REVISED STATEMENT OF WORK

January 2014

Project Title: Baseline Monitoring of Estuaries on the North Coast of California.

Project Leaders

Frank Shaughnessy, PhD (HSU): The lead PI in charge of overall project coordination; will oversee and participate in the biodiversity and focal species sampling in the mudlfat and eelgrass habitats; metadata and data analysis; oversight of a Project Technician and graduate student; MPA presentations; mentoring of the Intertribal Sinkyone Wilderness Council (ITSWC) intern.

Tim Mulligan, PhD (HSU): The co-PI who will oversee and participate in the fish sampling within the mudflat and eelgrass habitats; assist with data analysis & report writing; MPA presentations; mentoring of the ITSWC intern.

Adam Wagschal, MSc (H.T. Harvey & Associates): A fisheries and environmental biologist, who, along with another H.T. Harvey staff member, will be part of the fish sampling team. Mr. Wagschal will also assist with data analysis and writing.

Stephen Kullmann, MSc (Wiyot Tribe): TheNatural Resources Director for the Wiyot Tribe and will oversee Wiyot staff who will assist with the eelgrass and mudflat sampling in each of the four estuaries.

John Largier, PhD (UC Davis): The co-PI who, with a staff member, will oversee the use of existing abiotic variables to provide a contextual background for the habitat sampling; will help direct workshops with all the people participating in the project.

Other collaborators include the Intertribal Sinkyone Wilderness Council, Humboldt Baykeeper, and the Humboldt Bay Harbor, Recreation and Conservation District.

Project Goals

Our first goal is to describe the baseline conditions in four estuaries (3 MPA, 1 non-MPA) on the north coast. By “baseline”, we mean metrics of biodiversity, the population structure of focal species, and the summarizing of abiotic variables that capture watershed, estuarine and oceanic effects on estuarine life. The second goal is to use data from the first goal in order to develop recommendations for the testing of future estuarine MPA effects.

Rationale

The first goal will be a start on providing something that does not currently exist for any of the 16 estuaries on the North Coast: a coordinated baseline description of estuarine biological and physical environments. In addition to filling this knowledge gap, our baseline study will allow potential MPA effects to be tested in the future. MPA effects are not being tested in the present study because of the perception that fishing effort within north coast MPA estuaries is light and there are multiple exemptions (Table 1). The present study would therefore allow a before-and-after comparison to be made within each of the four estuaries. For the three MPA estuaries, the ability to make this comparison will be particularly valuable if exemptions (Table 1) are removed from a subset of these estuaries in the future. A before-after-comparison using all of the estuaries would also make it possible to evaluate the degree to which changes in baseline conditions are site specific or if they are responding to regional effects (e.g. potential differences in north and south region estuaries due to watershed and/or ocean circulation differences).

The second goal recognizes that the experience and data from the first goal provides the basis for making recommendations about how to efficiently monitor these four estuaries, and perhaps other estuaries, along the north coast in the future. While it is the case that much has been written on how to monitor the ecosystem health of estuaries, and there are studies from around the world that serve as examples on how to test for the effects of conservation efforts, it is also the case that the biotic and abiotic environments of north coast estuaries have been only narrowly described, if at all (Barnhart et al. 1992, Cairns et al. 1993, Wilson 1994, Whitfield & Elliott 2002, Halpern 2003, Bortone 2004, Lester et al. 2009, Carr et al. 2011, Syms & Carr 2001a,b). Thus, while we intend for some organisms and abiotic variables in this project to be part of a future study, discoveries will be made about these estuaries that we cannot anticipate.

The choice of the Mad River Estuary and then three MPA estuaries - Humboldt Bay, Big River and 10 Mile River - (Fig. 1) is based on the Goal 1 rationale and the fact that there are only four estuarine MPAs in the Northern California region. Further criteria include the financial cost of reaching MPA locations, partner participation, and representing the geomorphological diversity of north coast estuaries. The issue of cost has also led us to consider potential additional partners that exist in each estuary who could be approached to increase the scale of this study's baseline work.

<u>Mad River Estuary</u>. This is a linear river mouth estuary located in the north region (Figs 1 & 2) which is ecologically and recreationally (e.g. fishing, kayaking) important. It is under particular scrutiny now because, with the decrease in municipal use of water in the Ruth lake Reservoir, the volume and timing of flows into the Mad River is being altered. The Humboldt Bay Municipal Water District as well as state and federal regulatory agencies are seeking a better understanding of how this changing flow environment will affect the river-estuary ecosystem. *Baseline ecosystem conditions in the estuary have never been described.* This project may be able to partner with the Blue Lake Rancheria (Blue Lake, CA) who have a grant pending with NOAA NMFS to conduct three years of monitoring (starting Fall 2014) of both Pacific Eulachon and water quality (flow, temperature, salinity, etc.) for the eulachon critical habitat in Mad River, which includes the estuary. This collaboration could result in a better understanding of how discharge changes from Ruth Lake will affect estuarine life, and the Blue Lake Rancheria effort could provide contextual data to complement our project. Finally, the location of the Mad River estuary relative to where most of the project partners live makes working on this estuary financially attractive.

<u>South Humboldt Bay State Marine Recreational Management Area (SMRMA)</u>. Located in the north region (Fig. 1), the entirety of Humboldt Bay is characterized as an embayment because tributary inputs are small relative to the size of the bay (Barnhart et al. 1992). The estuarine MPA, located in the southwest corner of southern Humboldt Bay (Fig 3, 4), is far from any tributaries and, while clamming occurs in southern Humboldt Bay, its location makes it a long trip for most sport fishermen. Humboldt Bay has been relatively more studied than the other three estuaries (Barnhart et al. 1992, Schlosser and Rasmussen 2008), but a coordinated baseline effort does not exist for any section of this bay.

<u>Ten Mile Estuary State Marine Conservation Area (SMCA)</u>. This is a linear river mouth estuary located in the south region which can be closed off by sand bar formation during the summer (Figs 1, 5, 6). This estuary is important to numerous special status species (e.g. salmonids, eulachon) and our work would complement ongoing conservations efforts in the watershed by the Nature Conservancy.

<u>Big River Estuary State Marine Conservation Area (SMCA)</u>. This is another river mouth

estuary in the south region that is subject to seasonal closure (Figs 1, 7, 8; Marcus and Raneau 1979). We chose this estuary because much of the lower watershed is now part of the State Park system and management actions under this public ownership are expected to contribute to MLPA goals.

There is also a rationale for the estuarine habitats included in this project, the types of organisms that will get included in the biodiversity indices, the species that get singled out for focal species attention, and the abiotic variables that get used to describe contextual conditions.

Within the four estuaries, eelgrass and mudflat habitats have been included but salt marsh habitat has been excluded. The latter choice was made because of cost limitations and the fact that fish and bivalve species of management concern do not directly use this habitat. Within the eelgrass and mudflat habitats, **biodiversity descriptions** will be built from field protocols that are weighted towards sampling those eelgrass and mudflat organisms, including fish, which are residents in a particular estuary for the majority of their lives. This will increase the likelihood that a change in their abundances can be attributed to site conditions. This is one of the reasons why birds and marine mammals will not be monitored. Fluctuations in their abundance and fitness may have little to do with the estuarine sites in which they happen to be monitored and so have less value for detecting future MPA effects. Similarly, another choice affecting the project's baseline characterization is the decision to minimize the enumeration of species (e.g. birds) whose abundances would be misrepresented by a limited number of researcher visits to an estuary. This is a concern for sampling the estuarine fish community which can be temporally variable due to seasonal river and oceanic effects, temporary river/estuary mouth closures, and in some cases diadromous life histories (Norcross and Shaw 1984, Whitfield and Elliot 2002, Elliot et al. 2007). Each of the four estuaries will be sampled during two dissimilar seasons (winter, early summer) for two years. This will allow, for example, the winter spawning eulachon to be sampled, and organisms like Dungeness crab will have transitioned from the plankton to benthic estuarine habitats by early summer (Fernandez et al. 1993, McMillan et al. 1995, Williamson 2006, Frimodig 2007). There will be concurrent sampling of the eelgrass and mudflat biodiversity including the fish species using these habitats.

Different criteria were used to choose **focal species**, which will have their population structures enumerated. There is not yet an obvious set of species that could be used to test for an estuarine MPA effect because of the potentially low fishing effort and MPA exemptions (Table 1). The primary rationale for which focal species to choose is therefore the species that are completely or partially exempt from restrictions. If more restrictions are added in the future, then the detailed descriptions of population structure (e.g. size classes) from the present study will allow for more sensitive tests of future MPA effects, as has been the case in other MPA regions (Carr et al. 2011, Syms & Carr 2001a,b). Additional rationale for choosing focal species include those species of interest identified by north coast people during the year of pre-RFP outreach meetings run by HSU and the Monitoring Enterprise (ME); if a species was of commercial importance; if the species was managed by efforts independent of the MLPA process; the potential of a species for being a bioindicator (*sensu* Bortone 2004) of ecosystem health.

The rationale for the **contextual description** is the large effect that human activities and abiotic variables have on estuarine ecosystem processes (Largier and Taljaard 1991, Paerl et al. 2006, Largier and Behrens 2010, Behrens 2012). The abiotic variables used in this project are watershed, oceanic and estuarine forcing variables of estuarine ecosystems. The contextual description relies on sensor deployments of other agencies because the RFP limits this part of the study to existing data sources. Over the time span of the present study, the contextual description will enable seasonal and interannual changes in biodiversity and focal species to be correlated to these forcing variables. This description will also make it possible to determine if contextually similar estuaries also contain similar eelgrass and mudflat communities. Finally, in the future, an updated contextual analysis would make it possible to determine the degree to which biodiversity and focal species changes are due to estuary specific effects (e.g. the specific management and/or abiotic environment) or larger regional effects.

Methods

There are two approaches used to sample the eelgrass and tidal mudflat habitats. One approach is designed to enumerate the plants, algae, infauna, epifauna, crabs, shrimp and small fish in each habitat. The other approach is designed to sample the larger fish higher in the water column. Both sampling approaches occur at the same times and at the same places (Table 2 – Milestones). Data gathered from both approaches will be used to generate the biodiversity metrics and the more detailed descriptions of focal species. Some of the species gathered during the first approach will need to be brought to an HSU laboratory for further enumeration (e.g. eelgrass, small epifauna, bivalves; Table 2 – Milestones) whereas species that must be released after being caught (e.g. fish) will be measured in the field. Candidate sites will be identified within each estuary (within MPA boundaries for Southern Humboldt Bay, 10 Mile, Big River) where transects (Fig. 9) and fish sampling could occur. Two of these candidates will be randomly selected and then used for the duration of the study.

Plants, Algae, Infauna, Epifauna, Crabs, Shrimp, Small Fish

The transect lines are only used for sampling these organisms. The position of quadrats along transect lines will also be randomly determined (Fig. 9). Table 3 describes the particular variables that will be measured for biodiversity and focal species monitoring. While working on transect lines, disturbance to the soft substratum by field workers will be minimal because boogie boards and kayaks will be used during low tide habitat sampling (Fig. 10). For the biodiversity description, a species list (presence/absence) will be developed from all of the macrophytes, epifauna, infauna and mobile fauna in each habitat (Table 3). This will allow for similarity analyses to be made of biodiversity among times and among estuaries. Generally, measures of abundance for the biodiversity assessment will be made by functional groups rather than species unless it is practicable to enumerate by species. This data matrix will be less “zero rich” and so abundance can be a part of a multivariate analysis comparing sample times and estuaries. Abundances will be determined by using quadrats to measure % cover or density, coring cans for infaunal density, subsampling of macrophytes for epiphyte cover and the densities of epifauna, and two types of traps (minnow or box traps with oyster shells – Fig. 10; larger crab traps) for the small mobile fauna (Table 3).

Table 3 also specifies how the population structure of the focal species will be enumerated. In the mudflat habitat, bivalves will be sized by species in addition to already having their abundances recorded by species for the biodiversity sampling. The green algae, which can be strong indicators of estuarine eutrophication (Nelson and Lee 2001, Nelson et al. 2003, Sugimoto et al. 2007), will be divided into functional groups and measured for biomass (as wet then dry weight). Eelgrass itself will be a rigorously described focal species because it provides so much habitat structure and productivity in the low intertidal to shallow subtidal zones of estuaries (Williams and Heck 2001) and because it is a sensitive indicator of overall estuarine health (Duarte 1991, Krause-Jensen et al. 2005, Carr et al. 2011). Shoot densities and estimated above-ground biomass will describe the population structure of eelgrass. The methods demonstrated by Wilzbach et al. (2000) for estimating biomass from shoot lengths, which have been used in southern Humboldt Bay (Fig. 11), will be used for each estuary. The Leaf Area Index (based on a subsample of leaf lengths and widths) and depths of the deep edges of the eelgrass bed will indicate the amount of stress being experienced in the site (Dennison and Alberte 1982, Duarte 1991, Short et al. 2000, Wood and Lavery 2000). Multiple high quality GPS positions will be recorded to describe bed edges that could migrate in response to management actions or climate change (Moore and Short 2006, Shaughnessy et al. 2012). *Phyllaplysia taylori*, a coevolved opisthobranch grazer of eelgrass leaf epiphytes, will be subsampled for abundance and size because of its potential importance in buffering eelgrass from the negative effects of eutrophication (Keiser 2004, Shaughnessy et al. 2008). Crabs and bivalves will get focal species attention because they are prominent middle trophic members of both habitats and they are fished.

Water Column Fish

North coast estuaries provide important habitat for different life stages of fish species, including sensitive species such as juvenile salmonids, tidewater goby (*Eucyclogobius newberryi*) and eulachon (*Thaleichthys pacificus*). We have taken advantage of methods and fisheries ecology information that has come out of past studies of North Coast estuaries (Table 4). These surveys have allowed for a general understanding of the fish species present and fish species/habitat relationships in Humboldt Bay (Gleason et al. 2008). Fish species within the Humboldt Bay SMRMA have not been specifically assessed.

Methods similar to those of Boyd et al. (2002), Cole (2004), Pinnix et al. (2005) and Gleason et al. (2008) will be used within or close to the two randomly selected sites within each estuary. At each site, beach seines (100' x 6'), pole seines (50' x 6') and fyke nets (1.5m x 1.5m with wings and lead lines) will be used as appropriate. Seines will be set by boat and by hand. Boat sets will be performed by anchoring one end of the seine to the shore and "paying out" the rest of the net from a small boat as it returns in a semicircle back to the shore. Biologists will retrieve the net and identify and measure the captured fish. Fish will be returned alive to the estuary outside of subsequent seine locations. Fyke nets will be set at high tide and fished for approximately four hours as the tide ebbs. Fyke nets will be retrieved before minimum low tide to minimize any stress on captured species. All fish will be identified to species for the purpose of the biodiversity description and all species will be sized for the focal species analysis. If biologists are unable to identify individual fish, photos will be taken for future identification. Among others, focal fish species will include eulachon, surfperch, salmonids and rockfish.

Sampling of any of the organisms proposed for this study is contingent upon receiving the appropriate Scientific Collecting Permits from the California Department of Fish and Wildlife.

Lists of the actual and types of species that will be encountered by the combination of above sampling methods are in Frimodig (2007) and Gleason et al. (2008).

Contextual Environment

Data sources for freshwater inflow (river discharge), mouth closures, and estuarine water level and ocean water properties have been found for most sites - or there is a prospect of new data being collected in parallel efforts not funded by the ME. For example, we anticipate that the CeNCOOS site will provide valuable data on environmental conditions at South Humboldt Bay SMRMA. Some effort will be expended on finding further extant data and urging local organizations to collect data where none is available (e.g., daily observations of mouth condition). The aim of this modest effort is to characterize abiotic conditions in these estuaries (water depth, water properties, estuary-ocean exchange, residence time, stratification, etc.) as best as possible based on contemporary or recent historical data, and then to link these conditions to primary drivers (e.g., river inflow, tides and wave effects on mouth conditions, season) and also to explore process-oriented association of abiotic condition with biotic parameters. Through collaboration across the team, we will identify environmental indices, i.e., environmental data with skill in explaining changes in biotic response. However, without collection of needed abiotic data in this baseline characterization, we may not be able to evaluate the skill of identified indices.

Where water level recorders exist in estuaries, we will sight in still water level (no wind, no flow) to a local benchmark using laser theodolite on several occasions and obtain a mean (and error of the mean) to use to refer water level data to MLLW datum (and to quantify uncertainty in this reference level). These data will be related to existing data on forcing variables (e.g., tide, wind and river discharge). We will also collate any existing data from temperature or salinity recorders in the study systems. These data will yield indices of mouth state (relation between estuary tide range and ocean tide range indicates whether mouth open, closed, perched, muted, etc.), water residence (mass balance based on water level and river flow data yields exchange rate), intrusion of upwelled ocean waters (indexed by temperature at high tide), and stratification (combination of tidal strength, river flow strength and bathymetry).

Data Analyses & Deliverables

For the first goal of the study, baseline characterization, a variety of descriptive and multivariate deliverables will be produced. These deliverables, and the field methods used to gather the data upon which they are based, have been chosen to be as repeatable as possible.

- GPS points for transect locations, upper and lower eelgrass bed edges, benchmarks
- A complete description of all field, laboratory and data analysis methods
- Summaries of all the species present at each time in each estuary
- Species richness at each time in each estuary
- A matrix of species presence/absence for each sample time and estuary
- A matrix containing raw abundances (i.e. not relativized because of different units of measurement) of species and functional groups
- Diversity indices for each time and each estuary based on relativized abundances of species-functional group matrices
- Summaries of the seasonal and event-scale variability of the watershed, estuarine and oceanic contextual conditions in each estuary
- Summaries of population structure (i.e. defined by some combination of: abundance, body size, shoot density or biomass) for each focal species
- Regression equations for estimating above ground eelgrass biomass from shoot lengths
- Summaries of eelgrass Leaf Area Index and water depths at eelgrass bed edges
- Relationships between biodiversity and contextual variables would be explored using nonmetric multidimensional scaling (NMS) ordination following the removal of rare taxa, relativization and transformation as necessary. For examining correlations, joint plots (PC-ORD) derived from an environmental matrix will indicate which contextual parameters are correlated to NMS axes. The deliverable in this case, is an ordination figure that portrays assemblage relationships among sites and, via the joint plot correlations, the abiotic gradients along which they are arranged. This analysis would assist the second project goal, below, to identify the subset of contextual variables most important in structuring the estuarine communities.
- Relationships between focal species and contextual variables would be described using univariate or simple multivariate approaches. This analysis would help to identify the most useful focal species and contextual variables for testing potential MPA effects.

For our second goal - study design recommendations for detecting an MPA effect in the future - the following will be evaluated:

- The degree to which continued biodiversity studies are necessary after providing them for previously unknown estuaries
- Which of the focal species should be retained based on their value as bioindicators and/or whether they are likely to remain of concern to agencies and coastal people
- Which contextual variables should be retained, or which are needed, to allow managers to discriminate between species changing in response to MPA management versus environmental forcing variables
- The deliverable would be a refined study design for detecting an MPA effect (if use restrictions are added) that uses the present baseline data.

Table 1. MPA permitted and prohibited uses in the estuaries included in the proposed study.

Estuary	MPA Permitted &Prohibited Uses
Mad River Estuary	[1]None
South Humboldt Bay SMRMA	Take of all living marine resources is prohibited, except take of waterfowl in accordance with general waterfowl regulations. Includes take exemptions for some federal tribes[2]. Other authorized activities are listed in California Code of Regulations, Title 14, Section 632(a) (http://www.dfg.ca.gov/marine/mpa/title14section632.asp).
Ten Mile Estuary SMCA	Take of all living marine resources is prohibited, except waterfowl may be taken in accordance with general waterfowl regulations. Includes take exemptions for some federal tribes[2]. Other authorized activities are listed in California Code of Regulations, Title 14, Section 632(a) (http://www.dfg.ca.gov/marine/mpa/title14section632.asp).
Big River Estuary SMCA	Take of all living marine resources is prohibited, except recreational take of surfperch by hook-and-line from shore only, and Dungeness crab by hoop net or hand. Take of waterfowl in accordance with general waterfowl regulations. Includes take exemptions for some federal tribes[2]. Other authorized activities are listed in California Code of Regulations, Title 14, Section 632(a) (http://www.dfg.ca.gov/marine/mpa/title14section632.asp).

[1] For general regulations that apply to all estuaries see: http://www.dfg.ca.gov/regulations/.

[2] Certain federally recognized tribes are exempted from the area and take regulations for this MPA. For information regarding tribal take, please see California Code of Regulations, Title 14, Section 632(a)(11).

Figure 1. Locations of the four North Coast estuaries to be sampled.

Figure 2. Mad River Estuary. The upstream extent of the estuary is unknown, but may extend east of the 101 bridge. Sampling for this project could at least occur at the starred locations.

Figure 3. South Humboldt Bay State Marine Recreational Management Area (from: Guide to the Northern California Marine Protected Areas by the California Department of Fish and Wildlife). The CeNCOOS water quality station is NE of this site.

Figure 4. Northwest view of the southern half of the South Humboldt Bay SMRMA (photo by D. Swensen).

Figure 5. 10 Mile Estuary State Marine Conservation Area (from: Guide to the Northern California Marine Protected Areas by the California Department of Fish and Wildlife)

Figure 6. The middle section of the 10 Mile Estuary (from Wikimedia).

Figure 7. Big River Estuary State Marine Conservation Area (from: Guide to the Northern California Marine Protected Areas by the California Department of Fish and Wildlife)


Figure 8. Eastern view of Big River Estuary SMCA (photo by D. Russell)

Table 2. Estuary baseline tasks and milestones.

	2014											2015												2016												2017
Tasks & Milestones	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J
Hiring	■	■																																		
Field Training			■	■																																
Biodiversity: mudflat, eelgrass				■	■	■					■	■	■																							
Focal species: mudflat, eelgrass				■	■	■					■	■	■			■	■	■					■	■	■											
Biodiversity & focal: fish				■	■	■					■	■	■			■	■	■					■	■	■											
Labwork: mudflat, eelgrass					■	■	■					■	■	■			■	■	■					■	■	■										
Existing Abiotic Data			■	■	■													■	■								■									
Data QC, metadata to OceanSpaces.org										■	■											■	■				■	■						■	■	■
Progress Reports											■	■											■	■										■	■	■
Analysis: baseline data										■	■											■	■				■	■	■	■	■	■	■	■		
Theses and manuscripts																				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

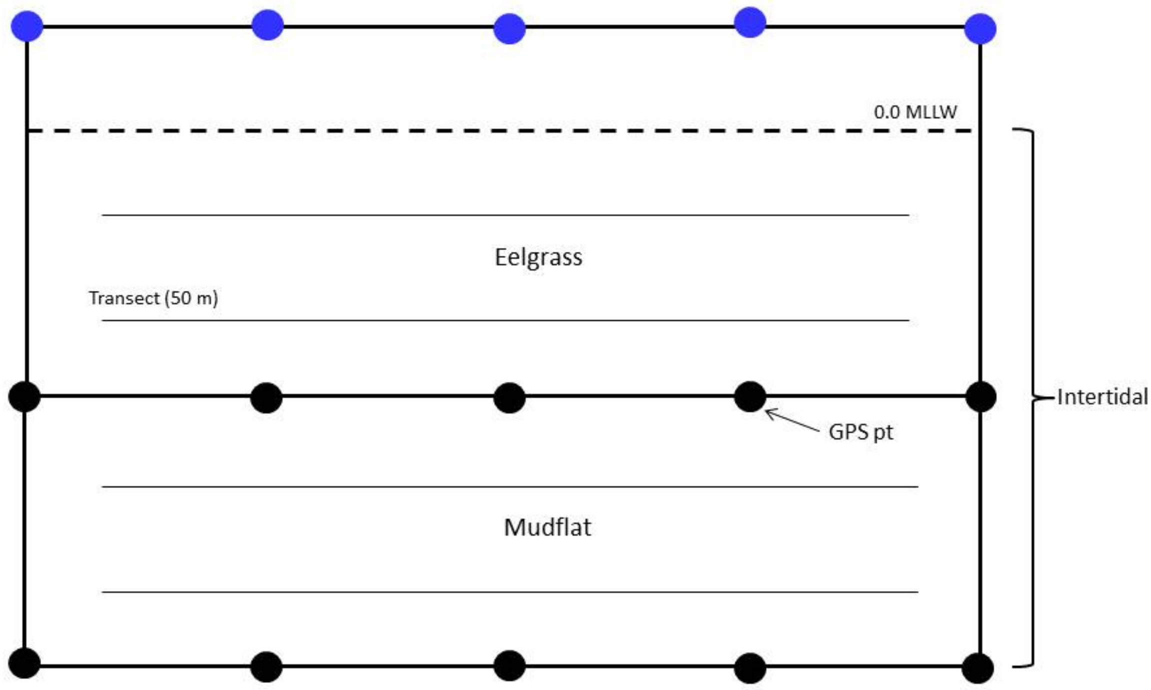

Figure 9. Site sampling design used within an estuary for everything except water column fish. Each site will have two semi-permanent transect lines established in each habitat. End positions of the lines will be marked with cryptic pvc pipe, GPS points, and photos. There will be 15 randomly placed quadrats (0.25 m^2 with divisions for subsampling) on each line and 4 of these on each line will be used for infaunal sampling. Transect and therefore quadrat sampling will only occur above 0.0 MLLW. The blue circles are GPS points for the deep edge of the eelgrass bed, which will likely occur below 0.0 MLLW. The deep edge will first be located with the miniROV then marked with a temporary buoy. Knowing the GPS position of the buoy along with the time that a depth reading is taken at the buoy will make it possible to calculate the depth at that location relative to MLLW.

Table 3. Assemblage and focal species variables to be measured in each habitat using the design illustrated in Figure (9). See the Methods text (Water Column Fish) for those water column fish that will get Focal Species attention.

Habitat	Biodiversity	Focal Species
Mudflat	Macrophytes: Species list. Abundance (as % cover) of *Zostera japonica* and *Gracilariopsis* and the following functional groups – green algae, sheet ulvoids, tubular ulvoids, green filaments, bare substratum Epifauna: Species list. Abundance as # / area for the following functional groups – amphipods & isopods Mobile fauna: Species list. Abundance by species of shrimp (including ghost and mudshrimp), crabs and small fish Infauna: Species list. Abundance (as # / volume) of each bivalve species and burrowing shrimp	Bivalves: density & size by species Green algae: biomass for functional groups - all ulvoids, all green algal filaments
Eelgrass (*Zostera marina*)	Macrophytes: Species list. Abundance (as % cover) of *Z. marina*, macroalgae, bare substratum Epiphytes: Abundance (as % cover diatoms, *Smithora* on *Z. marina* leaves) Epifauna: Species list. Abundance (# / leaf area) of *Phyllaplysia taylori* and the functional groups - amphipods, isopods, snails Mobile fauna: Species list. Abundance (# / trapping effort) by species of shrimp, crabs, small fish Infauna: Species list. Abundance (# / volume) of each bivalve species, burrowing shrimp	*Z. marina*: Shoot density, Leaf Area Index, Inflorescence density, actual and estimated above ground biomass, depths relative to MLLW for the deep and shallow edges of the eelgrass bed, GPS positions for bed edges *P. taylori*: # / leaf area, length then size class Crabs: Abundance by species (# / trapping effort), size and life history stage by species Bivalves: Abundance by species (density / volume), size by species

Figure 10. HSU faculty and students demonstrating field strategies for minimizing damage to the habitat. Boogie boards allow people to crawl from a channel edge into a sampling area without post- holing. Letting the water partially rise allows the retrieval of traps used for sampling small mobile fauna; both trap designs (open box, minnow trap) contain oyster shells where shrimp and crabs can hide so they are not eaten by larger fish and birds (photos from F. Shaughnessy).

Table 4. Significant fish studies that have been conducted in the 2 bioregions of the North Coast.

Humboldt Bay
Boyd et al. (2002) as part of an intensive non-indigenous species survey, used traps, gill nets, seines and trawls to sample Humboldt Bay's perimeter shoreline, un-vegetated mudflats and main channels.
Cole (2004) used a variety of seines and trawls to sample habitats throughout Humboldt Bay, including small channels, rip rapped areas and sloughs that had not been thoroughly sampled previously. Resulting data allowed for a description of the fish community and habitat types within Humboldt Bay.
Pinnix et al. (2005) used seines and fyke nets to sample eelgrass (*Zostera marina*) beds, un-vegetated mudflats, and oyster culture longlines in north Humboldt Bay.
Pinnix et al. (2012) monitored the movement of coho salmon in Humboldt Bay using telemetry.
Garwood et al. (2012) assessed data from epibenthic otter trawls to assess fish species associated with eelgrass in Humboldt Bay.

Southern Estuaries
Cannata (1998) used gill nets, seines and hook and line to sample fish in the Navarro river estuary.
Higgins (1995) used seines and direct observation to characterize the fish community in the Garcia River estuary. (Note: we don't propose to sample in the Garcia River estuary.)
A juvenile salmonid out-migrant screw trap is operated on the upper edge of the Ten Mile River estuary (D. Wright pers. comm.).
The Mendocino High School, School of Natural Resources (SONAR) routinely conducts estuarine fish and invertebrate surveys in the Big River estuary.

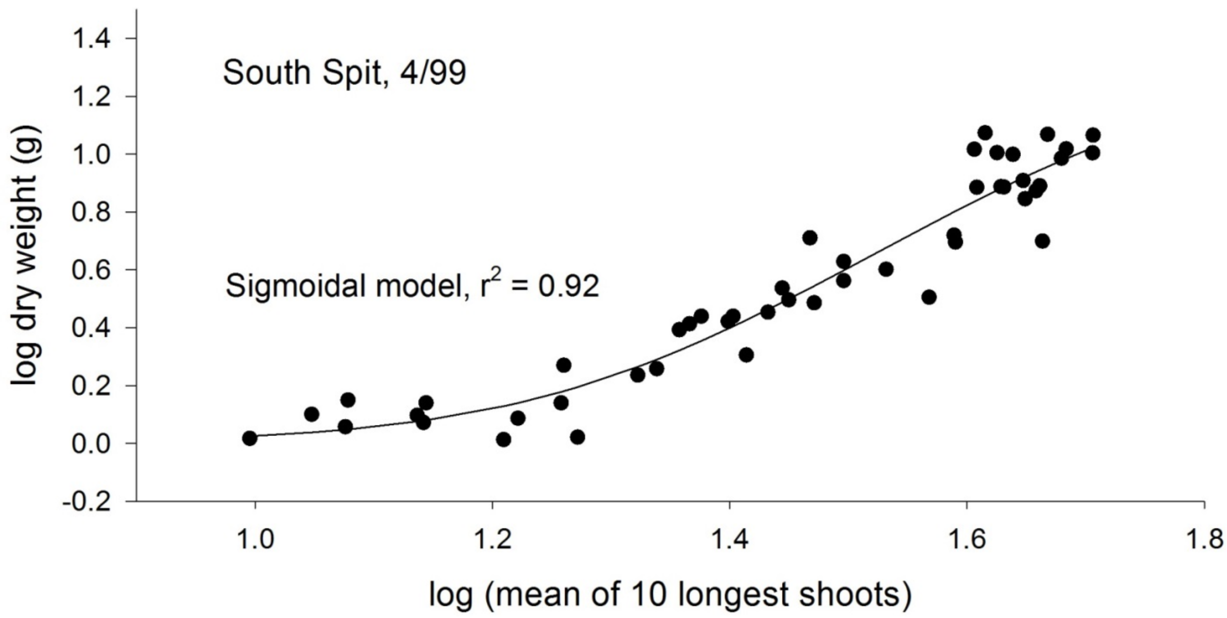

Figure 11. The mean of the 10 longest shoots in a quadrat versus the observed standing stock (g dry weight) of all shoots in a quadrat. While destructive sampling must occur for this relationship to be established, fitting a regression model to this relationship allows subsequent standing stock measures to be estimated at this site without destructive sampling.

References

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