Appendix D:

Eelgrass Technical Report

Native Eelgrass (*Zostera marina*) Impact Analysis for Coast Seafoods Company, Humboldt Bay Shellfish Aquaculture: Permit Renewal and Expansion Project

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NATIVE EELGRASS (*ZOSTERA MARINA*) IMPACT ANALYSIS FOR COAST SEAFOODS COMPANY, HUMBOLDT BAY SHELLFISH AQUACULTURE: PERMIT RENEWAL AND EXPANSION PROJECT

1.0 SUMMARY

This eelgrass technical report discusses the effects of Coast Seafoods Company's (Coast), Humboldt Bay Shellfish Aquaculture: Permit Renewal and Expansion Project (Project) on eelgrass habitat in Humboldt Bay and the potential changes to ecological function associated with the proposed expansion. The information in this eelgrass impact analysis will be summarized in the Draft Environmental Impact Report (DEIR) for the Project. The information includes:

- **Project Description** – background information, Project characteristics, Project siting, Project Alternatives, and culture methods.
- **Existing Conditions** – distribution and abundance of eelgrass, limitations to eelgrass growth, natural variability of eelgrass habitat, eelgrass at carrying capacity, and other habitat types.
- **Definition of Significance** –threshold of significance.
- **Impact Analysis of the Proposed Project** –conservation measures, assumptions used in the analysis, potential direct and indirect impacts, resilience of the system, and duration of impacts.
- **Cumulative Impacts** – cumulative impacts of like activities in Humboldt Bay.
- **Alternatives** – description of Project Alternatives and summary of potential eelgrass impacts by Alternative.
- **Mitigation Measures** – watershed approach, mitigation options, and mitigation accounting.
- **Determination of Significance** – whether the Project exceeds the established threshold of significance for impacts to eelgrass habitat function.

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 4,300 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 (504 acres in eelgrass) of cultch-on-longline culture methods and a maximum of 100 acres (96 acres in eelgrass) 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 which 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.

The major controlling factors for eelgrass in Humboldt Bay include: (1) light, (2) temperature, (3) energy, and (4) nutrients. As a result, eelgrass areal extent and shoot density in Humboldt Bay show a significant amount of natural variability. However, it also appears that eelgrass is occupying most, if not all, available suitable habitat and may be at, or near, carrying capacity. While eelgrass is an important and dominant habitat in Humboldt Bay, there are also large amounts of coastal marsh, macroalgae, and subtidal habitats in the bay. While quantities of individual habitats can be characterized, it is important to take into account the value of a habitat mosaic on species diversity in the context of major changes and ecological stability of habitat structure.

At the present scale within Humboldt Bay and other Pacific Northwest estuaries, shellfish aquaculture is sustainable, especially when compared to other human activities (e.g., marine infrastructure, coastal development, and urban and rural pollution), which can degrade and eliminate estuarine function (Dumbauld et al. 2009, Coen et al. 2011). For example, shellfish growers have continuously championed efforts to improve water quality because their product depends on ensuring that high water quality, and filtration provides improvements to water quality through the sequestration of nutrients (albeit a small benefit compared to nutrient input). Management decisions for the regulation of shellfish aquaculture need to, therefore, consider the full suite of impacts and benefits to eelgrass habitat function from shellfish aquaculture in Humboldt Bay. In addition, the functional value of a mosaic of habitats, including shellfish beds with edges and corridors, must be considered at the landscape scale in terms of the influence on ecological function. According to Coen et al. (2011), this concept of a habitat mosaic "may be an area where innovative practices and best management practices (BMPs) developed by growers in association with scientists can be applied to conserve and even enhance the functional value" of estuarine habitats.

The threshold of significance for impacts to eelgrass habitat was defined as Project effects that result in a change in areal extent of eelgrass or a greater than 25 percent change in eelgrass density. This threshold is based on metrics discussed in the California Eelgrass Mitigation Policy (CEMP), Fonseca et al.'s (1998) discussion of functional equivalency, and management documents (e.g., HBWAC and RCAA 2005, Schlosser et al. 2009).

Potential impacts to eelgrass or potential changes to habitat that eelgrass supports are discussed under Section 5.0, Impact Analysis of the Proposed Project, including: (1) gear and shellfish products, (2) working practices, (3) fragmentation, (4) floating eelgrass rafts and wrack, and (5) 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 directly under the longlines, the projected loss in eelgrass turion density is not anticipated to exceed the thresholds identified above. This effect incorporates impacts such as shading from gear and shellfish products (e.g., cultch, baskets, floats), mechanical abrasion, and desiccation of eelgrass blades. Finally, the analysis of potential impacts was based on empirical observations of loss directly under the longlines and between the lines, which inherently incorporate other working practices such as trampling.

The eelgrass impact analysis incorporates two key sets of observations by Rumrill (2015) and SHN Engineers and Geologists (SHN 2015) associated with existing culture operations in Humboldt Bay. According to Rumrill (2015), "eelgrass beds and commercial oyster cultivation can coexist in Humboldt Bay, and that implementation of best management practices that include reduced density of oysters (i.e., oyster culture at 5 ft and 10 ft spacing between the longlines) may aid in the conservation of eelgrass communities." The proposed Project expansion, including Alternatives, are consistent with Dr. Rumrill's recommendation that longlines be spaced at 5 ft or 10 ft intervals. While changes to the existing culture are not proposed, the current 2.5 ft spaced longlines do not exclude eelgrass. More importantly, existing culture is part of the current baseline, is occurring within areas that have been farmed since the 1950s, and was originally placed in areas that contained either no eelgrass or patchy eelgrass. While the existing culture operations are part of the environmental baseline under the California Environmental Quality Act (CEQA), they nevertheless do not exceed the threshold of significance established for this Project.

The concepts of ecological resiliency and duration of impacts are meaningful metrics when considering the changes associated with Coast's existing culture operations. Holling (1973) defined resilience as "a measure of the ability of these systems to absorb change of state variables, driving variables, and parameters, and still persist." One of the most important factors to consider when thinking about resiliency is that shellfish aquaculture does not result in permanent change. Culture methods can be altered and timing of activities can be modified. This was seen during the major change in BMPs from 1997 to 2006, when culture methods went from ground culture with mechanical dredge harvesting to off-bottom longline culture. This was followed by eelgrass recovery in most former dredge harvest areas within 2 to 4 years. While some areas still show scars from the previous dredge harvesting operations, all of the areas currently have eelgrass. Overall, if the scale of proposed aquaculture: (1) does not affect factors that are limiting eelgrass in Humboldt Bay (e.g., light, temperature, energy, nutrients), (2) does not result in impacts that are above the natural variability of the resource, and (3) does not significantly impact use of the landscape, then the Project can be considered within the resilience of the system. Based on available data, current shellfish aquaculture operations are within the resilience of Humboldt Bay eelgrass.

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 or 10 ft spacing. Eelgrass density reduction was 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 bed surrounding the culture plot). Neither of these results exceed the threshold of significance established for this Project. Despite this conclusion, Coast is proposing habitat improvements to ensure that the Project has an overall beneficial ecological impact in Humboldt Bay (as discussed in Section 8.0).

Using a watershed approach (e.g., Schlosser et al. 2009), the Project proposes to do a combination of in-kind mitigation (e.g., Buoy-Deployed Seeding System) and one of three out-of-kind coastal salt marsh restoration projects (e.g., Parcel 4 Restoration, Elk River Estuary Enhancement, Hoff Parcels). Special consideration was afforded salt marsh both due to its decline from historical levels and because few coastal salt marsh sites in Humboldt Bay have the potential to migrate or adjust in response to potential sea level rise (e.g., Shaughnessy et al. 2012). Finally, a mitigation accounting system was developed for Coast that draws from existing mitigation frameworks to describe an effective method for characterizing impacts (debits) and mitigation (credits) that will help to identify the adequacy of proposed mitigation to compensate for changes from the Project. This framework provides an effective analytical tool to evaluate the Project's impact to eelgrass habitat and habitat gained through the selected mitigation options, which can support an adaptive management component of the Project.

In summary, the proposed Project will meet the goals established by the CEMP to adhere to a no net loss of ecological function. The potential impacts from placing longline aquaculture in eelgrass habitat do not exceed the CEQA threshold of significance either individually or cumulatively. Coast has proposed to provide compensatory mitigation for potential loss of eelgrass regardless of whether there is a change to ecological functions, which means that the short-term impacts associated with shellfish aquaculture can be outweighed by the long-term net benefits provided by shellfish and the proposed mitigation associated with the Project. Therefore, potential impacts will be fully mitigated and net ecological functions of the Humboldt Bay watershed will be improved because of these efforts.

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 (e.g., cultch-on-longline and basket-on-longline) to cultivate Pacific and Kumamoto oysters[1] (Figure 1). The cultivated footprint has not changed since its 2006 approvals.

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:

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

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

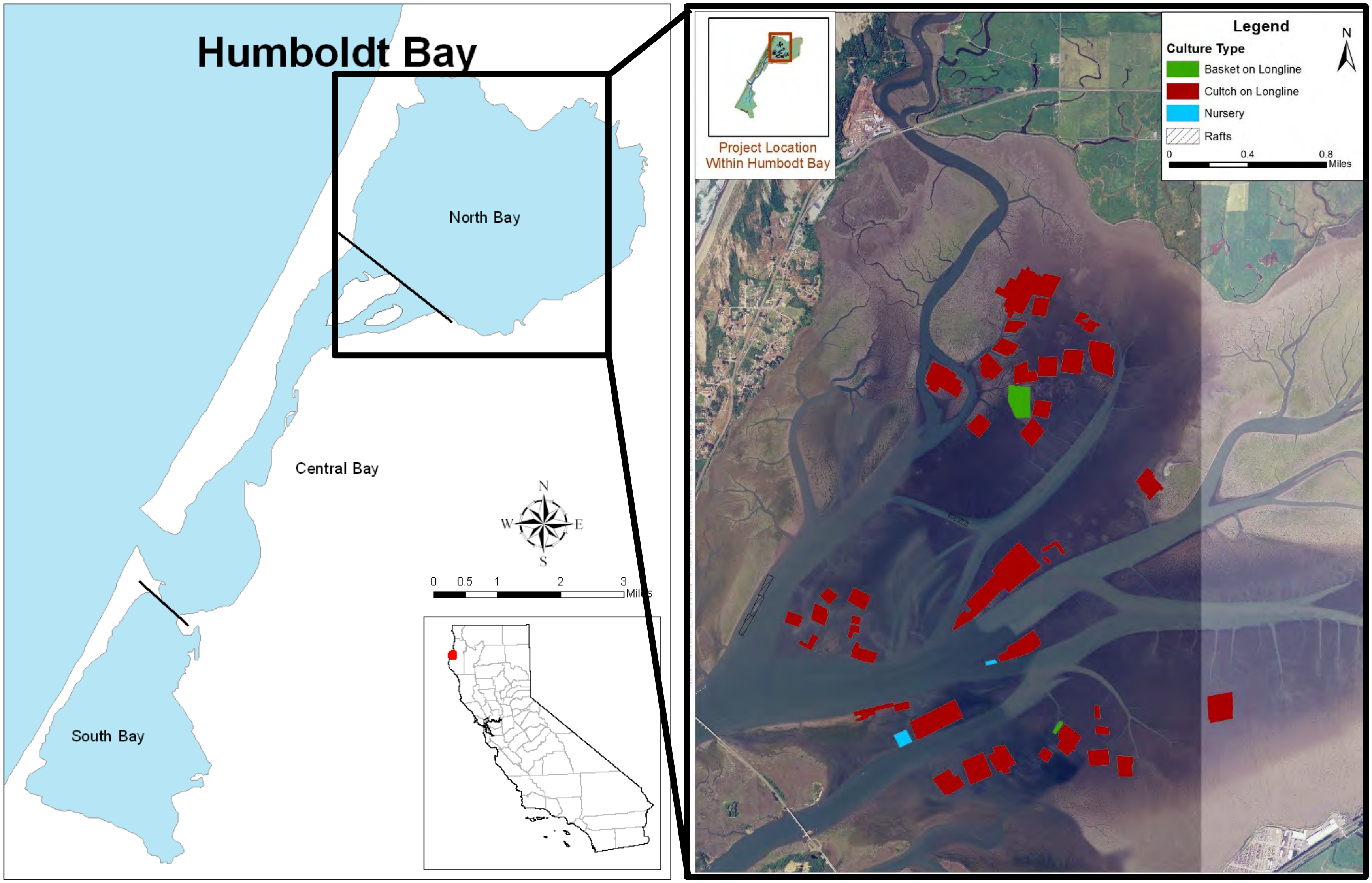

Figure 1 **Location of Humboldt Bay, California, and Existing Shellfish Aquaculture.**

Source: GIS layers provided by Wagschal, pers. comm., 2015; Notes: Habitat and shellfish culture areas based on data from NOAA (2012).

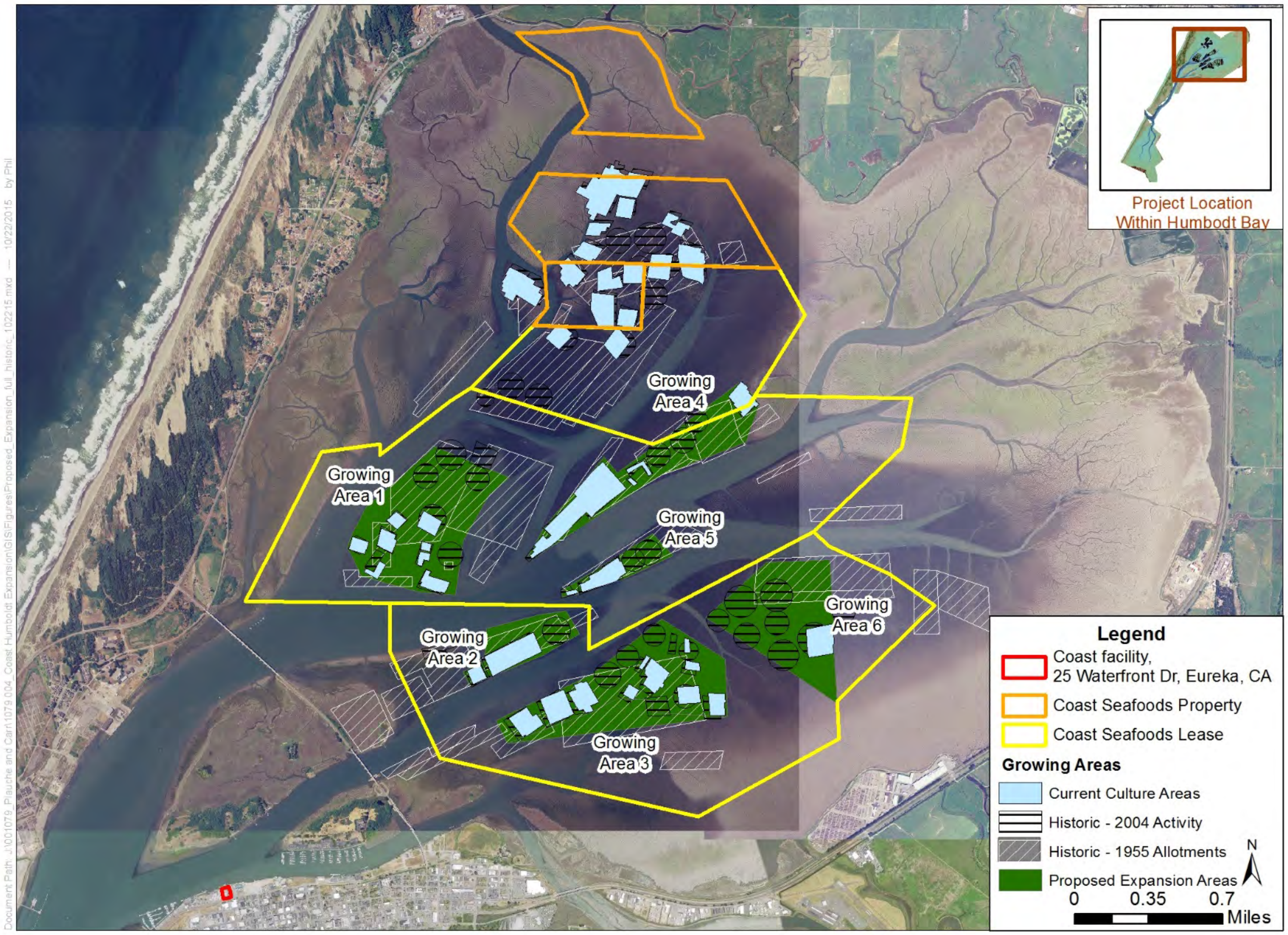

Figure 2 **Areas Proposed for Continued and Expanded Shellfish Culture Overlaid on Historical Growing Areas.**[2]
Source: GIS layers provided by Wagschal, pers. comm., 2015.

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[2] A portion of Coast's existing culture footprint is located in areas currently leased from the Harbor District but whose ownership has been questioned by the Department of State Lands. Coast is currently in the process of seeking leases from the tideland property owners. Figure 2 depicts the current understanding of Coast's Harbor District lease boundaries.

2.3 Project Siting

Of Coast's leased and owned acreage in North Bay that is suitable for growing oysters, there is significant overlap with existing eelgrass habitat. 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 (Gilkerson 2008). Within Coast's 4,308 acre footprint there are approximately 3,270 acres of intertidal areas (the remaining 1,038 acres are primarily subtidal and tidal channels), 63 percent of which overlap with eelgrass habitat, as follows: 644 acres (15% of Coast's overall footprint) of patchy eelgrass habitat and 1,428 acres (33% of Coast's overall footprint) of continuous eelgrass habitat[3]. However, as noted below, some of these intertidal areas are located at elevations not conducive to the successful cultivation of shellfish. Eelgrass is, therefore, growing on most of Coast's existing owned or leased land at tidal elevations that overlap with the preferred elevations for oyster culture.

As a Special Condition of Coast's current Coastal Development Permit (No. E-06-003), an elevation study was conducted to investigate whether it is feasible to grow oysters above elevations suitable for eelgrass habitat (Kalson and Lindke 2015). The major results of the elevation study indicate that oysters grown at the lower tidal elevations (+0.5 to +1.0 ft MLLW) had significantly higher productivity compared to those grown at higher elevations (+1.5 ft to +2.0 ft MLLW). Oyster weight was also significantly different at higher tidal elevations: Kumamoto oyster weight was 51 percent lower and Pacific oyster weight was 65 percent lower at the higher elevations compared to the control. Finally, the number per cluster of Kumamoto oysters was 52 percent lower at the higher elevations. The study results indicate that oysters grown above an elevation of +1.5 ft MLLW are less viable than those grown in the ranges that overlap with eelgrass habitat.

Therefore, in order to meet Coast's production needs and ensure the Project is economically viable, the Project siting prioritizes ideal tidal elevations for productive oyster culture rather than total avoidance of eelgrass habitat. Siting oyster cultivation in the most productive oyster growing areas allows Coast to maximize efficiency and productivity on its owned and leased footprint, thereby obtaining an increased yield while leaving a significant amount of its owned and leased acreage uncultivated. Given the significant overlap between eelgrass areas and ground for potential oyster cultivation in Coast's owned and leased footprint, total avoidance of eelgrass habitat would not meet any of the Project objectives, as further detailed in the Alternatives Analysis of the DEIR.

2.4 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

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3 Overlap with habitat based on GIS layers from Wagschal (pers. comm., 2015) and NOAA (2012) data.

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.

Project Alternatives are further discussed in Section 7.0.

2.5 Culture Methods

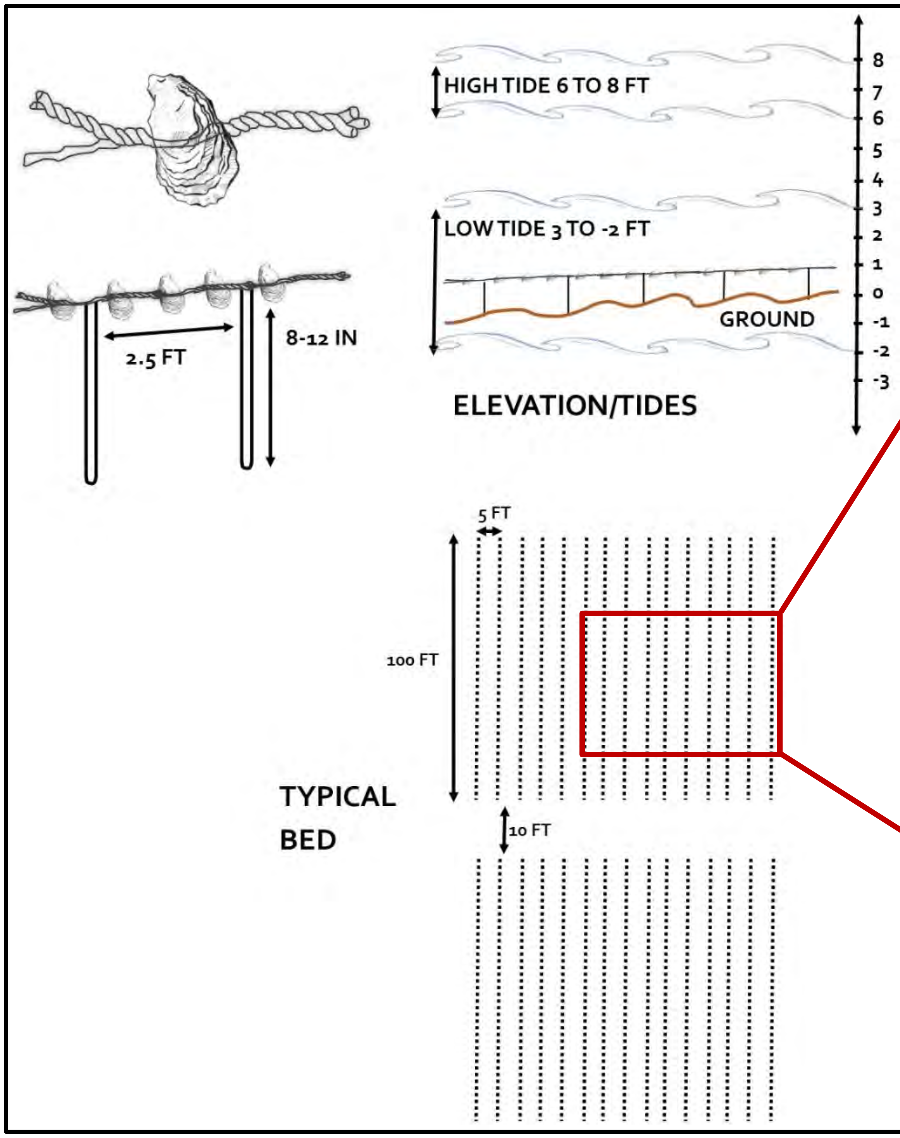
Existing culture methods used by Coast include cultch-on-longline, basket-on-longline, and floating culture. The proposed aquaculture expansion area would include similar methods as used in the existing culture areas. However, spacing between individual longlines would be increased, as described below. The DEIR provides a description of the existing culture methods. The information presented below includes a description of the proposed operations within the expansion area. A description of how culture methods would vary by Project Alternative is described in Section 7.0.

2.5.1 Cultch-on-Longline

Kumamoto oysters and Pacific oysters are grown using the cultch-on-longline method (Figure 3). This would be the primary method used by Coast in the expansion area. There are three main activities that would occur for cultch-on-longline operations: (1) planting, (2) maintenance, and (3) harvesting.

Planting

A crew of six would plant the cultch-on-longlines when the tide is low enough to access the expansion area. Prior to planting oyster seed, notched PVC stakes would be placed in 100 ft rows spaced at 5 ft intervals within the expansion area. The planting crew would gather enough bags from the nursery during the preceding high tide using a skiff and a hook and then plant during the subsequent low tide. Alternatively, the planting crew could pull the skiff into the nursery by hand on an in-coming tide when the water is only a foot or two deep and manually throw the bags into the skiff. The crew would then take the bags to the expansion area being planted and place them along the edge of a row of empty PVC stakes. At low tide, the crew would go back out to the growing area, cut the longline out of the bag and pull it alongside the empty PVC stakes. The longlines would be strung through notches on top of the PVC stakes, which suspends the oyster seed approximately 1 ft above the bay bottom.



Note: photograph shows 2.5 ft spacing.

Figure 3 **Configuration of Proposed Cultch-on-Longline Culture.**
Source: modified from Coast Seafoods Company 2007.

Maintenance

There would be a monthly inspection of each expansion area. A bed inspection would involve one or two people walking on the bed at low tide to make sure that the lines are in the notches and suspended above the bay bottom. Apart from the inspection, virtually no activity would take place until harvest.

Harvesting

Cultch-on-longline beds would be harvested after about 18 to 36 months, depending on market conditions, growth conditions, and other factors controlling consumer demand. The longlines would be harvested using two different methods. The first method uses a longline harvester (boat). The longline harvester would position a scow (barge) over the longline bed at high tide. Individual lines would be pulled onto the floating scow either by hand or by means of a hydraulically operated roller. If the lines are pulled by hand, they need to be cut into individual clusters, usually at the plant. If the lines are pulled mechanically, they are run through a breaker that strips the clusters from the line once on board the boat.

The second method, hand picking, would involve placing round 20-bushel tubs on the bed at high tide using a scow. The tubs would then be filled at low tide by hand. The picking crew would cut the longline into manageable, single clusters and place them in the picking tub. A floating ball would be attached to each tub, and at high tide the scow would return and lift the tubs out of the water onto the scow deck. The oysters would be dumped on the deck of the scow, and the tub placed back on the shellfish bed to be refilled at the next low tide.

2.5.2 Basket-on-Longline Culture

Kumamoto oysters would also be grown using the basket-on-longline methods. Basket-on-longline culture (Figure 4) would use baskets that hang from a monofilament line suspended off the bottom using 2-inch schedule 80 PVC pipe. The monofilament line would be 5 mm in diameter protected by a 3/8-inch polyethylene sleeve. The baskets would be approximately 24 inches x 10 inches x 6 inches and held on the line with plastic clips. A float, approximately 2.5 inches in diameter and 5.5 inches long, would be attached to the baskets to increase buoyancy when the beds are inundated at high tide. The lines would be positioned approximately 2.5 ft to 3.0 ft off the bottom so that the baskets are roughly 1 ft from the bay bottom when hanging down during low tides.

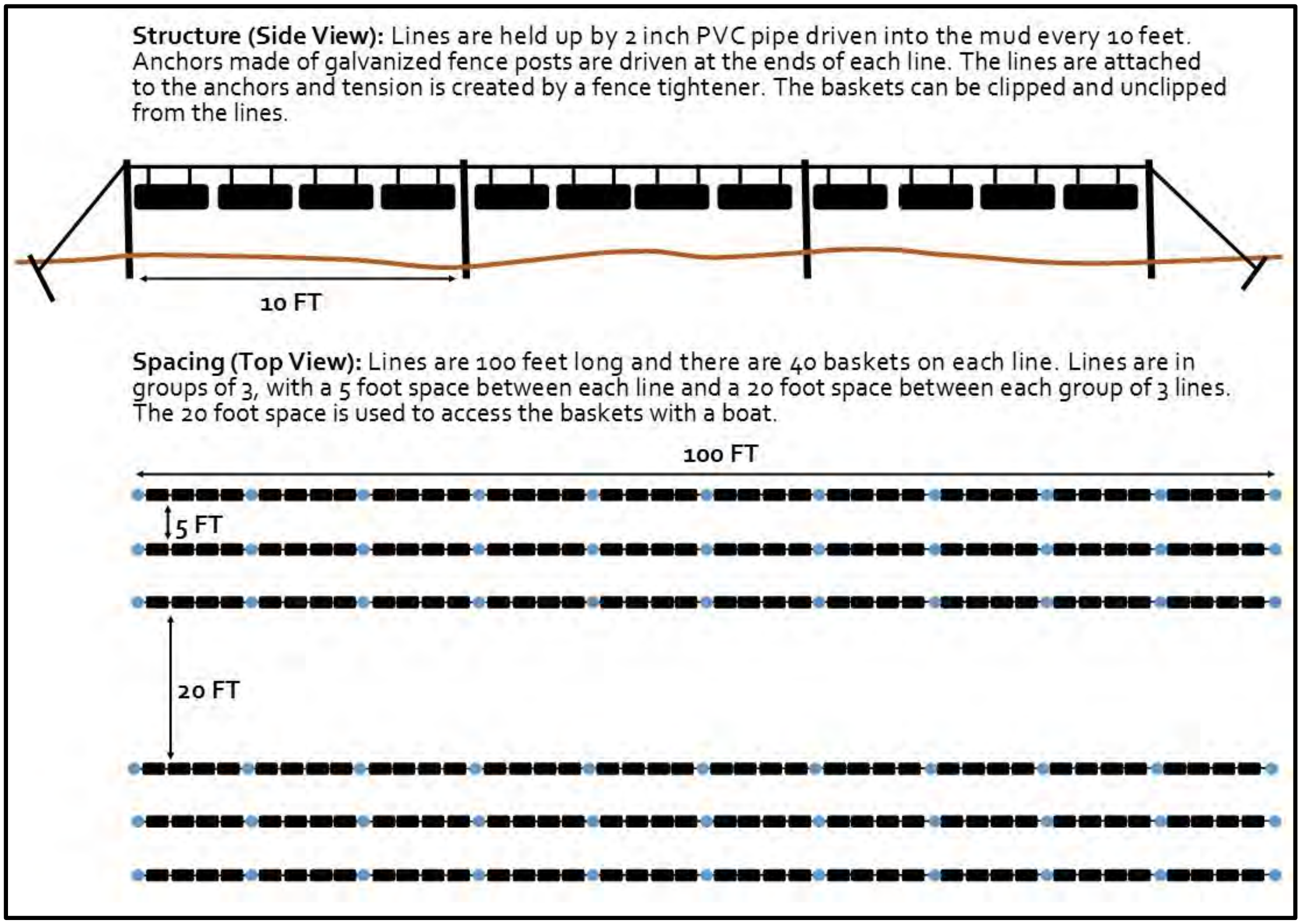


Figure 4 Configuration of Proposed Basket-on-Longline Culture.
Source: modified from Coast Seafoods Company 2007.

2.5.3 Rack-and-Bag Culture

Rack-and-bag culture would be used to grow Kumamoto oysters and Pacific oysters (Figure 5). The oysters would be grown as "singles," meaning they are not attached to any structure such as shells or to each other (i.e., they are "loose" in the bags). Rack-and-bag culture would use polyethylene mesh bags and rebar frames. Each rebar frame would be 3 ft x 12 ft and support 3 to 6 bags attached to the frame via industrial rubber bands. Each bag would be seeded with oysters and placed on the frames. The bags would be inspected up to 3 times per week and flipped approximately once every 2 weeks. It takes 1 to 2 years for the seed to grow into oysters of market size and then the bags of oysters would be harvested by hand (lifted from the racks into a skiff), processed, and brought to market. Any rack and bag culture placed within the expanded area will be placed at least 10 feet away from existing eelgrass beds.

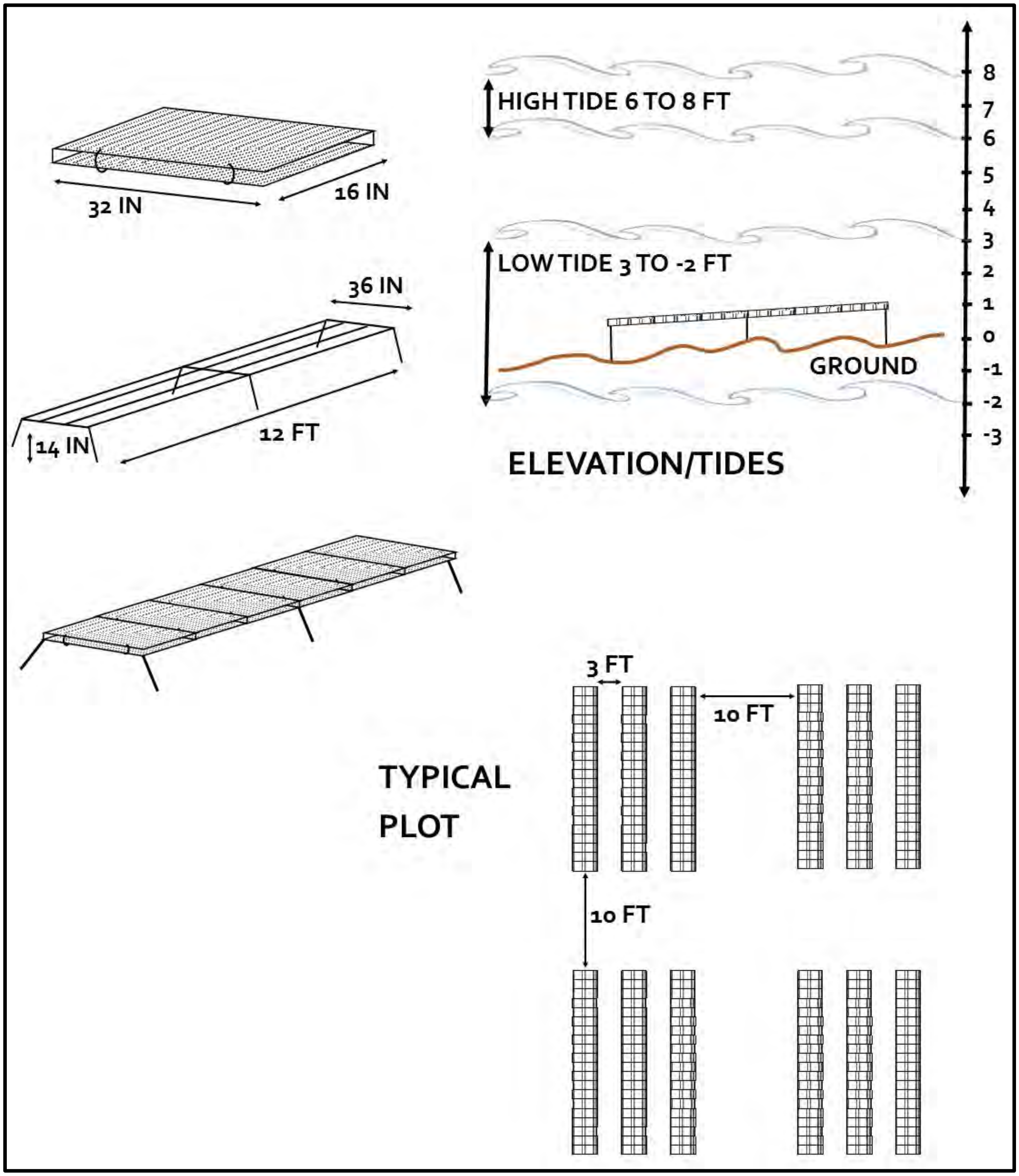


Figure 5 Configuration of Proposed Rack-and-Bag Culture.
Source: modified from Coast Seafoods Company 2007.

3.0 EXISTING CONDITIONS

Humboldt Bay is composed of three distinct sub-basins: (1) Arcata Bay (North Bay), (2) Entrance Bay, and (3) South Bay. Habitat within each of these sub-basins is a mixture of unconsolidated sediment (or mudflats), eelgrass beds (both continuous and patchy[4]), coastal salt marsh habitat, macroalgae, and subtidal habitat (Figure 6). The following discusses the environmental setting of Humboldt Bay, focusing on conditions related to eelgrass habitat.

3.1 Distribution and Abundance of Eelgrass

Native eelgrass is a common perennial aquatic plant that creates three-dimensional habitat structure and forms extensive intertidal and subtidal beds in estuaries and coastal areas. Eelgrass beds are an important component of coastal ecosystems because they stabilize coastal sediments, provide direct and indirect food sources for marine species, and act as a nursery for fish and invertebrates (e.g., Phillips 1984, Short et al. 2000). Eelgrass is a dominant habitat of Humboldt Bay, and has been documented throughout recorded history (Pierce 1871 *as cited in* Schlosser and Eicher 2012).

In 2009, Humboldt Bay contained 3,614 acres of continuous eelgrass beds and an additional 2,031 acres of patchy eelgrass beds (NOAA 2012, Schlosser and Eicher 2012). Although monitoring is sporadic within most areas of California, the eelgrass in Humboldt Bay represents up to 53 percent of California's eelgrass resource (Ramey, pers. comm., 2012). Further, relative to its size (17,759 acres of coastal wetland habitat), Humboldt Bay has the most eelgrass of any bay in California. Eelgrass in Humboldt Bay represents approximately 32 percent of the coastal wetland habitat in the bay. Comparatively, in San Francisco, out of 250,000 acres of coastal wetland habitat there were 3,707 acres of eelgrass (or 1.5%) in 2009 (Merkel 2010).

Gilkerson (2008) modeled eelgrass habitat, and found that a larger proportion of eelgrass beds were located in South Bay (84% of available habitat) compared to North Bay (39% of available habitat). Eelgrass beds in North Bay are exposed to winds from the south, which tend to accompany high energy winter storms that erode and degrade the beds (Gilkerson 2008). Additionally, studies evaluating surface temperatures showed that South Bay was comparatively cooler than North Bay (Weltz 2012), potentially providing some protection against heat stress and desiccation. Taken together, these observations suggest that eelgrass growing conditions are better in South Bay compared to North Bay, which results in higher abundance and wider distribution of continuous beds.

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

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

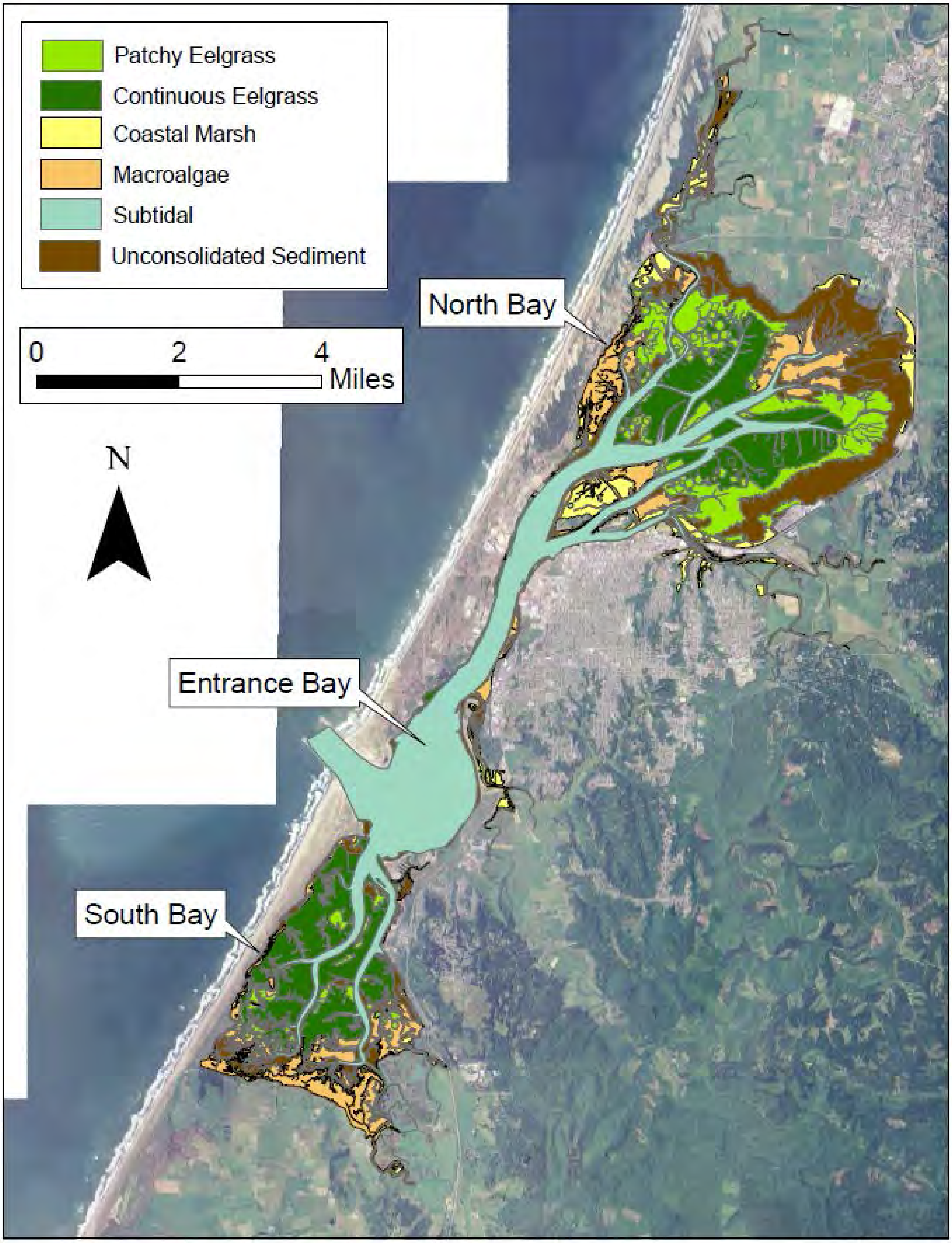

Figure 6 Distribution of Continuous and Patchy Eelgrass in Humboldt Bay.
Source: Wagschal, pers. comm., 2015; Notes: Habitat areas based on data from NOAA (2012).

3.2 *Limitations to Eelgrass Growth*

Eelgrass abundance and distribution varies over time and space, and although beds are often perceived as static, the edges tend to expand and contract in response to natural and anthropogenic stressors (Duarte and Sand-Jensen 1990, Robbins and Bell 2000, Gaeckle et al. 2011). The upper extent of eelgrass growth is typically limited by desiccation and wave exposure (Koch 2001, Boese et al. 2005). In addition, eelgrass growing near this upper limit often overlaps with algal growth (especially ulvoids) and epiphytes, which can directly compete and shade out eelgrass (van Montfrans et al. 1984, Mumford 2007). The lower limit of eelgrass growth is typically determined by light attenuation as water depth increases (Dennison 1987).

To aid in the analysis and discussion of controlling factors affecting eelgrass structure and health, this report presents a conceptual model that was created for Humboldt Bay eelgrass based on information presented in Thom et al. (2011) (Figure 7). Using this conceptual model as a guide, this report discusses the following controlling factors for eelgrass in Humboldt Bay: (1) light, (2) temperature, (3) energy, and (4) nutrients.

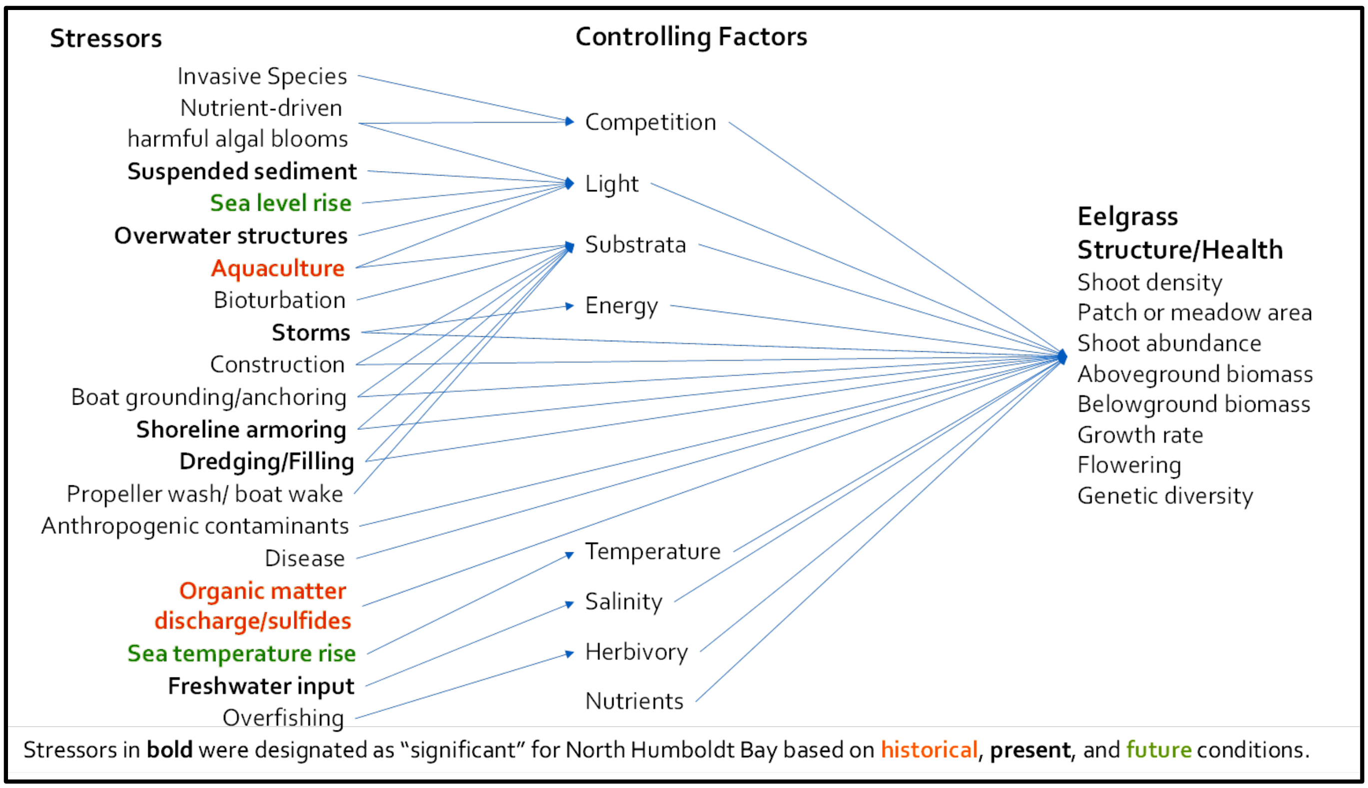

Figure 7 Conceptual Model Describing Factors Affecting Eelgrass Structure and Health.
Source: modified from Thom et al. 2011.

3.2.1 Light

Eelgrass requires light for photosynthesis, and the lower limit of growth is typically limited by light availability at depth (Dennison 1987). Light intensity attenuates exponentially with water depth, and the minimum light requirements for *Zostera marina* as a percentage of incidental light is approximately 20 percent (Dennison et al. 1993). The depth at which this incidental light level occurs depends on the depth of the water column, the amount of dissolved material, and the amount of suspended material (e.g., phytoplankton, sediment, etc.). Suspended sediments can limit light penetration and nutrients can stimulate growth of phytoplankton in the water column, which then absorb light and further limit photosynthesis by eelgrass. Light availability at depth in South Bay is not as much of a limitation compared to North Bay, which likely results in eelgrass growing at greater depths in South Bay (Table 1).

Table 1 Mean and Standard Deviations for the Upper and Lower Limits Suitable to the Growth of Eelgrass in Humboldt Bay.

Suitable Extent	Mean Depth (ft MLLW)	
	North Bay	South Bay
Lower Extent	**n=10**	**n=8**
Minimum	-1.5 ± 0.1	-3.3 ± 0.2
Mean	-3.1 ± 0.3	-5.6 ± 0.3
Maximum	-4.5 ± 0.6	-6.9 ± 0.4
Upper Extent	**n=14**	**n=11**
Minimum	+0.4 ± 0.1	+0.2 ± 0.1
Mean	+1.4 ± 0.4	+1.0 ± 0.4
Maximum	+4.7 ± 1.3	+2.6 ± 1.0

Source: Gilkerson 2008
MLLW = mean lower low water

A number of environmental factors contribute to suspended sediment increases and, thus, reductions in incidental light. Real-time turbidity was measured at various locations in Humboldt Bay and Northern California through the Central and Northern California Ocean Observing System (CeNCOOS) and by the Wiyot Tribe at Indian Island. Turbidity in Humboldt Bay varies both seasonally and daily. Baseline levels increase during the winter months, potentially due to northward oceanic currents carrying sediment from the Eel River into Humboldt Bay (Opler 1992). According to Shaughnessy (2014), the Eel River has the most clays of any river along the West Coast.

Gilkerson (2008) indicated that South Bay is closer to the ocean and receives less freshwater runoff than North Bay and, therefore, light penetrates deeper into the water column. More than 85 percent of the freshwater sources entering Humboldt Bay are located in the North and Entrance bays (Barnhart et al. 1992). Because the runoff entering the bay from freshwater sources is typically laden with suspended sediments, light is a greater limitation to eelgrass in North Bay.

Turbidity spikes occur annually during rain and wind events beginning in September or October, with the greatest frequency occurring between December and February (Figure 8). Wind shear increases suspended sediments, in particular during late spring low tides as the wind-driven waves disturb the mudflats and produce a spike in turbidity every June (Swanson et al. 2012, Shaughnessy and Hurst 2014). Daily suspended sediment increases occur from natural bottom disturbance during low tides and strong wind events, especially in the shallow North Bay mudflat habitat.

3.2.2 Temperature

Tidal exposure resulting in desiccation stress is one of the most important factors limiting the upper intertidal distribution of eelgrass. Desiccation is caused by exposure to elevated air temperatures, which results in heat stress and leaf necrosis (Boese et al. 2005). Coastal air temperatures are heavily influenced by sea surface temperatures, and a recent study by Lebassi et al. (2009) indicated that air temperatures in coastal low lying areas have cooled since the late 1940s. These findings are only partially supported by data from CeNCOOS (2014), which indicates that temperatures increased from 1950 to 1997 before decreasing through 2010. Despite this trend of decreasing average temperatures, eelgrass stress due to air exposure is primarily associated with short-term heat stress-related desiccation events.

3.2.3 Energy

Wave exposure is a major factor in controlling seagrass cover, and wave exposure indices have proven instructive for predicting cover (Fonseca and Bell 1998). The seabed is also dynamic, and sediment movement over time may bury plants, expose roots, or uproot plants (Kirkman and Kuo 1990, Preen et al. 1995). Gilkerson (2008) indicated that wave-related stress is highest within the western half of North Bay, Entrance Bay, and the North Bay Channel; the latter two correspond to the deepest portions of the dredged shipping channel. Similar to observations made by Kirkman and Kuo (1990) and Preen et al. (1995), water depth in Humboldt Bay is in a constant state of change, especially within dredged locations, resulting in shifting locations where wave-related stress is the greatest. Gilkerson (2008) developed a relative exposure index (REI) for Humboldt Bay to identify areas where eelgrass habitat may be prone to disturbance from wind and waves (Figure 9).

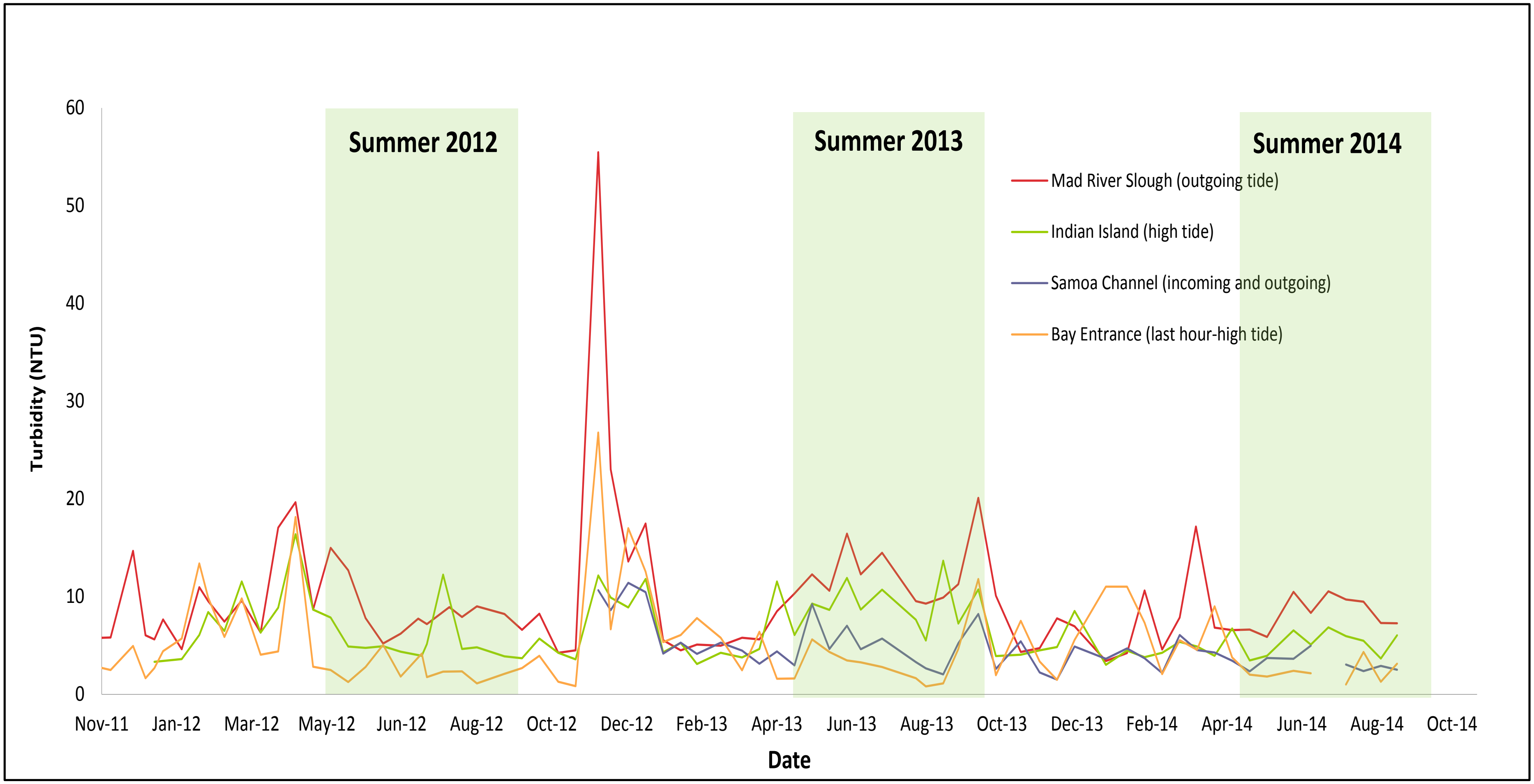

Figure 8 Temporal Variation of Turbidity in Humboldt Bay (2011-2014).

Source: Shaughnessy and Hurst 2014; Notes: Mad River Slough = North of Humboldt Bay; Indian Island = North Bay; Samoa Channel = Entrance Bay.

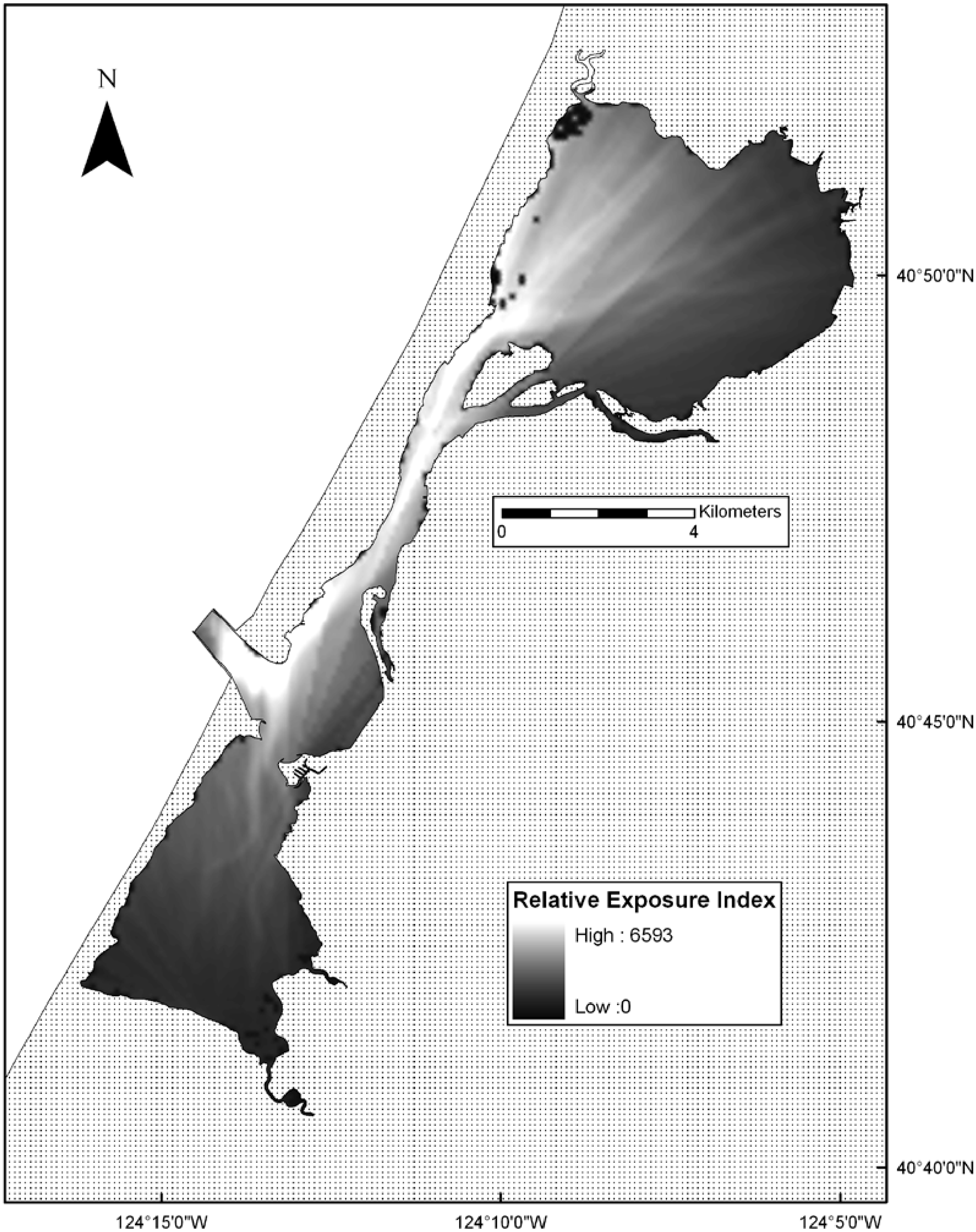

Figure 9 Relative Wave Exposure Index in Humboldt Bay.

Source: Gilkerson 2008; Notes: REI was calculated on the basis of local exceedance wind data (velocity > 10 m/s), effective fetch, bathymetry, a tidal stage of 1.5 m (4.9 ft) MLLW, and the proportion of time the wind blew from a given bearing.

3.2.4 Nutrients

The main nutrients that are used to monitor eutrophication potential are silicate (or silicic acid), phosphorus (or phosphates), and nitrogen (or nitrates). For example, silica can become a limiting factor in eutrophic areas where human sources of nitrogen and phosphorus are abundant. Eelgrass has lower nitrogen and phosphorus requirements than phytoplankton or macroalgae (Hemminga and Duarte 2000). Changes in the amounts of nutrients in the aquatic environment can shift the competitive balance between aquatic vegetation, allowing plants that can respond quickly to nutrients to dominate. As water column plankton increases, light penetration decreases, which can alter benthic aquatic vegetation distribution.

Nutrients enter Humboldt Bay via three pathways: municipal wastewater, runoff, and nearshore waters. Municipal wastewater, although historically a major nutrient source, has become much less significant as a result of various treatment improvements instituted in the 1980s and 1990s. Runoff, although potentially a significant source, occurs primarily during the wet winter months when there is little potential for nutrient uptake by flora and fauna in the bay, and most of the associated nutrients are probably exported from the bay via tidal exchange with the ocean. As a result, nutrient (specifically, nitrate) concentrations in the bay are chiefly driven by the nearshore ocean contribution, which consists of nearshore waters imported to the bay via tidal exchange.

Tennant (2006) evaluated the nutrients in Humboldt Bay and reported that low ammonium and seasonally low nitrate concentrations led to observed nitrogen:phosphorous ratios below the nutrient limitation threshold of about 5.0 suggested by Thom and Albright (1990). Ambient ratios should ideally be at 16:1 (the Redfield ratio), and ratios of less than 5:1 are considered to be limiting for eelgrass (Thom and Albright 1990). Experimental applications of fertilizer led to significant decreases in eelgrass density and below ground biomass in North Bay due to phosphate toxicity, suggesting that North Bay eelgrass may be vulnerable to increases in nutrient loading (Tennant 2006).

Tennant (2006) detected small amounts of phosphate loading in North Bay near Arcata Marsh, in Central Bay at the Elk River, and in South Bay near Table Bluff. Phosphate concentrations were also higher in Humboldt Bay than in the ocean, although nitrate concentrations were similar. Water quality monitoring by the Wiyot Tribe and CeNCOOS (Figure 10) for nitrates and silicic acid indicated that nutrients follow a similar pattern in North Bay (Indian Island) as compared to ocean conditions (Bay Entrance), with a few differences in the summer for nitrates that appear to correlate with peaks in phytoplankton abundance. Although a small number of low dissolved oxygen (DO) events have been observed in Humboldt Bay, which can be an indication of eutrophication, neither the bay nor its tributaries are currently listed for high nutrients or low DO (California SWRCD 2014).

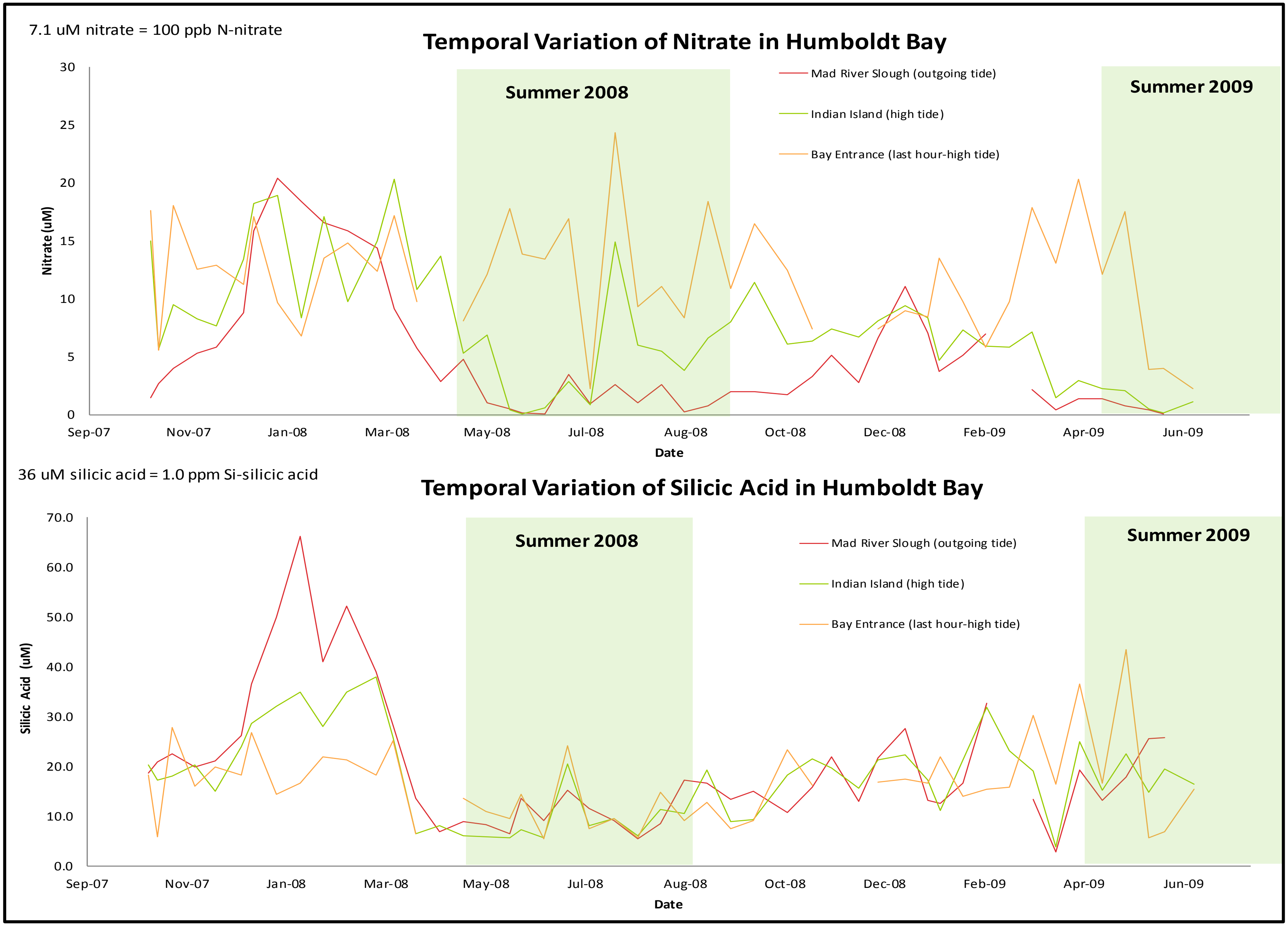

Figure 10 **Temporal Variation of Nitrate and Silicic Acid in Humboldt Bay (2012-2014).**

Source: Shaughnessy and Hurst 2014; Notes: Mad River Slough = North of Humboldt Bay; Indian Island = North Bay; Bay Entrance = Pacific Ocean.

3.3 Natural Variability of Eelgrass Habitat

There are a number of data sources in Humboldt Bay to provide an understanding of natural variability in eelgrass habitat, although there are limitations to each data set. For example, the SeagrassNet (2015) data spans the longest continuous time period (2007-2011 and 2013-2014) but the data were collected only along two transects (one in North Bay and the other in South Bay). Similarly, data by Rumrill and Poulton (2004) represents a wider range of sample locations, but only spans a three year period (2001-2003). The following information discusses available data sets that provide an indication of natural variability in areal extent and shoot density of eelgrass habitat in Humboldt Bay.

3.3.1 Areal Extent

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 (Figure 11). However, comparing mapped eelgrass between years may not be meaningful due to: (1) differences in mapping methods, and (2) the fact that eelgrass distribution varies seasonally and mapping was not necessarily done during the same season each year. While trends and inter-annual variability are difficult to determine from the bay-wide mapping efforts, a review of the data suggests that eelgrass is extensive and relatively stable in Humboldt Bay (Judd 2006, Gilkerson 2008, Schlosser and Eicher 2012).

3.3.2 Shoot Density

Eelgrass in Humboldt Bay tends to begin growing in April, and shoot density peaks in July before declining again. Eelgrass shoot density can vary dramatically between years and even within the same season, suggesting that differences in light penetration and/or nutrient conditions can cause dramatic changes in overall productivity (Harding 1973). Eelgrass shoot length typically reaches a peak in August or September, although in some years shoot length continues extending through December before die-back and storm damage reduce the plants to an annual low in January (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 (Figure 12). 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.

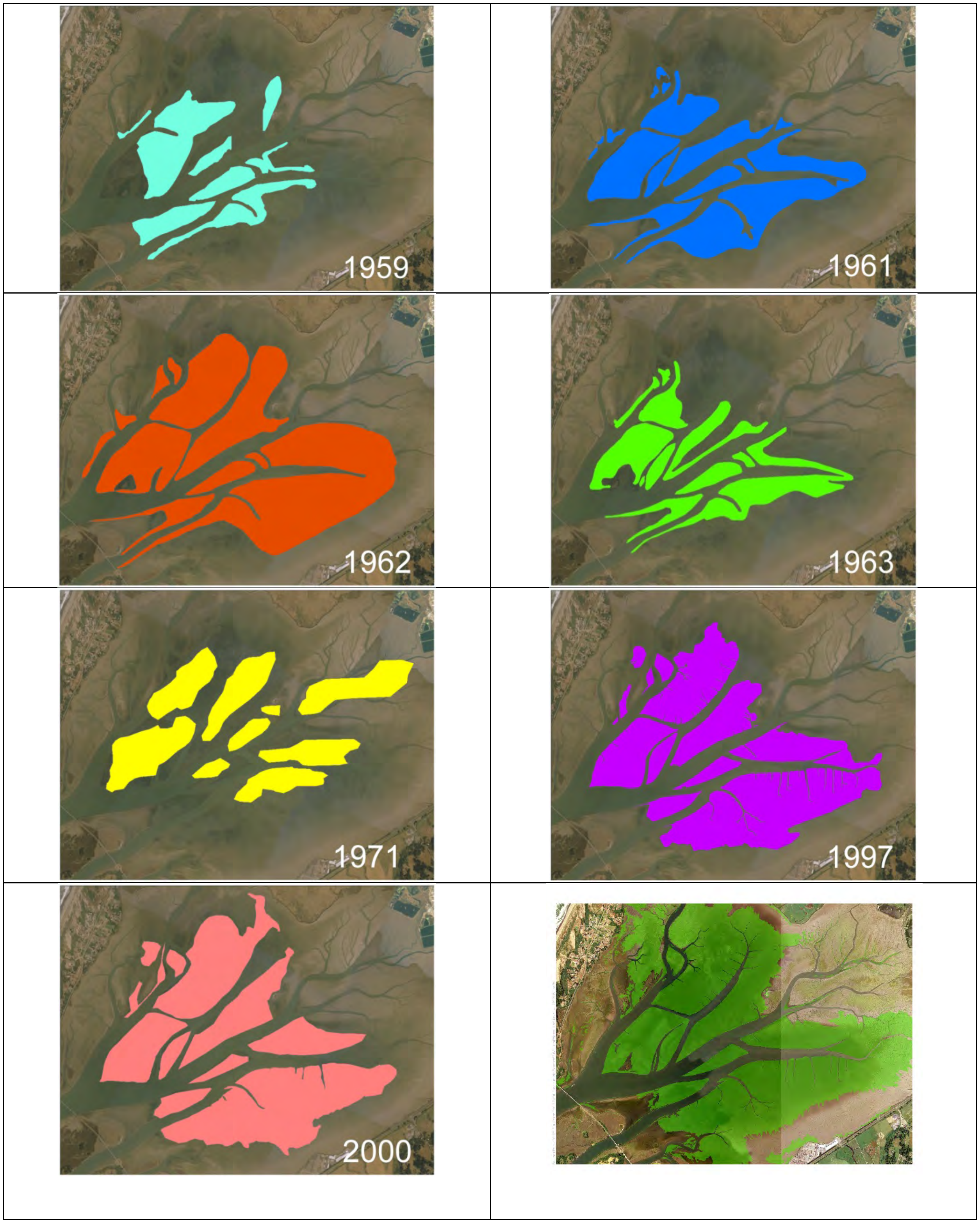

Figure 11 **North Bay Eelgrass Cover from 1959 to 2009.**
Source: modified from Schlosser and Eicher (2012).

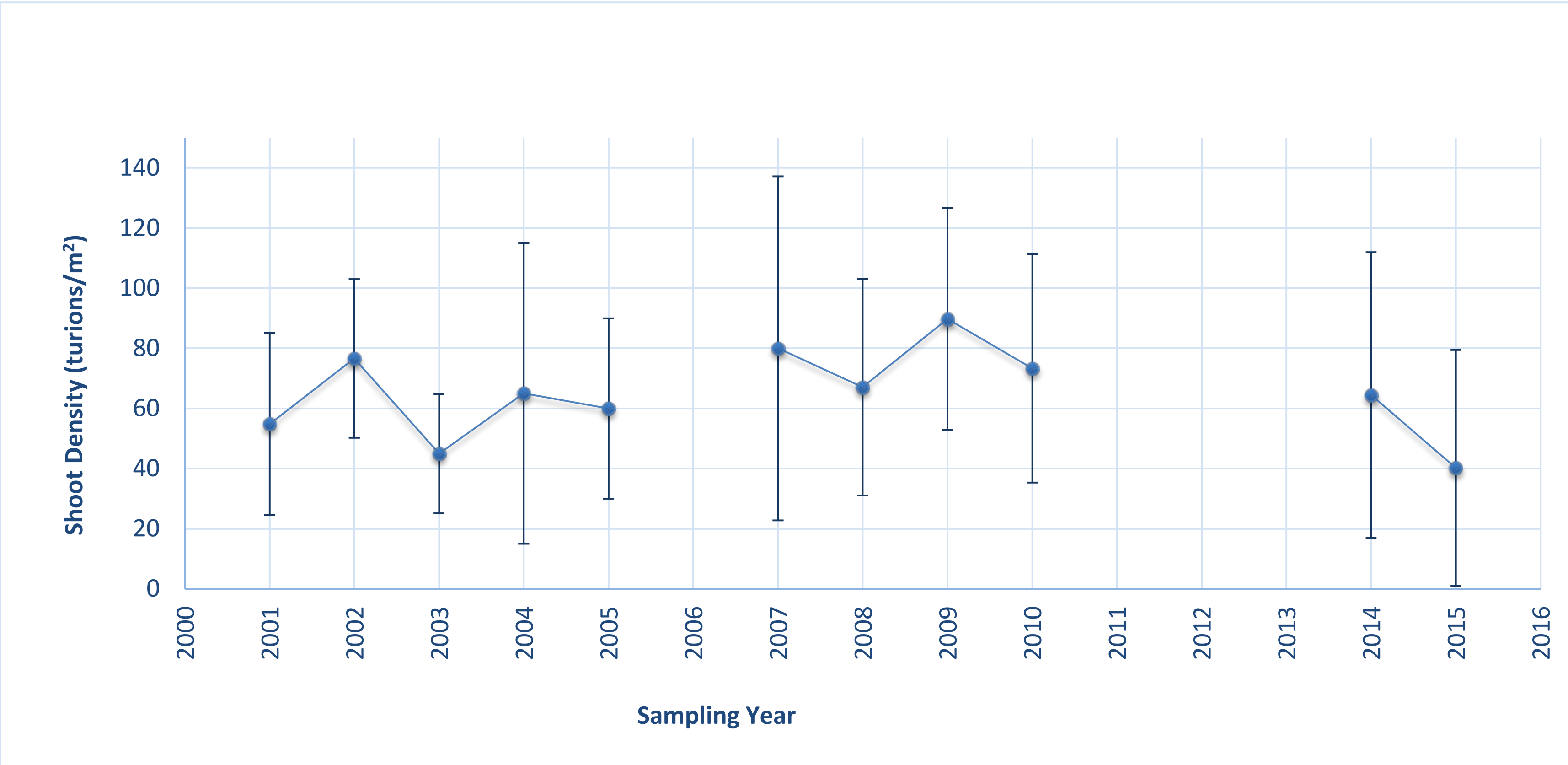

Figure 12 North Bay Summer (June-August) Eelgrass Shoot Density.
Sources: Rumrill and Poulton 2004, Schlosser and Eicher 2012, SeagrassNet 2015, Rumrill 2015, SHN 2015.
Note: No data were identified for the summer of 2006 and 2011-2013.

3.4 Eelgrass at Carrying Capacity

Work by Borde et al. (2001) in a laboratory setting suggests that eelgrass populations may overshoot their carrying capacity for a period before falling back to a sustainable level. It is unclear whether Humboldt Bay falls into this category, but the historic record seems to indicate that eelgrass in the bay is either stable or increasing. Gilkerson (2008) developed a predictive model of eelgrass presence based on water depth, as determined by a bay-wide bathymetry elevation model. This predictive model was then compared to hyperspectral imagery and field observations of eelgrass (i.e., the upper and lower boundaries of distribution throughout Humboldt Bay) to determine suitable habitat. There was a high level of agreement between the predictions and interpreted hyperspectral imagery, with 94 percent of observed eelgrass being captured within the predicted habitat.

Gilkerson (2008) reported that 22 percent of the predicted habitat lacked eelgrass in Humboldt Bay. The author indicated that the available habitat predicted in the model likely falls into three categories:

- A portion of this habitat is likely an over-prediction of habitat suitability and is not actually suitable habitat.
- A portion may have been beyond the capacity of hyperspectral imagery to detect, and eelgrass may actually be present though not registered in the dataset (e.g., might miss eelgrass due to turbid conditions or when integrated with macroalgae at upper end of distribution).
- A portion is likely suitable habitat that is currently unoccupied.

Given the high correspondence between predicted and observed eelgrass habitat, and that existing data sources indicate that eelgrass cover is increasing or stable, it appears that eelgrass may be at or approaching its carrying capacity in Humboldt Bay.

3.5 Other Habitat Types

Characterizing the full range of habitats found in Humboldt Bay is complicated by the lack of a unified habitat classification framework for coastal and marine systems (FGDC 2012). 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 quantities and areas. However, comparisons to historical values are complicated due to evolving data collection and classification methods. Using North Bay as an example, the results of the CMECS classification (Figure 13) illustrate that there are large amounts of coastal marsh, macroalgae, subtidal, and eelgrass habitats in the bay. A smaller, but significant, amount of habitat is currently used for shellfish culture.

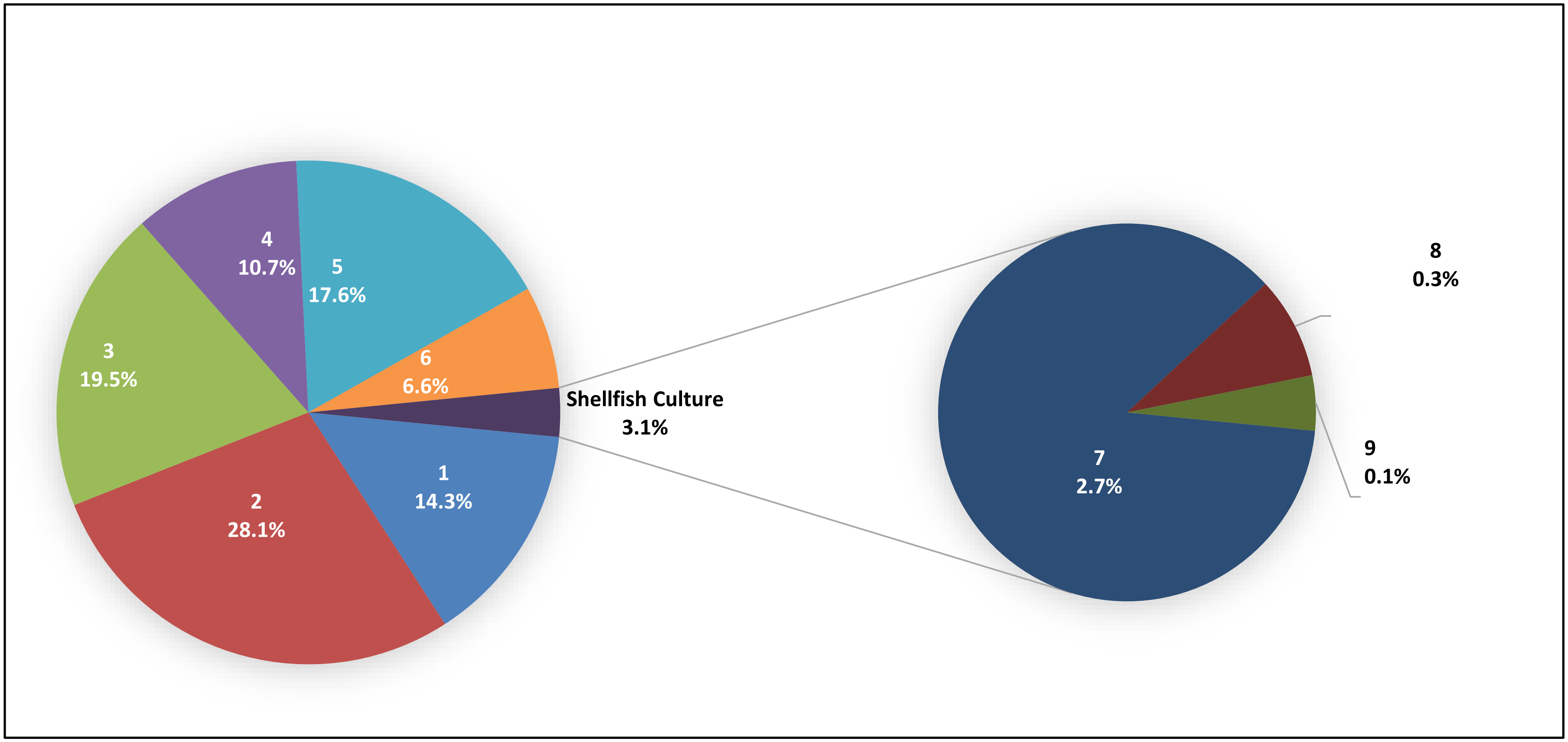

Figure 13 Habitats in North Bay Classified under the Coastal and Marine Ecological Classification Standard.
Source: Wagschal, pers. comm., 2015; Notes: Habitat areas based on data from NOAA (2012).

An example of direct habitat modification in Humboldt Bay is the diking and filling of salt marsh habitat from the 1880s to the 1980s, especially to the north and east of North Bay (Figure 14). According to Schlosser and Eicher (2012), Humboldt Bay has lost approximately 90 percent of its historic salt marsh habitat due to diking and filling primarily for agricultural purposes. The resulting channel confinement and gradient increase has contributed to ongoing erosion of the residual salt marshes, and may have contributed to sediment grain size changes (a slight coarsening) within the bay. Additionally, timber harvest greatly increased the sediment load in the Eel River, which enters the Pacific Ocean approximately 15 km south of the mouth of Humboldt Bay. The sediment plume from the river regularly enters Humboldt Bay during the months of peak runoff and constitutes the principal source of sediment delivery to the bay (Barnhart et al. 1992). The Mad River, which was once connected to the North Bay, also resulted in legacy sediments delivered to the bay (Shaughnessy 2014). Even though the Mad River is no longer hydrologically connected, large amounts of sediment (primarily mud) are occasionally delivered to North Bay during floods when the levees are overtopped. Because of the major habitat modifications to salt marsh habitat, there is limited capacity to retain sediments that are delivered by either the Eel or Mad Rivers.

The physical composition of Humboldt Bay sediments is controlled by tidal currents, which create a pattern of smaller grain sizes at higher tidal elevations or areas farther from the bay mouth (Schlosser and Eicher 2012). Intertidal coastal marshes tend to be in high elevation areas that are also fine-grained. Intertidal areas tend to either be vegetated by eelgrass or macroalgae with few areas remaining as unvegetated flats or rocky areas. While quantities of individual habitats can be characterized, the richness of Humboldt Bay's species assemblages (e.g., shorebirds and fish) are a result of the diversity of sandy beaches, rocky intertidal zones, intertidal flats, and seasonal freshwater wetlands, which provide a mosaic of foraging and roosting sites (Schlosser and Eicher 2012).

3.6 Summary of Existing Conditions

Eelgrass abundance and distribution varies over time and space, and the superficial stability of eelgrass beds tends to conceal the underlying balance between the continuous loss and replacement of shoots. The major controlling factors for eelgrass in Humboldt Bay include: (1) light, (2) temperature, (3) energy, and (4) nutrients. As a result, eelgrass areal extent and shoot density in Humboldt Bay show a significant amount of natural variability. However, it also appears that eelgrass is occupying most, if not all, available suitable habitat and may be at, or near, carrying capacity.

While eelgrass is an important and dominant 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 was a direct impact that resulted in channel confinement, gradient increase, and ongoing erosion of residual salt marsh habitat. While quantities of individual habitats can be characterized, it is important to also take into account the utility of a habitat mosaic on species diversity in the context of major changes to habitat structure.

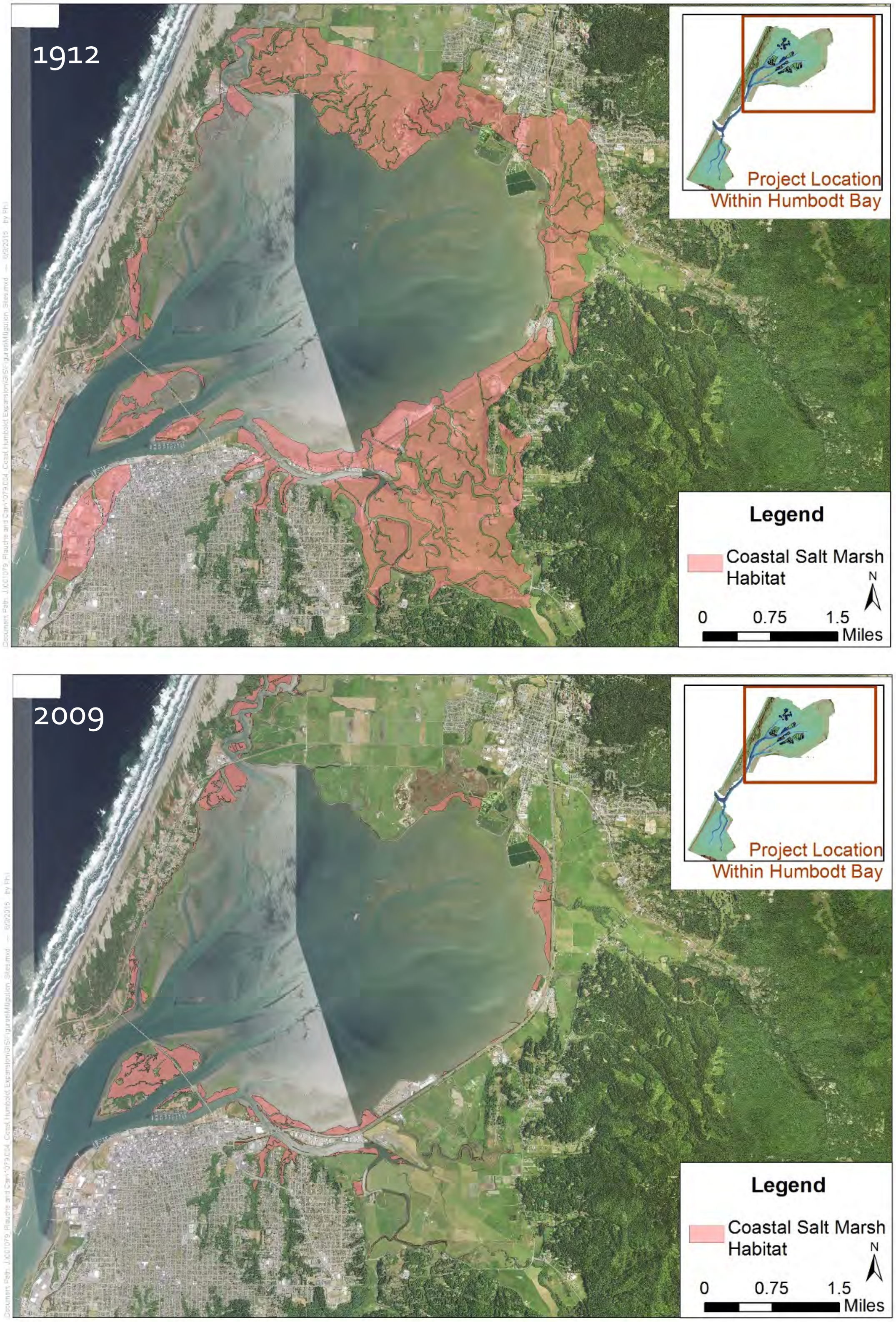

Figure 14 Coastal Salt Marsh Habitat between 1912 and 2009.
Source: modified from Schlosser and Eicher 2012.

4.0 DEFINITION OF SIGNIFICANCE

Shellfish aquaculture in Humboldt Bay is concentrated in North Bay. Existing aquaculture occurs primarily in patchy eelgrass habitat, along the margins of continuous eelgrass habitat, or outside of eelgrass habitat. According to Coast's southwest operations manager (Dale, pers. comm., 2015), many longlines were originally planted in areas adjacent to eelgrass that were later colonized by eelgrass after the aquaculture structure (e.g., longlines) was added to mudflat habitat. The current proposed expansion is primarily in continuous eelgrass, although all proposed expansion areas are in locations that were historically farmed (see Figure 2). Because the existing culture is part of the current environmental baseline, eelgrass impacts will be analyzed for the proposed expansion area.

Rumrill (2011) produced a simple conceptual model associated with the positive and negative interactions between Pacific oysters and eelgrass (Figure 15). These concepts will be discussed in both the impacts and mitigation sections below.

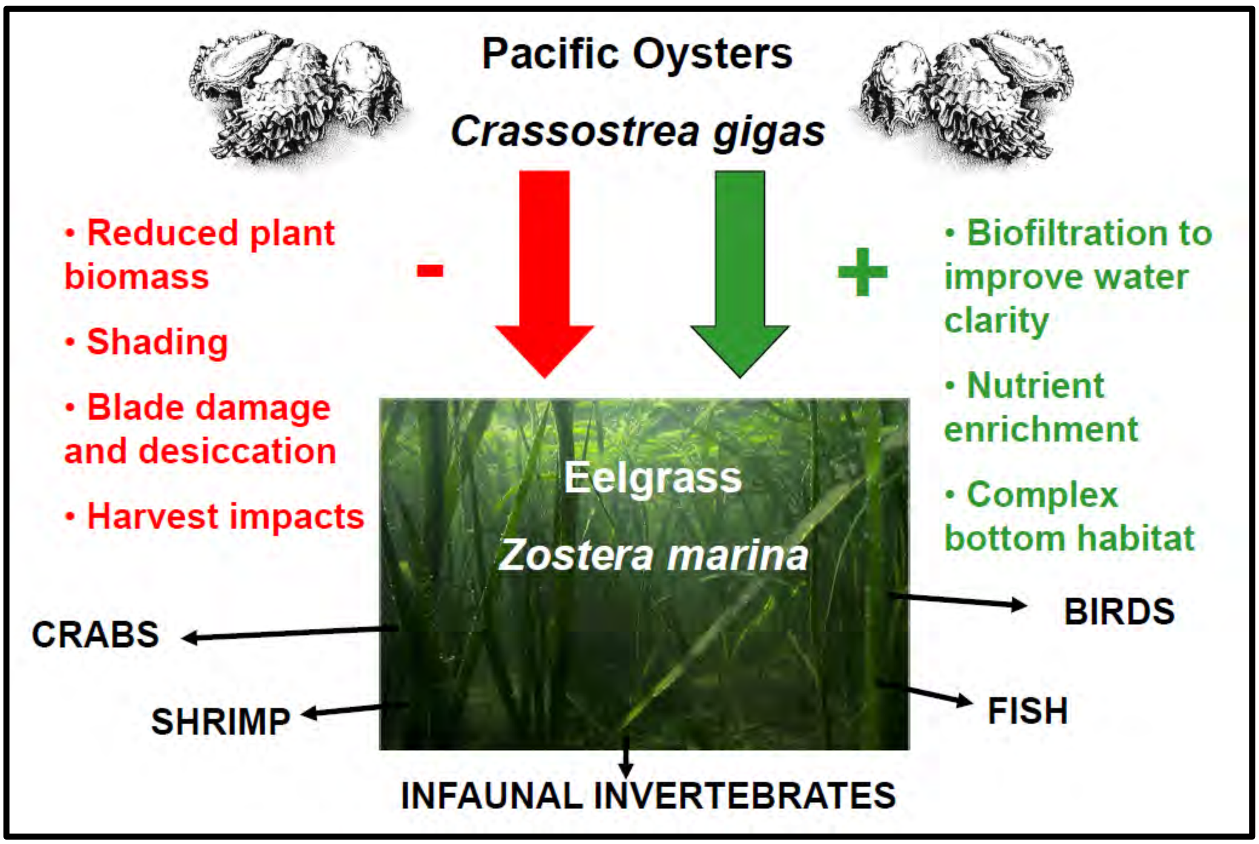

Figure 15 Biotic Interactions between Pacific Oysters and Eelgrass.
Source: Rumrill 2011.

According to Bass et al. (1999), under CEQA, "a threshold of significance is an identifiable quantitative, qualitative, or performance level of a particular environmental effect." Thresholds of significance are established pursuant to the CEQA Guidelines, state and federal regulations, or other regulatory and scientific guidance. Where specific thresholds have not been established, they can be developed through a public review process. A threshold of significance for impacts to eelgrass was established using the CEMP, the *Humboldt Bay Watershed Salmon and Steelhead Conservation Plan* (or SSCP), and the *Humboldt Bay Initiative* (or HBI).

In October 2014, the National Marine Fisheries Service (NMFS) (2014) released the CEMP, which recommends a "no net loss of eelgrass habitat function in California." Due to a lack of accepted methodology regarding how to evaluate impacts to eelgrass function, the CEMP suggests that eelgrass areal extent (or percent cover) and density could serve as a proxy for eelgrass habitat function:

- **Areal Extent:** The CEMP defines eelgrass habitat 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."

- **Eelgrass Density:** The CEMP also indicates that impacts to eelgrass density require mitigation if the Project results in a <u>permanent</u> reduction of eelgrass turion density greater than 25 percent. The CEMP further defines permanent as when the mean density of the Project site is found to be at least 25 percent below the reference site mean during two annual post-Project surveys following Project implementation.

While these metrics can be useful thresholds, evaluating change in eelgrass habitat function using only two parameters without consideration of scale or regard to the surrounding environmental context (i.e., abundance or limitation of eelgrass habitat) is overly narrow and does not follow an ecosystem or watershed approach, as recommended in regulatory guidance. A consideration of functionality and impact measured at the eelgrass bed scale and/or watershed scale is acknowledged in the CEMP in the discussion of the Corps/EPA Mitigation Rule (33 CFR Parts 325 and 332) and the reference to Fonseca et al. (1998).

Fonseca et al. (1998) reviewed a number of studies to examine "functional equivalency" at different seagrass densities and areal extent. One study (Fonseca et al. 1996 a,b) indicated that fish, shrimp, and crab density within shoalgrass (*Halodule wrightii*) and manatee grass (*Syringodium filiforme*) beds was equivalent between a natural bed and a bed that was approximately one-third of the mean shoot density of the natural bed. Another study (Short 1993) was considered initially successful if the planted bed covered 30 percent of the planted area in one year. Yet another study (Murphey and Fonseca 1995) indicated that seagrass beds that contained 30 percent to 40 percent cover had virtually indistinguishable penaeid shrimp densities compared to beds with continuous cover (100% cover). In general, the literature discussed in Fonseca et al. (1998) consistently found no differences in species presence in a seagrass bed when densities or percent cover were approximately 30 percent of the natural seagrass beds.

In defining a threshold of significance, this analysis also considered the scales discussed in the SSCP (HBWAC and RCAA 2005) and HBI (Schlosser et al. 2009). These documents recognize that large-scale watershed processes are important in creating and maintaining habitat in the Humboldt Bay watershed, which is why significance will be discussed at the local (0 m to 100 m), landscape (100 m to 10,000 m), and watershed (>10,000 m) scale. This also fits well with the regulatory context of the Endangered Species Act (ESA) and Magnuson-Stevens Fisheries Conservation and Management Act (MSA), which focus primarily on fish species, including salmonids, coastal pelagics, and groundfish species and the habitats upon which they depend (designated critical habitat and essential fish habitat). The highly mobile nature of ESA-listed and MSA-managed species is represented in considering the larger scales.

Using the above metrics, functional equivalency, and an understanding of scale, this report defines a threshold of significance for impacts to eelgrass habitat as Project effects that result in a change in areal extent and/or a greater than 25 percent change in eelgrass density. This is consistent with effects measured within individual expansion areas or at the eelgrass bed scale, which include both longlines and spaces between longlines.

5.0 IMPACT ANALYSIS OF THE PROPOSED PROJECT

There are five potential impacts to eelgrass or potential changes to habitat that eelgrass supports that are described below: (1) gear and shellfish products, (2) working practices, (3) fragmentation, (4) floating eelgrass rafts and wrack, and (5) sediment scouring and accumulation. In addition, the potential for consistent disturbances within the natural variability of the system is explored, as suggested by Dumbauld et al. (2009). Conservation Measures and Project assumptions used in this analysis are discussed first, followed by a discussion of potential impacts.

5.1 *Conservation Measures*

The following Conservation Measures will be used to avoid or minimize direct and indirect impacts:

- Proposed longline spacing would occur at 5 ft intervals in the expansion areas, following one of the recommendations from Dr. Rumrill (2015) in consultation with NMFS.
- Rack-and-bag culture methods would not be placed within 10 ft of existing eelgrass beds.
- 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.
- The longline harvester would not be anchored so as to shade the same area of eelgrass for a period exceeding 12 hours.
- No intentional deposition of shells or any other material would occur on the sea floor.

5.2 *Assumptions*

The following assumptions were made to conduct the impacts analysis:

- The 2009 locations of continuous and patchy eelgrass identified by NOAA (2012) are representative of 2015 conditions.
- The percentage of culture using cultch-on-longline methods in the expansion areas is 84 percent (522 acres) and using basket-on-longline and rack-and-bag is 16 percent (100 acres).
- Rack-and-bag is a minor portion of proposed culture methods (about 4 acres) and would not occur within 10 ft of existing eelgrass beds.
- Cultch-on-longline is spaced 5 ft apart, which results in 84 lines/acre.
- Basket-on-longline is spaced 5 ft apart for a group of 3 lines with 20 ft between groups, which results in 48 lines/acre.
- Effects under the longlines are the primary effect to eelgrass, which incorporates shading, mechanical abrasion, and desiccation potential.

5.3 *Gear and Shellfish Products*

Gear and shellfish products associated with longline aquaculture (e.g., cultch, baskets, floats) can lead to shading, which may affect the spatial extent and density of eelgrass beds in the immediate vicinity. The type and concentration of gear can influence the level of this effect. For example, Rumrill and Poulton (2004) determined that the spatial extent of an eelgrass bed and shoot density were negatively influenced when oyster longline culture was closely spaced (1.5 ft to 2.5 ft) but showed no effect compared to control sites when spacing occurred at 5 ft and 10 ft spaces between longlines.

Other potential impacts of shellfish aquaculture gear to eelgrass include the potential to abrade or desiccate eelgrass blades, although the overall effects to the eelgrass bed can be both positive and negative. For example, Tallis et al. (2009) reported that shellfish can break eelgrass blades through abrasion, but the reduction in density can release individual plants from intraspecific light competition and result in increased growth rates near the aquaculture plots. Eelgrass blades can also get caught on aquaculture gear and desiccate, which can eventually lead to a reduction in shoot size (Wisehart et al. 2007, Tallis et al. 2009). These effects are considered in the analysis below.

5.3.1 Change in Areal Extent within the Proposed Expansion Area

As noted above, the CEMP defines eelgrass habitat 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," but the Cowardin Classification system defines a "plant class" as covering more than 30 percent of the area. Given the scope of the project, it would be nearly impossible to identify eelgrass habitat at the scale at which a bed is defined under CEMP, which is why it is recognized in the CEMP that eelgrass habitat should be surveyed at appropriate scales to the action. For the purposes of this analysis, the NOAA (2012) data were used to define specific eelgrass beds in North Bay rather than the CEMP-specific definition; this data is consistent with the Cowardin Classification system's definition of plant class and with the CEMP's recognition of the large scale associated with this particular Project.

On May 18 to 19, 2015, SHN visited multiple sites throughout North Bay to evaluate interactions between existing shellfish aquaculture longlines and eelgrass. The survey looked at three different areas (see Figure 2 for locations of Growing Areas): (1) cultch-on-longline in Growing Area 6 (Plot 6/A), (2) basket-on-longline in the north end of the Coast-owned property (Plot 0/M), and (3) cultch-on-longline in Growing Area 1 (Plot 1/E). These locations represented cultch-on-longlines spaced 5 ft apart and basket-on-longline spaced 3 ft apart. For each survey area, three transect lines (100 ft in length) were placed in the culture areas and 0.0625 m^2 quadrat data (n=24) were collected along the three transect lines. Transect lines represented three locations within the shellfish aquaculture plot: (1) under the longline, (2) in between longlines, and (3) 10 ft from the longlines. Data collected in the quadrats included basic eelgrass metrics (e.g., percent cover and eelgrass density).

The SHN observations were consistent with Dr. Rumrill's analysis that the presence of longlines spaced 5 ft apart do not appear to change the areal extent of the surrounding eelgrass bed. Similarly, the NOAA (2012) data and other aerial imagery (e.g., GoogleEarth 2015) indicated that the presence of longlines (in most cases spaced closer than 5 ft apart) do not exclude eelgrass but can reduce eelgrass density at the closer spacing regimes. Therefore, based on available North Bay data, the proposed longline aquaculture is not expected to result in a loss of areal extent associated with eelgrass beds in North Bay.

This conclusion is in general agreement with the literature. For example, Wisehart et al. (2007) indicated that, while oysters grown on longlines caused some minor reduction in eelgrass density and cover, the highest eelgrass growth rates occurred at the longline culture and reference sites. Multiple authors suggest that oyster longlines can have direct impacts on eelgrass but that the effects occur over relatively small spatial and short temporal scales (Rumrill and Poulton 2004, Wisehart et al. 2007, Tallis et al. 2009, Dumbauld and McCoy 2015).

Actual changes to areal extent will be verified through a robust pre- and post-Project monitoring plan (see Appendix H of the DEIR). If changes to the areal extent are observed, Coast would mitigate for the observed loss through: (1) alteration of the Project footprint; (2) modification to aquaculture practices (possibly including alteration of culture spacing); (3) creation of eelgrass habitat; and/or (4) establishment of conservation easements over eelgrass beds.

5.3.2 Calculation of Eelgrass Density Reduction within the Proposed Expansion Area

The following calculations of eelgrass impacts start from the understanding that eelgrass habitat is not permanently lost due to oyster longline operations, and fish and wildlife can use areas intermixed with shellfish aquaculture and eelgrass in a similar fashion to eelgrass habitat. If greater than anticipated impacts are observed, then gear can easily be removed or reduced and recovery would occur very quickly. However, even in settings where oyster aquaculture occurs in over 22 percent of an estuary (e.g., Willapa Bay), eelgrass health appears to be sustainable in the presence of substantial aquaculture operations (Dumbauld and McCoy 2015).

Based on the best available scientific research (i.e., Western Regional Aquaculture Center (WRAC) study by Rumrill and Poulton 2004), it is apparent that oyster longlines can in certain areas reduce eelgrass turion density directly under the lines themselves while the space between longlines does not show a reduction in density. Similar information was discussed by Dr. Rumrill (2015) in relation to the WRAC study in Humboldt Bay that looked at the conversion of Coast's ground culture to oyster longlines. The following equations (Eq.) were used to calculate this reduction to determine the extent of impacts to North Bay eelgrass:

(1) $$X_{LL} * X_{WE} = A_{BL}$$

X_{LL} = length of longline (ft)
X_{WE} = width of effect (ft)
A_{BL} = area below longline (ft^2)

(2) $$A_{EA} * A_{BL} * NL = A_{AOI}$$

A_{EA} = expansion area (acre)
A_{BL} = area below longline (acre)
NL = number of longlines (#/acre)
A_{AOI}= area of influence (acre)

(3) $$A_{AOI} * ED * Rdct = LL_{Rdct}$$

A_{AOI} = area of influence (m²)
ED = eelgrass density (turions/m²)
$Rdct$ = percent reduction under longlines (%)
LL_{Red} = reduction of turions below longlines (turions)

(4) $$\frac{LL_{Rdct}}{TT} = T_{Rdct}$$

LL_{Red} = reduction of turions below longlines (turions)
TT = total turions within an area (turions)
T_{Red} = total percent reduction in eelgrass density (%)

The width of effect (X_{WE}) in Eq. (1) is the extent to which a reduction in eelgrass density would occur under the longline. 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. An average value for X_{WE} of 0.5 ft was used for cultch-on-longline culture. 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. An average value for X_{WE} of 0.9 ft was used for basket-on-longline culture.

Eelgrass density (ED) in Eq. (3) was based on the average eelgrass densities reported in Humboldt Bay (see Section 3.3 for a summary of existing data). A density of 50 turions/m² was used for patchy eelgrass areas and 80 turions/m² for continuous eelgrass areas. The overall breakdown of each density category within the expansion area is provided in Table 2. The "Growing Areas" are the six locations where culture is proposed (see Figure 2).

Table 2 General Habitat Categories within the Expansion Area

Growing Area	Culture Type	Non-Eelgrass (acre)	Patchy Eelgrass (acre)	Continuous Eelgrass (acre)	Total (acre)
1	Cultch-on-Longline	11.8	33.3	98.5	143.6
	Basket-on-Longline*	2.4	6.4	18.8	27.6
2	Cultch-on-Longline	0.4	2.8	28.7	31.9
	Basket-on-Longline*	0.2	0.5	5.5	6.2
3	Cultch-on-Longline	2.1	37.9	96.4	136.4
	Basket-on-Longline*	0.5	7.2	18.4	26.1
4	Cultch-on-Longline	2.2	9.6	60.3	72.1
	Basket-on-Longline*	0.4	1.8	11.5	13.7
5	Cultch-on-Longline	0	1.8	16.4	18.2
	Basket-on-Longline*	0.1	0.4	3.1	3.6
6	Cultch-on-Longline	1.7	5.3	112.8	119.8
	Basket-on-Longline*	0.3	1	21.5	22.8
Total	**Cultch-on-Longline**	**18.2**	**90.7**	**413.1**	**522.0**
	Basket-on-Longline*	**3.9**	**17.3**	**78.8**	**100.0**

Source: NOAA (2012)
**Basket-on-longline culture in non-eelgrass areas may include up to 4 acres of rack-and-bag*

The percent reduction under the longlines (*Rdct*) in Eq. (3) is based on values reported by Rumrill and Poulton (2004) during the WRAC study in Humboldt Bay, additional data provided by Rumrill (2015) in consultation with NMFS, and new data collected by SHN (unpublished data) within Coast's existing longline plots. Table 3 provides a summary of these data sources.

Table 3 Compiled Studies Reporting Eelgrass Density Reduction under Longlines

Plot	Transect Description	# of Quadrats (n)	Mean Eelgrass Density (turions per m²)	% Reduction (% change relative to control)
Cultch-on-Longline (5 ft Spacing)				
3A	EB 1-1/CON (no oyster lines)	12	38	
	EB 1-1/5 wide	12	18	-53%
3H	EB 6-2/CON (no oyster lines)	12	48	
	EB 6-2/5 wide	12	8	-83%
OLN Plots	OLN-CON (no oyster lines)	12	59	
	OLN-5 wide	12	21	-64%
1E	10 ft outside of bed (control)	24	72.7	
	under cultch line	24	42.7	-41.3%
6A	10 ft outside of bed (control)	21	119.3	
	under cultch line	24	62.7	-47.5%
Basket-on-Longline (5 ft Spacing)*				
3A	EB 1-1/CON (no oyster lines)	12	38	
	EB 1-1/2.5-5 narrow	12	16	-58%
3H	EB 6-2/CON (no oyster lines)	12	48	
	EB 6-2/2.5-5 narrow	12	3	-94%
OLN Plots	OLN-CON (no oyster lines)	12	59	
	OLN-2.5 narrow	12	10	-83%
oM	center of 20 ft gap (control)	24	64.7	
	under basket line	24	20.0	-69.1%

Sources: Rumrill and Poulton 2004; Rumrill 2015; SHN unpublished data
EB = East Bay; OLN = oyster longline
**There is no 5 ft basket-on-longline spacing within Coast's existing culture, and so a more conservative estimate related to 2.5 ft cultch-on-longline spacing was used to represent this effect. These values compare well with more recent data from SHN.*
Note: the Rumrill and Poulton (2004) data was collected in 0.25 m² quadrats while the SHN (unpublished data) was collected in 0.0625 m² quadrats. All data was converted into turions/m².

The range of values summarized in Table 3 was used to create a realistic scenario to understand potential effects of the oyster longlines on eelgrass habitat. A density reduction of 47 percent was used for cultch-on-longline areas because it represented the mean of the three values that were closest to each other. Similarly, a density reduction of 70 percent was chosen for basket-on-longlines because it represented the mean of the three closest values. Based on this realistic scenario, there would be approximately a 5.0 percent reduction in eelgrass density within the shellfish aquaculture expansion area. More detailed information on how this was calculated is provided in Appendix A of this report.

A sensitivity analysis of potential impacts indicated that eelgrass density would not be reduced more than the 25 percent threshold discussed under the CEMP. For example, if fouling organisms are 10x greater than assumed for the width of effect (X_{WE}) in Eq. (1), then a potential reduction in eelgrass density would increase from 5.0 percent to 10.5 percent within the expansion area. Similarly, if the percent reduction under the longlines (*Rdct*) in Eq. (3) is increased to 100 percent, then a potential reduction in eelgrass density could increase from 5.0 percent to 10.0 percent within the expansion area. Finally, if the width of effect is 10x greater than assumed *and* reduction under the longlines is 100 percent, then a potential reduction in eelgrass density could increase from 5.0 percent to 20.9 percent within the expansion area. Even in this final scenario, which is not supported by the literature or by current data, impacts to eelgrass would remain below the CEMP threshold for effects to eelgrass density. More importantly, this amount of reduction is well within the natural variability of eelgrass density within North Bay (see Section 3.3.2). This analysis focuses on the reduction of eelgrass density within eelgrass beds truncated by the boundary of the shellfish culture area. The actual extent of the eelgrass beds go well beyond the shellfish culture area. Therefore, the percent reduction in eelgrass density would be even lower if looking at the eelgrass bed scale.

5.3.3 Landscape or Watershed Scale

In other estuaries (e.g., Willapa Bay), eelgrass was found to be resilient to oyster aquaculture and effects were not persistent at the landscape scale (Dumbauld and McCoy 2015). The authors also indicated that, while shellfish aquaculture acts as an anthropogenic disturbance, it can also interact positively with eelgrass to the point that it may restore some of the services lost in areas where native bivalve populations may have declined. The fact that aquaculture activities can have both positive and negative interactions with eelgrass at a unit scale suggests that effects should be looked at from a broader perspective, such as the landscape or watershed scale, in order to understand the overall effects of shellfish aquaculture in relation to ecosystem health. This approach allows the resource to be managed in terms of the overall ecological function of a region, estuary, bay, or watershed. The landscape or watershed scale also provides an understanding of potential interactions with mobile organisms (e.g., salmonids, green sturgeon, Dungeness crabs), which occur within smaller units of area for only limited durations or life history stages.

To evaluate eelgrass density reductions at a larger scale, the potential reduction in eelgrass density discussed above was compared to eelgrass beds in North Bay (as defined using the 2009 eelgrass categories) and total eelgrass resources in North Bay (Table 4). As shown in Table 4, eelgrass density reduction would be 5.0 percent when looking only at eelgrass in the culture area, 1.7 percent when considering actual eelgrass bed area (shellfish culture area and contiguous eelgrass beds), and 0.9 percent when looking at all eelgrass in North Bay. It is also worth noting that these estimates are based on empirical observation of loss directly under the longlines, which takes into account the impacts identified below regarding working practices in areas around the longlines themselves.

Table 4 Potential Eelgrass Density Reduction at Different Scales and Scenarios

Culture Type	Realistic Scenario			Increased Fouling (10x) Scenario			100% Reduction under Longlines Scenario		
	Culture Area	Eelgrass Bed Area	North Bay	Culture Area	Eelgrass Bed Area	North Bay	Culture Area	Eelgrass Bed Area	North Bay
Cultch-on-Longline	-4.7%	-1.3%	-0.7%	-10.2%	-2.8%	-1.5%	-10.1%	-2.8%	-1.5%
Basket-on-Longline	-6.6%	-0.4%	-0.2%	-11.9%	-0.6%	-0.3%	-9.5%	-0.5%	-0.3%
Total Culture	**-5.0%**	**-1.7%**	**-0.9%**	**-10.5%**	**-3.5%**	**-1.8%**	**-10.0%**	**-3.3%**	**-1.7%**

Culture Area = expansion areas with oyster longlines that overlap with eelgrass (both patchy and continuous).
Eelgrass Bed Area = eelgrass polygons that overlap with the expansion areas (both patchy and continuous) based on the NOAA (2012) data.
North Bay = total eelgrass in North Bay based on the NOAA (2012) data.

5.4 *Working Practices*

Shellfish aquaculture operations vary seasonally and annually in their interactions with the surrounding habitat. There are two types of disturbance associated with aquaculture activities: pulse disturbance and press disturbance. Short-term disturbances are known in ecology as pulse disturbances because their temporary nature allows the affected biota to recover to the previous equilibrium state. This is contrasted with press disturbances, which are long-term in both duration and effect, and require the system to reach a new equilibrium (Bender et al. 1984). In general, shellfish aquaculture along the West Coast has been characterized as resulting in pulse disturbances (Rumrill and Poulton 2004, Wisehart et al. 2007, Tallis et al. 2009, Dumbauld and McCoy 2015).

Working practices during harvesting and general access of shellfish plots can lead to such pulse disturbances to eelgrass beds. The literature described below includes potential effects on eelgrass (or seagrass) directly and habitat in general from a range of anthropogenic activities including: (1) propeller scarring, (2) anchoring, (3) trampling, and (4) boat wakes.[5]

5.4.1 Propeller Scarring

The dominant method for site access is via flat-bottomed boats (or skiffs). Boat access can result in potential negative impacts to eelgrass shoots through propeller damage. Ruesink et al. (2012) conducted experimental treatments in Willapa Bay, Washington representative of two disturbance types associated with propellers: shoot damage and shoot removal. For the most part, the extent of damage from boat propellers is limited to cutting off the ends of the shoots (i.e., shoot damage).

[5] Please note that these impacts address only changes to eelgrass directly. Changes associated with the benthic community or other aquatic organisms are addressed within the Biological Resources Technical Report (Appendix E of the DEIR).

Regrowth for eelgrass that is only damaged on the surface requires branching of the plant to replace the lost biomass. In the Ruesink et al. (2012) study, growth rates of eelgrass affected by shoot damage recovered within 2 months following a single cutting event when the rhizome was still rooted. There would be no long-term damage in terms of eelgrass density for this type of action.

Shoot removal through uprooting or damage to eelgrass rhizomes was also evaluated, which represents the potential for longer term impacts. These impacts were calculated based on an accumulation of shoot removal over a year or more (e.g., propeller damage from consistent access routes). The removal area can be repopulated by rhizome extension from shoots at the edge (asexual reproduction) or germination of seeds (sexual reproduction). Ruesink et al. (2012) indicated that 4 m^2 gaps in eelgrass beds recovered in 2 years in Willapa Bay, which has high sexual reproduction potential (e.g., 20% to 56% of new shoots in experimental plots were from seedling production). Comparatively, Boese et al. (2009) reported up to 4 years of recovery time in Yaquina Bay within 4 m^2 plots because recovery was primarily accomplished through rhizome expansion and natural seedling production appeared to play no role in recovery.

Other studies with different species of seagrasses have reported even longer recovery times from shoot removal. In a study in Cockroach Bay, in the southeastern portion of Tampa Bay, Florida, Dawes et al. (1997) reported that recovery of turtle grass (*Thalassia testudinum*) took 2.3 to 8.5 years (mean = 4.3 years) in existing propeller scars and 2.3 to 10 years (mean = 7.6 years) in areas where shoots were experimentally removed from 1.5 m^2 trenches. The slow recovery of turtle grass is linked to the fact that it is a clonal species, sensitive to disturbance, and rhizome extension is the primary form of reproduction. Further, natural stressors (e.g., depressed salinities) were suspected to be the main cause in the wide range of rates of recovery from propeller damage in the Tampa Bay study. It should also be noted that propeller scars were observed using aerial photography in Tampa Bay due to continuous disturbance events. Humboldt Bay does not exhibit evidence of propeller scarring of eelgrass associated with aquaculture activities, and Coast's operational practices are aimed at avoiding or reducing impacts to eelgrass (e.g., using small skiffs to access shellfish beds when the area is inundated, anchoring larger vessels outside of eelgrass beds, and using a longline harvester that can be used when the area is inundated).

Eelgrass in Humboldt Bay appears to reproduce by a combination of sexual and asexual reproduction (Neely 2014). Therefore, recovery is likely similar to that reported by Ruesink et al. (2012) for Willapa Bay. Based on a recovery rate of 2 years for a 4 m^2 area where shoots are totally removed, the lost biomass from a propeller scar width of 1 m (or 3 ft) could be replaced in approximately 0.9 years. However, if rhizomes are still rooted and only shoot damage occurs, regrowth would be expected to occur within 2 months. As stated above, aerial photography in Humboldt Bay does not indicate that the eelgrass beds are being damaged by propellers on a continuous basis, so it appears that no significant loss in biomass is occurring or likely would occur.

5.4.2 Anchoring

When shellfish operators access oyster plots at high tide, boats may need to be anchored while work is performed. One study in Port-Cros National Park in France found that Brittany-type anchors with 10 m of chain and an electric windlass dropped into Neptune grass (*Posidonia oceanica*) resulted in an average of 34 uprooted or broken shoots per m^2 during each anchoring cycle (Francour et al 1999). Fragmentation of seagrass beds was positively correlated with moderate anchoring pressure (0.9 boats/day/2500 m^2), and recovery was evident after 3 years. It should be noted that successful recovery of Neptune grass is accomplished by vegetative growth rather than seed production and seedling establishment (Marba et al. 1996 *as cited in* Milazzo et al. 2004). Therefore, this study and recovery potential is more closely related to effects to turtle grass rather than eelgrass.

In contrast to the Francour et al. (1999) study, another study in a Neptune grass bed reported that damage from boat anchors ranged from 1.8±0.2 to 5.5±3.5 shoots per m^2 during each anchoring cycle (Milazzo et al. 2004). The main difference between the two results was that the Francour et al. (1999) study used larger boats with heavier anchors (12 kg) compared to anchors weighing 4 kg with 3 m of anchor chain. The main conclusion of the Milazzo et al. (2004) study was that: "In sites mainly frequented by small boats using light anchors…it could be important to implement a self-regulatory approach (Antonini and Sidman 1994) based on educating and informing boaters on correct anchor types to use when anchoring on *P. oceanica*, rather than enforcing restrictions on anchoring or deploying mooring buoys. Nevertheless, the use of these management strategies is still recommended in the case of anchorage frequented by bigger vessels using heavier anchors and chains (Francour et al. 1999)."

These studies can be used to understand conditions associated with the Project. There are two types of boats used by Coast: lighter skiffs and larger work boats. According to the Conservation Measures, larger work boats would be anchored in channels outside of eelgrass beds. The larger work boats have 11 to 23 kg Danforth anchors with 20 m of chain. Smaller skiffs would be used to access longlines. The lighter skiffs use 4 kg Danforth anchors with 2 m of chain. Compared to the Francour et al. (1999) study, anchoring pressure associated with Coast operations is a fraction of that studied. Currently, Coast uses approximately 8 boats/day to access its intertidal acreage, or 0.02 boats/day/2500 m^2. Even though two boats would be added to accommodate the increase in culture area, the amount of area would increase more than boat use. In other words, anchoring pressure would be reduced because there would be a much larger area covered with only a slight increase in boat use. Therefore, anchoring is considered a less than significant impact to eelgrass in North Bay.

5.4.3 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 (Figure 16), 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, with cultch-on-longline requiring approximately 1 day per month for each 10-acre area to monitor and repair lines and 2 days per acre every 1.5 to 3 years to plant and harvest. Visits occur during low tides and last for approximately 4 hours. 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 also requires daily visits, to inspect, monitor, and repair bags, but rack-and-bag culture would not be placed in eelgrass. 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. These disturbance events would be 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.

5.4.4 Harvesting

Shellfish harvest can cause localized and temporary increases in suspended sediments and physical damage and/or removal of eelgrass shoots, as well as changes to other eelgrass metrics (e.g., biomass, seed germination, growth). In terms of suspended sediments, the sediment grain size in the expansion area is primarily sand-silt-clay or clayey silt (see Figure 16), which either has higher settling velocities (sand) or would occur in eelgrass (fines), which is a suspended sediment sink. Mercaldo-Allen and Goldberg (2011) reported that suspended sediments may take 30 minutes to 24 hours to resettle in areas typical of oyster and clam aquaculture operations. More importantly, shellfish culture in Humboldt Bay occurs in shallow estuarine embayments where freshwater runoff, currents, and wind waves lead to naturally high background levels of suspended sediments (see Section 3.2.1 above). Therefore, pulse disturbances of suspended sediment by shellfish harvesting in Humboldt Bay are expected to fall within baseline measurements and the natural variability of the system.

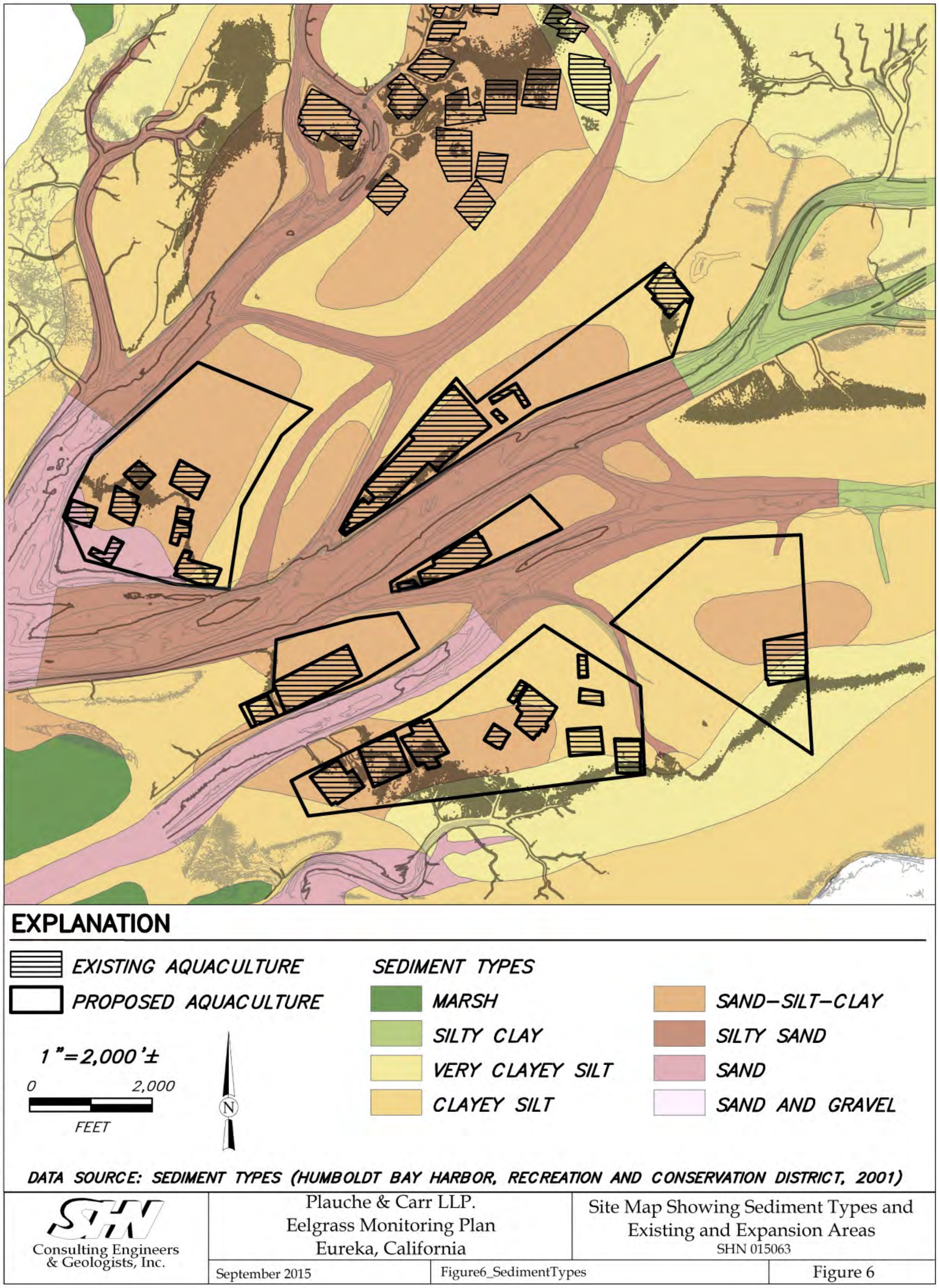

Figure 16 Sediment Types within the Existing Culture and Proposed Expansion Areas.

Source: SHN (2015); Notes: Black outline represents different growing areas. Hatched polygons represent growing area expansion.

Tallis et al (2009) compared eelgrass densities in areas associated with longline culture. The authors reported that eelgrass in longline areas typically occurred at densities "indistinguishable from nearby uncultivated areas," although the above-ground biomass of individual shoots was consistently 32 percent lower compared to control areas. Recovery potential of eelgrass following disturbance was related to site-specific conditions and the potential for seed dispersal into the disturbed areas. Tallis et al. (2009) pointed out that effects to eelgrass from aquaculture occurred in both directions (positive and negative), and the magnitude of effects observed were dependent on the site and type of harvest methods used. While the authors suggested that it is impossible to incur no effect when oyster aquaculture takes place in an eelgrass bed, they also indicated that there are ample opportunities for decreased impact with tailored culture methods and timing. Many of the culture practices employed by Coast (see Section 2.5) are aimed at avoiding or minimizing impacts to eelgrass.

5.5 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).

5.6 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 forlarval 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.

5.7 Scouring and Sediment Accumulation

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.

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. Typically, the detection limit for this type of study is 80 mm (Hannam and Mouskal 2015), which indicates that the change observed by Rumrill and Poulton (2004) is minor. 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.

5.8 Resilience of the System

Holling (1973) defined resilience as "a measure of the ability of these systems to absorb change of state variables, driving variables, and parameters, and still persist." Native eelgrass exhibits a stable and possibly increasing trend in distribution and abundance in areas like Willapa and Humboldt bays where oysters have been commercially farmed for over 100 years (Barrett 1963, Tallis et al. 2009, Dumbauld et al. 2011). In evaluating the resiliency of eelgrass in Humboldt Bay, it is important to consider whether the impacts from shellfish aquaculture are more important than limiting factors at the landscape scale (e.g., water quality conditions).

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. As described in Section 3.3, 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 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.

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), the limited Project effects to eelgrass density will not result in measurable or appreciable changes to overall eelgrass resources 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.

5.9 Duration of Impacts

Previous research in Humboldt Bay indicates that eelgrass is highly resilient to impacts associated with shellfish aquaculture. Between 1997 and 2006, ground culture areas that were mechanically dredge harvested[6] were replaced with off-bottom oyster longlines. Rumrill and Poulton (2004) studied the effects of this change in culture methods between August 2001 and August 2003. The study installed oyster longline plots at four densities within growing areas that had recently been disturbed by dredge harvest (Figure 17). The study results indicated that when spacing between cultch-on-longlines was wide (5 ft) or very wide (10 ft), eelgrass recovery was not interrupted. The authors also noted that eelgrass began to expand and recover within the two-year study within all of the longline plots.

Aerial images of North Bay provide additional visual representations of the Rumrill and Poulton (2004) work and extend observations beyond the 2003 data collection. Images of the East Bay growing area appear to show regrowth of eelgrass within two representative areas (Figure 18). In the first, in the

6 Dredge harvesting has been discontinued in Humboldt Bay and would not be permitted under the Project.

northeast (white circle), the scars[7] from the former dredge harvest locations are indistinguishable from the surrounding environment by December 2005. While the tide level in 2005 was not as low as the May 2003 image, and eelgrass would have been near a seasonal low in December, the scars in this area remained indiscernible from the surrounding area in October 2010. This area is within continuous eelgrass beds which typically provide active seed dispersal to increase recovery potential.

7 Areas recently dredged appear as lighter-colored circular areas within North Bay. These circular dredge areas are sometimes referred to as "scars," and typically have little-to-no vegetation. Over time, the scars become darker as vegetation regrows.

Figure 17 **Image of Oyster Longline Study Plots Taken 2 Years after Mechanical Dredge Harvesting to Longline Conversion.**
Source: Rumrill 2011.

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Figure 18 Historical Aerial Photographs from May 2003 through August 2012 of the East Bay Growing Area within Humboldt Bay.
Source: GoogleEarth 2015; Notes: yellow circle = former dredge harvest areas along patchy eelgrass habitat; white circle = former dredge harvest areas in continuous eelgrass.

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In the second area in the southwest corner (yellow circle), the scars are much less visible by August 2004 but still present. Oyster longlines were installed at 5 lines spaced 2.5 ft apart with 5 ft spaces between groups of 5 lines in the area shown in the October 2010 image. The planted longlines appear to have slowed eelgrass recovery. This area is also within patchy eelgrass, which does not typically have as much seed dispersal potential as continuous beds. However, by August 2012, the longlines are visible, but the area is more continuous with the surrounding vegetation, thereby exhibiting additional eelgrass regrowth in the area as compared to the October 2010 imagery.

The results of the Rumrill and Poulton (2004) work, and the historical aerial image analysis, indicate that oyster aquaculture and eelgrass bed success are not mutually exclusive. Eelgrass can re-establish and grow within oyster longline culture. Even within more closely-spaced longlines (2.5 ft), eelgrass recovery occurs but is slower compared to the wider spacing. If there is successful recovery of eelgrass in the presence of active oyster aquaculture, then the continued success of an eelgrass bed with the addition of cultch-on-longlines, particularly at the proposed wider spacing, is a likely outcome.

6.0 CUMULATIVE IMPACTS

Boström et al. (2006) conducted a meta-analysis of the scientific literature associated with plant-animal interactions in seagrass landscapes. According to this analysis, the authors indicated that, "[t]he growth and recruitment dynamics of seagrasses as well as man-made and/or natural disturbances create complex spatial configurations of seagrass over broad (metres to kilometres) spatial scales. Hence, it is important to identify mechanisms maintaining and/or threatening the diversity-promoting function of seagrass meadows and to understand their effects on benthic populations and communities." It is well recognized that there are a variety of natural and anthropogenic stressors on eelgrass (Dennison 1987, Fonseca and Bell 1998, Shaughnessy et al. 2004, Boese et al. 2005, Mumford 2007, Thom et al. 2011, Stevens and Lacy 2012).

6.1 Shellfish Aquaculture in Humboldt Bay

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 71 raft type structures in subtidal areas (35 rafts managed by Coast) and approximately 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 19). Approximately 93 percent of existing intertidal culture is in eelgrass (see Figure 13), of which the majority (84%) is considered patchy eelgrass. It is important to note that existing culture areas were originally planted adjacent to eelgrass and were colonized by eelgrass after shellfish structures were added (Dale, pers. comm., 2015). There is no way to determine whether eelgrass colonization was a result of the added structure or in spite of the structure, but it is relevant to note that eelgrass habitat and longline aquaculture have co-existed in Humboldt Bay for 18 years since Coast began the conversion from ground culture 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, which would include approximately 266 acres of intertidal culture. The 266 acres of intertidal culture would overlap with approximately 110 acres of non-eelgrass habitat, 149 acres of patchy eelgrass, and 7 acres of continuous eelgrass. Finally, Hog Island Oyster Company (Hog Island) and Taylor Mariculture LLC (Taylor Mariculture) have also recently obtained regulatory approvals to add 21 culture rafts in subtidal areas (15 FLUPSY rafts and 6 nursery rafts). The FLUPSYs and nursery rafts would not affect eelgrass habitat, and are specifically sited to avoid interactions with eelgrass.

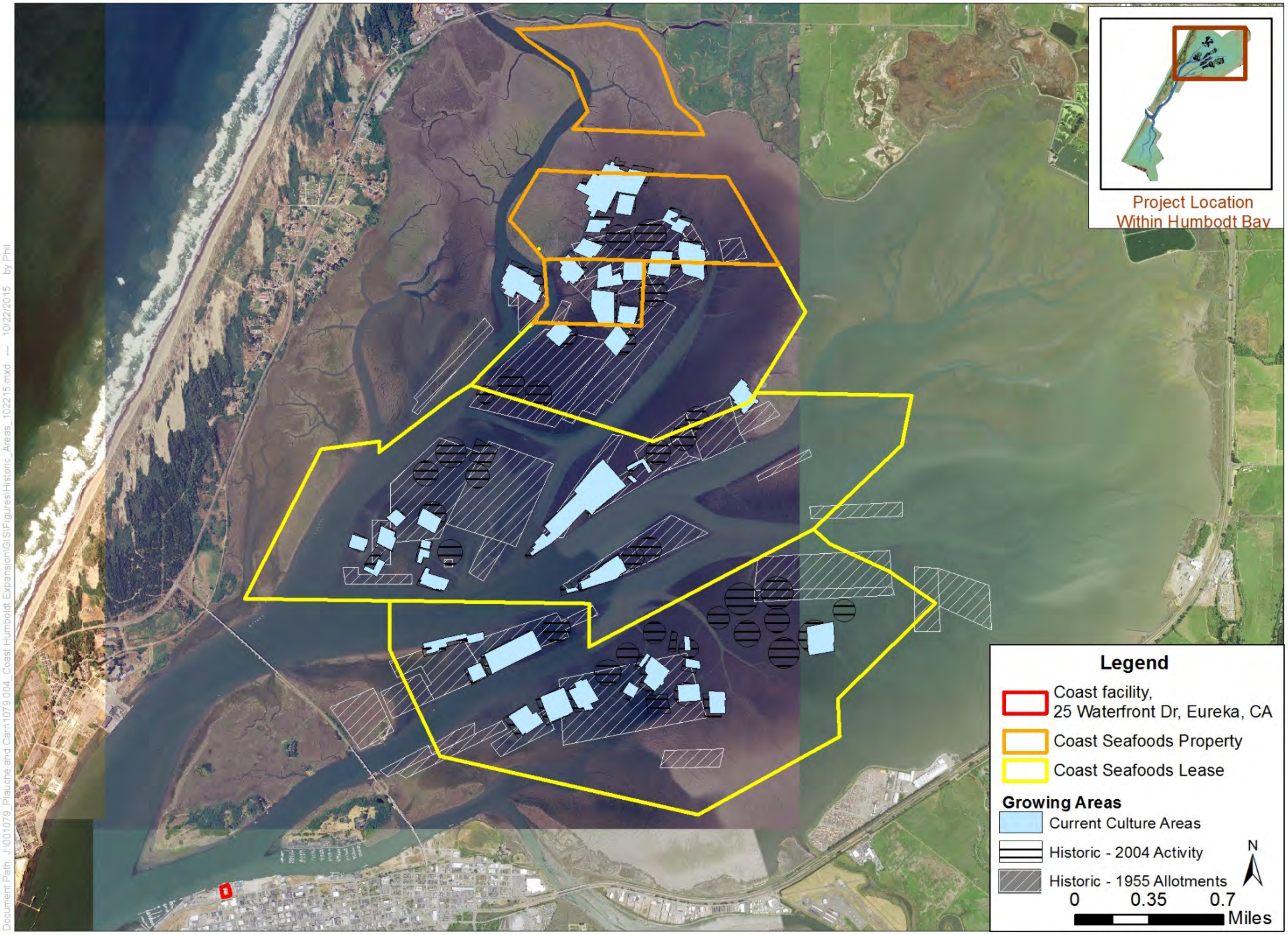

Figure 19 **Current and Historic Cultivation Areas Associated with the Coast Seafoods Lease Area.**
Source: GIS layers provided by Wagschal, pers. comm., 2015.

The cumulative amount of potential overlap with eelgrass habitat from existing culture, the Project, and the Pre-Permitting Project represents approximately 27 percent of North Bay eelgrass and 14 percent of intertidal habitat in North Bay overall (Figure 20). As discussed above, the Project would potentially result in a reduction of eelgrass density that equates to 1.7 percent of eelgrass bed habitat in North Bay (see Section 5.3.2). The Pre-Permitting Project constitutes 30 percent of the proposed culture in North Bay and is primarily sited in patchy eelgrass areas. The Harbor District is preparing its Final EIR for the Pre-Permitting Project and will be required to mitigate for significant impacts to eelgrass habitat associated with its activities; therefore, the Pre-Permitting Project is not likely to significantly contribute to overall cumulative effects to eelgrass habitat.

6.2 Comparison to a Large-Scale Study

The amount of shellfish aquaculture in Humboldt Bay and potential cumulative impacts to eelgrass are similar in scale to those studied in a large-scale study conducted in Willapa Bay, Washington (Dumbauld and McCoy 2015). Willapa Bay is similar to Humboldt Bay in many respects. For example, it has a large tidal exchange, well-mixed water column, is relatively shallow (62% is intertidal out of 88,464 acres total), and has nine small rivers contributing to the total watershed. Most importantly, Willapa Bay has a large eelgrass meadow on 27 percent to 38 percent of the intertidal habitat (~15-20,000 acres) at a similar tidal elevation as existing oyster aquaculture. Oyster aquaculture occurs on up to 22 percent (12,340 acres) of the intertidal habitat in Willapa Bay, with a significant overlap occurring with eelgrass habitat.

Dumbauld and McCoy (2015) modeled eelgrass density in Willapa Bay, Washington. A number of parameters were modeled, including: (1) distance to mouth, (2) distance to channel, (3) salinity, (4) elevation, (5) cumulative wave stress, and (6) shellfish aquaculture. The model results indicated that eelgrass density was lower in oyster aquaculture beds, but the impact directly associated with aquaculture represented less than 1.5 percent of the total predicted eelgrass in Willapa Bay.

Aside from the overall low amount of impact at the landscape scale, the Dumbauld and McCoy (2015) study also indicated that the type of disturbance was a significant predictor in explaining eelgrass loss. For example, mechanically harvested beds had a significantly lower amount of eelgrass compared to beds harvested by hand or with a mixed harvest technique. Comparatively, the type of aquaculture (e.g., longline, seed bed, fattening ground) was not a significant contributor to the variation of eelgrass predicted versus actually observed. The authors suggested that, overall, aquaculture resulted in a minor change to eelgrass at the landscape scale because the effect of culture was variable enough at smaller spatial scales so as to eliminate a significant effect at the landscape scale.

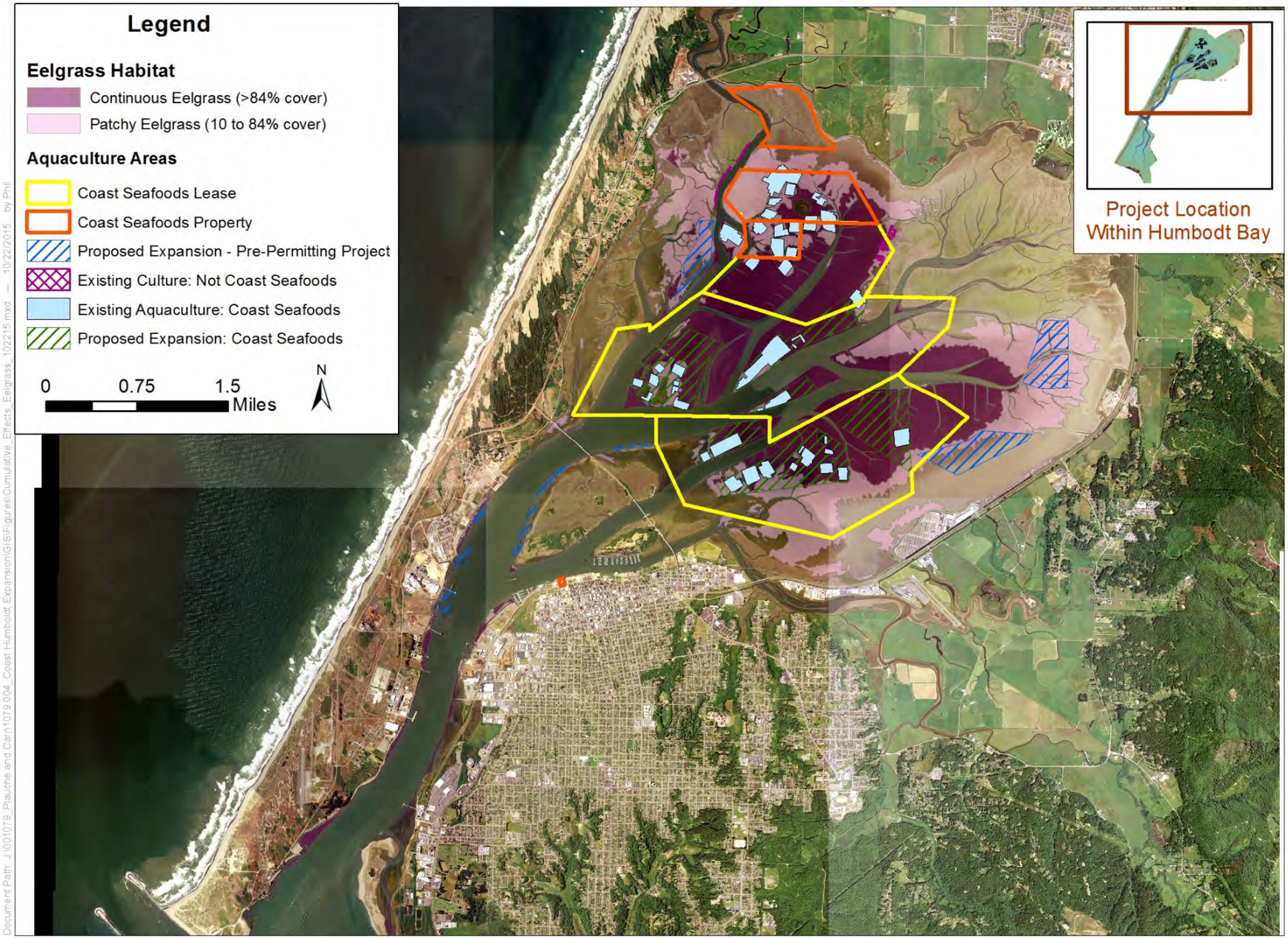

Figure 20 Existing and Proposed Shellfish Aquaculture in Humboldt Bay.
Source: GIS layers provided by Wagschal, pers. comm., 2015.

6.3 Cumulative Impacts to Ecological Functions

While there are impacts to eelgrass from shellfish aquaculture, there are also important ecological functions provided. According to Forrest et al. (2009), "the acceptability of aquaculture operations or new developments should recognize the full range of effects, since adverse impacts may be compensated to some extent by the nominally 'positive' effects of cultivation." The discussion below provides an introduction to the concept of ecological function, which is more thoroughly discussed in both the Biological Resources Technical Report (Appendix E of the DEIR) and the Estuarine Habitat Credit-Debit Mitigation Accounting Framework developed for the Project (Appendix B of this report).

Structured habitat is often associated with higher species diversity for benthic invertebrates but not directly for mobile species. 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. However, the authors went on to say 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." This is important because these mobile species use a mosaic of habitats, and one habitat is not necessarily more important than others as long as there is a diversity of habitat provided.

Additional work by Dr. Hosack and others helps to further illustrate this point. Hosack (2003) reported that important fish prey organisms, such as harpacticoid copepods, exhibited an inverse trend with higher densities in both continuous eelgrass and oyster habitats. These observations parallel those of Ferraro and Cole (2011, 2012), who studied oyster bottom 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 mudflat or sandy habitats. This serves to illustrate the relative importance of eelgrass *and* shellfish-rich habitat in coastal estuaries as refugia and a source of prey for foraging nekton and other marine life.

A recent manuscript by Dumbauld et al. (*in review*[8]) ties these concepts together. The study objective was to identify whether intertidal oyster aquaculture in Willapa Bay 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 that were found over low intertidal habitats were not dependent on structured habitat (e.g., eelgrass or oyster aquaculture) for prey items. Chum salmon, a typically smaller fish during estuarine residency, was the possible exception. The final conclusion by Dumbauld et al. (*in review*) was that:

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

> 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 outmigrants may pose a less significant threat to maintaining resilience of these fish populations.

Increased diversity and nursery habitat provided by both eelgrass and oyster habitat is typically considered an improved ecological function compared to sand or mudflat habitat. Therefore, conversion of mud or sandy habitats to either eelgrass or oyster habitat represents an increase in ecological functions. The increase in ecological function provided by the placement of oysters in areas of mud or sandy habitat should be considered as an improved condition or passive mitigation, similar to how the transplant or expansion of eelgrass into mud or sandy habitats would be considered an improved condition or serve as mitigation. As noted in the frequently asked questions section of the CEMP, prepared by NMFS, "[w]e acknowledge that some aquaculture activities may be beneficial or neutral with respect to eelgrass. Activities that empirically demonstrate wholly neutral or beneficial impacts to eelgrass habitat should not be subject to compensatory mitigation for eelgrass."

The Project is providing compensatory mitigation for potential effects to eelgrass regardless of whether there is a change to ecological functions (see Section 8.0). The short-term impacts associated with shellfish aquaculture would be outweighed by the long-term net benefits provided by shellfish and the proposed mitigation associated with the Project. Further, any identified significant impacts to eelgrass associated with the Pre-Permitting Project will require mitigation compliant with the CEMP and U.S. Army Corps of Engineers (Corps) regulations. Therefore, potential cumulative impacts will be fully mitigated and net ecological functions of the Humboldt Bay watershed would be improved because of these efforts.

7.0 ALTERNATIVES

The CEQA Guidelines require that Project Alternatives be feasible, attain most of the basic Project objectives, and avoid or substantially lessen any of the significant environmental impacts of the proposed Project. An Alternatives Analysis compares the merits of the Alternatives.

Effects to eelgrass and other biological resources that use eelgrass habitat was the primary screening criteria for the scope of the Alternatives. While the proposed Project is not expected to result in significant effects to eelgrass and species that use eelgrass habitat (see Appendix E of the DEIR), eelgrass is an important resource both socially and environmentally in Humboldt Bay. Therefore, the following range of Alternatives focusses on reducing potential impacts to eelgrass habitat.

7.1 Description of Project Alternatives

There are four proposed Project Alternatives: (1) 10 Ft Spacing Alternative, (2) Reduced Expansion Alternative, (3) Existing Footprint Alternative, and (4) No Action Alternative. These Alternatives are described below.

7.1.1 Alternative 1: 10 Foot Spacing

Under Alternative 1, Coast would renew regulatory approvals for its existing shellfish culture activities and add an additional 955 acres of intertidal longline oyster culture using 10 ft spacing between longlines (Figure 21). The amount of culture type within the expansion area would include 802 acres (84%) of cultch-on-longline and 153 acres (16%) of basket-on-longline/rack-and-bag culture. Similar to the preferred Alternative (the Project), rack-and-bag culture would not be placed within 10 ft of eelgrass.

Coast would also seek regulatory approval to add eight new upwelling bins to its existing FLUPSY. This would allow Coast to increase its oyster production to a level almost equal to that anticipated under the Project, while using a more conservative longline spacing regime. However, it is expected that some oyster production would be sacrificed by adopting a 10 ft spacing regime, as Coast would not be able to install as many longlines as under the Project. Further, the additional planted acreage may not be as suitable for oyster cultivation due to tidal elevation and other variables and thus may be less productive than areas identified for expansion under the Project. In addition, while 10 ft spacing would be more protective of eelgrass, the expansion area would be 333 acres larger than under the Project and the majority of this additional cultivated acreage would overlap with patchy and continuous eelgrass beds.

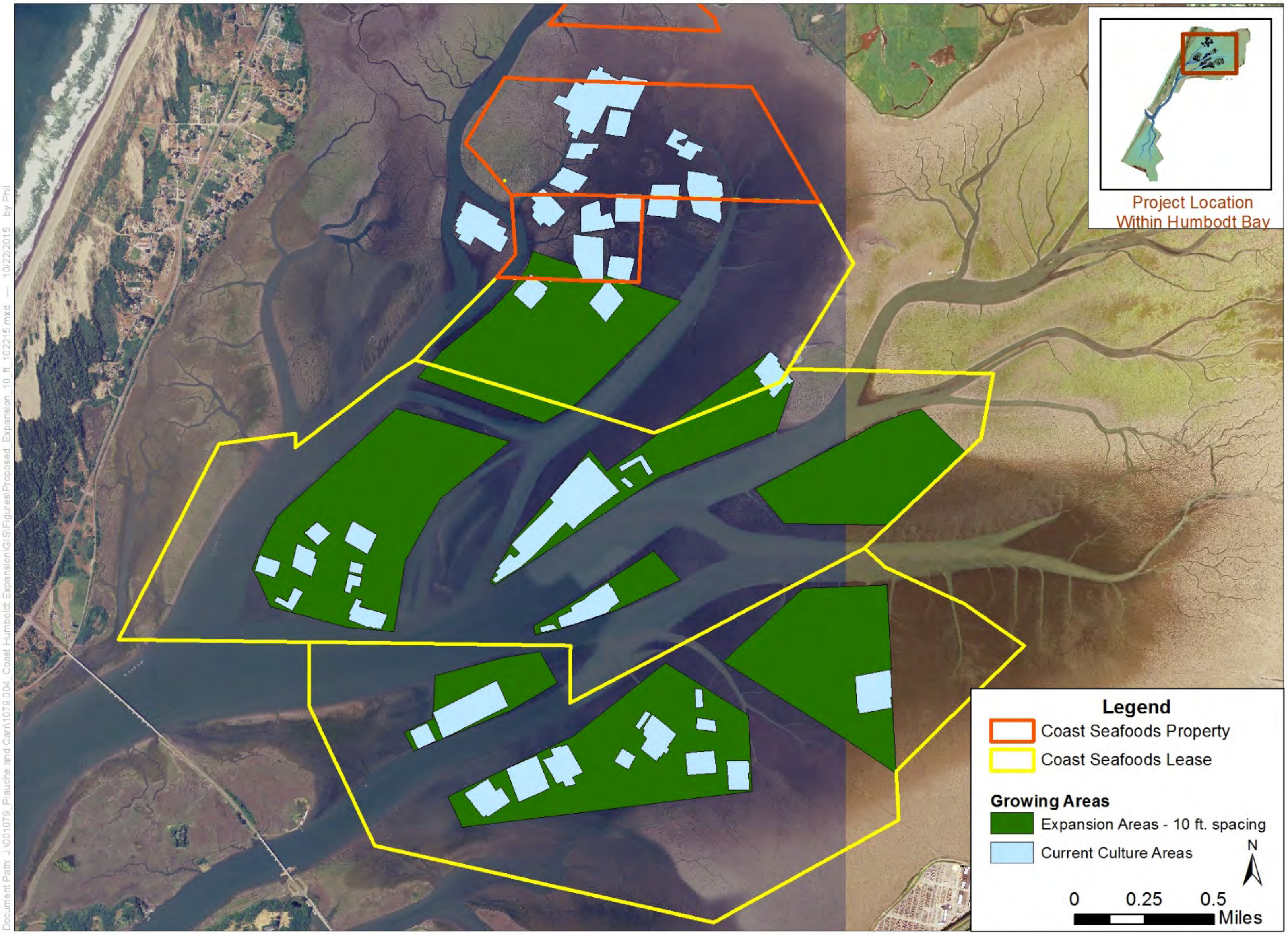

Figure 21 Areas Proposed for Continued and Expanded Shellfish Culture under Alternative 1 (10 ft Spacing)
Source: GIS layers provided by Wagschal, pers. comm., 2015.

7.1.2 Alternative 2: Reduced-Acreage

Under Alternative 2, Coast would renew regulatory approvals for its existing shellfish culture activities and add an additional 300 acres of intertidal longline oyster culture using 5 ft spacing between longlines (Figure 22). The amount of culture type within the expansion area would include 200 acres (67%) of cultch-on-longline and 100 acres (33%) of basket-on-longline.

Coast would also seek regulatory approval to add eight new upwelling bins to its existing FLUPSY. As with the Project, Coast would utilize 5 ft spacing between longlines in the proposed expansion areas. No additional culture would be placed in Indian Island and culture in all other proposed expansion areas would be reduced. Because this Alternative uses 5 ft spacing on a reduced expansion footprint, it would restrict Coast's ability to increase oyster production consistent with market demand and would significantly decrease the economic benefits of the Project.

7.1.3 Alternative 3: Existing Footprint

Under Alternative 3, Coast would renew regulatory approvals for its existing shellfish culture activities but would not seek to permit additional intertidal culture in Humboldt Bay (Figure 23). As such, the environmental baseline for the Project would not change. While this Alternative would be more protective of eelgrass, it would not meet the Project objectives.

7.1.4 Alternative 4: No Action

The No Action Alternative would prevent cultivation expansion by Coast under this Project and result in the non-renewal of Coast Seafood's existing permits for sites included in this application. Cessation of all related cultivation activities would occur and all present infrastructure would be removed. This Alternative is the most environmentally conservative but would not accomplish Project objectives. In addition, as discussed more fully below, removal of existing culture equipment would have potentially significant impacts on existing eelgrass beds and on other biological resources.

7.2 Summary of Potential Eelgrass Impacts by Alternative

Additional information describing potential impacts is also provided below by Alternative.

7.2.1 Conservation Measures

Many of the Conservation Measures used to avoid or minimize direct and indirect impacts are similar between the first three Alternatives since the type of action is similar. Table 5 summarizes the Conservation Measures proposed, and if they are associated with specific Alternatives.

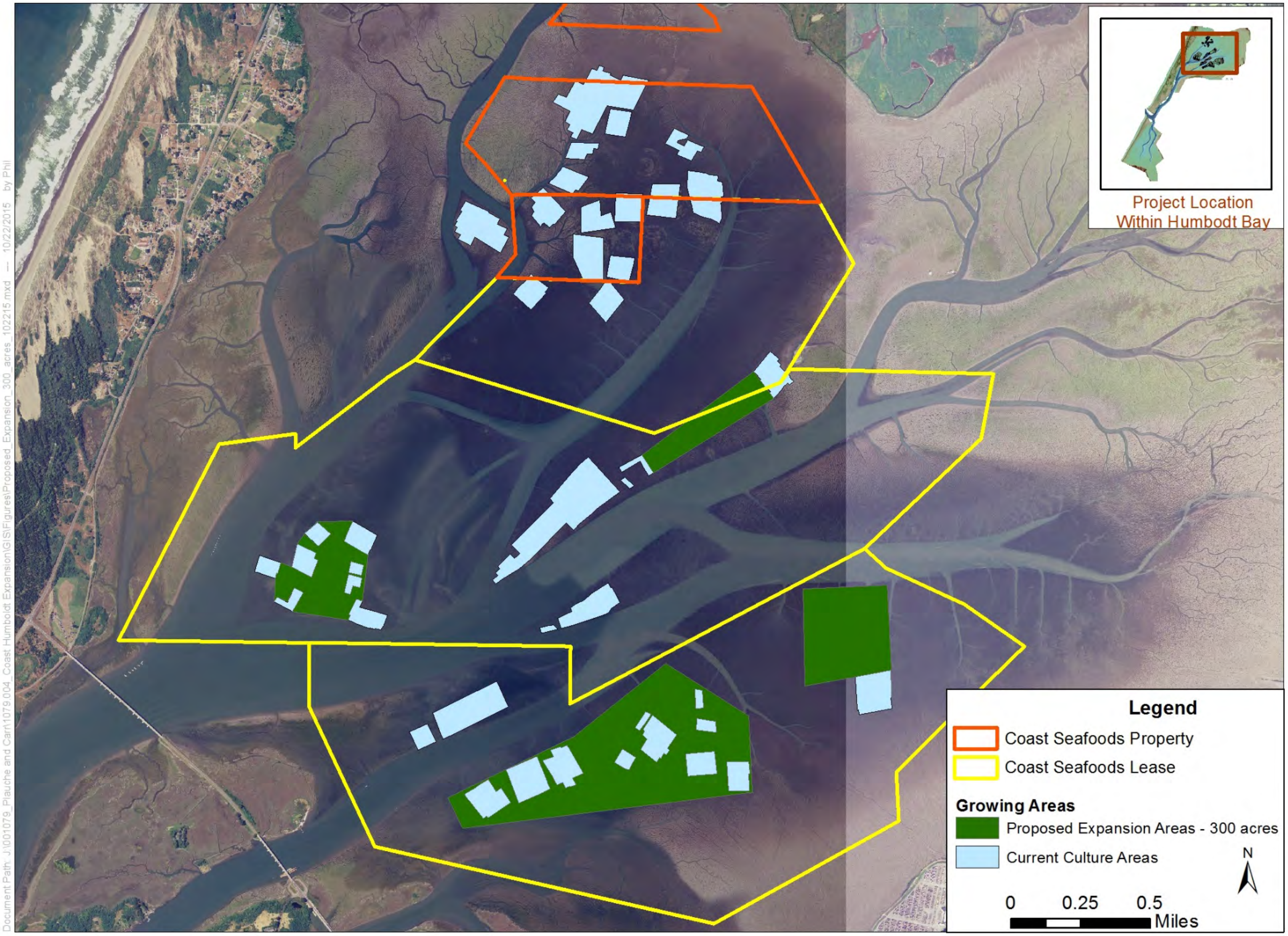

Figure 22 **Areas Proposed for Continued and Expanded Shellfish Culture under Alternative 2 (Reduced-Acreage).**
Source: GIS layers provided by Wagschal, pers. comm., 2015.

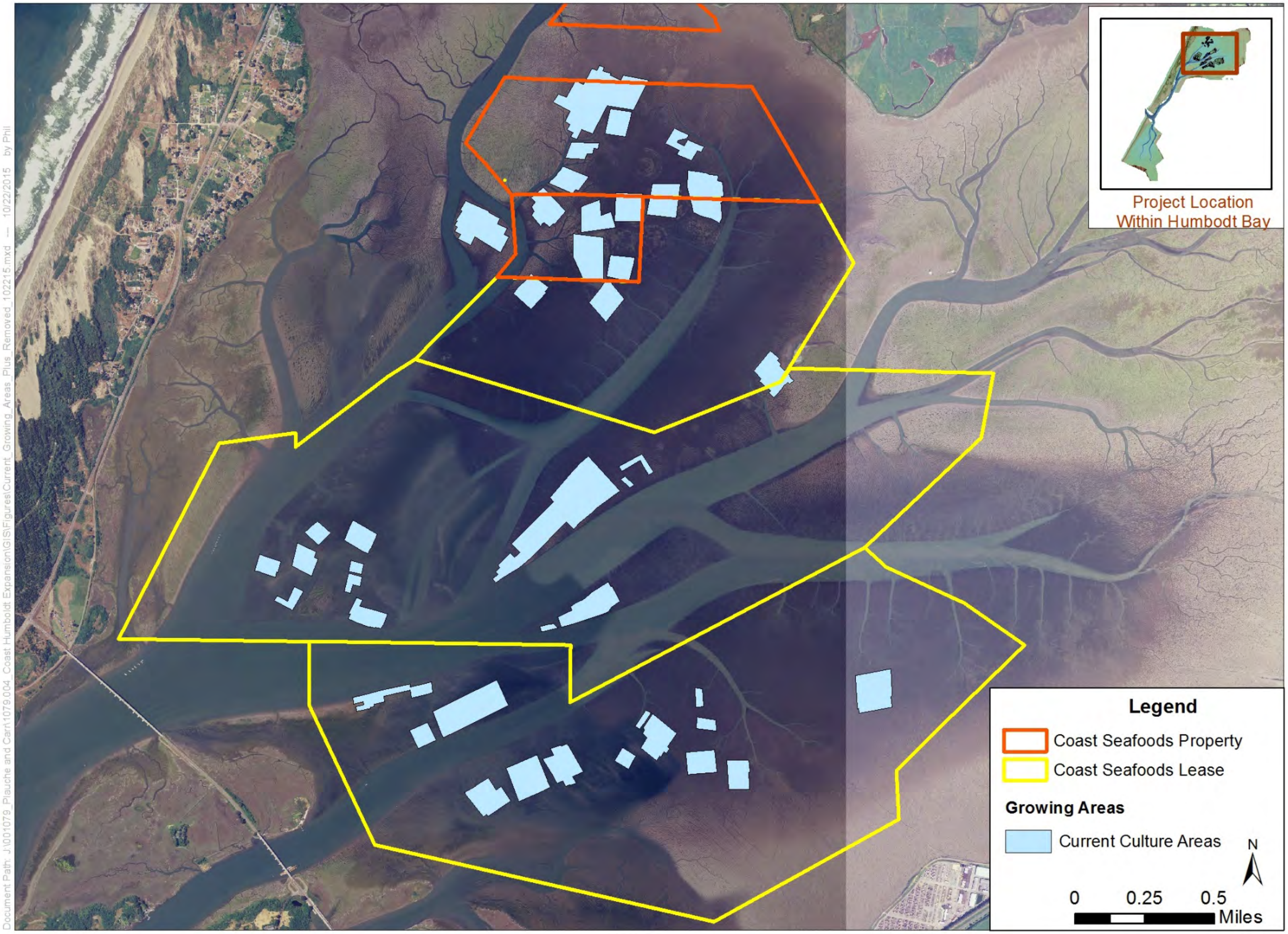

Figure 23 Areas Proposed for Continued Shellfish Culture under Alternative 3 (Existing Footprint).
Source: GIS layers provided by Wagschal, pers. comm., 2015.

Table 5 Summary of Conservation Measures by Alternative

Conservation Measures	Alternative			
	Project	1	2	3
No change to existing culture would occur.				✓
Existing culture would not change, with the exception of removal of 5.5 acres of subtidal culture.	✓	✓	✓	
Cultch-on-longline spacing would occur at 5 ft intervals, which results in 84 lines/acre.	✓		✓	
Cultch-on-longline spacing would occur at 10 ft intervals, which results in 44 lines/acre.		✓		
Basket-on-longline spacing would occur at 5 ft intervals for a group of 3 baskets and then a 20 ft gap between groups, which results in 48 lines/acre.	✓		✓	
Basket-on-longline spacing would occur at 10 ft intervals for a group of 3 baskets and then a 20 ft gap between groups, which results in 24 lines/acre.		✓		
Except for existing culture areas, rack-and-bag culture methods would not be used in eelgrass habitat including a 10 ft unvegetated buffer.	✓	✓		
The 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.	✓	✓	✓	✓
No anchoring the longline harvester would be done as to shade the same area of eelgrass for a period exceeding twelve hours.	✓	✓	✓	✓
No intentional deposition of shells or any other material would occur on the sea floor.	✓	✓	✓	✓

7.2.2 Direct Impacts

As described above, gear and shellfish products associated with longline aquaculture can lead to shading, abrasion, and desiccation of eelgrass blades. The type and concentration of gear can influence the level of this effect, which is why the Alternatives include an analysis of impacts under different spacing regimes. Potential impacts from shellfish aquaculture gear and products will be discussed according to areal extent and eelgrass density by Alternative. In addition, a short discussion of working practices is also provided by Alternative. Because existing aquaculture is part of the baseline against which these potential impacts will be discussed, there will be no change associated with the Alternatives Analysis for existing aquaculture areas. However, the No Action Alternative includes a number of construction activities that are not associated with other Alternatives.

Change in Areal Extent

As discussed above (Section 5.3.1), there does not appear to be a change in areal extent of an eelgrass bed by adding oyster longlines at 5 ft and 10 ft spacing. Therefore, this potential impact would not change based on the Alternatives proposed. As described for the Project, potential changes to areal extent will be verified through a robust monitoring plan pre- and post-Project implementation (SHN 2015). If changes to the areal extent are observed, Coast would mitigate for these areas.

Comparatively, construction impacts associated with Alternative 4 (No Action) would likely result in a loss of areal extent from the removal of shellfish gear, particularly if Coast is required to immediately remove all shellfish gear without the implementation of Conservation Measures. This effect would likely be similar to impacts associated with mechanical dredge harvesting and recovery would vary depending on site conditions (also similar to recovery potential described in Section 5.9). Depending on the level of asexual vs. sexual reproduction, recovery would likely occur on the order of 2 to 4 years, unless construction results in sediment deposition or scouring that would alter the elevation of the bay bottom.

Calculation of Eelgrass Density Reduction

The primary difference, in terms of eelgrass habitat, between the proposed Alternatives is the size of the expansion area. The proposed expansion area of each Alternative overlaps with eelgrass habitat to varying degrees (Table 6).

Table 6 General Habitat Categories by Alternative

Alternative		Existing Culture (acres)				Expansion Area (acres)			
		Non-Eelgrass	Patchy Eelgrass	Continuous Eelgrass	Total	Non-Eelgrass	Patchy Eelgrass	Continuous Eelgrass	Total
Project	Cultch	8.5*	249.5	25.5	**283.5***	18	91	413	**522**
	Basket	0	10	1	**11**	4	17	79	**100**
	Total*	**8.5***	**259.5**	**26.5**	**294.5***	**22**	**108**	**492**	**622**
Alt. #1	Cultch	8.5*	249.5	25.5	**283.5***	39	159	604	**802**
	Basket	0	10	1	**11**	8	30	115	**153**
	Total*	**8.5***	**259.5**	**26.5**	**294.5***	**47**	**189**	**719**	**955**
Alt. #2	Cultch	8.5*	249.5	25.5	**283.5***	10	49	141	**200**
	Basket	0	10	1	**11**	5.5	24.5	70	**100**
	Total*	**8.5***	**259.5**	**26.5**	**294.5***	**15.5**	**73.5**	**211**	**300**
Alt. #3	Cultch	14	249.5	25.5	**289**	No expansion			
	Basket	0	10	1	**11**				
	Total	**14**	**259.5**	**26.5**	**300**				
Alt. #4	Cultch	14**	249.5**	25.5**	**289****	No expansion			
	Basket	0	10**	1**	**11****				
	Total**	**14****	**259.5****	**26.5****	**300****				

*Does not include the 5.5 acres to be removed from non-eelgrass habitat, as indicated in the Project Description.
**All existing culture would be removed.

Similar to the Project impacts discussed above, this analysis assumes that oyster longlines can reduce eelgrass density directly under the lines themselves, while the space between longlines would not show a reduction in density. As above, for longlines spaced 5 ft apart (i.e., Project and Alternative 2), a density reduction of 47 percent was used for cultch-on-longline areas and 70 percent was used for basket-on-longline areas. For longlines spaced 10 ft apart (i.e., Alternative 1), a density reduction of 46 percent was used for cultch-on-longline areas and 67 percent was used for basket-on-longline areas. The values used to estimate density reduction under longlines spaced 10 ft apart were based on an average of the density reduction values discussed by Rumrill (2015) from the 2001 to 2003 WRAC data and more recent data collected by SHN (unpublished data) in May of 2015. Density reduction due to gear removal was based on slightly different calculations, as described below. Table 7 provides a summary of the potential reduction in eelgrass density by Alternative.

Table 7 Summary of Potential Eelgrass Density Reduction by Alternative

Alternative		Density Reduction (%)*		
		Culture Area	Eelgrass Bed Area	North Bay
Project	Cultch*	-4.7%	-1.3%	-0.7%
	Basket*	-6.6%	-0.4%	-0.2%
	Total*	**-5.0%**	**-1.7%**	**-0.9%**
Alt. #1	Cultch*	-2.4%	-0.9%	-0.5%
	Basket*	-3.4%	-0.2%	-0.1%
	Total*	**-2.6%**	**-1.0%**	**-0.7%**
Alt. #2	Cultch*	-2.5%	-0.2%	-0.1%
	Basket*	-3.3%	-0.1%	-0.1%
	Total*	**-2.8%**	**-0.3%**	**-0.2%**
Alt. #3	Cultch	No change beyond baseline conditions.		
	Basket			
	Total			
Alt. #4	Cultch**	**-32.2%**	**-6.0%**	**-1.8%**
	Basket**	**-6.6%**	**-0.1%**	**-0.01%**
	Total**	**-31.2%**	**-4.1%**	**-1.8%**

**Only includes values for eelgrass density reduction to existing baseline conditions.*
***Width of effect was increased by 1.0 ft above other Alternatives due to site access during gear removal. Reductions associated with Alternative 4 are an estimate of impacts due to gear removal; impacts would likely be temporary (i.e., eelgrass would recolonize the areas).*

Gear removal activities would result in a higher, but temporary, impact to eelgrass density because: (1) this activity is more intensive than placing gear; (2) it would likely occur all at the same time following permit expiration; and (3) all gear would be immediately removed regardless of Conservation Measures. For this analysis, the same equations were used as presented in Section 5.3.2 to account for density reduction. However, Table 8 provides a comparison of values that were used for specific metrics compared to what was used for the calculations associated with longline presence.

Table 8 Comparison of Metrics Used to Calculate Density Reduction

Metric	Alternative: Longline Alternatives	Alternative: No Action Alternative	Justification
Width of effect (X_{WE})	▪ 0.5 ft = cultch ▪ 0.9 ft = basket	▪ 1.5 ft = cultch ▪ 1.9 ft = basket	To account for intense activity
Number of longlines (*NL*)*	▪ 84 lines/acre = 5 ft cultch ▪ 48 lines/acre = 5 ft basket ▪ 44 lines/acre = 10 ft cultch ▪ 24 lines/acre = 10 ft basket	▪ 130 lines/acre = 1 line spaced 2.5 ft apart ▪ 164 lines/acre = 5 lines spaced 2.5 feet apart then 5 ft space ▪ 48 lines/acre = 3 baskets spaced 3 ft apart with 20 ft space between groups***	To account for spacing of existing culture
% reduction under longlines (*Rdct*)**	▪ -47% = 5 ft cultch ▪ -70% = 5 ft basket ▪ -46% = 10 ft cultch ▪ -67% = 10 ft basket	▪ -83% = 1 line spaced 2.5 ft apart ▪ -58% = 5 lines spaced 2.5 feet apart ▪ -70% = 3 baskets spaced 3 ft apart	To account for spacing of existing culture

**Dale, pers. comm., 2015*
***Rumrill and Poulton 2004, Rumrill 2015, SHN unpublished data*
****Note that this is the same for baskets spaced 5 ft apart. The reason the number is the same is because the 20 ft space between the groups of baskets restricts the ability to add in another row at the 3 ft spacing.*

It is estimated that gear removal would take 3 to 6 months if everything had to be removed right away or over approximately 18 months if removed after the oysters reached market size. Continuous removal activities would result in impacts to water quality from increased turbidity, even with the use of floating silt curtains. Relatively long-term increases in suspended sediments and increased turbidity from gear removal operations also would temporarily reduce water clarity, light transmittance through the water column, and could reduce primary production by eelgrass. Depending on the tidal cycle, turbidity may not be flushed out of the bay in a short time period. Reductions in eelgrass primary production during the active growth period (April through October) also could have cascading effects on organisms associated with or dependent on eelgrass. These impacts would be limited to the year that gear is removed. The same impacts would not be associated with any of the other Alternatives or with the Project because the intensity and frequency of access would be orders of magnitude lower for general operations.

Working Practices

Trampling is the primary working practice impact that may change with the different Alternatives. For example, trampling associated with Alternative 1 (10-Foot Spacing) may become more significant based on the expanded geographical extent. However, because access would still be infrequent (e.g., 0.4 hours per acre once a month for cultch-on-longline and 12 days per acre every 4 months for basket-on-longline), this is unlikely to be a significant impact even at this broader scale. Trampling associated with Alternative 2 is anticipated to be slightly less than the proposed Project due to the reduced expansion area. However, the trampling associated with gear removal under Alternative 4 is likely to be more significant because of the intense time frame that this would have to occur (e.g., 3 to 6 months). At that scale, the impacts would be more similar to the high intensity level reported by Eckrich and Holmquist (2000) in a recreational estuary in Puerto Rico.

7.2.3 Indirect Impacts

The primary indirect impacts discussed below concerns water clarity and light penetration, which will be discussed in relation to presence of shellfish aquaculture in Humboldt Bay (e.g., Alternatives 1-3) and absence of shellfish aquaculture in Humboldt Bay (e.g., Alternative 4).

Shellfish aquaculture can result in a reduction in turbidity due to removal of phytoplankton and particulate organic matter through filtration (Peterson and Heck 2001, Newell and Koch 2004, Cranford et al. 2011). By consuming phytoplankton and particulate organic matter, shellfish increase the amount of light reaching the sediment surface that is available for photosynthesis (Dame et al. 1984, Koch and Beer 1996, Newell 2004, Newell and Koch 2004). Improvements to water clarity and light penetration can improve habitat conditions that promote the growth of eelgrass.

The removal of nutrients (especially nitrogen) through filtration can also benefit eelgrass growth by reducing epiphytes and macroalgae (Figure 24). Epiphytes (primarily diatoms) can form thick layers on eelgrass blades. This is a natural process, and important in the food chain because this layer of epiphytes is grazed by aquatic invertebrates (van Montfrans et al. 1984, Nelson and Waaland 1997). However, overproduction of epiphytes is a result of nutrient water column pollution (Williams and Ruckelshaus 1993, Hauxwell et al. 2001, Nielsen et al. 2004). Shellfish aquaculture can provide mitigation of these conditions due to water filtration and control of nutrients that promote the growth of epiphytes.

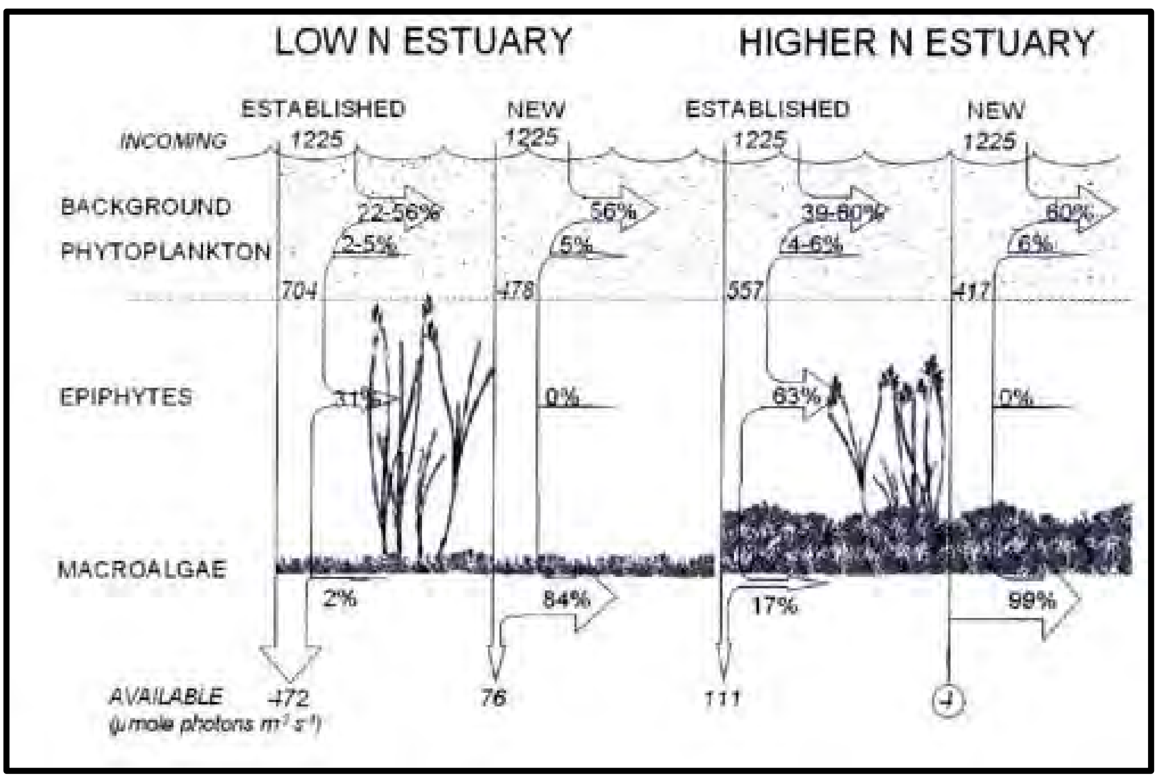

Figure 24 Illustration of Mean Summer Light Intensity Effects to Eelgrass.
Source: Hauxwell et al. 2001.

Another service potentially provided by shellfish related to epiphytes was explored by Peterson and Heck (2001). The authors observed a significantly reduced epiphytic load on seagrass leaves when mussels were present. Spaces between shells of adjacent mussels were thought to provide a predation refuge for epiphytic grazers (e.g., small gastropods and amphipods). Increased densities of epiphytic grazers could then lead to an increased amount of grazing, which consequently might lead to an increase in leaf light absorption. This study also noted that the mussels themselves may potentially reduce epiphytic loads by consuming the epiphyte propagules before recruitment to the leaves. Although likely a benefit to eelgrass, the shellfish would need to be in the eelgrass bed to provide this service for epiphytic grazers.

One of the primary indirect impacts from the No Action Alternative would be on nutrient loading and availability, particularly nitrogen and phosphorus from existing non-point sources of pollution (e.g., cattle ranches and stormwater runoff) within the watershed. One of the main ecosystem services provided by cultured shellfish is nitrogen removal. Cultured shellfish mitigate for non-point pollution sources through filtration, nitrogen sequestration, and total removal of nutrients from the system during harvest of the shell and tissue where the nutrients are sequestered (Newell et al. 2002, Newell 2004, Kellogg et al. 2013). For example, based on nitrogen sequestration values presented in Higgins et al. (2011), the harvest of approximately 2,700 tons of oysters annually by Coast results in the direct removal of approximately 219 tons nitrogen[9].

There is potentially even greater nutrient removal than this calculation. A recent paper by 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% of total standing stock) of the available nitrogen and phosphorous were sequestered in the shells of live oysters and mussels. Newell (2004) commented that bioextraction (e.g., shellfish harvest or macroalgae harvest) represents the only method of nitrogen removal once it has entered the system, which can then make that system more resilient to nutrient loading. Loss of the nutrient removal function performed by cultivated shellfish, especially in relation to the mitigation of upland sources of nutrients, could lead to eutrophication in parts of Humboldt Bay. Notably, Humboldt Bay isn't currently eutrophied, which may be at least partly due to existing cultured shellfish in the bay. However, this has not been studied.

Many researchers have identified water clarity as the most important factor limiting eelgrass distribution and abundance (Fonseca and Bell 1998, Cho and Poirrier 2005, Fonseca and Malhotra 2006). Similarly, Burkholder et al. (2007), have documented nutrient enrichment (eutrophication) as a major cause of degradation of water clarity and loss of seagrass (including eelgrass) habitat in estuaries. By consuming phytoplankton and particulate organic matter, shellfish increase the amount of light reaching the sediment surface that is available for photosynthesis (Koch and Beer 1996). The loss of the shellfish under the No Action Alternative could affect the spatial distribution of eelgrass habitat.

9 This conclusion is based on 7.9% nitrogen in oyster tissue and 0.2% nitrogen in oyster shell (Higgins et al. 2011).

However, the potential for cultured shellfish to improve conditions in West Coast estuaries may be limited (e.g., Dumbauld et al. 2009), and the benefits provided by shellfish in Humboldt Bay have not been studied.

8.0 MITIGATION MEASURES

While the Project does not exceed a threshold of significance for impacts to eelgrass habitat in Humboldt Bay, compensatory mitigation is proposed to promote the overall health of Humboldt Bay in association with the proposed Project. In considering applicant-led mitigation, the Corps' Compensatory Mitigation Rule (73 FR 19594) recognizes three potential scenarios: (1) following a watershed approach, (2) on-site/in-kind, and (3) off-site/out-of-kind. The rule suggests that when using a watershed approach, out-of-kind compensatory mitigation should be used when it will better serve the resource needs of the watershed.

Further guidance was developed in the CEMP (NMFS 2014) to help ensure mitigation satisfies regulatory needs. The CEMP indicates the following in relation to in-kind vs. out-of-kind mitigation:

> There may be some scenarios, however, where out-of-kind mitigation for eelgrass impacts is ecologically desirable or when in-kind mitigation is not feasible. This determination should be made based on an established ecosystem plan that considers ecosystem function and services relevant to the geographic area and specific habitat being impacted. Any proposal for out-of-kind mitigation should demonstrate that the proposed mitigation will compensate for the loss of eelgrass habitat function within the ecosystem. Out-of-kind mitigation that generates services similar to eelgrass habitat or improves conditions for establishment of eelgrass should be considered first.

The CEMP specifically states that out-of-kind mitigation may be appropriate for shellfish aquaculture projects. The mitigation options being pursued for the Project follow a watershed approach in the context of the potential eelgrass impacts discussed in Section 5.0 above. The goals of the mitigation options discussed below include:

- Located appropriately on the landscape
- Addresses restoration of watershed processes
- Maintains ecological functions for years to come
- Has a high likelihood of ecological success

8.1 Watershed Approach

Humboldt Bay has initiated the development of an ecosystem-based plan that considers ecosystem function and services relevant to the Humboldt Bay Ecosystem. The current iteration of this plan is enunciated in the HBI (Schlosser et al. 2009). This plan contains a goal that the 2025 eelgrass distribution and plant density remain within 20 percent of observed 2001 to 2006 levels, as measured by eelgrass acreage (areal extent) and plant density (turions/m^2). This goal appears to implicitly acknowledge that eelgrass coverage in the bay is at, or near, observed and modelled carrying capacity, having increased from an average of 3,000 acres between 1959 and 1992 to 2008/2009 estimates in excess of 5,500 acres (Gilkerson 2008, Schlosser and Eicher 2012). In addition, the HBI indicates that some level of decrease from current eelgrass estimates may occur due to natural variation and that such a change is unlikely to have significant, adverse effects to regional ecosystem health. Furthermore, of the 9 threats to the ecosystem from human activities that are identified within the HBI—climate change, invasive species, sediment, roads, development, shoreline infrastructure, forestry, urban runoff, and oil spills—none is directly associated with aquaculture.

Schlosser and Eicher (2012) compiled information regarding the historical and current distribution of habitats in Humboldt Bay. While historical estimates can be used as an indication of change from current conditions, they are often biased toward terrestrial habitats and commercially important habitats and species. That said, the data provide an important perspective on how Humboldt Bay's habitats have changed over time. For example, coastal salt marsh habitat has shown a significant reduction from an estimated 10,250 acres in 1912 to 905 acres in 2009 (Schlosser and Eicher 2012). Comparatively, the width and depth of some tidal channels was increased to accommodate vessel traffic, but the general configuration of mudflats, eelgrass habitat, and subtidal channels appears to have changed little over time.

Using the watershed approach, there is a special consideration for restoration of coastal salt marsh habitat both due to its decline from historical levels and because few sites in Humboldt Bay have the potential to migrate in response to potential sea level rise (e.g., Shaughnessy et al. 2012). Other considerations are those actions that directly protect or reduce threats to existing eelgrass beds, as identified in Section 5.0 and Figure 7 above. The following mitigation options focus on watershed-scale needs rather than exclusively depending on successful in-kind mitigation options. The pathway toward different mitigation options will depend on the mitigation accounting protocol, as discussed in Section 8.3.

8.2 Mitigation Options

Four mitigation options were identified for the Project: (1) seed bag deployment, (2) Parcel 4 public access development, (3) Elk River estuary enhancement and intertidal wetlands restoration, and (4) Hoff Parcels, Eureka, California (Figure 25). Table 9 is a summary of the major components of the mitigation options that are discussed below in more detail. Coast would propose to implement in-kind mitigation (Option 1) in combination with one of the other three options identified below.

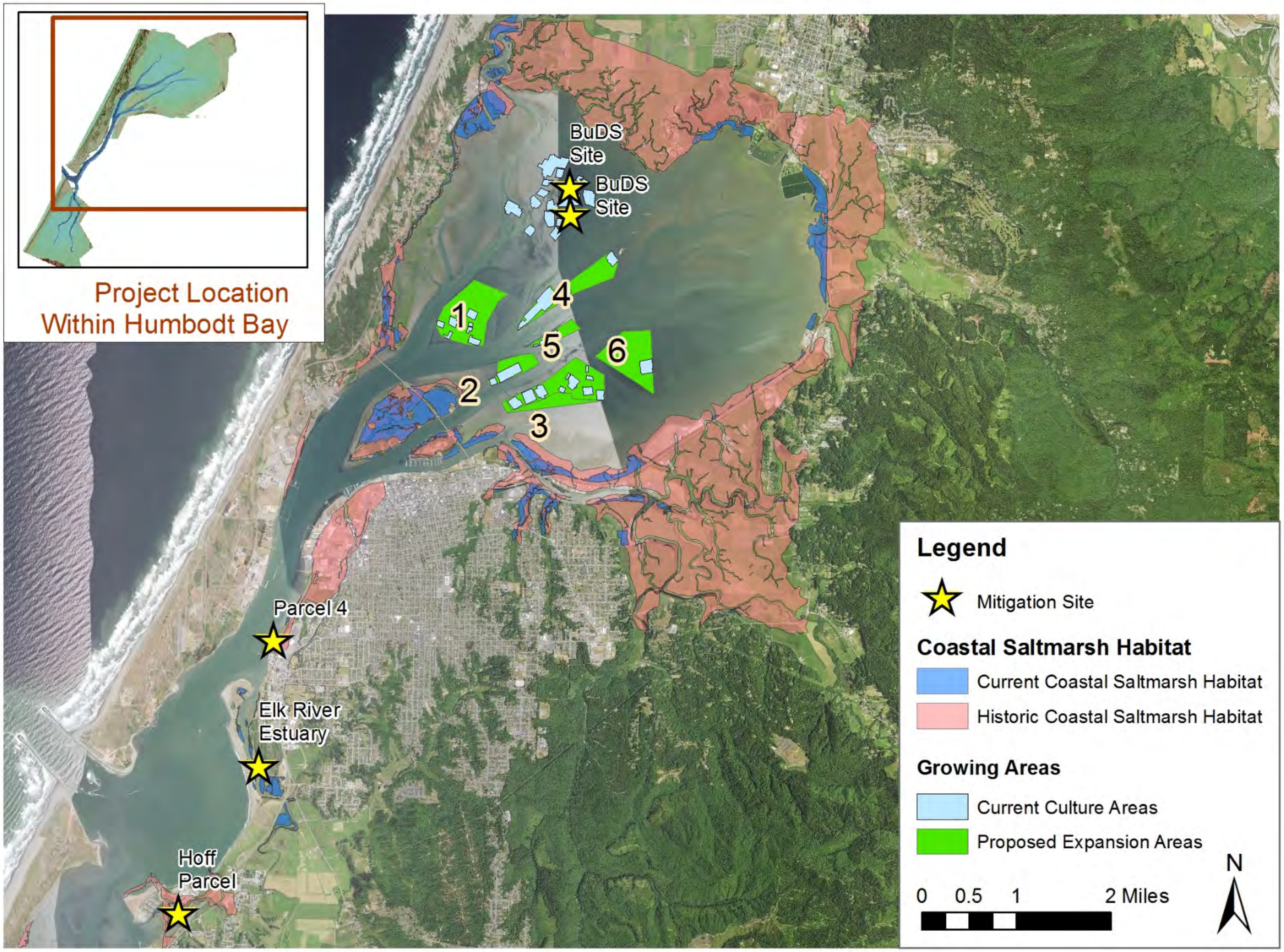

Figure 25 **Locations for Potential Habitat Restoration in Humboldt Bay.**

Table 9 Summary of Mitigation Options for the Project

Option	Name	Location	Habitat to be Modified	Potential Partners	Total Area (acres)
1	Buoy-Deployed Seeding System (BuDS)	North Bay	▪ Former dredge harvest locations ▪ Patchy eelgrass habitat ▪ Locations of wind/wave disturbance	▪ Harbor District ▪ Humboldt State University ▪ San Francisco State University	1-5
2	Parcel 4 Restoration	Bayshore Mall, PALCO Marsh	▪ Degraded freshwater wetlands ▪ Intertidal areas with eelgrass ▪ Deep water channel	▪ City of Eureka ▪ California State Coastal Conservancy ▪ Redwood Regional Audubon Society	10*
3	Elk River Estuary Enhancement	Eastern shore of Entrance Bay	▪ Elk River estuary ▪ Intertidal channels ▪ Brackish water wetlands	▪ City of Eureka ▪ Harbor District ▪ PG&E ▪ Private owners	23**
4	Hoff Parcels, Eureka, California	Entrance Bay	▪ Undeveloped pasture land with former tidally-influenced channels	▪ Westervelt Ecological Services ▪ Harbor District	53***

Sources: Pickerell et al. 2006, RCAA and GreenWay Partners 2012, Westervelt 2014, City of Eureka 2015
**This acreage is related to the potential restoration portion, not associated with the recreational component of the project.*
***The total project would be 223 acres, but Coast would fund approximately 23 acres associated with a "Phase 1" portion of the restoration effort.*
****The acreage to be used for Coast's mitigation project to be determined in coordination with Westervelt Ecological Services and other potential partners.*

8.2.1 Option 1: Buoy-Deployed Seeding System (BuDS)

A primary impact associated with the Project is a reduction in eelgrass shoot density (see Section 5.3.2). A Buoy-Deployed Seeding System (BuDS) takes advantage of the natural reproduction of eelgrass shoots to release seeds over a period of 4 weeks in order to boost eelgrass density within a 6 ft to 8 ft arc or broken circle from the BuDS, depending on the length of anchor line. The general methods involve harvesting eelgrass shoots with seedlings present, dispersal of seeds using a BuDS, and monitoring the site to validate effectiveness (Pickerell et al. 2006). While it is possible that eelgrass is growing in all suitable areas of the bay (see discussion in Appendix D regarding eelgrass carrying capacity), it is also possible that there are areas in Humboldt Bay where microtopography or energy may be impeding seed dispersal and/or seed recruitment. The BuDS system improves the chances that seeds will fall into or remain in areas that may not currently be recruiting or retaining seeds. While there is uncertainty in how effective the BuDS system may be, and it is considered experimental, it may provide a suitable in-kind mitigation that directly addresses the primary impact of the Project (e.g., eelgrass density reduction).

Mature reproductive shoots are easily distinguished from the surrounding leaf canopy because of their color (brighter green), texture, size, and epiphytic fouling. According to Pickerell et al. (2006), because it is easy to train individuals to recognize mature shoots, it allows for the possibility of shellfish employees to incorporate collection of flowering shoots into standard routine maintenance activities. Determining harvest times for flowering shoots is based on natural timing of flowering at the donor sites, as described by DeCock (1980).

The BuDS is a simple construction using the following materials: (1) 6.4 mm floating polypropylene line, (2) cement block, (3) 28 cm buoys, (4) 36 cm x 36 cm pearl nets with 6- or 9-mm mesh size, (5) used garden hose, and (6) wire ties. BuDS assembly is described in Pickerell et al. (2006).

There would be a total of 10 BuDS deployed throughout North Bay to develop a feasibility study for this system in Humboldt Bay. If successful, then additional BuDS would be used to result in a total of 1 to 5 acres of density enhancement (see Figure 25 for example locations).[10] The locations for deployment would be prioritized in the following manner:

1. Former mechanical dredge harvest locations.
2. Patchy eelgrass habitat.
3. Locations of wind/wave disturbance (as described by Gilkerson 2008).

Success Criteria

The goal of the BuDS mitigation option is to boost eelgrass density within 5 acres of North Bay that appear to be less dense due to various historical and natural stressors. The following success criteria would be used for this mitigation option:

- **Success Criteria:** Native eelgrass cover will be 30 percent (Year 1), 50 percent (Year 2), and 80 percent (Year 3) within a 5 m radius of the BuDS.
  Contingency Measure: If the percent cover success criteria are not met by Year 1, the cause will be investigated and corrected. Correction measures may include moving the BuDS to a new location. Up to 10 locations will be tested. If no success criteria can be met by Year 2, then the Project's out-of-kind mitigation will be re-evaluated pursuant to the Estuarine Habitat Credit-Debit Mitigation Accounting Framework to determine if additional mitigation is necessary.

- **Success Criteria:** Native eelgrass shoot density will be 20 turions/m^2 (Year 1), 50 turions/m^2 (Year 2), and 80 turions/m^2 (Year 3) within a 5 m radius of the BuDS.
  Contingency Measure: If the shoot density success criteria are not met by Year 1, the cause will be investigated and corrected. Correction measures may include moving the BuDS to a new location. Up to 10 locations will be tested. If no success criteria can be met by Year 2, then the Project's out-of-kind mitigation will be re-evaluated pursuant to the Estuarine Habitat Credit-Debit Mitigation Accounting Framework to determine if additional mitigation is necessary.

10 The total amount of acreage will be determined based on the effectiveness of the buoys deployed in the feasibility study and number of available sites in Humboldt Bay.

Monitoring

Monitoring the BuDS sites would be added to the monitoring effort associated with the Project (SHN 2015). The protocol typically monitors for seedlings during late winter and early spring (Pickerell et al. 2006). The perimeter of potential seedling dispersal would be monitored at least once a year to determine mitigation success. BuDS sites would be located within similar areas as the Project monitoring locations in order to reduce access concerns. The monitoring plan by SHN (2015) provides a description of this monitoring effort.

8.2.2 Option 2: Parcel 4 Restoration

A feasibility study funded by the California State Coastal Conservancy was conducted on Parcel 4 in the City of Eureka to understand the restoration potential for natural resource enhancement and public access of the site (RCAA and GreenWay Partners 2012). Parcel 4 is located behind the Bayshore Mall, adjacent to the PALCO Marsh section of waterfront open space and the Chevron petroleum storage facility. The site is approximately 14.8 acres, which includes approximately 10 acres of significantly degraded freshwater wetlands and a former salt marsh channel. The site is also adjacent to a deep water channel and eelgrass habitat. The site is owned by the City of Eureka, includes an open space easement that is controlled by the Redwood Regional Audubon Society, and is currently zoned for coastal-development industrial uses.

The Parcel 4 project has a number of goals and priorities, including the following that relate to the natural environment and use of the site:

- Re-establish wetland areas and enhance wildlife habitat at the site.
- Integrate the site into the Elk River Trail and corresponding Truesdale/Vista Point parking area and trail head facilities to the south.
- Assess and clean up brownfields contaminants.
- Remove invasive species (e.g., *Spartina*).
- Improve the natural experience, including clean-up of on-site debris and buffering visitor experience against surrounding development and industry.

Using these goals and priorities, a conceptual site plan was developed for the project (Figure 26). The work completed, to date, does not include specific designs. If this option is selected, Coast will work with the City of Eureka and other stakeholders to develop a final design plan. A key priority would be to reconnect the former salt marsh habitat. This would be accomplished by opening up holes in the existing bulkhead, excavating fill closest to the existing waterline, and removing concrete structures. There is eelgrass habitat in and around the pilings on site, which would be enhanced through removal of the in-water structures and bulkhead. Coast would partner with the City of Eureka and other public agencies to fund and implement the restoration of former salt marsh habitat on the site.

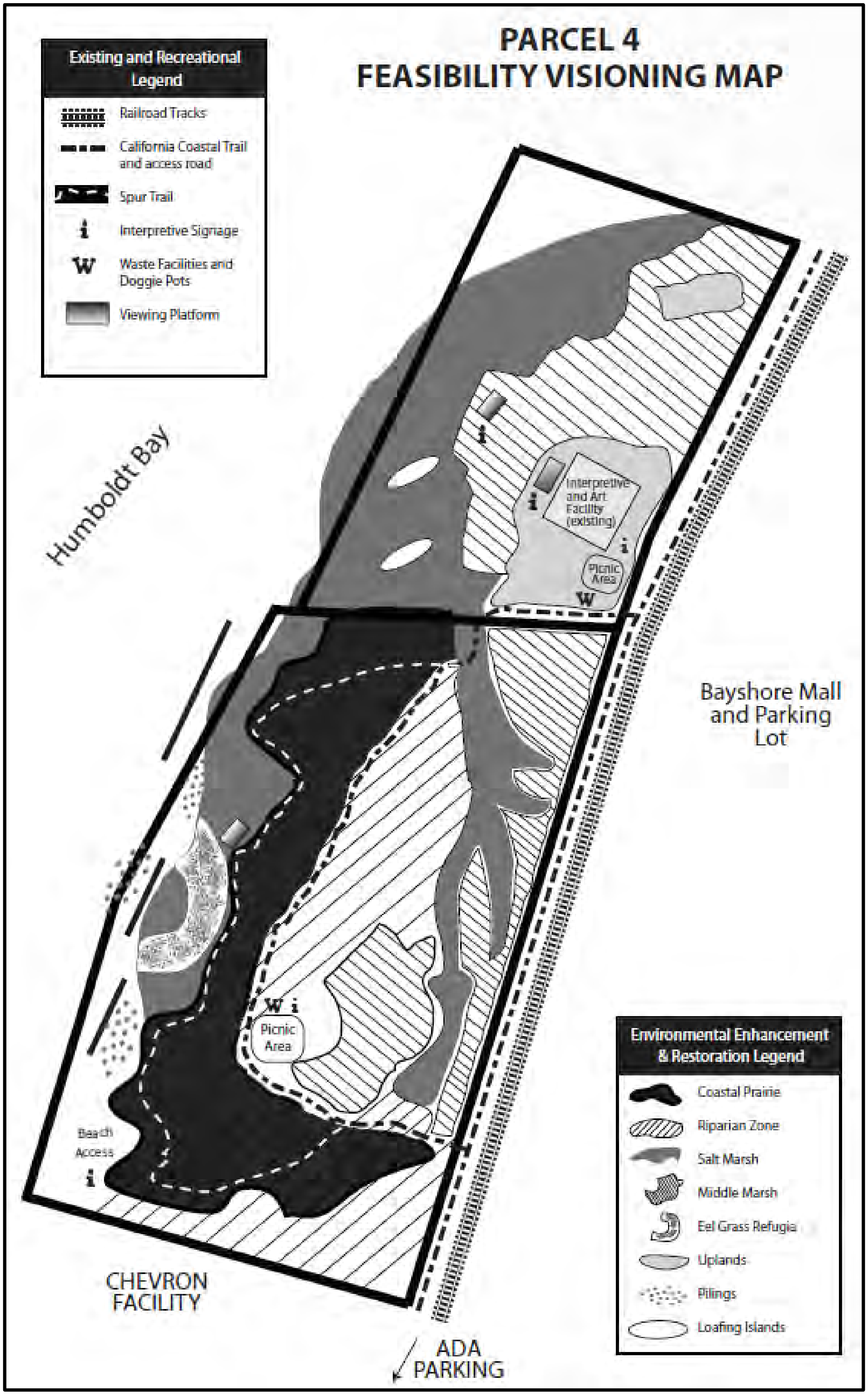

Figure 26 Conceptual Site Plan for Parcel 4 Restoration.

Source: RCAA and GreenWay Partners 2012.

Success Criteria and Contingency Measures

The goal of the Parcel 4 restoration would be to restore and enhance 10 acres of Humboldt Bay coastal salt marsh habitat. The following success criteria would be used for this mitigation option:

- **Success Criteria:** Native plant survival will be 90 percent (Year 1), 80 percent (Year 2), and 75 percent (Year 3).
  Contingency Measure: If the percent survival success criteria is not met, the cause will be investigated and corrected. Correction measures may include increased watering, soil amendments, or additional plantings.

- **Success Criteria:** Native plant cover will be 30 percent (Year 1) and 50 percent (Year 3).
  Contingency Measure: If the percent cover of success criteria is not met, the cause will be investigated and corrected. Correction measures may include increased watering, soil amendments, or additional plantings.

- **Success Criteria:** Invasive plant species cover will not exceed 20 percent (Year 1) and 10 percent (Year 3).
  Contingency Measure: If more than 10 percent of area is covered by invasive species, the cause of infestation will be investigated and corrective actions will be taken before weeds are removed. Contingency measures could include increasing the frequency of weeding until native vegetation can grow and dominate the area or increasing the density of native vegetation with additional plantings.

Monitoring

Because this project is still in the design phase, a monitoring plan has not yet been developed. However, the basics of a monitoring plan would include the following elements to ensure that plantings survive and establish successfully. In addition, the monitoring plan would provide enough data to establish whether the success criteria were achieved. The following are suggested components of the monitoring plan:

- **Transects and Photo Point:** Using rebar sheathed in white PVC pipe, two permanent, 100-ft-long transects will be established. At two points along each transect, permanent circular plots 15 ft in diameter, will be marked (T1-A, T1-B, T2-A, and T2-B). Coordinates for the location of the end points of each transect will be recorded using a global positioning system (GPS) system. Permanent photo points will be established at each end of each transect (P1, P2, etc.). At each of the photo points, a fixed-lens digital camera will be used to take four photographs, one at every 90 degrees of the compass.
- **Line Intercept Method:** The line-intercept method will be used to record the percent cover of trees and shrubs along each of the permanently marked transects. After laying a tape measure along a transect line, the lengths of tape directly under the branches and foliage of a tree or shrub will be recorded along with the species. The percent cover of each species is then

calculated by dividing the sum of lengths intercepted for that species by the total length of the transect line.

- **Percent Cover Method:** In each circular plot (two along each transect), the percent cover of herbaceous species, including bare ground, will be recorded.
- **Frequency:** Monitoring will occur during the growing season after deciduous plants have flowered or leafed-out for a total of 3 Years. The Year 0 monitoring event will occur within 30 days after trees and shrubs have been installed. Each of the subsequent monitoring events will occur within 30 days of the calendar date of the Year 0 monitoring.

8.2.3 Option 3: Elk River Estuary Enhancement and Intertidal Wetlands Restoration

The Elk River Estuary Enhancement and Intertidal Wetlands Restoration Project (Elk River project) is a restoration project that would expand the Elk River estuary by 223 acres and increase habitat diversity by creating intertidal wetlands/channels, coastal salt marsh habitat, and brackish water wetlands. The Elk River project is located in Humboldt Bay along the eastern shoreline of Entrance Bay. The project would include 23 acres north of Elk River, and 200 acres south of Elk River and west of U.S. Highway 101 (Figure 27). The site is owned by the City of Eureka, the Harbor District, PG&E, and several private land owners. The Elk River project has a number of goals and priorities, including the following that relate to the natural environment and use of the site:

- Remove the dike on the north bank of Elk River Slough to restore tidal inundation to former coastal salt marsh habitat.
- Excavate intertidal channels and brackish water ponds to the south of Elk River.
- Grade the salt marsh plains as "living shorelines" that would protect Highway 101 and the Northwest Pacific railroad from wind-induced erosion.

The City of Eureka City Council has indicated that it would be willing to move forward with the 23-acre portion of the project north of Elk River in partnership with Coast for salt marsh restoration. If this option is selected, Coast would work with the City of Eureka to develop a salt marsh restoration plan and monitoring plan for the mitigation project.

Success Criteria and Contingency Measures

The goal of this mitigation option is to create a 23-acre area that increases the habitat diversity of the Elk River Estuary and is dominated by coastal salt marsh vegetation. The success criteria for this project would be the same as for Mitigation Option 2: Parcel 4 Restoration.

Monitoring

A monitoring plan has not been developed for this mitigation option, but it would follow the same guidelines as discussed for Mitigation Option 2.

Figure 27 Elk River Estuary Enhancement and Intertidal Wetlands Restoration Project Area (yellow shading) along the Eastern Shoreline of Entrance Bay.

Source: City of Eureka 2015.

8.2.4 Option 4: Hoff Parcels, Eureka, California

A feasibility study was conducted on the Hoff Parcels in the City of Eureka to identify opportunities and constraints associated with developing a mitigation bank or permittee-responsible mitigation project on land owned by James Hoff (Westervelt 2014). The Hoff Parcels are located near Humboldt Bay between Elk River and Humboldt Hill (Figure 28). The site is approximately 53 acres, which includes undeveloped pasture land with former coastal salt marsh habitat. While Coast would need to work with Mr. Hoff and other adjacent property owners, it is anticipated that a portion of the site could be used by Coast and other partners for salt marsh restoration.

Opportunities for mitigation on the Hoff Parcels could include the following:

- Re-establish coastal salt marsh habitat and allow tidal influence to be restored. While there is no direct connection between the Hoff Parcels and Humboldt Bay; connection to the bay could be established in partnership with PG&E or the Harbor District.
- Creation of upland freshwater wetlands.

Success Criteria and Contingency Measures

- The goal of this mitigation option is to create a 53-acre area that is dominated by coastal salt marsh vegetation. Coast's mitigation commitment would be to develop and implement salt marsh restoration on a portion of the overall project. The success criteria for this project would be the same as for Mitigation Option 2: Parcel 4 Restoration.

Monitoring

- A monitoring plan has not been developed for this mitigation option, but it would follow the same guidelines as discussed for Mitigation Option 2.

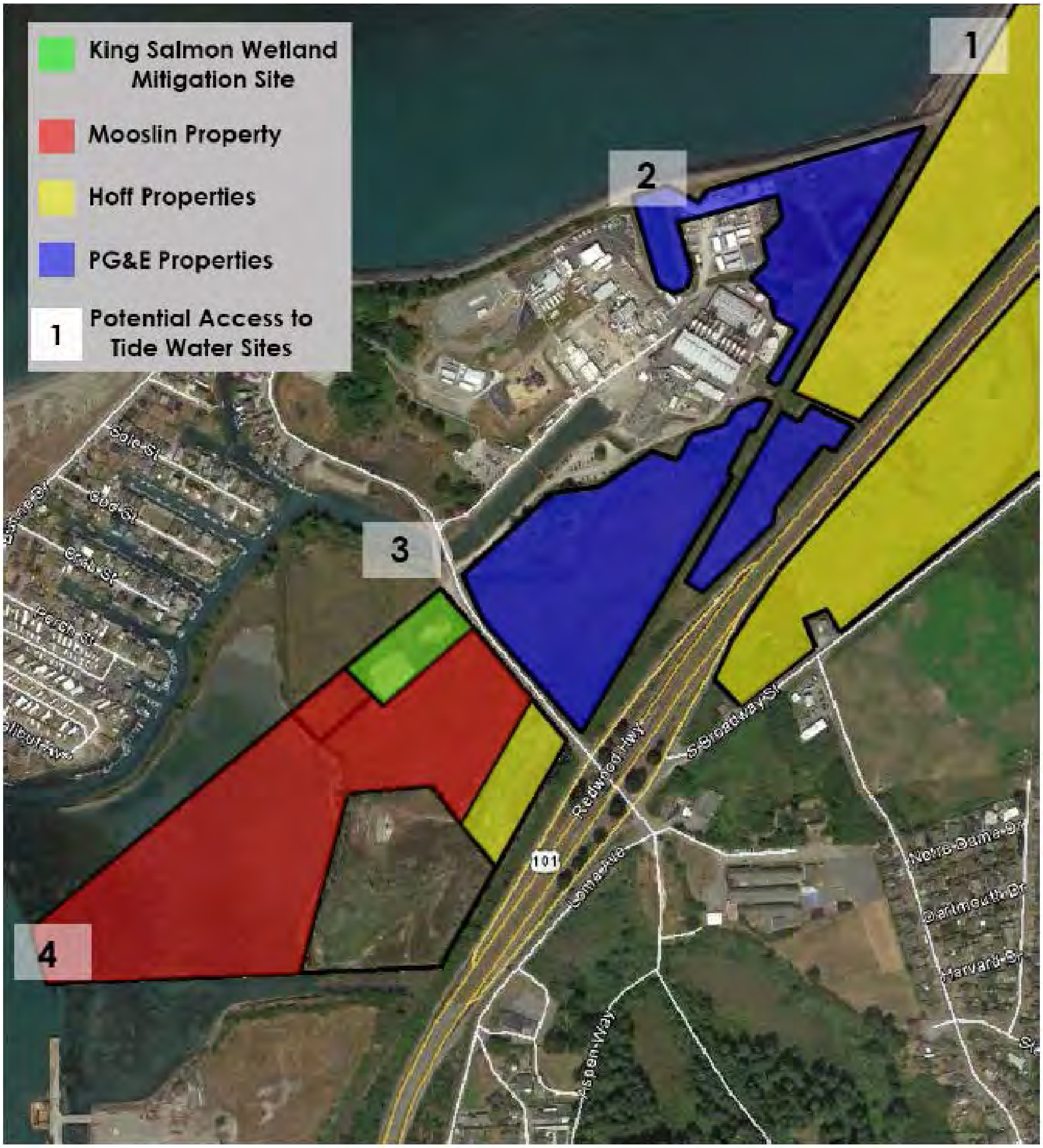

Figure 28 Tidal Access Sites adjacent to the Hoff Parcels in the City of Eureka, California.
Source: Westervelt 2014.

8.3 Mitigation Accounting

According to the CEMP, "it is NMFS's policy to recommend no net loss of eelgrass habitat function in California." However, there is no guidance on how to determine change in habitat function from a project or the ecological lift provided by out-of-kind mitigation. Mitigation accounting would provide this validation, but there are no suitable existing tools available to use within estuarine habitats. Therefore, a tool was developed for the Project to value ecological functions within estuarine habitats (Appendix B). An important step for assessing estuarine habitat function is the development of a meaningful framework that calculates impacts (debits) and mitigation (credits).

One framework that satisfies many of the characteristics needed for the Project was developed by Washington State to create a mechanism to address in-lieu fee mitigation efforts for wetlands (Hruby 2012). This framework calculates credits and debits for estimating whether a plan for compensatory mitigation will adequately replace the functions and values lost when aquatic resources are altered. However, this framework required modifications in two areas. First, the Hruby (2012) framework fails to address eelgrass and other estuarine habitats. Second, it requires adaptation to match the conditions in California. Complementary tools that address these limitations were used in the framework developed for Coast, namely the Oregon Rapid Wetland Assessment Protocol (Adamus et al. 2010) and the California Rapid Assessment Method for Wetlands (San Francisco Estuary Institute 2013).

The framework developed for Coast draws from each of these approaches to describe an effective method for characterizing impacts (debits) and mitigation (credits) to identify the adequacy of proposed mitigation to compensate for changes from the Project. This framework creates a currency of credits and debits based on acre-points and ecological function.

Following the approach of Hruby (2012), ecological functions were valued according to: (1) water quality, (2) habitat structure, and (3) prey resources. While there are a number of other functions provided by estuarine habitats, these three functions are integral components of the values discussed by Short et al. (2000) for eelgrass habitat (Table 10).

Table 10 Ecological Functions Provided by Eelgrass

Function	Value	Water Quality	Habitat	Prey Resources
Canopy structure	Habitat, refuge, nursery, settlement, and support of fisheries		✓	
Primary production	Food for herbivores and support of fisheries and wildlife			✓
Epibenthic and benthic production	Support of food web and fisheries			✓
Nutrient and contaminant filtration	Improved water quality and support of fisheries	✓		
Sediment filtration and trapping	Improved water quality, counter sea level rise and support of fisheries	✓		
Epiphyte and epifaunal substratum	Support of secondary production and fisheries		✓	✓

Function	Value	Water Quality	Habitat	Prey Resources
Oxygen production	Improved water quality and support of fisheries	✓		
Organic production and export	Support of estuarine, offshore food webs, and fisheries			✓
Nutrient regeneration and recycling	Support of primary production and fisheries			✓
Organic matter accumulation	Support of food webs and counter sea level rise			✓
Wave and current energy dampening	Prevents erosion/resuspension and increases sedimentation	✓	✓	
Source: Function and Value columns from Short et al. 2000				

Each of the three primary functions of eelgrass are then scored from three different environmental contexts: (1) site potential, (2) landscape potential, and (3) watershed priority. These scores are further modified based on the timing and risk associated with the mitigation proposed using a temporal loss factor and risk factors. A more detailed description of the accounting methodology, the approach to valuation of ecological functions, and example scoring forms is provided in Appendix B to this report. An example of working through the Mitigation Accounting using the proposed mitigation projects is provided in Appendix C.

The steps involved in determining mitigation needs and adaptively applying newer information are shown in Figure 29. The mitigation accounting framework was developed based on scientific literature and data from pre-Project monitoring. The mitigation accounting estimates of potential Project impacts are used to inform the determination of mitigation needs and development of a mitigation plan. Once the Project is underway and associated mitigation actions are implemented, impacts and mitigation success will be monitored and adaptive adjustments applied as needed. In this way, the best available science for the Project is applied to ensure Project impacts are adequately offset by mitigation.

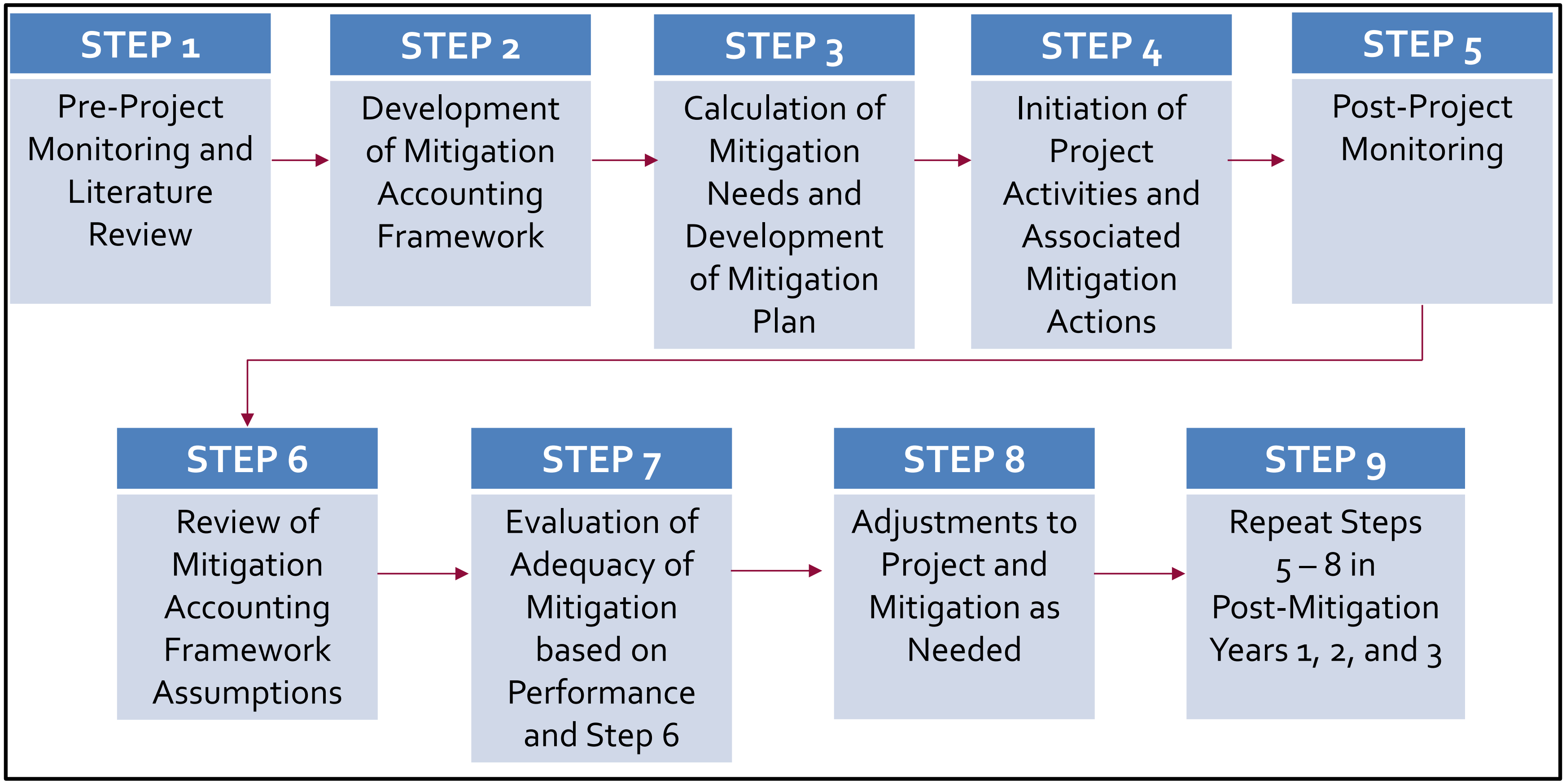

Figure 29 **Proposed Sequence for Determining Mitigation Needs and Applying Adaptive Responses.**

9.0 DETERMINATION OF SIGNIFICANCE

The CEQA threshold of significance for impacts to eelgrass habitat has been defined as Project effects that result in an areal extent of eelgrass and/or a greater than 25 percent change in eelgrass density . This threshold is based on metrics discussed in the CEMP, Fonseca et al.'s (1998) discussion of functional equivalency, and management documents (e.g., HBWAC and RCAA 2005, Schlosser et al. 2009). This scale is also appropriate in that it recognizes the highly mobile nature of ESA-listed and MSA-managed species, which is represented by the scale used in this threshold.

Potential impacts to eelgrass or potential changes to habitat that eelgrass supports that are discussed in Section 5.0, including: (1) gear and shellfish products, (2) working practices, (3) fragmentation, (4) floating eelgrass rafts and wrack, and (5) sediment scouring and accumulation. In addition, the analysis considers resilience of the ecological system, duration of impacts, and cumulative impacts. The only potentially significant impact identified was the reduction in eelgrass directly under the longlines. This effect incorporates impacts such as shading from gear and shellfish products (e.g., cultch, baskets, floats), mechanical abrasion, and desiccation of eelgrass blades. Finally, impacts were based on empirical observations of loss directly under the longlines and between the lines, which inherently incorporate other working practices.

In terms of the expansion area, the data and field observations do not support a loss of areal extent from the placement of longline aquaculture at 5 ft or 10 ft spacing. Eelgrass density reduction was 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). Both of these results are below the CEQA threshold of significance. Therefore, the Project is expected to have a less than significant impact on eelgrass habitat. Despite this conclusion, Coast is proposing habitat improvements to ensure that the Project has an overall beneficial ecological impact in Humboldt Bay (as discussed in Section 8.0).

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Appendix A

Calculation of Potential Eelgrass Reduction under the Longlines

APPENDIX A: CALCULATION OF POTENTIAL EELGRASS REDUCTION UNDER THE LONGLINES

REVIEW DRAFT

1.0 PURPOSE

The primary effect from the Coast Seafoods Company's (Coast) Humboldt Bay Shellfish Aquaculture: Permit Renewal and Expansion Project (Project) is the reduction of eelgrass density directly under the oyster longlines that are placed in eelgrass habitat. This document provides the approach and calculations associated with eelgrass turion reduction.

2.0 METHODS

The overall approach to eelgrass turion reduction is provided in Figure A-1. The following text describes the data used to calculate the reduction.

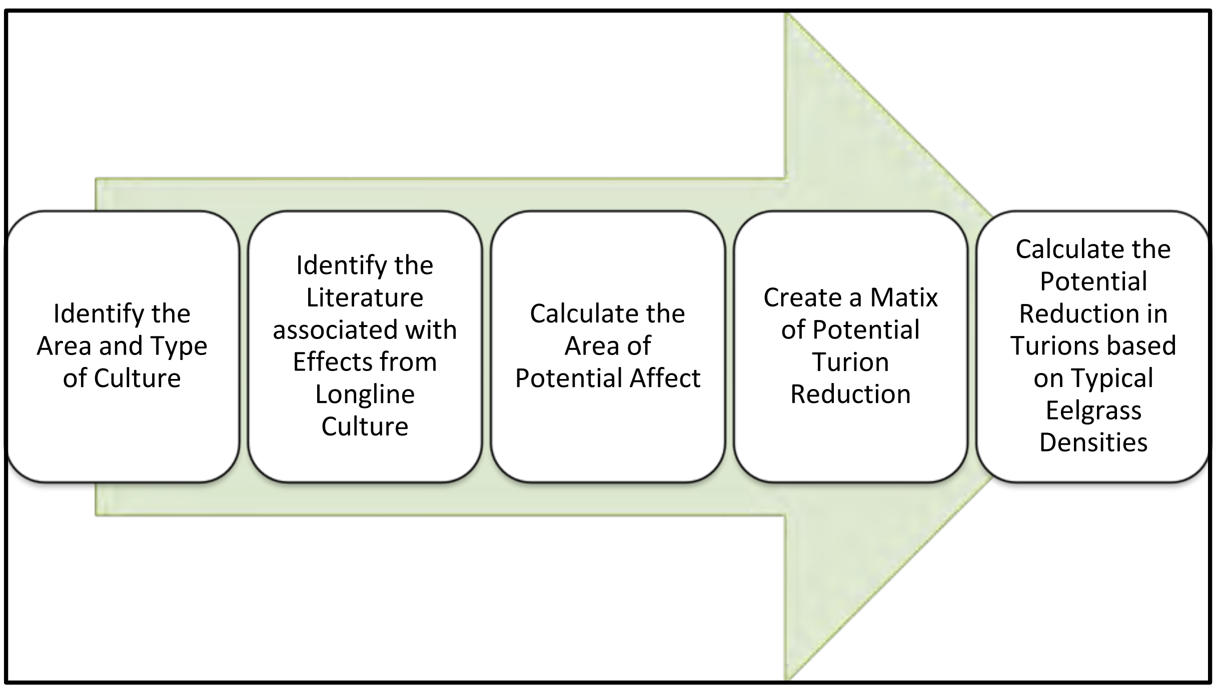

Figure A-1 Overall Approach to Calculating Eelgrass Density Reduction.

Based on several studies, such as the Western Regional Aquaculture Center (WRAC) study by Rumrill and Poulton (2004), and assuming longline spacing of 5 ft to 10ft, it is apparent that oyster longlines can in certain areas reduce eelgrass turion density directly under the lines themselves while the space between longlines does not show a reduction in density. This effect is also similar to other changes associated with shellfish aquaculture gear where the measureable effects occurred directly under the gear and typically extending only a short distance where the gear was placed (see review in Forrest et al. 2009 of off-bottom culture methods).

As per the approach identified in Figure A-1, potential eelgrass turion reduction was calculated using a number of steps. The following equations (Eq.) were used in these calculations:

(1)	$X_{LL} * X_{WE} = A_{BL}$	X_{LL} = length of longline (ft) X_{WE} = width of effect (ft) A_{BL} = area below longline (ft^2)
(2)	$A_{EA} * A_{BL} * NL = A_{AOI}$	A_{EA} = expansion area (acre) A_{BL} = area below longline (acre) NL = number of longlines (#/acre) A_{AOI}= area of influence (acre)
(3)	$A_{AOI} * ED * Rdct = LL_{Rdct}$	A_{AOI} = area of influence (m^2) ED = eelgrass density (turions/m^2) $Rdct$ = percent reduction under longlines (%) LL_{Red} = reduction of turions below longlines (turions)
(4)	$\frac{LL_{Rdct}}{TT} = T_{Rdct}$	LL_{Red} = reduction of turions below longlines (turions) TT = total turions within an area (turions) T_{Red} = total percent reduction in eelgrass density (%)

The width of effect (X_{WE}) in Eq. (1) is the extent to which a reduction in eelgrass density would occur under the longline. 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. An average value for X_{WE} of 0.5 ft was used for cultch-on-longline culture. 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. An average value for X_{WE} of 0.9 ft was used for basket-on-longline culture.

Eelgrass density (ED) in Eq. (3) was based on the average eelgrass densities reported in North Bay from 2001 to 2015 (Rumrill and Poulton 2004, Schlosser and Eicher 2012, SeagrassNet 2015, Rumrill 2015, SHN 2015). A density of 50 turions/m^2 was used for patchy eelgrass areas and 80 turions/m^2 for continuous eelgrass areas. The overall breakdown of each density category within the expansion area is provided in Table A-1.

Table A-1 General Habitat Categories within the Expansion Area

Growing Area	Culture Type	Non-Eelgrass (acre)	Patchy Eelgrass (acre)	Continuous Eelgrass (acre)	Total (acre)
1	Cultch-on-Longline	11.8	33.3	98.5	143.6
	Basket-on-Longline*	2.4	6.4	18.8	27.6
2	Cultch-on-Longline	0.4	2.8	28.7	31.9
	Basket-on-Longline*	0.2	0.5	5.5	6.2
3	Cultch-on-Longline	2.1	37.9	96.4	136.4
	Basket-on-Longline*	0.5	7.2	18.4	26.1
4	Cultch-on-Longline	2.2	9.6	60.3	72.1
	Basket-on-Longline*	0.4	1.8	11.5	13.7
5	Cultch-on-Longline	0	1.8	16.4	18.2
	Basket-on-Longline*	0.1	0.4	3.1	3.6
6	Cultch-on-Longline	1.7	5.3	112.8	119.8
	Basket-on-Longline*	0.3	1	21.5	22.8
Total	**Cultch-on-Longline**	**18.2**	**90.7**	**413.1**	**522.0**
	Basket-on-Longline*	**3.9**	**17.3**	**78.8**	**100.0**
Source: NOAA (2012) in non-eelgrass areas may include rack-and-bag					

The percent reduction under the longlines (*Rdct*) in Eq. (3) is based on values reported by Rumrill and Poulton (2004) during the WRAC study in Humboldt Bay, additional data provided by Rumrill (2015) in consultation with the National Marine Fisheries Service (NMFS), and new data collected by SHN (unpublished data) within Coast's existing longline plots. Table A-2 provides a summary of these data sources.

Table A-2 Compiled Studies Reporting Eelgrass Density Reduction under Longlines

Plot	Transect Description	# of Quadrats (n)	Mean Eelgrass Density (turions per m^2)	% Reduction (% change relative to control)
Cultch-on-Longline (5 ft Spacing)				
3A	EB 1-1/CON (no oyster lines)	12	38	
	EB 1-1/5 wide	12	18	-53%
3H	EB 6-2/CON (no oyster lines)	12	48	
	EB 6-2/5 wide	12	8	-83%
OLN Plots	OLN-CON (no oyster lines)	12	59	
	OLN-5 wide	12	21	-64%
1E	10 ft outside of bed (control)	24	72.7	
	under cultch line	24	42.7	-41.3%
6A	10 ft outside of bed (control)	21	119.3	
	under cultch line	24	62.7	-47.5%

Plot	Transect Description	# of Quadrats (n)	Mean Eelgrass Density (turions per m²)	% Reduction (% change relative to control)
Basket-on-Longline (5 ft Spacing)*				
3A	EB 1-1/CON (no oyster lines)	12	38	
	EB 1-1/2.5-5 narrow	12	16	-58%
3H	EB 6-2/CON (no oyster lines)	12	48	
	EB 6-2/2.5-5 narrow	12	3	-94%
OLN Plots	OLN-CON (no oyster lines)	12	59	
	OLN-2.5 narrow	12	10	-83%
oM	center of 20 ft gap (control)	24	64.7	
	under basket line	24	20.0	-69.1%

Sources: Rumrill and Poulton 2004; Rumrill 2015; SHN unpublished data
EB = East Bay; OLN = oyster longline
**There is no 5 ft basket-on-longline spacing within Coast's existing culture, and so a more conservative estimate related to 2.5 ft cultch-on-longline spacing was used to represent this effect. These values compare well with more recent data from SHN.*
Note: the Rumrill and Poulton (2004) data was collected in 0.25 m² quadrats while the SHN (unpublished data) was collected in 0.0625 m² quadrats. All data was converted into turions/m².

3.0 CALCULATIONS

The amount of eelgrass in North Bay was estimated by using the NOAA (2012) data categories for patchy and continuous eelgrass and assuming an average density of 50 turions/m² for patchy eelgrass areas and 80 turions/m² for continuous eelgrass areas, as noted above. This results in a total of 1,974 acres (399,333,675 turions) of patchy eelgrass and 2,013 acres (651,595,684 turions) of continuous eelgrass. The density reduction per Growing Area in the culture areas, eelgrass beds, and North Bay are provided in Table A-3. The following series of tables (A-4 through A-6) follows the approach identified in Figure A-1 in order to calculate these percentages.

Table A-3 Potential Project Effects to Eelgrass Density

Culture Type	Eelgrass Density Reduction (%)		
	Culture Area	Eelgrass Bed Area	North Bay
Cultch-on-Longline	-4.7%	-1.3%	-0.7%
Basket-on-Longline	-6.6%	-0.4%	-0.2%
Total	**-5.0%**	**-1.7%**	**-0.9%**

Culture Area = expansion areas with oyster longlines that overlap with eelgrass (both patchy and continuous).
Eelgrass Bed Area = eelgrass polygons that overlap with the expansion areas (both patchy and continuous) based on the NOAA (2012) data.
North Bay = total eelgrass in North Bay based on the NOAA (2012) data.

Table A-4 Area Affected by Oyster Longlines under the Project (622 acre Expansion) in North Bay.

NON-EELGRASS*					
	Growing Area and Treatment	Plot Area (acre)	Area under Line (acre/line)	# of Lines (lines/acre)	Total Area Affected (acre)
Area 1	Cultch (5-ft)	11.8	1.2E-03	84	1.2
Area 1	Basket** (5-ft group)	2.4	2.0E-03	48	0.2
Area 2	Cultch (5-ft)	0.4	1.2E-03	84	0.0
Area 2	Basket** (5-ft group)	0.2	2.0E-03	48	0.0
Area 3	Cultch (5-ft)	2.1	1.2E-03	84	0.2
Area 3	Basket** (5-ft group)	0.5	2.0E-03	48	0.0
Area 4	Cultch (5-ft)	2.2	1.2E-03	84	0.2
Area 4	Basket** (5-ft group)	0.4	2.0E-03	48	0.0
Area 5	Cultch (5-ft)	0.0	1.2E-03	84	0.0
Area 5	Basket** (5-ft group)	0.1	2.0E-03	48	0.0
Area 6	Cultch (5-ft)	1.7	1.2E-03	84	0.2
Area 6	Basket** (5-ft group)	0.3	2.0E-03	48	0.0
TOTAL	**Cultch (5-ft)**	**18.2**	**1.2E-03**	**84**	**1.8**
TOTAL	**Basket** (5-ft group)**	**3.9**	**2.0E-03**	**48**	**0.4**

PATCHY EELGRASS					
	Growing Area and Treatment	Plot Area (acre)	Area under Line (acre/line)	# of Lines (lines/acre)	Total Area Affected (acre)
Area 1	Cultch (5-ft)	33.3	1.2E-03	84	3.4
Area 1	Basket (5-ft group)	6.4	2.0E-03	48	0.6
Area 2	Cultch (5-ft)	2.8	1.2E-03	84	0.3
Area 2	Basket (5-ft group)	0.5	2.0E-03	48	0.1
Area 3	Cultch (5-ft)	37.9	1.2E-03	84	3.8
Area 3	Basket (5-ft group)	7.2	2.0E-03	48	0.7
Area 4	Cultch (5-ft)	9.6	1.2E-03	84	1.0
Area 4	Basket (5-ft group)	1.8	2.0E-03	48	0.2
Area 5	Cultch (5-ft)	1.8	1.2E-03	84	0.2
Area 5	Basket (5-ft group)	0.4	2.0E-03	48	0.0
Area 6	Cultch (5-ft)	5.3	1.2E-03	84	0.5
Area 6	Basket (5-ft group)	1.0	2.0E-03	48	0.1
TOTAL	**Cultch (5-ft)**	**90.7**	**1.2E-03**	**84**	**9.2**
TOTAL	**Basket (5-ft group)**	**17.3**	**2.0E-03**	**48**	**1.6**

CONTINUOUS EELGRASS					
	Growing Area and Treatment	Plot Area (acre)	Area under Line (acre/line)	# of Lines (lines/acre)	Total Area Affected (acre)
Area 1	Cultch (5-ft)	98.5	1.2E-03	84	10.0
Area 1	Basket (5-ft group)	18.8	2.0E-03	48	1.8
Area 2	Cultch (5-ft)	28.7	1.2E-03	84	2.9
Area 2	Basket (5-ft group)	5.5	2.0E-03	48	0.5
Area 3	Cultch (5-ft)	96.4	1.2E-03	84	9.7
Area 3	Basket (5-ft group)	18.4	2.0E-03	48	1.7
Area 4	Cultch (5-ft)	60.3	1.2E-03	84	6.1
Area 4	Basket (5-ft group)	11.5	2.0E-03	48	1.1
Area 5	Cultch (5-ft)	16.4	1.2E-03	84	1.7
Area 5	Basket (5-ft group)	3.1	2.0E-03	48	0.3
Area 6	Cultch (5-ft)	112.8	1.2E-03	84	11.4
Area 6	Basket (5-ft group)	21.5	2.0E-03	48	2.0
TOTAL	**Cultch (5-ft)**	**413.2**	**1.2E-03**	**84**	**41.7**
TOTAL	**Basket (5-ft group)**	**78.8**	**2.0E-03**	**48**	**7.4**

* Includes 6.5 acres of subtidal channel that would not be planted

** Basket-on-longline culture in non-eelgrass areas may include rack-and-bag culture

Non-eelgrass:

0.5	Width of effect under cultch-on-longline
0.9	Width of effect under basket-on-longline
2.3E-05	1 ft² to acre conversion (in acres)

Patchy eelgrass:

0.5	Width of effect under cultch-on-longline
0.9	Width of effect under basket-on-longline
2.3E-05	1 ft² to acre conversion (in acres)

Continuous eelgrass:

0.5	Width of effect under cultch-on-longline
0.9	Width of effect under basket-on-longline
2.3E-05	1 ft² to acre conversion (in acres)

Table A-5 Matrices of Potential Eelgrass Density Reduction for Oyster Longlines Spaced 5 ft Apart.

CULTCH-ON-LONGLINE

% Reduction	Eelgrass Density (turions per m²)																	
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
-41%	-2.E+04	-3.E+04	-5.E+04	-7.E+04	-8.E+04	-1.E+05	-1.E+05	-1.E+05	-2.E+05	-2.E+05	-2.E+05	-2.E+05	-2.E+05	-2.E+05	-3.E+05	-3.E+05	-3.E+05	-3.E+05
-47%	-2.E+04	-4.E+04	-6.E+04	-8.E+04	-1.E+05	-1.E+05	-1.E+05	-2.E+05	-2.E+05	-2.E+05	-2.E+05	-2.E+05	-2.E+05	-3.E+05	-3.E+05	-3.E+05	-3.E+05	-3.E+05
-52%	-2.E+04	-4.E+04	-6.E+04	-8.E+04	-1.E+05	-1.E+05	-1.E+05	-2.E+05	-2.E+05	-2.E+05	-2.E+05	-3.E+05	-3.E+05	-3.E+05	-3.E+05	-3.E+05	-4.E+05	-4.E+05
-57%	-2.E+04	-5.E+04	-7.E+04	-9.E+04	-1.E+05	-1.E+05	-2.E+05	-2.E+05	-2.E+05	-2.E+05	-3.E+05	-3.E+05	-3.E+05	-3.E+05	-3.E+05	-4.E+05	-4.E+05	-4.E+05
-58%	-2.E+04	-5.E+04	-7.E+04	-9.E+04	-1.E+05	-1.E+05	-2.E+05	-2.E+05	-2.E+05	-2.E+05	-3.E+05	-3.E+05	-3.E+05	-3.E+05	-4.E+05	-4.E+05	-4.E+05	-4.E+05
-63%	-3.E+04	-5.E+04	-8.E+04	-1.E+05	-1.E+05	-2.E+05	-2.E+05	-2.E+05	-2.E+05	-3.E+05	-3.E+05	-3.E+05	-3.E+05	-4.E+05	-4.E+05	-4.E+05	-4.E+05	-5.E+05
-68%	-3.E+04	-5.E+04	-8.E+04	-1.E+05	-1.E+05	-2.E+05	-2.E+05	-2.E+05	-2.E+05	-3.E+05	-3.E+05	-3.E+05	-4.E+05	-4.E+05	-4.E+05	-4.E+05	-5.E+05	-5.E+05
-73%	-3.E+04	-6.E+04	-9.E+04	-1.E+05	-1.E+05	-2.E+05	-2.E+05	-2.E+05	-3.E+05	-3.E+05	-3.E+05	-4.E+05	-4.E+05	-4.E+05	-4.E+05	-5.E+05	-5.E+05	-5.E+05
-78%	-3.E+04	-6.E+04	-9.E+04	-1.E+05	-2.E+05	-2.E+05	-2.E+05	-3.E+05	-3.E+05	-3.E+05	-3.E+05	-4.E+05	-4.E+05	-4.E+05	-5.E+05	-5.E+05	-5.E+05	-6.E+05
-83.33%	-3.E+04	-7.E+04	-1.E+05	-1.E+05	-2.E+05	-2.E+05	-2.E+05	-3.E+05	-3.E+05	-3.E+05	-4.E+05	-4.E+05	-4.E+05	-5.E+05	-5.E+05	-5.E+05	-6.E+05	-6.E+05

Average density range of eelgrass in Humboldt Bay in the summer

Potential Affected Area

Standard Area = 1

1 acre to m² conversion (in m²) = 4,047

Range of Loss based on the Literature

LOW -41%

MED -58%

HIGH -83%

BASKET-ON-LONGLINE

% Reduction	Eelgrass Density (turions per m²)																	
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
-58%	-2.E+04	-5.E+04	-7.E+04	-9.E+04	-1.E+05	-1.E+05	-2.E+05	-2.E+05	-2.E+05	-2.E+05	-3.E+05	-3.E+05	-3.E+05	-3.E+05	-4.E+05	-4.E+05	-4.E+05	-4.E+05
-63%	-3.E+04	-5.E+04	-8.E+04	-1.E+05	-1.E+05	-2.E+05	-2.E+05	-2.E+05	-2.E+05	-3.E+05	-3.E+05	-3.E+05	-3.E+05	-4.E+05	-4.E+05	-4.E+05	-4.E+05	-5.E+05
-68%	-3.E+04	-5.E+04	-8.E+04	-1.E+05	-1.E+05	-2.E+05	-2.E+05	-2.E+05	-2.E+05	-3.E+05	-3.E+05	-3.E+05	-4.E+05	-4.E+05	-4.E+05	-4.E+05	-5.E+05	-5.E+05
-70%	-3.E+04	-6.E+04	-8.E+04	-1.E+05	-1.E+05	-2.E+05	-2.E+05	-2.E+05	-3.E+05	-3.E+05	-3.E+05	-3.E+05	-4.E+05	-4.E+05	-4.E+05	-5.E+05	-5.E+05	-5.E+05
-76%	-3.E+04	-6.E+04	-9.E+04	-1.E+05	-2.E+05	-2.E+05	-2.E+05	-2.E+05	-3.E+05	-3.E+05	-3.E+05	-4.E+05	-4.E+05	-4.E+05	-5.E+05	-5.E+05	-5.E+05	-6.E+05
-81%	-3.E+04	-7.E+04	-1.E+05	-1.E+05	-2.E+05	-2.E+05	-2.E+05	-3.E+05	-3.E+05	-3.E+05	-4.E+05	-4.E+05	-4.E+05	-5.E+05	-5.E+05	-5.E+05	-6.E+05	-6.E+05
-86%	-3.E+04	-7.E+04	-1.E+05	-1.E+05	-2.E+05	-2.E+05	-2.E+05	-3.E+05	-3.E+05	-3.E+05	-4.E+05	-4.E+05	-5.E+05	-5.E+05	-5.E+05	-6.E+05	-6.E+05	-6.E+05
-91%	-4.E+04	-7.E+04	-1.E+05	-1.E+05	-2.E+05	-2.E+05	-3.E+05	-3.E+05	-3.E+05	-4.E+05	-4.E+05	-4.E+05	-5.E+05	-5.E+05	-6.E+05	-6.E+05	-6.E+05	-7.E+05
-93%	-4.E+04	-8.E+04	-1.E+05	-2.E+05	-2.E+05	-2.E+05	-3.E+05	-3.E+05	-3.E+05	-4.E+05	-4.E+05	-5.E+05	-5.E+05	-5.E+05	-6.E+05	-6.E+05	-6.E+05	-7.E+05
-94%	-4.E+04	-8.E+04	-1.E+05	-2.E+05	-2.E+05	-2.E+05	-3.E+05	-3.E+05	-3.E+05	-4.E+05	-4.E+05	-5.E+05	-5.E+05	-5.E+05	-6.E+05	-6.E+05	-6.E+05	-7.E+05

Average density range of eelgrass in Humboldt Bay in the summer

Potential Affected Area

Standard Area (acre) = 1

1 acre to m² conversion (in m²) = 4,047

Range of Loss based on the Literature

LOW -58%

MED -76%

HIGH -94%

Table A-6 Area Affected by Oyster Longlines and Potential Eelgrass Density Reduction under the Project (622 acre Expansion) in North Bay.

Growing Area and Treatment		Total Area (acre)			Eelgrass Density within Growing Areas (turions)			Affected Area (acre)			Potential Eelgrass Reduction (turions)		
		Non-Eelgrass	Patchy Eelgrass	Dense Eelgrass	Non-Eelgrass	Patchy Eelgrass	Dense Eelgrass	Non-Eelgrass	Patchy Eelgrass	Dense Eelgrass	Non-Eelgrass	Patchy Eelgrass	Dense Eelgrass
Area 1	Cultch (5-ft)	11.8	33.3	98.5	0	6,742,063	31,888,711	1.2	3.4	10.0	0	-320,169	-1,514,339
	Basket* (5-ft group)	2.4	6.4	18.8	0	1,284,877	6,086,472	0.2	0.6	1.8	0	-85,023	-402,755
Area 2	Cultch (5-ft)	0.4	2.8	28.7	0	560,490	9,306,086	0.0	0.3	2.9	0	-26,617	-441,930
	Basket* (5-ft group)	0.2	0.5	5.5	0	109,265	1,777,379	0.0	0.1	0.5	0	-7,230	-117,613
Area 3	Cultch (5-ft)	2.1	37.9	96.4	0	7,668,793	31,222,307	0.2	3.8	9.7	0	-364,177	-1,482,692
	Basket* (5-ft group)	0.5	7.2	18.4	0	1,460,915	5,956,973	0.0	0.7	1.7	0	-96,672	-394,186
Area 4	Cultch (5-ft)	2.2	9.6	60.3	0	1,946,133	19,525,920	0.2	1.0	6.1	0	-92,418	-927,251
	Basket* (5-ft group)	0.4	1.8	11.5	0	370,692	3,723,108	0.0	0.2	1.1	0	-24,529	-246,366
Area 5	Cultch (5-ft)	0.0	1.8	16.4	0	363,731	5,309,476	0.0	0.2	1.7	0	-17,273	-252,138
	Basket* (5-ft group)	0.1	0.4	3.1	0	80,937	1,008,023	0.0	0.0	0.3	0	-5,356	-66,703
Area 6	Cultch (5-ft)	1.7	5.3	112.8	0	1,062,300	36,518,832	0.2	0.5	11.4	0	-50,447	-1,734,215
	Basket* (5-ft group)	0.3	1.0	21.5	0	202,343	6,960,593	0.0	0.1	2.0	0	-13,389	-460,598
TOTAL	Cultch (5-ft)	18.2	90.7	413.2	0	18,343,510	133,771,332	1.8	9.2	41.7	0	-871,101	-6,352,564
	Basket* (5-ft group)	3.9	17.3	78.8	0	3,509,029	25,512,548	0.4	1.6	7.4	0	-232,200	-1,688,221

* Basket-on-longline culture in non-eelgrass areas may include rack-and-bag culture

50	Density of patchy eelgrass (in turions/m^2)
80	Density of dense eelgrass (in turions/m^2)
4,047	1 acre to m^2 conversion (in m^2)

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Appendix B

Estuarine Habitat Credit-Debit Mitigation Accounting Framework

APPENDIX B: ESTUARINE HABITAT CREDIT-DEBIT MITIGATION ACCOUNTING FRAMEWORK

REVIEW DRAFT

1.0 PURPOSE

The National Marine Fisheries Services (NMFS) has adopted a policy of no net loss of eelgrass habitat function in California (NMFS 2014). NMFS' California Eelgrass Mitigation Policy (CEMP) provides guidance to reviewing agencies and applicants on assessing the need for, planning, and implementing compensatory mitigation projects to achieve the no net loss goal. The CEMP recommends that compensatory mitigation opportunities be evaluated using: (1) comprehensive management plans, (2) in-kind mitigation, (3) mitigation banks, (4) in-lieu fee programs, and/or (5) out-of-kind mitigation. The most appropriate form of compensation is to be determined on a case-by-case basis.

This appendix builds on the CEMP's guidelines in the context of Coast Seafoods Company's (Coast) Humboldt Bay Shellfish Aquaculture: Permit Renewal and Expansion Project (Project), which proposes a 622-acre expansion of Coast's existing intertidal oyster culture in Humboldt Bay, California. A large portion of the expanded acreage will overlap with eelgrass habitat. Impacts to eelgrass are expected to be limited to reductions in eelgrass density directly under the longlines, which equates to about 5% of the expansion area. While the impact was determined to be insignificant based on the established threshold of significance (see Section 9.0 of the Eelgrass Impacts Analysis), Coast is proposing upfront mitigation to offset any potential reduction in ecological function. Due to the limited opportunities for eelgrass mitigation in Humboldt Bay, Coast is proposing out-of-kind mitigation in combination with in-kind mitigation.

This report is intended to provide an additional framework for analysis in order to:

- Determine when out-of-kind mitigation is appropriate;
- Assess eelgrass habitat function; and
- Compare potential reduction in eelgrass habitat function with functional uplifts provided by both in-kind and out-of-kind mitigation.

This mitigation accounting framework is intended to assist Coast in developing a mitigation project that satisfies the CEMP's standard of no net loss of eelgrass habitat function. The goal is to create a methodology that can value ecological functions of estuarine habitats in Humboldt Bay without additional research other than the proposed monitoring efforts.

2.0 EELGRASS HABITAT FUNCTIONS

Eelgrass is a highly productive habitat that contributes to ecosystem functions at multiple levels by providing refuge, food resources, and nursery grounds to a number of species. Ecosystem functions and values to society were enunciated by Short et al. (2000) and are described in Table B-1. Three functions were identified as integral components of the values discussed by Short et al. (2000) for eelgrass habitat: (1) water quality, (2) habitat structure, and (3) prey resources.

Table B-1 Ecological Functions Provided by Eelgrass

Function	Value	Water Quality	Habitat Structure	Prey Resources
Canopy structure	Habitat, refuge, nursery, settlement, and support of fisheries		✓	
Primary production	Food for herbivores and support of fisheries and wildlife			✓
Epibenthic and benthic production	Support of food web and fisheries			✓
Nutrient and contaminant filtration	Improved water quality and support of fisheries	✓		
Sediment filtration and trapping	Improved water quality, counter sea level rise and support of fisheries	✓		
Epiphyte and epifaunal substratum	Support of secondary production and fisheries		✓	✓
Oxygen production	Improved water quality and support of fisheries	✓		
Organic production and export	Support of estuarine, offshore food webs, and fisheries			✓
Nutrient regeneration and recycling	Support of primary production and fisheries			✓
Organic matter accumulation	Support of food webs and counter sea level rise			✓
Wave and current energy dampening	Prevents erosion/ resuspension and increases sedimentation	✓	✓	

Source: Function and Value columns from Short et al. (2000)

3.0 LIMITATIONS OF IN-KIND EELGRASS MITIGATION IN HUMBOLDT BAY

In-kind mitigation of eelgrass resources has a high historic rate of failure throughout the U.S. Seagrass transplantation was first attempted in 1939, with serious restoration efforts initiated in the 1960's (Paling et al. 2009). This timeline is far shorter than comparable efforts for terrestrial wetlands, and restoration efforts remain difficult and challenging (Gordon 1996). Despite progress in site selection, transplantation methods, and improvements in measuring recovery, numerous challenges remain (Paling et al. 2009). Furthermore, efforts to restore eelgrass have not proven universally effective, with some methods (e.g., direct seeding) proving successful in some locations (Orth et al. 2006) and failing in others (Orth et al. 2010).

Few opportunities exist in Humboldt Bay for in-kind eelgrass mitigation and past attempts at eelgrass restoration have met with low rates of success. The historically low success rate of eelgrass mitigation may be explained by the relatively high occupancy rate of potential eelgrass habitat in the bay. This is particularly relevant for Coast's leased and owned tideland areas, which are characterized by expansive eelgrass beds. Efforts to compare predicted eelgrass habitat to existing eelgrass habitat in Humboldt Bay revealed that most of the predicted habitat is currently occupied (Gilkerson 2008).

The CEMP responds to the historically high rate of mitigation failure by recommending a mitigation ratio of 4.82:1 to mitigate for areal (spatial) reductions in eelgrass beds for Northern California sites. While potentially effective at ensuring restored acreage exceeds impacted acreage, this approach discourages investment in improving restoration methods and avoids addressing the potential causes of low success rates.

In areas of Humboldt Bay where predictably suitable habitat was unoccupied, lack of eelgrass could be attributed to the site's high wind and wave exposure potential or to chronic disturbance from historic mechanical dredge harvesting practices for oyster ground culture. Since efforts to create eelgrass habitat in areas that are unoccupied for unknown reasons have historically had high rates of failure (Paling et al. 2009), few opportunities exist in Humboldt Bay for successful eelgrass restoration. This is in stark comparison to other types of critical habitat, like coastal salt marsh, that have significantly declined over the past several decades.

4.0 OUT-OF-KIND EELGRASS MITIGATION

Out-of-kind mitigation is compensatory mitigation that creates, restores, or enhances an environmental resource that is different from what is impacted. Until recently, U.S. mitigation policies explicitly identified a preference for in-kind mitigation (U.S. EPA and DA 1990). U.S. Army Corps of Engineers (Corps) regulations now focus instead on identifying the most "environmentally preferable" mitigation for aquatic resources in the watershed, based on the likelihood for ecological success and sustainability, mitigation site location, and mitigation cost, regardless of whether the restored resource is in-kind or out-of-kind (33 C.F.R. § 332.3[40 C.F.R. § 230.93]). Furthermore, out-of-kind mitigation may be preferred in situations where restoration success is uncertain or comparable ecological functions can be provided by alternative resources (33 CFR § 332.3; 73 Fed. Reg. 19602, 19619; CEMP at 17). The CEMP is less detailed on this issue, but similarly allows for out-of-kind mitigation when it is "ecologically desirable" or when in-kind mitigation "is not feasible" (CEMP at 19). Corps regulations also express a general preference for restoration (re-establishment or rehabilitation) projects that take place within the same "marine ecological system" as the impact (33 C.F.R. § 332.2, 33 C.F.R. § 332.3).

5.0 MITIGATION ACCOUNTING FRAMEWORK

An important step in the development of guidance for assessing estuarine habitat function is the development of a meaningful framework that calculates impacts (debits) and mitigation (credits). Numerous frameworks have been generated where a score, based on ecological characteristics, is applied to the area affected (Quétier and Lavorel 2011). A subset of these frameworks account for the possibility of out-of-kind offsets (e.g., Ludwig and Iannuzzi 2006). Such a framework for eelgrass and estuarine habitat should have the following characteristics:

- Be applicable to tidal and non-tidal estuarine aquatic resources
- Assess ecological functions
- Require less than 1 day of field and/or office assessment for each aquatic resource
- Be repeatable and objective while minimizing reliance on best professional judgement
- Be supported by best available science
- Provide a watershed perspective that captures the landscape context and surrounding uses
- Identify critical stressors that might prevent habitats from being restored or achieving full function
- Elevate high quality/value ecological conditions (e.g., ESA listed species, species aggregations, rare habitat types)

One framework that satisfies many of these characteristics was developed for Washington State to create a mechanism to address in-lieu fee mitigation efforts (Hruby 2012). The resulting "Credit-Debit Method" is a guidance document created by the Washington State Department of Ecology through a peer-review process involving more than 100 wetland scientists. It is based on the Federal and State "No Net Loss" policy that was established for land use regulations in 1989 (NRC 1995). The Credit-Debit Method is a tool for "estimating whether a plan for compensatory mitigation will adequately replace the functions and values lost when a wetland is altered."

The Credit-Debit Method is based on the Washington State Wetland Rating System for Western Washington (Ecology publication #04-06-025, attached to this document). It uses rapid assessment tools for analyzing riparian functions and values to establish a rating for three ecological functions that represent the most important values provided by wetland habitat. The Credit-Debit Method is intended to be a time- and cost-effective way to value wetlands, and is based on the collective judgement of regional experts (Hruby 2012). The methods are considered relatively rapid, while still providing scientific rigor.

While the Credit-Debit Method provides a good structure (e.g., sample worksheets for calculating credits and debits) to design a valuation system applicable to the Project, this framework requires significant modification in two areas before it can be applied in California. First, it must be modified to address eelgrass and other estuarine habitats. Second, it requires adaptation to match conditions important to California estuarine habitats. Complementary tools that address these limitations include the California Rapid Assessment Method (CRAM) for Wetlands (San Francisco Estuary Institute 2013).

The CRAM provides methods to conduct a rapid assessment of wetlands, including methods for valuing changes to estuarine habitats. For example, the CRAM describes methods for assessing the abundance of aquatic habitat using a method that calculates the portions of wetland or aquatic habitat that a

500 m transect line crosses. A blending of the Credit-Debit Method and the CRAM provides a simple accounting structure with criteria and methods that can be used to accurately assess the habitat associated with the Project.

5.1 Basic Structure

The framework developed for Coast describes an effective method for characterizing impacts (debits) and mitigation (credits) to identify the adequacy of proposed mitigation to compensate for changes from the Project. It creates a "currency" of credits and debits based on acre-points. While area is a factor in calculating the currency, it also includes a score for the rating of a function to define the currency.

The framework assesses credits and debits associated with three ecological functions, all of which are integral components of the values associated with eelgrass and other estuarine habitats:

- **Water Quality:** Potential to improve water quality by trapping sediments, reducing nutrient or contaminant levels, and increasing oxygen levels in the surrounding environment.
- **Habitat Structure:** Potential to contribute to habitat structure relative to historic area, proportion of areal cover, species diversity, habitat complexity, habitat for sensitive species or life stages, and potential for habitat to adapt to sea level rise.
- **Prey Resources:** Potential to support prey resources through primary production, secondary production, distribution of energy resources, and number of species groups supported.

Each ecological function is considered from three different scales or contexts:

- **Site Potential:** Measures the potential contribution of the site in isolation. Characterizes the site's potential to provide resources within the site and the ability of those resources to contribute to ecological functions.
- **Landscape Potential:** Measures the landscape context of the site. Characterizes the potential to allow the benefits to be exported from the site or results in constraints in terms of what is exported into the site.
- **Watershed Priority:** Relative importance of the site within the regional watershed context.

These ratings are further modified based on the timing and risk associated with the mitigation proposed. These characteristics are described as:

- **Temporal Loss Factor:** Characterizes whether the timing of the proposed mitigation is in advance, concurrent to, or subsequent to the impacting action. The Temporal Loss Factor increases the mitigation requirements for projects that propose concurrent or future mitigation actions.
- **Risk Factor:** Risk factor incorporates a measure of the likelihood of success. In-kind mitigation efforts receive the highest value, whereas out-of-kind efforts are lower due to the potential

differences in ecological functions. Furthermore, re-establishment, rehabilitation, and enhancement are valued higher than habitat creation due to the increased failure rates associated with habitat creation projects.

5.2 *Mitigation Accounting Process*

The mitigation accounting framework is a four-step process: (1) identify the sites, (2) evaluate function values or baseline values, (3) re-evaluate function values, and (4) compare changes (Figure B-1).

5.2.1 Identify the Sites

In order to identify appropriate mitigation sites that compensate for the potential change in functions and values at the Project site, there needs to be an assessment of what ecological functions could be modified from the Project actions. Furthermore, an analysis of what habitat is limiting within the system for species that use the area should also guide the identification of mitigation sites. Finally, the site must be feasible and sustainable for providing functions without constant intervention.

Mitigation sites determined to provide suitable compensation for the Project include both areas of reduced eelgrass density within Arcata Bay (North Bay) (in-kind mitigation) and coastal salt marsh within Entrance Bay (out-of-kind mitigation). As discussed above, a reduction in eelgrass density under Project longlines is the primary change associated with the Project. Therefore, projects that increase eelgrass density would provide an in-kind mitigation, particularly in areas that may still show slow recovery from historical mechanical dredge harvesting operations or natural wind-wave damage (Figure B-1). Buoy-deployed seeding systems (BuDS) are described in more detail in Section 8.2.1 of the Eelgrass Technical Report.

In conjunction with the BuDS, Coast would select one of the three other mitigation sites identified in the DEIR. All three sites are coastal salt marsh habitat, which Schlosser et al. (2009) identified as a habitat limitation within the Humboldt Bay watershed. From the 1880s to the 1980s, coastal salt marsh habitat has been significantly modified through diking and filling for upland agricultural land. As a result, salt marsh habitat in Humboldt Bay has been reduced to 10% of historic levels (Schlosser and Eicher 2012). Coastal salt marsh habitat provides connectivity between estuarine and freshwater habitats and important rearing habitat for juvenile salmonids and other fish and wildlife. The majority of potential restoration sites were identified near the Elk River estuary (Figure B-1), which has lost the majority of its functionality due to armoring and other activities associated with urban growth.

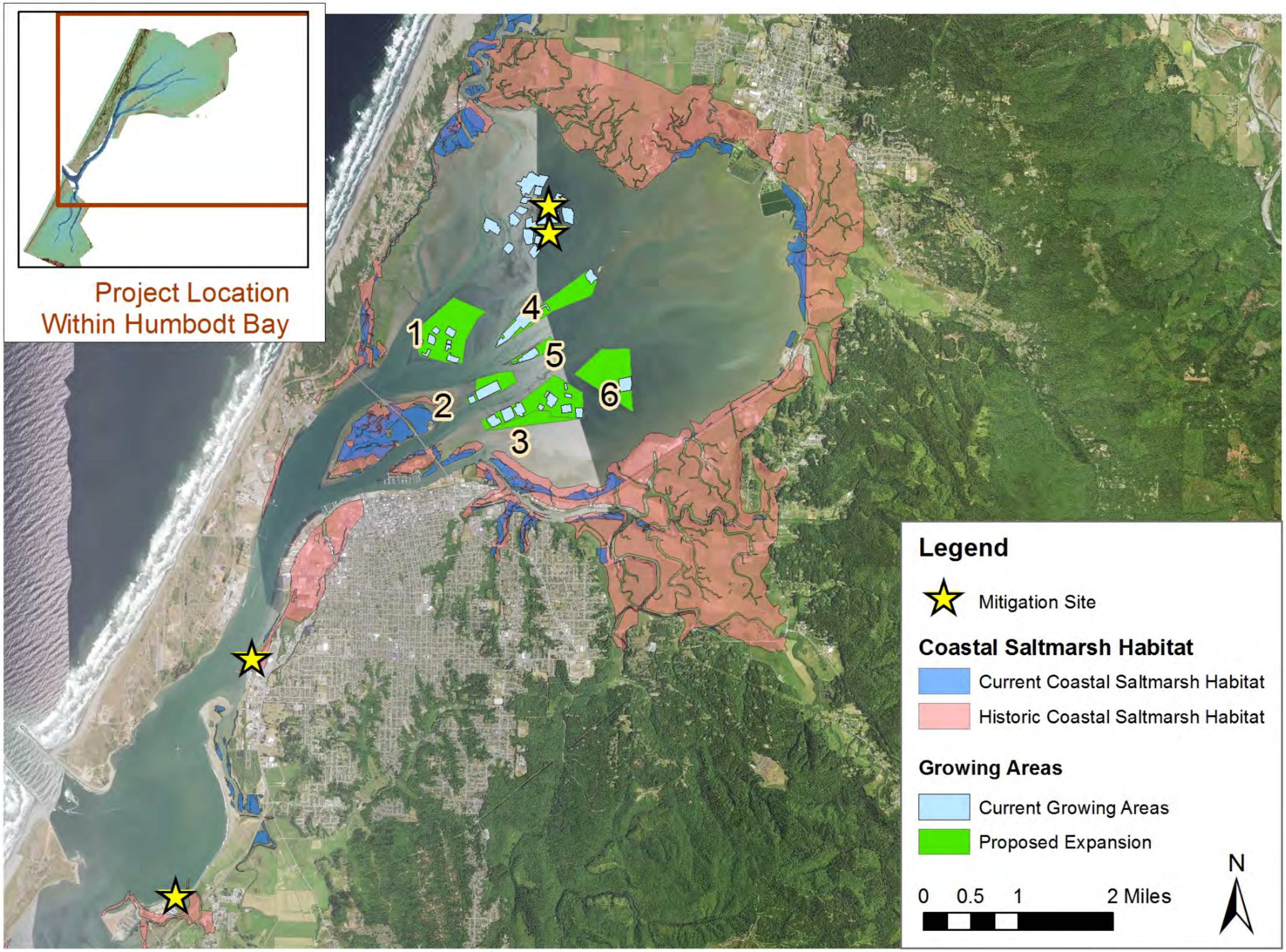

Figure B-1 **Locations for Potential Habitat Restoration in Humboldt Bay.**

5.2.2 Evaluate Function Values or Baseline Evaluation

Ecological functions are scored on a semi-quantitative scale. Scoring criteria are based on thresholds identified or implied by empirical studies of estuarine resources that include objective, easily assessed metrics that can be collected during a brief field review or review of existing monitoring data. For each ecological function and scale, one to five criteria are combined to generate a categorical High, Medium or Low score. These scores are subsequently combined to calculate an overall score for each location evaluated. Scoring forms are provided as an attachment to this document, with notes on why the questions are important. It should be noted that many of the questions incorporate scoring according to CRAM methodology, and it is anticipated that the CRAM guidance for rapid assessment would be used in conjunction with this valuation framework.

Water Quality Functions

Three components of water quality are nutrient loading, turbidity, and contaminant load. Ecological functions served by nearshore habitats may include reducing flow rates and trapping sediments, reducing nutrients and contaminant levels through fixation or sequestration, or producing oxygen through primary productivity. Metrics focus on the ability of the habitat to provide ecological function as well as the capacity of the resource to remove stressors from the water column.

- **Site:** Habitat condition and proximity to sediment sources are predictors of a site's potential to sequester sediment, nutrients, and contaminants. Potential sequestration scales with the total area and distance from sediment sources. Benefits can also be provided if the habitat has a mechanism to extract nutrients or contaminants from the surrounding environment or deliver oxygen to the surrounding environment. Algae and rooted vascular plants deliver oxygen to the water through photosynthesis, which is a major component of water quality conditions that support other organisms. One of the main ways to value how the site provides water quality benefits is the CRAM methodology for assessing the state of the vegetation (or buffer conditions) according to the extent and quality of vegetation cover, the overall condition of its substrate, and the amount of human visitation.

- **Landscape:** In Humboldt Bay, the primary sources of turbidity are from tidal currents and wind-driven waves on the mudflats, with secondary sources from sediment runoff in streams. The ability of the surrounding landscape to either contribute to sediments or improve water quality depends on the marine connectivity and degradation of the surrounding habitat. For example, watersheds above 10% impervious surface area show signs of degradation and increased sediment runoff (Booth 1991). Similarly, overgrazing, cultivation, and forest clearing have been associated with increases in sediment runoff from watersheds (e.g., Walling and Webb 1983). Signs of elevated nutrients regularly or persistently present in the watershed suggest that relevant thresholds for eutrophication may be exceeded. Signs of excess nutrients may include direct measurements of nutrient levels, algal blooms, presence of ulvoid mats, or low dissolved oxygen levels. One of the main ways to value the landscape context of the site is the CRAM method for assessing marine connectivity based on the portion of the coastline with an alteration to sediment supply and transport.

- **Regional or Watershed Priority:** Regional priorities for water quality are enunciated through the 303(d) list, which identifies impaired waters where existing pollution controls and/or biological removal is failing to maintain water quality for one or more parameters. Under the Clean Water Act, Total Maximum Daily Loads (TMDLs) must be developed for all impaired waters. However, prioritization for development of TMDLs is up to each state, and development can occur 5 to 15 years after initial listing. Therefore, in practice, higher priority waters are those that have remained on the 303(d) list and have TMDLs.

Habitat Structure Functions

Depending on the tidal elevation, nearshore vegetated habitats provide rich feeding opportunities, shelter from predators, and thermal refuge. The combination of structured habitat and food resources can create synergies that drive exceptionally high abundances of organisms during various periods (or seasons) of the year.

- **Site:** In general, increasing plant coverage and diversity of vegetation provides a wide variety of ecological niches and increases the diversity of fauna (Zedler 1993). Habitats that have declined substantially from historic levels or are known to be regionally rare are of greater ecological value and may support resources that other habitats cannot. The majority of studies have found a positive correlation between habitat heterogeneity/diversity and species diversity (Tews et al. 2004). Furthermore, taller plant heights provide more 3-dimensional habitat that can be used by a variety of organisms.

- **Landscape:** The landscape context helps identify whether species that might use the site are present, whether habitat is a limiting factor, and if different species are able to access the site. Habitat loss and fragmentation is a major consideration for management actions in Humboldt Bay (Schlosser et al. 2009, Schlosser and Eicher 2012), and the CRAM method for identifying average area of aquatic abundance provides a metric for identifying fragmentation. Species identified as important resources within Humboldt Bay, species that use a variety of habitat types, and species that occur over a broad seasonal range are assessed to identify valuable areas. Finally, the landscape context provides an understanding of the phenomenon called "coastal squeeze" where rising sea levels lead to the loss or compression of intertidal habitats due to the presence of artificial, vertical bank armoring, which is a management concern for Humboldt Bay (Schlosser and Eicher 2012). If there is no room for habitats to expand into (e.g., surrounded by fixed manmade structures), then there is no resiliency in the available habitat.

- **Regional or Watershed Priority:** At the watershed level, the goal is to identify whether the habitat supports regional conservation or restoration targets. If species or habitats that are listed as endangered are present, then these are highly valued areas because endangered status suggests either a substantial decline or naturally low population abundance creating a potential for extinction. Furthermore, documenting species endangerment requires sufficient data collection and scientific understanding to characterize the current population level and species biology. In addition, sites that are identified as critical habitat or essential fish habitat contain essential areas for conservation of species.

Prey Resources Functions

The capacity to support an abundance of invertebrates that spend part of their life associated with vegetated habitat is assessed under this ecological function. There is high scientific support for the relationship between vegetated habitats and invertebrate productivity, partly because submerged vegetation provides additional vertical habitat structure for invertebrates. Primary producers are also an important source of energy at the base of the food web that is processed by primary consumers and detritivores.

- **Site:** The site is characterized for the capacity to produce prey items used by higher trophic levels. Above ground biomass is available for direct consumption, as habitat structure for attachment organisms, and for conversion to detritus. Below ground biomass plays an important role in nutrition, anchoring, and spreading of vegetation. Due to incomplete decomposition in sediments, below ground biomass can represent long term carbon burial (e.g. Kenworthy and Thayer 1984).

  Other, more general, site questions are related to production and species present. Primary production is the primary mechanism for introducing energy into the food web. Secondary production is the generation of biomass by primary consumers (herbivorous organisms that feed on primary producers). Invasive organisms, such as *Spartina*, can convert diverse communities into monocultures (Mitchell 2012). Therefore, presence of invasive organisms was identified as playing a primarily role in degradation.

- **Landscape:** The site is characterized for the potential to export prey items to the landscape. The method from the CRAM for assessing stream continuity was used as a metric in identifying this export potential. Many species benefit from the configuration of habitats that allows for feeding, resting, and predator avoidance. Further benefits may occur for species that have special dietary needs (e.g., grit for brant). Merritt et al. (2001) identified ratios for invertebrate production as indicators of good supply for water column-feeding fish (drift invertebrates), and wading birds and benthic feeding fish (sprawlers).

- **Regional or Watershed Priority:** The site is characterized for the potential to support regional or watershed priority species. Types of recognized species aggregations (e.g., breeding aggregations, groundfish, anadromous fish) and diverse assemblages (e.g., Audubon Society's Important Bird Area program) are indicators of watershed priority for prey production.

5.2.3 Re-evaluate Function Values

Conduct a re-evaluation of the scoring forms post-project at the aquaculture plot and mitigation site, based on monitoring of both project impacts and mitigation project success. The re-evaluation follows the same protocols as the baseline evaluation.

5.2.4 Compare Changes

The changes (before and after) are added to credit and debit worksheets to calculate the mitigation required and mitigation credits available. These credit and debit sheets are the basis for the accounting system, which will be used to understand whether the mitigation balances the potential impact. The major components used to calculate credits and debits are described below:

- **Basic Mitigation Requirement (BMR):** The BMR is the product of the decrease in ecological function values (from Step 2 and 3) and the impact acres. This provides a threshold of change. The BMR is then modified by the temporal loss factor (TLF), depending on when the mitigation is completed. As described above, this factor provides an account for when the uplift in ecological functions is provided vs. when the impact occurs. This is a typical factor in calculating the mitigation ratio.

- **Mitigation Required (Debits):** The debits are provided in a currency called "acre-points", which also incorporates impact acres, a measure of the functional values that may have been modified by the Project, and the temporal loss factor.

- **Basic Mitigation Credit (BMC):** The BMC is the product of the increase in ecological function values (from Step 2 and 3) and the mitigation acres. Similar to the BMR, this provides a threshold of change. The BMC is then modified by the Risk Factor (RF) depending on the type of mitigation used. While in-kind mitigation more closely compensates for the direct impacts associated with the Project, out-of-kind mitigation may be more feasible or provides higher benefits to the watershed. However, there is a risk in using out-of-kind mitigation because it is not a direct compensation for the full suite of ecological functions provided by the reduced resource identified in the BMR. This is also a typical factor used in calculating the mitigation ratio.

- **Mitigation Credits Available (Credits):** The credits are also provided in a currency called "acre-points" that incorporates not just the mitigation acres, but also a measure of the functional values and the risk factor.

The overall credits and debits are compared in the final evaluation to determine whether the mitigation will compensate for changes associated with the Project (Figure B-2), which can also be summarized in the "Summary of Credits and Debits" worksheet. Sample credit, debit, and summary worksheets are provided as an attachment to this document.

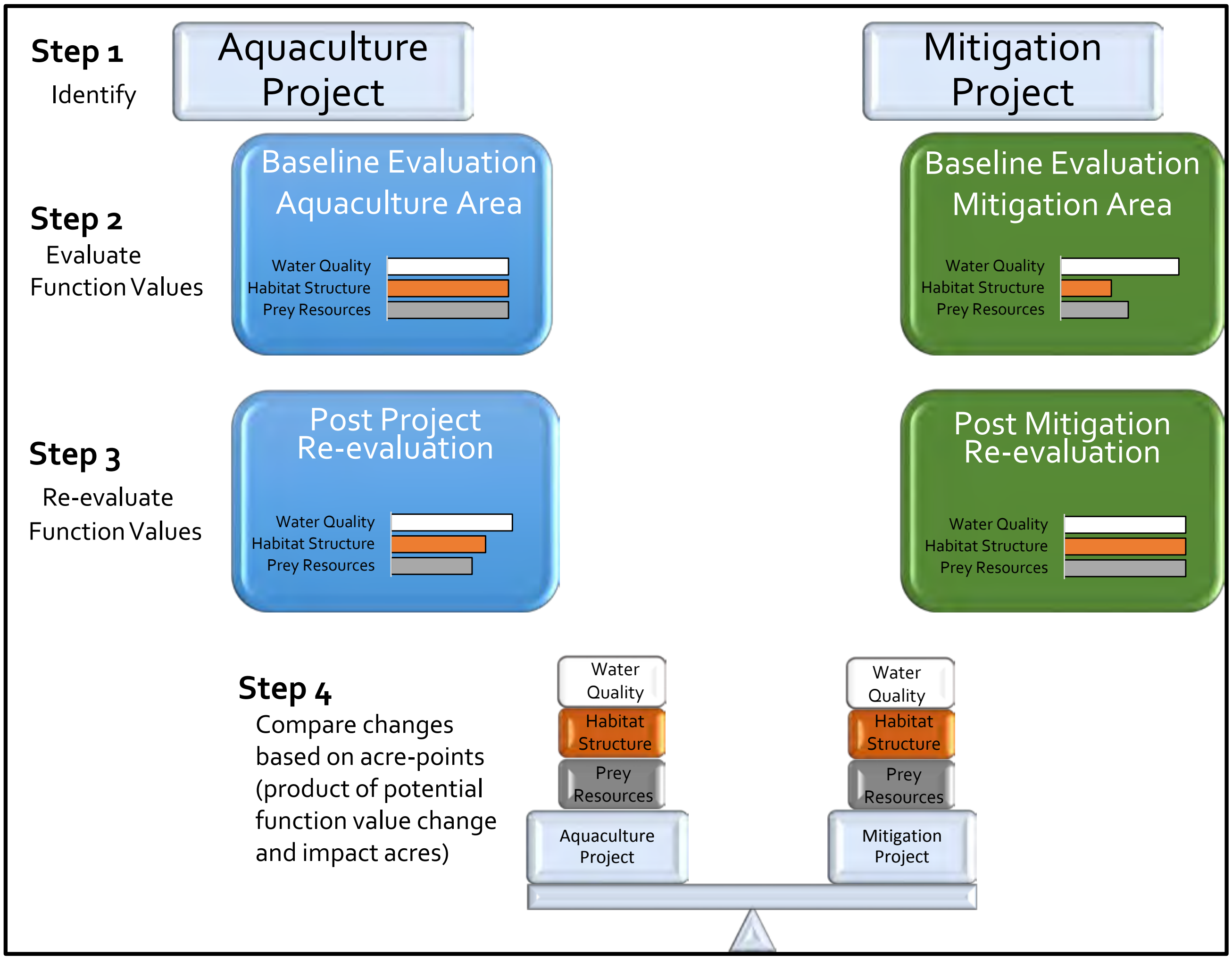

Figure B-2 Overview of Credit-Debit Framework

5.3 *Adaptive Management Responses*

The steps involved in determining mitigation needs and adaptively applying new information are shown in Figure B-3. The mitigation accounting framework was developed based on scientific literature and data from pre-project monitoring. The mitigation accounting estimates of potential project impacts are used to inform the determination of mitigation needs and development of a mitigation plan. Once the Project is underway and associated mitigation actions are implemented, project impacts and mitigation success will be monitored and adaptive adjustments applied as needed. In this way, the best available science for the Project is applied to ensure Project impacts are adequately offset by mitigation.

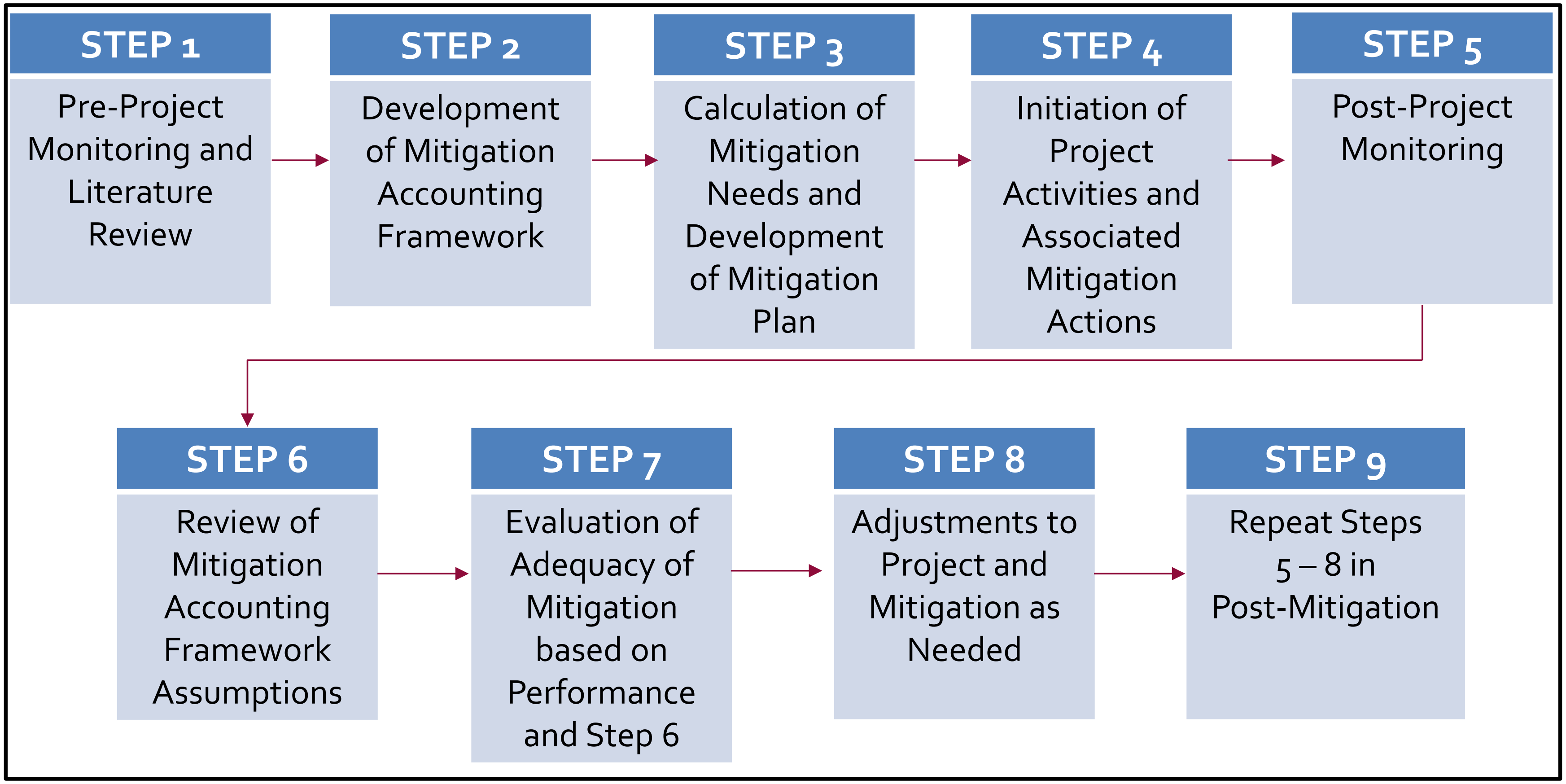

Figure B-3 Proposed Sequence for Determining Mitigation Needs and Applying Adaptive Responses.

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Figures

Tables

Mitigation Accounting Scoring Forms

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for double-sided printing

SCORING FORM

Site: ____________________ Date: ____

	WATER QUALITY FUNCTIONS - Indicators that improve water quality			NOTES
SITE	1.0 Does the habitat unit have the potential to improve water quality?			**Objective:** Identify the capacity of the habitat type to cause a change in water quality by removing sediment, nutrients, or toxins from the water column or adding dissolved oxygen to the water column.
	1.1 Condition of habitat to be able to trap sediments or contaminants:		Score:	According to the California Rapid Assessment Method (CRAM), the ability of vegetation (or buffer condition) to trap sediment/contaminants should be assessed according to the extent and quality of vegetation cover, the overall condition of the substrate, and the amount of human visitation.
	Native vegetation, undisturbed soils, little to no human visitation	points = 8		
	Native/non-native vegetation (25-75%), mostly undisturbed soils, low impact human visitation OR native vegetation but soils disturbance and low impact	points = 4		
	Non-native vegetation (>75%) AND moderate soil disturbance/compaction and/or moderate human disturbance	points = 2		
	Barren ground and/or highly compacted and/or intense human disturbance	points = 0		
	1.2 What is the proximity of the habitat unit to a significant sediment source (i.e., stream, estuary mouth):		Score:	Potential to trap and retain sediment is related to distance from sediment sources. The primary sediment sources of turbidity are from freshwater streams, tidal currents, and wind driven waves along the mudflats (Swanson et al. 2012, Shaughnessy and Hurst 2014).
	<0.25 mile	points = 8		
	0.5 to 0.25 mile	points = 4		
	>0.5 mile	points = 0		
	1.3 Does the habitat unit provide a way to extract nutrients or contaminants from the surrounding environment?		Score:	Surplus nutrients can lead to eutrophication and excessive algal growth, replacement of perennial species with annual species, and reduced maximum depth where vegetation grows. These processes can degrade water quality and reduce habitat available for species use. Nutrient removal can reduce potential impacts from nutrient loading.
	Yes	points = 4		
	No	points = 0		
	1.4 Does the habitat unit deliver oxygen to the water?		Score:	Algae and rooted vascular plants deliver oxygen to the water through photosynthesis (Short et al. 2000), which is a major component of water quality conditions that support other organisms.
	Yes	points = 4		
	No	points = 0		
	Total for 1.0			
	Rating of Site Potential: 16 - 24 = H	6 - 15 = M	0 - 5 = L	
LANDSCAPE	2.0 What is the landscape context for water quality services provided by the site?			**Objective:** Identify whether water quality concerns are present in the service area for the site. Turbidity, nutrients, and contaminants are important management considerations in Humboldt Bay (Schlosser and Eicher 2012).
	2.1 What is the abundance of altered sediment supply or marine connectivity from the site?		Score:	According to the CRAM, marine connectivity can be assessed based on the portion of the coastline with an alteration to sediment supply and transport (e.g., jetties, seawalls/riprap, piers, bridges, and dunes stabilized by invasive species). The measurement is based on 500 m up-coast and down-coast of the midpoint of the site.
	No signs	points = 6		
	<500 m AND/OR marine connectivity	points = 3		
	500 to 900 m OR marine connectivity	points = 2		
	>500 m AND mar.con. OR >900 m OR mar.con.	points = 0		
	2.2 Does at least 10% of the contributing watershed contain tilled fields, pastures, impervious surface area, or forests that have been clearcut within the last 5 years?		Score:	Watersheds above 10% impervious surface area show signs of degradation and increased sediment runoff (Booth 1991). Overgrazing, cultivation, and forest clearing have been associated with increases in sediment runoff from watersheds (e.g., Walling and Webb 1983).
	Yes	points = 4		
	No	points = 0		
	2.3 Are there consistent signs of excess nutrients in the habitat unit (e.g., increased ulvoids, high N, high P, high Si, HABs)?		Score:	Are the signs of elevated nutrients regularly or persistently present in the watershed. Persistence suggests that relevant thresholds for eutrophication are consistently present. Signs of excess nutrients may include direct measurements of nutrient levels, algal blooms, presence of ulvoid mats, or low dissolved oxygen levels.
	None	points = 4		
	1 - 3 years	points = 2		
	>3 years in the past 5 years	points = 0		
	Total for 2.0			
	Rating of Landscape Potential: 11 - 14 = H	5 - 10 = M	0 - 4 = L	
WATERSHED	3.0 Is water quality improvement identified as a watershed or regional priority?			**Objective:** Water quality impairment in the watershed can reduce ecosystem function and population levels.
	3.1 Are there any rivers, streams, or estuaries on the site on the 303(d) list?		Score:	The 303(d) list identifies impaired waters where existing pollution controls and/or biological removal is failing to maintain water quality for 1 or more parameters.
	Yes	points = 1		
	No	points = 0		
	3.2 Does the river or stream have TMDL limits for nutrients, toxics, or pathogens?		Score:	Under the clean water act, Total Maximum Daily Loads (TMDLs) must be developed for all impaired waters, however prioritization for development of TMDLs is up to each State and development can occur 5-15 years after initial listing.
	Yes	points = 1		
	No	points = 0		
	Total for 3.0			
	Rating of Value: 2 = H	1 = M	0 = L	

SCORING FORM

	HABITAT STRUCTURE FUNCTIONS - Indicators that improve habitat structure			NOTES
SITE	4.0 Does the habitat unit have the potential to improve habitat structure?			**Objective:** Habitat structure provides additional ecosystem niches thereby often increasing overall productivity while also providing for predator avoidance.
	4.1 What proportion of historic habitat exists?		Score:	Habitats that have declined substantially from historic levels or are known to be regionally rare are of greater ecological value.
	Decline of 80% or more from historic levels	points = 8		
	Decline of 50-80% from historic levels	points = 4		
	Decline of 20-50% from historic levels	points = 2		
	Decline of less than 20% or increase from historic levels	points = 0		
	4.2 Amount of habitat structure present (% cover or areal extent):		Score:	Percent cover (areal extent) is a common indicator of plant community, health, and development. The Cowardin classification defines a "plant class" as covering more than 30% of the area and Schlosser and Eicher (2012) define patchy eelgrass as >10% and <85%, and continuous eelgrass as >85%.
	Continuous coverage (>85% cover)	points = 8		
	Patchy coverage (10-85% cover)	points = 4		
	No coverage	points = 0		
	4.3 Number of plant species present (including macroalgae and/or microbial mats):		Score:	The majority of studies have found positive correlations between habitat heterogeneity/diversity and species diversity (Tews et al. 2004). In general, increasing diversity of vegetation generates diversity in ecological niches and increased diversity of fauna.
	>3 species	points = 4		
	2 species	points = 2		
	0-1 species	points = 0		
	4.4 Presence of mature, complex habitat that provides 3-dimensional structure:		Score:	Zedler (1993) identified a relationship between habitat structural complexity and species use. Vegetation height is an indicator of complex, mature habitat with 3-dimensional structure. The categories were taken from the CRAM heights for plant layers.
	Very tall (>3 m)	points = 4		
	Tall (1 to 3 m)	points = 3		
	Medium (0.3 to 1 m)	points = 2		
	Short (<0.3 m)	points = 0		
	Total for 4.0			
	Rating of Site Potential: 16 - 24 = H; 10 - 15 = M; 0 - 9 = L			
LANDSCAPE	5.0 Does the landscape have the potential to support habitat function and species use at the site?			**Objective:** Identify whether species that might use the site are present, whether habitat is a limiting factor and if they are able to access the site.
	5.1 In its current state, is the habitat considered a limiting factor for fish or wildlife?		Score:	A limiting factors analysis assesses and identifies factors limiting the productivity or abundance of endangered or sensitive species. There are documents in Humboldt Bay that have already conducted a limiting factors analysis for certain species (e.g., HBWAC and RCAA 2005)
	Yes	points = 2		
	No	points = 0		
	5.2 In its current state, is the habitat unit considered important nursery/rearing habitat for fish or wildlife?		Score: 1	Egg and juvenile stages tend to be the most sensitive to predation due to their relative inability to defend against or evade predation. Therefore, nursery areas that provide complex habitat which supports predation avoidance are high value areas.
	Yes	points = 1		
	No	points = 0		
	5.3 What is the average area of aquatic area abundance?		Score:	Aquatic area abundance is the spatial association with other areas of aquatic resources, such as wetlands, streams, and estuaries. According to the CRAM, transects that run parallel to the shoreline for 500 m on either side of the site are more important the higher the percentage of wetland habitat, other aquatic features, and open water.
	≥61% of the transects	points = 4		
	≥31 to 60% of the transects	points = 3		
	≥11 to 30% of the transects	points = 2		
	≤10% of the transects	points = 0		
	5.4 Does the habitat unit support the following species (add 1 point for every species)?		Score:	These species are identified as common or important within Humboldt Bay (e.g., Pinnix et al. 2005, Connolly and Colwell 2005), use a variety of habitat types, and occur over a broad seasonal range (for most species). See the phenology table for more details. Support defined as supporting feeding, refugia or reproduction by these species.
	Dungeness crab; green sturgeon; dunlin; long-billed			
	Pacific herring; coho salmon; common egret; great blue heron			
	English sole; black brant; surf scoter; harbor seal			
	5.5 Would sea level rise result in a reduction of habitat?		Score:	The phenomenon called "coastal squeeze" is a management concern for Humboldt Bay (Schlosser and Eicher 2012). If there is no room for habitats to expand into (e.g., surrounded by fixed manmade structures), then there is no resiliency in the available habitat.
	Habitat would remain/expand with sea level rise	points = 1		
	Habitat would decline with sea level rise	points = 0		
	Total for 5.0			
	Rating of Landscape Potential: 13 - 17 = H; 6 - 12 = M; 0 - 5 = L			
WATERSHED	6.0 Is the habitat function improvement provided by the site identified as a priority issue in the watershed?			**Objective:** Identify whether this this habitat supports regional conservation or restoration targets
	6.1 Has the current abundance triggered state, federal or natural heritage listing?		Score:	Listing a species as endangered suggests both a decline or naturally low population abundance creating a potential for extinction. A listing also suggests that there is sufficient data collection and scientific understanding to characterize the current population level and species biology.
	Habitat is recognized as priority for protection	points = 2		
	No formal recognition of habitat rarity/priority	points = 0		
	6.2 Are there recovery plans or ESA documents that include the habitat as a priority habitat?		Score:	Critical habitat or essential fish habitat contain features that are essential areas for conservation of species.
	Yes	points = 1		
	No	points = 0		
	6.3 Is there literature that provides the importance of the habitat for providing habitat function?		Score:	The Humboldt Bay Initiative (Schlosser et al. 2009) identifies Ecosystem-based Management (EBM) targets. If management plans specifically call out individual habitat, it gains a level of importance for the watershed.
	Yes	points = 1		
	No	points = 0		
	Total for 6.0			
	Rating of Value: 3 - 4 = H; 1 - 2 = M; 0 = L			

SCORING FORM

	PREY RESOURCES FUNCTIONS - Indicators that improve habitat structure		NOTES
SITE	7.0 Does the habitat unit have the potential to improve prey resources?		**Objective:** Characterize the capacity of the site to produce prey items used by higher trophic levels.
	7.1 Type of habitat structure that can provide resource for prey species: Above- and below-ground biomass/structure — points = 8 Above-ground biomass or structure — points = 4 Below-ground biomass or structure — points = 2 No habitat present — points = 0	Score:	Above ground biomass is available for direct consumption and conversion to detritus and provides 3-dimensional habitat structure. Below ground biomass plays an important role in nutrition as well as anchoring and spreading of vegetation. Due to incomplete decomposition in sediments, below ground biomass can represent long term carbon burial (e.g. Kenworthy and Thayer 1984).
	7.2 Density of habitat present: Dense (>100 turions/m^2 or >3 plants/m^2) — points = 8 Patchy (<100 turions/m^2 or <3 plants/m^2) — points = 4 No habitat present — points = 0	Score:	This metric is based on work by Hughes (2002) who found significant differences in fish abundance, biomass, species richness, and prey items between eelgrass densities above and below 100 shoots/m^2 (or in excess of 100 g/m^2).
	7.3 Does the habitat unit provide primary production? Yes — points = 4 No — points = 0	Score:	Primary production is use of light or chemical energy to generate organic compounds (e.g. photo or chemosynthesis). Primary production is the primary mechanism for introducing energy into the food web.
	7.4 Does the habitat unit support secondary production? Yes — points = 4 No — points = 0	Score:	Secondary production is the generation of biomass by primary consumers (herbivorous organisms that feed on primary producers).
	7.5 Does the habitat unit contain invasive or exotic species (e.g., *Spartina densiflora* , *Zostera japonica* , European green crab, *Ampithoe valida* amphipod) that may affect productivity or foraging? No — points = 4 Yes — points = 0	Score:	Spartina is a major invasive organism in salt marshes in Humboldt Bay with the potential to convert diverse salt marsh communities into Spartina dominated habitat, including facilitating a significant difference in invertebrate communities with non-native species. Native sites are comprised mostly of invertebrates from the family Heminiptera (Mitchell 2012).
	Total for 7.0		
	Rating of Site Potential: 20 - 28 = H; 11 - 19 = M; 0 - 10 = L		
LANDSCAPE	8.0 Does the landscape have the potential to support prey resources at the site?		**Objective:** Characterize the potential for the site to export prey items to the landscape.
	8.1 What is the distance of the stream corridor continuity based on the combined length of non-buffer segments? <100 m — points = 4 100 to 150 m — points = 3 150 to 200 m — points = 2 >200 m — points = 0	Score:	According to the CRAM, stream continuity considers the ability of areas of open water with connectivity of habitat to provide corridors for anadromous fish and other wildlife. The method combines the length of non-buffered land that crosses the riparian or aquatic area.
	8.2 Is the habitat unit adjacent to or on a sandy grit site used by black brant? Yes — points = 2 No — points = 0		Disturbances near traditional grit sites may limit the ability of black brant to replenish gizzard grit, which would reduce their digestive efficiency (Moore and Black 2005).
	8.2 For which seasons do fish or wildlife forage in the habitat unit? All seasons (fall, winter, spring, summer) — points = 4 At least two seasons — points = 3 At least one season — points = 2 None — points = 0	Score:	Sites that are used for multiple seasons are expected to support more types of species and more resident species.
	8.3 Potential for the habitat unit to produce benthic and drift prey items: Water-column and benthic prey items available — points = 4 Majority of prey are from the water-column — points = 2 Majority of prey are from the benthic habitat — points = 2 No prey items are available — points = 0	Score:	Merritt et al. (2002) identifed these ratios for invertebrate production as indicators of good supply for water column-feeding fish (drift invertebrates), wading birds and benthic feeding fish (sprawlers).
	Total for 8.0		
	Rating of Landscape Potential: 10 - 14 = H; 6 - 9 = M; 0 - 5 = L		
WATERSHED	9.0 Are prey resources produced by the site identified as watershed or regional priorities?		**Objective:** Identify the potential for the site to produce prey items consumed by regional or watershed priority species.
	9.1 How many species groups does the habitat unit support (add the total)? Shorebirds — Anadromous Fish — Groundfish — Yes = 1 Wading birds — Mammals — Pelagic fish — No = 0	Score:	The more diverse the habitat, the more diverse the type of species that use the habitat will be.
	9.2 Is there literature that provides an understanding of the importance of the habitat for providing prey resources? Yes — points = 1 No — points = 0	Score:	Structured habitat is often associated with higher species diversity for benthic invertebrates, but not directly for mobile species (Hosack 2003, Hosack et al. 2006).
	Total for 9.0		
	Rating of Value: 3 - 5 = H; 1 - 2 = M; 0 = L		

SCORING SUMMARY

Scoring functions to calculate mitigation credits and debits

These Scores are for the Following:		
Habitat Type	**Plot #**	**Site #**

Scores (order of ratings is not important)	
9 = H, H, H	6 = M, M, M
8 = H, H, M	5 = H, L, L
7 = H, H, L	4 = M, L, L
7 = H, M, M	3 = L, L, L
6 = H, M, L	

SUMMARY OF SCORING

FUNCTION ***Plot # _____ or Site # _____***	**Improving Water Quality**	**Improving Habitat Structure**	**Improving Prey Resources**
Rating of Site Potential			
Rating of Landscape Potential			
Rating of Watershed or Regional Priority			
Score Based on Ratings (see table below)			

FUNCTION ***Plot # _____ or Site # _____***	**Improving Water Quality**	**Improving Habitat Structure**	**Improving Prey Resources**
Rating of Site Potential			
Rating of Landscape Potential			
Rating of Watershed or Regional Priority			
Score Based on Ratings (see table below)			

FUNCTION ***Plot # _____ or Site # _____***	**Improving Water Quality**	**Improving Habitat Structure**	**Improving Prey Resources**
Rating of Site Potential			
Rating of Landscape Potential			
Rating of Watershed or Regional Priority			
Score Based on Ratings (see table below)			

FUNCTION ***Plot # _____ or Site # _____***	**Improving Water Quality**	**Improving Habitat Structure**	**Improving Prey Resources**
Rating of Site Potential			
Rating of Landscape Potential			
Rating of Watershed or Regional Priority			
Score Based on Ratings (see table below)			

NOTE: Put only the highest score for a question in each box of the form, even if more than one indicator applies to the unit.
Do not add the scores within a question.

"DEBIT" WORKSHEET

Expansion Plot Number: ______________________________ Date: ____________________

Use the following tables to calculate the Debits for each proposed expansion plot. Use a separate worksheet for each plot.

FUNCTION *Mitigation Site #1*	Improving Water Quality	Improving Habitat Structure	Improving Prey Resources
Rating of Site Potential			
Rating of Landscape Potential			
Rating of Value			
Score for Plot [B]efore	**B =**	**B =**	**B =**

FUNCTION *Mitigation Site #1*	Improving Water Quality	Improving Habitat Structure	Improving Prey Resources
Rating of Site Potential			
Rating of Landscape Potential			
Rating of Value			
Score for Plot [A]fter	**A =**	**A =**	**A =**

CALCULATIONS	Improving Water Quality	Improving Habitat Structure	Improving Prey Resources
Decrease in Score at plot (A - B) =	0	0	0
Impact - Acres			
Basic mitigation requirement (BMR) = *Score for function x acres impact*	0	0	0
Temporal loss factor (TLF) (see table below)			
Mitigation required *DEBITS = BMR x TLF (units = acre-points)*	0	0	0

TEMPORAL LOSS FACTORS

Timing of Mitigation	Temporal Loss Factor
Advanced - At least two years has passed since plantings were completed or one year since "as-built" plans were submitted to regulatory agencies.	1.0
Concurrent - Physical alterations at mitigation site are completed within a year of the impacts, but planting may be delayed by up to 2 years if needed to optimize conditions for success.	1.5
Delayed - Construction is not completed within one year of impact, but is completed (including plantings, if required) within 5 growing seasons of impact.	3.0

"CREDIT" WORKSHEET

Site: ______________________ Date: ______________

NOTE: Scores for habitat unit before mitigation takes place. Values are a replicate of what appears in the scoring summary.

B = 0 for Creation and Re-establishment

FUNCTION ***Mitigation Site #1***	**Improving Water Quality**	**Improving Habitat Structure**	**Improving Prey Resources**
Rating of Site Potential			
Rating of Landscape Potential			
Rating of Value			
Score for Mitigation Site [B]efore	**B =**	**B =**	**B =**

NOTE: Scores for unit based on the expected change when the mitigation site is established, vegetation reached maturity, and water regime has stabilized. Values are a replicate of what appears in the scoring summary.

FUNCTION ***Mitigation Site #1***	**Improving Water Quality**	**Improving Habitat Structure**	**Improving Prey Resources**
Rating of Site Potential			
Rating of Landscape Potential			
Rating of Value			
Score for Mitigation Site [A]fter	**A =**	**A =**	**A =**

CALCULATIONS ***Mitigation Site #1***	**Improving Water Quality**	**Improving Habitat Structure**	**Improving Prey Resources**
Increase in Score at mitigation site (**A - B**) =	0	0	0
Acres of mitigation (*should be the same for 3 functions for each type of mitigation*)			
Basic mitigation credit (BMC) = *Increase in Score x acres of mitigation*	0	0	0
Risk Factor (RF) (*see table below*)			
Mitigation credits available for each habitat unit *CREDITS = BMC x RF (units = acre-points)*	0	0	0

RISK FACTORS

Type of Mitigation	Risk Factor
In-kind mitigation used.	
Compensatory mitigation for vegetated and unvegetated eelgrass habitat will be successfully completed at a ratio of at least 1.2:1 mitigation area to impact area	0.8
Out-of-kind mitigation used.	
Re-establishment, rehabilitation, or enhancement.	0.7
Creation with data showing there is adequate habitat to maintain conditions 5 years out of every 10.	0.6
Placement of shellfish aquaculture gear.	0.3

SUMMARY OF CREDITS AND DEBITS

This summary has space for 12 impact plots and 12 mitigation sites. If more areas are planned, another sheet will be needed.

DEBITS *(all numbers are in acre-points)*	**Improving Water Quality**	**Improving Habitat Structure**	**Improving Prey Resources**
Mitigation required (Site #_____ or Plot #____)			
Mitigation required (Site #_____ or Plot #____)			
Mitigation required (Site #_____ or Plot #____)			
Mitigation required (Site #_____ or Plot #____)			
Mitigation required (Site #_____ or Plot #____)			
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Mitigation required (Site #_____ or Plot #____)			
Mitigation required (Site #_____ or Plot #____)			
Mitigation required (Site #_____ or Plot #____)			
Mitigation required (Site #_____ or Plot #____)			
TOTAL (*in acre-points*)	**0**	**0**	**0**
CREDITS *(all numbers are in acre-points)*	**Improving Water Quality**	**Improving Habitat Structure**	**Improving Prey Resources**
Mitigation credits available (Site #_____ or Plot #____)			
Mitigation credits available (Site #_____ or Plot #____)			
Mitigation credits available (Site #_____ or Plot #____)			
Mitigation credits available (Site #_____ or Plot #____)			
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Mitigation credits available (Site #_____ or Plot #____)			
Mitigation credits available (Site #_____ or Plot #____)			
Mitigation credits available (Site #_____ or Plot #____)			
TOTAL (*in acre-points*)	**0**	**0**	**0**
BALANCE *CREDITS - DEBITS (in acre-points)*	**0**	**0**	**0**

Appendix C

Evaluation of Coast Seafoods Expansion Using the Mitigation Accounting Framework

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APPENDIX C: EVALUTATION OF COAST SEAFOODS EXPANSION USING THE MITIGATION ACCOUNTING FRAMEWORK

Review Draft

1.0 OVERVIEW OF MITIGATION EVALUATION

The Estuarine Habitat Credit-Debit Mitigation Accounting Framework (Mitigation Framework) was applied to evaluate both potential impacts (debits) and mitigation opportunities (credits) associated with the Coast Seafoods Company's (Coast), Humboldt Bay Shellfish Aquaculture: Permit Renewal and Expansion Project (Project). This evaluation examines the proposed expansion of operations into 622 acres of North Bay in Humboldt Bay, California. This expansion will occur in six discrete growing areas separated by subtidal channels. Each of these growing areas is assessed separately to account for potential differences in both the existing and proposed conditions within the growing areas.

Evaluation of mitigation opportunities focused on two types of projects. First, the use of eelgrass seed bags to accelerate natural recovery in areas where habitat appears suitable for eelgrass, but eelgrass is either absent or patchy in its distribution. Buoy Deployed Seed Bags (BuDS) are an effective mechanism for establishing eelgrass in suitable locations by collecting viable eelgrass seed and then placing the seeds in a mesh bag tied to a float allowing natural processes to distribute seeds. This method has been used successfully on both the East and West Coasts for re-establishing and enhancing eelgrass beds. Second, partners were identified from organizations currently advancing mitigation opportunities associated with tidal and estuary enhancements along the shorelines of Humboldt Bay or tributary streams. Estuarine habitat has been reduced by more than 90 percent from historic levels in Humboldt Bay due to historic agricultural and railroad improvements. Due to this habitat loss, the protection and restoration of tidal and estuarine wetlands has been identified as a limiting factor for the ecosystem and a target for restoration efforts. Potential mitigation sites and existing and proposed growing areas are illustrated in Figure C-1.

2.0 DATA COLLECTION

The overall intent of the Mitigation Framework is to have a tool for comparing the impacts (debits) to the mitigation opportunities (credits), in particular to address the range of impacts and benefits that could occur in an estuarine context. Collection of data to evaluate sites is intended to be rapid and allow for evaluation using existing data resources and scientific judgement based on similar habitats in other contexts. Data was collected to evaluate each component of the Mitigation Framework (Water Quality, Habitat Structure, and Prey Resources) at each of the three scales (Site, Landscape and Watershed) primarily from existing reports or project proposals, Global Information System evaluations using widely available data, and review of existing watershed level reports.

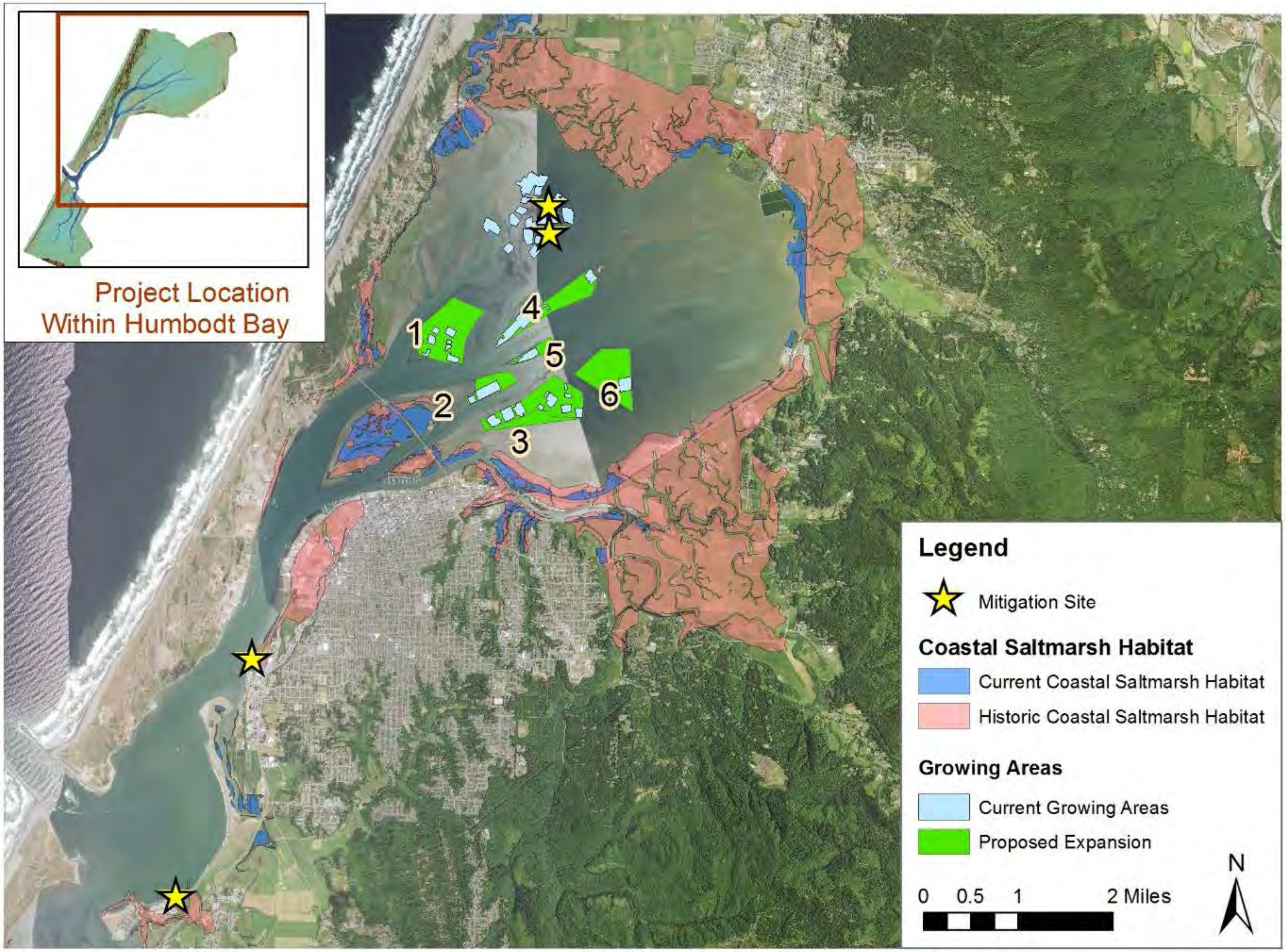

Figure C-1 **Potential mitigation sites and Coast Seafood Growing Areas.**

3.0 MITIGATION ACCOUNTING INITIAL RESULTS

Details of the ecological value scoring (including scoring forms) for each of the Growing Areas and mitigation projects are provided below. The following includes a summary of the debit and credit values for the Project and mitigation, and the summary of the Mitigation Accounting results based on the final debit and credit values.

3.1 Debit Values

Five of six Growing Areas were scored the same for existing (before) and future (after) conditions. These were Growing Areas 1, 2, 4, 5, and 6. Growing Area 3 scored slightly higher for water quality functions due to its proximity to Freshwater Creek and the status of that creek as a 303(d) listed water body for sediment. The evaluation for all sites showed no changes in the scores from existing to future conditions. This lack of transition from one category to another is unsurprising because the environmental context for each site is able to function in a similar manner as it would naturally, as discussed in the Biological Resources Technical Report (Appendix E of the DEIR). In other words, the effects of the Project on ecological function variables were not large enough to cause a shift from one class (e.g., High) to another (e.g., Medium). Therefore, a modifier of -5 percent was applied to water quality, habitat structure, and prey functions to account for change from a natural to human-induced system. The change in condition for each unit is then multiplied by the affected acreage and the temporal loss factor, which accounts for the timing of mitigation to create a credit value.

Debit values are unitless values calculated for water quality, habitat structure, and prey resources. The values incorporate the site's affected area, potential ecological loss due to the Project, and temporal loss factor to account for differences in timing between the impact and mitigation. For these calculations a temporal loss function associated with concurrent mitigation was applied suggesting that the mitigation site will be completed within 1-year of impacts. Debit values are shown in Table C-1.

Table C-1 Debit Values Calculated for Aquaculture Growing Areas

Growing Area	Acres Affected	Water Quality Mitigation Required	Habitat Structure Mitigation Required	Prey Resources Mitigation Required
Growing Area 1	7.9	-4.7	-4.1	-4.7
Growing Area 2	1.9	-1.1	-1.0	-1.1
Growing Area 3	8.1	-5.5	-4.3	-4.9
Growing Area 4	4.2	-2.5	-2.2	-2.5
Growing Area 5	1.1	-0.7	-0.6	-0.7
Growing Area 6	7.1	-4.3	-3.7	-4.3
Totals	**30.3**	**-18.8**	**-15.9**	**-18.2**

3.2 Credit Values

Three mitigation opportunities were evaluated to identify credits. These include: (1) Buoy-Deployed Seeding System (BuDS) – placement of eelgrass seedbags in approximately 1 acre of habitat to accelerate recovery of eelgrass in Humboldt Bay; (2) Elk River Estuary – restoration of approximately 23 acres of habitat from palustrine wetland and upland conditions to estuarine wetlands connected to Elk River Slough; (3) Parcel 4 – the restoration of approximately 10 acres of a former Pacific Lumber Company (PALCO) brownfields historic salt marsh, which would include new brackish marsh conditions in addition to improving culvert function and managing onsite debris and vegetation. Information for each of these projects was taken from project proposal documents, published information about similar projects, and public reports. Similar to the assessment of Growing Areas, the placement of BuDS as a habitat enhancement effort is not sufficient to change the rating of a site within the Mitigation Framework. Therefore, a modifier was used to account for the uplift to site conditions provided by placing BuDS and subsequent establishment of eelgrass.

As described in the Eelgrass Technical Report, there is ecological value to shellfish aquaculture. While it does not replace eelgrass habitat function, there are many similarities in the species that it supports. Because of this similarity in ecological function, the effect is not large enough to cause a shift from one class to another. Therefore, the same modifier as used above was applied to the values associated with shellfish aquaculture. Additionally, in recognition that shellfish aquaculture is a human-induced system, the affected acreage was further reduced by applying a risk factor of 0.3 to the final score.

Credit values for mitigation sites are unitless values calculated for water quality, habitat structure, and prey resources that integrate the mitigation area, ecological uplift, and risk factor. Elk River Estuary and Parcel 4 were both categorized as out-of-kind habitat creation. Eelgrass seed bags were given a risk factor associated with in-kind compensatory mitigation. The credit values for the three mitigation opportunities are shown in Table C-2.

Table C-2 Credit Values Calculated for Mitigation and Aquaculture Growing Areas

Mitigation Area	Acres Affected	Water Quality Mitigation Required	Habitat Structure Mitigation Required	Prey Resources Mitigation Required
Buoy-Deployed Seeding System (BuDS) + Parcel 4				
BuDS	1.0	3.2	3.6	3.2
Parcel 4	10.0	18.0	36.0	30.0
Growing Area 1	7.9	1.9	1.6	1.9
Growing Area 2	1.9	0.5	0.4	0.5
Growing Area 3	8.1	2.2	1.7	1.9
Growing Area 4	4.2	1.0	0.9	1.0
Growing Area 5	1.1	0.3	0.2	0.3
Growing Area 6	7.1	1.7	1.5	1.7
Totals	**41.3**	**28.8**	**45.9**	**40.5**

Mitigation Area	Acres Affected	Water Quality Mitigation Required	Habitat Structure Mitigation Required	Prey Resources Mitigation Required
BuDS + Elk River Estuary				
BuDS	1.0	2.8	3.6	3.2
Elk River Estuary	23.0	27.6	41.4	27.6
Growing Area 1	7.9	1.9	1.6	1.9
Growing Area 2	1.9	0.5	0.4	0.5
Growing Area 3	8.1	2.2	1.7	1.9
Growing Area 4	4.2	1.0	0.9	1.0
Growing Area 5	1.1	0.3	0.2	0.3
Growing Area 6	7.1	1.7	1.5	1.7
Totals	**57.2**	**38.4**	**51.3**	**38.1**

3.3 *Summary of Mitigation Accounting*

Although credits and debits may affect different resources, the Mitigation Framework provides an effective mechanism for ensuring that the range of resources affected by the Project are offset through appropriate mitigation efforts. Credits and debits provide for a transparent accounting system that illustrates how Project effects are offset by mitigation actions that result in ecosystem benefits. For this Project, mitigation credits are projected to exceed debits for two of the three functional groups for either mitigation scenario (Table C-3). Depending on the scenario either Water Quality of Prey Resources are not completely offset by mitigation credits, however surplus compensation in other categories suggests the mitigation scenarios evaluated provide appropriate compensation for predicted project effects. Ecological benefits will be distributed across a wide range of resources with benefits accruing to resources dependent on estuarine wetlands and eelgrass, while impacts are primarily to resources associated with shallow intertidal flats and eelgrass.

Table C-3 Mitigation Accounting for the Project

Mitigation Area	Water Quality Mitigation Required	Habitat Structure Mitigation Required	Prey Resources Mitigation Required
Buoy-Deployed Seeding System (BuDS) + Parcel 4 + Culture			
Debits	-18.8	-15.9	-18.2
Credits	28.8	45.9	40.5
Totals	**10**	**30**	**22.3**
BuDS + Elk River Estuary + Culture			
Debits	-18.8	-15.9	-18.2
Credits	38.4	51.3	38.1
Totals	**19.6**	**35.4**	**19.9**

Mitigation Accounting Example Scoring Forms

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SCORING FORM

Site: Coast Growing Areas 1,2,4,5,6 Date: 8-Oct-15

	WATER QUALITY FUNCTIONS - Indicators that improve water quality			NOTES
SITE	1.0 Does the habitat unit have the potential to improve water quality?			**Objective:** Identify the capacity of the habitat type to cause a change in water quality by removing sediment, nutrients, or toxins from the water column or adding dissolved oxygen to the water column.
	1.1 Condition of habitat to be able to trap sediments or contaminants: Native vegetation, undisturbed soils, little to no human visitation Native/non-native vegetation (25-75%), mostly undisturbed soils, low impact human visitation OR native vegetation but soils disturbance and low impact Non-native vegetation (>75%) AND moderate soil disturbance/compaction and/or moderate human disturbance Barren ground and/or highly compacted and/or intense human disturbance	 points = 8 points = 4 points = 2 points = 0	Score: 4	Although vegetation exceeds 90% within each growing area, more than 50% of these area has historically been used for on-bottom harvest. No change in after score because even if all impacts identified in Eelgrass Tech Report resulted in habitats becoming 'not eelgrass' (instead of patchy or remaining continuous), a minimum of 83% of each unit is expected to remain vegetated. According to the California Rapid Assessment Method (CRAM), the ability of vegetation (or buffer condition) to trap sediment/contaminants should be assessed according to the extent and quality of vegetation cover, the overall condition of the substrate, and the amount of human visitation.
	1.2 What is the proximity of the habitat unit to a significant sediment source (i.e., stream, estuary mouth): <0.25 mile 0.5 to 0.25 mile >0.5 mile	 points = 8 points = 4 points = 0	Score: 0	Growing areas are more than 0.5 miles from the nearest stream mouth. Potential to trap and retain sediment is related to distance from sediment sources. The primary sediment sources of turbidity are from freshwater streams, tidal currents, and wind driven waves along the mudflats (Swanson et al. 2012, Shaughnessy and Hurst 2014).
	1.3 Does the habitat unit provide a way to extract nutrients or contaminants from the surrounding environment? Yes No	 points = 4 points = 0	Score: 4	Eelgrass has the potential to detain and sequester nurtients and contaminants. Surplus nutrients can lead to eutrophication and excessive algal growth, replacement of perennial species with annual species, and reduced maximum depth where vegetation grows. These processes can degrade water quality and reduce habitat available for species use. Nutrient removal can reduce potential impacts from nutrient loading.
	1.4 Does the habitat unit deliver oxygen to the water? Yes No	 points = 4 points = 0	Score: 4	Site has primary production from eelgrass. Algae and rooted vascular plants deliver oxygen to the water through photosynthesis (Short et al. 2000), which is a major component of water quality conditions that support other organisms.
	Total for 1.0		**12**	
	Rating of Site Potential: 16 - 24 = H	6 - 15 = M	0 - 5 = L	
LANDSCAPE	2.0 What is the landscape context for water quality services provided by the site?			**Objective:** Identify whether water quality concerns are present in the service area for the site. Turbidity, nutrients, and contaminants are important management considerations in Humboldt Bay (Schlosser and Eicher 2012).
	2.1 What is the abundance of altered sediment supply or marine connectivity from the site? No signs <500 m AND/OR marine connectivity 500 to 900 m OR marine connectivity >500 m AND mar.con. OR >900 m OR mar.con.	 points = 6 points = 3 points = 2 points = 0	Score: 6	No signs of altered sediment supply at the growing sites. According to the CRAM, marine connectivity can be assessed based on the portion of the coastline with an alteration to sediment supply and transport (e.g., jetties, seawalls/riprap, piers, bridges, and dunes stabilized by invasive species). The measurement is based on 500 m up-coast and down-coast of the midpoint of the site.
	2.2 Does at least 10% of the contributing watershed contain tilled fields, pastures, impervious surface area, or forests that have been clearcut within the last 5 years? Yes No	 points = 4 points = 0	Score: 4	The Humboldt Bay watershed has more than 10% of it's area in recently harvest forestry, agriculture and urban land uses. Watersheds above 10% impervious surface area show signs of degradation and increased sediment runoff (Booth 1991). Overgrazing, cultivation, and forest clearing have been associated with increases in sediment runoff from watersheds (e.g., Walling and Webb 1983).
	2.3 Are there consistent signs of excess nutrients in the habitat unit (e.g., increased ulvoids, high N, high P, high Si, HABs)? None 1 - 3 years >3 years in the past 5 years	 points = 4 points = 2 points = 0	Score: 2	There are occasional periods of high algal growth in Humboldt Bay, however it does not appear to be extreme or persistant and does not appear to meet thresholds for eutrophication. ALthough there are no changes in the score after project, oyster aquaculture can be reasonably expected to consume and sequester a portion of the phytoplankton occuring during blooms. Are the signs of elevated nutrients regularly or persistently present in the watershed. Persistence suggests that relevant thresholds for eutrophication are consistently present. Signs of excess nutrients may include direct measurements of nutrient levels, algal blooms, presence of ulvoid mats, or low dissolved oxygen levels.
	Total for 2.0		**12**	
	Rating of Landscape Potential: 11 - 14 = H	5 - 10 = M	0 - 4 = L	
WATERSHED	3.0 Is water quality improvement identified as a watershed or regional priority?			**Objective:** Water quality impairment in the watershed can reduce ecosystem function and population levels.
	3.1 Are there any rivers, streams, or estuaries on the site on the 303(d) list? Yes No	 points = 1 points = 0	Score: 1	Several contributing streams to Arcata Bay are on the 303d list and have TMDL's for sediments. The 303(d) list identifies impaired waters where existing pollution controls and/or biological removal is failing to maintain water quality for 1 or more parameters.
	3.2 Does the river or stream have TMDL limits for nutrients, toxics, or pathogens? Yes No	 points = 1 points = 0	Score: 1	Several contributing streams to Arcata Bay are on the 303d list and have TMDL's for sediments. Under the clean water act, Total Maximum Daily Loads (TMDLs) must be developed for all impaired waters, however prioritization for development of TMDLs is up to each State and development can occur 5-15 years after initial listing.
	Total for 3.0		**2**	
	Rating of Value: 2 = H	1 = M	0 = L	

SCORING FORM

	HABITAT STRUCTURE FUNCTIONS - Indicators that improve habitat structure		Score	NOTES
SITE	4.0 Does the habitat unit have the potential to improve habitat structure?			**Objective:** Habitat structure provides additional ecosystem niches thereby often increasing overall productivity while also providing for predator avoidance.
	4.1 What proportion of historic habitat exists? Decline of 80% or more from historic levels Decline of 50-80% from historic levels Decline of 20-50% from historic levels Decline of less than 20% or increase from historic levels	 points = 8 points = 4 points = 2 points = 0	Score: 0	Eelgrass appears to be at or near historical peak abundance. Habitats that have declined substantially from historic levels or are known to be regionally rare are of greater ecological value.
	4.2 Amount of habitat structure present (% cover or areal extent): Continuous coverage (>85% cover) Patchy coverage (10-85% cover) No coverage	 points = 8 points = 4 points = 0	Score: 8	Percent cover (areal extent) is a common indicator of plant community, health, and development. The Cowardin classification defines a "plant class" as covering more than 30% of the area and Schlosser and Eicher (2012) define patchy eelgrass as >10% and <85%, and continuous eelgrass as >85%.
	4.3 Number of plant species present (including macroalgae and/or microbial mats): >3 species 2 species 0-1 species	 points = 4 points = 2 points = 0	Score: 0	Eelgrass is the primary dominant vegetation present. The majority of studies have found positive correlations between habitat heterogeneity/diversity and species diversity (Tews et al. 2004). In general, increasing diversity of vegetation generates diversity in ecological niches and increased diversity of fauna.
	4.4 Presence of mature, complex habitat that provides 3-dimensional structure: Very tall (>3 m) Tall (1 to 3 m) Medium (0.3 to 1 m) Short (<0.3 m)	 points = 4 points = 3 points = 2 points = 0	Score: 3	Mature eelgrass appears to be between 1 and 3 m tall in Arcata Bay. Zedler (1993) identified a relationship between habitat structural complexity and species use. Vegetation height is an indicator of complex, mature habitat with 3-dimensional structure. The categories were taken from the CRAM heights for plant layers.
	Total for 4.0		**11**	
	Rating of Site Potential: 16 - 24 = H	10 - 15 = M	0 - 9 = L	
LANDSCAPE	5.0 Does the landscape have the potential to support habitat function and species use at the site?			**Objective:** Identify whether species that might use the site are present, whether habitat is a limiting factor and if they are able to access the site.
	5.1 In its current state, is the habitat considered a limiting factor for fish or wildlife? Yes No	 points = 2 points = 0	Score: 0	Eelgrass is abundant in Arcata Bay and though valuable for many resources, has not been implicated as a population limiting factor. A limiting factors analysis assesses and identifies factors limiting the productivity or abundance of endangered or sensitive species. There are documents in Humboldt Bay that have already conducted a limiting factors analysis for certain species (e.g., HBWAC and RCAA 2005)
	5.2 In its current state, is the habitat unit considered important nursery/rearing habitat for fish or wildlife? Yes No	 points = 1 points = 0	Score: 1	Eelgrass is widely recognized as a nursery habitat generally, and in Humboldt Bay specifically. Egg and juvenile stages tend to be the most sensitive to predation due to their relative inability to defend against or evade predation. Therefore, nursery areas that provide complex habitat which supports predation avoidance are high value areas.
	5.3 What is the average area of aquatic area abundance? ≥61% of the transects ≥31 to 60% of the transects ≥11 to 30% of the transects ≤10% of the transects	 points = 4 points = 3 points = 2 points = 0	Score: 4	On average the growing areas are inundated approximately 89% of the time. Aquatic area abundance is the spatial association with other areas of aquatic resources, such as wetlands, streams, and estuaries. According to the CRAM, transects that run parallel to the shoreline for 500 m on either side of the site are more important the higher the percentage of wetland habitat, other aquatic features, and open water.
	5.4 Does the habitat unit support the following species (add 1 point for every species)? Dungeness crab — green sturgeon — dunlin — long-billed curlew Pacific herring — coho salmon — common egret — great blue heron English sole — black brant — surf scoter — harbor seal		Score: 5	Dungeness crab, pacific herring, english sole, coho salmon and black brant are all closely associated with eelgrass beds. Other species are known to use eelgrass, but do not necessarily use eelgrass habitat more than other habitats. These species are identified as common or important within Humboldt Bay (e.g., Pinnix et al. 2005, Connolly and Colwell 2005), use a variety of habitat types, and occur over a broad seasonal range (for most species). See the phenology table for more details. Support defined as supporting feeding, refugia or reproduction by these species.
	5.5 Would sea level rise result in a reduction of habitat? Habitat would remain/expand with sea level rise Habitat would decline with sea level rise	 points = 1 points = 0	Score: 1	Although the total area of eelgrass beds may decline with sea level rise, there appear to be ample opportunity for it to expand into adjacent unvegetated mudflats. Increased temperatures and dessication risks could lead to a narrower habitable range in the future. The phenomenon called "coastal squeeze" is a management concern for Humboldt Bay (Schlosser and Eicher 2012). If there is no room for habitats to expand into (e.g., surrounded by fixed manmade structures), then there is no resiliency in the available habitat.
	Total for 5.0		**11**	
	Rating of Landscape Potential: 13 - 17 = H	6 - 12 = M	0 - 5 = L	
WATERSHED	6.0 Is the habitat function improvement provided by the site identified as a priority issue in the watershed?			**Objective:** Identify whether this this habitat supports regional conservation or restoration targets
	6.1 Has the current abundance triggered state, federal or natural heritage listing? Habitat is recognized as priority for protection No formal recognition of habitat rarity/priority	 points = 2 points = 0	Score: 2	Eelgrass is not currently listed as endangered, however it's protection has been identified as a priority for federal and state agencies which have enunciated a no-net loss goal. Listing a species as endangered suggests both a decline or naturally low population abundance creating a potential for extinction. A listing also suggests that there is sufficient data collection and scientific understanding to characterize the current population level and species biology.
	6.2 Are there recovery plans or ESA documents that include the habitat as a priority habitat? Yes No	 points = 1 points = 0	Score: 1	Several ESA listed species, including salmonids, have included eelgrass as critical habitat. Critical habitat or essential fish habitat contain features that are essential areas for conservation of species.
	6.3 Is there literature that provides the importance of the habitat for providing habitat function? Yes No	 points = 1 points = 0	Score: 1	Numerous research studies have implicated the primary production and habitat structure from eelgrass as contributing to nursery and fishery productivity. The Humboldt Bay Initiative (Schlosser et al. 2009) identifies Ecosystem-based Management (EBM) targets. If management plans specifically call out individual habitat, it gains a level of importance for the watershed.
	Total for 6.0		**4**	
	Rating of Value: 3 - 4 = H	1 - 2 = M	0 = L	

SCORING FORM

	PREY RESOURCES FUNCTIONS - Indicators that improve habitat structure			NOTES
SITE	7.0 Does the habitat unit have the potential to improve prey resources?			**Point:** Characterize the capacity of the site to produce prey items used by higher trophic levels.
	7.1 Type of habitat structure that can provide resource for prey species: Above- and below-ground biomass/structure Above-ground biomass or structure Below-ground biomass or structure No habitat present	 points = 8 points = 4 points = 2 points = 0	Score: 8	Eelgrass produces above and below-ground biomass. Above ground biomass is available for direct consumption and conversion to detritus and provides 3-dimensional habitat structure. Below ground biomass plays an important role in nutrition as well as anchoring and spreading of vegetation. Due to incomplete decomposition in sediments, below ground biomass can represent long term carbon burial (e.g. Kenworthy and Thayer 1984).
	7.2 Density of habitat present: Dense (>100 turions/m^2 or >3 plants/m^2) Patchy (<100 turions/m^2 or <3 plants/m^2) No habitat present	 points = 8 points = 4 points = 0	Score: 8	Based on the presence of continuous eelgrass beds within the unit. This metric is based on work by Hughes (2002) who found significant differences in fish abundance, biomass, species richness, and prey items between eelgrass densities above and below 100 shoots/m^2 (or in excess of 100 g/m^2).
	7.3 Does the habitat unit provide primary production? Yes No	 points = 4 points = 0	Score: 4	Yes. Primary production is use of light or chemical energy to generate organic compounds (e.g. photo or chemosynthesis). Primary production is the primary mechanism for introducing energy into the food web.
	7.4 Does the habitat unit support secondary production? Yes No	 points = 4 points = 0	Score: 4	Yes. Secondary production is the generation of biomass by primary consumers (herbivorous organisms that feed on primary producers).
	7.5 Does the habitat unit contain invasive or exotic species (e.g., *Spartina densiflora* , *Zostera japonica* , European green crab, *Ampithoe valida* amphipod) that may affect productivity or foraging? No Yes	 points = 4 points = 0	Score: 4	While invasive species, including Z. japonica, are present in Humboldt Bay and numerous cosmopolitan invasive species are likely present, invasive species are not a particular concern in this unit. Spartina is a major invasive organism in salt marshes in Humboldt Bay with the potential to convert diverse salt marsh communities into Spartina dominated habitat, including facilitating a significant difference in invertebrate communities with non-native species. Native sites are comprised mostly of invertebrates from the family Heminiptera (Mitchell 2012).
	Total for 7.0		**28**	
	Rating of Site Potential: 20 - 28 = H	11 - 19 = M	0 - 10 = L	
LANDSCAPE	8.0 Does the landscape have the potential to support prey resources at the site?			**Point:** Characterize the potential for the site to export prey items to the landscape.
	8.1 What is the distance of the stream corridor continuity based on the combined length of non-buffer segments? <100 m 100 to 150 m 150 to 200 m >200 m	 points = 4 points = 3 points = 2 points = 0	Score: 0	According to the CRAM, stream continuity considers the ability of areas of open water with connectivity of habitat to provide corridors for anadromous fish and other wildlife. The method combines the length of non-buffered land that crosses the riparian or aquatic area.
	8.2 Is the habitat unit adjacent to or on a sandy grit site used by black brant? Yes No	 points = 2 points = 0	Score: 0	The primary sand grit site in Humboldt Bay is adjacent to Sandy Spit just south of the entrance channel to Humboldt Bay (Spragens et al. 2013). Disturbances near traditional grit sites may limit the ability of black brant to replenish gizzard grit, which would reduce their digestive efficiency (Moore and Black 2005).
	8.2 For which seasons do fish or wildlife forage in the habitat unit? All seasons (fall, winter, spring, summer) At least two seasons At least one season None	 points = 4 points = 3 points = 2 points = 0	Score: 4	Species are present and use eelgrass year-round, though there are distinct peaks, particularly in the early spring when annual spawning events and associated foraging take place. Sites that are used for multiple seasons are expected to support more types of species and more resident species.
	8.3 Potential for the habitat unit to produce benthic and drift prey items: Water-column and benthic prey items available Majority of prey are from the water-column Majority of prey are from the benthic habitat No prey items are available	 points = 4 points = 2 points = 2 points = 0	Score: 2	Majority of prey items are within the water column. However, eelgrass wrack does generate drift prey items. Merritt et al. (2002) identifed these ratios for invertebrate production as indicators of good supply for water column-feeding fish (drift invertebrates), wading birds and benthic feeding fish (sprawlers).
	Total for 8.0		**6**	
	Rating of Landscape Potential: 10 - 14 = H	6 - 9 = M	0 - 5 = L	
WATERSHED	9.0 Are prey resources produced by the site identified as watershed or regional priorities?			**Point:** Identify the potential for the site to produce prey items consumed by regional or watershed priority species.
	9.1 How many species groups does the habitat unit support (add the total)? Shorebirds Anadromous Fish Groundfish Wading birds Mammals Pelagic fish	 Yes = 1 No = 0	Score: 3	Anadromous fish, groundfish, shorebirds and wading birds are all directly supported by eelgrass. The more diverse the habitat, the more diverse the type of species that use the habitat will be.
	9.2 Is there literature that provides an understanding of the importance of the habitat for providing prey resources? Yes No	 points = 1 points = 0	Score: 1	Eelgrass is documented as a highly productive habitat for a wide variety of species. Structured habitat is often associated with higher species diversity for benthic invertebrates, but not directly for mobile species (Hosack 2003, Hosack et al. 2006).
	Total for 9.0		**4**	
	Rating of Value: 3 - 7 = H	1 - 2 = M	0 = L	

SCORING FORM

Site: Coast Growing Area 3 Date: 8-Oct-15

	WATER QUALITY FUNCTIONS - Indicators that improve water quality		Score	NOTES
SITE	1.0 Does the habitat unit have the potential to improve water quality?			**Objective:** Identify the capacity of the habitat type to cause a change in water quality by removing sediment, nutrients, or toxins from the water column or adding dissolved oxygen to the water column.
	1.1 Condition of habitat to be able to trap sediments or contaminants: Native vegetation, undisturbed soils, little to no human visitation Native/non-native vegetation (25-75%), mostly undisturbed soils, low impact human visitation OR native vegetation but soils disturbance and low impact Non-native vegetation (>75%) AND moderate soil disturbance/compaction and/or moderate human disturbance Barren ground and/or highly compacted and/or intense human disturbance	 points = 8 points = 4 points = 2 points = 0	Score: 4	Although vegetation exceeds 90% within each growing area, more than 50% of these area has historically been used for on-bottom harvest. No change in after score because even if all impacts identified in Eelgrass Tech Report resulted in habitats becoming 'not eelgrass' (instead of patchy or remaining continuous), a minimum of 83% of each unit is expected to remain vegetated. According to the California Rapid Assessment Method (CRAM), the ability of vegetation (or buffer condition) to trap sediment/contaminants should be assessed according to the extent and quality of vegetation cover, the overall condition of the substrate, and the amount of human visitation.
	1.2 What is the proximity of the habitat unit to a significant sediment source (i.e., stream, estuary mouth): <0.25 mile 0.5 to 0.25 mile >0.5 mile	 points = 8 points = 4 points = 0	Score: 4	At its closest edge the site is approximately 500 meters from Freshwater Creek. Potential to trap and retain sediment is related to distance from sediment sources. The primary sediment sources of turbidity are from freshwater streams, tidal currents, and wind driven waves along the mudflats (Swanson et al. 2012, Shaughnessy and Hurst 2014).
	1.3 Does the habitat unit provide a way to extract nutrients or contaminants from the surrounding environment? Yes No	 points = 4 points = 0	Score: 4	Eelgrass has the potential to detain and sequester nurtients and contaminants. Surplus nutrients can lead to eutrophication and excessive algal growth, replacement of perennial species with annual species, and reduced maximum depth where vegetation grows. These processes can degrade water quality and reduce habitat available for species use. Nutrient removal can reduce potential impacts from nutrient loading.
	1.4 Does the habitat unit deliver oxygen to the water? Yes No	 points = 4 points = 0	Score: 4	Site has primary production from eelgrass. Algae and rooted vascular plants deliver oxygen to the water through photosynthesis (Short et al. 2000), which is a major component of water quality conditions that support other organisms.
	Total for 1.0		**16**	
	Rating of Site Potential: 16 - 24 = H	6 - 15 = M	0 - 5 = L	
LANDSCAPE	2.0 What is the landscape context for water quality services provided by the site?			**Objective:** Identify whether water quality concerns are present in the service area for the site. Turbidity, nutrients, and contaminants are important management considerations in Humboldt Bay (Schlosser and Eicher 2012).
	2.1 What is the abundance of altered sediment supply or marine connectivity from the site? No signs <500 m AND/OR marine connectivity 500 to 900 m OR marine connectivity >500 m AND mar.con. OR >900 m OR mar.con.	 points = 6 points = 3 points = 2 points = 0	Score: 6	No signs of altered sediment supply at the growing sites. According to the CRAM, marine connectivity can be assessed based on the portion of the coastline with an alteration to sediment supply and transport (e.g., jetties, seawalls/riprap, piers, bridges, and dunes stabilized by invasive species). The measurement is based on 500 m up-coast and down-coast of the midpoint of the site.
	2.2 Does at least 10% of the contributing watershed contain tilled fields, pastures, impervious surface area, or forests that have been clearcut within the last 5 years? Yes No	 points = 4 points = 0	Score: 4	The Humboldt Bay watershed has more than 10% of it's area in recently harvest forestry, agriculture and urban land uses. Watersheds above 10% impervious surface area show signs of degradation and increased sediment runoff (Booth 1991). Overgrazing, cultivation, and forest clearing have been associated with increases in sediment runoff from watersheds (e.g., Walling and Webb 1983).
	2.3 Are there consistent signs of excess nutrients in the habitat unit (e.g., increased ulvoids, high N, high P, high Si, HABs)? None 1 - 3 years >3 years in the past 5 years	 points = 4 points = 2 points = 0	Score: 2	There are occasional periods of high algal growth in Humboldt Bay, however it does not appear to be extreme or persistant and does not appear to meet thresholds for eutrophication. ALthough there are no changes in the score after project, oyster aquaculture can be reasonably expected to consume and sequester a portion of the phytoplankton occuring during blooms. Are the signs of elevated nutrients regularly or persistently present in the watershed. Persistence suggests that relevant thresholds for eutrophication are consistently present. Signs of excess nutrients may include direct measurements of nutrient levels, algal blooms, presence of ulvoid mats, or low dissolved oxygen levels.
	Total for 2.0		**12**	
	Rating of Landscape Potential: 11 - 14 = H	5 - 10 = M	0 - 4 = L	
WATERSHED	3.0 Is water quality improvement identified as a watershed or regional priority?			**Objective:** Water quality impairment in the watershed can reduce ecosystem function and population levels.
	3.1 Are there any rivers, streams, or estuaries on the site on the 303(d) list? Yes No	 points = 1 points = 0	Score: 1	Several contributing streams to Arcata Bay are on the 303d list and have TMDL's for sediments. The 303(d) list identifies impaired waters where existing pollution controls and/or biological removal is failing to maintain water quality for 1 or more parameters.
	3.2 Does the river or stream have TMDL limits for nutrients, toxics, or pathogens? Yes No	 points = 1 points = 0	Score: 1	Several contributing streams to Arcata Bay are on the 303d list and have TMDL's for sediments. Under the clean water act, Total Maximum Daily Loads (TMDLs) must be developed for all impaired waters, however prioritization for development of TMDLs is up to each State and development can occur 5-15 years after initial listing.
	Total for 3.0		**2**	
	Rating of Value: 2 = H	1 = M	0 = L	

SCORING FORM

	HABITAT STRUCTURE FUNCTIONS - Indicators that improve habitat structure			NOTES
SITE	4.0 Does the habitat unit have the potential to improve habitat structure?			**Objective:** Habitat structure provides additional ecosystem niches thereby often increasing overall productivity while also providing for predator avoidance.
	4.1 What proportion of historic habitat exists?		Score:	Eelgrass appears to be at or near historical peak abundance. Habitats that have declined substantially from historic levels or are known to be regionally rare are of greater ecological value.
	Decline of 80% or more from historic levels	points = 8	0	
	Decline of 50-80% from historic levels	points = 4		
	Decline of 20-50% from historic levels	points = 2		
	Decline of less than 20% or increase from historic levels	points = 0		
	4.2 Amount of habitat structure present (% cover or areal extent):		Score:	Percent cover (areal extent) is a common indicator of plant community, health, and development. The Cowardin classification defines a "plant class" as covering more than 30% of the area and Schlosser and Eicher (2012) define patchy eelgrass as >10% and <85%, and continuous eelgrass as >85%.
	Continuous coverage (>85% cover)	points = 8	8	
	Patchy coverage (10-85% cover)	points = 4		
	No coverage	points = 0		
	4.3 Number of plant species present (including macroalgae and/or microbial mats):		Score:	Eelgrass is the primary dominant vegetation present. The majority of studies have found positive correlations between habitat heterogeneity/diversity and species diversity (Tews et al. 2004). In general, increasing diversity of vegetation generates diversity in ecological niches and increased diversity of fauna.
	>3 species	points = 4	0	
	2 species	points = 2		
	0-1 species	points = 0		
	4.4 Presence of mature, complex habitat that provides 3-dimensional structure:		Score:	Mature eelgrass appears to be between 1 and 3 m tall in Arcata Bay. Zedler (1993) identified a relationship between habitat structural complexity and species use. Vegetation height is an indicator of complex, mature habitat with 3-dimensional structure. The categories were taken from the CRAM heights for plant layers.
	Very tall (>3 m)	points = 4	3	
	Tall (1 to 3 m)	points = 3		
	Medium (0.3 to 1 m)	points = 2		
	Short (<0.3 m)	points = 0		
	Total for 4.0		**11**	
	Rating of Site Potential: 16 - 24 = H	10 - 15 = M	0 - 9 = L	
LANDSCAPE	5.0 Does the landscape have the potential to support habitat function and species use at the site?			**Objective:** Identify whether species that might use the site are present, whether habitat is a limiting factor and if they are able to access the site.
	5.1 In its current state, is the habitat considered a limiting factor for fish or wildlife?		Score:	Eelgrass is abundant in Arcata Bay and though valuable for many resources, has not been implicated as a population limiting factor. A limiting factors analysis assesses and identifies factors limiting the productivity or abundance of endangered or sensitive species. There are documents in Humboldt Bay that have already conducted a limiting factors analysis for certain species (e.g., HBWAC and RCAA 2005)
	Yes	points = 2	0	
	No	points = 0		
	5.2 In its current state, is the habitat unit considered important nursery/rearing habitat for fish or wildlife?		Score:	Eelgrass is widely recognized as a nursery habitat generally, and in Humboldt Bay specifically. Egg and juvenile stages tend to be the most sensitive to predation due to their relative inability to defend against or evade predation. Therefore, nursery areas that provide complex habitat which supports predation avoidance are high value areas.
	Yes	points = 1	1	
	No	points = 0		
	5.3 What is the average area of aquatic area abundance?		Score:	On average the growing areas are inundated approximately 89% of the time. Aquatic area abundance is the spatial association with other areas of aquatic resources, such as wetlands, streams, and estuaries. According to the CRAM, transects that run parallel to the shoreline for 500 m on either side of the site are more important the higher the percentage of wetland habitat, other aquatic features, and open water.
	≥61% of the transects	points = 4	4	
	≥31 to 60% of the transects	points = 3		
	≥11 to 30% of the transects	points = 2		
	≤10% of the transects	points = 0		
	5.4 Does the habitat unit support the following species (add 1 point for every species)?		Score:	Dungeness crab, pacific herring, english sole, coho salmon and black brant are all closely associated with eelgrass beds. Other species are known to use eelgrass, but do not necessarily use eelgrass habitat more than other habitats. These species are identified as common or important within Humboldt Bay (e.g., Pinnix et al. 2005, Connolly and Colwell 2005), use a variety of habitat types, and occur over a broad seasonal range (for most species). See the phenology table for more details. Support defined as supporting feeding, refugia or reproduction by these species.
	Dungeness crab; green sturgeon; dunlin	long-billed curlew	5	
	Pacific herring; coho salmon; common egret	great blue heron		
	English sole; black brant; surf scoter	harbor seal		
	5.5 Would sea level rise result in a reduction of habitat?		Score:	Although the total area of eelgrass beds may decline with sea level rise, there appear to be ample opportunity for it to expand into adjacent unvegetated mudflats. Increased temperatures and dessication risks could lead to a narrower habitable range in the future. The phenomenon called "coastal squeeze" is a management concern for Humboldt Bay (Schlosser and Eicher 2012). If there is no room for habitats to expand into (e.g., surrounded by fixed manmade structures), then there is no resiliency in the available habitat.
	Habitat would remain/expand with sea level rise	points = 1	1	
	Habitat would decline with sea level rise	points = 0		
	Total for 5.0		**11**	
	Rating of Landscape Potential: 13 - 17 = H	6 - 12 = M	0 - 5 = L	
WATERSHED	6.0 Is the habitat function improvement provided by the site identified as a priority issue in the watershed?			**Objective:** Identify whether this this habitat supports regional conservation or restoration targets
	6.1 Has the current abundance triggered state, federal or natural heritage listing?		Score:	Eelgrass is not currently listed as endangered, however it's protection has been identified as a priority for federal and state agencies which have enunciated a no-net loss goal. Listing a species as endangered suggests both a decline or naturally low population abundance creating a potential for extinction. A listing also suggests that there is sufficient data collection and scientific understanding to characterize the current population level and species biology.
	Habitat is recognized as priority for protection	points = 2	2	
	No formal recognition of habitat rarity/priority	points = 0		
	6.2 Are there recovery plans or ESA documents that include the habitat as a priority habitat?		Score:	Several ESA listed species, including salmonids, have included eelgrass as critical habitat. Critical habitat or essential fish habitat contain features that are essential areas for conservation of species.
	Yes	points = 1	1	
	No	points = 0		
	6.3 Is there literature that provides the importance of the habitat for providing habitat function?		Score:	Numerous research studies have implicated the primary production and habitat structure from eelgrass as contributing to nursery and fishery productivity. The Humboldt Bay Initiative (Schlosser et al. 2009) identifies Ecosystem-based Management (EBM) targets. If management plans specifically call out individual habitat, it gains a level of importance for the watershed.
	Yes	points = 1	1	
	No	points = 0		
	Total for 6.0		**4**	
	Rating of Value: 3 - 4 = H	1 - 2 = M	0 = L	

SCORING FORM

Site: Eelgrass Buoy Deployed Seed System (BuDS) - Before   Date: 8-Oct-15

	WATER QUALITY FUNCTIONS - Indicators that improve water quality			NOTES
SITE	1.0 Does the habitat unit have the potential to improve water quality?			**Objective:** Identify the capacity of the habitat type to cause a change in water quality by removing sediment, nutrients, or toxins from the water column or adding dissolved oxygen to the water column.
	1.1 Condition of habitat to be able to trap sediments or contaminants:		Score:	Although vegetation exceeds 90% within each growing area, more than 50% of these area has historically been used for on-bottom harvest. No change in after score because even if all impacts identified in Eelgrass Tech Report resulted in habitats becoming 'not eelgrass' (instead of patchy or remaining continuous), a minimum of 83% of each unit is expected to remain vegetated. According to the California Rapid Assessment Method (CRAM), the ability of vegetation (or buffer condition) to trap sediment/contaminants should be assessed according to the extent and quality of vegetation cover, the overall condition of the substrate, and the amount of human visitation.
	Native vegetation, undisturbed soils, little to no human visitation	points = 8	4	
	Native/non-native vegetation (25-75%), mostly undisturbed soils, low impact human visitation OR native vegetation but soils disturbance and low impact	points = 4		
	Non-native vegetation (>75%) AND moderate soil disturbance/compaction and/or moderate human disturbance	points = 2		
	Barren ground and/or highly compacted and/or intense human disturbance	points = 0		
	1.2 What is the proximity of the habitat unit to a significant sediment source (i.e., stream, estuary mouth):		Score:	Proposed seedbag areas are more than 0.5 miles from nearest stream mouth. Potential to trap and retain sediment is related to distance from sediment sources. The primary sediment sources of turbidity are from freshwater streams, tidal currents, and wind driven waves along the mudflats (Swanson et al. 2012, Shaughnessy and Hurst 2014).
	<0.25 mile	points = 8	0	
	0.5 to 0.25 mile	points = 4		
	>0.5 mile	points = 0		
	1.3 Does the habitat unit provide a way to extract nutrients or contaminants from the surrounding environment?		Score:	Eelgrass has the potential to detain and sequester nurtients and contaminants. Surplus nutrients can lead to eutrophication and excessive algal growth, replacement of perennial species with annual species, and reduced maximum depth where vegetation grows. These processes can degrade water quality and reduce habitat available for species use. Nutrient removal can reduce potential impacts from nutrient loading.
	Yes	points = 4	4	
	No	points = 0		
	1.4 Does the habitat unit deliver oxygen to the water?		Score:	Site has primary production from eelgrass. Algae and rooted vascular plants deliver oxygen to the water through photosynthesis (Short et al. 2000), which is a major component of water quality conditions that support other organisms.
	Yes	points = 4	4	
	No	points = 0		
	Total for 1.0		**12**	
	Rating of Site Potential: 16 - 24 = H; 6 - 15 = M; 0 - 5 = L			
LANDSCAPE	2.0 What is the landscape context for water quality services provided by the site?			**Objective:** Identify whether water quality concerns are present in the service area for the site. Turbidity, nutrients, and contaminants are important management considerations in Humboldt Bay (Schlosser and Eicher 2012).
	2.1 What is the abundance of altered sediment supply or marine connectivity from the site?		Score:	No signs of altered sediment supply at the growing sites. According to the CRAM, marine connectivity can be assessed based on the portion of the coastline with an alteration to sediment supply and transport (e.g., jetties, seawalls/riprap, piers, bridges, and dunes stabilized by invasive species). The measurement is based on 500 m up-coast and down-coast of the midpoint of the site.
	No signs	points = 6	6	
	<500 m AND/OR marine connectivity	points = 3		
	500 to 900 m OR marine connectivity	points = 2		
	>500 m AND mar.con. OR >900 m OR mar.con.	points = 0		
	2.2 Does at least 10% of the contributing watershed contain tilled fields, pastures, impervious surface area, or forests that have been clearcut within the last 5 years?		Score:	The Humboldt Bay watershed has more than 10% of it's area in recently harvest forestry, agriculture and urban land uses. Watersheds above 10% impervious surface area show signs of degradation and increased sediment runoff (Booth 1991). Overgrazing, cultivation, and forest clearing have been associated with increases in sediment runoff from watersheds (e.g., Walling and Webb 1983).
	Yes	points = 4	4	
	No	points = 0		
	2.3 Are there consistent signs of excess nutrients in the habitat unit (e.g., increased ulvoids, high N, high P, high Si, HABs)?		Score:	There are occasional periods of high algal growth in Humboldt Bay, however it does not appear to be extreme or persistant and does not appear to meet thresholds for eutrophication. ALthough there are no changes in the score after project, oyster aquaculture can be reasonably expected to consume and sequester a portion of the phytoplankton occuring during blooms. Are the signs of elevated nutrients regularly or persistently present in the watershed. Persistence suggests that relevant thresholds for eutrophication are consistently present. Signs of excess nutrients may include direct measurements of nutrient levels, algal blooms, presence of ulvoid mats, or low dissolved oxygen levels.
	None	points = 4	2	
	1 - 3 years	points = 2		
	>3 years in the past 5 years	points = 0		
	Total for 2.0		**12**	
	Rating of Landscape Potential: 11 - 14 = H; 5 - 10 = M; 0 - 4 = L			
WATERSHED	3.0 Is water quality improvement identified as a watershed or regional priority?			**Objective:** Water quality impairment in the watershed can reduce ecosystem function and population levels.
	3.1 Are there any rivers, streams, or estuaries on the site on the 303(d) list?		Score:	Several contributing streams to Arcata Bay are on the 303d list and have TMDL's for sediments. The 303(d) list identifies impaired waters where existing pollution controls and/or biological removal is failing to maintain water quality for 1 or more parameters.
	Yes	points = 1	1	
	No	points = 0		
	3.2 Does the river or stream have TMDL limits for nutrients, toxics, or pathogens?		Score:	Several contributing streams to Arcata Bay are on the 303d list and have TMDL's for sediments. Under the clean water act, Total Maximum Daily Loads (TMDLs) must be developed for all impaired waters, however prioritization for development of TMDLs is up to each State and development can occur 5-15 years after initial listing.
	Yes	points = 1	1	
	No	points = 0		
	Total for 3.0		**2**	
	Rating of Value: 2 = H; 1 = M; 0 = L			

SCORING FORM

SITE

HABITAT STRUCTURE FUNCTIONS - Indicators that improve habitat structure			NOTES
4.0 Does the habitat unit have the potential to improve habitat structure?			**Objective:** Habitat structure provides additional ecosystem niches thereby often increasing overall productivity while also providing for predator avoidance.
4.1 What proportion of historic habitat exists? Decline of 80% or more from historic levels Decline of 50-80% from historic levels Decline of 20-50% from historic levels Decline of less than 20% or increase from historic levels	 points = 8 points = 4 points = 2 points = 0	Score: 0	Eelgrass appears to be at or near historical peak abundance. Habitats that have declined substantially from historic levels or are known to be regionally rare are of greater ecological value.
4.2 Amount of habitat structure present (% cover or areal extent): Continuous coverage (>85% cover) Patchy coverage (10-85% cover) No coverage	 points = 8 points = 4 points = 0	Score: 4	Percent cover is projected to increase as a result of placement of seedbags and may increase from "patchy" coverage to "continuous" coverage class. Percent cover (areal extent) is a common indicator of plant community, health, and development. The Cowardin classification defines a "plant class" as covering more than 30% of the area and Schlosser and Eicher (2012) define patchy eelgrass as >10% and <85%, and continuous eelgrass as >85%.
4.3 Number of plant species present (including macroalgae and/or microbial mats): >3 species 2 species 0-1 species	 points = 4 points = 2 points = 0	Score: 0	Eelgrass is the primary dominant vegetation present. The majority of studies have found positive correlations between habitat heterogeneity/diversity and species diversity (Tews et al. 2004). In general, increasing diversity of vegetation generates diversity in ecological niches and increased diversity of fauna.
4.4 Presence of mature, complex habitat that provides 3-dimensional structure: Very tall (>3 m) Tall (1 to 3 m) Medium (0.3 to 1 m) Short (<0.3 m)	 points = 4 points = 3 points = 2 points = 0	Score: 3	Mature eelgrass appears to be between 1 and 3 m tall in Arcata Bay. Zedler (1993) identified a relationship between habitat structural complexity and species use. Vegetation height is an indicator of complex, mature habitat with 3-dimensional structure. The categories were taken from the CRAM heights for plant layers.
Total for 4.0		7	
Rating of Site Potential: 16 - 24 = H	10 - 15 = M	0 - 9 = L	

LANDSCAPE

Indicator	Points	Score	Notes
5.0 Does the landscape have the potential to support habitat function and species use at the site?			**Objective:** Identify whether species that might use the site are present, whether habitat is a limiting factor and if they are able to access the site.
5.1 In its current state, is the habitat considered a limiting factor for fish or wildlife? Yes No	 points = 2 points = 0	Score: 0	Eelgrass is abundant in Arcata Bay and though valuable for many resources, has not been implicated as a population limiting factor. A limiting factors analysis assesses and identifies factors limiting the productivity or abundance of endangered or sensitive species. There are documents in Humboldt Bay that have already conducted a limiting factors analysis for certain species (e.g., HBWAC and RCAA 2005)
5.2 In its current state, is the habitat unit considered important nursery/rearing habitat for fish or wildlife? Yes No	 points = 1 points = 0	Score: 1	Eelgrass is widely recognized as a nursery habitat generally, and in Humboldt Bay specifically. Egg and juvenile stages tend to be the most sensitive to predation due to their relative inability to defend against or evade predation. Therefore, nursery areas that provide complex habitat which supports predation avoidance are high value areas.
5.3 What is the average area of aquatic area abundance? ≥61% of the transects ≥31 to 60% of the transects ≥11 to 30% of the transects ≤10% of the transects	 points = 4 points = 3 points = 2 points = 0	Score: 4	On average the growing areas are inundated approximately 89% of the time. Aquatic area abundance is the spatial association with other areas of aquatic resources, such as wetlands, streams, and estuaries. According to the CRAM, transects that run parallel to the shoreline for 500 m on either side of the site are more important the higher the percentage of wetland habitat, other aquatic features, and open water.
5.4 Does the habitat unit support the following species (add 1 point for every species)? Dungeness crab, green sturgeon, dunlin, long-billed curlew Pacific herring, coho salmon, common egret, great blue heron English sole, black brant, surf scoter, harbor seal		Score: 5	Dungeness crab, pacific herring, english sole, coho salmon and black brant are all closely associated with eelgrass beds. Other species are known to use eelgrass, but do not necessarily use eelgrass habitat more than other habitats. These species are identified as common or important within Humboldt Bay (e.g., Pinnix et al. 2005, Connolly and Colwell 2005), use a variety of habitat types, and occur over a broad seasonal range (for most species). See the phenology table for more details. Support defined as supporting feeding, refugia or reproduction by these species.
5.5 Would sea level rise result in a reduction of habitat? Habitat would remain/expand with sea level rise Habitat would decline with sea level rise	 points = 1 points = 0	Score: 1	Although the total area of eelgrass beds may decline with sea level rise, there appear to be ample opportunity for it to expand into adjacent unvegetated mudflats. Increased temperatures and dessication risks could lead to a narrower habitable range in the future. The phenomenon called "coastal squeeze" is a management concern for Humboldt Bay (Schlosser and Eicher 2012). If there is no room for habitats to expand into (e.g., surrounded by fixed manmade structures), then there is no resiliency in the available habitat.
Total for 5.0		11	
Rating of Landscape Potential: 13 - 17 = H	6 - 12 = M	0 - 5 = L	

WATERSHED

Indicator	Points	Score	Notes
6.0 Is the habitat function improvement provided by the site identified as a priority issue in the watershed?			**Objective:** Identify whether this this habitat supports regional conservation or restoration targets
6.1 Has the current abundance triggered state, federal or natural heritage listing? Habitat is recognized as priority for protection No formal recognition of habitat rarity/priority	 points = 2 points = 0	Score: 2	Eelgrass is not currently listed as endangered, however it's protection has been identified as a priority for federal and state agencies which have enunciated a no-net loss goal. Listing a species as endangered suggests both a decline or naturally low population abundance creating a potential for extinction. A listing also suggests that there is sufficient data collection and scientific understanding to characterize the current population level and species biology.
6.2 Are there recovery plans or ESA documents that include the habitat as a priority habitat? Yes No	 points = 1 points = 0	Score: 1	Several ESA listed species, including salmonids, have included eelgrass as critical habitat. Critical habitat or essential fish habitat contain features that are essential areas for conservation of species.
6.3 Is there literature that provides the importance of the habitat for providing habitat function? Yes No	 points = 1 points = 0	Score: 1	Numerous research studies have implicated the primary production and habitat structure from eelgrass as contributing to nursery and fishery productivity. The Humboldt Bay Initiative (Schlosser et al. 2009) identifies Ecosystem-based Management (EBM) targets. If management plans specifically call out individual habitat, it gains a level of importance for the watershed.
Total for 6.0		4	
Rating of Value: 3 - 4 = H	1 - 2 = M	0 = L	

SCORING FORM

	PREY RESOURCES FUNCTIONS - Indicators that improve habitat structure		Score	NOTES
SITE	7.0 Does the habitat unit have the potential to improve prey resources?			**Point:** Characterize the capacity of the site to produce prey items used by higher trophic levels.
	7.1 Type of habitat structure that can provide resource for prey species: Above- and below-ground biomass/structure Above-ground biomass or structure Below-ground biomass or structure No habitat present	 points = 8 points = 4 points = 2 points = 0	Score: 8	Eelgrass produces above and below-ground biomass. Above ground biomass is available for direct consumption and conversion to detritus and provides 3-dimensional habitat structure. Below ground biomass plays an important role in nutrition as well as anchoring and spreading of vegetation. Due to incomplete decomposition in sediments, below ground biomass can represent long term carbon burial (e.g. Kenworthy and Thayer 1984).
	7.2 Density of habitat present: Dense (>100 turions/m^2 or >3 plants/m^2) Patchy (<100 turions/m^2 or <3 plants/m^2) No habitat present	 points = 8 points = 4 points = 0	Score: 8	Based on the presence of continuous eelgrass beds within the unit. This metric is based on work by Hughes (2002) who found significant differences in fish abundance, biomass, species richness, and prey items between eelgrass densities above and below 100 shoots/m ^{2} (or in excess of 100 g/m^2).
	7.3 Does the habitat unit provide primary production? Yes No	 points = 4 points = 0	Score: 4	Yes. Primary production is use of light or chemical energy to generate organic compounds (e.g. photo or chemosynthesis). Primary production is the primary mechanism for introducing energy into the food web.
	7.4 Does the habitat unit support secondary production? Yes No	 points = 4 points = 0	Score: 4	Yes. Secondary production is the generation of biomass by primary consumers (herbivorous organisms that feed on primary producers).
	7.5 Does the habitat unit contain invasive or exotic species (e.g., *Spartina densiflora* , *Zostera japonica* , European green crab, *Ampithoe valida* amphipod) that may affect productivity or foraging? No Yes	 points = 4 points = 0	Score: 4	While invasive species, including Z. japonica, are present in Humboldt Bay and numerous cosmopolitan invasive species are likely present, invasive species are not a particular concern in this unit. Spartina is a major invasive organism in salt marshes in Humboldt Bay with the potential to convert diverse salt marsh communities into Spartina dominated habitat, including facilitating a significant difference in invertebrate communities with non-native species. Native sites are comprised mostly of invertebrates from the family Heminiptera (Mitchell 2012).
	Total for 7.0		**28**	
	Rating of Site Potential: 20 - 28 = H; 11 - 19 = M; 0 - 10 = L			
LANDSCAPE	8.0 Does the landscape have the potential to support prey resources at the site?			**Point:** Characterize the potential for the site to export prey items to the landscape.
	8.1 What is the distance of the stream corridor continuity based on the combined length of non-buffer segments? <100 m 100 to 150 m 150 to 200 m >200 m	 points = 4 points = 3 points = 2 points = 0	Score: 0	According to the CRAM, stream continuity considers the ability of areas of open water with connectivity of habitat to provide corridors for anadromous fish and other wildlife. The method combines the length of non-buffered land that crosses the riparian or aquatic area.
	8.2 Is the habitat unit adjacent to or on a sandy grit site used by black brant? Yes No	 points = 2 points = 0	Score: 0	The primary sand grit site in Humboldt Bay is adjacent to Sandy Spit just south of the entrance channel to Humboldt Bay (Spragens et al. 2013). Disturbances near traditional grit sites may limit the ability of black brant to replenish gizzard grit, which would reduce their digestive efficiency (Moore and Black 2005).
	8.2 For which seasons do fish or wildlife forage in the habitat unit? All seasons (fall, winter, spring, summer) At least two seasons At least one season None	 points = 4 points = 3 points = 2 points = 0	Score: 4	Species are present and use eelgrass year-round, though there are distinct peaks, particularly in the early spring when annual spawning events and associated foraging take place. Sites that are used for multiple seasons are expected to support more types of species and more resident species.
	8.3 Potential for the habitat unit to produce benthic and drift prey items: Water-column and benthic prey items available Majority of prey are from the water-column Majority of prey are from the benthic habitat No prey items are available	 points = 4 points = 2 points = 2 points = 0	Score: 2	Majority of prey items are within the water column. However, eelgrass wrack does generate drift prey items. Merritt et al. (2002) identifed these ratios for invertebrate production as indicators of good supply for water column-feeding fish (drift invertebrates), wading birds and benthic feeding fish (sprawlers).
	Total for 8.0		**6**	
	Rating of Landscape Potential: 10 - 14 = H; 6 - 9 = M; 0 - 5 = L			
WATERSHED	9.0 Are prey resources produced by the site identified as watershed or regional priorities?			**Point:** Identify the potential for the site to produce prey items consumed by regional or watershed priority species.
	9.1 How many species groups does the habitat unit support (add the total)? Shorebirds; Anadromous Fish; Groundfish Wading birds; Mammals; Pelagic fish	 Yes = 1 No = 0	Score: 3	Anadromous fish, groundfish, shorebirds and wading birds are all directly supported by eelgrass. The more diverse the habitat, the more diverse the type of species that use the habitat will be.
	9.2 Is there literature that provides an understanding of the importance of the habitat for providing prey resources? Yes No	 points = 1 points = 0	Score: 1	Eelgrass is documented as a highly productive habitat for a wide variety of species. Structured habitat is often associated with higher species diversity for benthic invertebrates, but not directly for mobile species (Hosack 2003, Hosack et al. 2006).
	Total for 9.0		**4**	
	Rating of Value: 3 - 7 = H; 1 - 2 = M; 0 = L			

SCORING FORM

	PREY RESOURCES FUNCTIONS - Indicators that improve habitat structure		Score	NOTES
SITE	7.0 Does the habitat unit have the potential to improve prey resources?			**Point:** Characterize the capacity of the site to produce prey items used by higher trophic levels.
	7.1 Type of habitat structure that can provide resource for prey species: Above- and below-ground biomass/structure Above-ground biomass or structure Below-ground biomass or structure No habitat present	 points = 8 points = 4 points = 2 points = 0	Score: 8	Eelgrass produces above and below-ground biomass. Above ground biomass is available for direct consumption and conversion to detritus and provides 3-dimensional habitat structure. Below ground biomass plays an important role in nutrition as well as anchoring and spreading of vegetation. Due to incomplete decomposition in sediments, below ground biomass can represent long term carbon burial (e.g. Kenworthy and Thayer 1984).
	7.2 Density of habitat present: Dense (>100 turions/m^2 or >3 plants/m^2) Patchy (<100 turions/m^2 or <3 plants/m^2) No habitat present	 points = 8 points = 4 points = 0	Score: 8	Based on the presence of continuous eelgrass beds within the unit. This metric is based on work by Hughes (2002) who found significant differences in fish abundance, biomass, species richness, and prey items between eelgrass densities above and below 100 shoots/m^2 (or in excess of 100 g/m^2).
	7.3 Does the habitat unit provide primary production? Yes No	 points = 4 points = 0	Score: 4	Yes. Primary production is use of light or chemical energy to generate organic compounds (e.g. photo or chemosynthesis). Primary production is the primary mechanism for introducing energy into the food web.
	7.4 Does the habitat unit support secondary production? Yes No	 points = 4 points = 0	Score: 4	Yes. Secondary production is the generation of biomass by primary consumers (herbivorous organisms that feed on primary producers).
	7.5 Does the habitat unit contain invasive or exotic species (e.g., *Spartina densiflora* , *Zostera japonica* , European green crab, *Ampithoe valida* amphipod) that may affect productivity or foraging? No Yes	 points = 4 points = 0	Score: 4	While invasive species, including Z. japonica, are present in Humboldt Bay and numerous cosmopolitan invasive species are likely present, invasive species are not a particular concern in this unit. Spartina is a major invasive organism in salt marshes in Humboldt Bay with the potential to convert diverse salt marsh communities into Spartina dominated habitat, including facilitating a significant difference in invertebrate communities with non-native species. Native sites are comprised mostly of invertebrates from the family Heminiptera (Mitchell 2012).
	Total for 7.0		**28**	
	Rating of Site Potential: 20 - 28 = H	11 - 19 = M	0 - 10 = L	
LANDSCAPE	8.0 Does the landscape have the potential to support prey resources at the site?			**Point:** Characterize the potential for the site to export prey items to the landscape.
	8.1 What is the distance of the stream corridor continuity based on the combined length of non-buffer segments? <100 m 100 to 150 m 150 to 200 m >200 m	 points = 4 points = 3 points = 2 points = 0	Score: 0	According to the CRAM, stream continuity considers the ability of areas of open water with connectivity of habitat to provide corridors for anadromous fish and other wildlife. The method combines the length of non-buffered land that crosses the riparian or aquatic area.
	8.2 Is the habitat unit adjacent to or on a sandy grit site used by black brant? Yes No	 points = 2 points = 0	Score: 0	The primary sand grit site in Humboldt Bay is adjacent to Sandy Spit just south of the entrance channel to Humboldt Bay (Spragens et al. 2013). Disturbances near traditional grit sites may limit the ability of black brant to replenish gizzard grit, which would reduce their digestive efficiency (Moore and Black 2005).
	8.2 For which seasons do fish or wildlife forage in the habitat unit? All seasons (fall, winter, spring, summer) At least two seasons At least one season None	 points = 4 points = 3 points = 2 points = 0	Score: 4	Species are present and use eelgrass year-round, though there are distinct peaks, particularly in the early spring when annual spawning events and associated foraging take place. Sites that are used for multiple seasons are expected to support more types of species and more resident species.
	8.3 Potential for the habitat unit to produce benthic and drift prey items: Water-column and benthic prey items available Majority of prey are from the water-column Majority of prey are from the benthic habitat No prey items are available	 points = 4 points = 2 points = 2 points = 0	Score: 2	Majority of prey items are within the water column. However, eelgrass wrack does generate drift prey items. Merritt et al. (2002) identifed these ratios for invertebrate production as indicators of good supply for water column-feeding fish (drift invertebrates), wading birds and benthic feeding fish (sprawlers).
	Total for 8.0		**6**	
	Rating of Landscape Potential: 10 - 14 = H	6 - 9 = M	0 - 5 = L	
WATERSHED	9.0 Are prey resources produced by the site identified as watershed or regional priorities?			**Point:** Identify the potential for the site to produce prey items consumed by regional or watershed priority species.
	9.1 How many species groups does the habitat unit support (add the total)? Shorebirds Anadromous Fish Groundfish Wading birds Mammals Pelagic fish	 Yes = 1 No = 0	Score: 3	Anadromous fish, groundfish, shorebirds and wading birds are all directly supported by eelgrass. The more diverse the habitat, the more diverse the type of species that use the habitat will be.
	9.2 Is there literature that provides an understanding of the importance of the habitat for providing prey resources? Yes No	 points = 1 points = 0	Score: 1	Eelgrass is documented as a highly productive habitat for a wide variety of species. Structured habitat is often associated with higher species diversity for benthic invertebrates, but not directly for mobile species (Hosack 2003, Hosack et al. 2006).
	Total for 9.0		**4**	
	Rating of Value: 3 - 7 = H	1 - 2 = M	0 = L	

SCORING FORM

Site: Eelgrass Buoy Deployed Seed System (BuDS) - After   Date: 8-Oct-15

	WATER QUALITY FUNCTIONS - Indicators that improve water quality		Score	NOTES
SITE	1.0 Does the habitat unit have the potential to improve water quality?			**Objective:** Identify the capacity of the habitat type to cause a change in water quality by removing sediment, nutrients, or toxins from the water column or adding dissolved oxygen to the water column.
	1.1 Condition of habitat to be able to trap sediments or contaminants Native vegetation, undisturbed soils, little to no human visitatior Native/non-native vegetation (25-75%), mostly undisturbed soils, low impact human visitation OR native vegetation but soils disturbance and low impact Non-native vegetation (>75%) AND moderate soil disturbance/compaction and/or moderate human disturbance Barren ground and/or highly compacted and/or intense human disturbance	 points = 8 points = 4 points = 2 points = 0	Score: 4	Although vegetation exceeds 90% within each growing area, more than 50% of these area has historically been used for on-bottom harvest. No change in after score because even if all impacts identified in Eelgrass Tech Report resulted in habitats becoming 'not eelgrass' (instead of patchy or remaining continuous), a minimum of 83% of each unit is expected to remain vegetated. According to the California Rapid Assessment Method (CRAM), the ability of vegetation (or buffer condition) to trap sediment/contaminants should be assessed according to the extent and quality of vegetation cover, the overall condition of the substrate, and the amount of human visitation.
	1.2 What is the proximity of the habitat unit to a significantsediment source (i.e., stream, estuary mouth): <0.25 mile 0.5 to 0.25 mile >0.5 mile	 points = 8 points = 4 points = 0	Score: 0	Proposed seedbag areas are more than 0.5 miles from nearest stream mouth. Potential to trap and retain sediment is related to distance from sediment sources. The primary sediment sources of turbidity are from freshwater streams, tidal currents, and wind driven waves along the mudflats (Swanson et al. 2012, Shaughnessy and Hurst 2014).
	1.3 Does the habitat unit provide a way to extract nutrients or contaminants from the surrounding environment? Yes No	 points = 4 points = 0	Score: 4	Eelgrass has the potential to detain and sequester nurtients and contaminants. Surplus nutrients can lead to eutrophication and excessive algal growth, replacement of perennial species with annual species, and reduced maximum depth where vegetation grows. These processes can degrade water quality and reduce habitat available for species use. Nutrient removal can reduce potential impacts from nutrient loading.
	1.4 Does the habitat unit deliver oxygen to the water? Yes No	 points = 4 points = 0	Score: 4	Site has primary production from eelgrass. Algae and rooted vascular plants deliver oxygen to the water through photosynthesis (Short et al. 2000), which is a major component of water quality conditions that support other organisms.
	Total for 1.0		**12**	
	Rating of Site Potential: 16 - 24 = H	6 - 15 = M	0 - 5 = L	
LANDSCAPE	2.0 What is the landscape context for water quality services provided by the site?			**Objective:** Identify whether water quality concerns are present in the service area for the site. Turbidity, nutrients, and contaminants are important management considerations in Humboldt Bay (Schlosser and Eicher 2012).
	2.1 What is the abundance of altered sediment supply or marine connectivity from the site? No signs <500 m AND/OR marine connectivity 500 to 900 m OR marine connectivity >500 m AND mar.con. OR >900 m OR mar.con.	 points = 6 points = 3 points = 2 points = 0	Score: 6	No signs of altered sediment supply at the growing sites. According to the CRAM, marine connectivity can be assessed based on the portion of the coastline with an alteration to sediment supply and transport (e.g., jetties, seawalls/riprap, piers, bridges, and dunes stabilized by invasive species). The measurement is based on 500 m up-coast and down-coast of the midpoint of the site.
	2.2 Does at least 10% of the contributing watershed contain tilled fields, pastures, impervious surface area, or forests that have been clearcut within the last 5 years? Yes No	 points = 4 points = 0	Score: 4	The Humboldt Bay watershed has more than 10% of it's area in recently harvest forestry, agriculture and urban land uses. Watersheds above 10% impervious surface area show signs of degradation and increased sediment runoff (Booth 1991). Overgrazing, cultivation, and forest clearing have been associated with increases in sediment runoff from watersheds (e.g., Walling and Webb 1983).
	2.3 Are there consistent signs of excess nutrients in the habitat unit (e.g., increased ulvoids, high N, high P, high Si, HABs)? None 1 - 3 years >3 years in the past 5 years	 points = 4 points = 2 points = 0	Score: 2	There are occasional periods of high algal growth in Humboldt Bay, however it does not appear to be extreme or persistant and does not appear to meet thresholds for eutrophication. ALthough there are no changes in the score after project, oyster aquaculture can be reasonably expected to consume and sequester a portion of the phytoplankton occuring during blooms. Are the signs of elevated nutrients regularly or persistently present in the watershed. Persistence suggests that relevant thresholds for eutrophication are consistently present. Signs of excess nutrients may include direct measurements of nutrient levels, algal blooms, presence of ulvoid mats, or low dissolved oxygen levels.
	Total for 2.0		**12**	
	Rating of Landscape Potential: 11 - 14 = H	5 - 10 = M	0 - 4 = L	
WATERSHED	3.0 Is water quality improvement identified as a watershed or regional priority?			**Objective:** Water quality impairment in the watershed can reduce ecosystem function and population levels.
	3.1 Are there any rivers, streams, or estuaries on the site on the 303(d) list? Yes No	 points = 1 points = 0	Score: 1	Several contributing streams to Arcata Bay are on the 303d list and have TMDL's for sediments. The 303(d) list identifies impaired waters where existing pollution controls and/or biological removal is failing to maintain water quality for 1 or more parameters.
	3.2 Does the river or stream have TMDL limits for nutrients, toxics, or pathogens? Yes No	 points = 1 points = 0	Score: 1	Several contributing streams to Arcata Bay are on the 303d list and have TMDL's for sediments. Under the clean water act, Total Maximum Daily Loads (TMDLs) must be developed for all impaired waters, however prioritization for development of TMDLs is up to each State and development can occur 5-15 years after initial listing.
	Total for 3.0		**2**	
	Rating of Value: 2 = H	1 = M	0 = L	

SCORING FORM

	HABITAT STRUCTURE FUNCTIONS - Indicators that improve habitat structure		Score	NOTES
SITE	4.0 Does the habitat unit have the potential to improve habitat structure?			**Objective:** Habitat structure provides additional ecosystem niches thereby often increasing overall productivity while also providing for predator avoidance.
	4.1 What proportion of historic habitat exists?		Score: 0	Eelgrass appears to be at or near historical peak abundance. Habitats that have declined substantially from historic levels or are known to be regionally rare are of greater ecological value.
	Decline of 80% or more from historic levels	points = 8		
	Decline of 50-80% from historic levels	points = 4		
	Decline of 20-50% from historic levels	points = 2		
	Decline of less than 20% or increase from historic levels	points = 0		
	4.2 Amount of habitat structure present (% cover or areal extent):		Score: 8	Percent cover is projected to increase as a result of placement of seedbags and may increase from "patchy" coverage to "continuous" coverage class. Percent cover (areal extent) is a common indicator of plant community, health, and development. The Cowardin classification defines a "plant class" as covering more than 30% of the area and Schlosser and Eicher (2012) define patchy eelgrass as >10% and <85%, and continuous eelgrass as >85%.
	Continuous coverage (>85% cover)	points = 8		
	Patchy coverage (10-85% cover)	points = 4		
	No coverage	points = 0		
	4.3 Number of plant species present (including macroalgae and/or microbial mats):		Score: 0	Eelgrass is the primary dominant vegetation present. The majority of studies have found positive correlations between habitat heterogeneity/diversity and species diversity (Tews et al. 2004). In general, increasing diversity of vegetation generates diversity in ecological niches and increased diversity of fauna.
	>3 species	points = 4		
	2 species	points = 2		
	0-1 species	points = 0		
	4.4 Presence of mature, complex habitat that provides 3-dimensional structure:		Score: 3	Mature eelgrass appears to be between 1 and 3 m tall in Arcata Bay. Zedler (1993) identified a relationship between habitat structural complexity and species use. Vegetation height is an indicator of complex, mature habitat with 3-dimensional structure. The categories were taken from the CRAM heights for plant layers.
	Very tall (>3 m)	points = 4		
	Tall (1 to 3 m)	points = 3		
	Medium (0.3 to 1 m)	points = 2		
	Short (<0.3 m)	points = 0		
	Total for 4.0		**11**	
	Rating of Site Potential: 16 - 24 = H	10 - 15 = M	0 - 9 = L	
LANDSCAPE	5.0 Does the landscape have the potential to support habitat function and species use at the site?			**Objective:** Identify whether species that might use the site are present, whether habitat is a limiting factor and if they are able to access the site.
	5.1 In its current state, is the habitat considered a limiting factor for fish or wildlife?		Score: 0	Eelgrass is abundant in Arcata Bay and though valuable for many resources, has not been implicated as a population limiting factor. A limiting factors analysis assesses and identifies factors limiting the productivity or abundance of endangered or sensitive species. There are documents in Humboldt Bay that have already conducted a limiting factors analysis for certain species (e.g., HBWAC and RCAA 2005)
	Yes	points = 2		
	No	points = 0		
	5.2 In its current state, is the habitat unit considered important nursery/rearing habitat for fish or wildlife?		Score: 1	Eelgrass is widely recognized as a nursery habitat generally, and in Humboldt Bay specifically. Egg and juvenile stages tend to be the most sensitive to predation due to their relative inability to defend against or evade predation. Therefore, nursery areas that provide complex habitat which supports predation avoidance are high value areas.
	Yes	points = 1		
	No	points = 0		
	5.3 What is the average area of aquatic area abundance?		Score: 4	On average the growing areas are inundated approximately 89% of the time. Aquatic area abundance is the spatial association with other areas of aquatic resources, such as wetlands, streams, and estuaries. According to the CRAM, transects that run parallel to the shoreline for 500 m on either side of the site are more important the higher the percentage of wetland habitat, other aquatic features, and open water.
	≥61% of the transects	points = 4		
	≥31 to 60% of the transects	points = 3		
	≥11 to 30% of the transects	points = 2		
	≤10% of the transects	points = 0		
	5.4 Does the habitat unit support the following species (add 1 point for every species)?		Score: 5	Dungeness crab, pacific herring, english sole, coho salmon and black brant are all closely associated with eelgrass beds. Other species are known to use eelgrass, but do not necessarily use eelgrass habitat more than other habitats. These species are identified as common or important within Humboldt Bay (e.g., Pinnix et al. 2005, Connolly and Colwell 2005), use a variety of habitat types, and occur over a broad seasonal range (for most species). See the phenology table for more details. Support defined as supporting feeding, refugia or reproduction by these species.
	Dungeness crab; green sturgeon; dunlin; long-billed curlew			
	Pacific herring; coho salmon; common egret; great blue heron			
	English sole; black brant; surf scoter; harbor seal			
	5.5 Would sea level rise result in a reduction of habitat?		Score: 1	Although the total area of eelgrass beds may decline with sea level rise, there appear to be ample opportunity for it to expand into adjacent unvegetated mudflats. Increased temperatures and dessication risks could lead to a narrower habitable range in the future. The phenomenon called "coastal squeeze" is a management concern for Humboldt Bay (Schlosser and Eicher 2012). If there is no room for habitats to expand into (e.g., surrounded by fixed manmade structures), then there is no resiliency in the available habitat.
	Habitat would remain/expand with sea level rise	points = 1		
	Habitat would decline with sea level rise	points = 0		
	Total for 5.0		**11**	
	Rating of Landscape Potential: 13 - 17 = H	6 - 12 = M	0 - 5 = L	
WATERSHED	6.0 Is the habitat function improvement provided by thesite identified as a priority issue in the watershed?			**Objective:** Identify whether this this habitat supports regional conservation or restoration targets
	6.1 Has the current abundance triggered state, federal or natural heritage listing?		Score: 2	Eelgrass is not currently listed as endangered, however it's protection has been identified as a priority for federal and state agencies which have enunciated a no-net loss goal. Listing a species as endangered suggests both a decline or naturally low population abundance creating a potential for extinction. A listing also suggests that there is sufficient data collection and scientific understanding to characterize the current population level and species biology.
	Habitat is recognized as priority for protection	points = 2		
	No formal recognition of habitat rarity/priority	points = 0		
	6.2 Are there recovery plans or ESA documents that include the habitat as a priority habitat?		Score: 1	Several ESA listed species, including salmonids, have included eelgrass as critical habitat. Critical habitat or essential fish habitat contain features that are essential areas for conservation of species.
	Yes	points = 1		
	No	points = 0		
	6.3 Is there literature that provides the importance of the habitat for providing habitat function?		Score: 1	Numerous research studies have implicated the primary production and habitat structure from eelgrass as contributing to nursery and fishery productivity. The Humboldt Bay Initiative (Schlosser et al. 2009) identifies Ecosystem-based Management (EBM) targets. If management plans specifically call out individual habitat, it gains a level of importance for the watershed.
	Yes	points = 1		
	No	points = 0		
	Total for 6.0		**4**	
	Rating of Value: 3 - 4 = H	1 - 2 = M	0 = L	

SCORING FORM

	PREY RESOURCES FUNCTIONS - Indicators that improve habitat structure			NOTES
SITE	7.0 Does the habitat unit have the potential to improve prey resources?			**Point:** Characterize the capacity of the site to produce prey items used by higher trophic levels.
	7.1 Type of habitat structure that can provide resource for prey species: Above- and below-ground biomass/structure Above-ground biomass or structure Below-ground biomass or structure No habitat present	 points = 8 points = 4 points = 2 points = 0	Score: 8	Eelgrass produces above and below-ground biomass. Above ground biomass is available for direct consumption and conversion to detritus and provides 3-dimensional habitat structure. Below ground biomass plays an important role in nutrition as well as anchoring and spreading of vegetation. Due to incomplete decomposition in sediments, below ground biomass can represent long term carbon burial (e.g. Kenworthy and Thayer 1984).
	7.2 Density of habitat present: Dense (>100 turions/m^2 or >3 plants/m^2) Patchy (<100 turions/m^2 or <3 plants/m^2) No habitat present	 points = 8 points = 4 points = 0	Score: 8	Based on the presence of continuous eelgrass beds within the unit. This metric is based on work by Hughes (2002) who found significant differences in fish abundance, biomass, species richness, and prey items between eelgrass densities above and below 100 shoots/m^2 (or in excess of 100 g/m^2).
	7.3 Does the habitat unit provide primary production? Yes No	 points = 4 points = 0	Score: 4	Yes. Primary production is use of light or chemical energy to generate organic compounds (e.g. photo or chemosynthesis). Primary production is the primary mechanism for introducing energy into the food web.
	7.4 Does the habitat unit support secondary production? Yes No	 points = 4 points = 0	Score: 4	Yes. Secondary production is the generation of biomass by primary consumers (herbivorous organisms that feed on primary producers).
	7.5 Does the habitat unit contain invasive or exotic species (e.g.,*Spartina densiflora* , *Zostera japonica* , European green crab, *Ampithoe valida* amphipod) that may affect productivity or foraging? No Yes	 points = 4 points = 0	Score: 4	While invasive species, including Z. japonica, are present in Humboldt Bay and numerous cosmopolitan invasive species are likely present, invasive species are not a particular concern in this unit. Spartina is a major invasive organism in salt marshes in Humboldt Bay with the potential to convert diverse salt marsh communities into Spartina dominated habitat, including facilitating a significant difference in invertebrate communities with non-native species. Native sites are comprised mostly of invertebrates from the family Heminiptera (Mitchell 2012).
	Total for 7.0		**28**	
	Rating of Site Potential: 20 - 28 = H; 11 - 19 = M; 0 - 10 = L			
LANDSCAPE	8.0 Does the landscape have the potential to support prey resources at the site?			**Point:** Characterize the potential for the site to export prey items to the landscape.
	8.1 What is the distance of the stream corridor continuity based on the combined length of non-buffer segments? <100 m 100 to 150 m 150 to 200 m >200 m	 points = 4 points = 3 points = 2 points = 0	Score: 0	According to the CRAM, stream continuity considers the ability of areas of open water with connectivity of habitat to provide corridors for anadromous fish and other wildlife. The method combines the length of non-buffered land that crosses the riparian or aquatic area.
	8.2 Is the habitat unit adjacent to or on a sandy grit site used by black brant? Yes No	 points = 2 points = 0	Score: 0	The primary sand grit site in Humboldt Bay is adjacent to Sandy Spit just south of the entrance channel to Humboldt Bay (Spragens et al. 2013). Disturbances near traditional grit sites may limit the ability of black brant to replenish gizzard grit, which would reduce their digestive efficiency (Moore and Black 2005).
	8.2 For which seasons do fish or wildlife forage in the habitat unit? All seasons (fall, winter, spring, summer) At least two seasons At least one season None	 points = 4 points = 3 points = 2 points = 0	Score: 4	Species are present and use eelgrass year-round, though there are distinct peaks, particularly in the early spring when annual spawning events and associated foraging take place. Sites that are used for multiple seasons are expected to support more types of species and more resident species.
	8.3 Potential for the habitat unit to produce benthic and drift prey items Water-column and benthic prey items available Majority of prey are from the water-column Majority of prey are from the benthic habitat No prey items are available	 points = 4 points = 2 points = 2 points = 0	Score: 2	Majority of prey items are within the water column. However, eelgrass wrack does generate drift prey items. Merritt et al. (2002) identifed these ratios for invertebrate production as indicators of good supply for water column-feeding fish (drift invertebrates), wading birds and benthic feeding fish (sprawlers).
	Total for 8.0		**6**	
	Rating of Landscape Potential: 10 - 14 = H; 6 - 9 = M; 0 - 5 = L			
WATERSHED	9.0 Are prey resources produced by the site identified as watershed or regional priorities?			**Point:** Identify the potential for the site to produce prey items consumed by regional or watershed priority species.
	9.1 How many species groups does the habitat unit support (add the total)? Shorebirds; Anadromous Fish; Groundfish Wading birds; Mammals; Pelagic fish	 Yes = 1 No = 0	Score: 3	Anadromous fish, groundfish, shorebirds and wading birds are all directly supported by eelgrass. The more diverse the habitat, the more diverse the type of species that use the habitat will be.
	9.2 Is there literature that provides an understanding of the importance of the habitat for providing prey resources? Yes No	 points = 1 points = 0	Score: 1	Eelgrass is documented as a highly productive habitat for a wide variety of species. Structured habitat is often associated with higher species diversity for benthic invertebrates, but not directly for mobile species (Hosack 2003, Hosack et al. 2006).
	Total for 9.0		**4**	
	Rating of Value: 3 - 7 = H; 1 - 2 = M; 0 = L			

SCORING FORM

Site: Elk River Estuary - BEFORE Date: 8-Oct-15

	WATER QUALITY FUNCTIONS - Indicators that improve water quality			NOTES
SITE	1.0 Does the habitat unit have the potential to improve water quality?			**Objective:** Identify the capacity of the habitat type to cause a change in water quality by removing sediment, nutrients, or toxins from the water column or adding dissolved oxygen to the water column.
	1.1 Condition of habitat to be able to trap sediments or contaminants:		Score: 2	Wetland studies report compiled for PG&E suggest wetlands are likely dominated by non-natives including perennial ryegrass, birdsfoot trefoil and velvetgrass. According to the California Rapid Assessment Method (CRAM), the ability of vegetation (or buffer condition) to trap sediment/contaminants should be assessed according to the extent and quality of vegetation cover, the overall condition of the substrate, and the amount of human visitation.
	Native vegetation, undisturbed soils, little to no human visitation	points = 8		
	Native/non-native vegetation (25-75%), mostly undisturbed soils, low impact human visitation OR native vegetation but soils disturbance and low impact	points = 4		
	Non-native vegetation (>75%) AND moderate soil disturbance/compaction and/or moderate human disturbance	points = 2		
	Barren ground and/or highly compacted and/or intense human disturbance	points = 0		
	1.2 What is the proximity of the habitat unit to a significant sediment source (i.e., stream, estuary mouth):		Score: 8	Proposal includes sites adjacent to Elk River. Potential to trap and retain sediment is related to distance from sediment sources. The primary sediment sources of turbidity are from freshwater streams, tidal currents, and wind driven waves along the mudflats (Swanson et al. 2012, Shaughnessy and Hurst 2014).
	<0.25 mile	points = 8		
	0.5 to 0.25 mile	points = 4		
	>0.5 mile	points = 0		
	1.3 Does the habitat unit provide a way to extract nutrients or contaminants from the surrounding environment?		Score: 4	Existing Wetland vegetation has potential to detain and extract contaminants and nutrients from surrounding environment. Surplus nutrients can lead to eutrophication and excessive algal growth, replacement of perennial species with annual species, and reduced maximum depth where vegetation grows. These processes can degrade water quality and reduce habitat available for species use. Nutrient removal can reduce potential impacts from nutrient loading.
	Yes	points = 4		
	No	points = 0		
	1.4 Does the habitat unit deliver oxygen to the water?		Score: 0	At present there is a limited surface water connection to streams or marine environment. Algae and rooted vascular plants deliver oxygen to the water through photosynthesis (Short et al. 2000), which is a major component of water quality conditions that support other organisms.
	Yes	points = 4		
	No	points = 0		
	Total for 1.0		**14**	
	Rating of Site Potential: 16 - 24 = H	6 - 15 = M	0 - 5 = L	
LANDSCAPE	2.0 What is the landscape context for water quality services provided by the site?			**Objective:** Identify whether water quality concerns are present in the service area for the site. Turbidity, nutrients, and contaminants are important management considerations in Humboldt Bay (Schlosser and Eicher 2012).
	2.1 What is the abundance of altered sediment supply or marine connectivity from the site?		Score: 0	Sediment supply has been altered through the construction and maintenance of dikes and road and railroad infrastructure. According to the CRAM, marine connectivity can be assessed based on the portion of the coastline with an alteration to sediment supply and transport (e.g., jetties, seawalls/riprap, piers, bridges, and dunes stabilized by invasive species). The measurement is based on 500 m up-coast and down-coast of the midpoint of the site.
	No signs	points = 6		
	<500 m AND/OR marine connectivity	points = 3		
	500 to 900 m OR marine connectivity	points = 2		
	>500 m AND mar.con. OR >900 m OR mar.con.	points = 0		
	2.2 Does at least 10% of the contributing watershed contain tilled fields, pastures, impervious surface area, or forests that have been clearcut within the last 5 years?		Score: 4	The Humboldt watershed has more than 10% of it's area in recently harvest forestry, agriculture and urban land uses. Watersheds above 10% impervious surface area show signs of degradation and increased sediment runoff (Booth 1991). Overgrazing, cultivation, and forest clearing have been associated with increases in sediment runoff from watersheds (e.g., Walling and Webb 1983).
	Yes	points = 4		
	No	points = 0		
	2.3 Are there consistent signs of excess nutrients in the habitat unit (e.g., increased ulvoids, high N, high P, high Si, HABs)?		Score: 2	There are occasional periods of high algal growth in Humboldt Bay, however it does not appear to be extreme or persistant and does not appear to meet thresholds for eutrophication. Are the signs of elevated nutrients regularly or persistently present in the watershed. Persistence suggests that relevant thresholds for eutrophication are consistently present. Signs of excess nutrients may include direct measurements of nutrient levels, algal blooms, presence of ulvoid mats, or low dissolved oxygen levels.
	None	points = 4		
	1 - 3 years	points = 2		
	>3 years in the past 5 years	points = 0		
	Total for 2.0		**6**	
	Rating of Landscape Potential: 11 - 14 = H	5 - 10 = M	0 - 4 = L	
WATERSHED	3.0 Is water quality improvement identified as a watershed or regional priority?			**Objective:** Water quality impairment in the watershed can reduce ecosystem function and population levels.
	3.1 Are there any rivers, streams, or estuaries on the site on the 303(d) list?		Score: 0	The site currently has limited connectivity to areas listed on the 303d list. The 303(d) list identifies impaired waters where existing pollution controls and/or biological removal is failing to maintain water quality for 1 or more parameters.
	Yes	points = 1		
	No	points = 0		
	3.2 Does the river or stream have TMDL limits for nutrients, toxics, or pathogens?		Score: 0	The site currently has limited connectivity to areas listed on the 303d list. Under the clean water act, Total Maximum Daily Loads (TMDLs) must be developed for all impaired waters, however prioritization for development of TMDLs is up to each State and development can occur 5-15 years after initial listing.
	Yes	points = 1		
	No	points = 0		
	Total for 3.0		**0**	
	Rating of Value: 2 = H	1 = M	0 = L	

SCORING FORM

	HABITAT STRUCTURE FUNCTIONS - Indicators that improve habitat structure			NOTES
SITE	4.0 Does the habitat unit have the potential to improve habitat structure?			**Point:** Habitat structure provides additional ecosystem niches thereby often increasing overall productivity while also providing for predator avoidance.
	4.1 What proportion of historic habitat exists?		Score:	
	Decline of 80% or more from historic levels	points = 8	2	Although estuarine wetlands have declined by as much as 80% in Humboldt county, it is expected that wetland habitat has only declined by 20-50%. Habitats that have declined substantially from historic levels or are known to be regionally rare are of greater ecological value.
	Decline of 50-80% from historic levels	points = 4		
	Decline of 20-50% from historic levels	points = 2		
	Decline of less than 20% or increase from historic levels	points = 0		
	4.2 Amount of habitat structure present (% cover or areal extent):		Score:	
	Continuous coverage (>85% cover)	points = 8	4	Much of the site is currently identified as vegetated with wetland vegetation. Percent cover (areal extent) is a common indicator of plant community, health, and development. The Cowardin classification defines a "plant class" as covering more than 30% of the area and Schlosser and Eicher (2012) define patchy eelgrass as >10% and <85%, and continuous eelgrass as >85%.
	Patchy coverage (10-85% cover)	points = 4		
	No coverage	points = 0		
	4.3 Number of plant species present (including macroalgae and/or microbial mats):		Score:	Although more species are present, local wetland delineation efforts undertaken by PG&E suggest most sites in the area are likely to have 2 dominant species present. The majority of studies have found positive correlations between habitat heterogeneity/diversity and species diversity (Tews et al. 2004). In general, increasing diversity of vegetation generates diversity in ecological niches and increased diversity of fauna.
	>3 species	points = 4	2	
	2 species	points = 2		
	0-1 species	points = 0		
	4.4 Presence of mature, complex habitat that provides 3-dimensional structure:		Score:	
	Very tall (>3 m)	points = 4	2	Active mowing in the area likely keeps vegetation heights to between 0.3 and 1 m. Zedler (1993) identified a relationship between habitat structural complexity and species use. Vegetation height is an indicator of complex, mature habitat with 3-dimensional structure. The categories were taken from the CRAM heights for plant layers.
	Tall (1 to 3 m)	points = 3		
	Medium (0.3 to 1 m)	points = 2		
	Short (<0.3 m)	points = 0		
	Total for 4.0		**10**	
	Rating of Site Potential: 16 - 24 = H	10 - 15 = M	0 - 9 = L	
LANDSCAPE	5.0 Does the landscape have the potential to support habitat function and species use at the site?			**Objective:** Identify whether species that might use the site are present, whether habitat is a limiting factor and if they are able to access the site.
	5.1 In its current state, is the habitat considered a limiting factor for fish or wildlife?		Score:	In its current state, palustrine wetlands are not identified as a limiting factor.. A limiting factors analysis assesses and identifies factors limiting the productivity or abundance of endangered or sensitive species. There are documents in Humboldt Bay that have already conducted a limiting factors analysis for certain species (e.g., HBWAC and RCAA 2005)
	Yes	points = 2	0	
	No	points = 0		
	5.2 In its current state, is the habitat unit considered important nursery/rearing habitat for fish or wildlife?		Score:	Palustrine wetlands can provide important habitat functions for some species. Egg and juvenile stages tend to be the most sensitive to predation due to their relative inability to defend against or evade predation. Therefore, nursery areas that provide complex habitat which supports predation avoidance are high value areas.
	Yes	points = 1	1	
	No	points = 0		
	5.3 What is the average area of aquatic area abundance?		Score:	
	≥61% of the transects	points = 4	0	Pallustrine wetlands are not currently inundated.. Aquatic area abundance is the spatial association with other areas of aquatic resources, such as wetlands, streams, and estuaries. According to the CRAM, transects that run parallel to the shoreline for 500 m on either side of the site are more important the higher the percentage of wetland habitat, other aquatic features, and open water.
	≥31 to 60% of the transects	points = 3		
	≥11 to 30% of the transects	points = 2		
	≤10% of the transects	points = 0		
	5.4 Does the habitat unit support the following species (add 1 point for every species)?		Score:	
	Dungeness crab; green sturgeon; dunlin; long-billed		1	Common egrets likely use the wetlands.. These species are identified as common or important within Humboldt Bay (e.g., Pinnix et al. 2005, Connolly and Colwell 2005), use a variety of habitat types, and occur over a broad seasonal range (for most species). See the phenology table for more details. Support defined as supporting feeding, refugia or reproduction by these species.
	Pacific herring; coho salmon; common egret; great blue heron			
	English sole; black brant; surf scoter; harbor seal			
	5.5 Would sea level rise result in a reduction of habitat?		Score:	Wetland habitats in Humboldt Bay are constrained by roadway and railroad infrastructure which limit the ability of habitats to respond to rising sea levels. Increased temperatures and dessication risks could lead to a narrower habitable range in the future. The phenomenon called "coastal squeeze" is a management concern for Humboldt Bay (Schlosser and Eicher 2012). If there is no room for habitats to expand into (e.g., surrounded by fixed manmade structures), then there is no resiliency in the available habitat.
	Habitat would remain/expand with sea level rise	points = 1	0	
	Habitat would decline with sea level rise	points = 0		
	Total for 5.0		**2**	
	Rating of Landscape Potential: 13 - 17 = H	6 - 12 = M	0 - 5 = L	
WATERSHED	6.0 Is the habitat function improvement provided by the site identified as a priority issue in the watershed?			**Objective:** Identify whether this this habitat supports regional conservation or restoration targets
	6.1 Has the current abundance triggered state, federal or natural heritage listing?		Score:	Pallustrine wetlands are not listed, however wetlands are recognized as valuable components of the ecosystem and no net loss and mitigation requirements are applied to ensure their continued existence. Listing a species as endangered suggests both a decline or naturally low population abundance creating a potential for extinction. A listing also suggests that there is sufficient data collection and scientific understanding to characterize the current population level and species biology.
	Habitat is recognized as priority for protection	points = 2	0	
	No formal recognition of habitat rarity/priority	points = 0		
	6.2 Are there recovery plans or ESA documents that include the habitat as a priority habitat?		Score:	Several ESA listed species, including salmonids, have included eelgrass as critical habitat. Critical habitat or essential fish habitat contain features that are essential areas for conservation of species.
	Yes	points = 1	0	
	No	points = 0		
	6.3 Is there literature that provides the importance of the habitat for providing habitat function?		Score:	Wetlands have been a subject of intense conservation interest and study. The Humboldt Bay Initiative (Schlosser et al. 2009) identifies Ecosystem-based Management (EBM) targets. If management plans specifically call out individual habitat, it gains a level of importance for the watershed.
	Yes	points = 1	1	
	No	points = 0		
	Total for 6.0		**1**	
	Rating of Value: 3 - 4 = H	1 - 2 = M	0 = L	

Elk River Estuary - Before

SCORING FORM

	PREY RESOURCES FUNCTIONS - Indicators that improve habitat structure			NOTES
SITE	7.0 Does the habitat unit have the potential to improve prey resources?			**Objective:** Characterize the capacity of the site to produce prey items used by higher trophic levels.
	7.1 Type of habitat structure that can provide resource for prey species:		Score:	Pallustrine wetlands produce above and below ground biomass and structures. Above ground biomass is available for direct consumption and conversion to detritus and provides 3-dimensional habitat structure. Below ground biomass plays an important role in nutrition as well as anchoring and spreading of vegetation. Due to incomplete decomposition in sediments, below ground biomass can represent long term carbon burial (e.g. Kenworthy and Thayer 1984).
	Above- and below-ground biomass/structure	points = 8	8	
	Above-ground biomass or structure	points = 4		
	Below-ground biomass or structure	points = 2		
	No habitat present	points = 0		
	7.2 Density of habitat present:		Score:	This metric is based on work by Hughes (2002) who found significant differences in fish abundance, biomass, species richness, and prey items between eelgrass densities above and below 100 shoots/m^2 (or in excess of 100 g/m^2).
	Dense (>100 turions/m^2 or >3 plants/m^2)	points = 8	8	
	Patchy (<100 turions/m^2 or <3 plants/m^2)	points = 4		
	No habitat present	points = 0		
	7.3 Does the habitat unit provide primary production?		Score:	Yes. Primary production is use of light or chemical energy to generate organic compounds (e.g. photo or chemosynthesis). Primary production is the primary mechanism for introducing energy into the food web.
	Yes	points = 4	4	
	No	points = 0		
	7.4 Does the habitat unit support secondary production?		Score:	Yes. Secondary production is the generation of biomass by primary consumers (herbivorous organisms that feed on primary producers).
	Yes	points = 4	4	
	No	points = 0		
	7.5 Does the habitat unit contain invasive or exotic species (e.g., *Spartina densiflora*, *Zostera japonica*, European green crab, *Ampithoe valida* amphipod) that may affect productivity or foraging?		Score:	Spartina has been documented in adjacent areas and is presumed to be present. and numerous cosmopolitan invasive species are likely present. Spartina is a major invasive organism in salt marshes in Humboldt Bay with the potential to convert diverse salt marsh communities into Spartina dominated habitat, including facilitating a significant difference in invertebrate communities with non-native species. Native sites are comprised mostly of invertebrates from the family Heminiptera (Mitchell 2012).
	No	points = 4	0	
	Yes	points = 0		
	Total for 7.0		**24**	
	Rating of Site Potential: 20 - 28 = H	11 - 19 = M	0 - 10 = L	
LANDSCAPE	8.0 Does the landscape have the potential to support prey resources at the site?			**Objective:** Characterize the potential for the site to export prey items to the landscape.
	8.1 What is the distance of the stream corridor continuity based on the combined length of non-buffer segments?		Score:	According to the CRAM, stream continuity considers the ability of areas of open water with connectivity of habitat to provide corridors for anadromous fish and other wildlife. The method combines the length of non-buffered land that crosses the riparian or aquatic area.
	<100 m	points = 4	0	
	100 to 150 m	points = 3		
	150 to 200 m	points = 2		
	>200 m	points = 0		
	8.2 Is the habitat unit adjacent to or on a sandy grit site used by black brant?		Score:	The primary sand grit site in Humboldt Bay is adjacent to Sandy Spit just south of the entrance channel to Humboldt Bay (Spragens et al. 2013). Disturbances near traditional grit sites may limit the ability of black brant to replenish gizzard grit, which would reduce their digestive efficiency (Moore and Black 2005).
	Yes	points = 2	0	
	No	points = 0		
	8.2 For which seasons do fish or wildlife forage in the habitat unit?		Score:	Species are present and use wetlands year-round, though there are distinct peaks associated with migration and reproduction. Sites that are used for multiple seasons are expected to support more types of species and more resident species.
	All seasons (fall, winter, spring, summer)	points = 4	4	
	At least two seasons	points = 3		
	At least one season	points = 2		
	None	points = 0		
	8.3 Potential for the habitat unit to produce benthic and drift prey items:		Score:	Limited ability of prey to be delivered to water column from pallustrine wetlands with limited hydrologic connection to Humboldt Bay. Majority of prey items are within the water column. However, eelgrass wrack does generate drift prey items. Merritt et al. (2002) identifed these ratios for invertebrate production as indicators of good supply for water column-feeding fish (drift invertebrates), wading birds and benthic feeding fish (sprawlers).
	Water-column and benthic prey items available	points = 4	0	
	Majority of prey are from the water-column	points = 2		
	Majority of prey are from the benthic habitat	points = 2		
	No prey items are available	points = 0		
	Total for 8.0		**4**	
	Rating of Landscape Potential: 10 - 14 = H	6 - 9 = M	0 - 5 = L	
WATERSHED	9.0 Are prey resources produced by the site identified as watershed or regional priorities?			**Objective:** Identify the potential for the site to produce prey items consumed by regional or watershed priority species.
	9.1 How many species groups does the habitat unit support (add the total)?		Score:	Shorebirds are the primary species that may use a pallustrine wetland. . The more diverse the habitat, the more diverse the type of species that use the habitat will be.
	Shorebirds; Anadromous Fish; Groundfish	Yes = 1	1	
	Wading birds; Mammals; Pelagic fish	No = 0		
	9.2 Is there literature that provides an understanding of the importance of the habitat for providing prey resources?		Score:	Pallustrine wetlands have the capacity to generate prey. Structured habitat is often associated with higher species diversity for benthic invertebrates, but not directly for mobile species (Hosack 2003, Hosack et al. 2006).
	Yes	points = 1	1	
	No	points = 0		
	Total for 9.0		**2**	
	Rating of Value: 3 - 5 = H	1 - 2 = M	0 = L	

SCORING FORM

Site: Elk River Estuary - BEFORE Date: 8-Oct-15

	WATER QUALITY FUNCTIONS - Indicators that improve water quality			NOTES
SITE	1.0 Does the habitat unit have the potential to improve water quality?			**Objective:** Identify the capacity of the habitat type to cause a change in water quality by removing sediment, nutrients, or toxins from the water column or adding dissolved oxygen to the water column.
	1.1 Condition of habitat to be able to trap sediments or contaminants:		Score: 2	Wetland studies report compiled for PG&E suggest wetlands are likely dominated by non-natives including perennial ryegrass, birdsfoot trefoil and velvetgrass. According to the California Rapid Assessment Method (CRAM), the ability of vegetation (or buffer condition) to trap sediment/contaminants should be assessed according to the extent and quality of vegetation cover, the overall condition of the substrate, and the amount of human visitation.
	Native vegetation, undisturbed soils, little to no human visitation	points = 8		
	Native/non-native vegetation (25-75%), mostly undisturbed soils, low impact human visitation OR native vegetation but soils disturbance and low impact	points = 4		
	Non-native vegetation (>75%) AND moderate soil disturbance/compaction and/or moderate human disturbance	points = 2		
	Barren ground and/or highly compacted and/or intense human disturbance	points = 0		
	1.2 What is the proximity of the habitat unit to a significant sediment source (i.e., stream, estuary mouth):		Score: 8	Proposal includes sites adjacent to Elk River. Potential to trap and retain sediment is related to distance from sediment sources. The primary sediment sources of turbidity are from freshwater streams, tidal currents, and wind driven waves along the mudflats (Swanson et al. 2012, Shaughnessy and Hurst 2014).
	<0.25 mile	points = 8		
	0.5 to 0.25 mile	points = 4		
	>0.5 mile	points = 0		
	1.3 Does the habitat unit provide a way to extract nutrients or contaminants from the surrounding environment?		Score: 4	Existing Wetland vegetation has potential to detain and extract contaminants and nutrients from surrounding environment. Surplus nutrients can lead to eutrophication and excessive algal growth, replacement of perennial species with annual species, and reduced maximum depth where vegetation grows. These processes can degrade water quality and reduce habitat available for species use. Nutrient removal can reduce potential impacts from nutrient loading.
	Yes	points = 4		
	No	points = 0		
	1.4 Does the habitat unit deliver oxygen to the water?		Score: 0	At present there is a limited surface water connection to streams or marine environment. Algae and rooted vascular plants deliver oxygen to the water through photosynthesis (Short et al. 2000), which is a major component of water quality conditions that support other organisms.
	Yes	points = 4		
	No	points = 0		
	Total for 1.0		**14**	
	Rating of Site Potential: 16 - 24 = H	6 - 15 = M	0 - 5 = L	
LANDSCAPE	2.0 What is the landscape context for water quality services provided by the site?			**Objective:** Identify whether water quality concerns are present in the service area for the site. Turbidity, nutrients, and contaminants are important management considerations in Humboldt Bay (Schlosser and Eicher 2012).
	2.1 What is the abundance of altered sediment supply or marine connectivity from the site?		Score: 0	Sediment supply has been altered through the construction and maintenance of dikes and road and railroad infrastructure. According to the CRAM, marine connectivity can be assessed based on the portion of the coastline with an alteration to sediment supply and transport (e.g., jetties, seawalls/riprap, piers, bridges, and dunes stabilized by invasive species). The measurement is based on 500 m up-coast and down-coast of the midpoint of the site.
	No signs	points = 6		
	<500 m AND/OR marine connectivity	points = 3		
	500 to 900 m OR marine connectivity	points = 2		
	>500 m AND mar.con. OR >900 m OR mar.con.	points = 0		
	2.2 Does at least 10% of the contributing watershed contain tilled fields, pastures, impervious surface area, or forests that have been clearcut within the last 5 years?		Score: 4	The Humboldt watershed has more than 10% of it's area in recently harvest forestry, agriculture and urban land uses. Watersheds above 10% impervious surface area show signs of degradation and increased sediment runoff (Booth 1991). Overgrazing, cultivation, and forest clearing have been associated with increases in sediment runoff from watersheds (e.g., Walling and Webb 1983).
	Yes	points = 4		
	No	points = 0		
	2.3 Are there consistent signs of excess nutrients in the habitat unit (e.g., increased ulvoids, high N, high P, high Si, HABs)?		Score: 2	There are occasional periods of high algal growth in Humboldt Bay, however it does not appear to be extreme or persistant and does not appear to meet thresholds for eutrophication. Are the signs of elevated nutrients regularly or persistently present in the watershed. Persistence suggests that relevant thresholds for eutrophication are consistently present. Signs of excess nutrients may include direct measurements of nutrient levels, algal blooms, presence of ulvoid mats, or low dissolved oxygen levels.
	None	points = 4		
	1 - 3 years	points = 2		
	>3 years in the past 5 years	points = 0		
	Total for 2.0		**6**	
	Rating of Landscape Potential: 11 - 14 = H	5 - 10 = M	0 - 4 = L	
WATERSHED	3.0 Is water quality improvement identified as a watershed or regional priority?			**Objective:** Water quality impairment in the watershed can reduce ecosystem function and population levels.
	3.1 Are there any rivers, streams, or estuaries on the site on the 303(d) list?		Score: 0	The site currently has limited connectivity to areas listed on the 303d list. The 303(d) list identifies impaired waters where existing pollution controls and/or biological removal is failing to maintain water quality for 1 or more parameters.
	Yes	points = 1		
	No	points = 0		
	3.2 Does the river or stream have TMDL limits for nutrients, toxics, or pathogens?		Score: 0	The site currently has limited connectivity to areas listed on the 303d list. Under the clean water act, Total Maximum Daily Loads (TMDLs) must be developed for all impaired waters, however prioritization for development of TMDLs is up to each State and development can occur 5-15 years after initial listing.
	Yes	points = 1		
	No	points = 0		
	Total for 3.0		**0**	
	Rating of Value: 2 = H	1 = M	0 = L	

SCORING FORM

	HABITAT STRUCTURE FUNCTIONS - Indicators that improve habitat structure			NOTES
SITE	4.0 Does the habitat unit have the potential to improve habitat structure?			**Point:** Habitat structure provides additional ecosystem niches thereby often increasing overall productivity while also providing for predator avoidance.
	4.1 What proportion of historic habitat exists? Decline of 80% or more from historic levels Decline of 50-80% from historic levels Decline of 20-50% from historic levels Decline of less than 20% or increase from historic levels	 points = 8 points = 4 points = 2 points = 0	Score: 2	Although estuarine wetlands have declined by as much as 80% in Humboldt county, it is expected that wetland habitat has only declined by 20-50%. Habitats that have declined substantially from historic levels or are known to be regionally rare are of greater ecological value.
	4.2 Amount of habitat structure present (% cover or areal extent): Continuous coverage (>85% cover) Patchy coverage (10-85% cover) No coverage	 points = 8 points = 4 points = 0	Score: 4	Much of the site is currently identified as vegetated with wetland vegetation. Percent cover (areal extent) is a common indicator of plant community, health, and development. The Cowardin classification defines a "plant class" as covering more than 30% of the area and Schlosser and Eicher (2012) define patchy eelgrass as >10% and <85%, and continuous eelgrass as >85%.
	4.3 Number of plant species present (including macroalgae and/or microbial mats): >3 species 2 species 0-1 species	 points = 4 points = 2 points = 0	Score: 2	Although more species are present, local wetland delineation efforts undertaken by PG&E suggest most sites in the area are likely to have 2 dominant species present. The majority of studies have found positive correlations between habitat heterogeneity/diversity and species diversity (Tews et al. 2004). In general, increasing diversity of vegetation generates diversity in ecological niches and increased diversity of fauna.
	4.4 Presence of mature, complex habitat that provides 3-dimensional structure: Very tall (>3 m) Tall (1 to 3 m) Medium (0.3 to 1 m) Short (<0.3 m)	 points = 4 points = 3 points = 2 points = 0	Score: 2	Active mowing in the area likely keeps vegetation heights to between 0.3 and 1 m. Zedler (1993) identified a relationship between habitat structural complexity and species use. Vegetation height is an indicator of complex, mature habitat with 3-dimensional structure. The categories were taken from the CRAM heights for plant layers.
	Total for 4.0		**10**	
	Rating of Site Potential: 16 - 24 = H	10 - 15 = M	0 - 9 = L	
LANDSCAPE	5.0 Does the landscape have the potential to support habitat function and species use at the site?			**Objective:** Identify whether species that might use the site are present, whether habitat is a limiting factor and if they are able to access the site.
	5.1 In its current state, is the habitat considered a limiting factor for fish or wildlife? Yes No	 points = 2 points = 0	Score: 0	In its current state, palustrine wetlands are not identified as a limiting factor.. A limiting factors analysis assesses and identifies factors limiting the productivity or abundance of endangered or sensitive species. There are documents in Humboldt Bay that have already conducted a limiting factors analysis for certain species (e.g., HBWAC and RCAA 2005)
	5.2 In its current state, is the habitat unit considered important nursery/rearing habitat for fish or wildlife? Yes No	 points = 1 points = 0	Score: 1	Palustrine wetlands can provide important habitat functions for some species. Egg and juvenile stages tend to be the most sensitive to predation due to their relative inability to defend against or evade predation. Therefore, nursery areas that provide complex habitat which supports predation avoidance are high value areas.
	5.3 What is the average area of aquatic area abundance? ≥61% of the transects ≥31 to 60% of the transects ≥11 to 30% of the transects ≤10% of the transects	 points = 4 points = 3 points = 2 points = 0	Score: 0	Pallustrine wetlands are not currently inundated.. Aquatic area abundance is the spatial association with other areas of aquatic resources, such as wetlands, streams, and estuaries. According to the CRAM, transects that run parallel to the shoreline for 500 m on either side of the site are more important the higher the percentage of wetland habitat, other aquatic features, and open water.
	5.4 Does the habitat unit support the following species (add 1 point for every species)? Dungeness crab, green sturgeon, dunlin Pacific herring, coho salmon, common egret English sole, black brant, surf scoter	long-billed great blue heron harbor seal	Score: 1	Common egrets likely use the wetlands.. These species are identified as common or important within Humboldt Bay (e.g., Pinnix et al. 2005, Connolly and Colwell 2005), use a variety of habitat types, and occur over a broad seasonal range (for most species). See the phenology table for more details. Support defined as supporting feeding, refugia or reproduction by these species.
	5.5 Would sea level rise result in a reduction of habitat? Habitat would remain/expand with sea level rise Habitat would decline with sea level rise	 points = 1 points = 0	Score: 0	Wetland habitats in Humboldt Bay are constrained by roadway and railroad infrastructure which limit the ability of habitats to respond to rising sea levels. Increased temperatures and dessication risks could lead to a narrower habitable range in the future. The phenomenon called "coastal squeeze" is a management concern for Humboldt Bay (Schlosser and Eicher 2012). If there is no room for habitats to expand into (e.g., surrounded by fixed manmade structures), then there is no resiliency in the available habitat.
	Total for 5.0		**2**	
	Rating of Landscape Potential: 13 - 17 = H	6 - 12 = M	0 - 5 = L	
WATERSHED	6.0 Is the habitat function improvement provided by the site identified as a priority issue in the watershed?			**Objective:** Identify whether this this habitat supports regional conservation or restoration targets
	6.1 Has the current abundance triggered state, federal or natural heritage listing? Habitat is recognized as priority for protection No formal recognition of habitat rarity/priority	 points = 2 points = 0	Score: 0	Pallustrine wetlands are not listed, however wetlands are recognized as valuable components of the ecosystem and no net loss and mitigation requirements are applied to ensure their continued existence. Listing a species as endangered suggests both a decline or naturally low population abundance creating a potential for extinction. A listing also suggests that there is sufficient data collection and scientific understanding to characterize the current population level and species biology.
	6.2 Are there recovery plans or ESA documents that include the habitat as a priority habitat? Yes No	 points = 1 points = 0	Score: 0	Several ESA listed species, including salmonids, have included eelgrass as critical habitat. Critical habitat or essential fish habitat contain features that are essential areas for conservation of species.
	6.3 Is there literature that provides the importance of the habitat for providing habitat function? Yes No	 points = 1 points = 0	Score: 1	Wetlands have been a subject of intense conservation interest and study. The Humboldt Bay Initiative (Schlosser et al. 2009) identifies Ecosystem-based Management (EBM) targets. If management plans specifically call out individual habitat, it gains a level of importance for the watershed.
	Total for 6.0		**1**	
	Rating of Value: 3 - 4 = H	1 - 2 = M	0 = L	

SCORING FORM

	PREY RESOURCES FUNCTIONS - Indicators that improve habitat structure		Score	NOTES
SITE	7.0 Does the habitat unit have the potential to improve prey resources?			**Objective:** Characterize the capacity of the site to produce prey items used by higher trophic levels.
	7.1 Type of habitat structure that can provide resource for prey species: Above- and below-ground biomass/structure Above-ground biomass or structure Below-ground biomass or structure No habitat present	 points = 8 points = 4 points = 2 points = 0	Score: 8	Pallustrine wetlands produce above and below ground biomass and structures. Above ground biomass is available for direct consumption and conversion to detritus and provides 3-dimensional habitat structure. Below ground biomass plays an important role in nutrition as well as anchoring and spreading of vegetation. Due to incomplete decomposition in sediments, below ground biomass can represent long term carbon burial (e.g. Kenworthy and Thayer 1984).
	7.2 Density of habitat present: Dense (>100 turions/m^2 or >3 plants/m^2) Patchy (<100 turions/m^2 or <3 plants/m^2) No habitat present	 points = 8 points = 4 points = 0	Score: 8	This metric is based on work by Hughes (2002) who found significant differences in fish abundance, biomass, species richness, and prey items between eelgrass densities above and below 100 shoots/m^2 (or in excess of 100 g/m^2).
	7.3 Does the habitat unit provide primary production? Yes No	 points = 4 points = 0	Score: 4	Yes. Primary production is use of light or chemical energy to generate organic compounds (e.g. photo or chemosynthesis). Primary production is the primary mechanism for introducing energy into the food web.
	7.4 Does the habitat unit support secondary production? Yes No	 points = 4 points = 0	Score: 4	Yes. Secondary production is the generation of biomass by primary consumers (herbivorous organisms that feed on primary producers).
	7.5 Does the habitat unit contain invasive or exotic species (e.g., *Spartina densiflora*, *Zostera japonica*, European green crab, *Ampithoe valida* amphipod) that may affect productivity or foraging? No Yes	 points = 4 points = 0	Score: 0	Spartina has been documented in adjacent areas and is presumed to be present. and numerous cosmopolitan invasive species are likely present. Spartina is a major invasive organism in salt marshes in Humboldt Bay with the potential to convert diverse salt marsh communities into Spartina dominated habitat, including facilitating a significant difference in invertebrate communities with non-native species. Native sites are comprised mostly of invertebrates from the family Heminiptera (Mitchell 2012).
	Total for 7.0		**24**	
	Rating of Site Potential: 20 - 28 = H	11 - 19 = M	0 - 10 = L	
LANDSCAPE	8.0 Does the landscape have the potential to support prey resources at the site?			**Objective:** Characterize the potential for the site to export prey items to the landscape.
	8.1 What is the distance of the stream corridor continuity based on the combined length of non-buffer segments? <100 m 100 to 150 m 150 to 200 m >200 m	 points = 4 points = 3 points = 2 points = 0	Score: 0	According to the CRAM, stream continuity considers the ability of areas of open water with connectivity of habitat to provide corridors for anadromous fish and other wildlife. The method combines the length of non-buffered land that crosses the riparian or aquatic area.
	8.2 Is the habitat unit adjacent to or on a sandy grit site used by black brant? Yes No	 points = 2 points = 0	Score: 0	The primary sand grit site in Humboldt Bay is adjacent to Sandy Spit just south of the entrance channel to Humboldt Bay (Spragens et al. 2013). Disturbances near traditional grit sites may limit the ability of black brant to replenish gizzard grit, which would reduce their digestive efficiency (Moore and Black 2005).
	8.2 For which seasons do fish or wildlife forage in the habitat unit? All seasons (fall, winter, spring, summer) At least two seasons At least one season None	 points = 4 points = 3 points = 2 points = 0	Score: 4	Species are present and use wetlands year-round, though there are distinct peaks associated with migration and reproduction. Sites that are used for multiple seasons are expected to support more types of species and more resident species.
	8.3 Potential for the habitat unit to produce benthic and drift prey items: Water-column and benthic prey items available Majority of prey are from the water-column Majority of prey are from the benthic habitat No prey items are available	 points = 4 points = 2 points = 2 points = 0	Score: 0	Limited ability of prey to be delivered to water column from pallustrine wetlands with limited hydrologic connection to Humboldt Bay. Majority of prey items are within the water column. However, eelgrass wrack does generate drift prey items. Merritt et al. (2002) identifed these ratios for invertebrate production as indicators of good supply for water column-feeding fish (drift invertebrates), wading birds and benthic feeding fish (sprawlers).
	Total for 8.0		**4**	
	Rating of Landscape Potential: 10 - 14 = H	6 - 9 = M	0 - 5 = L	
WATERSHED	9.0 Are prey resources produced by the site identified as watershed or regional priorities?			**Objective:** Identify the potential for the site to produce prey items consumed by regional or watershed priority species.
	9.1 How many species groups does the habitat unit support (add the total)? Shorebirds Anadromous Fish Groundfish Wading birds Mammals Pelagic fish	 Yes = 1 No = 0	Score: 1	Shorebirds are the primary species that may use a pallustrine wetland. . The more diverse the habitat, the more diverse the type of species that use the habitat will be.
	9.2 Is there literature that provides an understanding of the importance of the habitat for providing prey resources? Yes No	 points = 1 points = 0	Score: 1	Pallustrine wetlands have the capacity to generate prey. Structured habitat is often associated with higher species diversity for benthic invertebrates, but not directly for mobile species (Hosack 2003, Hosack et al. 2006).
	Total for 9.0		**2**	
	Rating of Value: 3 - 5 = H	1 - 2 = M	0 = L	

SCORING FORM

Site: Elk River Estuary - BEFORE Date: 8-Oct-15

	WATER QUALITY FUNCTIONS - Indicators that improve water quality			NOTES
SITE	1.0 Does the habitat unit have the potential to improve water quality?			**Objective:** Identify the capacity of the habitat type to cause a change in water quality by removing sediment, nutrients, or toxins from the water column or adding dissolved oxygen to the water column.
	1.1 Condition of habitat to be able to trap sediments or contaminants:		Score: 2	Wetland studies report compiled for PG&E suggest wetlands are likely dominated by non-natives including perennial ryegrass, birdsfoot trefoil and velvetgrass. According to the California Rapid Assessment Method (CRAM), the ability of vegetation (or buffer condition) to trap sediment/contaminants should be assessed according to the extent and quality of vegetation cover, the overall condition of the substrate, and the amount of human visitation.
	Native vegetation, undisturbed soils, little to no human visitation	points = 8		
	Native/non-native vegetation (25-75%), mostly undisturbed soils, low impact human visitation OR native vegetation but soils disturbance and low impact	points = 4		
	Non-native vegetation (>75%) AND moderate soil disturbance/compaction and/or moderate human disturbance	points = 2		
	Barren ground and/or highly compacted and/or intense human disturbance	points = 0		
	1.2 What is the proximity of the habitat unit to a significant sediment source (i.e., stream, estuary mouth):		Score: 8	Proposal includes sites adjacent to Elk River. Potential to trap and retain sediment is related to distance from sediment sources. The primary sediment sources of turbidity are from freshwater streams, tidal currents, and wind driven waves along the mudflats (Swanson et al. 2012, Shaughnessy and Hurst 2014).
	<0.25 mile	points = 8		
	0.5 to 0.25 mile	points = 4		
	>0.5 mile	points = 0		
	1.3 Does the habitat unit provide a way to extract nutrients or contaminants from the surrounding environment?		Score: 4	Existing Wetland vegetation has potential to detain and extract contaminants and nutrients from surrounding environment. Surplus nutrients can lead to eutrophication and excessive algal growth, replacement of perennial species with annual species, and reduced maximum depth where vegetation grows. These processes can degrade water quality and reduce habitat available for species use. Nutrient removal can reduce potential impacts from nutrient loading.
	Yes	points = 4		
	No	points = 0		
	1.4 Does the habitat unit deliver oxygen to the water?		Score: 0	At present there is a limited surface water connection to streams or marine environment. Algae and rooted vascular plants deliver oxygen to the water through photosynthesis (Short et al. 2000), which is a major component of water quality conditions that support other organisms.
	Yes	points = 4		
	No	points = 0		
	Total for 1.0		**14**	
	Rating of Site Potential: 16 - 24 = H	6 - 15 = M	0 - 5 = L	
LANDSCAPE	2.0 What is the landscape context for water quality services provided by the site?			**Objective:** Identify whether water quality concerns are present in the service area for the site. Turbidity, nutrients, and contaminants are important management considerations in Humboldt Bay (Schlosser and Eicher 2012).
	2.1 What is the abundance of altered sediment supply or marine connectivity from the site?		Score: 0	Sediment supply has been altered through the construction and maintenance of dikes and road and railroad infrastructure. According to the CRAM, marine connectivity can be assessed based on the portion of the coastline with an alteration to sediment supply and transport (e.g., jetties, seawalls/riprap, piers, bridges, and dunes stabilized by invasive species). The measurement is based on 500 m up-coast and down-coast of the midpoint of the site.
	No signs	points = 6		
	<500 m AND/OR marine connectivity	points = 3		
	500 to 900 m OR marine connectivity	points = 2		
	>500 m AND mar.con. OR >900 m OR mar.con.	points = 0		
	2.2 Does at least 10% of the contributing watershed contain tilled fields, pastures, impervious surface area, or forests that have been clearcut within the last 5 years?		Score: 4	The Humboldt watershed has more than 10% of it's area in recently harvest forestry, agriculture and urban land uses. Watersheds above 10% impervious surface area show signs of degradation and increased sediment runoff (Booth 1991). Overgrazing, cultivation, and forest clearing have been associated with increases in sediment runoff from watersheds (e.g., Walling and Webb 1983).
	Yes	points = 4		
	No	points = 0		
	2.3 Are there consistent signs of excess nutrients in the habitat unit (e.g., increased ulvoids, high N, high P, high Si, HABs)?		Score: 2	There are occasional periods of high algal growth in Humboldt Bay, however it does not appear to be extreme or persistant and does not appear to meet thresholds for eutrophication. Are the signs of elevated nutrients regularly or persistently present in the watershed. Persistence suggests that relevant thresholds for eutrophication are consistently present. Signs of excess nutrients may include direct measurements of nutrient levels, algal blooms, presence of ulvoid mats, or low dissolved oxygen levels.
	None	points = 4		
	1 - 3 years	points = 2		
	>3 years in the past 5 years	points = 0		
	Total for 2.0		**6**	
	Rating of Landscape Potential: 11 - 14 = H	5 - 10 = M	0 - 4 = L	
WATERSHED	3.0 Is water quality improvement identified as a watershed or regional priority?			**Objective:** Water quality impairment in the watershed can reduce ecosystem function and population levels.
	3.1 Are there any rivers, streams, or estuaries on the site on the 303(d) list?		Score: 0	The site currently has limited connectivity to areas listed on the 303d list. The 303(d) list identifies impaired waters where existing pollution controls and/or biological removal is failing to maintain water quality for 1 or more parameters.
	Yes	points = 1		
	No	points = 0		
	3.2 Does the river or stream have TMDL limits for nutrients, toxics, or pathogens?		Score: 0	The site currently has limited connectivity to areas listed on the 303d list. Under the clean water act, Total Maximum Daily Loads (TMDLs) must be developed for all impaired waters, however prioritization for development of TMDLs is up to each State and development can occur 5-15 years after initial listing.
	Yes	points = 1		
	No	points = 0		
	Total for 3.0		**0**	
	Rating of Value: 2 = H	1 = M	0 = L	

SCORING FORM

	HABITAT STRUCTURE FUNCTIONS - Indicators that improve habitat structure		Score	NOTES
SITE	4.0 Does the habitat unit have the potential to improve habitat structure?			**Point:** Habitat structure provides additional ecosystem niches thereby often increasing overall productivity while also providing for predator avoidance.
	4.1 What proportion of historic habitat exists? Decline of 80% or more from historic levels Decline of 50-80% from historic levels Decline of 20-50% from historic levels Decline of less than 20% or increase from historic levels	 points = 8 points = 4 points = 2 points = 0	Score: 2	Although estuarine wetlands have declined by as much as 80% in Humboldt county, it is expected that wetland habitat has only declined by 20-50%. Habitats that have declined substantially from historic levels or are known to be regionally rare are of greater ecological value.
	4.2 Amount of habitat structure present (% cover or areal extent): Continuous coverage (>85% cover) Patchy coverage (10-85% cover) No coverage	 points = 8 points = 4 points = 0	Score: 4	Much of the site is currently identified as vegetated with wetland vegetation. Percent cover (areal extent) is a common indicator of plant community, health, and development. The Cowardin classification defines a "plant class" as covering more than 30% of the area and Schlosser and Eicher (2012) define patchy eelgrass as >10% and <85%, and continuous eelgrass as >85%.
	4.3 Number of plant species present (including macroalgae and/or microbial mats): >3 species 2 species 0-1 species	 points = 4 points = 2 points = 0	Score: 2	Although more species are present, local wetland delineation efforts undertaken by PG&E suggest most sites in the area are likely to have 2 dominant species present. The majority of studies have found positive correlations between habitat heterogeneity/diversity and species diversity (Tews et al. 2004). In general, increasing diversity of vegetation generates diversity in ecological niches and increased diversity of fauna.
	4.4 Presence of mature, complex habitat that provides 3-dimensional structure: Very tall (>3 m) Tall (1 to 3 m) Medium (0.3 to 1 m) Short (<0.3 m)	 points = 4 points = 3 points = 2 points = 0	Score: 2	Active mowing in the area likely keeps vegetation heights to between 0.3 and 1 m. Zedler (1993) identified a relationship between habitat structural complexity and species use. Vegetation height is an indicator of complex, mature habitat with 3-dimensional structure. The categories were taken from the CRAM heights for plant layers.
	Total for 4.0		**10**	
	Rating of Site Potential: 16 - 24 = H	10 - 15 = M	0 - 9 = L	
LANDSCAPE	5.0 Does the landscape have the potential to support habitat function and species use at the site?			**Objective:** Identify whether species that might use the site are present, whether habitat is a limiting factor and if they are able to access the site.
	5.1 In its current state, is the habitat considered a limiting factor for fish or wildlife? Yes No	 points = 2 points = 0	Score: 0	In its current state, palustrine wetlands are not identified as a limiting factor.. A limiting factors analysis assesses and identifies factors limiting the productivity or abundance of endangered or sensitive species. There are documents in Humboldt Bay that have already conducted a limiting factors analysis for certain species (e.g., HBWAC and RCAA 2005)
	5.2 In its current state, is the habitat unit considered important nursery/rearing habitat for fish or wildlife? Yes No	 points = 1 points = 0	Score: 1	Palustrine wetlands can provide important habitat functions for some species. Egg and juvenile stages tend to be the most sensitive to predation due to their relative inability to defend against or evade predation. Therefore, nursery areas that provide complex habitat which supports predation avoidance are high value areas.
	5.3 What is the average area of aquatic area abundance? ≥61% of the transects ≥31 to 60% of the transects ≥11 to 30% of the transects ≤10% of the transects	 points = 4 points = 3 points = 2 points = 0	Score: 0	Pallustrine wetlands are not currently inundated.. Aquatic area abundance is the spatial association with other areas of aquatic resources, such as wetlands, streams, and estuaries. According to the CRAM, transects that run parallel to the shoreline for 500 m on either side of the site are more important the higher the percentage of wetland habitat, other aquatic features, and open water.
	5.4 Does the habitat unit support the following species (add 1 point for every species)? Dungeness crab, green sturgeon, dunlin, long-billed Pacific herring, coho salmon, common egret, great blue heron English sole, black brant, surf scoter, harbor seal		Score: 1	Common egrets likely use the wetlands.. These species are identified as common or important within Humboldt Bay (e.g., Pinnix et al. 2005, Connolly and Colwell 2005), use a variety of habitat types, and occur over a broad seasonal range (for most species). See the phenology table for more details. Support defined as supporting feeding, refugia or reproduction by these species.
	5.5 Would sea level rise result in a reduction of habitat? Habitat would remain/expand with sea level rise Habitat would decline with sea level rise	 points = 1 points = 0	Score: 0	Wetland habitats in Humboldt Bay are constrained by roadway and railroad infrastructure which limit the ability of habitats to respond to rising sea levels. Increased temperatures and dessication risks could lead to a narrower habitable range in the future. The phenomenon called "coastal squeeze" is a management concern for Humboldt Bay (Schlosser and Eicher 2012). If there is no room for habitats to expand into (e.g., surrounded by fixed manmade structures), then there is no resiliency in the available habitat.
	Total for 5.0		**2**	
	Rating of Landscape Potential: 13 - 17 = H	6 - 12 = M	0 - 5 = L	
WATERSHED	6.0 Is the habitat function improvement provided by the site identified as a priority issue in the watershed?			**Objective:** Identify whether this this habitat supports regional conservation or restoration targets
	6.1 Has the current abundance triggered state, federal or natural heritage listing? Habitat is recognized as priority for protection No formal recognition of habitat rarity/priority	 points = 2 points = 0	Score: 0	Pallustrine wetlands are not listed, however wetlands are recognized as valuable components of the ecosystem and no net loss and mitigation requirements are applied to ensure their continued existence. Listing a species as endangered suggests both a decline or naturally low population abundance creating a potential for extinction. A listing also suggests that there is sufficient data collection and scientific understanding to characterize the current population level and species biology.
	6.2 Are there recovery plans or ESA documents that include the habitat as a priority habitat? Yes No	 points = 1 points = 0	Score: 0	Several ESA listed species, including salmonids, have included eelgrass as critical habitat. Critical habitat or essential fish habitat contain features that are essential areas for conservation of species.
	6.3 Is there literature that provides the importance of the habitat for providing habitat function? Yes No	 points = 1 points = 0	Score: 1	Wetlands have been a subject of intense conservation interest and study. The Humboldt Bay Initiative (Schlosser et al. 2009) identifies Ecosystem-based Management (EBM) targets. If management plans specifically call out individual habitat, it gains a level of importance for the watershed.
	Total for 6.0		**1**	
	Rating of Value: 3 - 4 = H	1 - 2 = M	0 = L	

SCORING FORM

	PREY RESOURCES FUNCTIONS - Indicators that improve habitat structure			NOTES
SITE	7.0 Does the habitat unit have the potential to improve prey resources?			**Objective:** Characterize the capacity of the site to produce prey items used by higher trophic levels.
	7.1 Type of habitat structure that can provide resource for prey species: Above- and below-ground biomass/structure Above-ground biomass or structure Below-ground biomass or structure No habitat present	 points = 8 points = 4 points = 2 points = 0	Score: 8	Pallustrine wetlands produce above and below ground biomass and structures. Above ground biomass is available for direct consumption and conversion to detritus and provides 3-dimensional habitat structure. Below ground biomass plays an important role in nutrition as well as anchoring and spreading of vegetation. Due to incomplete decomposition in sediments, below ground biomass can represent long term carbon burial (e.g. Kenworthy and Thayer 1984).
	7.2 Density of habitat present: Dense (>100 turions/m^2 or >3 plants/m^2) Patchy (<100 turions/m^2 or <3 plants/m^2) No habitat present	 points = 8 points = 4 points = 0	Score: 8	This metric is based on work by Hughes (2002) who found significant differences in fish abundance, biomass, species richness, and prey items between eelgrass densities above and below 100 shoots/m^2 (or in excess of 100 g/m^2).
	7.3 Does the habitat unit provide primary production? Yes No	 points = 4 points = 0	Score: 4	Yes. Primary production is use of light or chemical energy to generate organic compounds (e.g. photo or chemosynthesis). Primary production is the primary mechanism for introducing energy into the food web.
	7.4 Does the habitat unit support secondary production? Yes No	 points = 4 points = 0	Score: 4	Yes. Secondary production is the generation of biomass by primary consumers (herbivorous organisms that feed on primary producers).
	7.5 Does the habitat unit contain invasive or exotic species (e.g., *Spartina densiflora*, *Zostera japonica*, European green crab, *Ampithoe valida* amphipod) that may affect productivity or foraging? No Yes	 points = 4 points = 0	Score: 0	Spartina has been documented in adjacent areas and is presumed to be present. and numerous cosmopolitan invasive species are likely present. Spartina is a major invasive organism in salt marshes in Humboldt Bay with the potential to convert diverse salt marsh communities into Spartina dominated habitat, including facilitating a significant difference in invertebrate communities with non-native species. Native sites are comprised mostly of invertebrates from the family Heminiptera (Mitchell 2012).
	Total for 7.0		**24**	
	Rating of Site Potential: 20 - 28 = H	11 - 19 = M	0 - 10 = L	
LANDSCAPE	8.0 Does the landscape have the potential to support prey resources at the site?			**Objective:** Characterize the potential for the site to export prey items to the landscape.
	8.1 What is the distance of the stream corridor continuity based on the combined length of non-buffer segments? <100 m 100 to 150 m 150 to 200 m >200 m	 points = 4 points = 3 points = 2 points = 0	Score: 0	According to the CRAM, stream continuity considers the ability of areas of open water with connectivity of habitat to provide corridors for anadromous fish and other wildlife. The method combines the length of non-buffered land that crosses the riparian or aquatic area.
	8.2 Is the habitat unit adjacent to or on a sandy grit site used by black brant? Yes No	 points = 2 points = 0	Score: 0	The primary sand grit site in Humboldt Bay is adjacent to Sandy Spit just south of the entrance channel to Humboldt Bay (Spragens et al. 2013). Disturbances near traditional grit sites may limit the ability of black brant to replenish gizzard grit, which would reduce their digestive efficiency (Moore and Black 2005).
	8.2 For which seasons do fish or wildlife forage in the habitat unit? All seasons (fall, winter, spring, summer) At least two seasons At least one season None	 points = 4 points = 3 points = 2 points = 0	Score: 4	Species are present and use wetlands year-round, though there are distinct peaks associated with migration and reproduction. Sites that are used for multiple seasons are expected to support more types of species and more resident species.
	8.3 Potential for the habitat unit to produce benthic and drift prey items: Water-column and benthic prey items available Majority of prey are from the water-column Majority of prey are from the benthic habitat No prey items are available	 points = 4 points = 2 points = 2 points = 0	Score: 0	Limited ability of prey to be delivered to water column from pallustrine wetlands with limited hydrologic connection to Humboldt Bay. Majority of prey items are within the water column. However, eelgrass wrack does generate drift prey items. Merritt et al. (2002) identifed these ratios for invertebrate production as indicators of good supply for water column-feeding fish (drift invertebrates), wading birds and benthic feeding fish (sprawlers).
	Total for 8.0		**4**	
	Rating of Landscape Potential: 10 - 14 = H	6 - 9 = M	0 - 5 = L	
WATERSHED	9.0 Are prey resources produced by the site identified as watershed or regional priorities?			**Objective:** Identify the potential for the site to produce prey items consumed by regional or watershed priority species.
	9.1 How many species groups does the habitat unit support (add the total)? Shorebirds / Anadromous Fish / Groundfish Wading birds / Mammals / Pelagic fish	 Yes = 1 No = 0	Score: 1	Shorebirds are the primary species that may use a pallustrine wetland. . The more diverse the habitat, the more diverse the type of species that use the habitat will be.
	9.2 Is there literature that provides an understanding of the importance of the habitat for providing prey resources? Yes No	 points = 1 points = 0	Score: 1	Pallustrine wetlands have the capacity to generate prey. Structured habitat is often associated with higher species diversity for benthic invertebrates, but not directly for mobile species (Hosack 2003, Hosack et al. 2006).
	Total for 9.0		**2**	
	Rating of Value: 3 - 5 = H	1 - 2 = M	0 = L	

SCORING FORM

Site: Elk River Estuary - AFTER   Date: 8-Oct-15

	WATER QUALITY FUNCTIONS - Indicators that improve water quality		Score	NOTES
SITE	1.0 Does the habitat unit have the potential to improve water quality?			**Objective:** Identify the capacity of the habitat type to cause a change in water quality by removing sediment, nutrients, or toxins from the water column or adding dissolved oxygen to the water column.
	1.1 Condition of habitat to be able to trap sediments or contaminants: Native vegetation, undisturbed soils, little to no human visitation Native/non-native vegetation (25-75%), mostly undisturbed soils, low impact human visitation OR native vegetation but soils disturbance and low impact Non-native vegetation (>75%) AND moderate soil disturbance/compaction and/or moderate human disturbance Barren ground and/or highly compacted and/or intense human disturbance	 points = 8 points = 4 points = 2 points = 0	Score: 4	Restoration would target a reduction in non-native species, however elimination of them is unlikely. According to the California Rapid Assessment Method (CRAM), the ability of vegetation (or buffer condition) to trap sediment/contaminants should be assessed according to the extent and quality of vegetation cover, the overall condition of the substrate, and the amount of human visitation.
	1.2 What is the proximity of the habitat unit to a significant sediment source (i.e., stream, estuary mouth): <0.25 mile 0.5 to 0.25 mile >0.5 mile	 points = 8 points = 4 points = 0	Score: 8	Proposal includes sites adjacent to Elk River. Potential to trap and retain sediment is related to distance from sediment sources. The primary sediment sources of turbidity are from freshwater streams, tidal currents, and wind driven waves along the mudflats (Swanson et al. 2012, Shaughnessy and Hurst 2014).
	1.3 Does the habitat unit provide a way to extract nutrients or contaminants from the surrounding environment? Yes No	 points = 4 points = 0	Score: 4	Existing Wetland vegetation has potential to detain and extract contaminants and nutrients from surrounding environment. Surplus nutrients can lead to eutrophication and excessive algal growth, replacement of perennial species with annual species, and reduced maximum depth where vegetation grows. These processes can degrade water quality and reduce habitat available for species use. Nutrient removal can reduce potential impacts from nutrient loading.
	1.4 Does the habitat unit deliver oxygen to the water? Yes No	 points = 4 points = 0	Score: 4	A primary goal of restoration would be to restore and enhance the hydrologic connection to Humboldt Bay and Elk River. Algae and rooted vascular plants deliver oxygen to the water through photosynthesis (Short et al. 2000), which is a major component of water quality conditions that support other organisms.
	Total for 1.0		**20**	
	Rating of Site Potential: 16 - 24 = H	6 - 15 = M	0 - 5 = L	
LANDSCAPE	2.0 What is the landscape context for water quality services provided by the site?			**Objective:** Identify whether water quality concerns are present in the service area for the site. Turbidity, nutrients, and contaminants are important management considerations in Humboldt Bay (Schlosser and Eicher 2012).
	2.1 What is the abundance of altered sediment supply or marine connectivity from the site? No signs <500 m AND/OR marine connectivity 500 to 900 m OR marine connectivity >500 m AND mar.con. OR >900 m OR mar.con.	 points = 6 points = 3 points = 2 points = 0	Score: 2	A major goal of restoration is to create marine connectivity. Sediment supply has been altered through the construction and maintenance of dikes and road and railroad infrastructure. According to the CRAM, marine connectivity can be assessed based on the portion of the coastline with an alteration to sediment supply and transport (e.g., jetties, seawalls/riprap, piers, bridges, and dunes stabilized by invasive species). The measurement is based on 500 m up-coast and down-coast of the midpoint of the site.
	2.2 Does at least 10% of the contributing watershed contain tilled fields, pastures, impervious surface area, or forests that have been clearcut within the last 5 years? Yes No	 points = 4 points = 0	Score: 4	The Humboldt watershed has more than 10% of it's area in recently harvest forestry, agriculture and urban land uses. Watersheds above 10% impervious surface area show signs of degradation and increased sediment runoff (Booth 1991). Overgrazing, cultivation, and forest clearing have been associated with increases in sediment runoff from watersheds (e.g., Walling and Webb 1983).
	2.3 Are there consistent signs of excess nutrients in the habitat unit (e.g., increased ulvoids, high N, high P, high Si, HABs)? None 1 - 3 years >3 years in the past 5 years	 points = 4 points = 2 points = 0	Score: 2	There are occasional periods of high algal growth in Humboldt Bay, however it does not appear to be extreme or persistant and does not appear to meet thresholds for eutrophication. Are the signs of elevated nutrients regularly or persistently present in the watershed. Persistence suggests that relevant thresholds for eutrophication are consistently present. Signs of excess nutrients may include direct measurements of nutrient levels, algal blooms, presence of ulvoid mats, or low dissolved oxygen levels.
	Total for 2.0		**8**	
	Rating of Landscape Potential: 11 - 14 = H	5 - 10 = M	0 - 4 = L	
WATERSHED	3.0 Is water quality improvement identified as a watershed or regional priority?			**Objective:** Water quality impairment in the watershed can reduce ecosystem function and population levels.
	3.1 Are there any rivers, streams, or estuaries on the site on the 303(d) list? Yes No	 points = 1 points = 0	Score: 1	Proposed connections to Humboldt Bay and Elk River is listed on the 303d list and has TMDL for sediments. The 303(d) list identifies impaired waters where existing pollution controls and/or biological removal is failing to maintain water quality for 1 or more parameters.
	3.2 Does the river or stream have TMDL limits for nutrients, toxics, or pathogens? Yes No	 points = 1 points = 0	Score: 1	Proposed connections to Humboldt Bay and Elk River is listed on the 303d list and has TMDL for sediments. Under the clean water act, Total Maximum Daily Loads (TMDLs) must be developed for all impaired waters, however prioritization for development of TMDLs is up to each State and development can occur 5-15 years after initial listing.
	Total for 3.0		**2**	
	Rating of Value: 2 = H	1 = M	0 = L	

SCORING FORM

	HABITAT STRUCTURE FUNCTIONS - Indicators that improve habitat structure			NOTES
SITE	4.0 Does the habitat unit have the potential to improve habitat structure?			**Point:** Habitat structure provides additional ecosystem niches thereby often increasing overall productivity while also providing for predator avoidance.
	4.1 What proportion of historic habitat exists?		Score: 8	Conversion of the site to a tidal wetland restores it to its original context a type of wetland that has experienced steep declines in Humboldt Bay. Habitats that have declined substantially from historic levels or are known to be regionally rare are of greater ecological value.
	Decline of 80% or more from historic levels	points = 8		
	Decline of 50-80% from historic levels	points = 4		
	Decline of 20-50% from historic levels	points = 2		
	Decline of less than 20% or increase from historic levels	points = 0		
	4.2 Amount of habitat structure present (% cover or areal extent):		Score: 8	Restoration would target continuous coverage.. Percent cover (areal extent) is a common indicator of plant community, health, and development. The Cowardin classification defines a "plant class" as covering more than 30% of the area and Schlosser and Eicher (2012) define patchy eelgrass as >10% and <85%, and continuous eelgrass as >85%.
	Continuous coverage (>85% cover)	points = 8		
	Patchy coverage (10-85% cover)	points = 4		
	No coverage	points = 0		
	4.3 Number of plant species present (including macroalgae and/or microbial mats):		Score: 4	Restoration planting plan would seem to create a naturally diverse wetland complex that grades from estuarine to tidal fresh.. The majority of studies have found positive correlations between habitat heterogeneity/diversity and species diversity (Tews et al. 2004). In general, increasing diversity of vegetation generates diversity in ecological niches and increased diversity of fauna.
	>3 species	points = 4		
	2 species	points = 2		
	0-1 species	points = 0		
	4.4 Presence of mature, complex habitat that provides 3-dimensional structure:		Score: 3	The removal of mowing effort and any planting plan that includes shrub scrub vegetation would allow for increased complexity.. Zedler (1993) identified a relationship between habitat structural complexity and species use. Vegetation height is an indicator of complex, mature habitat with 3-dimensional structure. The categories were taken from the CRAM heights for plant layers.
	Very tall (>3 m)	points = 4		
	Tall (1 to 3 m)	points = 3		
	Medium (0.3 to 1 m)	points = 2		
	Short (<0.3 m)	points = 0		
	Total for 4.0		23	
	Rating of Site Potential: 16 - 24 = H	10 - 15 = M	0 - 9 = L	
LANDSCAPE	5.0 Does the landscape have the potential to support habitat function and species use at the site?			**Objective:** Identify whether species that might use the site are present, whether habitat is a limiting factor and if they are able to access the site.
	5.1 In its current state, is the habitat considered a limiting factor for fish or wildlife?		Score: 2	Tidal and estuarine wetlands have been identified as a limiting factor. for salmonids. A limiting factors analysis assesses and identifies factors limiting the productivity or abundance of endangered or sensitive species. There are documents in Humboldt Bay that have already conducted a limiting factors analysis for certain species (e.g., HBWAC and RCAA 2005)
	Yes	points = 2		
	No	points = 0		
	5.2 In its current state, is the habitat unit considered important nursery/rearing habitat for fish or wildlife?		Score: 1	Wetlands can provide important habitat functions for some species. Egg and juvenile stages tend to be the most sensitive to predation due to their relative inability to defend against or evade predation. Therefore, nursery areas that provide complex habitat which supports predation avoidance are high value areas.
	Yes	points = 1		
	No	points = 0		
	5.3 What is the average area of aquatic area abundance?		Score: 3	It is expected that future inundation would be 31-60%. Aquatic area abundance is the spatial association with other areas of aquatic resources, such as wetlands, streams, and estuaries. According to the CRAM, transects that run parallel to the shoreline for 500 m on either side of the site are more important the higher the percentage of wetland habitat, other aquatic features, and open water.
	≥61% of the transects	points = 4		
	≥31 to 60% of the transects	points = 3		
	≥11 to 30% of the transects	points = 2		
	≤10% of the transects	points = 0		
	5.4 Does the habitat unit support the following species (add 1 point for every species)?		Score: 5	Coho salmon, dunlin, common egret, long billed curlews and great blue herons are all associated with tidal and estuarine wetlands. These species are identified as common or important within Humboldt Bay (e.g., Pinnix et al. 2005, Connolly and Colwell 2005), use a variety of habitat types, and occur over a broad seasonal range (for most species). See the phenology table for more details. Support defined as supporting feeding, refugia or reproduction by these species.
	Dungeness crab; green sturgeon; dunlin; long-billed			
	Pacific herring; coho salmon; common egret; great blue heron			
	English sole; black brant; surf scoter; harbor seal			
	5.5 Would sea level rise result in a reduction of habitat?		Score: 0	Wetland habitats in Humboldt Bay are constrained by roadway and railroad infrastructure which limit the ability of habitats to respond to rising sea levels. Increased temperatures and dessication risks could lead to a narrower habitable range in the future. The phenomenon called "coastal squeeze" is a management concern for Humboldt Bay (Schlosser and Eicher 2012). If there is no room for habitats to expand into (e.g., surrounded by fixed manmade structures), then there is no resiliency in the available habitat.
	Habitat would remain/expand with sea level rise	points = 1		
	Habitat would decline with sea level rise	points = 0		
	Total for 5.0		11	
	Rating of Landscape Potential: 13 - 17 = H	6 - 12 = M	0 - 5 = L	
WATERSHED	6.0 Is the habitat function improvement provided by the site identified as a priority issue in the watershed?			**Objective:** Identify whether this this habitat supports regional conservation or restoration targets
	6.1 Has the current abundance triggered state, federal or natural heritage listing?		Score: 2	Tidal and Estuarine wetlands are recognized by Natural Heritage as valuable components of the ecosystem and no net loss and mitigation requirements are applied to ensure their continued existence. Listing a species as endangered suggests both a decline or naturally low population abundance creating a potential for extinction. A listing also suggests that there is sufficient data collection and scientific understanding to characterize the current population level and species biology.
	Habitat is recognized as priority for protection	points = 2		
	No formal recognition of habitat rarity/priority	points = 0		
	6.2 Are there recovery plans or ESA documents that include the habitat as a priority habitat?		Score: 1	Several ESA listed species, including salmonids, have included tidal wetlands as critical habitat. Critical habitat or essential fish habitat contain features that are essential areas for conservation of species.
	Yes	points = 1		
	No	points = 0		
	6.3 Is there literature that provides the importance of the habitat for providing habitat function?		Score: 1	Wetlands have been a subject of intense conservation interest and study. The Humboldt Bay Initiative (Schlosser et al. 2009) identifies Ecosystem-based Management (EBM) targets. If management plans specifically call out individual habitat, it gains a level of importance for the watershed.
	Yes	points = 1		
	No	points = 0		
	Total for 6.0		4	
	Rating of Value: 3 - 4 = H	1 - 2 = M	0 = L	

SCORING FORM

	PREY RESOURCES FUNCTIONS - Indicators that improve habitat structure		Score	NOTES
SITE	7.0 Does the habitat unit have the potential to improve prey resources?			**Objective:** Characterize the capacity of the site to produce prey items used by higher trophic levels.
	7.1 Type of habitat structure that can provide resource for prey species: Above- and below-ground biomass/structure Above-ground biomass or structure Below-ground biomass or structure No habitat present	 points = 8 points = 4 points = 2 points = 0	Score: 8	Pallustrine wetlands produce above and below ground biomass and structures. Above ground biomass is available for direct consumption and conversion to detritus and provides 3-dimensional habitat structure. Below ground biomass plays an important role in nutrition as well as anchoring and spreading of vegetation. Due to incomplete decomposition in sediments, below ground biomass can represent long term carbon burial (e.g. Kenworthy and Thayer 1984).
	7.2 Density of habitat present: Dense (>100 turions/m^2 or >3 plants/m^2) Patchy (<100 turions/m^2 or <3 plants/m^2) No habitat present	 points = 8 points = 4 points = 0	Score: 8	This metric is based on work by Hughes (2002) who found significant differences in fish abundance, biomass, species richness, and prey items between eelgrass densities above and below 100 shoots/m^2 (or in excess of 100 g/m^2).
	7.3 Does the habitat unit provide primary production? Yes No	 points = 4 points = 0	Score: 4	Yes. Primary production is use of light or chemical energy to generate organic compounds (e.g. photo or chemosynthesis). Primary production is the primary mechanism for introducing energy into the food web.
	7.4 Does the habitat unit support secondary production? Yes No	 points = 4 points = 0	Score: 4	Yes. Secondary production is the generation of biomass by primary consumers (herbivorous organisms that feed on primary producers).
	7.5 Does the habitat unit contain invasive or exotic species (e.g., *Spartina densiflora* , *Zostera japonica* , European green crab, *Ampithoe valida* amphipod) that may affect productivity or foraging? No Yes	 points = 4 points = 0	Score: 0	Spartina has been documented in adjacent areas and is presumed to be present. and numerous cosmopolitan invasive species are likely present. Spartina is a major invasive organism in salt marshes in Humboldt Bay with the potential to convert diverse salt marsh communities into Spartina dominated habitat, including facilitating a significant difference in invertebrate communities with non-native species. Native sites are comprised mostly of invertebrates from the family Heminiptera (Mitchell 2012).
	Total for 7.0		**24**	
	Rating of Site Potential: 20 - 28 = H	11 - 19 = M	0 - 10 = L	
LANDSCAPE	8.0 Does the landscape have the potential to support prey resources at the site?			**Objective:** Characterize the potential for the site to export prey items to the landscape.
	8.1 What is the distance of the stream corridor continuity based on the combined length of non-buffer segments? <100 m 100 to 150 m 150 to 200 m >200 m	 points = 4 points = 3 points = 2 points = 0	Score: 0	According to the CRAM, stream continuity considers the ability of areas of open water with connectivity of habitat to provide corridors for anadromous fish and other wildlife. The method combines the length of non-buffered land that crosses the riparian or aquatic area.
	8.2 Is the habitat unit adjacent to or on a sandy grit site used by black brant? Yes No	 points = 2 points = 0	Score: 0	The primary sand grit site in Humboldt Bay is adjacent to Sandy Spit just south of the entrance channel to Humboldt Bay (Spragens et al. 2013). Disturbances near traditional grit sites may limit the ability of black brant to replenish gizzard grit, which would reduce their digestive efficiency (Moore and Black 2005).
	8.2 For which seasons do fish or wildlife forage in the habitat unit? All seasons (fall, winter, spring, summer) At least two seasons At least one season None	 points = 4 points = 3 points = 2 points = 0	Score: 4	Species are present and use eelgrass year-round, though there are distinct peaks, particularly in the early spring when annual spawning events and associated foraging take place. Sites that are used for multiple seasons are expected to support more types of species and more resident species.
	8.3 Potential for the habitat unit to produce benthic and drift prey items: Water-column and benthic prey items available Majority of prey are from the water-column Majority of prey are from the benthic habitat No prey items are available	 points = 4 points = 2 points = 2 points = 0	Score: 4	Tidal and estuarine wetlands will generate water column and benthic prey items for salmonids. Merritt et al. (2002) identifed these ratios for invertebrate production as indicators of good supply for water column-feeding fish (drift invertebrates), wading birds and benthic feeding fish (sprawlers).
	Total for 8.0		**8**	
	Rating of Landscape Potential: 10 - 14 = H	6 - 9 = M	0 - 5 = L	
WATERSHED	9.0 Are prey resources produced by the site identified as watershed or regional priorities?			**Objective:** Identify the potential for the site to produce prey items consumed by regional or watershed priority species.
	9.1 How many species groups does the habitat unit support (add the total)? Shorebirds, Anadromous Fish, Groundfish Wading birds, Mammals, Pelagic fish	 Yes = 1 No = 0	Score: 3	Shorebirds, wading birds and anadromous fish may use a tidal or estuarine wetland. The more diverse the habitat, the more diverse the type of species that use the habitat will be.
	9.2 Is there literature that provides an understanding of the importance of the habitat for providing prey resources? Yes No	 points = 1 points = 0	Score: 1	Pallustrine wetlands have the capacity to generate prey. Structured habitat is often associated with higher species diversity for benthic invertebrates, but not directly for mobile species (Hosack 2003, Hosack et al. 2006).
	Total for 9.0		**4**	
	Rating of Value: 3 - 5 = H	1 - 2 = M	0 = L	