfish may locally reduce turbidity and represent a net removal of nitrogen from the bay, as well as a net translocation of nitrogen from the water column to the sediments. The turbidity changes are too small to represent a measurable change from natural variation. The net removal of nitrogen is beneficial, as it compensates for anthropogenic additions of nitrogen, but data are not adequate to quantitatively compare anthropogenic nitrogen influx vis-à-vis nitrogen removal via oyster harvest. The effects of nitrogen translocation are unclear, and it is not possible to predict with confidence how those effects are altering North Bay, or whether the effects are adverse or beneficial.

Contaminants

Oyster culture has the potential to increase contaminants in the water column associated with the use of work skiffs for accessing the oyster beds and associated areas. As with any mechanized machinery, there is a limited risk of accidental discharge of fuel, lubricants, or hydraulic fluids. The risk to water quality depends on the type of contaminant spilled, time of year, spill amount, and success of containment efforts. Although spills of this nature are detrimental to aquatic organisms, it is expected the impacts would be negligible because of the limited occurrence of spills. Coast is also implementing a number of Conservation Measures (HAZ-1, HAZ-2 and HAZ-3 from Table 5 above and DEIR Section 6.10, Hazards) to minimize the potential for spills and to reduce impacts from any spill that does occur. For example, Coast fuels its boats at the local commercial fuel dock and maintains oil spill absorption pads and seals wash decks or isolates fueling areas prior to fueling so as to prevent any contaminants from entering the water. Coast has also converted all of its skiff motors to highly efficient, less polluting 4-stroke outboards. Coast regularly cleans and maintains all of their equipment and is highly motivated to avoid any spillage of contaminants due to the sensitive nature of oysters both in terms of growth and taste with respect to petrochemicals. With the Conservation Measures discussed above, this impact is considered less than significant under CEQA.

5.2.6 Sediment Quality

Shellfish consume nutrients (via filtration of phytoplankton) and create of biodeposits (feces and pseudofeces); a process called "benthic-pelagic coupling." Nitrogen and phosphorous that are not digested by bivalves and incorporated into tissue are excreted as soluble ammonia and biodeposits. When these biodeposits become incorporated into aerobic surficial sediments, microbially-mediated processes facilitate nitrification-denitrification coupling to permanently remove sediment-associated nitrogen as nitrogen gas (detailed above in Figure 8). According to Newell et al. (2005):"[T]he species of bivalves that can exert the greatest influence on benthic-pelagic coupling are those, such as oysters and mussels, which maintain high clearance rates and reject relatively large amounts of POM [particulate organic matter] as pseudofeces."

Peterson and Heck (1999) suggested that by increasing sediment nutrient levels, shellfish may create new habitat areas for colonization of seagrasses, or maintain sufficient nutrient levels for the continued existence of seagrasses in stressful environments. Eelgrass can derive nutrients from both the sediments and the water column. The interstitial water (or sediment porewater) contains higher concentrations of dissolved inorganic and organic nutrients than the water column, and eelgrass obtains most macronutrients from sediments. Sediment reservoirs of nutrients can become depleted when biogeochemical regeneration rates cannot meet plant demands (Short 1983, 1987). However, in the course of removing water column particulates, shellfish also alter sediment characteristics. Positive impacts occur because the shellfish move carbon and nutrients from the water column to the benthos. Although studies related to sediment "fertilization" from bivalve deposition have shown enhanced eelgrass growth along the East Coast (e.g., Peterson and Heck 1999), similar studies in the Pacific Northwest appear to show no effect on eelgrass growth (Wagner et al. 2012, Ruesink and Rowell 2012, Wheat and Ruesink 2013). Studies in the Pacific Northwest indicate that eelgrass is not generally nutrient limited or that sediment porewater nutrients are naturally high.

While the introduction of biodeposits can be a benefit to the system (or at least neutral), there are studies that report potential negative effects from the addition of organics below shellfish aquaculture gear. For example, Nugues et al. (1996) studied rack-and-bag culture in the River Exe estuary (England) and reported that increased organics deposited under the racks resulted in a small, but detectable, localized change in oxygenated sediment. According to Forrest et al. (2009), "the capacity of the environment to assimilate and disperse farm wastes will mainly depend on water current velocity and wave action (Souchu et al. 2001), as these factors control the size and concentration of the depositional 'footprint'." For example, Mallet et al. (2006) reported that oysters from South St-Simon Bay (New Brunswick) raised at a biomass ranging between 4 and 8 kg/m^2 in an 86.5 acre oyster lease using rack-and-bag and floating bag culture showed no significant differences in sediment chemistry between the culture and control sites. St-Simon Bay is characterized as a shallow open bay with excellent water exchange, an extensive eelgrass bed, and bottom sediments that are frequently re-suspended by wind events, particularly during the spring and fall. Comparatively, in Humboldt Bay, oysters in the expansion area are proposed to occur at a biomass of 0.12 kg/m^2 and the bay has many similarities to St-Simon Bay, as described by Mallet et al. (2006). Based on the literature related to sediment quality changes at different shellfish aquaculture densities and the lack of evidence of organic enrichment in a well-flushed system, the density of culture and circulation or wave energy in Humboldt Bay would reduce this potential effect to be less than significant under CEQA.

5.3 Potential Impacts to Benthic Communities

The following section discusses four potential impacts to benthic communities: (1) changes to species composition, (2) trampling effects, (3) introduction of NIS and fouling organisms, and (4) establishment of non-native bivalves.

5.3.1 Changes to Species Composition

Changes to species composition can affect prey resources for fish and wildlife using Humboldt Bay. The two primary potential drivers of change to the benthic community as a result of shellfish aquaculture are changes to sediment quality from increased biodeposition and the addition of structured habitat where organisms can colonize.

The majority of studies related to changes from increased biodeposition are from rack-and-bag culture in France (e.g., Castel et al. 1989, Leguerrier et al. 2004, Dubois et al. 2007, Bouchet and Sauriau 2008). The information from these studies should be interpreted cautiously. Standing stock of oysters in France significantly dwarfs the current production in California estuaries. For example, the rack culture in Pertuis Charentais (SW France), which includes Marennes-Oléron Bay, extends over 4,000 ha (or 9,884 acres) and includes a standing stock of approximately 125,000 tons of Pacific oysters (Bouchet and Sauriau 2008). This areal extent, which does not consider density (i.e., standing stock), is over 10 orders of magnitude greater than what is proposed for the Project. According to Dubois et al. (2007), the presence of shellfish in high densities (>125 individuals per m^2) can increase the organic matter content in the sediment and result in opportunistic species of crustaceans and annelids that feed directly on the detritus, or predators (e.g., carnivorous polychaetes and crabs) that are attracted to the increase in detritus feeders. In comparison, Coast oyster densities are approximately 50 individuals per m^2 for cultch-on-longline (84% of proposed culture), 60 individuals per m^2 for basket-on-longline (15% of proposed culture), and 120 individuals per m^2 for rack-and-bag culture (1% of proposed culture). Therefore, densities are lower than the threshold established by Dubois et al. (2007) in terms of noting changes to the organic content of the sediment. In addition, this does not account for circulation dynamics in the system among other factors that are relevant to changes in sediment quality.

A carbon-based food web model investigated the effects of oyster cultivation (rack-and-bag methods) in Marennes-Oléron Bay (Leguerrier et al. 2004). The authors indicated that, "meiofauna enhancement by the oyster cultures played a key role in carbon transfer." According to simulations of oyster production in Marennes-Oléron Bay, the system remained stable even when oyster culture was doubled from 4,448 acres to 8,896 acres, suggesting either that oyster culture has a small impact on the stability of the ecosystem or that the ecosystem has adapted to oyster culture. Leguerrier et al. (2004) concluded that the oyster culture's positive influence on meiofauna biomass resulted in a positive impact on the food supply of two biotic vectors: birds and fishes. In Humboldt Bay, a carrying capacity analysis was performed (Appendix G), which also provides some indication of potential effects to the food web, at least for phytoplankton resources. The analysis indicated that 5 to 9 percent[10] of the carbon fixed by phytoplankton would be diverted to cultured shellfish, depending on the clearance rate of cultured shellfish. This value does not account for the carbon consumed but recycled to the environment (e.g., benthic-pelagic coupling).

The second driver of change, addition of structure, has been studied by multiple authors in relation to different types of structured habitat. Hosack et al. (2006) reported that benthic invertebrates were strongly associated with habitat type, and structured habitats (oyster beds and eelgrass) had higher species abundance. Earlier work by Hosack (2003) reported that important fish prey organisms, such as harpacticoid copepods, exhibited higher densities in both dense eelgrass and oyster habitats. These observations parallel those of Ferraro and Cole (2011, 2012), who studied oyster culture in Yaquina Bay (Oregon), Willapa Bay (Washington), and Grays Harbor (Washington). The authors reported similar species abundance and richness in benthic macrofaunal communities between native eelgrass and oyster habitat in the three areas studied. Both eelgrass and oyster habitats had significantly more prey resources than unstructured habitats. These studies lead to the conclusion that adding oyster longlines to eelgrass would not substantially change prey resources available in Humboldt Bay, and adding longline and rack-and-bag gear to unstructured habitat may increase prey resources.

In order to understand whether fish are attracted to or avoid oyster gear compared to eelgrass habitat and unstructured environments, a study performed by Pinnix et al. (2005) directly addressed the question of difference in use by fish between cultch-on-longline culture, eelgrass habitat, and mudflat habitat in Humboldt Bay. The major results of the study indicated that: (1) more fish were collected from oyster culture areas compared to mudflat and eelgrass habitats using trawl and fyke net sampling gear (Figure 9); (2) species richness and diversity of fyke net samples were similar between oyster culture and eelgrass habitat, which were both significantly higher than mudflat habitats; (3) 42 percent of the total number of fish captured were using these habitats as nursery habitat; and (4) the dominant species collected included English sole and shiner surfperch. A possible confounding variable in the Pinnix et al. (2005) sample design was that the oyster habitats were slightly higher in elevation than the eelgrass or mudflat habitats, which may have led to a greater proportion of area drained on each tidal cycle leading to higher abundances in the fyke net sampling. Alternatively, these fish may have been using this habitat preferentially, but that type of result cannot be determined from these data. Although not studied, basket-on-longline would likely have similar changes with the exception that there are not as many interstitial spaces available for colonization by prey organisms.

10 This result is for all cultured shellfish, including culture proposed under the Pre-permitting project, as discussed in Section 7.0, Cumulative Impacts of the DEIR.

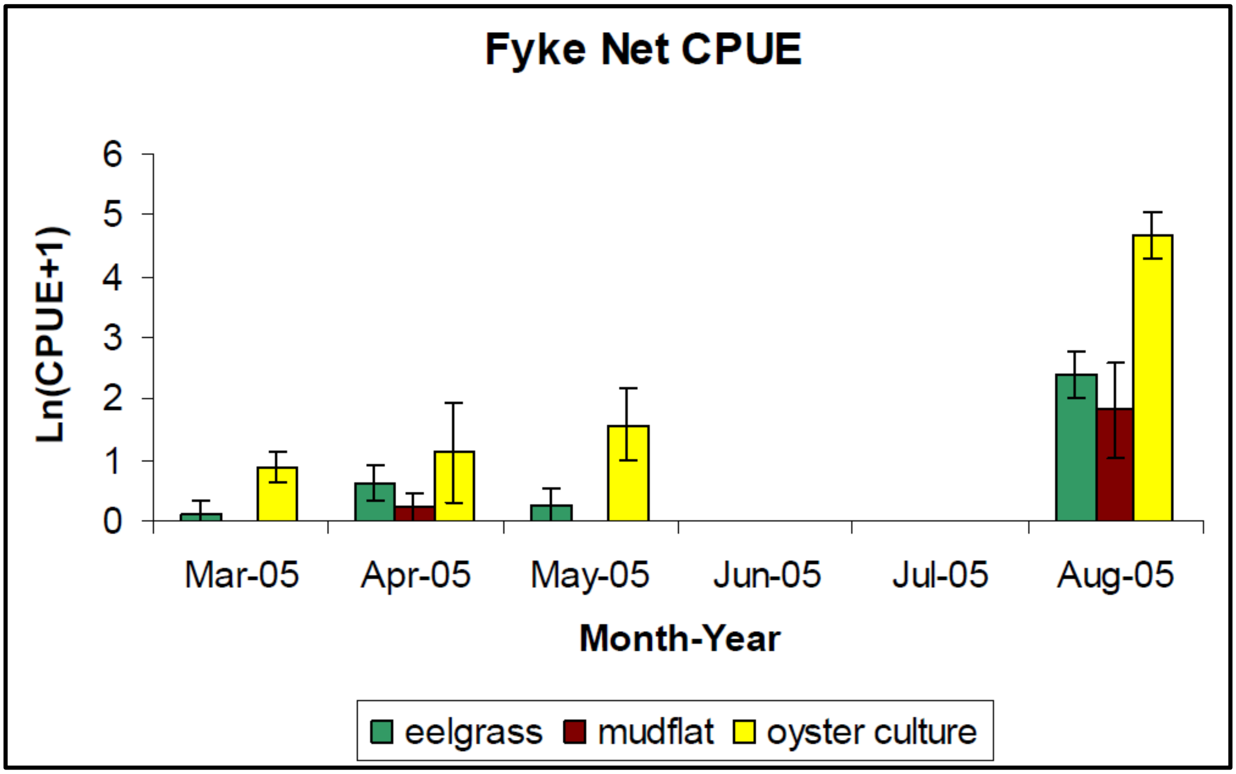

Figure 9 **Mean Monthly Natural Log of Catch per Unit Effort (CPUE+1) of Fyke Net Samples Collected in North Bay, March 2005 to August 2005**

Source: Pinnix et al. (2005)

Simenstad and Fresh (1995) noted that in Washington, the diversity of epibenthic harpacticoid copepods was higher on active ground oyster culture plots with 3-year old oysters present compared to an inactive plot where oysters and eelgrass were present. Simenstad and Fresh (1995) also compared epibenthic prey taxa between active and inactive oyster culture areas. They noted that prey for epibenthic feeding fish (e.g., juvenile salmonids) were more abundant on the inactive plot, but this trend was reversed for English sole prey. Simenstad and Fresh (1995) suggested that species utilize specific prey resources associated with unique habitats and their use of an area may be linked to species-specific productivity of these prey. In the Pinnix et al. (2005) study, oyster culture may have increased the epibenthic species present such that fish species targeting specific prey resources may have accounted for the higher abundance found in oyster culture areas (compared to eelgrass or mudflat habitats). That is, specific fish (e.g., English sole and surfperch) may utilize the oyster culture areas because they are taking advantage of the epibenthic invertebrate prey species found on the aquaculture gear or shellfish.

Overall, the literature supports the conclusion that oyster aquaculture gear provides similar foraging habitat and species composition as found in other structured environments (e.g., eelgrass), and may provide more benthic invertebrates and epibenthic invertebrates than mudflat habitat because of the addition of attachment points for organisms. While this is a change to the system, the literature indicates that these changes provide an advantage to smaller organisms or life history stages that are using these areas as rearing habitat. Therefore, change to species composition is considered a less than significant impact under CEQA.

5.3.2 Trampling Effects

There is some literature indicating that trampling effects can impact the benthic community, both in unvegetated areas and in areas with eelgrass, but these studies are unlikely to represent conditions associated with Coast operations. Rossi et al (2007) researched trampling in an intertidal mudflat of Paulina Polder (the Netherlands) at a rate of 2 visits per month by 5 people over an 8-month period within a 0.15 acre study area. The authors reported that trampling at this rate indirectly enhanced the recruitment rate of the macoma clam (*Macoma balthica*), while the smaller cockle (*Cerastoderma edule*) did not react to the trampling. The authors concluded that trampling at this rate may eventually lead to the dominance of the macoma clam. The Eckrich and Holmquist (2000) study discussed above (associated with turtle grass in Puerto Rico) looked at impacts to invertebrates and fish at different trampling intensities. They found that, at a trampling rate of 20 events per month and greater, abundances of shrimp decreased while fish did not change.

Two main factors are relevant to how applicable the above studies are at predicting potential changes to Humboldt Bay habitat: (1) habitat type, and (2) frequency and intensity of human presence. As discussed above, turtle grass is less resilient than eelgrass because of its reproductive strategy, thus it is unlikely that similar results as the Eckrich and Holmquist (2000) study would be observed in Humboldt Bay. More importantly, the trampling frequency and intensity in Coast shellfish aquaculture plots would be much lower. For example, for cultch-on-longline (which is the majority of proposed culture methods), activity occurs about 2 days per acre every 1.5 to 3 years for planting and harvesting and 4 hours per 10 acre area once each month. Frequency and intensity for basket-on-longline is about 12 days per acre with the same line in rotation about every 4 months.

Aside from the low frequency of access for longlines, a portion of the access is conducted when the beds are inundated (approximately 44% for cultch-on-longline and 80% for basket-on-longline/rack-and-bag). Therefore, potential trampling does not occur at the rates discussed above even though human presence occurs more frequently. The most intensive culture method proposed, in terms of trampling potential, is rack-and-bag. This culture method is proposed in 4 acres of unstructured habitat outside of eelgrass, and would require daily activity for maintenance. Within Coast's current culture footprint, they have converted all rack-and-bag culture to basket-on-longline culture. The main reason that Coast has transitioned to longline methods is to reduce its ecological footprint in the bay. Longlines (both cultch-on-longline and basket-on-longline) require less maintenance than rack-and-bag culture and allow the site to be accessed when the plots are inundated. However, even with the higher level of activity associated with rack-and-bag culture, sites can only be accessed an average of 11 percent of the year when the plots are exposed during a low tide, which naturally reduces trampling potential associated with shellfish aquaculture operations.

Overall, the culture methods proposed by Coast have a lower frequency of activity within specific areas of the bay than those studied by either Rossi et al (2007) or Eckrich and Holmquist (2000). Further, these studies do not support a major shift in species composition due to trampling effects, especially within higher trophic levels such as fish. Disturbance associated with shellfish aquaculture in Humboldt Bay is infrequent and of short duration within any one location. Therefore, trampling effects to the benthic community are considered to be less than significant under CEQA.

5.3.3 Introduction of Non-Indigenous Species and Fouling Organisms

Boyd et al. (2002) conducted a census of NIS throughout Humboldt Bay from August 2000 to December 2001. Fouling invertebrates were sampled at 21 intertidal sites and 5 marina locations. Benthic invertebrates were collected at 87 stations. Fish were surveyed using seines, traps, and trawls at over 300 locations. Almost all NIS species identified were fouling organisms at marinas, although a number of species were also found in oyster growing areas (see Appendix A of this report). Out of 95 organisms identified in Humboldt Bay by Boyd et al. (2002), 14 species were found in oyster growing areas. The species identified were from nine different groups: (1) marine algae (mentioned above), (2) sponges, (3) anemones, (4) a limpet, (5) Pacific oysters (cultured), (6) a copepod commonly found in oysters, (7) amphipods, (8) bryozoans, and (9) a tunicate (*Botrylloides* sp.).

The list of NIS sampled from Humboldt Bay were compared to surveys of NIS in San Francisco Bay (Cohen and Carlton 1995). The majority of introductions were from the long history of maritime commerce, including both commercial shipping and mariculture, in Humboldt Bay (e.g., introductions from ballast water or in marine algae used as packing material for oysters). Boyd et al. (2002) indicated that most organisms were likely present in Humboldt Bay for over 100 years, with the exception of more recent introductions of some tunicates. New introductions that were identified are primarily associated with commercial shipping activity, especially from vessels that transit between San Francisco Bay and Humboldt Bay.

The probability that an expansion of oyster culture would expand NIS and fouling organisms outside of the culture areas is considered unlikely. Most NIS that colonize aquaculture gear and shellfish products are sessile (e.g., sponges, anemones, bryozoans, and tunicates) and require structured habitat. Fouling organisms are cleaned on-site from the harvested oysters to conserve water during processing, which means that they can be redistributed into the surrounding habitat. However, the only "hard structure" in the intertidal habitats where Coast is operating is the aquaculture gear and oyster shell itself, which means that there is no suitable substrate to attach to even if the NIS is present after cleaning. This concern was also raised for Drakes Estero where the existing shellfish aquaculture gear contained an invasive tunicate (*Didemnum* sp.). Mercer et al. (2009) surveyed the benthic community adjacent to cultured areas and reported that "the abundance of epifaunal organisms was not significantly affected by presence of the ascidian mats." None of the NIS identified in oyster growing areas were considered invasive[11] (Boyd et al. 2002), and these organisms are not expected to affect the native benthic community or the Humboldt Bay environment. On the contrary, the majority of literature related to organisms that colonize shellfish aquaculture gear are considered to provide additional food resources for fish and larger invertebrates (see discussion above).

One of the main ways in which historic oyster operations contributed to NIS in Humboldt Bay was from the shells of oyster spat imported from Japan. Beginning in the 1930's, the California Division of Fish and Game (now CDFW) helped to introduce Pacific oysters from Japan in order to revive the oyster industry in Humboldt Bay (Barrett 1963). Legacy introductions from this activity are evident from the pattern of exotic marine algae species found in Humboldt Bay. The distribution of *Lomentaria hakodatensis* and *Sargassum muticum* was primarily reported in Entrance Bay and to a lesser extent in North Bay (Figure 10). Boyd et al. (2002) specifically noted that these species occurred in oyster growing areas of North Bay. During the most recent surveys by SHN (2015), *S. muticum* was observed but not considered common in the proposed Coast expansion areas and *L. hakodatensis* was not reported. When *S. muticum* was observed, it was usually a single plant (~3 ft long) emanating from the sediment surface, likely attached to a rock just under the surface layer (O'Connell, pers. comm., 2015).

While there are legacy introductions from oyster operations in Humboldt Bay, current operations involve a number of stringent management measures to avoid introductions. Coast is a participant in a disease prevention program (the "Shellfish High Health Program") sponsored by the Pacific Coast Shellfish Growers Association (PCSGA). This program requires examination of larval oyster seed from West Coast hatcheries by a USDA-certified Shellfish Pathologist. Interstate and foreign export into California must be certified and regulated by a CDFW permit. The hatcheries that export shellfish seed submit inspection reports on a regular basis to CDFW, and the importation of seed from established hatcheries is allowed only if the hatchery has a minimum two-year history of documented absence of disease. Given these management measures to control for disease and NIS, it is unlikely that current oyster operations would result in NIS introductions.

11 Species that are identified as invasive have to fit the criteria of "non-native organisms which cause economic or environmental harm" (ISCC 2015).

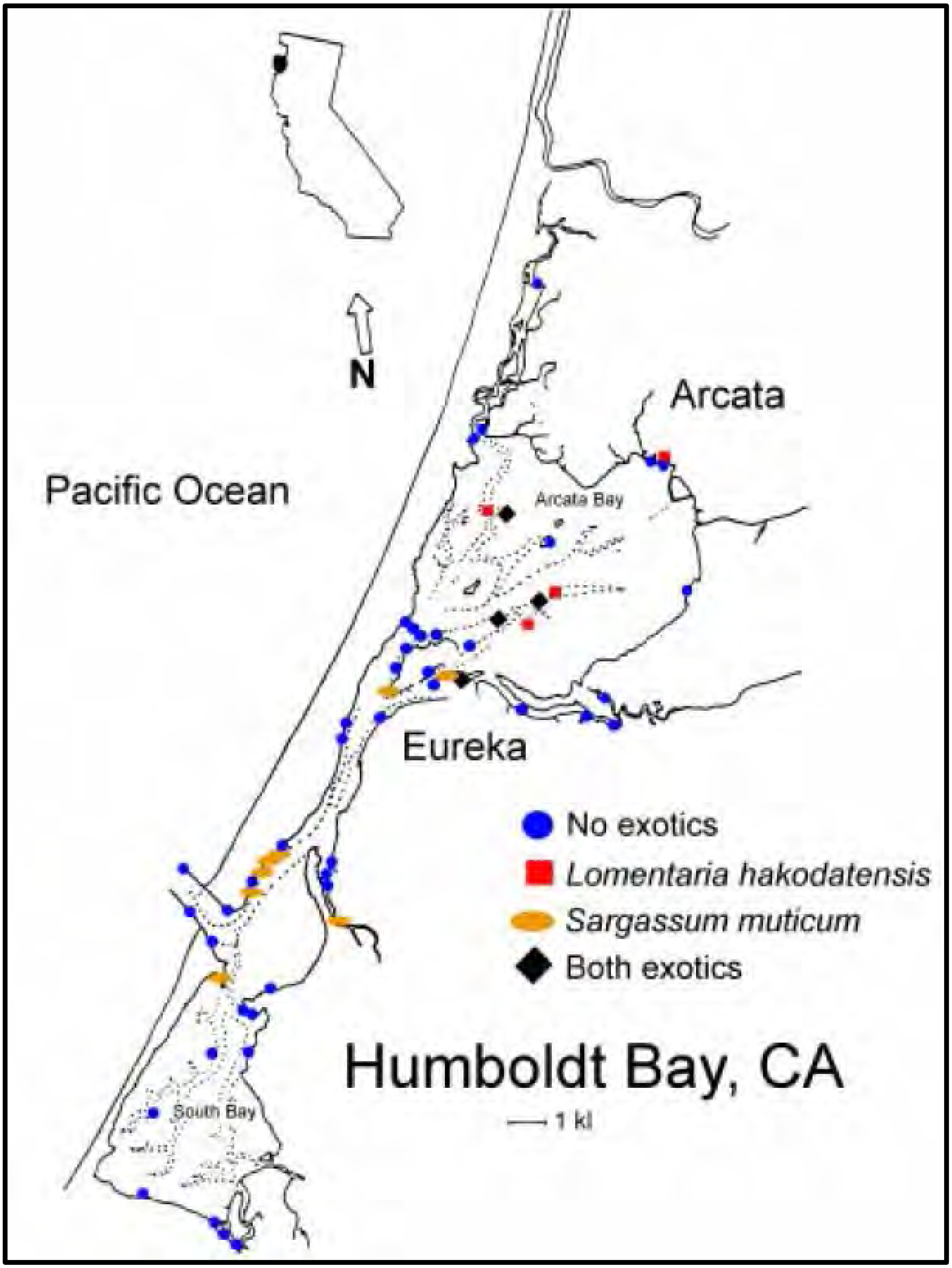

Figure 10 Distribution of Exotic Algae Species in 2000 and 2001.
Source: Boyd et al. 2002

5.3.4 Establishment of Non-Native Bivalves

The cultured species of oysters (Pacific oyster and Kumamoto oyster) are both non-native to Humboldt Bay. Their ability to spread and persist beyond the culture area is low, primarily because water temperature limits the functioning of oysters (Barrett 1963). The oyster species imported into California tolerate water temperatures below 70°F well enough to permit them to grow, but not necessarily to reproduce or for larvae to develop (Barrett 1963, Elliott-Fisk et al. 2005). This is why these species have to be incubated in hatcheries for several weeks before they are placed on the tideflats for grow-out. Further, Pacific oysters and Kumamoto oysters have a larval stage that lasts for 2 to 3 weeks (Barrett 1963). As discussed in the Carrying Capacity Analysis (Appendix G), reported flushing times in Humboldt Bay range from 2.5 days to 14 days. Structured habitat is also limiting in terms of locations where oysters can settle and grow. Finally, anecdotal evidence indicates that native Olympia oysters (*Ostrea lurida*) are setting on shellfish aquaculture gear (Dale, pers. comm., 2015), which may provide a benefit to the native species in a location where structured habitat is limited .

The NRC similarly concluded that there was a low risk of non-native oysters establishing in Drakes Estero, an estuary where shellfish aquaculture occurred. The NRC (2009) concluded that, "the combination of factors such as shellfish culture locations within the Estero, hydrography of the system (short residence time), and the lack of suitable natural habitat for settlement (as opposed to habitat associated with oyster culture) might mitigate against the successful establishment of the Pacific oysters in Drakes Estero." If oysters were to spread beyond the culture area, they would not be considered to be an "invasive" species, as defined above. Based on the 80+ year history of culturing non-native oysters in Humboldt Bay, there do not appear to be adverse impacts from non-native bivalves, displacement of native species, or establishment of Pacific oysters and Kumamoto oysters . Therefore, this potential impact is considered less than significant under CEQA.

5.4 Potential Impacts to Dungeness Crab

The Dungeness crab fishery is one of the most profitable fisheries in California (Hackett et al. 2009). While adult crabs are rare in Humboldt Bay (Emmett et al. 1991), juvenile crabs use the shallow intertidal habitat of North and South bays. There is also abundant crab larvae in the planktonic community of the bay in November through February. Predation by fish, birds, and marine mammals, loss of habitat due to dredging, bycatch within Northwest fisheries[12], and commercial harvest are the most common threats to Dungeness crab (Pauley et al. 1989, NMFS 2013). Dungeness crab populations

12 The bycatch of Dungeness crab in 2010 in Northwest fisheries included:

Pounds of Crab	Fishery
586, 148.87	West Coast limited entry bottom trawl
552,347.25	California halibut trawl
2,355.09	West Coast groundfish non-trawl gear: limited entry sablefish-endorsed fixed gear
1,763.63	Oregon/California pink shrimp
511.59	California/Oregon nearshore rockfish
503.74	West Coast groundfish non-trawl gear: non-endorsed fixed gear
400 individual crabs	West Coast mid-water trawl for whiting

also appear to be sensitive to, and respond to, oceanographic conditions, which can affect larval transport and settlement as well as predator populations (Wild and Tasto 1983). Most of these threats are not associated with shellfish aquaculture and are not discussed further. Four key ways in which potential Project impacts could affect Dungeness crab are discussed below.

5.4.1 Human Disturbance

There is no known information in the literature on the potential for human activity associated with oyster longline or rack-and-bag culture to result in impacts to Dungeness crabs. In general, individual lines or racks would be accessed at a rate of approximately 12 trips per acre on a four month rotation, which is an overestimate because cultch-on-longline represents 84 percent of the proposed expansion and has the lowest frequency of access (see Table 4). Further, the longlines are frequently accessed when the area is inundated (approximately 44% for cultch-on-longline and 80% for basket-on-longline/rack-and-bag), which would reduce potential disturbances to the bay bottom. Rack-and-bag culture would also be accessed at a rate of approximately 12 trips per acre at a four month interval but would only be accessed when the site is exposed. Because aquaculture gear would be exposed for approximately 11 percent of the year (Wagschal, pers. comm., 2015), and that time would include activity throughout the bay and not just isolated to rack-and-bag culture, this represents a small fraction of potential human presence in any one area where Dungeness crab may be present. Therefore, potential impacts from human disturbance from the proposed Project are less than significant for Dungeness crabs under CEQA.

5.4.2 Habitat Degradation or Alteration

The majority of the Project (97%) is proposed in patchy or continuous eelgrass habitat. Williamson (2006) indicated that the size threshold for Dungeness crab where eelgrass habitat may not be an important factor is approximately 30 to 35 mm. At these larger sizes, Dungeness crab movement and foraging efficiency appears to be reduced in complex habitats, including high density eelgrass and on-bottom aquaculture (Holsman et al. 2010). Williamson (2006) also reported that juvenile Dungeness crab were observed between 4 m and 75 m from a channel, while adults are unlikely to use the shallow habitats of North Bay.

Spatial overlap of the expansion area represents 6.8 percent (or 241 acres) of near channel habitat (within 100 m of a main channel) available in North Bay. In terms of eelgrass habitat, significant changes are not predicted directly under the longlines (e.g., 5% potential reduction in eelgrass density), there is no predicted change to areal extent of eelgrass beds, and the addition of structure can increase forage potential associated with benthic organisms that occur on or under shellfish aquaculture gear (although see discussion below). Overall, potential changes to Dungeness crab habitat would represent a less than significant impact to this species.

5.4.3 Reduction in Prey Resources

As discussed in Section 5.2.1 and 5.3.1 above, structured habitat is often associated with higher species diversity for benthic invertebrates, and many of the species present are considered important prey items for mobile invertebrates and fish. However, the presence of mobile species may not be directly associated with specific types of structured habitat. In a comparison of intertidal mudflat, seagrass (*Zostera marina*), and oyster (*Crassostrea gigas*) habitat use, Hosack et al. (2006) indicated that, "Fish and decapod species richness and the size of ecologically and commercially important species, such as Dungeness crab (*Cancer magister*), English sole (*Parophrys vetulus*), or lingcod (*Ophiodon elongatus*), were not significantly related to habitat type." The authors noted that these mobile species are using a diversity of habitat and the most important factor in their fitness was the presence of a habitat mosaic that included structured habitat, open spaces, and subtidal channels. The Project is not significantly affecting the mosaic of habitat present in North Bay. Oyster longlines can provide similar prey resources as eelgrass, and there would be no impacts to subtidal channels adjacent to eelgrass and intertidal habitats. Therefore, the potential impact of a reduction in prey resources is considered less than significant for Dungeness crab.

5.4.4 Obstructions to Access or Migration Corridors

Studies of derelict fishing gear and crab pots suggest that marine debris can create a risk of capturing and killing a range of marine invertebrates, fish, birds, and marine mammals (e.g., Matsuoka et al. 2005, Gilardi et al. 2010). However, entanglement of Dungeness crabs is considered unlikely due to: (1) oyster longlines and rack-and-bag structures are not designed with the intention of trapping organisms (i.e., much different than fishing gear and crab pots), and (2) longlines and rack-and-bag structures are placed from 1 to 3 ft off the bottom, and crabs would be able to access the area under the lines when the habitat is inundated. Based on an analysis of hourly tidal elevation data between 1993 to 2012 and the elevation range of oyster longlines (+1.5 ft to -2.0 ft MLLW) that occur 1 ft off the bay bottom, longlines would be fully inundated for approximately 89 percent of the year (Wagschal, pers. comm., 2015). Note that this calculation does not include the tidal elevations where crabs can access more shallow inundation areas or even exposed areas. Proactive maintenance and correction of line failures would essentially eliminate the potential for entanglement. Therefore, the effects of the proposed Project related to access and migration corridors for Dungeness crab is considered to be less than significant.

5.5 *Potential Impacts to Pacific Lamprey*

Pacific lamprey are a CDFW Species of Special Concern. The most common threats to lamprey are: dams and diversions, agriculture runoff, urbanization, instream mining, logging, estuary alteration, harvest, and alien species (CDFW 2015b). Most of these threats are not associated with shellfish aquaculture and are not discussed further. Since the lamprey life history is similar to that of salmonids, many of the threats and pressures may be similar. Four key ways in which potential Project impacts could affect Pacific lamprey are discussed below.

5.5.1 Human Disturbance

Pacific lamprey tend to stay relatively close to their natal stream for several years before returning to spawn (CDFW 2015b), and adult migrants have been observed using Freshwater Creek (a main tributary to Humboldt Bay). Coast employees would not interact with early life stages of Pacific lamprey as their habitat is in freshwater. Migrating and holding adult Pacific lamprey may come into contact with Coast employees, but individual culture areas are visited infrequently and disturbance would not be expected. Therefore, the potential for human disturbance to affect Pacific lamprey using the bay is expected to be less than significant.

5.5.2 Habitat Degradation or Alteration

The Project is not expected to significantly alter habitat used by Pacific lamprey for foraging and holding in North Bay. Pacific lamprey spend most of their life in fresh or marine water, rather than estuaries. Estuaries are important to Pacific lamprey for foraging, holding, and transitioning from freshwater to marine waters (CDFW 2015b). Although the body of research on Pacific lamprey habitat needs is small, the Project is not expected to limit use of Humboldt Bay by Pacific lamprey. The primary built element that is associated with lamprey decline is dams (CDFW 2015b). Therefore, the effects of the Project are expected to be less than significant with respect to habitat loss or degradation for Pacific lamprey in the bay.

5.5.3 Reduction in Prey Resources

The Project is not expected to reduce prey resources of Pacific lamprey. Juvenile Pacific lamprey are filter feeders in freshwater. Adult Pacific lamprey are predators of larger fish and marine mammals. The Project would not be expected to exclude larger fish or marine mammals from areas of the North Bay. The shallow intertidal habitats associated with oyster aquaculture in North Bay are primarily used for nursery habitat. For example, Pinnix et al. (2005) estimated 44 percent of species were using oyster longlines as nursery habitat. Therefore, the potential impact to a reduction of prey resources is considered less than significant to Pacific lamprey.

5.5.4 Obstructions to Access or Migration Corridors

There are numerous tributaries to Humboldt Bay which Pacific lamprey may use to spawn. Additionally, estuaries are important to Pacific lamprey for foraging, holding, and transitioning from freshwater to marine waters (CDFW 2015b). Thus, it is likely that Pacific lamprey would be in Humboldt Bay as a migratory corridor to spawning grounds. Because of the proposed 5 ft spacing of longlines, this would not be considered an obstruction to migrating fish. The potential impact of obstructions to Pacific lamprey access or migration corridors is considered less than significant.

5.6 Potential Impacts to Sturgeon

Green and white sturgeon are very long-lived fish. Sturgeon may live 50 years or more. Major dams, agriculture and mining runoff, road construction, legacy effects from logging, estuary alteration, and habitat loss in spawning streams, overharvesting and poaching, and bycatch from Northwest fisheries[13] are the most common threats to sturgeon (Benson et al 2007, CDFW 2015b, NMFS 2015a). Fishing pressure may also affect green sturgeon because their documented long distance migrations may subject them to fishing seasons in multiple locations (Moser and Lindley 2007). Most of these threats are not associated with shellfish aquaculture and are not discussed further. Four key ways in which potential Project impacts could affect sturgeon are discussed below.

5.6.1 Human Disturbance

Sturgeon move into estuaries up and down the West Coast taking advantage of foraging opportunities in bays and estuaries along the way. During the summer and early fall months, sturgeon will remain in bays for weeks to months at a time. Green sturgeon have been observed in Humboldt Bay between April and October (see Table 2). Pinnix (per. comm., 2015), reported incidental reception of tags on green sturgeon while conducting surveys tracking the movement of coho salmon in Humboldt Bay (Pinnix et al 2013). The tracking data, and anecdotal observations during tracking, indicated that surgeon primarily use the deeper channels of the bay for foraging and holding (Figure 11) but will make excursions into shallow mudflat habitat to forage.

Green sturgeon appear to be particularly persistent in the North Bay Main Channel and Arcata Channel (*see* Figure 5 for the channel labels), and frequently migrate between the Samoa Bridge and Sand Island (Pinnix, pers. comm., 2015). Moser and Lindley (2007) speculate that green sturgeon may use coastal bays as foraging habitat due to their high productivity. The acoustic tag detections shown in Figure 11 suggest that green sturgeon are moving in channels. However, 97% of observations occurred at two detection locations: Arcata Channel and North Bay Main Channel near the Samoa Bridge. Tracking studies in San Francisco Bay suggest that sturgeon detections are associated with either movement or feeding activity and that directional movement of sturgeon is rapid (Kelly et al. 2006). Taken together, these observations suggest that the large number of detections (148,997) near the extreme north end of Arcata Channel likely represents an area where feeding is occurring. These detections are adjacent to proposed Growing Area 4, including an area occupied by existing culture. However, the detections are also adjacent to extensive mudflat habitats unrelated to shellfish aquaculture operations, which are believed to represent preferred intertidal feeding habitat. Acoustic receivers on the other side of Growing Area 4, and in channels adjacent to all other proposed growing areas have low numbers of detections, suggesting these areas were used primarily for movement activities. White sturgeon also prefer deeper habitats (CDFW 2015b), and use of Humboldt Bay is likely similar to green sturgeon. Human interaction with sturgeon on the oyster plots would be restricted to periods of time when the area is inundated and activity is occurring (approximately 44% for cultch-on-longline and 80% for basket-on-longline/rack-and-bag). Sturgeon present in shallow waters are easy to observe (rolling and splashing), and would be easy for Coast employees to avoid.

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13 The bycatch of green sturgeon in 2010 from the California halibut trawl fishery included 182 individual fish. Green sturgeon were also bycatch in the West Coast limited entry bottom trawl fishery (8 individual fish).

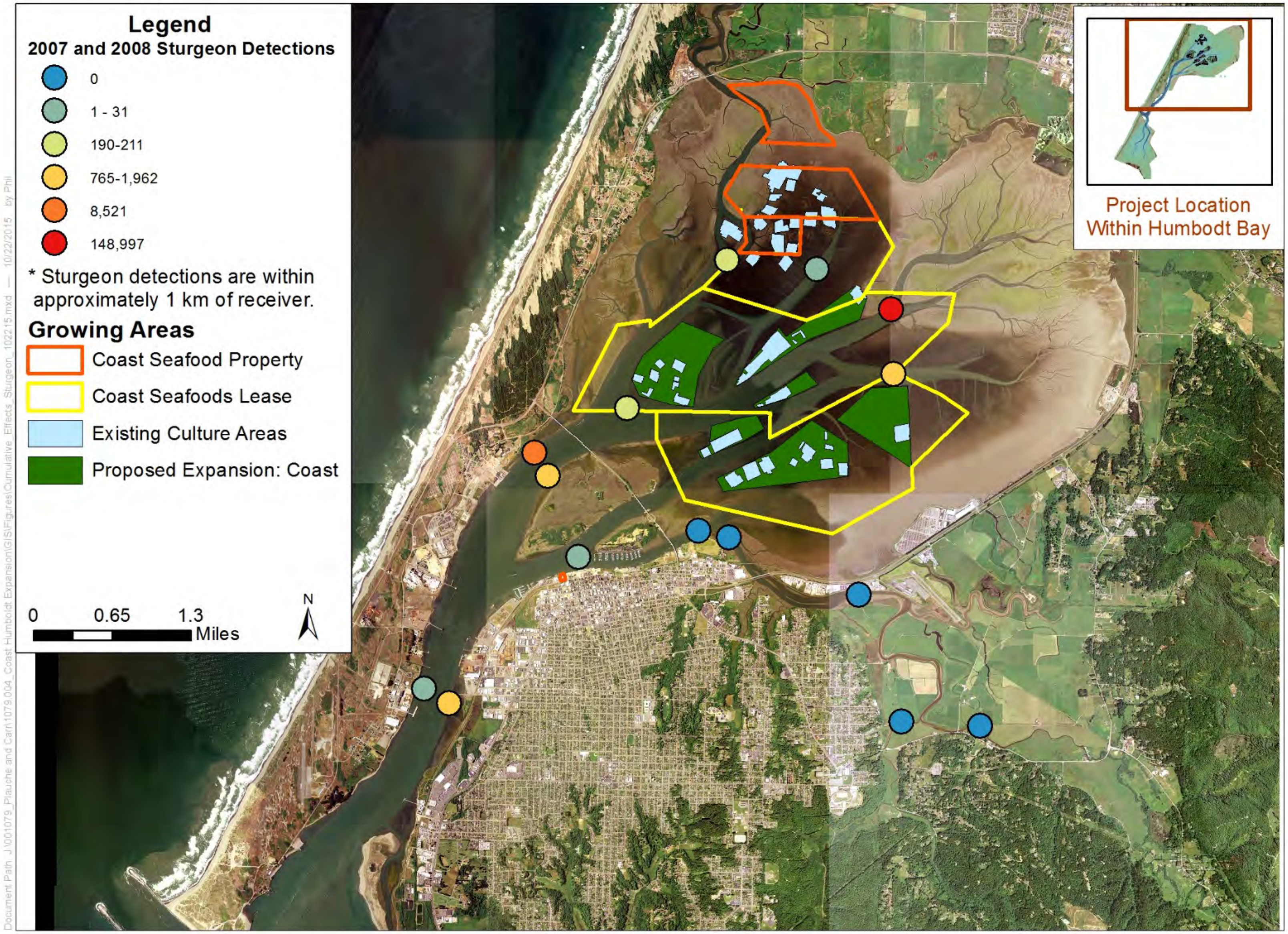

Figure 11 Green Sturgeon Tracking Data from 2007 and 2008

Source: modified from CDFW data provided to Dale (pers. comm., 2015).

Note 1: 1 km detection limits for the acoustic receivers and a detection in Freshwater Creek were presented in maps prepared by CDFW, but Pinnix (pers. comm., 2015) indicated that these elements were not necessarily an accurate depiction of where sturgeon are found. Please see discussion in the text.

Note 2: Lease boundaries are approximate based on a review of the legal description and do not represent surveyed locations.

5.6.2 Habitat Degradation or Alteration

There are two potential impacts to habitat for sturgeon: (1) changes to unstructured habitat, and (2) changes to near channel eelgrass habitat. The potential overlap of near channel areas (up to 100 m from the channel) in unstructured habitat is approximately 0.4 percent of North Bay habitat and the potential overlap of near channel areas in eelgrass habitat is approximately 13.1 percent. This does not represent habitat that sturgeon are excluded from, but does represent a change to that habitat. For example, Pinnix (pers. comm., 2015), suggested that a 5-ft spacing of oyster longlines would allow sufficient area for these fish to maneuver in the event that they do occur in the shellfish growing areas. Sturgeon would be able to access foraging areas in the 5 ft spaces between oyster longlines (both cultch-on-longline and basket-on-longline), and 20 ft spaces between a group of three baskets[14]. Rack-and-bag culture, while spaced closer together for groups of three racks (3 ft apart), also has a 5 ft space between groups and represents a minor component of potential foraging habitat. Overall, habitat degradation or alteration is considered less than significant under CEQA for green or white sturgeon.

5.6.3 Reduction in Prey Resources

Sturgeon are typically benthic feeders in deeper habitats (targeting fish), although they are also known to forage within shallow mudflat habitat for ghost shrimp (e.g., Dumbauld et al. 2008). Their preferred prey species include various crustaceans, mollusks, and, for adults, various fish species (Moyle et al. 1992, Moser and Lindley 2007, Dumbauld et al. 2008). Foraging sturgeon tend to frequent areas less than 33 ft deep, moving on and off mudflats with tidal fluctuations (Kelly et al. 2007). No site-specific data are available from Humboldt Bay that informs specific uses of certain areas (e.g., census of key prey items such as burrowing shrimp), although as described above the acoustic tag data suggest that the upper mudflats at the north end of Arcata Channel may represent preferred feeding habitat. It has been speculated that use of Sand Island may reflect key foraging habitat; however, without a diet analysis or more directed observations, it is unknown why sturgeon frequent this location in North Bay. It is important to note that shellfish culture has existed on Sand Island and near the north end of Arcata Channel since the late 1950s and no impacts to sturgeon have been observed as a result of the oyster operations. In addition, there are no Project actions expected to significantly affect the habitats that these fish may be using for foraging, and there is no expected reduction in preferred prey species. Therefore, potential impacts to prey resources for green or white sturgeon are considered less than significant under CEQA.

5.6.4 Obstructions to Access or Migration Corridors

Pinnix (pers. comm., 2015) indicated that green sturgeon would occasionally migrate from the major channels of North Bay onto the adjacent tideflats, but that these sightings were rare in comparison to the observations from the deep channels. These observations do, however, indicate that at least occasionally these fish could encounter oyster aquaculture gear deployed for the proposed Project. The

14 See below for a discussion of Conservation Measures incorporated to address migration through available corridors.

gear is not expected to pose a threat to these fish, and Pinnix (pers. comm., 2015) suggested that a 5 ft spacing of oyster longlines (both cultch-on-longline and basket-on-longline) would allow sufficient area for these fish to maneuver in the event that they do occur in the shellfish growing areas. Rack-and-bag has groups of 3 racks that are more closely spaced (3 ft), but have 5 ft rows between groups of three. In addition, placement of rack-and-bag is a minor component of habitat likely used by sturgeon. Overall, the Project is not expected to result in obstructions to access or migration corridors for green or white sturgeon, and is considered less than significant under CEQA.

5.7 Potential Impacts to Salmonids

Humboldt Bay supports three ESA listed salmonids (coho salmon SONCC ESU, Northern California steelhead trout DPS, and California coastal Chinook salmon ESU) and coastal cutthroat trout, which is a CDFW species of special concern. Interactions with hatchery stocks, habitat degradation (usually for upland agriculture), fisheries harvest, legacy effects from logging, road construction, rural development, and cattle grazing are the most common threats to salmonids (CDFW 2015b). Most of these threats are not associated with shellfish aquaculture and are not discussed further. Four key ways in which potential Project impacts could affect salmonids are discussed below.

5.7.1 Human Disturbance

Site-specific studies in Humboldt Bay indicate that there may be limited use of eelgrass beds and intertidal mudflats in Humboldt Bay by juvenile salmonids. A long-term (1994-1995 and 2003-2006) otter trawl survey conducted in Entrance Bay sampled a small eelgrass bed adjacent to the main channel near the mouth and only collected one juvenile steelhead and no other salmonids (Garwood et al. 2013). Pinnix et al. (2005) sampled the tideflats in North Bay, including eelgrass beds and oyster longlines, for three years (2003 to 2005) using six different gear types and no salmonids were collected. In particular, these authors considered the fyke net system to be very effective at capturing the entire composition of fish that were present in the sampling area, but even the fyke nets did not sample juvenile salmonids (Pinnix, pers. comm., 2015).

Based on these results, additional studies using tagged coho smolts (greater than 120 mm) were conducted between April and July 2007 and again in 2008 (Pinnix et al. 2013). This study reported that coho smolts (at least the size tagged in the study – fork length of 123±5.8 mm and 125±5.2 mm) used the deeper channel areas and the margins of these channels exclusively during their migration through the bay (Figure 12). Pinnix et al. (2013) reported that the average residence time in North Bay was 15 to 22 days before leaving for the open ocean, which indicates that the tagged fish were primarily migrating out and not rearing in the estuarine habitat. However, the study also tagged only the largest fraction of the population, and it's possible that smaller fish may spend more time in the bay and use eelgrass to a greater extent (Pinnix, pers. comm., 2015). Work by CDFW has reported extensive use by juvenile salmonids of the upper intertidal areas (which include eelgrass) close to the stream-estuary ecotone that is not associated with oyster growing areas (Wallace 2006, Wallace and Allen 2007, Wallace and Allen 2015).

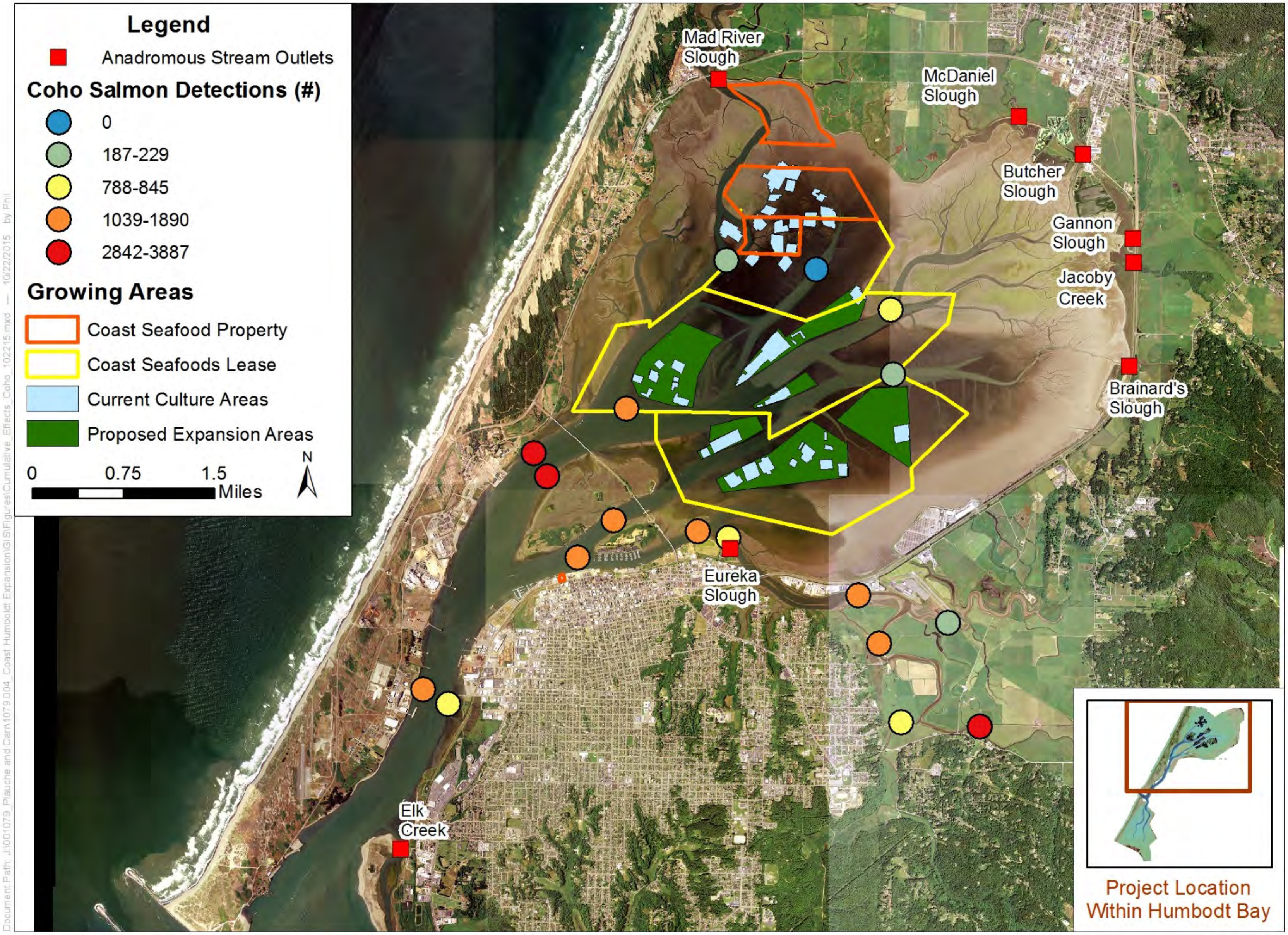

Figure 12 **Coho Salmon Tracking Data from 2007 and 2008**

Note: Lease boundaries are approximate based on a review of the legal description and do not represent surveyed locations.

Studies in other areas along the West Coast indicate that most anadromous salmonids that rear for an extended time in freshwater (e.g., coho, spring Chinook, steelhead, sockeye, sea run cutthroat) are oriented toward deeper water when they are present in estuaries (Simenstad et al. 1982). However, the early migrant fry of chum, pink, and fall Chinook salmon use the shallower margins of estuaries for a few weeks in the spring before moving into deeper water as they grow larger (Simenstad and Eggars 1981, Simenstad et al. 1982). (Note that chum and pink salmon do not occur in Humboldt Bay.) Together, these data suggest that coho and other salmonids are not substantially using the locations where oyster longline culture is being proposed. In addition, the primary interaction with Coast employees would be during transit between sites in work vessels and fish would be able to easily avoid boats when present. Finally, even if fish were present in oyster longline areas, individual lines are visited infrequently and disturbance would not be expected. Therefore, the potential for human disturbance to affect juvenile salmon using the bay is expected to be less than significant under CEQA.

5.7.2 Habitat Degradation or Alteration

Magnusson and Hilborn (2003) assessed the survival of coho and fall Chinook salmon released from West Coast hatcheries with respect to three characteristics: (1) size of the estuary, (2) percentage of the estuary that is in natural condition, and (3) presence of oyster culture in the estuary. While Humboldt Bay was not one of the estuaries assessed, the results suggested that oyster culture was not having an adverse impact on salmon survival in estuaries where there were substantial runs. Willapa Bay, which has a 150+ year history of extensive oyster culture in dense eelgrass beds, had the highest coho salmon survival. Grays Harbor, also an important oyster farming estuary, had the third highest coho survival of the twenty estuaries included in the study. Despite the large number of oyster cultivation operations in Willapa Bay and Grays Harbor (over 25% of the oysters consumed in the U.S. are grown in these estuaries), these Washington estuaries have some of the best released coho salmon survival among the areas examined.

Pinnix et al. (2005) found that fish species richness in oyster culture areas of North Bay was greater than or equal to eelgrass areas without oyster culture and in all cases significantly greater than mudflats. This suggests that oyster culture does not lead to habitat loss or degradation with respect to fish habitat, even though no salmonids were sampled during the Pinnix et al. (2005) study. It should be noted that species composition was slightly different in eelgrass compared to oyster culture, which means that oyster culture may support a different community of fishes (Pinnix, pers. comm., 2015). However, there is no indication that the change in community would alter the stability of Humboldt Bay's food web, as discussed in Section 5.3.1 above. Therefore, the effects of the Project are expected to be less than significant under CEQA with respect to habitat loss or degradation for salmonids in the bay.

5.7.3 Reduction in Prey Resources

Multiple studies have looked at prey resources associated with shellfish aquaculture gear in relation to salmonid prey items. Simenstad et al. (1991) reported that densities of a harpacticoid copepod (*Tisbe* sp.), which is an important prey item for some juvenile salmonids (e.g., chum salmon), were enhanced in areas of oyster culture compared to bare mudflat. Densities of gammarid amphipods and cumaceans (principally *Cumella vulgaris*), which are important prey items for juvenile Chinook and coho salmon, were enhanced at one site but depressed at another site. Brooks (1995) found that *Corophium acherusicum*, another critical prey resource for salmonids, was enhanced in actively cultured oyster beds. Brooks (1995) also reported greater densities of gammarid amphipods and small tellinid clams. Therefore, oyster aquaculture areas can provide abundant suitable prey resources for salmonids if the fish are found in culture areas.

Dumbauld et al. (*in review*[15]) conducted a study to identify whether intertidal oyster aquaculture in Willapa Bay, Washington, effects the distribution and feeding ecology of juvenile salmonids. The study identified no significant differences in the density of juvenile salmonids caught in the four habitat types analyzed (undisturbed open mudflat, seagrass, channel habitats, and oyster aquaculture), and few significant associations with the prey items that the fish consumed. In other words, the majority of salmon found over low intertidal habitats were not dependent on structured habitat (e.g., eelgrass or oyster aquaculture) for prey items. Chum salmon was the possible exception, which is typically a smaller fish during estuarine residency. The final conclusion by Dumbauld et al. (*in review*) was that: "Permanent or 'press' disturbances like diking marshes, dredging and filling shallower estuarine habitats and even hardening shorelines would be expected to have significant impacts for other stocks and life history variants with smaller juveniles that utilize upper intertidal areas (Fresh 2006, Bottom et al. 2009), but our research suggests that short term 'pulse' disturbances like aquaculture which alter the benthic substrate in lower intertidal areas used primarily by larger juvenile salmon out-migrants may pose a less significant threat to maintaining resilience of these fish populations."

These studies indicate that prey resources targeted by juvenile salmonids in oyster culture areas are likely equivalent to other productive habitats, such as eelgrass meadows. Therefore, the potential impact to a reduction of prey resources is considered less than significant under CEQA to salmonids.

5.7.4 Obstructions to Access or Migration Corridors

Site-specific studies in Humboldt Bay suggest that there may be limited use of eelgrass beds and intertidal mudflats by juvenile salmonids that would be associated with the Project. However, it is an accepted paradigm that these habitats are important for salmonids, especially early migrant juveniles in the upper portions of estuaries (e.g., Simenstad and Eggars 1981, Simenstad et al. 1982, Wallace 2006, Wallace and Allen 2007, Wallace and Allen 2015). If salmonids do use the areas proposed for oyster longlines, gear would not pose an obstruction to access or migration corridors. Juvenile salmonids can move between and even under longlines when plots are inundated. Because of the nature of the gear (i.e., suspended off the bottom) , the potential impact of obstructions to salmonid access or migration corridors is considered less than significant under CEQA.

15 Although the information presented was taken from the manuscript, it is also discussed in the Western Regional Aquaculture Center (WRAC) project termination report that supported the manuscript (Dumbauld 2006).

5.8 Potential Impacts to Forage Fish

Forage fish are an important dietary resource for higher trophic-level fish and marine mammals. The main forage fish species used in this document as an indicator for potential Project impacts is the Pacific herring. The analysis also pertains to potential impacts to eulachon and longfin smelt because they are considered special status species. Information on direct and indirect impacts to forage fish is discussed below, including general population information and four key ways in which potential Project impacts could affect forage fish.

Gustafson et al. (2010) indicated that sightings of the southern eulachon from creeks and rivers outside of the critical habitat (e.g., south of Mad River) is extremely infrequent and have consisted of very few fish. NMFS (2011) indicated that: "we do not consider these areas to be essential to the conservation of the southern DPS of eulachon." Spawning habitat loss and degradation, particularly in the Columbia River basin, dredging activities that entrain or kill fish, bycatch from other fisheries[16], and historical overfishing are the most common threats to eulachon (NMFS 2013, NMFS 2015a). Longfin smelt in California have experienced a steep population decline from an estimated peak of "tens of millions" of adults in 1982 to "tens of thousands" by 2007 (CDFG 2009). Identified threats to longfin smelt include reduction in outflows, entrainment in water diversions, climactic variation, toxic substances, predation and competition with introduced species (Moyle et al. 1995). Pacific herring typically spawn adhesive eggs onto eelgrass, marine algae, and hard substrates at depths of less than 30 ft MLLW (CDFG 2008, Stick 2005). Predation, temperature and salinity variability as well as turbidity are the most common threats to juvenile Pacific herring (CDFG 2008). A commercial fishery for herring occurred in Humboldt Bay until 2005 (CDFG 2008). The commercial fishery was closed due to insufficient fishery biomass and only occurs when sufficiently large spawning schools exist.

5.8.1 Human Disturbance

Human disturbance can reduce fitness when fish engage in predator avoidance behavior in response to the perceived threat of humans or human activity (e.g., Frid and Dill 2002). Avoidance reactions by schooling fish include diving, horizontal movements, and altered tilt angles in response to approaching motorized vessels (e.g., De Robertis and Handegard 2012). Aquaculture activity will increase human disturbance in the vicinity of the aquaculture beds where eulachon (if present), longfin smelt, and Pacific herring are likely found. Disturbance of fish would be limited to the arrival and departure of crews, which would occur approximately 2 days per acre every 1.5 to 3 years for cultch-on-longline and 12 days per acre every 4 months for basket-on-longline and rack-and-bag. These disturbances are unlikely to substantially increase the predator avoidance behaviors of these fish because visits will be limited in duration and area. When oyster plots are accessed when there is not surface water (i.e., during a low tide that drains the tideflats), fish would not be present in the area. Project longlines would be exposed for approximately 11 percent of the year (Wagschal, pers. comm., 2015), but Coast presence

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16 The bycatch of eulachon in 2010 from the Oregon/California pink shrimp fishery included 1,075,081 individual fish. In the Northwest region in 2010, eulachon were also bycatch in the West Coast limited entry bottom trawl fishery (21 individual fish)

during low tides within a particular one acre area is a smaller portion of the year. For example, for cultch-on-longline, the average number of hours per acre is about 0.2 percent of the year (100 hours out of 61,320), but activity occurs in phases which vary by intensity of culture activities. Similarly, when the area is accessed during inundation (e.g., during high tides when plots are covered by water), fish would be able to easily avoid locations where Coast employees are present. These visits are also limited in duration and, therefore, effects are expected to be similar to other boating activity in Humboldt Bay.

The pre-spawning timeframe for Pacific herring is an important component of spawning activities. According to Stick (pers. comm., 2014), when herring are ripe and ready to spawn (within a two- to three-week period between holding and spawning), the fish can be sensitive to changes in their surroundings (e.g., continuous shading, excessive underwater noise). However, once spawning activities start, there is little that will disturb the fish from spawning. According to Ray (pers. comm., 2015), pre-spawning holding areas for herring are typically located in deep channels adjacent to spawning locations. The extent to which particular channels are used is dependent on tidal stage, size of the tidal exchange, time (day or night), maturity level, herring abundance, predator activity, and freshwater influx (Ray, pers. comm., 2015). As they mature, the herring begin to spend more time in closer proximity to spawning grounds and there is considerable movement of fish up into the channels of North Bay on flood tides and then out again on ebb tides. Based on data from CDFW about past and current spawning locations, the East Bay channel and Arcata channel (adjacent to the East Bay Management Area) are likely locations for pre-spawning holding activities (Mello et al. 2007, Ray, pers. comm., 2015). These channels are used to transit to oyster plots, but other than temporary passage of work vessels, there would be no human activities in the pre-spawning holding areas. This impact is anticipated to be minor, given that the Project would result in a small increase of approximately 18 boat trips per week throughout the bay, a smaller portion of which would be in the East Bay and Arcata channels.

Herring spawning occurs primarily in the East Bay Management Area, but has also been observed in other locations of North Bay (Figure 13). Coast will employ a herring-specific Mitigation Measure BIO-1 in the culture areas to avoid impacting potential spawning locations. Culture beds to be worked would be visually surveyed to determine whether herring have spawned on eelgrass, culture materials, or substrate during December through March (e.g., herring spawning season in Humboldt Bay). If spawn is observed, CDFW would be notified and aquaculture activities will be postponed until all of the eggs have hatched.

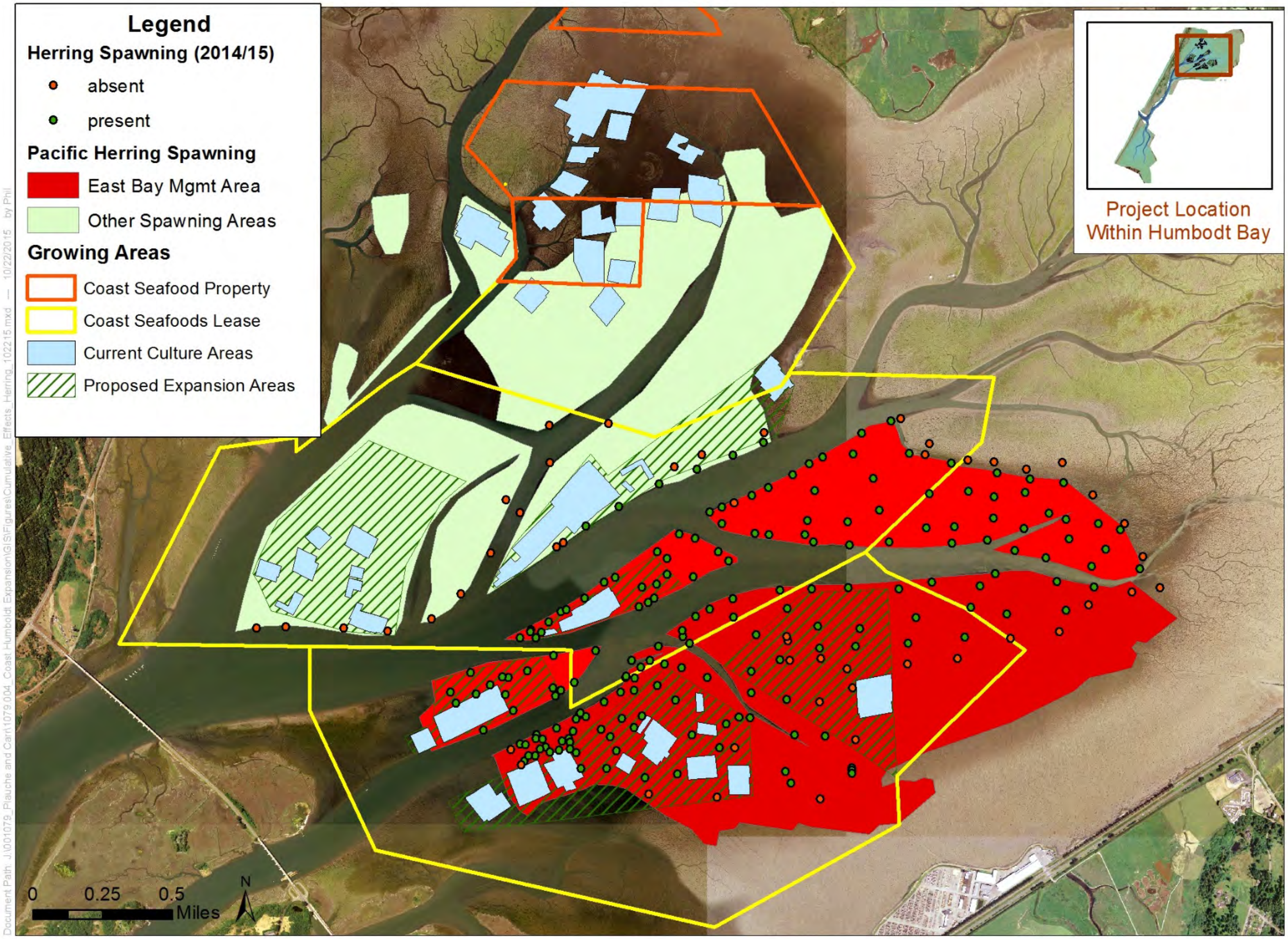

Figure 13 Pacific Herring Spawning Locations in East Bay, Humboldt Bay, California

Source: modified from CDFW data provided to Dale (pers. comm., 2015).

Note: Lease boundaries are approximate based on a review of the legal description and do not represent surveyed locations.

A recent example of Coast's compliance with this condition was on July 23, 2015, when a Coast employee observed fish spawn on oysters on the Gunther Island nursery on cultch bags. They were identified as plainfin midshipman, *Porichthys notatus*, eggs, which had been observed around the oyster ground previous to the egg deposition (Kinziger, pers. comm., 2015). The bags were photographed but not moved. Although the egg deposition was not Pacific herring, the crews were taking the same appropriate precautions to identify the eggs prior to conducting activities in the area (because the eggs were identified as plainfin midshipman, CDFW was not notified).

Based on the low frequency of access to individual oyster plots, minimal interaction with pre-spawning areas, and a Mitigation Measure (BIO-1) to avoid areas with spawn deposition, the potential impact of human disturbance on forage fish is considered less than significant under CEQA.

5.8.2 Habitat Degradation or Alteration

Eulachon are not likely to use Humboldt Bay. There are no major spawning streams that drain into the bay and Humboldt Bay is south of their known geographical extent (NMFS 2011). Longfin smelt spawn primarily in freshwater habitat, so use of the expansion area would be by juvenile and adult smelt. Use of open-water habitat is affected by salinity, turbidity, temperature, and levels of contaminants (CDFG 2009). Being flushed out of freshwater streams and into the ocean during wet years presents a risk for larval longfin smelt populations. According to data provided by CDFW (Dale, pers. comm., 2015), longfin smelt were captured primarily from Freshwater Creek, Eureka Slough, East Bay Channel, and North Bay Main Channel (see Figure 5 for channel names). These areas avoid the majority of proposed culture operations. In the event that these forage fish species are found in habitats associated with aquaculture (5.8% potential overlap), the primarily potential change is a 5 percent reduction in eelgrass density. Therefore, the potential impact to habitat degradation or alteration is considered less than significant under CEQA for eulachon and longfin smelt.

There is likely overlap with Pacific herring because they spawn on eelgrass habitat and herring were recently observed spawning in areas where the Project will occur (see Figure 13). There is potentially 10.1% overlap of potential spawning habitat (channel and eelgrass habitat) and the Project. However, trends in eelgrass abundance and shellfish aquaculture operations appear to be unrelated to herring spawning biomass or locations of spawn deposition in Humboldt Bay. Eelgrass is extensive and relatively stable in Humboldt Bay (Judd 2006, Gilkerson 2008, Schlosser and Eicher 2012), but herring populations have suffered a precipitous decline from 950 tons to 7 tons before monitoring was suspended in 2007 (Figure 14). These significant population reductions have occurred during a period when Coast reduced its aquaculture footprint in the bay, including areas within the East Bay Management Area where spawn has historically been dominant (e.g., Rabin and Barnhart 1986, Mello 2007) and where the majority of spawn deposition was identified during the 2014/2015 spawn survey (see Figure 13). Herring spawn surveys are not conducted by CDFW within existing culture areas. However, there were successful detects of spawn deposition in historic aquaculture growing areas and areas directly adjacent to actively farmed oyster plots.

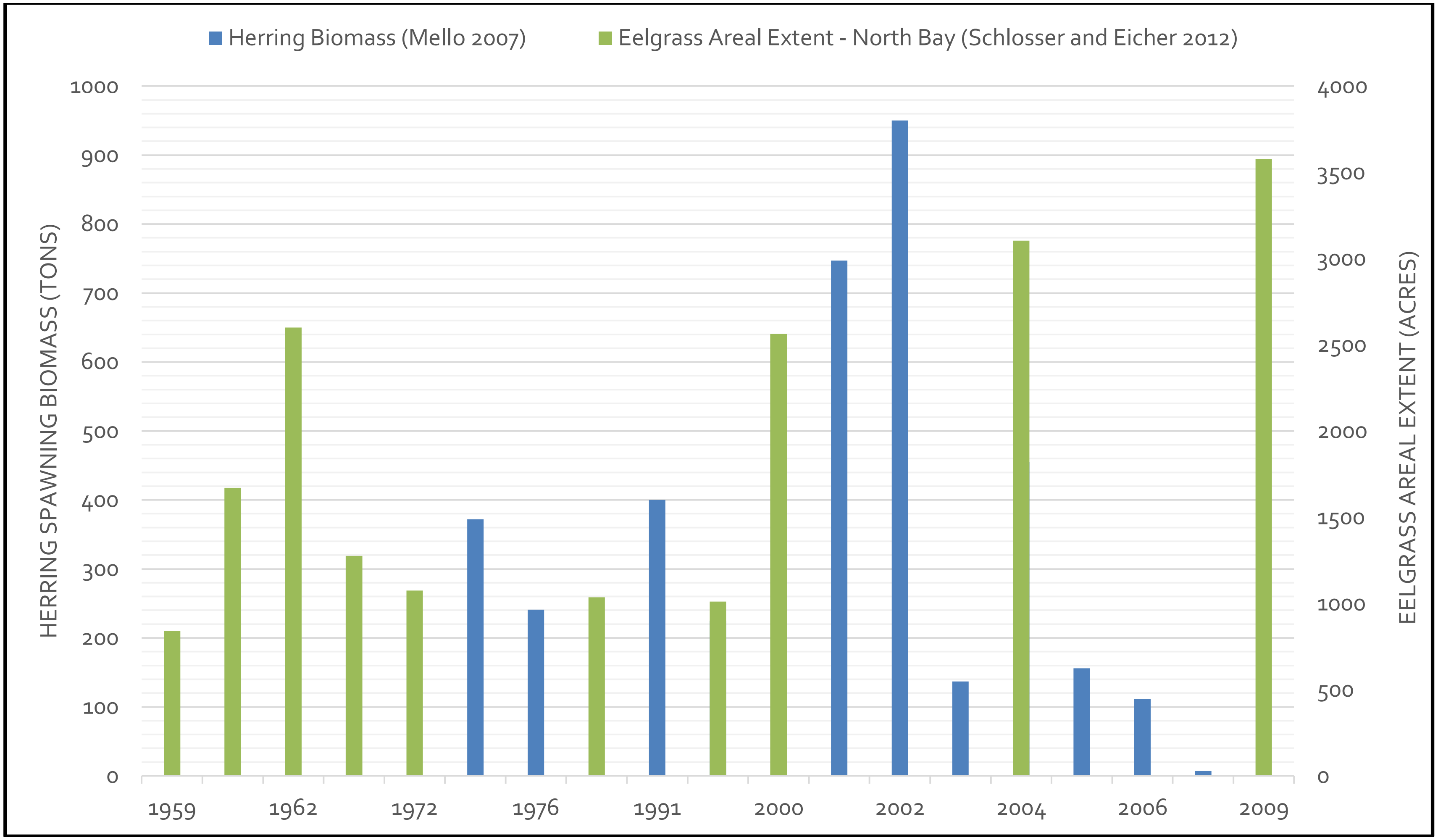

Figure 14 Herring Spawning Biomass and Eelgrass Areal Extent in North Bay (Humboldt Bay)

Sources: Schlosser and Eicher 2012, Mello 2007

Note: While this represents the best available information, there are limitations to mapping methods that make direct comparisons complicated. In general, eelgrass appears to be stable in Humboldt Bay but overall areal extent may be inaccurate between years.

Project-specific impacts to herring spawning locations would include a potential eelgrass density reduction of up to 5 percent directly under the longlines. However, Pacific herring are not limited by spawning substrates in Humboldt Bay, using a maximum of approximately 10 percent of the available spawning substrate during a typical spawning event (Mello and Ramsay 2004). Shelton et al. (2014) indicated that spawn survival varies with spawning populations, not by spawning substrate type. The authors reported that egg loss rates were not significantly different on the three spawning substrates studied, including native eelgrass (*Z. marina*), non-native eelgrass (*Z. japonica*), and non-native algae (*S. muticum*). Aquaculture gear can also be used as a spawning substrate, but is elevated approximately 1 ft above the bay bottom, and herring eggs on aquaculture gear would have slightly greater periods of exposure during low tides. Based on an exposure elevation analysis of aquaculture gear (Wagschal, pers. comm., 2015), spawn on gear potentially represents an increase of exposure to air by approximately 11 percent. Jones (1972) estimated that herring eggs deposited at higher elevations have up to 3 percent higher mortality based solely on desiccation potential. However, increased mortality due to desiccation is likely to be offset by reduced predation pressure from invertebrates and fish during periods of exposure (Palsson 1984, Rooper and Haldorson 2000). These latter authors noted that desiccation potential and predation pressure are the main trade-offs for Pacific herring spawning locations.

Another potential impact to herring spawn is potential survival on shellfish aquaculture gear (e.g., PVC, basket-on-longlines). The effects of artificial substrate on spawn survival were evaluated by Palsson (1984) and Hourston et al. (1984). Hourston et al. (1984) found no difference in egg viability between eggs spawned on plastic versus 11 natural substrates, including eelgrass. Palsson (1984) evaluated a total of 6 artificial substrates placed in natural spawning substrates and found that egg survival rates were somewhat lower on artificial substrates than on adjacent natural substrata. However, Palsson (1984) also speculated that reduced survival may have been due to characteristics of his sampling array rather than characteristics of the artificial substrate.

Based on the amount of overlap with potential herring spawning habitat (10.1%), and the potential for herring to spawn on aquaculture gear, impacts to Pacific herring egg deposition is potentially significant if gear or shellfish products are removed from the intertidal zone when eggs are present. Therefore, Coast will avoid potential impacts to spawning locations (Mitigation Measure BIO-1). Culture beds to be worked are visually surveyed to determine whether herring have spawned on eelgrass, culture materials, or substrate during December through March (e.g., herring spawning season in Humboldt Bay). If spawn is observed, CDFW will be notified and aquaculture activities will be postponed until all of the eggs have hatched.

5.8.3 Reduction in Prey Resources

Juvenile eulachon and larvae are pelagic, foraging on phytoplankton, copepod eggs, copepods, mysids, ostracods, and barnacle larvae (Gustafson et al. 2010, DFO 2014). Limited samples from adult eulachon suggest that their main prey is the euphausiid (*Thysanoessa spinifera*), along with other euphasiids, fish, and invertebrates (DFO 2014). Juvenile longfin smelt feed primarily on copepods during the first few months of their lives before shifting to mysids and other small crustaceans (CDFG 2009). Smelt are known to feed on prey species found in native eelgrass, and therefore any effects to eelgrass may affect smelt prey availability. Similarly, Pacific herring feed primarily on copepods and small crustaceans (CDFG 2008). The types of prey resources identified for forage fish are associated with both oyster aquaculture and eelgrass habitat (e.g., Castel et al 1989, Simenstad and Fresh 1995, Hosack 2003, Hosack et al 2006, Ferraro and Cole 2011, 2012). Changes to prey resources due to Project actions are unlikely to significantly change prey availability for eulachon, longfin smelt, or Pacific herring.

There is also an overlap of prey resources between forage fish and those typically consumed by shellfish (Kimmerer 2002). Based on the most recent carrying capacity analysis (*see* Appendix G to the DEIR), filtration pressure of cultured shellfish would be equivalent to approximately 5 to 9% of the carbon fixed by phytoplankton in North Bay. Additionally, modeling results indicate that the phytoplankton turnover rate is too fast to be significantly affected by current and proposed shellfish culture. Therefore, the potential impact in prey resources is considered less than significant under CEQA for these forage fish species.

5.8.4 Obstructions to Access or Migration Corridors

Four species of Osmeridae (or the smelt family) were collected by Pinnix et al. (2005) in both eelgrass habitat and oyster growing areas, including longfin smelt. Surf smelt was one of the most abundant species collected. Larval smelt was one of the dominant species in the otter trawl sampling in January 2003 to 2006 in a small eelgrass bed near the entrance to Humboldt Bay (Garwood et al. 2013). No eulachon were collected in either survey. Pinnix et al. (2005) also collected three species of Clupeidae (or the herring family) from oyster growing areas and eelgrass, including Pacific herring. The authors reported that Pacific herring was one of the dominant species during their surveys and the purse seine was especially effective at capturing schooling mid-water fishes such as herring. There is no evidence or rationale that oyster longlines or rack-and-bag structures would affect access or migration of eulachon (if present), longfin smelt, and Pacific herring. Presence or absence in specific areas is likely related to annual recruitment success. Therefore, this impact is considered less than significant under CEQA.

5.9 Potential Impacts to Groundfish

Groundfish include over 80 species from several different families of fishes which, with a few exceptions, live on or near the bottom of marine environments. Pacific Coast groundfish include species such as rockfish, flatfish, Pacific whiting (hake), sablefish, and lingcod (NMFS 2015b). Pinnix et al (2005) studied the fish communities in eelgrass, oyster culture, and mudflat habitats of North Bay from 2003 to 2005. English sole was the most abundant groundfish species caught during the study. Similarly, Garwood et al. (2013) surveyed the benthic community in Entrance Bay adjacent to and in eelgrass habitat from 1994 to 1995 and 2003 to 2006. The authors reported that black rockfish (*Sebastes melanops*) accounted for 22.5 percent of the total species collected. A complete list of groundfish species collected during these surveys is provided in Table 7.

Table 7 Groundfish Species Collected in Entrance Bay and North Bay

Common Name	Scientific Name	Guild	Location and Abundance		
			Entrance Bay*		North Bay
			1994-1995	2003-2006	2003-2005
Carcharhinidae (requiem sharks)					
Brown smoothhound	*Mustelus henlei*	Resident	NR	NR	4
Leopard shark	*Triakis semifasciata*	Resident	NR	NR	4
Myliobatididae (eagle and manta rays)					
Bat ray	*Myliobatis californica*	Resident	0	2	37
Scorpaenidae (scorpionfishes or rockfishes)					
Copper rockfish	*Sebastes caurinus*	Resident	228	785	24
Black rockfish	*S. melanops*	Resident	**5,532**	**3,036**	147
Grass rockfish	*S. rastrelliger*	Resident	45	2	2
Bocaccio rockfish	*S. paucispinis*	Occasional Visitor	0	8	1
Brown rockfish	*S. auriculatus*	Feeding	NR	NR	11
Hexagrammidae (greenlings)					
Kelp greenling	*Hexagrammos decagrammus*	Spawning	402	365	2
Rock greenling	*H. lagocephalus*	Occasional Visitor	0	4	NR
Lingcod	*Ophiodon elongates*	Feeding, Nursery	20	14	14
Cottidae (sculpin)					
Brown Irish lord	*Hemilepidotus spinosus*	Transient	51	33	NR
Red Irish lord	*H. hemilepidotus*	Occasional Visitor	4	33	NR
Buffalo sculpin	*Enophrys bison*	Resident	27	6	2
Cabezon	*Scorpaenichthys marmoratus*	Resident	530	351	12
Staghorn sculpin	*Leptocottus armatus*	Resident	55	24	243
Padded sculpin	*Artedius fenestralis*	Occasional Visitor	0	4	NR
Silverspotted sculpin	*Blepsias cirrhosis*	Occasional Visitor	6	0	NR
Paralichthyidae (large-tooth flounders)**					
Speckled sanddab	*Citharichthys stigmaeus*	Resident	1,830	410	2,568
California halibut	*Paralichthys californicus*	Occasional Visitor	NR	NR	2
Pleuronectidae (righteye flounders)					
C-O turbot	*Pleuronichthys coenosus*	Occasional Visitor	4	0	NR
Curlfin turbot	*P. decurrens*	Nursery	16	2	5
Sand sole	*Psettichthys melanostictus*	Occasional Visitor	16	2	NR
English sole	*Parohrys vetulus*	Nursery	177	90	**5,553**
Starry flounder	*Platichthys stellatus*	Resident	0	20	65

Sources: Pinnix et al. 2005, Garwood et al. 2013
**Numbers are based on a reverse calculation of relative abundance (total number/total of tows) in 204 otter tows. Original abundance data was not available.*
***Listed as Bothidae, but current family is Paralichthyidae (FishBase 2015).*
Bolded values = dominant species collected during the survey period.

Overfishing and accidental by-catch are the main threats to groundfish (NMFS 2015b). The Pacific Coast Groundfish Fishery Management Plan describes how the groundfish fishery is managed in association with Essential Fish Habitat (EFH) (PFMC 2014). The management plan identifies the non-fishing activities that have the potential to adversely affect the quantity or quality of habitat used by groundfish. These activities include dredging, disposal of dredged material, vessel operations, introduction of exotic species, pile installation and removal, overwater structures, and others. Most of these threats are not associated with shellfish aquaculture and are not discussed further. Four key ways in which potential Project impacts could affect groundfish are discussed below.

5.9.1 Human Disturbance

Juvenile rockfish and flatfish (at least more common species such as English sole) use intertidal mudflat and eelgrass habitats in North Bay (Pinnix et al. 2005). A total of two California halibut were collected in a combined total of six years of sampling effort (see Table 7), and surveys in Humboldt Bay have identified this species as an "occasional visitor." There would be overlap with habitats used by groundfish and the proposed shellfish aquaculture activities. Similar to other fish species discussed above, there is a potential to disturb groundfish during oyster aquaculture activities. However, the level of disturbance is considered less than significant under CEQA based on the frequency and duration of activities. When oyster plots are accessed when there is not surface water , fish would not be present in the area. Similarly, when the area is accessed when the plots are inundated, fish would be able to easily avoid locations where Coast employees are present. While there would be some energetic costs associated with avoiding culture activities, it is minimal. Therefore, the potential impact of human disturbance on groundfish species is considered less than significant under CEQA.

5.9.2 Habitat Degradation or Alteration

Eelgrass has been identified as a habitat area of particular concern for various species within the Pacific Coast Groundfish EFH (PFMC 2014). Groundfish use eelgrass habitat, especially the juvenile life stage, and aquaculture activities have the potential to affect eelgrass beds. In addition, as discussed in Section 4.2.2 above, alteration of unstructured habitat can also affect flatfish species that use this type of habitat for cover and ambush predation. There is no known specific information regarding the use of habitat based on the density of structure for groundfish species. There is general information associated with the fact that juvenile rockfish prefer structure and California halibut avoid structure, but there are otherwise no thresholds that will result in a change in behavior. Additionally, there is some conflicting information presented within the same timeframe and general locations within Humboldt Bay. Schlosser and Bloeser (2006) indicated that juvenile rockfish are associated primarily with mud habitat that contains drift algae or pilings, while Garwood et al. (2013) emphasized the importance of eelgrass habitat.

Data collected by Pinnix et al. (2005) in North Bay, which is the most relevant for the proposed Project, indicated that fish abundance and diversity (including juvenile rockfish and flatfish species) was higher in oyster culture areas and eelgrass habitat compared to open mudflats. Most groundfish species showed a seasonal peak in the habitats sampled, with June and August having the greatest amount of overlap in species presence. While California halibut may avoid structure, their presence is fairly rare in Humboldt Bay, especially in the shallow intertidal areas associated with oyster aquaculture.

The Project has the potential to reduce eelgrass density by 5 percent within the overall culture area. While eelgrass density would be reduced, it is not removed from the area and fish would be able to use the habitat in a manner similar to their current use of eelgrass beds. Based on work by Pinnix et al. (2005), there is no indication that groundfish species are restricted or substantially affected by the presence of oyster longlines. Therefore, the potential impact of habitat degradation or alteration is considered less than significant under CEQA.

5.9.3 Reduction in Prey Resources

A potential reduction in eelgrass density or changes to unstructured habitat also has the potential to alter prey resources for groundfish species, thus potentially affecting foraging opportunities. Planktonic and epifaunal crustaceans are important prey resources for juvenile rockfish in Humboldt Bay (Studebaker and Mulligan 2009). Structurally complex habitats (e.g., eelgrass) have been shown to enhance the abundance of these types of invertebrates (Bell et al.1984, Attrill et al. 2000, Jenkins et al. 2002), and impacts to eelgrass could adversely impact epifaunal invertebrates and thus impact the foraging ability of groundfish. However, several studies have shown that epifaunal invertebrate densities are similar between eelgrass beds and areas with oyster culture and both of these types of habitat have greater densities of epibenthic invertebrates and fish compared to open mudflats (Castel et al. 1989, Simenstad and Fresh 1995, Hosack 2003, Hosack et al. 2006, Ferraro and Cole 2011, 2012).

In addition, Simenstad and Fresh (1995) found that many potential disturbances from aquaculture activities were within the scale of natural variation experienced by smaller epibenthic crustaceans. The authors also indicated that large-scale disturbances (e.g., mechanical dredge harvesting) that result in the removal or major reduction of eelgrass may induce chronic shifts in the benthic community. As further described in the Eelgrass Technical Report (Appendix D of the DEIR), large-scale removal or reduction of eelgrass is not expected. Oyster harvesting in Humboldt Bay no longer uses mechanical dredge harvesting and the proposed expansion of oyster longlines would potentially reduce eelgrass density by approximately 5 percent in the culture area. Therefore, impacts to groundfish foraging habitat from the proposed Project are not expected.

5.9.4 Obstructions to Access or Migration Corridors

Groundfish would primarily use channels for migration or shallow mudflats when inundated. There is no evidence that oyster longlines would affect access or migration of groundfish species. As discussed in Section 4.2.2, changes to unstructured habitat are not necessarily negative for groundfish species. California halibut may be affected by changes to unstructured habitat and are occasional visitors to Humboldt Bay; however, they primarily use near channel habitat, which is a minor component of the Project (e.g., 0.4% overlap with North Bay near channel habitat in unstructured environments). Other flatfish (English sole) and juvenile rockfish can be a dominant species within oyster growing areas (Pinnix et al. 2005), and would not be excluded from aquaculture areas with gear present. Therefore, the potential impact of obstructions to access or migration corridors are considered less than significant under CEQA.

5.10 Potential Impacts to Marine Mammals

There are three main marine mammals that use Humboldt Bay: (1) California sea lions, (2) harbor seals, and (3) harbor porpoises. Only harbor seals reproduce in the bay, and the main pupping locations for harbor seals are in South Bay (Laughlin 1974). Incidental capture in fishing gear, ship strikes, oil spill exposure, chemical contaminants, power plant entrainments, and harassment by humans are the most common threats to marine mammals (NMFS 2015a). Most of these threats are not associated with shellfish aquaculture and are not discussed further. Four key ways in which potential Project impacts could affect marine mammals are discussed below.

5.10.1 Human Disturbance

Marine mammals produce and use sound (or vocalizations) for various biological functions, including social interactions, foraging, orientation, and predator detection. Interference with producing or receiving sounds could have adverse consequences on individuals or populations, including impaired foraging efficiency from masking, altered movement of prey, increased energetic expenditures, and temporary or permanent hearing threshold shifts due to chronic stress from noise (Southall et al. 2007). Marine mammals, like other mammals, can experience a masking effect from noise exposure. Masking occurs when environmental noise is loud enough to cover or mask other noises. Potential impacts from a sound source depend on: (1) sound frequency compared to the hearing frequency range of the animal, and (2) intensity and energy from the source that are received by an animal. Impacts range from masking to a behavioral response to physical injury.

Underwater noise produced by Coast work vessels could impact marine mammals if they are present in the vicinity. Skiffs, like those typically used by Coast, can produce underwater noise levels ranging from 157 to 169 dB_{PEAK} 3 ft from the motor (Kipple and Gabriele 2003). The threshold used by NMFS for behavior impacts to marine mammals is 120 dB_{RMS} (root mean squared). It is not possible to convert peak levels to RMS levels directly, but a conservative rule of thumb can be applied in noise assessments. Peak levels are generally 10 to 20 dB higher than RMS levels. Therefore, to convert from peak to RMS, subtract 10 dB. This likely overestimates the RMS value, but enables the assessment to remain as conservative as possible. Using the conservative conversion of peak to RMS and then using the spherical spreading loss formula to calculate the distance for the underwater noise created by the motor to attenuate to the behavior threshold of marine mammals, the maximum underwater noise generated by a skiff (169 dB_{PEAK}) will attenuate to the marine mammal behavior threshold (120 dB RMS for non-pulse noise) within 136 ft of the skiff.

This does not take into account the background underwater noise levels of Humboldt Bay, to which marine mammals are habituated. NMFS (2015c) suggested that the 120 dB_{RMS} threshold may be slightly adjusted if background noise levels are at or above this level. There are numerous contributing sources to background marine sound conditions. Sound levels produced by other sources not associated with the Project include recreational boating in the area. Background noise in North Bay was estimated to be between 164 and 182 dB_{PEAK} at 1-yard distance, based on recreational and commercial boat use in the area (Kipple and Gabriele 2003). Coast's boat trips would increase (approximately 18 additional/week), although the type of boat would not change. Additionally, Coast recently upgraded from 2-stroke to quieter 4-stroke engines in their boats. Thus, the use of Coast's boats at 157 to 169 dB_{PEAK} would be similar to the background noise conditions currently experienced from existing boat traffic.

Potential human disturbance also includes the potential to impact haul-out locations. Harbor seals and California sea lions haul out on land for rest, thermal regulation, social interaction, predator avoidance, and to give birth (NMFS 2015a). The closest pupping haul-out site is in South Bay, more than six miles away. Therefore, Coast's activities should have no impact on breeding or pupping activities at these haul-out sites. While there are closer non-pupping haul-out locations to the Project (Figure 15), only one haul-out location is near a culture area (Sand Island) and that area has been actively cultured for over 60 years with no indication that there are significant effects to harbor seal populations. Regardless, Coast will not undertake any activities that would be defined as take or harassment (as defined by the MMPA) of any marine mammals (Conservation Measure BIO-11). In addition, Coast will also employ Mitigation Measure BIO-2, which includes avoiding activities that would disturb marine mammals and staying more than 100 m from animals hauled out on Sand Island.

Multiple studies have looked at human disturbance of seals and have reported significant differences between passive recreational activities (e.g., kayaking) and motor boats in relation to haul-out locations. When an alarm signal is observed or danger is detected, the response by harbor seals is to flee the haul-out and enter the water. Allen et al. (1984) and Henry and Hammill (2001) both observed that harbor seals more often left haul-out sites when kayaks or canoes were present compared to vessels with motors. Henry and Hammill (2001) hypothesized that this was likely due to the fact that kayaks and canoes typically approach slowly, quietly, and low in the water (i.e., similar to a predator) compared to small boats that tended to be quicker and audible to the seals before visual contact is made.

While there are temporary haul-out locations, most of the major haul out locations do not overlap with the proposed oyster culture areas. Coast will not undertake any activities that would be defined as take or harassment (as defined by the MMPA) of any marine mammals. For example, as a Conservation Measure (BIO-11), Coast will not conduct any activity when a marine mammal is observed hauled out in or near a culture area ready for planting, scheduled maintenance, or harvesting until the mammal has left on its own and without provocation from Coast. In addition, marine mammals hauled out on Sand Island will be avoided using a 100 m buffer (Mitigation Measure BIO-2). Therefore, impacts to marine mammals at haul-out locations are considered less than significant under CEQA.

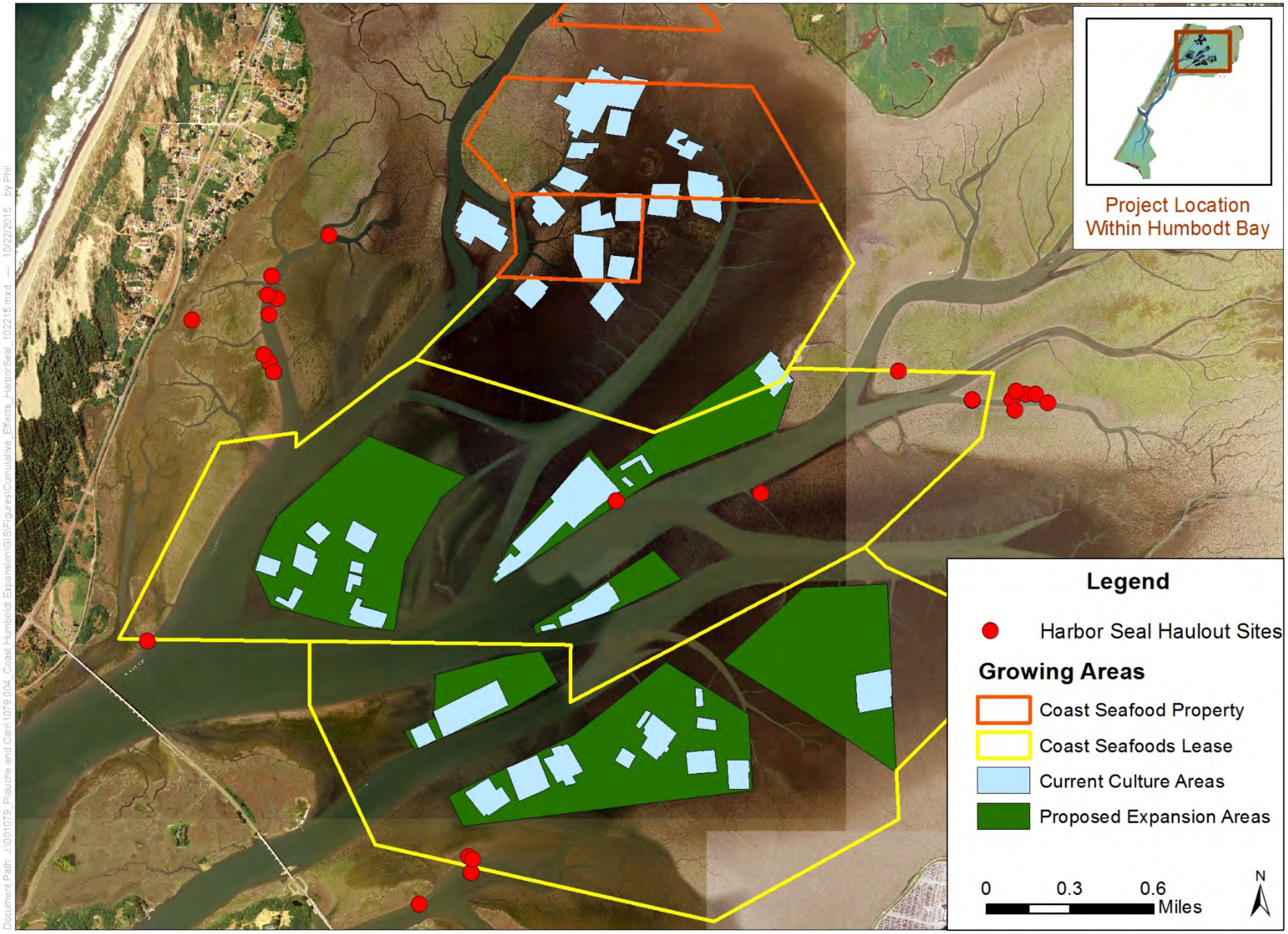

Figure 15 **Harbor Seal Haul-Out Locations in North Bay, Humboldt Bay, California**
Source: modified from CDFW data provided to Dale (pers. comm., 2015).
Note: Lease boundaries are approximate based on a review of the legal description and do not represent surveyed locations.

5.10.2 Habitat Degradation or Alteration

Marine mammals typically use the channels and haul-out locations adjacent to the channels. No activities that result in habitat degradation or alteration were identified that would impact these locations. Forrest et al. (2009) states that studies have found that small dolphin species are reluctant to swim through wooden structure or structure with rope. Harbor porpoises are small dolphins which may exhibit similar behavior as those studied in Forrest et al (2009). However, no structure is proposed in the channels where porpoises would likely be swimming. Therefore, the potential impact associated with habitat degradation or alteration is considered less than significant under CEQA.

5.10.3 Reduction in Prey Resources

Harbor seals, California sea lions, and harbor porpoises primarily feed on crustaceans, mollusks, squid, and fish (NMFS 2015a; WDFW 2005) in open water. These marine mammals will also alter their foraging behavior in response to seasonal prey pulses. For example, pinnipeds are known to take advantage of Pacific herring spawning aggregations (Hourston and Haegele 1980, Lassuy 1989, Willson and Womble 2006, Therriault et al. 2009). Aquaculture activities that occur when there is not surface water would not impact foraging behavior of marine mammals because marine mammals forage in open water. Activities that occur when the site is inundated, such as when the longline harvester is being used, would avoid areas with marine mammals and so would also not affect foraging behaviors. As described above, there are no expected significant impacts to invertebrates or fish, and so a reduction in prey resources for marine mammals is not expected as a result of Project activities. Therefore, the potential impacts associated with a reduction in prey resources is considered less than significant under CEQA.

5.10.4 Obstructions to Access or Migration Corridors

Coast will implement Conservation Measure (BIO-11) and will not undertake any activity that would be defined as take or harassment (as defined by the MMPA) of any marine mammals. If a marine mammal is observed foraging in or near a culture area ready for planting, scheduled maintenance, or harvesting, no activity would occur in the area until the mammal has left on its own and without provocation from Coast. Therefore, impacts to marine mammals using the channels or shallow mudflats for access or migration from Coast operations are less than significant under CEQA.

6.0 CUMULATIVE IMPACTS

There are five companies farming shellfish in North Bay, and Coast is the largest of these companies currently operating in the bay. As of 2015, there were approximately 91 raft type structures in subtidal areas (including 35 managed by Coast and 21 recently approved for Hog Island Oyster Company and Taylor Mariculture) and 314 acres of intertidal areas cultured (299 acres managed by Coast). Historically, Coast farmed on as many as 1,000 intertidal acres using a variety of bottom culture methods (Figure 16). Approximately 95 percent of Coast's existing culture is in eelgrass, and the majority (87%) is considered patchy eelgrass. It is important to note that culture areas were originally planted adjacent to eelgrass and were colonized by eelgrass after shellfish structures were added (Dale, pers. comm., 2015). Eelgrass expansion has occurred and continues to occur in areas of Humboldt Bay where Coast began the conversion from ground culture starting in 1997.

In addition to the proposed Project and existing culture, the Humboldt Bay Harbor, Recreation, and Conservation District ("Harbor District") is proposing a Humboldt Bay Mariculture Pre-Permitting Project (Pre-Permitting Project) for new shellfish aquaculture. The Pre-Permitting Project would increase production of Kumamoto oysters, Pacific oysters, and Manila clams. It may also include culture of native macroalgae. Culture operations would include approximately 3.1 acres of subtidal habitat and 266 acres of intertidal culture. The 266 acres of intertidal culture would overlap with approximately 109.6 acres of non-eelgrass habitat, 149.3 acres of patchy eelgrass, and 7.3 acres of continuous eelgrass. The effects of the Pre-Permitting Project are considered in Section 7.0 of the DEIR.

The cumulative amount of potential spatial overlap with habitat in North Bay from existing culture, the Project, and the Pre-Permitting Project is equivalent to approximately 27 percent of eelgrass in North Bay, 13 percent of near channel habitat in North Bay, and 14 percent of the intertidal habitat in North Bay overall (Figure 17; Table 8). As with the discussion associated with the Project, it is important to understand that overlap is not a quantification of impact because impacts occur in discrete areas of culture areas. In addition, species do not use types of habitat to the same degree. Examples of how the addition of culture in North Bay would affect the species discussed above is provided.

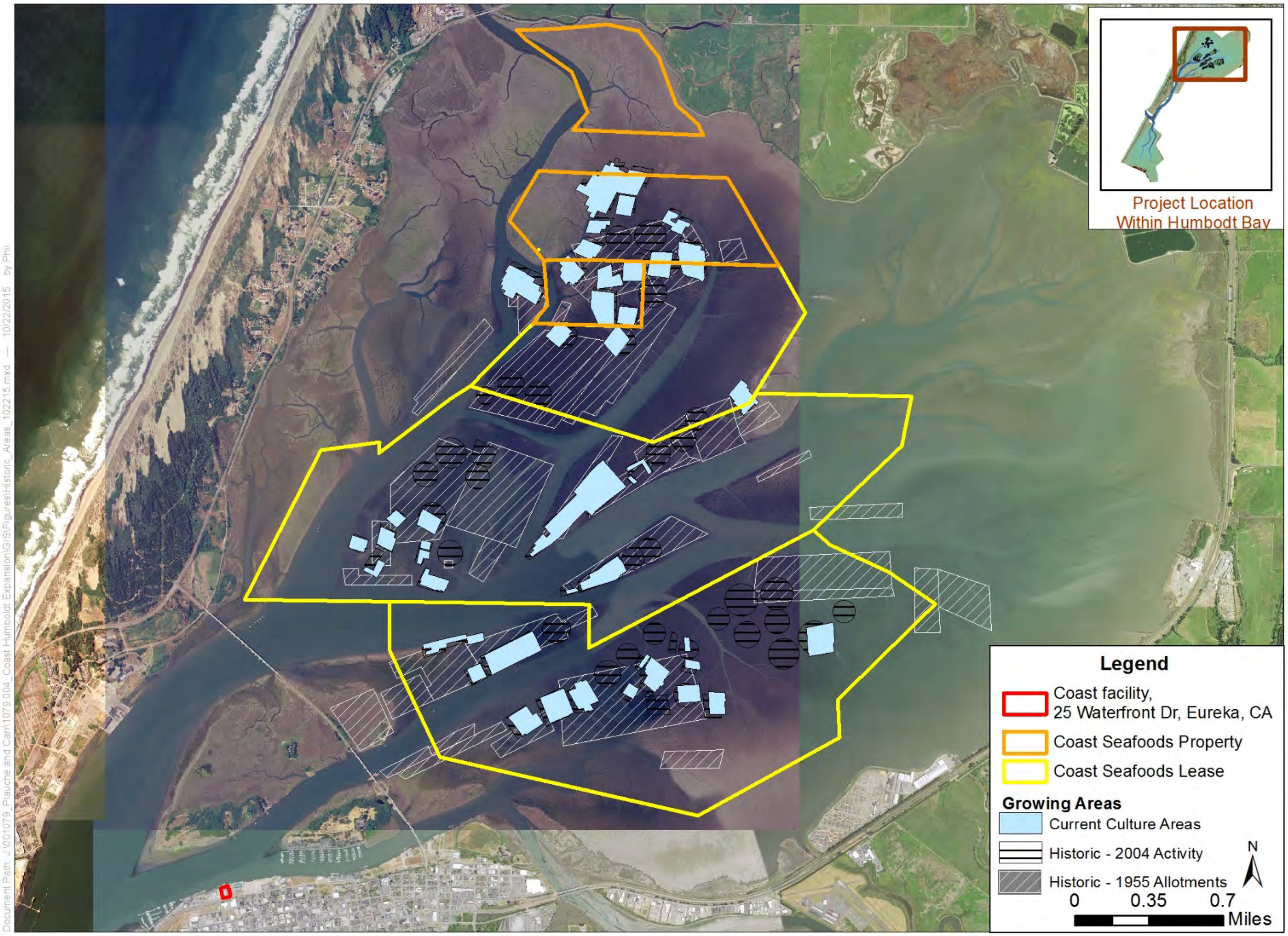

Figure 16 Current and Historic Cultivation Areas associated with the Coast Seafoods Lease Area.
Source: modified CDFW data (Dale, pers. comm., 2015).
Note: Lease boundaries are approximate based on a review of the legal description and do not represent surveyed locations.

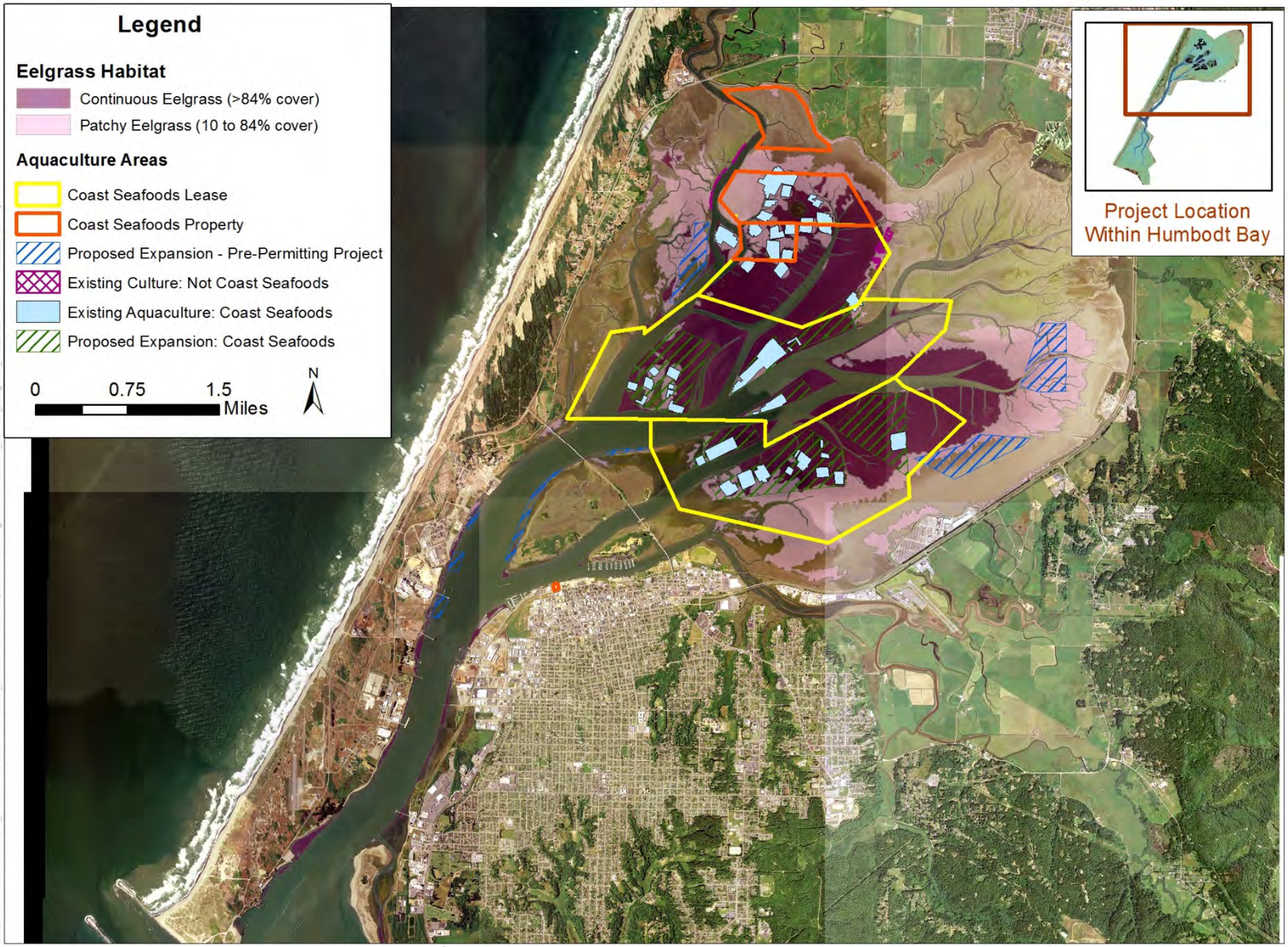

Figure 17 Existing and Proposed Shellfish Aquaculture in Humboldt Bay.

Source: GIS layers provided by Wagschal, pers. comm., 2015.

Note: Lease boundaries are approximate based on a review of the legal description and do not represent surveyed locations.

Table 8 Spatial Overlap of Existing and Proposed Expansion Projects with Habitats in North Bay

Area	Subtidal Channel Habitat	Near Channel Habitat			Intertidal Habitat		
		Non Eelgrass	Patchy Eelgrass	Continuous Eelgrass	Non Eelgrass	Patchy Eelgrass	Continuous Eelgrass
Existing Culture							
North Bay (acre)	2,110	1,736	657	1,134	3,035	1,301	827
Culture Area (acre)	3.5	14*	93	15	9	173	12
Area of Influence (%)	0.2%	0.8%	14.1%	1.3%	0.3%	13.3%	1.4%
All Proposed Expansion Areas							
North Bay (acre)	2,110	1,736	657	1,134	3,035	1,301	827
Culture Area (acre)	3**	34	81	210	91	177	290
Area of Influence (%)	0.1%	1.9%	12.3%	18.5%	3.0%	13.6%	35.1%

Sources: NOAA 2012; Wagschal, pers. comm., 2015 (GIS layers for Pre-permitting Project)
**Area calculations include 5.5 acres that will be removed.*
***Although intertidal expansion areas for Coast include approximately 6.5 acres of subtidal channel habitat, no culture would be planted in subtidal channels, including a 10-ft buffer; therefore, that value was taken out of this calculation and only actual overlap with subtidal channel habitat (e.g., floating culture) was included.*

The cumulative amount of potential human presence would also increase with the various shellfish aquaculture projects. A maximum of 18 additional boat trips/week are expected throughout the bay in order to maintain the Project, increasing the number of boat hours necessary to maintain the beds and conduct harvest and planting activities by 74 hours per week. It is likely that the same culture methods used in either the Project or the Pre-Permitting Project will require a similar number and frequency of site visits for operation, maintenance, planting, and harvesting, although the Pre-Permitting Project allows culturalists flexibility in determining what culture method to pursue, making accurate predictions of boat traffic difficult. However, because the District's project is smaller in spatial scale to Coast's expansion project, fewer boat trips will likely be needed on a daily and weekly basis.

Overall, the cumulative effects of biological resources are identified and described by H.T. Harvey and Associates (2015) for existing and proposed mariculture activities in Humboldt Bay. The Pre-Permitting DEIR came to the same conclusions for biological resources as discussed above for aquatic habitat, green sturgeon, salmonids, Pacific herring, groundfish, and marine mammals. These conclusions were reached without the need for mitigation. Given the spatial separation, low frequency of activities (within 1 acre or even 10 acre areas), and low impact of activities, the cumulative effect to Humboldt Bay biological resources is considered to be less than significant under CEQA.

7.0 DETERMINATION OF SIGNIFICANCE

Estuaries are important nursery and feeding areas for many species. Use of these habitats may be controlled by habitat structure, which influences the supply of food and abundance of predators. An individual habitat type rarely captures all life stages for the species found there, which emphasizes the importance of connectivity and movement between habitats (Sheaves 2009). Heck et al. (2003) conducted a meta-analysis of more than 200 papers that compared seagrass beds to other habitats, and examined the data using the attributes suggested by Beck et al. (2001) for defining the ecological processes operating in nursery habitats, including: density, growth, survival, and migration to adult habitat. The results indicated that few significant differences existed between the relevant attributes when seagrass meadows were compared to other structured habitats, such as oyster reefs, cobble reefs, or macroalgal beds. The most important determinant of nursery value was the presence of structure rather than the type of structure.

7.1 Habitat

Changes to unstructured habitat, eelgrass habitat, sediment distribution and tidal circulation, water quality, and sediment quality were all considered to be less than significant under CEQA based on an analysis of the proposed Project and existing literature related to off-bottom oyster aquaculture. While there will be changes, these changes are not likely to significantly change habitat use or the stablility of the system in terms of the species that it supports.

7.2 Special-Status Species

Impacts to the species that depend on the habitat associated with the Project were also determined to be less than significant under CEQA. A summary of the determination of significance for each species group is provided in Table 9 below.

7.3 Level of Significance Before Mitigation

Compliance with the Conservation Measures (Table 5 above) identified above would reduce potential impacts associated with potential impacts to biological resources except for Pacific herring spawning and marine mammals interactions. These last two are potentially significant without mitigation, but all other potential impacts to biological resources are less than significant without mitigation.

7.4 Mitigation Measures

Mitigation Measure BIO-1 is intended to reduce impacts to Pacific herring.

Mitigation Measure BIO-1: During the months of December through March, Coast will visually survey those beds to be worked on each day to determine whether herring have spawned on eelgrass, culture materials, or substrate. If herring spawn is observed, Coast will: (1) notify the CDFW's Eureka Marine Region office within 24 hours, and (2) postpone activities on those beds until all eggs have hatched.

Mitigation Measure BIO-2 is intended to reduce impacts to marine mammals.

Mitigation Measure BIO-2: No activity involving human disturbance will occur within 100 m of the area of Sand Island that is above mean higher high water to avoid the harbor seal haul-out location and nesting birds on Sand Island.

7.5 Level of Significance After Mitigation

Upon incorporation of the above mitigation measures, the Project will have no significant and unavoidable impacts to biological resources.

Table 9 Determination of Significance for Special Status and Commercially Important Animal Species Potentially Affected by the Project

Species	Habitat Overlap	Frequency of Disturbance	Conservation and Mitigation Measures	Justification	Determination of Significance
Invertebrates					
Dungeness crab	▪ 4.4% channel and near channel habitat	▪ Planting Harvest: maximum of 12 days per acre every 4 months ▪ Maintenance: 0.4 hours per acre every month	▪ 5 ft longline spacing (Cons. Meas. BIO-2) ▪ Monthly inspection to maintain gear (Cons. Meas. BIO-4) ▪ New shellfish culture not planted within 10 ft of a subtidal channel (Cons. Meas. BIO-10)	▪ No indication that aquaculture activities would result in significant disturbance to crabs as long as gear is well maintained and does not pose an entanglement threat. ▪ Reduction in eelgrass density directly under the longlines would not result in significant habitat degradation. ▪ Aquaculture gear provides similar prey resources for crabs as currently available in Humboldt Bay. ▪ Crabs would easily migrate through the area with aquaculture gear positioned above the bottom.	Less than Significant
Sturgeons					
Green and white sturgeon	▪ 4.4% channel and near channel habitat	▪ Planting Harvest: maximum of 12 days per acre every 4 months ▪ Maintenance: 0.4 hours per acre every month ▪ Transit channels: 18 trips/week	▪ New shellfish culture not planted within 10 ft of a subtidal channel (Cons. Meas. BIO-2) ▪ 5 ft longline spacing (Cons. Meas. BIO-10)	▪ Green sturgeon are primarily located in the major channels and not on the tideflats, especially when work is being conducted. When present in areas where humans are present, it is easy to avoid sturgeon based on visual observations. ▪ Changes to unstructured habitat are minor in comparison to available habitat for foraging, especially considering the mudflats north of Arcata Channel that are likely frequented by sturgeon. ▪ One of the potential hot-spots for foraging (Sand Island) has been cultured for the last 60 years with no indication of impacts to sturgeon. ▪ Longlines spaced 5 ft apart and rack-and-bag structures with 5 ft spaces between groups of 3 racks would allow sufficient space for fish to maneuver.	Less than Significant

Salmonids					
Coho salmon, steelhead, Chinook salmon, and coastal cutthroat	▪ 4.4% channel and near channel habitat	▪ Planting Harvest: maximum of 12 days per acre every 4 months ▪ Maintenance: 0.4 hours per acre every month Transit channels: 18 trips/week	▪ New shellfish culture not planted within 10 ft of a subtidal channel (Cons. Meas. BIO-10) ▪ 5 ft longline spacing (Cons. Meas. BIO-2)	▪ If present, salmonids would avoid areas where work is being conducted, which would not result in a signicant cost in terms of energetics. ▪ Potential reduction in eelgrass density (5%) or changes to unstructured habitat would not significantly reduce habitat used by salmonids. ▪ Aquaculture gear can provide prey resources commonly associated with juvenile salmonids. ▪ Salmonids would easily migrate through the area with aquaculture gear positioned above the bottom. The addition of overwater structure is not a significant change to subtidal habitat.	Less than Significant
Forage Fish					
Eulachon and longfin smelt	▪ 5.8% all habitat types	▪ Planting Harvest: maximum of 12 days per acre every 4 months ▪ Maintenance: 0.4 hours per acre every month	▪ None proposed.	▪ If present, eulachon and longfin smelt would avoid areas where work is being conducted, which would not result in a signicant cost in terms of energetics. ▪ Potential reduction in eelgrass density (5%) or changes to unstructured habitat would not significantly reduce habitat used by eulachon and longfin smelt. ▪ Aquaculture gear can provide similar prey resources as used by eulachon and longfin smelt. Carrying capacity analysis does not indicate that phytoplankton populations would be significantly reduced. ▪ Eulachon and longfin smelt would easily migrate through the area with longlines positioned above the bottom.	Less than Significant
Pacific herring*	▪ 10.1% of channel and eelgrass habitat	▪ Planting Harvest: maximum of 12 days per acre every 4 months ▪ Maintenance: 0.4 hours per acre every month Transit channels: 18 trips/week	▪ Visually survey beds to be worked for herring spawn. If present: (1) postpone activities until eggs hatch, and (2) notify the CDFW within 24 hours (Mit. Meas. BIO-1).	▪ Pre-spawning areas would not be disturbed aside from general vessel traffic, which is part of the environmental baseline. ▪ Herring use approximately 10% of the available habitat to spawn, and Mitigation Measure BIO-1 would provide mitigation for spawn that occurs in or near aquaculture plots. ▪ Aquaculture gear can provide similar prey resources as used by herring. Carrying capacity analysis does not indicate that phytoplankton populations would be significantly reduced.	Less than Significant

				▪ Herring would easily migrate through the area with longlines positioned above the bottom.	
Groundfish					
Rockfish	▪ 4.4% of channel and near channel habitat	▪ Planting Harvest: maximum of 12 days per acre every 4 months ▪ Maintenance: 0.4 hours per acre every month	▪ None proposed.	▪ If present, groundfish would avoid areas where work is being conducted, which would not result in a signicant cost in terms of energetics. ▪ Reduction in eelgrass density directly under the longlines would not result in significant habitat degradation. ▪ Aquaculture gear can provide similar prey resources as used by rockfish. Smaller fish and juvenile life stages may benefit from an increase in meiofauna under the gear. ▪ Rockfish would easily migrate through the area with longlines positioned above the bottom.	Less than Significant
California halibut	▪ 0.4% of near channel non-eelgrass habitat	▪ Planting Harvest: maximum of 12 days per acre every 4 months ▪ Maintenance: 0.4 hours per acre every month Transit channels: 18 trips/week	▪ None proposed.	▪ If present, California halibut would avoid areas where work is being conducted, which would not result in a signicant cost in terms of energetics. ▪ Change in unstructured habitat is a small fraction of the available habitat and flatfish are a common group of species in oyster culture areas. ▪ California halibut are not likely foraging on aquaculture gear, although smaller flatfish and juvenile life stages may benefit from an increase in meiofauna under the gear. ▪ California halibut likely avoid the structured habitat such as aquaculture gear. The amount of habitat affected is a small portion of the habitat used for migration.	Less than Significant
Marine Mammals					
California sea lion, harbor seal, and harbor porpoise	▪ 4.4% of channel and near channel habitat	▪ Planting Harvest: maximum of 12 days per acre every 4 months ▪ Maintenance: 0.4 hours per acre every month Transit channels: 18 trips/week	▪ No take or harassment (as defined by the MMPA) of any marine mammal will be allowed (Cons. Meas. BIO-11). ▪ No activity will occur within 100 m of the area of Sand Island that is above the MHHW to avoid the harbor seal haul-out location (Mit. Meas. BIO-2).	▪ Avoidance would limit potential interactions with marine mammals. ▪ No indication that aquaculture activities would result in significant habitat degradation, especially in channels or haul-out areas. ▪ Because less than significant impacts were identified for fish and crabs, potential impacts to prey resources for marine mammals are also less than significant. ▪ Longlines spaced 5 ft apart and rack-and-bag structures with 5 ft spaces between groups of 3 racks would allow sufficient space for marine mammals to maneuver.	Less than Significant

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Appendix A: Non-Indigenous Marine Species of Humboldt Bay, California

Group (Phylum/Group)	Scientific Name	Location[1]				
		Sloughs/Marshes	Pilings/Marinas	Oyster Growing	Subtidal Channels	Klopp Lake/Muddy Intertidal
Algae						
Brown seaweed (Heterokontophyta)	*Sargassum muticum*	✓	✓	✓		
Red seaweed (Rhodophyta)	*Chondracanthus teedii*		✓	✓		
	Lomentaria hakodatensis		✓	✓		✓
Vascular Plants						
Perennial grass (Monocot)	*Spartina densiflora*	✓				
Perennial herb (Eudicot)	*Cotula coronopifolia*	✓				
Japanese eelgrass (Monocot)	*Zostera japonica* [2]	✓				✓
Invertebrates						
Sponges (Porifera)	*Cliona* sp.	✓	✓	✓		
	Halichondria bowerbanchia	✓	✓			
	Microciona prolifera	✓	✓			
Jellyfish (Cnidaria)	*Aurelia aurita*				✓	
Anemone (Cnidaria)	*Diadumene leucolena*		✓			
	Diadumene lineata		✓	✓		
	Nematostella vectensis	✓				
Hydroid (Cnidaria)	*Obelia dichotoma*		✓			
Polychaetes (Annelida)	*Autolytus cornutus*		✓		✓	
	Boccardiella hamata	✓				✓
	Dipolydora socialis	✓	✓		✓	
	Dodecaceria concharum				✓	
	Euchone limnicola				✓	
	Exogone lourei	✓	✓		✓	✓
	Fabricia sabella	✓				
	Glycera Americana				✓	
	Harmothoe imbricate	✓	✓			
	Heteromastus filiformis	✓				
	Heteropodarke heteromorpha				✓	
	Marphysa sanguinea	✓				
	Myxicola infundibulum	✓	✓			
	Nereis pelagica		✓			
	Pholoe minuta					✓
	Polydora cornuta		✓			✓
	P. limicola				✓	
	Pseudopolydora kempi				✓	✓
	P. paucibranchiata	✓			✓	✓
	Pygospio elegans					✓
	Sabellaria gracilis		✓		✓	
	Serpula vermicularis				✓	

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		Sloughs/Marshes	Pilings/ Marinas	Oyster Growing	Subtidal Channels	Klopp Lake/Muddy Intertidal
	Spiophanes bombyx				✓	
	S. wigleyi				✓	
	Steblospio benedicti	✓			✓	✓
	Typosyllis hyalina		✓		✓	✓
Snails and Limpets (Mollusca)	*Crepidula* sp.			✓		✓
	Ovatella myosotis	✓				
	Urosalpinx cinerea					✓
Sea Slugs (Mollusca)	*Alderia modesta*	✓				
	Dendronotus frondosus	✓	✓			
Bivalves (Mollusca)	*Crossostrea gigas*	✓		✓		
	Gemma gemma	✓			✓	✓
	Laternula marilina	✓				✓
	Macoma balthica					✓
	Mya arenaria	✓			✓	✓
	Venerupis phillippinarum	✓				✓
Copepods (Crustacea)	*Mytilicola orientalis* [3]	✓		✓		
Isopods (Crustacea)	*Iais californica*	✓				✓
	Limnoria lignorum		✓			
	L. quadripunctata		✓			
	Sphaeroma quoyanum	✓				✓
Tanaids (Crustacea)	*Leptochelia savignyi*	✓	✓		✓	
	Sinelobus standfordi	✓				✓
Leptostracans (Crustacea)	*Nebalia pugettensis*					✓
Amphipods (Crustacea)	*Ampithoe valida*	✓	✓			✓
	Caprella equilibra		✓			
	C. mutica	✓				
	Chelura terebrans [4]					✓
	Chaetocorophium lucasi	✓				✓
	Corophium sp.[5]	✓	✓	✓	✓	✓
	Grandidierella japonica	✓	✓	✓	✓	✓
	Hyale plumulosa		✓		✓	
	Incisocalliope nipponensis				✓	
	Jassa slatteryi	✓	✓		✓	✓
	Melita nitida					✓
	Microdeutopus gryllotalpa	✓		✓		✓
	Microjassa litotes					
	Paracorophium sp.	✓			✓	✓
	Podocerus cristatus		✓		✓	
	Photis pachydactyla	✓			✓	✓
	Stenothoe valida		✓			
Crabs (Crustacea)	*Carcinus meanas*	✓				✓

Appendix A: Non-Indigenous Marine Species of Humboldt Bay, California

Group (Phylum/Group)	Scientific Name	Location[1]				
		Sloughs/Marshes	Pilings/Marinas	Oyster Growing	Subtidal Channels	Klopp Lake/Muddy Intertidal
Bryozoans (Bryozoa)	*Alcyonidium polyoum*		✓		✓	
	Bowerbankia gracilis		✓		✓	
	Sertularia neritina		✓			
	Celleporella hyaline		✓		✓	
	Conopeum sp.		✓			
	Cryptosula pallasiana		✓	✓	✓	
	Schizoporella unicornis		✓	✓		
	Watersipora subtorquata		✓			
Entoprocts (Entoprocta)	*Barentsia benedeni*				✓	
Tunicates (Chordata)	*Botrylloides* sp.		✓	✓		
	Ciona intestinalis		✓			
	Mogula manhattensis		✓			
	Styela clava		✓			
Fish						
Mosquitofish (Chordata)	*Gambusia affinis*	✓				

Source: Boyd et al. 2002

[1] *Took out rocky intertidal habitats from the list, but they are mentioned in Boyd et la. 2002*

[2] *not found during the 2000-2001 census, but reported from Schlosser and Eicher (2007)*

[3] *found in* Mytilus trossulus *and* Crassostrea gigas

[4] *found in wood on mudflat*

[5] *six species of* Corophium *identified, and three are introduced (* C. acherisicum, C. insidiosum, *and* C. uenoi*).* Corophium acherisicum *was the most abundant in a variety of habitats*