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

Review Draft

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, and culture methods.
- **Environmental Setting** – distribution and abundance of eelgrass, limitations to eelgrass growth, natural variability of eelgrass habitat, eelgrass at carrying capacity, and other habitat types.
- **Potential Eelgrass Impacts** – threshold of significance, direct and indirect impacts, duration of impacts, and cumulative impacts.
- **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% 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 foot gap between groups of 3 lines. Oysters are grown at tidal elevations ranging from +3.0 ft to -2.0 ft mean lower low water (MLLW), compared to the mean tidal elevation of eelgrass in North Bay which ranges from +1.4 ft to -3.1 ft MLLW (Gilkerson 2008). 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). In fact, the presence of shellfish aquaculture in Humboldt Bay has led to improvements in water quality due to the intrinsic water filtering capacity of shellfish. In addition, shellfish growers have continuously championed efforts to improve water quality because their product depends on ensuring that high water quality. 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 greater than 30% change in areal extent of eelgrass or a greater than 25% change in eelgrass density at the landscape scale (100 m to 10,000 m). 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).

The three interactions that can potentially result in a direct loss of eelgrass discussed under Section 4.0, Potential Eelgrass Impacts include: (1) gear and shellfish products, (2) working practices, and (3) sediment scouring and accumulation. In addition, the analysis considers resilience of the ecological system, duration of impacts, and cumulative impacts. While the analysis identified a reduction in eelgrass directly under the longlines, the projected loss in eelgrass turion density is not anticipated to exceed the thresholds identified above when evaluated at an eelgrass bed or landscape scale. 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.

The analysis incorporated two key sets of observations by Rumrill (2015) and 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 best management practices (BMP) 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% of eelgrass in the culture area and 1.7% when considering the larger eelgrass bed area (i.e., the shellfish culture and the contiguous eelgrass beds surrounding the expansion areas). Neither of these results exceed the threshold of significance established for this

Project. 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 6.0).

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) 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 meets the goals established by the CEMP to adhere to the goal of no net loss of ecological function. The potential impacts from placing longline aquaculture in eelgrass habitat do not exceed a 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. 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.

DRAFT

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Prepared for:

Coast Seafoods Company

August 24, 2015

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

DRAFT

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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 cultivated shellfish in Humboldt Bay, California, since the early 1950s. Humboldt Bay encompasses roughly 62.4 square kilometers (about 15,400 acres) at mean high tide in three geographic segments: Arcata Bay (North Bay), Entrance Bay, and South Bay (Figure 1). Coast owns or leases approximately 4,300 intertidal acres in the North and Central bays for shellfish aquaculture and has historically farmed on approximately 1,000 of those acres.

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. Operations in Humboldt Bay primarily occur in intertidal habitats at elevations ranging from +3 ft MLLW to -2 ft MLLW.

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 (504 acres in eelgrass), 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 feet 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).

Overall, the Project would result in a total of 916.5 cultured acres, which is equivalent to approximately 21% of the area leased or owned by Coast.

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

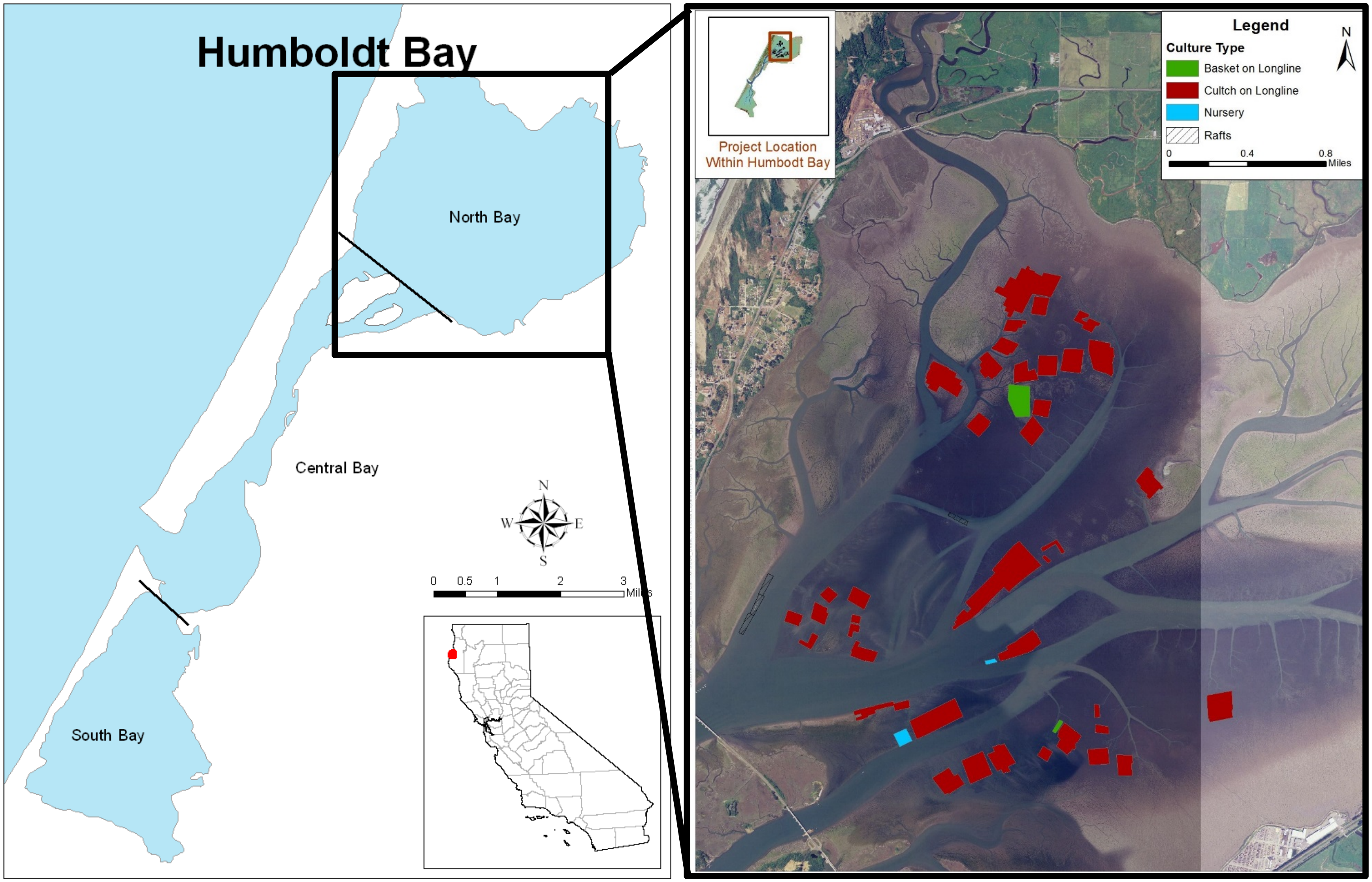

Figure 1 **Location of Humboldt Bay, California, and Existing Shellfish Aquaculture.**

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

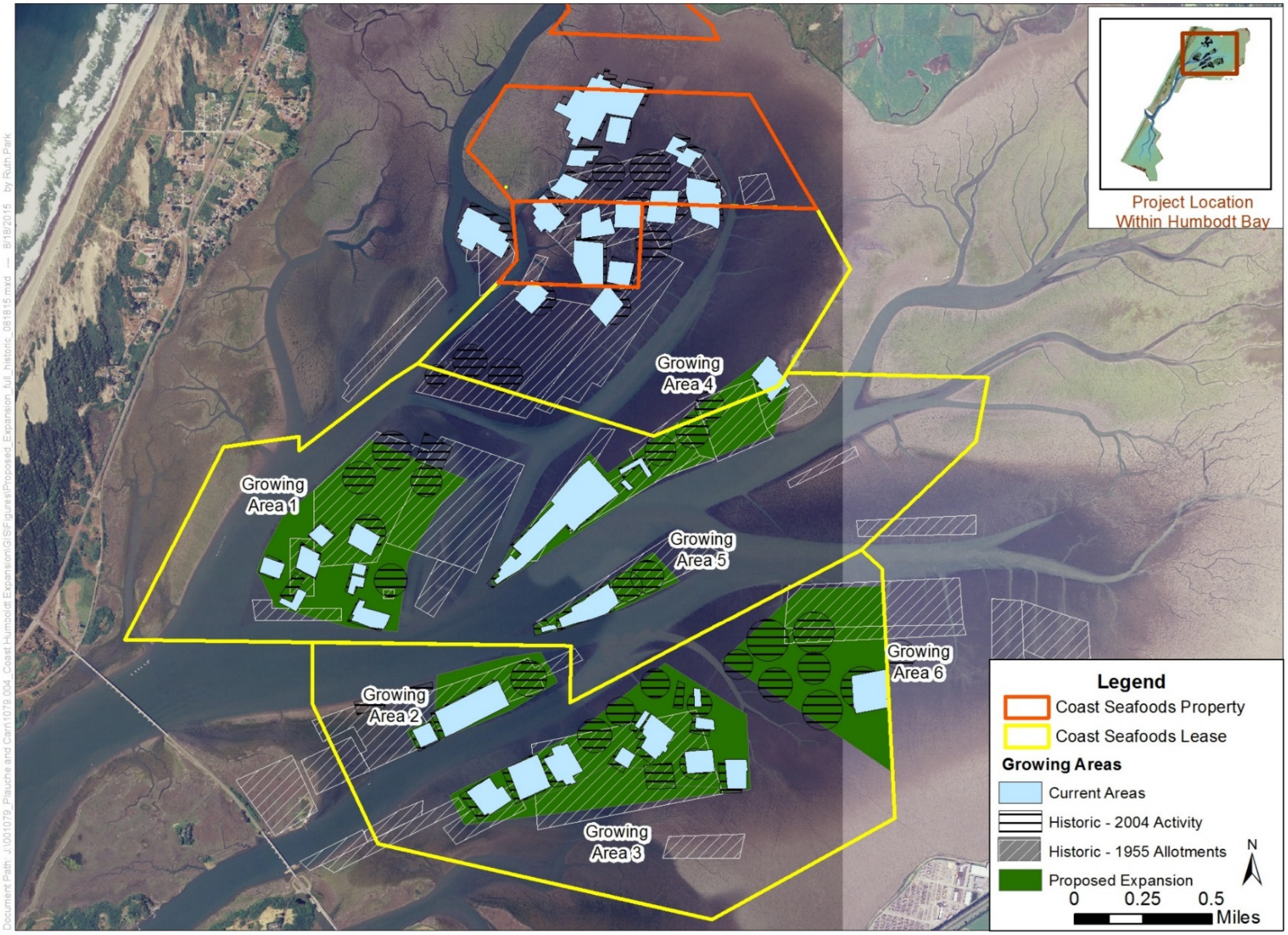

Figure 2 **Areas Proposed for Continued and Expanded Shellfish Culture Overlaid on Historical Growing Areas.**[2]

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 grown at tidal elevations ranging from +3.0 ft to -2.0 ft MLLW and 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% 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% lower and Pacific oyster weight was 65% lower at the higher elevations compared to the control. Finally, the number per cluster of Kumamoto oysters was 52% 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 section of the DEIR.

2.4 Project Alternatives

In addition, the EIR considers four project alternatives, as follows:

- **Alternative 1:** 10-foot Spacing Alternative – Coast would renew regulatory approval for its existing 300 cultivated acres and would expand its shellfish aquaculture operation by 955 intertidal acres using 10 ft spacing between longlines. This would allow for an increase in shellfish production equivalent to that provided by the preferred alternative but, due to the increased spacing between longlines, would result in a larger operational footprint.

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

- **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-Project alternative – Coast would cease all shellfish aquaculture operations in Humboldt Bay and remove all associated equipment.

Project Alternatives are further discussed in Section 5.0.

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 5.0.

2.5.1 Cultch-on-Longline

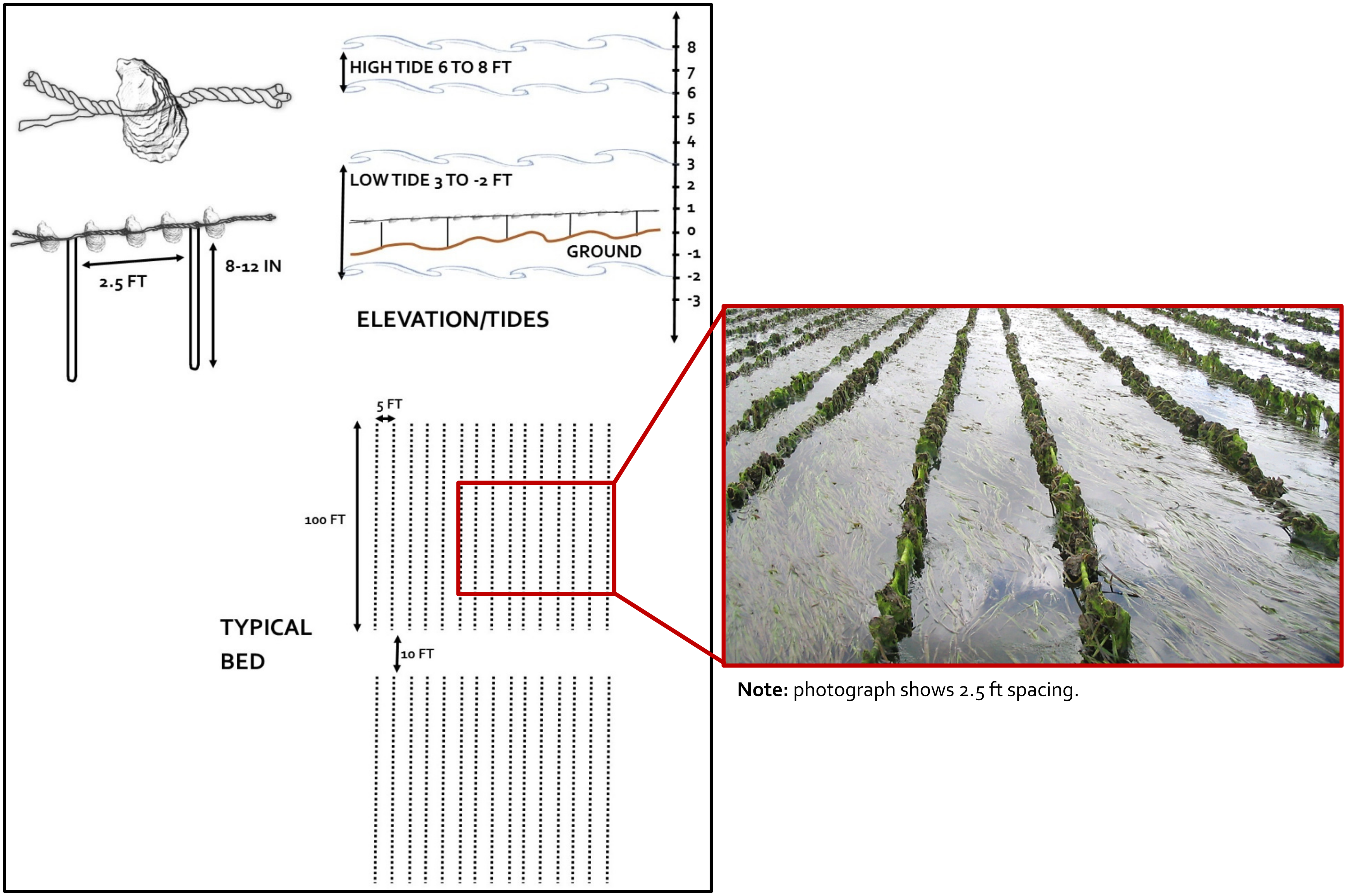
Kumamoto oysters and Pacific oysters are grown using the cultch-on-longline method (Figure 3). This would be the primary method used by Coast in the expansion area. There are three main activities that would occur for cultch-on-longline operations: (1) planting, (2) maintenance, and (3) harvesting.

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.

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.



Note: photograph shows 2.5 ft spacing.

Figure 3 **Configuration of Proposed Cultch-on-Longline Culture.**

Source: modified from Coast Seafoods Company 2007.

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.

2.5.1 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.

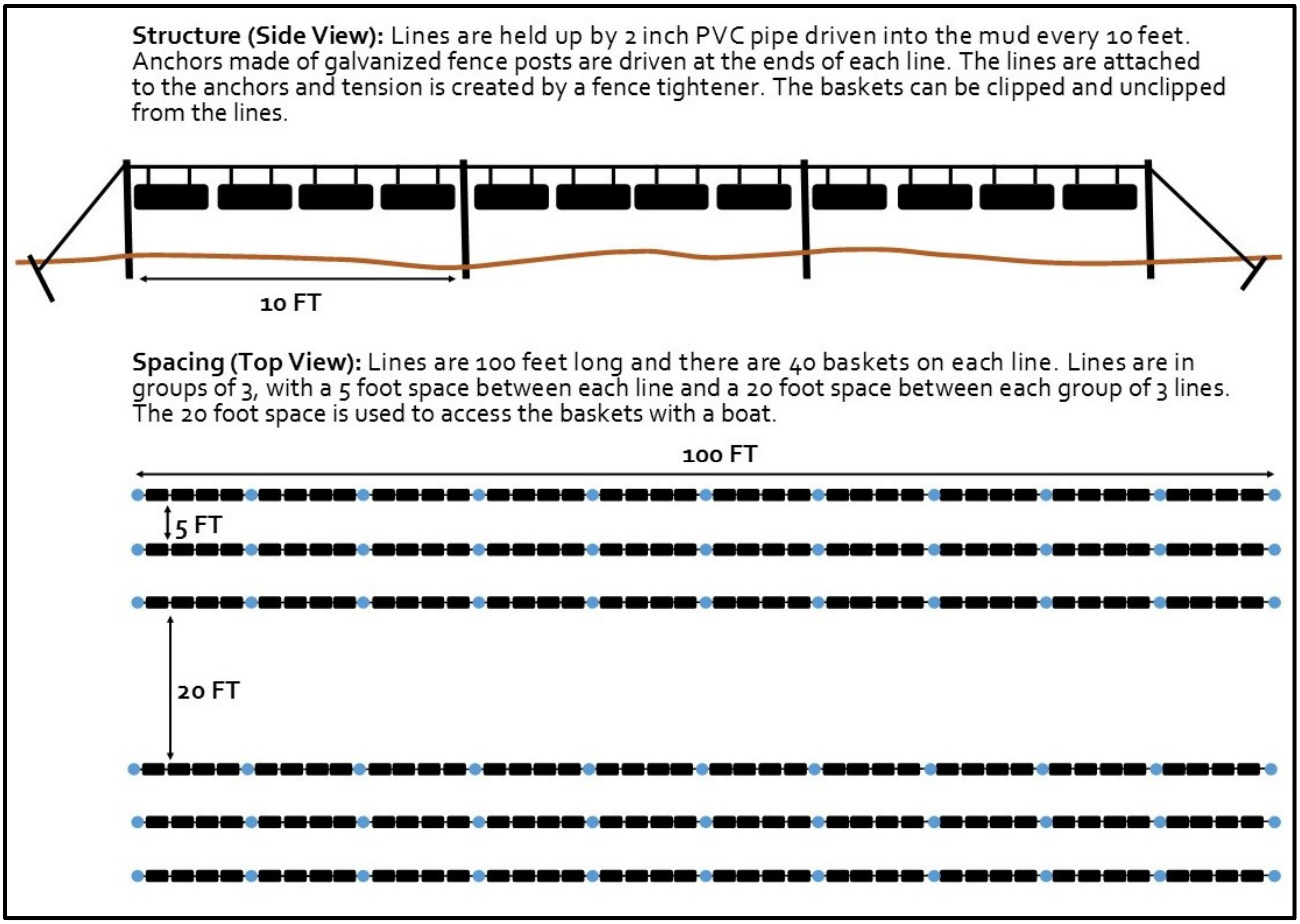


Figure 4 Configuration of Proposed Basket-on-Longline Culture.
Source: modified from Coast Seafoods Company 2007.

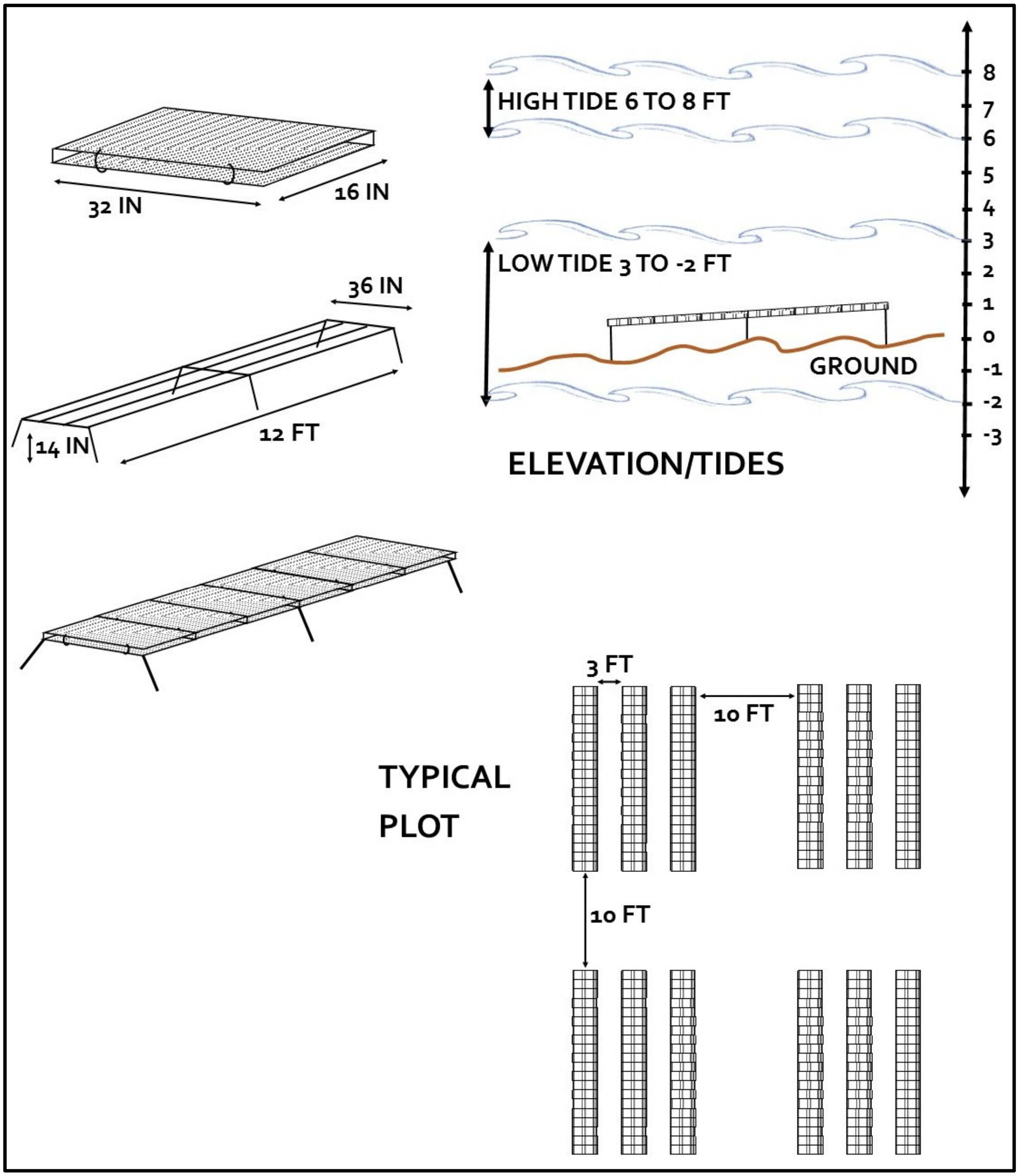


Figure 5 **Configuration of Proposed Rack-and-Bag Culture.**
Source: modified from Coast Seafoods Company 2007.

3.0 ENVIRONMENTAL SETTING

Humboldt Bay is comprised 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 (Schlosser and Eicher 2012). Although monitoring is sporadic within most areas of California, the eelgrass in Humboldt Bay represents up to 53% 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% 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.

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

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

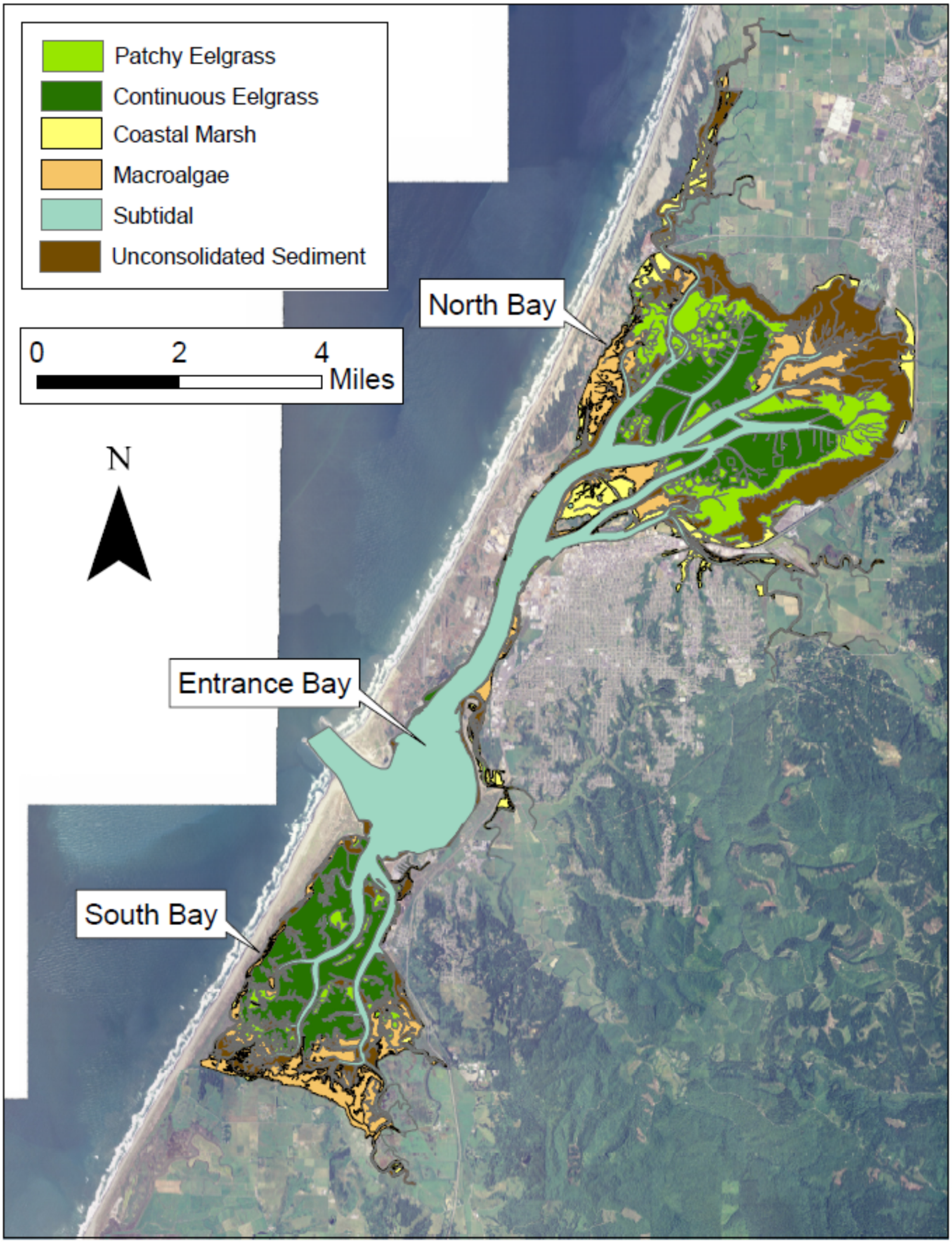


Figure 6 Distribution of Continuous and Patchy Eelgrass in Humboldt Bay.
Source: Wagschal, pers. comm., 2015; Notes: Habitat areas based on data from NOAA (2012).

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.

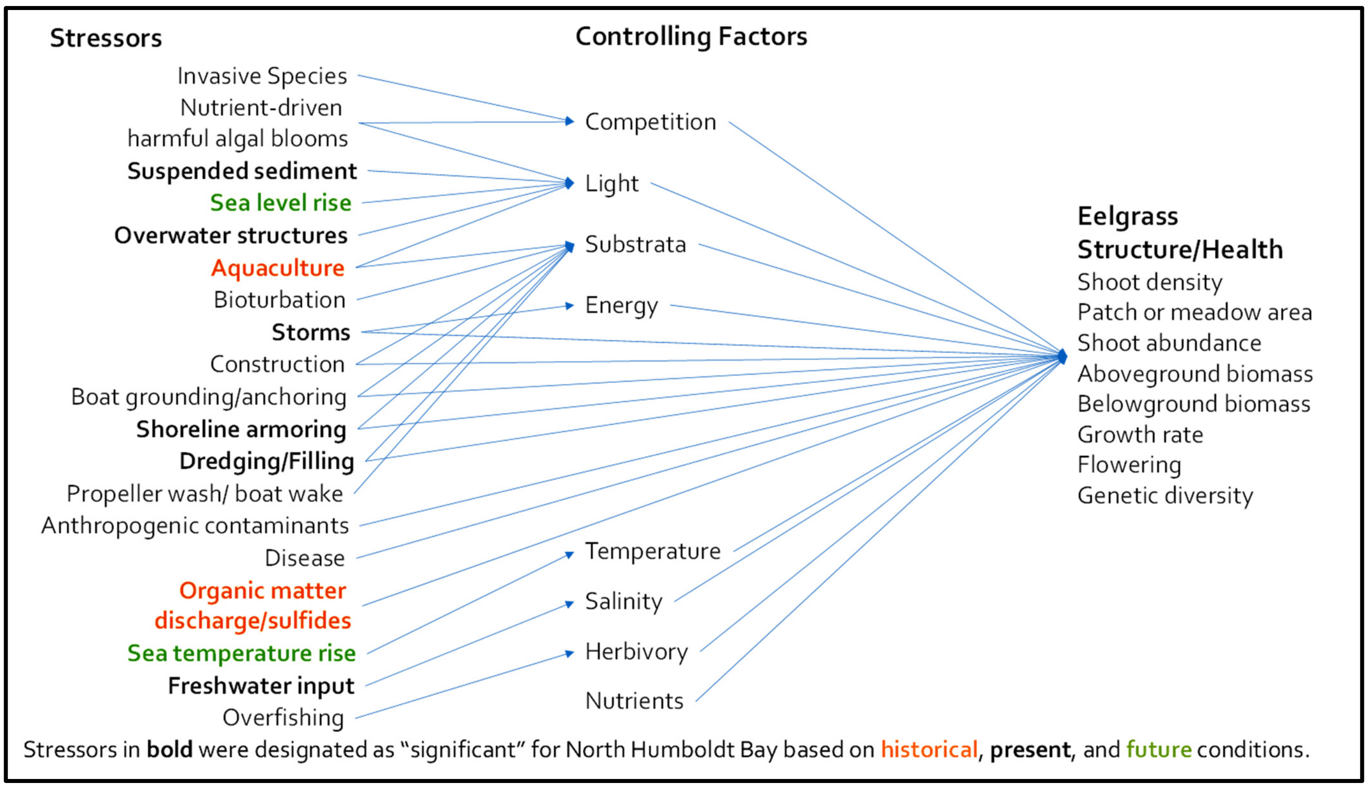


Figure 7 Conceptual Model Describing Factors Affecting Eelgrass Structure and Health.
Source: modified from Thom et al. 2011.

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% (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 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% 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).

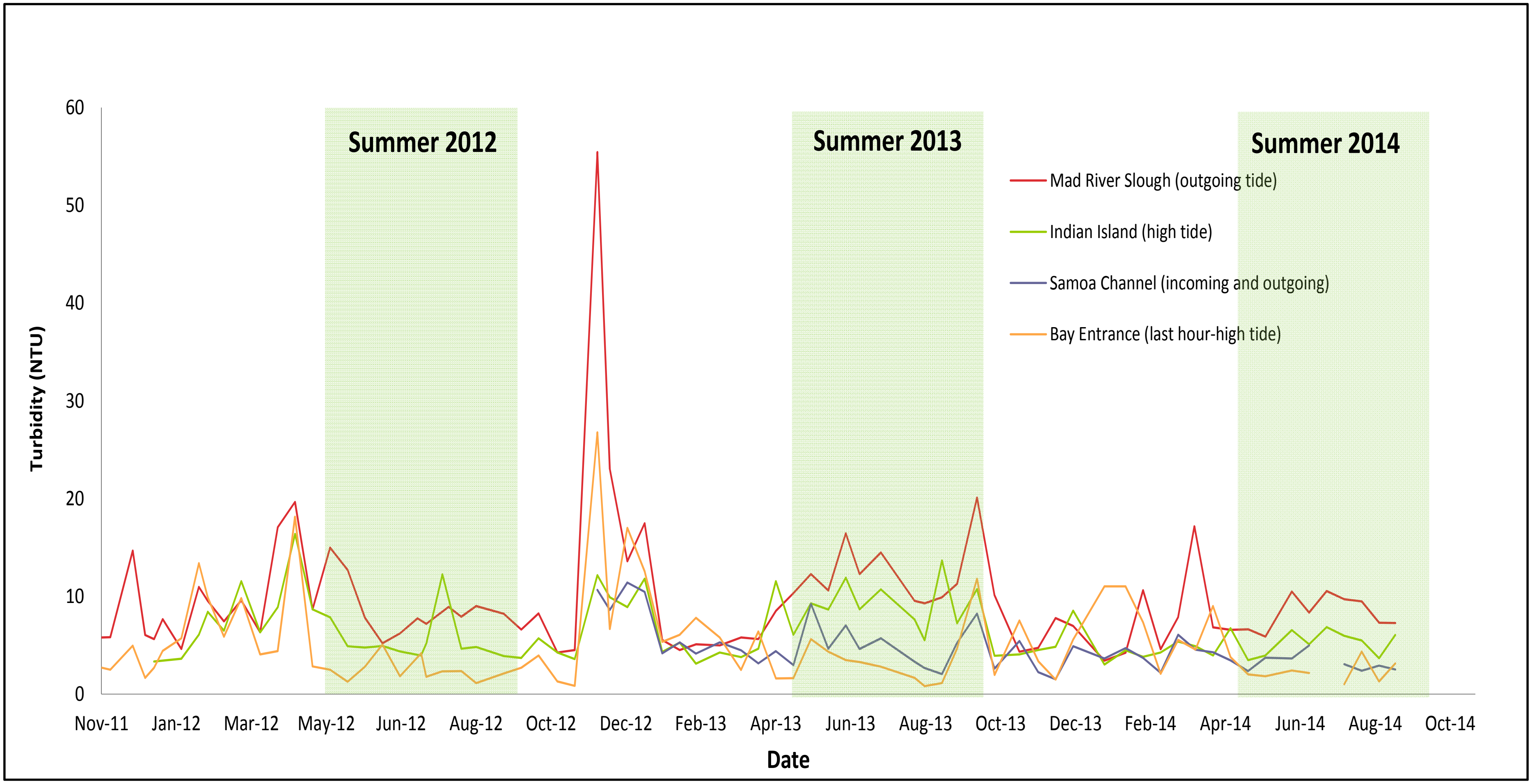


Figure 8 Temporal Variation of Turbidity in Humboldt Bay (2011-2014).
Source: Shaughnessy and Hurst 2014; Notes: Mad River Slough = North of Humboldt Bay; Indian Island = North Bay; Samoa Channel = Entrance Bay.

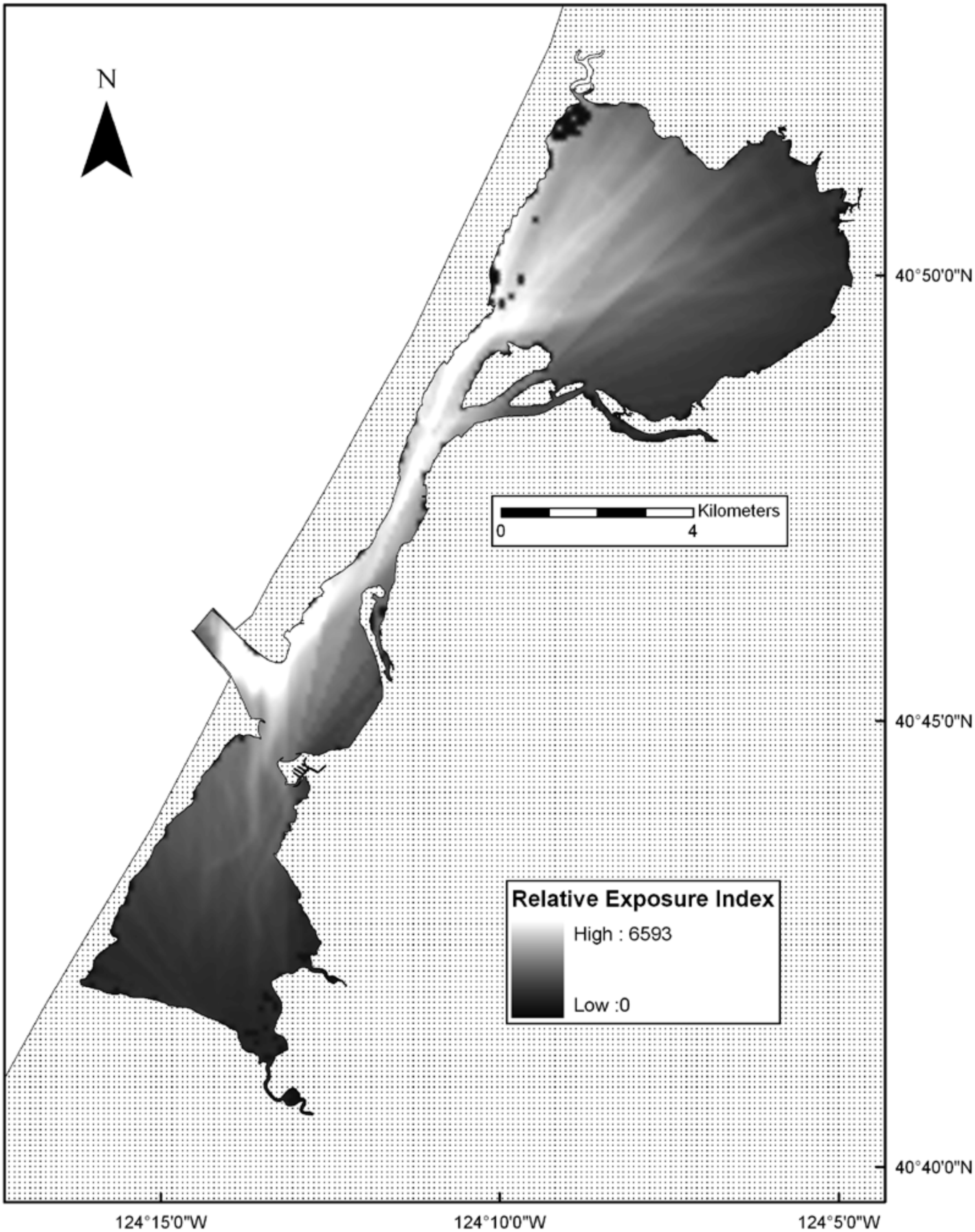


Figure 9 Relative Wave Exposure Index in Humboldt Bay.

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).

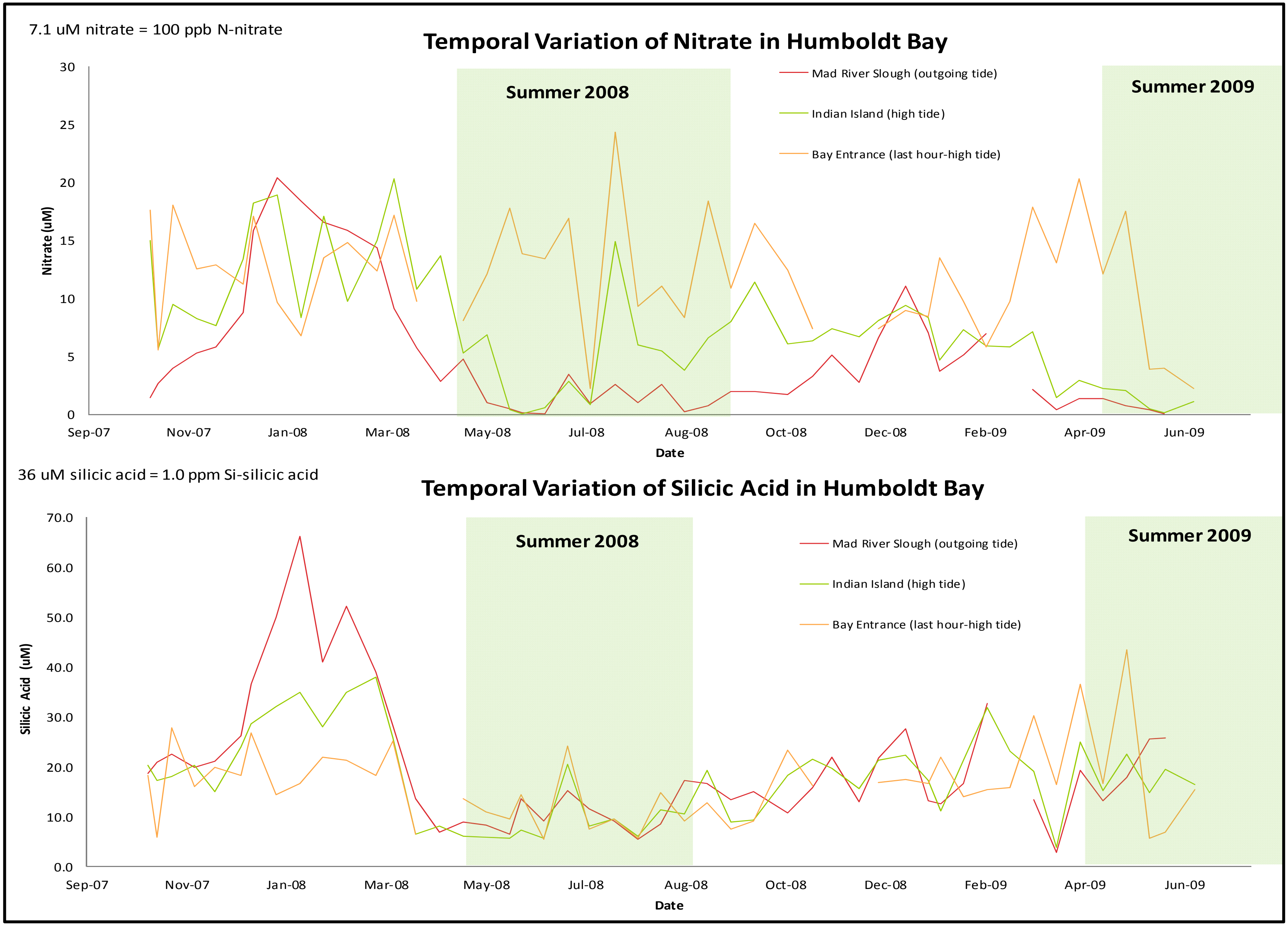


Figure 10 **Temporal Variation of Nitrate and Silicic Acid in Humboldt Bay (2012-2014).**

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 of 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% and 77% 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% and +45% between years. Overall, shoot density has high natural variability within North Bay.

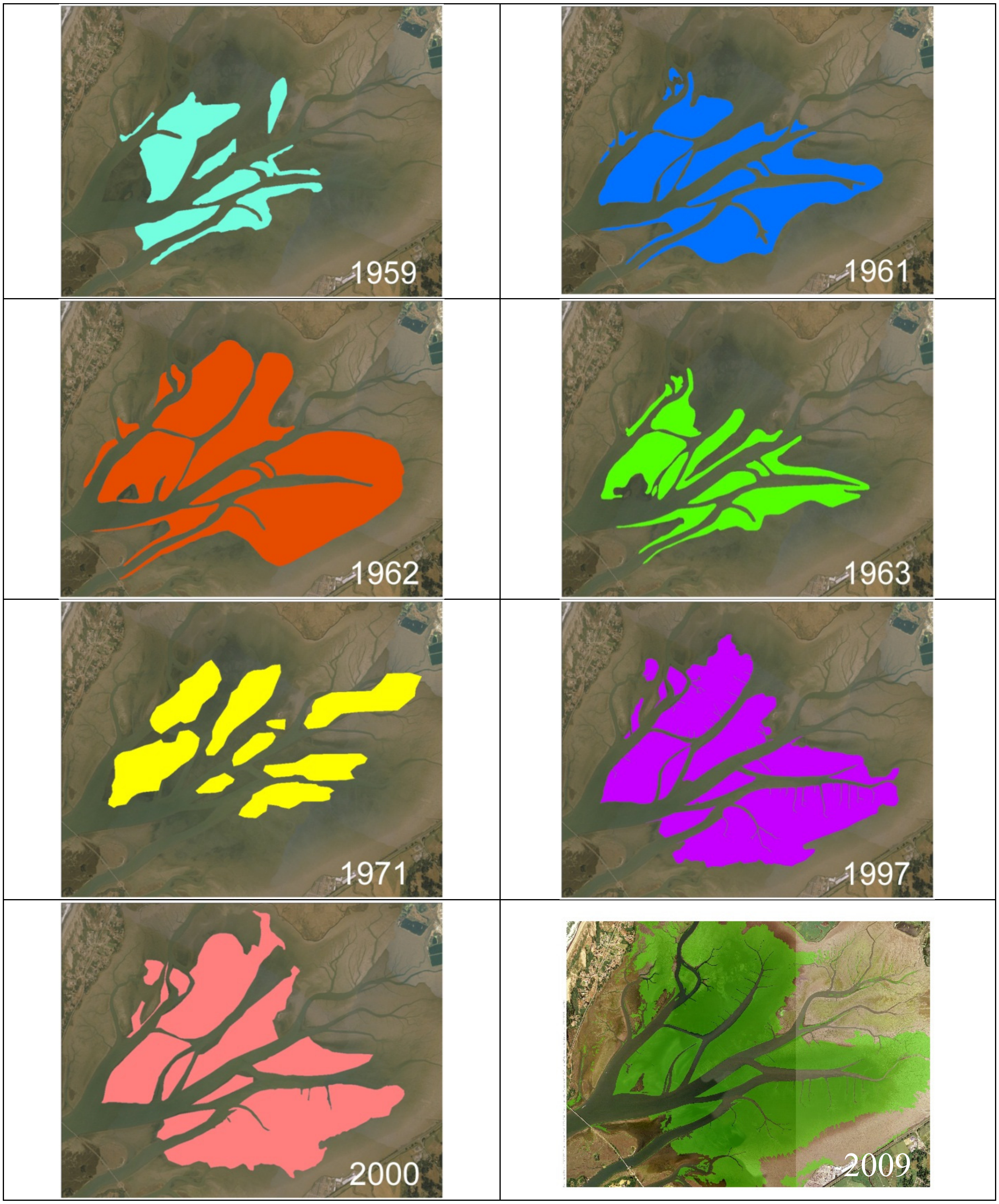


Figure 11 North Bay Eelgrass Cover from 1959 to 2009.
Source: modified from Schlosser and Eicher (2012).

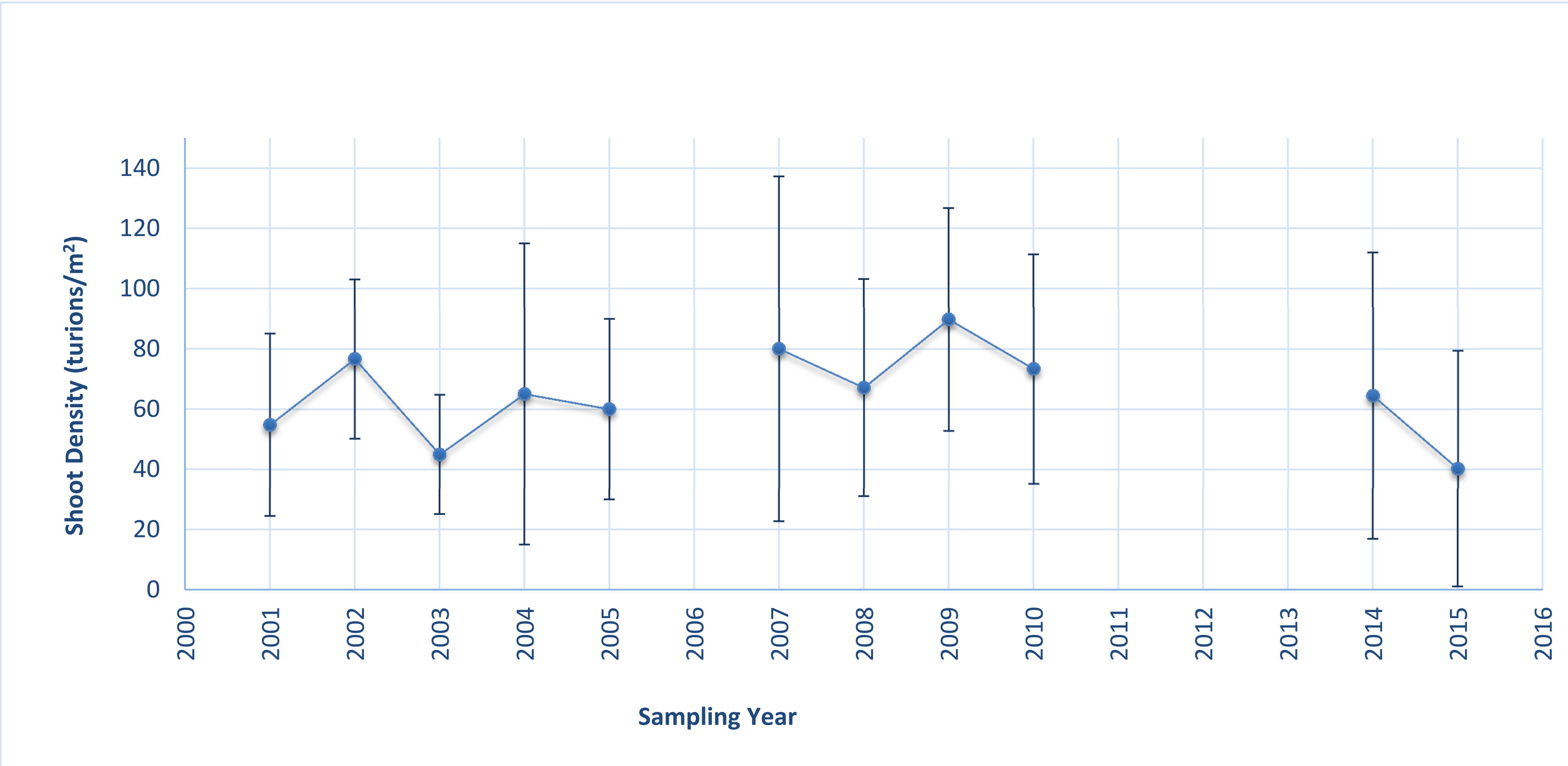


Figure 12 North Bay Summer (June-August) Eelgrass Shoot Density.

Sources: Rumrill and Poulton 2004, Schlosser and Eicher 2012, SeagrassNet 2015, Rumrill 2015, SHN 2015.

Note: No data was 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% of observed eelgrass being captured within the predicted habitat.

Gilkerson (2008) reported that 22% 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.

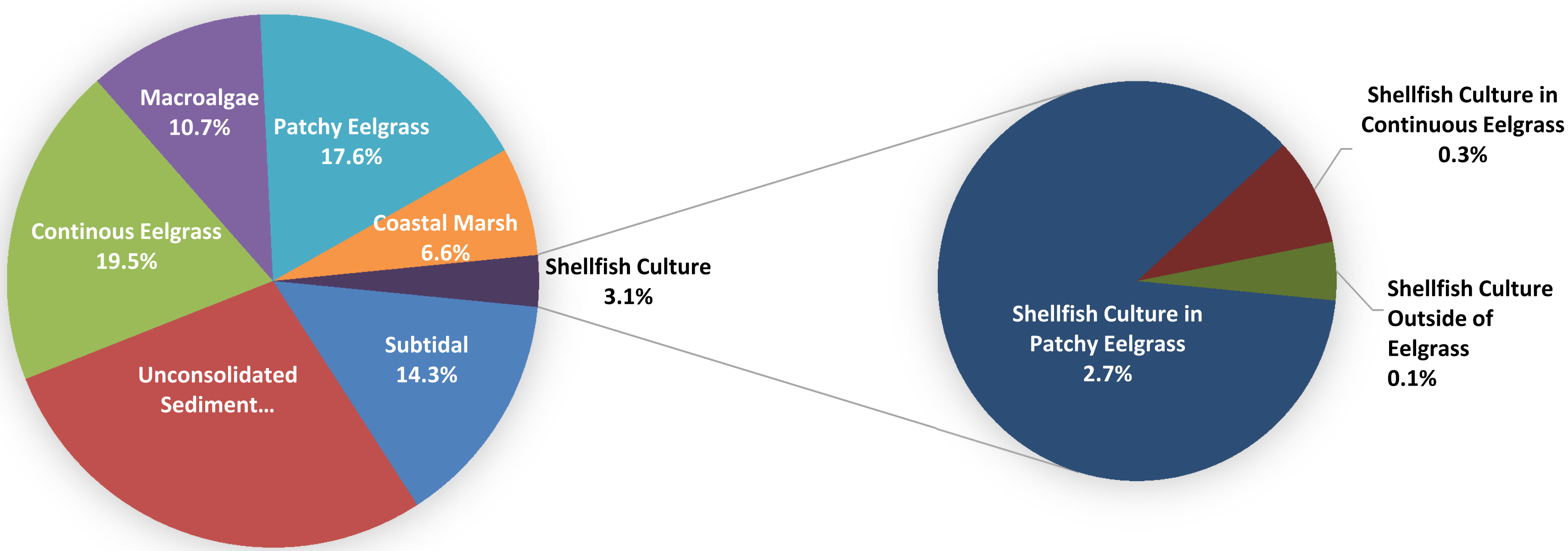


Figure 13 Habitats in North Bay Classified under the Coastal and Marine Ecological Classification Standard.
Source: Wagschal, pers. comm., 2015; Notes: Habitat areas based on data from NOAA (2012).

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% 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 Environmental Setting

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.

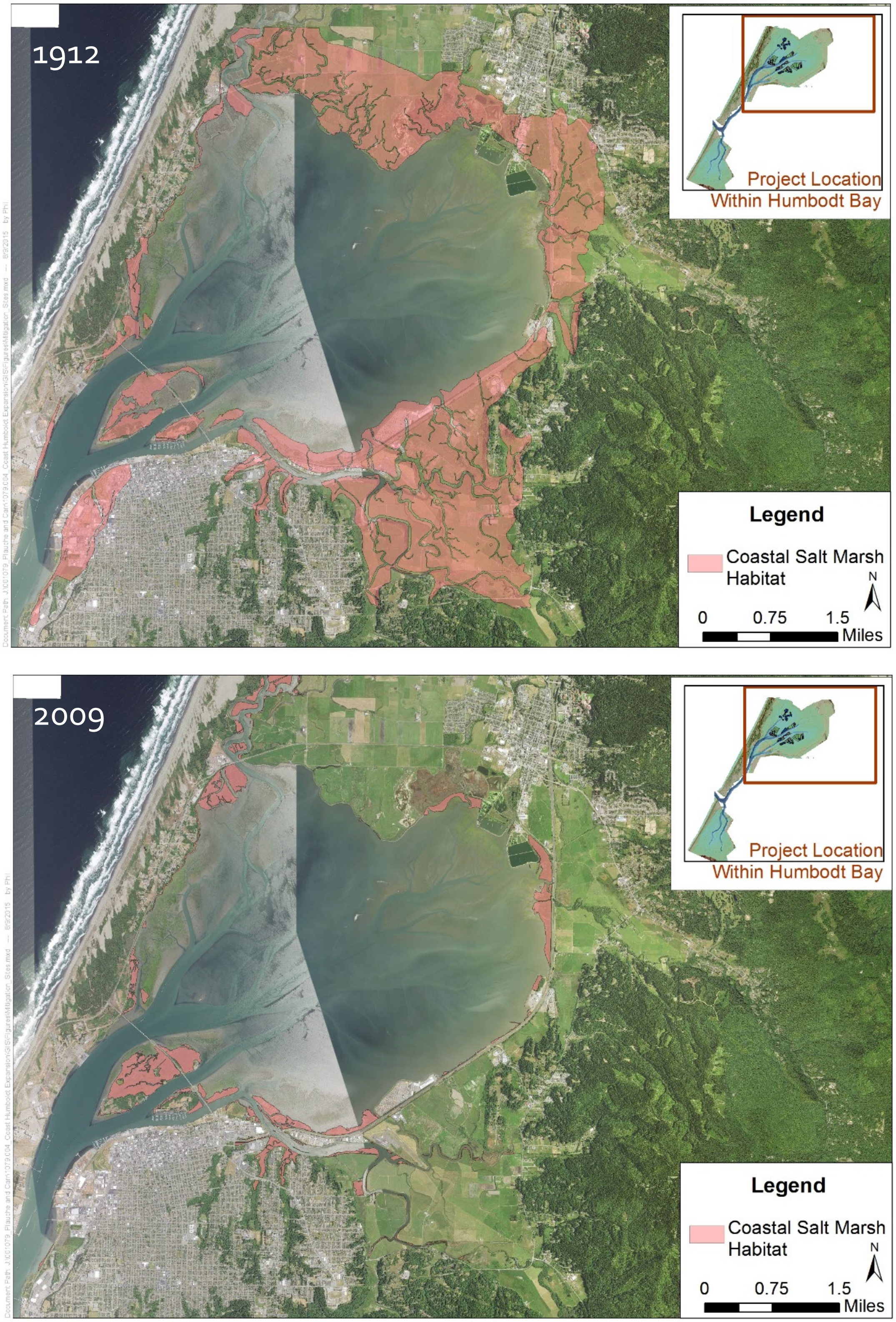


Figure 14 Coastal Salt Marsh Habitat between 1912 and 2009.

Source: modified from Schlosser and Eicher 2012.

4.0 POTENTIAL EELGRASS IMPACTS

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.

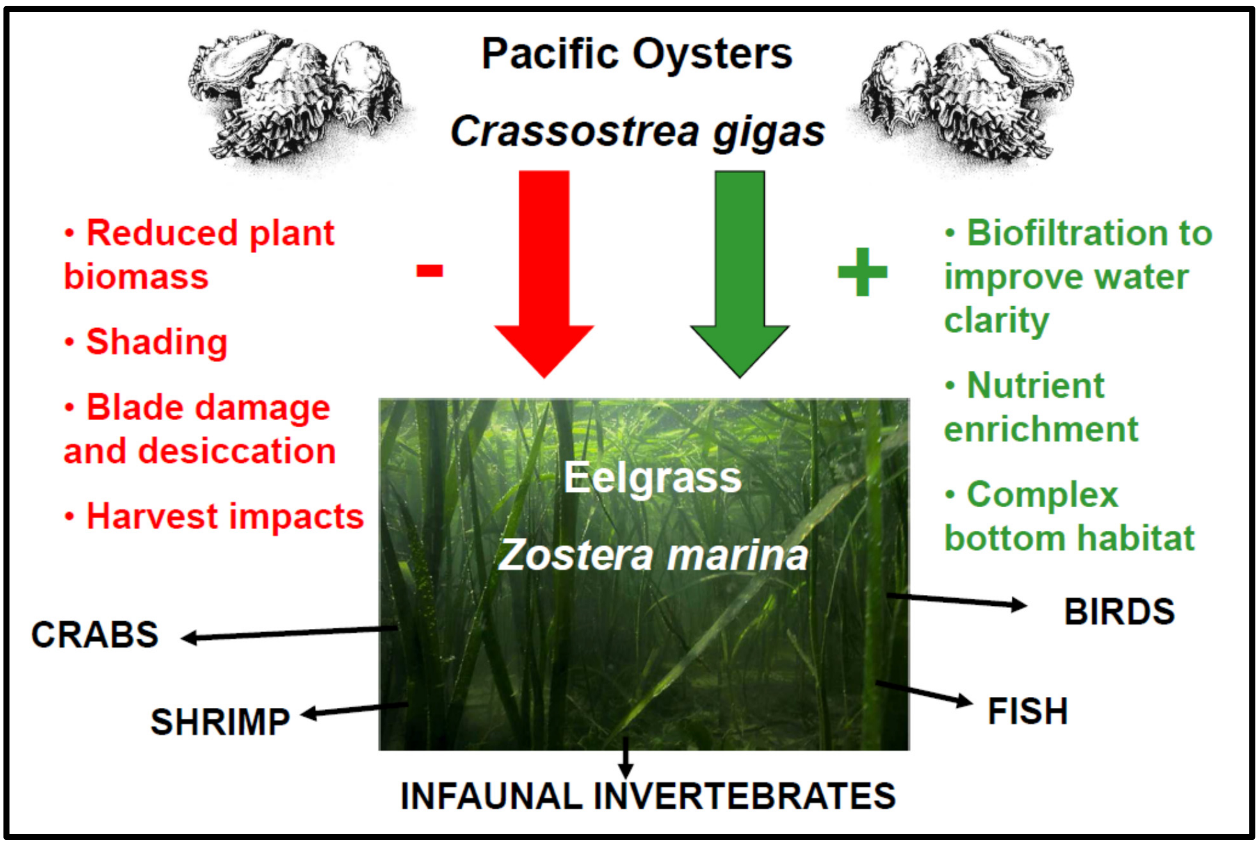


Figure 15 Biotic Interactions between Pacific Oysters and Eelgrass.
Source: Rumrill 2011.

4.1 Threshold of Significance

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%. The CEMP further defines permanent when the mean density of the project site is found to be at least 25% 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% of the planted area in one year. Yet another study (Murphey and Fonseca 1995) indicated that seagrass beds that contained 30 to 40% 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% 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 greater than 30%[5] change in areal extent or a greater than 25% change in eelgrass density at the landscape scale (100 m to 10,000 m). This is consistent with effects measured within individual expansion areas or at the eelgrass bed scale, which include both longlines and spaces between longlines.

4.2 *Direct and Indirect Impacts*

There are three interactions described below that can potentially result in a direct loss of eelgrass, including: (1) gear and shellfish products, (2) working practices, and (3) 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). Project assumptions and BMPs used in this analysis are discussed first, followed by a discussion of potential impacts.

4.2.1 Best Management Practices

The following BMPs will be used to avoid or minimize direct and indirect impacts to eelgrass:

- 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.
- In areas with eelgrass present, activities would primarily occur during inundation to avoid contact with the bay bottom (e.g., use of a longline harvester). The exception would be the initial installation of culture gear, and occasional visits for maintenance and hand-pick harvesting methods.
- 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.

5 The 30% threshold is also supported by the Cowardin Classification for plant classes. According to Hruby (2012), "if the total cover of plants is less than 30% the area does not have a plant class. Areas with less than 30% plant cover should be categorized as open water or sand/mud flats." Further, the polygon in which the plants are located has to represent at least 10% of a 2.5-acre unit or at least 0.25 acres of a larger unit.

- The longline harvester would not be anchored so 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.

4.2.2 Assumptions

The following assumptions were made to conduct the impacts analysis:

- The 2009 locations of continuous and patchy eelgrass identified by Schlosser and Eicher (2012) are representative of 2015 conditions.
- The percentage of culture using cultch-on-longline methods in the expansion areas is 84% (522 acres) and using basket-on-longline and rack-and-bag is 16% (100 acres).
- Rack-and-bag is a minor portion of proposed culture methods and would not occur in eelgrass.
- 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.

4.2.3 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.

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% of the area. 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 Schlosser and Eicher (2012) data were used to define specific eelgrass beds in North Bay rather than the CEMP-specific definition; this data is more 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 18-19, 2015, SHN Engineers and Geologists (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) was 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 Schlosser and Eicher (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) does not appear to change the characterization of the surrounding eelgrass bed. 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. 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 (SHN 2015). 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.

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 (see Section 4.3). However, even in settings where oyster aquaculture occurs in over 22% 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 several studies, such as the 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 (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 Humboldt Bay (see Section 3.3 for a summary of existing data). 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 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	12	34	99	144
	Basket-on-Longline*	2	6	19	27
2	Cultch-on-Longline	0	3	29	32
	Basket-on-Longline*	0	0	6	6
3	Cultch-on-Longline	2	41	93	137
	Basket-on-Longline*	0	8	18	26
4	Cultch-on-Longline	2	10	60	72
	Basket-on-Longline*	0	2	12	14
5	Cultch-on-Longline	0	2	16	18
	Basket-on-Longline*	0	0	3	3
6	Cultch-on-Longline	2	5	113	120
	Basket-on-Longline*	0	1	22	23
Total	**Cultch-on-Longline**	**18**	**94**	**410**	**522**
	Basket-on-Longline*	**4**	**18**	**78**	**100**

Source: Schlosser and Eicher (2012)
*Basket-on-longline culture 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 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%

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 m^2 quadrats while the SHN (unpublished data) was collected in 0.0625 m^2 quadrats. All data was converted into turions/m^2.

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% 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% 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% reduction in eelgrass density within the shellfish aquaculture expansion area.

A sensitivity analysis of potential impacts indicated that eelgrass density would not be reduced more than the 25% 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% to 10.5% within the expansion area. Similarly, if the percent reduction under the longlines (*Rdct*) in Eq. (3) is increased to 100%, then a potential reduction in eelgrass density could increase from 5.0% to 10.0% within the expansion area. Finally, if the width of effect is 10x greater than assumed *and* reduction under the longlines is 100%, then a potential reduction in eelgrass density could increase from 5.0% to 20.9% 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.

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% when looking only at eelgrass in the culture area, 1.7% when considering actual eelgrass bed area (shellfish culture area and contiguous eelgrass beds), and 0.9% 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 Schlosser and Eicher (2012) data.
North Bay = total eelgrass in North Bay based on the Schlosser and Eicher (2012) data.

4.2.4 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: (1) pulse disturbance, and (2) 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.[6]

Propeller Scarring

The dominant means of 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). 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 potential 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.

[6] 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 DEIR.

Other studies with different species of aquatic vegetation have reported even longer recovery times from seagrass 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 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 to harvest shellfish beds when eelgrass is present).

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.

Anchoring

When shellfish operators access the site at high tide, boats may need to be anchored while work is performed. One study in Port-Cros National Park in France found that anchors dropped into seagrass resulted in an average of 50 uprooted or broken shoots per m^2 (Francour et al 1999). Recovery took approximately 3 years after anchoring was discontinued. Frequent anchoring caused a decrease in both shoot density and seagrass bed cover. For the proposed Project, anchoring within eelgrass would not be a frequent event. According to the BMPs, larger work boats would be anchored in channels outside of eelgrass beds and smaller skiffs would be used to access longlines where eelgrass is present when the area is inundated.

Trampling

There are a few activities that require access to shellfish aquaculture plots by foot (e.g., setting up longline plots, gear repair, and occasional harvesting). Based on the low tide cycle, crews typically work for a period of 4 to 8 hours in one area for about 1 week out of every several months. Therefore, these disturbance events would be considered infrequent and of short duration within any one location relative to the time that the beds remain submerged. Nonetheless, eelgrass rhizomes may be uprooted or shoots broken from trampling or moving gear around.

Seagrasses may be less tolerant of trampling than terrestrial grasses because they have not been subjected to historical trampling pressure, and because substrates are inundated.[7] 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." Based on substrate type, the eelgrass in Humboldt Bay may be more susceptible to trampling effects. However, turtle grass is known to have slower recovery times compared to eelgrass because it recovers primarily by rhizome extension rather than sexual reproduction (as discussed above). Additionally, the Eckrich and Holmquist (2000) study was done in an area of Puerto Rico that was heavily trafficked by recreationalists. The potential trampling activity within Coast aquaculture plots would occur at a *maximum* frequency of 3 to 4 times every two years when it is planted and harvested. There is very little monthly activity once a bed is planted, and access in eelgrass areas would almost exclusively occur when the area is inundated. Therefore, trampling effects are not expected to be a significant impact to eelgrass within aquaculture plots.

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 (SHN 2015), 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.

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7 According to Eckrich and Holmquist (2000): "Substrates saturated with water are generally more easily penetrated than dry substrates, and trampling in saturated substrates is more likely to lead to substrate breakthroughs and subsequent rhizome damage than trampling in dry substrates."

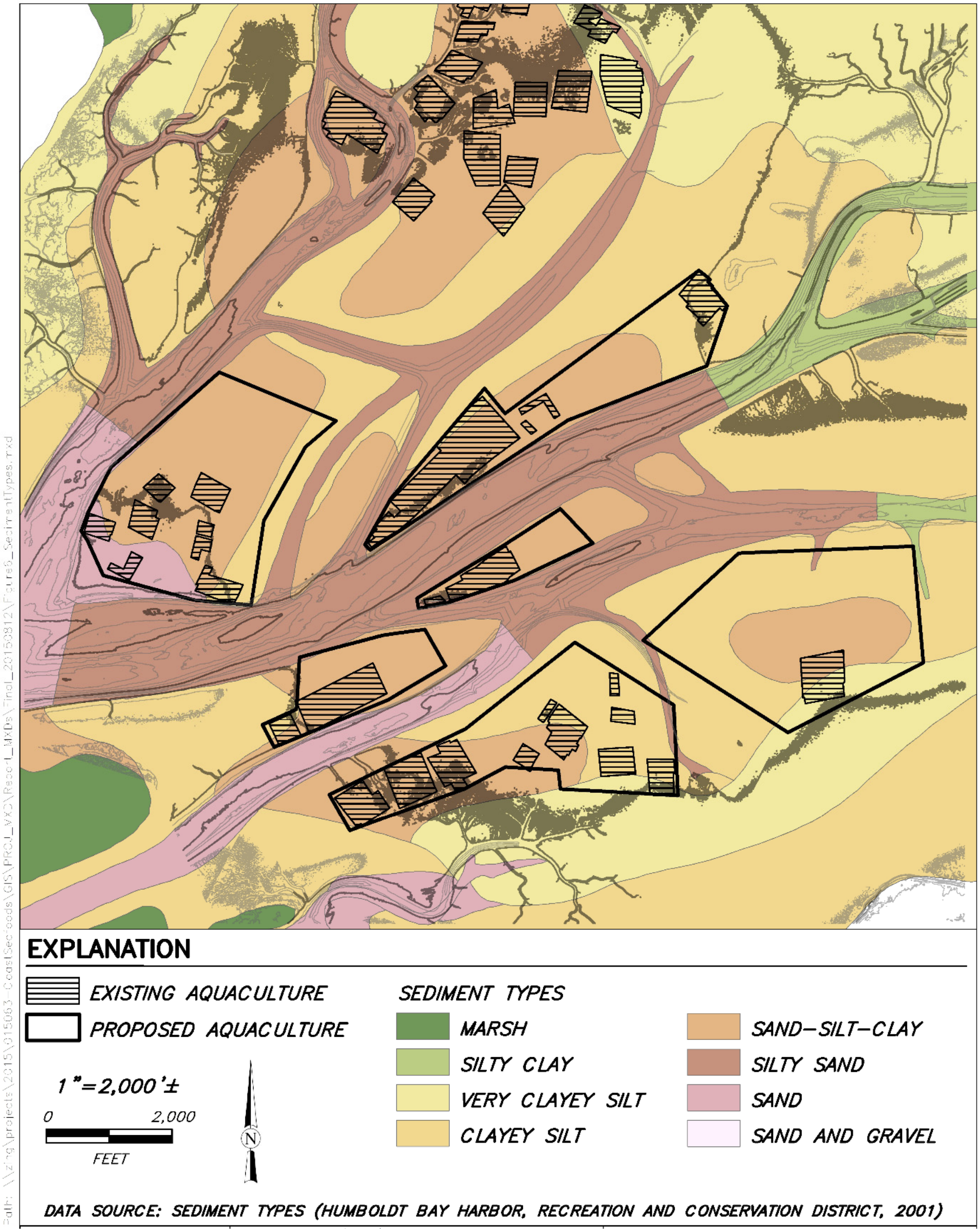

Figure 16 Sediment Types within the Existing Culture and Proposed Expansion Areas.

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% 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 4.2.1) are aimed at avoiding or minimizing impacts to eelgrass.

4.2.5 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). Rumrill and Poulton (2004) observed greater sediment deposition in the vicinity of longlines compared to control areas, with 5 ft and 10 ft spacing showing the least difference from controls. In areas with longlines spaced at 5 ft, deposition of fine sediments was evident in May (up to 95 mm) and eroded by July (down to 51 mm). No indication of level of significance compared to the control plot was provided in the study results. Given that the typical detection limit for this type of study is 80 mm (Hannam and Mouskal 2015), it is unlikely that the change observed by Rumrill and Poulton (2004) would be considered significant. 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% 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% and 40.6% compared values up drift (or up current). Therefore, placing longlines in eelgrass is not likely to significantly change sediment dynamics beyond the natural conditions exhibits in eelgrass beds.

4.3 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). For example, coastal salt marsh habitat has been reduced to 10% of its historic distribution (Schlosser and Eicher 2012). The effects of this to eelgrass likely include reduced light penetration due to increased suspended sediments. However, eelgrass does not appear to be limited in Humboldt Bay, and so effects to eelgrass may not be as important to the landscape as connectivity of habitat for salmonids and other migratory species. 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.

4.4 *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[8] 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 northeast (white circle), the scars[9] 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.

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.

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8 Dredge harvesting has been discontinued in Humboldt Bay and would not be permitted under the Project.
9 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.

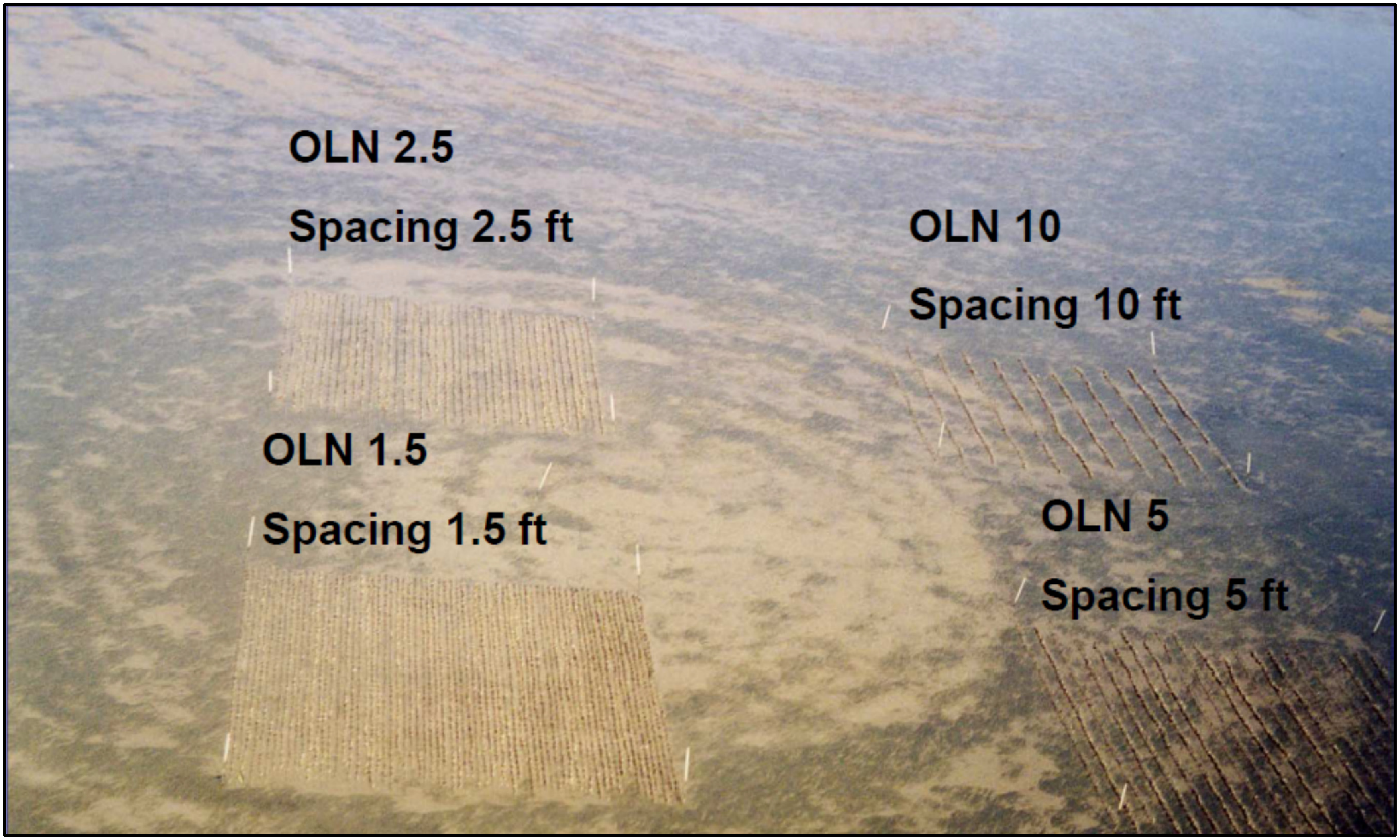

Figure 17 Image of Oyster Longline Study Plots Taken Two Years after Mechanical Dredge Harvesting to Longline Conversion.
Source: Rumrill 2011.

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.

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.

4.5 *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).

4.5.1 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 70 raft type structures in subtidal areas (35 rafts managed by Coast) and approximately 300 acres of intertidal areas cultured (294 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 95% of existing culture is in eelgrass (see Figure 13), and the majority (87%) is considered patchy eelgrass. It is important to note that culture areas were originally planted adjacent to eelgrass and were colonized by eelgrass after shellfish structures were added (Dale, pers. comm., 2015). 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 54 new culture rafts and 527 acres of intertidal culture. The 527 acres of intertidal culture would overlap with approximately 173 acres of non-eelgrass habitat, 306 acres of patchy eelgrass, and 48 acres of continuous eelgrass. Finally, Taylor Mariculture and Hog Island Oyster Company are implementing efforts that would collectively add a total of 21 culture rafts (15 FLUPSYs and 6 nursery rafts). Their permits have already been obtained, with culture currently being implemented. The FLUPSYs and nursery rafts would not affect eelgrass habitat, and are specifically sited to avoid interactions with eelgrass.

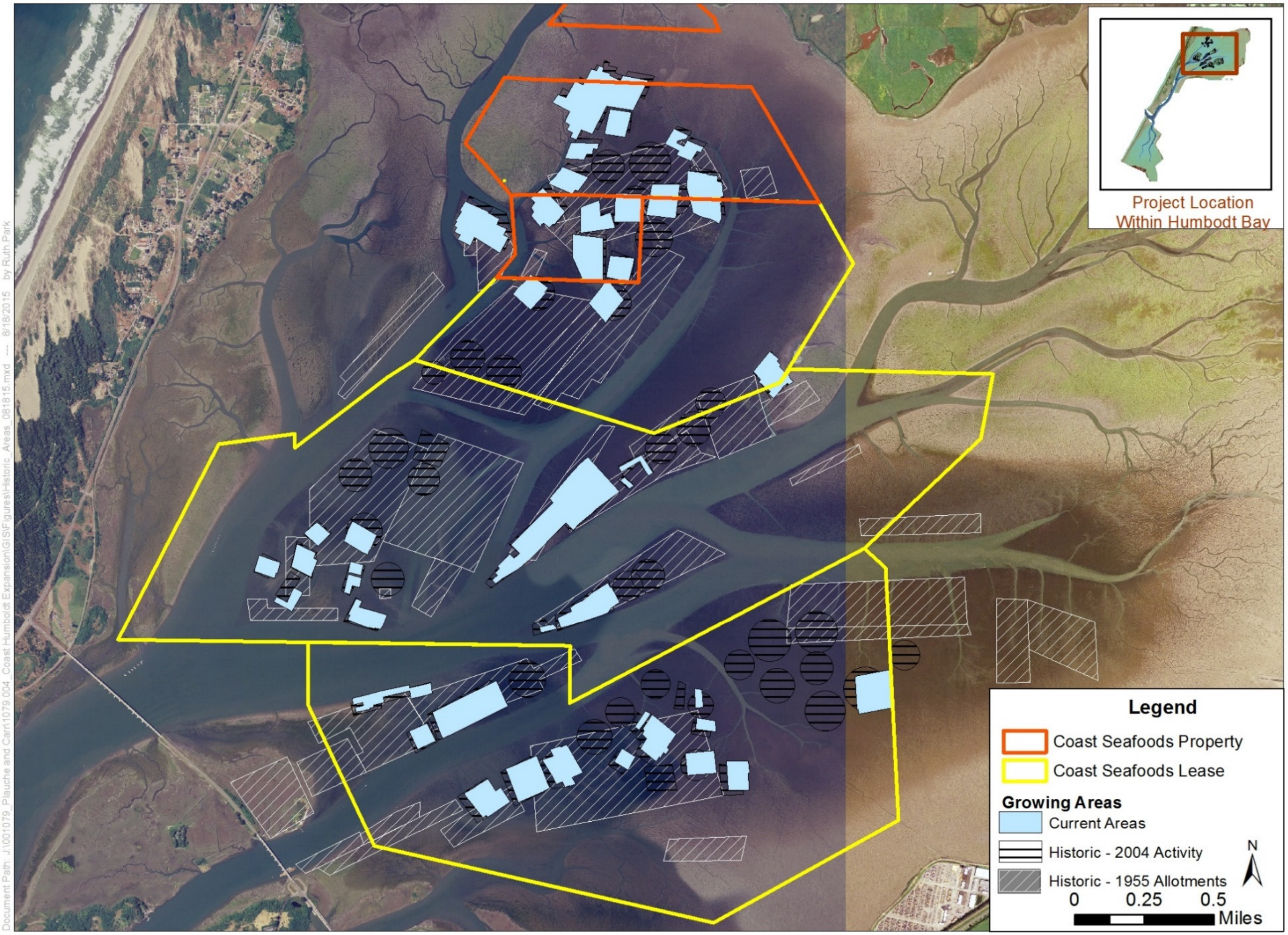

Figure 19 **Current and Historic Cultivation Areas associated with the Coast Seafoods Lease Area.**
Source: GIS layers provided by Wagschal, pers. Comm., 2015.

The cumulative amount of potential overlap with eelgrass habitat from existing culture, the Project, and the Pre-permitting Project represents approximately 31% of North Bay eelgrass and 11% of North Bay overall (Figure 20). As discussed above, the Project would potentially result in a reduction of eelgrass density that equates to -1.7% of eelgrass bed habitat in North Bay (see Section 4.2). The Pre-Permitting Project constitutes 46% 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 any potential significant impacts to eelgrass habitat associated with its project; therefore, the Pre-Permitting Project is not likely to significantly contribute to overall cumulative effects to eelgrass habitat.

4.5.2 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% to 38% of the intertidal habitat (~15-20,000 acres) at a similar tidal elevation as existing oyster aquaculture. Oyster aquaculture occurs on up to 22% (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% 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.

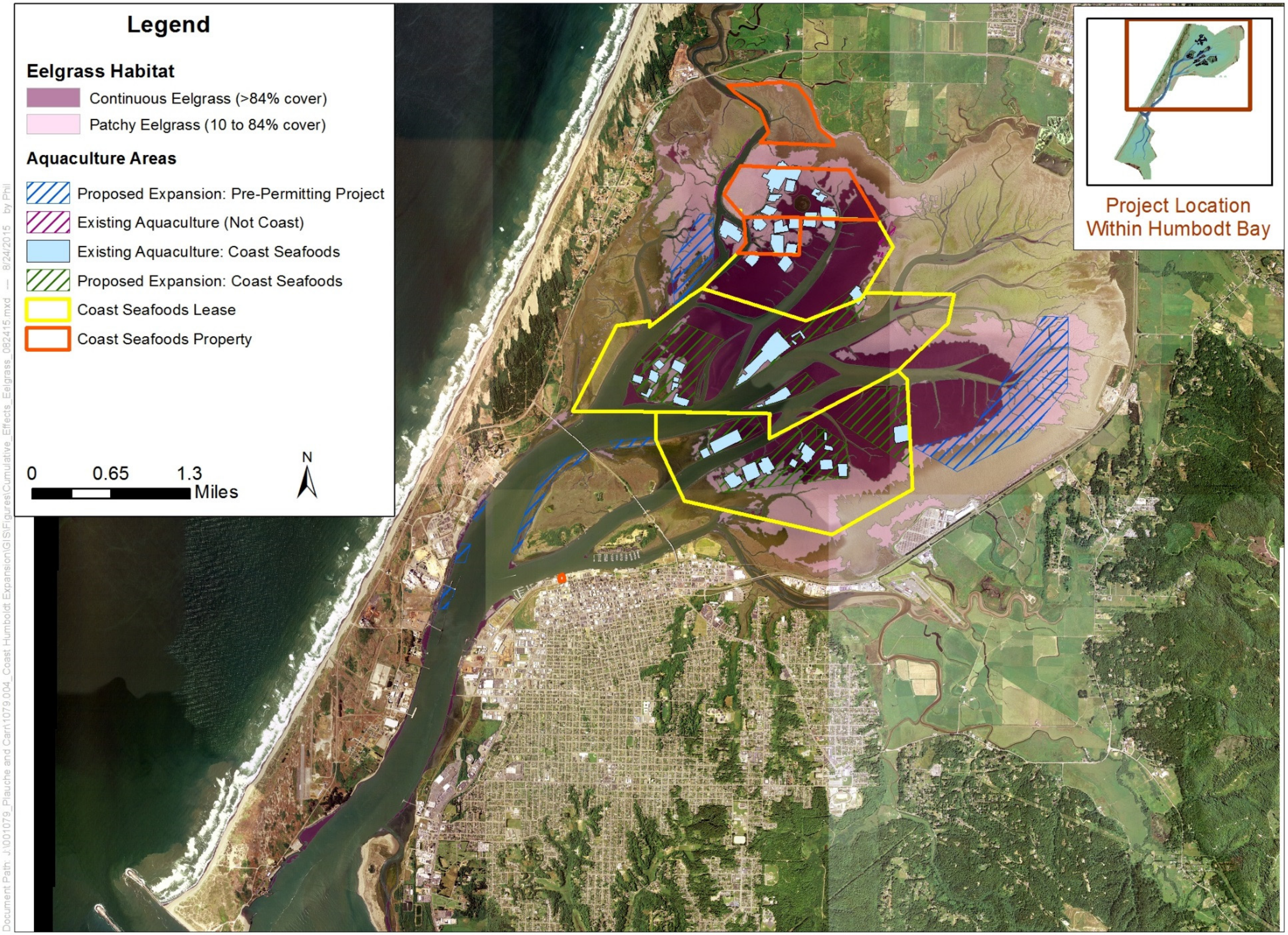

Figure 20 **Existing and Proposed Shellfish Aquaculture in Humboldt Bay.**
Source: GIS layers provided by Wagschal, pers. comm., 2015.

4.5.3 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 section of the DEIR and the *Estuarine Habitat Credit-Debit Mitigation Accounting Framework* developed for the Project (Appendix A 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*[10]) 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:

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

> 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 6.0). 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.

5.0 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.

According to the DEIR, effects to eelgrass and other biological resources that use eelgrass habitat was the primary screening criteria for the scope of the alternatives. While the proposed Project is not expected to result in significant effects to eelgrass and such species (see Section 7.0 below), 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.

5.1 Description of Project Alternatives

The DEIR analyses four project alternatives as follows: (1) a 10 ft spacing alternative, (2) a reduced expansion alternative, (3) an existing footprint alternative, and (4) a no action alternative. These alternatives are described below.

5.1.1 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, 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 preferred alternative, 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 preferred alternative. 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 preferred alternative. In addition, while 10 ft spacing would be more protective of eelgrass, the expansion area would be 333 acres larger than under the preferred alternative and the majority of this additional cultivated acreage would overlap with patchy and continuous eelgrass beds.

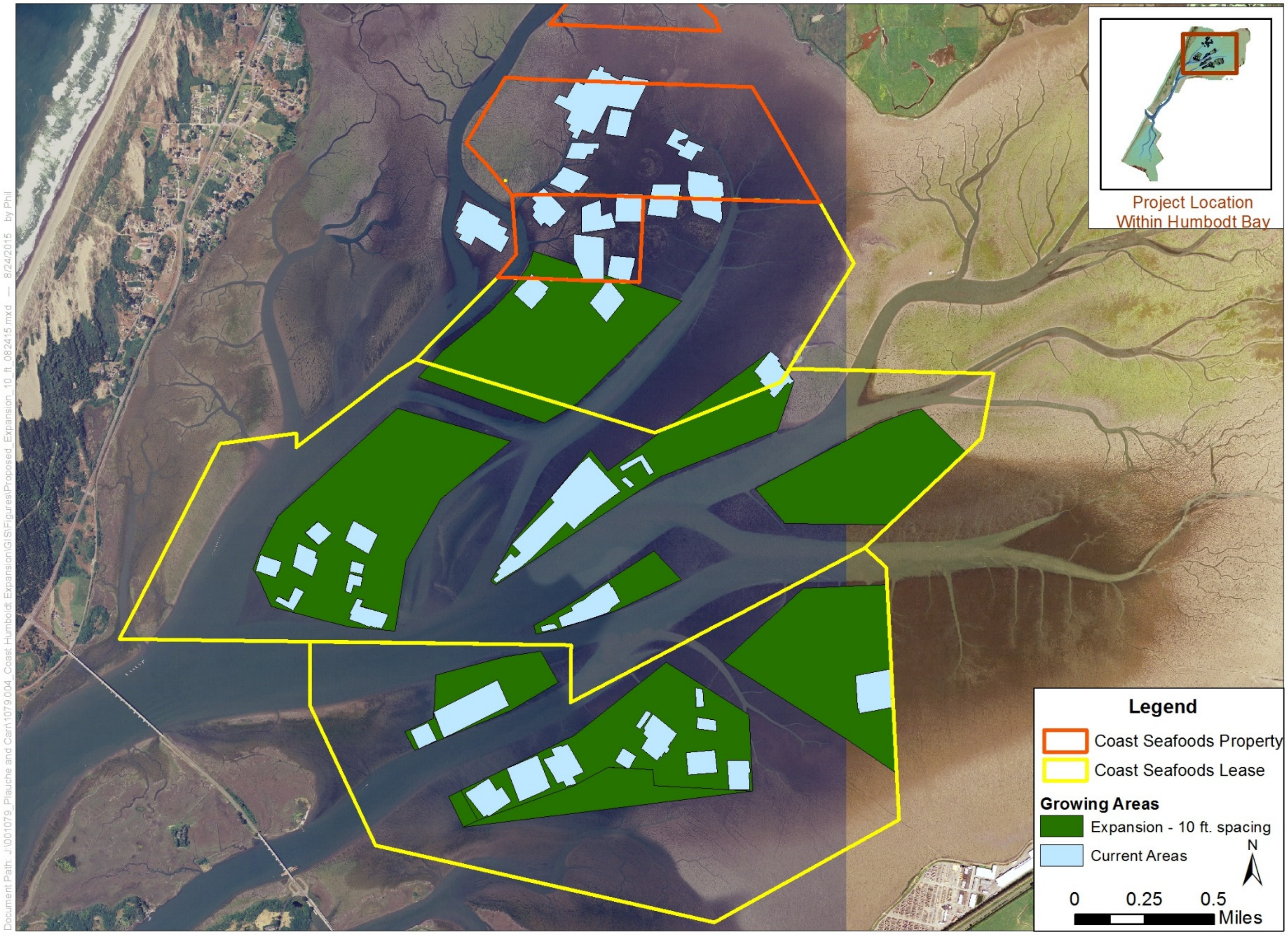

Figure 21 Areas Proposed for Continued and Expanded Shellfish Culture under Alternative 1 (10 ft Spacing)

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

5.1.2 Alternative 2: Reduced Footprint

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/rack-and-bag culture. Similar to the preferred alternative, 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. As with the preferred alternative, 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.

5.1.3 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.

5.1.4 Alternative 4: No-Project

The No-Project 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.

5.2 Summary of Potential Eelgrass Impacts by Alternative

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

5.2.1 Best Management Practices (BMPs)

Many of the BMPs 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 BMPs proposed, and if they are associated with specific alternatives.

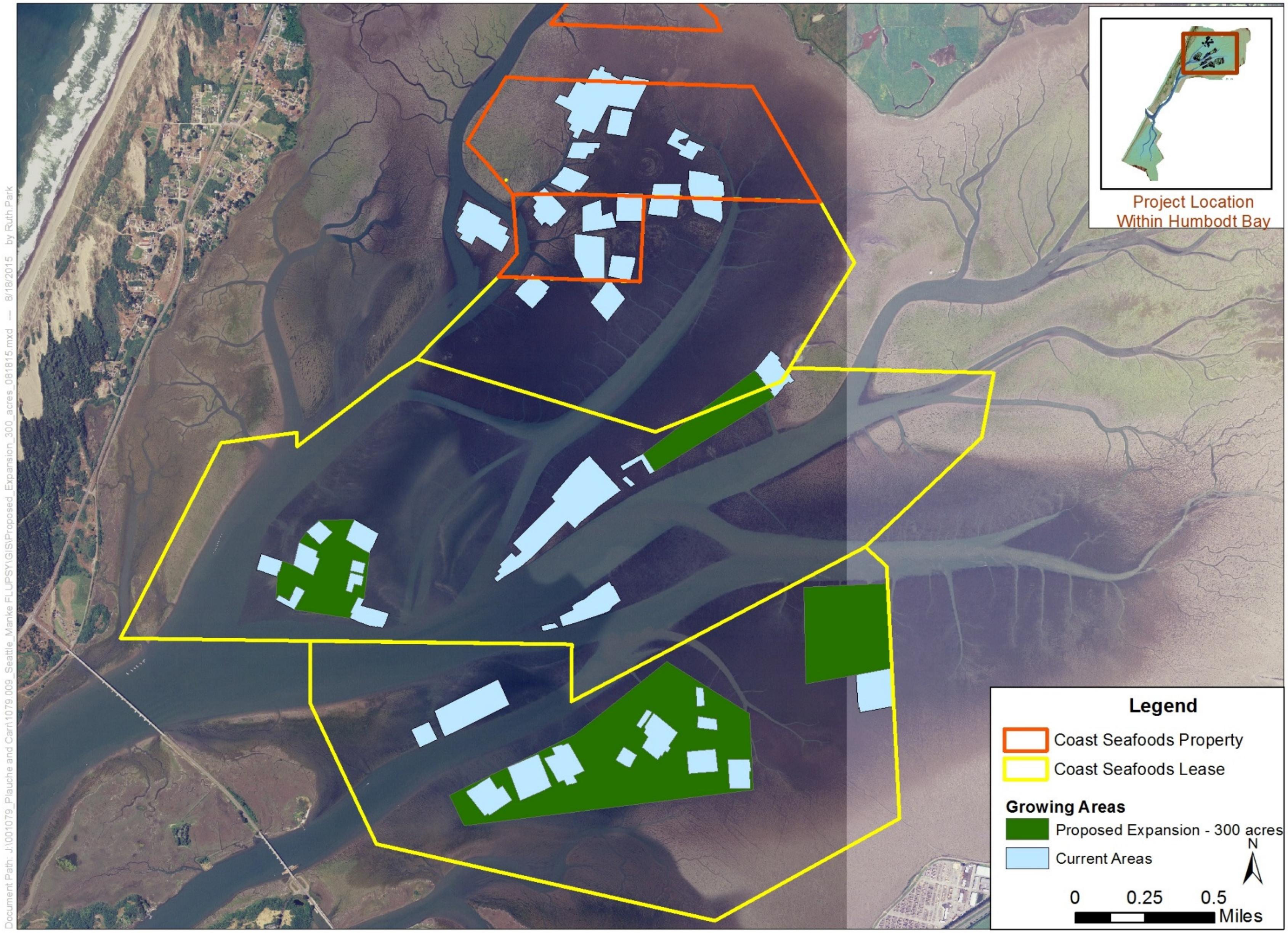

Figure 22 Areas Proposed for Continued and Expanded Shellfish Culture under Alternative 2 (Reduced Footprint).

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

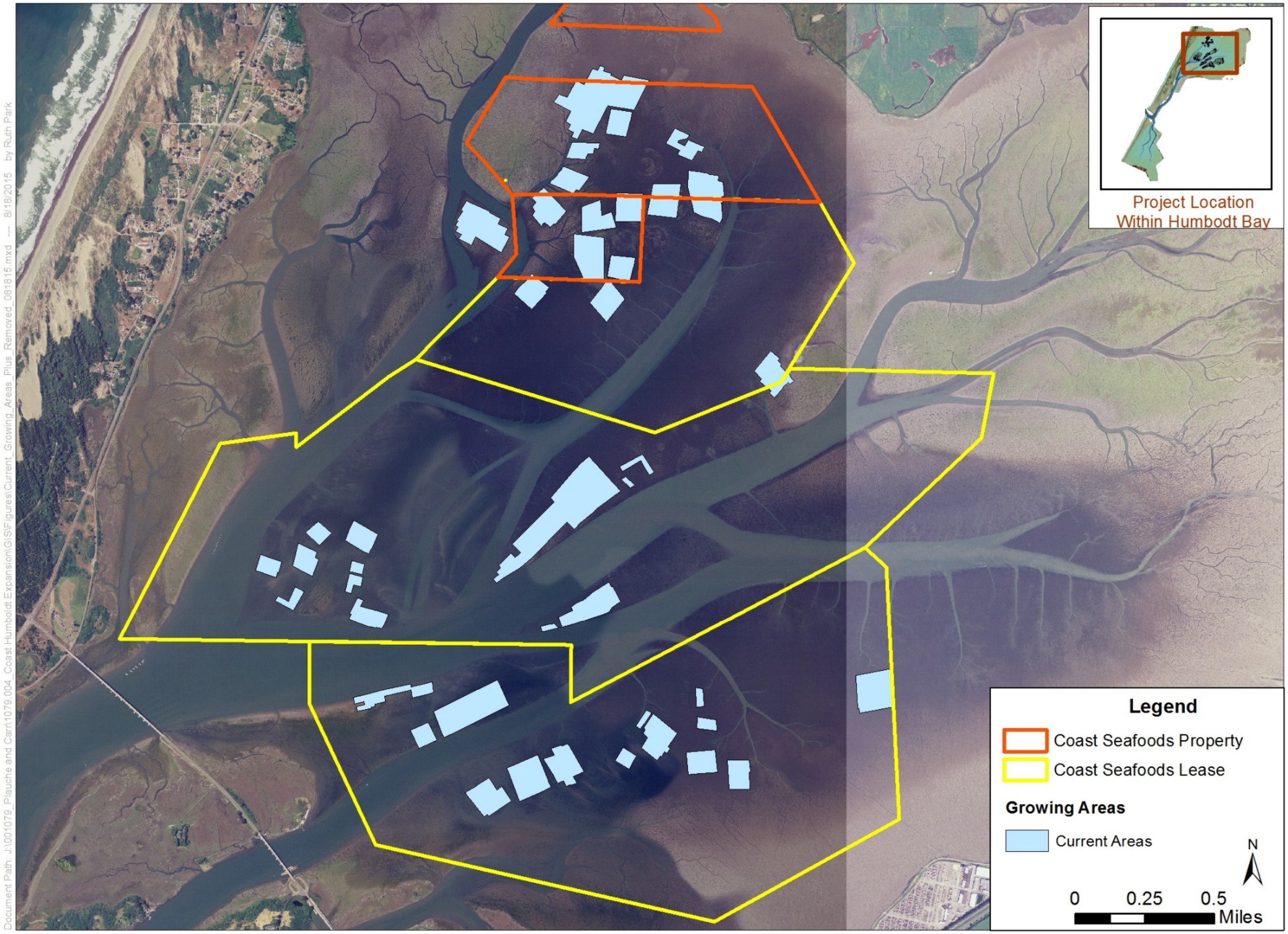

Figure 23 **Areas Proposed for Continued Shellfish Culture under Alternative 3 (Existing Footprint).**
Source: GIS layers provided by Wagschal, pers. comm., 2015.

Table 5 Summary of BMPs by Alternative

Best Management Practices (BMPs)	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.	✓	✓	✓	
In areas with eelgrass present, activities would primarily occur during inundation to avoid contact with the bay bottom (e.g., use of a longline harvester). The exception would be the initial installation of culture gear, and occasional trips for maintenance and harvesting.	✓	✓	✓	✓
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.	✓	✓	✓	✓

5.2.2 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-Project Alternative includes a number of construction activities that are not associated with other alternatives.

Change in Areal Extent

As discussed above (Section 4.2.3), 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-Project) 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 best management practices . 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 4.3). 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	244	25.5	**277.5**	18	94	410	**522**
	Basket	0	10	1	**11**	4	18	78	**100**
	Total*	**8**	**254**	**26.5**	**288.5*** **	**22**	**112**	**488**	**622**
Alt. #1	Cultch	8	244	25.5	**277.5**	39.5	159	604	**802.5**
	Basket	0	10	1	**11**	7.5	30	115	**152.5**
	Total*	**8**	**254**	**26.5**	**288.5*** **	**47**	**189**	**719**	**955**
Alt. #2	Cultch	8	244	25.5	**277.5**	11	51	138	**200**
	Basket	0	10	1	**11**	5	26	69	**100**
	Total*	**8**	**254**	**26.5**	**288.5*** **	**16**	**77**	**207**	**300**
Alt. #3	Cultch	8	249.5	25.5	**283**	No expansion			
	Basket	0	10	1	**11**				
	Total	**8**	**259.5**	**26.5**	**294*** **				
Alt. #4	Cultch	8	249.5	25.5	**283**	No expansion			
	Basket	0	10	1	**11**				
	Total* *	**8**	**259.5**	**26.5**	**294*** **				

*Does not include 5.5 acres to be removed.
**All existing culture would be removed.
***There are 6 acres in FLUPYs and floating nurseries that are not accounted for in these figures.

Similar to the Project impacts discussed above (Section 4.2.3), 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% was used for cultch-on-longline areas and -70% was used for basket-on-longline areas. For longlines spaced 10 ft apart (i.e., Alternative #1), a density reduction of -46% was used for cultch-on-longline areas and -67% 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 Impacts from Shellfish Gear and Products 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.

Gear removal activities would result in a higher 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 expiry; and (3) all gear would be immediately removed regardless of BMPs. For this analysis, the same equations were used as presented in Section 4.2.3 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-Project 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 cumulative 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 reduce water clarity, light transmittance through the water column, and 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. This impact would be limited to the year that gear is removed, however, these impacts would not be associated with any of the other alternatives or with the Project.

Working Practices

Trampling is the only potential working practice impact that may change with the different alternatives. For example, trampling associated with Alternative #1 (10-ft spacing) may become more significant based on the expanded geographical extent. However, because access would still be a maximum of 3 to 4 trips every two years at a culture plot, 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 level reported by Eckrich and Holmquist (2000) in a recreational estuary in Puerto Rico.

5.2.3 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.

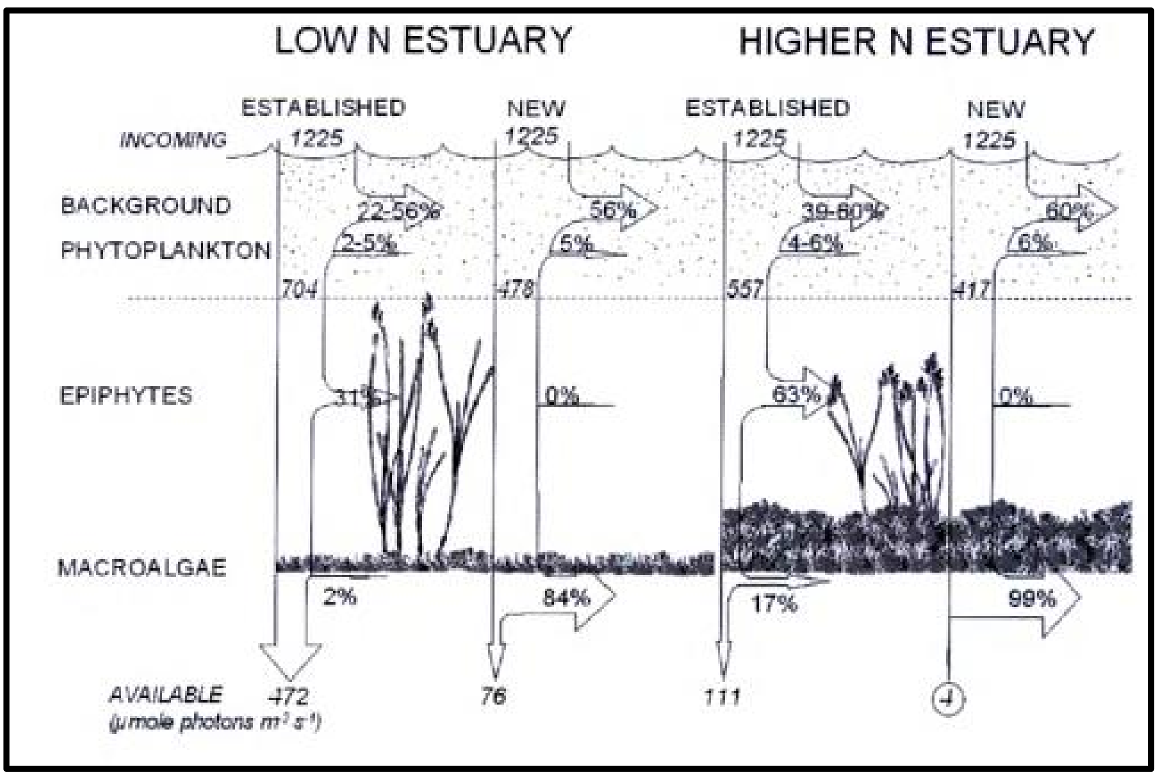

Figure 24 **Illustration of Mean Summer Light Intensity Effects to Eelgrass.**
Source: Hauxwell et al. 2001.

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-Project 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[11].

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 cultural eutrophication in parts of Humboldt Bay.

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-Project Alternative could result in a loss of spatial distribution and extent of eelgrass habitat.

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

6.0 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 4.2 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

6.1 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% 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 are 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 towards 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 3.2 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 6.3.

6.2 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. 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.

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	▪ City of Eureka ▪ California State Coastal	10*

			▪ Intertidal areas with eelgrass ▪ Deep water channel	Conservancy ▪ Redwood Regional Audubon Society	
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.*

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

The main impact associated with the Project is a reduction in eelgrass shoot density (see Section 4.2). 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).

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.[12] The locations for deployment would be prioritized in the following manner:

1. Former mechanical dredge harvest locations.

12 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.

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% (Year 1), 50% (Year 2), and 80% (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.

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.

6.2.2 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 25). 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.

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% (Year 1), 80% (Year 2), and 75% (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% (Year 1) and 50% (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.

Figure 25 Conceptual Site Plan for Parcel 4 Public Access Development.

Source: RCAA and GreenWay Partners 2012.

- **Success Criteria:** Invasive plant species cover will not exceed 20% (Year 1) and 10% (Year 3). **Contingency Measure:** If more than 10% 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-foot-long transects will be established. At two points along each transect, permanent circular plots 15 feet 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.

6.2.3 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 26). The site is owned by the City of Eureka, the Harbor District, PG&E, and several private land owners.

Figure 26 Elk River Estuary Enhancement and Intertidal Wetlands Restoration Project Area (yellow shading) along the Eastern Shoreline of Entrance Bay.

Source: City of Eureka 2015.

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.

6.2.4 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 27). 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.

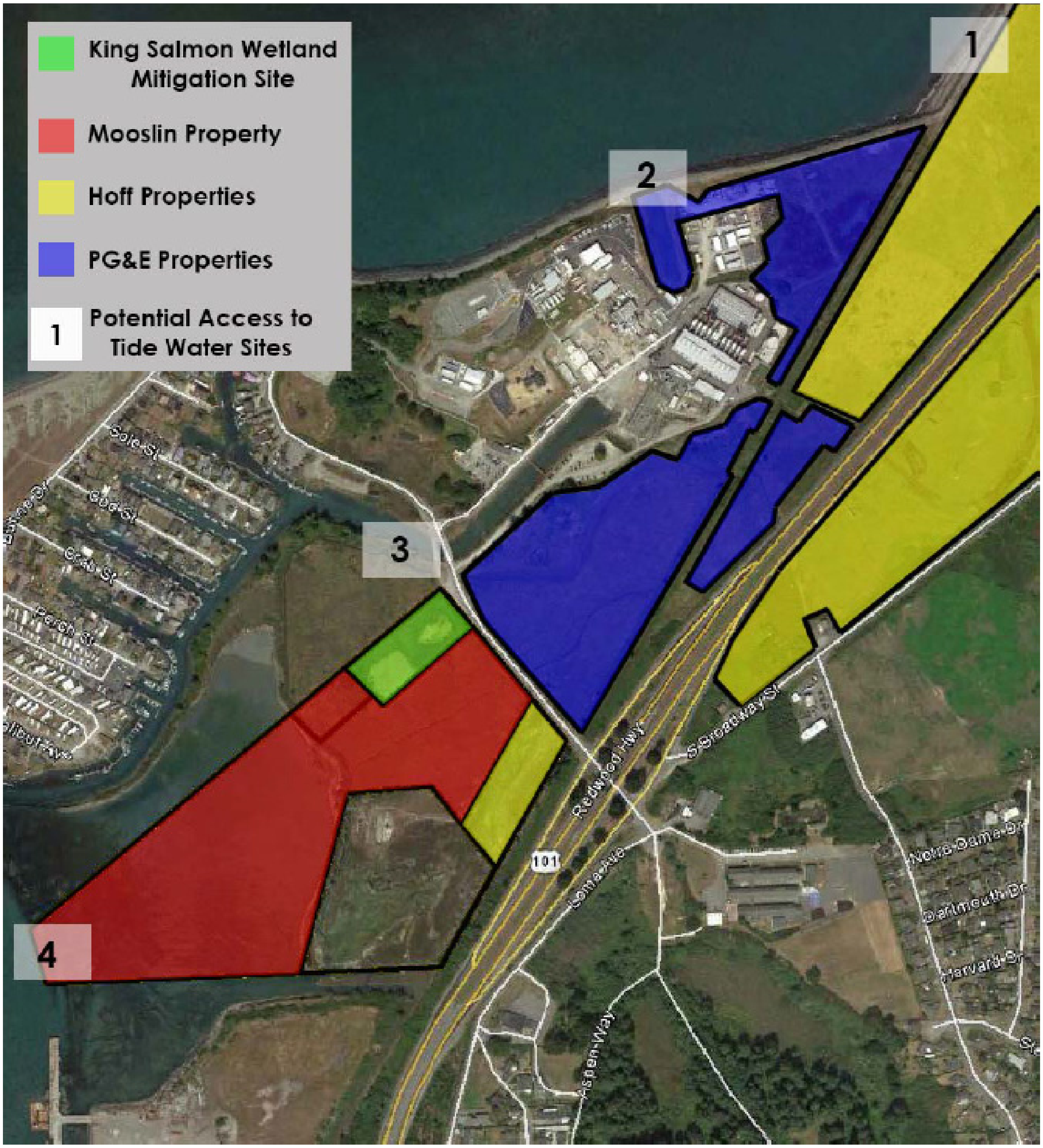

Figure 27 **Tidal Access Sites adjacent to the Hoff Parcels in the City of Eureka, California.**
Source: Westervelt 2014.

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.

6.3 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 A). 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 (ORWAP) (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		✓	✓
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 A to this report.

The steps involved in determining mitigation needs and adaptively applying newer information are shown in Figure 28. 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.

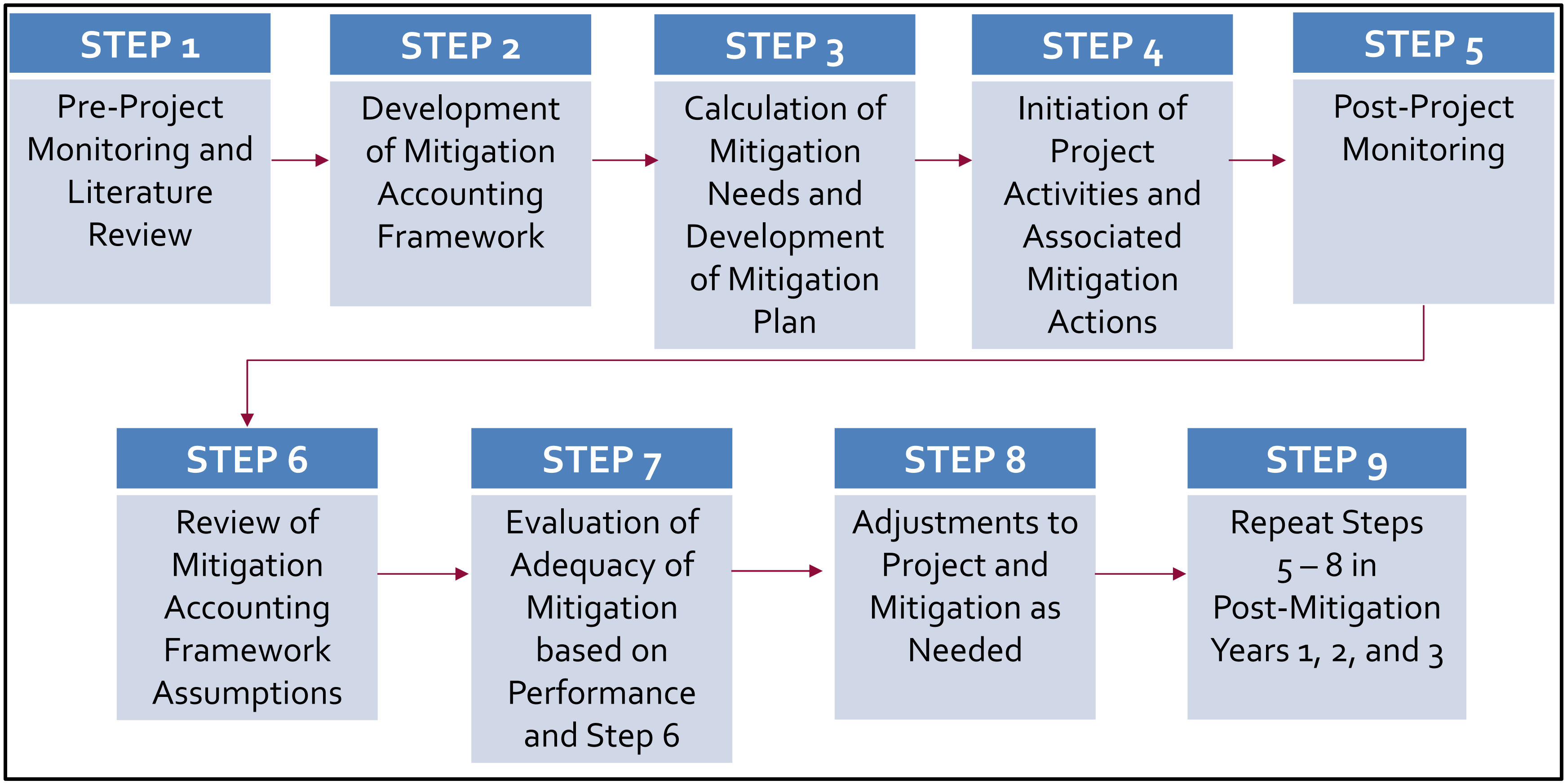

Figure 28 Proposed Sequence for Determining Mitigation Needs and Applying Adaptive Responses.

7.0 DETERMINATION OF SIGNIFICANCE

The threshold of significance for impacts to eelgrass habitat has been defined as Project effects that result in a greater than 30% change in areal extent of eelgrass or a greater than 25% change in eelgrass density at the landscape scale (100 m to 10,000 m). 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.

The three interactions that can potentially result in a direct loss of eelgrass that were discussed under *Potential Eelgrass Impacts* (Section 4.0) include: (1) gear and shellfish products, (2) working practices, and (3) sediment scouring and accumulation. In addition, the analysis considers resilience of the ecological system, duration of impacts, and cumulative impacts. 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% of eelgrass in the culture area and 1.7% 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 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 6.0).

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Appendix A

Estuarine Habitat Credit-Debit Mitigation Accounting Framework

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APPENDIX A: 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's) 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 7.0 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 A-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 A-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 (Quetier 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 A-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 A-1). Buoy-deployed seeding systems (BuDS) are described in more detail in Section 6.2.1 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 A-1), which has lost the majority of its functionality due to armoring and other activities associated with urban growth.

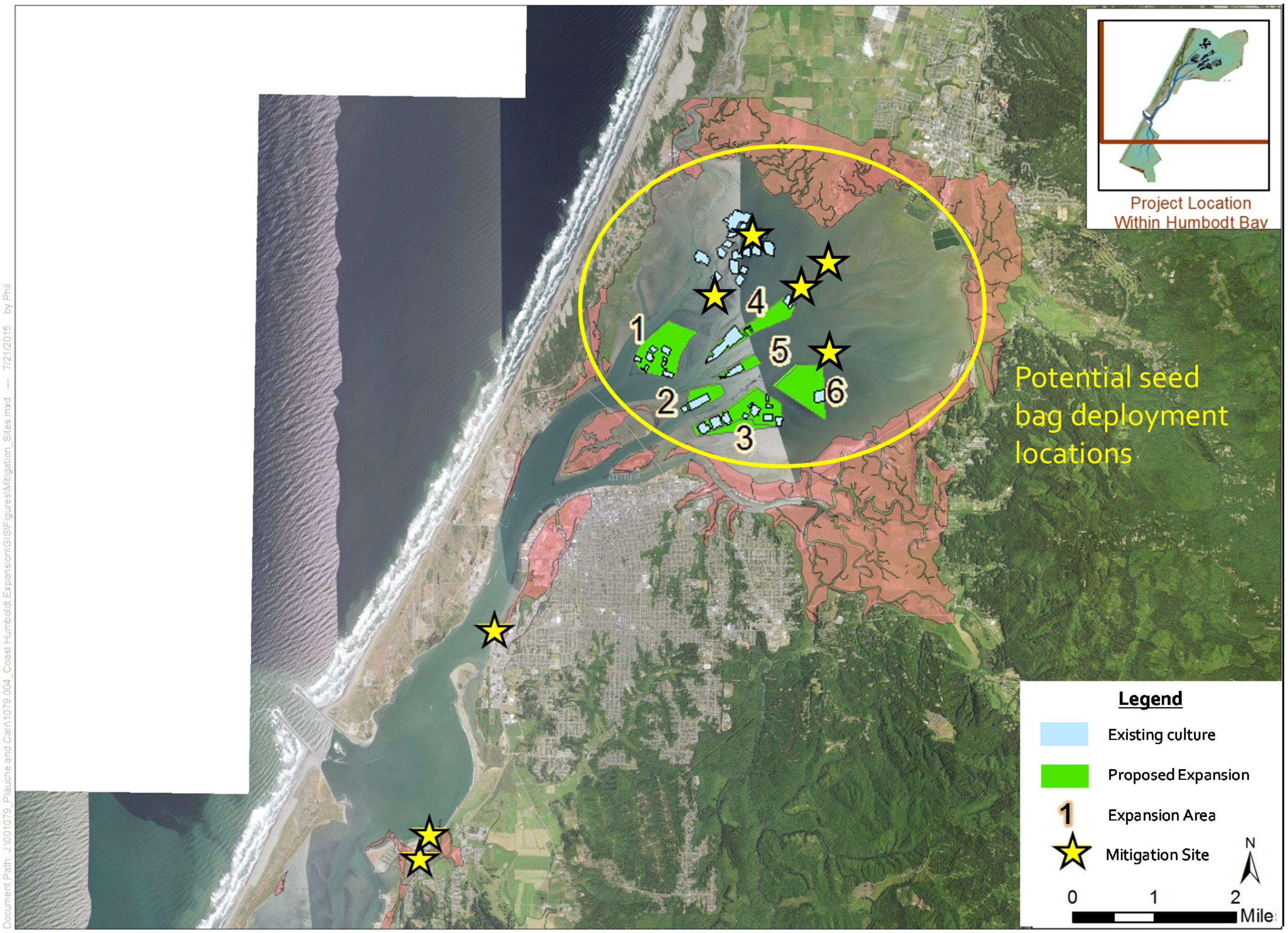

Figure A-1 Identified Potential Locations for Potential Mitigation for the Coast Project

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 A-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.

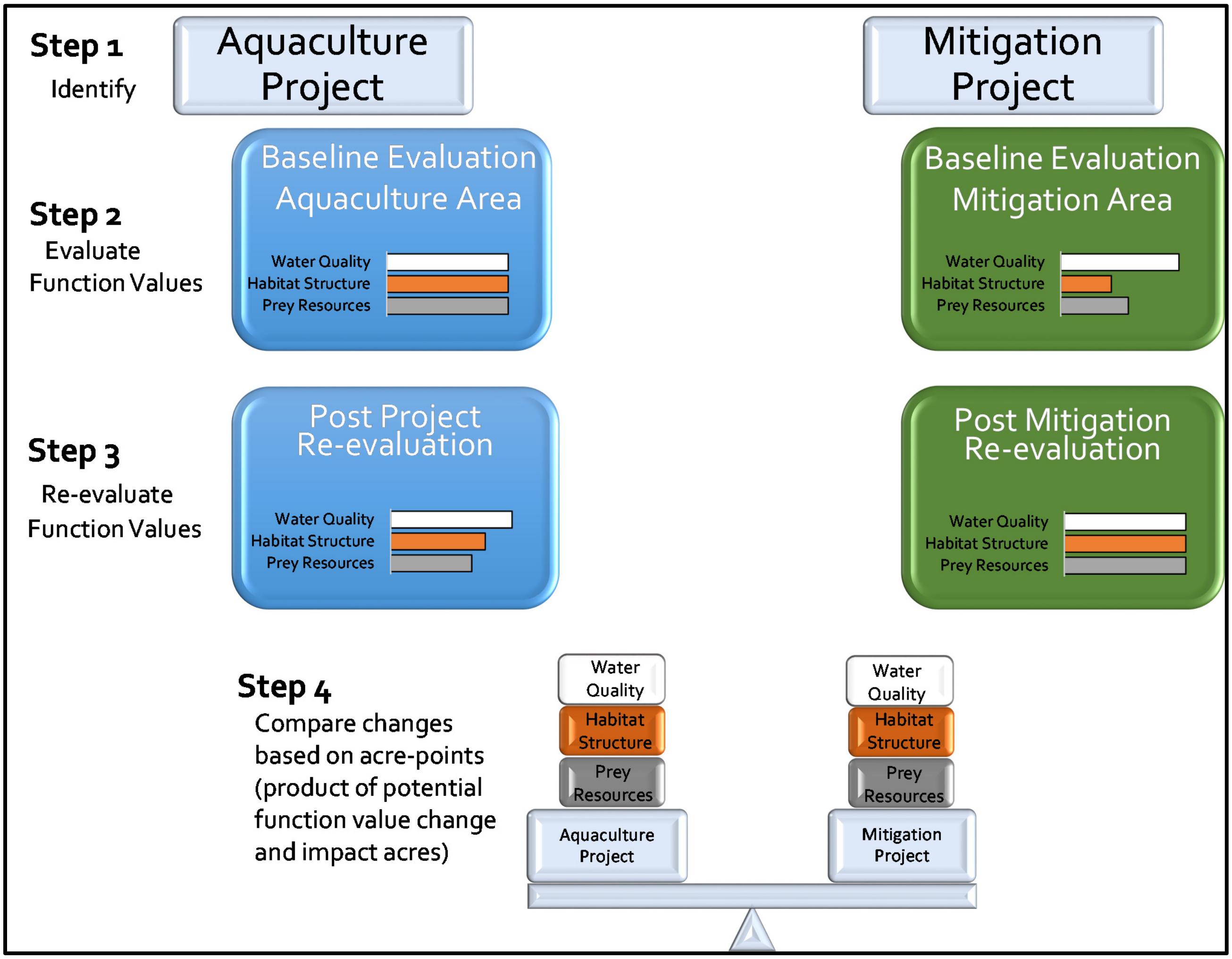

Figure A-2 Overview of Credit-Debit Framework

5.3 Adaptive Management Responses

The steps involved in determining mitigation needs and adaptively applying new information are shown in Figure A-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.

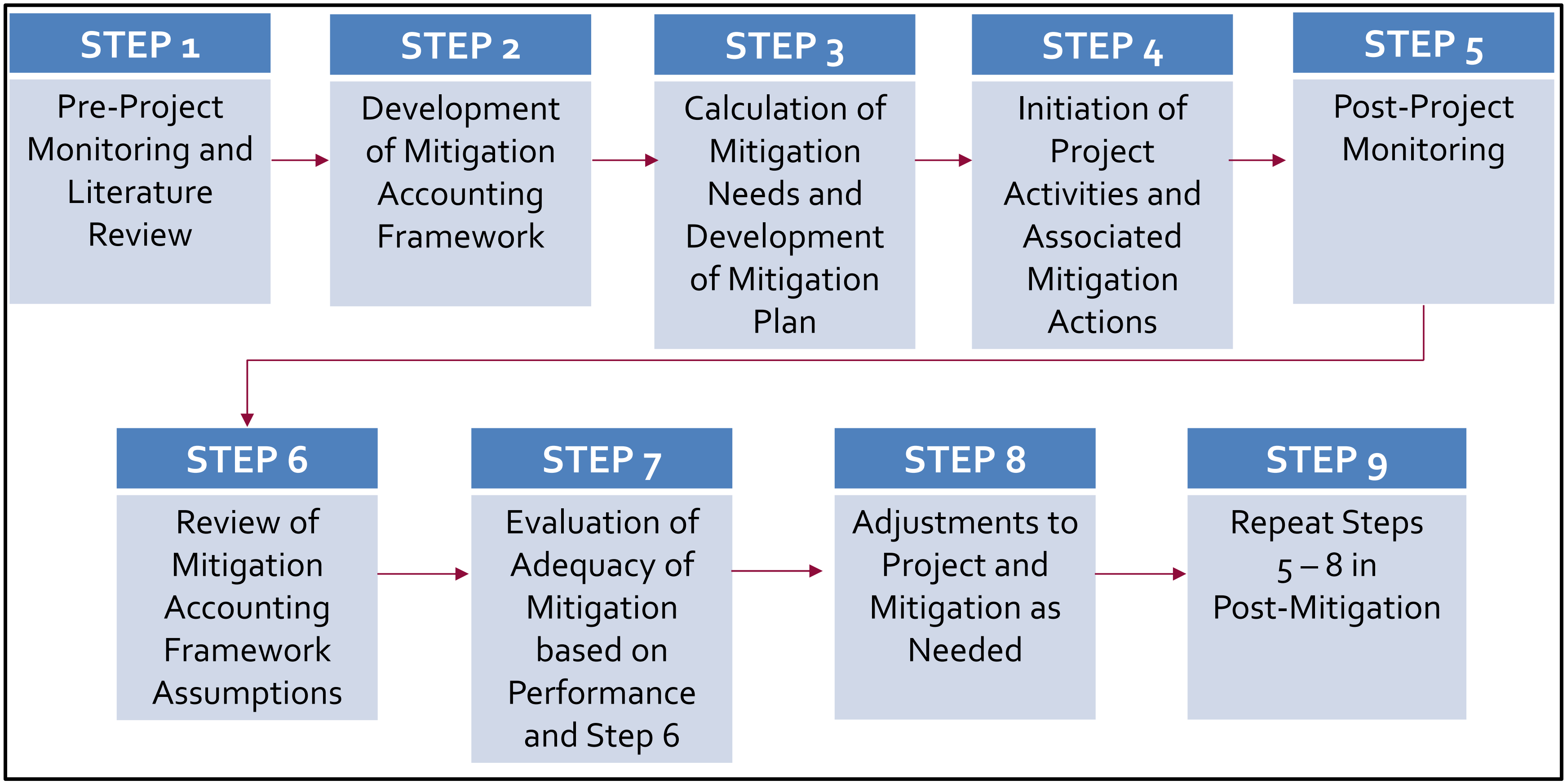

Figure A-3 Proposed Sequence for Determining Mitigation Needs and Applying Adaptive Responses.

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Mitigation Accounting Scoring Forms

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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?			**Point:** 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:	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:	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:	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:	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		**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?			**Point:** 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:	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:	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:	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		**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?			**Point:** 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:	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:	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		**0**	
	Rating of Value: 2 = H	1 = M	0 = L	

SCORING FORM

SITE

HABITAT STRUCTURE FUNCTIONS - Indicators that improve habitat structure		Score	NOTES
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 less than 20% or increase from historic levels Decline of 20-50% from historic levels Decline of 50-80% from historic levels Decline of 80% or more from historic levels	 points = 8 points = 4 points = 2 points = 0	Score:	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:	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:	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:	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		0	
Rating of Site Potential: 16 - 24 = H	10 - 15 = M	0 - 9 = L	

LANDSCAPE

		Score	NOTES
5.0 Does the landscape have the potential to support habitat function and species use at the site?			**Point:** 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:	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:	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:	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:	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	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		0	
Rating of Landscape Potential: 13 - 17 = H	6 - 12 = M	0 - 5 = L	

WATERSHED

		Score	NOTES
6.0 Is the habitat function improvement provided by the site identified as a priority issue in the watershed?			**Point:** 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	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	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: 0	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		0	
Rating of Value: 3 - 4 = H	1 - 2 = M	0 = L	

SCORING FORM

SITE — PREY RESOURCES FUNCTIONS - Indicators that improve habitat structure	Points	Score	NOTES
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:		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).
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		
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		
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:	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		
No	points = 0		
7.4 Does the habitat unit support secondary production?		Score:	Secondary production is the generation of biomass by primary consumers (herbivorous organisms that feed on primary producers).
Yes	points = 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 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		
Yes	points = 0		
Total for 7.0		**0**	
Rating of Site Potential: 20 - 28 = H; 11 - 19 = M; 0 - 10 = L			

LANDSCAPE	Points	Score	NOTES
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?		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		
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:	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		
No	points = 0		
8.2 For which seasons do fish or wildlife forage in the habitat unit?		Score:	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		
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:	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		
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		**0**	
Rating of Landscape Potential: 10 - 14 = H; 6 - 9 = M; 0 - 5 = L			

WATERSHED	Points	Score	NOTES
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)?		Score:	The more diverse the habitat, the more diverse the type of species that use the habitat will be.
Shorebirds; Anadromous Fish; Groundfish	Yes = 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:	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		
No	points = 0		
Total for 9.0		**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

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Calculating Credits and Debits for Compensatory Mitigation in Wetlands of Western Washington

DEPARTMENT OF
ECOLOGY
State of Washington

Calculating Credits and Debits for Compensatory Mitigation in Wetlands of Western Washington

Final Report
March 2012

Publication #10-06-011

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Calculating Credits and Debits for Compensatory Mitigation in Wetlands of Western Washington

FINAL REPORT
March 2012

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SUMMARY

This document is one of a series of guidance documents developed by the Department of Ecology to improve wetland mitigation in the State of Washington. It describes a tool (called the Credit-Debit Method) for estimating whether a plan for compensatory mitigation will adequately replace the functions and values lost when a wetland is altered. The tool is designed to provide guidance for both regulators and applicants during two stages of the mitigation process: 1) estimating the functions and values lost when a wetland is altered, and 2) estimating the gain in functions and values that result from the mitigation. The Department of Ecology, however, does not require the use of this method. The adequacy of a mitigation project can also be determined by using any other method that addresses the "no-net-loss" policy.

The Credit-Debit Method is based on the Washington State Wetland Rating System for Western Washington (Ecology publication #04-06-025). It also incorporates some refinements in characterizing functions and values that have been developed since then, and that have been summarized in a previous article. [Hruby (2009). Developing rapid methods for analyzing upland riparian functions and values. Environmental Management 43:1219-1243.]

The ecological functions of wetlands that provide value to society fall into three major groups: 1) hydrologic 2) improving water quality, and 3) habitat and maintaining food webs. Functions are first scored based on: 1) the potential of the site to provide each of three functions, 2) the potential the landscape has to maintain each function at the site scale, and 3) the value each function may have for society. Each aspect of the function is then transformed to a qualitative rating of high, medium, or low.

The scores for each of the three functions at the wetland being altered (impact site) are used as the basis for calculating how much mitigation is needed. The gains in functions and values at a mitigation site are compared to the losses at the impact site to determine if the "no-net-loss" policy is being met.

First, the wetland being altered is rated for its functions and values and these ratings are transformed into a currency called "acre-points." The acre-points lost at the impact site are called the "debits." The gains in functions described in the mitigation plan are also calculated and these are called "credits." Appendix E has worksheets for doing both calculations. A mitigation project is usually deemed adequate when the "credit" score for the project is higher than the "debit" score for the impacted wetland. These calculations, however, are not intended to represent a quantitative measure of loss or gain in functions. Rather, the results provide qualitative ratings of the functions that are then transformed into numbers for the purpose of tracking changes.

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Appendices:

Acknowledgements

The Credit-Debit Method would not have been possible without the help of all those who have participated in developing Ecology's earlier wetland tools on which this one is based. These include the seven methods for assessing wetland functions, the two wetland rating systems, and the two volumes of guidance for managing wetlands. The Credit-Debit Method described in this document relies heavily on the data we collected and the experience we have gained over the last 15 years. All together, over 100 wetland scientists, regulators, and planners have participated in Ecology's efforts to provide usable tools to better manage our wetlands. We have published their names in Appendix A of each of the previous documents (Ecology publications #99-115, #00-06-47, #04-06-025, #04-06-015, #05-06-008). All these experts volunteered more than 6000 hours of their time to improve our knowledge and management of the wetlands in our State. In addition I would like to thank the 25 reviewers of the first draft and the operational draft of this method. Their comments and recommendations were an important part of process in developing this tool. Their comments and my responses to them will be available in a separate document. Finally, thanks to Yolanda Holder who made sure I crossed all my "t's" and dotted my "i's".

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CHAPTER 1

Introduction

1.1 Background

Wetlands are complex ecosystems that can improve water quality, provide natural flood control, provide important habitat, and stabilize shorelines. They often support a wide variety of plants and animals, including rare and endangered species, migratory birds, and the young of commercially valuable fishes (NRC 2001). In recent years, concern about the loss of wetlands in the United States and in Washington State has led to efforts to protect wetlands on both public and private lands. Compensatory mitigation is one of the ways used to protect the functions and values of wetlands that are lost as a result of changes in land use.

Definition of Compensatory Mitigation

For purposes of Section 10 and Section 404 of federal laws, compensatory mitigation is the restoration, creation, enhancement, or in exceptional circumstances, preservation of wetlands and/or other aquatic resources for the purpose of compensating for unavoidable adverse impacts which remain after all appropriate and practicable avoidance and minimization has been achieved.
http://www.nap.usace.army.mil/cenap-op/regulatory/definitions.html#Comp%20Mit

The basic policy used in compensating for impacts to wetlands is called the "No Net Loss" policy. "No net loss of wetland functions and values" is a Federal and State policy goal that emerged in 1989 and has been a mainstay of land use regulations since then (NRC 2001). To date, the no net loss policy has been interpreted to mean that wetlands should be conserved wherever possible, and that wetlands converted to other uses must be offset through compensatory mitigation to provide the same functions and values that have been lost. However, the National Academy of Sciences has concluded that mitigation projects have not met the policy goal despite some progress in the last 20 years (NRC 2001).

Many tools have been developed to understand the functions and values of wetlands. The methods range from detailed scientific analyses that may require many years to complete, to the judgments of individual resource experts done during one visit to the wetland. Managers of our wetland resources, however, are faced with a dilemma. Scientific rigor is often time consuming and costly. Tools are needed to provide information on the functions and values of wetlands in a time- and cost-effective way (Kusler 2004). One way to accomplish this is to rate wetland functions by their important attributes or characteristics based on the collective judgment of regional experts. Such methods are relatively rapid but still provide some scientific rigor (Hruby 1999).

The purpose of the Credit-Debit Method (method) is to provide a tool by which applicants and regulators can determine if actions taken to mitigate an impact to wetlands will adequately replace the functions and values lost. It is based on the Washington State Wetland Rating System for Western Washington (Ecology publication #04-06-025). The method also incorporates improvements in rating functions and values that have been developed for "rapid" methods since then and that have been summarized in Hruby (2009).

Chapter 2 provides an introduction to methods used in Washington State to characterize wetland functions and how they were calibrated. Chapter 3 describes the process used for estimating losses in functions that result from impacts to wetlands and the gains that can be achieved through compensatory mitigation. Chapters 4 and 5 are the "field guide" for collecting the data needed to calculate gains and losses in functions and values. Appendices A and E contain the worksheets for rating functions and values and then calculating the gains and losses in functions.

The Credit-Debit Method is suitable only for freshwater vegetated wetlands as defined by state and federal delineation manuals. It should not be used for estuarine wetlands, streams, or upland riparian areas. Furthermore, the ratings of functions and values are valid only for entire wetland units as defined in Chapter 4. As of February 2012, no rapid methods have been calibrated for the wetlands in the State that can rate small sub-areas of wetlands in an accurate and repeatable manner.

1.2 The Credit-Debit Method in Relation to Other Wetland Guidance by Ecology

This document is one of a series of guidance documents developed by the Department of Ecology to improve wetland mitigation and protection in the State of Washington. The first document was the original wetland rating system published in 1991. Since then the department has been expanding and revising their guidance documents to incorporate the latest scientific information about wetlands and mitigation. For example, the current version of the wetland rating system for western Washington published in 2004 (Ecology publication #04-06-025) is the third revision of this guidance, and the 2006 joint agency guidance for developing mitigation plans (Ecology publication #06-06-011b) is an update of the 1994 joint agency publication on the same topic (Ecology publication #94-029).

The recommendations made in these documents from Ecology are not regulatory requirements. They do, however, provide useful information for protecting wetlands and doing mitigation. The Credit-Debit Method provides one tool for determining the adequacy of compensatory wetland mitigation. It does not set any new regulatory requirements. Many local regulations use area-based ratios to determine mitigation requirements, and this guidance does not change these regulatory requirements.

The Credit-Debit Method is Technical Guidance

The method for calculating mitigation requirements is not a regulation. It does not have any independent regulatory authority and it does not establish new regulatory requirements. Its use, however, may be requested by regulatory agencies or local jurisdictions.

Existing laws, regulations, and policies require that impacts to wetlands be mitigated to replace the functions, values, and area lost. Currently mitigation ratios are the most commonly used approaches to determine the adequacy of wetland compensatory mitigation. The Credit-Debit Method provides regulatory agencies, developers, and project proponents with another method to apply at the project level. If the method is implemented correctly, it should result in compliance with existing requirements for offsetting the losses of wetland functions and values.

The Credit-Debit Method is not the only method for providing an estimate of wetland functions that can be used in determining mitigation needs. As of February 2012, however, it is the only "rapid" method available in Washington that has undergone peer review and been calibrated to wetlands in the State. Studies done using other indicator-based methods all conclude that results are not accurate unless they are calibrated for the wetlands within a region. This has been found in Oregon, Pennsylvania, New Jersey, and the Appalachian region (Adamus and others 2010, Stander and Ehrenfeld 2009, Cole and others 2002, Rheinhard and others 1997, Cole and others 2008). The Credit-Debit Method was calibrated in 120 wetlands in western Washington and 91 wetlands in eastern Washington.

Using the Credit-Debit Method will change how the requirements for mitigation are calculated. Past guidance (Ecology publication #05-06-008) recommends that Wetland Category, the type of mitigation, the risk of failure, and the temporal loss of functions be used as factors in calculating the area of mitigation required. This is called the "mitigation ratio" and is summarized as the acres of mitigation required for each acre of wetland that is altered or lost. The mitigation ratio will probably remain one way to establish the adequacy of a mitigation project for some time to come because it is well known, has been accepted by both applicants and regulators, and has been incorporated into regulations.

The Credit-Debit Method substitutes a rating of three wetland functions and their values for the wetland category to provide a more accurate measure of wetland losses and gains. The method no longer uses area as the "currency" for estimating the adequacy of a mitigation project. It does use area as a factor, but it also includes a score for the rating of a function to define the "currency." This new currency is called "acre-points." The method still uses the type of mitigation, the risk of failure, and the temporal loss of functions as factors in the calculations. The values assigned to these latter factors, however, have been modified slightly from the previous Ecology guidance to reflect the latest scientific information (see discussion in Chapter 3).

This final draft of the Credit-Debit Method has undergone a two-step review process. The operational draft released in February 2011 included peer review and general public review as well as eight months of field testing. This final draft has undergone a year of field testing as well as further review by wetland scientists and wetland experts.

1.3 Process for Selecting a Mitigation Site

Selecting a mitigation site that compensates for the functions and values (now commonly called "ecosystem services") lost at the impact site is a complex process. First, you must identify the functions and values lost at the impact site, then you must try to find a site where those functions can be compensated, and finally you must determine if the mitigation will be feasible and sustainable. Figure 1 provides a graphical representation of the steps that should be taken in selecting an appropriate mitigation site. This method addresses only two of the questions in the process (the two boxes highlighted with a shadow in Figure 1). Figure 1 also includes the web links to other guidance documents published by the Department of Ecology that can help you address the other questions.

Figure 1: The technical questions that need to be addressed when developing wetland compensation projects. Other Department of Ecology guidance documents on the subjects are listed with links to their location on the Ecology web site.

Can impacts to wetlands and their buffers be avoided and minimized?
Guidance on avoidance and minimization
forthcoming

↓

What functions and values will be lost when you alter the wetland?
Credit Debit method – this document

↓

Do you need to replace the specific functions and values lost in the wetland that is altered?
OR,
Should your mitigation restore important functions and values identified in regional or watershed plans?
These questions need to be addressed in discussions with the regulatory agencies on a case by case basis

↓

Choose a possible site for mitigation, then ask: Will the site be sustainable and will mitigation actions improve ecological processes at a watershed scale?

Methods for analyzing landscape processes
http://www.ecy.wa.gov/biblio/1006014.html
http://www.ecy.wa.gov/biblio/0506027.html
Guide for Selecting Sites Using a Watershed Approach
http://www.ecy.wa.gov/biblio/0906032.html

↓

Does the mitigation site have constraints that might prevent you from improving the functions you need to replace?
Guide for Selecting Sites Using a Watershed Approach
http://www.ecy.wa.gov/biblio/0906032.html

↓

Can actions taken at the mitigation site increase functions and values enough to compensate for the functions and values lost?
Credit Debit Method – this document

↓

Develop a mitigation plan for the site

Guide for developing mitigation plans
http://www.ecy.wa.gov/biblio/0606011b.html

1.4 How the Method Works

The forms attached at the end of this document ask the user to collect information about the wetland to be altered and the mitigation site in a step-by-step process. These steps include:

1. Establish a wetland unit for rating impacts to functions (Chapter 4).
2. Classify the wetland unit using the Hydrogeomorphic (HGM) classification (Chapter 5).
3. Rate the functions and values being lost (Chapter 5, and Appendix A).
4. Estimate the amount of mitigation you will need (Debits Worksheet in Appendix E).
5. Choose a possible mitigation site and develop an outline of the actions you propose for creation, re-establishment, rehabilitation, enhancement, and/or preservation.
6. Rate the functions of the mitigation site in the future based on your draft plan (Chapter 5, Appendix A).
7. Estimate the gains in functions through mitigation (Credits Worksheet in Appendix E).
8. Determine if your mitigation will replace the functions and values lost (Summary in Appendix E).

We recommend careful reading of the guidance before filling out the forms. You need to be sure that the correct forms are being used. For this reason, it is important to understand the system used to classify wetlands (see Chapter 5).

Three functions of wetlands are characterized: hydrologic functions, improving water quality, and habitat. Each function is rated based on three aspects of the functions – the site potential, the landscape potential, and the value to society. The final score for a function can range from 3-9 and is based on assigning a score of 1, 2, or 3 to the ratings of high, medium, or low.

1.5 Time Involved

The time necessary to rate the functions of wetlands will vary from as little as fifteen minutes to several hours. Several of the questions on the Scoring Form are best answered by using aerial photographs, topographic maps, other documents, or a combination of these resources with field observations. Filling out the Scoring Form, however, does require a site visit to answer some of the questions that cannot be answered from aerial photographs. In some cases, it may also be necessary to visit the wetland more than once. Some of the questions cannot be answered if the ground is covered with snow or the surface water is frozen. If this is the case at the time a site is being characterized, it may be necessary to revisit the site later.

1.6 Experience Needed to Complete the Form

It is important that the person(s) using the Credit-Debit Method have experience and education in identifying natural features, indicators of wetland function, plants classes, and some ability to distinguish geomorphic differences in the landscape. We recommend that knowledgeable environmental consultants or wetland experts be used to analyze most sites, particularly the larger and more complex ones.

In addition, users of this method should be familiar with the Washington State Wetland Rating system for Western Washington, and have taken the training provided by the Department of Ecology on this method. Most of the data needed to fill out the Scoring Form (>90%) are also found on the form used in the Washington State Wetland Rating System.

Users of this method who have not taken the training on the wetland rating system or this Credit-Debit Method can expect that, **on the average**, their scores for the functions will be off by at least 1 point. This is based on data collected during the calibration of the wetland rating system and subsequent training sessions. Untrained users will underestimate, or over estimate, the amount of mitigation required by 15%. This is an average, and actual differences may be as high as 40%.

CHAPTER 2

Modeling Functions and Values in This Rapid Method

2.1 The Structure of the Method

Rapid methods for analyzing the environment often use data that are both qualitative and quantitative. The analyses may also involve numeric models that in themselves represent qualitative, multi-criteria, decision tools (Hruby 1999). As a result, generating a single score or index for a wetland function requires algorithms (rules that are similar to equations), for combining different characteristics that may not be mathematically compatible. Qualitative data and quantitative data both have to be transformed into ordinal numbers so they can be combined. In the method described here, wetland functions are first scored using ordinal numbers based on three separate aspects of a function (Site Potential, Landscape Potential, and Value). Each aspect is then rated as [H]igh, [M]edium, and [L]ow based on the sum of the ordinal numbers. The ratings are combined using a decision matrix that assigns final scores to each function (see first page of the field form in Appendix A).

The three aspects of functions used to rate it are: 1) the potential of the site to provide each of function, 2) the potential the landscape has to maintain the function at the site scale, and 3) the value each function may have for society at that location. Each aspect of a function is scored, but the score is transformed to a qualitative rating of high, medium, or low. The rating of each aspect is then given equal weight in the final score for that function.

The questions and scoring of the "site potential" used in this method are the same as the "Potential" used in the Washington State Wetland Rating System for Western Washington (Ecology publication #04-06-025). The "opportunity" score from the wetland rating system, however, is not used. Rather, the information once provided by the opportunity score is expanded into two categories. Functions are rated based on their "landscape potential" and the "values" instead of opportunity. These changes provide better information to meet the objectives of this method.

The numeric models used to characterize functions in rapid methods do not model actual environmental processes but rather are multi-criteria decision models where each indicator represents a decision criterion to describe the level of function (Hruby 1999).

2.2 Wetland Functions and Their Indicators

The functions provided by wetlands derive from the interactions among different components of the ecosystem and the landscape. These interactions are called *environmental processes*. Processes are dynamic and can occur at all geographic scales. Thus the functions performed by a wetland can be influenced by events occurring within the wetland unit as well as in the watershed. For example, the river adjacent to a wetland may be deepened (downcut) as a result of increased runoff from up-gradient development. This changes the effectiveness of the wetland at storing overbank flood waters (a hydrologic function).

Any factor that changes how well, or how much, a function is performed by a wetland can be considered a "control" of that function. Another term often used in the scientific literature is *driver*. The drivers of functions in wetlands determine how well the functions are performed. An event that affects a driver is called a *disturbance* by ecologists (Dale and others. 2000). The type, intensity, and duration of disturbances can significantly change environmental processes (Dale and others 2000), and thereby wetland functions.

Climate, geology, and the topography are major processes in a watershed that control how water, sediment, and nutrients move. These processes, along with factors that occur within the boundary of a wetland, control the functions performed by the wetland. If human activities change these processes in a watershed then the functions in a wetland will also change (Sheldon and others 2005). Any rating of functions at a site, therefore, also requires information about the watershed in which it lies.

The ecological functions that provide value to society fall into three major groups: 1) hydrologic [e.g. flood storage], 2) improving water quality, and 3) habitat and maintaining food webs. Each of these can be sub-divided into separate functions. For example, hydrologic functions may include flood storage, velocity reduction, groundwater recharge, and de-synchronization of flood-flows (Hruby 2001). The Credit-Debit Method characterizes only the three major groups of functions to maintain consistency with the rating system on which it is based (Hruby 2004b).

In "rapid" methods such as this one, functions and values are analyzed by answering a series of questions that note the presence, or make simple measurements, of environmental indicators. Indicators are easily observable characteristics that are correlated with quantitative or qualitative observations of the performance of a function (Hruby 1999, NRC 2002). Most indicators represent relatively stable characteristics that describe the structure of the ecosystem or its physical or geologic properties (Brinson and others 1995). Indicators, unfortunately, cannot reflect actual rates at which functions are performed because rates can change in time. Our knowledge however, "is sufficiently well developed such that indicators can be used as shortcuts to judge whether functions are occurring at appropriate levels" (NRC 2002, p. 120).

2.3 The Values of Functions

The three basic functions rated in the Credit-Debit Method are all considered to be valuable and need to be replaced if lost. The wetland functions that are addressed in the tools developed by Ecology for Washington State are defined as the ecological processes that provide services/values to society (Hruby 2001). This is a subset of the possible functions wetlands perform. There are many ecological processes that are not usually considered of any significant value to society (e.g. providing habitat for Nematode worms or mosquitoes; taking up nitrogen from surface waters but then releasing back into the surface water when plants decompose).

Since all three functions are considered to be valuable, the approach used in the "value" sub-unit of the method is to rate the values relative to other wetlands in the landscape. The value part of the score is intended to highlight those wetlands where a function is more valuable to society because of factors in the surrounding landscape. For example, flood storage is more valuable in a watershed where flooding causes major damage than in a watershed without flooding. A wetland that is moderately effective at cleaning up pollutants is assigned a higher value if it is in a watershed that already does not meet water quality standards. In this case, the wetland removes pollutants that would otherwise further degrade water quality. A wetland that provides habitat for Threatened and Endangered Species (T/E species) is more valuable than one that provides habitat for other wetland dependent species since society has passed laws that give preference and added value to T/E species.

2.4 Calibrating the Indicators

An initial list of indicators identified from a review of the literature was used to develop protocols and data sheets for sampling reference sites. Indicators were divided into three types:

- Those present at the site itself (indicators of site potential).
- Those found in the surrounding landscape (indicators of landscape potential).
- Those that indicate the function performed is providing some value to society (indicators of value).

Data on each indicator were collected at a minimum of 20 sites for each Hydrogeomorphic Class of wetlands in western Washington. Sites were chosen to represent the widest possible range of environmental conditions found in the class. Data on some of the indicators could be collected from aerial color photographs, but all of this information was verified by at least one visit to each site.

The calibration process involved the following steps:

1. Deletion of indicators that could not be readily estimated from aerial photographs or during a brief field visit (< 3hrs). This represents a compromise between the science and the needs of the user. Some important indicators of function could not be used because they could not be measured within the time allocated, or could not

be collected with reproducible results by the majority of environmental scientists. For example, the organic or clay contents of wetland soils are an important indicator of chemical processes that improve water quality (Rosenblatt and others 2001, NRC 2002), but these cannot be readily measured in the field. The indicators of organic and clay soils therefore had to be simplified. Users are asked to determine if organic soils or clay soils are present in the unit based on the mapping done by the National Resource Conservation Service (NRCS). If it is not mapped, users are asked to perform one simple field test to determine if the soil meets the NRCS criteria. If the organic or clay content does not meet the percent needed to classify it as an organic soil or clay soil, the unit is considered not to have the indicator. In this case, the reproducibility of the data collection among different users was judged to be more important than achieving additional scientific rigor by scaling the amount of organic or clay material in the soil.

2. Reviewing the literature on wetland indicators, and determining what aspect of the indicators represent the high and low levels of functioning.

3. The data for each indicator collected at the reference sites are then sorted based on the values representing the highest level of function to the lowest in the reference wetlands. This ranking of data generates a distribution that is used to help determine where the breaks in the scoring should occur. The final decisions on scoring, however, were developed from graphical analyses of the distribution of scores of all sites. The goal was to ensure a relatively even distribution of ratings among the calibration sites. Although statistical methods are being developed for multi-criteria decision models (e.g. Ferguson and others 2007, Fuller and others 2008), these methods are not yet applicable to a categorization that incorporates values, special characteristics, as well as quantitative indicators.

4. Developing an independent, and qualitative, assessment of how well a wetland performs a function and then calibrating the scores of the indicators to get the best fit to the independent assessment. The calibration involved alternatively changing the scoring for each indicator and the scaling within an indicator to get the best fit to the independent assessment.

Further details on the approach used to calibrate the rapid assessment methods developed by Ecology can be found in Hruby and others (1999), Hruby (2001), and Hruby (2009).

CHAPTER 3

Estimating the Adequacy of Wetland Mitigation

> Sites for mitigation in western Washington should be chosen using the latest guide from the Department of Ecology, the U.S. Army Corps of Engineers, and the U.S. Environmental Protection Agency. As of February 2012, this is *Selecting Wetland Mitigation Sites Using a Watershed Approach* (Ecology publication #09-06-032 http://www.ecy.wa.gov/biblio/0906032.html).

The adequacy of a mitigation project is estimated by filling out worksheets that score the functions and values of the wetland being impacted (called debits) and then score the increase in functions that result from activities described in the mitigation plan (called credits). Appendix A has the worksheets for scoring the functions at both the impact and mitigation sites. Appendix E has worksheets for calculating the debits and credits for these functions. A project is usually deemed adequate when the "credit" scores for the three functions are higher than the "debit" scores for these same functions. The calculations, however, are not intended to represent an exact measure of loss or gain in functions. Even though the method uses numbers, it depends on qualitative ratings of the level of functions that were developed through a formal decision making process described in Hruby (1999, 2001).

The worksheets in this method are intended to establish a clear, understandable, and consistent method for determining if a mitigation project will replace the functions and values lost when a wetland is altered. **However, nothing in this method should be interpreted as a promise or guarantee that a project which satisfies the guidelines given herein will be assured of approval.** Also, the method does not change any requirements given in the 404(b)(1) Guidelines or other applicable regulations regarding avoidance, sequencing, minimization, etc. Such requirements need to be addressed independently of this method.

> **NOTE**: The Credit-Debit Method should not be used in developing design criteria for a mitigation plan because it does not provide enough detail. For guidance on developing mitigation plans please see Ecology's guide on this subject: (Ecology publication # 06-06-011b, http://www.ecy.wa.gov/biblio/0606011b.html).

The Credit-Debit Method is **not** appropriate for:

- Projects planning to use a wetland mitigation bank, unless the method is specified in the mitigation banking instrument for the bank.
- Wetlands that meet any of the criteria listed in the "Special Characteristics" section of the rating systems for western Washington. Mitigation for wetlands with Special Characteristics needs to be addressed on a case-by-case basis.
- Addressing impacts to societal values (e.g., historic, cultural, aesthetic) that may need to be mitigated in addition to the environmental functions.

3. 1 Information Needed When Using the Method

You will need the following information to determine if the compensatory mitigation you are planning is adequate to replace the functions and values lost at the impact site.

1. Mitigation Plan

You will need a draft mitigation plan that provides enough detail to properly fill out the worksheets and estimate the mitigation credits available. The plan should be prepared according to the guidance developed by Ecology, the US Army Corps of Engineers (Corps), and US Environmental Protection Agency (EPA) for Washington State (Ecology publication #06-06-011b, http://www.ecy.wa.gov/biblio/0606011b.html).

2. Score for Loss of Functions at Impact site

You will need to score the functions of the wetland being altered before the impacts are sustained using the Scoring Form described in Chapter 5. **The scoring has to be based on a "wetland unit" as defined in Chapter 4**. The method is not scientifically valid if you score only the area that will sustain the impacts (impact area). You will however calculate the amount of mitigation needed based only on the area of the wetland being altered.

3. Score for the Gain in Functions Resulting from Mitigation

You will need to score the functions of the site proposed for the mitigation using the same method. Use the information in the draft mitigation plan to estimate what the indicators of function would be when all the goals for the mitigation site have been achieved. If the proposed mitigation site is already a wetland (e.g. you are doing re-habilitation or enhancement) you will need to score the functions for the existing conditions as well. In the latter case, the scoring again has to be based on a "wetland unit" as defined in Chapter 4.

Two calculations are needed; one to quantify the amount of impact sustained, and one to quantify the amount of mitigation proposed. These are called the Debits and Credits. The "currency" for the transaction is a number called an "acre-point." It represents a score for a rating of wetland function assigned to one acre. The size of the impact or proposed mitigation is multiplied by the score for a function to determine how many acre-points are needed. For example, a wetland may score 7 points for habitat functions on the Scoring

Form. If the footprint of the impact is 0.5 acres, the amount of mitigation required is 3.5 acre-points of the habitat function.

Debits: Debits are the amount of mitigation, in acre-points, needed to replace the functions lost at the impact site. The debits are based on the existing condition of the wetland before the impact. For example, if a wetland is to be impacted by filling, then the debits shall be calculated based on the existing, unfilled, condition.

You will be calculating three separate values for debits: one for each of the three functions (improving water quality, hydrologic function, and habitat functions).

Credits: The increase in functions, measured in acre-points, that results from the activities at the mitigation site. The credits are calculated based on the conditions in the wetland expected at the time when all structural and hydrologic elements proposed in the plan have reached maturity. If different types of mitigation are proposed for different areas of a site, then each such area will need a separate calculation of credits (see Section 3.3). For example, the creation of an emergent marsh in one area and the enhancement of a forest community in another will require separate calculations. The credits are then totaled to calculate the overall credits generated by the mitigation plan. In addition, if mitigation is proposed for different sites, then a worksheet should be prepared for each site and the credits for each function added together to determine if the mitigation is adequate.

You will be calculating three separate values for credits: one for each of the three functions (improving water quality, hydrologic functions, and habitat functions).

A mitigation plan is deemed adequate for replacing the functions lost when the credits that will be generated through the mitigation are at least as large as the debits resulting from the impact **for each of the three functions individually.** Thus,

Credits - improving water quality ≥ Debits - improving water quality

Credits - hydrologic function ≥ Debits - hydrologic function

Credits - habitat function ≥ Debits - habitat function

NOTE: It is not always necessary to replace all three functions at one site. In some cases, especially in urbanizing areas, a mitigation plan that replaces hydrologic and water quality functions nearby and the habitat functions in another hydrologic unit might be more sustainable.

NOTE: It may be possible to negotiate an exchange of functions where excess credits for one function are used to balance a lack of credits for another function. This may be appropriate in areas where a watershed plan or watershed analysis has indicated there is a higher need for restoring one function over another, or where other data exist showing one function is more important than another.

4. Maps and aerial photographs

Some of the information required to rate the functions can be obtained from aerial photographs. We suggest you print out aerial photos of both the impact and mitigation sites for mapping the information required in the Scoring Form.

The amount of mitigation required (debits) and the amount of mitigation achieved (credits) depends on the types of plants at both the impacted site and the mitigation site. It is important therefore to map the Cowardin plant classes within the wetland being impacted and at the mitigation site. Use the procedures for mapping Cowardin classes that are described in Section 5.2.

You will also need to map separately the areas that will be created or re-established from those that will be rehabilitated or enhanced. Credits will be calculated separately for each type of mitigation.

3.2 Calculating Losses in Functions and Values (Debit Worksheet)

Use the Wetland Scoring Form in Appendix A to determine the scores for each function in the wetland being altered or filled. **The scores need to be determined for the entire wetland unit.** Chapter 4 describes how to establish a wetland unit. The procedures for collecting the data needed to fill out the Scoring Form are described in Chapter 5. Finally, transfer the ratings and scores from the first page of the scoring sheet to the Debit Worksheet.

Temporal Loss Factors

Scientific studies have shown that it will take decades if not centuries to fully replace the functions lost at an impact site even if the mitigation is started concurrently with the impacts (reviewed in Sheldon and others 2005). If functions are replaced only to the level present at the impact site there will be a net loss of functions for the project (Figure 2).

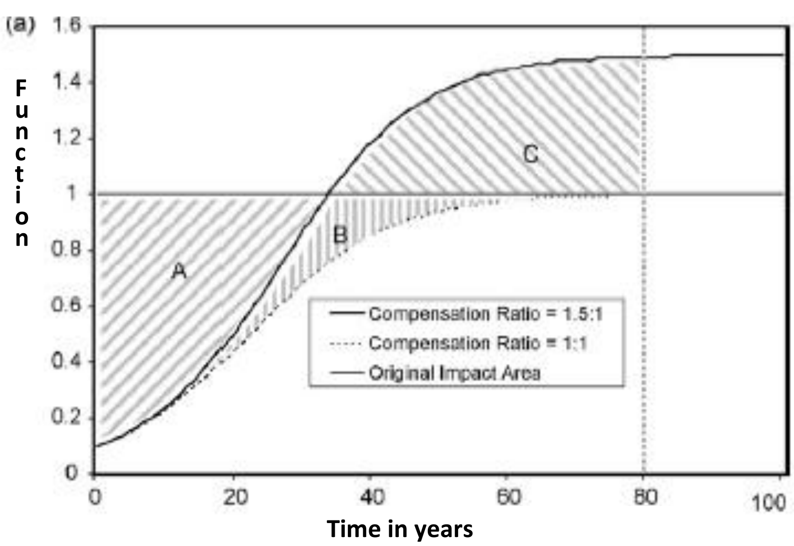


Figure 2 (from Bendor 2009): A hypothetical graph showing temporal loss of functions for two mitigation scenarios. If functions are replaced only on a one for one basis there is a net loss of functions (area A+B on the graph). A "no net loss" of functions is achieved only when Area A on the graph is equal to or smaller than Area C on the graph.

Regulators often require compensation for such temporal losses in functions by increasing the size of the mitigation needed (Bendor 2009). This is known as the "mitigation ratio," which is currently defined as the ratio of the area of mitigation required to the area of wetland impacted (Figure 2).

Previous Department of Ecology guidance (Granger and others 2005) recommends a ratio of 1.5:1 to account for the temporal losses in functions to emergent and shrub wetlands. The ratio is 2.2:1 for forested wetlands. These ratios are based on area only, not functions. There have been suggestions that such ratios are too low (Bendor 2009), but the ones recommended by Ecology were used as the starting point in developing the temporal loss factors (ratios) in this method.

The temporal loss of functions is included in the calculations of Debits since it represents an impact on the wetland resource and is not related to the type of mitigation being proposed. The temporal loss factors in the worksheet are further refined by the plant community being altered. Forests, especially evergreen forests, take longer to mature and so the functions they support will take longer to become established. As a result, the temporal loss factor is larger for evergreen forests than for deciduous forests, and the loss factor is higher for forests than for emergent or shrub communities.

If a mitigation project is done in advance of an impact we can assume the overall temporal losses will be reduced. Some of the functions, such as the hydrologic ones, can be established fairly early in the evolution of a mitigation site. Thus, the temporal loss factor is set at 1.25:1 for advance mitigation rather than 1.5:1.

On the other hand, if a mitigation project is delayed, and impacts are incurred before a mitigation project is installed, there is an increase in the temporal losses. Thus, the temporal loss factor is increased for projects that are delayed. To avoid a higher temporal loss factor, the physical alterations at the mitigation site have to be completed within one year of the impacts. The plantings, however, may be delayed by up to two years, if needed to optimize conditions for success. Construction that is not completed in this time frame has a higher temporal loss factor. A dynamic modeling of temporal losses in functions has indicated that delays of more than 10 years will always result in a net loss and cannot be corrected by increasing the ratios - even to 100:1 or higher (Bendor 2009).

> **NOTE:** The ratings, scoring and calculations are valid for only five years because wetlands and their functions will change with time. If delays in the construction of the site are more than 5 years the mitigation plan will probably have to be re-negotiated and the calculation re-done. This time limit was chosen to be consistent with time that the U.S. Army Corps of Engineer considers delineations to be valid.
>
> **NOTE:** In general it may take decades or more for mitigation sites to develop to the point where they fully perform ecological functions. The hydrologic functions of depressional wetlands, however, can sometimes be created or restored to the proposed levels as soon as the project is constructed. In this wetland class, the function depends mostly on the amount of storage in the unit and the characteristics of its outlet. These are characteristics of a depressional wetland that can be established at the time of

construction. It may be possible to negotiate a lower temporal loss factor for the hydrologic functions on a case-by-case basis. In this case you will need to demonstrate how the hydrologic functions will be restored at the time of construction. Factors that need to be discussed include, but are not limited to:

1. The predicted water levels in the depressional wetland relative to the outlet elevations.
2. Detailed contours (elevations) of the proposed mitigation site.
3. Evidence that excavations will not pierce aquitards that could drain the wetland.

A reduction in the temporal loss factor for the hydrologic functions, however, is generally not appropriate for riverine, lake-fringe, or slope wetlands. The hydrologic functions in these HGM classes partially depend on the structure of the plant community, and this can take several years to develop.

Temporary Impacts

Some impacts to wetlands can be considered temporary. An activity in a wetland may impact the functions for a time, but the functions can be re-established on site. Examples include laying pipelines or power lines through wetlands. The Army Corps of Engineers, the U.S. Environmental Protection Agency, and Ecology divide temporary impacts into two categories: those that can be considered short-term and those that are long-term. The definitions below are based on those from the interagency guide *Wetland Mitigation in Washington State: Part 1: Agency Policies and Guidance* (Ecology publication #06-06-011a).

Short-term temporary impacts last for a limited time. In general, an impact is considered short-term if the functions return to pre-impact levels within one year or one growing season of the impact. For example, cutting emergent vegetation without damaging the soil structure is a short-term impact. The emergent vegetation that is cut will usually return within one growing season if the disturbance is not severe. Cutting shrub species that are fast growing, such as willow, may also be considered as short-term temporary impacts. The cutting of forests that take decades to grow, however, is not considered short-term. Compensatory mitigation is often not required for short-term temporary impacts.

Long-term temporary impacts last for more than one year but the loss of functions will eventually be restored over time. Long-term temporary impacts or alterations also carry a risk of permanent loss if the ecosystem is changed. Examples include soils that are compacted by equipment, deep excavation, or pipeline trenches that alter the water regime. Clearing a forested wetland for a temporary access road changes the plant community and degrades functions, such as song bird habitat provided by the tree canopy. It will take many years for a forest to grow back and re-establish the previous level of function.

Long-term temporary impacts should be rated and scored as if they were permanent impacts with the mitigation occurring within the footprint of the impact. The mitigation is then considered as re-establishment in an area where wetland functions were absent for a time. If all the functions at the site are re-established to their previous levels, the mitigation site would have the same scores as the site before the impacts. The only additional mitigation needed would be to compensate for the temporal loss of functions and for the potential risk the re-establishment would fail. Risk is part of the credit calculations in the next section.

NOTE: Some sites used for new pipelines or power lines can never be fully "restored" to their previous condition because the vegetation may need to be cut or mowed on a regular basis to provide access for service. In this case, the future condition of the re-established site can only be scored based on its "mowed" or "cut" condition. Score the indicators on the form based on a description of the conditions at the site when it is mowed or cut.

NOTE: Some long-term temporary impacts may change the water regime to the extent that the Hydrogeomorphic class of the wetland will change. For example, a pipeline through a slope wetland may create a raised berm that impounds water and changes the wetland to a depressional one. In this case, the future condition of the site should be scored and rated based on what the HGM class will be in the future.

NOTE: Some long-term temporary impacts to highly degraded wetlands may be successfully mitigated within the original footprint of the impact. All the temporal losses of functions and risks of failure could be addressed by improving the functions of the impact site beyond what they were before the impact.

3.3 Calculating Gains in Functions and Values Proposed Through Mitigation (Credit Worksheet)

The increases in wetland functions and values that result from mitigation activities are calculated the same way as the Debits. If a project establishes a wetland from an upland (also known as creation), or re-establishes a wetland, then it is assumed that the mitigation site had no wetland functions to start. You calculate credits assuming all functions score [0] in the beginning. If the mitigation includes an existing wetland (rehabilitation or enhancement), the credits will be based on the difference between the current scores for the wetland unit and the future scores. This is often called the “Lift” in functions. The four types of mitigation activities are defined in the box below.

Definitions of Mitigation Activities

Establishment (Creation). The manipulation of the physical, chemical, or biological characteristics present to develop a wetland on an upland or deepwater site, where a wetland did not previously exist. Establishment results in a gain in wetland acreage and function. (**NOTE**: The U.S. Army Corps of Engineers’ Regulatory Guidance Letter 02-02 uses the term “establishment” rather than the previously accepted term “creation.” Federal agencies, as well as the Department of Ecology, have started using the term “establishment.”)

Re-establishment. The manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural or historic functions to a former wetland. Activities could include removing fill material, plugging ditches or breaking drain tiles.
Re-establishment results in a gain in wetland acres and functions.

Enhancement. The manipulation of the physical, chemical, or biological characteristics of a wetland site to heighten, intensify or improve specific function(s) or to change the growth stage or composition of the vegetation present. Enhancement is undertaken for specified purposes such as water quality improvement, flood water retention or wildlife habitat. Activities typically consist of planting vegetation, controlling non-native or invasive species, modifying site elevations or the proportion of open water to influence hydroperiods, or some combination of these. Enhancement results in a change in some wetland functions and can lead to a decline in other wetland functions, but does not result in a gain in wetland acres.

Rehabilitation. The manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing natural or historic functions and processes of a degraded wetland. Activities could involve breaching a dike to reconnect wetlands to a floodplain, restoring tidal influence to a wetland, or breaking drain tiles and plugging drainage ditches. Rehabilitation results in a gain in wetland function but does not result in a gain in wetland acres.

Use the Scoring Form in Appendix A to determine the scores for each of the three functions before the mitigation project is started, and for the time when the site has matured. Use the information in the draft mitigation plan to estimate what the indicators of function would be when the site has met its goals for water regime, physical structure, plant communities and soils.

Risk Factors

All studies of compensatory mitigation reviewed by Ecology (Sheldon and others 2005) and the National Academy of Sciences (NRC 2002) indicated that many mitigation projects have not been successful at replacing the functions lost through impacts. The studies prior to 2005 showed that about one-half of the mitigation projects involving re-establishment and re-habilitation failed. The failure rate was even worse for enhancement (reviewed in Sheldon and others 2005). As a result, the risk of a failure became a factor in the calculation of how much mitigation is needed. Generally, the risk of failure was compensated by increasing the area of mitigation required (the mitigation ratio) (NRC 2002).

Based on these early studies of the success of mitigation, the Department of Ecology recommended a ratio of 2:1 (based on acreage) to account for the chance that half of the projects would fail (Granger and others 2005). For example, two acres of mitigation were required for every acre of impacts to wetlands to account for the risk of failure. In the Credit-Debit Method we reduce the credits available through mitigation by a “risk factor” rather than asking for an increase in area. This requires a different approach to the calculations. The risk of failure is addressed by multiplying the credits by a number less than one. For example, the original mitigation ratio of 2:1 would be equivalent to a risk factor of 0.5. The credits available through mitigation would be multiplied by 0.5. This means that the increase in functions at the mitigation site has to be twice that of the functions lost to account for risk. Instead of saying that the area of mitigation has to be twice the area of the impacts, we are saying that the increase in functions has to be twice the level of functions lost at the impact site.

Recent data, however, suggests that mitigation has improved, and the risk of failure is less than 50% for replacing functions, and especially for replacing wetland area (Balcombe 2003 – 11 out of 11 mitigation sites successfully replaced habitat functions; Kettlewell and others 2008 - 22% loss of area in 22 sites but some differences in structure and functions; Reiss and others 2009 - 17% rate of complete failure to replace functions in 29 sites; Gutrich and others 2009 - no percentages, but conclusion was that most sites were “relatively successful”). Based on these results, the factor to account for the risk of failure has been reduced in the calculations of how much mitigation is required. Instead of requiring a 2:1 ratio in functions (functions increased through mitigation/functions lost), the ratio has been decreased to 1.5:1.

The calculations used in the Credit-Debit Method start with the gain in functions in a project assuming there is no risk of failure. This basic credit score is then reduced by the “risk factor” to reflect different levels of risk. This requires that the previous mathematical approach be reversed. Rather than calculating mitigation needs by multiplying the "impact" by a factor larger than one, we calculate the adequacy of the mitigation by multiplying the "mitigation" by a factor smaller than one (see example in box below). This approach was necessary because the method is now based on functions rather than area. A mitigation site may provide different levels of increased functions as well as different levels of risk. The approach to the calculations used here makes it easier to determine up front if a mitigation project will replace the functions lost.

Example of how ratios were used to establish risk factors

Example:

- Impact = 10 acre-points to hydrologic functions (2 acres of impact to a wetland with a score of [5] for the hydrologic function)
- If we assume a 75% success rate, the basic mitigation ratio to account for risk of failure is 1.5 to 1. This means mitigation has to provide 10 x 1.5 = 15 acre-points of hydrologic functions to compensate for the 10 acre-points of impacts.

The calculations of risk in this method use the credits provided by the mitigation site rather than the debits incurred at the impact site. The risk needs be on the credit side of the equation because it is the mitigation that is risky, not the impact. If impacts are not multiplied by a risk factor, the credits need to be multiplied by 0.67 to balance the equation. Assume that the mitigation site provides 15 acre-points of hydrologic functions. We calculate: 15 x 0.67 = 10 acre-points. Thus, mitigation adequately replaces hydrologic functions since 10 acre-points were needed.

As a starting point, the basic credits achieved through mitigation are reduced by a risk factor of 0.67 (representing a ratio of 1.5:1) instead of 0.5 (representing a ratio of 2:1).

The risk factor can be further reduced in certain cases. Specifically:

- "If a mitigation project is completed in "advance" and meets the criteria in Ecology's guide for selecting mitigation sites using a watershed approach (Ecology publication #09-06-032) the risk factor is [1.0]. We assume there is little risk of failure and the gains in functions are not discounted. "Advance" mitigation is currently defined in guidance as "At least two years has passed since plantings were completed or one year since "as-built" plans were submitted to regulatory agencies" before impacts are incurred.

- If a mitigation project is completed in advance, but does not meet the criteria in the guide for selecting mitigation sites, the risk ratio is increased to 1:2 to 1. This means the risk factor in the calculation is 0.83

- Concurrent mitigation in which the sites meet criteria in Charts 1 and 3 and the appropriate charts in Charts 4-11 of the Site Selection Guide (Ecology publication #09-06-032) are considered to have a lower risk of failure than the "average" project. We assume that sites identified in watershed plans will be more successful because larger scale environmental processes are taken into account. Furthermore, a watershed plan usually includes analyses of the potential success of different sites chosen for restoration. Such sites are given a risk factor of [0.9]. This is equal to a risk ratio of 1.11:1 instead of 1.5:1. There is still a risk of failure, but it is considered to be less than that of projects whose sites have not undergone a larger scale analysis. *To qualify for this risk factor you will need to submit the answers to the questions in Chart 3 of the guide and fill out the worksheets in Appendix B of the site selection guide.*

- In the absence of a formal watershed plan, you may wish to do your own analysis of the watershed using principles outlined in Chart 2 of the Site Selection Guide (Ecology publication #09-06-032). If this analysis is presented in the mitigation plan and the site also meets the appropriate criteria in Charts 4 – 11 in the guide, the risk factor is [0.80]. This is equal to a risk ratio of 1.25:1 instead of 1.5:1. *To qualify for this risk factor you will need to submit the answers to the questions in Chart 3 of the guide and fill out the worksheets in Appendix B of the Site Selection Guide.*

The experience with mitigation, however, has also shown that certain types of projects have a higher risk of failure when the watershed and landscape processes have not been analyzed. Thus, the risk factor is increased for certain types of projects when no watershed analyses have been done. Specifically:

- Establishing a wetland dominated by herbaceous plants is usually less successful than one dominated by shrubs and trees. The problem lies with the difficulty in controlling aggressive herbaceous plants such as reed canarygrass (Hovick and Reinartz 2007, Wilcox and others 2007). Projects whose goal is to develop an herbaceous plant community are assigned a higher risk than the average. The risk factor is "increased" to 0.5 for sites where no landscape or watershed analyses have been done. This is equal to a risk ratio of 2:1 instead of the basic 1.5:1.

- Creating a wetland from upland often has a higher risk of failure because it is more difficult to create a water regime appropriate for a wetland than to restore one (Hunt 1996). Creation projects that do not provide data to show the water regime is adequate for maintaining a wetland are assigned a "higher" risk factor [0.5 instead of 0.67]. To avoid the higher risk factor proponents of creation need to provide (at a minimum) the following analyses:
    - Proof that excavations will not break through confining layers that keep water near the surface.
    - There is enough water to account for evapotranspiration of the plant community but not too much to flood the entire area.
    - They have the water rights necessary for the water losses through evapotranspiration and infiltration (if surface water is the source).

Preservation

Preservation is a tool used for mitigation even though it does not replace the actual functions or area lost. Preservation is important at a societal level because there is currently no way to continue economic growth or population growth without some type of environmental impacts. Preservation is one way to limit the impact of continued growth on the environment (Semlitsch 2008). Preservation is given mitigation credits based on a number of different factors that include the type of wetland or upland being protected, proximity to the site being altered, and the degree of threat present at the site.

For a wetland, you will need to rate its functions using the Scoring Form in Appendix A and determine its Category using the Washington State Wetland Rating System. In addition, the credits for preserving a Category II wetland can be increased if there are disturbances to the wetland that can be removed or reduced.

Criteria used to determine the credits that can be achieved through preservation of uplands are:

- Its value as habitat based on criteria used by the Department of Fish and Wildlife and the Department of Natural Resources-Natural Heritage Program.
- Location relative to the "impact" site.
- Degree of threat from human activities.

The hydrologic and water quality functions that uplands provide are not directly comparable to those provided by wetlands, and we do not have methods for rating them. Habitat for wildlife and plants are the only functions that are marginally comparable. **As a result, credits from the preservation of uplands can only be used to compensate for impacts to the habitat functions.** Upland areas are assigned a "habitat" score for the purpose of calculating the credits available through preservation.

The Department of Ecology does not have specific guidance on ratios for preservation. As a result, the scaling factors used to calculate credits are derived from the conclusions of the multi-agency team (WSPI) assembled by the Washington State Department of Transportation (WSDOT 1999). Although it is not possible to correlate the ratios in the WSDOT report directly to those used in this method, the low range of possible ratios falls within the range reported in Table 1, of the report (WSDOT 1999). The factors for preservation are scaled so the basic ratio (assuming area is the only criterion) is approximately 4:1 for the preservation of the highest quality wetland under direct threat.

Rather than ratios, the calculations again use scaling factors that are less than one. This maintains consistency with the other credit calculations.

In addition, the best ratios for preservation apply only if the mitigation project includes the creation or re-establishment of wetland area that is equal to the area lost. If wetland area is not replaced acre for acre, the scaling factors are reduced by ½. This represents an increase in the ratio by a factor of 2. This increase represents a policy decision to compensate for the net loss of wetland area that results when an equal area of wetland is not created or re-established. Thus, one would have to preserve approximately 4 acres of the highest scoring wetland (Category I under direct threat) to replace 1 acre of impacts to a Category III wetland if an equal area is created or re-established, and 8 acres of wetland preservation if the wetland area is not adequately replaced.

Certain wetlands and uplands may not be suitable for preservation. Less suitable sites are given low scaling factors that are equal to very high ratios which can exceed 100:1 by area. Some sites might even score a negative "credit" indicating they are completely unsuitable for preservation.

CHAPTER 4

Identifying Wetland Boundaries for Rating

To begin, determine the location and approximate boundaries of all wetlands at the site you are investigating. A surveyed delineation of the wetland, however, is not necessary to complete data collection, unless this information is required for another part of your project. The boundary, however, will need to be verified in the field. Boundaries that are not verified by a field survey may cause problems in the scoring of the indicators. This is especially true in forested wetlands where the boundaries are difficult to determine from aerial photographs.

It is also highly recommended that you obtain aerial photos of the site. The field form identifies the information that needs to be included on aerial photos or maps and submitted with the form.

The entire wetland unit has to be scored. Usually it is the entire delineated wetland that is scored. Small areas within a wetland unit (such as the footprint of an impact) cannot be rated separately. The method is not sensitive enough, or complex enough, to allow division of a wetland unit into smaller units based on level of disturbance, property lines, or plant communities. DO NOT SCORE ONLY THE PART BEING ALTERED OR MITIGATED.

Furthermore, you do not subdivide a wetland unit into different hydrogeomorphic classes if more than one is present. A wetland unit with several wetland classes within its boundary is treated as one class. The second page of the classification key in Appendix A provides guidance on how to classify wetlands having several HGM classes within its boundary.

There are, however, ecological criteria that can be used to separate very large wetlands into smaller units for scoring. These criteria are described below.

If you do not have access to the entire unit you should do the best you can to answer the questions from aerial photos, using binoculars, or any other additional information. Note your lack of access on the data form and record which questions are based on incomplete data.

The rating of an entire wetland unit rather than just the part of it being mitigated or impacted is a trade-off made between scientific rigor and the need for a "rapid" method. None of the rapid methods developed by Ecology (the rating systems and function assessment methods) are rigorous enough to adequately assess the functions of only a small area within a wetland unit. We did numerous tests of this question, and both methods gave us invalid results when applied to small areas within a wetland. More detailed data are needed to adequately assess functions in only a part of a wetland unit. This would require monitoring and measuring the actual processes taking place in different parts of a wetland rather than characterizing the structural indicators present, and will certainly require monthly sampling for at least one year.

4.1 Identifying Boundaries of Large Contiguous Wetlands in Valleys (Depressional and Riverine)

Wetlands can often form large contiguous areas that extend over hundreds of acres. This is especially true in river valleys where there is some surface water connection between all areas of the floodplain. In these situations the initial task is to identify the wetland "unit" that will be rated. A large contiguous area of wetland can be divided into smaller units using the criteria described below.

The guiding principles for separating a wetland in a valley into different units are the changes in the water regime or a lack of wetland plants. Boundaries between different units should be set at the point where the volume, flow, or velocity of the water changes abruptly. These changes in water regime can be either natural or human-made (anthropogenic). The following sections describe some common situations that might occur. The criteria for separating wetlands into different units are based on the observations made during the calibration of the rating systems and the methods for assessing wetland functions. They reflect the collective judgment of the teams of wetland experts that developed and calibrated the methods.

Examples of Changes in Water Regime

- Berms, dikes, cascades, rapids, falls, and culverts.
- Features that change flow, volume, or velocity of water over short distances.
- The presence of drainage ditches that significantly reduce water detention in one area of a wetland.

Wetlands in a Series of Depressions in a Valley

Wetlands that form ponded depressions in river corridors may contain constrictions where the wetland narrows between two or more depressions. The key consideration is the direction of flow through the constriction. If the water moves back and forth freely it is **not** a separate unit. If the flow between depressions is unidirectional, down-gradient, and has a change in elevation from one part to the other, then a separate unit should be created. The justification for separating wetlands increases as the flow between two areas becomes more unidirectional and has a higher velocity. Constrictions can be natural or man-made (e.g. culverts) (Figure 3). Generally, if the high water mark in the lower wetland is 6 inches or more lower than the high water mark in the upper wetland, then the two should be considered as separate units for rating.

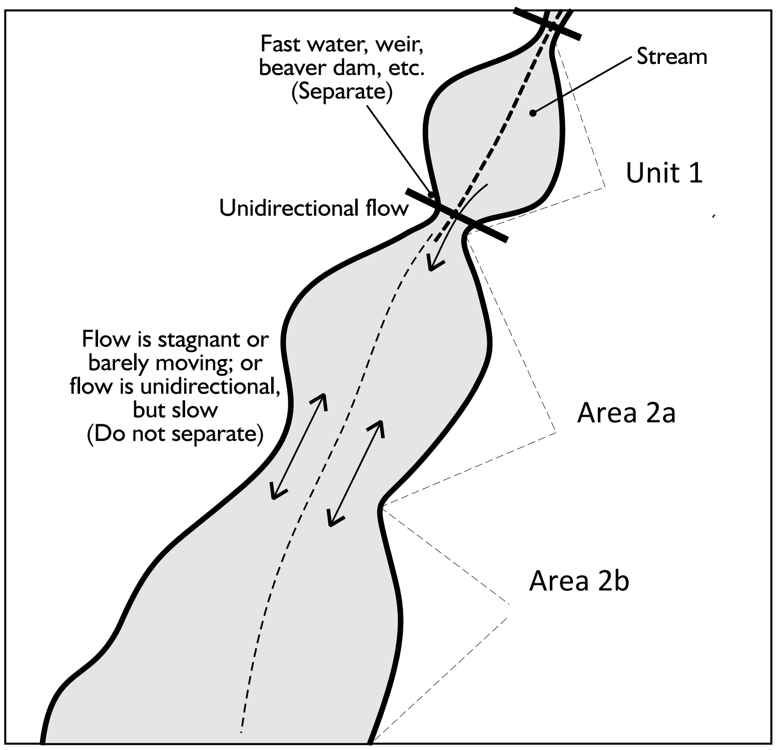


Figure 3: Determining depressional wetland units along a stream corridor with constrictions. Areas 2a and 2b should be rated as one unit.

Wetlands along the banks of streams or rivers

In western Washington, linear wetlands contiguous with a stream or river may be broken into units using criteria based on either hydrologic factors or the distribution plants. Figure 4 presents a diagram of how wetland units might be separated along a stream corridor based on change in the water regime. Three changes in water regime are illustrated: 1) a weir or dam, 2) a series of rapids, and 3) a tributary coming into the main stream that increases the flow significantly (generally > 25%).

NOTE: Unit 1 in Figure 4 should be classified as a depressional wetland. Units 2, 3, and 4 would probably be riverine or slope, depending on the area of overbank flooding.

Figure 5 illustrates how units can be separated based on the distribution of plants. Units can be separated when: 1) plants disappear and are replaced with unvegetated bars or banks for at least 50 ft along the stream, and 2) the wetland plant community is less than 30 ft wide along the shore for at least 100 feet.

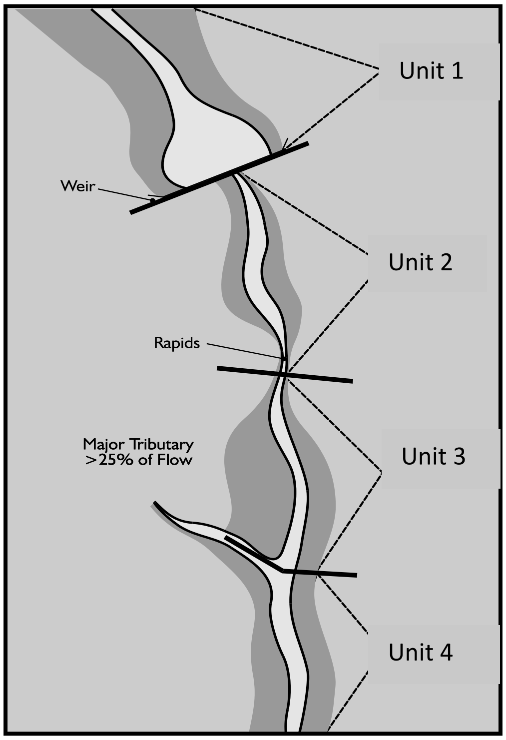


Figure 4: Determining wetland units in a riverine system based on changes in water regime.

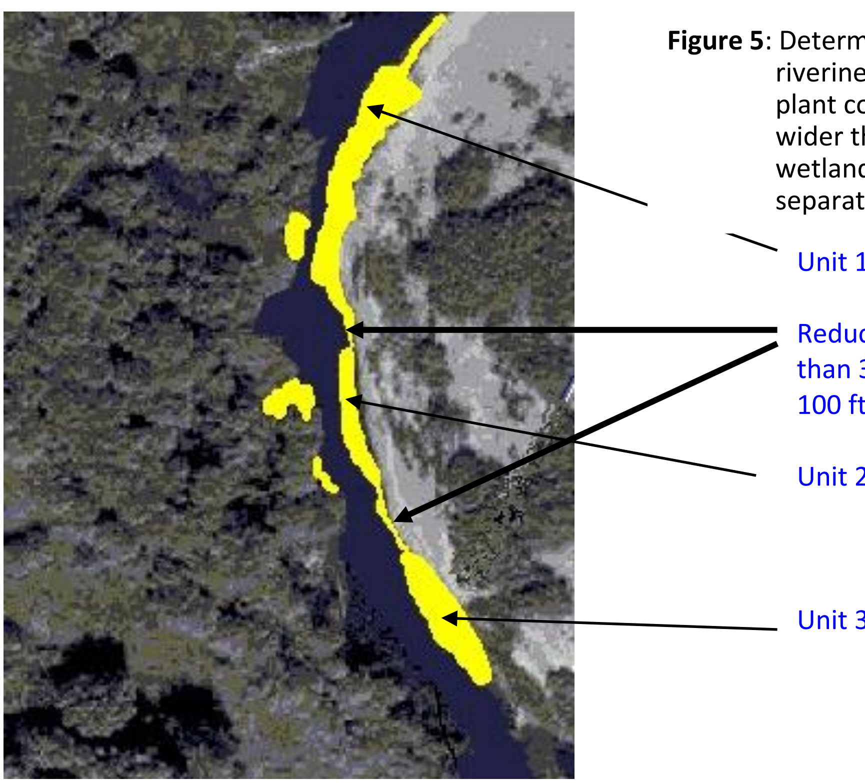


Figure 5: Determining wetland units in a riverine setting based on reduced plant cover. In this case the river is wider than 50ft. and the vegetated wetlands on either side are rated separately.

In cases when a wetland contains a stream or river, you must also decide if the stream or river is a part of the wetland. Use the following guidelines to make your decision:

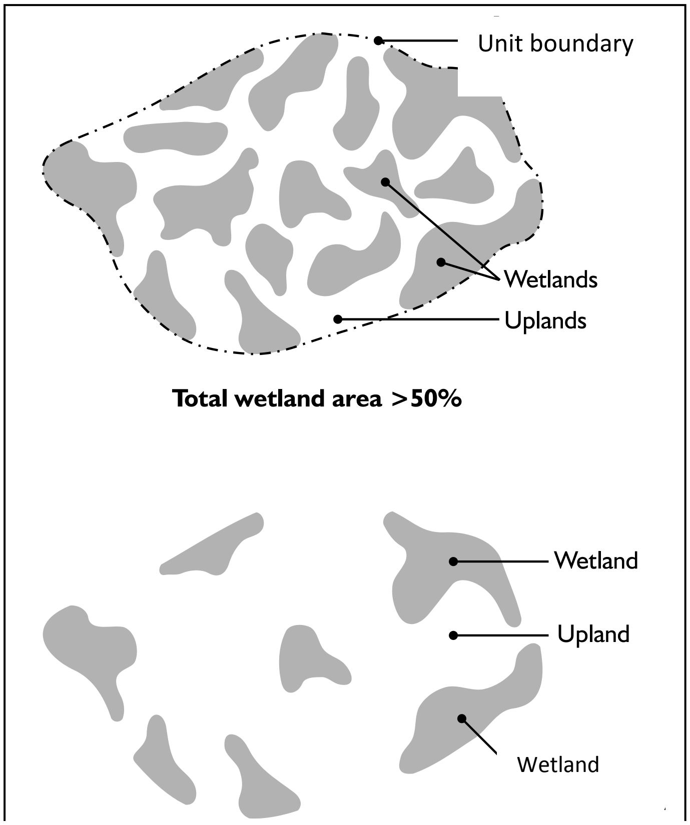
- Wetland on one side only — If the wetland area is contiguous to, but only on one side of, a river or stream, **do not** include the river as a characteristic of the wetland unit for rating.
- Wetland on both sides of a wide stream or river — If the river or stream has an unvegetated channel that is more than 50 ft (15 m) wide, and there are contiguous wetland areas on both sides, treat **each side as a separate unit** for rating. **Do not** include the river as a characteristic of the wetland unit for rating.
- Wetland on both sides of a narrow river or stream — If the river or stream has an unvegetated channel less than 50 ft (15 m) wide, and there are contiguous vegetated wetlands on both sides, treat **both sides together** as one unit, and **include** the river as a characteristic of the wetland.

4.2 Identifying Wetlands in a Patchwork on the Landscape (Mosaic)

If the wetland area being scored contains a mosaic of wetlands and uplands, the entire mosaic **should be considered one unit** when:

- Each patch of wetland is less than 1 acre (0.4 hectares), AND
- Each patch is less than 100 ft (30 m) away from the nearest wetland, AND
- The total area delineated as vegetated wetland is more than 50% of the total area of wetlands and uplands, open water, and river bars around which you can draw a polygon (see Figure 6), AND
- There are at least three patches of wetland that meet the size and distance thresholds.

If these criteria are not met, each wetland area should be considered as a separate unit for this method (see Figure 6).



Total wetland area < 50% of polygon – each wetland is a separate unit

Figure 6: Determining unit boundaries when wetlands are in small patches. Each wetland polygon should be scored separately when the total area is less than 50% wetland.

4.3 Identifying Unit Boundaries Along the Shores of Lakes or Reservoirs (Lake-fringe Wetlands Only)

Lakes or reservoirs will often have a fringe of wetland plants along their shores. Different areas of this vegetated fringe can be separated into different units if there are gaps where the width of plants narrows or they disappear completely. Use the following criteria for separating units along a lakeshore.

Only the vegetated areas along the lake shore are considered part of the wetland unit for rating. Open water within areas of plants are considered to be part of the wetland, but open water that separates patches of plants along a shore is not considered to be part of the wetland (Figure 7).

If only some parts of the lakeshore are vegetated with wetland plants, separate the vegetated parts into different units at the points where the wetland plants thin out to less than a foot in width for at least 33ft (10m) (Figure 8).

> **NOTE**: If the open water is less than 20 acres, the entire area (open water and any other vegetated areas) is considered as one wetland unit, and is a depressional or riverine wetland.

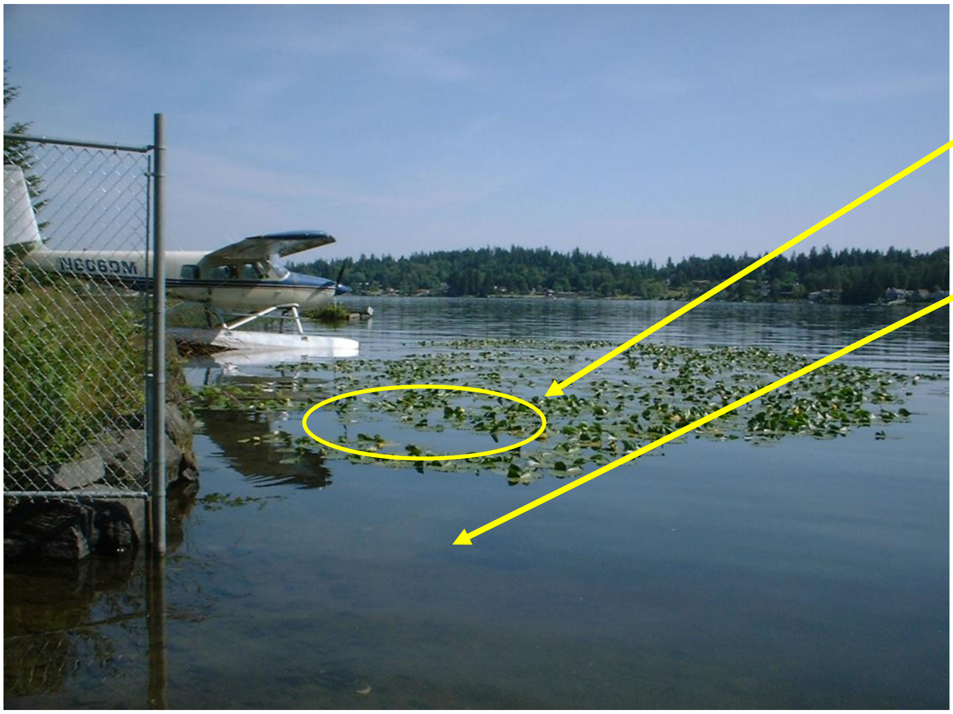


Figure 7: Lake-fringe wetland showing open water that is included within the wetland boundary

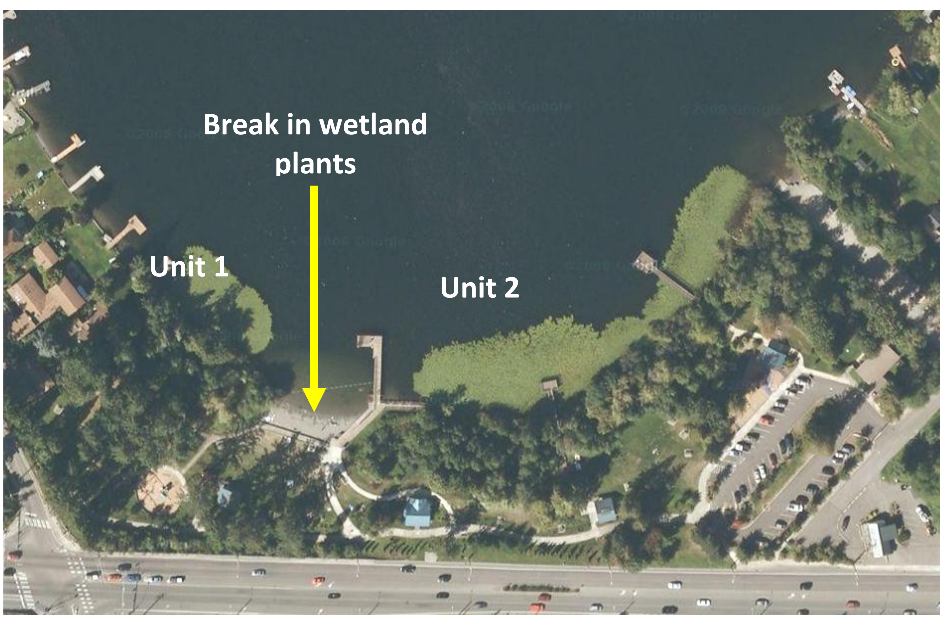


Figure 8: Absence of wetland plants along the shore of a lake that separates the wetlands into two units for rating.

Another common situation found in western Washington is a lake-fringe wetland that is contiguous with a large wetland that extends far from the edge of the lake (Figure 9).

These wetlands are usually classified as depressional or riverine. The entire unit of riverine and lake-fringe wetlands should be rated as one unit.

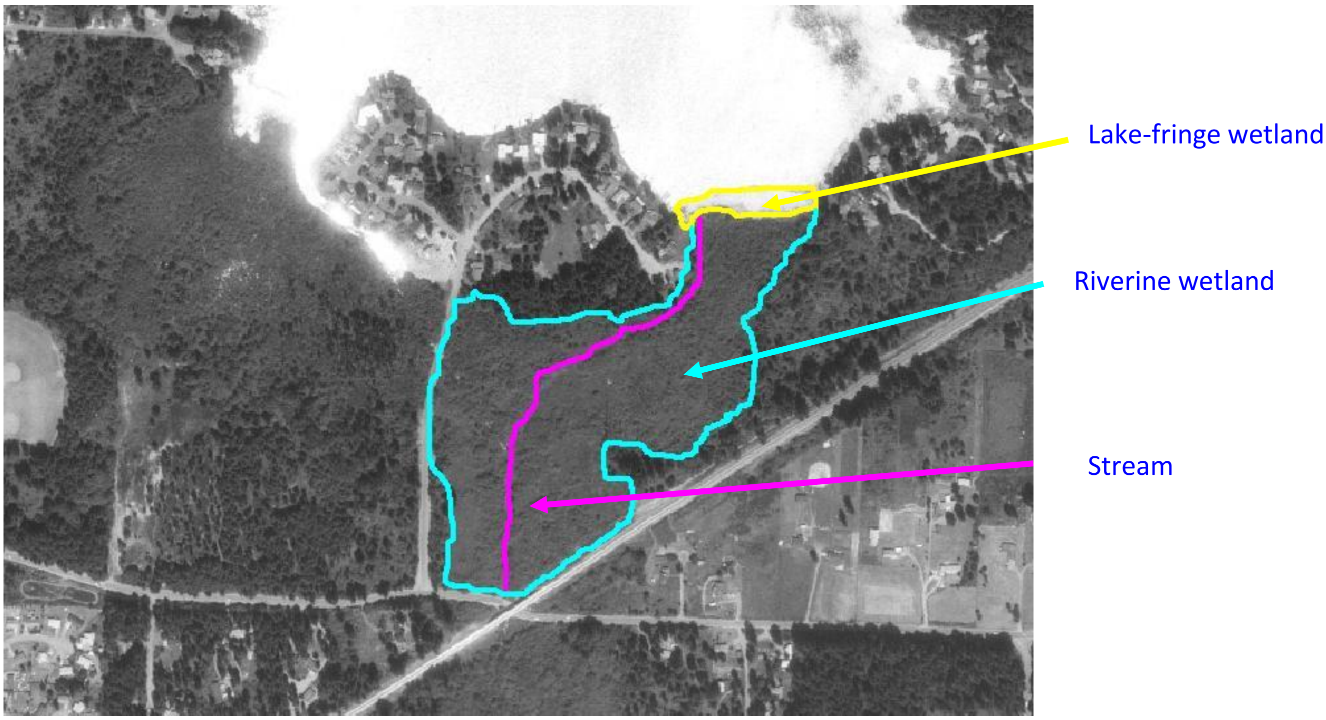


Figure 9: Aerial photograph of a lake-fringe wetland connected to a riverine wetland without any topographic or hydrologic breaks between them. Both types of wetlands are rated as one using the questions for Riverine wetlands.

Sometimes a strip of open water is found between the wetland plants further from shore and those closer to shore. In this situation, the open water is considered a part of one unit that encompasses both the rooted submerged plants offshore and the shore-side plants. The absence of plants in the area of open water may only be temporary, or the submerged plants are present but not visible because they do not grow to the surface. The plants may also be absent due to wave action or physical removal.

4.4 Wetlands Bisected by Human-Made Features

When a depressional wetland is divided by a human-made feature, such as a road embankment, the wetland should not be divided into different units if there is a level surface-water connection between the two parts of the wetland. Water should be able to flow equally well between the two areas. For example, if there is a wetland on either side or a road with a culvert connecting the two, and both sides of the culvert are partially or completely underwater for most of the year, the wetland should be treated as one unit. Make the down gradient wetland a separate unit, however, if the bottom of the culvert is above the high water marks in the receiving wetland, or the high water marks on either side differ by more than 6 inches in elevation.

4.5 Cases When a Wetland Should Not be Divided

Differences in land use within a wetland should not be used to define units unless they coincide with the circumstances described above. Many functions that wetlands perform are independent of the land use in the wetland. For example, a depressional wetland has approximately the same amount of live storage whether the surface is a shrub community or a pasture.

Furthermore, the rating system used in this method is not robust enough to capture slight differences in habitat functions within different portions of the same wetland unit. Attempts were made during the calibration of the wetland rating system to score different portions of a wetland unit based on differences in land use, but the results did not provide an accurate representation of the system. This compromise is necessary in order to make the tool rapid and easy to use. For example, if half a wetland has been recently cleared for farming and the other half left intact, the entire area functions as, and should be categorized as, one unit. Figure 10 shows a wetland that is a lawn along one side and a shrub community on the other side. In this case, the entire wetland should be rated as one unit.

Figure 10: A wetland with two land uses and separated by a fence. The entire wetland should be treated as one unit.

4.6 Very Small Wetlands

Users often question the effectiveness of using rapid methods in wetlands that are ¼ acre or less. One tree or shrub may be all that is needed in a small wetland to score points on the Scoring Form for certain questions. The data collected during the calibration of the rating systems, however, indicate that wetlands smaller than a ¼ acre can be rated accurately. The smallest wetlands rated during the calibration were about 1/10 acre in size (see Figure 11 for an example of a small wetland that is about 1/10 acre in size), and all were judged by the field teams to be adequately characterized.

Figure 11: A slope wetland near Padilla Bay that is approximately 1/10 acre in size.

At present, the accuracy of the scoring has not been tested for wetlands smaller than 1/10 acre, but the method may be applicable to even smaller wetlands because the scoring of most functions is not dependent on the size or the number of characteristics in the wetland. The scoring for the "water quality" functions is independent of size because the functions are rated on the potential per unit area. For example, the ability of a square yard of organic soil in a wetland to remove nitrogen is not dependent on the size of the wetland. A square yard of soil in a wetland of 1/10 acre can be just as effective at performing a function as a square yard in a large wetland.

The same is true for the hydrologic functions. A small wetland that stores 3 ft of water during a flooding event is more effective, on a per acre basis, than a large wetland that stores only 1 ft. The larger wetland may store a larger volume overall, but it is the volume per unit area that needs to be characterized. Impacts to wetlands are usually calculated by area. For example, an impact to 1/10 acre of a wetland that stores 3 ft of water needs to be mitigated by replacing a similar amount of storage (i.e. 3 ft over 1/10 acre). It makes no difference if the size of the wetland impacted is ¼ acre, 10 acres, or 100 acres.

The field testing, however, indicated that the method will not work well for scoring habitat functions in wetlands smaller than 1/10 acre (4000 ft^2). For example, one large tree may cover 400 square feet of a 4000 square foot wetland and this would give it a "forested" class. It is not expected however that the tree will provide functions to the same level as a forested class in a larger wetland. On the other hand, wetlands that are larger than 1/10 acre are adequately characterized. This is based on the consensus of the different teams (function assessment and rating) that went out into the field.

Also, very small wetlands may not provide good habitat for some of the larger wildlife species such as otter or beaver, but they are known to provide critical habitat for many smaller species. For example, amphibians were found using and breeding in wetlands as small as 270 ft^2 in the Palouse region of northern Idaho (Monello and Wright 1999).

Thus, very small wetlands may be less important for large wildlife but more important for smaller wildlife. Since the methods were judged to be accurate for wetlands as small as a 1/10 of an acre, the review team and the Department of Ecology staff decided not to develop additional questions for very small wetlands less than 1/10 acre in size. Very small wetlands can be rated with the understanding that the results are not as robust as in larger wetlands.

CHAPTER 5

Detailed Guidance for the Scoring Form

This chapter provides detailed guidance for answering the questions on the scoring form. The questions are listed in the order they appear on the form. Results from each section should be summarized on the first page of the form. More than three fourths of the questions are the same, or similar, to those used in the Washington State Wetland Rating System for Western Washington (Ecology publication #04-06-025). Questions that are identical to those in the rating system are noted on the scoring form in Appendix A.

A correctly filled out wetland rating form requires six maps for depressional wetlands, seven for riverine, six for lake-fringe and four for slope wetlands. These are also required to correctly fill out the forms for the Credit-Debit Method. In addition, the method requires one additional map to answer three new questions. This map does not have to be digitized or put into a CAD system. Downloading an aerial photo, drawing a 1 km circle around the wetland unit and estimating the area of different land uses using a gridded overlay takes less than 15 minutes for an experienced user. **Do not estimate percent area visually without a graphic aid such as gridded overlay.** Visual estimates of area can be off by 30-40% and this will change the results.

Users of this method who have not taken any training can expect that, **on the average**, their scores for the functions will be off by at least 1 point. This means that the scores calculated for credits or debits will be either 1 acre-point higher or 1 acre-point lower for every acre of impact or mitigation (average error is+/-15%). Our initial analysis suggests that errors of 2 acre-points will occur in 1/3 of the cases for untrained users. These statistics are based on the data collected during the development of the wetland rating system.

5.1 Classifying the Wetland

Scientists have come to understand that wetlands can perform functions in different ways. The way wetlands function depends to a large degree on hydrologic and geomorphic conditions (Brinson 1993). As a result, we group wetlands into categories based on the geomorphic and hydrologic characteristics that control many functions. This classification system is called the Hydrogeomorphic (HGM) Classification.

The Credit-Debit Method described here uses only the highest grouping in the HGM classification (i.e., wetland class). The more detailed methods for assessing wetland functions developed for eastern and western Washington (Hruby and others 1999, Hruby and others 2000) refine this classification and subdivide some of the classes further. This method, however, does not require such a level of detail.

A classification key is provided with the Scoring Form to help you identify whether the wetland is tidal-fringe, flats, lake-fringe, slope, riverine, or depressional. The key contains eight questions that need to be answered sequentially. Each question is described below in more detail than found on the key.

Question 1: Tidal Fringe Wetlands

Tidal fringe wetlands are found along the coasts and in river mouths to the extent of tidal influence. The dominant source of water is from the ocean or river. The unifying characteristic of this class is the hydrodynamics. All tidal fringe wetlands have water flows dominated by tidal influences, and water depths controlled by tidal cycles in the adjacent ocean.

> This method does not score the functions and values of estuarine wetlands, but it can be used to score freshwater tidal fringe wetlands.

Tidal fringe wetlands, in which the water has a salinity higher than 0.5 parts per thousand, are classified as “Estuarine” and not scored. Tidal fringe wetlands in which the waters are tidal but freshwater (salinities below 0.5 parts per thousand), are scored using the forms for riverine freshwater wetlands.

There are numerous tidal fringe wetlands in the estuaries and tidal sloughs in the Puget Sound region as well as in Willapa Bay and Grays Harbor. The difficulty is in identifying the boundary between fresh and brackish waters. In the absence of local information (e.g., the salt wedge in the Snohomish River extends upstream to the Route 2 bridge), users will have to rely on plants to identify the boundaries between fresh and salt water. Appendix B lists common wetland plants that are tolerant of salt (from Hutchinson 1991). If the dominant plants in the community are those listed as “Tolerant” or “Very Tolerant,” it can be assumed that the waters in the slough or river at that point are saline.

Figure 12 shows Edison Slough which has a fringe of *Triglochin* sp. and *Carex lyngbyei* along the edge of the mudflat. On this basis the wetland was classified as “estuarine.” If you have the situation presented in Figure 12; a fringe of freshwater plants that is above an area of salt-tolerant plants, you should consider the entire unit as estuarine. See question 8 on the classification key in the field form.

Figure 12: An estuarine slough at low tide with salt tolerant plants along the edges.

Question 2: Flats Wetlands

"Flats" wetlands occur in topographically flat areas that are hydrologically isolated from surrounding groundwater or surface water. The main source of water in these wetlands is precipitation directly on the wetland itself. They receive virtually no groundwater discharge or surface runoff from the surrounding landscape. This characteristic distinguishes them from depressional and slope wetlands. In western Washington flats wetlands are very rare. They occur in areas raised above the surrounding landscape and underlain by glacial till. It is highly unlikely that you can find a flats wetland in areas where the rate of evapotranspiration is greater than rainfall, such as eastern Washington.

Wetlands that should be classified as flats may be hard to distinguish from flat depressional wetlands that are fed by groundwater. This need not be a concern however, because both depressional and flats wetlands use the same questions in the scoring form.

Question 3: Lake-fringe Wetlands

Lake-fringe wetlands are separated from other wetlands based on the area and depth of open water adjacent to them. If the area of open water next to a vegetated wetland is larger than 20 acres (8 hectares), and more than 6.6 feet deep (2m) over 30% of the open water areas, the wetland is considered to be "lake-fringe." The criterion here is 20 acres of open water without any aquatic plants. The Shoreline Management Act requires 20 acres within Ordinary High Water Mark (OHWM). Thus a 20 acre shallow pond that is completely vegetated would be a lake under the Act but a depressional wetland for the purpose of this method.

Figure 13: Lake-fringe wetland with an area of aquatic bed plants and a narrow band of wetland shrubs along the shore.

The definition of lakes is based on limnological characteristics and not the criteria used in the Shoreline Management Act. Lakes have different environmental processes than small ponds (e.g., stratification, spring turnover, etc.). In general. these processes occur in western Washington only in systems that have at least 20 acres of open water that is deeper than 2 meters. Figure 13 shows a lake-fringe wetland in Snohomish County with aquatic bed plants and a fringe of wetland shrubs.

Wetlands found along the shores of large reservoirs such as those found behind the dams along the major rivers are also considered to be lake-fringe. Although the area was once a river valley, the wetlands along the shores of the reservoirs function more like lake-fringe wetlands rather than riverine wetlands. The technical teams developing the wetland rating systems (Hruby 2004 a, b) decided to include wetlands along the shores of reservoirs as lake-fringe if they meet the thresholds for open water and depth.

Question 4: Slope Wetlands

Slope wetlands occur on hill or valley slopes where groundwater "daylights" and begins running along the surface, or immediately below the surface. Water in these wetlands flows only in one direction (down the slope) and the gradient is steep enough that the water is not impounded. The "downhill" side of the wetland is always the point of lowest elevation in the wetland. Figure 14 shows a slope wetland that formed where the slope of the hillside changed and caused groundwater to come to the surface.

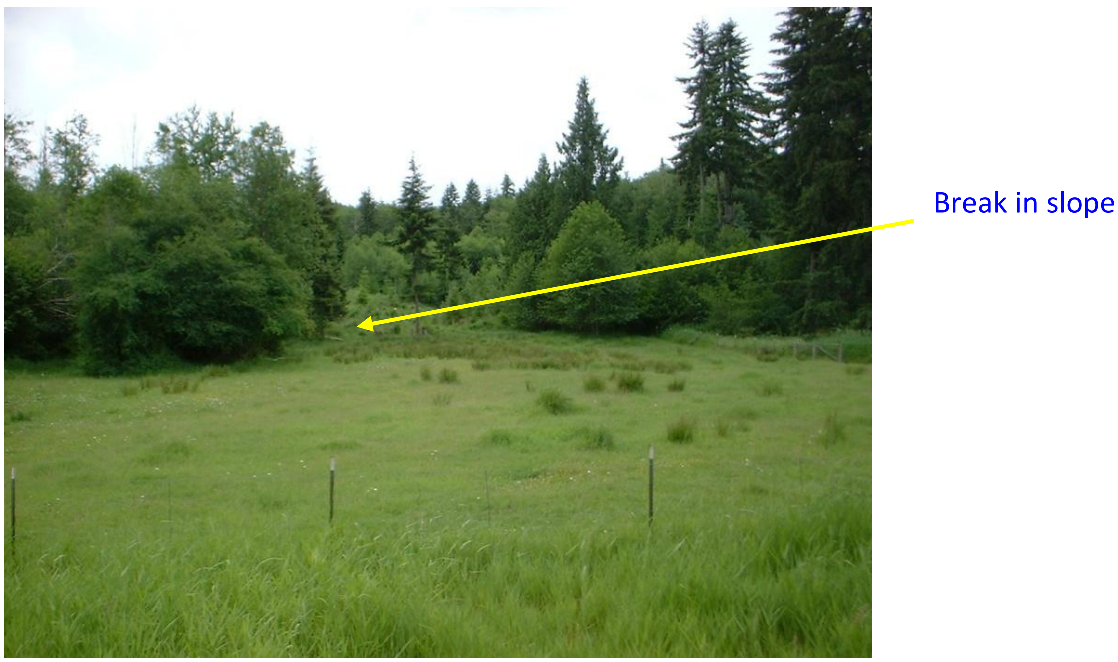


Figure 14: Slope wetland in Lewis County identified by the presence of wetland plants (*Carex* sp. *Juncus* sp.) and hydric soils. Wetland occurs where there is a major break in the slope of the hillside.

Slope wetlands with surface flows can be distinguished from riverine wetlands by the lack of a defined stream bed with banks. Slope wetlands may develop small rivulets along the surface, but they serve only to convey water away from the wetland. There is no surface flow coming into the wetland through channels. Also, slope wetlands do not impound water except in very small depressions that may form on the surface. These are only a few inches in diameter and a few inches deep.

Question 5: Riverine Wetlands

Riverine wetlands occur in valleys associated with stream or river channels. They lie in the active floodplain, and have important hydrologic links to the flows in the river or stream. Their proximity to the river facilitates the rapid transfer of floodwaters in and out of the wetland, and the import and export of sediments. The distinguishing characteristic of riverine wetlands in western Washington is that they are flooded by overbank flow from the river at least once every two years. Riverine wetlands, however, may also receive significant amounts of water from other sources such as groundwater and slope discharges.

Wetlands that lie in floodplains but are not frequently flooded are **not** classified as riverine. Also, wetlands behind dikes are usually disconnected from the active floodplain and are no longer regularly flooded. In cases where wetlands in the floodplains are not frequently flooded they should be classified as depressional or slope.

Riverine wetlands are often replaced by depressional or slope wetlands near the headwaters of streams and rivers, where the channel (bed) and bank disappear, and overbank flooding grades into surface or groundwater inundation. In headwaters, the dominant source of water becomes surface runoff or groundwater seepage. However, for the purposes of classification, wetlands that show evidence of frequent overbank flooding, even if from an intermittent stream, are considered riverine even if they receive water from surface flows or groundwater.

Riverine wetlands normally merge with tidal fringe wetlands near the mouths of rivers. The interface occurs where tidal fluctuations become the dominant hydrologic driver (Brinson and others 1995). This interface has been significantly modified in western Washington by diking. Many wetlands that were once freshwater tidal are now either riverine or depressional (depending on the frequency of flooding).

The operative characteristic of riverine wetlands in Washington is that of being "frequently flooded" by overbank flows (Figure 15).

Figure 15: A riverine wetland being inundated by flood waters from North Creek. The creek is in the background. This flooding occurs at least once a year.

In western Washington the technical committees developing assessment methods decided that the frequency of overbank flooding needed to call a wetland riverine is at least once in two years (2 yr. "return" frequency). This characteristic, however, cannot be easily measured in the field and needs to be established from field indicators. The following are some field indicators that can be used to classify a wetland as riverine:

- Scour marks are common in the wetland.
- Recent sediment deposits.
- Plants are bent in one direction or damaged.
- Soils with layered deposits of sediment.
- Flood marks on plants along the edge of the bank at different levels.

Wetlands that are created in a stream channel by impounded water from an obstruction such as a beaver dam, weir, or debris dam are considered to be depressional rather than riverine. The major hydrologic factor that maintains and provides the structures in these systems is the ongoing flow that is impounded. The overbank flooding is not as important a factor. A wetland would be considered riverine, however, if the dam or weir impounds water for only a short time, such as a single storm. The impounded water must be present for at least two months every year to be considered depressional.

Question 6: Depressional Wetlands

Depressional wetlands occur in topographic depressions where the elevation of the surface within the wetland is lower than in the surrounding landscape. The shapes of depressional wetlands vary, but in all cases, the movement of surface water and shallow subsurface water is toward the lowest point in the depression. The depression may have an outlet, but the lowest point in the wetland is somewhere within the boundary, not at the outlet.

Depressional wetlands can sometimes be hard to identify because the depression in which they are found are not very evident. By working through the key it may not be necessary to look at topographic maps, or try to identify that the lowest point of the wetland is in the middle. If a wetland has surface ponding, even if only for a short time, and is not lake-fringe, or riverine, it can be classified as depressional (Figure 16).

Figure 16: A depressional wetland. Note the surface ponding in the low point of the wetland where the cattails are found.

Question 7: Flat Areas Maintained by High Groundwater

Many wetlands have developed on the outwash plains left by the glaciers. These are maintained by high levels of groundwater in the region and do not easily fit into either the depressional, riverine, or flats class. These wetlands are fairly flat, are often ditched, and do not seem to have an identifiable natural outlet (Figure 17). If they pond water it is usually only because groundwater levels are high in the entire region and the water has nowhere to drain. These wetlands are classified as "depressional" for the purpose of scoring them.

Figure 17: Wetland maintained by high levels of groundwater. It is not in an easily identified topographic depression and has slope wetlands along its upper edge.

Question 8: Wetland Is Hard to Classify

Sometimes it is hard to determine if the wetland unit you are scoring meets the criteria for a specific wetland class. You may find characteristics of several different hydrogeomorphic classes within one wetland boundary. For example, seeps at the base of a slope often grade into a riverine wetland, or a small stream within a depressional wetland has a zone of flooding along its sides that would be classified as riverine.

If you have a wetland with the characteristics of several HGM classes present within its boundaries use Table 1 to identify the appropriate class to use for scoring. Use this table only if the area encompassed by the "recommended" class is at least 10% of the total area of wetland being rated. For example, if a slope wetland grades into a riverine wetland and the area of the riverine wetland is ¼ of the total wetland unit you are rating, use the questions for riverine wetlands. However, if the area that would be classified as riverine is less than 10% (e.g., ½ acre of a 10 acre unit is frequently flooded) use the questions for the slope wetlands. The same applies for other combinations of classes. A unit in which the depressional area is only 5% of the entire unit that is otherwise a slope wetland should be rated as a slope wetland. If, however, the area classified as depressional is 15% of the area of the unit it should be rated as depressional.

Table 1: Classification of wetlands with multiple hydrogeomorphic classes for the purpose of rating their functions.

HGM classes found within one wetland unit	HGM Class to use if area of this class > 10% total area of unit
Slope + Riverine	Riverine
Slope + Depressional	Depressional
Slope + Lake-fringe	Lake-fringe
Depressional + Riverine	Depressional
Depressional + Lake-fringe	Depressional
Riverine + Lake-fringe	Riverine
Salt Water Tidal fringe and any other class of wetland	Treat as ESTUARINE and do not score. Categorize the wetland based on the Special Characteristics section.

If you are still unable to determine which of the above criteria apply to your wetland, or you have more than two HGM classes within a wetland boundary, classify the wetland as depressional. Hydrologically complex wetlands found in western Washington during the calibration of the methods have always had features of depressional wetlands, and thus, could be classified as depressional.

Once you have classified the wetland, you will need to answer only the questions that pertain to the HGM class of the wetland being rated. The first letter of the question on the Scoring Form identifies the wetland class for which the question is intended:

D = Depressional or flats

R = Riverine or Freshwater Tidal Fringe

L = Lake-fringe

S = Slope

The guidance in the following sections is divided according to the HGM class of the wetland being rated. Each question on the Scoring Form is addressed in turn.

NOTE: The questions for scoring habitat functions are labeled [H] and apply to all HGM classes of wetlands.

5.2 Classifying the Plant Communities

There are several questions on the data sheet that ask you to classify the plant communities found within the wetland unit. This should not be confused with classifying the wetland unit as described earlier. The Credit-Debit Method uses several different classification schemes for plant communities; only one of which is the commonly used "Cowardin" classification. The Cowardin classification is the most complex one and is described in more detail below. You will need to carefully read the description of each question to insure that you use the classification scheme appropriate for that question. **Use caution in filling out the Scoring Form because the thresholds for scoring differ among the questions as well as the way plants are classified.**

The Cowardin Classification

"Cowardin" plant classes are distinguished by the uppermost layer of plants (forest, shrub, etc.) that provides more than 30% surface cover within part or all of a wetland. This area is often called a Cowardin "polygon" when mapping the distribution of plants. If the total cover of plants is less than 30% the area does not have a plant class. Areas with less than 30% plant cover should be categorized as open water or sand/mud flats. If the plants are deciduous and you are rating the wetland during periods when leaves have fallen, try to reconstruct what the cover would be when the plants are fully leafed out. A deciduous forest of big-leaf maple would still be considered a forest using the Cowardin classification even in winter when there are no leaves present and the cover may be less than 30%.

This method uses only four of the major Cowardin plant classes to map the plant communities in a wetland. These are:

1. **Forested class:** An area (polygon) in the wetland unit where the canopy of woody plants over 20 ft. (6 m) tall (such as cottonwood, aspen, cedar, etc.) covers at least 30% of the ground. Trees need to be partially rooted in the wetland in order to be counted towards the estimates of cover (unless the unit is a mosaic of small wetlands as described in Section 4.2). Some small wetlands may have a canopy over the unit but the trees are not rooted within the wetland. In this case the wetland does not have a forested class.
2. **Scrub/shrub class**: An area (polygon) in the wetland unit where woody plants less than 20 ft. (6 m) tall are the top layer of plants. To count, the shrub plants must provide at least 30% cover and be the uppermost layer. Examples of common shrubs in western Washington wetlands include the native rose, young alder, young cottonwoods, hardhack (*Spiraea)*, willows, and red-osier dogwood.
3. **Emergent class:** An area (polygon) in the wetland unit covered by erect, rooted herbaceous plants excluding mosses and lichens. These plants have stalks that will support the plant vertically in the absence of surface water during the growing season. These plants are present for most of the growing season in most years. To count, the emergent plants must provide at least 30% cover of the ground and be the uppermost layer. Cattails and bulrushes are good examples of plants in the "emergent" plant category.

Herbaceous plants are defined as seed-producing species that do not develop persistent woody tissue (stems and branches). Most species die back at the end of the growing season.

4. **Aquatic bed class:** An area (polygon) in the wetland unit where rooted aquatic plants, such as lily pads, pondweed, etc., cover more than 30% of the surface of the standing water. These plants grow principally on or below the surface of the water for most of the growing season in most years. This is in contrast to the emergent plants described above that have stems and leaves that extend above the water most of the time. Aquatic bed plants are found only in areas where there is seasonal or permanent ponding or inundation. *Lemna sp.* (duckweed) is not considered an aquatic bed species because it is not rooted. Aquatic bed plants do not always reach the surface and care must be taken to look into the water.

NOTE: Sometimes it is difficult to determine if a plant found in the water is "aquatic bed" or "emergent." A simple criterion to separate emergent and aquatic bed plants most of the time is--If the stalk will support the plant vertically in the absence of water, it is emergent. If, however, the stalk is not strong enough to support the plant when water is removed, it is aquatic bed.

NOTE: The definition of emergent plants used by Cowardin is different than the one used in delineation for determining the boundaries between "vegetated wetlands" and "vegetated shallows."

Examples of how different areas might be classified are given below.

- An area (polygon) of trees within the wetland unit having a 50% cover of trees and with an understory of shrubs that have a 60% cover would be classified as a "forest." The trees are the highest layer of plants and meet the minimum requirement of 30% cover.
- An area with 20% cover of trees overlying a shrub layer with 60% cover would be classified as a "shrub." The trees do not meet the requirement for minimum cover.
- An area where trees or shrubs each cover less than 30%, but together have a cover greater than 30% is classified as "shrub."
- When trees and shrubs together cover less than 30% of an area, the polygon is classified based on the next highest plant class that has a 30% cover. This would e either "emergent" or "aquatic bed."

Each polygon with a wetland unit can only have one Cowardin class. For this reason, it is useful to map the Cowardin classes on an aerial photo. This will avoid the common mistake of counting emergent plants under a canopy of trees or shrubs as a separate class.

5.3 Water Quality and Hydrologic Functions of Wetlands in the Depressional or Flats Class (*Questions starting with 'D' on the Scoring Form)*

D 1.0 Does the Site have the Potential to Improve Water Quality?

D 1.1 Characteristics of surface water outflows from the wetland: (This indicator is used for both the water quality and the hydrologic functions.)

Rationale for indicator: Pollutants that are in the form of particulates (e.g., sediment, or phosphorus that is bound to sediment) will be retained in a wetland with no outlet. Wetlands with no outlet are scored the highest for this indicator. An outlet that flows only seasonally is usually better at trapping particulates than one that is flowing all the time because there is no chance for a downstream release of particulates for most of the year (a review of the scientific literature on the "trapping" potential of wetlands is found in Adamus et. al. 1991).

As you walk around the edge of the depressional unit note carefully if there are any indications that surface water leaves the wetland and flows further down-gradient. The question is relatively easy to answer if you find a channel.

Figure 18: A small depressional wetland with no outlet.

You are asked to characterize the surface outlet in one of four ways, and these are:

Unit has no surface water outlet - You find no evidence that water leaves the wetland on the surface. The wetland lies in a depression in which the water never goes above the edge (Figure 18).

Unit has an intermittently flowing, or highly constricted, outlet. Intermittently flowing means that there is no outflow from the unit at some times during the year. The water levels in the unit fall below the elevation of the outlet. Highly constricted outlets, on the other hand **are permanently flowing** but are small relative to the flow. Marks of flooding or inundation have to be three feet or more above the bottom of the outlet (live storage is ≥ 3 ft) for the outlet to be considered constricted. Note: A depressional wetland with occasional outflow resulting from stormwater runoff from an adjacent developed area is considered to have intermittent flow.

Unit has an unconstricted or slightly constricted outlet with permanent flow that allows water to flow out of the wetland without backing up. The outlet does not provide much hindrance to flood waters flowing through the wetland. In general, the distance between the low point of the outlet and average height of inundation will be less than three feet. Beaver dams are considered to be unconstricted unless there are indicators that water is backed up at least 3 ft above the top of the dam.

Unit is flat and has no obvious outlet or the outlet is a ditch. The bottom of the ditch usually has a lower elevation than the rest of the unit. This characteristic is commonly found in the wetlands described on p. 43. Answer this question as "YES" if you find no outlet and there are no indicators that the unit ponds more than 6-10 inches of water. Usually, these wetlands have no indicators that they pond. These types of wetlands are often drained by man-made ditches. If the ditch is not permanently flowing score the unit as intermittently flowing.

NOTE: If you cannot find an outlet but know the wetland is not completely closed, score it as intermittently flowing.

D 1.2 The soil two inches below the surface is a true clay, or true organic soil.

Rationale for indicator: Clay soils and organic soils are good indicators that a wetland can remove a wide range of pollutants from surface water. The uptake of dissolved phosphorus and toxic compounds through adsorption to soil particles is highest when soils are high in clay or organic content (Mitsch and Gosselink 1993). We only consider the type of soil near the surface because this is where the soil actually has contact with the surface waters carrying the pollutants. This is where most of the chemical and biological reactions occur.

If the unit is found within an area that is mapped as an organic or clay soil by the NRCS on their county soil maps consider the unit to have clay or organic soils. If it is not mapped as an organic or clay soil, you will need to take at least one sample at the site and determine its composition.

To look at the soil: dig a small hole within the wetland boundary and pick a sample from the area that is about 2-3 inches below the duff layer. Usually it is best to sample the soil toward the middle of the wetland rather than at the edge. Do not sample the soil under areas of permanent ponding. Avoid picking up any of the duff or recent plant material that lies on the surface. Determine if the soil is organic or clay. If you are unfamiliar with the methods for doing this, a key for clay soils is provided in Appendix C.

> **NOTE**: The presence of organic or clay soils anywhere within the wetland unit counts. There is no scaling for this question based on the size of the patch of soil. This simplification is necessary because it is not possible to develop a reproducible map of different soils in a wetland unit within the time frame for doing a rating.

See the NRCS web page on soils for more descriptions on how to identify soils.

http://soils.usda.gov/technical/manual/contents/chapter3.html (as of Feb. 2012)

D 1.3 Characteristics and distribution of persistent plants (emergent, shrub, and/or forest classes).

> **Rationale for indicator:** Plants enhance sedimentation by acting like a filter, and cause sediment particles to drop to the wetland surface (review in Adamus and others 1991). Plants in wetlands can take on different forms and structures. The intent of this question is to characterize how much of the wetland is covered with plants that persist throughout the year and provide a vertical structure to trap or filter out pollutants. It is assumed, however, that the effectiveness at trapping sediments and pollutants is severely reduced if the plants are grazed.

Use the Cowardin classification of plants for this question. You are looking for the areas that would be classified as "Emergent", "Scrub/shrub," or "Forested" (see Section 5.2). These are all "persistent" types of plants; those species that normally remain standing at least until the beginning of the next growing season (Cowardin and others 1979). Emergent plants do not have to be alive at the time of the site visit to qualify as persistent. The dead stalks of emergent species will provide a vertical structure to trap pollutants as well as live stalks.

You are asked to characterize the plants in terms of how much area within the wetland unit is covered by persistent, ungrazed plants. There are three size thresholds used to score this characteristic – more than 1/10 of the wetland unit is covered in persistent plants; more than 1/2 of the wetland unit is covered; or more than 95% of the wetland unit is covered. These thresholds can usually be estimated visually in small wetlands. Large wetlands, however, may require you to draw the area of persistent plants on a map or aerial photo before you can feel confident that your estimates are accurate. **NOTE: this question applies only to persistent plants that are not grazed or mowed** (or if grazed or mowed, the plants are taller than 6 inches).

An easy way to estimate the amount of persistent plants is to map the areas that are open water, covered with aquatic bed plants, mudflats or rock on an aerial photograph. Also include areas that are grazed because much of the vertical structure of wetland plants is removed when plants are grazed. The remaining area is then by default the area of persistent plants. Figure 19 shows a depressional wetland in which persistent plants cover between 50% and 95% of the area of the wetland. The remainder is open water.

NOTE 1: To meet the "class" requirement for Cowardin, a polygon of plants within the wetland unit needs at least 30% cover of the specified plants type (forest, shrub, etc.). However, to count the Cowardin polygon as a "plants structure" in the rating system the “Cowardin” polygon itself has to represent at least 10% of the wetland unit in units that are smaller than 2.5 acres, or at least 1/4 acre in units that are larger. A plant class does not have to cover 30% of the entire wetland unit to be counted, just 10% or ¼ acre.

NOTE 2: If the unit has just been mowed or grazed, but you suspect this occurs infrequently, you will need to determine if the plants in the wetland are 6 inches or less at the time when the wetland is receiving surface waters that transport sediment and pollutants. If the grazing occurs in summer (because the area is too wet for cows in the winter) but the plants have time to grow again before the flood season, then the unit is ungrazed because the plants will meet the height threshold at the time of flooding. If however, the grazing pressure is intense enough that the grass does not have time to recover during the flood season then it should be considered "grazed”. The same question can be asked of seasonal mowing or haying.

Figure 19:
A depressional wetland in which persistent, ungrazed, plants cover is between 50% and 95% of the area of the wetland.

D 1.4 Characteristics of seasonal ponding or inundation.

> **Rationale for indicator**: The area of the wetland that is seasonally ponded is an important characteristic in understanding how well it will remove different forms of nitrogen that cause eutrophication. The highest levels of nitrogen transformation occur in areas of a wetland that undergo a cyclic change between oxic (oxygen present) and anoxic (oxygen absent) conditions. The oxic regime is needed so certain types of bacteria can change nitrogen that is in the form of ammonium ion (NH_4^+) to nitrate, and the anoxic regime is needed for denitrification (changing nitrate to nitrogen gas) (Mitsch and Gosselink 1993). The area that is seasonally ponded is used as an indicator of the area in the wetland that undergoes this seasonal cycling. The soils are oxygenated when dry but become anoxic during the time they are flooded.

To answer this question you will need to estimate how much of the wetland is seasonally ponded with water. Areas that are seasonally ponded must be inundated for at least 2 consecutive months, but then dry out for part of the year.

One way to estimate this area is to make a rough sketch of the boundary of the wetland unit, and on this diagram draw the outside edge of the area you believe has surface water during the wet season. If the wetland also has permanent surface water you will have to draw this and subtract it when making your estimate (see Figure 20).

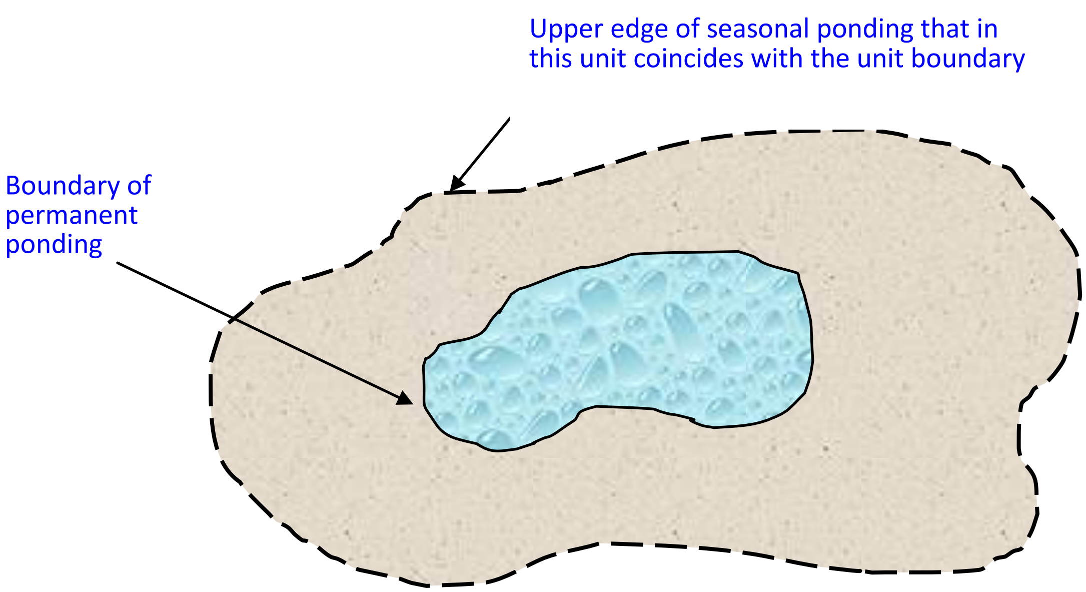


Figure 20: Sketch showing the boundaries of areas that are seasonally ponded and permanently ponded. The answer to question D 1.4 for this wetland is that the area seasonally ponded is more than ½ the total area of the wetland unit.

During the dry season, the boundary of areas ponded for several months (*seasonal ponding*) will have to be estimated by using indicators such as:

- Marks on trees and shrubs of water/sediment/debris (Figure 21). The boundary of seasonal ponding can be estimated by extrapolating a horizontal line from this mark to the edge of the wetland.
- Water stained plants lying on wetland surface (grayish or blackish appearance of leaves on the surface).
- Dried algae left on the stems of emergent plants and shrubs and on the wetland surface (Figures 22 and 23).

Figure21: Water mark on tree showing vertical extent of seasonal ponding

Figure 22: Small depressional wetland covered with algae. The edge of the algae marks the area that is seasonally ponded.

Figure23: Algae left hanging on plants as wetland dried out. The top of the algae marks the vertical extent of seasonal ponding. The boundary of seasonal ponding can be estimated by extrapolating a horizontal line from this mark to the edge of the wetland.

NOTE: Avoid making visual estimates of area covered by seasonal ponding when standing at the wetland edge. These estimates can be very inaccurate. Drawing the boundary on an aerial photograph and then using a graphic tool such as a grid to calculate area is a more accurate way to estimate area. A Global Positioning System (GPS) that has been corrected for positional inaccuracies can also be used to locate the boundaries and estimate area.

D 2.0 Does the Landscape Have the Potential to Support the Water Quality Function of the Site?

Wetlands can remove many pollutants coming into them. It is the removal of this excess pollution that is considered to be a valuable function for society. The landscape surrounding the wetland will to some degree determine how well a wetland improves water quality. If the wetland receives a heavy load of pollutants from the surrounding areas it will function to its maximum capacity. However, if, there are no pollutants coming in, the wetland cannot remove them, even if it has the necessary physical and chemical characteristics. Thus, the “landscape potential” for the function is related to the amount of pollutants that come into the wetland from the surrounding areas. Qualitatively, the level of pollutants can be correlated with the level of disturbance, development, and intensity of agriculture in the landscape. For example, relatively undisturbed watersheds will carry much lower sediment and nutrient loads than those that have been impacted by development, agriculture, or logging practices (Hartmann and others 1996, Reinelt and Horner 1995).

D 2.1 Does the wetland unit receive stormwater discharges?

> **Rationale for indicator**: Stormwater coming from residential or developed areas is often discharged into wetlands. Untreated stormwater is a source of many different pollutants (reviewed in Sheldon and others 2005). Furthermore, stormwater ponds do not remove all pollutants leaving them, even those constructed recently (Mallin and others 2002). Thus, any stormwater discharge into a wetland increases the pollutants coming into it.

Answer "YES" to the question if you see any pipes coming into the wetland from the surrounding land. These are usually stormwater discharges. Also, look on the aerial photograph of the wetland and its surroundings for stormwater ponds. If you see any ponds, determine if their discharges can get into the wetland.

D 2.2 Is more than 10% of the area within 150 ft of the wetland unit in agricultural, pasture, residential, commercial, or urban?

> **Rationale for indicator**: Farming, grazing, residential areas, commercial land uses, and urban areas in general are major sources of pollutants (reviewed in Sheldon and others 2005). The review also found that a well vegetated buffer of 150 ft will only remove 60-80% of some pollutants from surface runoff into a wetland. Thus, pollutants from such land uses will probably reach the wetland unit if they are within 150 ft of the wetland.

Use your aerial photo and draw a line around the unit that is 150 ft from the edge of the unit you have mapped for rating. Answer "YES" to this question if you find the listed uses within 150 ft of the wetland and they cover more than 10% of the "donut" polygon around the unit. Use a graphic aid, such as an acetate overlay with a grid or dots, to estimate area. Visual estimates are not accurate enough and may result in significant errors.

D 2.3 Are there septic systems within 250 ft of the wetland unit?

> **Rationale for indicator**: Septic systems can pollute groundwater because nitrogen is not removed underground. Plumes of nitrogen from septic systems can be traced at least 250 ft in the groundwater (Aravena and others 1993).

Use the aerial photograph of the unit to determine if there are any residences within 250 ft of the unit. Septic systems are still in common use in many areas of western Washington that are outside of city boundaries. If your unit is within a city limit you will need to check with the local planning office to determine if the area has sewers serving the houses or if they are still on septic systems. If you are outside city limits in areas with lots of 1/2 acre or larger you can assume the houses are on septic systems.

D 2.4 Are there other sources of pollutants coming into the wetland that are not listed in questions D 2.1 – D 2.3?

Rationale for indicator: The three sources of pollutants listed in questions D 2.1-D 2.3 may not be the only sources coming into the wetland unit from the surrounding landscape.

Answer "YES" to the question if you can identify any source of pollutants in the groundwater or surface water coming into the wetland caused by human activities. Identify the source of the pollution on the Scoring Form. Wetlands can receive polluted waters even if they have well vegetated and large buffers. For example, a stream that drains areas where pollutants are released far from the unit can pass through the wetland. Also, silt fences often do not prevent all the sediment from reaching the wetland during construction. Other sources of pollutants may be pesticide spraying on golf courses, particulates in exhausts from airplanes or motor vehicles and pesticides used in mosquito control.

D 3.0 Is the Water Quality Improvement Provided by the Site Valuable to Society?

D 3.1 Does the unit discharge directly to a stream, river, or lake that is on the 303(d) list?

Rationale for indicator: The term "303(d) list" is short for the list of impaired waters (stream segments, lakes) that the Clean Water Act requires all states to submit to the Environmental Protection Agency (EPA) every two years. In Washington, we identify all waters where pollution controls are not sufficient to attain or maintain applicable water quality standards. Wetlands that discharge directly to these polluted waters are judged to be more valuable than those that discharge to unpolluted bodies of water because their role at cleaning up the pollution is critical for reducing further degradation of water quality.

To answer this question you will need to access the Department of Ecology's web site that lists all the bodies of water that do not meet water quality standards http://www.ecy.wa.gov/programs/wq/303d/2008/index.html. Determine from the aerial photo if the wetland unit you are rating is within at least 1 mile of any aquatic resource listed as Category 2, 4, or 5 waters and has a surface water channel, ditch, or other discharge to it.

D 3.2 Is the unit in a basin or sub-basin where water quality is an issue in some aquatic resource? There is an aquatic resource in the basin that is on the 303(d) list.

> **Rationale for indicator**: Wetlands can mitigate the impacts of pollution even if they do not discharge directly to a polluted body of water. Wetlands can remove nitrogen from groundwater as well as surface water. They can also trap airborne pollutants. Thus, wetlands can provide an ecosystem service and value to our society in any basin and sub-basin that has pollution problems. The removal of pollutants by wetlands is judged to be more valuable in basins where other aquatic resources are already polluted or have problems with eutrophication. Any further degradation of these resources by destroying the wetland could result in irreparable damage to the ecosystem.

To answer this question you will need to access the Department of Ecology's web site that lists all the bodies of water that do not meet water quality standards http://www.ecy.wa.gov/programs/wq/303d/2008/index.html. Determine from the aerial photo if the wetland unit you are rating is in the contributing basin of any aquatic resource listed as Category 2, 4, or 5 waters. To find the boundaries of contributing basins in the area consult with the planning department of the local jurisdiction. If this information is not available, use the guidance for mapping contributing basin described in question D 4.3 on p. 61.

D 3.3 Has the site been identified in a watershed or local plan as important for maintaining water quality?

> **Rationale for indicator**: Not all pollution and water quality problems are identified by Ecology's water quality monitoring program. Local and watershed planning efforts sometimes identify wetlands that are important in maintaining existing water quality. These wetlands provide a value to society at the local level that needs to be replaced if they are impacted.

To answer this question you will need to seek information from the planning department of the local jurisdiction where the site is located. Information on regional or local plans can often be found on the web site of the city or county in which the site is found. Useful "search" phrases include: "watershed plan," "water quality," or "wetland protection." If the basin in which the wetland is found has a TMDL plan (also called a Water Clean Up Plan) developed for it, then you should answer "YES" for this question. It is assumed that all wetlands are valuable in a basin where water quality is poor enough to require a TMDL. The Department of Ecology's web site lists all the bodies of water that have TMDL's: http://www.ecy.wa.gov/programs/wq/tmdl/TMDLsbyWria/TMDLbyWria.html .

D 4.0 Does the Site Have the Potential to Reduce Flooding and Stream Erosion?

D 4.1 Characteristics of surface water outflows from the wetland:

Rationale for indicator: Wetlands with no outflow are more likely to reduce flooding than those with outlets, and those with a constricted outlet will more likely reduce flooding than those with an unconstricted outlet (review in Adamus and others 1991). In wetlands with no outflow, all waters coming in are permanently stored and do not enter any streams or rivers. Constricted outlets will hold back flood waters and release them slowly to reduce flooding downstream. Wetlands with intermittent flow also provide a higher level of protection than those with unconstricted permanently flowing discharges because they can hold back flash floods that can occur during storms.

See the description for question D 1.1. This question is answered the same way as question D 1.1. The difference between D 1.1 and D 4.1, however, is in the scores assigned each type of outflow. Differences in scores are based on the difference in importance of the outflow characteristics to the two functions.

D 4.2 Depth of storage during wet periods (estimating "live storage"):

Rationale for indicator: The amount of water a depressional wetland stores is an important indicator of how well it functions to reduce flooding and erosion. Retention time of flood waters is increased as the volume of storage is increased for any given inflow (Fennessey and others 1994). It is too difficult to estimate the actual amount of water stored for a rapid method such as this one, and we use an estimate of the maximum depth of the "live storage" as a surrogate. This is only an approximation because depressional wetlands may have slightly different shapes and thus the volume of water they can store is not exactly correlated to the maximum depth of storage.

Live storage is a measure of the volume of storage available during major rainfall events that cause flooding in western Washington. This indicator recognizes that some wetlands, particularly those with groundwater connections, have water present all year around, or have some storage below the elevation of the outlet that does not contribute to reductions in peak flows (so called "dead storage"). In most depressional wetlands in western Washington the depressions have filled to the edge of the outlet by the time the peak flooding occurs in late winter and early spring (Hruby and others 1999).

Locate the outlet of the unit and identify its lowest point (Figures 24, 25). In wetlands without outlets: 1) identify the deepest "hole" if the wetland is dry (Figure 26), or 2) the level of the areas that are permanently flooded. Estimate the difference in elevation between these low points and the marks of seasonal ponding (use information from D 1.4). This will provide an estimate of the depth of live-storage during the seasonal high water. Try to find water marks as close to the outlet as possible so you can estimate the height from the outlet. Figures 24 and 25 show water marks directly on the culverts. Estimate the difference in elevation between the lowest point of the outlet and the level at which you noted marks of inundation. There are four thresholds of concern: 1) more than 3 ft of storage, 2) between 2-3 ft of storage, 3) between 6 inches and 2 ft of storage, and 4) less than 6 inches of storage. These thresholds can usually be estimated without needing to use special equipment.

NOTE 1: If the outlet is a beaver dam or weir, treat the top of the dam or weir as the lowest point. If water is flowing over the dam then the water surface anywhere in the wetland can be used to establish the low point. Beaver dams generally have less than 6 inches of live storage because they allow water to flow out over a wide area. Four inches of live storage was the highest measured in the 11 beaver dams that were visited during the calibration of the method.

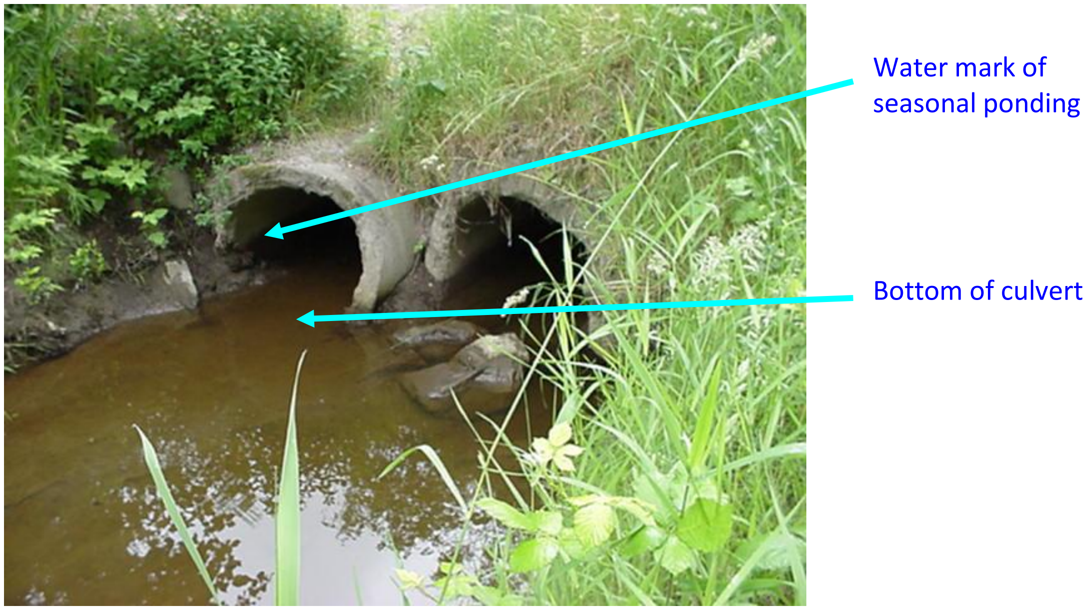
NOTE 2: If the wetland has multiple outlets, try to find the one that has the lowest topographic elevation.

NOTE 3: Sometimes the lowest point of the outlet is flooded or flowing. In these cases, measure from the bottom of the outlet to the mark of the seasonal flooding. A common mistake is to measure from the current water level in the outlet to the marks of flooding.

NOTE 4: It can be difficult to extrapolate the height of flooding above the lowest point of the outlet in large wetlands where the flood marks are distant from the outlet.

Figure24: A box culvert that is the outlet of a depressional wetland. The live-storage is measured as the distance between the bottom of the culvert and the water marks on the side. The distance here is approximately 15 inches.

Figure25: A round culvert with water still present. Live storage is measured from the bottom of the culvert, not the present water level. The depth of storage is approximately 7 inches.



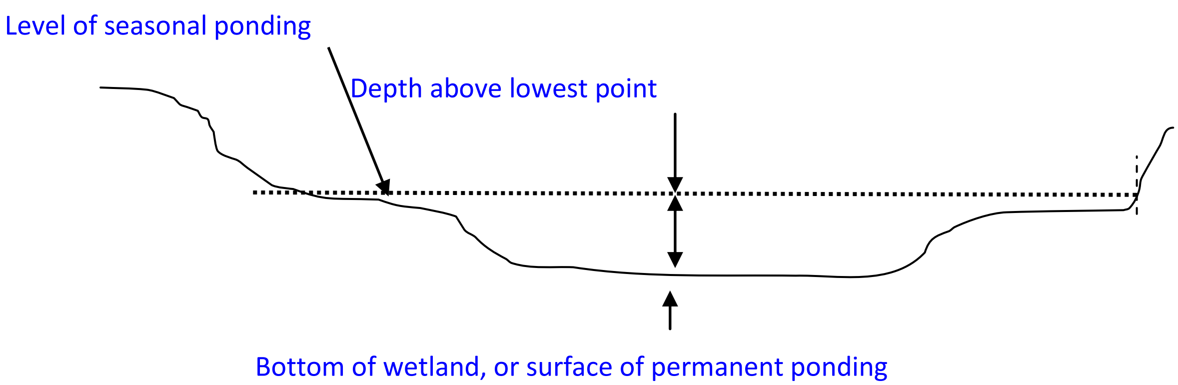


Figure26: Measuring maximum depth of seasonal ponding in a wetland without an outlet.

<u>Headwater wetlands</u>: This question also asks if the wetland being categorized is a "headwater" wetland. Depressional wetlands found in the headwaters of streams often do not store surface water to any great depth. They can, however, be important in reducing peak flows because they slow down and "desynchronize" the initial peak flows from a storm (Brassard and others 2000). Their importance in hydrologic functions is often under-rated (statement of Michael L. Davis, Deputy Assistant of the Army, before the committee on Environment and Public Works, Subcommittee on Clean Air, Wetlands, Private Property and Nuclear Safety, United State Senate, June 26, 1997). The depth of seasonal storage in headwater wetlands was judged to be an inadequate representation of the importance of these wetlands in the hydrologic functions. For this reason, headwater wetlands are scored 5 points, out of 7 possible, regardless of the depth of seasonal storage.

To identify if the unit is a "headwater" wetland, use the information collected in question D 1.1. If the unit has a permanent or seasonal outflow through a defined channel but NO inflow from a permanent or seasonal channel, it is a headwater wetland for the purposes of this categorization. **NOTE:** One exception to this criterion is wetlands whose water regime is dominated by groundwater coming from water storage facilities. Depressional wetlands at the base of irrigation reservoirs, dams or the edge of irrigation canals are not headwater wetlands, even if they have surface water that flows out of them without an inflow.

D 4.3 Contribution of the wetland to storage in the watershed:

Rationale for indicator: The potential of a wetland to reduce peak flows from its contributing basin is a function of its retention time (volume coming into a unit during a storm event/the amount of storage present). The area of the contributing basin is used to estimate the relative amount of water entering it, while the area of the wetland is used to estimate the amount of storage present. Large contributing basins are expected to have larger volumes for any given storm event than smaller basins. Thus a small wetland with a large contributing basin is not expected to reduce peak flows as much as a large wetland with a small contributing basin.

This question asks you first to estimate the geographic area that is found upstream of the wetland that contributes surface water to the wetland unit you are rating. This is called the contributing basin of the unit. You will then need to estimate the area of the unit and calculate the ratio of the two. You do not need to estimate these areas exactly because the scoring is based on thresholds for the ratio. If the contributing basin is less than 10 times the size of the wetland itself, the wetland will score the most points. On the other hand, if the area of the contributing basin is more than 100 times the area of the wetland the score is [0], and you will not need to make any further estimates.

> **NOTE:** You can use whatever means available to estimate the area of the upstream basin contributing surface water to a wetland. A topographic map works well if the landscape is not too confusing. If you have GIS with basin boundaries you will have to be careful to include only the areas upgradient of the wetland unit. If you are unfamiliar with the methods for mapping contributing basins, the procedure is described in a fact sheet by the NRCS "How to Read a Topographic Map and Delineate a Watershed" http://www.nh.nrcs.usda.gov/technical/Publications/Topowatershed.pdf .

D 5.0 Does the Landscape Have the Potential to Support the Hydrologic Functions of the Site?

Human changes in land use tend to de-stabilize the flows of water in a watershed. Generally, human activities reduce infiltration and increase the run-off during storm events and thus increase flooding problems (review in Sheldon and others 2005). A wetland located in areas where run-off has increased can provide more flood protection than one located in an undeveloped area. Thus, the "landscape potential" for the function is related to the increased amounts of water coming into the wetland from human sources.

Qualitatively, the increase is modeled as the number of different new sources of water coming into the unit.

D 5.1 Does the unit receive any stormwater discharges?

> **Rationale for indicator**: A depressional wetland that receives stormwater directly has a higher potential for providing hydrologic functions. It will receive more water during a rain event than under normal (no stormwater discharges) conditions.

Answer "YES" to the question if you see any pipes coming into the wetland from the surrounding uplands. These are usually stormwater discharges. Also, look on the aerial photograph of the wetland and look for stormwater ponds within 300 ft of the unit. If you see any ponds, determine if their discharges can get into the wetland.

D 5.2 Is more than 10% of the area within 150 ft of wetland unit in agricultural, pasture, residential, commercial, or urban?

> **Rationale for indicator**: Water can also flow into the depression directly from surrounding land uses that prevent some or all water from infiltrating. For example, a lawn can reduce infiltration by as much as 65% relative to a forest (Kelling and Peterson 1975).

Use your aerial photo and draw a line that is 150 ft from the edge of the unit you have mapped for rating. Answer "YES" to this question if you find the listed uses within 150 ft of the wetland and they cover more than 10% of the "donut" polygon around the unit.

D 5.3 Is more than 25% of the contributing basin of the wetland unit covered with intensive human land uses (residential at >1 residence/acre, urban, commercial, agriculture, etc.)?

> **Rationale for indicator**: Human changes in land use tend to de-stabilize the flows of water in a watershed. Generally, human activities reduce infiltration and increase the run-off during storm events and thus increase flooding problems (review in Sheldon and others 2005). Research in the Puget Sound area by the University of Washington has found that there are significant increases in water flows when intensive land uses represent more than 25 – 35% of the contributing basin (Azous and Horner 1997).

Use the map of the contributing basin you developed for question D 4.3 and estimate the area within the basin that has intensive land uses that de-stabilize surface flows.

D 6.0 Are the Hydrologic Functions Provided by the Site Valuable to Society?

D 6.1 Is the unit in a landscape that has flooding problems?

Rationale for indicator: The value of wetlands in reducing the impacts of flooding and erosion is based on the presence of human or natural resources that can be damaged by these disturbances. In general, the value of a wetland in reducing flood damage is judged to decrease with the distance downstream because the amount of water stored by the wetland relative to the overall flows decreases.

You will need to do some fact finding if you do not know whether floods have caused damage downstream of the unit. Your best sources of information on flooding problems are the emergency planning office in your local government, the local FEMA (Federal Emergency Management Agency), or the USGS for groundwater issues.

Choose the descriptions that best match conditions within the wetland unit being rated. Choose the description that generates the highest score on the Scoring Form.

- The site has been identified as important for flood storage or flood conveyance in a regional flood control plan.
- The wetland captures surface water that would otherwise flow down-gradient into areas where flooding has damaged human or natural resources (e.g., salmon redds).
- Flooding occurs in sub-basin that is immediately down-gradient of unit.
- Surface flooding problems are in a sub-basin further down-gradient.
- Flooding from groundwater is an issue in the sub-basin where the unit is found. For example, certain areas of Pierce and Thurston counties have problems with flooding and damage from groundwater. See USGS information for Puget Sound at: http://wa.water.usgs.gov/projects/pugethazards/urbanhaz/PDF/fs111_00.pdf
- The existing or potential outflow from the wetland is so constrained by human or natural conditions that the water stored by the wetland cannot reach areas that flood.

NOTE 1: Many depressional wetlands with no surface water outflow can protect natural or human resources from flooding. They are performing the hydrologic functions at the highest levels possible. No surface water leaves the wetland to cause flooding or erosion. The water either infiltrates to groundwater or it evaporates. To answer the "value" question for a wetland with no outflow, try to picture the wetland as "filled" with a parking lot. Where would the surface water it normally stores flow? If it would flow into a swale, channel, or stream, there is a possibility that the flow would increase flooding or erosion.

NOTE 2: (a landscape constraint on function): When a depressional wetland is situated upslope of a road where water movement through the road is limited by ineffective culverts, the roadway typically acts as a levee, de-coupling upslope wetlands from downstream flooding. The roadway, rather than the wetland, delays storm flows, and acts like a flood-control dam. This indicates that the hydrologic connection between the floodway and the upslope area is impaired. If, however, the water impounded on the upslope side of the road recedes at the same rate as a flooding event, you can assume the connections through the road are not constrained. In this case, the storage provided by the wetland on the upslope side is important, and the wetland unit should be scored accordingly.

NOTE 3: (a landscape constraint on function): Depressional wetlands situated at the base of a hillside typically receive significant water inputs from groundwater. Generally, you can conclude that wetlands that receive less than 10% of their water from surface flows do not provide much protection from flooding because they are not connected to the major patterns of surface flows. If the only water inputs are from a spring or seep emerging from a hillslope, then the wetland unit likely does not provide much value in reducing flooding. If, however, there are indicators that the wetland receives surface runoff from further up the slope (e.g., small gullies, washes, etc.) as well as groundwater, then the wetland may be valuable if there are flooding problems further downstream. A wetland can be considered to have more than a 90% groundwater influence if there is no seasonal or permanent surface water inflow and a very small contributing basin. Depressional wetlands in western Washington, however, rarely, if ever get most of their water from groundwater. For example, assume an average rainfall of 48" in western Washington and an average rate of evapotranspiration of 18"/year for a forest. Thus, a minimum of 30"/year of water comes into the unit from rain alone within its boundary. To exceed the 90% threshold the unit would need to receive the equivalent of 300 inches of groundwater/unit area. A 1 acre wetland would need a minimum of 25 acre feet of groundwater flowing through the system to meet the volume threshold for being dominated by groundwater, even if the only source of surface water is rain within its boundaries.

NOTE 4: (a landscape constraint on function): A depressional wetland that receives only return flow from irrigation is not in a landscape position to perform the hydrologic functions. Since the inflow is controlled, there is little chance that the water coming into the wetland will cause downstream flooding or erosion.

5.4 Water Quality and Hydrologic Functions in Riverine and Freshwater-Tidal Wetlands *(Questions Starting with 'R')*

R 1.0 Does the Site have the Potential to Improve Water Quality?

R 1.1 Total area of surface depressions within the wetland that can trap sediments and associated pollutants during a flooding event:

Rationale for indicator: Depressions in riverine wetlands will tend to accumulate sediment and the pollutants associated with sediment (phosphorus and some toxics) because they reduce water velocities (Fennessey and others 1994) when the river floods. Wetlands where a larger part of the total area has depressions are relatively better at removing pollutants associated with sediments than those that have no such depressions.

For this question, you will need to estimate the fraction of the wetland that is covered by depressions. Make a simple sketch of the unit boundary, and on this superimpose the areas where depressions are found. From this you can make a rough estimate of the area that has depressions. Determine if this area is more than ¾ or more than ½ of the total area of the wetland unit. Standing or open water present in the wetland when the river is not flooding are good indicators of depressions. Figure 27 shows a riverine wetland with depressions filled with water.

NOTE: Generally you should count only depressions that hold water for more than a week after a flood recedes. If a depression is not flooded at the time of your site visit, look for the deposition of fine or mucky sediments in the bottom of the depression. Sediments in the depression usually have a finer texture than those in the immediate area indicate the water was present in the depression for longer periods of time.

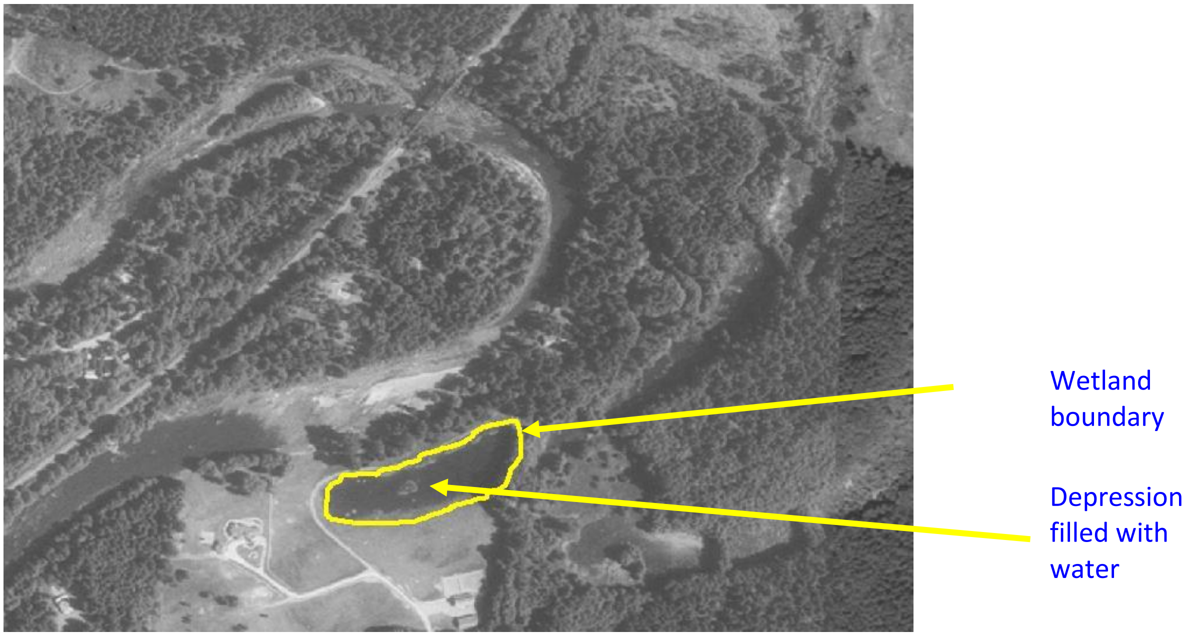


Figure 27: A riverine wetland in an old oxbow of the Nisqually River with one big depression that is filled with water and covers more than ¾ of the wetland.

R 1.2 Characteristics of the plants in the wetland:

> **Rationale for indicator**: Plants in a riverine wetland will improve water quality by acting as a filter to trap sediments and associated pollutants. The plants also slow the velocity of water which results in the deposition of sediments. Persistent, multi-stemmed plants enhance sedimentation by offering frictional resistance to water flow (review in Adamus and others 1991). Shrubs and trees are considered to be better at resisting water velocities than emergent plants during flooding and are scored higher. Aquatic bed species or grazed, herbaceous (non-woody) plants are not judged to provide much resistance to water flows and are not counted as "filters."

For this question you will need to group the plants found within the wetland into three categories: 1) forest or shrub, 2) ungrazed or unmowed emergent plants (> 6 inches high), and 3) neither forest, shrub, or ungrazed emergent plants.

NOTE: This question about plant cover is NOT based on the Cowardin classification. The polygons you draw of emergent and shrub plants must have a 90% cover of the ground when you look down from a person's height (5ft).

NOTE: You will need to judge if the plants in the unit are 6" high or more at the time when the river floods and is actually transporting sediment. If grazing or mowing occurs in summer but the plants have time to grow again before the time when the riverine wetland gets flooded, then the system is ungrazed. If, however, the grazing pressure is intense enough that the grass does not have time to recover during the flood season then it should be considered grazed.

There are two size thresholds used to score this characteristic: 1) more than 2/3 of the wetland area is covered (>66% cover) in either emergent, forest, or shrubby plants, and 2) more than 1/3 is covered. These thresholds can usually be estimated visually in small wetlands. Large wetlands, however, may require you to draw the area of plant types on a map or aerial photo before you can feel confident that your estimates are accurate.

R 2.0 Does the Landscape Have the Potential to Support the Water Quality Function of the Site?

Wetlands will remove many pollutants coming into them, and it is the removal of this excess pollution that is considered to be a valuable function for society. The landscape surrounding the wetland will to some degree determine how well a wetland improves water quality. If the wetland receives a heavy load of pollutants from the surrounding areas it will function to its maximum capacity. If, however, there are no pollutants coming in, the wetland cannot remove them, even if it has the necessary physical and chemical characteristics. Thus, the "landscape potential" for the function is related to the amount of pollutants that come into the wetland from the surrounding areas. Qualitatively, the level of pollutants can be correlated with the level of disturbance, development, and intensity of agriculture in the landscape. For example, relatively undisturbed watersheds will carry much lower sediment and nutrient loads than those that have been impacted by development, agriculture, or logging practices (Hartmann and others 1996, and Reinelt and Horner 1995).

R 2.1 Is the unit within an incorporated city or within its Urban Growth Area (UGA)?

R 2.2 Does the contributing basin to the unit include a UGA or incorporated area?

Rationale for indicators: Urban and suburban areas are a major source of pollutants to streams (review in Sheldon and others 2005). The presence of development adjacent and upstream of the wetland is a good indicator that there are pollutants in the surface waters reaching the riverine unit from the stream.

To begin, trace the stream or river to its source and determine if there are any urban areas or suburban areas adjacent to the stream that floods the unit. Answer "YES" to this question if there are any incorporated cities and towns or their Urban Growth Areas upstream of the unit or if the unit is within an urban area or UGA. Maps of UGA and urban areas can be found at http://www.ecy.wa.gov/programs/air/aginfo/ugamaps.htm.

If there are no developed areas adjacent to the stream you will need to identify the contributing basin to the stream that floods the wetland unit you are rating. This can be done using topographic maps or through web sites such as the USGS http://water.usgs.gov/wsc/map_index.html. Answer "YES" to this question if there are any incorporated cities and towns or UGAs within the contributing basin.

R 2.2 Does at least 10% of the contributing basin contain tilled fields, pastures, or forests that have been clearcut within the last 5 years?

> **Rationale for indicator**: Tilled fields are a source of nutrients, pesticides, and sediment. Pastures are a source of nutrients and pathogenic bacteria, and clearcut areas are a source of sediment (reviews in Sheldon and others 2005). The presence of these conditions upstream of the wetland unit are a good indicator that there are pollutants in the river waters reaching the unit.

Define the boundaries of the contributing basin to the stream that floods the wetland unit as in question R 2.1. Answer "YES" to this question if at least 10% of the total area of the upstream contributing basin has at least one or a combination of pasture, tilled fields or clearcut logging. Land uses can be determined from aerial photographs of the area or by downloading land use maps from the USGS http://eros.usgs.gov/#/Find_Data/Products_and_Data_Available/Land_Cover_Products.

R 2.3 Is more than 10% of the area within 150 ft of wetland unit in agriculture, pasture, golf courses, residential, commercial, or urban land uses?

> **Rationale for indicator**: Farming, grazing, golf courses, residential areas, commercial land uses, and urban areas, in general, are major sources of pollutants (reviewed in Sheldon and others 2005). The review also found that a well vegetated buffer of 150 ft will only remove 60-80% of some pollutants from surface runoff into a wetland. Thus, pollutants from such land uses will probably reach the wetland unit if they are within 150 ft of the wetland.

Use your aerial photo and draw a line around the unit that is 150 ft from the edge of the unit you have mapped for rating. Answer "YES" to this question if you find the listed uses within 150 ft of the wetland and they cover more than 10% of the "donut" polygon around the unit.

R 3.0 Is the Water Quality Improvement Provided by the Site Valuable to Society?

R 3.1 Is the unit along a stream or river that is on the 303(d) list or on a tributary that drains to a stream on the 303(d) list?

> **Rationale for indicator**: The term, "303(d) list," is short for the list of impaired waters (stream segments, lakes) that the Clean Water Act requires all states to submit to the Environmental Protection Agency (EPA) every two years. In Washington, we identify all waters where required pollution controls are not sufficient to attain or maintain water quality standards. The sites are ranked from 1-5 based on the uses of the water and severity of the pollution problem. Wetlands that discharge directly to these polluted waters are judged to be more valuable than those that discharge to unpolluted bodies of water because their role at cleaning up the pollution is critical for reducing further degradation of water quality.

To answer this question you will need to access the Department of Ecology's web site that lists all the bodies of water that do not meet water quality standards http://www.ecy.wa.gov/programs/wq/303d/2008/index.html. Determine from the aerial photo if the wetland unit you are rating is flooded by a stream or river listed as Category 2, 4, or 5 waters or is on a tributary to it.

R 3.2 Does the drainage in which the unit is found have TMDL limits for nutrients, toxics, or pathogens? *(see Rationale for definition of TMDL)*

> **Rationale for indicator**: Total Maximum Daily Loads (TMDLs or Water Cleanup Plans) describe the type, amount and sources of water pollution in a particular water body. They analyze how much the pollution needs to be reduced or eliminated to meet water quality standards, and then provide targets and strategies to control the pollution. Wetlands that discharge directly to these polluted waters are judged to be more valuable because they function at a landscape scale to mitigate discharges of pollutants. TMDL's are based on models that estimate the natural decay and absorption of pollutants under current conditions. Wetlands are an important part of that "natural" decay and their destruction would require a recalibration of the models, and force polluters to further reduce their discharges.

To answer this question you will need to access the Department of Ecology's web site that lists all the bodies of water that have TMDL's: http://www.ecy.wa.gov/programs/wq/tmdl/TMDLsbyWria/TMDLbyWria.html. Determine if the wetland unit you are rating is flooded by a stream or river in a drainage for which TMDL's have been developed.

R 3.3 Has the site been identified in a watershed or local plan as important for maintaining water quality?

> **Rationale for indicator**: Not all pollution and water quality problems are identified by Ecology's water quality monitoring program. Local and watershed planning efforts sometimes identify wetlands that are important in maintaining existing water quality. These wetlands provide a value to society that needs to be replaced if they are impacted.

To answer this question you will need to seek information from the planning department of the local jurisdiction where the site is located. Information on regional or local plans can often be found on the web site of the city or county in which the site is found. Useful "search" phrases include: "watershed plan," "water quality," or "wetland protection." If the drainage in which the wetland is found has a TMDL plan developed for it, then answer "YES" for this question. It is assumed that all wetlands are valuable in a basin where water quality is poor enough to require a TMDL. The Department of Ecology's web site lists all the bodies of water that have TMDL's (see above)

R 4.0 Does the Site Have the Potential to Reduce Flooding and Stream Erosion?

R 4.1 Characteristics of the "overbank" flood storage the wetland provides, based on the ratio of the channel width to the distance of the wetland perpendicular to the flow:

> **Rationale for indicator**: The ratio of the width of the channel to the width of the wetland perpendicular to the flow is an indicator of the relative volume of storage available within the wetland. The width of the stream between banks is an indicator of the relative flows at that point in the watershed. Wider streams will have higher volumes of water than narrower streams. More storage is therefore needed in larger systems to lessen the impact of peak flows. The distance of the wetland perpendicular to the stream is used as an indicator of the amount of short-term storage available during a flood event. A wetland that is wide relative to the width of the stream is assumed to provide more storage during a flood event than a narrow one. The ratio of the two values provides an estimate that makes it possible to rank wetlands relative to each other in terms of their overall potential for storage.

You will need to estimate the average distance of the wetland perpendicular to the direction of the flow, and the width of the stream or river channel (distance between the top of the banks of the stream). Calculate this ratio by taking the width of the wetland and dividing by the width of the stream. There are five thresholds for scoring: a ratio more than 20, a ratio between 10 – 20, a ratio between 5 – <10 , a ratio between 1 - <5, and a ratio < 1.

Riverine wetlands are found in different positions in the floodplain and it may sometimes be difficult to estimate this indicator. The following bullets describe some common types of riverine wetland and how to estimate this indicator.

- If the vegetated wetland lies within the banks of the stream or river, the ratio is estimated as the average width of the "delineated" wetland/average distance between banks. Figure 28 shows a wetland where plants fill only a small part of the distance between the banks. In this case the ratio is < 1.

- If the wetland lies outside the existing banks of the river, you may need to estimate the distances using a map or aerial photograph. Riverine wetlands in old oxbows may be some distance away from the river banks. Instead of trying to estimate a width for the wetland and the distance between banks in feet or yards, it may be easier to estimate the ratio directly. Ask yourself if the average width of the wetland is more or less than the distance between banks. If it is more, is it more than five times as wide? If not, the ratio is between 1- <5. If it is more than five times greater, is it more than 10 times, etc. Figure 29 shows a riverine wetland in an old oxbow where the ratio was judged to be between 1- <5.

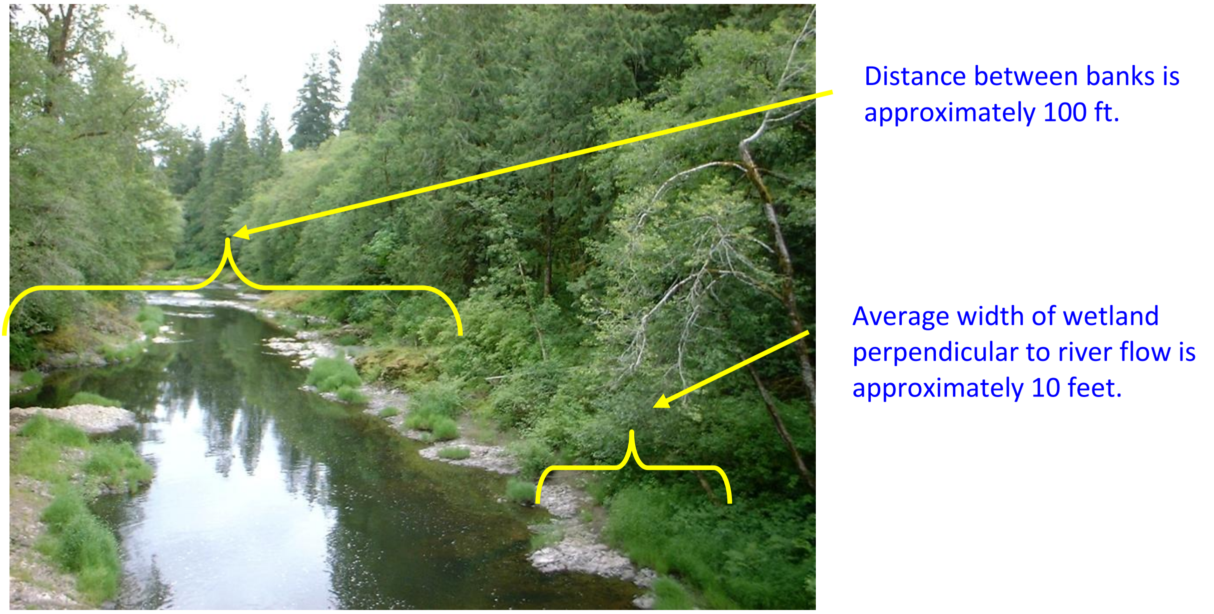


Figure 28: A riverine wetland where the width of the wetland is less than the distance between the banks (ratio ≤ 1).

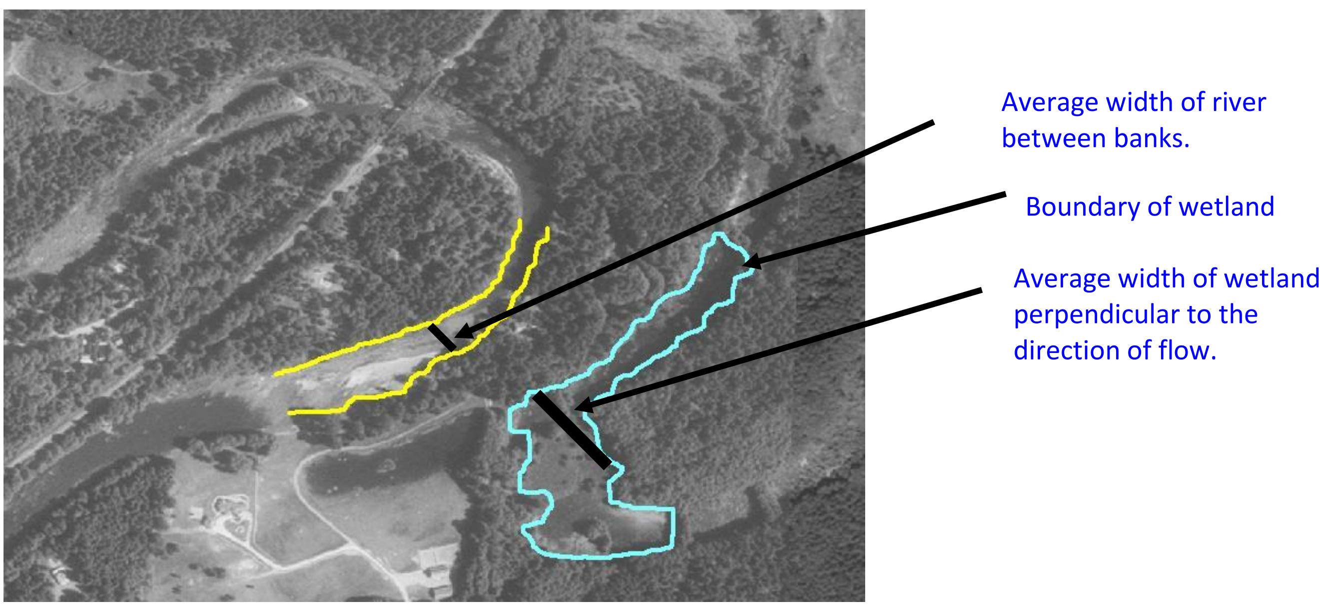


Figure 29: A riverine wetland in an old oxbow of the Nisqually River where the average width of the wetland is between 1-5 times the width of the river channel.

- If you are including the river or stream as part of the wetland, then the width of the stream is also included in the estimate of the width of the wetland.

- Braided channels: If the wetland is associated with only one braid you should use the cumulative width of all channels to calculate the average width of the channel.

R 4.2 Characteristics of plants that slow down water velocities during floods:

> **Rationale for indicator**: Riverine wetlands play an important role during floods because the plants act to slow water velocities and thereby erosive flows. This reduction in velocity also spreads out the time of peak flows, thereby reducing the maximum flows. The potential for reducing flows will be greatest where the density of wetland plants and other obstructions is greatest and where the obstructions are rigid enough to resist water velocities during floods (Adamus and others 1991). The indicator used combines both characteristics for the scoring. Shrubs and trees are considered to be better at resisting water velocities than emergent plants. Aquatic bed species are judged not to provide much resistance and are not counted. Wetlands with a dense cover of trees and shrubs are scored higher than those with only a cover of emergent species.

For this question you will need to group the plants found within the wetland into two categories: 1) emergent, and 2) forest and scrub/shrub.

There are four size thresholds used to score this characteristic: 1) forest or shrub > 1/3 the area of the wetland, 2) emergent plants > 2/3 area, 3) forest or shrub > 1/10 area, 4) emergent plants > 1/3 area. Figure 30 shows an aerial photograph of a riverine wetland that has dense shrub plants over most of its area.

> **NOTE**: This plant cover is NOT based on the Cowardin classification. The polygons you draw of emergent and shrub plants must have a 90% cover of the ground when you look down from a person's height (5ft).
>
> **NOTE**: If the wetland is covered with downed trees, you can treat large woody debris as "forest or shrub."

Figure 30: A riverine wetland in Bothell that has shrub plants over more than 1/3 of its area in many patches. Other important characteristics are: 1) the stream is part of the wetland because it is smaller than 50 ft. and there are wetland plants on both sides, 2) the average ratio of width of wetland to width of stream is greater than 20.

R 5.0 Does the Landscape Have the Potential to Support the Hydrologic Functions of the Site?

R 5.1 Is the stream or river adjacent to the unit downcut?

Rationale for indicator: Streams in developed areas are often downcut because of the increased flows from impermeable surfaces (review in Sheldon and others 2005). As a result the streams can become disconnected from the surrounding floodplain and floodwaters go overbank less frequently. A riverine wetland that is directly adjacent to a downcut stream will not provide the same level of flood attenuation as one that is adjacent to a stream with no downcutting.

To answer this question you will need to **view the section of the stream that provides the overbank flows to the wetland unit.** Generally, downcutting becomes visible when its watershed contains more than 10% impervious surface (Donaldson and Hefner 2005). Figures 31, 32, 33 and 34 show a progression of different levels of downcutting that result from development. For the purposes of this rating, Figures 33 and 34 show streams for which the answer to R 5.1 would be "YES". Figures 31 and 32 are streams for which the answer would be "NO" because the floodplain is still somewhat connected to the stream. Figures 31-34 are from Donaldson and Hefner 2005.

Figure 31: Stream in a watershed with less than 5 percent impervious cover, showing no downcutting.

Figure 32: A stream in a watershed with 8-10% impervious cover. Streambed is still relatively stable, but signs of stream erosion are more apparent. Not much downcutting is evident.

Figure 33: A stream in a watershed with approximately 20% impervious cover showing downcutting. You would answer "YES" to question R 5.1 for this stream.

Figure 34: This stream has a surrounding area of approximately 30%impervious cover. The manhole in the middle of the picture was originally in the floodplain and is an indicator of the degree to which the channel has been downcut.

R 5.2 Does the upgradient watershed include an UGA or incorporated area?

> **Rationale for indicator**: Urban and suburban areas are a major source of impervious surface. These areas increase both intensity of peak flows and the amount of water flowing during a storm event (review in Sheldon and others 2005). The presence of development upstream of the wetland is a good indicator that the landscape is increasing the flood flows to the wetland unit and thereby increases its level of functioning.

To begin, trace the stream or river to its source and determine if there are any urban areas or suburban areas adjacent to the stream. Answer "YES" to this question if there are any incorporated cities and towns or their Urban Growth Areas upstream of the unit. Maps of UGA and urban areas can be found at
http://www.ecy.wa.gov/programs/air/aginfo/ugamaps.htm and
http://www.commerce.wa.gov/DesktopModules/CTEDPublications/CTEDPublicationsView.aspx?tabID=0&ItemID=7518&MId=944&wversion=Staging

If there are no developed areas adjacent to the stream you will need to identify the contributing basin to the stream that floods the wetland unit you are rating. This can be done using topographic maps or through web sites such as the USGS http://water.usgs.gov/wsc/map_index.html. Answer "YES" to this question if there are any incorporated cities and towns or UGAs within the contributing basin.

R 5.3 Is the upgradient stream or river controlled by dams?

> **Rationale for indicator**: Dams will buffer the flood waters that a wetland receives by holding much of the waters back upstream of the unit. This can reduce the flood storage and attenuation that the wetland itself performs. The landscape potential for a wetland performing hydrologic functions is therefore reduced when dams are present upstream.

To answer this question you will have to trace on a map or aerial photo the stream or river adjacent to the unit you are rating. You answer "YES" to this question if there is a dam within 10 miles upstream of the unit. Look only for dams on the main channel. Dams on tributaries to the main stream do not count.

R 6.0 Are the Hydrologic Functions Provided by the Site Valuable to Society?

R 6.1 Distance to the nearest areas downstream that have flooding problems?

Rationale for indicator: The value of wetlands in reducing the impacts of flooding and erosion is based on the presence of human or natural resources that can be damaged by these processes. The indicator used characterizes whether the wetland's position in the landscape protects down-gradient resources from flooding. In general, the value of a wetland in reducing flood damage is judged to decrease with the distance downstream to flood-prone areas because the amount of water stored by the wetland relative to the overall flows decreases.

If you do not know if floods have caused damage in the sub-basin further downstream you will need to do some research. Your best sources of information on flooding problems are the emergency planning office in your local government and the local FEMA (Federal Emergency Management Agency). You may also find useful information using search engines on the web. Search for "watershed name" + flooding (or flood problems, flood history).

Determine if flooding occurs that damages resources in:

- The sub-basin that is immediately down-gradient of the unit.
- A sub-basin further down-gradient.

R 6.2 Has the site has been identified as important for flood storage or flood conveyance in a regional flood control plan?

Rationale for indicator: The values of flood storage and flood conveyance provided by wetlands are often recognized in regional flood control plans, and specific sites are mentioned in these plans.

To answer this question contact the jurisdiction in which the site is found to determine if any regional flood control plans exist. A search of web sites will probably also list flood control plans for the watershed in question. If plans exist, try to determine if the site has been identified as important or valuable. To answer "YES" to this question, the flood control district needs to have developed a flood control plan or flood hazard mitigation plan that identifies the site as one that needs to be preserved or enhanced to improve flood protection.

5.5 Water Quality and Hydrologic Functions in Lake-Fringe Wetlands *(Questions Starting with "L")*

L 1.0 Does the Site have the Potential to Improve Water Quality?

NOTE: Lake-fringe wetlands have a maximum score of only 12 points for the water quality functions instead of 16. The technical review team developing the Washington State Wetland Rating systems concluded that lake-fringe wetlands do not improve water quality to the same extent as riverine or depressional wetlands because any pollutants taken up in plant material will be more easily released into the water column and dispersed when the plants die off.

L 1.1 Average width of plants along the lakeshore:

Rationale for indicator: The intent of this question is to characterize the width of the zone of plants that provide a vertical structure to filter out pollutants or absorb them. Wetlands in which the average width of plants is large are more likely to retain sediment and toxic compounds than where plants are narrow (Adamus and others 1991). Even aquatic bed species that die back every year are considered to play a role in improving water quality. These plants take up nutrients in the spring and summer that would otherwise be available to stimulate algal blooms in the lake. In addition, aquatic bed species change the chemistry of the lake bottom to facilitate the binding of phosphorus (Moore and others 1994).

It is often difficult to map the outside edge of a wetland when it is along the shores of a lake where open water can extend out for large distances. For this reason the question is phrased in terms of width of plants perpendicular to the shore rather than the area of plants. There are three thresholds for scoring the average width of plants:

1) 33 ft or more (10 m)

2) 16 ft - < 33 ft (5–10 m)

3) 6 ft - <16 ft. (2 – 5 m)

For large wetlands along the shores of a lake it may be necessary to sketch the plants and average the width by segment, and then calculate an overall average. Figure 35 gives an example of such a sketch. Figure 36 shows an actual lake-fringe wetland where the average width of plants is greater than 33 ft.

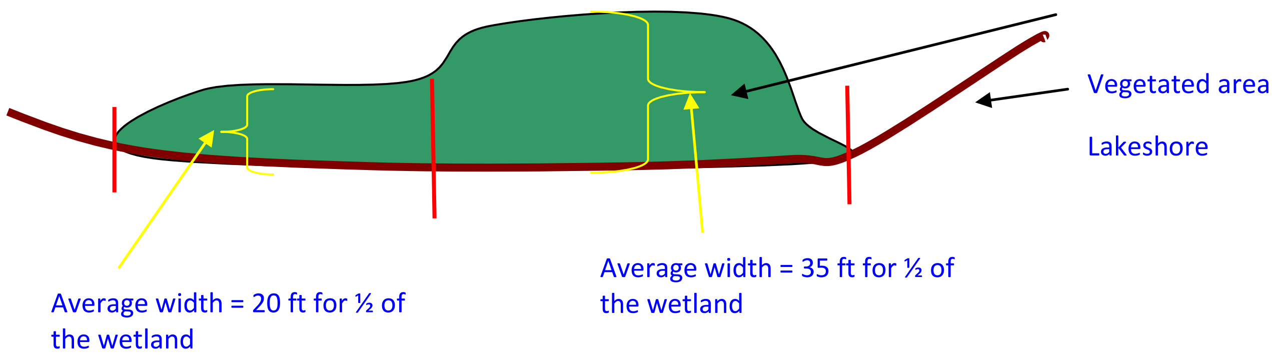


Figure 35: Estimating width of plants along the shores of a lake. The average width of plants for the entire area is: (20 ft x 0.5) + (35 ft x 0.5) = 27.5 ft.

Figure 36: A lake-fringe wetland where the plants are wider than 33 ft. The plants along the shores of this lake consist of a zone of shrubs and a zone of aquatic bed and emergent species.

L 1.2 Characteristics of the plants in the wetland:

Rationale for indicator: The intent of this question is to characterize how much of the wetland is covered with plants that are more effective at improving water quality in a lake environment. Herbaceous emergent species have, in general, been found to sequester metals and remove oils and other organics better than other plant species (Hammer 1989, and Horner 1992).

For this question you will need to group the plants found within the wetland into three categories: 1) herbaceous, 2) aquatic bed, and 3) any other plants. For this question, the herbaceous plants can be either the dominant plant form (in this case it would be called emergent class) or as an understory in a shrub or forest community. **These again are not the Cowardin classes for plants.**

There are several size thresholds used to score this characteristic – more than 90%, more than 2/3, or more than 1/3, of the vegetated area is covered in herbaceous plants or other types. These thresholds can usually be estimated visually in small wetlands. Large wetlands, however, may require you to draw the area of plant types on a map or aerial photo before you can feel confident that your estimates are accurate.

> **NOTE**: In lake-fringe wetlands the area of the wetland used as the basis for determining thresholds is only the area that is vegetated. Do not include open water beyond the outer edge of the unit in determining the area of the wetland covered by a specific type of plants.

L 2.0 Does the Landscape Have the Potential to Support the Water Quality Function of the Site?

L 2.1 Is the lake used by power boats?

> **Rationale for indicator:** The presence of power boats on a lake will increase the pollutants entering a lake fringe wetland. Toxic chemicals, oils, cleaners, and paint scrapings from boat maintenance can make their way into the water (review in Asplund 2000). In addition, older two stroke engines still found on many recreational boats and jet skis were purposely designed to discharge gasoline and oil into the water. The landscape potential of a wetland along a lake-shore to improve water quality is higher if the lake itself is directly receiving pollutants from power boats.

To answer this question you will need to know if the lake has any restrictions on use by power boats. The local planning department or parks department should have this information. The answer to this question is "NO" if there is a complete ban on gasoline or diesel motors on the lake. Many lakes are limited to small outboards of less than 5 or 10 hp, but these are still sources of pollutants. Other lakes are limited to electric motors only. In this latter case, the answer would also be "NO".

The answer to this question should be "YES" unless you can provide evidence that the bans on power boats are present.

L 2.2 Is more than 10% of the area within 150 ft of the wetland unit (on the shore side) agricultural, pasture, residential, commercial, or urban?

> **Rationale for indicator**: Farming, grazing, residential areas, commercial land uses, and urban areas in general are major sources of pollutants (reviewed in Sheldon and others 2005). The review also found that a well vegetated buffer of 150 ft will only remove 60-80% of some pollutants from surface runoff into a wetland. Thus, pollutants from such land uses will probably reach the wetland unit along the lake if they are within 150 ft of it.

Use your aerial photo and draw a line around the unit that is 150 ft from the upland edge of the unit. The line should be 150 ft upslope of the unit boundary. Answer "YES" to this question if you find the listed uses within 150 ft of the wetland and they cover more than 10% of the polygon.

L 2.3 Does the lake have problems with algal blooms or excessive plant growth such as milfoil?

> **Rationale for indicator**: Algal blooms and blooms of larger plants such as milfoil are an indication of excessive nutrients in the lake water (Schindler and Fee 1974, Smith and others 1999). The increased levels of nutrients in the lake increase the amount of nutrients that the wetland plants absorb (Venterink and others 2002) and thus also increase the level of function within the wetland unit.

To answer this question you will need to visit the lake in the summer, or examine aerial photographs taken in the summer, to determine if there is excessive plant growth (Figures 37, 38). If you are rating the unit in the winter, you will need to inquire locally (residents, board of health officials, or parks departments) to determine if blooms occur in the summer.

Figure 37: Algal blooms in a lake in the Puget Sound area.

Figure 38: A lake infested with milfoil indicating the presence of excess nutrients (photo courtesy of NHDEP).

L 3.0 Is the Water Quality Improvement Irovided by the Site Valuable to Society?

L 3.1 Is the lake on the 303(d) list of degraded aquatic resources?

Rationale for indicator: In Washington we identify all waters where required pollution controls are not sufficient to attain or maintain applicable water quality standards. The sites are ranked from 1-5 based on the uses of the water and severity of the pollution problem. Wetlands along the shores of lakes on the 303(d) list are judged to be more valuable because their role at cleaning up the pollution is critical for reducing further degradation of water quality.

To answer this question you will need to access the Department of Ecology's web site that lists all the bodies of water that do not meet water quality standards http://www.ecy.wa.gov/programs/wq/303d/2008/index.html. Determine if the wetland unit is along the shores of a lake on the 303(d) list.

L 3.2 Is the lake is in a sub-basin where another aquatic resource is on the 303(d) list?

Rationale for indicator: Lake-fringe wetlands can mitigate the impacts of pollution even if they are not located directly on a polluted body of water. At a watershed scale, lake-fringe wetlands can remove pollutants that might otherwise cause problems further downstream. They can also trap airborne pollutants. Thus, wetlands can provide an ecosystem service and value to our society in any basin and sub-basin that has pollution problems. The removal of pollutants by wetlands is judged to be more valuable in basins where other aquatic resources are already polluted. The 303(d) list is used as an indicator of pollution problems in a basin.

To answer this question you will need to access the Department of Ecology's web site that lists all the bodies of water that do not meet water quality standards (see above).. Determine if the wetland unit is in a basin or sub-basin where any body of water is on the 303(d) list.

L 3.3 Has the site been identified in a watershed or local plan as important for maintaining water quality?

Rationale for indicator: Not all pollution and water quality problems are identified by Ecology's water quality monitoring program. Local and watershed planning efforts sometimes identify wetlands that are important in maintaining existing water quality. These wetlands provide a value to society that needs to be replaced if they are impacted.

To answer this question you will need to seek information from the planning department of the local jurisdiction where the site is located. Information on regional or local plans can often be found on the web site of the city or county in which the site is found. Useful "search" phrases include: "watershed plan," "water quality," or "wetland protection." If the basin in which the wetland is found has a TMDL plan (also called a Water Clean Up Plan) developed for it, then you answer "YES" for this question. It is assumed that all wetlands are valuable in a basin where water quality is poor enough to require a TMDL. The Department of Ecology's web site lists all the bodies of water that have TMDL's: http://www.ecy.wa.gov/programs/wq/tmdl/TMDLsbyWria/TMDLbyWria.html .

L 4.0 Does the Site Have the Potential to Reduce Shoreline Erosion?

Lake-fringe wetlands have a maximum score of only 6 points for the hydrologic functions instead of 16. The technical review team developing the wetland rating system (Hruby 2004b) concluded that lake-fringe wetlands do not provide hydrologic functions to the same extent as riverine or depressional wetlands. The function of reducing shoreline erosion at the local scale was not judged to be as important as reducing peak flows and reducing erosion at the watershed scale, and should not be scored as highly. Lake-fringe wetlands, however, do reduce erosion by dissipating wave energy before it reaches the shore.

L. 4.1 Average width and characteristics of plants along the lakeshore (do not include aquatic bed species):

Rationale for indicator: The intent of this question is to characterize how much of the wetland is covered with plants that provide a physical barrier to waves and protect the shore from erosion. This protection consists of both shoreline anchoring and the dissipation of erosive forces (Adamus and others 1991). Wetlands that have extensive, persistent (especially woody) plants provide protection from waves and currents associated with large storms that would otherwise penetrate deep into the shoreline (Adamus and others 1991). Emergent plants provide some protection but not as much as the stiffer shrubs and trees.

This characteristic is similar to that used in L 1.1 and L 1.2, but the grouping of plants types and thresholds for scoring are different. If you are familiar with the Cowardin classification of plants you are looking for the areas that would be classified as "Scrub/shrub," "Forested," or "Emergent." **This indicator is based on the Cowardin plant classes.**

It is difficult to map the outside edge of a wetland when it is along the shores of a lake where open water can extend out for large distances. For this reason the question is phrased in terms of the width and type of plants found only within the area of shrubs, trees, and emergents. There are two thresholds for measuring the average width of plants [33 ft (10m) and 6 ft (2m)], and two thresholds based on distance along the shore [¾ and ¼ of the distance along the shore]. For large wetlands along the shores of a lake it may be necessary to sketch the plants types and average the width by type. Figure 39 gives an example of such a sketch.

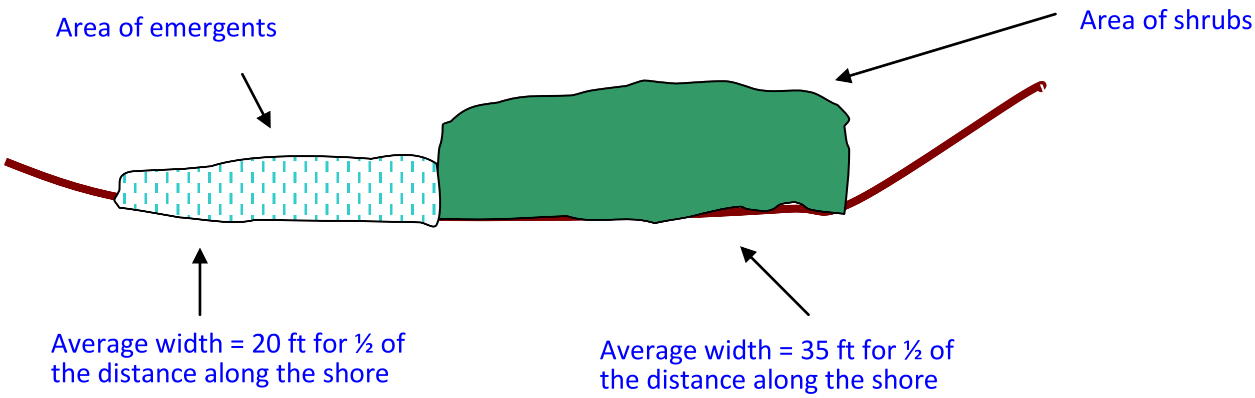


Figure 39: Estimating width of plants types along the shores of a lake. The average width of shrubs is 35 ft for ½ the distance along the shore and the width of emergents is 20 ft for ½ of the distance. This wetland would score 4 points because more than 1/4 distance consists of shrubs wider than 33ft.

L 5.0 Does the Landscape Have the Potential to Support the Hydrologic Functions of the Site?

L 5.1 Is the lake used by power boats with more than 10 hp?

Rationale for indicator: Boat wakes can be a major source of shoreline erosion (Maynord and others 2008, review in Asplund 2000). Lakes with boat traffic will have larger waves than lakes without. Wetlands along the shores of the latter will provide a higher level of function by reducing the impact of the larger waves.

To answer this question you will need to know if the lake has any restrictions on power boats. The local planning department or parks department should have this information. The answer to this question is “NO” if there is a complete ban on gasoline or diesel motors on the lake. Many lakes are limited to small outboards of less than 5 hp or 10 hp. Other lakes are limited to electric motors only. In both cases the answer would also be “NO” because the speed of these smaller boats is limited and correspondingly their wakes will be smaller.

The answer to this question should be “YES” unless you can provide evidence that the bans on power boats are present.

L 5.2 Is the fetch on the lake side of the unit at least 1 mile in distance?

Rationale for indicator: The size of wind generated waves on lakes depends on the fetch. The fetch is the uninterrupted distance over which the wind blows without a significant change in direction. Lakes with larger fetches will have larger waves. Wetlands along the shores of lakes with longer fetches will provide a higher level of function by reducing the impact of the larger waves. The threshold of 1 mile was chosen because in many lakes such a fetch will generate a wave of approximately 1ft in a 20 mph wind.
http://woodshole.er.usgs.gov/staffpages/csherwood/sedx_equations/RunSPMWave.html

Use a topographic map or scaled aerial photograph to measure the farthest distance to another shore or obstruction. This is the maximum fetch over which a wind can blow. Answer "YES" to this question if the distance is one mile or more.

L 6.0 Are the Hydrologic FunctionsPprovided by the Site Valuable to Society?

L 6.1 Are there resources, both human and natural, along the shore that can be impacted by erosion?

Rationale for indicator: Lake-fringe wetlands provide value by protecting a shoreline from erosion if there is some resource that could be damaged by this erosion. For example, houses are often built along a shoreline, and these can be damaged by shoreline erosion, especially if the house is on a bluff. Buildings, however, are not the only resource that can be impacted. A mature forest along the shores of a lake is an important natural resource that provides important habitat. Shoreline erosion, especially man-made erosion from boat wakes, may topple trees into the lake and reduce the overall area of this resource.

Users of this method must make a qualitative judgment on the value of the lake-fringe wetland in protecting resources from shoreline erosion. Generally, a lake-fringe wetland does have value if:

- There are human structures or old growth/mature forests within 25 ft of OHWM of the shore in the unit.
- There are nature trails or other paths and recreational activities within 25 ft of OHWM.

The Scoring Form has space to note observations of resources along the shore that do not meet the criteria above. If you observe or know of other resources, note this on the form and score it.

5.6 Water Quality and Hydrologic Functions in Slope Wetlands *(Questions Starting with "S")*

S 1.0 Does the Site Have the Potential to Improve Water Quality?

Slope wetlands have a maximum score of only 12 points for the water quality functions instead of 16. The technical review teams that developed the Washington State Wetland Rating System concluded that slope wetlands do not improve water quality to the same extent as riverine or depressional wetlands because slope wetlands will tend to release surface water fairly quickly. They are usually less effective at trapping sediment and all the pollutants associated with sediment because of their topography and the way water moves through them.

S 1.1 Characteristics of the average slope of the wetland:

> **Rationale for indicator**: Water velocity decreases with decreasing slope. This increases the retention time of surface water in the wetland and the potential for retaining sediments and associated toxic pollutants. The potential for sediment deposition and the retention of toxics by burial increases as the slope decreases (review in Adamus and others 1991).

For this question you will need to estimate the average slope of the wetland unit. Slope is measured either in degrees or as a percent (%). In this method, we use the latter measurement, (%), which is calculated as the ratio of the vertical change between two points and the horizontal distance between the same two points [vertical drop in feet (or meters) / horizontal distance in feet (or meters)]. For example, a 1 ft drop in elevation between two points that are 100 ft. apart is a 1% slope, and a 2 foot drop in the same distance is a 2% slope.

For large wetlands the slope can be estimated from USGS topographic maps of the area. The change in contour lines can be used to calculate the vertical drop between the top and bottom edges of the wetland unit. The horizontal distance can be estimated using the appropriate scale (printed at the bottom of the map). Local jurisdictions sometimes have assessor's maps that are contoured at 2 ft intervals. These can be very useful in estimating the slope.

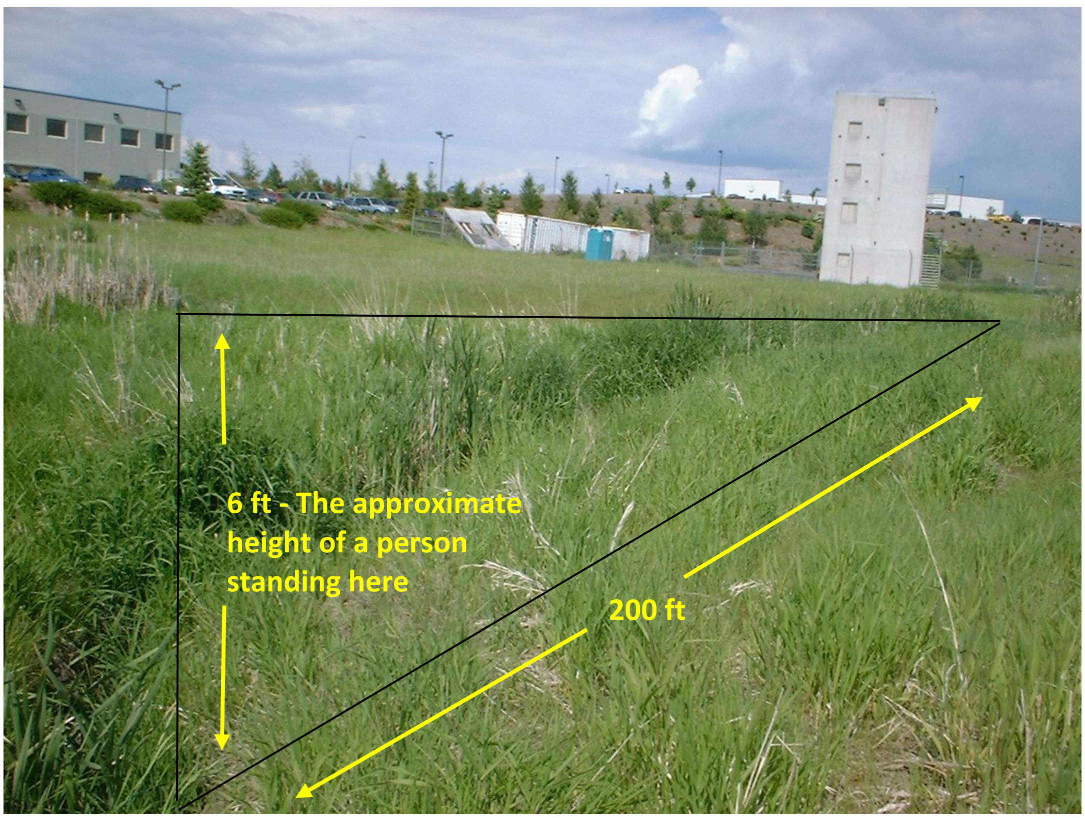
For small wetlands it will be necessary to estimate the vertical drop visually and the horizontal distance by pacing or using a tape measure. Visual estimates of the vertical drop are more accurate if you can find a point of reference near the bottom edge of the wetland. Stand at the upper edge of the wetland and visualize a horizontal line to a tree, telephone pole, or another person at the lower edge of the slope wetland. The point at which the" horizontal line intersects the object at the lower edge can be used to estimate the vertical drop between the upper and lower edges of the wetland (see Figure 40).

NOTE: If you are standing at the upper edge of the wetland looking for a visual marker at the lower edge, do not forget to subtract your height from the total.

NOTE: If the slope of a wetland changes the best way to estimate the average is to calculate the slope between the upper most unit boundary and the lowest point on the boundary. This will average out all the variations unless the unit has a much higher slope for a short distance at either end.

NOTE: If the slope wetland has a ditch along its bottom side DO NOT use the bottom of the ditch for calculating the slope. Use the elevation of the top of the ditch for calculating the slope.

Figure 40: Estimating the slope of a small slope wetland. The top of a six foot person is about level with the upper edge of the wetland. The average slope is approximately 6/200 = 0.03 or 3%.



Upper edge of wetland

Lower edge of wetland

S 1.2 The soil 2 inches below the surface is a true clay or true organic soil.

Rationale for indicator: Clay soils and organic soils are both good indicators that a wetland can remove a wide range of pollutants from surface water. The uptake of dissolved phosphorus and toxic compounds through adsorption to soil particles is highest when soils are high in clay or organic content (Mitsch and Gosselink 1993).

If the unit is found within an area that is mapped as an organic or clay soils by the NRCS in their county soil maps, you do not need to do any further investigations. Consider the unit to have clay or organic soils. If it is not mapped as an organic or clay soil you will need to take at least one sample at the site.

To look at the soil: dig a small hole within the unit boundary and pick a sample from the area that is about 2 inches below the duff layer. Usually it is best to sample the soil toward the middle of the wetland rather than at the edge. Avoid picking up any of the duff or recent plant material that lies on the surface. Determine if the soil is organic or clay. If you are not familiar with procedures for identifying organic or clay soils, a key is provided in Appendix C.

> **NOTE**: The presence of organic or clay soils anywhere within the wetland unit counts. There is no scaling for this question based on the size of the patch of soil. This simplification is necessary because it is not possible to develop a reproducible map of different soils in a wetland unit within the time frame for doing the field work.

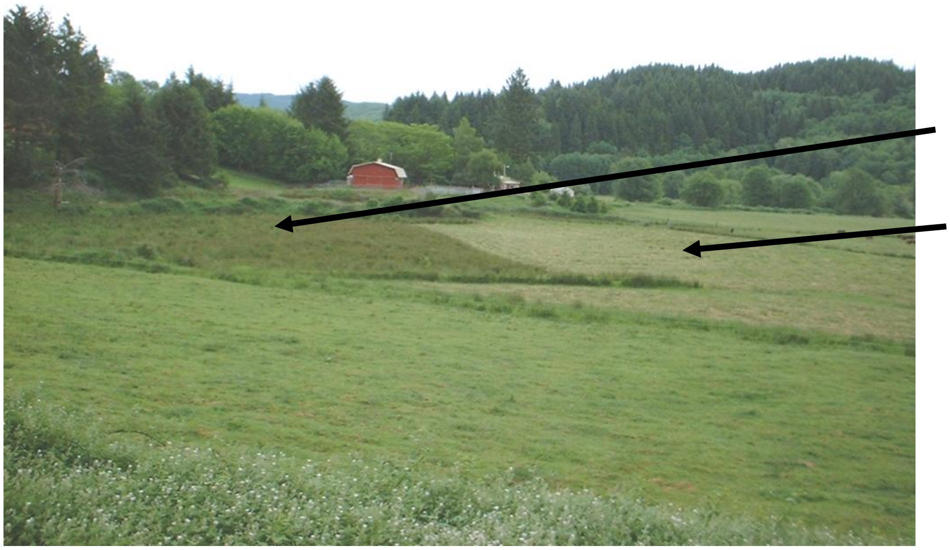
See the NRCS web page for more descriptions on how to identify organic soils: ftp://ftp-fc.sc.egov.usda.gov/NSSC/Soil_Taxonomy/keys/2010_Keys_to_Soil_Taxonomy.pdf

S 1.3 Characteristics of the plants that trap sediments and pollutants:

> **Rationale for indicator**: The intent of this question is to characterize how much of the wetland is covered with plants that are more effective at improving water quality in a slope environment. Herbaceous species have, in general, been found to sequester metals and remove oils and other organics better than other plant species (Hammer 1989, and Horner 1992). Furthermore, dense herbaceous plants present the greatest resistance to the surface flow often found on slope wetlands. Water in this environment tends to flow very close to the surface and be shallow (not more than a few inches). Trees and shrubs tend to be widely spaced relative to herbaceous plants and don't provide as much resistance to this type of surface flow.

For this question you will need to group the plants found within the wetland into only two groups: 1) dense, ungrazed, herbaceous plants, and 2) all other types (Figure 41). **NOTE**: **The Cowardin plants types are NOT used for this question.** For this question the herbaceous plants includes the areas of emergent plants as classified by Cowardin and the herbaceous understory in a shrub or forest. To qualify for "dense", the herbaceous plants must cover at least ¾ (75%) of the ground (as opposed to the 30% requirement in the Cowardin plant classes).

> **NOTE**: The best information on reducing surface flows in a slope is provided by the basal cross-section of the plants. However, this is not easy to measure. The best indicator we were able to find is an estimate of the cover from a person's height. Generally, if less than 25% of the ground is visible at 5-6ft., then there will be a fairly high stem density and basal cross section to trap sediments and reduce flows. In Question S 1.3 we differentiate between herbaceous and non-herbaceous plants while in S 4.1 it is between rigid, dense, plants and other types.



Unmowed part of the wetland covered by *Juncus* sp.

Figure 41: A slope wetland where dense unmowed, plants are between 1/4 and 1/2 the area of the wetland.

S 2.0 Does the Landscape Have the Potential to Support the Water Quality Function of the Site?

S 2.1 Is >10% of the buffer area within 150 ft upslope of wetland unit in agricultural, pasture, residential, commercial, or urban?

Rationale for indicator: Farming, grazing, residential areas, commercial land uses, and urban areas in general are major sources of pollutants (reviewed in Sheldon and others 2005). The review also found that a well vegetated buffer of 150 ft will only remove 60-80% of some pollutants from surface runoff into a wetland. Thus, pollutants from such land uses will probably reach the wetland unit if they are within 150 ft of the unit and upslope of it.

Use your aerial photo and draw a line around the unit that is 150 ft from the edge of the unit. The line should be 150 ft upslope of the unit boundary. Answer "YES" to this question if you find the listed uses within 150 ft of the wetland and they cover more than 10% of the polygon upslope of the unit.

S 3.0 Is the Water Quality Improvement Provided by the Site Valuable to Society?

S 3.1 Does the unit discharge directly to a stream, river, or lake that is on the 303(d) list?

Rationale for indicator: Wetlands that discharge directly to these polluted waters are judged to be more valuable than those that discharge to unpolluted bodies of water because their role at cleaning up the pollution is critical for reducing further degradation of water quality.

To answer this question you will need to access the Department of Ecology's web site that lists all the bodies of water that do not meet water quality standards http://www.ecy.wa.gov/programs/wq/303d/2008/index.html. Determine from the aerial photo if the wetland unit you are rating is within at least 1 mile of any aquatic resource listed as Category 2, 4, or 5 waters and has a surface water channel, ditch or other discharge to it.

S 3.2 Is the unit in a basin or sub-basin where another aquatic resource is on the 303(d) list?

Rationale for indicator: Wetlands can mitigate the impacts of pollution even if they do not discharge directly to a polluted body of water. Wetlands can remove nitrogen from groundwater as well as surface water. They can also trap airborne pollutants. Thus, wetlands can provide an ecosystem service and value to our society in any basin and sub-basin that has pollution problems. The removal of pollutants by wetlands is judged to be more valuable in basins where other aquatic resources are already polluted. Any further degradation of these resources could result in irreparable damage to the ecosystem.

To answer this question you will need to access the Department of Ecology's web site that lists all the bodies of water that do not meet water quality standards (see above). Determine from the aerial photo if the wetland unit you are rating is in the hydrologic basin or sub-basin of any aquatic resource listed as Category 2, 4, or 5 waters. To find the boundaries of hydrologic units in the area consult with the planning department of the local jurisdiction or use the map of hydrologic units developed by USGS. http://water.usgs.gov/GIS/huc.html

S 3.3 Has the site been identified in a watershed or local plan as important for maintaining water quality?

Rationale for indicator: Not all pollution and water quality problems are identified by Ecology's water quality monitoring program. Local and watershed planning efforts sometimes identify wetlands that are important in maintaining existing water quality. These wetlands provide a value to society that needs to be replaced if they are impacted.

To answer this question you will need to seek information from the planning department of the local jurisdiction where the site is located. Information on regional or local plans can often be found on the web site of the city or county in which the site is found. Useful "search" phrases include: "watershed plan," "water quality," or "wetland protection." If the basin in which the wetland is found has a TMDL plan (also called a Water Clean Up Plan) developed for it, then answer "YES" for this question. It is assumed that all wetlands are valuable in a basin where water quality is poor enough to require a TMDL. The Department of Ecology's web site lists all the bodies of water that have TMDL's: http://www.ecy.wa.gov/programs/wq/tmdl/TMDLsbyWria/TMDLbyWria.html .

S 4.0 Does the Site Have the Potential to Reduce Flooding and Stream Erosion?

Slope wetlands have a maximum score of only 8 points for the hydrologic functions instead of 16. The technical review teams that developed the Washington State Wetland Rating Systems concluded that slope wetlands may provide some velocity reduction but do not provide flood storage. Thus, they should be scored less than wetlands that can perform both aspects of the function.

S 4.1 Characteristics of plants that reduce the velocity of surface flows.

Rationale for indicator: The intent of this question is to characterize how much of the wetland is covered with plants that provide a physical barrier to sheetflow coming down the slope. Plants on slopes will reduce peak flows and the velocity of water during a storm event (U.S. Geologic Service, http://ga.water.usgs.gov/edu/urbaneffects.html, accessed July 31, 2003). The importance of plants on slopes in reducing flows has been well documented in studies of logging (Lewis and others 2001) though not specifically for slope wetlands. The assumption is that plants in slope wetlands play the same role as plants in forested areas in reducing peak flows.

For this question you will need to estimate the area of two categories of plants found within the wetland: 1) dense, uncut, rigid plants, and 2) all other plants. This indicator of plants is **not** related to any of the Cowardin classes. **Dense** means that individual plants are spaced closely enough that the soil is barely, if at all, (> 75% cover of plants) visible when looking at it from the height of an average person. **Uncut,** means that the height of the plants has not been significantly reduced by grazing or mowing. "Significantly reduced" means that the height is less than 6 inches. **Rigid** is defined as having stems thick enough (usually > 1/8 in.) to remain erect during surface flows.

There is only one threshold used to score this characteristic: dense, ungrazed, rigid plants for more than 90% of the area of wetland (Figure 42), The wetland in Figure 41 was mowed over much of its area, except where the *Juncus sp.* was growing. The mowed plants were less than 6 inches high, so the only plants that were included for this indicator were the *Juncus*.

NOTE: This is a simpler version of the questions in the wetland rating system. Only one answer resulted in a [M]oderate rating of 6 or more points. As a result the other questions were dropped since all resulted in a [L]ow rating.

NOTE: This description is not species specific because a species may be rigid in one environment and not rigid in another. For example, reed canarygrass (*P. arundinaceae*) can grow very thick and rigid stems in areas with high nutrients. In other situations, however, it can be very thin (e.g., shady environment) and would easily be bent to the ground by runoff.

Figure 42: A slope wetland with dense, rigid, ungrazed plants (reed canarygrass and *Juncus* sp., shrubs and trees) over more than 90% of its area. The direction of the slope is from the left of the photograph to the right.

S 5.0 Does the Landscape Have the Potential to Support the Hydrologic Functions of the Site?

S 5.1 Is more than 10% of the buffer area within 150 ft upslope of wetland unit in agricultual, pasture, residential, commercial, or urban land use?

Rationale for indicator: Human land uses tend to de-stabilize the flows of water in a watershed. Generally, human activities reduce infiltration and increase the run-off during storm events (review in Sheldon and others 2005). For example, a lawn can reduce infiltration by as much as 65% (Kelling and Peterson 1975). Thus, a slope unit located in areas where run-off has increased can provide more velocity reduction of surface flows than one located in an undeveloped area.

Use your aerial photo and draw a line around the unit that is 150 ft from the edge of the unit. The line should be 150 ft upslope of the unit boundary. Answer "YES" to this question if you find the listed land uses within 150 ft of the wetland and they cover more than 10% of the polygon.

S 6.0 Are the Hydrologic Functions Provided by the Site Valuable to Society?

S 6.1 Distance to the nearest areas downstream that have flooding problems.

Rationale for indicator: The value of wetlands in reducing the impacts of flooding and erosion is based on the presence of human or natural resources that can be damaged by these processes. The indicator used characterizes whether the wetland's position in the landscape protects down-gradient resources from flooding. In general, the value of a wetland in reducing flood damage is judged to decrease with the distance downstream because the amount of water flowing through the unit relative to the overall flows decreases.

If you do not know if floods have caused damage in the sub-basin further downstream you will need to do some research. Your best sources of information on flooding problems are the emergency planning office in your local government and the local FEMA (Federal Emergency Management Agency).

Choose the description that best matches conditions around the wetland unit being rated.

The wetland reduces velocities that would otherwise impact down-gradient areas where flooding has damaged human or natural resources (e.g., salmon redds):

- In the sub-basin that is immediately down-gradient of unit.
- In a sub-basin further down-gradient.

S 6.2 Has the site has been identified as important for flood storage or flood conveyance in a regional flood control plan?

Rationale for indicator: The values of flood storage and flood conveyance provided by wetlands are often recognized in regional flood control plans, and specific sites are mentioned in these plans.

To answer this question contact the jurisdiction in which the site is found to determine if any regional flood control plans exist. If so, try to determine if the site has been identified as important or valuable.

5.7 Habitat Functions (*Questions starting with "H" for all HGM classes)*

A rapid method such as this one relies on indicators of function that are fixed and present throughout most of the year (see Chapter 2). As a result it is not possible to actually monitor the species that use a wetland, nor determine their abundance. The one aspect of habitat that we can determine is a relative number for habitat niches present. The questions below describe indicators that represent different habitat niches. The basic assumption is that wetlands with more niches can provide higher level of the habitat function than one with fewer. The rating for this function is based on the potential number of species for which a site can provide habitat.

H 1.0 Does the Site Have the Potential to Provide Habitat?

H 1.1 Structure of plant community:

Rationale for indicator: More habitat niches are provided within a wetland as the number of plant communities increases. The increased structural complexity provided by different plants optimizes potential breeding areas, escape, cover, and food production for the greatest number of species (Hruby and others 1999). This increased species richness arising from the increased structural diversity also supports a greater number of terrestrial species in the overall wetland food web (Hruby and others 1999). The Cowardin plants classes are used as indicators of different types of structure in the plant community. In addition, the presence of vertical structure in forested communities is considered a characteristic that increases habitat complexity and niches.

For this question you will need to map the "Cowardin" classes of plants in the wetland and whether the forested class has different strata present under the canopy. The plant community is divided into the following habitat types:

- Aquatic bed
- Emergent
- Scrub/shrub (areas where shrubs have >30% cover)
- Forested (areas where trees have >30% cover)
- Multiple strata within the forest class. Do the areas mapped as a Cowardin forested class have at least three out of the five strata (canopy, sub-canopy, shrubs, herbaceous, moss/ground-cover)?

NOTE 1: Each plant class has to cover more than ¼ acre, or if the wetland is smaller than 2.5 acres, the threshold is 10% of the area of the wetland. "Cowardin" plant classes are distinguished on the basis of the uppermost layer of plants (forest, shrub, etc.) that provides more than 30% surface cover within the area of its distribution (see Section 5.2).

NOTE 2: Aquatic bed plants do not always reach the surface and care must be taken to look beneath the water's surface. Because waterfowl can graze certain species of aquatic bed early in the growing season, you may incorrectly conclude that aquatic bed plants are not present if the field visit is made during this time period**. Therefore, examine the pond bottom in areas of open water for evidence of aquatic bed species that have senesced.** If a wetland is being rated very late in the growing season, when either the standing water is gone or very limited in extent, examine mudflats and adjacent vegetated areas for the presence of dried aquatic bed species.

NOTE 3: If a plant class is distributed in several patches, the patches can be added together to meet the size threshold. However, the patches have to be large enough so that no more than 10 are needed to meet the size threshold. For example, if 15 patches of shrubs are needed to meet the size threshold then the unit does NOT have a scrub/shrub class.

NOTE 4: Count how many strata (i.e., canopy, sub-canopy, shrubs, herbaceous, moss/groundcover) are present in forested areas of the wetland. If three or more of the five strata are present, record this on the field form.

NOTE 5: Each stratum (canopy, sub-canopy, shrub, herbaceous, or groundcover) has to cover at least 20% of the ground within the polygon identified as "forest" when looking at it from above. If the field visit is during the winter you will have to estimate cover based on your expectation of what the plants would cover when in full leaf.

H 1.2 Hydroperiods

Rationale for indicator: Many aquatic species have their life cycles keyed to different water regimes (e.g., permanent, seasonal, or saturated conditions). A number of different water regimes in a wetland will, therefore, support more species than a wetland with fewer water regimes. For example, some species are tolerant of permanent pools, while others can live in pools that are temporary (Wiggins and others 1980).

For this question you will need to identify areas in the wetland with different water regimes. You are looking for areas with different patterns of flooding or saturation. For example, does part of the wetland have surface ponding only for a very short time (we call this occasionally flooded) or are there areas that have surface water all year (permanently flooded). The purpose is to identify the wettest water regime within different areas of the wetland unit. Thus, an area that is seasonally flooded, but only saturated during the field visit in the summer, would still be categorized as "seasonally flooded." **To count, the water regime has to cover more than 10% of the wetland or ¼ acre.** This includes streams and rivers. Often there is a small stream in a depressional wetland or along the side of a riverine one but it **cannot** be counted because the total area between the banks of the stream that is in the unit or adjacent to it does not meet the size threshold.

The six water regimes that you need to identify are:

Permanently Flooded or Inundated — Surface water covers the land surface throughout the year, in most years.

> **NOTE:** During high water in the winter and spring, it may be difficult to determine the area that would be permanently flooded during the summer dry period. One indicator of permanent water is an area of open water without plants inside the zone of seasonal inundation. Aerial photos taken during the summer may also show areas of permanent water.

Seasonally Flooded or Inundated — Surface water is present for extended periods (for more than 2 consecutive months during a year), especially early in the growing season, but is absent by the end of the season in most years. During the summer dry season it may be difficult to determine the area that is seasonally inundated. Use the indicators described in D1.4 to help you determine areas that are seasonally flooded or inundated.

Occasionally Flooded or Inundated — Surface water is present for brief periods of less than two months during the growing season, but the water table usually lies below the soil surface for most of the season. Plants that grow in both uplands and wetlands are characteristic of this water regime (facultative).

Saturated — The soil is saturated near the surface for long enough to create a wetland, but surface water is seldom present. The latter criterion separates saturated areas from inundated areas. In this case, there will be no signs of inundation on plant stems or surface depressions.

Permanently Flowing Stream — The wetland unit contains a river, stream, channel, or ditch with water flowing in it throughout the year within its boundaries or along one edge (most often in a riverine situation).

Intermittently Flowing Stream — The wetland unit contains a river, stream, channel, or ditch in which water flow is intermittent or seasonal within its boundaries or along one edge.

Figure 20 shows a hypothetical wetland with two water regimes – permanently flooded and seasonally flooded. Figure 43 shows a photograph of a slope wetland, also with two water regimes - some areas are **occasionally flooded** from sheet flow during storms and the rest is **saturated** from subsurface flows. Figure 44 shows a depressional wetland with three water regimes.

> **NOTE 1**: Wetlands that are classified as **Lake-fringe or Freshwater Tidal Fringe are scored 2 points for this question**. The water regimes in these two types of wetlands do not fit the descriptions above or are too difficult to determine in the field.
>
> **NOTE 2:** An area (polygon) within a wetland unit being rated can only have one hydroperiod. Different areas within a unit, however, may have different hydroperiods.

NOTE 3: You should map the hydroperiods as they would appear at the wettest time of the year.

NOTE 4: A drawing such as Figure 20 should be made on a copy of the aerial photograph or map outlining the different hydroperiods. Such a drawing will reduce common errors (e.g., failure to confirm the size threshold or counting the same area as having two hydroperiods).

NOTE 5: Depressional wetlands often have their water regimes in concentric rings. In addition to permanently ponded and seasonally ponded, a wetland could have an additional ring that is occasionally ponded and then even just saturated. To count, however, each of these hydroperiods needs to meet the size threshold. Slope wetlands often have only a saturated hydroperiod and if they get surface runoff then they have "occasional" surface inundation as well. Thus, for depressional, riverine, or lake fringe wetlands that are joined to slope wetlands you need to record the hydroperiods of the area classified as slope as well as those with another classification.

NOTE 6: Many streams in wetlands however cannot be counted because the area of the stream where the water flows does not meet the size threshold.

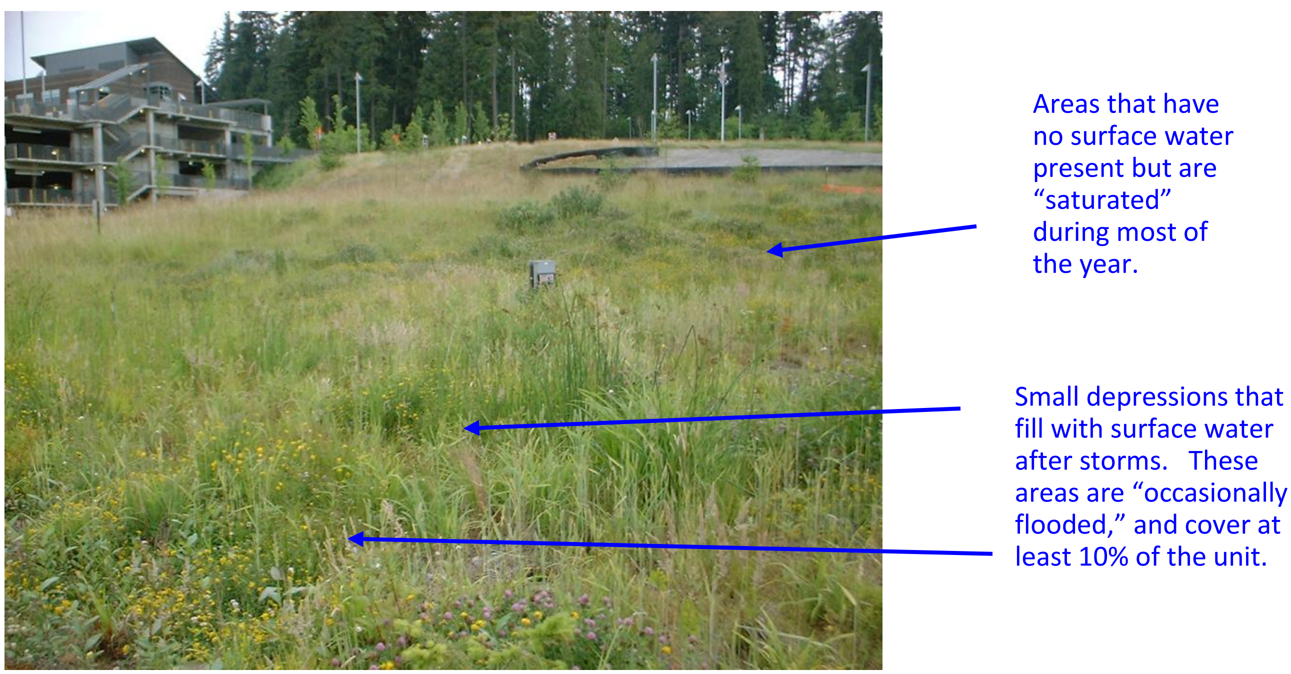


Figure 43: Slope wetland with two water regimes.

Figure 44: A large depressional wetland with three water regimes: permanently flooded, seasonally flooded, and occasionally flooded. The areas that are seasonally and occasionally flooded are found around the outer edge of the wetland.

H 1.3 Richness of Plant Species:

Rationale for indicator: The number of plant species present in a wetland reflects the potential number of niches available for invertebrates, birds, and mammals. The total number of animal species in a wetland is expected to increase as the number of plant species increases (Hruby and others 1999). For example, the number of invertebrate species is directly linked to the number of plant species (Knops and others 1999). This indicator includes both native and non-native plant species (with the exceptions noted below) because both provide habitat for invertebrate and vertebrate species. The four aggressive species excluded from the count tend to form large mono-cultures that exclude other species and reduce the structural richness of the habitat.

As you walk through the wetland unit keep a list of the patches of different plant species you find. You should count both wetland and upland plants. However, you include only species that form patches that cover at least 10 square feet within the unit. Different patches of the same species can be combined to meet the size threshold. This threshold was established to reduce the variability among users with different levels of expertise in identifying plants.

You should try to identify plants, but keying them out is not necessary. All you need to track is the total number, so you can identify species as Species 1, Species 2, etc. In order to capture the full range of plant species present during the year, record any species that are "dead" and recognizably different from other species present. There are 3 thresholds to keep in mind: 20 or more species, 5-19, and less than 5 species. If you count more than 19 species you do not need to continue identifying plants.

For this question the following species are **NOT TO BE INCLUDED** in the total: Eurasian water-milfoil (*Myriophyllum spicatum*), reed canarygrass (*Phalaris arundinaceae*), Purple Loosestrife (*Lythrum salicaria*), and Canadian thistle (*Circium arvense*). These species were judged to reduce the number of niches present in a wetland by the team of wetland scientists who developed this indicator.

H 1.4 Interspersion of Habitats:

> **Rationale for indicator:** In general, interspersion among different physical structures (e.g., open water) and classes of plants (e.g., aquatic bed, emergent plants, shrubs) increases the suitability for different guilds of wildlife by increasing the number of ecological niches (Hruby and others 1999). For example, a higher diversity of plant forms is likely to support a higher diversity of macro-invertebrates (Chapman 1966, Dvorak and Best 1982, Lodge 1985).

In question H.1.1 you determined how many different Cowardin plant classes are present in the unit being rated. This question uses this information and also asks you to identify if there are any areas of open water in the unit (open means without plants on or above the water surface during the spring, summer, or fall). You are asked to rate the "interspersion" between these structural characteristics of the wetland. The diagrams on the field form show what is meant by ratings of High, Medium, Low, or None. Each polygon with a different shading represents a different plant class or open water.

To answer this question first consider if the interspersion falls into the two "default" ratings. If the wetland has only one class of plants present (question H 1.1) and no open water, it will always be rated as NONE (see Figure 45). If the wetland has four plant classes (from question H 1.1), or three plant classes and open water it will always be rated as HIGH. Figure 44 is a depressional wetland with open water, emergent, aquatic bed, shrub, and forest classes. Thus, it automatically rates a HIGH. The only time you will have to make a decision is when the wetland has two or three types of structure that provide habitat.

Additional notes for determining the interspersion are:

- Lake-fringe wetlands will always have <u>at least</u> two categories of structure (open water and one class of plants).
- A wetland with a meandering, unvegetated, stream (seasonal or permanent) should be rated MODERATE if it has only one plant class, or HIGH if it has two or more.
- Several isolated patches of one structural category (e.g., patches of open water) should be considered the same as one "patch" with many lobes.

In scoring units with two types of structure the difference between LOW and MODERATE interspersion is the amount of edge habitat between the structures. Units with convoluted edges are scored moderate. Those with relatively straight edges are scored LOW. For units with three types of structure the same criterion is used to differentiate between a MODERATE and HIGH scoring.

Figure 45: A depressional wetland with only one class of plants and no open water. The interspersion is rated as NONE.

H 1.5 Special Habitat Features:

Rationale for indicator: There are certain habitat features in a wetland that provide refuge and resources for many different species. The presence of these features increases the potential that the wetland will provide a wide range of habitats (Hruby and others 1999). These special features include:

1) Large downed woody debris in the wetland that provides major niches for decomposers (i.e., bacteria and fungi) and invertebrates,
2) Snags that provide perches and cavities for birds and other animals,
3) Undercut banks that provide protection for fish and amphibians,
4) Stable, steep banks of fine material that might be used by aquatic mammals for denning,
5) Thin-stemmed plants that provide structure on which amphibians can lay their eggs, and
6) A plant community that does not have aggressive (invasive) species. This indicates the wetland unit is relatively undisturbed.

Record the presence of any the following special habitat features within the wetland on the Scoring Form:

- Large woody debris within the wetland that is more than 4 inches in diameter at the base and more than 6 ft long (Figure 46).

- Snags present in the wetland that are more than 4 inches in diameter at breast height (Figure 46). **The snag has to have been "rooted" in the wetland to count**. Fence posts or other vertical posts that meet the size threshold can be counted.
- Steep banks of fine material for denning, or evidence of use of the wetland by beaver or muskrat. Banks need to be at least 33 ft long, 2 ft high within or immediately adjacent to the wetland and have the following characteristics: at least a 30 degrees slope, with at least a 3 ft depth of fine soil such as sand, silt, or clay. OR, Evidence the area has been recently used by beaver, such as downed trees and shrubs with teeth marks, and where the wood has not turned gray yet (Figure 47). Evidence of grazing or activity by muskrat does not count because it may be the result of Nutria, an invasive aquatic mammal. It is very difficult to differentiate between these two species in the field.
- At least ¼ acre of thin-stemmed persistent plants or woody branches that are in areas that are permanently or seasonally inundated. These plants provide egg-laying structures for amphibians. A ¼ acre of such plants provide optimal conditions for egg-laying (K. Richter, personal communications), and a unit will score a point only if this criterion is met. This does not mean that a wetland does not provide amphibian habitat in the absence of this; just that wetland provides better habitat if these conditions are present.
- The cover of invasive plants is less than 25% within EACH stratum present in the unit. The five possible strata are canopy, sub-canopy, shrub, herbaceous/emergent, and ground-cover. For example, a forested wetland with a 100% canopy of native species but with an understory of reed canarygrass that covered 70% of the ground would not qualify for this characteristic. The species that are considered "invasive" for answering this question are as follows:

  Circium arvense (Canadian thistle)
  Rubus laciniatus (evergreen blackberry)
  Rubus discolor (Himalayan blackberry)
  Polygonum cuspidatum (Japanese knotweed)
  Polygonum sachalinense (giant knotweed)
  Polygonum cuspidatum x sachalinense (hybrid of Japanese and giant knotweeds)
  Lysimachia vulgaris (garden loosestrife)
  Lythrum salicaria (purple loosestrife)
  Myriophyllum spicatum (Eurasian milfoil)
  Phalaris arundinaceae (reed canarygrass)
  Phragmites australis (common reed)
  Tamarix spp.(either Tamarix ramosissima and/or T. parviflora, salt cedar).

  Only the species on this list count as invasive. This is the list on which the experts developing and reviewing the rating system could agree. Other species may be considered invasive by one of more botanists but we could not achieve consensus to include any others on the list.

Check off each habitat feature on the data form. Add the total number of checks and record that as a score in the right-hand column.

Figure 46:
Large woody debris and snags in wetland

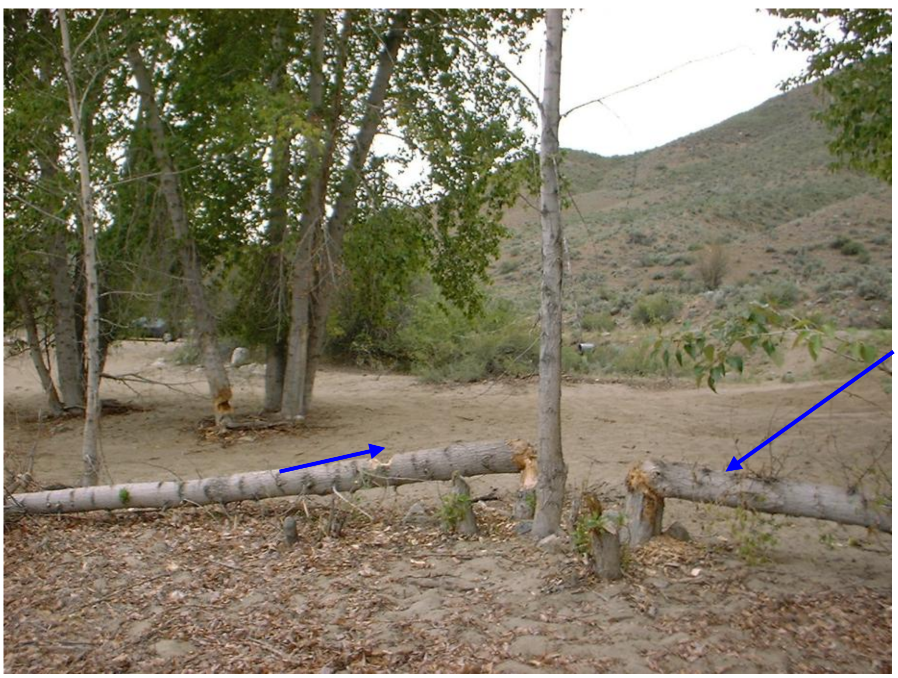


Figure 47:
Evidence of beaver activity. Note the conical shape of the cut.

H 2.0 Does the Landscape Have the Potential to Support the Habitat Functions of the Site?

Habitat loss and fragmentation are a major source of losses in biodiversity (Fahrig 2003). Thus, wetlands in areas that have not been subject to fragmentation and habitat loss are in a better landscape position to provide habitat for a wide range of species that require both uplands and wetlands to survive. Questions H 2.1 and H 2.2 describe two indicators for characterizing the availability of good habitat around a wetland.

Land uses that are often called "high intensity" such as dense residential areas, manufacturing areas, and commercial all have negative impacts on habitat because of noise, light, toxic runoff, and other disturbances (reviewed in Sheldon and others 2005). Wetlands that are located in such areas are therefore less suited as habitat for many species. Question H 2.3 attempts to characterize these impacts by reducing the overall landscape potential of a site if these high intensity land uses are present.

All three questions ask you to map three types of land uses in a 1 km circle around the wetland unit being scored. These are "high intensity" land uses, "moderate and low intensity" land uses, and "relatively undisturbed." Do this by:

1. Drawing a polygon around the unit that extends 1 km from the edge. Use an aerial photograph or a map of land uses if available.
2. Drawing smaller polygons within this 1 km circle around the areas that are relatively undisturbed, have moderate intensity land uses and have high intensity land uses.

Terms are defined in the following box and in Table 2. If you find a land use that is not listed you will have to decide how to categorize it (high intensity, moderate intensity, relatively undisturbed). In this case you should document your rationale on the data form or attached to the figures you submit.

"***Relatively undisturbed***" is a general term used to describe areas that are almost completely free of human impacts and activities. This includes uplands, other wetlands, lakes and other bodies of water. It means that the area is free of regular disturbances such as:

- Tilling and cropping
- Residential and urban development
- Grazing
- Paved roads or frequently used gravel roads
- Mowing
- Pets

NOTE 1: Areas dominated by invasive species are not considered disturbed unless you also have other evidence that disturbances are still present. The invasive species could be a result of some past disturbance that is no longer present.

NOTE 2: Logged areas that have been undisturbed for at least 5 years can qualify as "relatively undisturbed." This includes hybrid poplar plantations that are more than 5 years old.

NOTE 3: Areas that are regularly accessible to dogs, either from residential areas or from people walking their dog should be treated as disturbed. Dogs and other pets cause stress among the animals using a wetland.

NOTE 4: A rarely used path or gravel road can be considered "relatively undisturbed" if it is used less than once or twice a week. Daily usage of a road or area is considered "disturbed."

NOTE 5: Lakes, ponds and other bodies of open water can be considered relatively undisturbed if they are not regularly used for boating or for other water related activities. Daily usage of the lake by boats would be considered "disturbed." A lake can be considered undisturbed if it is used only once or twice a week.

Table 2: Land uses that can be classified as high and moderate/low intensity based on their impacts to wetland habitat.

Level of Impact	Types of Land Use Based on Common Zoning Designations
High Intensity	• Commercial • Urban • Industrial • Institutional • Retail sales • Residential (more than 1 unit/acre) • High-intensity agriculture (dairies, nurseries, greenhouses, growing and harvesting crops requiring annual tilling and raising and maintaining animals, etc.) • High-intensity recreation (golf courses, ball fields, etc.)
Moderate and Low Intensity	• Residential (1 unit/acre or less) • Parks • Moderate-intensity agriculture (orchards, hay fields, pastures.) • Trails • Forestry • Utility corridors

H .2.1 What is the area of accessible habitat?

Rationale for indicator: It is difficult to separate the effects of habitat loss from the fragmentation of habitat (Fahrig 2003). Thus, Eigenbrod and others (2008) have developed an indicator, called "accessible habitat," that integrates these two concepts into one measurable indicator. Accessible habitat is defined as the amount of habitat that can be reached from the wetland without crossing a human land use (e.g., roads, fields, and development). Some lower intensity human land uses such as parks do not completely isolate a habitat. As a result, low and moderate intensity land uses are totally discounted as accessible habitat. The total area of low and moderate intensity land uses adjacent to the unit is divided by two and then added to the area of undisturbed habitat. This addresses the issue that some lower intensity land uses do still provide habitat, but not to the same level as undisturbed areas.

To calculate the accessible habitat around the wetland unit you are scoring follow these steps.

1. Highlight all polygons of "relatively undisturbed" land uses on your map that are contiguous with the unit boundary.
2. Estimate the area of all such polygons as a percent of the total area within the larger 1 km polygon unit. You do not need to measure actual acreages, just the percent of

the total areas within the larger polygon (Figure 48). Include this number on the Scoring Form.

3. Highlight all polygons of "moderate or low intensity" land uses that are contiguous with the unit boundary or the relatively undisturbed areas mapped in #1 above.
4. Estimate the area of the polygons categorized as "moderate or low intensity" as a percent of the total area within the larger 1 km polygon unit. Divide this result by 2 and add it to the percent accessible, undisturbed, habitat calculated in steps #1 and #2 above.

Use the sum as the area of Accessible Habitat to answer question H 2.1.

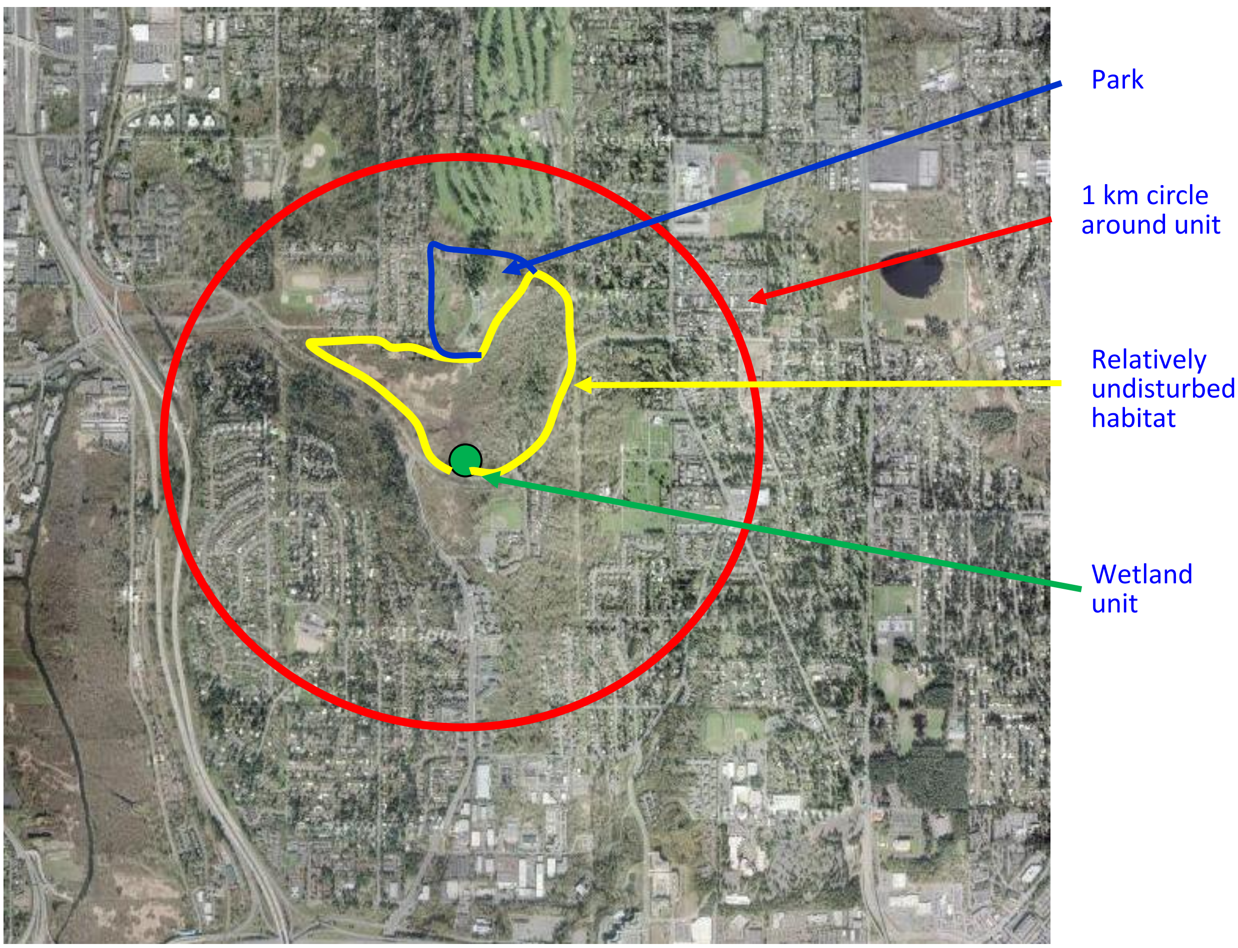


Figure 48: A 1 km circle around a wetland unit showing the Accessible Habitat. Accessible Habitat is 10 – 25 % of the total area of the 1 km polygon.

H 2.2 Total undisturbed habitat in 1 km circle around unit

> **Rationale for indicator**: The focus of this indicator is more toward the fragmentation of the surrounding landscape. Flying species such as birds are not dependent on undisturbed corridors to move from habitat patch to habitat patch but more on the total area of habitat available (Rodewald and Bakermans 2006). This indicator characterizes the overall habitat available surrounding the wetland unit.

Use the diagram of land uses within 1 km of the unit to answer this question as well, but analyze using the following criteria:

1. Select only the polygons identified as relatively undisturbed even if they are separated from the unit by some human disturbance.
2. Calculate the total area of undisturbed habitat in the 1 km circle. If it is more than 50% of the total record that on the Scoring Form.
3. If the area is between 10% and 50% count the number of distinct patches in the circle and score this using the criteria on the Scoring Form.

H 2.3 Land use intensity in 1 km circle

> **Rationale for indicator:** Land uses that are often called "high intensity" such as dense residential areas, manufacturing areas, and commercial all have negative impacts on habitat because of noise, light and other disturbances (reviewed in Sheldon and others 2005). Wetlands that are located in such areas are therefore less suited as habitat for many species.

Use the diagram of land uses within 1 km of the unit to answer this question as well, but analyze using the following criterion.

1. Identify all polygons of high intensity land uses.
2. Calculate the total area of in the 1 km circle. If it is more than 50% of the total record that on the Scoring Form and subtract two points from the total.

H 3.0 Is the Habitat Provided by the Site Valuable to Society?

People do not value all species equally. Some are valued for their "charismatic" characteristics, some because they are in danger of extinction, some for their commercial, aesthetic, or moral values (Perry 2010). The value of the habitat a wetland provides for society is therefore linked to the presence of these more valued species. However, as individuals we often place different values on wildlife. For example, some may value a beaver more than frogs while others disagree.

Question H 3.1 attempts to characterize the values of different species of wildlife at a broad level by highlighting wetlands that provide habitat for species that are formally recognized by jurisdictions, the state, and federal agencies as having some importance and that are protected by laws and regulations. In this case, we are relying on the agencies and jurisdictions (as representatives of society as a whole) to identify the valuable species and habitats. The Department of Ecology does not have the resources, or the mandate, to develop a different list of "valuable" species.

H 3.1 Does the site provides habitat for species valued in laws, regulations, or policies?

Rationale for indicator: There are lists of species that are identified through federal and state Endangered Species Acts or are the focus of management and conservation by the Washington State Department of Fish and Wildlife through their priority species and habitat program (http://wdfw.wa.gov/hab/phspage.htm). These species are judged to have a higher value to society than others. Wetland units that provide habitat for these species are thus considered to have a higher habitat value.

Wetlands are assigned a high value for habitat if the unit:

- Provides habitat for Threatened or Endangered species on either a state or federal list. This includes both plants and animals. For the latest information on T/E species you will have to access the National Marine Fisheries Service and the WA Dept. of Fish and Wildlife (WDFW) links below or contact the local WDFW biologist. These links are active as of March 2012.
  http://www.nwr.noaa.gov/ESA-Salmon-Listings/Salmon-Populations/Maps/
  http://wdfw.wa.gov/conservation/endangered/
  For information on plants contact the Natural Heritage Program:
  http://www1.dnr.wa.gov/nhp/refdesk/plants.html
  NOTE: Be aware that wetlands with streams running through them in the Puget Sound area and on the Columbia River will probably be providing habitat for Endangered Salmonids.

- Is a "priority area" for an individual WDFW priority species. The WDFW maintains maps of important habitat areas for species on their priority species list. These maps should be used to identify if the unit falls within one of their mapped "priority areas." Information on how to obtain these maps and how to access them is available on the WDFW web sites. http://wdfw.wa.gov/hab/phspage.htm

- Contains a High-Quality Plant Community or Wetland Ecosystem as determined by the Department of Natural Resources.
  http://www1.dnr.wa.gov/nhp/refdesk/lists/communitiesxco/countyindex.html

- Has at least three different WDFW priority habitats within 100 m of the unit. This means the unit scores 4 points on question H 2.3 of the Wetland Rating System for Western Washington (Ecology publication #04-06-025 page 16 of the field form). Use Appendix D to identify priority habitats within 100 m if the unit has not been categorized using the wetland rating system. The latest definitions for priority habitats will be found on the WDFW web page:
  http://wdfw.wa.gov/publications/00165/wdfw00165.pdf)

NOTE: Wetlands are specifically excluded from the list of priority habitats because all wetlands are a priority habitat.

- Has been categorized as an important habitat site in a local or regional comprehensive plan, Shoreline Master Plan, or a watershed plan. The Department of Ecology does not maintain a database of important habitat areas identified in local plans. You will need to contact the planning department of the jurisdiction in which your wetland unit is found to determine if it has been identified as an area that provides valuable habitat.

Wetlands are assigned a moderate value for habitat if the unit scores 1-3 points on question H 2.3 of the Wetland Rating System for Western Washington (Ecology publication #04-06-025, Appendix D has question H 2.3 from the rating system).

Wetlands are assigned a low value for habitat if they do not meet any of the criteria above.

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Appendix A. Scoring Form for the Credit and Debit Method

Wetland name or number _____

SCORING FORM

Scoring functions to calculate mitigation credits and debits in Western Washington

Name of wetland (if known): ______________________________ Date of site visit: ____

Scored by________________________
SEC: __ TWNSHP: ___ RNGE: ___ Estimated size:_____ Aerial photo included? ________

These scores are for:
_________Wetland being altered
_________Mitigation site before mitigation takes place
_________Mitigation site after goals and objectives are met

SUMMARY OF SCORING

FUNCTION	**Improving Water Quality**	**Hydrologic**	**Habitat**
Rating of Site Potential			
Rating of Landscape Potential			
Rating of Value			
Score Based on Ratings (see table below)			

	Wetland HGM Class Used for Rating	
	Depressional	
	Riverine	
	Lake-fringe	
	Slope	
	Flats	
	Freshwater Tidal	
	Check if unit has multiple HGM classes present	

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

NOTE: Form is not complete without the figures requested.
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.

HGM Classification of Wetlands in Western Washington

For questions 1-7 the criteria described must apply to the entire unit being rated.

If the hydrologic criteria listed in each question do not apply to the entire unit being rated, you probably have a unit with multiple HGM classes. In this case, identify which hydrologic criteria in questions 1-7 apply, and go to Question 8.

1. Are the water levels in the entire unit usually controlled by tides (i.e., except during floods)?

NO – go to 2 **YES** – the wetland class is **Tidal Fringe** – go to 1.1

1.1 Is the salinity of the water during periods of annual low flow below 0.5 ppt (parts per thousand)?

YES – Freshwater Tidal Fringe **NO – Saltwater Tidal Fringe (Estuarine)**

*If your wetland can be classified as a Freshwater Tidal Fringe use the forms for **Riverine** wetlands. If it is Saltwater Tidal Fringe it is an **Estuarine** wetland and not scored. This method cannot be used for estuarine wetlands.*

2. The entire wetland unit is flat and precipitation is the only source (>90%) of water to it. Groundwater and surface water runoff are NOT sources of water to the unit.

NO – go to 3 **YES** – The wetland class is **Flats**

*If your wetland can be classified as a "Flats" wetland, use the form for **Depressional** wetlands.*

3. Does the entire wetland unit **meet all** of the following criteria?

___The vegetated part of the wetland is on the shores of a body of permanent open water (without any plants on the surface) at least 20 acres (8 ha) in size;

___At least 30% of the open water area is deeper than 6.6 ft (2 m)?

NO – go to 4 **YES** – The wetland class is **Lake-fringe** (Lacustrine Fringe)

4. Does the entire wetland unit **meet all** of the following criteria?

____The wetland is on a slope (*slope can be very gradual*),

____The water flows through the wetland in one direction (unidirectional) and usually comes from seeps. It may flow subsurface, as sheetflow, or in a swale without distinct banks.

____The water leaves the wetland **without being impounded**?

NOTE: Surface water does not pond in these type of wetlands except occasionally in very small and shallow depressions or behind hummocks (depressions are usually <3 ft diameter and less than 1 ft deep).

NO - go to 5 **YES** – The wetland class is **Slope**

5. Does the entire wetland unit **meet all** of the following criteria?

____The unit is in a valley, or stream channel, where it gets inundated by overbank flooding from that stream or river

____The overbank flooding occurs at least once every two years.

NOTE: The riverine unit can contain depressions that are filled with water when the river is not flooding.

NO - go to 6 **YES –** The wetland class is **Riverine**

6. Is the entire wetland unit in a topographic depression in which water ponds, or is saturated to the surface, at some time during the year? *This means that any outlet, if present, is higher than the interior of the wetland.*

NO – go to 7 **YES –** The wetland class is **Depressional**

7. Is the entire wetland unit located in a very flat area with no obvious depression and no overbank flooding? The unit does not pond surface water more than a few inches. The unit seems to be maintained by high groundwater in the area. The wetland may be ditched, but has no obvious natural outlet.

NO – go to 8 **YES –** The wetland class is **Depressional**

8. Your wetland unit seems to be difficult to classify and probably contains several different HGM classes. For example, seeps at the base of a slope may grade into a riverine floodplain, or a small stream within a depressional wetland has a zone of flooding along its sides. GO BACK AND IDENTIFY WHICH OF THE HYDROLOGIC REGIMES DESCRIBED IN QUESTIONS 1-7 APPLY TO DIFFERENT AREAS IN THE UNIT (make a rough sketch to help you decide). Use the following table to identify the appropriate class to use for the rating system if you have several HGM classes present within the wetland unit being scored.

NOTE: Use this table only if the class that is recommended in the second column represents 10% or more of the total area of the wetland unit being rated. If the area of the class listed in column 2 is less than 10% of the unit; classify the wetland using the class that represents more than 90% of the total area.

HGM Classes Within the Wetland Unit Being Rated	HGM Class to Use in Rating
Slope + Riverine	Riverine
Slope + Depressional	Depressional
Slope + Lake-fringe	Lake-fringe
Depressional + Riverine along stream within boundary of depression	Depressional
Depressional + Lake-fringe	Depressional
Riverine + Lake-fringe	Riverine
Salt Water Tidal Fringe and any other class of freshwater wetland	Treat as ESTUARINE

If you are still unable to determine which of the above criteria apply to your wetland, or if you have more than 2 HGM classes within a wetland boundary, classify the wetland as Depressional for the rating.

Depressional and Flats Wetlands **WATER QUALITY FUNCTIONS** - Indicators that the site functions to improve water quality. Questions D 1.1 – D 1.4 are from the Wetland Rating System (Hruby 2004b).	
D 1.0 Does the wetland unit have the potential to improve water quality?	
D 1.1 Characteristics of surface water flows out of the wetland: *Provide photo or drawing* Unit is a depression with no surface water leaving it (no outlet) points =3 Unit has an intermittently flowing, OR highly constricted permanently flowing outlet points = 2 Unit has an unconstricted, or slightly constricted, surface outlet (*permanently flowing*) points = 1 Unit is a "flat" depression (Q. 7 on key), or in the Flats class, with permanent surface outflow **and no obvious natural outlet** and/or outlet is a man-made ditch points = 1 (If ditch is not permanently flowing treat unit as "intermittently flowing")	Figure __
D 1.2 The soil 2 inches below the surface (or duff layer) is clay or organic *(use NRCS definitions)* YES: points = 4 NO: points = 0	
D 1.3 Characteristics of persistent plants (emergent, shrub, and/or forest Cowardin class *Provide map of Cowardin plant classes* Wetland has persistent, ungrazed, plants ≥ 95% of area points = 5 Wetland has persistent, ungrazed, plants ≥ 1/2 of area points = 3 Wetland has persistent, ungrazed plants ≥ 1/10 of area points = 1 Wetland has persistent, ungrazed plants <1/10 of area points = 0	Figure __
D 1.4 Characteristics of seasonal ponding or inundation. *Provide map of hydroperiods* This is the area of the wetland unit that is ponded for at least 2 months, but dries out sometime during the year. Do not count the area that is permanently ponded. Estimate area as the average condition 5 out of 10 yrs. Area seasonally ponded is > ½ total area of wetland points = 4 Area seasonally ponded is > ¼ total area of wetland points = 2 Area seasonally ponded is < ¼ total area of wetland points = 0	Figure __
Total for D 1 Add the points in the boxes above	

Rating of Site Potential: If score is 12 – 16 = H
6 - 11 = M
0 - 5 = L

Record the rating on the first page

NOTES and FIELD OBSERVATIONS:

Wetland name or number ______

D 2.0 Does the landscape have the potential to support the water quality function at the site?	
D 2.1 Does the Wetland unit receive stormwater discharges? Yes = 1 No = 0	
D 2.2 Is more than 10% of the area within 150 ft of wetland unit in agricultural, pasture, residential, commercial, or urban? Yes = 1 No = 0	
D 2.3 Are there septic systems within 250 ft of the wetland unit? Yes = 1 No = 0	
D 2.4 Are there other sources of pollutants coming into the wetland that are not listed in questions D 2.1 – D 2.3? Source______________ Yes = 1 No = 0	
Total for D 2 Add the points in the boxes above	

Rating of Landscape Potential: If score is 3 or 4 = H
1 or 2 = M
0 = L

Record the rating on the first page

D 3.0 Is the water quality improvement provided by the site valuable to society?	
D 3.1 Does the unit discharge directly to a stream, river, or lake that is on the 303d list? Yes = 1 No = 0	
D 3.2 Is the unit in a basin or sub-basin where an aquatic resource is on the 303(d) list? Yes = 1 No = 0	
D 3.3 Has the site been identified in a watershed or local plan as important for maintaining water quality? (*answer YES if there is a TMDL for the basin in which unit is found*) Yes = 2 No = 0	
Total for D 3 Add the points in the boxes above	

Rating of Value: If score is 2-4 = H
1 = M
0 = L

Record the rating on the first page

NOTES and FIELD OBSERVATIONS:

Depressional and Flats Wetlands **HYDROLOGIC FUNCTIONS** - Indicators that the site functions to reduce flooding and stream degradation. Questions D 4.1 – D 4.3 are from Wetland Rating System (Hruby 2004b).	
D 4. 0 Does the wetland unit have the potential to reduce flooding and erosion?	
D 4.1 Characteristics of surface water flows out of the wetland: Unit is a depression with no surface water leaving it (no outlet) points = 4 Unit has an intermittently flowing OR highly constricted permanently flowing outlet points = 2 Unit is a "flat" depression (Q. 7 on key), or in the Flats class, with permanent surface outflow **and no obvious natural outlet** and/or outlet is a man-made ditch points = 1 Unit has an unconstricted, or slightly constricted, surface outlet and is permanently flowing) points = 0 (If ditch is not permanently flowing treat unit as "intermittently flowing")	
D 4.2 Depth of storage during wet periods *Estimate the height of ponding above the bottom of the outlet. For units with no outlet measure from the surface of permanent water or deepest part (if dry).* Marks of ponding are 3 ft or more above the surface or bottom of outlet points = 7 The wetland is a "headwater" wetland" points = 5 Marks of ponding between 2 ft to < 3 ft from surface or bottom of outlet points = 5 Marks are at least 0.5 ft to < 2 ft from surface or bottom of outlet points = 3 Unit is flat (yes to Q. 2 or Q. 7 on key) but has small depressions on the surface that trap water points = 1 Marks of ponding less than 0.5 ft points = 0	
D 4.3 Contribution of wetland unit to storage in the watershed *Estimate the ratio of the area of upstream basin contributing surface water to the wetland to the area of the wetland unit itself.* The area of the basin is less than 10 times the area of the unit points = 5 The area of the basin is 10 to 100 times the area of the unit points = 3 The area of the basin is more than 100 times the area of the unit points = 0 Entire unit is in the FLATS class points = 5	
Total for D 4 Add the points in the boxes above	

Rating of Site Potential: If score is 12 – 16 = H
6 - 11 = M
0 - 5 = L

Record the rating on the first page

NOTES and FIELD OBSERVATIONS:

Wetland name or number ______

D 5.0 Does the landscape have the potential to support hydrologic functions at the site?	
D 5.1 Does the unit receive any stormwater discharges? Yes = 1 No = 0	
D5.2 Is >10% of the land use within 150 ft of the wetland unit agriculture, pasture, residential, urban, or commercial? Yes = 1 No = 0	
D 5.3 Is more than 25% of the contributing basin of the wetland unit covered with intensive human land uses (residential at >1 residence/1 acre, urban, commercial, agriculture, etc.)? Yes = 1 No = 0	
Total for D 5 Add the points in the boxes above	

Rating of Landscape Potential: If score is **3 = H**
1,2 = M
0 = L

Record the rating on the first page

D 6.0 Are the hydrologic functions provided by the site valuable to society?	
D 6.1 The unit is in a landscape that has flooding problems. Choose the description that best matches conditions around the wetland unit being rated. Do not add points. Choose the highest score if more than one condition is met. ☐ The site has been identified as important for flood storage or flood conveyance in a regional flood control plan. points = 2 ☐ The wetland captures surface water that would otherwise flow downgradient into areas where flooding has damaged human or natural resources (e.g., salmon redds), AND ○ Damage occurs in sub-basin that is immediately down-gradient of unit. points = 2 ○ Damage occurs in a sub-basin further down-gradient. points = 1 ☐ Flooding from groundwater is an issue in the sub-basin. points = 1 ☐ The existing or potential outflow from the wetland is so constrained by human or natural conditions that the water stored by the wetland cannot reach areas that flood. *Explain why* ______________________ points = 0 ☐ There are no problems with flooding downstream of the unit. points = 0	

Rating of Value: **If score is** **2 = H**
1 = M
0 = L

Record the rating on the first page

NOTES and FIELD OBSERVATIONS:

Wetland name or number _____

Riverine and Freshwater Tidal Fringe Wetlands **WATER QUALITY FUNCTIONS** - Indicators that site functions to improve water quality Questions R 1.1 – R 1.2 are from the Wetland Rating System (Hruby 2004b).	
R 1. Does the wetland unit have the potential to improve water quality?	
R 1.1 Area of surface depressions within the riverine wetland that can trap sediments during a flooding event: *If depressions > ½ of area of unit draw polygons on aerial photo or map* Depressions cover >3/4 area of wetland points = 8 Depressions cover > 1/2 area of wetland points = 4 Depressions present but cover < 1/2 area of wetland points = 2 No depressions present points = 0	Figure __
R 1.2 Characteristics of the plants in the unit (areas with >90% cover at person height): *Include photo or map showing polygons of different plants types* Trees or shrubs > 2/3 area of the unit points = 8 Trees or shrubs > 1/3 area of the unit points = 6 Herbaceous plants (> 6" high) > 2/3 area of unit points = 6 Herbaceous plants (> 6" high) > 1/3 area of unit points = 3 Trees, shrubs, and ungrazed herbaceous < 1/3 area of unit points = 0	Figure __
Total for R 1 Add the points in the boxes above	

Rating of Site Potential: If score is 12 – 16 = H
6 - 11 = M
0 - 5 = L

Record the rating on the first page

R 2.0 Does the landscape have the potential to support the water quality function at the site?	
R 2.1 Is the unit within an incorporated city or within its UGA? Yes = 2 No = 0	
R. 2.2 Does the contributing basin include a UGA or incorporated area? Yes = 1 No = 0	
R 2.3 Does at least 10% of the contributing basin contain tilled fields, pastures, or forests that have been clearcut within the last 5 years? Yes = 1 No = 0	
R 2.4 Is more than 10% of the area within 150 ft of the wetland unit in agricultural, pasture, golf courses, residential, commercial, or urban? Yes = 1 No = 0	
Total for R 2 Add the points in the boxes above	

Rating of Landscape Potential: If score is 3 - 5 = H
1 or 2 = M
0 = L

Record the rating on the first page

R 3.0 Is the water quality improvement provided by the site valuable to society?	
R 3.1 Is the unit along a stream or river that is on the 303(d) list or on a tributary that drains to one? Yes = 1 No = 0	
R 3.2 Does the river or stream have TMDL limits for nutrients, toxics, or pathogens? Yes = 1 No = 0	
R 3.3 Has the site been identified in a watershed or local plan as important for maintaining water quality? (*answer YES if there is a TMDL for the drainage in which unit is found*) Yes = 2 No = 0	
Total for R 3 Add the points in the boxes above	

Rating of Value: If score is 2 - 4 = H
1 = M
0 = L

Record the rating on the first page

Riverine and Freshwater Tidal Fringe Wetlands **HYDROLOGIC FUNCTIONS** - Indicators that site functions to reduce flooding and stream erosion Questions R 4.1 and R 4.2 are from Wetland Rating System (Hruby 2004b).	
R 4.0 Does the wetland unit have the potential to reduce flooding and erosion?	
R 4.1 Characteristics of the overbank storage the unit provides: *Provide aerial photo showing average widths* Estimate the average width of the wetland unit perpendicular to the direction of the flow and the width of the stream or river channel (distance between banks). Calculate the ratio: (average width of unit)/(average width of stream between banks). If the ratio is more than 20 points = 9 If the ratio is between 10 – 20 points = 6 If the ratio is between 5 - <10 points = 4 If the ratio is between 1 - <5 points = 2 If the ratio is < 1 points = 1	Figure __
R 4.2 Characteristics of plants that slow down water velocities during floods: *Treat large woody debris as "forest or shrub". Choose the points appropriate for the best description* (polygons need to have >90% cover at person height NOT Cowardin classes): *Provide photo or map showing polygons of different plants types* Forest or shrub for >1/3 area OR herbaceous plants > 2/3 area points = 7 Forest or shrub for > 1/10 area OR herbaceous plants > 1/3 area points = 4 Plants do not meet above criteria points = 0	Figure __
Total for R 4 Add the points in the boxes above	

Rating of Site Potential: If score is 12 – 16 = H
6 - 11 = M
0 - 5 = L

R 5.0 Does the landscape have the potential to support the hydrologic functions at the site?	
R5.1 Is the stream/river adjacent to the unit downcut? Yes = 0 No = 1	
R 5.2 Does the contributing basin include a UGA or incorporated area? Yes = 1 No = 0	
R 5.3 Is the upgradient stream or river controlled by dams? Yes = 0 No = 1	
Total for R 5 Add the points in the boxes above	

Rating of Landscape Potential: If score is 3 = H
1 or 2 = M
0 = L

Record the rating on the first page

R 6.0 Are the hydrologic functions provided by the site valuable to society?	
R 6.1 Distance to the nearest areas downstream that have flooding problems? *Choose the description that best fits the site.* The sub-basin immediately down-gradient of site has surface flooding problems that results in $$ loss or loss of natural resources. points = 2 Surface flooding problems are in a sub-basin further down-gradient. points = 1 No flooding problems anywhere downstream. points = 0	
R 6.2 Has the site been identified as important for flood storage or flood conveyance in a regional flood control plan? Yes = 2 No = 0	
Total for R 6 Add the points in the boxes above	

Rating of Value: If score is 2 – 4 = H
1 = M
0 = L

Record the rating on the first page

NOTES and FIELD OBSERVATIONS:

Wetland name or number _____

Lake-fringe Wetlands **WATER QUALITY FUNCTIONS** - Indicators that the site functions to improve water quality. Questions L 1.1 – L 1.2 are from the Wetland Rating System (Hruby 2004b).	
L 1.0 Does the wetland unit have the potential to improve water quality?	
L 1.1 Average width of plants along the lakeshore *(use polygons of Cowardin classes)*: *Provide map of Cowardin classes with widths marked* Plants are more than 33 ft (10m) wide points = 6 Plants are more than 16 ft (5m) wide and <33ft points = 3 Plants are more than 6 ft (2m) wide and <16 ft points = 1 Plants are less than 6 ft wide points = 0	Figure __
L 1.2 Characteristics of the plants in the wetland: choose the appropriate description that results in the highest points, and do not include any open water in your estimate of coverage. The herbaceous plants can be either the dominant form or as an understory in a shrub or forest community. These are not Cowardin classes. Area of cover is total cover in the unit, but it can be in patches. *Herbaceous does not include aquatic bed.* *Provide map with polygons of different plants types* Cover of herbaceous plants are >90% of the vegetated area points = 6 Cover of herbaceous plants are >2/3 of the vegetated area points = 4 Cover of herbaceous plants are >1/3 of the vegetated area points = 3 Other plants that are not aquatic bed > 2/3 unit points = 3 Other plants that are not aquatic bed in > 1/3 vegetated area points = 1 Aquatic bed plants and open water cover > 2/3 of the unit points = 0	Figure __
Total for L 1 Add the points in the boxes above	
Rating of Site Potential: If score is 8 - 12 = H **4 – 7 = M** **0 - 3 = L** *Record the rating on the first page*	

L 2. Does the landscape have the potential to support the water quality function at the site?	
L 2.1 Is the lake used by power boats? Yes = 1 No = 0	
L 2.2 Is more than 10% of the area within 150 ft of wetland unit (on the shore side) agricultural, pasture, residential, commercial, or urban? Yes = 1 No = 0	
L 2.3 Does the lake have problems with algal blooms or excessive plants such as milfoil? Yes = 1 No = 0	
Total for L 2 Add the points in the boxes above	
Rating of Landscape Potential: If score is 2 or 3 = H **1 = M** **0 = L** *Record the rating on the first page*	

L 3.0 Is the water quality improvement provided by the site valuable to society?	
L 3.1 Is the unit on a lake that is on the 303(d) list? Yes = 1 No = 0	
L 3.2 Is the lake in a sub-basin where water quality is an issue? (at least one aquatic resource in the basin is on the 303(d) list) Yes = 1 No = 0	
L 3.3 Has the site been identified in a watershed or local plan as important for maintaining water quality? Yes = 2 No = 0	
Total for D 3 Add the points in the boxes above	

Rating of Value: If score is 2 - 4 = H
1 = M
0 = L

Record the rating on the first page

Lake-fringe Wetlands

HYDROLOGIC FUNCTIONS - Indicators that the wetland unit functions to reduce shoreline erosion

Question L 4.1 is from Wetland Rating System (Hruby 2004b).

L 4.0 Does the wetland unit have the potential to reduce shoreline erosion?	
L 4.1 Distance along shore and average width of Cowardin classes along the lakeshore (**do not** include aquatic bed): *(choose the highest scoring description that matches conditions in the wetland)* *Include aerial photo or map with Cowardin plant classes* > ¾ of distance is shrubs or forest at least 33 ft (10m) wide points = 6 > ¾ of distance is shrubs or forest at least 6 ft (2 m) wide points = 4 > ¼ distance is shrubs or forest at least 33 ft (10m) wide points = 4 Plants are at least 6 ft (2m) wide (any type except aquatic bed) points = 2 Plants are less than 6 ft (2m) wide (any type except aquatic bed) points = 0	Figure__

Rating of Site Potential: If score is 6 = M
0 - 5 = L

Record the rating on the first page

Wetland name or number ______

L 5.0 Does the landscape have the potential to support hydrologic functions at the site?	
L 5.1 Is the lake used by power boats with more than 10 hp? Yes = 1 No = 0	
L 5.2 Is the fetch on the lake side of the unit at least 1 mile in distance? Yes = 1 No = 0	
Total for L 5 Add the points in the boxes above	

Rating of Landscape Potential: If score is 2 = H
1 = M
0 = L

Record the rating on the first page

L 6.0 Are the hydrologic functions provided by the site valuable to society?	
L 6.1 If more than one resource is present, choose the one with the highest score. There are human structures or old growth/mature forests within 25 ft of OHWM of the shore in the unit. points = 2 There are nature trails or other paths and recreational activities within 25 ft of OHWM. points = 1 Other resources that could be impacted by erosion. points = 1 There are no resources that can be impacted by erosion along the shores of the unit. points = 0	

Rating of Value: If score is 2 = H
1 = M
0 = L

Record the rating on the first page

NOTES and FIELD OBSERVATIONS:

Slope Wetlands **WATER QUALITY FUNCTIONS** - Indicators that the site functions to improve water quality Questions S 1.1 – S 1.3 are from Wetland Rating System (Hruby 2004b).	
S 1. Does the wetland unit have the potential to improve water quality?	
S 1.1 Characteristics of average slope of unit: *(a 1% slope has a 1 ft vertical drop in elevation for every 100 ft horizontal distance*) Slope is1% or less — points = 3 Slope is 1% - 2% — points = 2 Slope is 2% - 5% — points = 1 Slope is greater than 5% — points = 0	
S 1.2 The soil 2 inches below the surface (or duff layer) is clay or organic *(use NRCS definitions)* YES = 3 points NO = 0 points	
S 1.3 Characteristics of the plants in the wetland that trap sediments and pollutants: Choose the points appropriate for the description that best fits the plants in the wetland. *Dense plants means you have trouble seeing the soil surface (>75% cover), and uncut means not grazed or mowed and plants are higher than 6 inches.* *Provide photo or map showing polygons of different plants types* Dense, uncut, herbaceous plants > 90% of the wetland area — points = 6 Dense, uncut, herbaceous plants > ½ of area — points = 3 Dense, woody, plants > ½ of area — points = 2 Dense, uncut, herbaceous plants > ¼ of area — points = 1 Does not meet any of the criteria above for plants — points = 0	Figure__
Total for S 1 — Add the points in the boxes above	

Rating of Site Potential: If score is 12 = H
6 - 11 = M
0 - 5 = L

Record the rating on the first page

S 2. 0 Does the landscape have the potential to support the water quality function at the site?	
S 2.1 IS >10% of the buffer area within 150 ft upslope of wetland unit in agricultural, pasture, residential, commercial, or urban? Yes = 1 No = 0	

Rating of Landscape Potential: If score is 1 = M
0 = L

Record the rating on the first page

S 3.0 Is the water quality improvement provided by the site valuable to society?	
S 3.1 Does the unit discharge directly to a stream, river, or lake that is on the 303(d) list? Yes = 1 No = 0	
S 3.2 Is the unit in a sub-basin where water quality is an issue? (at least one aquatic resource in the basin is on the 303(d) list) Yes = 1 No = 0	
S 3.3 Has the site been identified in a watershed or local plan as important for maintaining water quality? Yes = 2 No = 0	
Total for D 3 Add the points in the boxes above	

Rating of Value: If score is 2 - 4 = H
1 = M
0 = L

Record the rating on the first page

Slope Wetlands **HYDROLOGIC FUNCTIONS** - Indicators that the site functions to reduce flooding and stream erosion Questions S 4.1 – S 4.2 are from Wetland Rating System (Hruby 2004b).	
S 4.0 Does the wetland unit have the potential to reduce flooding and stream erosion?	
S 4.1 Characteristics of plants that reduce the velocity of surface flows during storms. Choose the points appropriate for the description that best fit conditions in the wetland. *(Stems of plants should be thick enough (usually > 1/8 in), or dense enough, to remain erect during surface flows)* Dense, uncut, **rigid** plants covers > 90% of the area of the wetland. YES = 1 All other conditions = 0	

Rating of Site Potential: If score is 1 = M
0 = L

Record the rating on the first page

NOTES and FIELD OBSERVATIONS:

Wetland name or number ______

S 5.0 Does the landscape have the potential to support the hydrologic functions at the site?	
S 5.1 Is more than 25% of the buffer area within 150 ft upslope of wetland unit in agricultural, pasture, residential, commercial, or urban ? Yes = 1 No = 0	

Rating of Landscape Potential: If score is 1 = M
0 = L

Record the rating on the first page

S 6.0 Are the hydrologic functions provided by the site valuable to society?	
S 6.1 Distance to the nearest areas downstream that have flooding problems? Immediate sub-basin down-gradient of site has surface flooding problems that results in $$ loss or loss of natural resources points = 2 Surface flooding problems are in a sub-basin further down-gradient points = 1 No flooding problems anywhere downstream points = 0	
S 6.2 Has the site been identified as important for flood storage or flood conveyance in a regional flood control plan? Yes = 2 No = 0	
Total for R 6 Add the points in the boxes above	

Rating of Value: If score is 2 - 4 = H
1 = M
0 = L

Record the rating on the first page

NOTES and FIELD OBSERVATIONS:

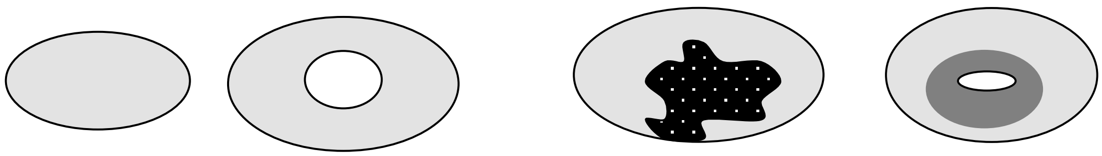
These questions apply to wetlands of all HGM classes. **HABITAT FUNCTIONS** - Indicators that site functions to provide important habitat. Questions H 1.1 – H 1.5 are from Wetland Rating System (Hruby 2004b).	
H 1. Does the wetland unit have the potential to provide habitat for many species?	
H 1.1 Structure of plant community – *indicators are Cowardin classes and layers in forest* Check the Cowardin plant classes in unit – *Polygons for each class must total ¼ acre, or more than 10% of the unit if it is smaller than 2.5 acres*. *Provide map of Cowardin plant classes* ___Aquatic bed ___Emergent plants ___Scrub/shrub (areas where shrubs have > 30% cover) ___Forested (areas where trees have > 30% cover) If the unit has a forested class check if: ___The forested class has 3 out of 5 strata (canopy, sub-canopy, shrubs, herbaceous, moss/ground-cover) that each cover 20% within the forested polygon Add the number of structures checked. If you have: 4 structures or more points = 4 3 structures points = 2 2 structures points = 1 1 structure points = 0	Figure__
H 1.2. Hydroperiods Check the types of water regimes (hydroperiods) present within the wetland. The water regime has to cover more than 10% of the wetland or ¼ acre to count (*see text for descriptions of hydroperiods*). *Provide map of polygons with different hydroperiods* ___Permanently flooded or inundated — 4 or more types present points = 3 ___Seasonally flooded or inundated — 3 types present points = 2 ___Occasionally flooded or inundated — 2 types present points = 1 ___Saturated only — 1 type present points = 0 ___Permanently flowing stream or river in, or adjacent to, the wetland ___Seasonally flowing stream in, or adjacent to, the wetland **___Lake-fringe wetland = 2 points** **___Freshwater tidal wetland = 2 points**	Figure__
H 1.3. Richness of Plant Species Count the number of plant species in the wetland unit that cover at least 10 ft^2. *Different patches of the same species can be combined to meet the size threshold and you do not have to name the species.* Do not include Eurasian Milfoil, reed canarygrass, purple loosestrife, Canadian Thistle If you counted: > 19 species points = 2 *List species below if you want to:* 5 - 19 species points = 1 < 5 species points = 0	

H 1.4. Interspersion of habitats

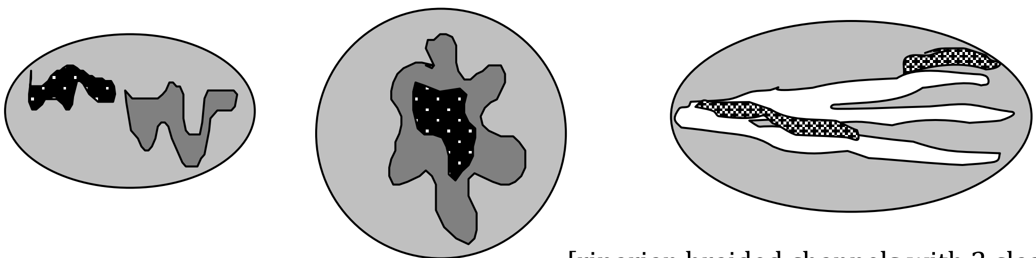
Figure__

Decide from the diagrams below whether interspersion between Cowardin plants classes (described in H 1.1), or the classes and unvegetated areas (can include open water or mudflats) is high, medium, low, or none.

Provide map of Cowardin plant classes (same as H1.1)



None = 0 points   Low = 1 point   Moderate = 2 points



[riparian braided channels with 2 classes]

High = 3 points

NOTE: If you have four or more classes or three plants classes and open water the rating is always "high."

H 1.5. Special Habitat Features:

Check the habitat features that are present in the wetland. The number of checks is the number of points you put into the next column.

___Large, downed, woody debris within the unit (>4 inches diameter and 6 ft long).

___Standing snags (diameter at the bottom > 4 inches) within the unit

___Undercut banks are present for at least 6.6 ft (2m) **and/or** overhanging plants extends at least 3.3 ft (1m) over a stream (or ditch) in, or contiguous with the unit, for at least 33 ft (10m)

___Stable steep banks of fine material that might be used by beaver or muskrat for denning (>30degree slope) OR signs of recent beaver activity are present *(cut shrubs or trees that have not yet weathered where wood is exposed)*

___At least ¼ acre of thin-stemmed persistent plants or woody branches are present in areas that are permanently or seasonally inundated.*(structures for egg-laying by amphibians)*

___Invasive plants cover less than 25% of the wetland area in every stratum of plants (*see H 1.1 for list of strata*)

H 1. TOTAL Score - potential for providing habitat

Add the scores from H 1.1, H 1.2, H 1.3, H 1.4, and H 1.5

Rating of Site Potential: If score is **15 - 18 = H**

7 – 14 = M

0 – 6 = L

Record the rating on the first page

H 2.0 Does the landscape have the potential to support habitat at the site?	
H 2.1 Accessible habitat (include *only habitat that directly abuts wetland unit*). *Calculate:* % undisturbed habitat **+** [(% moderate and low intensity land uses)/2] **=** ______ *Provide map of land use within 1 km of unit edge* If total accessible habitat is: > 1/3 (33.3%) of 1 km circle *(~100 hectares or 250 acres)* points = 3 20 - 33% of 1 km circle points = 2 10 - 19% of 1 km circle points = 1 <10% of 1 km circle points = 0	Figure__
H 2.2 Undisturbed habitat in 1 km circle around unit. If: Undisturbed habitat > 50% of circle points = 3 Undisturbed habitat 10 - 50% and in 1-3 patches points = 2 Undisturbed habitat 10 - 50% and > 3 patches points = 1 Undisturbed habitat < 10% of circle points = 0	
H 2.3 Land use intensity in 1 km circle. If: > 50% of circle is high intensity land use points = (- 2) Does not meet criterion above points = 0	
Total for H 2 Add the points in the boxes above	

Rating of Landscape Potential: If score is 4- 6 = H
1-3 = M
< 1 = L

Record the rating on the first page

H 3.0 Is the Habitat provided by the site valuable to society?	
H3.1Does the site provides habitat for species valued in laws, regulations or policies? *(choose only the highest score)* Site meets ANY of the following criteria: points = 2 — It provides habitat for Threatened or Endangered species (any plant or animal on the state or federal lists) — It is a “priority area” for an individual WDFW species — It is a Natural Heritage Site as determined by the Department of Natural Resources — It scores 4 on question H2.3 of the wetland rating system — It has been categorized as an important habitat site in a local or regional comprehensive plan, in a Shoreline Master Plan, or in a watershed plan Site scores 1-3 on question H2.3 of the wetland rating system points = 1 Site does not meet any of the criteria above points = 0	

Rating of Value: If score is 2 = H
1 = M
0 = L

Record the rating on the first page

Appendix B. Salt tolerant plants

Salt sensitivity rating of the estuarine wetlands and associated uplands flora of the Pacific Northwest (*=estimated) from Hutchinson (1991).

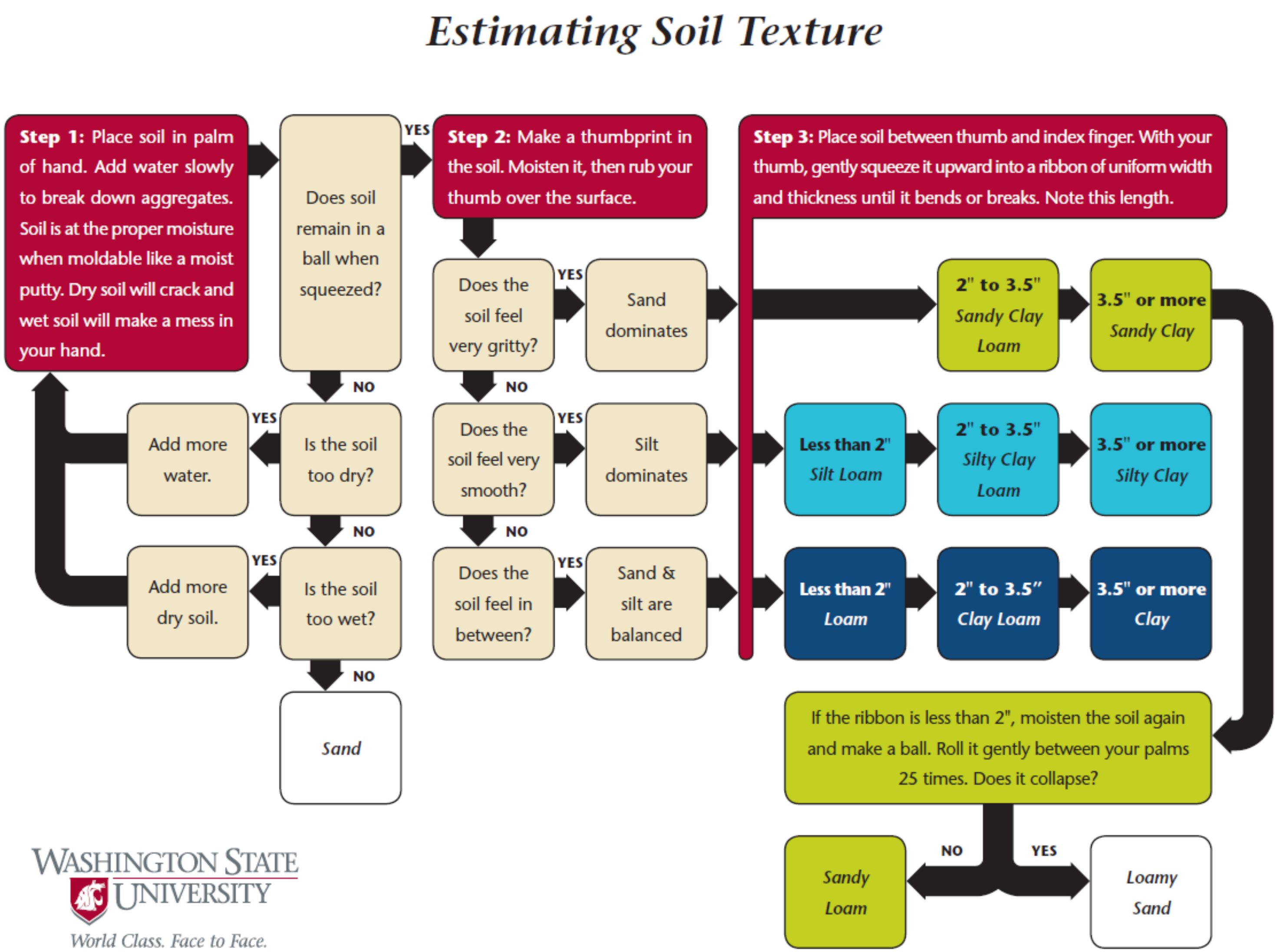
Tolerant

- *Orthocarpus castillejoides
- *Typha angustifolia
- Carex lyngbyei
- Deschampsia caespitosa
- Glaux maritima
- Hordeum jubatum
- Juncus gerardii
- Liliaeopsis occidentalis
- Scripus maritimus
- Stellaria humifusa

Very Tolerant

- Grindelia integrifolia
- Suaeda maritima
- Triglochin concinnum
- Triglochin maritimum
- Atriplex patula
- Cotula coronopifolia
- Distichlis spicata
- Jaumea carnosa
- Juncus balticus
- Plantago maritima
- Salicornia europea
- Salicornia viginica
- Spergularia canadensis
- Spergularia marina

Appendix C. Estimating Soil Texture



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Appendix D: Question H 2.3 of the Wetland Rating System

H 2.3 Near or adjacent to other priority habitats listed by WDFW (see complete descriptions of WDFW priority habitats, and the counties in which they can be found, in: Washington Department of Fish and Wildlife. 2008. Priority Habitat and Species List. Olympia, Washington. 177 pp. http://wdfw.wa.gov/publications/00165/wdfw00165.pdf)

Count how many of the following priority habitats are within 330 ft (100m) of the wetland unit? *NOTE: the connections do not have to be relatively undisturbed.*

____**Aspen Stands:** Pure or mixed stands of aspen greater than 0.4 ha (1 acre).

____**Biodiversity Areas and Corridors**: Areas of habitat that are relatively important to various species of native fish and wildlife (*full descriptions in WDFW PHS report p. 152*).

____**Herbaceous Balds:** Variable size patches of grass and forbs on shallow soils over bedrock.

____**Old-growth/Mature forests:** (Old-growth west of Cascade crest) Stands of at least 2 tree species, forming a multi-layered canopy with occasional small openings; with at least 20 trees/ha (8 trees/acre) > 81 cm (32 in) dbh or > 200 years of age. (Mature forests) Stands with average diameters exceeding 53 cm (21 in) dbh; crown cover may be less that 100%; crown cover may be less that 100%; decay, decadence, numbers of snags, and quantity of large downed material is generally less than that found in old-growth; 80 - 200 years old west of the Cascade crest.

____**Oregon white Oak:** Woodlands Stands of pure oak or oak/conifer associations where canopy coverage of the oak component is important (*full descriptions in WDFW PHS report p. 158 – see web link above*).

____**Riparian**: The area adjacent to aquatic systems with flowing water that contains elements of both aquatic and terrestrial ecosystems which mutually influence each other.

____**Westside Prairies:** Herbaceous, non-forested plant communities that can either take the form of a dry prairie or a wet prairie (*full descriptions in WDFW PHS report p. 161 – see web link above*).

____**Instream:** The combination of physical, biological, and chemical processes and conditions that interact to provide functional life history requirements for instream fish and wildlife resources.

____**Nearshore**: Relatively undisturbed nearshore habitats. These include Coastal Nearshore, Open Coast Nearshore, and Puget Sound Nearshore. (*full descriptions of habitats and the definition of relatively undisturbed are in WDFW report – see web link on previous page).*

____**Caves:** A naturally occurring cavity, recess, void, or system of interconnected passages under the earth in soils, rock, ice, or other geological formations and is large enough to contain a human.

____**Cliffs:** Greater than 7.6 m (25 ft) high and occurring below 5000 ft.

____**Talus:** Homogenous areas of rock rubble ranging in average size 0.15 - 2.0 m (0.5 - 6.5 ft), composed of basalt, andesite, and/or sedimentary rock, including riprap slides and mine tailings. May be associated with cliffs.

____**Snags and Logs:** Trees are considered snags if they are dead or dying and exhibit sufficient decay characteristics to enable cavity excavation/use by wildlife. Priority snags have a diameter at breast height of > 51 cm (20 in) in western Washington and are > 2 m (6.5 ft) in height. Priority logs are > 30 cm (12 in) in diameter at the largest end, and > 6 m (20 ft) long.

Note: All vegetated wetlands are by definition a priority habitat but are not included in this list because they are addressed elsewhere.

Scoring for H 2.3:

- If wetland has 3 or more priority habitats = 4 points
- If wetland has 2 priority habitats = 3 points
- If wetland has 1 priority habitat = 1 point
- No habitats = 0 points

Appendix E: Worksheets for Estimating the Adequacy of Wetland Mitigation

"DEBIT" WORKSHEET

Wetland unit to be altered: ____ Date __________

Use the following tables to calculate the Debits for the impact site. Use a separate worksheet for each wetland unit being altered. In addition, you will need to calculate the debits separately for forested areas and for emergent/shrub areas. Use the map of Cowardin plant types from question H 1.1 on the Scoring Form to determine the boundaries between forested areas and non-forested areas.

FUNCTION ***From Scoring Form***	**Improving Water Quality**	**Hydrologic**	**Habitat**
Rating of Site Potential			
Rating of Landscape Potential			
Rating of Value			
Score for Wetland			

CALCULATIONS **emergent or shrub areas**	**Improving Water Quality**	**Hydrologic**	**Habitat**
Score for wetland unit (see above)			
Impact - Acres of **non-forested** areas *(same for all functions)*			
Basic mitigation requirement (BMR) = *Score for function x acres impacted*			
Temporal loss factor (TLF) (See table below)			
Mitigation required DEBITS = BMR x TLF			
CALCULATIONS **forested areas**	**Improving Water Quality**	**Hydrologic**	**Habitat**
Score for wetland unit (see above)			
Impact - Acres of **forest** *(Create a separate column for each type of forest)* Deciduous (D), Evergreen (E), Cat. 1 deciduous (>50%cover) (CD) Cat. 1 evergreen (>50% cover)(CE)	D E CD CE	D E CD CE	D E CD CE
Basic mitigation requirement (BMR) = *Score x acres impacted*			
Temporal loss factor (TLF) (See table below)			
Mitigation required DEBITS = BMR x TLF			
TOTAL for forested areas (D+E+CD+CE)			

Temporal Loss Factors:

Timing of Mitigation	Temporal Loss Factor
Advance – At least two years has passed since plantings were completed or one year since "as-built" plans were submitted to regulatory agencies	1.25
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.	
For impacts to an emergent or shrub community	1.5
For impacts to a deciduous forested wetland community	2.0
For impacts to an evergreen forested wetland community	2.5
For impacts to a deciduous Category I forested wetland community	3
For impacts to an evergreen Category I forested wetland community	3.5
Delayed - Construction is not completed within one year of impact, but is completed (including plantings if required) within 5 growing seasons of impact.	
For impacts to an emergent or shrub community	3
For impacts to a deciduous forested wetland community	4
For impacts to an evergreen forested wetland community	5
For impacts to a deciduous Category I forested wetland community	6
For impacts to an evergreen Category I forested wetland community	7

NOTE: The ratings, scoring and calculations are valid for only five years because wetlands and their functions will change with time. If delays in the construction of the site are more than 5 years, the mitigation plan will probably have to be re-negotiated and the calculation re-done. This time limit was chosen to be consistent with the validity of wetland delineations as established by the U.S. Army Corps of Engineers.

TOTALS

	Improving Water Quality	Hydrologic	Habitat
DEBITS - Emergent or shrub areas	Acre-points	Acre-points	Acre-points
DEBITS - Forested areas	Acre-points	Acre-points	Acre-points
TOTAL	Acre-points	Acre-points	Acre-points

"CREDIT" WORKSHEET

Mitigation Site: _______________ Wetland Unit: ______________________ Date __________

To calculate the CREDITS fill out the following worksheets using the data from the Scoring Form. Also,

- Use additional worksheets if more than one wetland unit is being used for mitigation.
- Use the map of Cowardin plant types from question H 1.1 on the Scoring Form to determine the boundaries of areas dominated by emergent plants (if needed for the calculations).
- Map out and estimate the areas in the wetland unit that will be created or re-established and the areas that will be rehabilitated or enhanced. The credits from creation/re-establishment and rehabilitation/enhancement are calculated separately before being combined at the end.

Additional notes:

Note 1: B = 0 for all three functions in mitigation sites that are not currently wetlands (creation or re-establishment).

Note 2: If you are increasing the size of an existing wetland the credits are calculated by rating the functions for the entire future wetland (original wetland + area created or re-established). However, you only get credits based on the area (footprint) of the area created or re-established.

Note 3: For enhancement and rehabilitation you cannot score only the parts of a wetland where mitigation takes place. You need to score the entire unit as defined in Chapter 4. This is done for both "before" and "after" conditions. The score for the unit after mitigation [A] will be the same for either enhancement or rehabilitation. This method is based on calculating the "lift" in functions without considering whether the mitigation is called enhancement or rehabilitation.

Note 4: Scoring the landscape potential of a mitigation site to calculate credits after the mitigation takes place depends on how its rating changes. Specifically:

4.1 **If the score for the landscape potential decreases as a result of the mitigation activity** then the score for the current conditions can be used for calculating credits. For example, the rating of landscape potential might decrease for a large mitigation project that removes sources of pollutants in the buffer. In this case the scores for the site might decrease even though positive actions are being taken.

4.2 **If the score for the landscape potential decreases as a result of the development or proposed impacts** then the score for the “future” condition should be used to calculate credits. For example, on-site mitigation should be getting a lower rating for the landscape potential if development to which it is linked breaks corridors or reduces the area of undisturbed habitat. These reduce the effectiveness of the mitigation site as habitat.

4.3 **If the score for the landscape potential increases as a result of the mitigation actions** then the score for the “future” condition can be used in calculating credits. For example, new corridors or habitat connections that are made as a result of the project should be given credit. Also, riverine wetlands that are reconnected to their floodplain should get credit (e.g., question R 5.1).

4.4 **If the score for the landscape potential increases as a result of the development or proposed impacts** then the score for landscape potential for the current conditions has to be used in calculating credits. A development could provide a source of pollutants or excess water to the mitigation site that would increase its level of flood storage and removal of pollutants. We do not want to give mitigation credits to increases in functioning of a wetland that are a result of the impacts associated with the project.

Use the following worksheet to calculate credits. Totals are in acre-points for comparison with the debits worksheet. Separate the mitigation site into different areas (polygons on a map) by the type of mitigation proposed (creation, re-establishment [C/R], and rehabilitation/enhancement [R/E]) and by the plant community proposed for that polygon. These areas have different risk factors.

Scores for unit before any mitigation takes place

B = 0 for Creation and Re-establishment

FUNCTION ***From Scoring Form - Unit ID_________***	**Improving Water Quality**	**Hydrologic**	**Habitat**
Rating of Site Potential			
Rating of Landscape Potential			
Rating of Value			
Score for mitigation site [B]efore	**B =**	**B =**	**B =**

Scores for unit based on the expected wetland ecosystem when all the vegetation has reached maturity and the water regime has stabilized

FUNCTION ***From Scoring Form - Unit ID_________***	**Improving Water Quality**	**Hydrologic**	**Habitat**
Rating of Site Potential			
Rating of Landscape Potential			
Rating of Value			
Score for mitigation site [A]fter	**A =**	**A =**	**A =**

Calculations for Credits **Unit ID____________**	**Improving Water Quality**		**Hydrologic Function**		**Habitat Function**	
Increase in Score at mitigation site (**A – B**) = [f/s] – forest/shrub/aquatic bed [e] – emergent	C/R f/s e	R/E f/s e	C/R f/s e	R/E f/s e	C/R f/s e	R/E f/s e
Acres of mitigation (*should be same for the 3 functions for each type of mitigation*)						
Basic mitigation credit (BMC) = Increase in Score x acres of mitigation						
Risk factor (RF) (see table below)						
Mitigation credits available for each area CREDITS = BMC x RF						
TOTAL CREDITS AVAILABLE Add the credits from the different types of mitigation						

Risk Factors:

Type of Mitigation	Risk Factor
Advance mitigation The site meets **criteria in Charts 1 and 3** of the site selection guidance [i.e., identified in a local plan and is sustainable] **AND** meets the **criteria in Charts 4-11** for the appropriate functions. (Ecology publication #09-06-032) ***Advance** means that at least two years has passed since plantings were completed or one year since "as-built" plans were submitted to regulatory agencies.*	1.0
Advance mitigation without meeting criteria in Ecology publication #09-06-032	0.83
Concurrent Mitigation Mitigation site meets **criteria in Charts 1 and 3** of the site selection guidance [i.e., identified in a local plan and is sustainable] **AND** meets the **criteria in Charts 4-11** for the appropriate functions. (All worksheets for Chart 3 and in Appendix D of Ecology publication #09-06-032 are submitted) *Risk factor applies to all types of mitigation.*	0.9
Mitigation site chosen meets the **criteria in Charts 2 and 3** of the site selection guidance [i.e., identified as a site with potential and that is sustainable] ; **AND** meets **criteria in Charts 4-11** for the appropriate functions. (All worksheets for Chart 3 and in Appendix D of Ecology publication #09-06-032 are submitted) *Risk factor applies to all types of mitigation.*	0.80
Site does not meet criteria in site selection guide, or guide was not used.	
Re-establishment, rehabilitation, or enhancement of an aquatic bed, shrub, or forest community	0.67
Re-establishment, rehabilitation, or enhancement of an emergent community	0.5
Creation of an aquatic bed, shrub, or forest community with data showing there is adequate water to maintain wetland conditions 5 years out of every 10.	0.67
Creation of an emergent community with data showing there is adequate water to maintain wetland conditions 5 years out of every 10.	0.5
Creation of an aquatic bed, shrub, or forest community <u>without</u> adequate hydrologic data.	0.5
Creation of an emergent community <u>without</u> adequate hydrologic data.	0.4

Calculating credits achieved through preservation

The credits available from preservation are calculated by scoring the importance and location of the site being proposed for preservation.

- If you are preserving wetlands use the first table below. The wetland will have to be scored for its functions using the Scoring Sheet in Appendix A.
- If you are preserving uplands use the second table.

To come up with ratios for preservation that are similar to those currently in use we modify the "Basic Score" by "Scaling Factors" that reflect the importance of the site and the potential threats to the site. The descriptions of the criteria used for determining the scaling factors are given after the tables. The tables show two scaling factors for each criterion. Use the first scaling factor if the mitigation plan you are proposing also meets the "no net loss of area" policy. This means you are creating or re-establishing an area of wetland that is equivalent to the area lost. Use the second scaling factor if wetland area is not fully replaced (i.e., the mitigation consists of only mostly rehabilitation, enhancement and/or preservation).

Preservation of Existing Wetlands

Calculating Credits When Preserving Wetlands	Improving Water Quality	Hydrologic Functions	Habitat Functions
Scores of wetland being preserved (*from Scoring Sheet*)			
Acres of preservation			
Basic Score = Score x acres of wetland preserved			
Scaling Factors see tables below Wetland Category			
Location			
Threat			
Sum of scaling factors			
CREDITS AVAILABLE (Basic Score) *x* (sum of scaling factors) =	Acre-points	Acre-points	Acre-points

Preservation of Uplands

The hydrologic and water quality functions that uplands provide are not directly comparable to those provided by wetlands, and we do not have methods for rating them. Habitat for wildlife and plants are the only functions that are marginally comparable. **As a result, credits from the preservation of uplands can only be used to compensate for impacts to the habitat functions.** Different types of upland habitat are assigned an equivalent "wetland habitat" score for the purpose of calculating the credits. The scoring for uplands is as follows:

Type of Upland Habitat	Habitat Score to be applied in calculation
Upland is Identified as important habitat for preservation in a watershed plan	9
Upland is a "Priority area" for priority species as defined by WDFW OR upland is listed as Natural Heritage site by the Department of Natural Resources	8
Upland is a priority habitat as defined by WDFW (other than wetlands) (see Appendix D for list)	7
Other relatively undisturbed uplands (see definition of relatively undisturbed on page 106)	5

Calculating Credits When Preserving Uplands	Habitat Score
Habitat Score for type of upland from table above	
Acres of preservation	
Basic Score = Score x acres of preservation	
Scaling Factors see tables below Connections	
Location	
Threat	
Sum of scaling factors	
HABITAT CREDITS AVAILABLE Basic Score *x* sum of scaling factors =	Acre-points

Criteria and Their Scaling Factors

Each criterion has two scaling factors. The first is to be used if the mitigation plan includes the creation or re-establishment of an area of wetland that is equivalent to the area lost. The second is to be used if wetland area is not replaced and the mitigation consists of only rehabilitation or enhancement and preservation.

Factor if area is replaced = Creation or re-establishment replaces, at a minimum, the area of wetland lost.

Factor if area is not replaced = Enhancement, rehabilitation, or preservation provides the bulk of the mitigation. The wetland area lost is not completely replaced by the proposed mitigation.

Areas may be separated for calculations if they represent different types of preservation.

Criterion - Wetland Category (*applies only if preserving wetlands*) – the category of the wetland from the Washington State Wetland Rating System. Some Category II wetlands have ongoing disturbances such as grazing ditches, or drain tiles. The scaling factor for Category II wetlands can be increased if the mitigation plan includes the removal of these disturbances.

	Category 1 wetland	**Category 2 wetland**	**Category 2 wetland with removal of disturbances**	**Category III or IV wetland**
Scaling Factor if area is replaced	0.1	0.05	0.08	0
Scaling Factor if area is not replaced	0.05	0.025	0.04	0

Criterion - Habitat Connections for Uplands *(applies only if preserving uplands)* - The connection of the preservation site relative to other relatively undisturbed habitat areas (see definition for relatively undisturbed on page 105).

	Site connected to at least 250 acres of undisturbed habitat	**Site connected to ≥ 25 acres of undisturbed habitat**	**Site provides a habitat corridor**	**No corridors**
Scaling Factor if area is replaced	0.1	0.05	0.025	0
Scaling Factor if area is not replaced	0.05	0.025	0.013	0

Definitions:

Site connected to an undisturbed habitat at least 250 acres in size– Use a map or aerial photograph to determine if site being preserved is part of, or connected to, a relatively undisturbed upland, wetland, or estuary, at least 250 acres in size. Relatively undisturbed means the area is not subject to regular disturbances from human activities (see p. 105). If site is connected by a corridor, the corridor must be relatively undisturbed and at least 100 ft wide.

Site part of an undisturbed habitat of at least 25 acres - Use same criteria as above, but the size of undisturbed habitat only has to be 25 acres instead of 250.

Site provides a habitat corridor – The preservation site is a relatively undisturbed vegetated habitat corridor at least 50' wide between two existing patches of relatively undisturbed habitat at least 10 acres in size, or a relatively undisturbed riparian corridor that is at least ¼ mile in length and at least 50 ft wide.

Criterion – Location *(Use for both upland and wetland preservation)* - characterizes the position of the preservation site relative to the impact site*.*

Location of mitigation site relative to impact site	Same hydrologic unit*	Adjacent hydrologic unit*	Site chosen with no analysis of hydrologic units (negative scaling factor)
Scaling Factor if area is replaced	0.05	0.025	-0.02
Scaling Factor if area is <u>not</u> replaced	0.025	0.013	-0.04

*See site selection guide (Ecology publication #09-06-032) for defining hydrologic units used in watershed analyses.

Definitions:

Same hydrologic unit – The preservation site is in the same hydrologic unit as the impact site as defined in the site selection guide (Ecology publication #09-06-032). The scale of the hydrologic unit chosen should be compatible with those used in any available local planning efforts.

Adjacent hydrologic unit - The site is in a hydrologic unit that is contiguous with the one where the impacts will occur. (see above for defining hydrologic units)

Site chosen with no analysis of hydrologic units – the location of the preservation site was chosen without any analysis of the hydrologic units in the watershed.

Criterion - Degree of Threat *(Use for both upland and wetland preservation)* – Characterizes the level of imminent risk of loss or damage to the preservation site.

Threat	High	Moderate	Low
Scaling Factor if area is replaced	0.1	.05	0
Scaling Factor if area is not replaced	0.05	0.025	0

Definitions:

Threat High – There is a demonstrable threat to the site based on documented evidence of proposed destructive land use. The threat has to be documented. Also any areas within the boundaries of an incorporated city or town are under a High Threat.

Threat Moderate – There is threat to the site based on local and regional land use trends that are generally not the consequence of actions under the control of the land owner. Any areas within an urban growth boundary can be considered as having a moderate threat.

Threat Low – There is little evidence of an imminent risk to the preservation site.

Summary of Credits and Debits

This summary provides space for three separate impact sites and three mitigation areas. If more areas are planned, another sheet will be needed.

DEBITS (all numbers are acre-points)	**Improving Water Quality**	**Hydrologic Function**	**Habitat Function**
	Site #1 Site #2 Site #3	Site #1 Site #2 Site #3	Site #1 Site #2 Site #3
TOTAL (in acre-points)			
CREDITS (all numbers are acre-points)	**Improving Water Quality**	**Hydrologic Function**	**Habitat Function**
Creation/re-establishment	Site #1 Site #2 Site #3	Site #1 Site #2 Site #3	Site #1 Site #2 Site #3
Rehabilitation			
Enhancement			
Wetland Preservation			
Upland Preservation			
TOTAL Credits available (In acre-points)			
BALANCE Credits - Debits			

Eelgrass Monitoring Plan

Coast Seafoods Company, Humboldt Bay Shellfish Culture Permit Renewal and Expansion Project
Eureka, California

Prepared for:

Plauché & Carr LLP

SHN Engineers & Geologists

812 W. Wabash Ave.
Eureka, CA 95501-2138
707-441-8855

August 2015

015063.001

Reference: 015063.001

Eelgrass Monitoring Plan

Coast Seafoods Company, Humboldt Bay Shellfish Culture Permit Renewal and Expansion Project Eureka, California

Prepared for:

Plauché & Carr LLP
811 First Avenue, Suite 630
Seattle, WA 98104

Prepared by:

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August 2015

QA/QC: SEC_SEC

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Appendices

List of Illustrations

Abbreviations and Acronyms

ft^2	square feet
m	meter
m^2	square meters
mph	miles per hour
°	degree

BACI	before/after—control/impact
CEMP	California Eelgrass Mitigation Policy and Implementing Guidelines
CFR	code of federal regulations
Coast	Coast Seafoods Company
D	effect size
FLUPSY	floating upwelling systems
GIS	geographic information system
GPS	global positioning system
HSU	Humboldt State University
MLLW	mean lower low water
NOAA	National Oceanic and Atmospheric Administration
PVC	polyvinyl chloride
SD	standard deviation
SHN	SHN Engineers & Geologists

1.0 Introduction

This eelgrass monitoring plan was developed by SHN Engineers & Geologists to monitor the effects of Coast Seafoods Company's (Coast) Humboldt Bay Shellfish Culture: Permit Renewal and Expansion Project (Project). As part of the Project and the study area of this monitoring plan (Figure 1), Coast is planning to permit an additional 622 acres of intertidal shellfish aquaculture on historically cultivated shellfish beds (expansion area). Eelgrass is designated as a "Habitat Area of Particular Concern" for federally managed salmonid and groundfish species (NOAA, 2014). Eelgrass beds are also recognized as a conservation concern by local and state agencies, including the California Department of Fish and Wildlife, California Coastal Commission, City of Eureka, and the Humboldt Bay Harbor, Recreation and Conservation District.

1.1 Purpose

This monitoring plan is designed to quantify aquaculture-induced changes in eelgrass percent cover, shoot density, and areal extent within the Project's expansion area. Monitoring is proposed using flyover photography in addition to a before/after-control/impact (BACI) experimental design that includes two years of baseline data (before) and two years of post-project implementation data (after). Nested plots with the two shellfish cultivation methods proposed to take place in eelgrass (cultch-on-longline and basket-on-longline) will be compared to control plots in a blocked design. Monitoring results will be used to evaluate project-related impacts to eelgrass habitat function.

1.2 Project Description

The Project has three components:

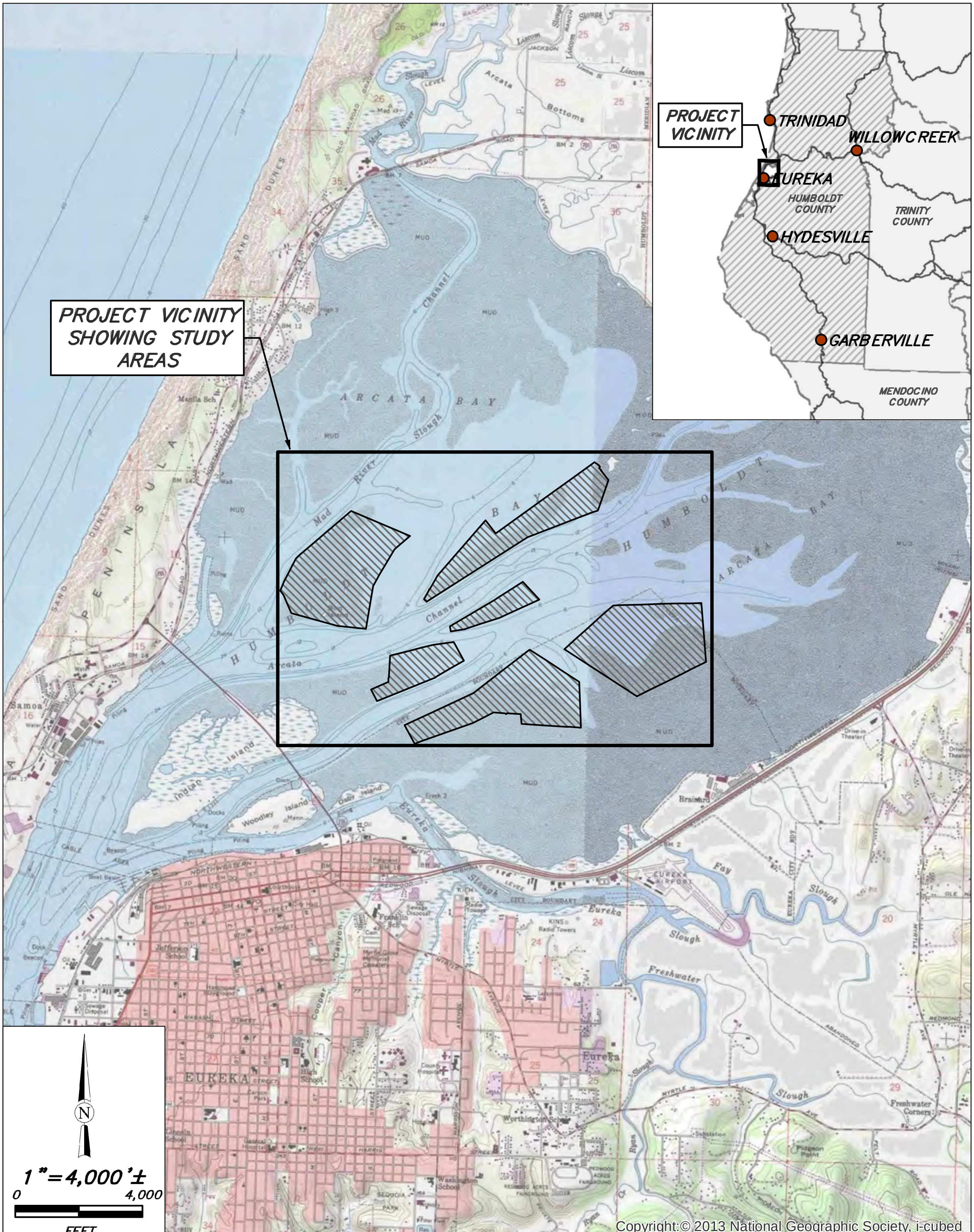
1) renewing regulatory approvals for 294.5 acres of existing shellfish culture,
2) increasing shellfish culture within an already permitted FLUPSY by adding eight culture bins, and
3) adding an additional 622 acres of intertidal shellfish culture within the expansion area.

Two cultivation methods are proposed for intertidal expansion areas where eelgrass occurs: cultch-on-longline and basket-on-longline.[1] Cultch-on-longline is proposed to occupy 522 acres within the expansion areas, of which 504 acres occurs in eelgrass habitat. Cultch-on-longline areas will have 100-foot lines spaced 5 feet apart. Basket-on-longline is proposed to occur on approximately 96 acres of eelgrass habitat within the expansion areas. Basket-on-longline areas will have three groups of 100-foot lines spaced 5 feet apart with 20-foot gaps between groups of three lines.

2.0 Regulatory Setting

This monitoring plan has been developed in conformance with the California Eelgrass Mitigation Policy and Implementing Guidelines (CEMP) (NOAA, 2014). CEMP recommends compensatory

[1] Rack-and-bag cultivation is proposed to occur in a maximum of 4 acres of the expansion area and will not be placed within 10 feet of eelgrass.



Path: \\zing\projects\2015\015063-CoastSeafoods\GIS\PROJ_MXD\Report_MXDs\Figure1_ProjectVicinityMap.mxd

SHN Consulting Engineers & Geologists, Inc.	Plauche & Carr LLP. Eelgrass Monitoring Plan Eureka, California	Project Vicinity Map Showing Study Areas SHN 015063
July 2015	Figure1_ProjectVicinityMap	Figure 1

mitigation on an equivalent area basis for loss of spatial cover or statistically significant reductions in eelgrass turion (shoot) density greater than 25 percent. This monitoring plan is designed to assess project-related changes in the percent cover and shoot density eelgrass parameters described in CEMP.

3.0 Location Setting/Characterization

Humboldt Bay is a shallow, multi-basin, coastal lagoon with limited freshwater input. Its surface area spans 66 square kilometers at high tide, at least half of which drains during low tides, revealing shallow mudflats connected by subtidal channels. The region has mixed semi-diurnal tides that range in excess of +2.5 meters (m) above mean lower low water (MLLW) to below -0.6 m. Arcata Bay (North Bay) is the northern portion of Humboldt Bay and is the primary location for intertidal shellfish aquaculture. North Bay supports several unique habitat types in addition to an aquaculture industry.

In 2009, Humboldt Bay contained 3,614 acres of continuous eelgrass beds and an additional 2,031 acres of patchy eelgrass beds (Schlosser and Eicher, 2012). Although monitoring is sporadic for various locations throughout California, the eelgrass in Humboldt Bay represents up to 53% of California's eelgrass resource. Most of the continuous eelgrass beds are located in South Bay (84% occupied) compared to North Bay (39% occupied; Gilkerson, 2008). A variety of environmental factors limit eelgrass growth in the bay, including light and suspended sediments, wind and wave exposure, nutrients, sea surface temperature, space competition, and herbivory.

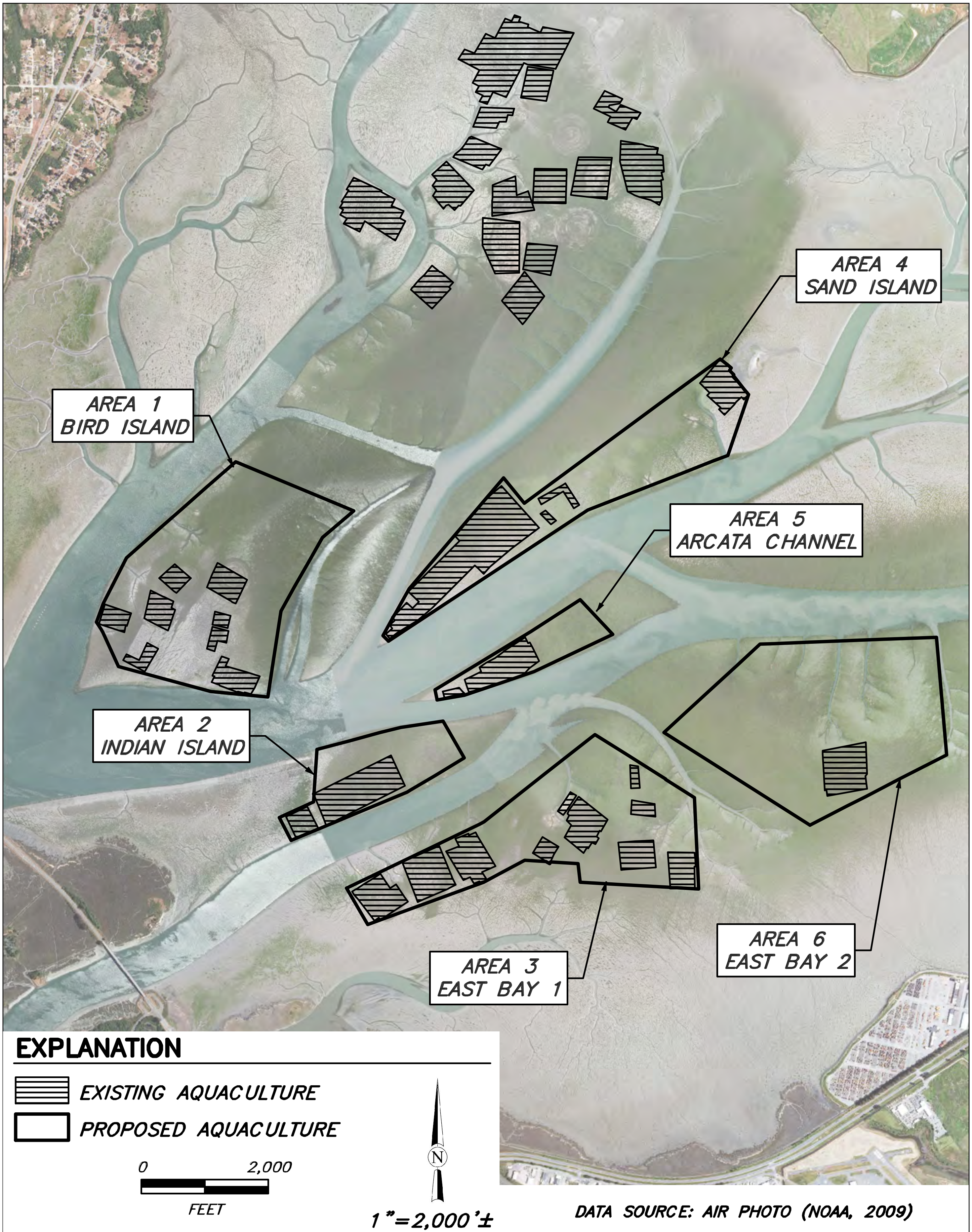
3.1 Location of Expansion Areas

Coast proposes to expand its existing commercial shellfish aquaculture operation in six intertidal areas in North Bay (See Figure 2 and Tables 1 and 2).[2]

3.2 Elevation

As shown in Figures 3 and 4, and presented in Table 1, the expansion area ranges in elevation from -1.07 m MLLW to +0.38 m MLLW (Gilkerson, 2014).

[2] A portion of Coast's existing culture footprint is located in areas currently leased from the Humboldt Bay Harbor, Recreation and Conservation District (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 underlying tideland property owners. This monitoring report was developed before the issue arose and is based on Coast's existing Harbor District lease maps, which are being revised and updated consistent with the Harbor District's renewal of Coast's lease. The analysis and calculations in this monitoring plan will be revised to reflect the current understanding of the boundaries of Coast's Harbor District lease and proposed expansion areas prior to incorporation into the draft Environmental Impact Report (EIR) in September 2015. The final monitoring plan included in the draft EIR will be based on updated maps of Coast's lease area and planned expansion area, as shown in Figures 1a, 2a, 3a, 6a and 11a (Appendix C).



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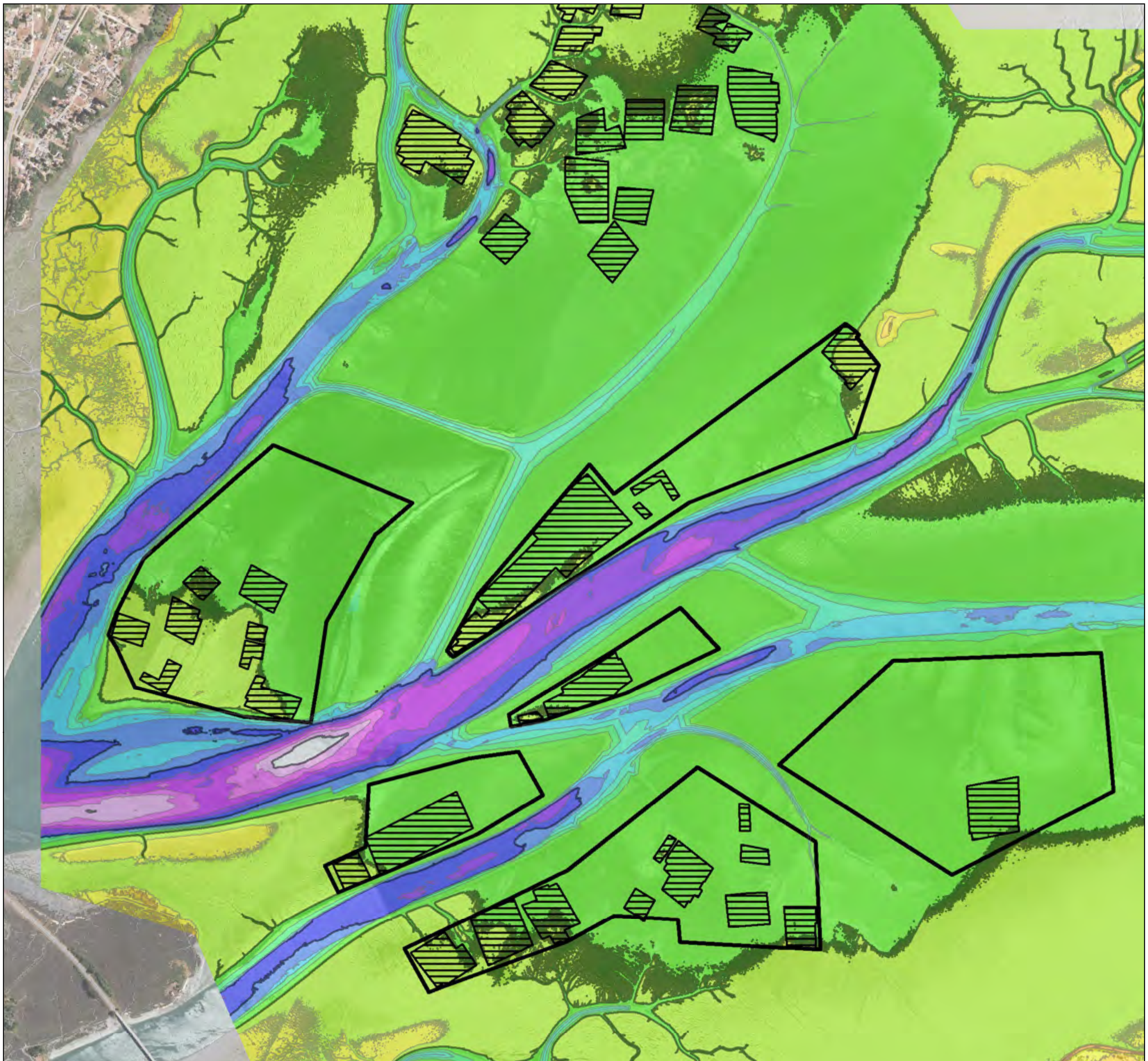
SHN Consulting Engineers & Geologists, Inc.	Plauche & Carr LLP. Eelgrass Monitoring Plan Eureka, California	Site Map Showing Existing and Expansion Areas SHN 015063	
	July 2015	Figure2_StudyAreas	Figure 2



EXPLANATION

EXISTING AQUACULTURE
PROPOSED AQUACULTURE

1"=2,000'±
0 2,000
FEET

ELEVATION (FEET)		
-11 TO -10	-5 TO -4	1 TO 2
-10 TO -9	-4 TO -3	2 TO 3
-9 TO -8	-3 TO -2	3 TO 4
-8 TO -7	-2 TO -1	4 TO 5
-7 TO -6	-1 TO 0	5 TO 6
-6 TO -5	0 TO 1	6 TO 7

DATA SOURCE: ELEVATION DATA (GILKERSON, 2014)

Path: \\zing\projects\2015\015063-CoastSeafoods\GIS\PROJ_MXD\Report_MXDs\Final_20150715\Figure3_ElevationMap.mxd

SHN Consulting Engineers & Geologists, Inc.

Plauche & Carr LLP.
Eelgrass Monitoring Plan
Eureka, California

Site Map Showing 1-Foot Elevations and Existing and Expansion Areas
SHN 015063

July 2015 | Figure3_ElevationMap | Figure 3

Table 1 Elevation Categories Coast Seafoods Eelgrass Monitoring Plan (in m²)[1]								
Elevation Range (m MLLW)[2,3]	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Total**	**Percent of Grand Total**
0.3 to 0.38	163	-	-	-	-	-	163	0.0
0.23 to 0.3	4,953	-	-	-	-	-	4,953	0.2
0.15 to 0.23	22,305	-	9	1,019	-	-	23,332	0.9
0.08 to 0.15	31,292	2,650	4,882	9,219	-	-	48,041	1.9
0 to 0.08	110,328	4,450	22,204	18,400	832	558	156,773	6.2
-0.08 to 0	149,066	15,457	207,164	110,435	5,868	138,440	626,429	24.9
-0.15 to -0.08	371,984	116,377	222,219	204,802	62,186	580,854	1,558,422	62.0
-0.23 to -0.15	2,000	14,951	3,085	3,220	18,571	52,236	94,062	3.7
-1.07 to -0.23	1,063	-	1,222	-	-	-	2,285	0.1
Total	**693,153**	**153,884**	**460,784**	**347,095**	**87,456**	**772,088**	**2,514,461**	**100**
Percent of Grand Total	**27.6**	**6.1**	**18.3**	**13.8**	**3.5**	**30.7**	**100**	**-**

1. m²: square meters
2. m: meter
3. MLLW: mean lower low water

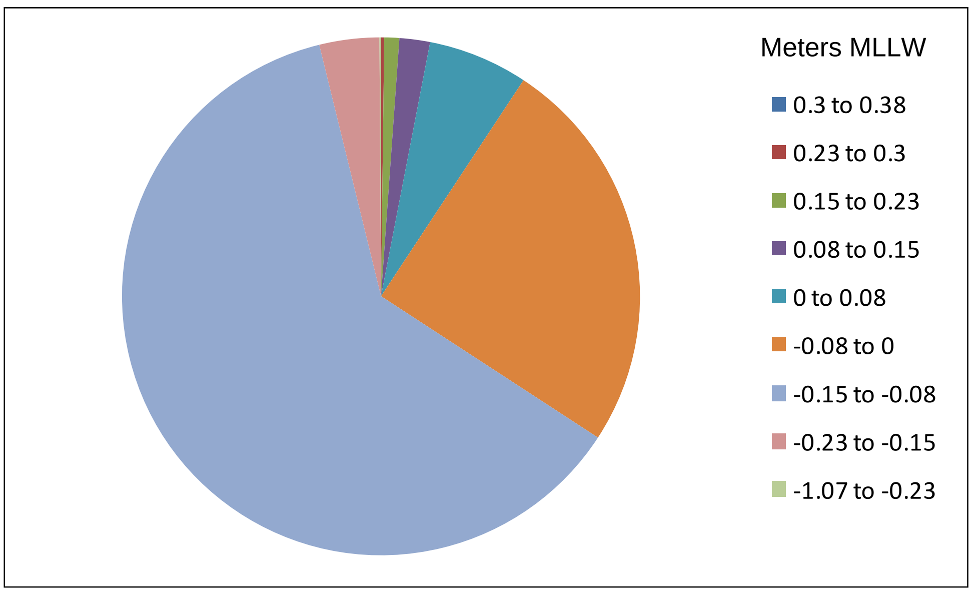


Figure 4: Percent Elevation of Expansion Areas.

3.3 Sediment Texture

As shown in Figures 5 and 6 and presented in Table 2, sediment types within the expansion areas range from very clayey silt to sand (HBHD, 2001).

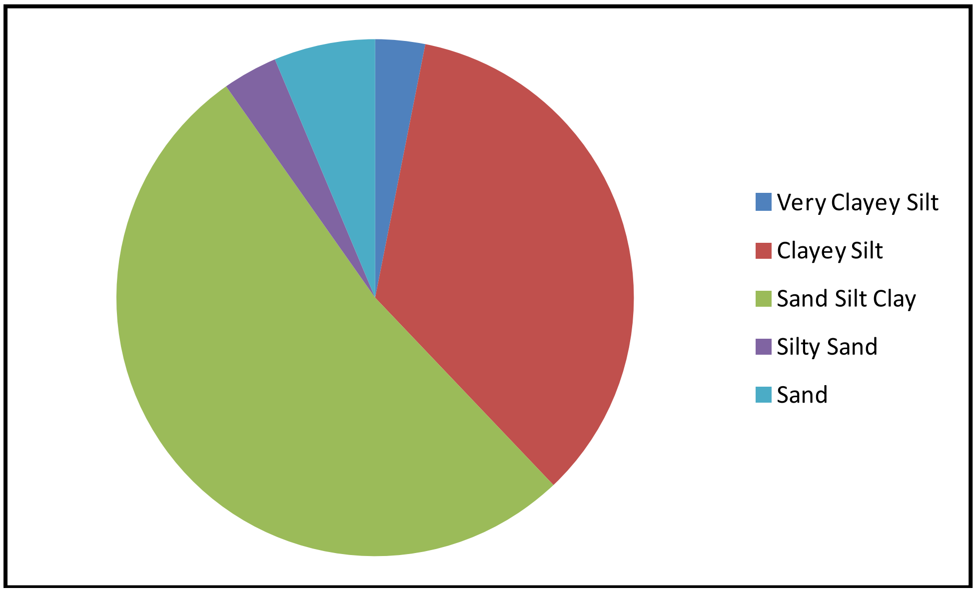


Figure 5: Percent Sediment of Expansion Areas.

Table 2
Sediment Categories
Coast Seafoods Eelgrass Monitoring Plan
(in m²)[1]

Sediment Types	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Total	Percent of Grand Total
Very Clayey Silt	-	-	26,353	-	-	51,996	78,349	3.1
Clayey Silt	17,851	12,497	272,129	93,727	-	478,972	875,176	34.8
Sand Silt Clay	481,264	133,427	163,033	242,098	66,312	230,550	1,316,685	52.3
Silty Sand	34,917	8,032	-	11,533	21,265	10,766	86,512	3.4
Sand	159,252	-	-	-	-	-	159,252	6.3
Total	**693,285**	**153,955**	**461,516**	**347,357**	**87,576**	**772,284**	**2,515,974**	**100**
Percent of Grand Total	**27.6**	**6.1**	**18.3**	**13.8**	**3.5**	**30.7**	**100**	**-**

1. m^2: square meters

4.0 Development of Monitoring Plan Methodology

This monitoring plan includes collection of pre-project eelgrass baseline data for two years (2015 and 2016) followed by two years monitoring after aquaculture gear has been in place (2017 and 2018). Methodologies used in previous eelgrass studies within Humboldt Bay, and their subsequent results, were reviewed in the development of this monitoring plan (Keiser, 2004; Rumrill and Poulton, 2004; Short et al., 2006; Williamson, 2006; Tennant, 2006; Schlosser and Eicher, 2012; NOAA, 2009; 2012; SeagrassNet, 2015).

EXPLANATION

EXISTING AQUACULTURE

PROPOSED AQUACULTURE

1"=2,000'±

0 2,000

FEET

N

SEDIMENT TYPES

MARSH

SILTY CLAY

VERY CLAYEY SILT

CLAYEY SILT

SAND–SILT–CLAY

SILTY SAND

SAND

SAND AND GRAVEL

DATA SOURCE: SEDIMENT TYPES (HUMBOLDT BAY HARBOR, RECREATION AND CONSERVATION DISTRICT, 2001)

SHN Consulting Engineers & Geologists, Inc.	Plauche & Carr LLP. Eelgrass Monitoring Plan Eureka, California	Site Map Showing Sediment Types and Existing and Expansion Areas SHN 015063
July 2015	Figure6_SedimentTypes	Figure 6

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4.1 Summary of Metrics

Surveying is done using 0.25-m quadrats positioned as described in Section 4.2.3. Several quantitative variables are recorded for each 0.0625-square meter (m^2) quadrat area, including shoot density, percent eelgrass cover, and percent seaweed cover. Metrics are surveyed and recorded in compliance with the guidelines established by the CEMP. Example data sheets are provided in Appendix A.

4.1.1 Depth of Water

The depth of water will be estimated at the central point of each quadrat area surveyed. This metric allows for interpretation of sampling conditions, such as, elevation of each quadrat area compared to other quadrat areas within a transect. Additionally, variation in tidal elevation at the time of sampling as compared to sampling in other years may be evaluated by the depth of water metric.

4.1.2 Percent Bare Ground

Percent bare ground is recorded as bare substrate that does not contain eelgrass, seaweed, living bivalves, or shell material.

4.1.3 Percent Shell

While the quadrat is still at the same sampling position, percent shell is recorded as the portion of each quadrat area that contains living bivalves or shell material on top of the surface sediment.

4.1.4 Percent Seaweed Cover

Seaweed cover within quadrat areas is visually estimated using laminated reference cards containing examples of percent cover categories. The quadrat is placed over each sampling point without disturbing the orientation of seaweeds or eelgrass. Seaweed taxa commonly encountered in the study area include, *Sargassum muticum* (Yendo) Fensholt, *Porphyra* spp. C. Agardh, *Polysiphonia* spp. Greville, and others.

4.1.5 Percent Eelgrass Cover

Eelgrass cover within 0.0625 m^2 quadrat areas is visually estimated using laminated reference cards containing examples of percent cover categories. The quadrat is placed over each sampling point without disturbing the orientation of eelgrass blades. It is possible to record a high percent cover within a quadrat area containing zero shoots if leaves from shoots originating outside the quadrat area lay within the survey quadrat area.

Percent cover is recorded as absolute percent cover. In some cases, the cumulative absolute cover could add up to over 100 percent. For example, if seaweed overlaps with eelgrass, then relative percent cover can be calculated by dividing the absolute percent cover for each variable by the cumulative absolute cover.

4.1.6 Shoot (Turion) Density

After recording percent cover, eelgrass turion density is counted by hand within the 0.0625-m^2 quadrat areas (Short et al., 2006). Data will be presented as shoots per m^2.

4.2 Sampling Design

4.2.1 Power Analysis

The CEMP defines a statistically significant reduction in eelgrass turion density as when "the mean turion density of the impact site is found to be statistically different (α=0.10 and β=0.10) from the density of a reference and at least 25 percent below the reference mean during two annual sampling events following implementation of an action" (NOAA, 2014).

To detect a statistically significant difference between changes in eelgrass shoot density, a power analysis (assuming that the data is normally distributed and allows for the use of a paired *t*-test) was performed to determine the minimum sample size needed to achieve a power of 0.9 given an alpha of 0.1. Average shoot density and standard deviations were calculated from SeagrassNet data during summer surveys in North Bay from 2007-2010 (Table 3).

Table 3
Power Analysis
Coast Seafoods Eelgrass Monitoring Plan

Number of Pairs	Effect Size d = # of standard deviations	Detectable Change In # Shoots (Effect Size * SD)	25% Reduction of Mean
6	-1.149067	-45.59497856	19.39
12	-0.9026754	-35.81815987	19.39
18	-0.6194674	-24.58046643	19.39
24	-0.5328939	-21.14522995	19.39
30	**-0.4747843**	**-18.83944102**	**19.39**
36	-0.4323229	-17.15457267	19.39
42	-0.3995113	-15.85260838	19.39
60	-0.3332061	-13.22161805	19.39

R syntax: pwr.t.test (n=12, power=0.9, sig.level=0.1, type=c (paired), alternative=c (less))
Mean Shoot Density= 77.56 shoots/m^2
Standard Deviation = 39.68
One-tailed, paired t-test
Significance Level=0.10 (alpha)
Power=0.9 (1-beta)

The alpha and beta statistical criteria will have been met for the given dataset when the detectable change in shoot density is 25 percent lower than the mean. The power analysis results (based on existing SeagrassNet data) indicate 30 replicates in a paired *t*-test will be necessary to detect a statistically significant difference at the required 25% CEMP threshold, given an alpha of 0.1 and a beta of 0.1 (Table 3).

4.2.2 Experimental Design

The experimental design is composed of three nested plots within a blocked configuration. Blocks will be replicated 30 times throughout the expansion areas. Two treatment plot categories (cultch-on-longline and basket-on-longline) will be nested within a block along with a control plot (Figure 7).

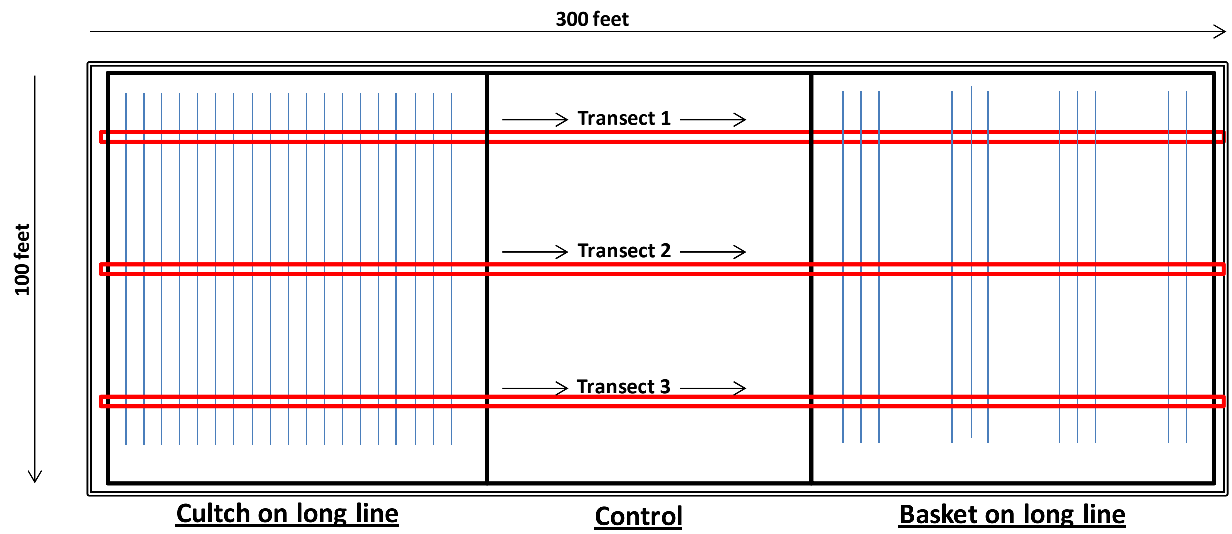


Figure 7. Example of blocked sampling design containing three square plots and three horizontal transects (in red).

Plots will be composed of two treatment plots (cultch-on-longline and basket-on-longline) and a control. Cultch-on-longline plots will contain lines spaced 5 feet apart; control plots contain no lines; and basket-on-longline plots will contain three lines spaced 5 feet apart with 20-foot gaps between groups of three lines.

Note: The project will be implemented using imperial units (feet); therefore, relevant portions of this monitoring plan are presented in imperial units rather than metric units.

Blocks will be 300 feet wide and 100 feet long (or 0.7 acres). Each of the three plots (2 treatment plots and a control) within a block will be 100 feet long and 100 feet wide. Plot and transect positions will be randomized for each block (Table 4). The positions of plots will be randomized from west to east for each replicate block. Transects across blocks will also be randomized and occur within three sections (0-33, 34-66, and 67-100 feet) along the 100-foot axis of the block going from north to south. The 300-foot survey transects will go from west to east, where the western edge of the block is at zero (0) feet and the eastern edge of the block is at 300 feet.

Table 4 Randomized Plot and Transect Positions Within Blocks Coast Seafoods Eelgrass Monitoring Plan				
Block#	**Plot Orientation (West to East)**	**Transect 1 (feet)**	**Transect 2 (feet)**	**Transect 3 (feet)**
0	Basket, Control, Cultch	7	65	77
1	Basket, Control, Cultch	21	61	90
2	Basket, Control, Cultch	11	59	91
3	Cultch, Control, Basket	10	43	71
4	Control, Cultch, Basket	6	62	86
5	Basket, Control, Cultch	19	41	93
6	Cultch, Basket, Control	1	45	72
7	Basket, Control, Cultch	26	46	93
8	Cultch, Basket, Control	13	55	73
9	Basket, Control, Cultch	18	47	86
10	Cultch, Control, Basket	21	39	96
11	Basket, Cultch, Control	9	37	84
12	Basket, Cultch, Control	30	46	73
13	Control, Basket, Cultch	17	41	99
14	Basket, Control, Cultch	25	64	86
15	Control, Cultch, Basket	29	60	91
16	Cultch, Basket, Control	31	37	95
17	Cultch, Basket, Control	8	59	98
18	Basket, Control, Cultch	9	54	74
19	Cultch, Basket, Control	13	56	92
20	Basket, Cultch, Control	15	43	78
21	Basket, Cultch, Control	24	45	73
22	Cultch, Control, Basket	4	63	76
23	Cultch, Control, Basket	27	51	68
24	Control, Cultch, Basket	11	59	71
25	Basket, Cultch, Control	5	66	92
26	Cultch, Control, Basket	4	40	72
27	Control, Cultch, Basket	12	56	93
28	Cultch, Basket, Control	15	53	79
29	Cultch, Control, Basket	11	36	79

4.2.3 Sampling within Plots

Quadrat sampling along the three survey transects within plots will be stratified by locations under lines, next to lines, and between lines. Quadrats will be placed on the north side of survey transects. The quadrat will be placed so that the quadrat side touching the survey transect is centered on the randomly-selected transect position being surveyed (e.g., 0 meters, 2 meters) (Figure 8). Block 1 data sheets are presented as examples in Appendix A.

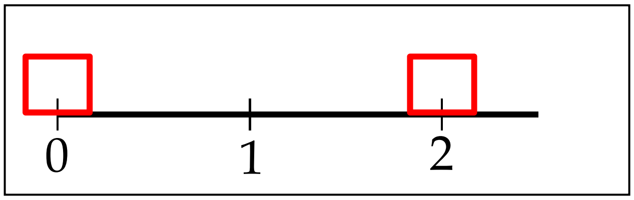


Figure 8. Quadrat placement (in red) on survey transects where hypothetical random quadrat locations are at 0 and 2 feet on the survey transect.

4.2.3.1 Cultch-on-Longline

In cutch-on-longline treatments, there will be three possible 0.0625-m^2 quadrat position categories (#1-3 identified in Figure 9):

1) under the line,
2) next to the line, and
3) centered 2.5 ft from a line.

There will be 20 lines spaced 5 feet apart within a 100-foot wide area (that is, sample plot). Therefore, each of the three possible quadrat position categories will be sampled twice in random locations per transect per plot (Table 5), totaling 6 quadrat areas per transect within plots and 18 total per plot.

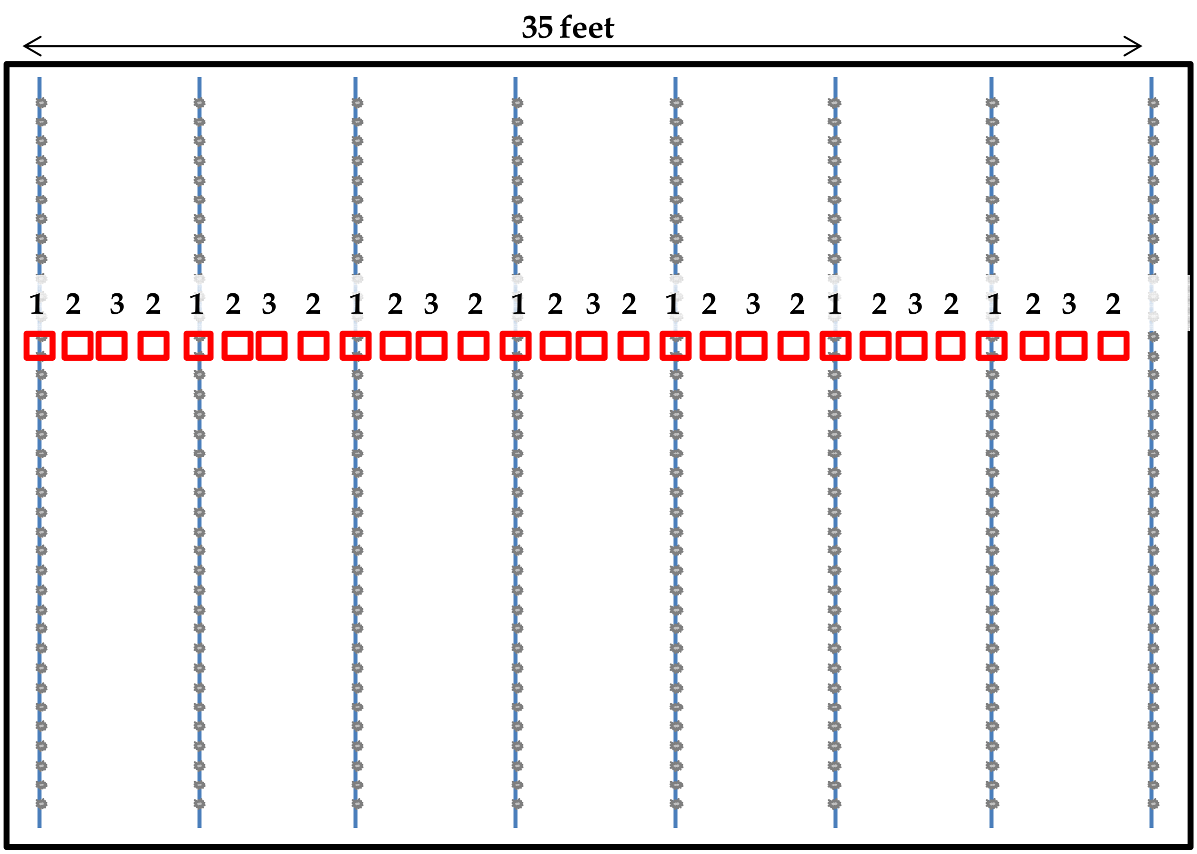


Figure 9. Example of quadrat position categories in cultch-on-longline plots.

Table 5[3] Cultch-On-Longline Plots–Quadrat Positions and Categories Coast Seafoods Eelgrass Monitoring Plan		
Quadrat Position	**Transect Location (feet)**	**Transect Location (meters)**
1	0	0
2	1.25	0.381
3	2.5	0.762
2	3.75	1.143
1	5	1.524
2	6.25	1.905
3	7.5	2.286
2	8.75	2.667
1	10	3.048
2	11.25	3.429
3	12.5	3.81
2	13.75	4.191
1	15	4.572
2	16.25	4.953
3	17.5	5.334
2	18.75	5.715
1	20	6.096
2	21.25	6.477
3	22.5	6.858
2	23.75	7.239
1	25	7.62
2	26.25	8.001
3	27.5	8.382
2	28.75	8.763
1	30	9.144
2	31.25	9.525
3	32.5	9.906
2	33.75	10.287
1	35	10.668
2	36.25	11.049
3	37.5	11.43
2	38.75	11.811
1	40	12.192
2	41.25	12.573
3	42.5	12.954
2	43.75	13.335
1	45	13.716
2	46.25	14.097

[3] Two quadrat locations per position category will be randomly selected from Table 5, where quadrat position 1 is under lines, 2 is next to lines, and 3 is between lines. (Note: plots are 100 feet wide.)

Table 5[3] Cultch-On-Longline Plots–Quadrat Positions and Categories Coast Seafoods Eelgrass Monitoring Plan		
Quadrat Position	**Transect Location (feet)**	**Transect Location (meters)**
3	47.5	14.478
2	48.75	14.859
1	50	15.24
2	51.25	15.621
3	52.5	16.002
2	53.75	16.383
1	55	16.764
2	56.25	17.145
3	57.5	17.526
2	58.75	17.907
1	60	18.288
2	61.25	18.669
3	62.5	19.05
2	63.75	19.431
1	65	19.812
2	66.25	20.193
3	67.5	20.574
2	68.75	20.955
1	70	21.336
2	71.25	21.717
3	72.5	22.098
2	73.75	22.479
1	75	22.86
2	76.25	23.241
3	77.5	23.622
2	78.75	24.003
1	80	24.384
2	81.25	24.765
3	82.5	25.146
2	83.75	25.527
1	85	25.908
2	86.25	26.289
3	87.5	26.67
2	88.75	27.051
1	90	27.432
2	91.25	27.813
3	92.5	28.194
2	93.75	28.575
1	95	28.956

4.2.3.2 Basket-on-Longline

In basket-on-longline treatments, there will be four possible 0.0625-m² quadrat position categories (#1-4 identified in Figure 10):

1) under the line,
2) next to the line,
3) 5 feet from the closest line in 20-foot gaps, and
4) 10 feet from the closest line in 20-foot gaps.

Within a 100-foot wide area (same sample plot) there will be groups of 3 lines spaced 5 feet apart with 20-foot gaps between groups lines (see Figure 10, below). Therefore, each of the four possible quadrat positions will be sampled twice in random locations per transect (Table 6), totaling 8 quadrat areas per transect and 24 per plot.

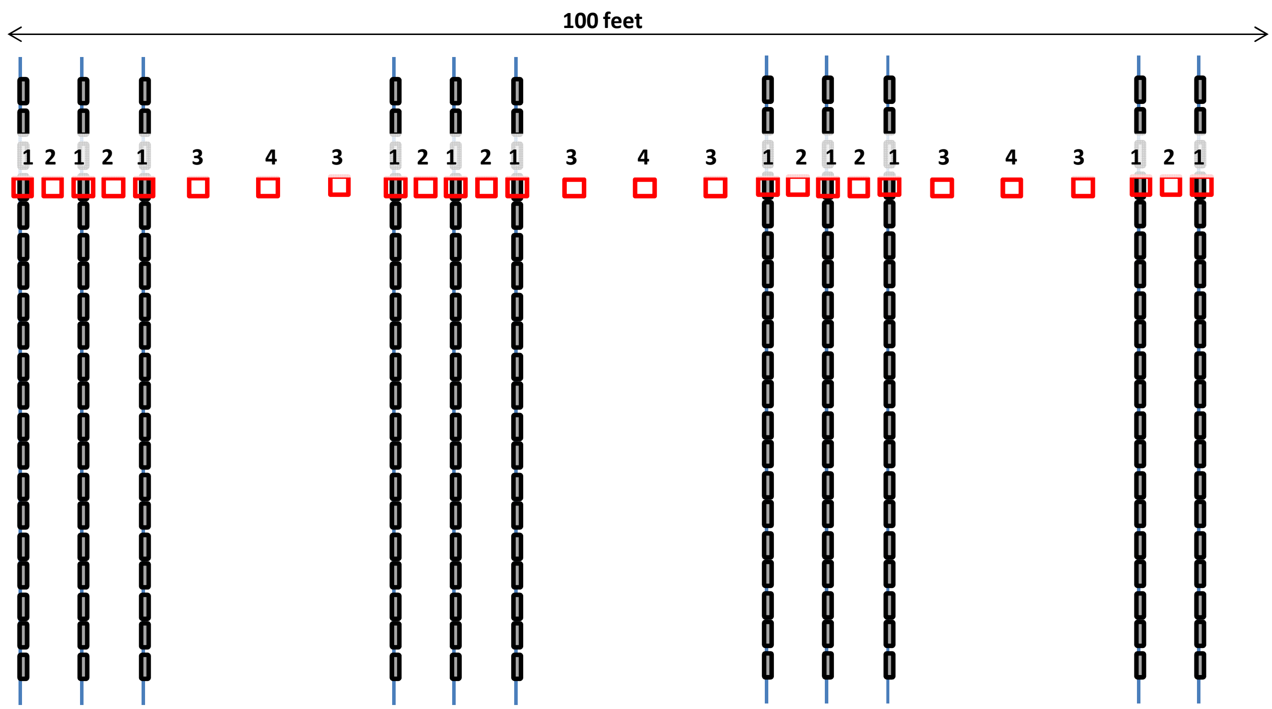


Figure 10. Example of quadrat position categories in basket-on-longline plots.

Table 6[4] Basket-On-Longline Plots–Quadrat Positions and Categories Coast Seafoods Eelgrass Monitoring Plan		
Quadrat Position	**Transect Location (feet)**	**Transect Location (meters)**
1	0	0
2	2.5	0.762
1	5	1.524
2	7.5	2.286
1	10	3.048
3	15	4.572
4	20	6.096
3	25	7.62
1	30	9.144
2	32.5	9.906
1	35	10.668
2	37.5	11.43
1	40	12.192
3	45	13.716
4	50	15.24
3	55	16.764
1	60	18.288
2	62.5	19.05
1	65	19.812
2	67.5	20.574
1	70	21.336
3	75	22.86
4	80	24.384
3	85	25.908
1	90	27.432
2	92.5	28.194
1	95	28.956

4.2.4 Control

Because the control plots will not have longlines, the quadrat position spacing for cultch-on-longline plots will be used within control plots without designations pertaining to positions under, next to, or between lines.

[4]Two quadrat locations per position category will be selected from Table 6, where quadrat position 1 is under lines, 2 is between lines spaced 5 feet apart, 3 is next to lines spaced 20 feet apart, and 4 is between lines spaced 20 feet apart.

4.2.5 Stratification and Randomization of Block Locations

Block locations will be randomized throughout the expansion areas after stratifying by elevation, sediment type, and area (Table 7).[5]

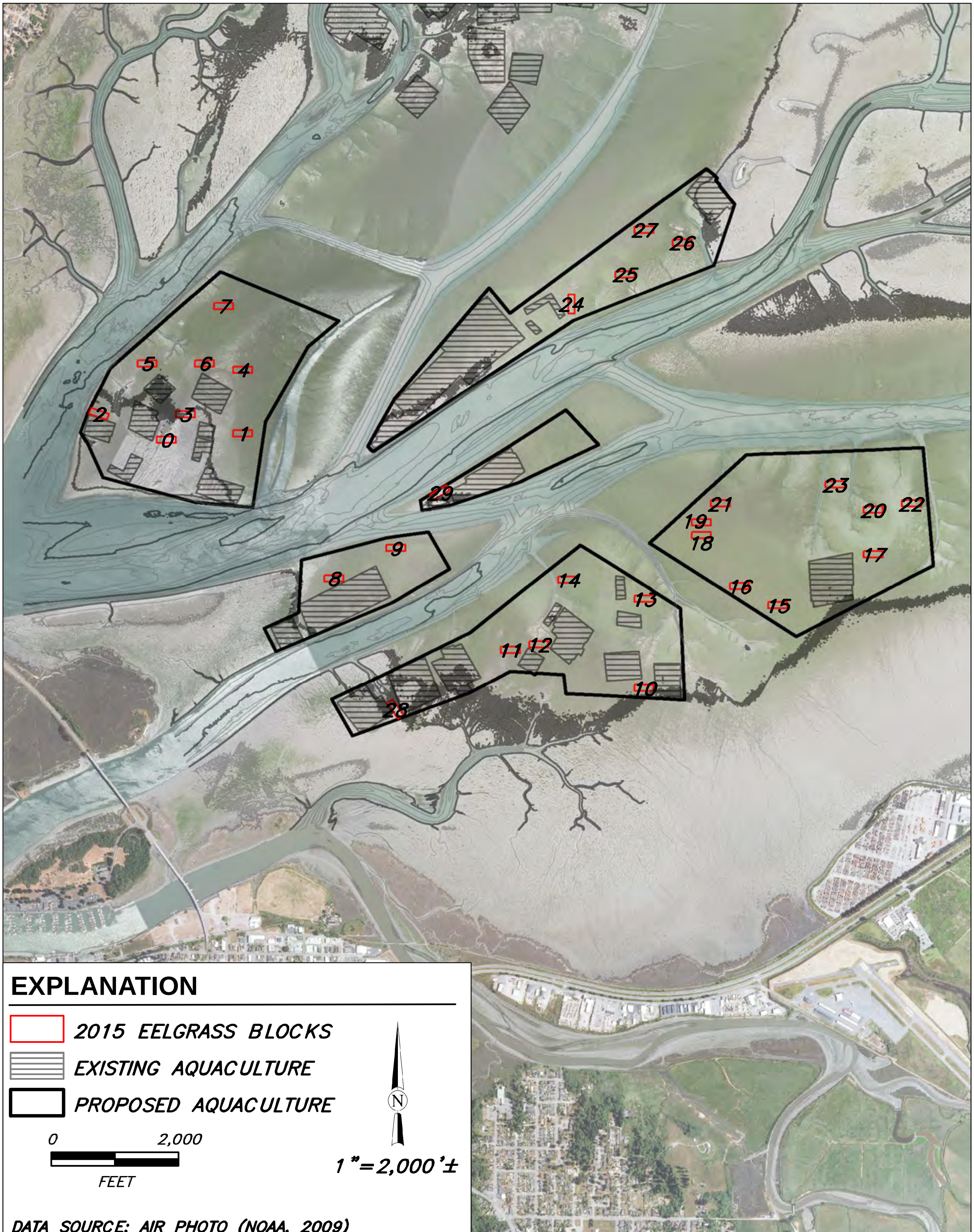
Table 7
Stratification of Blocks
Coast Seafoods Eelgrass Monitoring Plan

Category	Metric	Percent of Category	Percent Times 30 Blocks	# Blocks per Category
Expansion Area	Area 1	27.6	8.3	8
	Area 2	6.1	1.8	2
	Area 3	18.3	5.5	6
	Area 4	13.8	4.1	4
	Area 5	3.5	1.0	1
	Area 6	30.7	9.2	9
Elevation Range (m MLLW)[1,2]	0.3 to 0.38	0.0	0.0	0
	0.23 to 0.3	0.2	0.1	0
	0.15 to 0.23	0.9	0.3	0
	0.08 to 0.15	1.9	0.6	1
	0 to 0.08	6.2	1.9	2
	-0.08 to 0	24.9	7.5	8
	-0.15 to -0.08	62.0	18.6	18
	-0.23 to -0.15	3.7	1.1	1
	-1.07 to -0.23	0.1	0.0	0
Sediment Type	Very Clayey Silt	3.1	0.9	1
	Clayey Silt	34.8	10.4	10
	Sand Silt Clay	52.3	15.7	16
	Silty Sand	3.4	1.0	1
	Sand	6.3	1.9	2

1. m: meters
2. MLLW: mean lower low water

Thirty block locations (block numbers 0-29) were randomized within the expansion areas by elevation, sediment type, and percent contribution to total expansion footprint area (Figure 11). Using geographic information system (GIS) software, the expansion area region was overlaid with a grid of 300- by 100-foot cells, resulting in 1,348 possible block locations. Selection of the 30 sampling block locations began by creating a randomized list of numbers within the range of 1 though 1,348. Random numbers were assessed stepwise in the sequence they were created in order

[5] See footnote, 2, above. Some of the selected block locations are located outside of the revised boundaries of Coast's Harbor District lease and the current proposed expansion areas (see Figure 11a, Appendix C). Prior to release of the draft EIR in September 2015, the selection criteria described herein will be used to reallocate sampling block locations within the revised expansion areas, and this monitoring report will be updated accordingly. The maps included as Appendix C depict the current status of Coast's lease area and proposed expansion areas.



Path: \\zing\projects\2015\015063-CoastSeafoods\GIS\PROJ_MXD\Report_MXDs\Final_20150812\Figure11_StudyBlocks.mxd

SHN Consulting Engineers & Geologists, Inc.	Plauche & Carr LLP. Eelgrass Monitoring Plan Eureka, California	Site Map Showing Eelgrass Study Blocks and Existing and Expansion Areas SHN 015063	
	July 2015	Figure11_StudyBlocks	Figure 11

to fill the allocated number of blocks per category. If a number in the selection process occurred in a category that was already filled, that number was discarded and the next number was evaluated to fill a category. If the majority of a randomly selected block location was out of the expansion area or overlapping with existing aquaculture, that block was also discarded. In a few instances, where obstructions such as minor sloughs or other edge effects occurred, randomly selected block locations were adjusted to the closest possible configuration. Detailed block locations are shown in Appendix B.[6]

4.3 Statistical Analysis[7]

Summary statistics for percent eelgrass cover and shoot density within plots will include the average, standard deviation, and sample size. After completion of the second year of surveying post impact, a paired *t*-test will be run comparing the average shoot density per plot before impact and after impact, after adjusting before impact data if there are reductions in shoot density in the control plots (NOAA, 2014). If the data does not appear to be normally distributed, then other statistical methods will be used (for example, multivariate) to analyze the data.

Shoot densities will be averaged within plots by quadrat position. Cultch-on-longline and control plots will have quadrat position representation areas equally spaced along transects. Therefore, this data represents an equal proportion of area surveyed. Variable quadrat position representation area spacing in the basket-on-longline plots will require that quadrat positions be weighted by their contribution to the total area within the survey area (Table 8). For basket-on-longline plots, quadrat positions 1 and 2 represent a 0.76-m by 0.25-m area (0.19 m^2). The 0.76-m value was derived by splitting the difference between the mid-points of adjacent quadrat positions; the 0.25-m value is the length of the quadrat area. Position 3 represents a 1.91-m by 0.25-m area (0.48 m^2) where 1.91 m was derived as the width between the end of the area represented by position 2 and the mid-point between positions 3 and 4. Finally, position 4 represents a 1.52-m by 0.25-m area (0.38 m^2;); 1.52 m was derived as the width between position 4 and the position 3 on each side.

Table 8
Weighting Coefficients for Basket-on-Longline Quadrat Positions
Coast Seafoods Eelgrass Monitoring Plan

Quadrat Position #	1	2	3	4
Number of Positions per Transect	11	7	6	3
Position Representation Area (m^2)[1]	0.19	0.19	0.48	0.38
Total Transect Area (m^2)	7.43	7.43	7.43	7.43
Total Area of Quadrat Position per Transect (m^2)	2.10	1.33	2.86	1.14
Weighting Coefficient (Fraction of Grand Total)	0.28	0.18	0.38	0.15
1. m^2: square meters				

[6] The maps included as Appendix B have not been updated to reflect the revisions to the proposed expansion areas. These maps will be updated prior to inclusion in the draft EIR.
[7] The design of this monitoring report's statistical analysis is undergoing peer review and may be revised prior to publication of the draft EIR in September 2015.

4.4 Survey Logistics and Schedule

Blocks will be located by global positioning system (GPS) coordinates of block corners. Half-inch polyvinyl chloride (PVC) pipe, approximately 1.5 m long, will be used to mark block corners. Transect tapes measuring 100 feet in length will be deployed from the northern block corners to the southern block corners, so that the north end is at zero (0) feet and the south end is 100 feet. After the 100-foot transect tapes are in place, 300-foot survey transect tapes will be deployed from west to east at the randomly chosen transect locations, so that the west side is at zero (0) feet and the east side is 300 feet. The northwest block corner is the 0,0 location that serves as an anchor point from which all other location adjustments are based after locating GPS block corner locations.

Each block will be surveyed by a team of six people. Each plot within a block will be surveyed by two people, where one person records data on datasheets and the other person calls out the data to the scribe. Impacts to soft sediment and eelgrass will be minimized by the use of boogie boards as surfaces on which the surveyors stand and kneel.

Sampling will occur on tides predicted to be -0.3 m MLLW or lower during the active growth period for eelgrass in northern California (May-September) (NOAA, 2014) during the years of 2015, 2016, 2017, and 2018.

5.0 Spatial Distribution and Areal Extent of Eelgrass

In compliance with the CEMP, this monitoring plan proposes the use of aerial photography to determine the pre- and post-project areal extent and spatial distribution of eelgrass habitat within the project vicinity. The CEMP defines an eelgrass habitat as “areas of vegetated eelgrass cover (any eelgrass within 1 m of another shoot) bounded by a 5 m wide perimeter of unvegetated area.” Therefore, under the CEMP, if there is a reduction in the areal extent (i.e., acreage) of eelgrass habitat that results in a greater than 1-m gap it is considered a significant impact. Areal extent of eelgrass habitat is defined as the quantitative area of the spatial distribution, categorized as vegetated cover or unvegetated habitat.

The most recent complete dataset for eelgrass distribution in North Bay was mapped using camera imagery from airplane flyovers (NOAA, 2009). Because high-quality aerial imagery requires minimum sun angles, clear weather and low tides, there were substantial logistical difficulties in obtaining this imagery. The only tides low enough (-0.3 m or lower) to reveal the full extent of eelgrass beds in Humboldt Bay during daylight hours occur in the early mornings between May and August each year. These months coincide with weather conditions that make aerial photography difficult, particularly heavy morning fog when the tide is at its lowest. As a result, it took NOAA three years of attempted flyovers before there was one day when all of the following logistics lined up: a tide of -0.3 m or lower; sky clear from clouds, fog, or haze; a sun angle of 30° or higher; and winds of 10 miles per hour (mph) or less.

This monitoring plan recognizes the challenges in mapping eelgrass spatial distribution within the 622 acres of expanded aquaculture. Therefore, this plan recommends a flexible approach in assessing the spatial distribution of eelgrass within the expansion areas. In order to obtain visible light and/or infrared spectrum images during the eelgrass active growth season during the years 2016 (pre-project) and 2017-18 (two years post-project), this plan recommends using either: 1) an airplane with pilot and photographer flown at an approximately 500-m elevation: or 2) a remote controlled airplane/drone flown at an approximately 120-m elevation. The most appropriate method of aerial photography will be selected on any given day based on the status of the above variables.

5.1 Manned Airplane Imagery Collection

Imagery from the manned airplane would be combined to create one large composite image of the expansion area vicinity within North Bay. Attempts to orthorectify and georeference the dataset will be made pending the outcome of composite image.

5.2 Remote Controlled Airplane/Drone Imagery Collection

Imagery from the remote controlled airplane/drone would be acquired from a camera mounted to the aircraft. All images will contain location coordinates and be post-processed to create one composite image that is orthorectified and georeferenced.

5.3 Mapping Spatial Distribution

Spatial distribution will be mapped at a resolution to be determined by the outcome of composite imagery. The 2009 NOAA imagery contains 0.5- x 0.5-m pixels and is the highest resolution imagery publically available for Humboldt Bay. This monitoring plan anticipates a mapping resolution equal to or better than the 2009 NOAA imagery and anticipates that the composite image of the expansion area vicinity will be orthorectified and georeferenced, allowing GIS mapping of vegetated cover and unvegetated habitat. The resolution of this mapping effort will be determined by the resolution of the images obtained.

5.4 Calculating Areal Extent

Areal extent of vegetated cover and unvegetated habitat will be calculated from the spatial distribution map using GIS software.

5.4 Evaluating Project-Induced Changes in Areal Extent

The areal extent of eelgrass within the expansion areas after two years of full project implementation (2018) will be compared to pre-project (2016) conditions. In coordination with regulatory agencies, reference sites outside the influence of aquaculture activities will be selected within the vicinity of the expansion areas and within the area of imagery collected. These reference sites will be used to characterize natural fluctuations in eelgrass areal extent to which potential aquaculture induced impacts can be compared.

6.0 References

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A

Example Data Sheets

Coast Seafoods Eelgrass Monitoring
SHN #: 015063

Date:		General loaction: Block #: 1			Plot: Basket		begin/end times:			surveyors:
transect location (ft)	quadrat #	quad position	quadrat location (ft)	depth of water (cm)	% bare ground	% shell	% cover seaweed	% cover ZM	ZM shoot density (0.0625m^2)	other notes (grazing, epiphytes, ect)
21	1	2	2.5							
	2	1	5							
	3	2	7.5							
	4	3	25							
	5	3	45							
	6	4	50							
	7	1	60							
	8	4	80							
61	1	2	7.5							
	2	4	20							
	3	1	30							
	4	1	40							
	5	4	50							
	6	2	62.5							
	7	3	75							
	8	3	85							
90	1	2	7.5							
	2	3	15							
	3	4	20							
	4	1	60							
	5	1	65							
	6	2	67.5							
	7	4	80							
	8	3	85							

Block west to east: Basket, Control, Cultch
Notes:

Coast Seafoods Eelgrass Monitoring
SHN #: 015063

Date:		General loaction: Block #: 1			Plot: Control		begin/end times:			surveyors:
transect location (ft)	quadrat #	quad position	quadrat location (ft)	depth of water (cm)	% bare ground	% shell	% cover seaweed	% cover ZM	ZM shoot density (0.0625m²)	other notes (grazing, epiphytes, ect)
21	1	3	102.5							
	2	2	111.25							
	3	1	120							
	4	1	145							
	5	3	182.5							
	6	2	191.25							
61	1	2	113.75							
	2	3	132.5							
	3	1	135							
	4	2	148.75							
	5	1	150							
	6	3	162.5							
90	1	1	105							
	2	2	116.25							
	3	1	140							
	4	3	142.5							
	5	3	167.5							
	6	2	193.75							

Block west to east: Basket, Control, Cultch
Notes:

Coast Seafoods Eelgrass Monitoring
SHN #: 015063

Date:		General loaction: Block #: 1			Plot: Cultch		begin/end times:			surveyors:
transect location (ft)	quadrat #	quad position	quadrat location (ft)	depth of water (cm)	% bare ground	% shell	% cover seaweed	% cover ZM	ZM shoot density (0.0625m^2)	other notes (grazing, epiphytes, ect)
21	1	1	205							
	2	3	212.5							
	3	1	215							
	4	2	241.25							
	5	2	253.75							
	6	3	292.5							
61	1	1	225							
	2	2	228.75							
	3	3	232.5							
	4	2	236.25							
	5	3	257.5							
	6	1	270							
90	1	2	223.75							
	2	1	240							
	3	3	257.5							
	4	3	272.5							
	5	2	273.75							
	6	1	275							

Block west to east: Basket, Control, Cultch
Notes:

B

Block Locations By Area

EXPLANATION

2015 EELGRASS BLOCKS
EXISTING AQUACULTURE
PROPOSED AQUACULTURE

0 600
FEET

ELEVATION (FEET)

- −3.75 TO −0.75
- −0.75 TO −0.5
- −0.5 TO −0.25
- −0.25 TO 0
- 0 TO 0.25
- 0.25 TO 0.5
- 0.5 TO 0.75
- 0.75 TO 1
- 1 TO 1.25

N
1"=600'±

DATA SOURCE: ELEVATION DATA (GILKERSON, 2014)

Path: \\zing\projects\2015\015063-CoastSeafoods\GIS\PROJ_MXD\Report_MXDs\Final_20150812\FigureB1a_Area1_Elevation.mxd

SHN Consulting Engineers & Geologists, Inc.	Plauche & Carr LLP. Eelgrass Monitoring Plan Eureka, California	Site Map Showing Area 1-Bird Island Elevation Ranges SHN 015063
	July 2015 / FigureB1a_Area1_Elevation	Figure B-1a

EXPLANATION

2015 EELGRASS BLOCKS
EXISTING AQUACULTURE
PROPOSED AQUACULTURE

SEDIMENT TYPE
CLAYEY SILT
SAND–SILT–CLAY
SILTY SAND
SAND

N
1"=600'±
0 600
FEET

DATA SOURCE: SEDIMENT TYPES (HUMBOLDT BAY HARBOR, RECREATION AND CONSERVATION DISTRICT, 2001)

Path: \\zing\projects\2015\015063-CoastSeafoods\GIS\PROJ_MXD\Report_MXDs\Final_20150812\FigureB1b_Area1_SedType.mxd

SHN Consulting Engineers & Geologists, Inc.	Plauche & Carr LLP. Eelgrass Monitoring Plan Eureka, California	Site Map Showing Area 1-Bird Island Sediment Types SHN 015063
	July 2015 | FigureB1b_Area1_SedType	Figure B-1b

EXPLANATION

2015 EELGRASS BLOCKS
EXISTING AQUACULTURE
PROPOSED AQUACULTURE

0 400
FEET

ELEVATION (FEET)
-0.75 TO -0.5
-0.5 TO -0.25
-0.25 TO 0
0 TO 0.25
0.25 TO 0.5

N

DATA SOURCE: ELEVATION DATA (GILKERSON, 2014)

1"=400'±

Path: \\zing\projects\2015\015063-CoastSeafoods\GIS\PROJ_MXD\Report_MXDs\Final_20150812\FigureB2a_Area2_Elevation.mxd

SHN Consulting Engineers & Geologists, Inc.

Plauche & Carr LLP.
Eelgrass Monitoring Plan
Eureka, California

Site Map Showing Area 2-Indian Island
Elevation Ranges
SHN 015063

July 2015 | FigureB2a_Area2_Elevation | Figure B-2a

EXPLANATION

2015 EELGRASS BLOCKS
EXISTING AQUACULTURE
PROPOSED AQUACULTURE

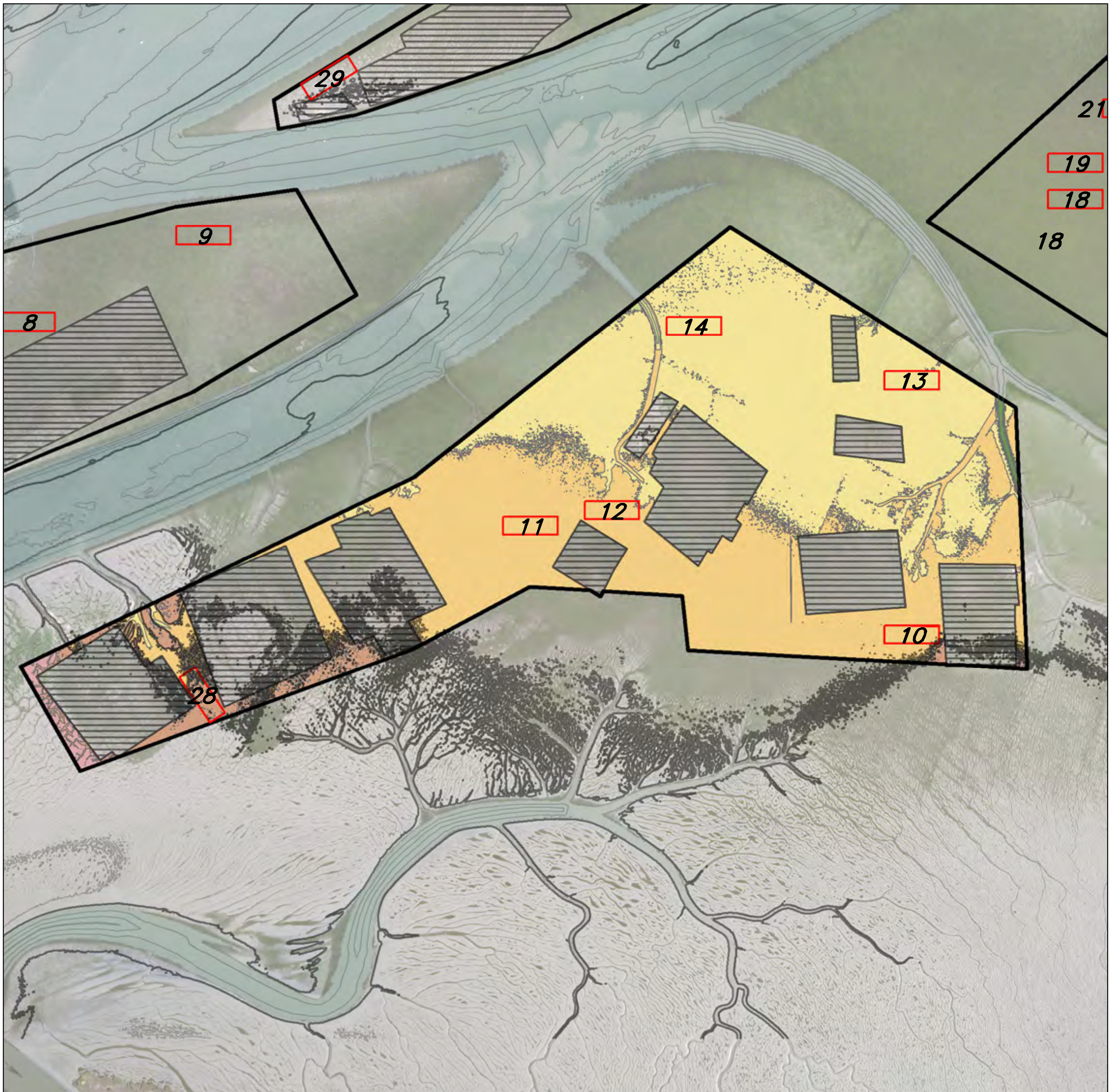
SEDIMENT TYPE
CLAYEY SILT
SAND–SILT–CLAY
SILTY SAND

N
1"=400'±
0 400
FEET

DATA SOURCE: SEDIMENT TYPES (HUMBOLDT BAY HARBOR, RECREATION AND CONSERVATION DISTRICT, 2001)

Path: \\zing\projects\2015\015063-CoastSeafoods\GIS\PROJ_MXD\Report_MXDs\Final_20150812\FigureB2b_Area2_SedType.mxd

SHN Consulting Engineers & Geologists, Inc.	Plauche & Carr LLP. Eelgrass Monitoring Plan Eureka, California	Site Map Showing Area 2-Indian Island Sediment Types SHN 015063
July 2015	FigureB2b_Area2_SedType	Figure B-2b



EXPLANATION

2015 EELGRASS BLOCKS
EXISTING AQUACULTURE
PROPOSED AQUACULTURE

0 800
FEET

ELEVATION (FEET)
−3.75 TO −0.75
−0.75 TO −0.5
−0.5 TO −0.25
−0.25 TO 0
0 TO 0.25
0.25 TO 0.5
0.5 TO 0.75

N

1"=800'±

DATA SOURCE: ELEVATION DATA (GILKERSON, 2014)

Path: \\zing\projects\2015\015063-CoastSeafoods\GIS\PROJ_MXD\Report_MXDs\Final_20150812\FigureB3a_Area3_Elevation.mxd

SHN Consulting Engineers & Geologists, Inc.	Plauche & Carr LLP. Eelgrass Monitoring Plan Eureka, California		Site Map Showing Area 3-East Bay 1 Elevation Ranges SHN 015063
	July 2015	FigureB3a_Area3_Elevation	Figure B-3a

EXPLANATION

2015 EELGRASS BLOCKS
EXISTING AQUACULTURE
PROPOSED AQUACULTURE

SEDIMENT TYPE
VERY CLAYEY SILT
CLAYEY SILT
SAND-SILT-CLAY
SILTY SAND

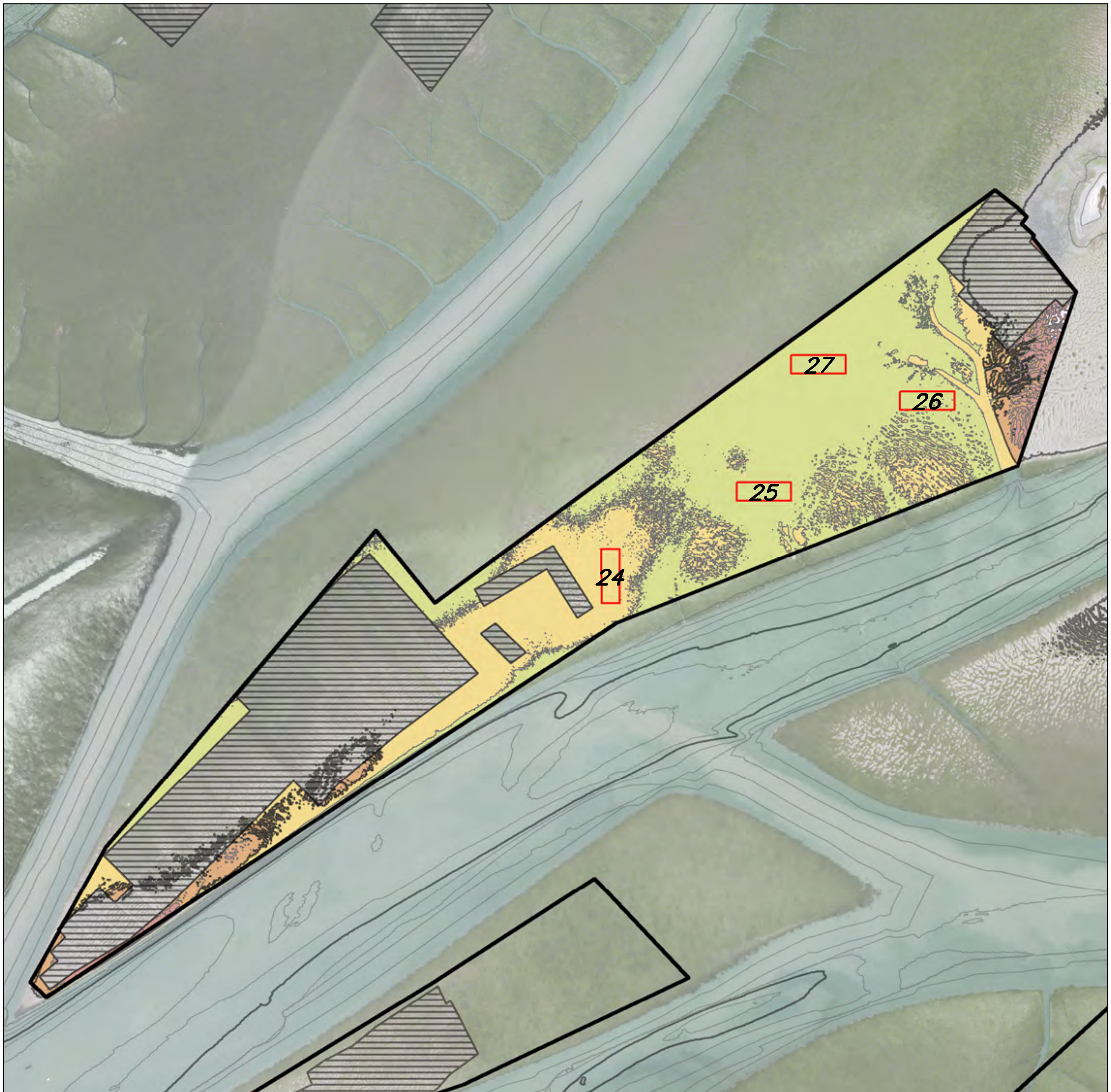
N
1"=800'±
0 800
FEET

DATA SOURCE: SEDIMENT TYPES (HUMBOLDT BAY HARBOR, RECREATION AND CONSERVATION DISTRICT, 2001)

Path: \\zing\projects\2015\015063-CoastSeafoods\GIS\PROJ_MXD\Report_MXDs\Final_20150812\FigureB3b_Area3_SedType.mxd

SHN Consulting Engineers & Geologists, Inc.

Plauche & Carr LLP. Eelgrass Monitoring Plan Eureka, California	Site Map Showing Area 3-East Bay 1 Sediment Types SHN 015063	
July 2015	FigureB3b_Area3_SedType	Figure B-3b



EXPLANATION

2015 EELGRASS BLOCKS
EXISTING AQUACULTURE
PROPOSED AQUACULTURE

0 800
FEET

ELEVATION (FEET)
−0.75 TO −0.5
−0.5 TO −0.25
−0.25 TO 0
0 TO 0.25
0.25 TO 0.5
0.5 TO 0.75

N

DATA SOURCE: ELEVATION DATA (GILKERSON, 2014)

1"=800'±

Path: \\zing\projects\2015\015063-CoastSeafoods\GIS\PROJ_MXD\Report_MXDs\Final_20150812\FigureB4a_Area4_Elevation.mxd

SHN Consulting Engineers & Geologists, Inc.

Plauche & Carr LLP.
Eelgrass Monitoring Plan
Eureka, California

Site Map Showing Area 4-Sand Island
Elevation Ranges
SHN 015063

July 2015 | FigureB4a_Area4_Elevation | Figure B-4a

EXPLANATION

2015 EELGRASS BLOCKS
EXISTING AQUACULTURE
PROPOSED AQUACULTURE

SEDIMENT TYPE
CLAYEY SILT
SAND-SILT-CLAY
SILTY SAND

N

1"=800'±
0 800
FEET

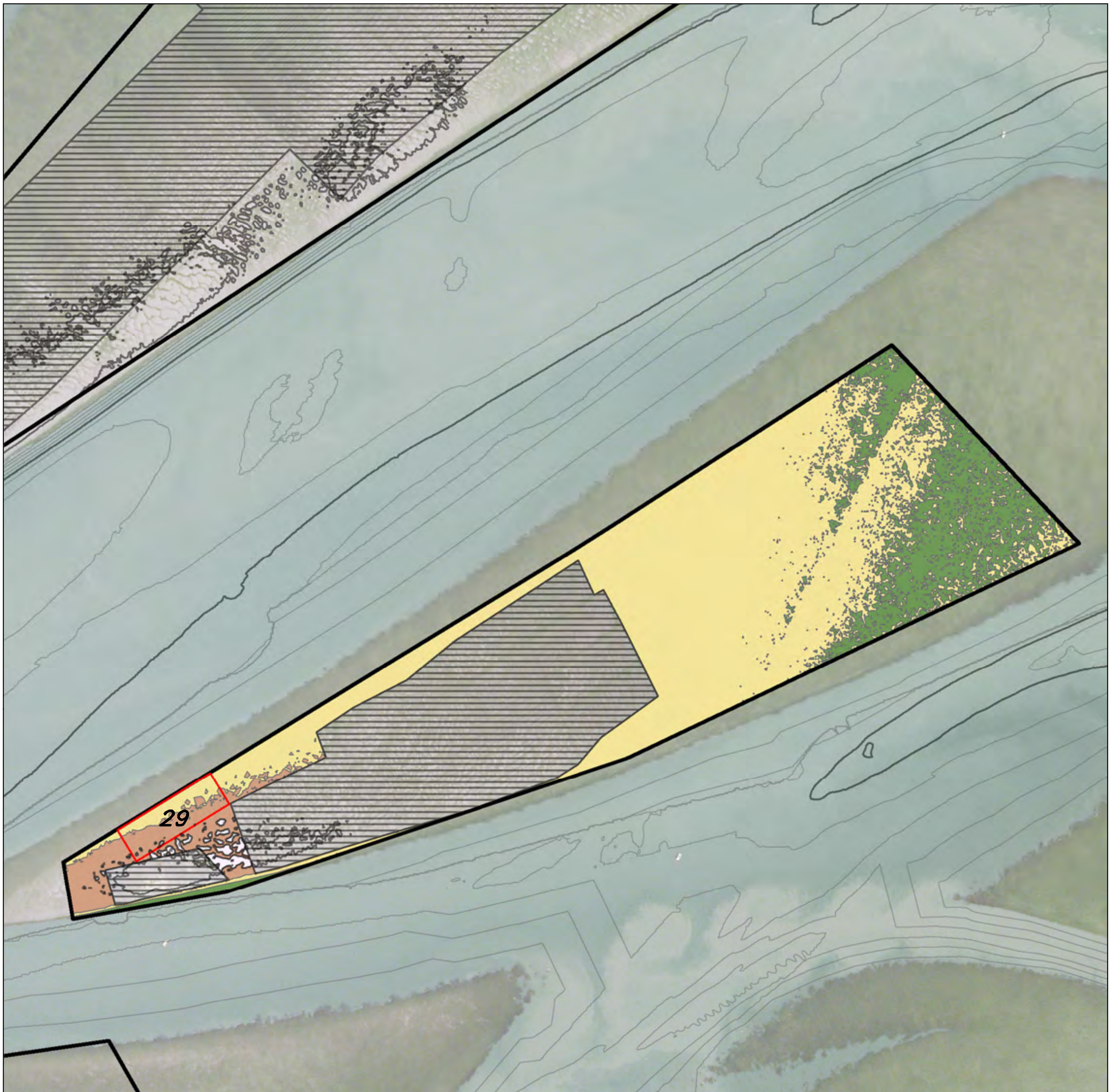
DATA SOURCE: SEDIMENT TYPES (HUMBOLDT BAY HARBOR, RECREATION AND CONSERVATION DISTRICT, 2001)

SHN Consulting Engineers & Geologists, Inc.

Plauche & Carr LLP.
Eelgrass Monitoring Plan
Eureka, California

Site Map Showing Area 4-Sand Island Sediment Types
SHN 015063

July 2015 | FigureB4b_Area4_SedType | Figure B-4b



EXPLANATION

- 2015 EELGRASS BLOCKS
- EXISTING AQUACULTURE
- PROPOSED AQUACULTURE

0 400
FEET

ELEVATION (FEET)

- -0.75 TO -0.5
- -0.5 TO -0.25
- -0.25 TO 0
- 0 TO 0.25

N

DATA SOURCE: ELEVATION DATA (GILKERSON, 2014)

1"=400'±

Path: \\zing\projects\2015\015063-CoastSeafoods\GIS\PROJ_MXD\Report_MXDs\Final_20150812\FigureB5a_Area5_Elevation.mxd

SHN Consulting Engineers & Geologists, Inc.	Plauche & Carr LLP. Eelgrass Monitoring Plan Eureka, California	Site Map Showing Area 5-Arcata Channel Elevation Ranges SHN 015063	
	July 2015	FigureB5a_Area5_Elevation	Figure B-5a

EXPLANATION

- 2015 EELGRASS BLOCKS
- EXISTING AQUACULTURE
- PROPOSED AQUACULTURE

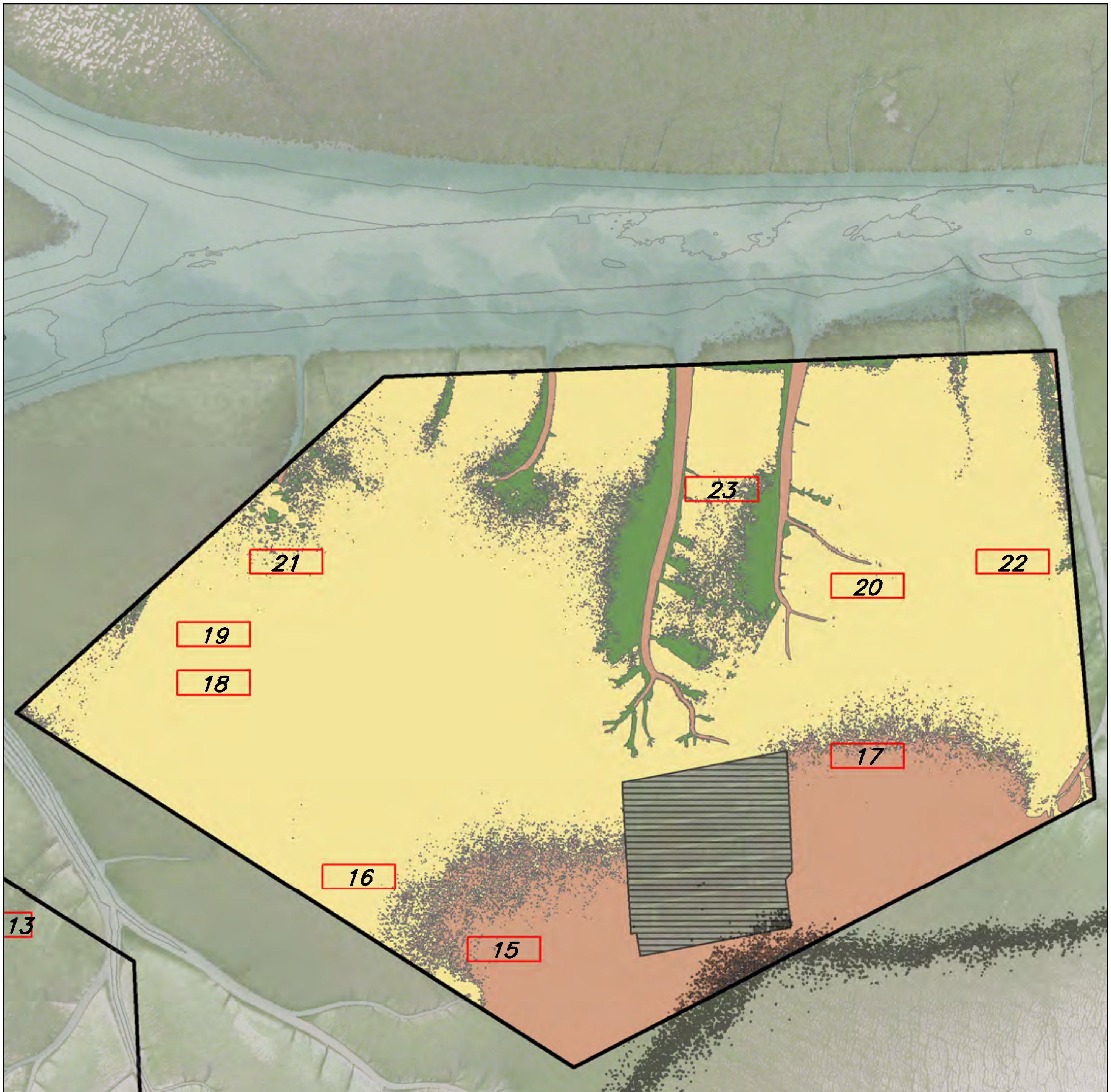
SEDIMENT TYPE
- SAND–SILT–CLAY
- SILTY SAND

1"=400'±
0 400
FEET

DATA SOURCE: SEDIMENT TYPES (HUMBOLDT BAY HARBOR, RECREATION AND CONSERVATION DISTRICT, 2001)

Path: \\zing\projects\2015\015063-CoastSeafoods\GIS\PROJ_MXD\Report_MXDs\Final_20150812\FigureB5b_Area5_SedType.mxd

SHN Consulting Engineers & Geologists, Inc.	Plauche & Carr LLP. Eelgrass Monitoring Plan Eureka, California	Site Map Showing Area 5-Arcata Channel Sediment Types SHN 015063
July 2015	FigureB5b_Area5_SedType	Figure B-5b



EXPLANATION

2015 EELGRASS BLOCKS
EXISTING AQUACULTURE
PROPOSED AQUACULTURE

0 600
FEET

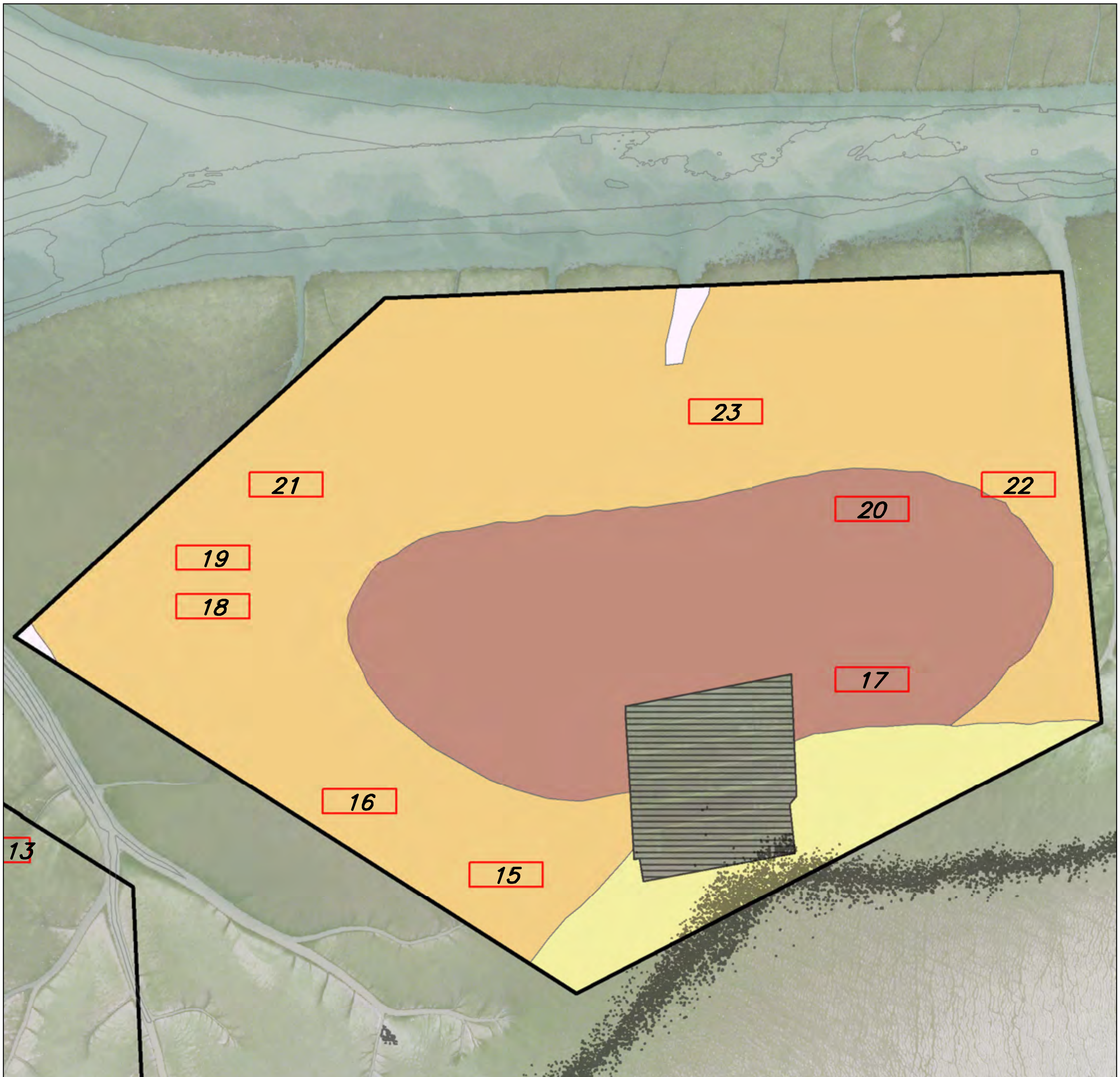
ELEVATION (FEET)
−0.75 TO −0.5
−0.5 TO −0.25
−0.25 TO 0
0 TO 0.25

N

DATA SOURCE: ELEVATION DATA (GILKERSON, 2014)

1"=600'±

SHN Consulting Engineers & Geologists, Inc.	Plauche & Carr LLP. Eelgrass Monitoring Plan Eureka, California		Site Map Showing Area 6-East Bay 2 Elevation Ranges SHN 015063
	July 2015	FigureB6a_Area6_Elevation	Figure B-6a



EXPLANATION

2015 EELGRASS BLOCKS
EXISTING AQUACULTURE
PROPOSED AQUACULTURE

SEDIMENT TYPE
SILTY CLAY
VERY CLAYEY SILT
CLAYEY SILT
SAND–SILT–CLAY
SILTY SAND

N
1"=600'±
0 600
FEET

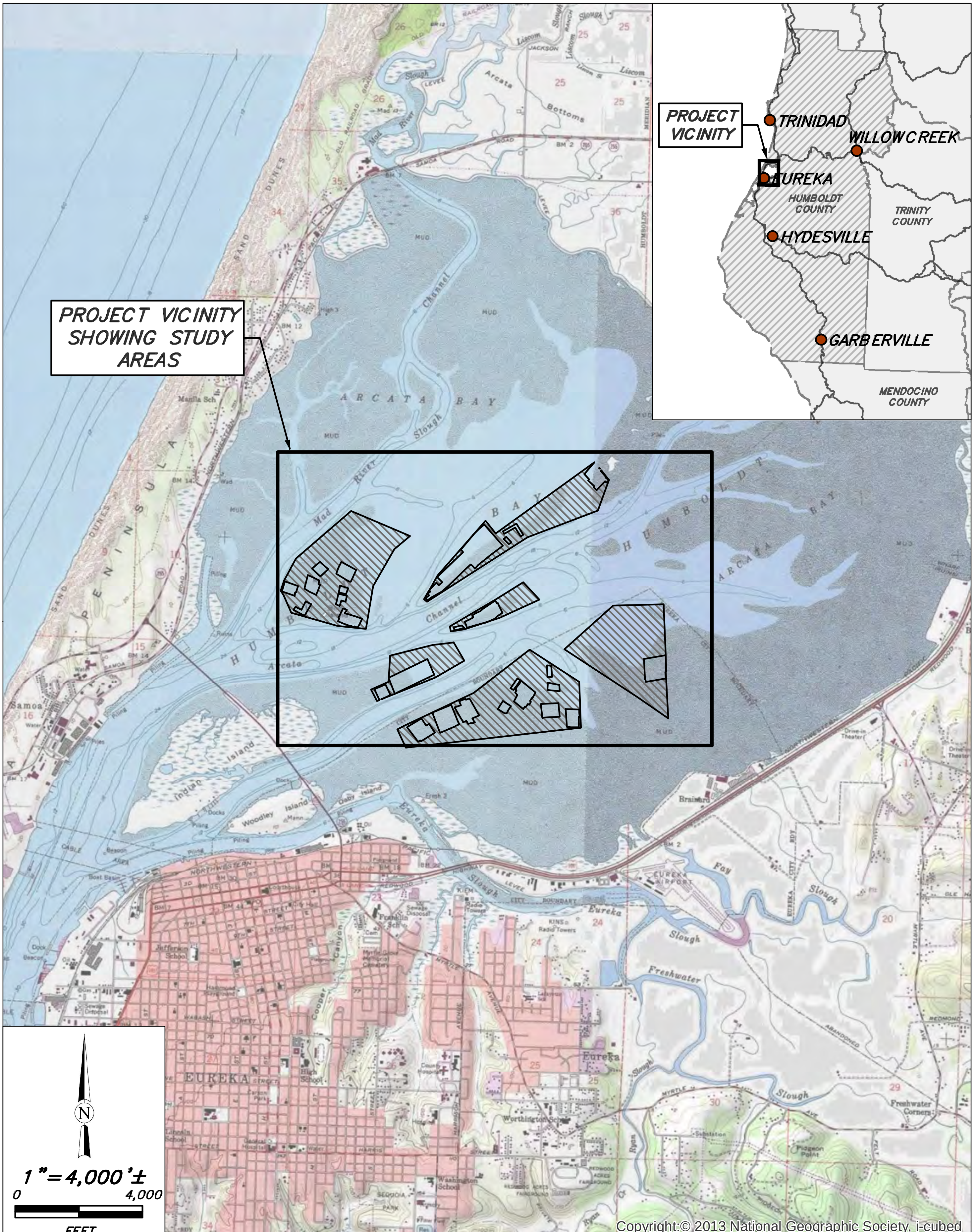
DATA SOURCE: SEDIMENT TYPES (HUMBOLDT BAY HARBOR, RECREATION AND CONSERVATION DISTRICT, 2001)

Path: \\zing\projects\2015\015063-CoastSeafoods\GIS\PROJ_MXD\Report_MXDs\Final_20150812\FigureB6b_Area6_SedType.mxd

SHN Consulting Engineers & Geologists, Inc.	Plauche & Carr LLP. Eelgrass Monitoring Plan Eureka, California		Site Map Showing Area 6-East Bay 2 Sediment Types SHN 015063
	July 2015	FigureB6b_Area6_SedType	Figure B-6b

C

Updated Expansion Area Boundaries



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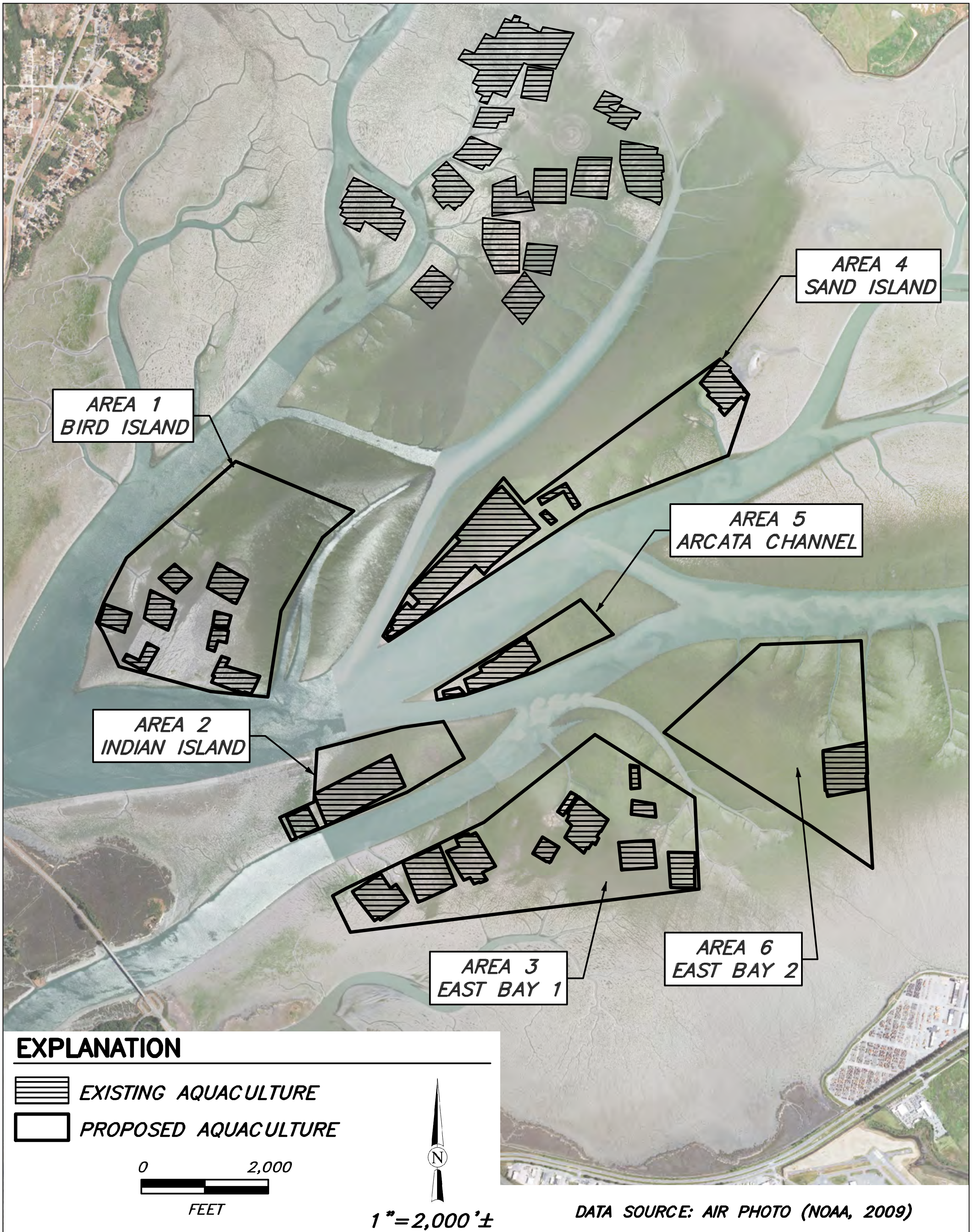
SHN
Consulting Engineers & Geologists, Inc.

Plauche & Carr LLP. Eelgrass Monitoring Plan Eureka, California		Project Vicinity Map Showing Study Areas SHN 015063
July 2015	Figure1a_ProjectVicinityMap	Figure 1a



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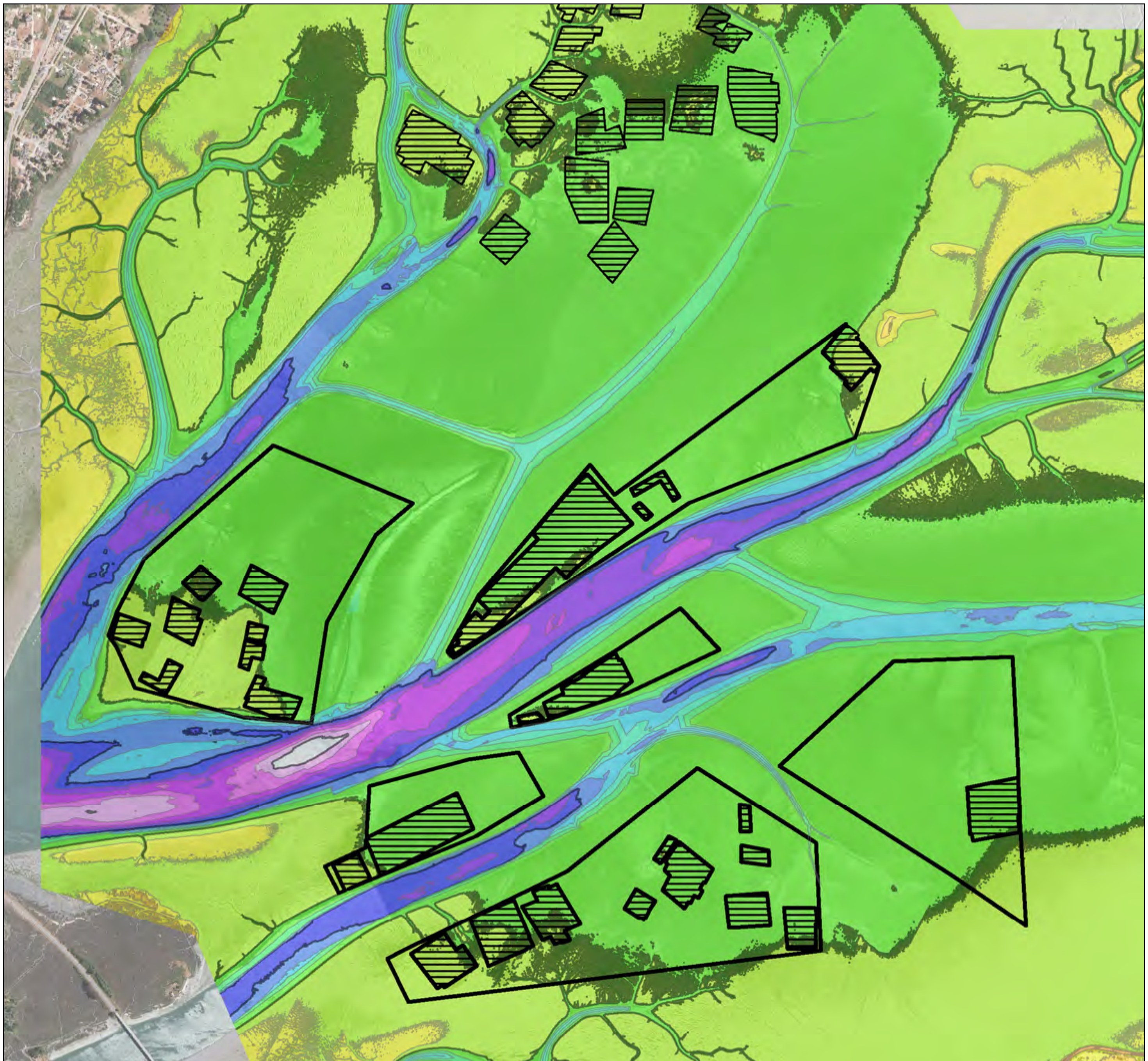
SHN Consulting Engineers & Geologists, Inc.	Plauche & Carr LLP. Eelgrass Monitoring Plan Eureka, California	Site Map Showing Existing and Expansion Areas SHN 015063
	July 2015	Figure2a_StudyAreas
		Figure 2a



EXPLANATION

(hatched box)	EXISTING AQUACULTURE
(outlined box)	PROPOSED AQUACULTURE

1"=2,000'±

0 — 2,000 FEET

N

ELEVATION (FEET)

-11 TO -10	-5 TO -4	1 TO 2
-10 TO -9	-4 TO -3	2 TO 3
-9 TO -8	-3 TO -2	3 TO 4
-8 TO -7	-2 TO -1	4 TO 5
-7 TO -6	-1 TO 0	5 TO 6
-6 TO -5	0 TO 1	6 TO 7

DATA SOURCE: ELEVATION DATA (GILKERSON, 2014)

SHN Consulting Engineers & Geologists, Inc.	Plauche & Carr LLP. Eelgrass Monitoring Plan Eureka, California	Site Map Showing 1-Foot Elevations and Existing and Expansion Areas SHN 015063
July 2015	Figure3a_ElevationMap	Figure 3a

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EXPLANATION

EXISTING AQUACULTURE
PROPOSED AQUACULTURE

1"=2,000'±
0 2,000
FEET

N

SEDIMENT TYPES
- MARSH
- SILTY CLAY
- VERY CLAYEY SILT
- CLAYEY SILT
- SAND-SILT-CLAY
- SILTY SAND
- SAND
- SAND AND GRAVEL

DATA SOURCE: SEDIMENT TYPES (HUMBOLDT BAY HARBOR, RECREATION AND CONSERVATION DISTRICT, 2001)

SHN Consulting Engineers & Geologists, Inc.

Plauche & Carr LLP. Eelgrass Monitoring Plan Eureka, California	Site Map Showing Sediment Types and Existing and Expansion Areas SHN 015063
July 2015 / Figure6a_SedimentTypes	Figure 6a

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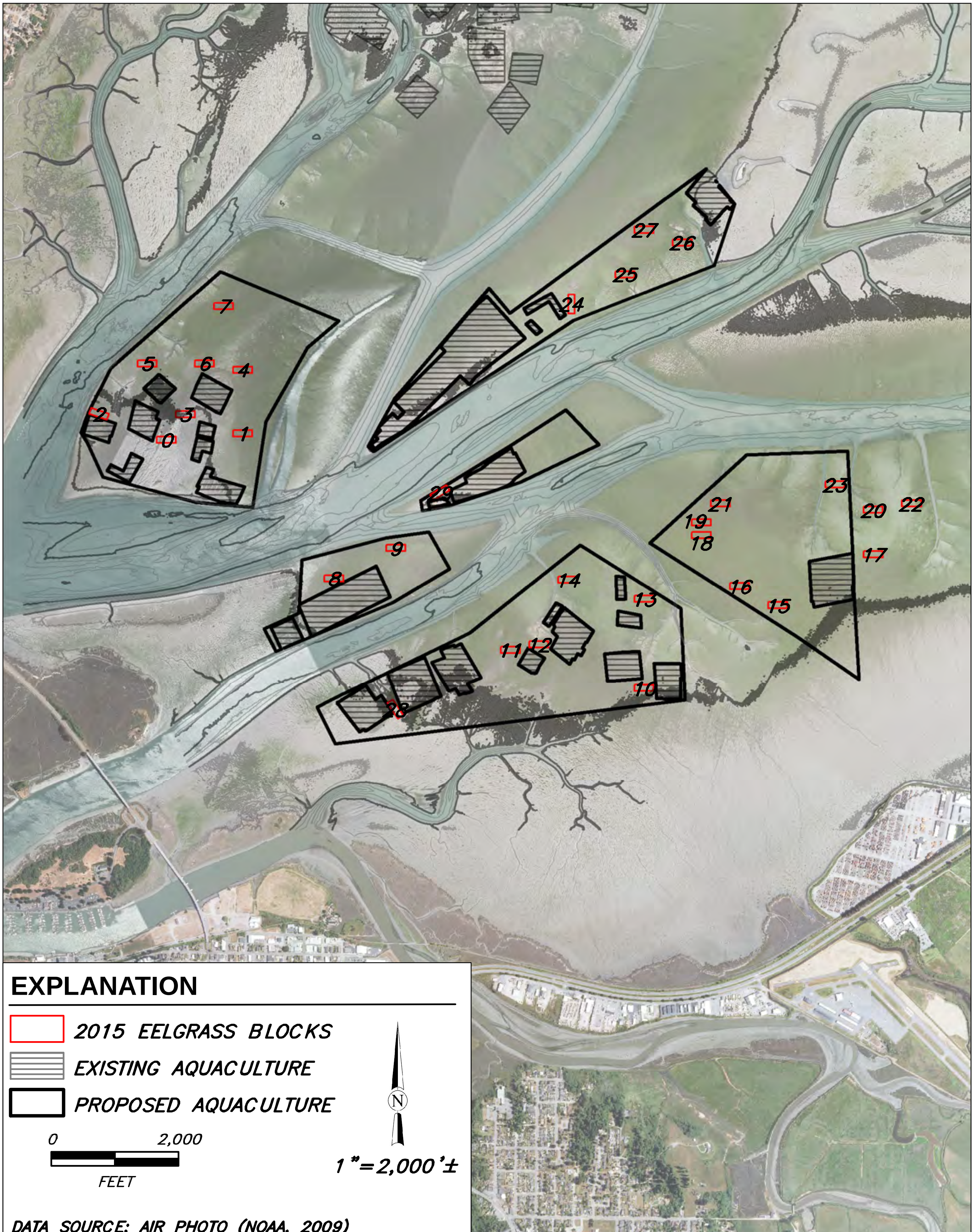

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SHN Consulting Engineers & Geologists, Inc.

Plauche & Carr LLP.
Eelgrass Monitoring Plan
Eureka, California

Site Map Showing Eelgrass Study Blocks and Existing and Expansion Areas
SHN 015063

July 2015 | Figure11a_StudyBlocks | Figure 11a

2015 Eelgrass Monitoring Results

Coast Seafoods Company, Humboldt Bay Shellfish Culture Permit Renewal and Expansion Project
Eureka, California

Prepared for:

Plauché & Carr LLP

SHN Engineers & Geologists
812 W. Wabash Ave.
Eureka, CA 95501-2138
707-441-8855

August 2015
015063.400

Reference: 015063.400

2015 Eelgrass Monitoring Results

Coast Seafoods Company, Humboldt Bay Shellfish Culture Permit Renewal and Expansion Project
Eureka, California

Prepared for:

Plauché & Carr LLP
811 First Avenue, Suite 630
Seattle, WA 98104

Prepared by:

Engineers & Geologists
812 W. Wabash Ave.
Eureka, CA 95501-2138
707-441-8855

August 2015

QA/QC: SEC SEC

Table of Contents

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Abbreviations and Acronyms

m	meter
m^2	square meters
Ave	average (arithmetic mean)
BACI	before/after–control/impact
Coast	Coast Seafoods Company
MLLW	mean lower low water
N	sample size
NOAA	National Oceanic and Atmospheric Administration
RC plane	remote controlled plane
SHN	SHN Engineers & Geologists
StdDev	standard deviation

1.0 Introduction

This 2015 eelgrass (*Zostera marina* L.) monitoring results report was prepared by SHN Engineers & Geologists for Coast Seafoods Company's (Coast) Humboldt Bay Shellfish Culture: Permit Renewal and Expansion Project. This report provides the results of the first year of eelgrass data collection in accordance with the project's Eelgrass Monitoring Plan (SHN, 2015).

2.0 Methodology

2.1 Summary of Metrics

Several quantitative variables were recorded for each 0.0625-square meter (m^2) quadrat area, including shoot density, percent eelgrass cover, and percent seaweed cover. Metrics were surveyed and recorded in compliance with the guidelines established by the California Eelgrass Mitigation Policy and Implementing Guidelines (NOAA, 2014).

2.1.1 Depth of Water

The depth of water was estimated at the central point of each quadrat area surveyed. This metric allows for interpretation of sampling conditions, such as, elevation of each quadrat area as compared to other quadrat areas within a transect. Additionally, variation in tidal elevation at the time of sampling as compared to future sampling events may be evaluated by the depth-of-water metric.

2.1.2 Percent Bare Ground

Bare substrate that did not contain eelgrass, seaweed, living bivalves, or shell material was recorded as percent bare ground.

2.1.3 Percent Shell

While the quadrat was still at the same sampling position, the portion of each quadrat area that contained living bivalves or shell material on top of the surface sediment was recorded as percent shell.

2.1.4 Percent Seaweed Cover

Seaweed cover within quadrat areas was visually estimated using laminated reference cards containing examples of percent cover categories. The quadrat was placed over each sampling point without disturbing the orientation of seaweeds or eelgrass. Seaweed taxa commonly encountered in the study area included, *Sargassum muticum* (Yendo) Fensholt, *Porphyra* spp. C. Agardh, *Polysiphonia* spp. Greville, *Ceramium* sp. Roth, and others.

2.1.5 Percent Eelgrass Cover

Eelgrass cover within 0.0625-m^2 quadrat areas was visually estimated using laminated reference cards containing examples of percent cover categories. The quadrat was placed over each sampling point without disturbing the orientation of eelgrass blades. It is possible to record a high percent cover within a quadrat area containing zero shoots if leaves from shoots originating outside the quadrat area lay within the survey quadrat area.

Percent cover was recorded as absolute percent cover. In some cases, the cumulative absolute cover could add up to more than 100 percent. For example, if seaweed overlapped with eelgrass, then relative percent cover was calculated by dividing the absolute percent cover for each variable by the cumulative absolute cover.

2.1.6 Shoot (Turion) Density

After recording percent cover, eelgrass shoot density was counted by hand within the 0.0625-m^2 quadrat areas. Data is presented as shoots per m^2. Shoot density counts for 5 plots (102 of 1,798 quadrats sampled) were quantified in paired measurements using 0.0625-m^2 and 0.25-m^2 quadrats. The decision to collect this additional data was made mid-way though the 2015 sampling effort because of concerns that shoot density within the expansion areas may have a higher level of variation than the North Bay SeagrassNet survey locations used in the statistical power analysis (SHN, 2015). These paired measurements allow a comparison of the effect of different quadrat sizes on estimating shoot density.

2.2 Experimental Sampling Design[1]

The sampling design is a before/after–control/impact (BACI) experiment composed of three nested plots within a blocked configuration (Figure 1). Two treatment plot categories (cultch-on-longline and basket-on-longline) are nested within a block along with a control plot (SHN, 2015). Blocks were replicated 30 times (blocks 0-29) throughout the expansion areas (Figure 2). The 2015 eelgrass survey is in the "before" phase of the BACI experiment and represents initial baseline conditions before aquaculture cultivation gear has been deployed.

[1] A portion of Coast's existing culture footprint is located in areas currently leased from the Humboldt Bay Harbor, Recreation and Conservation District (Harbor District); however, ownership of this area has been questioned by the Department of State Lands. Coast is currently in the process of seeking leases from the underlying tideland property owners. The locations of sampling blocks monitored in 2015 were allocated based on the prior understanding of Coast's lease area boundaries. Sampling block locations for subsequent monitoring efforts will be reallocated where necessary to reflect the current understanding of Coast's Harbor District lease area boundaries prior to release of the draft Environmental Impact Report in September 2015.

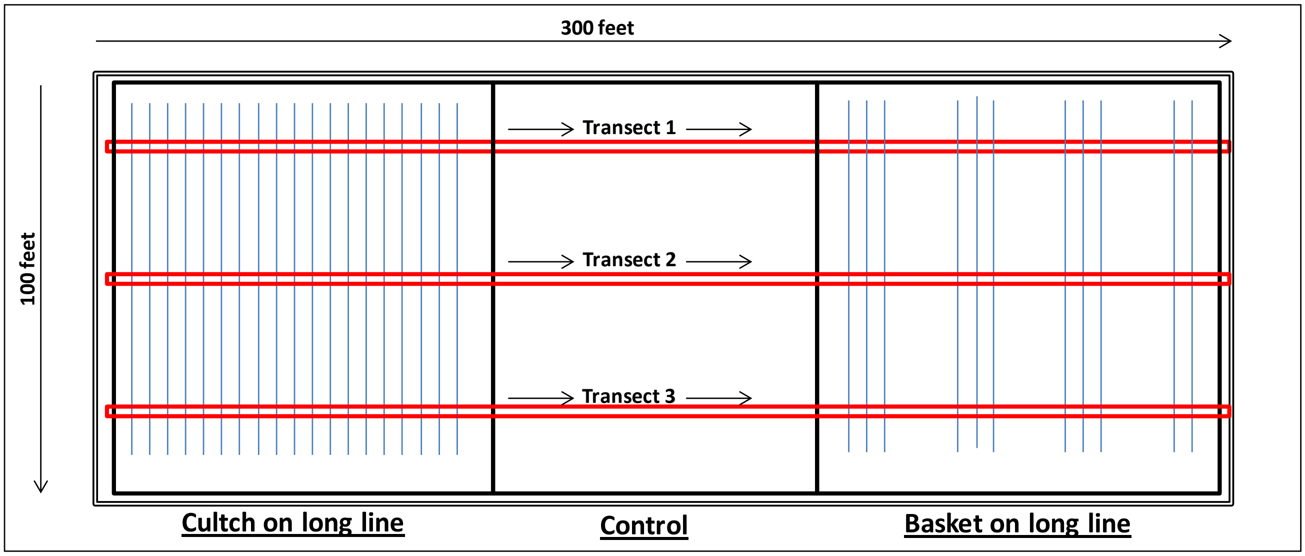


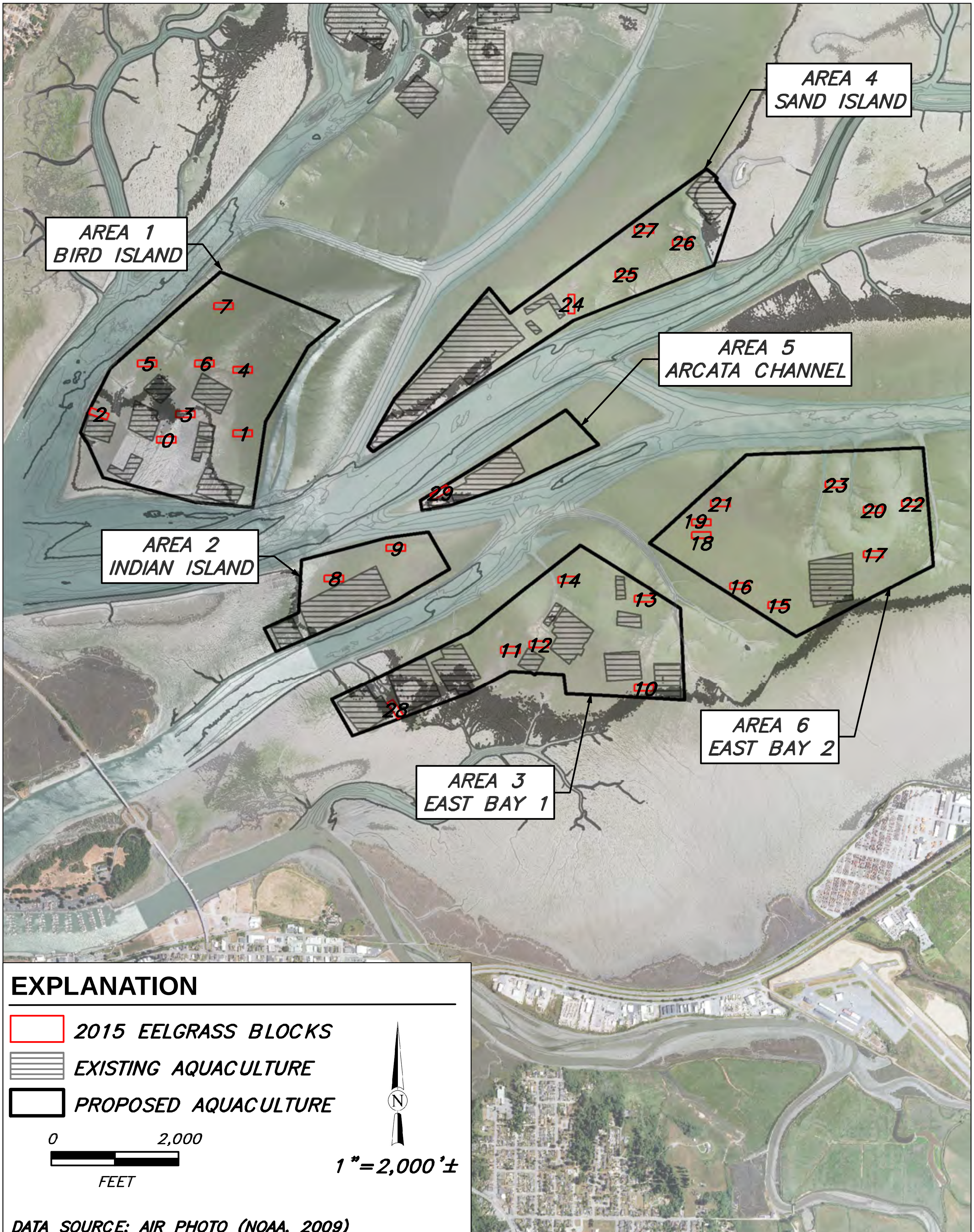
Figure 1. Example of Blocked Sampling Design
This sampling design contains three square plots and three horizontal transects (in red).

2.3 Survey Dates

Eelgrass surveys of the 30 experimental blocks occurred during 9 days within 2 sequences of negative tides (Table 1).

Table 1
Survey Dates of Experimental Blocks
Coast Seafoods 2015 Eelgrass Results

Date	Time	Tidal Elevation	
		(feet)	(meters)
6/15/2015	5:56 a.m.	-1.3	-0.40
6/16/2015	6:40 a.m.	-1.5	-0.46
6/17/2015	7:23 a.m.	-1.5	-0.46
6/18/2015	8:04 a.m.	-1.3	-0.40
6/19/2015	8:45 a.m.	-1.0	-0.30
7/1/2015	6:23 a.m.	-1.1	-0.34
7/2/2015	7:04 a.m.	-1.4	-0.43
7/3/2015	7:45 a.m.	-1.5	-0.46
7/4/2015	8:27 a.m.	-1.4	-0.43



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SHN Consulting Engineers & Geologists, Inc.

Plauche & Carr LLP.
Eelgrass Monitoring Plan
Eureka, California

Site Map Showing Eelgrass Study Blocks and Existing and Expansion Areas
SHN 015063.400

August 2015 | Figure2StudyBlocks | Figure 2

3.0 Results

3.1 Eelgrass Percent Cover

A total of 30 blocks (90 plots and 1,799 quadrats) were surveyed for eelgrass percent cover. One quadrat position in the basket plot of block 23 was accidentally duplicated when randomizing quadrat locations on the data sheet. This duplicate was omitted from analysis, resulting in a total of 1,799 quadrat measurements for eelgrass percent cover for the entire study.

3.1.1 Eelgrass Percent Cover by Expansion Area

Average (arithmetic mean) eelgrass percent cover by expansion area ranged from 30.51% to 56.92% (Table 2, Figure 3).

Table 2
Eelgrass Percent Cover by Expansion Area
Coast Seafoods 2015 Eelgrass Results

Expansion Area	N[1]	Ave[2]	Standard Deviation
1	480	30.51	34.93
2	120	56.92	26.58
3	360	54.49	34.99
4	240	43.39	32.56
5	60	50.37	38.36
6	539	44.01	29.15

1. N: sample size
2. Ave: average eelgrass percent cover

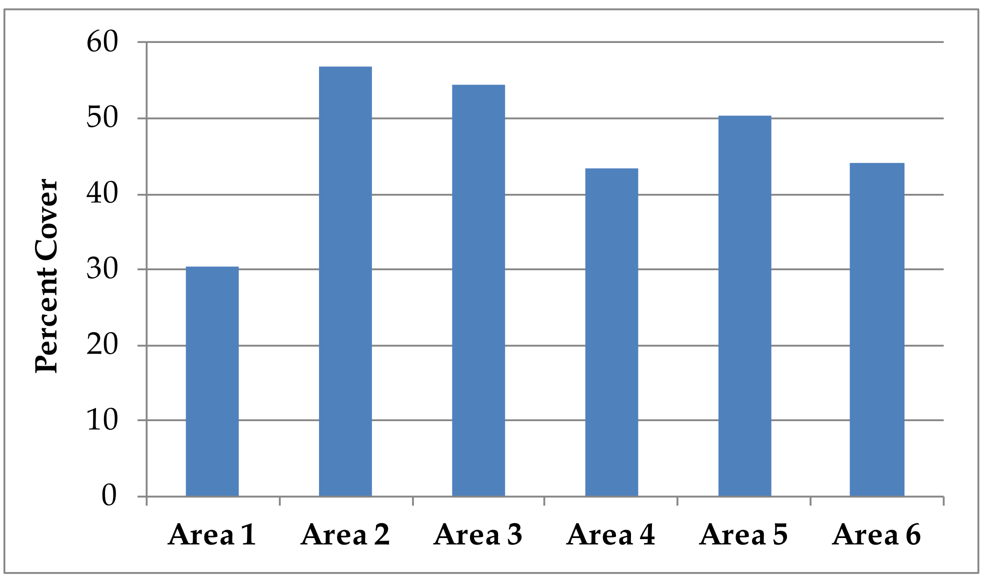


Figure 3. Average Eelgrass Percent Cover by Expansion Area

3.1.2 Eelgrass Percent Cover by Block

Average eelgrass percent cover by block ranged from 0.55% to 88.67% (Table 3, Figure 4).

Table 3
Eelgrass Percent Cover by Block
Coast Seafoods 2015 Eelgrass Results

Block	N[1]	Ave[2]	Standard Deviation
0	60	0.55	3.88
1	60	64.67	29.77
2	60	1.75	5.19
3	60	3.60	11.98
4	60	65.17	29.88
5	60	21.15	26.04
6	60	44.78	34.06
7	60	42.38	27.66
8	60	56.58	27.87
9	60	57.25	25.45
10	60	17.68	21.62
11	60	63.80	28.68
12	60	69.08	26.18
13	60	63.33	22.90
14	60	88.67	13.46
15	60	18.95	19.11
16	60	30.12	23.78
17	60	48.42	25.17
18	60	32.62	25.59
19	60	34.95	27.82
20	60	66.18	25.78
21	60	55.67	26.13
22	60	41.58	27.81
23	59	67.54	19.37
24	60	33.25	31.97
25	60	47.46	33.69
26	60	38.92	32.03
27	60	53.92	29.26
28	60	24.40	29.99
29	60	50.37	38.36

1. N: sample size
2. Ave: average eelgrass percent cover

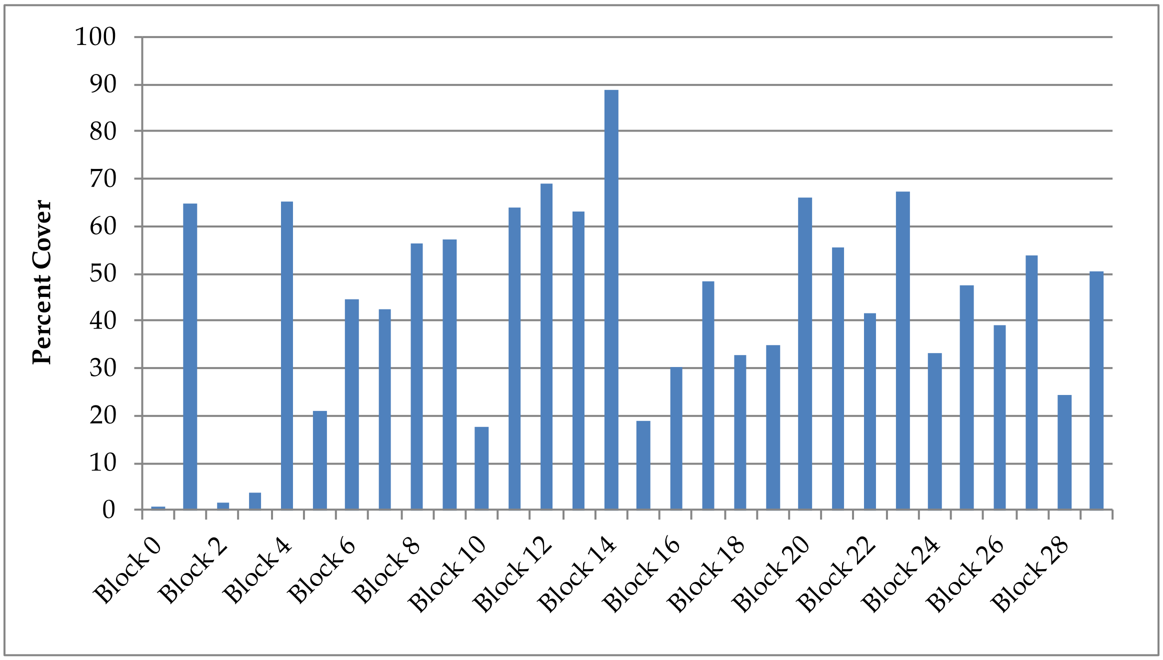


Figure 4. Average Eelgrass Percent Cover by Block

3.1.3 Eelgrass Percent Cover by Plot

Average eelgrass percent cover by plot ranged from 0.00% to 91.94% (Table 4).

Table 4
Eelgrass Percent Cover by Plot
Coast Seafoods 2015 Eelgrass Results

Block	Plot	N[1]	Ave[2]	Standard Deviation
0	Basket	24	1.38	6.11
0	Control	18	0.00	0.00
0	Cultch	18	0.00	0.00
1	Basket	24	55.83	31.44
1	Control	18	80.28	22.52
1	Cultch	18	60.83	29.12
2	Basket	24	2.92	6.41
2	Control	18	1.94	5.72
2	Cultch	18	0.00	0.00
3	Basket	24	0.33	1.01
3	Control	18	0.33	0.97
3	Cultch	18	11.22	20.20
4	Basket	24	53.75	27.55
4	Control	18	76.67	32.25
4	Cultch	18	68.89	26.32
5	Basket	24	17.21	24.21
5	Control	18	14.11	16.69
5	Cultch	18	33.44	32.36
6	Basket	24	45.33	32.21
6	Control	18	36.06	38.60

Table 4
Eelgrass Percent Cover by Plot
Coast Seafoods 2015 Eelgrass Results

Block	Plot	N[1]	Ave[2]	Standard Deviation
6	Cultch	18	52.78	31.35
7	Basket	24	37.38	29.53
7	Control	18	47.50	27.29
7	Cultch	18	43.94	25.77
8	Basket	24	49.38	28.56
8	Control	18	60.56	26.40
8	Cultch	18	62.22	27.77
9	Basket	24	52.29	26.82
9	Control	18	62.50	26.30
9	Cultch	18	58.61	22.74
10	Basket	24	17.75	20.75
10	Control	18	20.83	27.77
10	Cultch	18	14.44	15.71
11	Basket	24	55.00	29.56
11	Control	18	72.50	23.65
11	Cultch	18	66.83	30.22
12	Basket	24	72.08	28.89
12	Control	18	66.11	28.88
12	Cultch	18	68.06	19.79
13	Basket	24	57.08	19.50
13	Control	18	65.83	27.29
13	Cultch	18	69.17	21.51
14	Basket	24	87.50	15.67
14	Control	18	91.94	11.77
14	Cultch	18	86.94	11.90
15	Basket	24	14.70	17.14
15	Control	18	11.67	11.37
15	Cultch	18	31.67	22.03
16	Basket	24	26.25	20.92
16	Control	18	30.00	25.95
16	Cultch	18	35.39	25.42
17	Basket	24	46.04	25.71
17	Control	18	54.17	26.75
17	Cultch	18	45.83	23.22
18	Basket	24	30.54	24.50
18	Control	18	33.83	29.68
18	Cultch	18	34.17	23.84
19	Basket	24	18.83	15.05
19	Control	18	35.00	28.34
19	Cultch	18	56.39	26.89
20	Basket	24	75.00	20.11
20	Control	18	40.00	20.51
20	Cultch	18	80.61	16.83

Table 4 Eelgrass Percent Cover by Plot Coast Seafoods 2015 Eelgrass Results				
Block	**Plot**	**N[1]**	**Ave[2]**	**Standard Deviation**
21	Basket	24	58.96	27.07
21	Control	18	56.39	25.88
21	Cultch	18	50.56	25.78
22	Basket	24	44.79	27.84
22	Control	18	46.11	28.26
22	Cultch	18	32.78	26.80
23	Basket	23	70.43	22.36
23	Control	18	70.00	21.28
23	Cultch	18	61.39	11.09
24	Basket	24	39.92	34.79
24	Control	18	25.94	24.47
24	Cultch	18	31.67	34.50
25	Basket	24	42.71	33.20
25	Control	18	42.08	33.91
25	Cultch	18	59.17	33.02
26	Basket	24	36.04	30.66
26	Control	18	38.06	38.08
26	Cultch	18	43.61	28.33
27	Basket	24	44.17	23.94
27	Control	18	73.06	24.50
27	Cultch	18	47.78	32.14
28	Basket	24	10.25	16.53
28	Control	18	50.72	27.95
28	Cultch	18	16.94	29.91
29	Basket	24	70.63	36.57
29	Control	18	26.06	29.62
29	Cultch	18	47.67	34.76
1. N: sample size 2. Ave: average eelgrass percent cover				

3.1.4 Eelgrass Percent Cover by Elevation

Average eelgrass percent cover by elevation area ranged from 0.55% to 55.67% throughout all expansion areas combined (Table 5, Figure 5).

Table 5 Eelgrass Percent Cover by Elevation Coast Seafoods 2015 Eelgrass Results			
Elevation (m MLLW)[1,2]	N[3]	Ave[4]	Standard Deviation
-0.229 to -0.152	60	55.67	26.13
-0.152 to -0.076	1079	51.62	31.37
-0.076 to 0	480	36.67	34.15
0 to 0.076	120	13.08	24.26
0.076 to 0.152	60	0.55	3.88

1. m: meters
2. MLLW: mean lower low water
3. N: sample size
4. Ave: average eelgrass percent cover

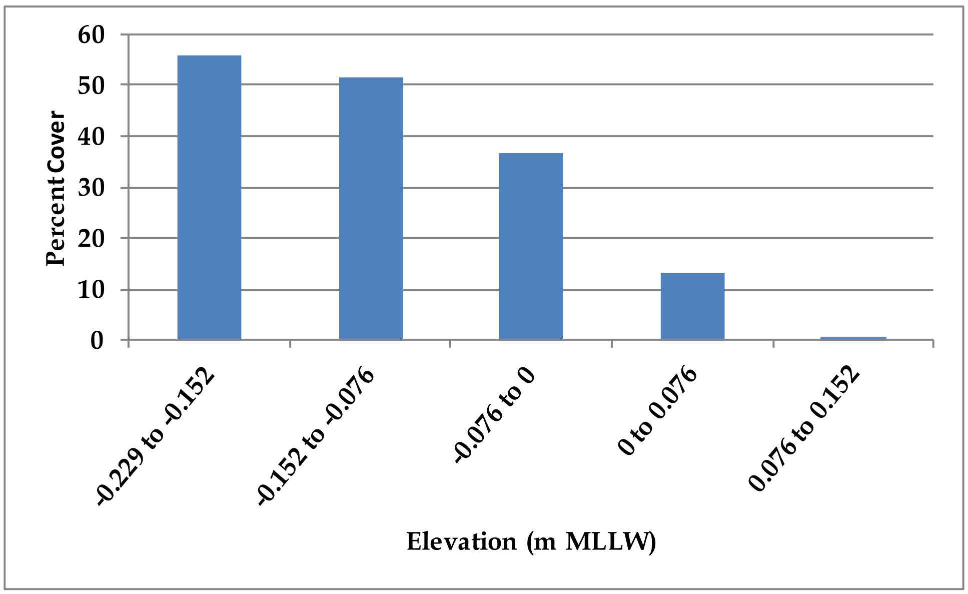


Figure 5. Average Eelgrass Percent Cover by Elevation

3.1.5 Eelgrass Percent Cover by Sediment Type

Average eelgrass percent cover by sediment type ranged from 1.15% to 50.37% throughout all expansion areas combined (Table 6, Figure 6).

Table 6 Eelgrass Percent Cover by Sediment Type Coast Seafoods 2015 Eelgrass Results			
Sediment Type	**N[1]**	**Ave[2]**	**Standard Deviation**
Very Clayey Silt	60	17.68	21.62
Clayey Silt	599	48.82	31.27
Sand Silt Clay	960	46.65	33.38
Silty Sand	60	50.37	38.36
Sand	120	1.15	4.60

1. N: sample size
2. Ave: average eelgrass percent cover

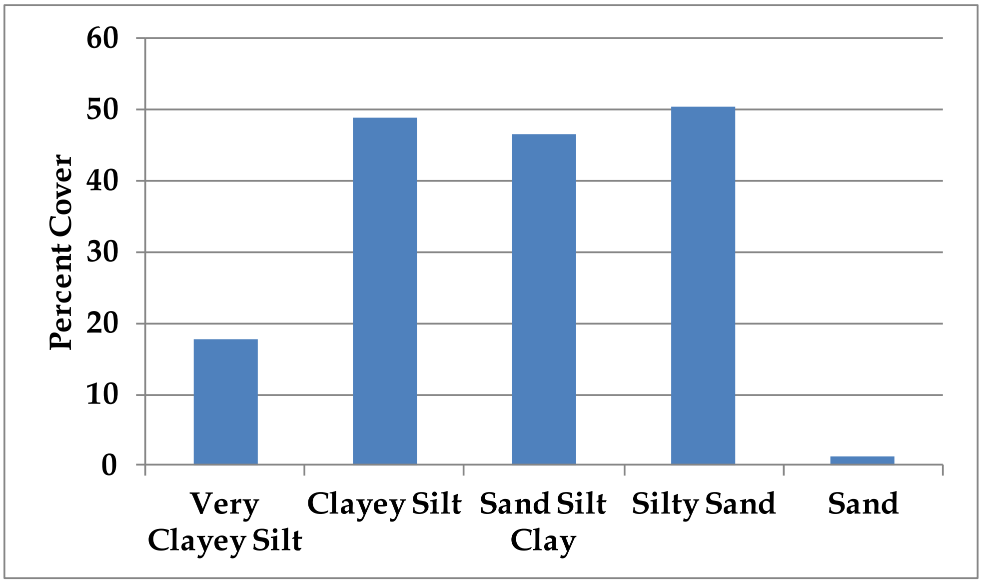


Figure 6. Average Eelgrass Percent Cover by Sediment Type

3.2 Eelgrass Shoot Density

A total of 30 blocks (90 plots and 1,798 quadrats) were surveyed for eelgrass shoot density. One quadrat position in the basket plot of block 23 was accidentally duplicated when randomizing quadrat locations on the data sheet. This duplicate was omitted from analysis. Eelgrass shoot density data from another quadrat position in the cultch plot of block 27 was not recorded or accidentally left blank on the data sheet. These two missing quadrats result in a total of 1,798 quadrat measurements for eelgrass shoot density for the entire study.

3.2.1 Eelgrass Shoot Density by Expansion Area

Average eelgrass shoot density by expansion area ranged from 26.63 to 54.49 shoots per m^2 (Table 7, Figure 7).

Table 7
Eelgrass Shoot Density by Expansion Area
Coast Seafoods 2015 Eelgrass Results
(shoots per m^2)[1]

Expansion Area	N[2]	Ave[3]	Standard Deviation
1	480	26.63	35.57
2	120	43.33	29.44
3	360	54.49	46.54
4	239	36.35	37.64
5	60	37.60	36.06
6	539	44.08	35.64

1. m^2: square meters
2. N: sample size
3. Ave: average eelgrass shoots per m^2

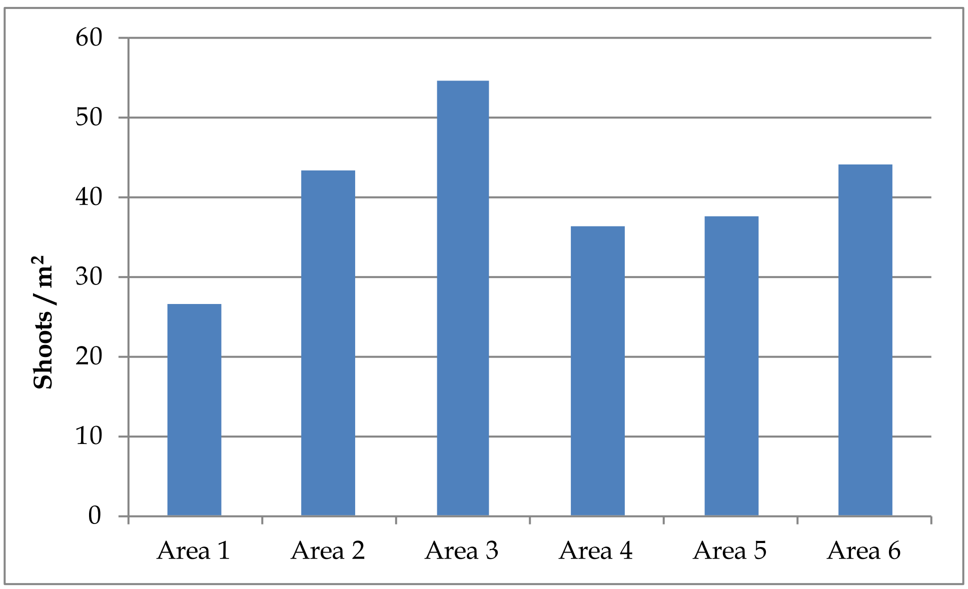


Figure 7. Average Eelgrass Shoot Density by Expansion Area

3.2.2 Eelgrass Shoot Density by Block

Average eelgrass shoot density by block ranged from 0.80 to 92.00 shoots per m² (Table 8, Figure 8).

Table 8
Eelgrass Shoot Density by Block
Coast Seafoods 2015 Eelgrass Results
(shoots per m²)[1]

Block	N[2]	Ave[3]	Standard Deviation
0	60	0.80	6.20
1	60	45.07	43.34
2	60	2.93	12.67
3	60	2.40	7.11
4	60	43.47	30.63
5	60	25.87	30.34
6	60	56.53	40.01
7	60	36.00	34.68
8	60	42.40	31.15
9	60	44.27	27.85
10	60	22.40	26.71
11	60	57.87	33.73
12	60	63.73	35.53
13	60	68.53	45.74
14	60	92.00	53.81
15	60	14.93	19.95
16	60	24.27	24.91
17	60	48.80	25.75
18	60	34.13	30.40
19	60	33.60	34.44
20	60	58.13	28.10
21	60	57.07	39.45
22	60	52.53	30.34
23	59	73.76	41.60
24	60	24.00	34.29
25	60	29.33	27.82
26	60	28.53	34.24
27	59	64.00	39.86
28	60	22.40	35.37
29	60	37.60	36.06

1. m²: square meters
2. N: sample size
3. Ave: average eelgrass shoots per m²

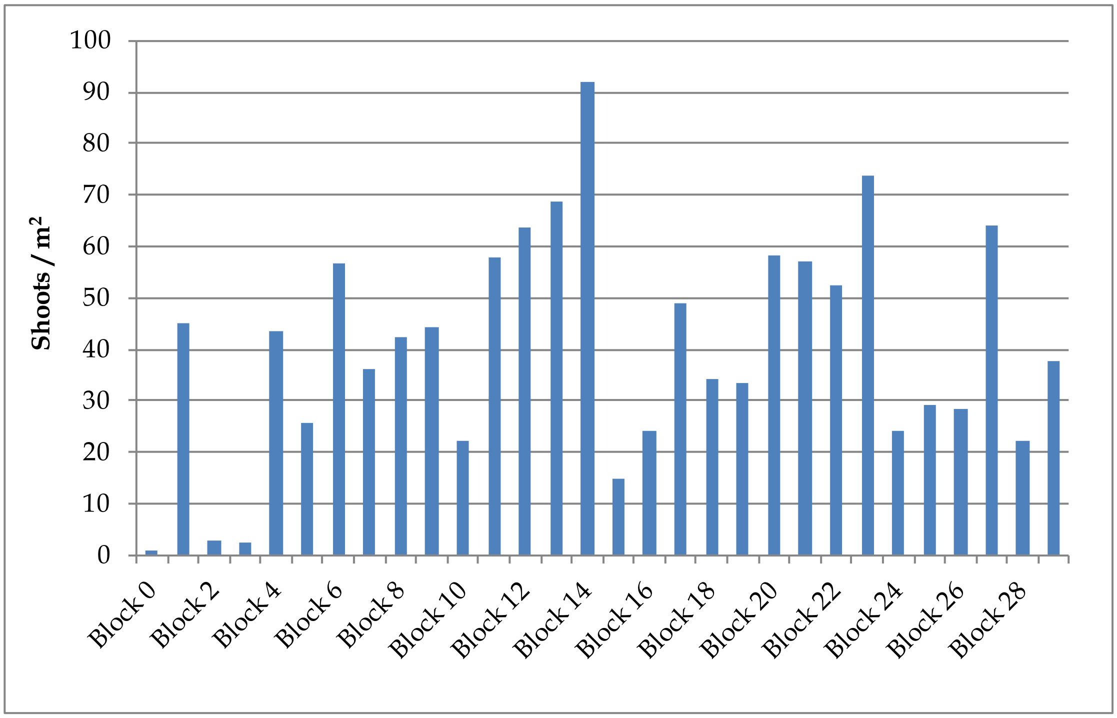


Figure 8. Average Eelgrass Shoot Density by Block

3.2.3 Eelgrass Shoot Density by Plot

Average eelgrass shoot density by plot ranged from 0.00 to 126.22 shoots per m^2. The average eelgrass shoot density amongst all plots is 40.78 shoots per m^2 (StDev= 28.97; N= 90) (Table 9).

Table 9
Eelgrass Shoot Density by Plot
Coast Seafoods 2015 Eelgrass Results
(shoots per m^2)[1]

Block	Plot	N[2]	Ave[3]	Standard Deviation
0	Basket	24	2.00	9.80
0	Control	18	0.00	0.00
0	Cultch	18	0.00	0.00
1	Basket	24	31.33	30.02
1	Control	18	63.11	60.49
1	Cultch	18	45.33	32.12
2	Basket	24	4.00	16.51
2	Control	18	4.44	13.22
2	Cultch	18	0.00	0.00
3	Basket	24	0.67	3.27
3	Control	18	1.78	5.17
3	Cultch	18	5.33	10.98
4	Basket	24	31.33	28.50
4	Control	18	57.78	33.44
4	Cultch	18	45.33	24.70

Table 9 Eelgrass Shoot Density by Plot Coast Seafoods 2015 Eelgrass Results (shoots per m²)[1]				
Block	**Plot**	**N[2]**	**Ave[3]**	**Standard Deviation**
5	Basket	24	27.33	27.70
5	Control	18	19.56	34.95
5	Cultch	18	30.22	29.50
6	Basket	24	52.67	27.30
6	Control	18	40.89	38.50
6	Cultch	18	77.33	48.23
7	Basket	24	31.33	38.18
7	Control	18	31.11	29.79
7	Cultch	18	47.11	33.59
8	Basket	24	48.00	30.94
8	Control	18	26.67	21.25
8	Cultch	18	50.67	35.25
9	Basket	24	42.00	33.96
9	Control	18	46.22	22.55
9	Cultch	18	45.33	24.70
10	Basket	24	17.33	21.58
10	Control	18	21.33	30.56
10	Cultch	18	30.22	28.46
11	Basket	24	47.33	29.27
11	Control	18	69.33	30.56
11	Cultch	18	60.44	39.40
12	Basket	24	73.33	33.00
12	Control	18	56.00	42.95
12	Cultch	18	58.67	29.04
13	Basket	24	38.00	24.43
13	Control	18	94.22	54.30
13	Cultch	18	83.56	35.38
14	Basket	24	86.67	44.49
14	Control	18	126.22	61.82
14	Cultch	18	64.89	38.60
15	Basket	24	14.67	18.82
15	Control	18	9.78	13.60
15	Cultch	18	20.44	25.63
16	Basket	24	13.33	13.89
16	Control	18	35.56	33.63
16	Cultch	18	27.56	21.12
17	Basket	24	36.00	24.63
17	Control	18	43.56	16.29
17	Cultch	18	71.11	20.70
18	Basket	24	24.67	21.09
18	Control	18	54.22	41.12
18	Cultch	18	26.67	17.35

Table 9
Eelgrass Shoot Density by Plot
Coast Seafoods 2015 Eelgrass Results
(shoots per m^2)[1]

Block	Plot	N[2]	Ave[3]	Standard Deviation
19	Basket	24	16.67	15.27
19	Control	18	39.11	46.64
19	Cultch	18	50.67	29.68
20	Basket	24	64.67	25.18
20	Control	18	38.22	19.12
20	Cultch	18	69.33	30.06
21	Basket	24	50.67	29.34
21	Control	18	24.89	21.41
21	Cultch	18	97.78	29.50
22	Basket	24	39.33	34.34
22	Control	18	48.00	16.46
22	Cultch	18	74.67	23.28
23	Basket	23	75.13	41.06
23	Control	18	70.22	46.93
23	Cultch	18	75.56	38.73
24	Basket	24	22.67	31.62
24	Control	18	31.11	38.21
24	Cultch	18	18.67	34.38
25	Basket	24	33.33	32.66
25	Control	18	24.89	22.77
25	Cultch	18	28.44	26.06
26	Basket	24	27.33	31.47
26	Control	18	26.67	43.90
26	Cultch	18	32.00	27.98
27	Basket	24	58.67	37.94
27	Control	18	73.78	42.56
27	Cultch	17	61.18	40.09
28	Basket	24	7.33	14.14
28	Control	18	48.89	44.07
28	Cultch	18	16.00	32.00
29	Basket	24	45.33	39.66
29	Control	18	24.00	33.49
29	Cultch	18	40.89	31.15
Ave. for all Plots		90	40.78	28.97

1. m^2: square meters
2. N: sample size
3. Ave: average eelgrass shoots per m^2

3.2.4 Eelgrass Shoot Density by Elevation

Average eelgrass shoot density by elevation ranged from 0.80 to 57.07 shoots per m^2 throughout all expansion areas combined (Table 10, Figure 9).

Table 10
Eelgrass Shoot Density by Elevation
Coast Seafoods 2015 Eelgrass Results
(shoots per m^2)[1]

Elevation (meters)	N[2]	Ave[3]	Standard Deviation
-0.229 to -0.152	60	57.07	39.45
-0.152 to -0.076	1,078	47.21	40.00
-0.076 to 0	480	34.20	34.65
0 to 0.076	120	12.67	28.20
0.076 to 0.152	60	0.80	6.20

1. m^2: square meters
2. N: sample size
3. Ave: average eelgrass shoots per m^2

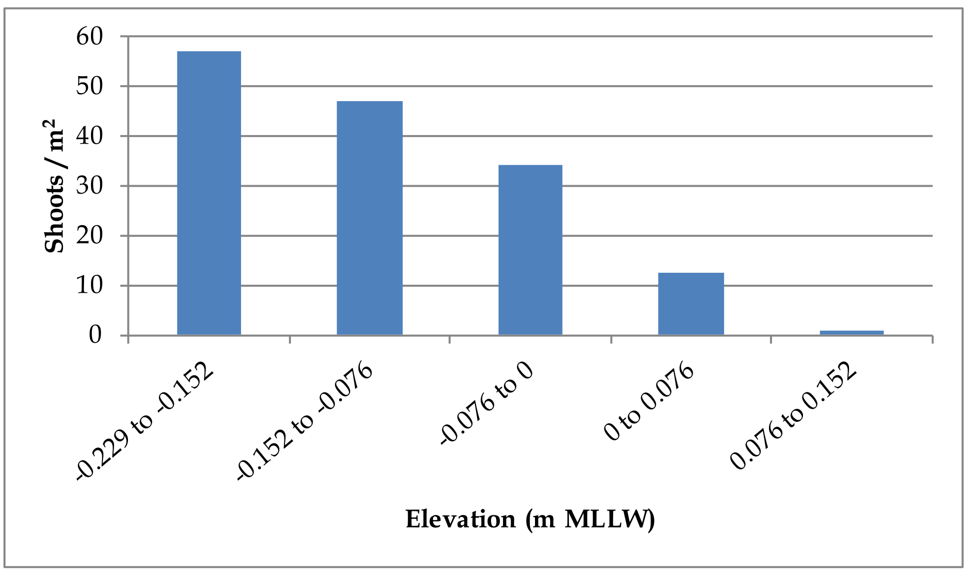


Figure 9. Average Eelgrass Shoot Density by Elevation

3.2.5 Eelgrass Shoot Density by Sediment Type

Average eelgrass shoot density by sediment type ranged from 1.87 to 47.07 shoots per m^2 throughout all expansion areas combined (Table 11, Figure 10).

Table 11
Eelgrass Shoot Density by Sediment Type
Coast Seafoods 2015 Eelgrass Results
(shoots per m^2)[1]

Sediment Type	N[2]	Ave[3]	Standard Deviation
Very Clayey Silt	60	22.40	26.71
Clayey Silt	599	47.07	43.24
Sand Silt Clay	959	42.01	36.60
Silty Sand	60	37.60	36.06
Sand	120	1.87	9.99

1. m^2: square meters
2. N: sample size
3. Ave: average eelgrass shoots per m^2

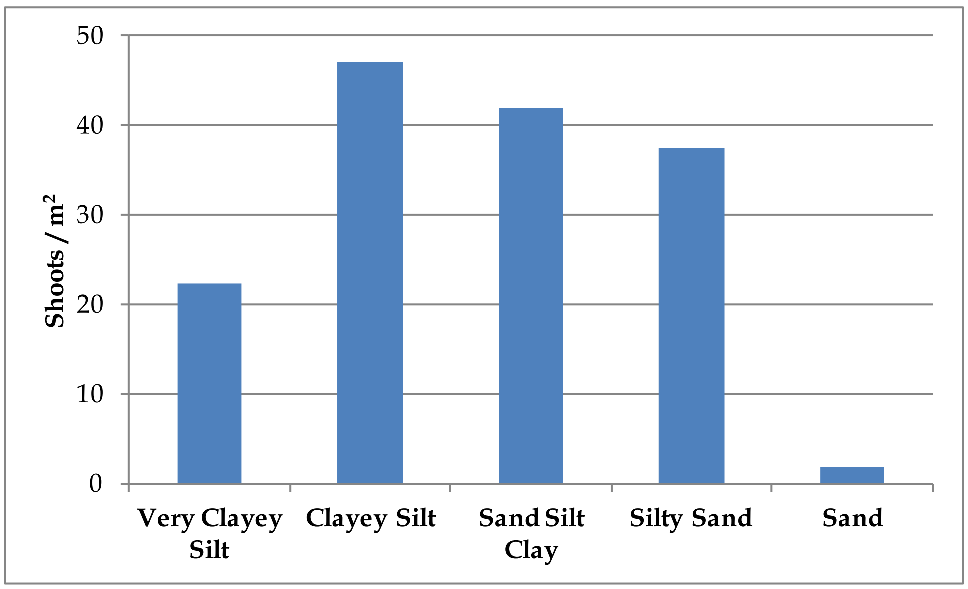


Figure 10. Average Eelgrass Shoot Density by Sediment Type

3.2.6 Eelgrass Shoot Density by Quadrat Size

The effect of quadrat size on estimating eelgrass shoot density was assessed in five plots (102 quadrats). The decision to collect this data was made after encountering a higher variation in shoot density than expected during the first several days of surveying, based on comparisons to North Bay SeagrassNet summer data (SHN, 2015). Three plots were chosen to represent areas of contiguous (block 7, basket plot), patchy (block 24, basket plot), and very patchy eelgrass (block 29, control plot) distribution based on 2009 National Oceanic & Atmospheric Administration (NOAA) imagery (Table 12). The remaining two plots within block 7 received paired quadrat measurements, because time allowed for it on the last day of surveying. A further discussion of the effect of quadrat size on estimating eelgrass shoot density can be found in Section 5.0.

Table 12
Eelgrass Shoot Density by Quadrat Size
Coast Seafoods 2015 Eelgrass Results

Block	Plot	N[1]	Data Collected Using 0.0625-m² Quadrat		Data Collected Using 0.25-m² Quadrat	
		$(m^2)^2$	Ave Shoot Density (per m²)	StdDev Shoot Density (per m²)	Ave Shoot Density (per m²)	StdDev Shoot Density (per m²)
7	Basket	24	31.3	38.2	30.3	24.1
7	Control	18	31.1	29.8	30.2	20.7
7	Cultch	18	47.1	33.6	34.7	18.3
24	Basket	24	22.7	31.6	27.5	26.5
29	Control	18	24.0	33.5	23.8	22.6

1. N: sample size
2. m^2: square meters
3. StdDev: standard deviation

4.0 Spatial Distribution and Areal Extent of Eelgrass

Successful aerial photography requires negative tides during daylight hours, which typically occurs between May and August each year during the eelgrass active growth period. These months coincide with frequent early morning fog conditions which make obtaining a high quality image difficult. As detailed below, weather conditions during the available low tides in 2015 prevented the collection of high quality aerial imagery of the entire expansion area.

4.1 RC Plane Results

A PixHawk 3DR Autonomous Fixed Wing Aircraft remote controlled plane (RC plane) mounted with a 20 megapixel Pentax digital camera was preloaded with flight paths and readied for deployment on a total of six days (Table 13). Imagery was successfully collected during two of those days (June 15 and 16, 2015). Poor visibility (fog) or technical logistics prevented image collection the other days.

Table 13
Aerial Imagery Flight Dates
Coast Seafoods 2015 Eelgrass Results

Date	Time	Tide (feet)	Tide (meters)	RC Plane[1]	Airplane
6/15/2015	5:56 a.m.	-1.3	-0.40	√	
6/16/2015	6:40 a.m.	-1.5	-0.46	√	
7/3/2015	7:45 a.m.	-1.5	-0.46	√	
7/31/2015	6:40 a.m.	-1.2	-0.37	√	
8/1/2015	7:21 a.m.	-1.3	-0.40	√	√
8/2/2015	8:03 a.m.	-1.1	-0.34	√	√

1. RC plane: remote controlled plane

Imagery from successful RC plane flight deployments was processed with Pix4d software to orthorectify and georeference the images using the onboard GPS and integrated inertial measurement unit. In total, imagery for 150 acres of Expansion Area 1 (Bird Island) and 65 acres of Expansion Area 6 (East Bay 2) was successfully collected by RC plane.

The 2015 imagery resolution was sufficient to identify broad boundaries of contiguous eelgrass beds. Expansion Area 1 (Bird Island) provides examples of relatively contiguous eelgrass beds, patchy areas, and areas with very low (or no) eelgrass (Figure 11). The 2015 imagery from Expansion Area 1 suggests a reduction in eelgrass areal extent in southern Bird Island as compared to the 2009 NOAA imagery (Figure 12). Eelgrass percent cover and shoot density recorded in 2015 within blocks 0, 2, and 3 support the interpretation of 2015 aerial imagery representing very low, or no eelgrass throughout the southern section of Bird Island. The cause and mechanisms responsible for this reduction in eelgrass are not known at this time.

4.2 Airplane Results

A Cessna 182 airplane, mounted with a Canon 5D Mark 3 camera, was readied for flight on two consecutive days (August 1 and 2, 2015; Table 13). The airplane flights were attempted after achieving minimal success with the RC plane due to weather. The airplane's ability to fly higher than the RC plane, coupled with its higher resolution camera, would have allowed for fewer passes over the expansion areas, resulting in a complete image set in one or two days. However, the airplane's two scheduled flights were also met with poor visibility conditions that prevented flight takeoff. These two days (August 1 and 2, 2015) were also the last remaining days of -0.3 m MLLW or lower tides during proper lighting conditions (daytime) for the remainder of the year 2015.

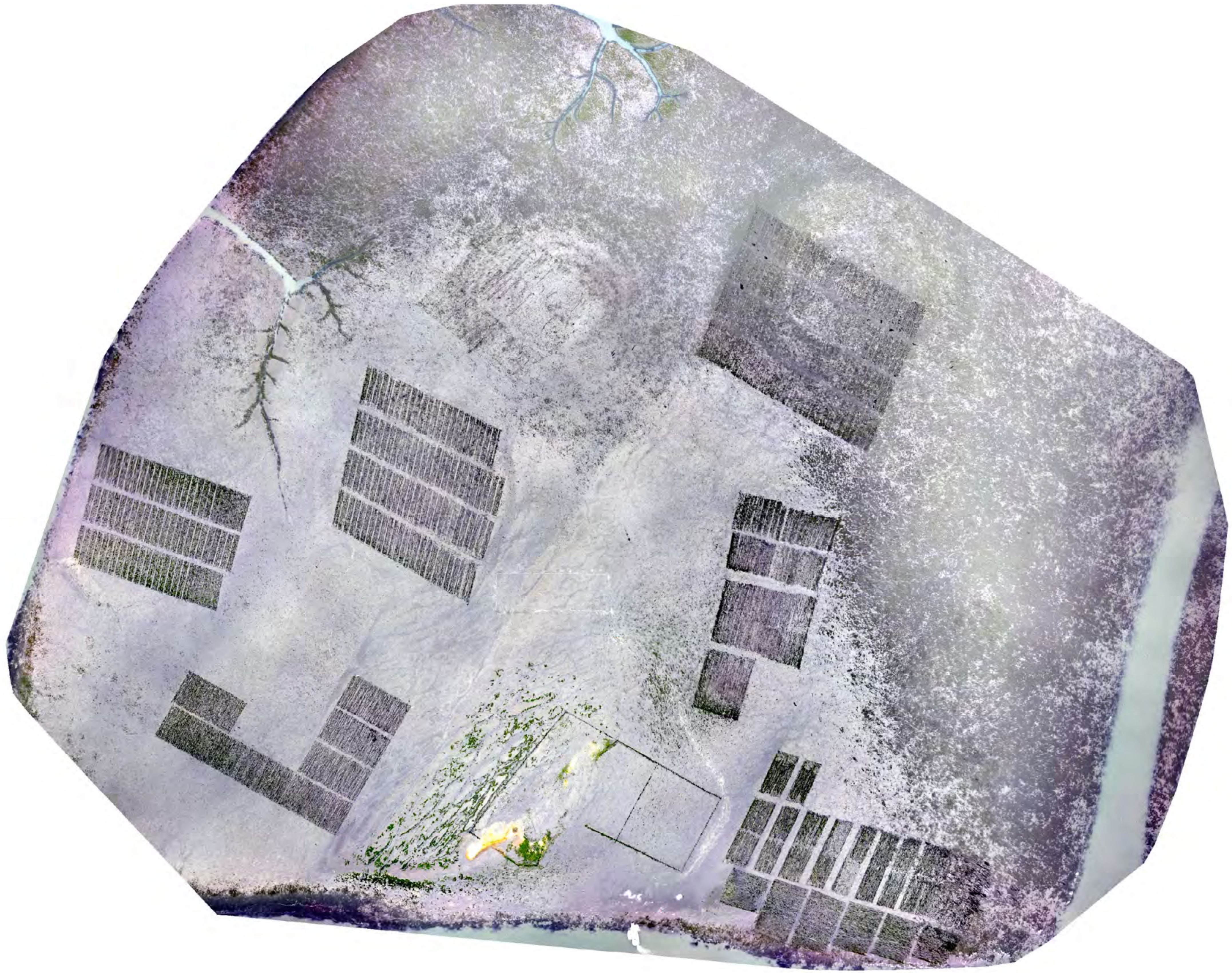
5.0 Conclusions

The 2015 eelgrass survey results provide an initial assessment of eelgrass baseline conditions within experiment blocks of Coast Seafood's six aquaculture expansion areas.[2] Three out of the 90 plots contained no eelgrass (Tables 4 and 9). The remaining 87 plots contained eelgrass, with blocks 13, 14, and 21 containing plots with the highest shoot density.

Quadrat size (0.0625-m^2 and 0.25-m^2) does not appear to have a substantial effect on estimating the average number of shoots per m^2, although the smaller quadrat produced averages with a higher variance.

Mapping the areal extent of eelgrass beds within the 622 acres of the expansion area proved difficult due to foggy, poor visibility conditions, an issue that was similarly experienced by NOAA when it attempted to survey eelgrass beds using aerial photography in 2006-2009. RC plane flyovers at lower elevation must be performed over several days in order to record clear, high-quality images of the entire expansion area. Because windows of good weather tend to be very short when the sun angle and tide level are appropriate for aerial photography, it may not be feasible to map the entire expansion area each year using RC plane flyover. However, the higher elevation flight path of the airplane will reduce the number of hours and flight paths needed to map the entire expansion area, requiring shorter windows of good weather during low tides in

[2] *See* Footnote 1.



Path: C:\Users\nhummel\Desktop\GIS\IAS\BirdIsland1\BirdIsland.mxd

IMAGE SOURCE: OVERVIEW SOLUTIONS 2015

SHN Consulting Engineers & Geologists, Inc.

Coast Seafoods
2015 Eelgrass Monitoring
Eureka, California

South Bird Island
OVERVIEW SOLUTIONS 2015
SHN 015063.400

August 2015 | BirdIsland | Figure 11

IMAGE SOURCE: NOAA 2009

SHN
Consulting Engineers & Geologists, Inc.

Coast Seafoods
2015 Eelgrass Monitoring
Eureka, California

South Bird Island
NOAA 2009
SHN 015063.400

August 2015 | BirdIslandNOAA | Figure 12

Path: C:\Users\nhummel\Desktop\GIS\UAS\BirdIsland1\BirdIslandNOAA.mxd daylight hours. High priority will be given to securing a complete image catalogue of the expansion area and adjacent eelgrass reference areas during the 2016 eelgrass active growing season.

6.0 References

National Geographic Society, i-cubed. (2013). "Map of Humboldt Bay, California." Accessed at: http://maps.nationalgeographic.com/maps

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SHN Engineers & Geologists. (2015). *Eelgrass Monitoring Plan. Coast Seafoods Company, Humboldt Bay Shellfish Culture Permit Renewal and Expansion Project.* Eureka, CA:SHN.

Section 3.0 Project Description

3.1 Project Location

The Project site is located in the north and central parts of Humboldt Bay, California. Humboldt Bay encompasses roughly 62.4 square kilometers (about 15,400 acres) at mean high tide in three geographic segments: South Bay, Entrance Bay, and North Bay. The leased area includes approximately 1,827 acres owned or held in trust by the City of Eureka, approximately 1,452 acres owned or held in trust by the Harbor District, approximately 515 acres owned by Karamu Corporation, and approximately 514 acres owned by Coast. Figure 3.1 depicts the Project site within Humboldt Bay and North Bay. Figure 3.2 depicts the boundaries of Coast's leased and owned area in North Bay. Figure 3.3 depicts the area historically and currently farmed by Coast. Figure 3.4 depicts the acreage currently farmed by Coast and the additional 622 intertidal acres proposed for cultivation as part of this Project.

3.2 Surrounding Land Use Settings

Coast's aquaculture operations are located on intertidal and subtidal lands of North Bay and Central Bay that are owned or leased by Coast. The areas surrounding Coast's operations are dominated by tidal flats, tidal channels and open water. The project area is located within tidal and submerged lands granted to the Harbor District and City of Eureka by the State Lands Commission. Because the project is located within Humboldt Bay tidelands, the Harbor District has permitting authority. The entire project area is zoned "Natural Resources – Wetland" by Humboldt County. The Harbor District's Humboldt Bay Management Plan classifies the area as "Combined Water Use – Mariculture".[1] Surrounding areas are either classified "Combined Water Use – Mariculture" or "Bay Conservation" by the Harbor District and zoned "Natural Resources – Wetland" by Humboldt County.

[1] Humboldt Bay Harbor, Recreation and Conservation District, Humboldt Bay Management Plan Vol. 1, Ch. 2.0, Fig. 2-1 (2007).

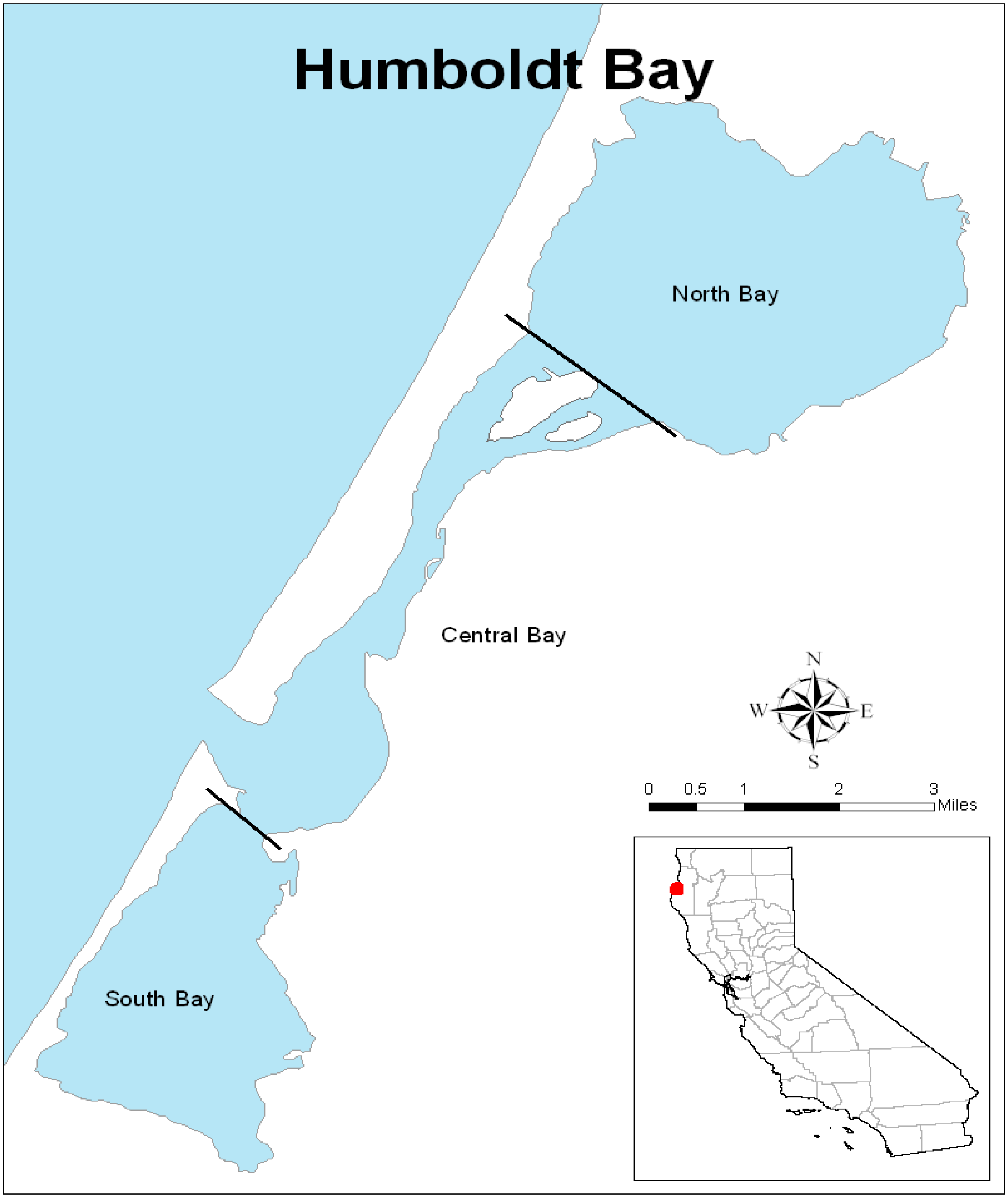


Figure 3.1. Map of Humboldt Bay depicting South, Central and North Bays. The Project is located in North Bay and Central Bay.

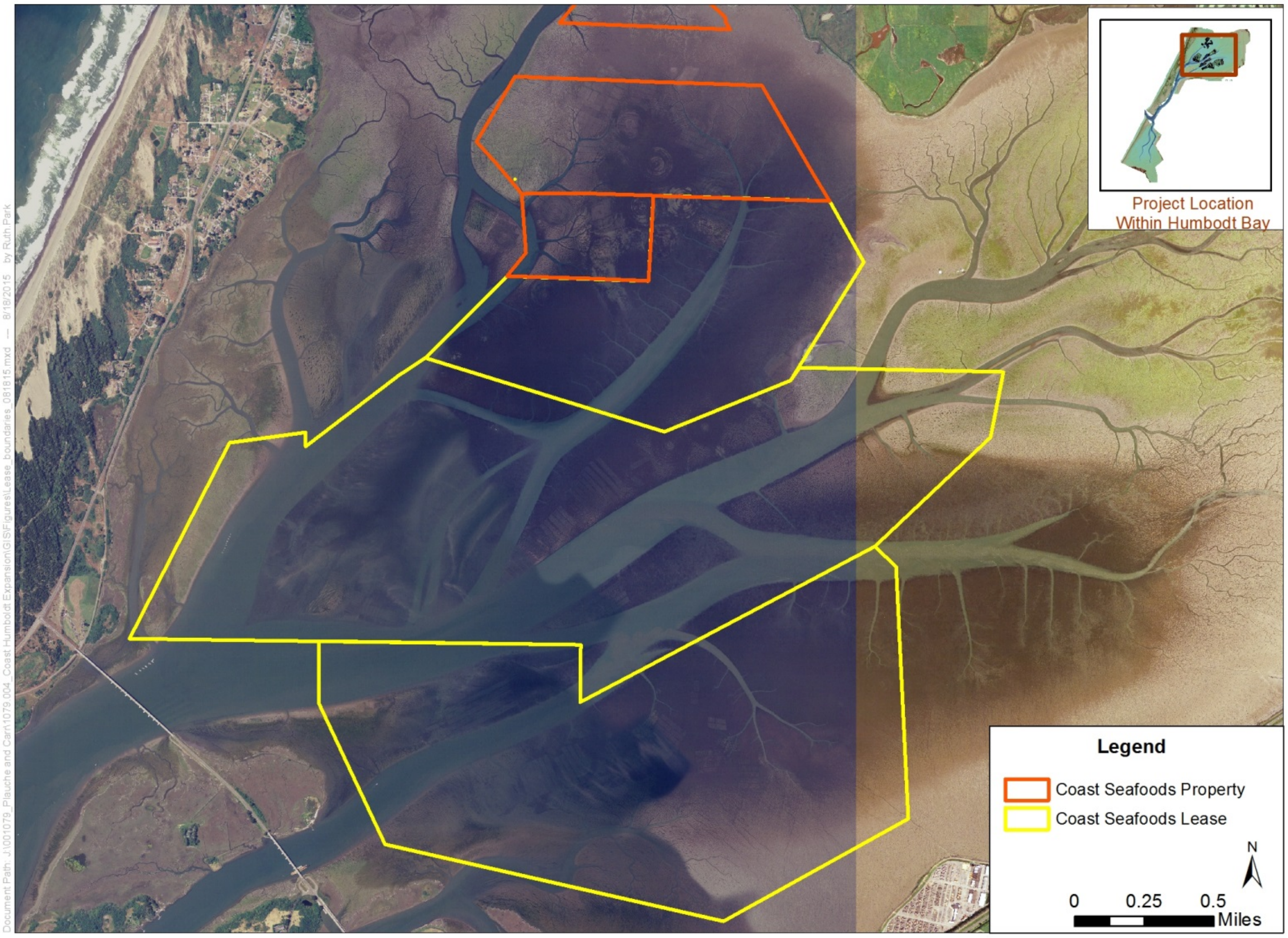


Figure 3.2. Coast's shellfish culture leases and ownership in Humboldt Bay, California.

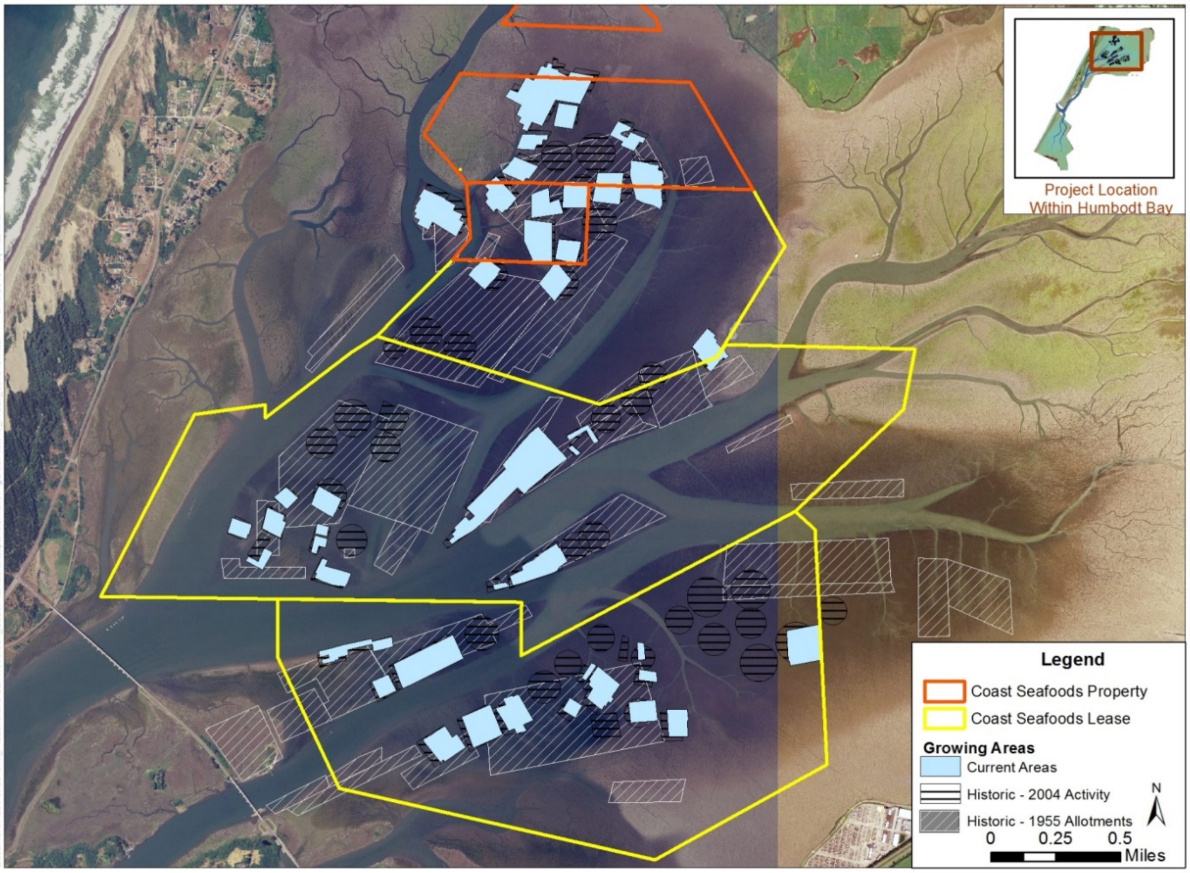


Figure 3.3. Map of Coast's historical and current culture footprint within North Bay and of the boundaries of Coast's current owned and leased area.[2]

[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.

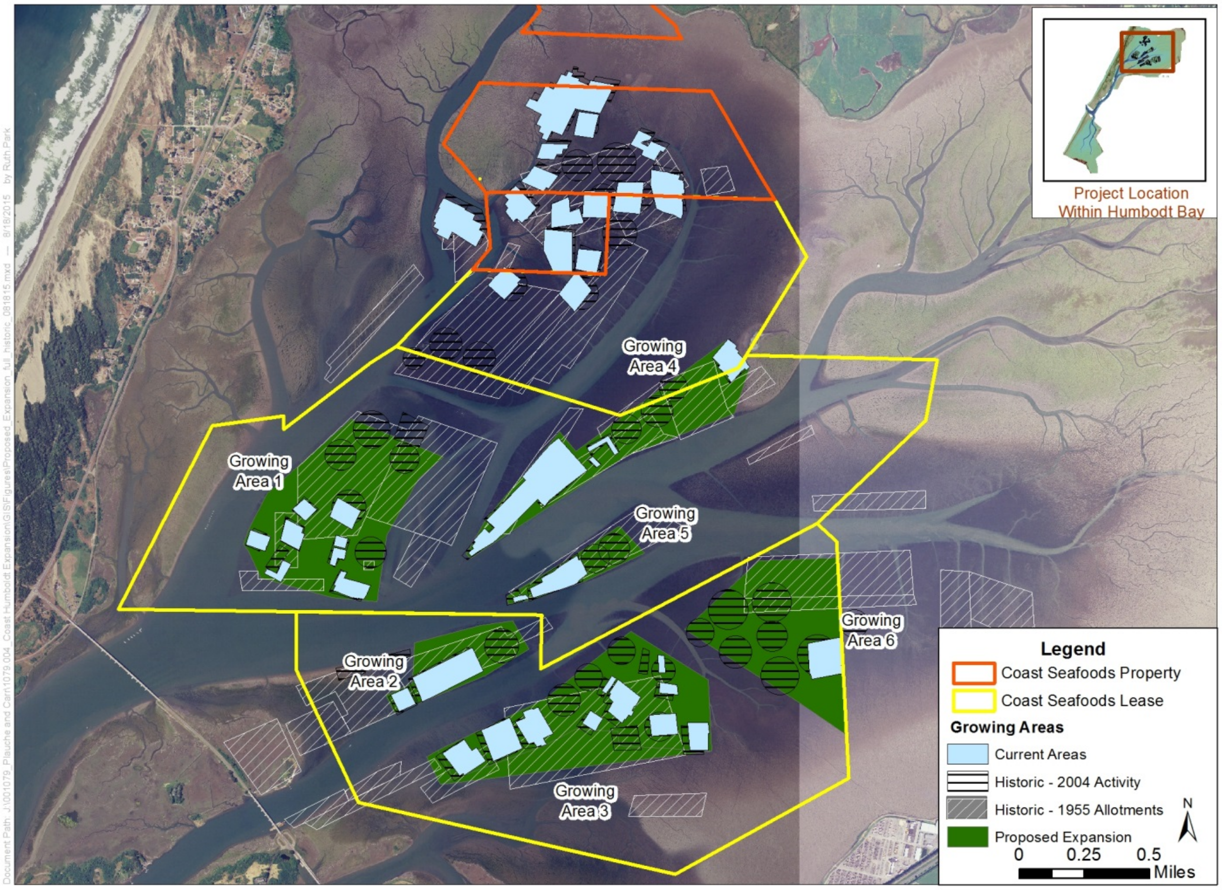


Figure 3.4. Areas proposed for continued and expanded shellfish culture in North Bay.

3.3 Project Background and Existing Operations

Coast has been culturing shellfish in Humboldt Bay, California since the early 1950's. Coast's predecessors in interest cultured shellfish in Humboldt Bay since the early 1900s. Historically, Coast cultured as much as 1000 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 300 acres within North Bay and Central Bay using exclusively off-bottom culture methods (cultch-on-longline, basket-on-longline, and rack and bag) to cultivate Pacific and Kumamoto oysters. Coast's cultivated footprint boundaries have not changed since its 2006 approvals. The off-bottom culture methods were approved pursuant to a Mitigated Negative Declaration (SCH 99062069), Harbor District Permit 04-03, U.S. Army Corps of Engineers (Corps) Permit No. 26912N, and Coastal Commission Coastal Development Permit E-06-003. These approvals also permitted 10 clam rafts, a FLUPSY, intertidal nursery, and wet storage areas. Coast also received approval for an additional 20 clam rafts within its leased area in 2012, pursuant to a Negative Declaration, Harbor District Permit Amendment 04-03-1, Corps Permit No. 2011-00428, and Coastal Commission Permit E-02-005-A2. This EIR incorporates by reference the analysis presented in the prior Mitigated Negative Declarations and accompanying Initial Studies. Figures 3.5 and 3.6 depict Coast's existing culture activities in Humboldt Bay.

Coast currently uses approximately 294 acres of its existing beds to cultivate Pacific and Kumamoto oysters using longline culture (cultch-on-longline and basket-on-longline). The existing footprint includes approximately 34,665 longlines (466 basket-on-longline and 34,199 cultch-on-longline). These culture methods, which will also be utilized in the proposed expansion area, are discussed below.

The remaining acreage within the existing operational footprint is apportioned as follows: approximately 4.8 acres utilized as a nursery area; approximately 0.04 acres utilized for the FLUPSY; approximately 0.04 acres utilized for wet storage floats; and approximately 0.93 acres utilized for clam rafts.[3] Other than slightly reducing the existing planted footprint, as described below, Coast does not propose any changes to the existing cultivated area.

[3] While Coast's existing permits allow for one 20-foot-wide by 27-foot-long floating work platform associated with the clam rafts, Coast currently does not moor a permanent work platform to the clam raft operations. The work platform may be moored to the clam rafts on a temporary basis as needed.

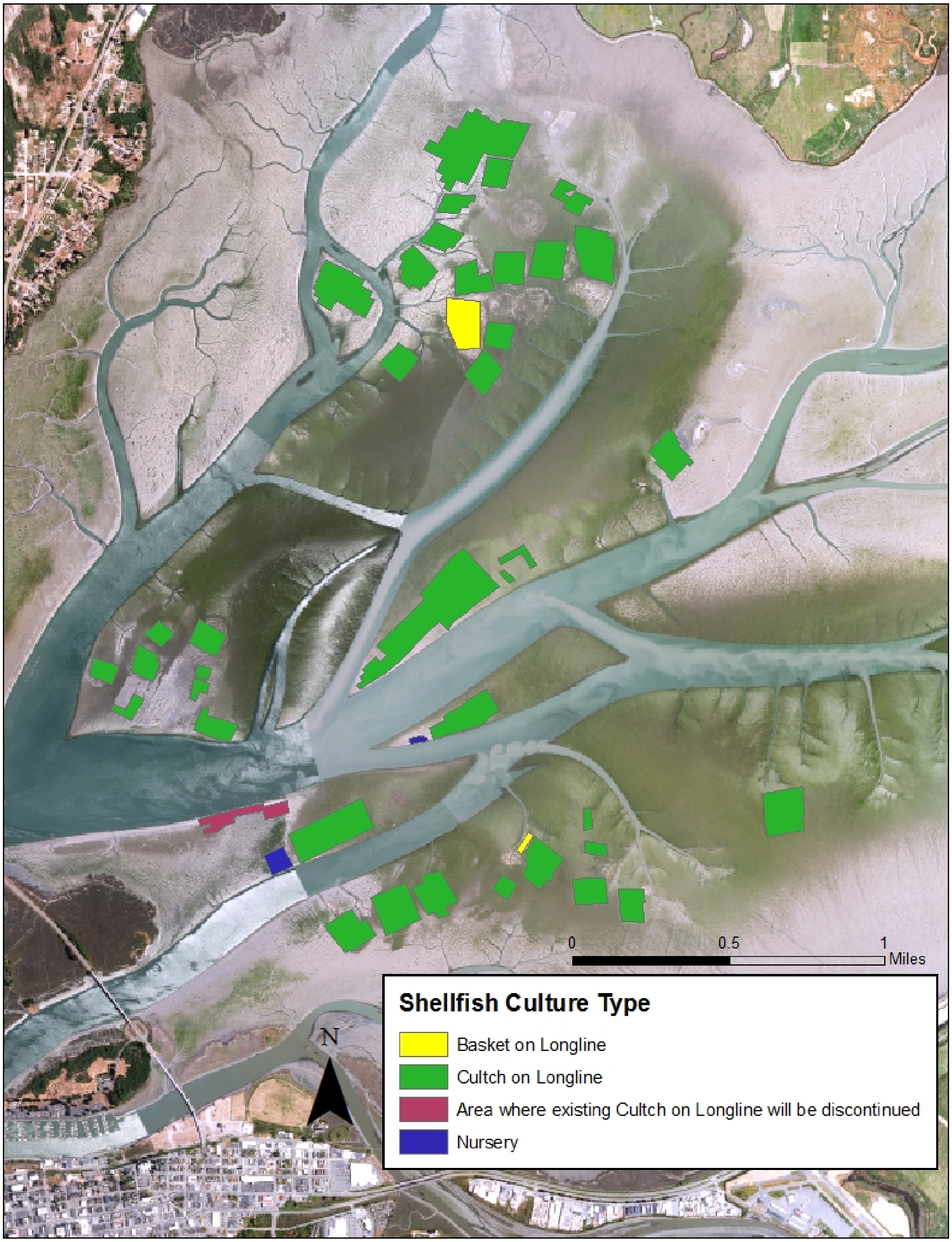


Figure 3.5. Coast's existing intertidal shellfish culture footprint and methods, including a 5.5 acre area where existing culture will be discontinued.

Figure 3.6. Coast's existing subtidal shellfish culture footprint and methods.

3.3.1 Intertidal Nurseries

Figure 3.7. Seed bags at a nursery.

Long-line culture utilizes cultch set with spat attached, collectively referred to as seed. Coast transports the seed by truck from Quilcene, Washington. Each year a representative sample of each type of seed is examined by a United States Department of Agriculture/Animal Plant Health Inspection Service certified veterinarian and the results of this examination are sent to the California Department of Fish and Wildlife (CDFW) with an application for import of seed. Once appropriate results are verified, CDFW issues a certification for the import of oyster seed. Upon arrival, Coast places the bags of seed in the intertidal nursery on Gunther Island. Coast stacks the seed on pallets in order to prevent the bottom of the stack from becoming silted in, which suffocates the seed (Figure 3.7). After a period of time, which varies due to seasonal conditions (usually 2-3 months) the seed is removed from the nursery in small batches daily and is brought to the processing plant. At the plant, individual pieces of cultch are braided into the long-line rope and rebagged. Once the cultch has been braided into the rope and bagged it is put into the bay and placed on either a bed or on Coast's Arcata Channel nursery to await planting.

The seed is transported by boat to nursery areas located in Humboldt Bay on mudflats north of Gunther Island and along Arcata Channel. At these nursery areas the seed is allowed to grow to a less fragile size and age. This process, called beach hardening, is needed to allow the seed to gain size and strength prior to planting. The seed is allowed to beach harden for 3 to 8 months depending on time of year, growth and condition of the seed.

3.3.2 Intertidal Cultch-on-Longline Culture

Kumamoto oysters and Pacific oysters are grown using the cultch-on-longline method. Planting is accomplished by placing the seeded long-line on notched PVC stakes that are arranged in rows on the mudflats. The longlines are strung through notches on top of the PVC stakes, suspending the oyster seed approximately 1 foot above the bay bottom (Figures 3.8 & 3.10). Long-line spacing within Coast's existing operational footprint varies, with most spaced 2.5 feet apart, with 10 feet between each group of 5 lines (Figure 3.9). Some beds have 2.5 foot spacing over the entire bed.

Long-lines are planted by crews of six at tides low enough to allow for walking on the planting bed. Bags from the nursery are gathered with a skiff and a hook during a high tide, to plant during the subsequent low tide. Alternatively, the planting crew can pull the skiff into the nursery by hand when the tide is coming in and manually throw the bags into the skiff. Bags are then transported to the bed and placed along the edge of a row of empty long-line pipe. At low tide, the longlines are cut and pulled out alongside the empty pipe. Each bag is clipped to the long-line on the notch of each pipe. This continues until all bags are planted. Due to the infrequency of adequately low tides, the planting crew works every available low tide.

Planted beds are inspected monthly, with virtually no other activity occurring on the bed until harvest. Inspection involves walking on the bed at low tide to make sure that the lines are in the notches.

Oysters are harvested when they reach harvestable size (18 to 36 months) subject to seasonal conditions and consumer demand. Two long-line harvest methods are used. Hand picking involves placing round 20-bushel tubs on the bed at high tide using an oyster scow. Tubs are hand filled at low tide. Longlines are cut into manageable single clusters and placed in the tub with a floating ball attached. At high tide, tubs are placed in the oyster scow, unloaded, then placed back on the bed to be refilled. The long-line harvester method involves pulling individual lines onto a scow at high tide, either by hand or with a hydraulically operated roller. Hand-pulled lines are cut into individual clusters, usually at the plant. Mechanically pulled lines are run through a breaker that strips the clusters from the line.

Figure 3.8. Cultch-on-longline oyster culture.

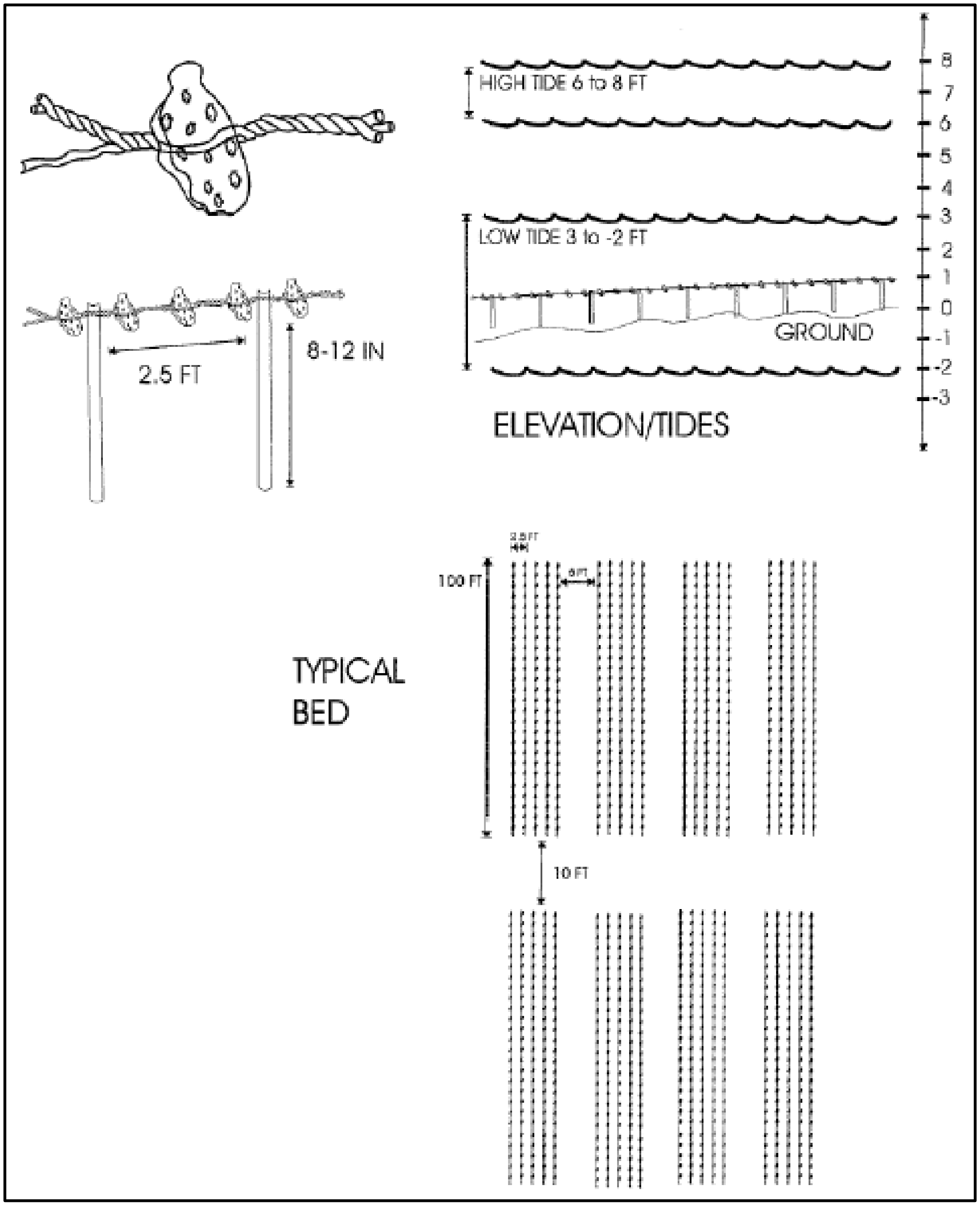


Figure 3.9. Configuration of cultch-on-longline oyster culture within Coast's existing culture area.

Figure 3.10. Cultch-on-longline culture at 2.5 foot spacing.

3.3.3 Intertidal Basket-on-Longline Culture

Kumamoto oysters are grown using the basket-on-longline culture method which utilizes baskets suspended on monofilament line tied between 2 inch diameter schedule 80 PVC pipes (Figure 3.11).

A 3/8" polyethylene sleeve encases the 5mm diameter monofilament line. The baskets are approximately 24"x10"x6" in size and held on the line with plastic clips. A float, approximately 2.5" in diameter and 5.5" long, is often attached to the baskets so they float up during high tides. The line is positioned approximately 2.5' to 3.0' off the bottom making the baskets roughly 1' from the bottom during low tides.

Basket-on-longline lines within Coast's existing culture areas use 3-foot spacing between groups of three lines, with an open row of 20 feet between groups of three lines. Basket-on-longline spacing in the existing culture area is shown in (Figure 3.12).

Figure 3.11. Basket-on-longline culture.

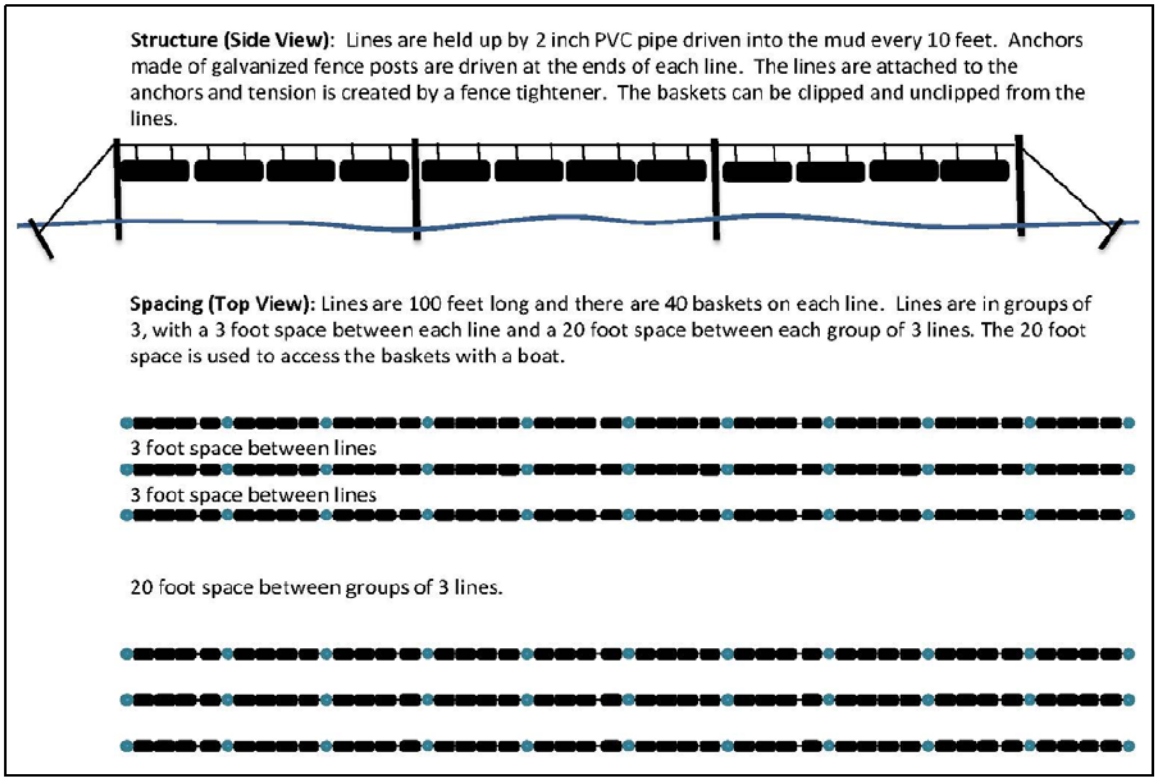


Figure 3.12. Basket-on-longline culture configuration within Coast's existing cultivated acreage. Line length maximum: 100'.

3.3.4 Subtidal Floating Upwelling System

Manila clams, Kumamoto and Pacific oyster seeds are matured in the FLUPSY. The FLUPSY is located on the west side of the entrance channel south of the Simpson wood chip loading dock in Fairhaven, 200 yards from the shoreline in 20 feet of water. The FLUPSY is tied to the dock at the Eureka Boat yard. The FLUPSY is constructed of aluminum with poly-encapsulated floats with a submerged trough containing a paddle wheel (Figure 3.13). This trough is surrounded by 16 open wells containing upwelling bins. The paddle wheel moves the water out of the trough. For the trough to fill, the water must pass through the upwelling bins containing shellfish seed. The bins are removable for seed maintenance. The seed is about 1.4 mm long when it arrives and matured to roughly 6 mm before being placed in bags. FLUPSY activities include maintaining the seed by rinsing off bins with water, and seed grading based on size.

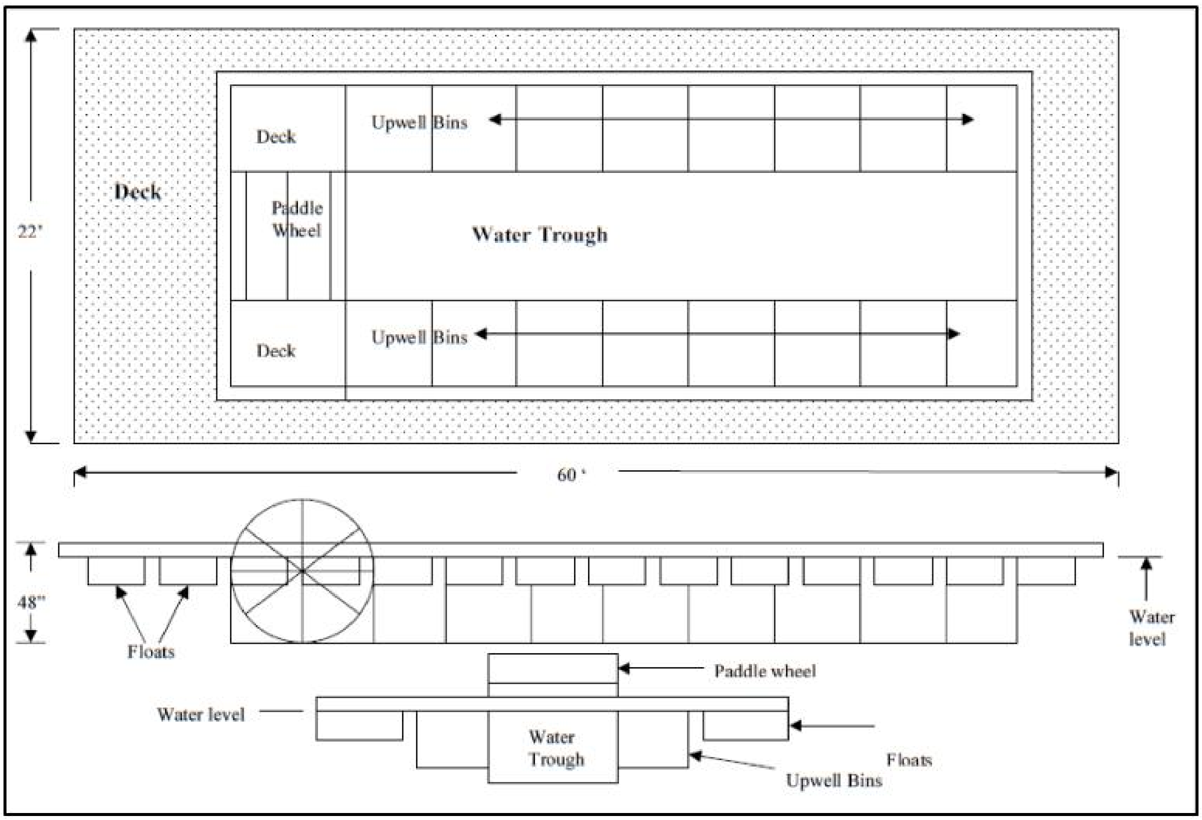


Figure 3.13. FLUPSY Configuration.

3.3.5 Subtidal Clam Rafts

Manila clam seed is matured in clam rafts (Figure 3.14). The clam rafts are located along the west side of the entrance to Mad River Slough Channel opposite Bird Island, approximately ½ mile north of the Samoa/Hwy 255 bridges. Rafts are attached to concrete anchors in approximately 20 feet of water and accessed by skiff. There are 30 floating rafts arrayed in two groups of fifteen, each 12 feet wide by 20 feet long. Rafts are constructed from aluminum and use polyethylene encapsulated Styrofoam for floatation. Each raft has 24 tray wells containing seed nursery trays in stacks of 20 suspended in each well. The rafts only contain seed, which are shipped elsewhere for grow-out and harvest. The activities at the clam rafts include placing and removing stacks of trays daily, cleaning and routine maintenance. Twice each year, anchors and ground tackle are examined and repaired as necessary by divers using scuba, skiffs and an oyster barge.

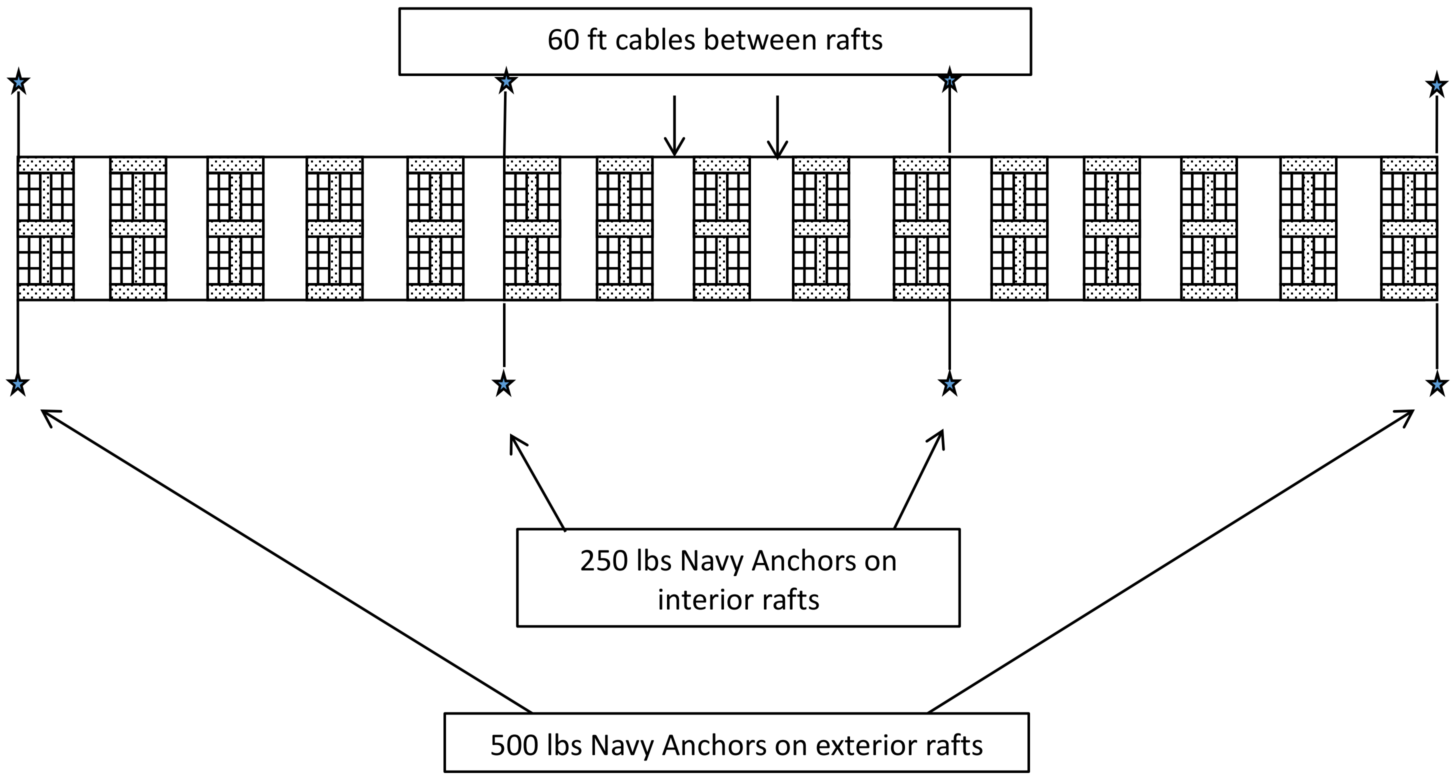


Figure 3.14. Configuration of clam rafts.

3.3.6 Subtidal Wet Storage Floats

The wet storage floats are located in the "cut across" channel between Bird Island and Mad River. The floats are anchored in approximately 20 feet of water in a series of four 20-foot by 20-foot square wooden frames, with 60 feet between floats (Figure 3.15). Bags of mature oysters recently harvested and ready for distribution to wholesalers are temporarily placed in the floats to maintain the oysters' fresh condition. Bags of oysters are placed and removed by hand and transported by boat.

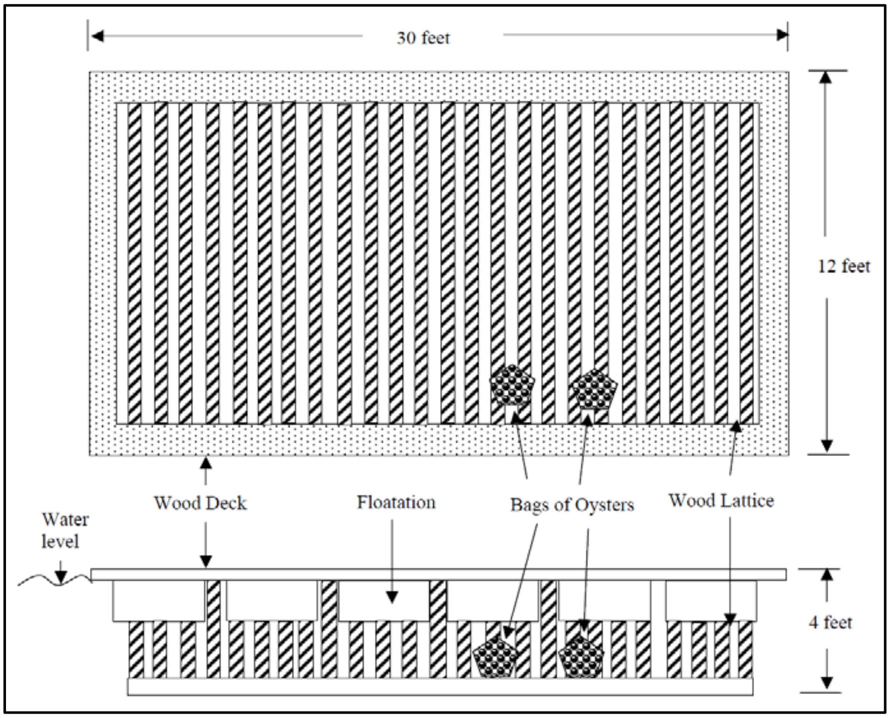


Figure 3.15. Configuration of wet storage floats.

3.4 Project Overview

Coast is proposing to extend regulatory approvals for 294.5 of the 300 acres it currently farms in North Bay and to discontinue farming on 5.5 of its existing acres (Figure 3.4). Coast is also proposing to increase shellfish aquaculture production by planting an additional 622 intertidal acres and increasing the capacity of its already-permitted FLUPSY by adding eight new culture bins. In total, the project would result in 916.5 acres of intertidal oyster culture, which represents 21% of Coast's owned and leased land.

3.5 Project Characteristics

3.5.1 Project Objectives

The overall purpose of the project is to provide a comprehensive plan for management of Coast's owned and leased area and expansion of its shellfish farm to meet the increasing demand for its product. The project is guided by several major objectives that will aid decision makers in their review of the project and associated environmental impacts:

- To expand Coast's shellfish farm to increase future oyster production and meet Coast and Pacific Seafood's increasing customer demand for raw and shucked oysters.
- To conduct comprehensive eelgrass monitoring and develop sustainable oyster cultivation practices that can be adapted to documented site conditions.
- To create additional job opportunities and sustainable economic development for Humboldt Bay and local jurisdictions.
- To enhance a source of local sustainable seafood and reduce Humboldt County and California's reliance on imported seafood.
- To provide comprehensive planning of Coast's owned and leased areas in Humboldt Bay.
- To develop a flexible farming plan that can adapt to Coast's operational and management needs, environmental conditions, and farm conditions.
- To utilize Coast's existing historic leased and owned areas while maintaining undeveloped areas for habitat and recreational uses.
- To locate oyster beds in areas with optimal growing conditions to maximize efficiency and limit the spatial footprint of the farm.

3.5.2 Species Cultivated

The species proposed for cultivation are Kumamoto oysters, Pacific oysters, and Manila clams, which are already cultivated by Coast on its existing acreage.

3.5.3 Culture Methods

Coast will use the same general culture methods in the 622 acre expansion area that are currently being utilized within its existing footprint described above (intertidal cultch-on-longline and basket-on-longline), as well as a limited amount of and rack and bag culture.

3.5.3.1 Intertidal Cultch-on-Longline Culture

Coast will grow Kumamoto and Pacific oysters using cultch-on-longline culture on a maximum of 522 acres of the expansion area, utilizing 5 foot spacing between longlines with a 10 foot row between shellfish beds. Figure 3.16 depicts the spacing regime for cultch-on-longline that will be used in the expansion area. The expanded area will include approximately 43,900 additional cultch-on-longlines.[4]

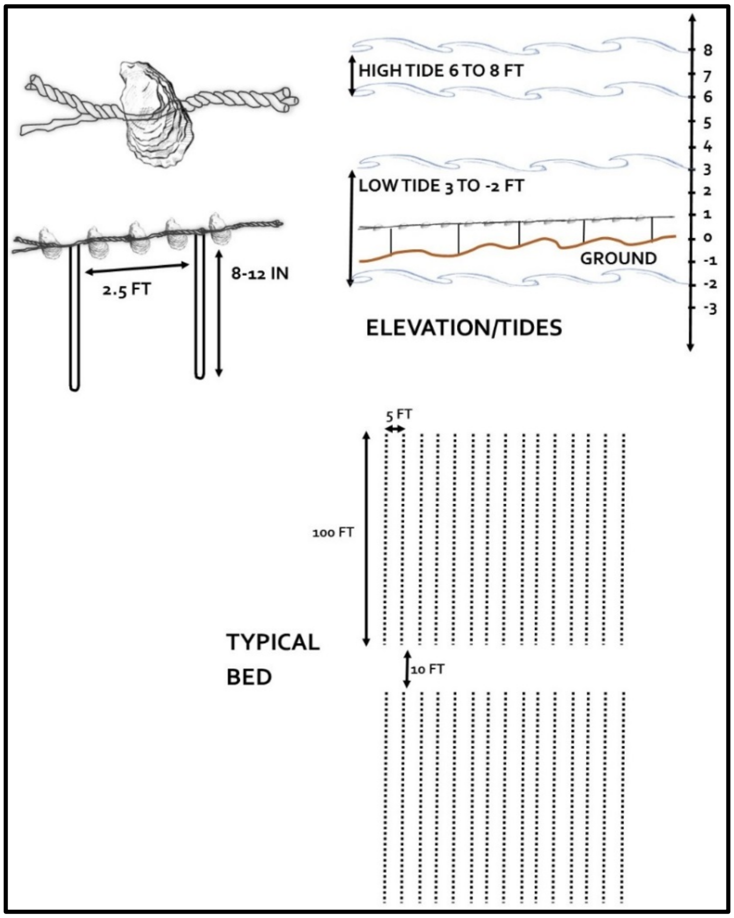


Figure 3.16. Proposed configuration of cultch-on-longline within Coast's expanded culture area.

[4] This estimate is based on Coast's conceptual planting design incorporating the proposed longline spacing. The final planting design will be based on Coast's operational needs, farm conditions, environmental factors, and conditions of approval and mitigation measures. Coast reserves the right to modify the planting design as needed to respond to such factors, provided that it is consistent with the overall project description and regulatory permits.

3.5.3.2 Intertidal Basket-on-Longline Culture

Coast will plant Kumamoto oysters using basket-on-longline culture on a maximum of 96 acres of the expansion area, utilizing groups of three lines spaced 5 feet apart with an open row of 20 feet between groups of 3 longlines and 10 feet between shellfish beds. Figure 3.17 depicts the spacing regime for basket-on-longline that will be used in the expansion area. The expanded area will include approximately 4,780 additional basket-on-longlines.[5]

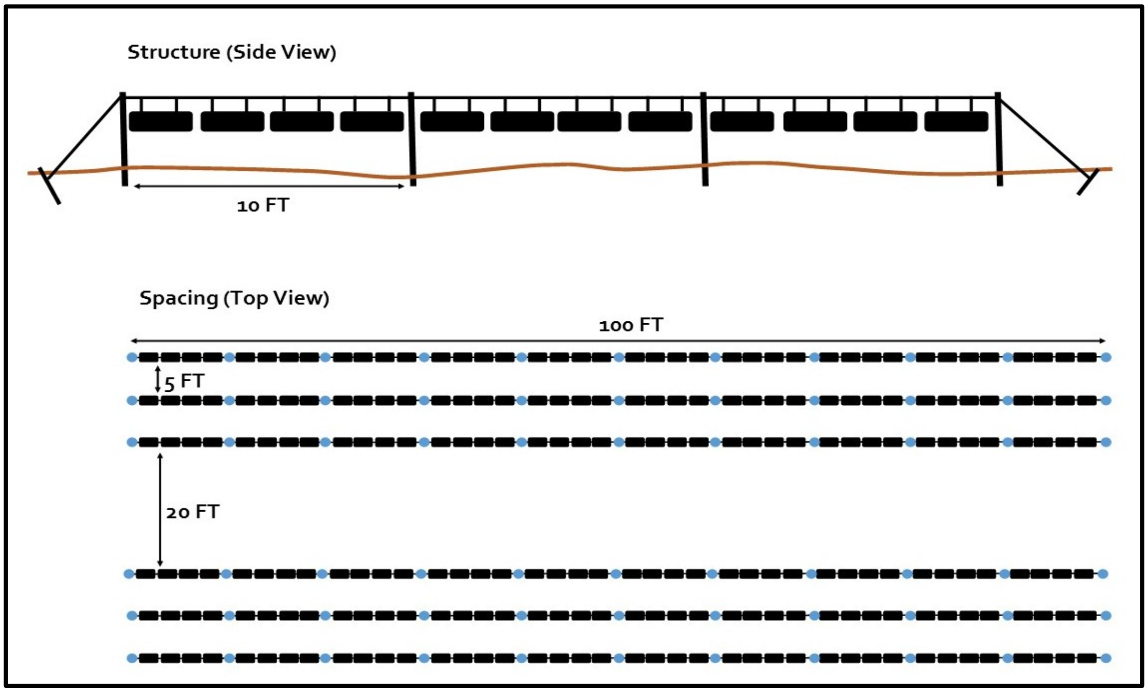


Figure 3.17. Proposed configuration for basket-on-longline culture within Coast's expanded culture area. Line length maximum: 100'.

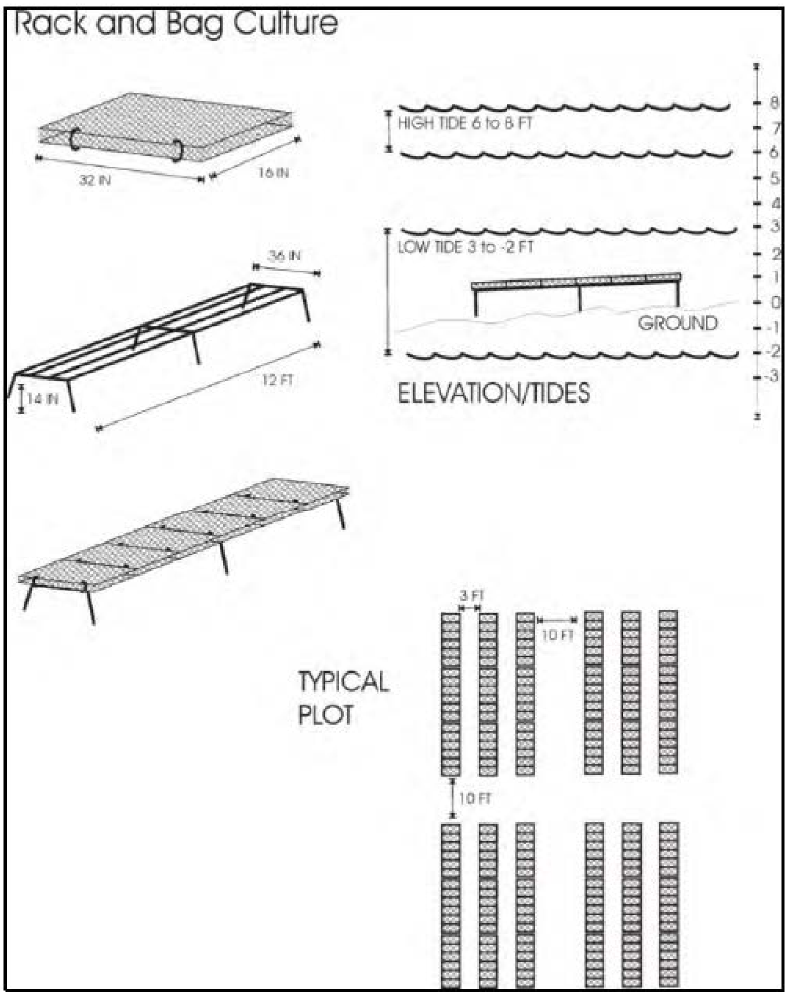
3.5.3.3 Intertidal Rack and Bag Culture

Coast will plant rack and bag culture on a maximum of 4 acres of the expansion area to grow Kumamoto and Pacific oysters. The oysters are grown as "singles", not attached to any structure or to each-other, in polyethylene mesh bags on rebar frames. Each frame is 3 ft x 12 ft and supports 3-6 bags attached to the frame via industrial rubber bands (Figure 3.18). A bag is initially seeded with oysters and placed in intertidal areas. The bags are inspected up to three times per week and flipped approximately once every two weeks. Oyster seeds grow to market size in one-two years, depending on tidal height and primary productivity. Bags are harvested by hand (lifted from the racks into a skiff), processed and brought to market. Three rows of rack and bag structures are spaced 3 feet apart with an open row of 10 feet between groups of three racks lines, as illustrated in Figure 3.19. Any rack and bag culture placed within the expanded area will be placed at least 10 feet away from existing eelgrass beds.

[5] *See* footnote 4.

Figure 3.18. Rack and bag culture in Humboldt Bay.

Figure 3.19. Rack and bag culture configuration.



3.5.3.4 Subtidal Floating Upwelling System

As part of the Project, eight upwell bins would be added to the FLUPSY as described in Section 3.3.4 above. Each bin will be 3 feet long x 3 feet wide x 3 feet deep.

3.6 Project Approvals

This EIR examines the environmental impacts of Coast's Project and is also being prepared to address various actions by the City of Eureka, Harbor District and others. The anticipated approvals required for the Project include but are not limited to those shown in Table 3.1.

Table 3.1

Agency	Permit Type
Humboldt Bay Harbor, Recreation & Conservation District	Use Permit
City of Eureka	Conditional Use Permit
United States Army Corps of Engineers	Section 10 Rivers and Harbors Act
California Coastal Commission	Coastal Development Permit and Coastal Zone Management Consistency Determination

Note: There is uncertainty as to whether certification from the North Coast Regional Water Quality Control Board will be needed. This is currently being assessed.

CONFLUENCE ENVIRONMENTAL COMPANY

H.T. HARVEY & ASSOCIATES
Ecological Consultants

SHN
Engineers & Geologists

Coast Seafoods Proposed Expansion in Humboldt Bay, California

Potential Impacts, Monitoring, and Mitigation

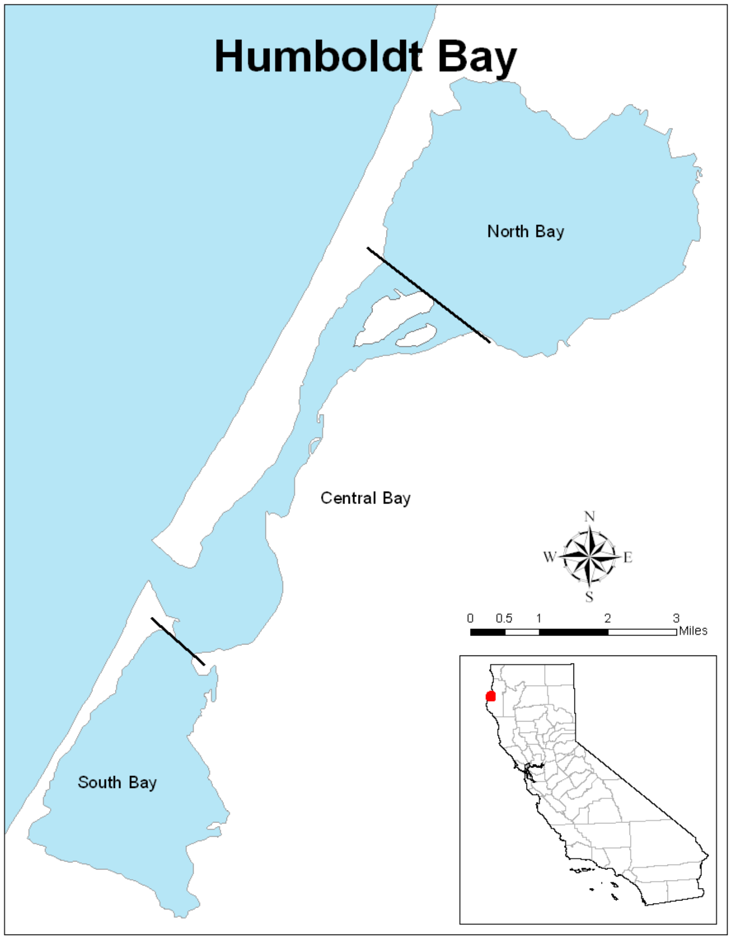
September 1, 2015

www.confenv.com

Outline

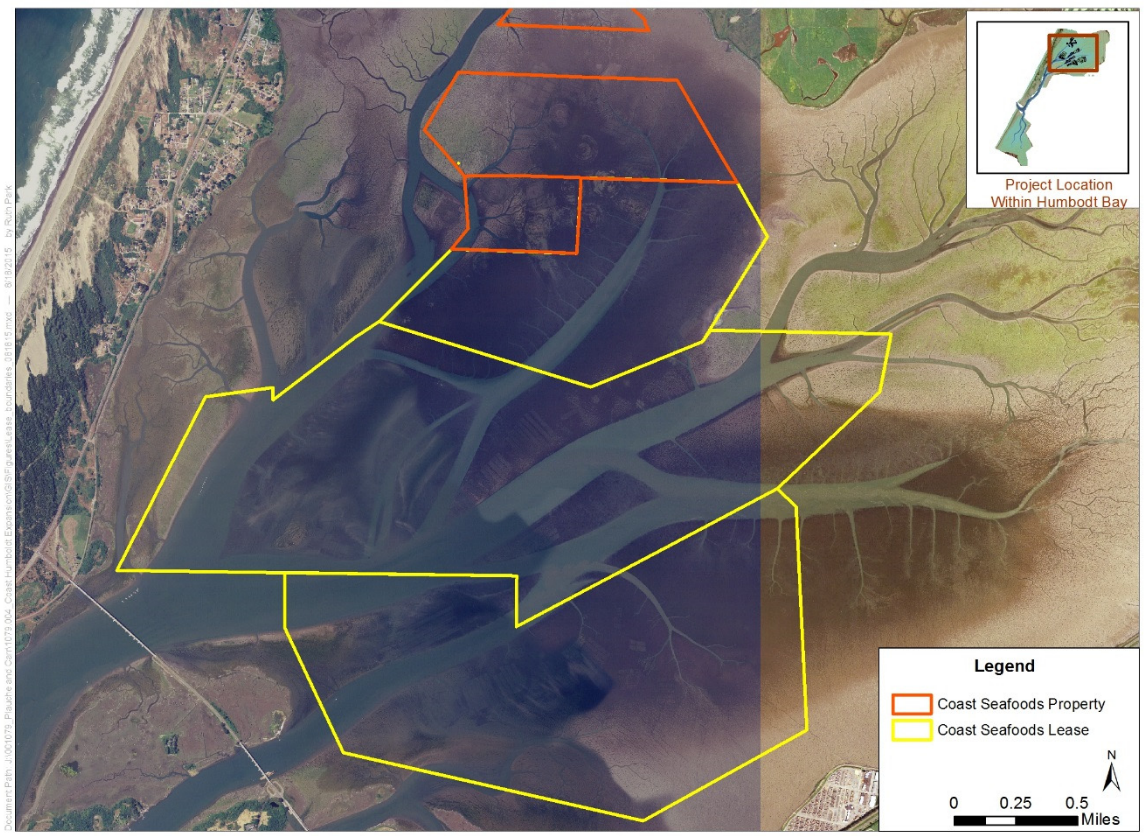
- Project Description
- Eelgrass in Humboldt Bay
- Eelgrass Mitigation Sequencing
- Eelgrass Impacts and Monitoring
- Eelgrass Mitigation Options
- Eelgrass Mitigation Accounting
- Brant and Bird Impacts
- Fish Impacts
- Other Biological Resources
- Project Summary

Project Description:
Understanding the Context of the Farm



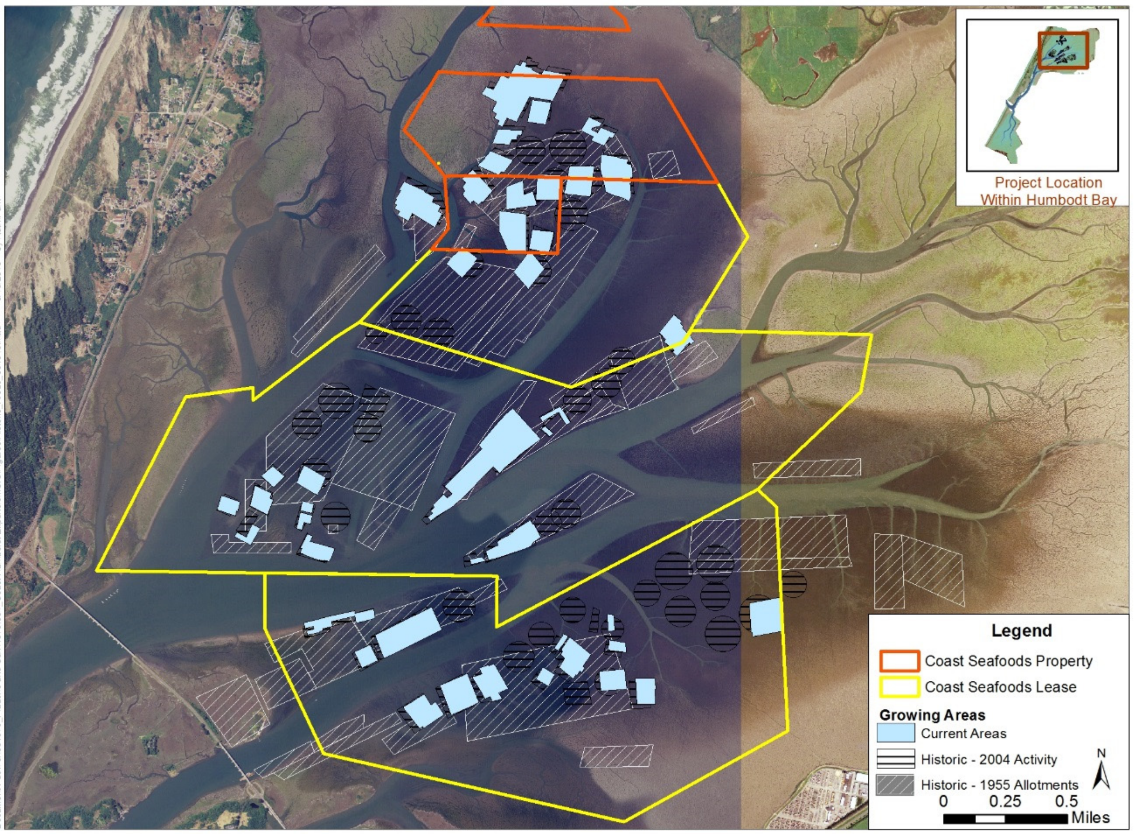
- Shellfish Aquaculture
  - Shellfish aquaculture has occurred at a commercial scale since at least the 1950s
  - Humboldt Bay produces about 70% of the oysters grown in California (K. Ramey, pers. comm., 2015)
- Humboldt Bay Eelgrass
  - Currently represents up to 53% of California's eelgrass habitat
  - Increased over 3,000 acres since the 1950s, although this is partially a result of monitoring techniques
  - Wide range in natural variability of eelgrass density, especially in North Bay

Project Description:
Understanding the Context of the Farm



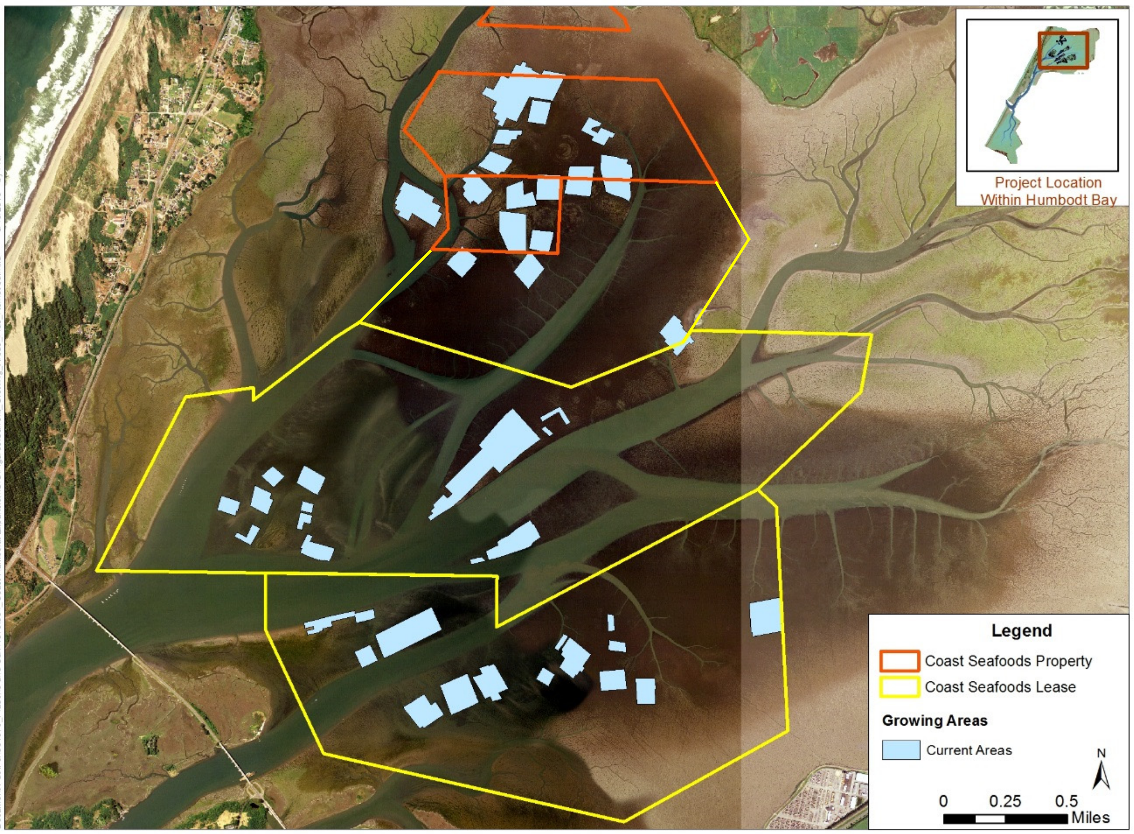
- Owned and Leased Area
  - Total Area = ~4,300 acres
- Culture Methods
  - Originally a Pacific oyster bottom-culture operation
  - Bottom-culture methods included mechanical dredge harvesting
  - Culture also included nursery areas (i.e., seed grow-out prior to planting in tide flats) and Manila clam rafts

Project Description:
Understanding the Context of the Farm



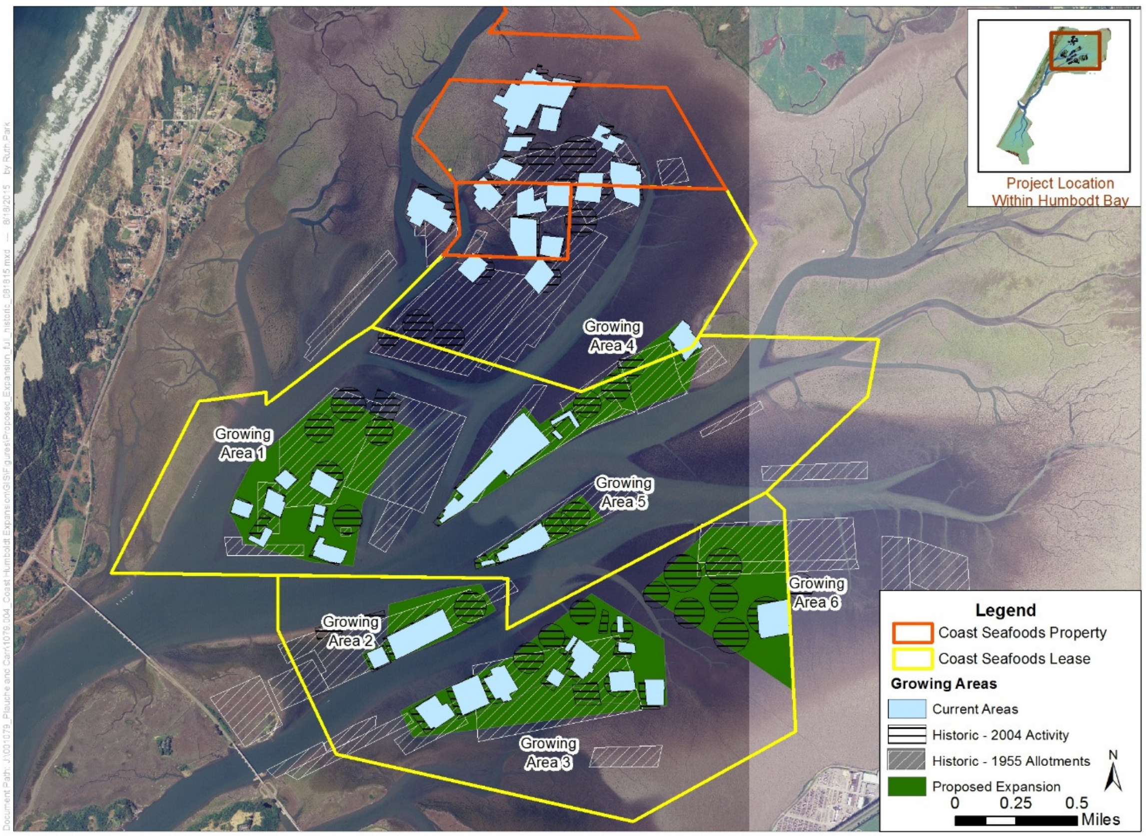
- Historical Footprint
  - Cumulative area farmed since 1950s = ~1,000 acres
- Culture Methods
  - 1950s-1960s: Pacific oyster bottom culture
  - 1960s-1970s: began using off-bottom methods, including stake, rack-and-bag, and longline culture
  - Early 1970s: started culturing Kumamoto oysters using longline and rack-and-bag

Project Description:
Understanding the Context of the Farm



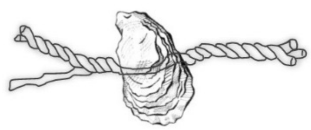
- Existing Footprint
  - Farmed footprint since 2006 = 300 acres
- Culture Methods
  - 1997-2006: converted >500 acres from ground to cultch-on-longline and basket-on-longline culture
  - Conversion allowed for BMP research on culture methods in eelgrass (WRAC study)
  - WRAC results provided BMPs to guide how to design a proposed expansion project

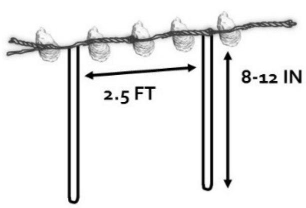
Project Description:
Understanding the Context of the Farm

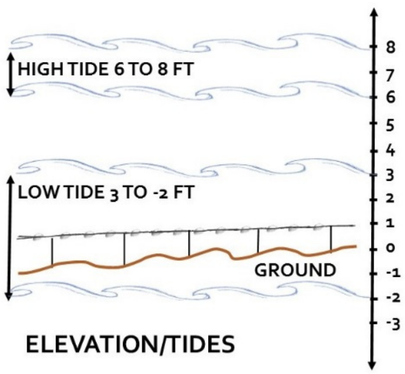


- Proposed Project
  - Existing Culture: 294.5 acres (removes 5.5 acres)
  - Expansion: 622 acres
- Proposed Culture Methods
  - Primarily (84%) includes cultch-on-longline operations
  - Remaining (16%) includes basket-on-longline and rack-and-bag culture
  - No rack-and-bag culture would be placed within 10 feet of existing eelgrass beds

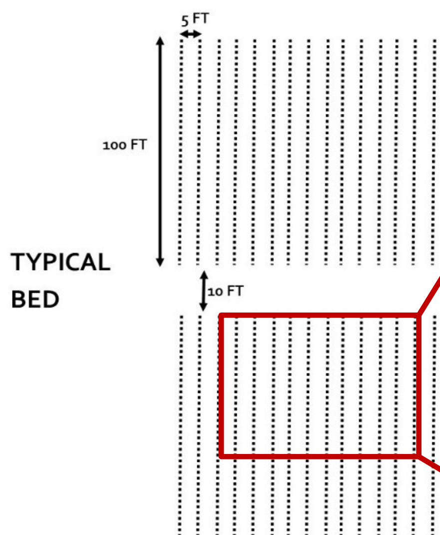
Project Description:
Proposed Culture Methods







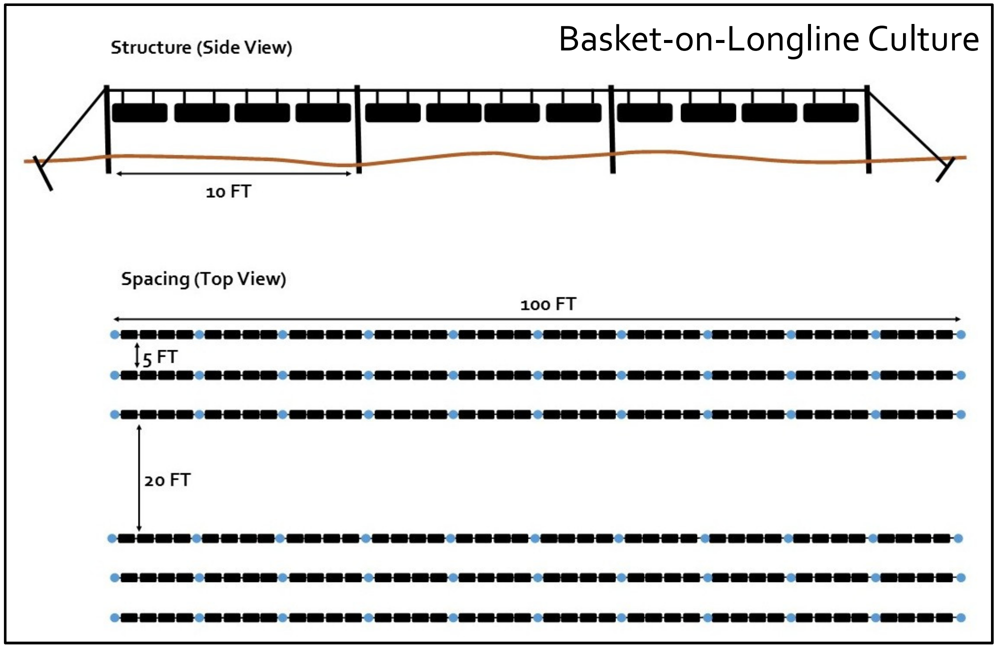
- Cultch-on-Longline
  - Total Area: 522 acres
  - Total in Eelgrass: 504 acres
- Proposed Spacing
  - Single 100-ft longline every 5 ft
  - Open row of 10 ft between shellfish beds

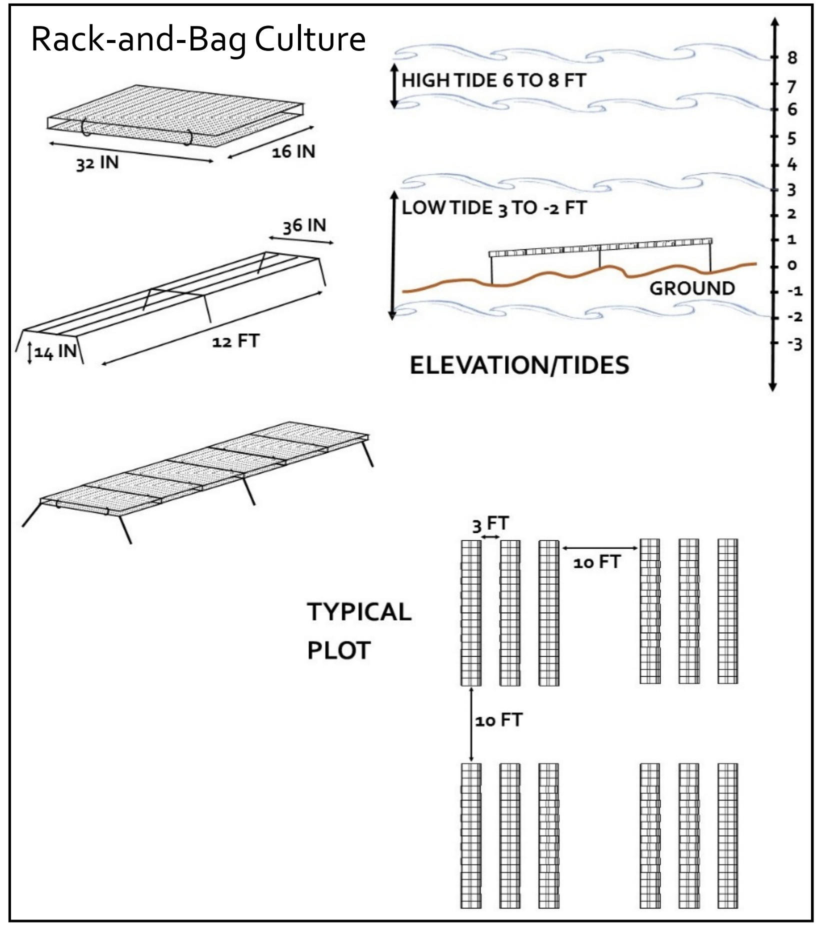


Note: photograph shows 2.5-ft spacing

Project Description:
Proposed Culture Methods

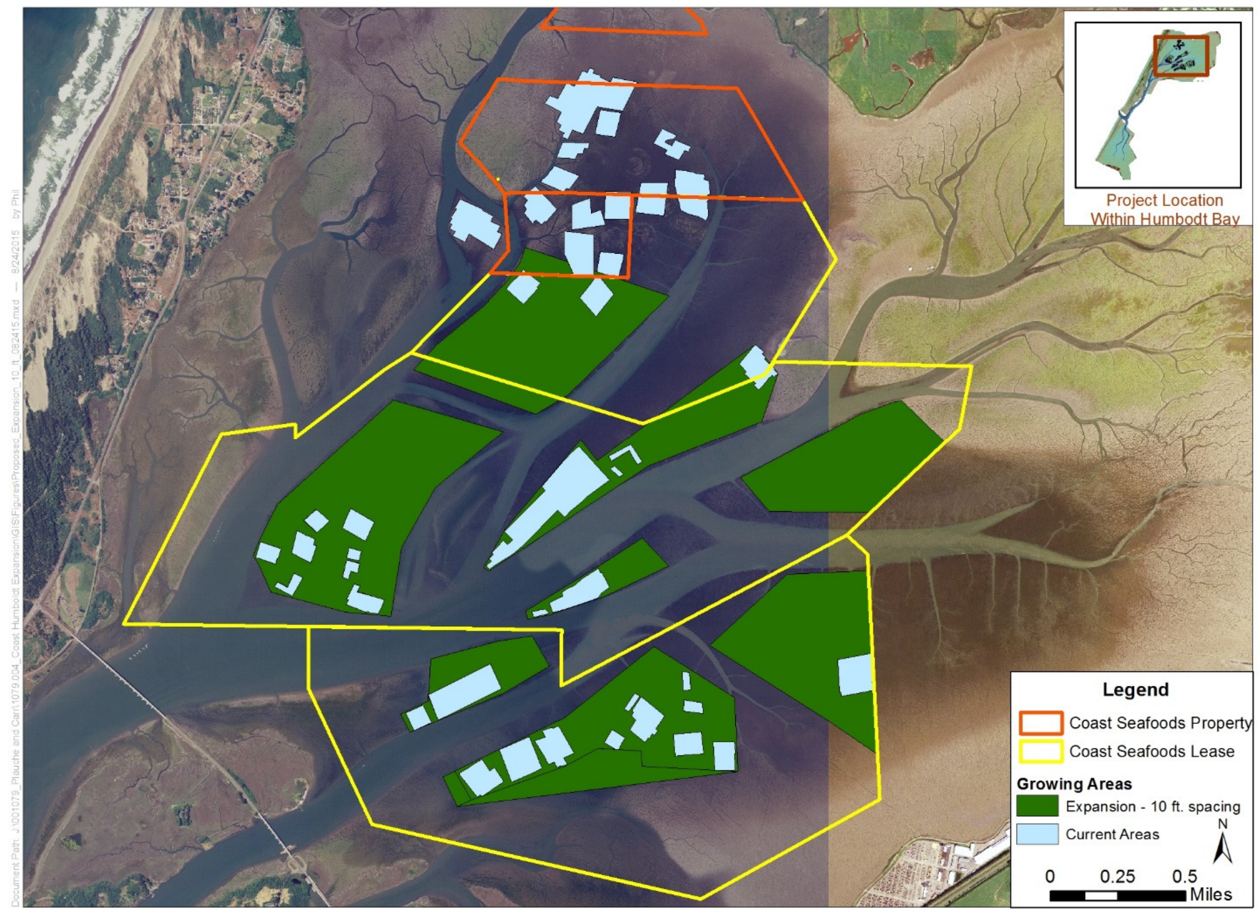
- Basket-on-Longline/Rack-and-Bag
  - Total Area: 100 acres
  - Total Basket-on-Longline in Eelgrass: 96 acres
  - Rack-and-bag culture would be planted at least 10 feet away from existing eelgrass beds





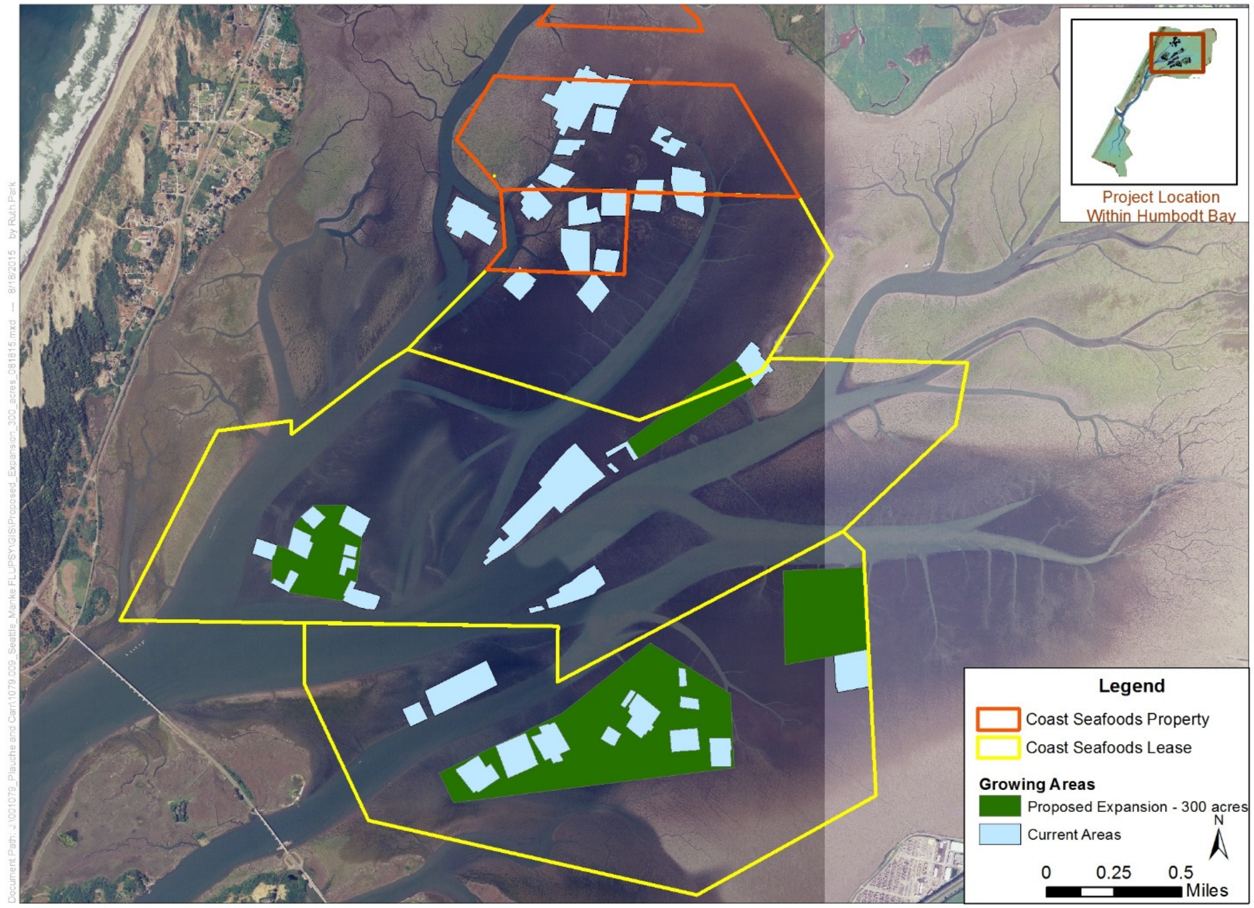
Project Description:
Proposed EIR Alternatives

- Alternative #1:
  10-ft spacing
  - Total Area: 955 acres
  - Longline culture (both cultch and basket) spaced 10 ft apart
  - Expanded footprint provides for lost oyster production due to wider spacing



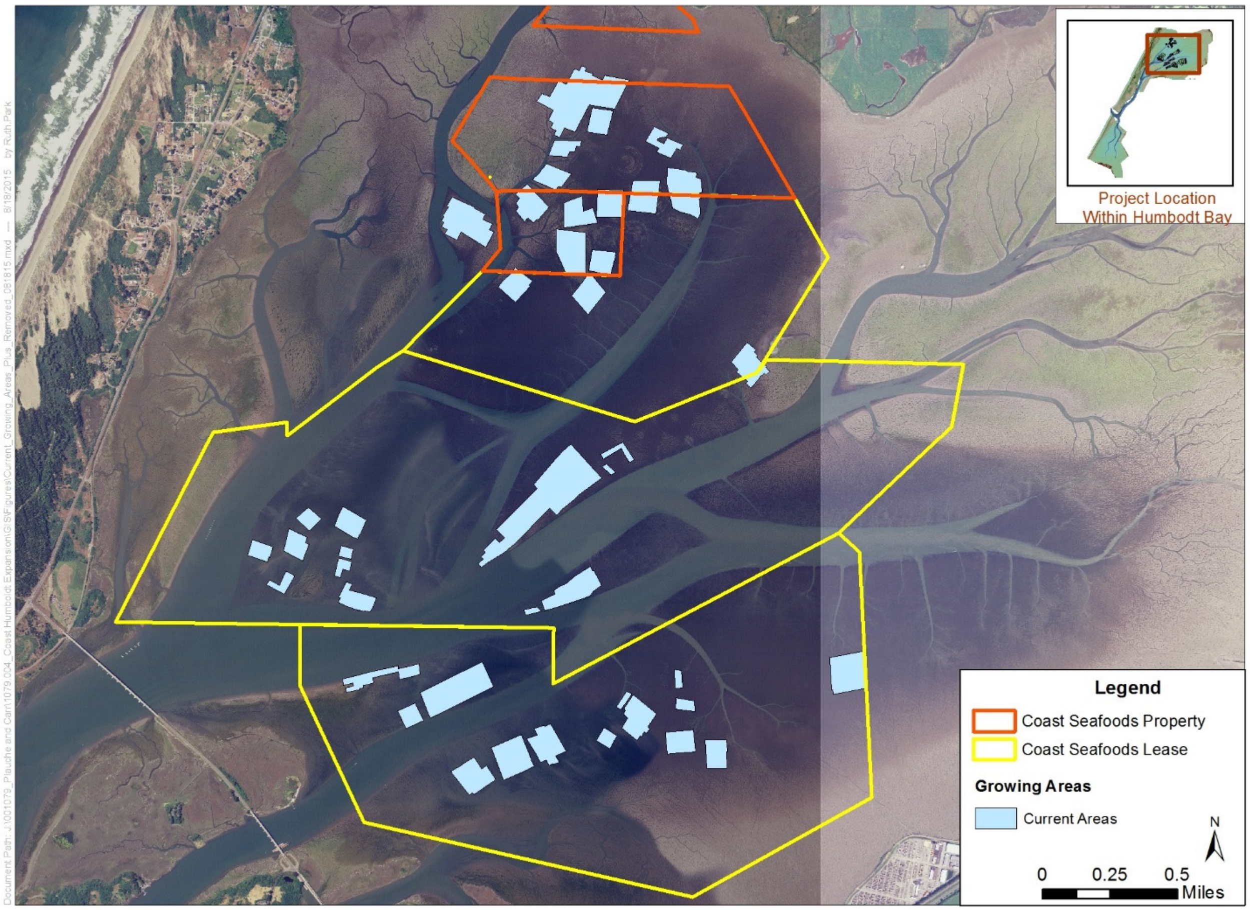
Project Description:
Proposed EIR Alternatives

- Alternative #2: Reduced Footprint
  - Total New Culture Area: 300 acres
  - Reduced footprint at 5-ft spacing
  - Proposed culture removed from Indian Island and reduced in all other locations

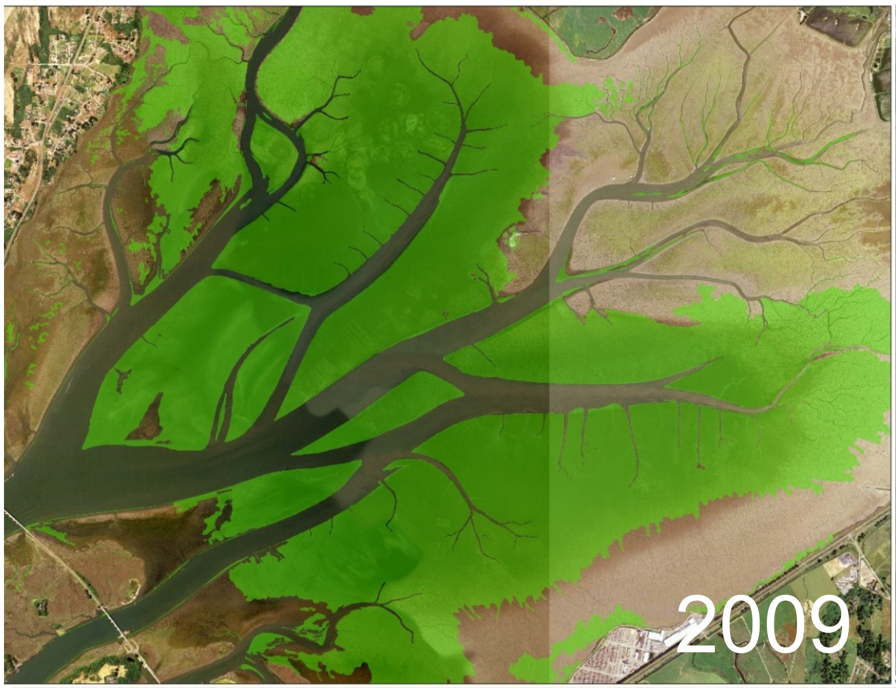


Project Description:
Proposed EIR Alternatives

- Alternative #3:
  Existing Footprint
  - Total Area: 300 acres
  - No expansion area
  - Culture would continue with existing operations
- Alternative #4:
  No Action
  - Total Area: 0 acres
  - Culture removed from Humboldt Bay
  - Includes removal of all gear and discontinuing oyster production



Eelgrass in Humboldt Bay:
Current and Historical Distribution

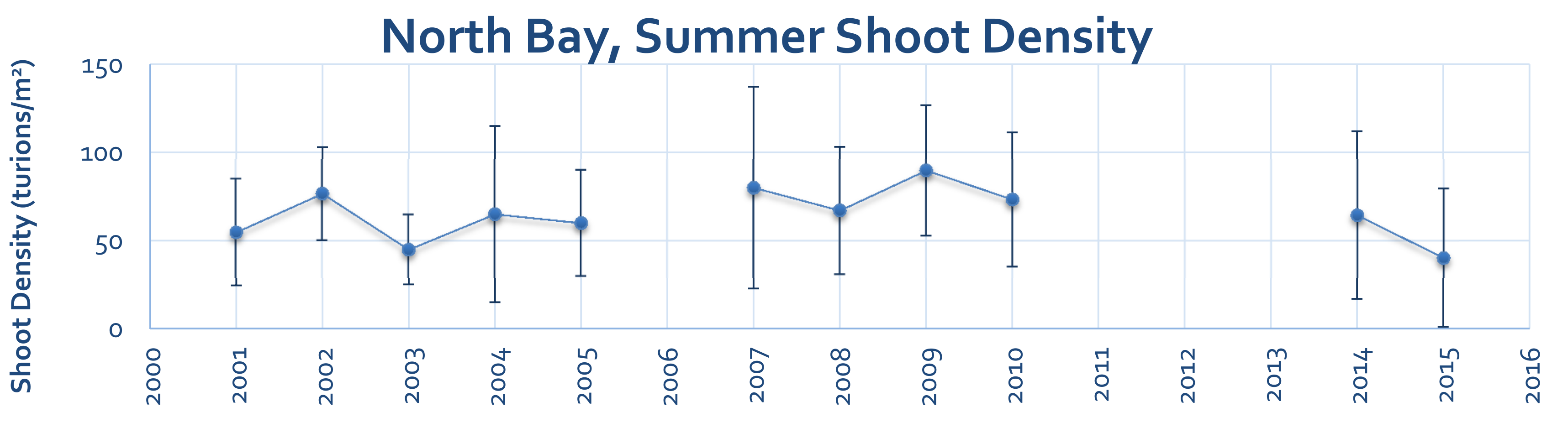


Source: *Schlosser and Eicher (2012)*

- General Trends
  - Minimum of 840 acres (1959) to maximum of 3,986 acres (2009)
  - Eelgrass is extensive and consistently present
  - High inter-annual variability, even considering limitations in mapping methods
  - Majority of current culture is in patchy eelgrass (originally planted outside of eelgrass beds)

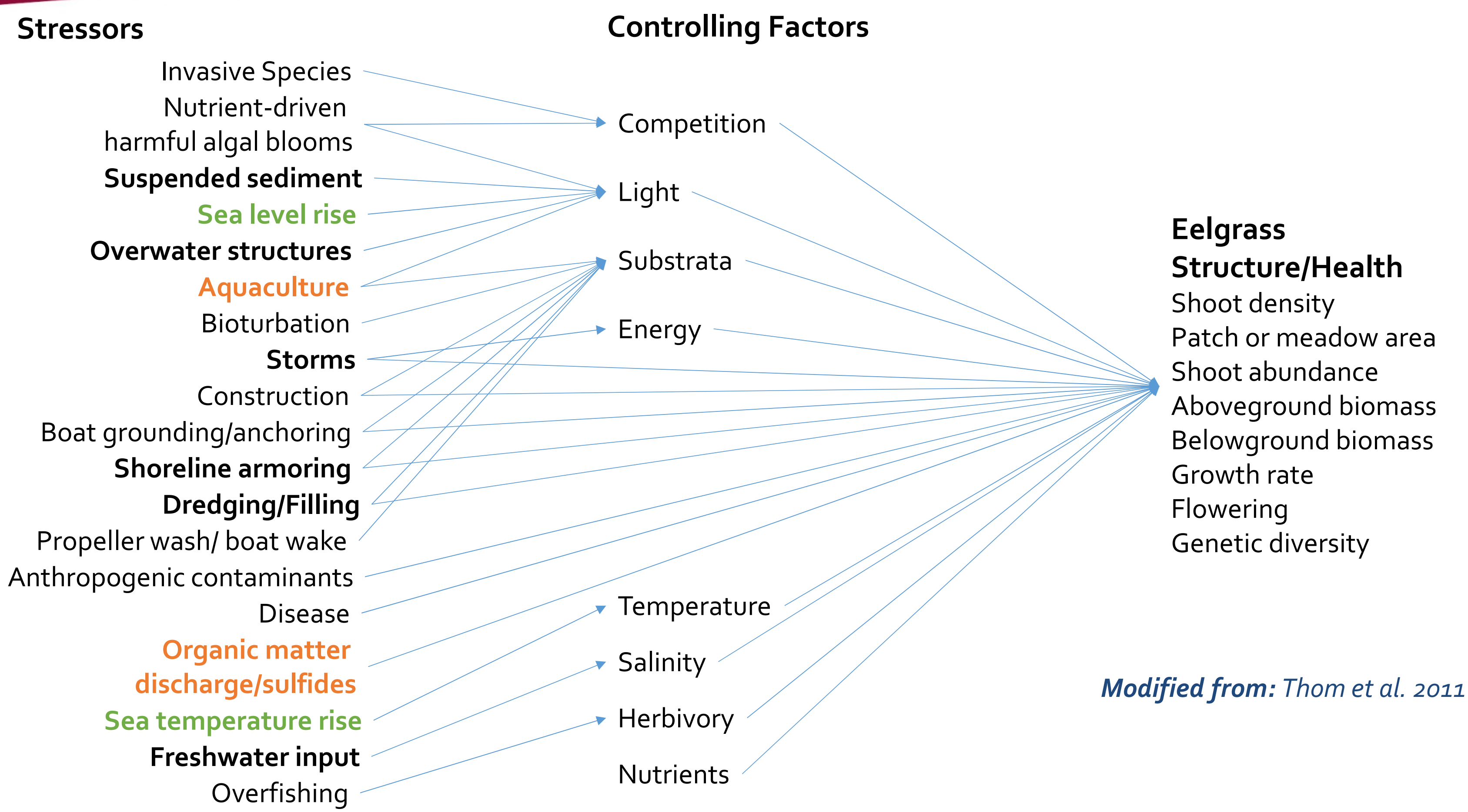
Eelgrass in Humboldt Bay:
Existing Data Sources

- Main Observations (Summer Eelgrass Density)
  - Wide range in density (48 to 272 turions/m²) within same area
  - High temporal variability (Density Δ = -41% to +45% bet. years)
  - High spatial variability (Density σ = 34% to 97% of average)



Data Sources: *Rumrill and Poulton 2004, Schlosser and Eicher 2012, SeagrassNet 2014, SHN 2015*

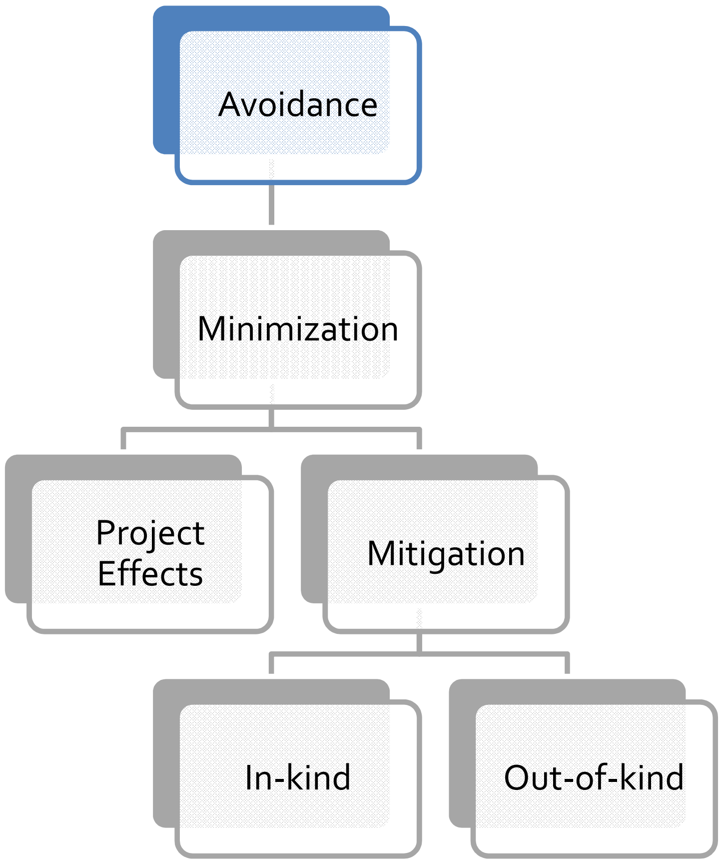
Eelgrass in Humboldt Bay:
Limiting Factors



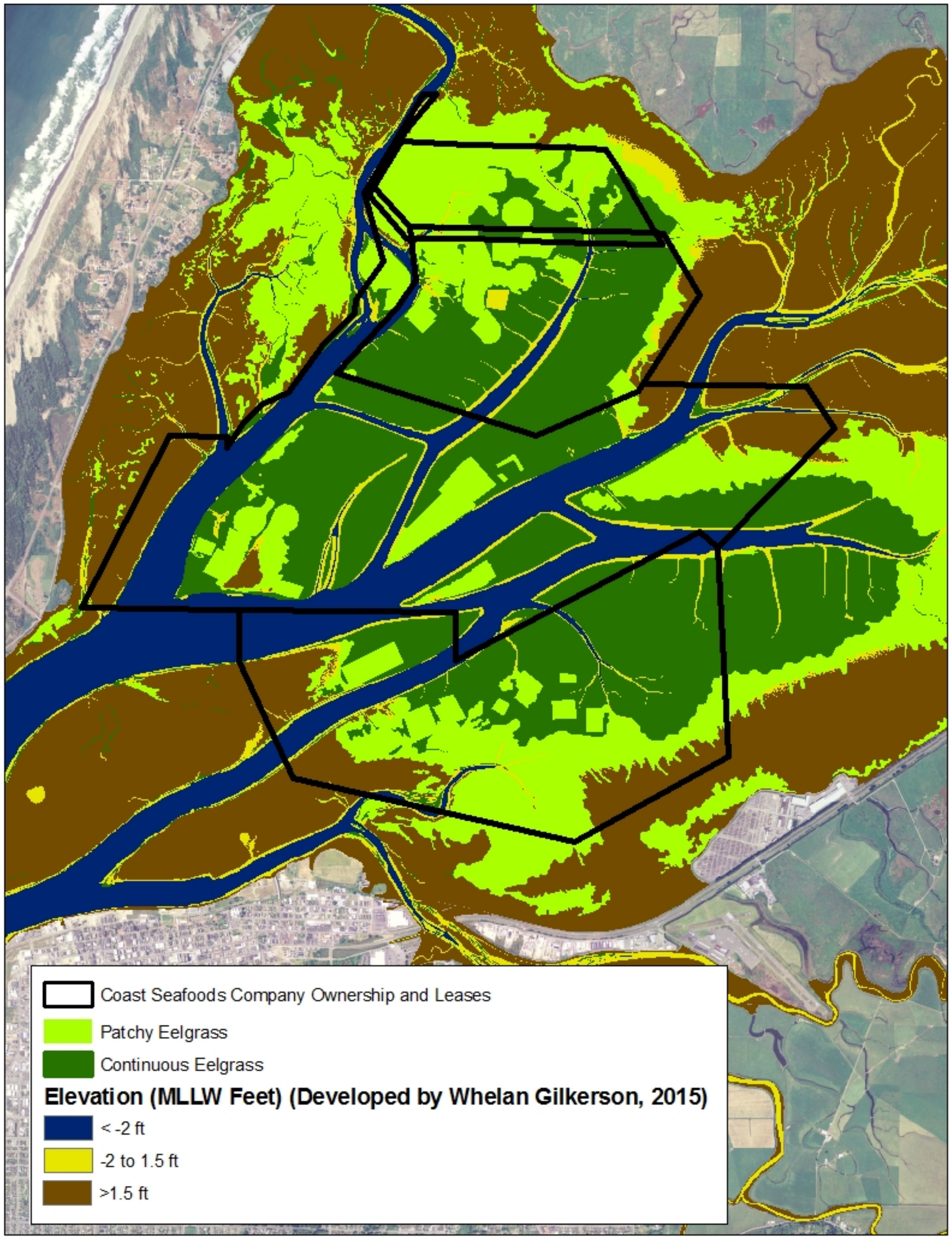
Stressors in **bold** were designated as "significant" for North Humboldt Bay based on historical, **present**, and future conditions.

Mitigation Sequencing: Avoidance

- Eelgrass is growing in most of Coast's existing lease area
- Elevation Study (Kalson and Lindke 2015)
  - Results indicated that oysters at the lower elevations (+0.5 to +1.0 ft MLLW) had significantly higher productivity compared to the higher elevations (+1.5 ft to +2.0 ft MLLW)
  - Kumamoto weight was 51% lower and number per cluster was 52% lower at the higher elevations compared to the control
  - Pacific oyster weight was 65% lower at the higher elevations compared to the control
- Increased production needed to meet Coast/Pacific demand needs

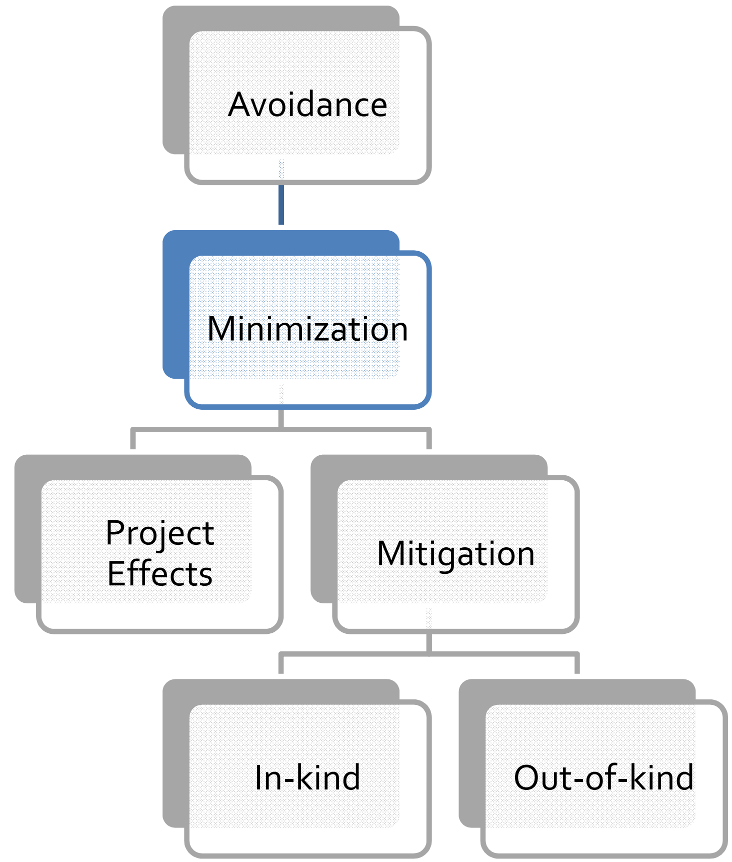


Mitigation Sequencing:
Avoidance



Mitigation Sequencing:
Minimization

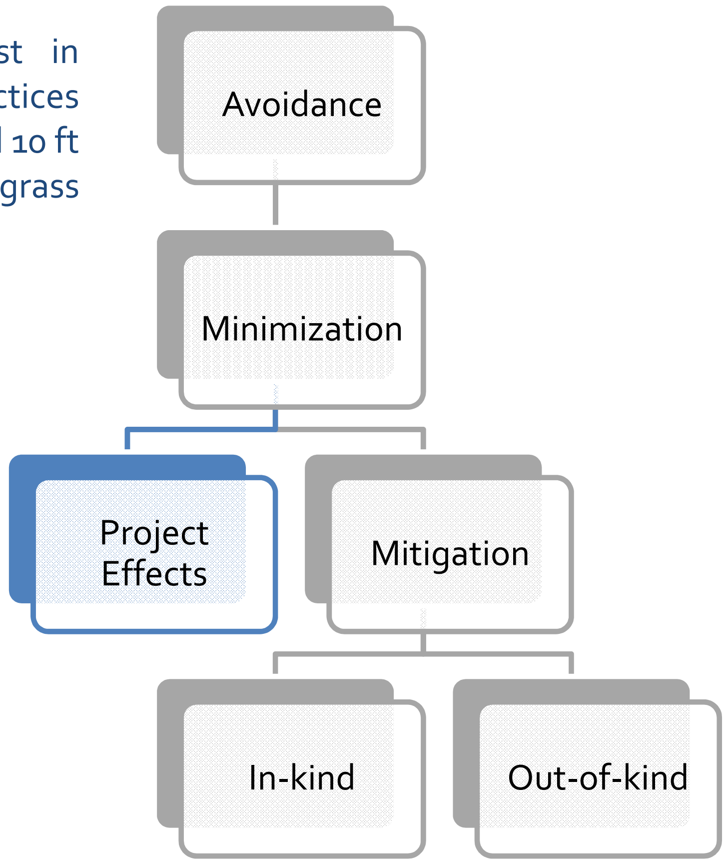
- Expand proposed longline spacing to 5-ft intervals
- Avoiding rack-and-bag culture methods in eelgrass habitat
- Most activities will be done during inundation to avoid contact with the bay bottom
- No anchoring the longline harvester in such a way as to shade the same area of eelgrass for a period exceeding twelve hours
- No intentional deposition of shells or any other material on the sea floor



Mitigation Sequencing:
Project Eelgrass Effects Overview

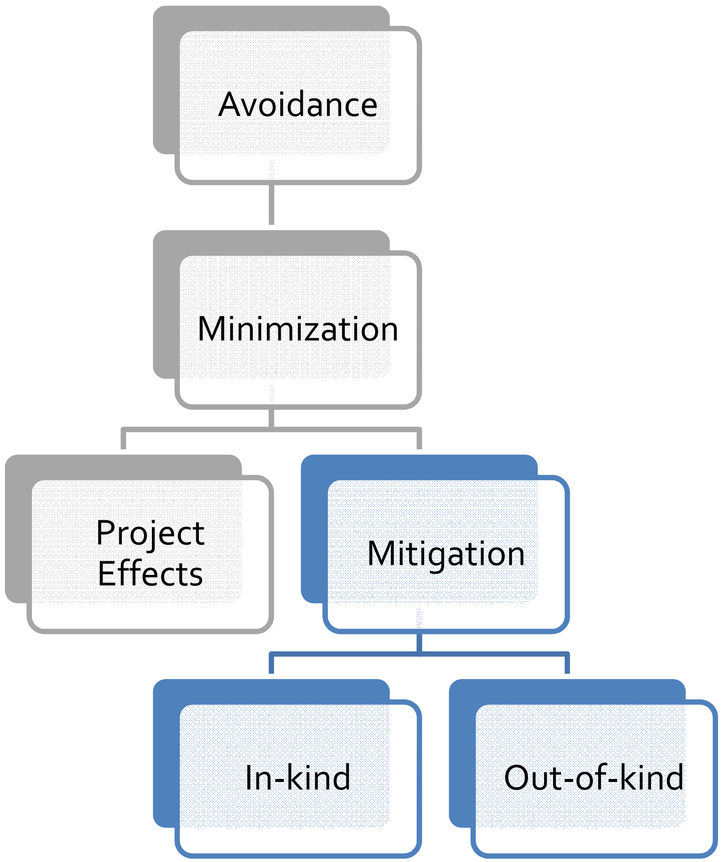
"Eelgrass beds and commercial oyster cultivation can coexist in Humboldt Bay, and that implementation of best management practices that include reduced density of oysters (i.e., oyster culture at 5 ft and 10 ft spacing between the longlines) may aid in the conservation of eelgrass communities." – Rumrill (2015)

- Proposed project alternatives are consistent with Dr. Rumrill's opinion
- No expected change to eelgrass bed areal extent – to be confirmed through monitoring
- Estimated reduction of 1.7% or less eelgrass density in relevant eelgrass beds associated with culture areas
- Reduction in eelgrass density is not likely to result in loss of eelgrass function
- Regardless of whether or not there is a loss of eelgrass function, Coast is proposing upfront mitigation



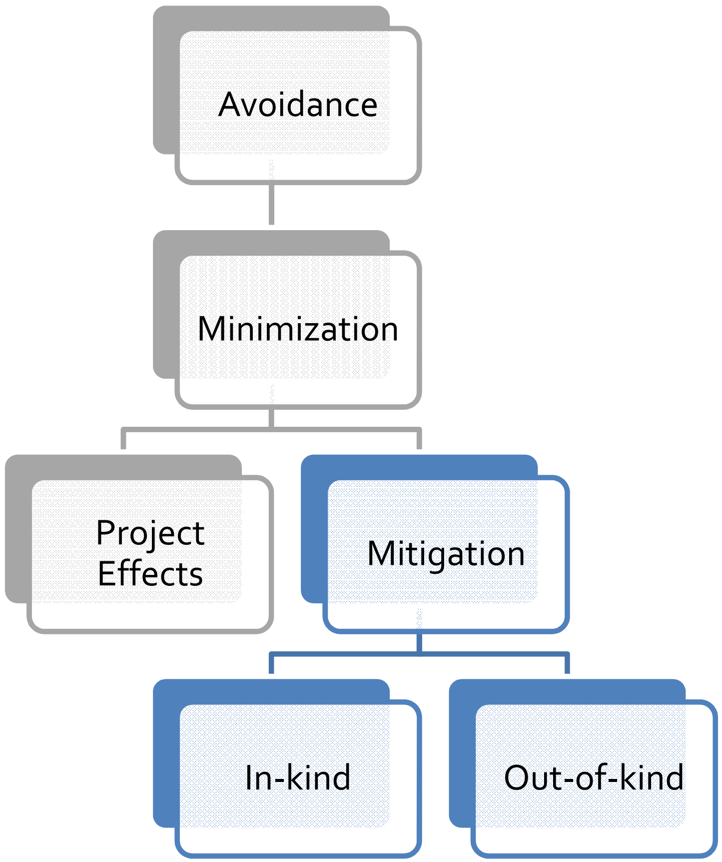
Mitigation Sequencing: Mitigation

- CEMP Guidelines
  - Compensatory mitigation should be recommended for loss of eelgrass function
  - May be scenarios where out-of-kind mitigation is ecologically desirable or in-kind is not feasible
  - Determination should be based on an established **ecosystem-based plan** that considers ecosystem function and services relevant to the geographic area and specific habitat being impacted
  - Out-of-kind mitigation that generates services similar to eelgrass habitat or improves the ability to establish eelgrass should be considered first
  - Out-of-kind mitigation may be appropriate for shellfish aquaculture projects
  - There is a 1:1 mitigation ratio for projects that reduce turion density by more than 25% with no areal loss



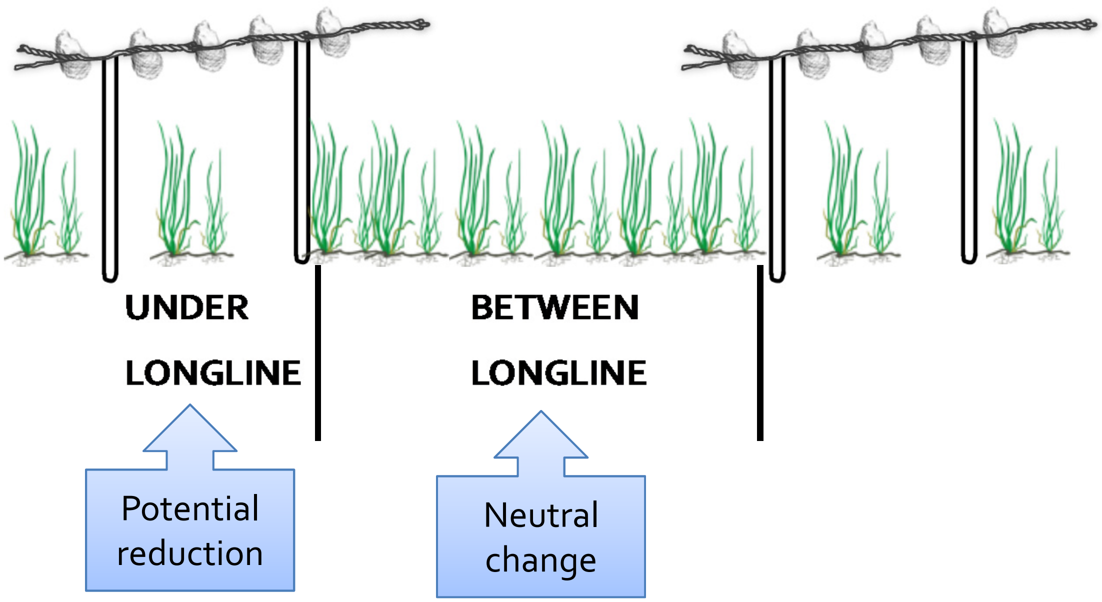
Mitigation Sequencing: Mitigation

- U.S. Army Corps of Engineers Compensatory Mitigation Rule (19594 FR 73)
  - Out-of-kind mitigation should be used when it will better serve the resource needs of the watershed
- Humboldt Bay Initiative
  - Ecosystem-based plan that considers ecosystem function and services
  - Goal: 2025 eelgrass distribution and plant density remain within 20% of observed 2001-2006 levels as measured by eelgrass acreage (areal extent) and plant density (shoots/m^2)
  - The plan acknowledges that eelgrass coverage in the bay is at, or near, observed and modelled carrying capacity
  - Comparatively, intertidal coastal marsh habitat has been reduced to **<10%** of its historical footprint



Impacts and Monitoring:
Calculating Potential Effect

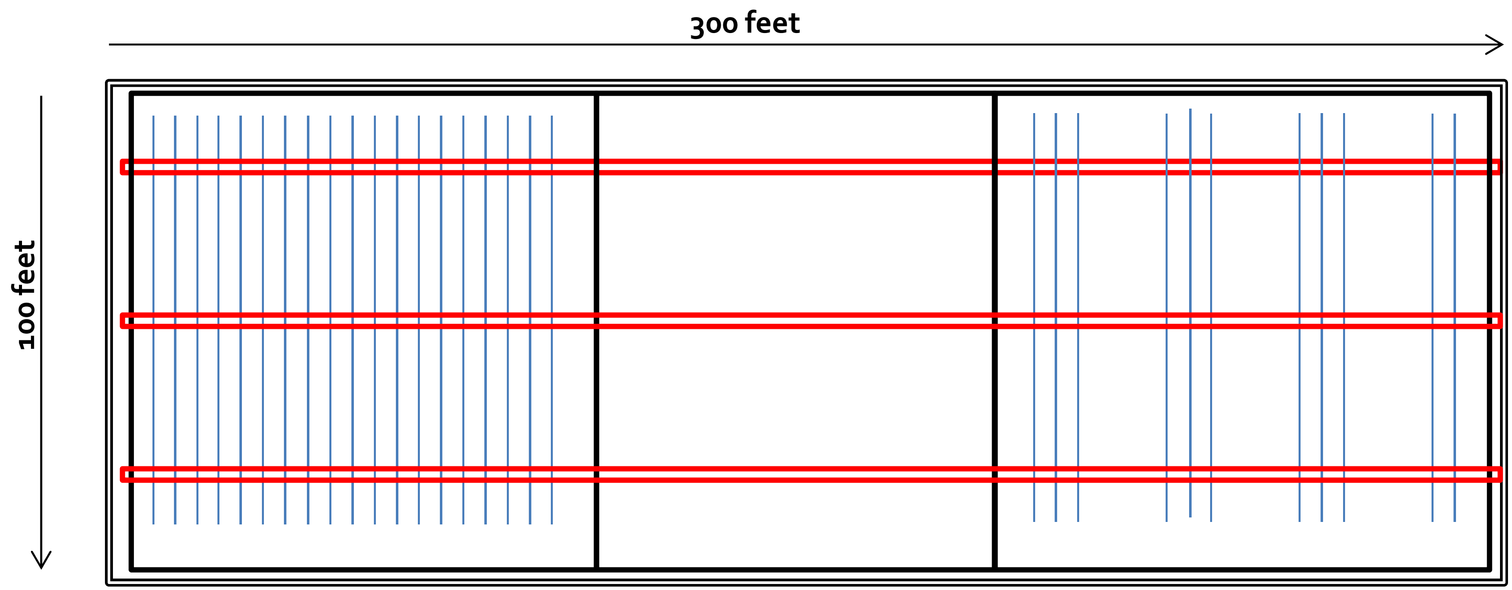
- Key Assumptions
  - Effects directly under the longlines would be similar to that reported in the literature
  - 2015 data from existing culture areas provides a more current perspective since major changes in 1997-2006
  - The effect under the longlines is the only measureable effect to eelgrass
- Major Results
  - There is not likely a loss to areal extent of eelgrass
  - Longlines reduce eelgrass density but not overall function of the eelgrass bed



- Overall Effect
  - 5.0% reduction in density at the culture plot scale
  - 1.7% reduction in density within eelgrass bed

Eelgrass in Humboldt Bay:
Eelgrass Monitoring Plan (SHN)

- Before-After Control-Impact (BACI) stratified block design
- 2 years of baseline data (before) and 2 years of post-project implementation data (after)



Cultch on long line
spaced at 5 ft

Control
No lines

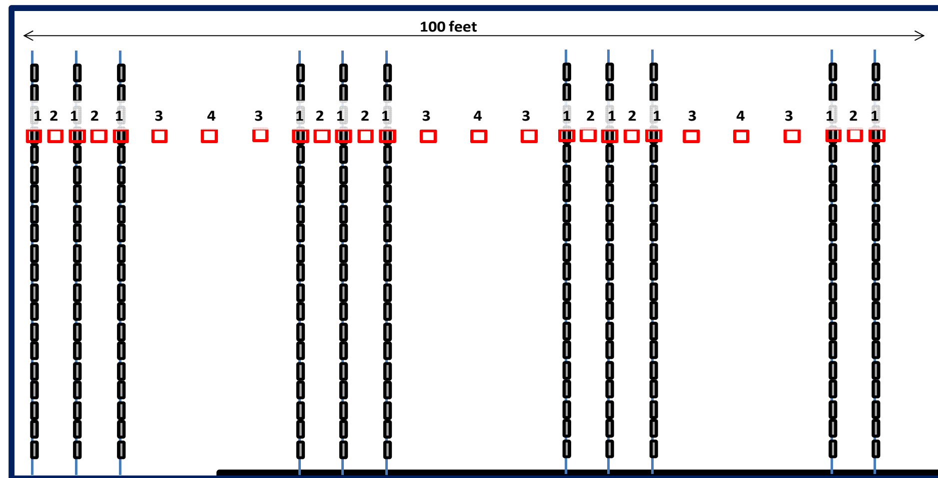
Basket on long line
with groups of three lines spaced 5 ft apart and 20ft gaps between groups of three

Eelgrass in Humboldt Bay:

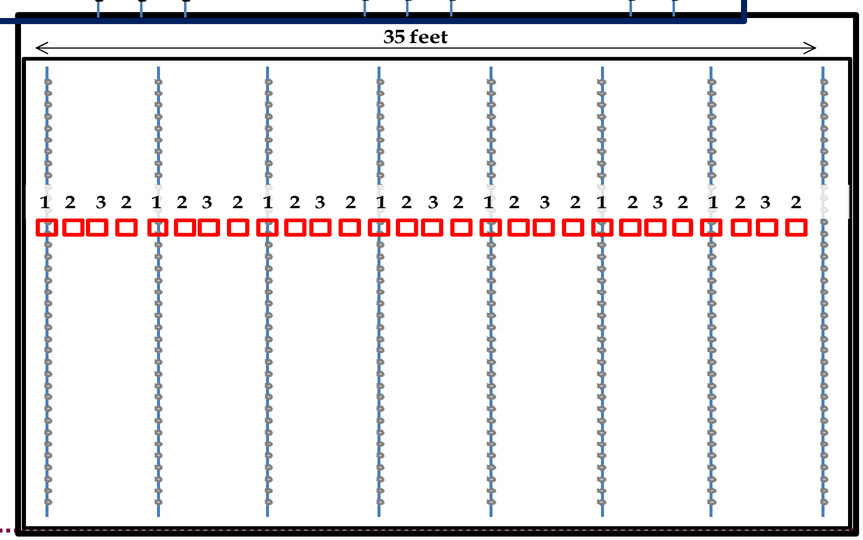
Eelgrass Monitoring Plan (SHN)

Stratification by Quadrat Proximity To Lines:

Basket-on-longline



Cultch-on-longline

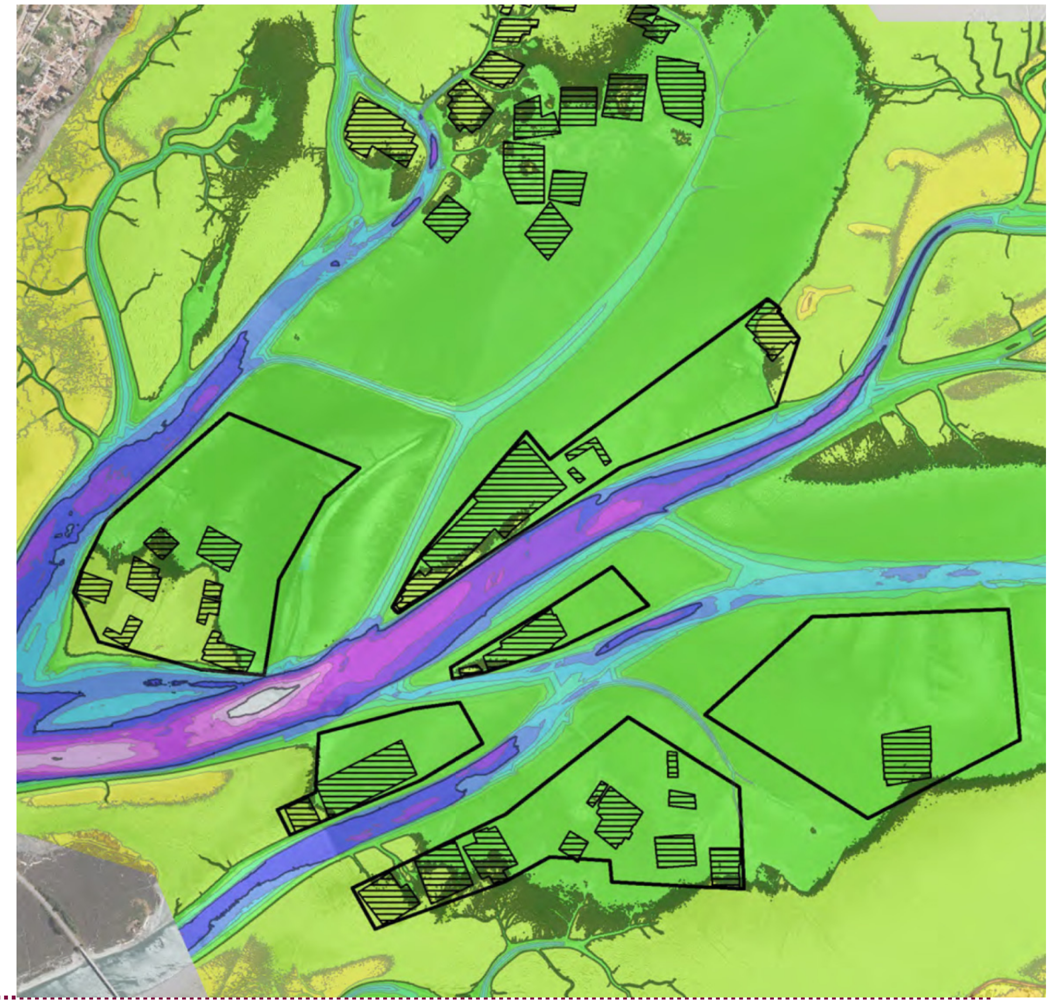


Impacts and Monitoring:
Eelgrass Monitoring Plan (SHN)

- Blocks located based on co-variates (e.g., substrate, elevation)
- Sample size (number of blocks) based on power analysis using SeagrassNet summer data
- Seagrass experts also consulted
- Total of 30 blocks included, meets or exceeds expert recommendations

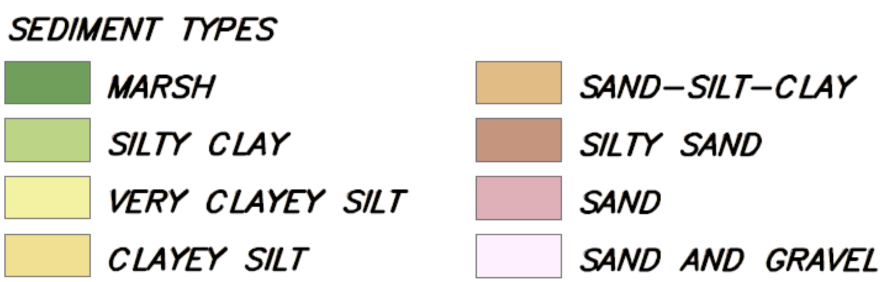
ELEVATION (FEET)

−11 TO −10	−5 TO −4	1 TO 2
−10 TO −9	−4 TO −3	2 TO 3
−9 TO −8	−3 TO −2	3 TO 4
−8 TO −7	−2 TO −1	4 TO 5
−7 TO −6	−1 TO 0	5 TO 6
−6 TO −5	0 TO 1	6 TO 7



Eelgrass in Humboldt Bay:
Eelgrass Monitoring Plan (SHN)

- Blocks stratified by substrate



Impacts and Monitoring:
Eelgrass Monitoring Plan (SHN)

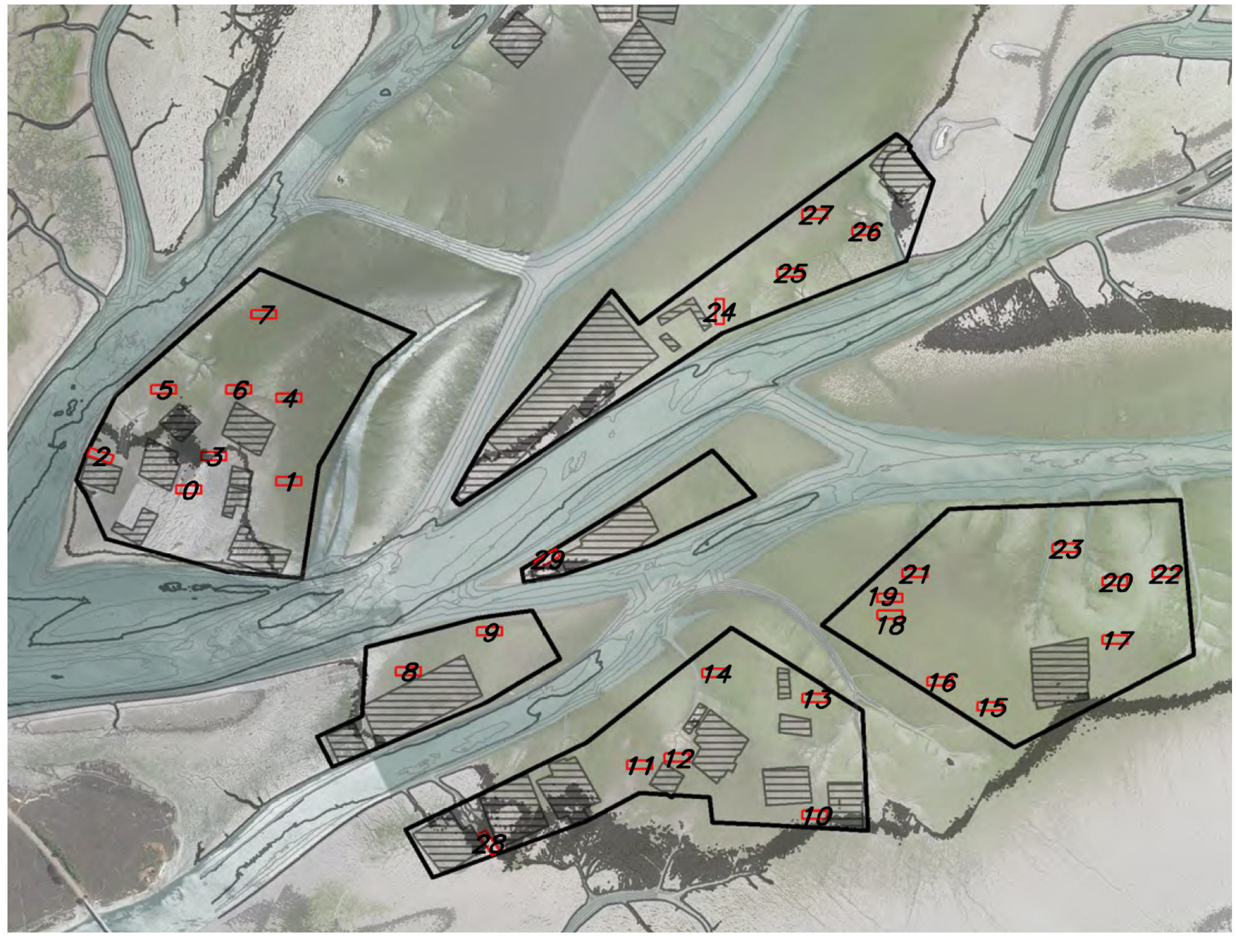
- Stratification of Blocks

Category	Metric	Percent of Category	Percent Times 30 Blocks	# Blocks per Category
Expansion Area	Area 1	27.6	8.3	8
	Area 2	6.1	1.8	2
	Area 3	18.3	5.5	6
	Area 4	13.8	4.1	4
	Area 5	3.5	1.0	1
	Area 6	30.7	9.2	9
Elevation Range (m MLLW)[1,2]	0.3 to 0.38	0.0	0.0	0
	0.23 to 0.3	0.2	0.1	0
	0.15 to 0.23	0.9	0.3	0
	0.08 to 0.15	1.9	0.6	1
	0 to 0.08	6.2	1.9	2
	-0.08 to 0	24.9	7.5	8
	-0.15 to -0.08	62.0	18.6	18
	-0.23 to -0.15	3.7	1.1	1
	-1.07 to -0.23	0.1	0.0	0
Sediment Type	Very Clayey Silt	3.1	0.9	1
	Clayey Silt	34.8	10.4	10
	Sand Silt Clay	52.3	15.7	16
	Silty Sand	3.4	1.0	1
	Sand	6.3	1.9	2

1. m: meters
2. MLLW: mean lower low water

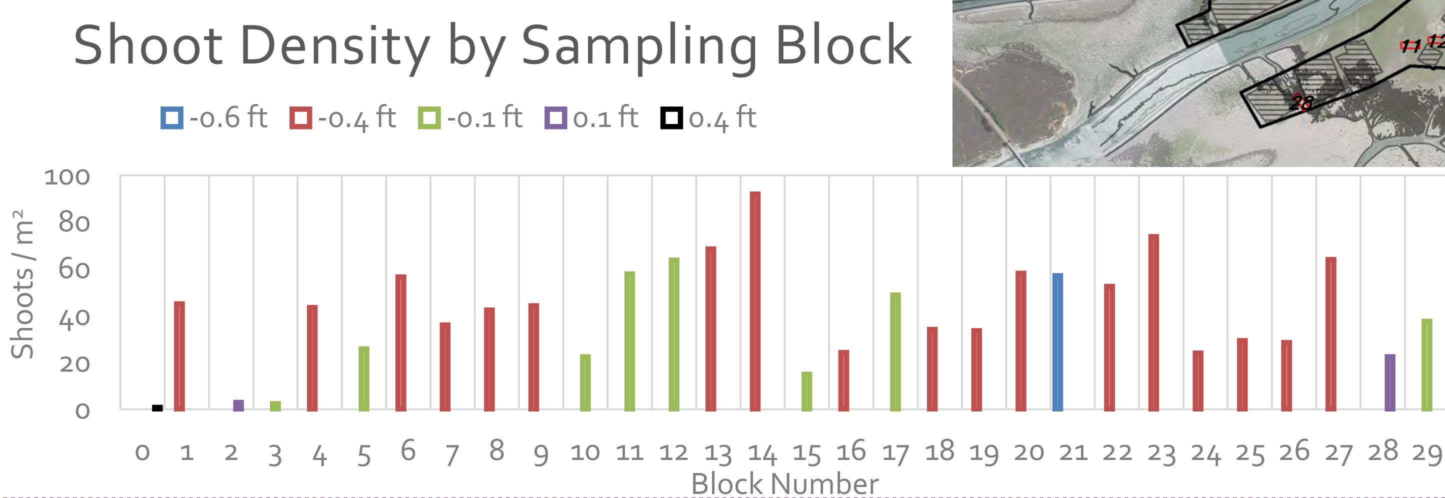
Impacts and Monitoring:
Eelgrass in Expansion Areas

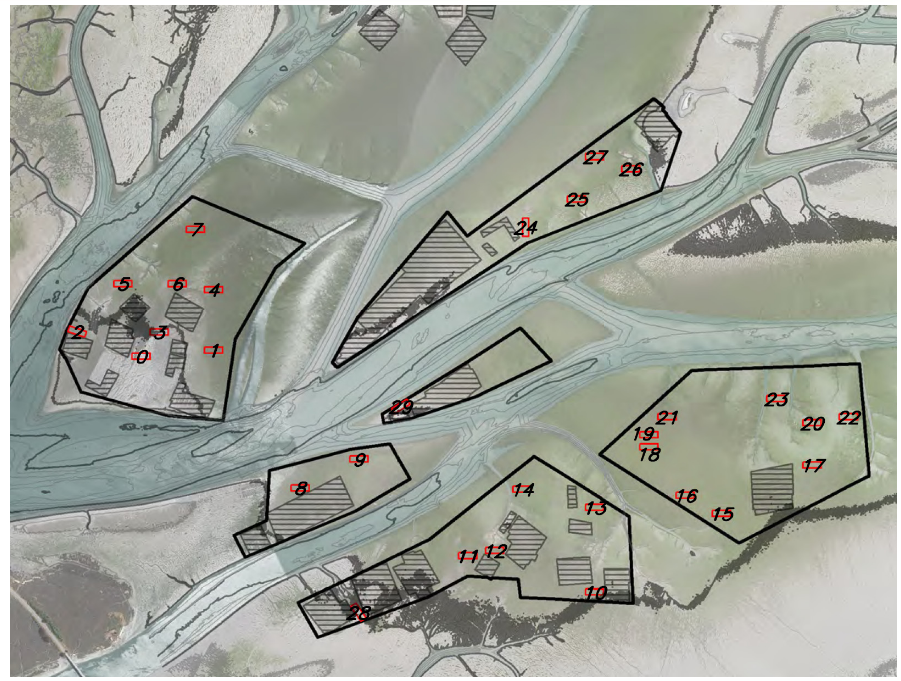
- Most thorough survey of eelgrass in Humboldt Bay to-date (based on number of transects, data points, and proposed area to be surveyed)
- Level of Effort
  - Sampling Days = 9
  - Number of Staff = 28
  - Sampling Hours = 787
  - Data Points = 1,800



Impacts and Monitoring:
Eelgrass in Expansion Areas

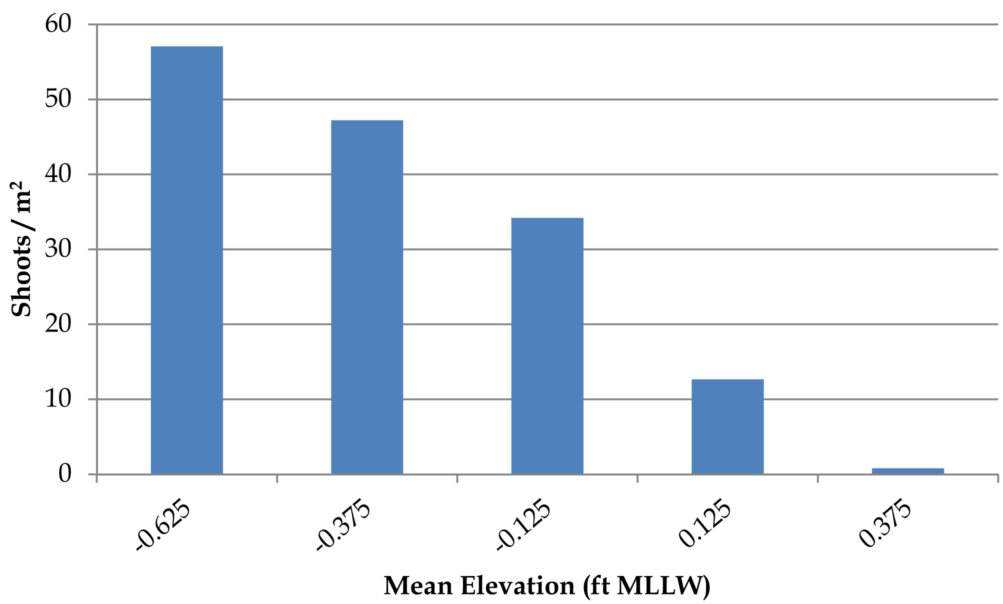
- Major Results
  - Wide range in natural variability of eelgrass density within expansion area
  - Depth appears to be a significant predictor in eelgrass density (e.g., higher density at lower depths), although there is still substantial variation



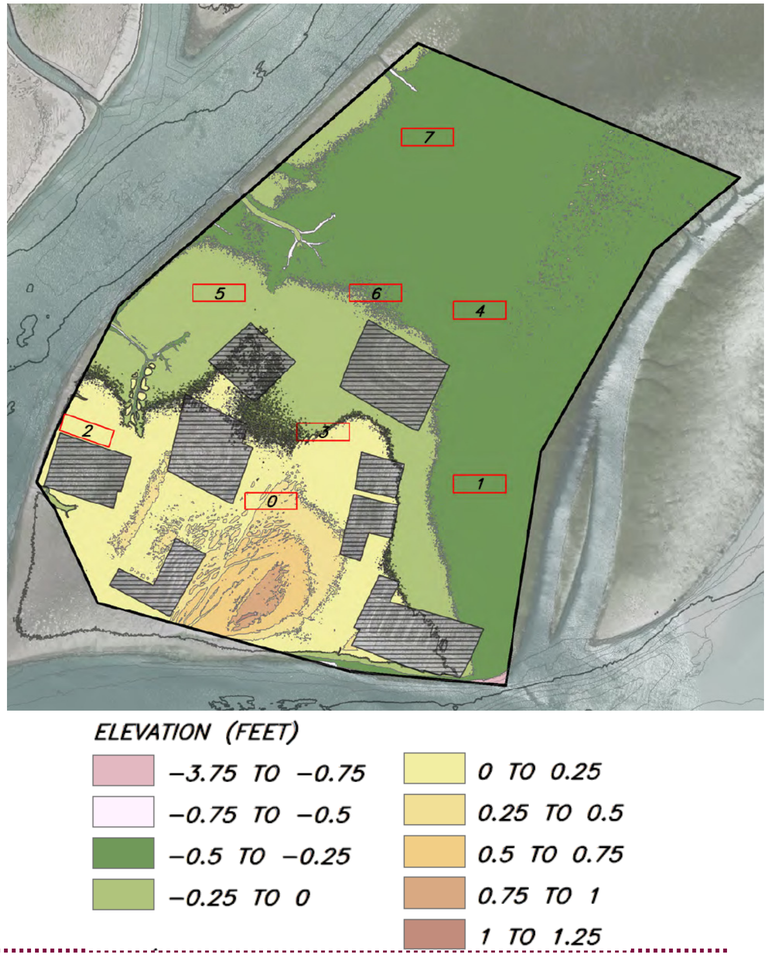


Eelgrass in Humboldt Bay:
Eelgrass in Expansion Areas

- 2015 Monitoring Results
  - Shoot Density by Elevation

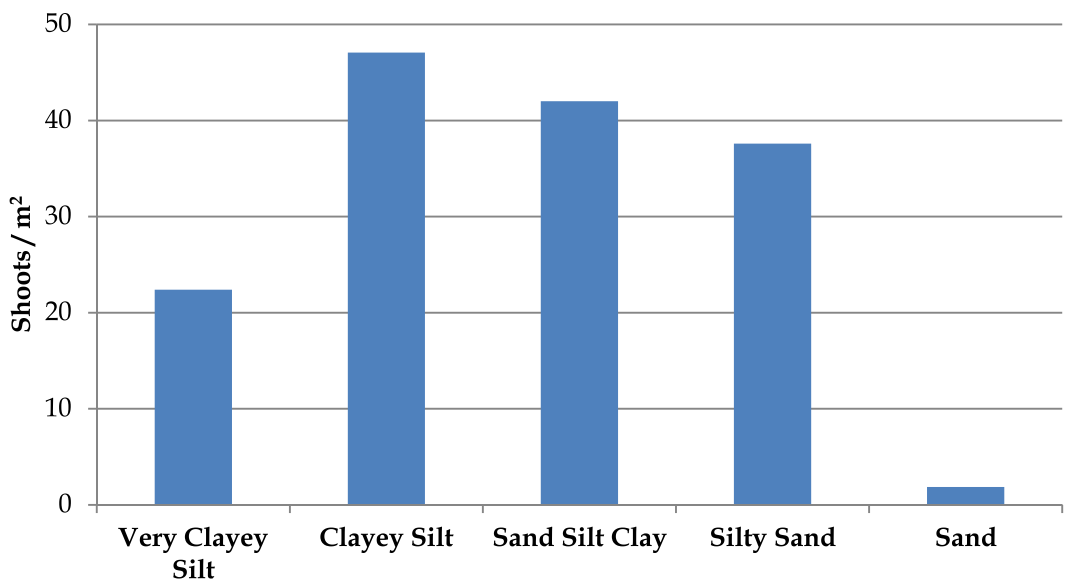


Area 1: Bird Island

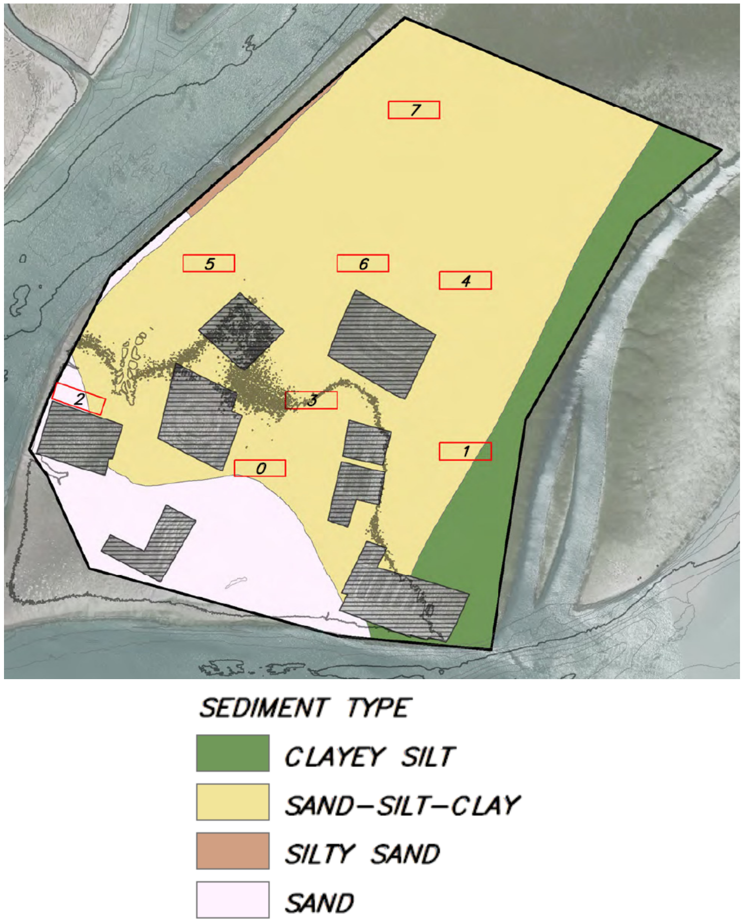


Eelgrass in Humboldt Bay:
Eelgrass in Expansion Areas

- 2015 Monitoring Results
  - Shoot Density by Substrate

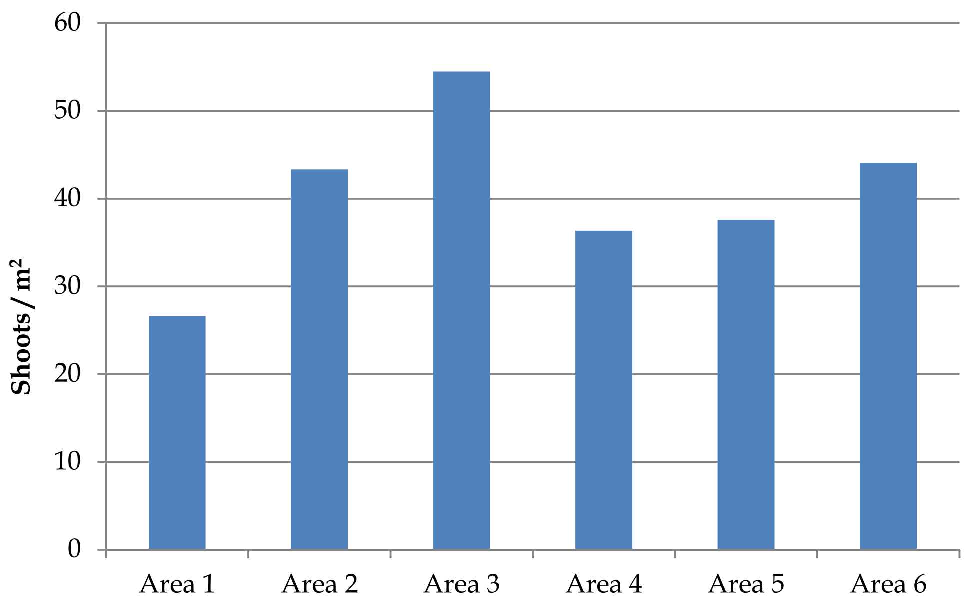


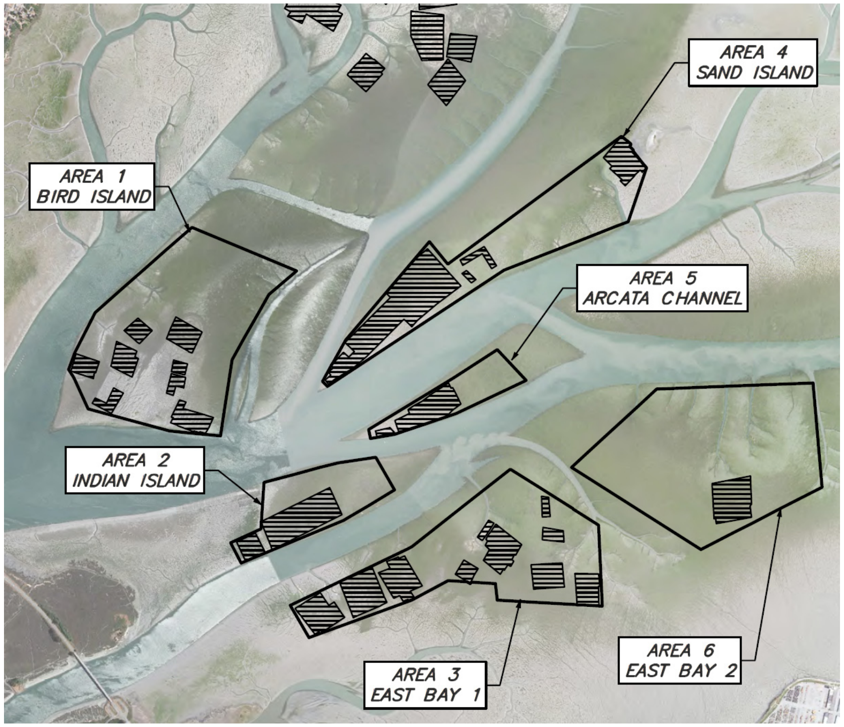
Area 1: Bird Island



Eelgrass in Humboldt Bay:
Eelgrass in Expansion Areas

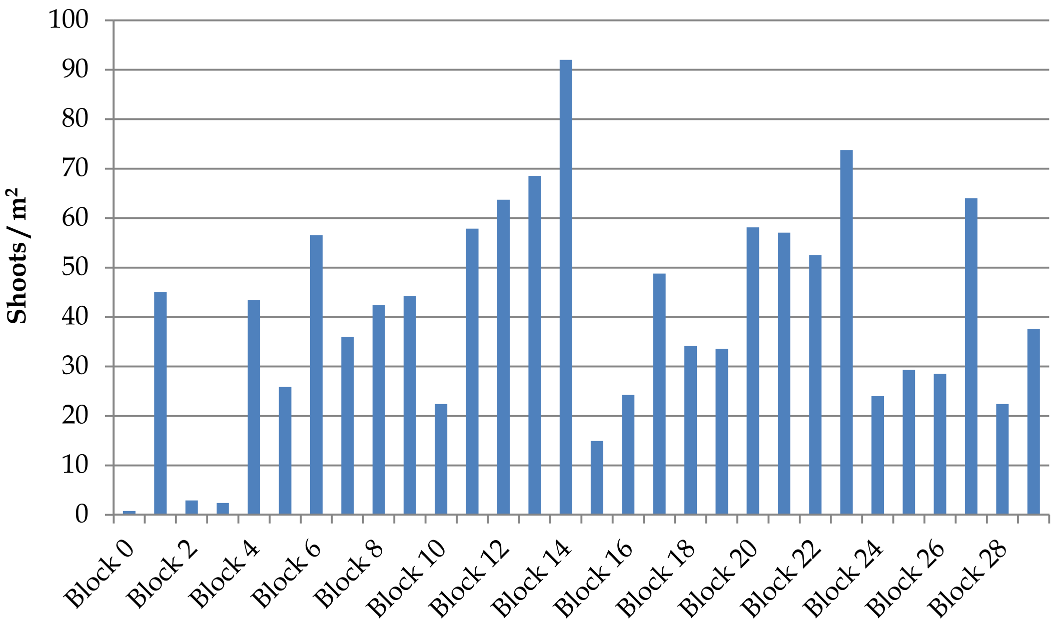
- 2015 Monitoring Results
  - Shoot Density by Expansion Area

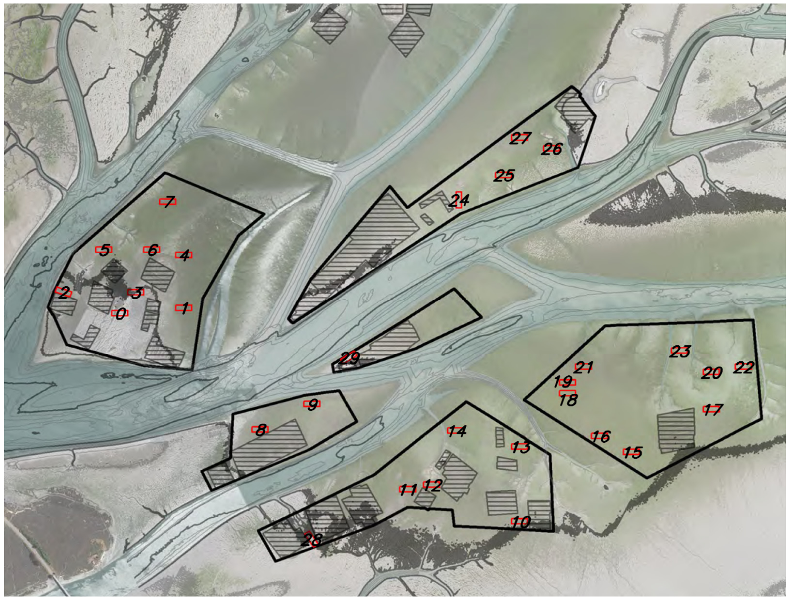




Eelgrass in Humboldt Bay:
Eelgrass in Expansion Areas

- 2015 Monitoring Results
  - Shoot Density by Block

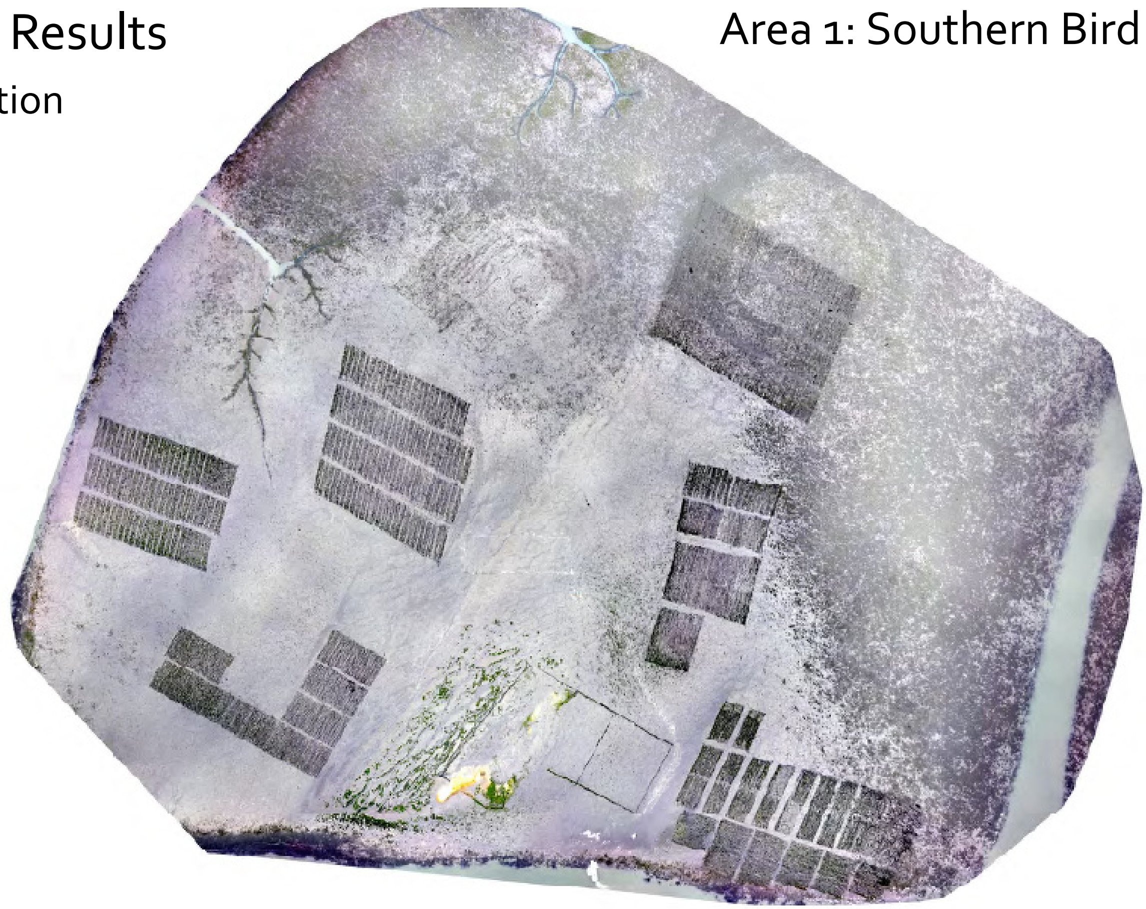


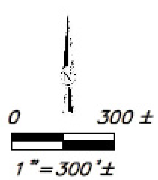


Eelgrass in Humboldt Bay:
Eelgrass in Expansion Areas

- 2015 Monitoring Results
  - Spatial Distribution

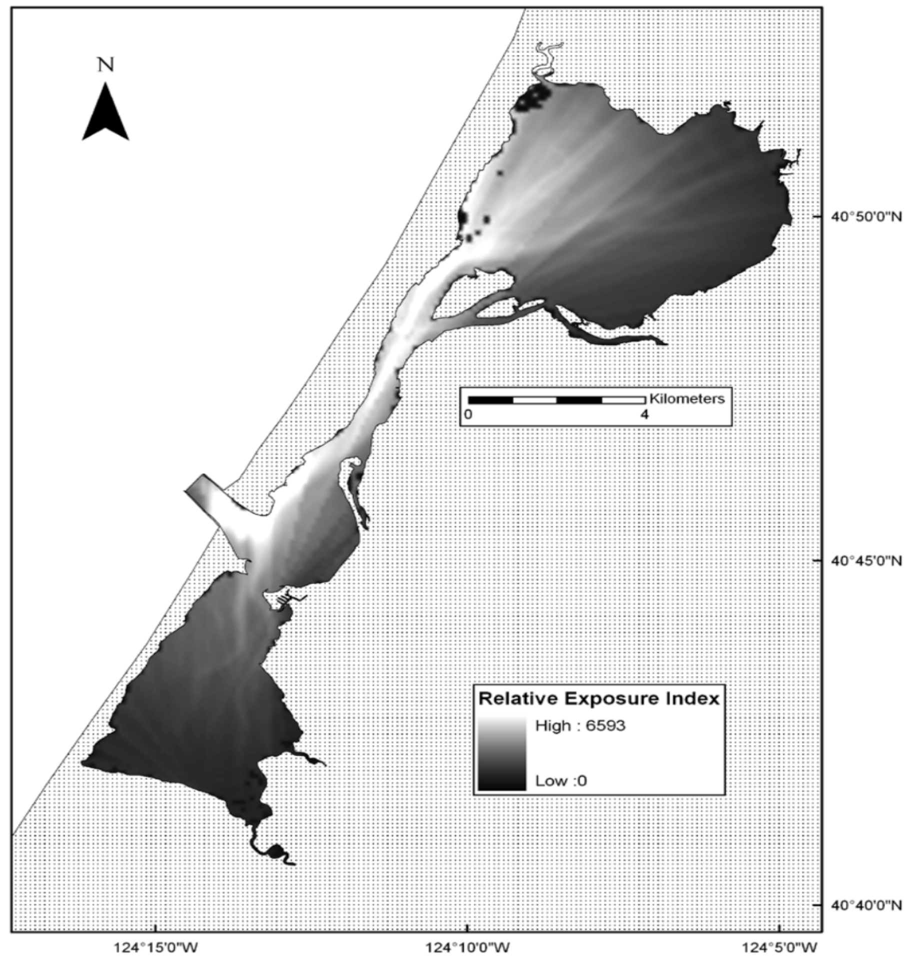
Area 1: Southern Bird Island





Mitigation Options: Buoy-Deployed Seeding System

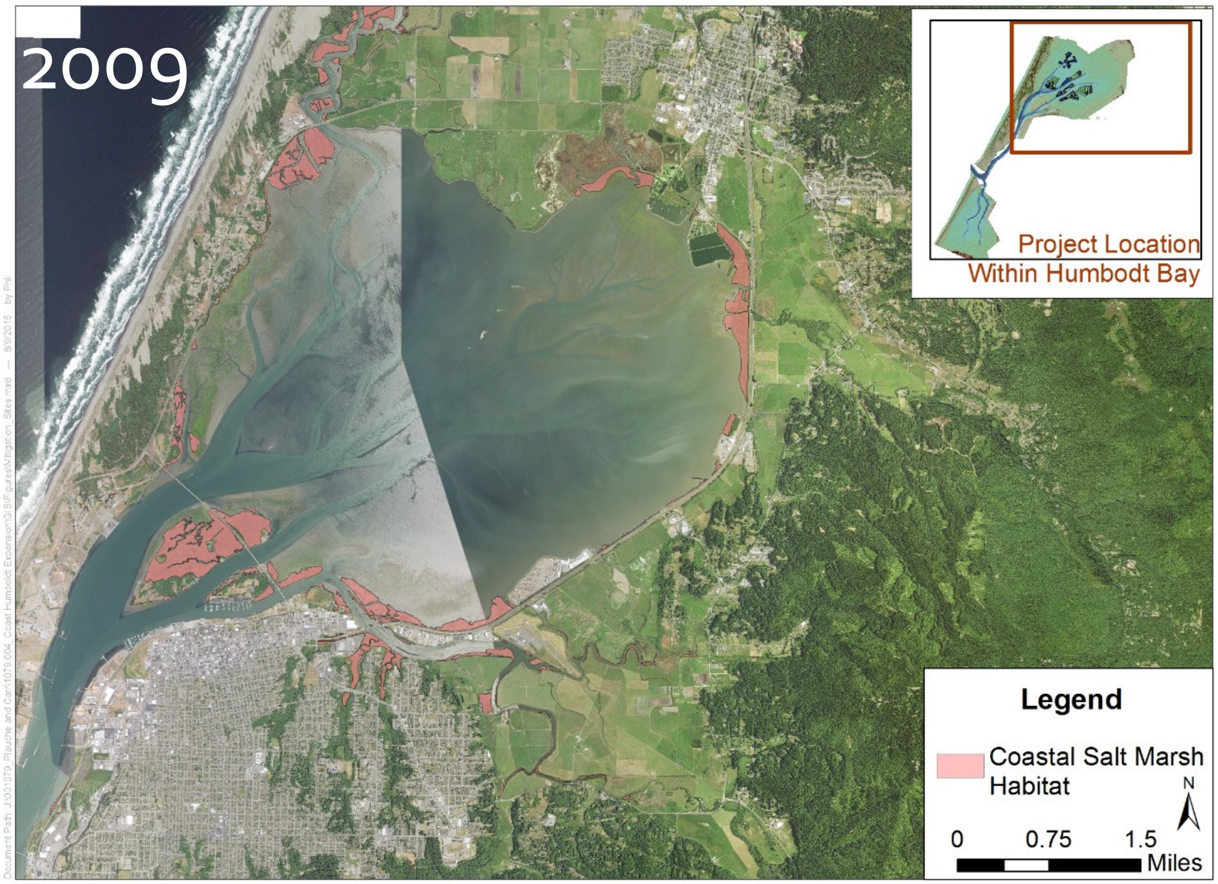
- Location
  - Humboldt Bay, North Bay
- Habitat
  - Former dredge harvest locations
  - Patchy eelgrass habitat
  - Locations that show signs of wind/wave disturbance
- Potential Partners
  - Humboldt Bay Harbor District
  - Humboldt State University
  - San Francisco State University
- Total Acreage
  - 1 to 5 acres



Mitigation Options:
CEMP Guidelines

- Compensatory mitigation should be recommended for loss of eelgrass function
- May be scenarios where out-of-kind mitigation is ecologically desirable or in-kind is not feasible
- Determination should be based on an established **ecosystem-based plan** that considers ecosystem function and services relevant to the geographic area and specific habitat being impacted
- Out-of-kind mitigation that generates services similar to eelgrass habitat or improves the ability to establish eelgrass should be considered first
- Out-of-kind mitigation may be appropriate for shellfish aquaculture projects

Mitigation Options:
Watershed Approach



Mitigation Options:
Parcel 4 Restoration

- Location
  - Behind Bayshore Mall, PALCO Marsh waterfront open space
- Habitat
  - Freshwater/tidal wetlands (e.g., coastal salt marsh)
  - Intertidal areas with eelgrass
  - Deep water channel
- Key Partners
  - City of Eureka
  - California State Coastal Conservancy
  - Redwood Regional Audubon Society
- Total Acreage
  - 14.8 acres

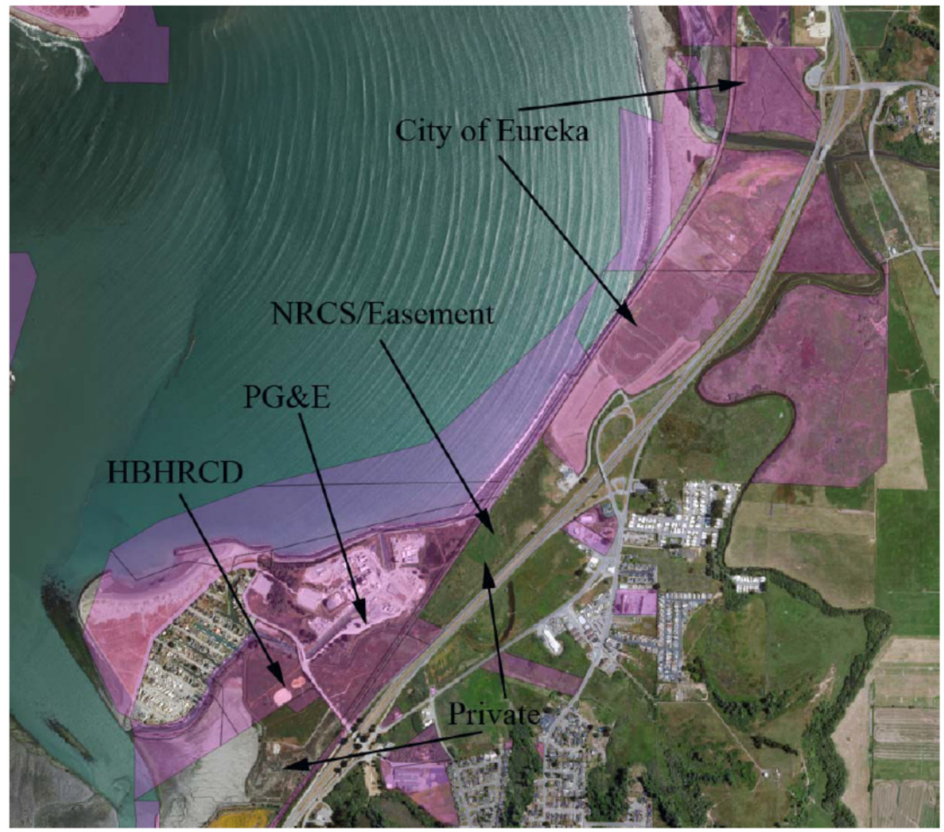


Parcel 4 Restoration (continued)

- Integrate the site into the Elk River Trail
- Assess and clean up brownfields contaminants
- Remove invasive species
- Improve the natural experience
- Re-establish wetland areas and enhance wildlife habitat

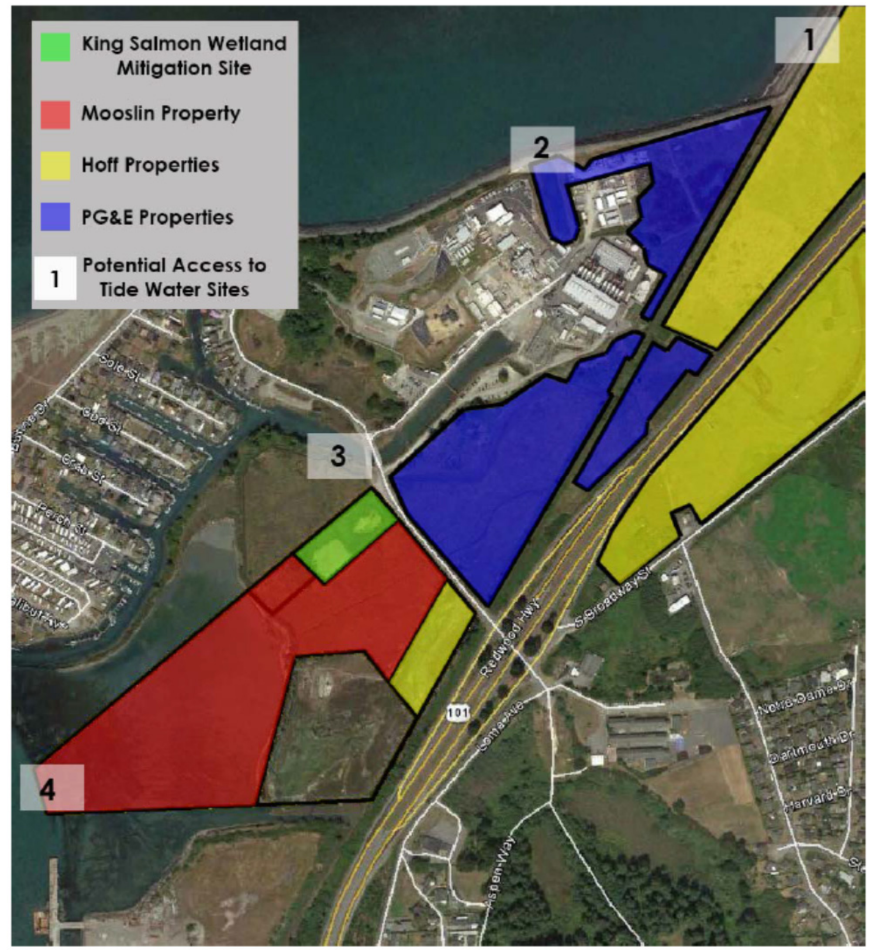
Mitigation Options:
Elk River Estuary Enhancement and Intertidal Wetlands Restoration

- Location
  - Eastern shore of Entrance Bay, just south of King Salmon Avenue
- Habitat
  - Elk River estuary
  - Tidal wetlands (e.g., coastal salt marsh)
  - Intertidal channels
  - Brackish water wetlands
- Key Partners
  - City of Eureka
  - Humboldt Bay Harbor District
  - PG&E
  - Private owners
- Acreage
  - 23 acres



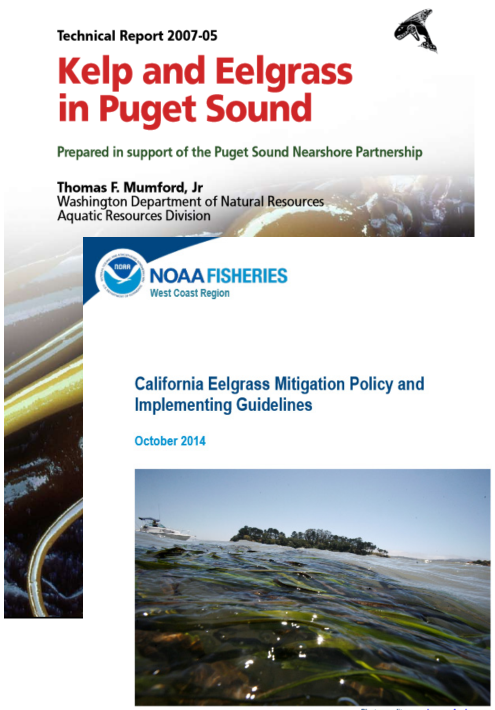
Mitigation Options:
Hoff Parcels, Eureka, California

- Location
  - Humboldt Bay between Elk River and Humboldt Hill near King Salmon
- Habitat
  - Undeveloped pasture land with former tidally-influence channels
  - Coastal salt marsh habitat
- Key Partners
  - Westervelt Ecological Services
  - Humboldt Bay Harbor District
- Total Acreage
  - 53 acres

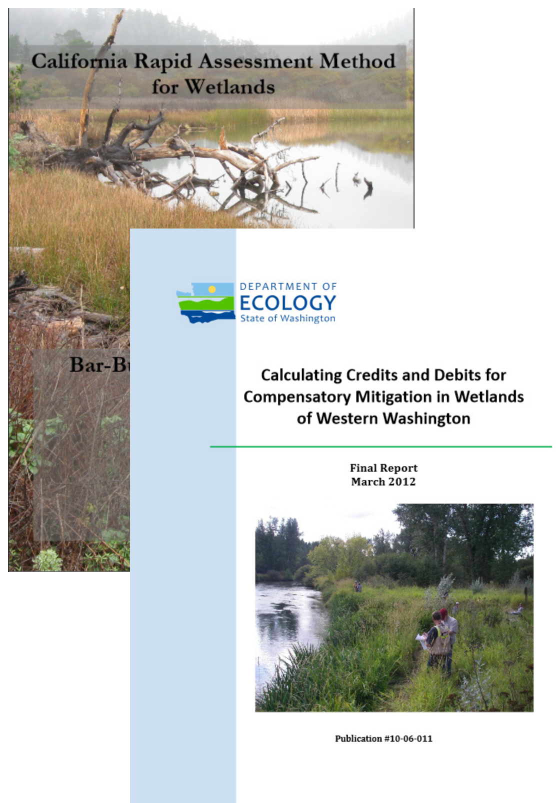


Mitigation Accounting: Assessment Tools

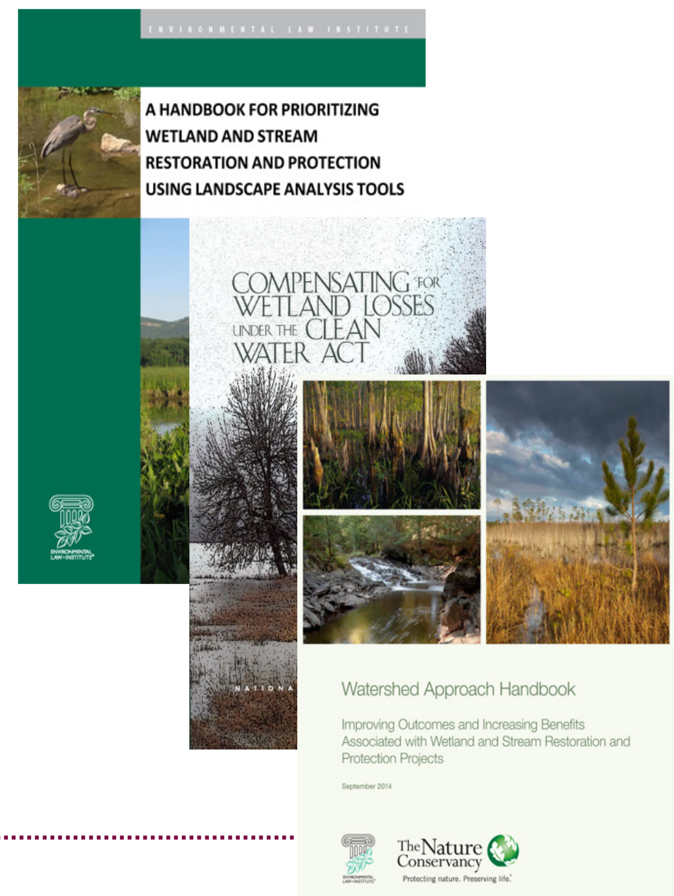
Eelgrass



Habitat Functional Assessment



Watershed Prioritization

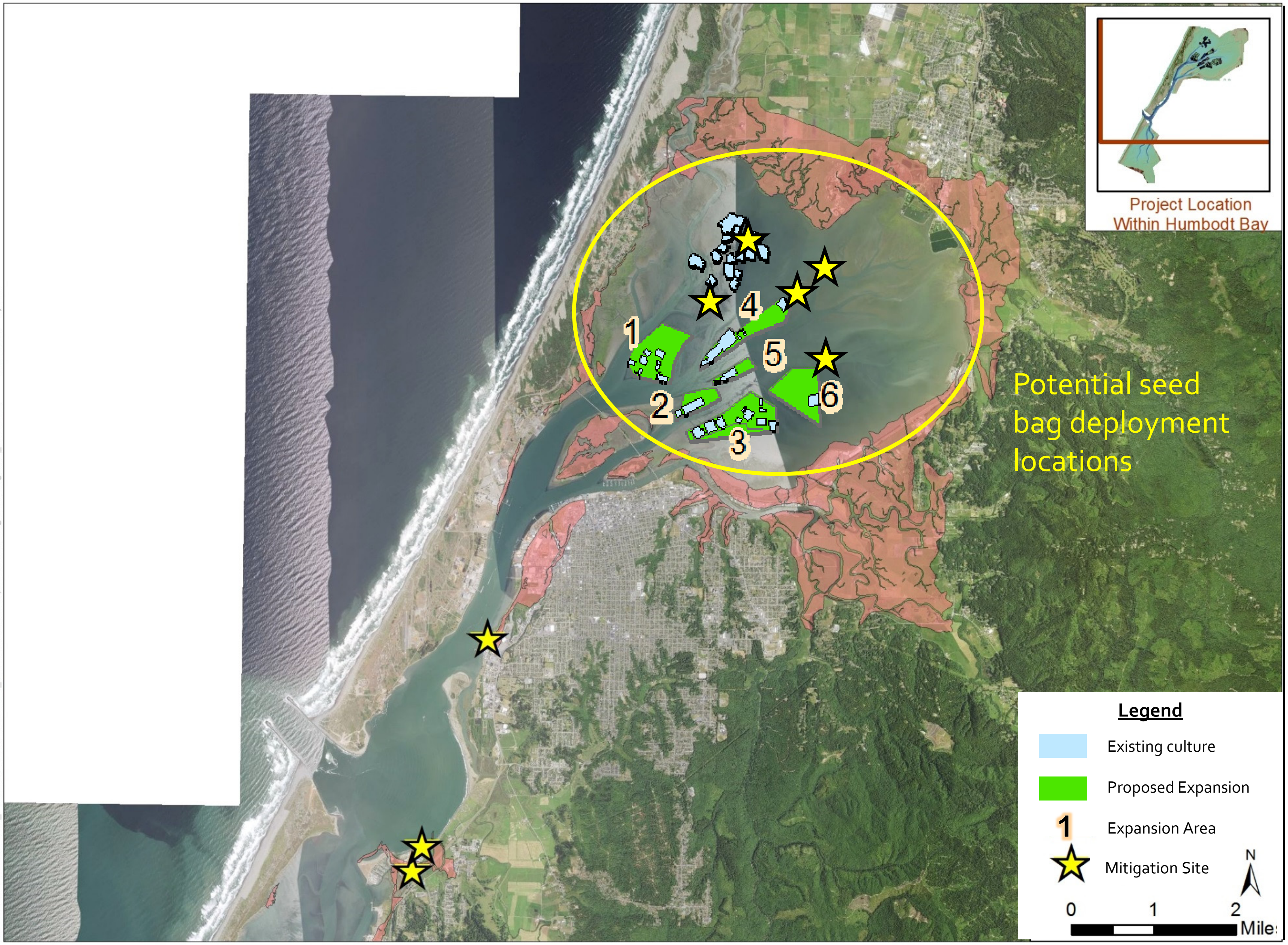


Mitigation Accounting:
Valuing Ecological Functions

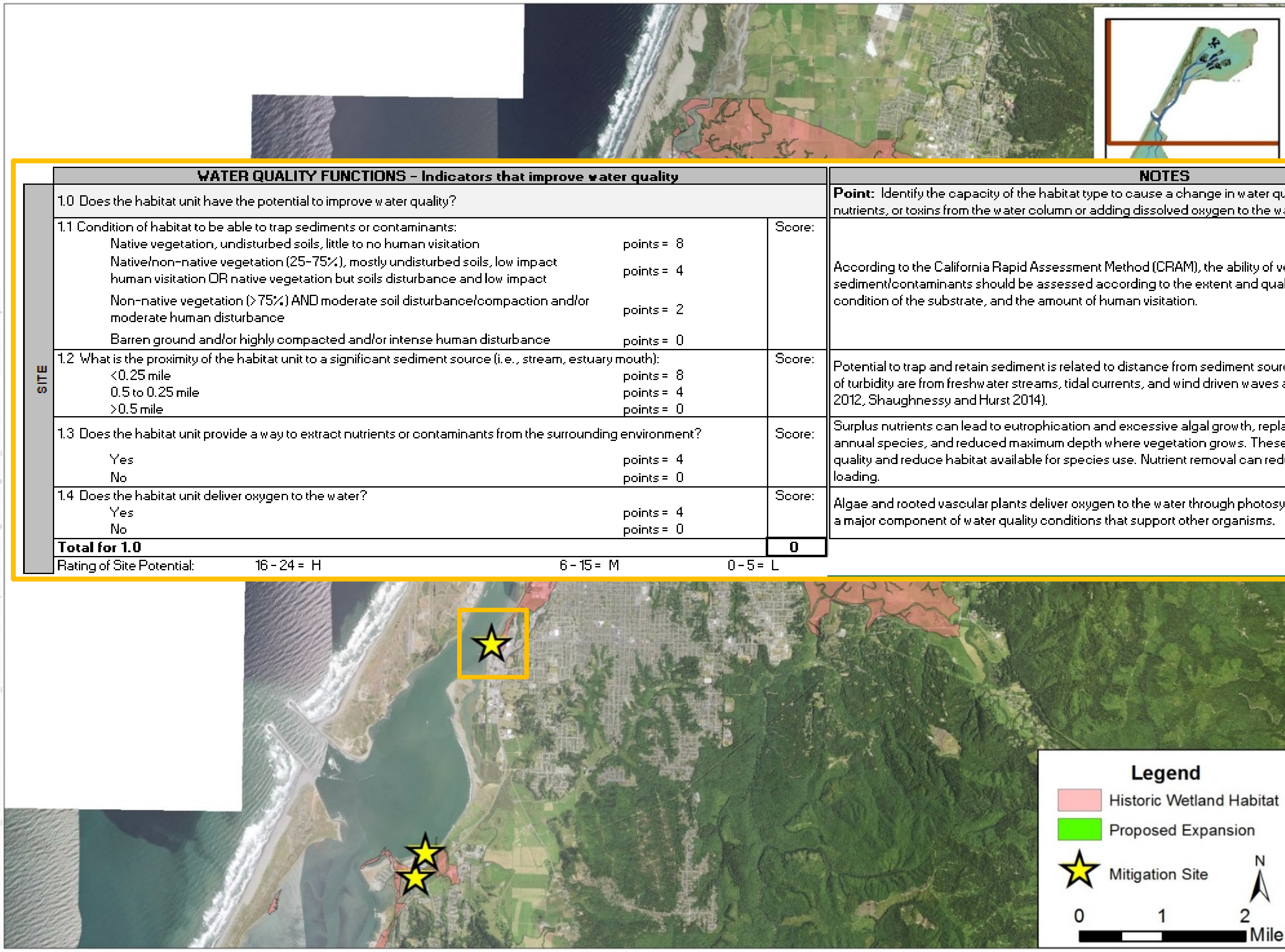
- Goal
  - To create a methodology that can value ecological functions of estuarine habitats in Humboldt Bay without additional research
- Methods
  - Uses existing literature to value three of the most important functions
  - Uses site-specific data to more accurately value ecological functions
- Example
  - Conceptual model of how to use an accounting system for ecological function for the shellfish aquaculture expansion proposal

- Water Quality Functions:
  - Site potential
  - Landscape context
  - Watershed or regional priority
- Habitat Structure Functions:
  - Site potential
  - Landscape context
  - Watershed or regional priority
- Prey Resource Functions:
  - Site potential
  - Landscape context
  - Watershed or regional priority

Step 1: Identify Sites



Step 2: Evaluate Function Values (Baseline): Mitigation Site



SITE	WATER QUALITY FUNCTIONS – Indicators that improve water quality			NOTES
	1.0 Does the habitat unit have the potential to improve water quality?			**Point:** 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		0	
	Rating of Site Potential: 16 - 24 = H	6 - 15 = M	0 - 5 = L	

Debit Worksheet

"DEBIT" WORKSHEET

Expansion Plot Number: Plot 1 Date: Aug-19-2015

Use the following tables to calculate the Debits for each proposed expanion 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	M	L	M
Rating of Landscape Potential	M	L	M
Rating of Value	H	L	M
Score for Plot [B]efore	B = 9	B = 9	B = 9

FUNCTION *Mitigation Site #1*	Improving Water Quality	Improving Habitat Structure	Improving Prey Resources
Rating of Site Potential	H	H	H
Rating of Landscape Potential	H	H	H
Rating of Value	H	H	H
Score for Plot [A]fter	A = 9	A = 7	A = 6

CALCULATIONS	Improving Water Quality	Improving Habitat Structure	Improving Prey Resources
Decrease in Score at plot (A - B) =	0	-2	-3
Impact - Acres	4	4	4
Basic mitigation requirement (BMR) = *Score for function x acres impact*	0	-8	-12
Temporal loss factor (TLF) (see table below)	1.5	1.5	1.5
Mitigation required *DEBITS = BMR x TLF (units = acre-points)*	0	-12	-18

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 wihin one year of impact, but is completed (including plantings, if required) within 5 growing seasons of impact.	3.0

Credit Worksheet

"CREDIT" WORKSHEET

Site: Mitigation Site #1　　　　Date: Aug-19-2015

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	M	L	M
Rating of Landscape Potential	M	L	M
Rating of Value	H	L	M
Score for Mitigation Site [B]efore	**B =** 6	**B =** 3	**B =** 4

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

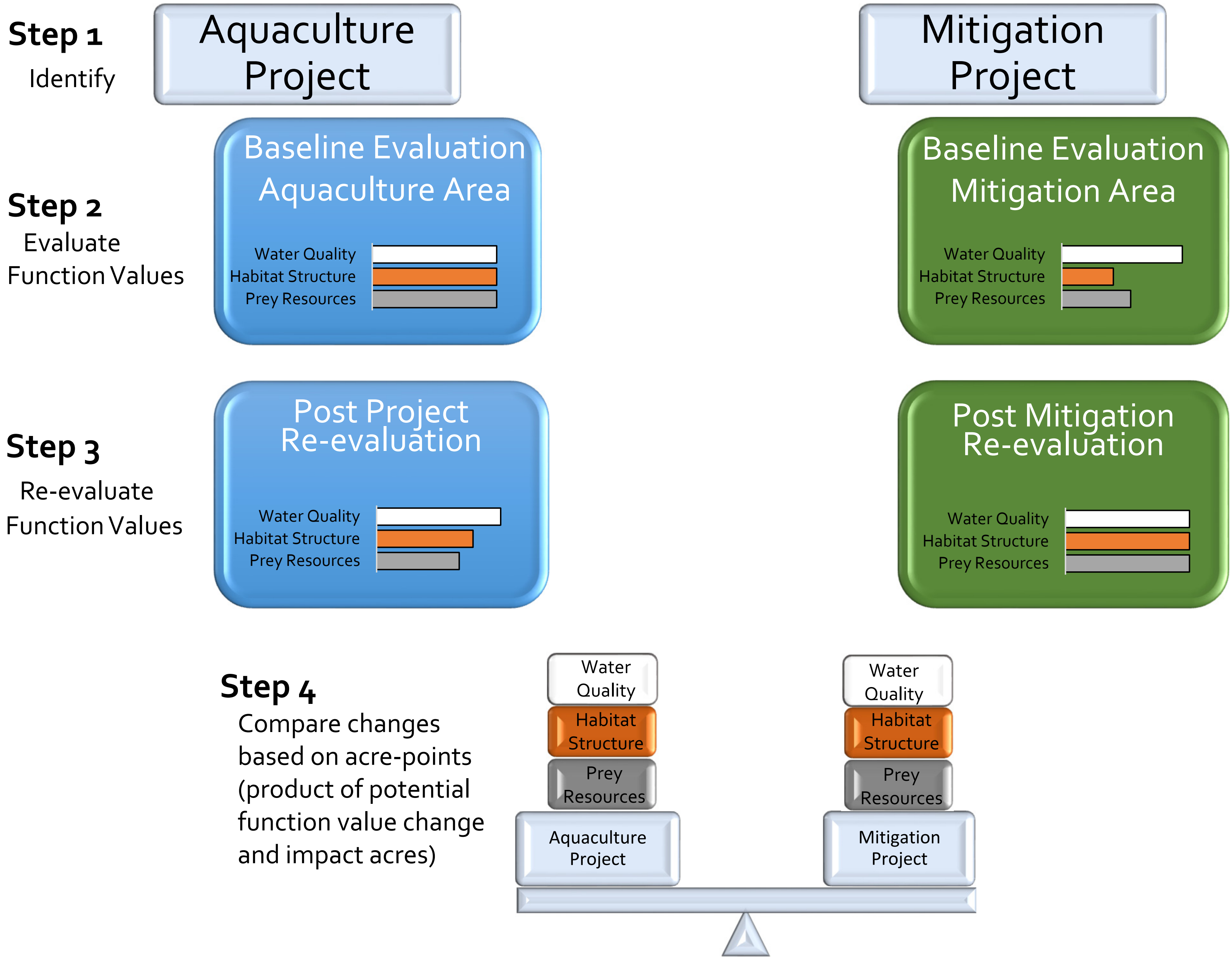
FUNCTION ***Mitigation Site #1***	**Improving Water Quality**	**Improving Habitat Structure**	**Improving Prey Resources**
Rating of Site Potential	H	H	H
Rating of Landscape Potential	H	H	H
Rating of Value	H	H	H
Score for Mitigation Site [A]fter	**A =** 9	**A =** 9	**A =** 9

CALCULATIONS ***Mitigation Site #1***	**Improving Water Quality**	**Improving Habitat Structure**	**Improving Prey Resources**
Increase in Score at mitigation site (A - B) =	3	6	5
Acres of mitigation *(should be the same for 3 functions for each type of mitigation)*	5	5	5
Basic mitigation credit (BMC) = *Increase in Score x acres of mitigation*	15	30	25
Risk Factor (RF) *(see table below)*	0.7	0.7	0.7
Mitigation credits available for each habitat unit *CREDITS = BMC x RF (units = acre-points)*	10.5	21	17.5

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

Ecological Function: Debits and Credits



Black Brant: Background

- Humboldt Bay is an important winter/spring staging site for black brant (*Branta bernicla nigricans*)
- Pacific Flyway brant population was estimated at 150,000 birds
- Humboldt Bay supports large proportion of population (estimated 28% of the flyway population in 2000 and 58% in 2001 [Lee et al. 2007])
- "Wintering" birds are winter residents but many migrants pass through in spring (mean stopover duration = 13 days)
- Brant rely exclusively on eelgrass throughout flyway
- High use of Humboldt Bay likely due to geographic isolation
- Eelgrass shortages appear to be rare event

Black Brant:
Distribution Change

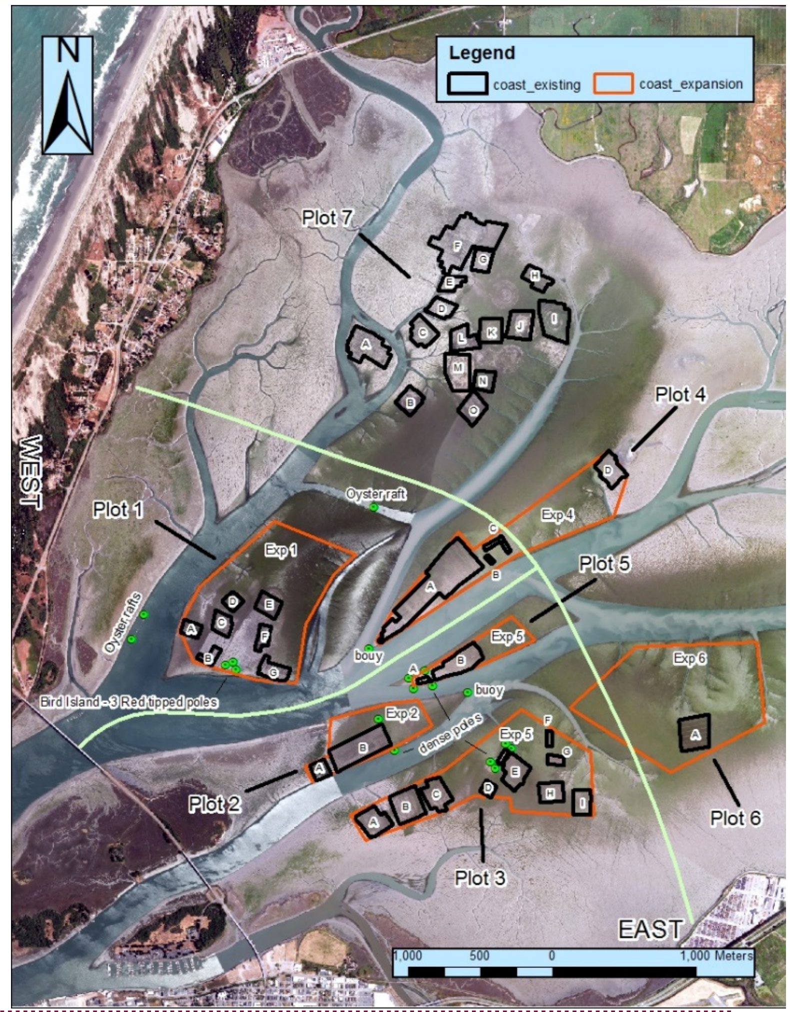
- Humboldt Bay NWR conducted South Bay and Arcata Bay surveys in 2015

Date	Arcata Bay	South Bay
2/13/2015	2,600	1,360
2/17/2015	2,730	3,270
3/10/2015	4,420	1,360
3/16/2015	3,750	1,960
3/24/2015	3,960	3,000
3/30/2015	2,610	2,050
4/7/2015	3,310	4,640
4/13/2015	3,650	2,860

- Total Bird-use Days: South Bay = 147,930
  Arcata Bay = 192,400

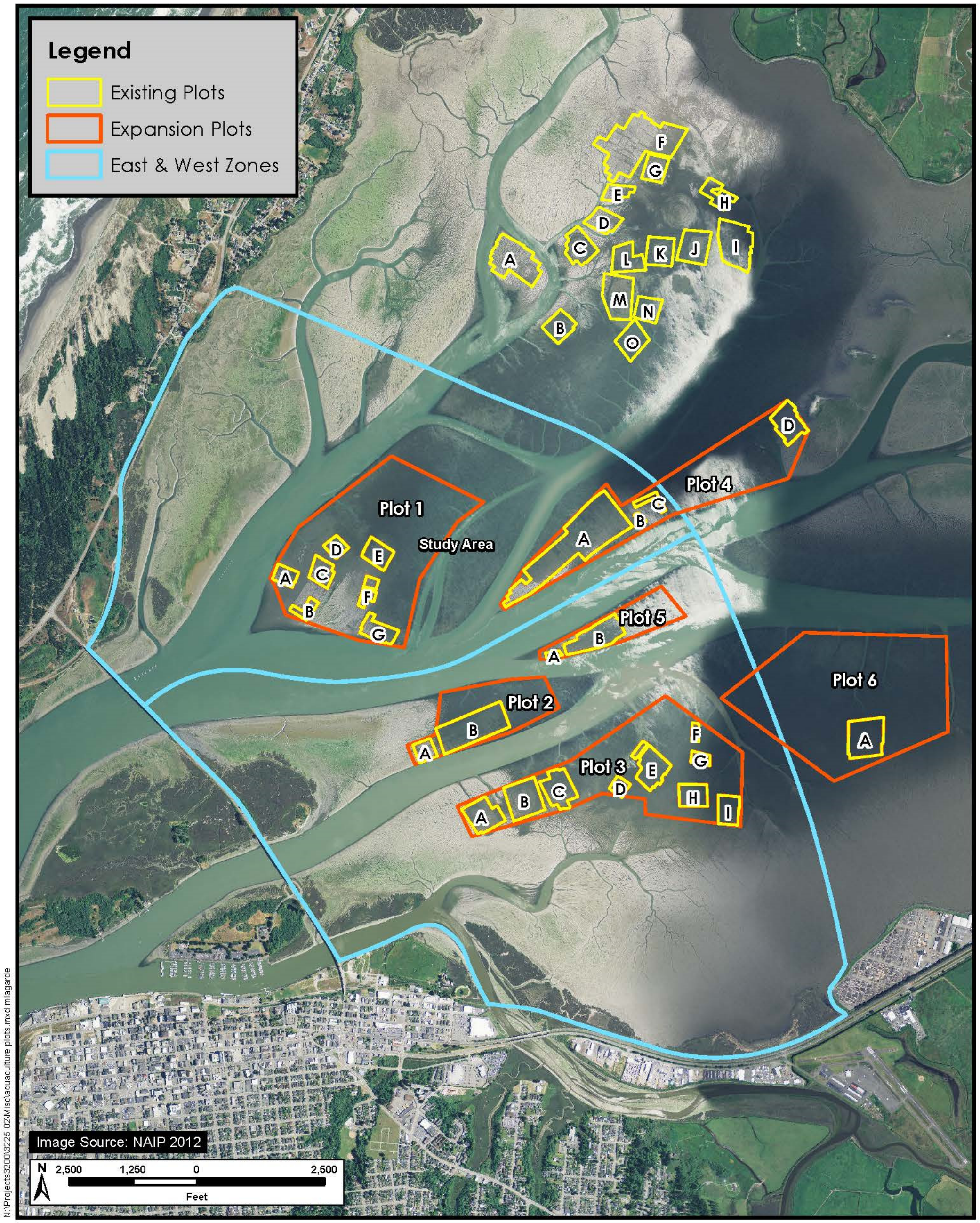
Black Brant:
Survey Methods

- Estimate # of brant using Arcata Bay
- Assess brant use of existing aquaculture plots (existing plots) and areas proposed for expansion (expansion plots)
- Conducted 10 high tide and 10 low tide surveys
- High = 4 to 2 ft outgoing tide
  Low = trough of lowest tide (~0.5 ft)
- Surveys conducted 2 April to 23 April 2015; peak spring period
- Used experienced observers
  (Pia Gabriel, Betsy Elkinton, Rob Fowler)



Survey Methods

Date:		Name:		Survey
Survey Start Time:		Survey End Time:		
Survey Start Tide Height:		Survey End Tide Height:		
Weather Conditions (temp, wind speed/direction; sun/fog, visibility assessment):				
Total Brant Estimate Arcata Bay:				
Brant Estimate East Zone:				
Brant Estimate West Zone:				
Estimate the # of Brant in existing and expansion plots (that are visible) below:				
Plot 1		**Expansion 1**		
A				
B				
C				
D				
E				
F				
G				
Plot 2		**Expansion 2**		
A				
B				
Plot 3		**Expansion 3**		
A				
B				
C				
D				
E				
F				
G				
H				
I				
Plot 4		Not counting north of Plot 4 B		
A, B, C		Plots B and C very close to A, combine counts		
Plot 5		**Expansion 5**		
A				
B				



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Ecological Consultants

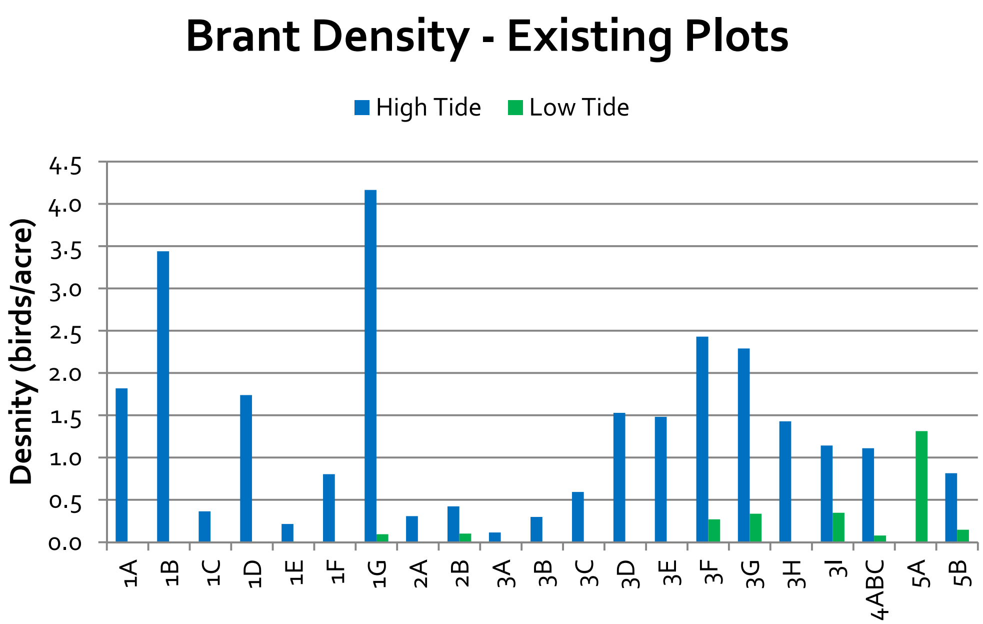
Aquaculture Plots
Coast Seafoods Company 1.5' Elevation Oyster Culture Feasibility Study
Northern Humboldt Bay, California (3225-05)
April 2015

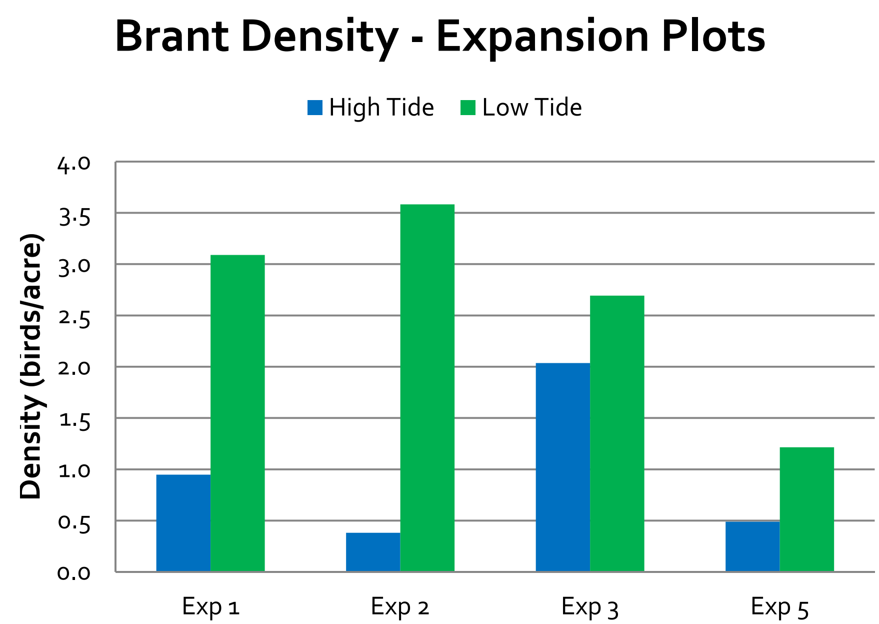
Black Brant: Survey Results

- Count
  - Mean low tide count = 4,164 brant (range of 3,120-5,559)
  - Mean high tide count = 3,170 brant (range of 2,234-4,340)
  - Brant would congregate in sheltered areas during high tide

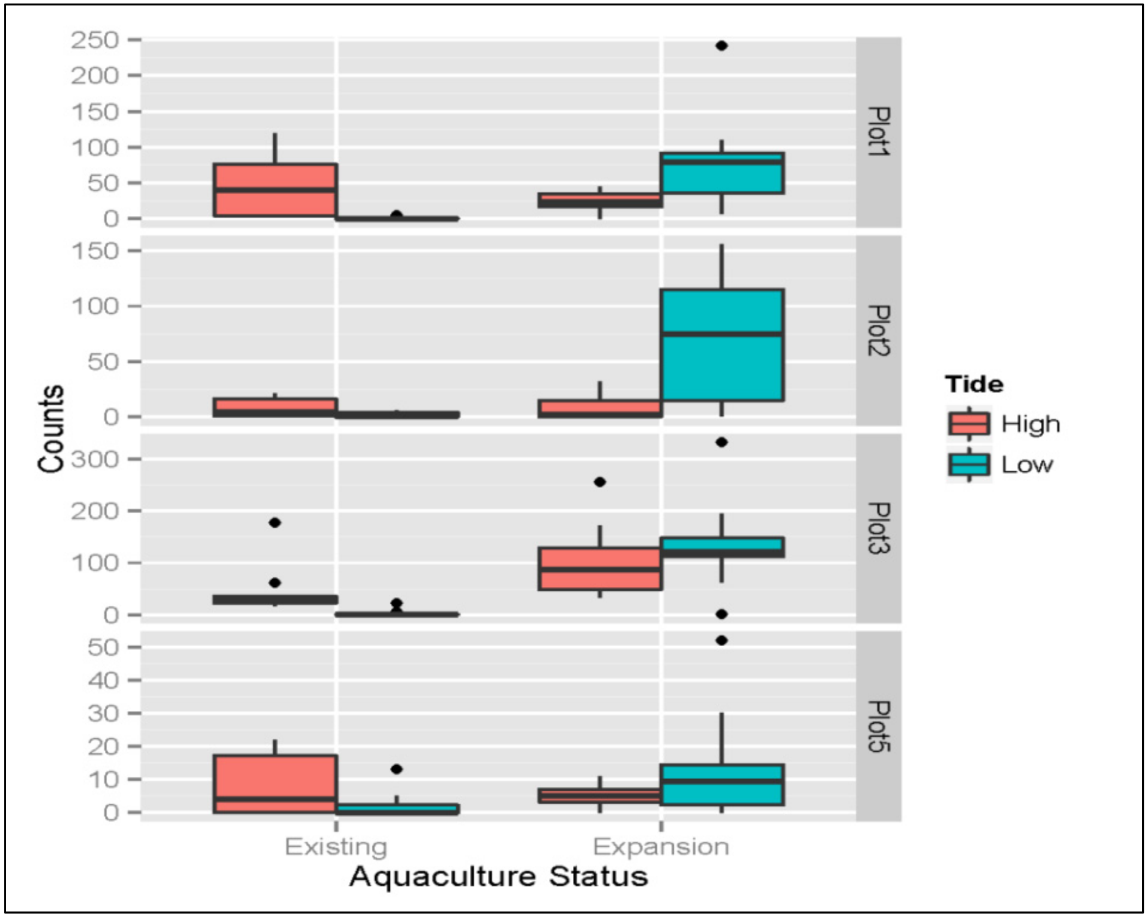
Black Brant:
Survey Results

- Use of Existing vs. Expansion Plots
  - Brant used both existing and expansion plots during high tides (existing = 1.3 birds/acre; expansion 1.0 birds/acre)
  - Brant appeared to avoid existing aquaculture plots during low tides (existing = 0.1 birds/acre; expansion = 2.6 birds/acre)





Black Brant:
Survey Results



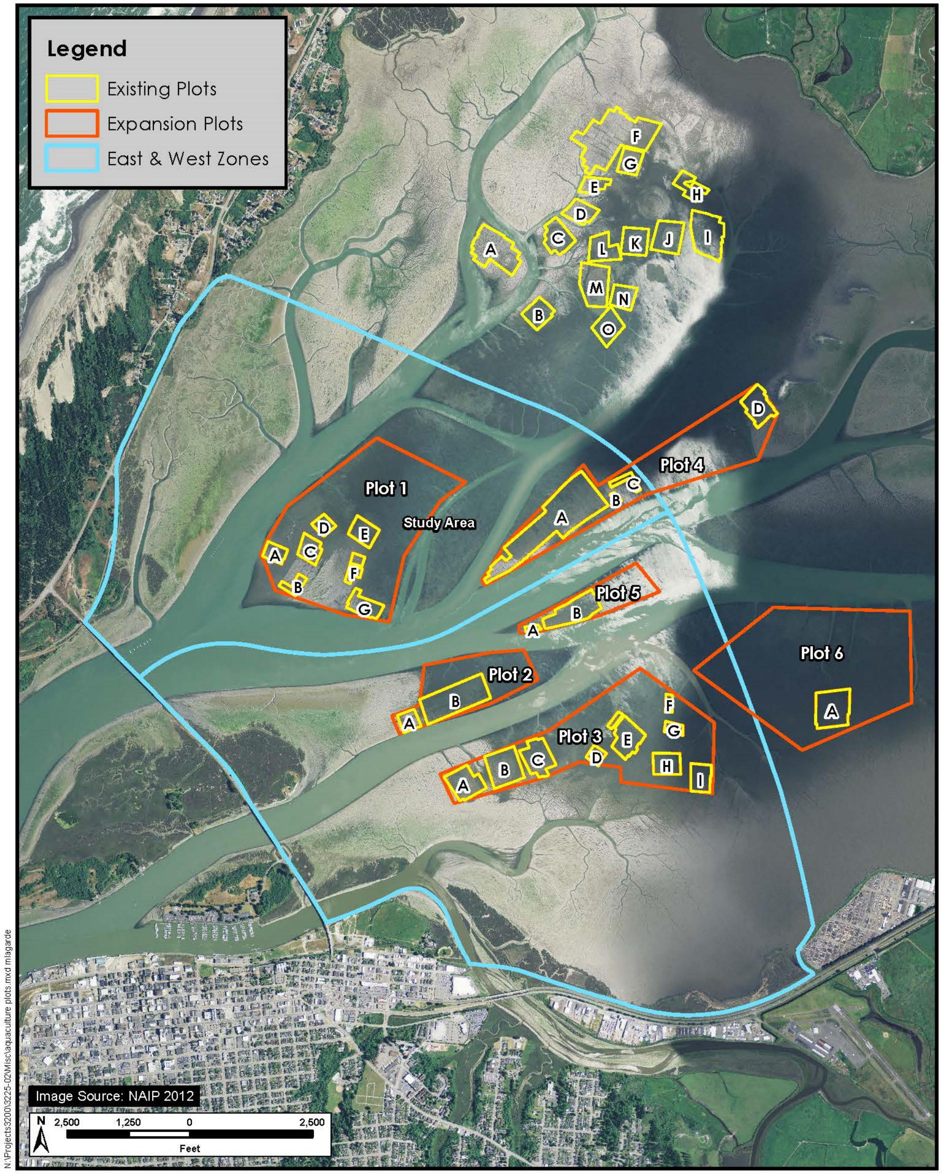
- Top AICc-ranked model included plot number, tide cycle, aquaculture status, and the interaction between tide cycle and aquaculture status
- Brant appeared excluded from aquaculture at lower tides but not higher tides

Black Brant:
Survey Results Summary

- High use of Arcata Bay (surveys suggest 50/50 split between basins)
- Observers noted no "buffer effect" around aquaculture

Black Brant: Camera Monitoring

- Fill in data gaps re: brant behavior, relate to tide height and use of existing aquaculture
- Assess use of “boat rows”
  - Deployed 2 cameras
  - One on Plot 4A (existing, 10-ft rows)
  - One on Expansion 4 (expansion, control site)
  - 3 days of footage, 1 shot/10 seconds



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Aquaculture Plots
Coast Seafoods Company 1.5' Elevation Oyster Culture Feasibility Study
Northern Humboldt Bay, California (3225-05)
April 2015

Black Brant:
Camera Monitoring Results

- Brant readily swam through aquaculture equipment but generally stopped using sites when structure was above water line
- Brant did not avoid aquaculture equipment (no "buffer effect"); they tend to stop moving through when movements were impeded
- No use of "boat rows" (10-ft rows) compared to 2.5-ft rows

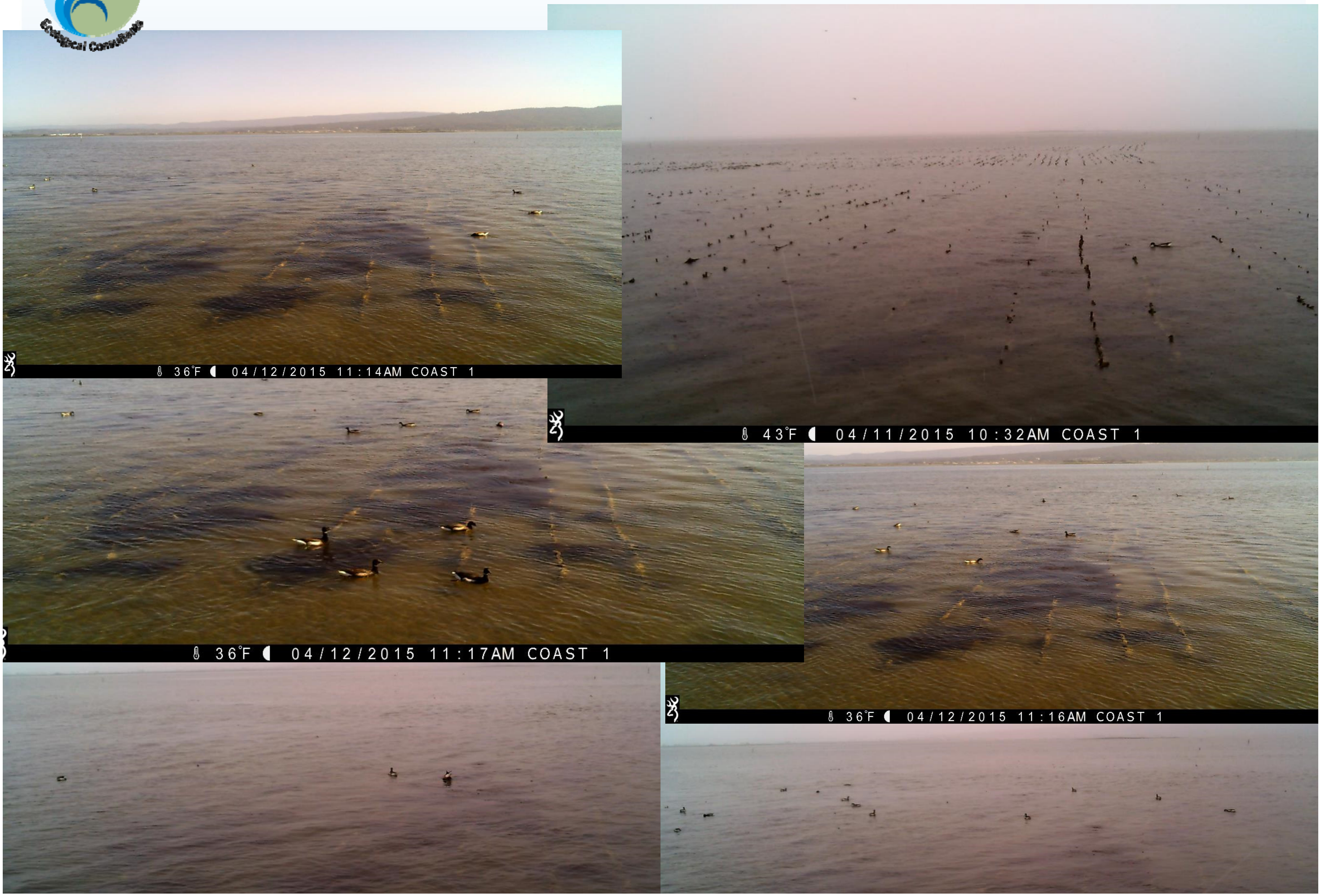

43°F 04/11/2015 10:50AM COAST 1


61°F 04/10/2015 12:21PM COAST 1


43°F 04/11/2015 10:32AM COAST 1


43°F 04/11/2015 01:14PM COAST 1

H.T. HARVEY & ASSOCIATES
Ecological Consultants



Black Brant:
Modeling Approach

- HTH Approach
  - Energetics Model
- Determine
  - Energetic needs of brant using Humboldt Bay for wintering/spring staging/migration
  - Caloric availability of food resource (eelgrass) in the bay
  - Amount of reduction resulting from aquaculture expansion
  - Whether brant will be energetically constrained such that reproductive success could be hindered

Black Brant:
Stillman et al. (2015) Modeling Approach

- Published model developed in coordination with Whelan Gilkerson and others to evaluate the effects of changes in eelgrass abundance and human disturbance on daily mass gain and stop-over duration of black brant in Humboldt Bay
- Uses best available data on brant and eelgrass for model parameters, Humboldt Bay-specific whenever possible
- Temporal and spatially explicit model follows population of brant through a 183-day spring season

Black Brant: Bioenergetics Model

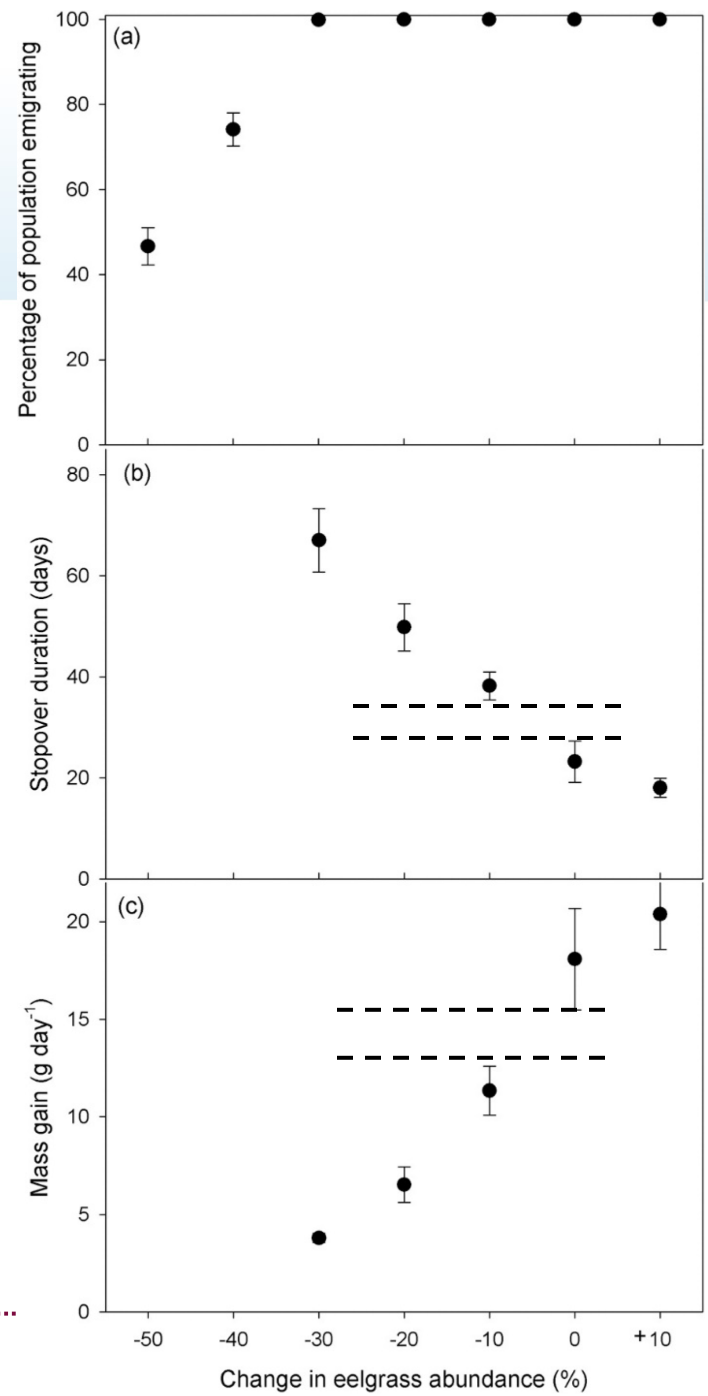
- Brant arrive, forage, grow, and emigrate according to numerical functions previously described for
  - Brant foraging and energetics
  - Eelgrass distribution, density, and growth

Table 1. Parameter values used in the model.

Name	Value	Derivation
(a) Environmental parameters		
Time step length (hours)	1	Time interval to account for tidal cycle and individual forager behavior; standard time step length for estuarine bird models (e.g. Pettifor et al. 2000)
Duration of daylight (hours)	9 to 15	Range of hours of daylight over the December–May period, calculated using the United States Naval Observatory Astronomical Applications Department calculator (www.usno.navy.mil/data/docs/RS_OneDay.php) for 2012
Model length (days)	183	1 December to 31 May; the period of usage of Humboldt Bay by migratory brant (Moore et al. 2004, Lee et al. 2007)
Water level (m MLLW)	2.6 to −0.6	Hourly tidal water level data for North Bay Spit tide gage (tidesandcurrents.noaa.gov/geo.shtml?location=9418767) for December 2011 to December 2012
(b) Patch parameters		
Patch size (m^2)	500 × 500 = 250000	Maximum area exploited by an individual in a single hour time step
No. patches	150	Total number of discrete 500 × 500 m areas occupied by eelgrass within Humboldt bay
Elevation (m MLLW)	0.3 to −2.1	Shaughnessy et al. (2012)
Eelgrass initial biomass (g DM m^{-2})	0 to 418	Range of values derived from surveys reported by Gilkerson (2008) multiplied by the proportion of biomass comprised by the three youngest leaves which the brant target (0.65; Moore 2002)
Eelgrass shoot length (m)	0.25 to 0.85	Range of values derived from Gilkerson (2008)
Eelgrass metabolizability (%)	46	*Zostera marina* leaves; Buchsbaum et al. (1986)
Eelgrass energy content (kJ g^{-1} DM)	16.8	*Zostera marina* leaves; Baldwin and Lovvorn (1994)
Eelgrass growth rate (g DM d^{-1})	$B_{t+1} = a[S_t + (\Delta G_t 10^4) - mS_t - H_t]$	Moore (2002), see text for derivation
Eelgrass floating biomass (% of total)	5	Estimated from information in Elkinton et al. (2013)
(c) Brant parameters		
Brant population size (no. ind.)	60000	Based mark-recapture estimates for 2001 (Lee et al. 2007)
Arrival date of first brant	1 January	Based on arrival dates given in Lee et al. (2007)
Brant mass on arrival (g)	1320	Derived from mean mass of adult female brant at San Quintin Bay, Mexico in January (1440 g; Mason et al. 2006) minus the cost of a non-stop flight to Humboldt Bay (120 g) following Calder (1974) in Vangilder et al. (1986)
Brant target mass on departure (g)	1580	Derived the mean mass of adult female brant at San Quintin Bay, Mexico prior to departure in late March (1580 g from Mason et al. [2006])
Brant target mass gain during stopover (g)	260	Departure mass − arrival mass
Brant lean mass (g)	964	Spaans et al. (2007) estimated the lean mass (i.e., with no energy stores) of dark-bellied brent goose *Branta bernicla bernicla* to be 73% of mass on arrival at breeding area. Thus for brant, 1320 g × 0.73 = 964 g
Brant energy density (kJ g^{-1})	34.3	Energy content of avian tissue, given in Kersten and Piersma (1987)
Brant energy store on arrival (kJ)	15984	(arrival mass − lean mass) × energy density
Brant target energy store on departure (kJ)	24902	(departure mass − lean mass) × energy density
Brant BMR (W)	5.77	Calculated from allometric equation derived by Bruinzeel et al. (1997); BMR = 4.59 × ($M^{[illegible]}$), where M = mass (1.4 kg; Boyd 2005)
Brant energy expenditure whilst foraging (W)	9.81	1.7 × BMR; based on value given in Table 1 of Clausen et al. (2012)
Brant energy expenditure whilst resting (W)	9.23	1.6 × BMR; based on value given in Table 1 of Clausen et al. (2012)
Brant maximum feeding depth (m)	0.40	Clausen (2000), Moore and Black (2006a)

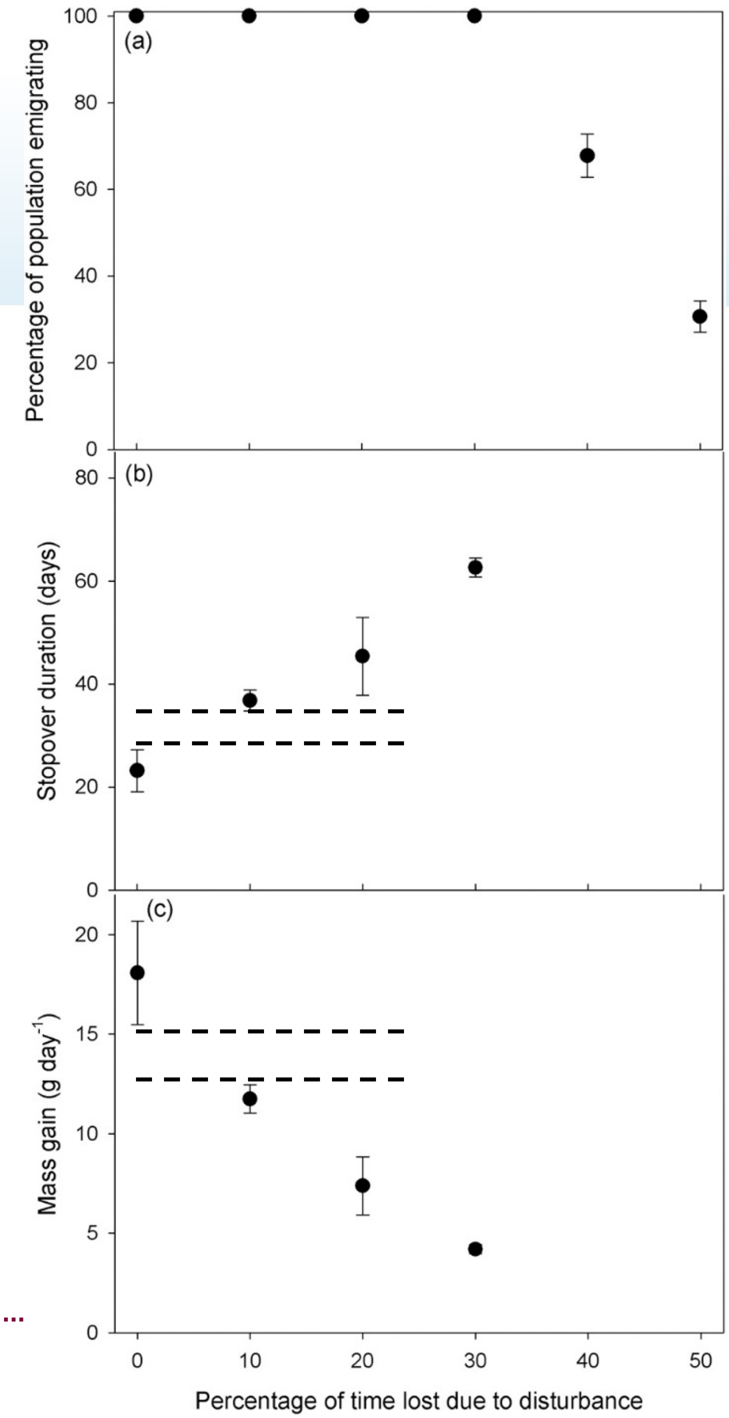
Black Brant: Bioenergetics Model

- Impact Threshold
  - *As little as a 10% reduction in total eelgrass biomass may significantly decrease daily mass gain and increase stop-over duration*



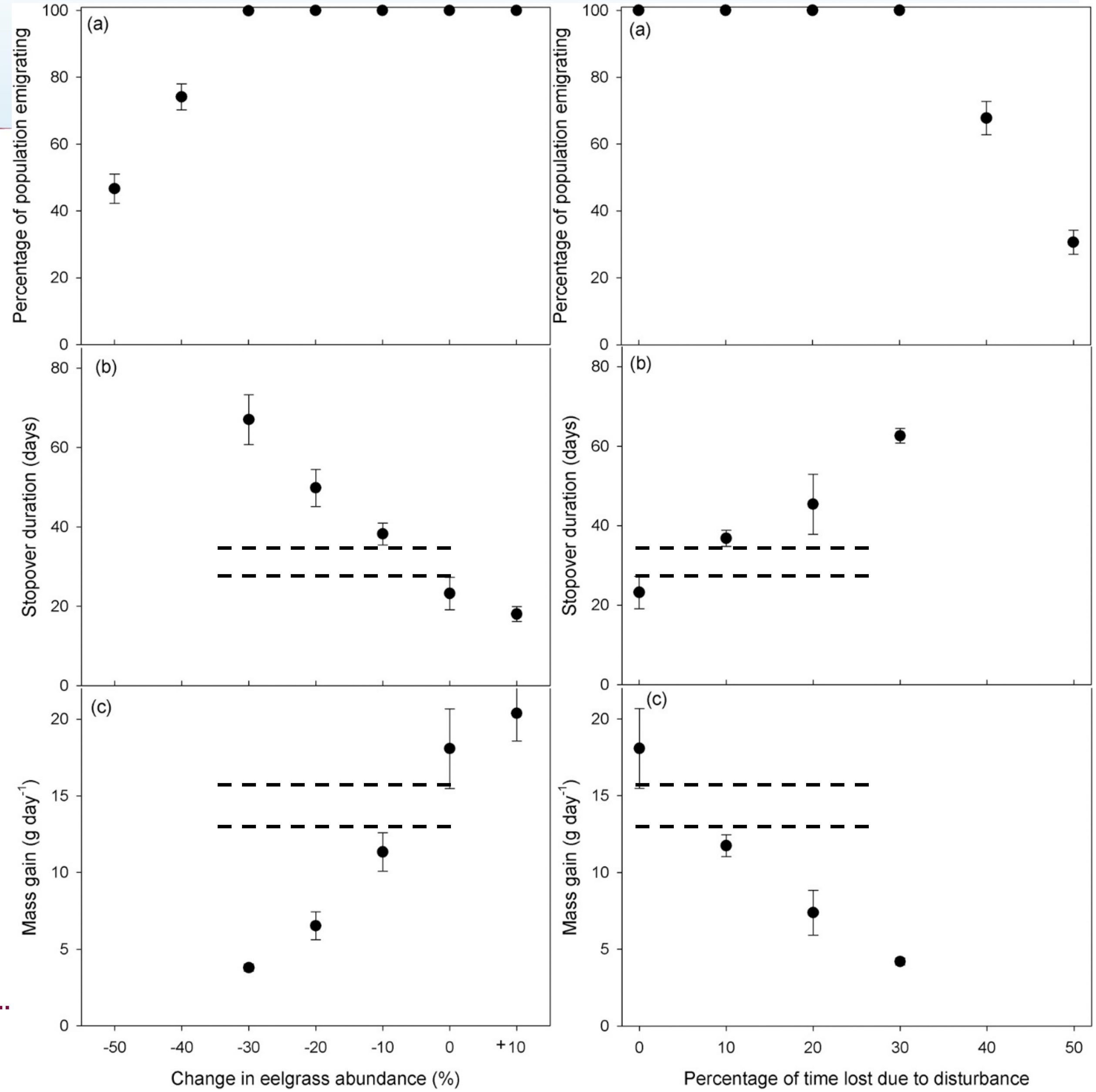
Black Brant: Bioenergetics Model

- When brant experience human disturbance:
  - Model estimates 10% increase in disturbance may significantly decrease daily mass gain and increase stop-over duration



Bioenergetics Model

- CEQA significance is met when stopover duration is lengthened, as this can result in lower reproductive success (conservative approach)



Black Brant:
Bioenergetics Model Assumptions

- Biomass estimates are conservative
  - Biomass estimates only include the 3 youngest shoots
  - Patchy eelgrass was not considered
  - Both of these biases also result in an underestimate of floating eelgrass because of the way it was calculated in the model (5% of total biomass)
- It should be noted:
  - Many model parameters are held constant, so uncertainty in estimates of those parameters are not included in model predictions
  - Sensitivity analysis indicated that model results varied substantially with only 10% changes in some model parameters
  - However, model predicts a very reasonable biological response to eelgrass reduction (and disturbance). This is the best available model using the best available data. Given the size of the estimated effect and conservative assumptions, uncertainty is not anticipated to effect the conclusions of the analysis.

Black Brant: Bioenergetics Model Methods

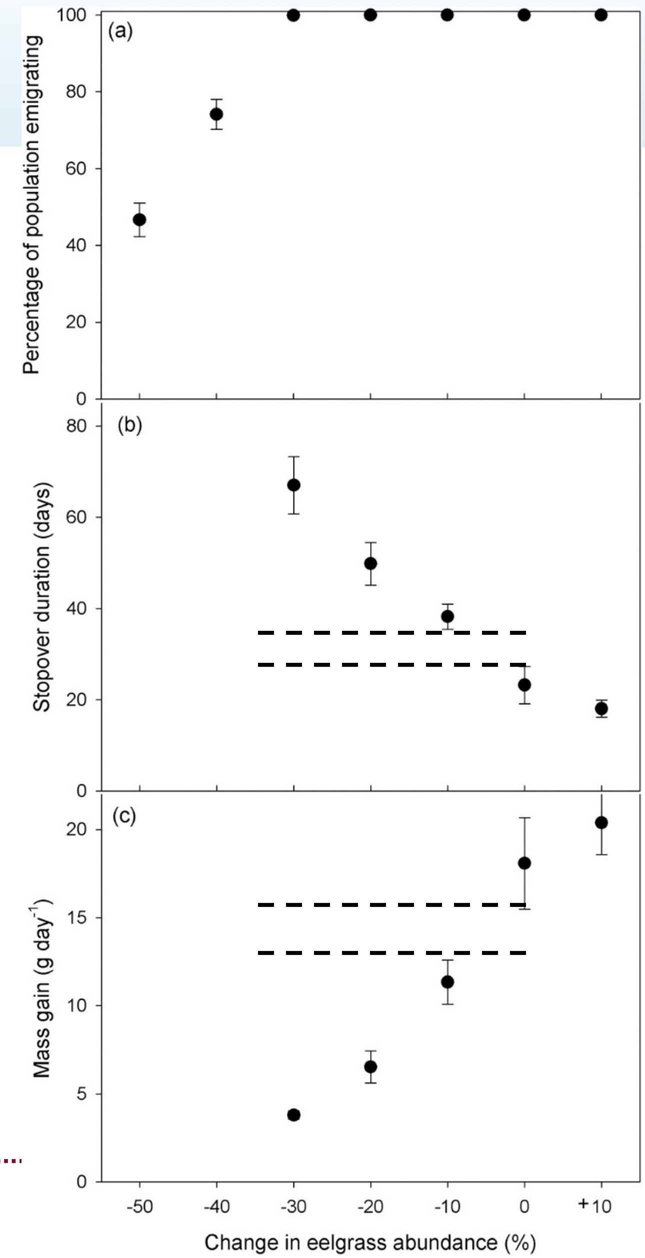
- Base data on eelgrass biomass used in Stillman et al. (2015) was used to estimate total biomass in Humboldt Bay and Arcata Bay, but at a 25 m^2 resolution (2001/02 and 2002/03, CA Sea Grant)
  - Eelgrass occurring at depths greater than 0.4 m below the lowest low tide during daylight hours in winter was excluded (effectively unavailable to foraging brant)
  - Note that Stillman et al. (2015) did not account for existing aquaculture - our analysis uses higher resolution than Stillman et al. (2015); more accurate for project footprint)
- To estimate project effects on functionally available biomass:
  - 4.8% reduction in biomass applied to all existing and expansion areas
  - Within existing and expansion areas, biomass below the elevation of aquaculture infrastructure (1 ft for longlines; 26” and 40” for basket-on-line) was excluded
  - No buffer around the project footprints was incorporated

Black Brant: Bioenergetics Model Results

- Total biomass in Arcata and South Humboldt Bay were more evenly distributed in 2001-2003 as compared to previous studies
  - 53% in South Bay and 47% in Arcata Bay
  - Greater density in South Bay, but longer shoot length in Arcata Bay, likely provides a longer window of opportunity for foraging in Arcata Bay
- Estimated biomass within existing and expansion areas (no project effects) was:
  - 12% of bay-wide total biomass (9% expansion, 3% existing)
  - Expansion areas contain 18% total biomass in Arcata Bay

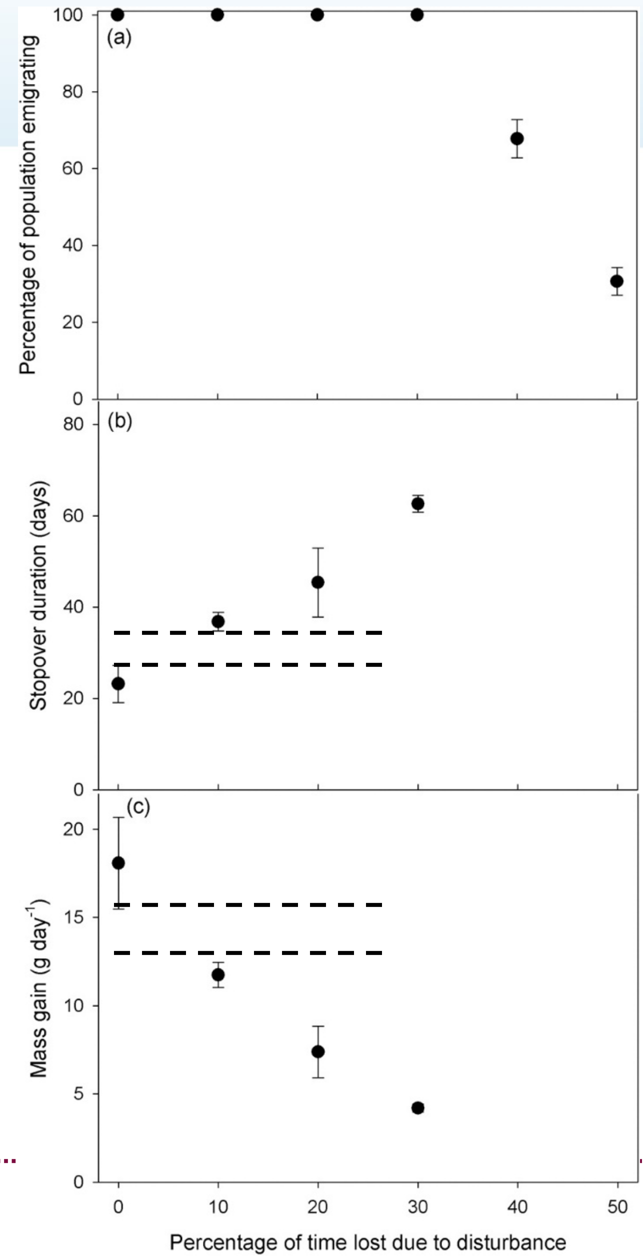
Black Brant: Results and Interpretation

- Considering project effects as described:
  - 3.6% reduction in bay-wide biomass with 1 ft longlines (522 ac) and 26” basket-on-line (96 ac)
  - 3.7% reduction in bay-wide biomass with 1 ft longlines (522 ac) and 40” basket-on-line (96 ac)
- Assumes:
  - 1-ft longline height
  - 40” max basket-on-line height
  - Basket-on-lines will occur in densest eelgrass
  - 4.8% reduction in biomass (note: measured in density) within project footprint
- A reduction in functionally-available biomass under 4% is not expected to result in delayed stopover duration



Black Brant: Disturbance

- Disturbance Effects :
  - Model estimates 10% increase in disturbance may significantly decrease daily mass gain and increase stop-over duration
  - Previous estimates indicate brant experience disturbance 3.3% of daylight hours in Humboldt Bay (Schmidt 1999)
  - Project will involve longer trips and more personnel but no additional boats expected
  - Unlikely to result in a significant impact that exceeds the thresholds established in the Stillman model
- Gritting Sites:
  - 6 gritting locations documented in South Bay
  - Less studied in Arcata Bay; multiple sites apparently used: Sand Island and northwest shore of Indian Island noted
  - Identified sites for brant grit locations are not within project area



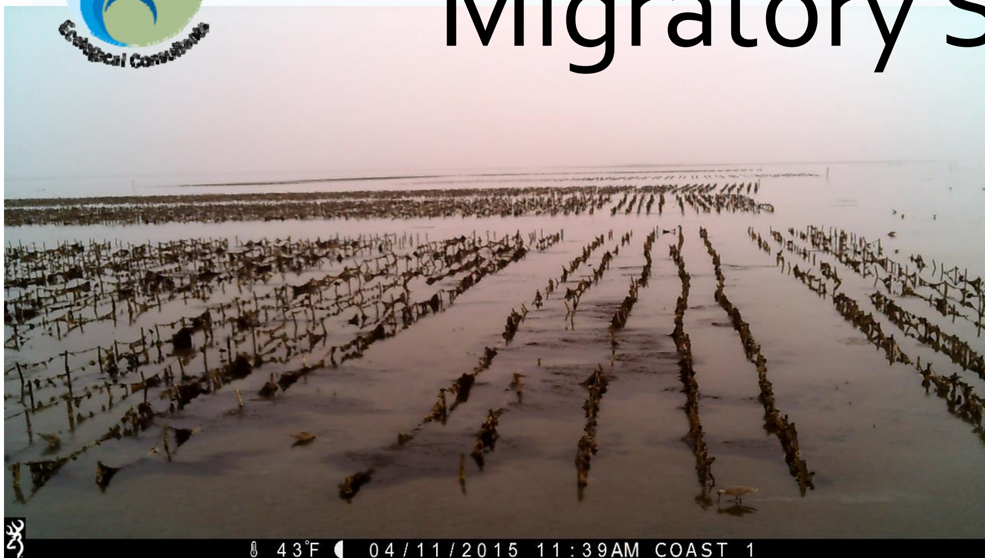
Migratory Shorebirds

- Humboldt Bay is Western Hemisphere Shorebird Reserve Network "Site of International Importance"
- Non-breeding shorebirds (up to 32 species) use intertidal mudflats for foraging
- Water depth key for foraging (more than specific locations) – forage at edge of waterline (concentration of food)
- Many shorebirds use alternative sites for foraging during high tide
- Connolly and Colwell (2005) examined shorebird use of aquaculture (longline) sites vs. control sites in Arcata Bay
  - Greater diversity in aquaculture plots (possibly due to increased prey density/diversity)
  - Black-bellied plovers used control plots more (possibly due to visual foraging)
- Kelly et al. (1996) suggest some shorebirds avoided aquaculture areas in Tomales Bay, but based on on-bottom oyster culture methods

Migratory Shorebirds

- Some species may be differentially affected (black-bellied plovers, long-billed curlews)
- Most Coast's aquaculture expansion proposed for lower-elevation, eelgrass areas (as opposed to higher elevation mudflats where these birds occur)
- Shorebird use of aquaculture sites appears to be correlated with water level, foraging sandpipers seem to use sites irrespective of longlines

Migratory Shorebirds



Other Avian Species

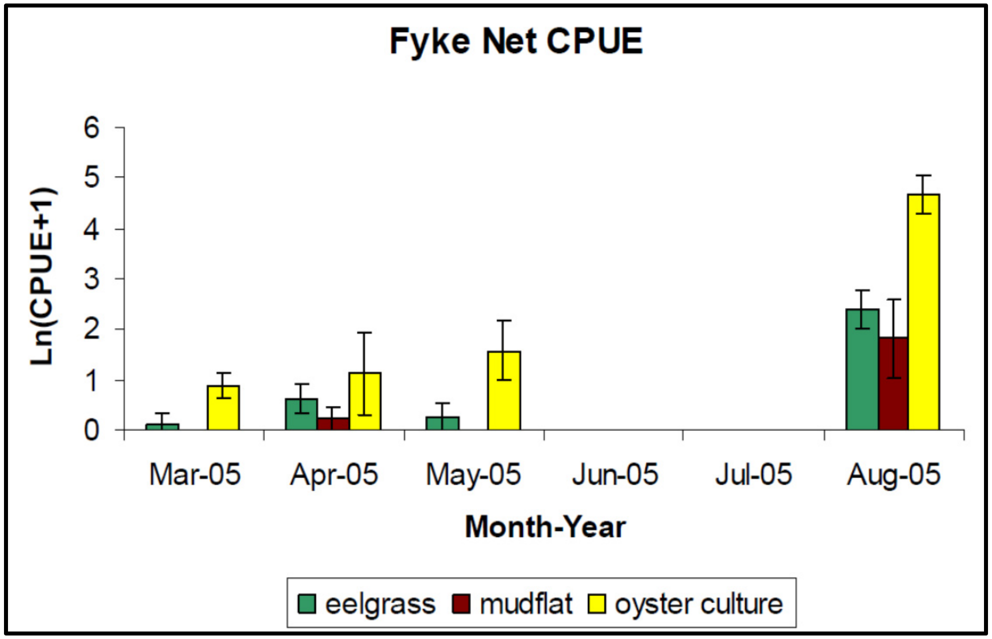
- Nesting Birds
  - Sand Island nesting birds: double-crested cormorants (400 nests in 2014), Caspian terns (300 nests in 2014)
  - Potential for colony abandonment due to human disturbance
  - Disturbance-free buffer of 100 m during breeding season
- Waterfowl
  - Common dabbling ducks in Humboldt Bay: American wigeon, green-winged teal, northern pintail, and mallard
  - Common diving ducks in Humboldt Bay: greater and lesser scaup, bufflehead, and surf scoter
  - Wigeon – first to arrive in fall
    - Freshwater ponds (fall); tidal habitats (mid-winter); flooded pastures (spring)
    - Forage on emergent and free-floating eelgrass
    - Similar potential impacts and mitigation (eelgrass management) discussed for brant applies

Other Avian Species: Endangered Species

- Marbled Murrelet
  - Nest in mature coniferous forest (old growth redwoods)
  - Occur in small numbers in Humboldt Bay as foragers
  - Observed primarily in the subtidal entrance portion of the bay between King Salmon and the Elk River mouth
- Western Snowy Plover
  - Nonbreeding western snowy plovers infrequently occur on the interior of Humboldt Bay
  - Occasionally observed in South Bay on sandier substrates

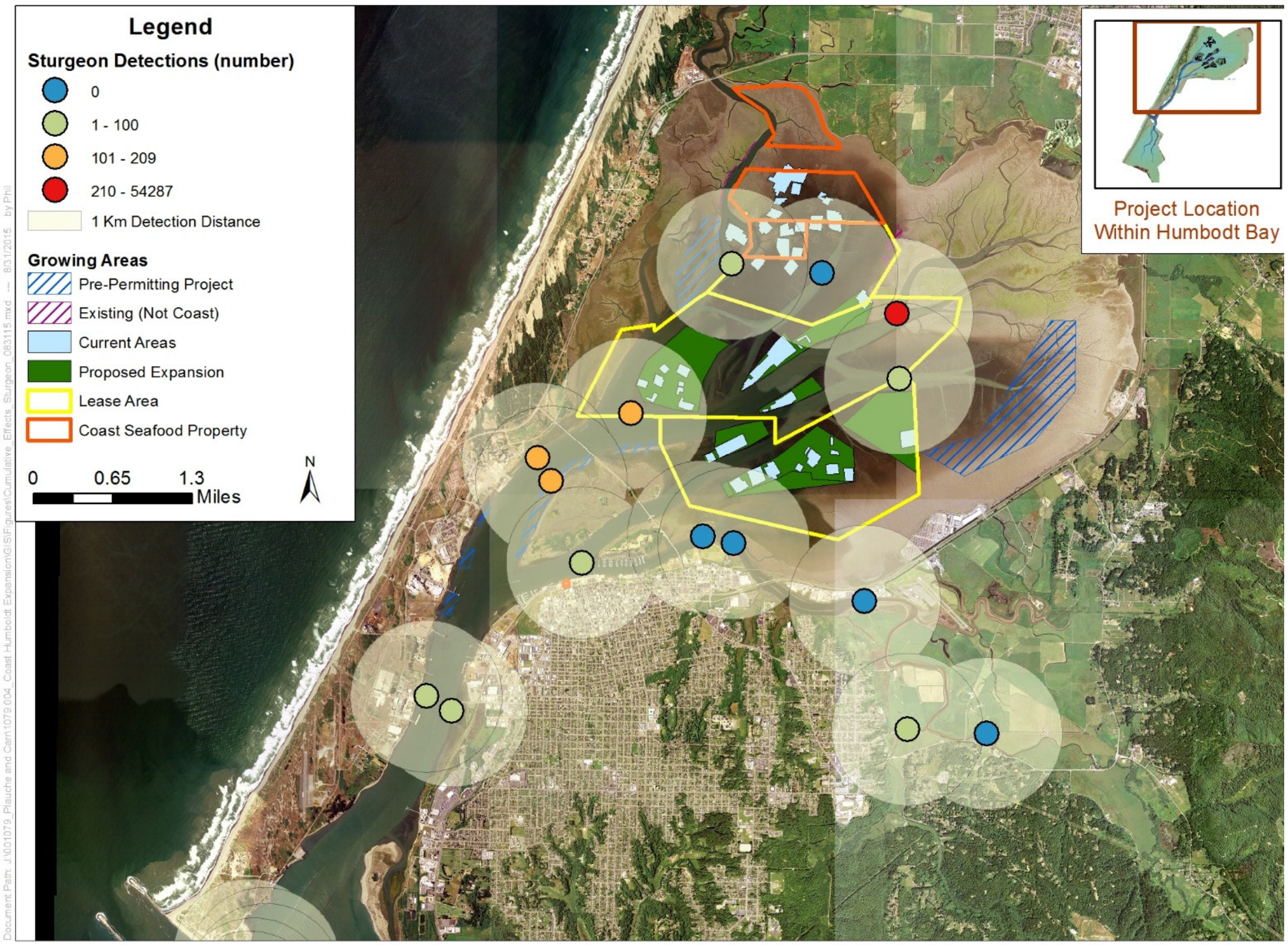
Biological Resources:
Fish Sampling

- Use of Humboldt Bay
  - Major overlap April through August, but numerous resident species
  - More fish collected from oyster culture compared to mudflat and eelgrass using trawl and fyke net gear
  - Species richness and diversity of fyke net samples similar between oyster culture and eelgrass habitat
  - 42% of fish were using habitat for nursery areas
  - Dominant species in oyster culture was English sole and shiner surfperch
- Project-related Effects
  - Neutral effect (i.e., structured habitat similar to eelgrass)



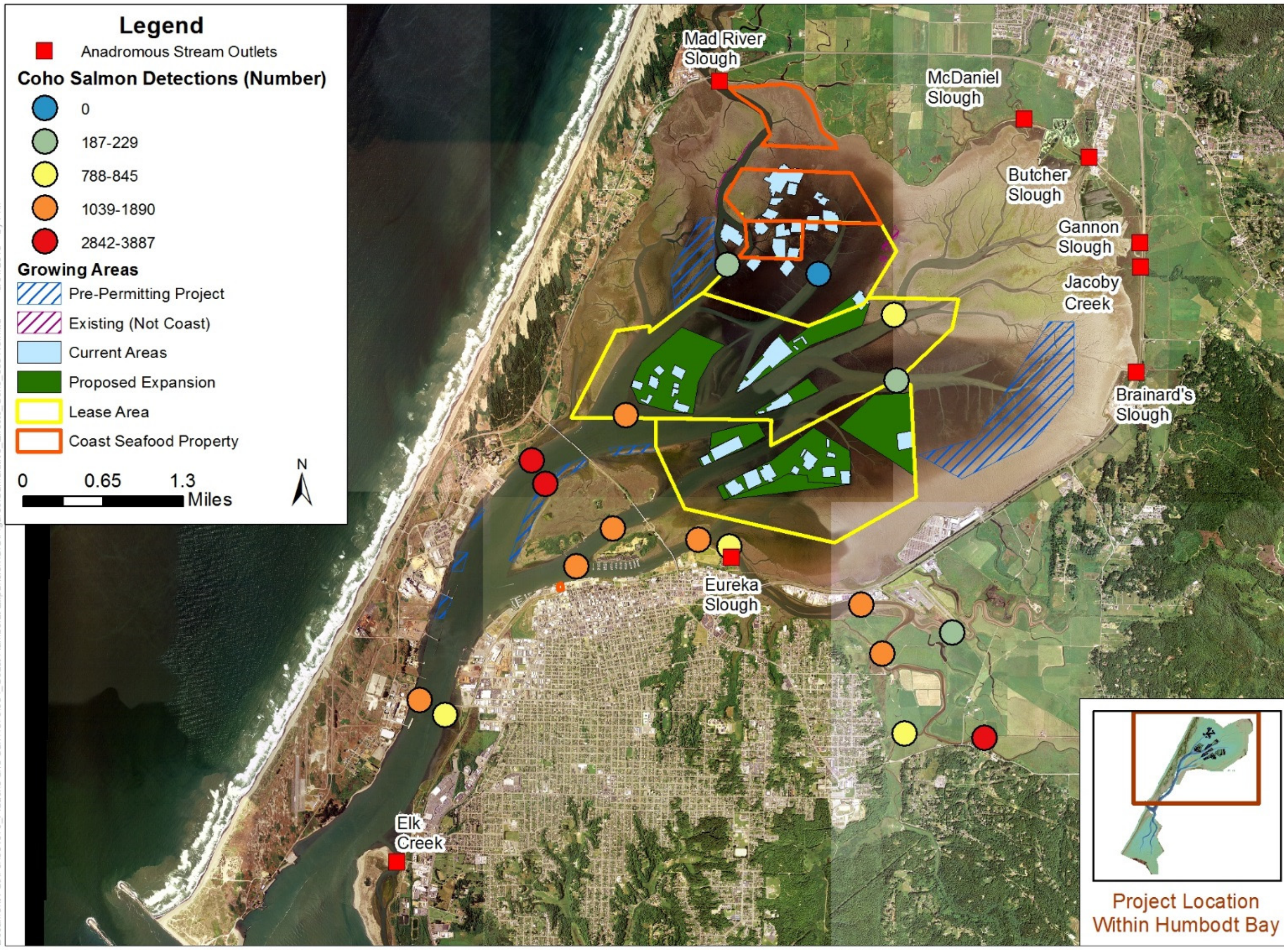
Biological Resources:
Green Sturgeon

- Use of North Bay
  - Associated with deep channels
  - Detections similar to larger nonnatal river estuaries
  - Summer use by subadult and adult sturgeon that are not spawning
- Project-related Effects
  - Neutral effect (i.e., structured habitat similar to eelgrass)



Biological Resources: Salmonids

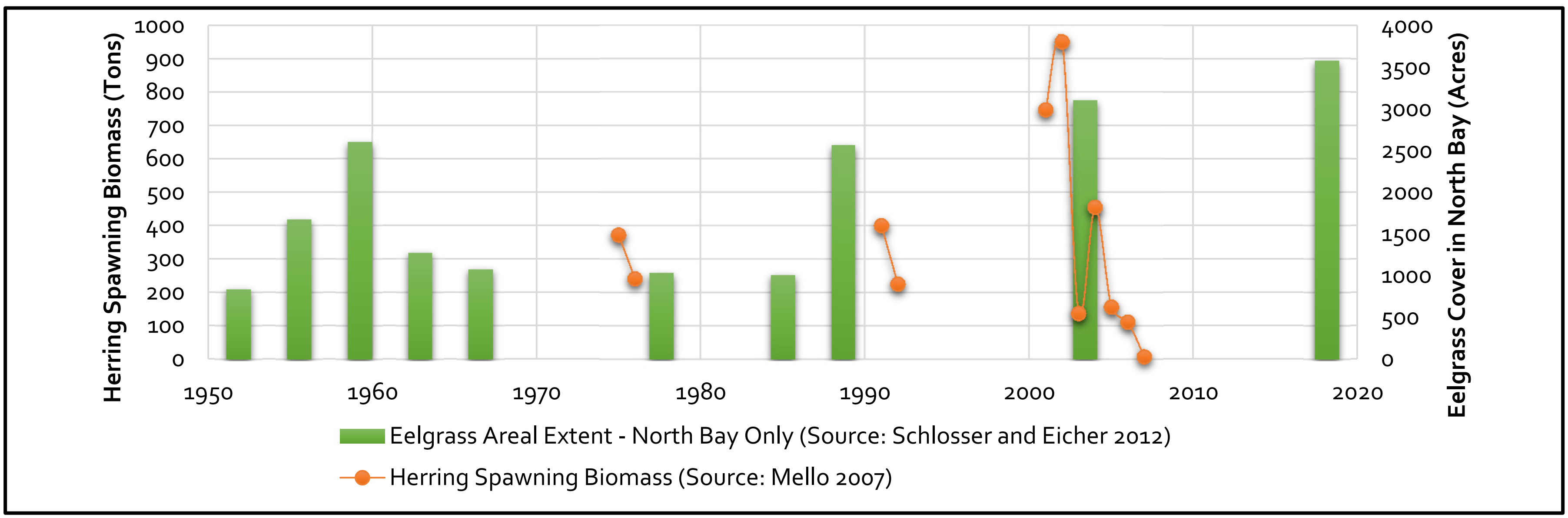
- Use of North Bay
  - Major migration = June to August
  - Associated with deep channels and channel margins
  - Edge habitat appears to be important to foraging activities
- Project-related Effects
  - Neutral effect (i.e., structured habitat similar to eelgrass)



Biological Resources:
Pacific Herring

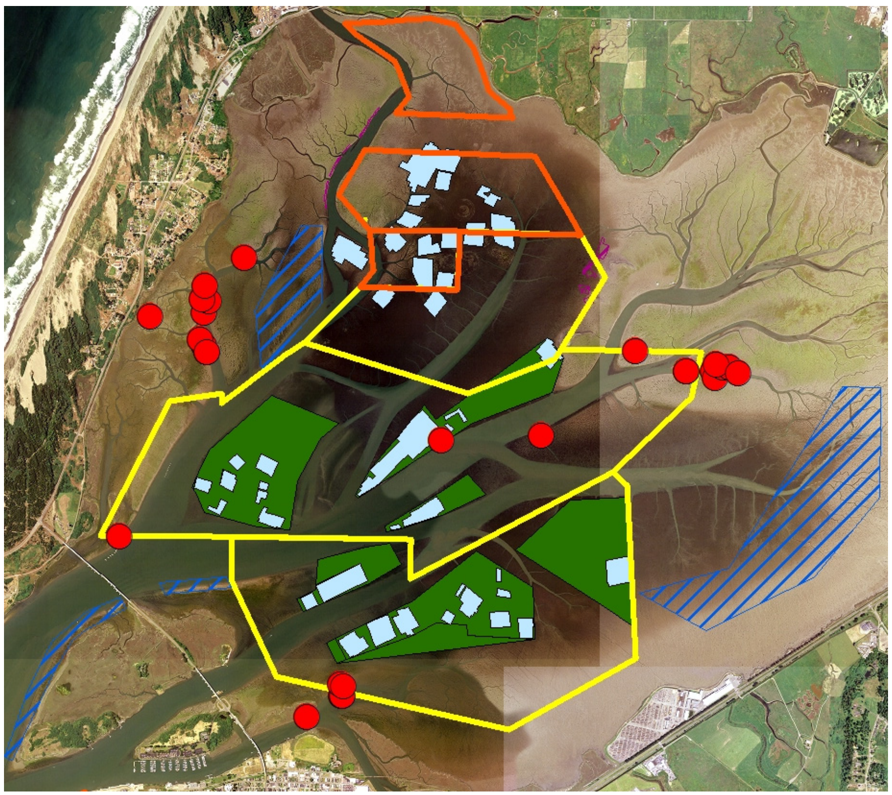
- Spawning Habitat
  - Spawning occurs January to early March (based on 2006-2007 data)
  - Most spawning occurs in North Bay
  - Typical spawning event uses <10% of available eelgrass
  - No apparent substrate limitation

- Pacific Herring Population Trends
  - Unrelated to eelgrass or shellfish aquaculture
  - Eelgrass has been stable while herring populations have dramatically declined
  - Herring declined even when shellfish aquaculture was reduced by 200 acres



Biological Resources:
Marine Mammals

Harbor Seal Haul-out Sites



- Use of Humboldt Bay
  - Harbor seals, California sea lions, and harbor porpoise are year-round residents
  - River otters are occasional visitors
  - South Bay = main harbor seal pupping area
  - North Bay = haul-out sites and foraging
- Project-related Effects
  - Human disturbance can pose a threat, but have BMPs to avoid culture area if mammal is observed foraging in or near the area
  - Higher potential impacts to populations from kayaks and canoes than motor boats due to the noise level and reaction
  - Habitat limitation associated with haul-out sites appears to be a more significant determinant to population-level changes

Biological Resources: Invertebrates

- Project-related Effects
  - Biodeposits from shellfish can support a large and diverse benthic and pelagic community
  - Oyster longlines are a three-dimensional structure that increase the amount of "above-bottom" habitat
  - Use by mobile invertebrates (e.g., crabs) depends on life stage and size; young crabs typically prefer structured habitat and adults unstructured habitat

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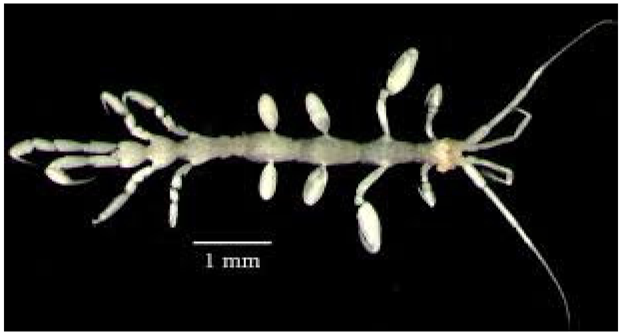

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Project Summary

- Oyster longlines do not inhibit eelgrass ecological functions
- Longlines are a type of structured habitat that is not permanent
- Presence of longlines does not inhibit use of the habitat by species protected under ESA or EFH
- Mitigation is proposed regardless of impact conclusions
- Mitigation based on an ecosystem plan that "considers ecosystem function and services relevant to the geographic area and specific habitat being impacted"
- Monitoring plan was designed based on the recommendations in the CEMP and developed in consultation with resource agencies and local experts
- Monitoring will inform whether additional mitigation or adaptive management is needed
- Less than significant impact to black brant and other biological resources

Key Questions and Answers Regarding Coast Seafoods Company's Humboldt Bay Shellfish Aquaculture: Permit Renewal and Expansion Project

Prepared for the Pacific Fishery Management Council, Habitat Committee
Thursday, September 10, 2015

Introduction

Coast Seafoods Company ("Coast") currently farms shellfish on 300 intertidal and subtidal acres in Humboldt Bay, California. Coast's operations are primarily located in Humboldt Bay's North Bay and include intertidal culture of oysters using longline culture methods as well as rearing of oyster and Manila clam seed in a Floating Upwelling System ("FLUPSY"). Coast's Humboldt Bay Shellfish Aquaculture: Permit Renewal and Expansion Project ("Project") proposes to renew regulatory approvals for 294.5 acres of Coast's existing culture in North Bay and to discontinue farming on 5.5 of its existing acres (Figure 3.4). Coast is also proposing to increase shellfish aquaculture production by planting an additional 622 intertidal acres and increasing the capacity of its already-permitted FLUPSY by adding 8 new culture bins. In total, the Project would result in 916.5 acres of intertidal oyster culture.

Coast is preparing a draft Environmental Impact Report ("DEIR") for the Project pursuant to the California Environmental Quality Act ("CEQA"). In anticipation of the DEIR's publication in September 2015, Coast met with state and federal regulatory agencies to discuss the project on September 1, 2014. Agencies represented at the meeting included: the National Oceanic and Atmospheric Administration (Fisheries); the National Marine Fisheries Service; the U.S. Fish and Wildlife Service; the U.S. Army Corps of Engineers; the California Department of Fish and Wildlife; and the California Coastal Commission.

This document was prepared to summarize some of the key questions that were posed about the Project during the September 1, 2015 meeting with agency representatives and to provide preliminary answers thereto. Given the long duration of the meeting, it is not intended to be a comprehensive summary of all questions asked or items discussed.

Key Questions

Question No. 1: Why is a Project alternative that does not involve expansion in existing eelgrass beds not being considered?

<u>Response</u>: *During Project scoping and planning, an alternative to expand shellfish culture in areas without eelgrass was considered and rejected due to its inability to meet the Project's basic objectives. Coast's leased and owned footprint in Humboldt Bay includes 644 acres of patchy eelgrass beds (15% of total footprint) and 1,428 acres of continuous eelgrass habitat (33% of Coast's total footprint). An additional 1,038 acres are not suitable for intertidal oyster cultivation, given that these areas are characterized primarily by tidal and subtidal channels. The total combined acreage occupied by subtidal or tidal areas and eelgrass is 3,110 acres, or 72% of Coast's total footprint.*

In addition, very little of Coast's leased and owned footprint is both at tidal elevations suitable for shellfish aquaculture and in areas that do not support existing eelgrass beds. Special Condition No. 5 of Coast's existing California Coastal Development Permit required Coast to evaluate the feasibility of planting and harvesting oysters at elevations typically unsuitable for eelgrass growth. 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). As shown in Figure 1, the vast majority of Coast's leased and owned area is either above +1.5 MLLW, in areas occupied by eelgrass, or in subtidal and tidal areas of the Bay. There is very little, if any, available acreage at productive elevations for oyster cultivation within Coast's leased and owned footprint that is not occupied by eelgrass.

Question No. 2: You are predicting an approximately 5.0% reduction in turion density associated with the longlines within the aquaculture expansion area. How did you arrive at these numbers?

<u>Response</u>: *Based on several studies, including the Western Regional Aquaculture study by Rumrill and Poulton in 2004, it is assumed that oyster longlines can reduce eelgrass turion density directly under the lines while areas between the lines are not impacted. A series of calculations were performed to determine the total percent reduction in eelgrass density expected as a result of the Project (see Page 35, Eelgrass Impacts Analysis). The first calculation multiplies longline length (100 ft) by **width of effect** to get the area below the longline ("ABL"). The second calculation multiplies the expansion area acreage by ABL and number of lines/acre to get area of influence. The third calculation multiplies area of influence by **eelgrass density**, by **percent reduction under the longlines** to get reduction of turions below longlines. The final calculation multiplies reduction*

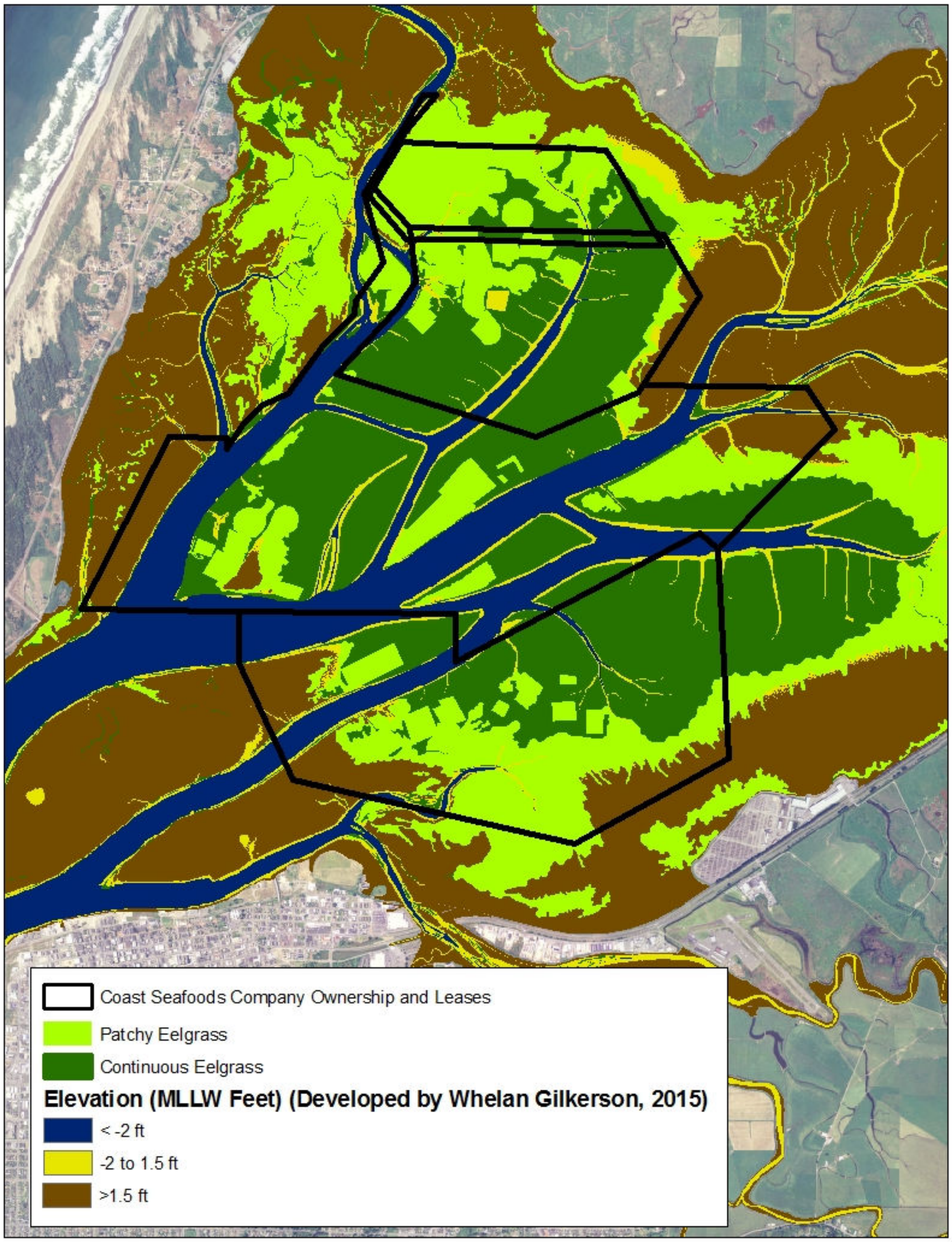

Figure 1: Tidal elevation and eelgrass cover within Coast's leased and owned footprint in Humboldt Bay, California. This map depicts two layers of information—tidal elevation and eelgrass coverage (light and dark green). The layer depicting tidal elevation is "underneath" the layer depicting eelgrass such that elevation is only depicted in areas without eelgrass coverage.

of turions below longlines by total turions within an area to get total percent reduction in eelgrass density. Three variables in these calculations were determined based on external inputs: width of effect, eelgrass density and percent reduction under the longlines.

- *Width of effect (the extent of reduction in density under the longlines) was calculated differently depending on the culture method being considered. For cultch-on-longline, the width of effect was based on the amount of length of cultch per line, average width of cultch (weighted by species cultured), growth of oysters, number of floats and posts per line, and width of fouling organisms attached to the cultch. For basket-on-longline, the width was based on the length of baskets per line, width of baskets, width of floats and post, and width of fouling organisms.*
- *Values representing starting eelgrass density under the longlines were determined based on the average eelgrass densities reported in Humboldt Bay. Thus a density of 50 turions/m^2 was used for patchy eelgrass areas and 80 turions/m^2 for continuous eelgrass.*
- *Multiple data sources were consulted to determine the expected percent reduction in turion density under the longlines, including the 2004 Rumrill and Poulton study, additional data provided by Rumrill in 2015, and data collected by SHN Engineers and Geologists. Using the mean of the values derived from these information sources, it was determined that a density reduction of -47% was appropriate for cultch-on-longline and -70% for basket on longline.*

Based on the values and calculations described above, the project is expected to result in approximately a 5.0% reduction in eelgrass density within the shellfish aquaculture expansion area.

Question No. 3: Will monitoring be sensitive enough to detect whether you have used an appropriate value for width of effect?

<u>*Response*</u>*: Yes. Coast is proposing a comprehensive monitoring plan including two years of pre-project monitoring and two years of post-project monitoring (See Eelgrass Monitoring Plan). In addition to monitoring using a before/after-control/impact sampling design, Coast is proposing the use of aerial photography to survey eelgrass areal extent. The monitoring proposed will detect trends in eelgrass density under, beside and between longlines (cultch and basket).*

Question No. 4: Why are you focusing on out-of-kind, rather than in-kind mitigation?

Response: *Coast is using a watershed approach, as recommended by both NMFS' California Eelgrass Mitigation Policy and the U.S. Army Corps of Engineers' Mitigation Regulations, to propose both in-kind eelgrass mitigation and out-of-kind salt marsh restoration (see Eelgrass Impacts Analysis, pg. 64). The best available evidence suggests that eelgrass is at or near its carrying capacity in Humboldt Bay. As a result, and because efforts to restore eelgrass in areas where it is absent for unknown reasons have historically had high rates of failure, there are very few opportunities in Humboldt Bay for successful eelgrass mitigation. Special consideration was afforded out-of-kind salt marsh restoration because of the significant decline in salt marsh habitat from historical levels and because few salt marshes in Humboldt Bay have the potential to migrate in response to potential sea level rise. Coast has also developed an Estuarine Habitat Credit-Debit Mitigation Accounting Framework to characterize project impacts and mitigation benefits in order to identify the adequacy of proposed mitigation (see Appendix A, Eelgrass Impacts Analysis). Coast welcomes input and continues to have an open dialogue with federal and state regulatory agencies regarding the proposed mitigation and other potential mitigation options that improve the watershed.*

Question No. 5: What is the extent of the impact on Black brant?

Response: *Based on surveys performed by H.T. Harvey & Associates and the U.S. Fish and Wildlife Humboldt Bay National Wildlife Refuge, eelgrass does not appear to be a limiting factor for brant in North Bay, Humboldt Bay. As will be more fully discussed in the forthcoming DEIR, surveys suggest that brant will be excluded from foraging in aquaculture equipment when that equipment is exposed by falling tides. However, brant were observed readily foraging over aquaculture equipment during high tides. H.T. Harvey modeled the impact on brant associated with this temporal limitation on foraging based on the model recently published by Stillman et al.; modeling results suggest that the Project will not result in delayed stopover duration in Humboldt Bay for migrating brant. Modeling similarly suggests that the Project will not have any significant impact on brant as a result of increased human disturbance. A more in-depth discussion of impacts to avian species, including brant, will be included in the DEIR; further information is also available in the PowerPoint presentation Coast gave to federal and state regulatory agencies during meetings this summer (submitted to the PFMC briefing book).*

Question No. 6: What is the expected impact on herring spawn?

Response: *The Project's impact on herring spawn is expected to be less than significant. Herring spawning occurs in January to early March in Humboldt Bay, with most spawning occurring in North Bay. A typical spawning event uses less than 10% of available eelgrass, thus there are no apparent* *limitations to herring spawning substrate. Trends in herring population in Humboldt Bay also appear to be unrelated to shellfish aquaculture. To further ensure that the Project's impacts on herring spawn are minimized to the extent feasible, Coast has committed to performing visual surveys of aquaculture beds prior to harvesting or planting in December, January and February in order to detect herring spawn (including on the substrate, eelgrass and aquaculture equipment). If herring spawn is present, Coast will postpone harvest/planting for two weeks on the beds where spawning has occurred and notify the California Department of Fish and Wildlife within 24 hours.*

Question No. 7: What effects do you expect to other special status fish species?
Response: *Effects on other special status species, including green sturgeon and salmonids, are expected to be less than significant. For both salmonid and green sturgeon, aquaculture equipment provides structured habitat similar to eelgrass. Green sturgeon do not typically occur in intertidal areas where the vast majority of new shellfish aquaculture gear will be placed.*

Conclusion

These and other questions regarding project design, potential impacts and proposed mitigation will be more fully addressed in the DEIR. Coast looks forward to continuing its dialogue with PFMC and state and federal regulatory agencies in order to further refine its analysis and the project both before publication of the DEIR and in the public comment period following publication.

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