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A Pre-Feasibility Study Examining Oyster Mariculture Expansion in Humboldt Bay, CA

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Executive Summary:

Humboldt Bay is the largest producer of oysters in the State of California, with approximately 4,000 acres of certified mariculture growing area (CDPH, 2010). At the same time, it has about 40% of the eel grass (*Zostera marina*) habitat in the state (Schlosser et al., 2009). Eel grass is protected under the Endangered Species Act as a critical habitat for several listed species, including steelhead trout (*Oncorhynchus mykiss*), Coho salmon (*Oncorhynchus kisutch*) and Chinook salmon (*Oncorhynchus tshawytscha*) (HBWAC and RCAA, 2005). This can pose a problem when trying to balance the production of oysters and conserving the eel grass. Some oyster cultivation practices can have adverse effects on eel grass (NAS, 2010). This includes one of several methods currently being utilized in Humboldt Bay, long-line cultivation. Long-lines are suspended about a foot above the bay floor by notched PVC tubes, these lines are then spaced about 2.5 feet apart from each other (Coast Seafoods, 2007). Without appropriate best management practices, this has the potential to shade eelgrass and decrease its productivity.

The Humboldt Bay Harbor, Recreation and Conservation District (Henceforth known as "the Harbor District") is assessing whether the current 300 acres or so of shellfish mariculture that exists in the Bay has the potential for expansion. This current acreage is less than a third of historical cultivation coverage. The focus of this study was to assess the feasibility of expanding oyster mariculture in Humboldt Bay. Species other then oysters were not analyzed and the primary focus of this study was long-line culture methods to grow out adults, rather than other operations in the bay such as seed maturation. The Humboldt State University Natural Resource Planning Team did this study as a pre-feasibility study for the Harbor District in order to evaluate if a full scale study is warranted. We looked at physical and regulatory opportunities and constraints. The Humboldt State University Natural Resource Planning Team analyzed four different parameters for the physical criteria. These parameters were depth (based on acceptable depths for cultivation), Humboldt Bay ownership and leases, current eel grass beds and predicted future eel grass habitat. When considering regulatory constraints on mariculture expansion, we examined the required permitting processes, as well as required consultations. We also discussed water quality and climate change issues in our study, but did not include them in the final analysis.

In order to asses the areas of feasible expansion into the bay, we obtained Arc GIS data layers for each of the physical criteria. We then used Arc GIS to analyze the data and create a new layer with 6 categories of feasibility. These categories were No Feasibility, Very Low Feasibility, Low Feasibility, Medium Feasibility, High Feasibility and Very High Feasibility (Refer to Table 1 for an explanation of these categories.). We also created four maps detailing each of the criteria used in the analysis in order to demonstrate how we derived our final map. The regulatory analysis was done through document research, as well as through contacts with agency staff obtained from the Harbor District and from HSU staff.

The results show that between the Very High, High and Medium feasibility categories, oyster mariculture could be expanded into as many as 2,647 acres of the Bay. These areas have no surveyed eel grass, are within the acceptable tidal heights for oyster cultivation, and are within the defined mariculture production zone. The Very High feasibility areas are the only places where the predicted eel grass habitat was not shown to occur, while still meeting all of the previous criteria. Low feasibility areas are located outside of existing leases for oyster mariculture, in areas without existing eel grass. Very low feasibility areas correspond to areas with surveyed eel grass. Areas of no feasibility were outside of the acceptable depth range.

The results of the regulatory analysis showed that there are numerous, redundant and sometimes lengthy permit application and consultation processes. A programmatic permitting process for mariculture in Humboldt Bay would help to remove the redundancy of the permitting and still allow for ample protection of the Bay's natural resources. The Endangered Species Act (ESA) would still require consultation with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service because of the ESA listed species (Coho salmon, Chinook salmon, steelhead) and critical habitat (eelgrass) in Humboldt Bay. It is advised that all applicants setup pre-application meetings with all of the agencies involved in the permitting and consultation processes.

Feasibility of oyster mariculture expansion depends on the flexibility of depths utilized by growers. If growers can utilize methods that take advantage of the full range of depths, the feasibility is greater. The feasibility is greater in areas that already have leases for mariculture operations, and in areas that don't have projected or surveyed sensitive habitats. Ultimately, our analysis revealed that there are sufficient acres in the North Bay where mariculture operations might, under a range of constraints, expand. Given these findings, it is the recommendation of this pre-feasibility study that the Harbor District pursue a full feasibility study examining the potential for mariculture expansion in Humboldt Bay.

Recommended Actions Summary

- Conduct a full scale feasibility study
- Obtain a high resolution DEM
- Conduct additional eel grass surveys
- Remove navigation channels from future analysis
- Ground truth to confirm GIS analysis
- Meet with regulatory agencies
- Consider a programmatic NEPA/CEQA document

Introduction:

Background

The Humboldt Times and Humboldt Standard ran regular stories about the oyster industry. This provides a historical record from which the team gathered information on the history of oyster cultivation in Humboldt Bay.

The first mention of oyster cultivation in Humboldt Bay occurs in the 1880's. Over a century has passed since then and there have been many changes to the bay. Cultivation is now focused on the Pacific and Kumamoto oyster, rather than the local species first harvested here. The first known feasibility study for oyster cultivation in Humboldt Bay was conducted in 1931. It was commissioned by the North Coast Council of the State Chamber of Commerce in Humboldt and Sonoma Counties and investigated whether Humboldt Bay was suitable for oyster beds. H.C. McMillan, one of the biologists that conducted the study, determined that there were 1,000 acres of tidelands suitable for the cultivation of native oysters, which were already abundant. (Humboldt Standard, 1931)

Within five years of the first oyster operations the venture was declared a success by an article in the Humboldt Times. The oysters had done so well in the big city markets, like San Francisco, that the "Humboldt Eastern Oyster" was more popular than Eastern Oysters grown in other areas on the West Coast. In the first year there were only five acres of beds cultivated, however the number quickly increased. As quickly as the acreage increased the type of oyster farmed changed; in 1931 biologist H.C. McMillan recommended that Humboldt Bay oyster cultivation be limited to native oysters, as the threat of introducing oyster drills and other pests was too great (Humboldt Standard, 1931). By 1934 H.C. McMillan was recommending that companies start importing Japanese oysters because of their ability to thrive in diverse habitat. Even though the native oysters were "tastier", the Japanese (Pacific) oyster grew faster and larger, maximizing the profit for the companies. (Humboldt Standard, 1934)

Predation was once a greater threat to the oyster industry and in the 1960's oyster companies took steps to decrease the size of the bat ray population. In the early spring bat rays enter the bay to reproduce; they use the bay as a nursery, and remain until the fall. In the 1960's bat ray traps were common in the bay. Each trap consisted of a rough pen staked out on the mud flats. When the tide was in bat rays would enter the pens and become trapped when the tide receded. One article in the Humboldt Standard detailed Coast Oyster Company's war on the bat rays; between the first of April and May 19^{th} 697 rays were caught and killed (Humboldt Standard, 1961).

Today in order to grow commercial oysters in the bay, a company must conduct an Environmental Assessment under the California Environmental Quality Act to determine any effects that the project will have on the environment. Permits must be obtained from agencies that have jurisdiction over the bay including the Army Corps of Engineers, California Coastal Commission, the Humboldt Bay Harbor, Recreation and Conservation District, the City of Eureka and the City of Arcata. There are multiple agencies that have jurisdiction over Humboldt Bay and its resources. Eelgrass, and the effect that oyster cultivation has on this sensitive habitat, is a chief concern for Federal, State and local agencies. Each agency has a different policy for eelgrass and what mitigation is necessary for any loss.

In Humboldt Bay methods of cultivation have switched from on-bottom culture, which primarily used the hydraulic dredge, to off-bottom culture. Off-bottom culture is far less harmful to the environment and includes long line, rack and bag, flupsy, and raft cultivation methods. All current oyster operations within Humboldt bay are off-bottom. Since implementing these new culture practices, the threat of predation has diminished. Bat rays are bottom feeders, so any off-bottom cultivation practices have the additional benefit of minimizing losses due to predation.

Our Study Concept

The purpose of this study was to examine the feasibility of sustainably expanding oyster mariculture in Humboldt Bay, California, viewing the 300 acres of current use as a baseline. This pre-feasibility study was a collaborative effort of the Humboldt Bay Harbor, Recreation and Conservation District and members of Humboldt State University's Natural Resource Planning Senior Practicum class. The study was designed to provide the Harbor District with the tools and information necessary to determine if a full scale feasibility study is warranted.

In March of 2007, the Harbor District completed an environmental review under the California Environmental Quality Act (CEQA) for Coast Seafoods' Application for Continued Mariculture operations in Humboldt Bay. Based on their review, the Harbor District found there were no significant effects from the project, if mitigation measures were implemented. The Harbor District adopted a Mitigated Negative Declaration approving continued mariculture on 300 acres. The 300 acres now in use represent a reduction in area from historical levels of up to 1000 acres.

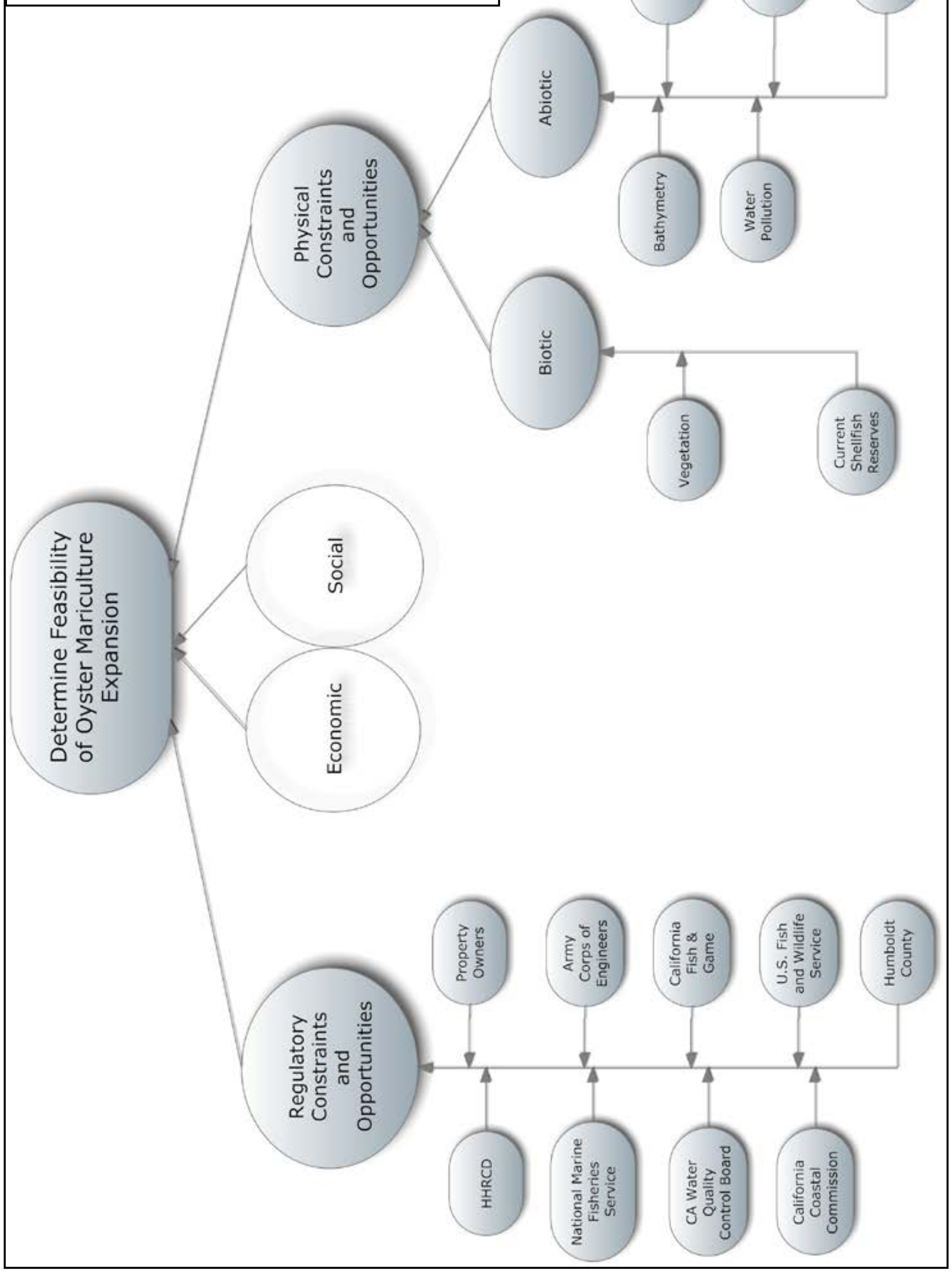
The Humboldt State University Natural Resource Planning Team, in coordination with the Harbor District, established that there are regulatory, physical, social, and economic constraints and opportunities affecting mariculture expansion. We determined to focus on regulatory and physical constraints and opportunities for the purpose of this project. In an effort to provide a detailed analysis, the project's scope was limited to the North Bay ecosystem and concentrated on the feasibility of oyster cultivation expansion, specifically looking at expanding for the Pacific oyster (*Crassostrea gigas)* long-line culture. In maintaining a perspective that considers sustainability and environmental responsibility, the scope was further limited to considering the feasibility of off-bottom culture methods. We investigated current and potential vegetation, bathymetry, Humboldt Bay ownership, current shellfish reserves, water quality and climate change. However, we chose to limit the criteria to current and potential vegetation, bathymetry and Humboldt Bay ownership in our analysis. The issues of water quality and climate change were discussed, but not analyzed.

In examining regulatory constraints and opportunities, we reviewed permitting requirements and identified the agencies that require consultation. These agencies and authorities included the U.S. Army Corps of Engineers (USACE), U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), California Coastal Commission (CCC), California Department of Fish and Game (CDFG), the California Department of Public Health (CDPH), the Humboldt Bay Harbor Conservation and Recreation District (HBHCRD), the City of Eureka, the City of Arcata, and the North Coast Water Quality Control Board (NCWQCB).

Physical opportunities and constraints considered by the team included both the biotic and abiotic factors that influence the maximum sustainability of mariculture expansion. In other words, the team was looking to minimize environmental impacts associated with the expansion of oyster mariculture in Humboldt Bay. Although some overlap is acceptable, areas of dense eelgrass habitat preclude oyster production. This is due to the many laws and policies that apply to, and protect eelgrass, such as the Clean Water Act and the policies of the California Coastal Commission. According to research compiled by the National Academy of Sciences Committee on Best Practices for Shellfish Mariculture, mariculture can interact both positively and negatively with eelgrass habitats. The Committee refers to studies indicating a loss in the total production of eelgrass in areas where oyster mariculture occurred. In particular, high eelgrass loss was associated with methods that reduced the light reaching eelgrass beds. However, there have been documented overlaps between oyster mariculture and eelgrass habitat where there was no or reduced loss of habitat. The scale of loss was found to be due to the density and spacing of lines and stakes. In addition, there are benefits associated with oyster mariculture that may improve eelgrass habitat. In particular, water clarity is improved by the filter-feeding actions of bivalves. This has the potential to expand the lower elevation limits of eelgrass habitat, which are primarily affected by water clarity and light availability (NAS, 2010).

Both the Clean Water Act (1977) and the California Coastal Act (2008) protect eelgrass habitat. There are concerns that oyster cultivation has the potential for significant effects on salmonids, herring, brant, and invertebrates. These concerns are directly linked to concerns over eelgrass habitat, which is important to these species at several lifecycle stages (HHRCD, 2007). Therefore we used eel grass as a sort of umbrella for representing impacts to the previously mentioned species. A flowchart that illustrates the conceptual process of our study is shown in Figure 1.

Figure 1: Flowchart Depicting Project Design

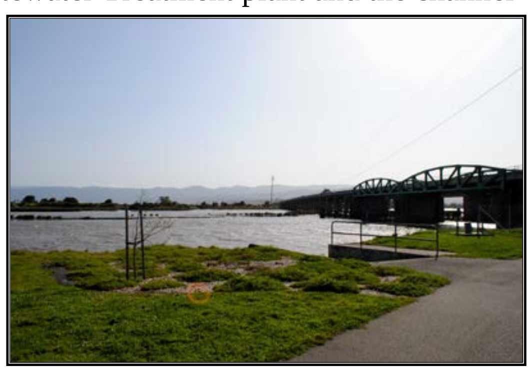


Methods:

Analysis Area

Looking northwest under the Samoa Bridge toward the North Bay. Photo by Carrie Carter-Griffin (4/22/10).

This study was focused in Humboldt Bay, California. Humboldt Bay is one of the largest enclosed bays in California. At mean high tide it has an area of roughly 62.4 km², and is roughly 28.0 km² at mean low tide (Gilkerson, 2008). This is the equivalent of 15,419 acres and 6,919 acres, respectively. The study area was limited to the North Bay sub-basin, and further defined as the area to the north of the Samoa Bridge. Figure 2 shows Humboldt Bay and relevant locations of interest around the bay. In part, the study area was limited due to project time constraints; restricting the area reduced required analysis. Second, the study area was limited because only areas north of the Samoa Bridge have been classified according to the National Shellfish Sanitation Program. Classified areas are described in the *Management Plan for Commercial Shellfishing in Humboldt Bay, California* (CDPH/PSU, 2010). For the most part, unclassified areas are considered prohibited, and closed to commercial shellfish operation. To the north of Samoa Bridge, most of the Mad River Slough, all of the Eureka Slough and other tidal tributaries are unclassified and prohibited under the Commercial Shellfishing Plan. Other prohibited areas include an area around the Arcata Wastewater Treatment plant and the channel between Indian and Woodley Islands as a safety zone around the marinas (CDPH/PSU, 2010). The Marina Prohibited Area was excluded from this study when the study area was defined as being north of the Samoa Bridge. The Arcata Wastewater Treatment Prohibited Area was excluded through analysis steps.



The Eureka Slough and the Highway 101 Bridge, taken from behind Target in Eureka. Photo by Carrie Carter-Griffin (4/22/10)

The Mad River and Eureka Sloughs, while unclassified and prohibited in the Commercial


Figure 2: Humboldt Bay, California
N
Arcata
North Bay
Eureka
South Bay
0 0.5 1 Miles
California
N
0 50 100 200 Miles
HUMBOLDT STATE UNIVERSITY
Map by: Carson Hubauer
Humboldt State University Natural Resource Planning
Practicum Group Group Spring 2010 Coordinate System:
WGS_84_UTM_10NScale 1:90,000 2005 NAIP I
magery and California Map Provided by HSU Data Files

Shellfishing Plan, were kept within the study area to provide an analysis of their depths and other influencing parameters.

GIS Analysis

The purpose of this pre-feasibility study was to examine the regulatory and physical constraints and opportunities associated with oyster mariculture expansion in the North Bay. We examined feasibility in terms of a continuum, establishing a ranking of six feasibility options based on four key parameters. Table 1 displays the matrix of parameters used to derive the six feasibility categories.

Table 1. Feasibility Categories - Matrix of Parameters Used to Establish a Feasibility Continuum

	Very High	High	Medium	Low	Very Low	No Feasibility
Surveyed Eelgrass	excluded	excluded	excluded	excluded	not excluded	not excluded
Potential Eelgrass	excluded	not excluded	not excluded	not excluded	not excluded	not excluded
Leases in place	yes	yes	yes	maybe	maybe	maybe
Depth	≤ 0.5 m	≤ 0.5 m	0.6 m - 0.9 m	≤ 0.9 m	≤ 0.9 m	≥ 0.9 m

Existing oyster bed locations (totaling approximately 280 acres) were removed from consideration in all categories under the assumption that there was no need to look at locations already in use. The matrix was designed so that there would be only one difference in the parameters from one category to the next. Three of the parameters were focused on the physical (biological) constraints and opportunities, while the fourth (leases) was focused on regulatory constraints and opportunities. The geoprocessing steps and layers used throughout analysis are displayed in Figure 3. All GIS analysis was conducted using ESRI's ArcGIS 9.3x software package. All data layers were projected into WGS_1984_UTM_Zone_10. Projections from NAD 27 to UTM_WGS84 were made using the NAD_27_to_WGS_84_4 geographic transformation, while projections from NAD 83 to UTM_WGS84 were made using the NAD_83_to_WGS_84_1 geographic transformation. Table 2 lists each data layer used, the source of the data layer, and the original and final projection.

Figure 3. Data Layers and Analysis Steps

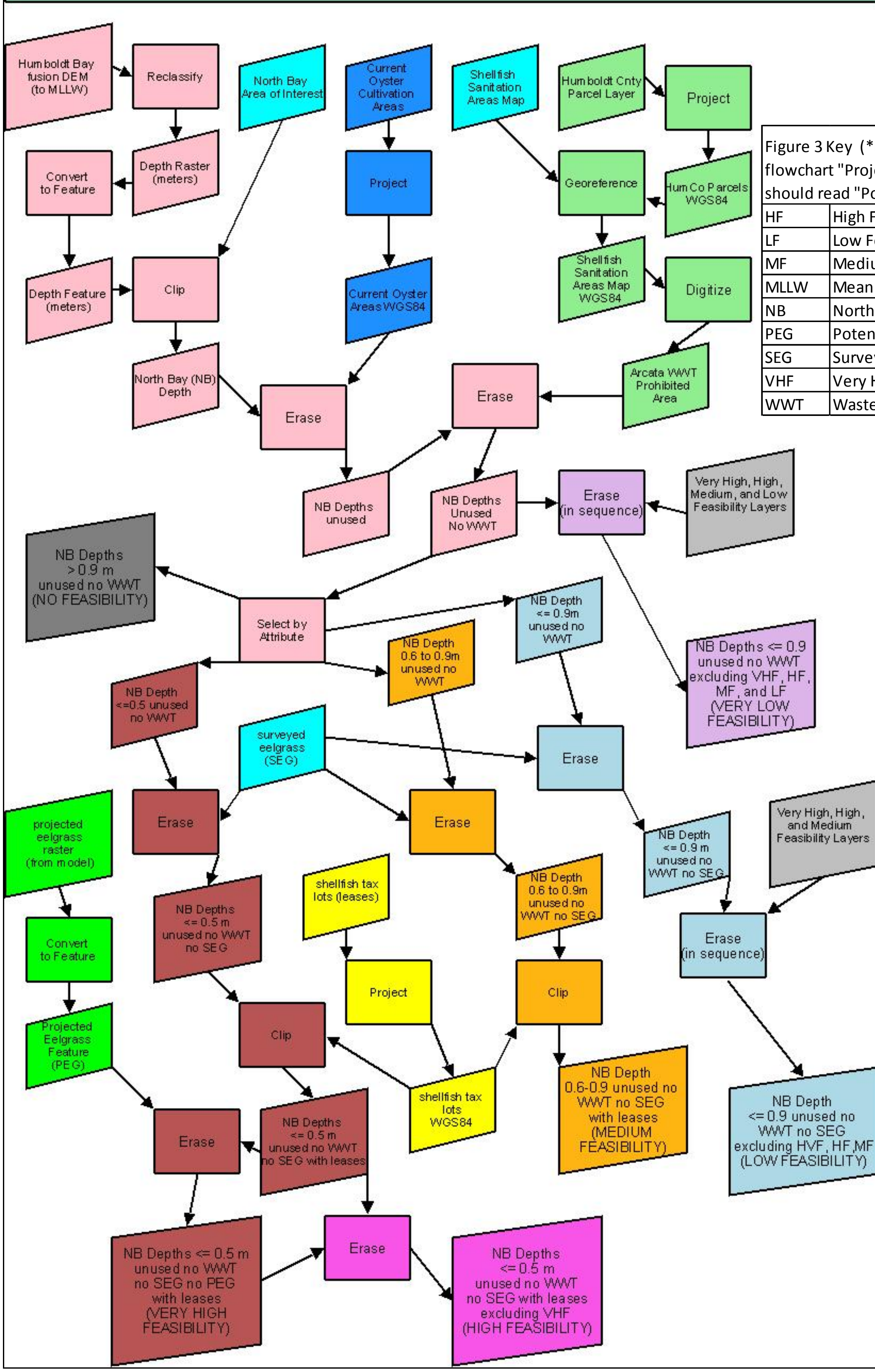


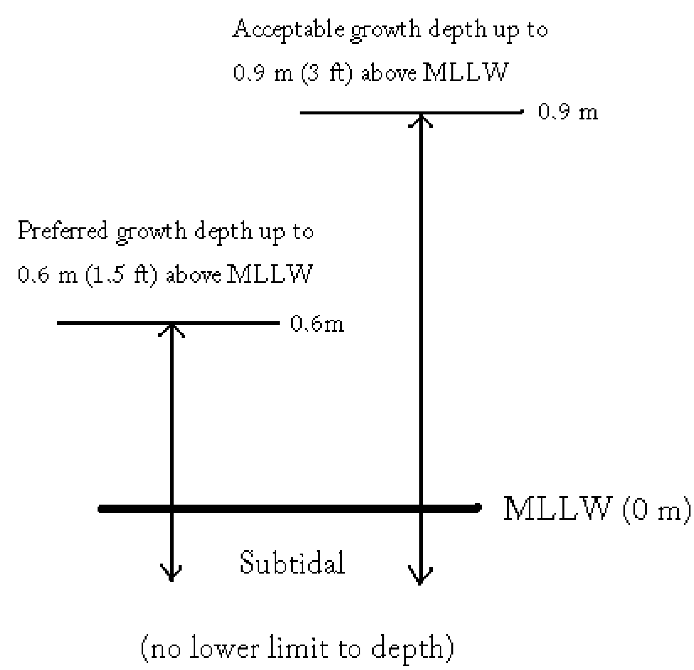
Figure 3 Key (*Note that in the flowchart "Projected Eelgrass" should read "Potential Eelgrass")	
HF	High Feasibility
LF	Low Feasibility
MF	Medium Feasibility
MLLW	Mean Lower Low Water
NB	North Bay
PEG	Potential Eelgrass*
SEG	Surveyed Eelgrass
VHF	Very High Feasibility
WWT	Wastewater Treatment

Table 2. Geospatial Data Layer Tracking Form **Project:** HSU Natural Resource Planning Team

	File Name (on drive)	File Description	Geospatial Format (shapefile, GRID, etc.)	Source Location (website, agency office, etc.)	Coord. Syst. (PCS)	Datum/ GCS	Metadata?
ORIGINAL DATA	2007beds_additions	current commercial oyster cultivation areas	shapefile	provided on CD by Adam Wagschal at HHRCD	UTM_Zone_10N	NAD 27	none given
CONVERTED TO	2007beds_additions_WGS				UTM_Zone_10N	GCS_WGS_1984	
ORIGINAL DATA	eelgrass_NC	surveyed location and area of eelgrass	polygon shapefile	provided on CD by Adam Wagschal at HHRCD	UTM_Zone_10N	GCS_WGS_1984	limited
CONVERTED TO							
ORIGINAL DATA	MLPA_NC_Shellfish_All	tax lots of leased shellfish operations in bay	polygon shapefile	forwarded via email by Adam W. at HHRCD, orig from Jon Bonkoski at Ecotrust	Albers Conical Equal Area	NAD_1983	yes- created for MLPA project
CONVERTED TO							
ORIGINAL DATA	humbay_5m_dem	fushion DEM of Hum Bay with xy cell resolution of 5m, based on MLLW	raster	provided on CD by Adam Wagschal at HHRCD...originally from Whelan Gilkerson thesis	UTM_Zone_10N	GCS_WGS_1984	limited - refer to thesis
CONVERTED TO							
ORIGINAL DATA	CNTYOUTL	outline of humboldt county	polygon shapefile	Humboldt Count Planning GIS page	Lambert_Conformal_Conic	GCS_North_American_1927	yes
CONVERTED TO	CntyOutl_Wgs				UTM_Zone_10N	GCS_WGS_1984	
ORIGINAL DATA	humtrans20080626sp	humboldt county and city roads, streets, highways	line shapefile	Humboldt Count Planning GIS page	Lambert_Conformal_Conic	GCS_North_American_1927	yes
CONVERTED TO	humtrans20080626sp_WGS84				UTM_Zone_10N	GCS_WGS_1984	
ORIGINAL DATA	nb_zm_cont_08	projected/modeled eelgrass locations in north bay	raster	provided on CD by Adam Wagschal at HHRCD...originally from Whelan Gilkerson thesis	UTM_Zone_10N	GCS_WGS_1984	yes
CONVERTED TO							
ORIGINAL DATA	2005 NAIP	Humboldt County Image	raster	obtained from HSU GIS server	UTM_Zone_10N	NAD 83	yes
CONVERTED TO							
ORIGINAL DATA	Humboldt County Parcels	Parcels with attributes	polygon shapefile	Humboldt Count Planning GIS page	StatePlane California	NAD 27	yes
CONVERTED TO					UTM_Zone_10N	GCS_WGS_1984	
ORIGINAL DATA	California	Outline of California	shapefile	Humboldt State GIS Server	UTM_Zone_10N	GCS_North_America_1983	yes
CONVERTED TO							

Depth was a key parameter in differentiating feasibility areas, and the main physical limitation. According to a report investigating the expansion of Pacific oyster farming in Australia and New Zealand, suitable intertidal growing depths are determined by several factors. One key determinate is sediment build-up; it is important to place long-line structures at depths where sediments won't accumulate on structures and inhibit feeding. Also, while water flow through the structures should be maximized to improve food delivery to the oysters, the structures should also be sheltered from harsh wave action. Finally, the depth of the structures determines the ease of servicing (Handley and Jeffs, 2003). We established that the preferred elevation or depth for growing oysters was subtidally to 1.5 feet (0.6 meters), but that oysters could be grown up to 3 feet (0.9 meters). There is no lower depth limit as mariculture in subtidal areas relies on floating cultivation methods. Information on preferred growing depths was obtained though interviews and correspondence with Greg Dale, manager of Coast Seafoods, the largest mariculture company operating in Humboldt Bay.

Figure 4. Depth Ranges Suitable for Oyster Growth



According to the *Classification of Wetlands and Deepwater Habitats of the United States*, subtidal refers to marine areas in which "the substrate is continuously submerged" (Cowardin, 1979). Therefore the zero level from which elevation should be measured is the Mean Lower Low Water (MLLW), which is "the average of the lower low water height of each tidal day observed over the National Tidal Datum Epoch" (NOAA, 2009). Figure 4 shows the depth ranges suitable for growing oysters in reference to the MLLW.

Depth was derived from the fusion digital elevation model (DEM) used in Whelan Gilkerson's eelgrass habitat model. This fusion DEM was modified from the original DEM so that depth values were referenced to MLLW (Gilkerson, 2008). By reclassifying the DEM, we were able to differentiate areas of the bay based on elevation above or below 0 m (MLLW). For ease of analysis, this raster layer was ultimately converted into vector format. Default vectorization settings were used for this process.

Surveyed eelgrass represented a second key physical factor. Data on surveyed eelgrass were obtained from the Humboldt Bay Harbor, Recreation and Conservation District. Because eelgrass habitat was linked to other sensitive biological factors such as salmonids, herring, brant, and invertebrates, surveyed eelgrass areas were removed from all categories except the Very Low Feasibility and No Feasibility categories. Surveyed eelgrass areas were analyzed as part of the Very Low Feasibility category to allow for a continuum of feasibility options.

Potential eelgrass was another physical factor considered, but the only category to exclude areas based on potential eelgrass was the Very High Feasibility category. The potential eelgrass GIS layer was obtained from Gilkerson's (2008) model in which eelgrass habitat was based on bathymetry, hyperspectral and NAIP imagery from 2005, and physical surveys of both the upper and lower limits of growth. Gilkerson sampled a total of 44 sites around the entire bay. He used the results to establish the upper and lower growing ranges for eelgrass, which he incorporated into his model along with bathymetry and hyperspectral and NAIP imagery from 2005. Based on these factors, the model predicted potential eelgrass habitat across the bay (Gilkerson, 2008). For our study, the potential eelgrass was initially in raster format and was vectorized using default settings. By not excluding this factor from the remaining five categories, we established that these categories could overlap with potential eelgrass. This allowed for a continuum of feasibility options, and was made under the assumption that each considered mariculture site would be physically surveyed for eelgrass prior to selection.

In order to account for regulatory constraints and opportunities, the feasibility matrix included information on existing leases in the North Bay. Lease information was obtained from data layers created by Ecotrust and provided to the Harbor District. These data represent tax lots leased to the five mariculture operators in Humboldt Bay. The data include information on who owns the leased area and who operates under the lease. The Very High, High, and Medium Feasibility categories were constrained to areas within existing leases under the assumption that the regulatory process would be somewhat simpler for expansion in these areas. The remaining categories were not constrained to areas inside existing leases, but they were also not excluded from leased areas; the Low and Very Low Feasibility Categories had the potential to fall both inside and outside leased areas.

While not included in the feasibility matrix, land uses were also considered in terms of general impacts on mariculture. A Humboldt County parcel map was obtained from the Humboldt County Community Service and Development Department. Using ArcGIS, parcels were selected by proximity to the North Bay. The selected parcels were then separated based on their designated land uses.

Regulatory constraints were also considered by determining areas of the North Bay closed to mariculture operations. A map from the *Management Plan for Commercial Shellfishing in Humboldt Bay, California* (CDPH/PSU, 2010) displayed the location of current oyster beds with respect to point and non-point coliform pollution sources (shown as Figure 12 in the Discussion). This map was georeferenced to the projected Humboldt County parcel map. A new polygon layer was created by digitizing the prohibited zone in the bay near the Arcata Wastewater Treatment Plant. This polygon was used to exclude the Arcata Wastewater prohibited area from all feasibility categories.

Regulatory Analysis

The permitting requirements for new or expanding mariculture operations in Humboldt Bay were explored through a review of current and past documents, as well as through interviews with agency staff. These Documents Included:

- Humboldt Bay and Fecal Coliform Study. Humboldt Bay Shellfish Technical Advisory Committee. February 2003.
- Coast Seafoods Mitigated Negative Declaration. Humboldt Bay Harbor, Recreation & Conservation District. January 2007.
- Humboldt Bay Management Plan. Humboldt Bay Harbor, Recreation & Conservation District. May 2007.

- Humboldt County Draft General Plan. Humboldt County. 2008.
- Humboldt Bay Initiative: Adaptive Management in a Changing World. Schlosser, Susan et al. May 2009.
- Management Plan for Commercial Shellfishing in Humboldt Bay, California. California Department of Public Health, Preharvest Shellfish Unit. January 2010.
- Endangered Species Act Section 7 Consultation Handbook. U.S. Fish and Wildlife Service and National Marine Fisheries Service. March 1998.
- A Spatial Model of Eelgrass (*Zostera marina*) Habitat in Humboldt Bay, California. Gilkerson, Whelan. 2008.

The second method used in gathering the information needed for this analysis was through personal communication. Contact information was provided to us both by the Harbor District and by faculty at HSU. Also, some contacts were found through independent research. A list of personal communications is provided in the 'Personal Communication' section of this document.

Results:

GIS Analysis

Using the feasibility matrix described in the methods, we established six different feasibility categories in the North Bay area. Together, all categories totaled 8,266 acres of the Bay. As shown in Figure 5, the Very High, High and Medium Feasibility areas are located predominantly towards the center of the bay, corresponding to the locations of existing leases. Low Feasibility areas are located outside of existing leases in areas without surveyed eelgrass, while Very Low Feasibility areas correspond to locations of surveyed eelgrass. Existing leases in the bay are identified in Figure 6 by property owner (lease-holder information is not identified). Surveyed eelgrass locations are displayed in Figure 7, while Figure 8 illustrates the coverage of potential eelgrass habitat from Whelan Gilkerson's 2008 model. Finally, Figure 9 demonstrates the depths of the North Bay area in meters (relative to MLLW). Figures 6-9 also show the location of the Arcata Wastewater Treatment plant, the area of the bay closed to mariculture by close proximity to the treatment plant, and land around the bay that is zoned agricultural. As shown on the 2005 NAIP Image included on all maps, land uses around the bay include agriculture, rural family homes, small industry, open space/parks, and city.

Within the study area, portions designated as No Feasibility are outside of the suitable depth range, falling at more than 0.9 m above MLLW. As shown in Chart 1, the majority of the North Bay area classifies at some level of mariculture feasibility. Chart 2 provides an analysis of each feasibility category by acres available. While the No Feasibility category has the most acres of any single category at 2,836 acres, the Very High, High, and Medium together come to 2,647 acres. While the Low Feasibility category is second only to No Feasibility by acres, portions of Low Feasibility do fall within the Eureka Slough, which is at this time considered unclassified for mariculture. As mentioned earlier, this classification is contained within the *Management Plan for Commercial Shellfishing in Humboldt Bay, California* (CDPH/PSU, 2010). This is, however, a relatively small proportion of the total acres for the Low Feasibility category.

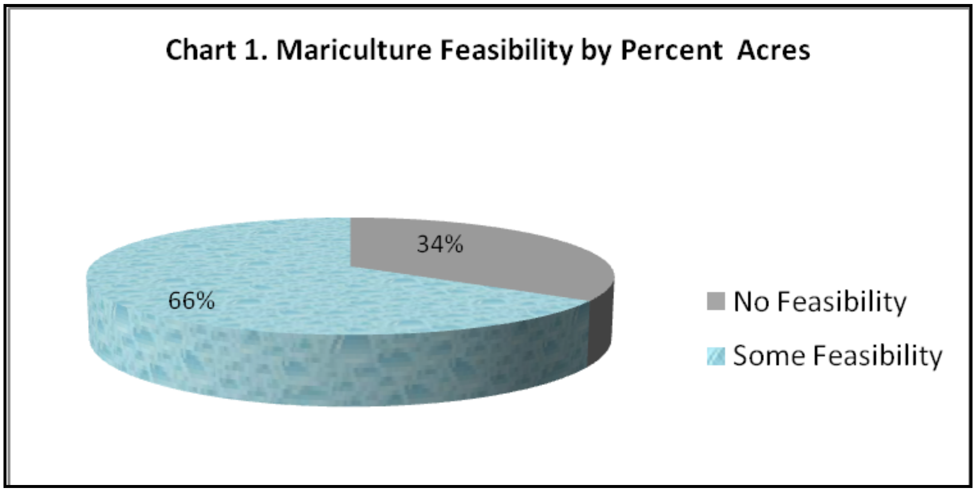


Chart 1. Mariculture Feasibility by Percent Acres

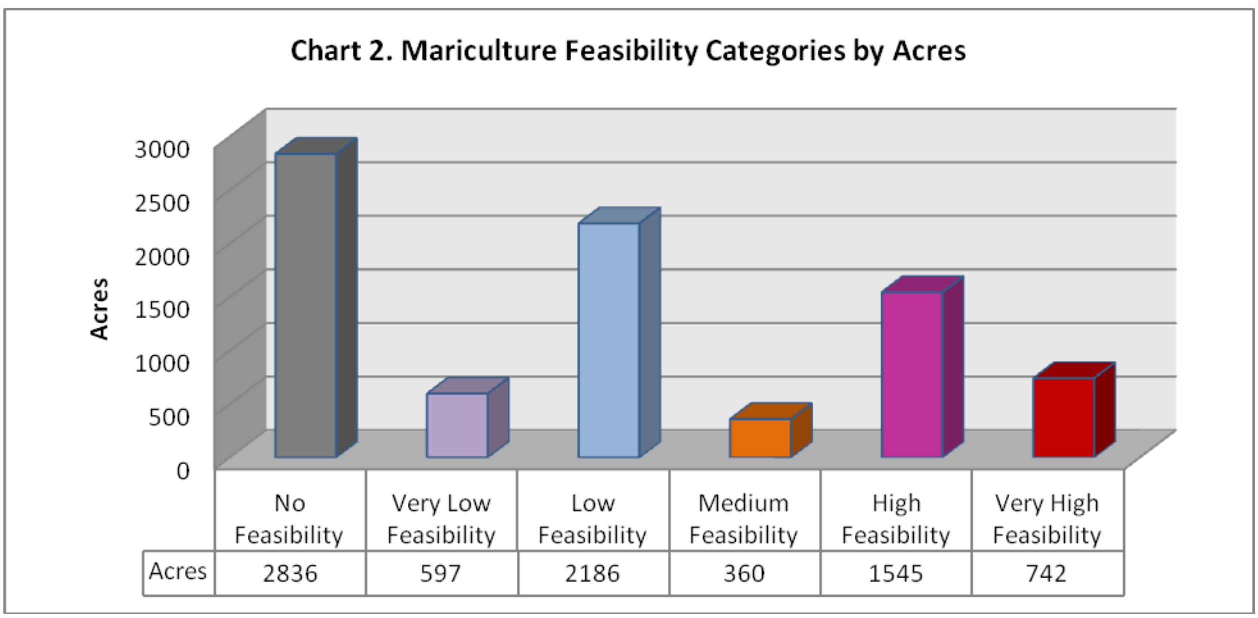
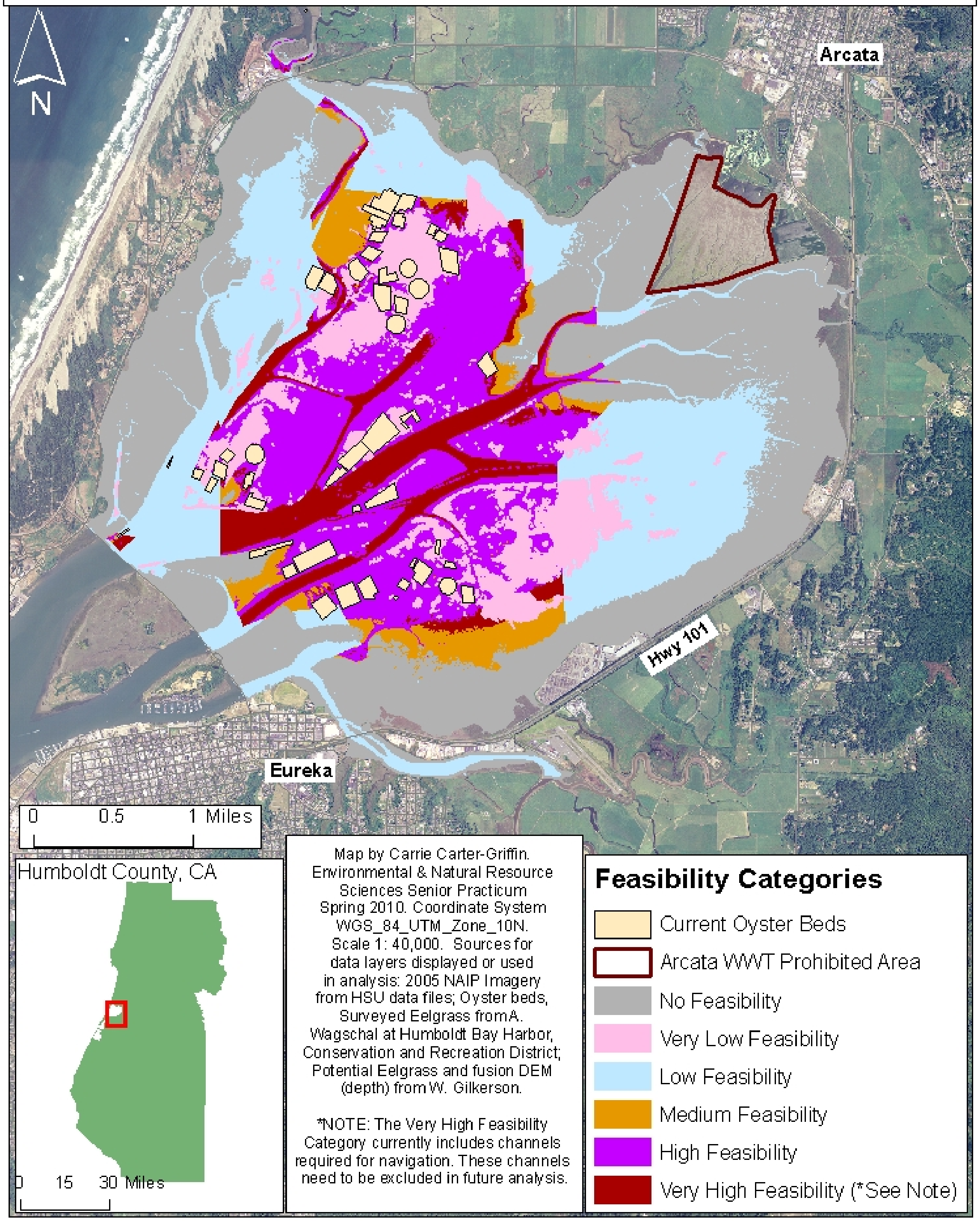


Chart 2. Mariculture Feasibility Categories by Acres

	No Feasibility	Very Low Feasibility	Low Feasibility	Medium Feasibility	High Feasibility	Very High Feasibility
Acres	2836	597	2186	360	1545	742

Figure 5. North Humboldt Bay Mariculture Feasibility Categories



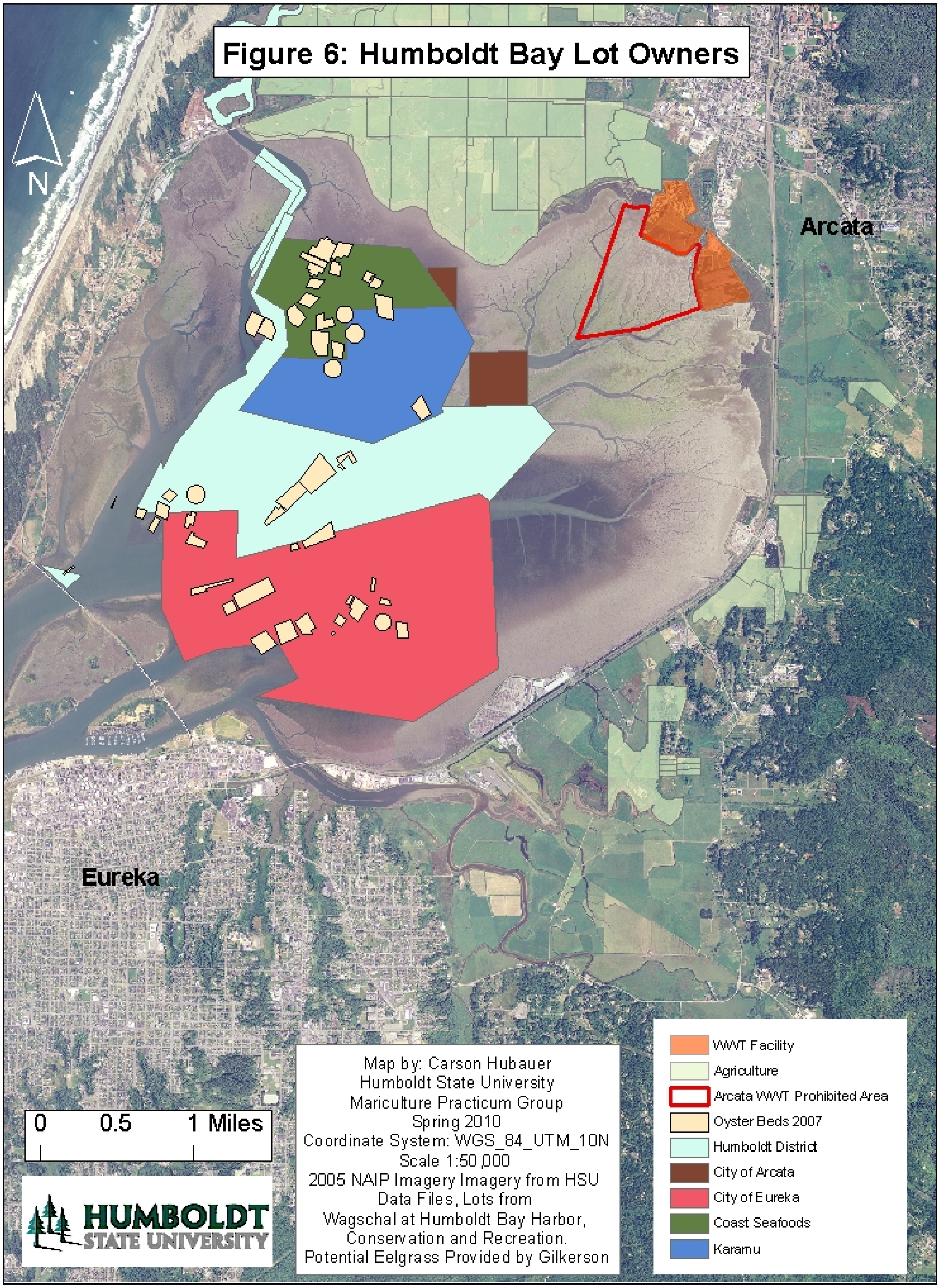


Figure 6: Humboldt Bay Lot Owners
N
Arcata
Eureka
0 0.5 1 Miles
Map by: Carson Hubauer
Humboldt State University
Mariculture Practicum Group
Spring 2010
Coordinate System: WGS_84_UTM_10N
Scale 1:50,000
2005 NAIP Imagery Imagery from HSU
Data Files, Lots from
Wagschal at Humboldt Bay Harbor,
Conservation and Recreation.
Potential Eelgrass Provided by Gilkerson
WWT Facility
Agriculture
Arcata WWT Prohibited Area
Oyster Beds 2007
Humboldt District
City of Arcata
City of Eureka
Coast Seafoods
Karamu
HUMBOLDT
STATE UNIVERSITY

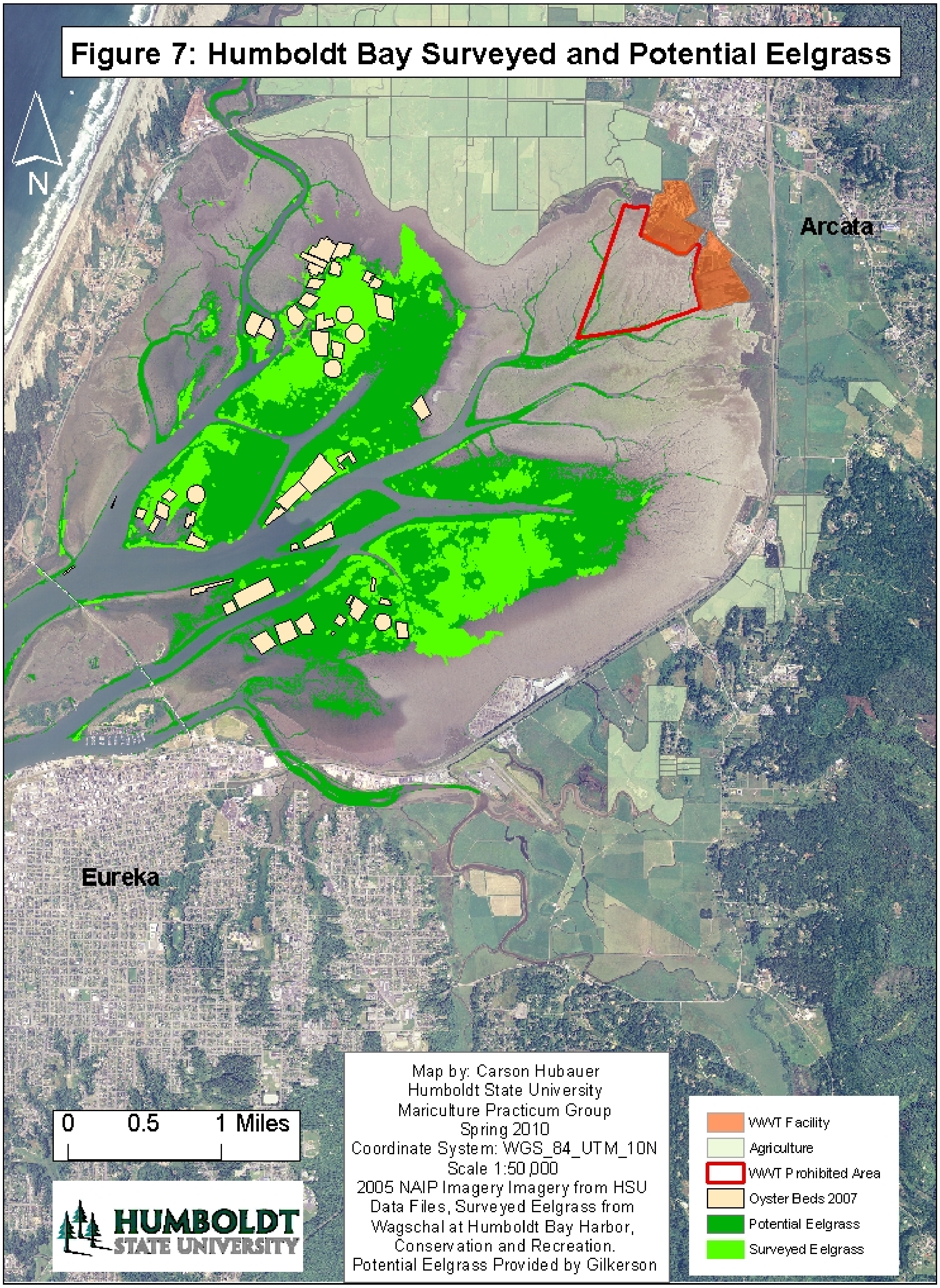


Figure 7: Humboldt Bay Surveyed and Potential Eelgrass
N
Arcata
Eureka
0
0.5
1 Miles
Map by: Carson Hubauer
Humboldt State University
Mariculture Practicum Group
Spring 2010
Coordinate System: WGS_84_UTM_10N
Scale 1:50,000
2005 NAIP Imagery Imagery from HSU
Data Files, Surveyed Eelgrass from
Wagschal at Humboldt Bay Harbor,
Conservation and Recreation.
Potential Eelgrass Provided by Gilkerson
WWT Facility
Agriculture
WWT Prohibited Area
Oyster Beds 2007
Potential Eelgrass
Surveyed Eelgrass
HUMBOLDT
STATE UNIVERSITY

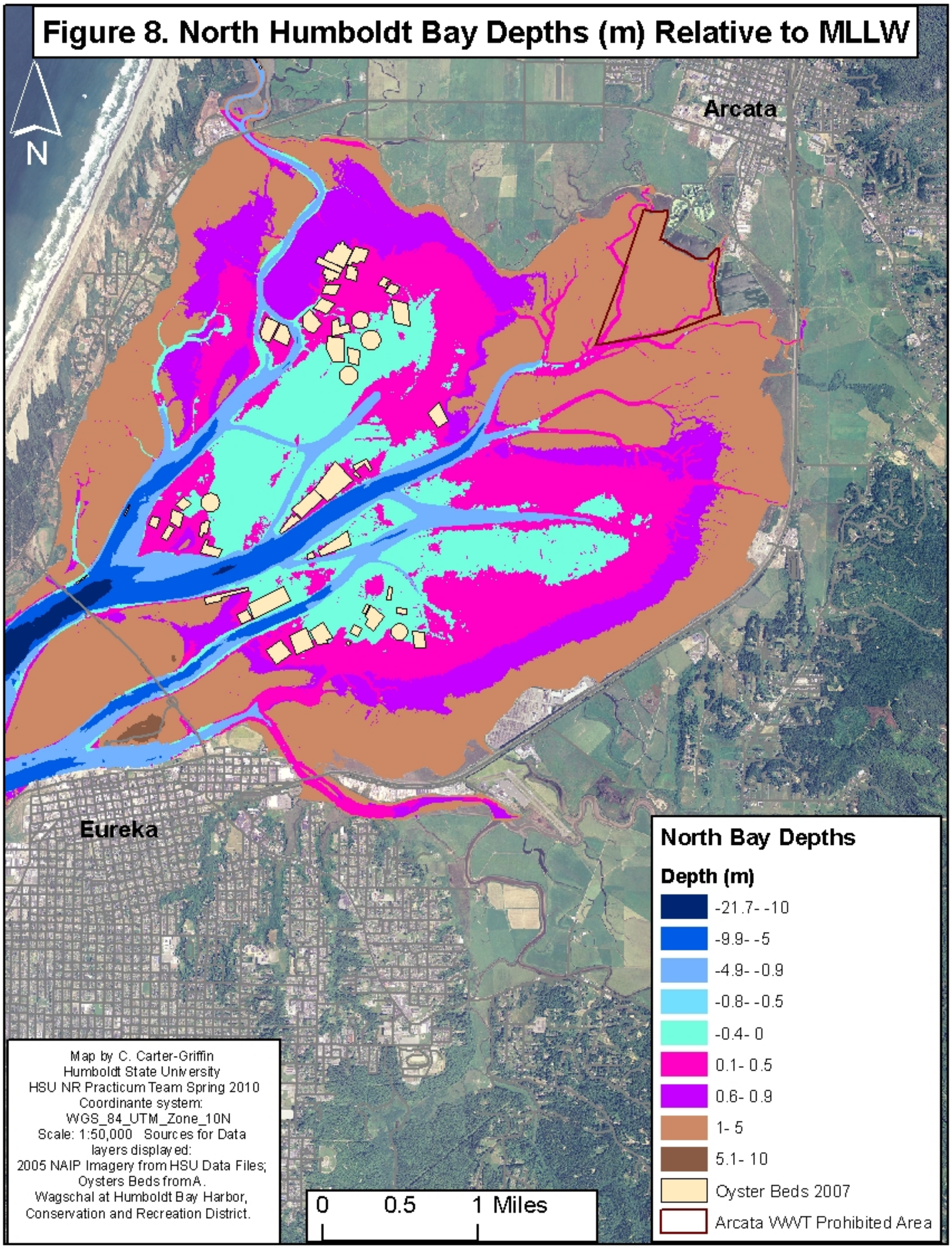


Figure 8. North Humboldt Bay Depths (m) Relative to MLLW
N
Arcata
Eureka
North Bay Depths
Depth (m)
-21.7- -10
-9.9- -5
-4.9- -0.9
-0.8- -0.5
-0.4- 0
0.1- 0.5
0.6- 0.9
1- 5
5.1- 10
Oyster Beds 2007
Arcata WWT Prohibited Area
0 0.5 1 Miles
Map by C. Carter-Griffin
Humboldt State University
HSU NR Practicum Team Spring 2010
Coordinante system:
WGS_84_UTM_Zone_10N
Scale: 1:50,000 Sources for Data
layers displayed:
2005 NAIP Imagery from HSU Data Files;
Oysters Beds from A.
Wagschal at Humboldt Bay Harbor,
Conservation and Recreation District.

Regulatory Analysis

The majority of the permits required for new or expanding mariculture operations in Humboldt Bay are outlined in the 2007 Coast Seafoods Mitigated Negative Declaration. These required and conditionally required permits are listed according to the responsible permitting agency. Any applicant who seeks to expand their current mariculture activities, or apply for new mariculture operations, must consult a variety of agencies and organizations. Each of which will have detailed requirements for the applicant. Specific information and recommendations for these permits and procedures are provided in the discussion portion of this document. The agencies and associated permits, along with consultations, are listed below.

<u>Army Corps of Engineers:</u>

- Permit under Section 10 of the Rivers and Harbors Act of 1899.
- Permit under Section 404 of the Clean Water Act.

<u>U.S. Fish and Wildlife Service</u>

- Consultation under Section 7 of the Endangered Species Act (ESA).

<u>National Marine Fisheries Service</u>

- Consultation under Section 7 of the ESA.

<u>California Coastal Commission:</u>

- Coastal Development Permit

<u>California Department of Fish and Game:</u>

- Import Permit
- Brood Stock Permit

<u>Humboldt Bay Harbor, Recreation and Conservation District:</u>

- Development Permit, Lease or Franchise.

North Coast Regional Water Quality Control Board:

- Water Quality Certification under Section 401 of the Clean Water Act.

Discussion:

GIS Results

The results of our GIS analysis indicated a fairly balanced mix of both opportunities for feasible expansion and constraints limiting expansion. In terms of acres, the main limiting factor for mariculture expansion was bay depth. The No Feasibility category, which was differentiated by being above suitable growing elevations, accounted for more than a third of the total acres. These acres were constrained by physical limitations that could not be negotiated, barring major changes to current mariculture methods. The second largest limiting factor by acres was regulatory. The existence of current leases was a regulatory constraint that limited feasibility categories Very High, High, and Medium. Leases were used as a constraint under the assumption that the expansion of mariculture operations into areas without existing leases would require a considerably more difficult regulatory or permitting process. In addition, existing leases correspond closely to areas in the 2007 *Humboldt Bay Management Plan* that were designated for mariculture. Figure 6 in the results section displays the existing leases and land ownership in the North Bay. The Water Use Designation Map (Figure 9) from the 2007 plan is shown below. In the management plan, mariculture areas are identified as a combined water use area that mixes Bay Conservation and Harbor designations. The plan identifies allowable uses within the designated Mariculture Use Area as focusing on shellfish mariculture operations and aquaculture operations focused around kelp or aquatic plants (HHRCD, Management Plan, 2007).

On the one hand, then, the existing leases were viewed in terms of the opportunities presented for expansion. By corresponding closely to the designated mariculture boundary, areas within existing lease boundaries had passed an important regulatory hurdle. This includes those areas this study ranked as Very High, High, and Medium Feasibility. Within the boundaries of the existing leases, the feasibility continuum was further refined by physical factors. Outside the boundaries of the existing leases, the leases were no longer viewed in terms of opportunities but rather as constraints. They were constraints in the sense that only areas inside their boundaries were designated for mariculture uses under the 2007 *Humboldt Bay Management Plan*, thus leaving areas outside their boundaries in other designations. The two other designations that occurred in our study area were Bay Conservation and Marine Recreation. Marine Recreation was also a combined use designation. As shown in Figure 9, areas designated for Marine Recreation occurred primarily along the outer edges of the North Bay and were comparatively small (HHRCD, Management Plan, 2007). The vast majority of this already small designated area fell into what this study considered the No Feasibility category.

The Harbor District's Bay Conservation designation encompassed essentially all of those areas classified by this study as having Low Feasibility. In addition, it encompassed Very Low Feasibility areas that fell outside the lease boundaries. In the 2007 *Humboldt Bay Management Plan*, one of the stated purposes of the Bay Conservation designation was to allow resource-dependant use. The combined Mariculture designation was created to fulfill this purpose, by default appearing to remove resource-dependant uses as a purpose of the remaining designated Bay Conservation areas. Preferred uses as authorized under the Bay Conservation designation include educational and scientific studies, restoration and enhancement activities, recreational activities, and maintenance of existing shoreline structures (HHRCD, Management Plan, 2007).

As mentioned, the feasibility categories falling exclusively inside existing lease boundaries (Very High, High, and Medium Feasibility) are differentiated by physical factors. Areas up to the preferred growing depth of 0.5 m fell into the Very High or High categories, with Very High being differentiated by the absence of potential eelgrass. Therefore, those areas considered to have Very High feasibility correspond to deeper channel areas that are below the depths at which eelgrass can survive. Surveyed eelgrass and potential eelgrass are shown on Figure 7 in the Results section, while North Bay depths (relative to MLLW) can be seen in Figure 8. According to Whelan Gilkerson, the lower depth ranges for eelgrass survival are determined primarily by the availability of light.

Figure 9: Water Use Designations
(HHRCD, Management Plan, 2007)

His research found the lower range, or maximum depths, for eelgrass habitat ranged predominantly between -2.11 m and -0.47 m (MLLW), while upper limit elevations ranged between 0.07 m and 0.77 m (MLLW). These ranges were reflected in the model he used to project eelgrass distribution throughout the bay (Gilkerson, 2008). Given that eelgrass was defined in this study to be the main physical constraint to mariculture expansion, it was significant that over 500 acres of the study area were found to have neither the potential eelgrass from Gilkerson's model nor the surveyed eelgrass.

As earlier stated, the only category to exclude areas based on potential eelgrass was the Very High Feasibility category. While the most feasible option was the one that has the least possibilities for conflict with all potentially sensitive habitats, we determined that it was also feasible to look at areas with potentially sensitive habitats. The assumption was that all sites considered for mariculture expansion would be physically surveyed for sensitive habitats. By "ground-truthing," actual eelgrass habitats can be verified for density of cover and patch size, which was not information contained in the potential eelgrass layer. Because the surveyed eelgrass layer was created as a result of field studies, and had in essence already been "ground-truthed," it was used as a constraining physical factor for all categories except the Very Low Feasibility category. In other words, the top feasibility categories were constrained to fall outside surveyed eelgrass habitats, while the very lowest category was allowed to overlap with this habitat. While Very Low feasibility might for all intents and purposes be "no feasibility" due to the regulatory constraints associated with eelgrass habitat, the importance of field verification is again stressed. The surveyed eelgrass layer is not accompanied by metadata information that includes the parameters used to define eelgrass habitat. For example, the surveyed eelgrass was not described by density. While many surveyed eelgrass areas may have represented large continuous habitats, there may also have been some smaller, sparse surveyed areas. These may not be incompatible with mariculture operations. For example, Gilkerson found that eelgrass habitats in the upper and lower elevation ranges were frequently patchy (2008). While Gilkerson's model accounted for the patchy nature of eelgrass at its habitat extremes, the surveyed eelgrass data did not account for this information. Actual density of eelgrass at proposed sites will need to be verified. Given that existing mariculture operations were found to overlap with some surveyed eelgrass locations, there appears to be partial flexibility in the sensitivity threshold.

Ultimately, this study served only as a starting point. By ranking different areas of the North Bay according to their feasibility, we provided the Harbor District with preliminary information on the distribution of constraints and opportunities. It is, however, important to note that there are many limitations associated with this study. First and foremost is the resolution of the data. Being able to classify portions of the bay based on depth was fundamental to the analysis. And yet, the fusion DEM used for that purpose had a cell resolution of 5 meters. That limited our analysis to areas of the bay 25 m^2 and larger. In order to obtain more meaningful results, future studies examining the feasibility of mariculture expansion should first put effort into acquiring a finer-resolution DEM.

In addition, there are certain factors that were not explored in detail as part of this study. For example, maintaining open navigation channels may be considered a high priority even outside the main harbor area. And yet, most of the area we classified as Very High Feasibility fell into deep channel areas that would be required for navigation. While these channel areas may represent the highest feasibility for mariculture expansion, the entire channel may not be practical or even permissible. The Army Corps of Engineers, which issues permits for activities affecting navigable water, may have the most input here.

Finally, it should be noted that areas and acres presented in this study are at best good approximations. Both the DEM (which contained depth information) and the potential eelgrass layers were initially in raster format, and were converted into vector format to facilitate GIS analysis. This vectorization is, however, inherently accompanied by error, as angular pixels are smoothed into polygons and lines are created out of joined pixels (ESRI, 2009). This study did not explore the effect of different settings on output. Table 3 (shown in the Appendix A) displays the changes in the area of each depth class that occurred as a result of the conversion from raster to polygon feature. Each depth class experienced some change in its area as a result of the conversion process. The average change was 0.1 acres increase in area, yet there was also considerable variability, with some depth classes decreasing in area while others showed increases. The percent change in area of all depth classes was 0.006%. While this may not be a significant portion of total acres under consideration in the North Bay, it still represents a notable error. In the future, when a more accurate and detailed analysis might be needed, it would be advisable to consider the optimal conversion settings for the particular data being used. Alternately, one could explore means of analyzing the data that did not involve a format conversion.

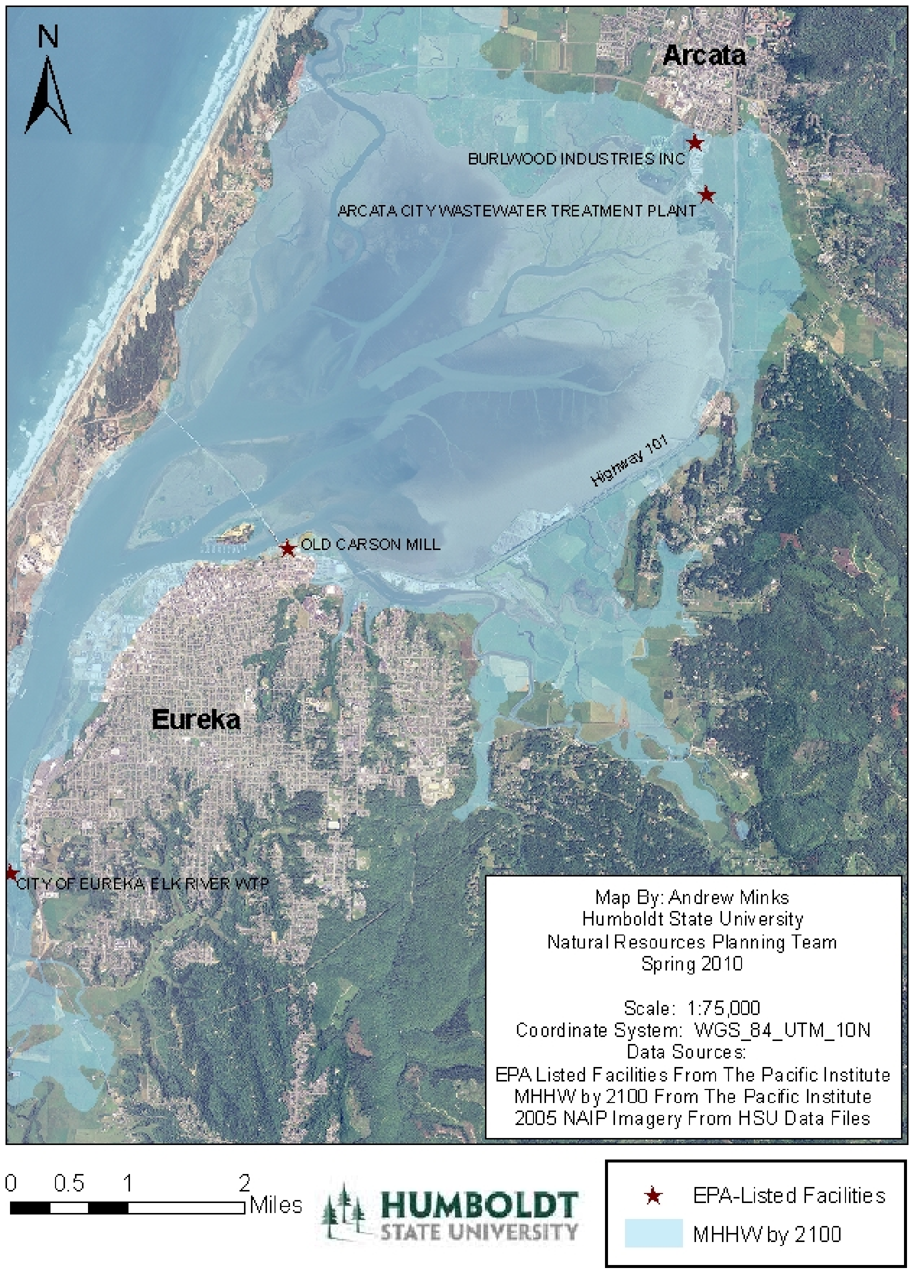
Climate Change

Climate change came up several times during discussions of what should be included in our feasibility study. However, we decided to avoid detailed analysis due to the speculative nature of the impacts that climate change and sea level rise will have on the Bay. Future infrastructure improvements to structures such as sea walls and levees around Humboldt Bay are unknown. Spatial Analysis of these potential impacts would be conjecture.

The Pacific Institute projects sea level rise of 1.4 meters by 2100. This has several possible implications that can be discussed (Pacific Institute, 2009). The rise could provide more available area for mariculture due to the increased surface area that the Bay will cover. The amount of expansion regarding surface area will vary, again depending on infrastructure improvements. Whether this area will be suitable for mariculture is highly debatable and at this point unknown. Also the sea level rise could cause problems with water quality, with the water reaching areas with contaminated soils and EPA listed facilities. Of specific concern is the inundation of the Arcata Wastewater Treatment Plant, which is a significant source of fecal coliform in the Bay (HBSTAC, 2003). Fecal coliform is again the pollutant that is of primary concern when considering mariculture activities (Humboldt Bay Shellfish Technical Advisory Committee, 2003). There could also be impacts to water quality from brown fields depending on the infrastructure improvements made to prepare for sea level rise.

As mentioned before, the changes in infrastructure that may be made around Humboldt Bay by 2100 are unknown. Sea level rise could negatively affect current mariculture operations due to changes in tides as well as the MLLW and MHHW marks. This will change the areas available in Humboldt Bay that will have the appropriate elevations and tidal influences for mariculture, and specifically oyster cultivation activities. Refer to Figure 10 for a visual representation of the areas predicted to be inundated under high tide in North Bay, with the current infrastructure in place. Figure 10 also includes listed EPA facilities around the Bay.

Figure 10: Inundation Due To 1.4m Sea Level Rise By 2100



Water Quality

Water quality was considered for inclusion in our analysis, but we ultimately decided to exclude it for several reasons. In 2003 a study was completed by the Humboldt Bay Shellfish Technical Advisory Committee for Humboldt Bay that addressed the issue of fecal coliform, the main water quality issue for oyster cultivation. The study identified several point sources of fecal coliform for Humboldt Bay including the Arcata wastewater treatment plant, the Eureka wastewater treatment plant and the College of the Redwoods wastewater treatment plant. The Arcata plant was the main concern for oyster cultivation as it is in North Bay, where mariculture occurs. An area was established around the Arcata Wastewater Treatment Plant in which mariculture was prohibited. (HBSTAC, 2003)

Furthermore, in 2010 the Management Plan for Commercial Shellfishing in Humboldt Bay, California was released. This document outlined the sources of pollution for Humboldt Bay including point and non-point sources. The plan also described what would trigger a harvest closure and included updated details on specific closure areas and rules applying to those areas. (CDPH/PSU, 2010)

Non-point sources of fecal coliform come primarily from rainfall events. Standards are in place to deal with differing levels of rainfall and how they affect particular areas in the Bay. These standards were set by the North Coast Regional Water Quality Control Board (NCRWQCB) and accepted by the California Department of Health Services-Preharvest Shellfish Sanitation Unit. The standards close certain areas of the Bay to oyster harvesting based on the amount of rainfall (Refer to Figure 11 for specific closure information). The figure originates from the 2010 Management Plan for Commercial Shellfishing in Humboldt Bay, California. More information regarding harvest closures can be found in the Performance Standards section of the plan.

According to the 2003 Fecal Coliform study, Humboldt Bay waters meet the NCRWQCB objectives during times of harvest (Humboldt Bay Shellfish Technical Advisory Committee, 2003). Also, the Bay flushes much of its waters every tidal cycle, inducing water circulation and mixing, which further dilutes potential pollutants in the Bay (Schlosser, Susan et al., 2009).

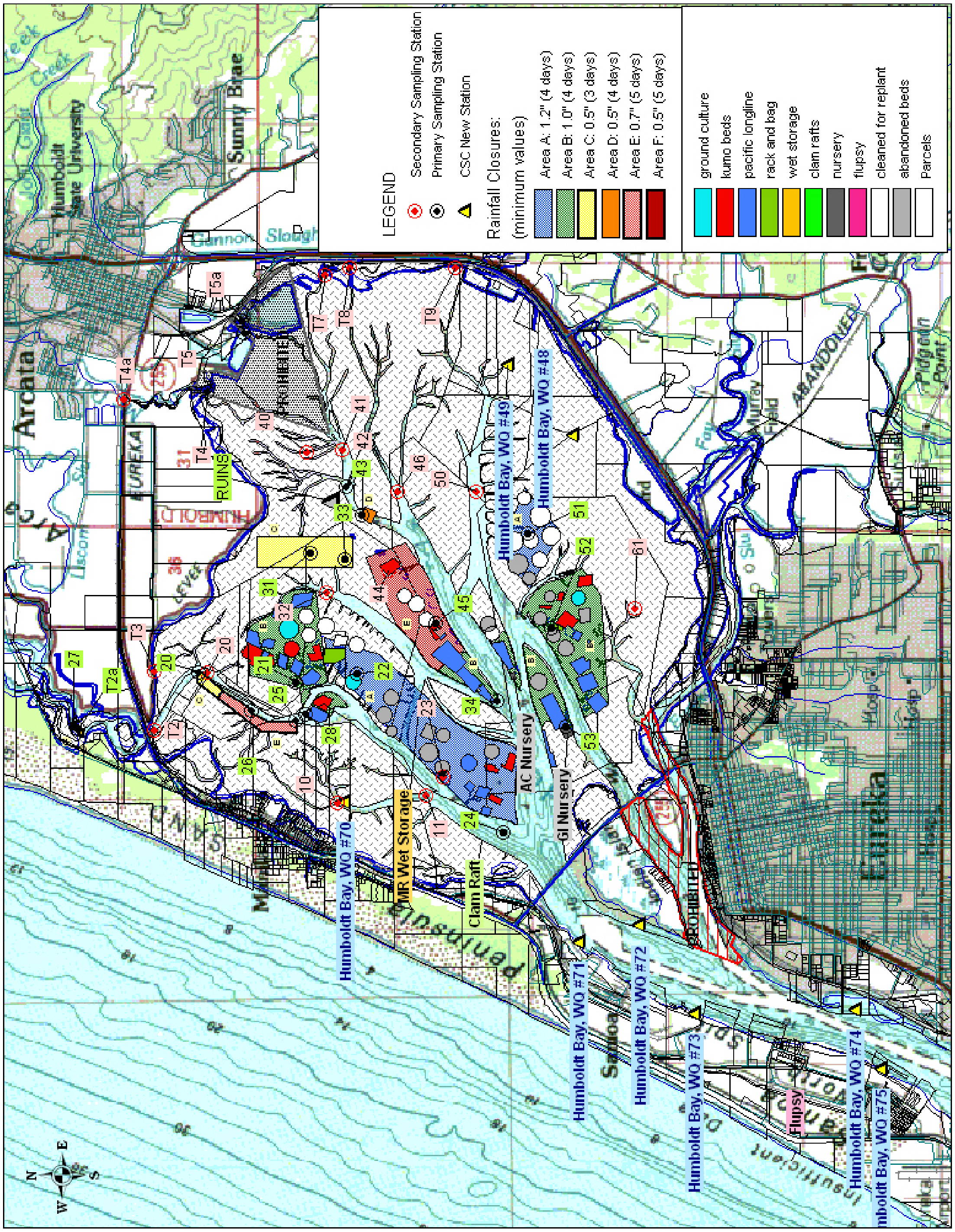
There are many water quality sampling stations in strategic locations and around the Bay to ensure that water quality is meeting the specified standards. These sampling stations are also shown in Figure 11**.** Marinas are another non-point source of pollution in the Bay and are included in the prohibited areas for mariculture in the 2010 plan (CDPH/PSU, 2010).

Dioxins came up as a possible source of contamination for oysters and other mariculture activities. Humboldt Bay is listed under section 303(d) of the Clean Water Act as impaired for dioxins (NCRWQCB, 2006). We discovered that even though Humboldt Bay is listed as impaired for them, dioxins are not an issue for oyster mariculture activities (A. Wagschal, personal communication, February 5, 2010). This is due to the oysters being cultured off of the bottom of the Bay using long-lines. Dioxins are hydrophobic and thus are generally not found in high concentrations in the water column. They are found mostly in the sediment and the soil in the Bay, as dioxins bind themselves to organic matter such as sediments, soils and vegetative matter (FDA, 2008). All things considered, the current management of Humboldt Bay, in regards to shellfish harvesting, are sufficient and effective at preventing the contamination of shellfish and protecting public health.

The rainfall closure areas shown in Figure 11 are broken up into six categories, which are named by letters A-F. These categories specify how much rainfall it takes to close those areas to shellfish harvesting for a particular amount of time. The rainfall requirement shown represent the amount of rainfall within a 24-hour period. For example, if Area A receives at least 1.2” of rainfall within a 24-hour period, shellfish harvesting cannot take place for at least 4 days. The day limits shown on the map are minimums and can be extended. If the rainfall over a 7 day period is more than 3”, then harvesting in all of the areas must stop for at least 1 additional day. If the rainfall over a 7 day period is more than 5”, then 1 more day is added to the closures for all areas, totaling 2 additional days of harvesting closure for all areas. (CDPH/PSU, 2010)

Figure 11: Rainfall Harvest Closures and Water Quality Testing Sites

(CDPH/PSU, 2010)



Regulatory Procedures and Recommendations

The regulatory procedures required for expanding mariculture in Humboldt Bay would be very similar to those Coast Seafoods complied with leading up to the 2007 Mitigated Negative Declaration. The same permits would be required for the most part, possibly excluding a permit regarding section 404 of the Clean Water Act which deals with the discharge of dredged material or fill material in navigable waters. Much of the regulatory process is due to the presence of eelgrass and its association with species that are listed under the Endangered Species Act.

The U.S. Army Corps of Engineers Permitting Process:

The U.S. Army Corps of Engineers regulates activities in navigable waters within the U.S. Specifically regarding mariculture, USACE regulates the placement of structures or dredging in navigable waters of the United States subject to tidal action or interstate commerce under Section 10 of the Rivers and Harbors Act (1899) and requires a permit regarding the placement of structures for new or expanding mariculture activities. Some current mariculture practices in Humboldt Bay use long-lines, which are supported by structures commonly made from PVC tubes. This keeps the oysters off the bottom of the Bay, but it also places structures in navigable waters. This triggers the need for the Section 10 permit.

The Army Corps also has regulatory authority over the discharge of dredged or fill materials into navigable waters and other waters of the U.S. under Section 404 of the Clean Water Act (1977). Not all mariculture operations require a permit regarding the discharge of dredged or fill materials, and the Army Corps determines if a permit is needed on a case by case basis. In other words, if a project would deposit material that would need to be dredged and discharged into waters of the U.S., it would require this permit. (D. Ammerman, personal communication, April 2, 2010)

The application for permits from the USACE can be found at the local office, or at http://www.usace.army.mil/CECW/Documents/cecwo/reg/eng4345a.pdf.

The U.S. Fish and Wildlife Service and the National Marine Fisheries Service Consultation Process:

Consultation with the USFWS and NMFS is required under Section 7 of the Endangered Species Act (1973) (ESA) for certain protected species in the North Bay including green sturgeon, eulachon, Coho salmon and Chinook salmon. The handbook for this consultation process is available at: http://www.fws.gov/endangered/consultations/s7hndbk/s7hndbk.htm. The process will be explained in brief.

Section 7 of the ESA requires that all federal agencies "insure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed [ESA] species or result in the destruction or adverse modification of designated critical habitat. In fulfilling these requirements, each agency is to use the best scientific and commercial data available." (USFWS and NMFS, 1998) Humboldt Bay has both listed ESA species (mentioned above) and designated critical habitat (eel grass). Mariculture operations have been known to adversely affect eel grass, and that in turn can affect the listed species that use it (NAS, 2010) . This triggers section 7 of the ESA and requires consultation.

The USFWS and NMFS state "the Section 7 process achieves greatest flexibility when coordination between all involved agencies and non-Federal representatives, and the Services, begins early. Often, proposed actions can be modified so there is no need for formal consultation." This early coordination is advised and can help a great deal in the consultation process. Often alternatives can be found that minimize impacts of incidental takes of ESA listed species. (USFWS and NMFS, 1998)

The process also allows for coordination with local and state agencies. This allows for information sharing and ensures that all information is consistent and accurate. With all the information gathered and analyzed, the USFWS and the NMFS make a "determination of 'jeopardy/no jeopardy' to listed species or 'destruction or adverse modification/no destruction or adverse modification' to designated critical habitats" (USFWS and NMFS, 1998) where the new or expanding mariculture operations would occur. This determines if the proposed mariculture operations would be allowed under the ESA.

The California Coastal Commission (CCC) has jurisdiction over all lands in the Coastal Development Zone. Any projects that fall within this require a Coastal Development Permit. The application form may be acquired from the CCC website, www.coastal.ca.gov, or from the local office. The application must include as much detailed information about the project as possible. After the application has been submitted to the Commission, the staff evaluates it based on Section 3 of the California Coastal Act. Section 3 details the Coastal Resource Planning and Management policies (C. Teufel, personal communication, April 13, 2010). There are a few sections that the staff of the Coastal Commission focus on for aquaculture:

The California Coastal Act states that "the development shall not interfere with the public's right of access to the sea where acquired through use or legislative authorization…to the first line of terrestrial vegetation." (California Coastal Act, 2008). In Humboldt Bay the oyster beds are accessed via boat, and as long as this type of operation continues there will be little conflict. Every project has to comply with this policy and must allow public access to beaches and coastal waters. The California Coastal Act also states, "Marine resources shall be maintained, enhanced, and where feasible, restored. Special protection shall be given to areas and species of special biological or economic significance. Uses of the marine environment shall be carried out in a manner that will sustain the biological productivity of coastal waters and that will maintain healthy populations of all species of marine organisms adequate for long-term commercial, recreational, scientific, and educational purposes." (California Coastal Act 2008). This policy states that operations must not negatively impact sensitive habitat. A specific consideration for Humboldt Bay is eelgrass. The policy of the CCC is that any project that causes a removal of eelgrass will have to use mitigation. The standard mitigation is a 2:1 ratio. If one acre of eelgrass is lost, two will have to be restored.

In assessing the application for the Coastal Development Permit, CCC staff will work with the applicant to ensure that all policies are complied with. If there is an aspect of the project that is not in compliance, staff work with the applicant to come up with conditions and mitigations that will bring the project into compliance with the Coastal Act. The staff of the

CCC writes a report that is submitted to the Commission at their monthly meeting. The Commission takes the staff's recommendations into consideration, but the decision ultimately lies with the Commission. They choose whether the recommendations of the staff are a requirement of the permit, and whether or not to approve the project. (C. Teufel, personal communication, April 13, 2010)

In the case of the CCC, a company that has already obtained a permit from the CCC, can obtain an amendment to their permit for minor changes, including expanding the acreage of their oyster beds. They will have to go through the same process as obtaining the first permit. However the review will be focused on the new aspects, rather than the project as a whole. (C. Teufel, personal communication, April 13, 2010)

<u>California Department of Fish and Game Permitting Process:</u>

Permits issued by the department of Fish and Game for aquaculture are Import Permits and Brood Stock Permits. Oyster cultivation companies need to obtain both permits. Any seed that is imported has to be inspected and approved by the Department of Fish and Game. The purpose of this inspection is to insure that no invasive species (such as drills) or diseases are imported with the oyster seed. A company only needs to obtain a Brood Stock Permit if they wish to collect brood stock from their oyster beds. (K. Ramey, personal communication, April 6, 2010)

All Department of Fish and Game land leases are handled by the Harbor District; no permits need to be obtained from DFG to lease land for oyster cultivation. . (K. Ramey, personal communication, April 6, 2010)

The Department of Fish and Game's 'No Net Loss of Wetlands' policy applies to eelgrass. While they have guidelines which state there can be no net loss and no adverse impacts to eelgrass in the bay, there is no official policy. There are regulations in the California Fish and Game Code that state that there shall be no disturbance or cutting of eelgrass. While long-line oyster cultivation is off-bottom, and poses less of a threat to eelgrass beds, the Department of Fish and Game count this cultivation as a disturbance. Long-lines can shade out the beds, and cause eelgrass to be less productive. Studies have shown that there is less eelgrass directly underneath and adjacent to long-line oyster beds. Other studies have found that the wider the spacing between the long-lines, the less impact there is to eelgrass. Eelgrass beds that have long lines spaced at least 10 feet apart have shown no impact to the eelgrass; these eelgrass beds exhibit the same density as those found outside of the oyster beds (Rumrill & Poulton, 2004).

<u>The Humboldt Bay Harbor, Recreation and Conservation District Permits:</u>

According to the Harbor Districts website, "the Harbor District's regulatory jurisdiction includes all of Humboldt Bay up to the mean higher high water level except for Indian, Woodley and Daby Islands where the Harbor District jurisdiction is up to the mean high water level." "The Humboldt Bay Harbor, Recreation and Conservation District Act [of 1970] empowered the Board of Commissioners to grant permits, franchises and leases. Any individual, agency, association or corporation proposing a development within the jurisdiction of the Harbor District, must obtain a permit, lease or franchise from the Harbor District." The Harbor District also states that they are usually the first agency to permit a development within the Bay. The Army Corps of Engineers and California Coastal Commission generally issue permits after the Harbor District. (HHRCD, 2010)

<u>North Coast Regional Water Quality Control Board Certification Process:</u>

Under section 401 of the Clean Water Act (1977), if a project "is located within or adjacent to "Waters of the State", and a proposed project may impact those waters, the proponent is required to apply for a Water Quality Certification and/or Waste Discharge Requirements (Dredge/Fill Projects)." (California EPA, 2009) Humboldt Bay falls under the category of State waters and mariculture activities may impact it, thus a certificate is needed.

In order to receive a certificate, an applicant must first submit Water Quality Certification and/or Waste Discharge Requirements application. These are available online or by request. After submitting this application with the applicable fees, the applicant will be notified with in 7 days that the application has been received. Within 30 days of receiving the packet, staff will determine if the application is complete. Once the application is complete, staff will issue a public notice which lasts for 21 days. During this time the public may comment on the project and comments will be considered during the certification determination process. The Board will have 1 year to make a determination of whether to grant the applicant the certificate. Generally the process takes between 1-4 months. (California EPA, 2009)

Humboldt County:

Humboldt County does not have any direct authority over Humboldt Bay and does not issue any permits regarding mariculture. They also do not do any water quality testing for the Bay (D. Spinosa, personal communication, April 2, 2010). They are a stakeholder for activities that occur in Humboldt Bay, as those activities directly affect Humboldt County. This being the case, the Humboldt County Community Services District as well as the Humboldt County Department of Public Health (Division of Environmental Health) were asked by the California Department of Public Health to approve the 2010 Management Plan for Commercial Shellfishing in Humboldt Bay California (California Department of Public Health Preharvest Shellfish Unit, 2010). The Public Health Department's Division of Environmental Health is also on the list to be notified if any substance is discharged into the bay such as sewage, hazardous chemicals, pesticides, or petroleum products that would adversely affect mariculture activities (California Department of Public Health Preharvest Shellfish Unit, 2010).

Lastly, the Humboldt County Draft General Plan includes the following reference to mariculture, illustrating the local government's interest in supporting mariculture: "Mariculture (shellfish farming) has particularly strong potential in Humboldt Bay. These operations depend on protecting the water quality of the bay. Expansion of this industry should be supported with permit coordination and streamlining, improved dock and processing facilities, and public education" (Humboldt County, 2008, p.9).

When considering the requirements for new or expanding mariculture operations, a programmatic permitting process is recommended in order to reduce redundancy in permitting. The programmatic permitting process should provide the same amount of environmental protection that currently exists, while reducing the amount of redundancy, as well as time and energy required for oyster mariculture permitting. The current permitting scheme is repetitive, with different permitting agencies requiring a separate analysis for impacts also addressed in other agencies permitting processes. The policies regarding impacts to eelgrass are also inconsistent between the agencies, and could be made more consistent by a programmatic permitting process. Applicants would still have to participate in the ESA consultation process with the USFWS and the NMFS due to Humboldt Bay containing ESA listed species (Coho salmon, Chinook salmon and steelhead) and critical habitat (eelgrass).

To further streamline the permitting process, information from the 2007 Coast Seafoods Mitigated Negative Declaration, as well as from the 2006 Environmental Impact Report for the Humboldt Bay Management Plan, can be used in assessing the impacts of new and expanding mariculture operations in Humboldt Bay. It may even be possible to tier information and studies from the Humboldt Bay Management Plan EIR and use that information in future analysis.

Something the Harbor District might consider when trying to create a more streamlined process for mariculture expansion for Humboldt Bay, is to complete a programmatic NEPA/CEQA document for mariculture in the Bay. This document should explore all aspects and potential effects of mariculture in the designated mariculture zone. This document then could be used as a tiering tool, allowing individual expansion projects to use information already discussed in the programmatic document. The document would allow for a clear understanding of the effects a proposed mariculture operation would have. There would still need to be some analysis done for individual projects based on the projects specific design. However, the process would be much less cumbersome than assessing the full impacts that the individual project would have. (R. Brown, Personal Communication, April 22, 2010)

Furthermore, it would be beneficial for applicants wanting to expand current mariculture operations, or wanting to apply for new mariculture permits, to have preliminary meetings with all the agencies involved so they know what to expect. At minimum they should consult the USACE, USFWS, NMFS, California Coastal Commission, and the Harbor District.

When considering the regulatory component of this study, along with the results from the GIS analysis, the possibility for mariculture expansion in Humboldt Bay is present. Because of the criteria we used in our GIS analysis, the impact to current eel grass would be minimal for the very high, high and medium categories. Also the impacts to the ESA listed species that use eel grass would most likely be minimal for these same categories. The regulatory process required to expand mariculture, or create a new operation entirely, are redundant, extensive and often demanding. However, based on our study, compliance with these regulations should be feasible.

Conclusion:

This study set out to determine the feasibility of mariculture expansion in the North Bay based on associated physical and regulatory constraints and opportunities. Rather than make an explicit yes-no determination as to feasibility, we determined to look at feasibility in terms of a continuum. To this end, we established feasibility categories that ranged from No Feasibility to Very High Feasibility, and explored regulatory constraints and opportunities through research and interviews. While it may be simple to ask “How feasible is it to expand mariculture in Humboldt Bay?” the answer is anything but simple. In part, feasibility depends on the flexibility of depths utilized by growers. If growers can utilize methods that take advantage of the full range of depths, the feasibility is greater. The feasibility is greater in areas that already have leases for mariculture operations, and in areas that don’t have projected or surveyed sensitive habitats. And yet, if additional field surveys can be conducted to identify the density of eelgrass habitats, and a density threshold can be established wherein low levels of eelgrass density may overlap with mariculture sites, feasibility may increase in some areas. A programmatic permitting process for oyster mariculture would reduce the redundancy present in the current permitting process, while still sufficiently protecting natural resources. Compliance with the current regulations regarding mariculture expansion in Humboldt Bay is feasible, despite being redundant. Complete streamlining of the permitting process is limited in Humboldt Bay due to the required consultation processes under the ESA for listed endangered and threatened species (Coho salmon, Chinook salmon and steelhead) and critical habitat (eelgrass) in the Bay. Ultimately, our analysis revealed that there are sufficient acres in the North Bay where mariculture operations might, under a range of constraints, expand. Given these findings, it is the recommendation of this pre-feasibility study that the Harbor District pursue a full feasibility study examining the potential for mariculture expansion in Humboldt Bay. A list of recommendations follows.

Recommended Actions

1. Conduct a full-scale feasibility on the potential for mariculture expansion in Humboldt Bay
2. As part of (or prior to) a full-scale feasibility study, acquire a high-resolution DEM to provide the potential for a detailed depth and area analysis
3. Remove navigation channels from consideration in future feasibility analysis
4. Fill information gaps in eelgrass data, especially as related to patch density and cover
5. "Ground-truth" potential mariculture sites to confirm GIS analysis
6. Conduct preliminary meetings with regulatory agencies to clarify expectations
7. Complete a programmatic NEPA/CEQA document to allow for an expedited impact analysis of proposed mariculture operations

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Appendix A

Table 3. Area of Depth Classes From Raster and Polygon Feature, showing Change in Area with Conversion from Raster to Feature by Class, and Average (Mean) Change				
Depth Class	raster area (sq m)	polygon area (sq m)	change in area (sq m) raster to polygon	change in area (acres) raster to polygon
-21.7- -10	2969175	2968972	203	0.05
-9.9- -5	4757125	4758091	-966	-0.24
-4.9- -0.9	8586600	8598041	-11441	-2.8
-0.8- -0.5	986475	957455	29020	7.2
-0.4- 0	8611100	8666400	-55300	-14
0.1- 0.5	15650350	15617416	32934	8.1
0.6- 0.9	8101275	8076402	24873	6.1
1- 5	18653350	18669549	-16199	4
5.1- 10	113300	112764	536	0.13
All depths	65459575	65456118	3660	0.9
average change (mean)			407	0.1
(3660/65456118)100 = 0.006 % change in area of all depth classes				