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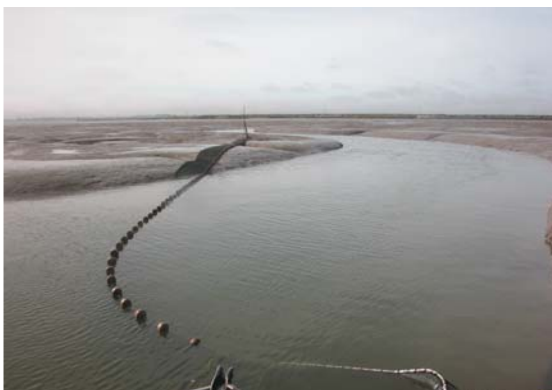
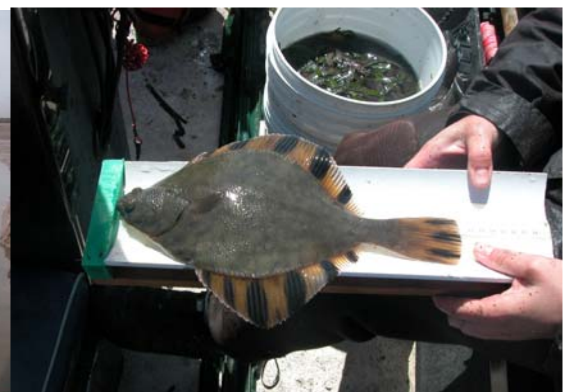
Fish Communities in Eelgrass, Oyster Culture, and Mudflat Habitats of North Humboldt Bay, California
Final Report

William D. Pinnix, Thomas A. Shaw, Kirsten C. Acker, and Nicholas J. Hetrick

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Abstract. Fish communities were surveyed in eelgrass (*Zostera marina)* meadows, oyster culture (*Crassostrea gigas*), and mudflat habitats in North Humboldt Bay, California from August 2003 to August 2005 using a variety of gears. Six gear types were qualitatively assessed to determine their effectiveness in capturing fishes in different habitats in the bay, including a shrimp trawl, beach seine, purse seine, cast net, minnow traps, and fyke net. Catch rates and species diversity indices were calculated from catch data to compare seasonal distributions and relative abundance of fishes and fish community structure between the three main habitat types present in the North Bay.

Forty-nine fish species representing 22 families were collected by the six gear types used. No juvenile salmonids were captured. The shrimp trawl and fyke net were the most effective gear types in addressing the main objectives of this study. Catch per unit effort of fish (CPUE) of both shrimp trawl and fyke net samples differed significantly between habitat types, with greater catches in oyster culture than in mudflat and eelgrass habitats, which did not differ significantly from one another. Species richness and diversity of fyke net catches also differed significantly between habitat types, with samples collected in oyster culture and eelgrass habitats having greater species diversity than in mudflat habitats. Species richness and diversity of shrimp trawl samples did not differ significantly between habitat types. Shrimp trawl and fyke net CPUE differed significantly between paired day-night samples. Species diversity of fyke net catches differed between day and night for one of the two indices used to describe species diversity. Species diversity of shrimp trawl and fyke net samples did not differ significantly by habitat types between day and night samples.

Introduction

Humboldt Bay is the second largest estuary in California, encompassing over 17,000 acres. The bay is about 22 km long, 7 km across at it widest point, and can be geographically segregated into three main areas: North Bay, South Bay and Central Bay (Figure 1). Ecologically, Humboldt Bay is important as it provides estuarine habitat for numerous species of invertebrates, fish, birds, and mammals (Barnhart 1992). Humboldt Bay is also economically important, supporting both recreational and industrial uses (Barnhart 1992).

Commercial culture of oysters first began in Humboldt Bay in the early 1900's (Barrett 1963). However, these operations were apparently not successful until the introduction of Pacific oysters (*Crassostrea gigas)*, in the mid-1950's (Barrett 1963). Since that time, the effects of commercial oyster culture activities on Bay resources have raised concerns and received some evaluation (see e.g. Gray 1994, Moore 2001, Trianni 1996, Waddell, 1964). With Federal listing under the Endangered Species Act (ESA) of 26 Evolutionarily Significant Units of anadromous salmonids on the Pacific Coast since the late-1980's, additional questions have been raised about the effect of mariculture operations on listed salmonids. When permitting activities under section 404 of the Clean Water Act, and section 10 of the Rivers and Harbors Act, the Army Corps of Engineers (Corps) is required to conduct ESA section 7 consultation when listed species may be affected by the proposed action. In tidally influenced waters, the Corps must also consult with the National Marine Fisheries Service regarding the effects to "essential fish habitat" for commercial and recreationally important fish species regulated by the Magnuson-Stevens Fishery Conservation and Management Act. The conduct of this study was initiated due to the current lack of information available about the fish use of Humboldt Bay habitats, i.e. mudflats and eelgrass (*Zostera marina)* meadows where oyster culture structures are located. This study is also coincident, and expected to be complementary, to other studies nearing completion that have been focused on the interaction of mariculture activities with species and habitats of concern in Humboldt Bay and other west coast estuaries (Dumbauld 2004, Rumrill and Poulton 2004).

Four fish species that inhabit Humboldt Bay and its tributaries are listed as threatened under the Endangered Species Act of 1973: coho salmon (*Oncorhynchus kisutch*), Chinook salmon (*O. tshawytscha*), steelhead (*O. mykiss*) and the tidewater goby (*Eucyclogobius newberryi*). In the early 1990's, Hassler (1991) reported that nine tributaries entering Humboldt Bay supported runs of coho salmon. Juvenile salmonids are known to use estuaries as nursery areas after out-migrating from natal streams as smolts. Protection and recovery of estuarine habitats is important because research indicates that estuarine rearing by juvenile salmonids is critical for survival (Pearcy 1992). However, specifics on habitat use, feeding, and survival of juvenile salmonids residing in estuaries, particularly during the winter months, has not been thoroughly described and is lacking for Humboldt Bay.

Larval and juvenile fish surveys conducted previously in Humboldt Bay have failed to detect large numbers of juvenile salmonids (Eldridge and Bryan 1972; Dr. T. Mulligan, Fisheries Department, Humboldt State University**,** Arcata, California, personal communication). Juvenile steelhead, coho salmon, and Chinook salmon have been captured in Humboldt Bay, but specific data on habitat use are limited (Emmett et al. 1991, Barnhart et al. 1992). A limited number of studies have documented specific habitats, particularly eelgrass, that are used by juvenile salmonids rearing in estuaries. Murphy et al. (2000) documented higher beach seine catches of juvenile pink salmon (*O. gorbuscha*) in eelgrass beds than in open bay environments in Alaska. Bayer (1981) also documented the use of eelgrass beds by immature salmonids in the Yaquina estuary in Oregon. Dumbauld (Washington Department of Fish and Wildlife, Nahcotta Field Station, Nahcotta, Washington, personal communication) found juvenile salmonids residing in eelgrass beds in Willapa Bay, Washington.

Various marine fish species within the taxonomic families Clupeidae (herring and relatives), Scorpaenidae (rockfish), and Pleuronectidae/Paralichthyidae (flatfish) have also been shown to depend on eelgrass as nursery habitat. However, the relationship between eelgrass and the various marine fish species present in Humboldt Bay has not been thoroughly documented (Gotshall et al. 1982). In addition, the overall community composition of nekton inhabiting eelgrass in Humboldt Bay has not been quantified. This lack of baseline information is of concern as Humboldt Bay is the only major estuary north of Bodega Bay, California, and south of Coos Bay, Oregon, that has large areas of eelgrass beds.

Studies in other estuaries in the Pacific Northwest have documented the use of eelgrass by various marine species (Murphy et al. 2000, Raposa and Oviatt 2000, Hughes et al. 2002, Hosack 2003, Johnson et al. 2003, Bloomfield and Gillanders 2005). Adults and juveniles from more than 75 different species have been observed in eelgrass habitats with over 50% of these species reported as being transient species in eelgrass habitats, residing temporarily to feed or rear during a particular life stage (Phillips 1984). Additional information is needed to define the importance of eelgrass to fish communities and transient species present in Humboldt Bay. A thorough understanding of the association between eelgrass, fish communities, and species-specific habitat requirements can provide guidance to managers that can be used to avoid or minimize potential impacts to fishes and fish habitats that may result from various activities that occur in Humboldt Bay.

The goal of this study was to describe the fish community structure in eelgrass, mudflat, and oyster culture habitats in the North Bay of Humboldt Bay from August 2003 to August 2005. Specific objectives of this project were:

- Test the effectiveness and selectivity of six different gear types in sampling fish communities in three different habitats present in North Humboldt Bay.
- Document baseline fish community composition, including seasonal and spatial distribution of fishes in North Humboldt Bay.

- Compare fish community structure and catch rates of fishes in eelgrass, oyster culture, and mudflat habitats in North Humboldt Bay.

Study Area

There are four major tidal channels in North Humboldt Bay and sample sites were stratified and assigned names based on these channels (Figure 2). The four channels sampled, from east to west, were East Bay Channel (beginning between Woodley and Indian Islands), Arcata Channel (the north side of Indian Island and continuing east towards the historic Arcata Wharf), Sand Island Channel (just to the west of Sand Island), and the Mad River Channel (the most westerly of the North Humboldt Bay channels, which becomes the Mad River Slough at its northern reach). These channels were named after Coast Seafood's channel designations.

Four sample sites were selected within each channel, except for the Mad River channel in which eight sample sites were selected. Sample sites were subjectively selected within one of three predefined habitat categories based on the presence or absence of oyster culture and/or eelgrass. The three habitat categories were mudflat, eelgrass, and oyster culture.

Methods

Access to Sample Sites

Sample sites were accessed with a17 foot aluminum hull jet boat. The boat was either launched daily at the Eureka public boat basin, or moored at Woodley Island Marina; both sites are located in the southern portion of North Humboldt Bay. A Trimble GEOXT handheld GPS unit was used to navigate within the bay, return to established sampling sites, and to record the location of new sampling sites. Crews consisted of 2 to 4 persons, depending on the sampling method used on a particular day.

Because of the shallow depths over much of North Humboldt Bay and the exposure to prevailing winds, safe sampling was conducted only during favorable weather conditions. Prior to sample collection, weather conditions and daily forecasts were obtained from the National Weather Service website (http://www.ndbd.noaa.gov). Sampling occurred when winds were less than 15 knots and no small craft advisories were in effect. Occasionally wind speeds would begin to blow stronger than 15 knots while sampling was underway causing a rapid increase in sea heights and steepness which made sampling unsafe. During these conditions sampling would be curtailed until weather improved.

Sampling over flats was limited to high tide. Depths were monitored regularly with a handheld depth meter when over flats to ensure adequate water depths considered safe for sampling (about 0.67 meters) were present. Rapid tide changes and dewatering of flats are common in the North Bay. When caught on the flats in depths less than 0.67 meters, the crew would turn off the motor and either use oars to push off the flats or physically get in the water and push the boat into the nearest channel.

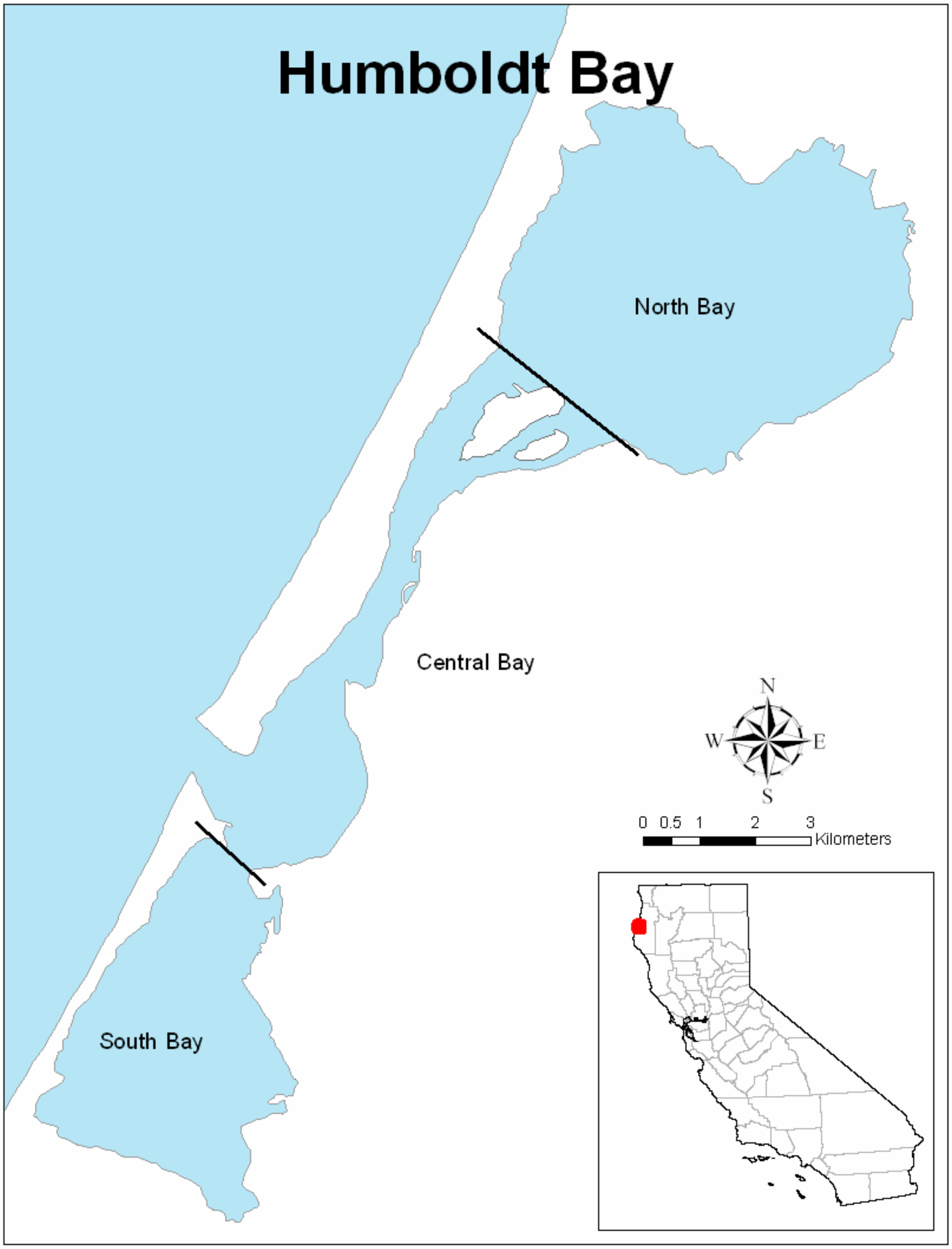


Figure 1. Map of Humboldt Bay, California, showing three main areas within the bay, North Bay, Central Bay, and South Bay.

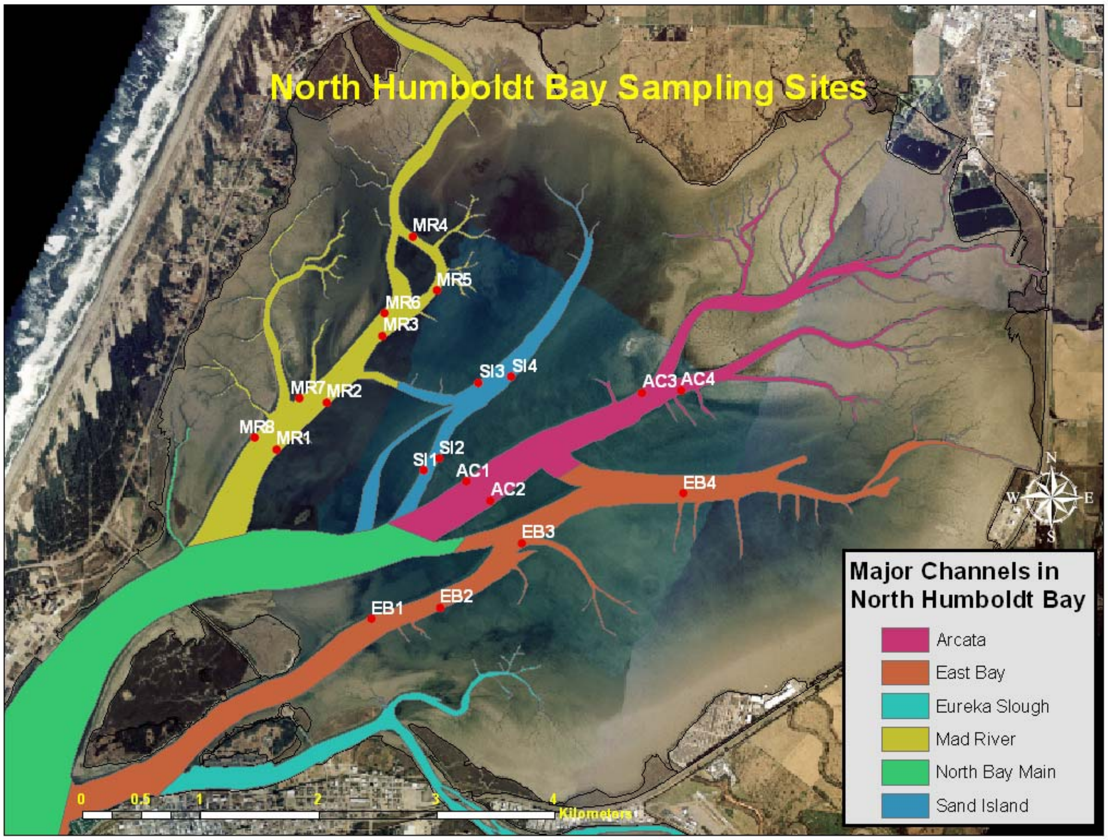


Figure 2. Major channels and locations of study sample sites in North Humboldt Bay, California.

Sampling Design

2003 and 2004

Sampling in 2003 and 2004 focused on testing selectivity of gear types and documenting baseline seasonal variability in fish communities in North Humboldt Bay. Shrimp trawl samples were conducted once per month at each of the 20 sites established in North Bay from August 2003 to October 2004. In some months poor weather conditions or boat mechanical problems did not allow for sampling all 20 sites, so a subset of sites was sampled that represented the three habitat types.

2005

Sampling in 2005 focused on fyke netting within specific habitats. Three fyke nets were deployed each sampling day at high tide over flats, each in a different habitat category. One net was set in a oyster culture site, one net was set over eelgrass beds without culture, and one net was set over mudflats without culture or eelgrass. The location of the oyster culture sampling sites dictated the location of the eelgrass and mudflat sites, which were chosen based on logistic feasibility of sampling all three sites as close as possible in time. Once the fyke nets were set, three shrimp trawl samples were collected adjacent to each fyke net sampling site. Fyke nets were pulled approximately 4 hours after being set, or when tidal levels dropped low enough that the net was not collecting fish; nets were checked prior to complete dewatering to ensure that fish caught in the trap would have adequate water for survival in the net.

Sample sites were chosen from sites established during 2003 and 2004. Sampling occurred on three separate days, with nets set at sites contained within a major channel. For instance, on day one all nets were set at sites in the Mad River Channel, on day two nets were set at sites in the Sand Island Channel, and so on. Sampling sites were identified based on suitability and the sampling area on a particular day was chosen at random.

Daytime samples generally occurred between 0600 and 1700 or between posted sunrise and sunset. Night sampling occurred between 2200 and 0500 or between posted sunset and sunrise.

Sampling Gear

Different gear types were tested to qualitatively determine their effectiveness and selectivity in sampling fish communities in the three different habitats sampled in North Humboldt Bay. Gear types tested included a shrimp trawl, beach seine, purse seine, cast net, fyke net, and minnow traps. We were unable to test all gears in the three different habitat types because of limitations specific to each of the gear types.

Shrimp Trawl

A 3.05 m shrimp trawl with a 7.94-mm stretch mesh cod-end was used to sample in channels and over mud-flats and eelgrass beds. Shrimp trawl samples were not collected directly over or in oyster culture sites due to the inability to sample with a shrimp trawl without damaging the culture operations. Shrimp trawl samples identified as an oyster culture site were located immediately adjacent to oyster culture areas. A shrimp trawl set consisted of towing the shrimp trawl for three minutes against the prevailing tide. Three sets were conducted within 15 minutes of each other at each sample site per month. Boat speed over ground was maintained at about 5 knots/hour to compensate for variability in tidally-influenced current velocity and to ensure the shrimp trawl fished correctly and consistently between sets. Catch per unit of effort of shrimp trawl data was calculated monthly for each site, channel, and habitat type by adding the total number of individual fish captured by the number of sets made. Data were log-transformed (Ln(CPUE+1)) prior to analyses because CPUE data were log-normal distributed.

Beach Seine

Beach seine hauls were conducted using a 36.6 m long by 3.05 m deep net with 6.35 mm mesh. The seine was deployed along channel margins at one sample site in each of the four channels. Three hauls were made at each site during the outgoing tide.

Purse Seine

A 30.48 m long by 3.05 m deep purse seine with 3.18 mm mesh was used to sample the upper water column. Three sets were made in each channel during a given month.

Cast Net

A 3.58 m cast net was thrown into the water from the bow of a boat. Multiple throws were performed over a 15-minute period over eelgrass beds and in Arcata Channel.

Fyke Net

A 1.22 m Maine fyke net with 30.48 m leads with 6.35 mm mesh was set at high tide on flats adjacent to sample sites where water depth was approximately 1.5 - 2 m deep. Leads were staked in place with metal fence posts, forming a 90 degree angle that was aligned to funnel the outgoing tide into the body of the net. The net was retrieved approximately 4 hours after high tide.

Minnow Trap

Minnow traps were set exclusively within oyster culture beds. Traps were unbaited, weighted down with 1 kg weights and retrieved using an attached buoy line. Six numbered traps were set for 4-hour sample periods.

Specimen Identification

Fish captured were identified to the lowest possible taxon in the field. If a fish could not be positively identified on site, it was preserved in formalin and transported to the laboratory for later identification. In the lab, specimens were preserved in 75% ethanol and submitted to the Humboldt State University (HSU) Department of Fisheries fish collection in Arcata, California. Identification of species was verified by Andrew Kinziger, Ph.D. of the HSU Fisheries Department.

Fish Community Analyses

Species richness was calculated as the total number of species captured at a given site, channel or habitat type by month. The Simpson's Index (D) of diversity (Magurran 1988) was calculated using the equation:

$$D = 1 \Big/ \sum p_i^{\,2}$$

Where: p_i is the proportional abundance of species *i* in a given sample

The Shannon-Wiener Index (H') of diversity (Magurran 1988) was calculated from the following equation:

$$H' = -\sum p_i \ln p_i$$

Where: p_i is the proportional abundance of species *i* in a given sample

To compensate for biases and assumptions inherent in the two indices (Magurran 1988), both were calculated monthly for each habitat type.

Water Quality

Salinity, dissolved oxygen, water temperature, specific conductance, and pH were measured monthly at the beginning of each sampling set using a YSI 556 MPS multi-meter. Water samples were collected at each sampling site (August 2003 to July 2004) from surface waters in 100 ml plastic bottles and analyzed in the lab to quantify turbidity, expressed in nephelometric turbidity units (ntu). Water clarity was also assessed by taking measurements with a 20-cm diameter Secchi disk.

Sediment

Sediment was collected at each site with a long-handled scoop that sampled the surface layer. Three samples of about 200 ml each were collected from each site monthly and were analyzed in the lab to determine percent fines following methods detailed by Simenstad et al. (1991). A subsample of 80 ml of sediment from each sample was sieved through a Number 230 U.S.A. Standard Testing Sieve (63 microns or 0.0025 inches) and rinsed three times. The volume of coarse particles remaining in the sieve was measured to the nearest ml and percent fines was calculated as the complement of the percentage of coarse material. Percent fines from the three samples were then averaged for each site.

Fyke Netting

The first 18 months (August 2003 to October 2004) of sampling documented seasonal trends in numbers of fish in North Humboldt Bay as well as how those seasonal changes affected different species. However, shrimp trawl samples cannot be made *within* oyster culture areas. We decided to employ fyke nets to sample within oyster culture as well as eelgrass and mudflat habitats. In order to compare fyke net catches to previous sampling with shrimp trawls, simultaneous trawling was done in conjunction with fyke netting. To test for diurnal differences in fish abundance and species present, sampling was conducted day and night during August 2005. Specific hypotheses to be tested during this specific study element were:

> Ho1: There is no significant difference at the α=0.10 level in fish community composition in Humboldt Bay eelgrass beds, mudflats, and oyster culture sites.
>
> Ho2: There is no significant difference at the α=0.10 level in fish community composition between day and night samples.

The hypotheses were tested by performing Two-way Analysis of Variance (treatment [habitat type], and time) on diversity indices, species richness, and CPUE. Significant interaction terms led to performing pair-wise comparisons using Fishers Least Significant Differences (LSD) test.

Results

Sampling Gear Evaluation

The shrimp trawl caught the most functionally diverse assemblage of species, which included both benthic and mid-water species. The beach seine was effective in capturing benthic fish species at low tides. The purse seine was effective at capturing schooling mid-water fishes, including Pacific herring (*Clupea pallasii*), northern anchovy (*Engraulis mordax*), and topsmelt (*Atherinops affinis*). In shallow water (< 3 m), the purse seine also captured benthic species, including speckled sanddab (*Citharichthys stigmaeus*) and English sole (*Parophrys vetulus*). The cast net did capture a small number of individual fish, but was ineffective at capturing a diversity of fish species. The Maine fyke net captured both benthic and mid-water species, but could not be deployed in water deeper than 2 m. Unbaited minnow traps were highly selective, capturing only bay goby (*Lepidogobius lepidus*).

A total of 376 shrimp trawl samples (3 sets per sample = 1072 individual trawl sets), and 45 Maine fyke net sets were conducted in the study area (Appendix A) from August 2003 to August 2005. Due to boat problems and inclement weather, shrimp trawl sampling during November 2003 and March 2004 was infrequent. In addition, no sampling was conducted from November 2004 to February 2005, and June and July 2005.

Species Captured

A total of 49 fish species representing 22 families were collected during the study (Table 1), including juveniles from many of the taxa captured. Most of the species captured, 56% by number of species and 57% by number of individuals captured, were classified as resident species based on information reported by Gotshall et al. (1982). Forty-two percent of the total number of individuals captured were considered to be using Humboldt Bay as a nursery (Gotshall et al. 1982), representing 17% of the total number of species captured.

The dominant species in trawl catches were as follows: English sole, 41% of the total shrimp trawl catch; Figure 3), and shiner surfperch (*Cymatogaster aggregata*, 32% of the total shrimp trawl catch; Figure 3). Other species captured included speckled sanddab, 9% of the total shrimp trawl catch; Figure 3), bay pipefish (*Syngnathus leptorhynchus*, 4% of the total shrimp trawl catch; Figure 4), bay goby, 3% of the total shrimp trawl catch; Figure 4), walleye surfperch (*Hyperprosopon argenteum*; 3% of the total shrimp trawl catch; Figure 4), northern anchovy, 2% of total shrimp trawl catch; Figure 5), staghorn sculpin (*Leptocottus armatus,* 1% of the total shrimp trawl catch, Figure 5), juvenile black rockfish (*Sebastes melanops ,* 1% of the total shrimp trawl catch, Figure 5), and saddleback gunnel (*Pholis ornata,* 1% of the total shrimp trawl catch, Figure 6). These species accounted for 97% of the individual fish captured in shrimp trawls.

Table 1. List of fish species collected in North Humboldt Bay using six different gear types between August 2003 and August 2005. Guild designations were determined from Gotshall et al. (1982). Lifestage represents the lifestage(s) captured during this study and n = number of individuals captured.

Scientific Family	Common Name	Scientific Name	Guild	Lifestage	n
Ammodytidae	Pacific Sandlance	*Ammodytes hexapterus*	Resident	Adult	1
Atherinidae	Topsmelt	*Atherinops affinis*	Resident	Adult, Juvenile	671
	Jacksmelt	*Atherinops californiensis*	Feeding	Adult	23
Aulorhynchidae	Tubesnout	*Aulorhynchus flavidus*	Resident	Adult, Juvenile	55
Batrachoididae	Plainfin midshipman	*Porichthys notatus*	Resident	Adult, Juvenile	46
Bothidae	Speckled Sanddab	*Citharichthys stigmaeus*	Resident	Adult, Juvenile	2568
	California Halibut	*Paralichthys californicus*	Occasional Visitor	Juvenile	2
Carcharhinidae	Brown Smoothhound	*Mustelus henlei*	Resident	Adult	4
	Leopard Shark	*Triakis semifasciata*	Resident	Adult	4
Clupeidae	Pacific Herring	*Clupea harengus*	Resident	Adult, Juvenile	1077
	American Shad	*Alosa sapidissima*	Occasional Visitor	Juvenile	4
	Pacific Sardine	*Sardinops sagax caeruleus*	Occasional Visitor	Juvenile	647
Cottidae	Staghorn Sculpin	*Leptocottus armatus*	Resident	Adult, Juvenile	243
	Cabezon	*Scorpaenichthys marmoratus*	Resident	Juvenile	12
	Buffalo Sculpin	*Enophrys bison*	Resident	Adult, Juvenile	2
Cynoglossidae	California Tonguefish	*Symphurus atricauda*	Occasional Visitor	Adult	1
Embiotocidae	Redtail Surfperch	*Amphistichus rhodoterus*	Feeding	Adult	5
	Shiner Surfperch	*Cymatogaster aggregata*	Resident	Adult, Juvenile	6277
	Silver Surfperch	*Hyperprosopon ellipticum*	Spawning	Adult, Juvenile	8
	Spotfin Surfperch	*Hyperprosopon anale*	Occasional Visitor	Adult	2
	Striped Surfperch	*Embiotoca lateralis*	Resident	Juvenile	6
	Walleye Surfperch	*Hyperprosopon argenteum*	Resident	Adult, Juvenile	528
	White Surfperch	*Phanerodon furcatus*	Spawning	Adult	47
	Pile Surfperch	*Damalichthys vacca*	Resident	Adult, Juvenile	99
Engraulididae	Northern Anchovy	*Engraulis mordax*	Resident	Adult, Juvenile	2568
Gadidae	Pacific Tomcod	*Microgadus proximus*	Feeding	Adult	8
Gasterosteidae	Threespine Stickleback	*Gasterosteus aculeatus*	Resident	Adult, Juvenile	16
Gobiidae	Goby spp.			Larval	38
	Bay Goby	*Lepidogobius lepidus*	Resident	Adult, Juvenile	413
	Arrow Goby	*Clevelandia ios*	Resident	Adult, Juvenile	5
	Blackeye Goby	*Coryphopterus nicholsii*	Resident	Adult	2
Hexagrammidae	Kelp Greenling	*Hexagrammos decagrammus*	Spawning	Adult	2
	Lingcod	*Ophiodon elongatus*	Feeding, Nursery	Juvenile	14
Liparididae	Slimy snailfish	*Liparis mucosus*	Resident	Adult	2
Myliobatididae	Bat Ray	*Myliobatis californica*	Resident	Adult	37
Osmeridae	Night Smelt	*Spirinchus starksi*	Feeding	Adult	1
	Surf Smelt	*Hypomesus pretiosus*	Feeding	Adult, Juvenile	348
	Longfin Smelt	*Spirinchus thaleichthys*	Feeding	Adult	12
	Whitebait Smelt	*Allosmerus elongatus*	Feeding	Adult	17
Pholidae	Saddleback Gunnel	*Pholis ornata*	Resident	Adult, Juvenile	94
	Penpoint Gunnel	*Apodichthys flavidus*	Resident	Adult	2
Pleuronectidae	Curlfin Turbot	*Pleuronichthys decurrens*	Nursery	Juvenile	5
	English sole	*Parophrys vetulus*	Nursery	Juvenile	5553
	Starry Flounder	*Platichthys stellatus*	Resident	Adult, Juvenile	65
Scorpaenidae	Copper rockfish	*Sebastes caurinus*	Resident	Juvenile	24
	Black Rockfish	*Sebastes melanops*	Resident	Juvenile	147
	Grass Rockfish	*Sebastes rastrelliger*	Resident	Juvenile	2
	Bocaccio Rockfish	*Sebastes paucispinis*	Resident	Juvenile	1
	Brown Rockfish	*Sebastes auriculatus*	Feeding	Juvenile	11
Syngnathidae	Bay Pipefish	*Syngnathus leptorhynchus*	Resident	Adult, Juvenile	559

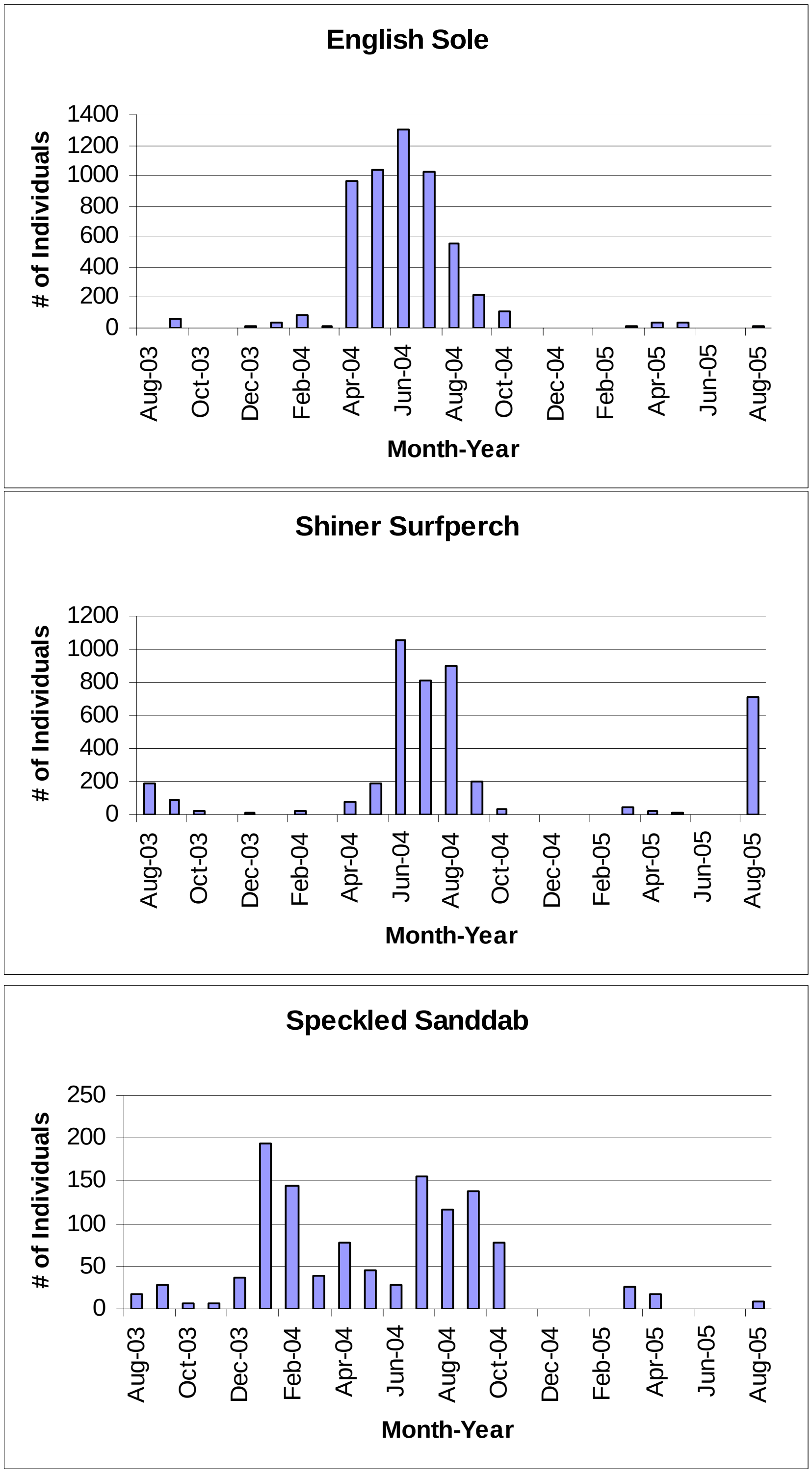
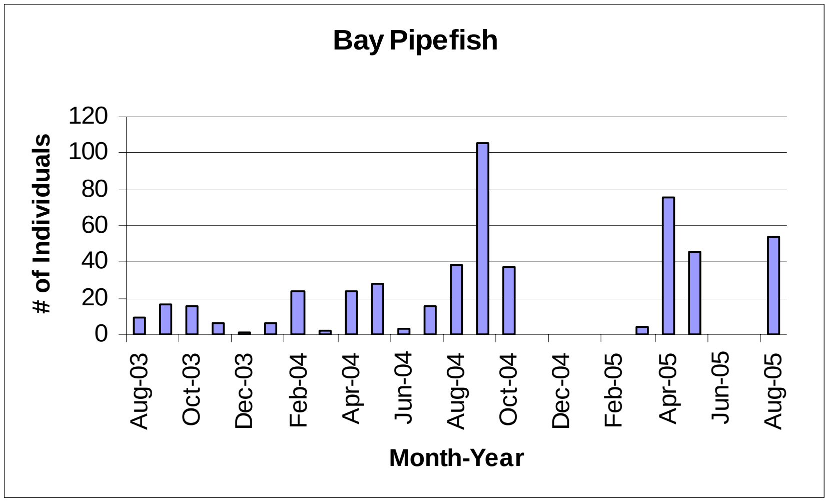
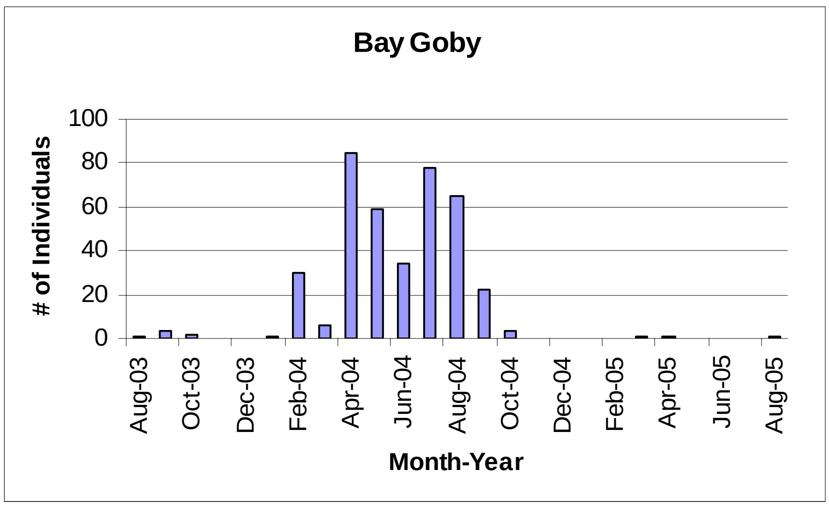


Figure 3. Catch of English sole, shiner surfperch, and speckled sanddab by month from shrimp trawl samples conducted in North Humboldt Bay between August 2003 to August 2005. No sampling was conducted November 2004 through February 2005, and June 2005 through July 2005.





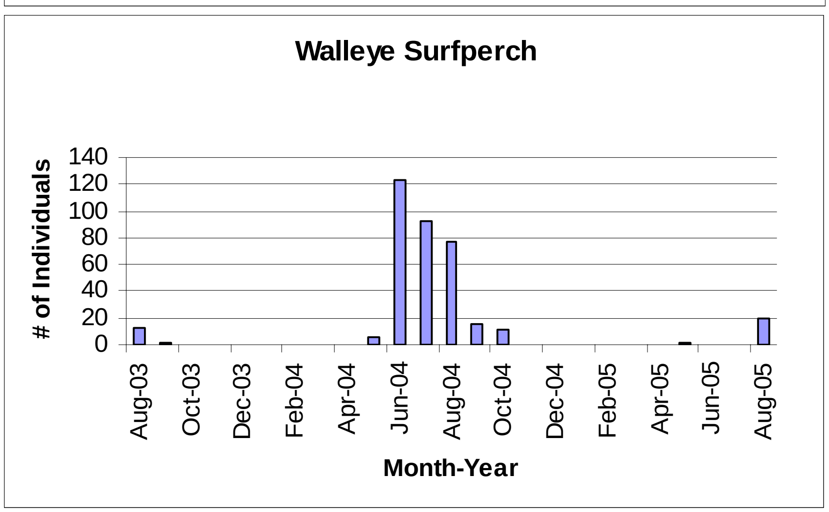


Figure 4. Catch of bay pipefish, bay goby, and walleye surfperch by month from shrimp trawl samples conducted in North Humboldt Bay between August 2003 to August 2005. No sampling was conducted November 2004 through February 2005, and June 2005 through July 2005

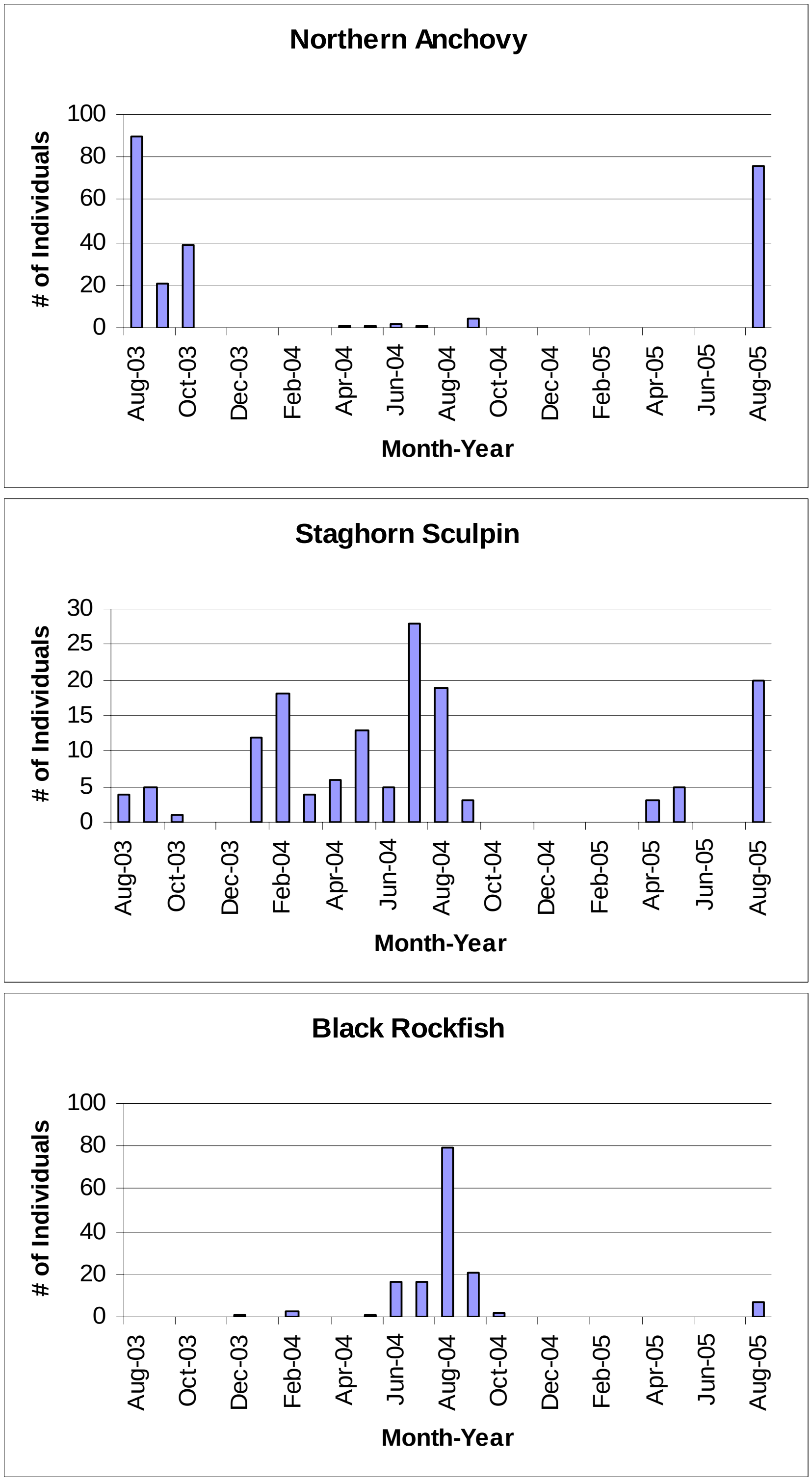


Figure 5. Catch of northern anchovy, staghorn sculpin, and juvenile black rockfish by month from shrimp trawl samples conducted in North Humboldt Bay between August 2003 to August 2005. No sampling was conducted November 2004 through February 2005, and June 2005 through July 2005.

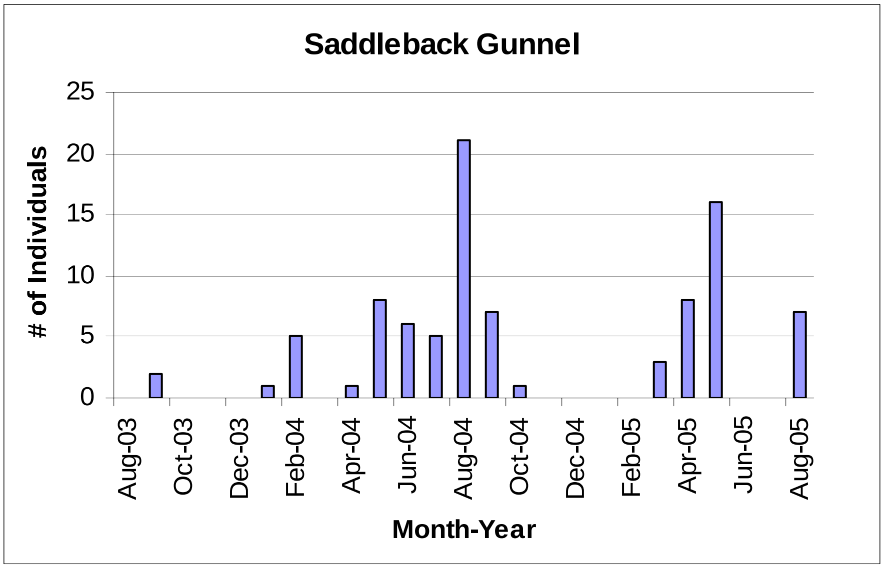


Figure 6. Catch of saddleback gunnel by month from shrimp trawl samples conducted in North Humboldt Bay between August 2003 to August 2005. No sampling was conducted November 2004 through February 2005, and June 2005 through July 2005.

The dominant species in fyke net catches were northern anchovy (46% of the total fyke catch), and shiner surfperch (42% of the total fyke catch). Other species captured in fyke nets included topsmelt (5% of the total fyke catch), walleye surfperch (4% of the total fyke catch), and bay pipefish (1% of the total shrimp trawl catch). These species accounted for 98% of the individual fish captured in fyke nets.

Catch per Unit Effort

Shrimp trawl

A seasonal change in the CPUE for the shrimp trawl data was observed, ranging from 1.1 fish/trawl in November 2003 to 110.0 fish/trawl in June 2004 (Figure 7). Catch per unit effort also varied by habitat type (Figure 8). CPUE in day shrimp trawl samples varied significantly by month ($p<0.001$) and habitat ($p=0.078$; Table 2). CPUE varied significantly ($p=0.068$) between day-night shrimp trawl samples but habitat was not significant ($p=0.913$) to the day-night variation in shrimp trawl CPUE (Table 3).

Fyke Net

CPUE of fyke net catches ranged from 0 fish/hour in March 2005 to 162 fish/hour in August 2005 (Figure 9). CPUE in day fyke net samples varied significantly by month ($p<0.001$) and habitat ($p<0.001$) as well as having a significant ($p<0.001$) interaction term (Table 2). Pairwise comparisons of the means using LSD mean comparison tests showed no significant difference between eelgrass and mudflat catches ($p=0.821$), and oyster culture catches were significantly greater than eelgrass ($p<0.001$) and mudflat ($p<0.001$) CPUE. CPUE varied significantly ($p=0.041$) between day and night fyke net samples, but habitat was an insignificant ($p=0.197$) contribution to the day-night variation in fyke net CPUE (Table 3).

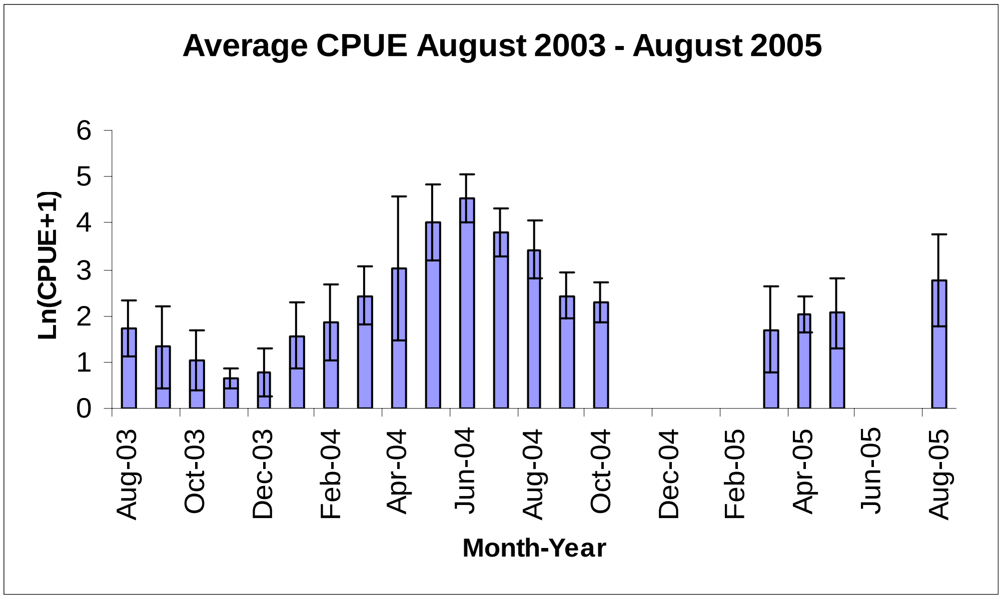


Figure 7. Monthly mean natural log of catch per unit effort (CPUE+1) of shrimp trawls conducted in North Humboldt Bay, California, between August 2003 and August 2005. Error bars are equal to one standard deviation of the mean. No sampling was conducted November 2004 through February 2005, and June 2005 through July 2005.

Table 2.ANOVA results of Month x Habitat of shrimp trawl and fyke net day catches. Values listed are p–values, bold values indicate significance at the α=0.10 level.

Month x Habitat	Trawl			Fyke		
	Month	Habitat	Mo x Hab	Month	Habitat	Mo x Hab
CPUE	**<0.001**	**0.078**	0.350	**<0.001**	**<0.001**	**<0.001**
Species Richness	**<0.001**	0.885	0.160	**<0.001**	**<0.001**	0.735
Simpson D	**0.028**	0.818	0.529	**0.006**	**0.001**	0.267
S-W H’	**<0.001**	0.470	0.339	**0.004**	**0.001**	0.328

Table 3. ANOVA results of Day/Night x Habitat of shrimp trawl and fyke net catches. Values listed are p–values, bold values indicate significance at the α=0.10 level.

Day/Night x Habitat	Trawl			Fyke		
	Day/Night	Habitat	DN x Hab	Day/Night	Habitat	DN x Hab
CPUE	**0.068**	0.913	0.898	**0.041**	0.197	0.197
Species Richness	0.756	0.437	0.189	0.241	0.527	0.779
Simpson D	**0.093**	0.427	0.950	0.192	0.224	0.350
S-W H’	**0.030**	0.779	0.421	**0.045**	0.406	0.270

Fish Community Analyses

Species Richness - Shrimp Trawl

Species richness pooled by month ranged from 5 species in November 2003, to 25 species in February 2004 (Figure 10). Species richness in day shrimp trawl samples varied significantly (p<0.001) by month but did not vary significantly (p=0.885) by habitat (Table 2). Species richness did not vary significantly (p=0.756) between day and night shrimp trawl samples and habitat was not a significant (p=0.437) contribution to the day-night variation in shrimp trawl richness (Table 3).

Species Richness – Fyke Net

Species richness pooled by month ranged from 0 (zero) species in March and May in mudflat habitats to 13 species in August night samples in both eelgrass and oyster culture habitats (Figure 11). Within all habitat types, species richness generally increased throughout the sampling season. Species richness was greatest in oyster culture habitats in March, April and May while it was similar for all habitats in the August-day samples. Species richness within eelgrass and oyster culture habitats was greater than in mud flat habitats for the August-night samples, and species diversity of the August samples was greater for night samples compared to day samples except for mud flat habitats.

Species richness in day fyke net samples varied significantly (p<0.001) by month and by habitat (p<0.001) (Table 2). Species richness in oyster culture sites was significantly greater than in eelgrass habitats (p=0.025) and mudflat habitats (p<0.001) and species richness in eelgrass habitats was significantly greater than mudflat habitats (p=0.032). Species richness did not vary significantly (p=0.241) between day and night fyke net samples and habitat was an insignificant (p=0.527) contribution to the day night variation in species richness of fyke net catches (Table 3).

Diversity Indices – Shrimp Trawl

Diversity indices for day shrimp trawl samples varied significantly by month (Simpson's D p=0.028) and Shannon-Weiner's H' p<0.001), but neither varied significantly (p=0.818, p=0.470, respectively) between habitat types (Table 2, Figure 10). Diversity indices varied significantly between day and night shrimp trawl samples (Simpson's D p=0.093 and Shannon-Weiner's H' p=0.030), but neither varied significantly (p=0.427, p=0.779, respectively) between habitat types (Table 3).

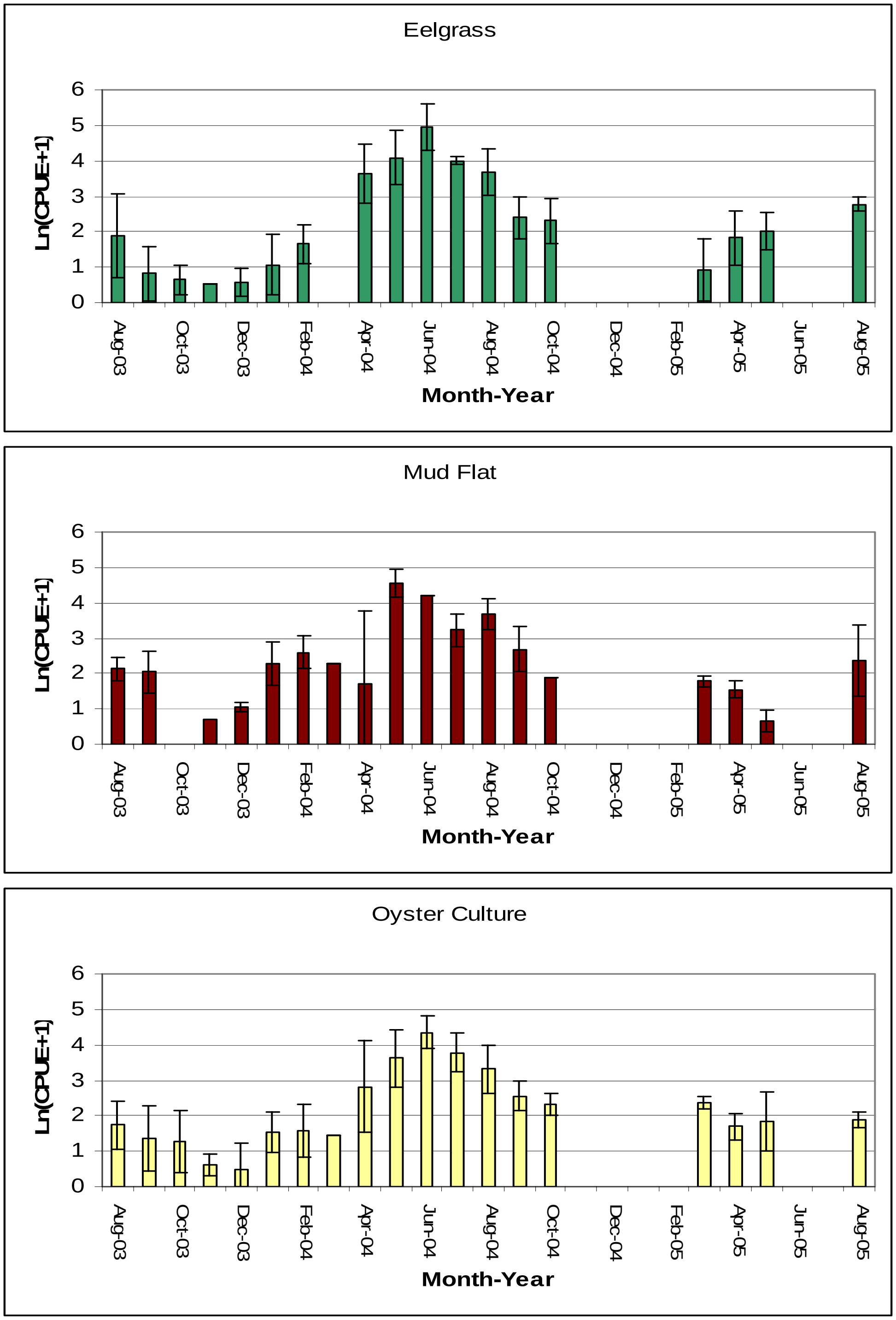


Figure 8. Monthly mean natural log of catch per unit effort (CPUE+1) of shrimp trawl samples in eelgrass, mudflat, and oyster culture habitat types in North Humboldt Bay, California. Error bars are +/- 1 standard deviation. No sampling was conducted November 2004 through February 2005, and June 2005 through July 2005.

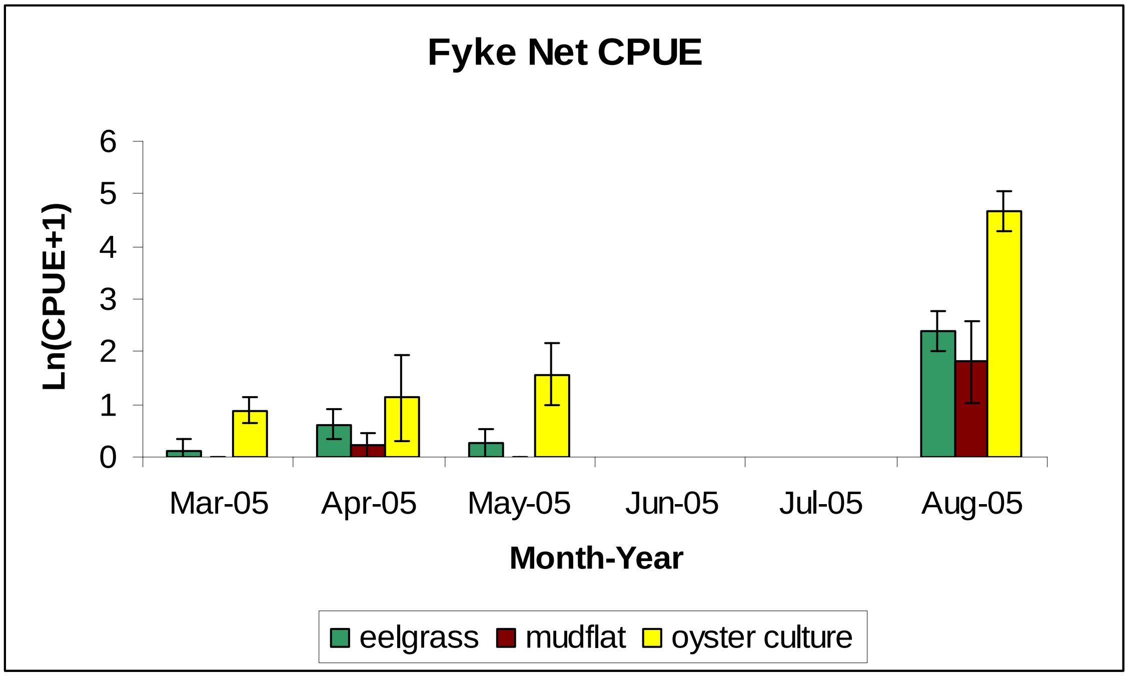


Figure 9. Monthly mean natural log of catch per unit effort (CPUE+1) of fyke net samples collected in three different habitat types (Oyster Culture, Eelgrass, and Mudflat) in North Humboldt Bay, March 2005 to August 2005.

Diversity Indices – Fyke Net

Both the Simpson and Shannon-Weiner diversity indices showed similar trends through time and among habitats (Figure 11). Fish diversity in eelgrass habitats increased from March to April, decreased in May, peaked in August while fish diversity in mud flat and oyster culture habitats remained fairly constant. Among habitat types, mud flat habitats had the lowest fish diversity with eelgrass habitat generally having similar or greater fish diversity than oyster culture habitats except for the March and May indices for the Shannon-Weiner index. Between the day and night sampling in August, fish diversity in eelgrass habitats was greatest during the day, greater at night in the mudflat habitats, and similar between day and night in the oyster culture habitats.

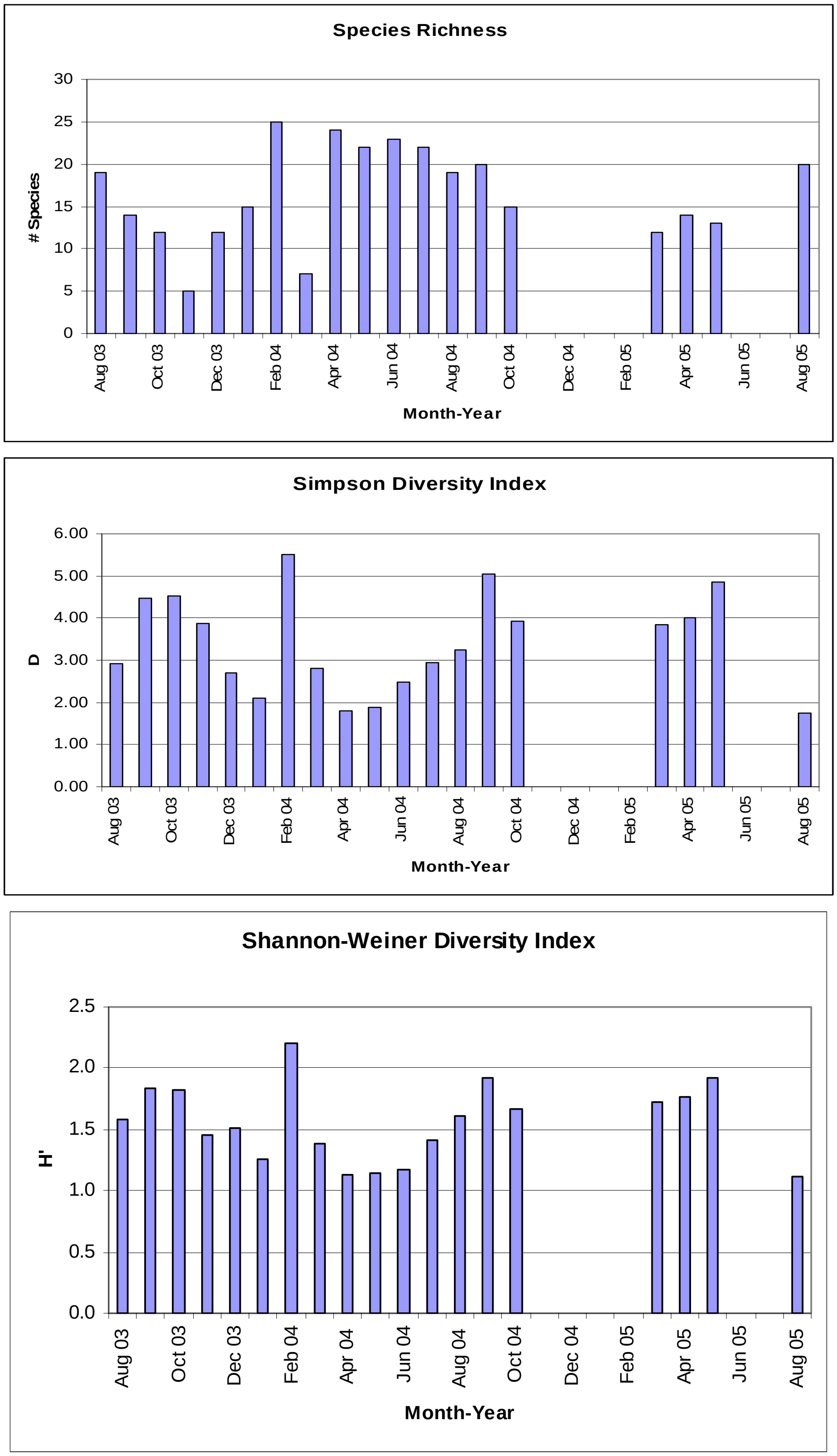


Figure 10. Monthly species richness, Simpson Diversity Index (D), and Shannon-Weiner Diversity Index (H') for fish species captured by shrimp trawling during 2003 to 2005 sampling in North Humboldt Bay, CA. No sampling was conducted November 2004 through February 2005, and June 2005 through July 2005.

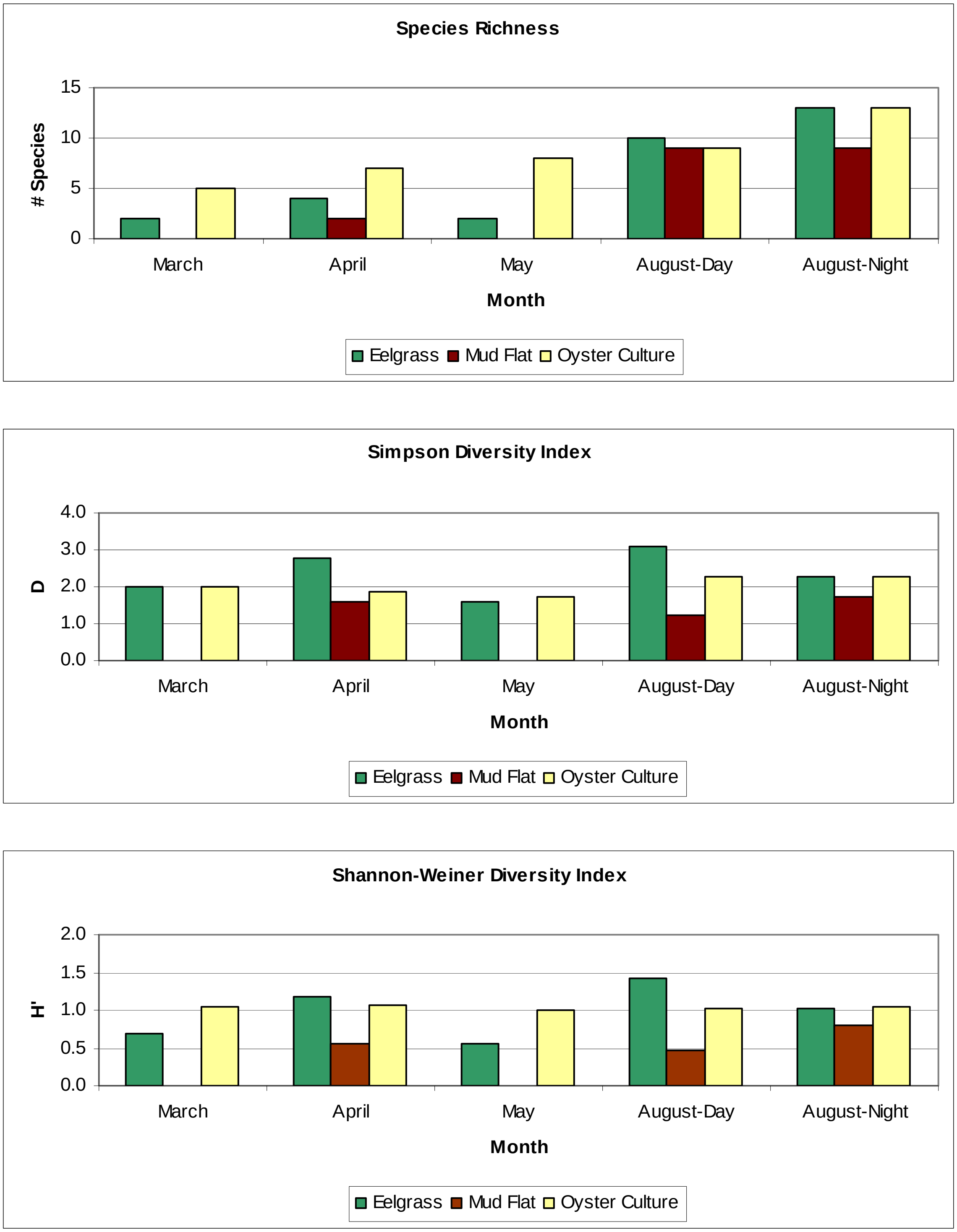


Figure 11. Monthly species richness, Simpson Diversity Index (D), and Shannon-Weiner Diversity Index (H’) by habitat type for fish species captured in fyke nets during 2005 sampling in North Humboldt Bay, CA. Data for March, April, and May are day samples.

Both diversity indices, Simpson's D and Shannon-Weiner's H', varied significantly by month (p=0.006, p=0.004, respectively) as well as by habitat (p=0.001, p=0.001, respectively; Table 2). Simpson's D did not differ significantly between oyster culture and eelgrass habitats (p=0.235) but was significantly greater in both oyster culture (p<0.001) and eelgrass (p=0.005) compared to mudflat habitats. Shannon-Weiner H' indices did not differ significantly between oyster culture and eelgrass habitats (p=0.119), which were both greater than indices calculated for mudflat habitats (p<0.001, p=0.014, respectively). Although Simpson's D did not significantly (p=0.192) vary between day and night samples, Shannon-Weiner's H' varied significantly (p=0.045) between day and night fyke net samples (Table 3).

Water Quality

Over the course of study, mean monthly salinity measurements collected during fish sampling at all sample sites ranged from 20.04 parts per thousand (ppt) in February 2004 to 36.98 ppt in April 2004 (Figure 12). Mean monthly water temperature collected during fish sampling ranged from a low of 10^{o}C in February 2004 to 21^{o}C in July 2004 (Figure 13). Turbidity ranged from a low of 1.34 ntu in November of 2003 to 24.3 ntu in May of 2004 (Appendix B). Measurements of pH ranged from a low of 7.42 in October of 2004 to 8.54 in November of 2003 (Appendix B). Specific conductance ranged from a low of 32.70 µS in February of 2004 to 58.49 in September of 2004 (Appendix B). Dissolved oxygen ranged from a low of 5.25 mg/l in July of 2004 to 10.95 mg/l in February of 2004 (Appendix B)..

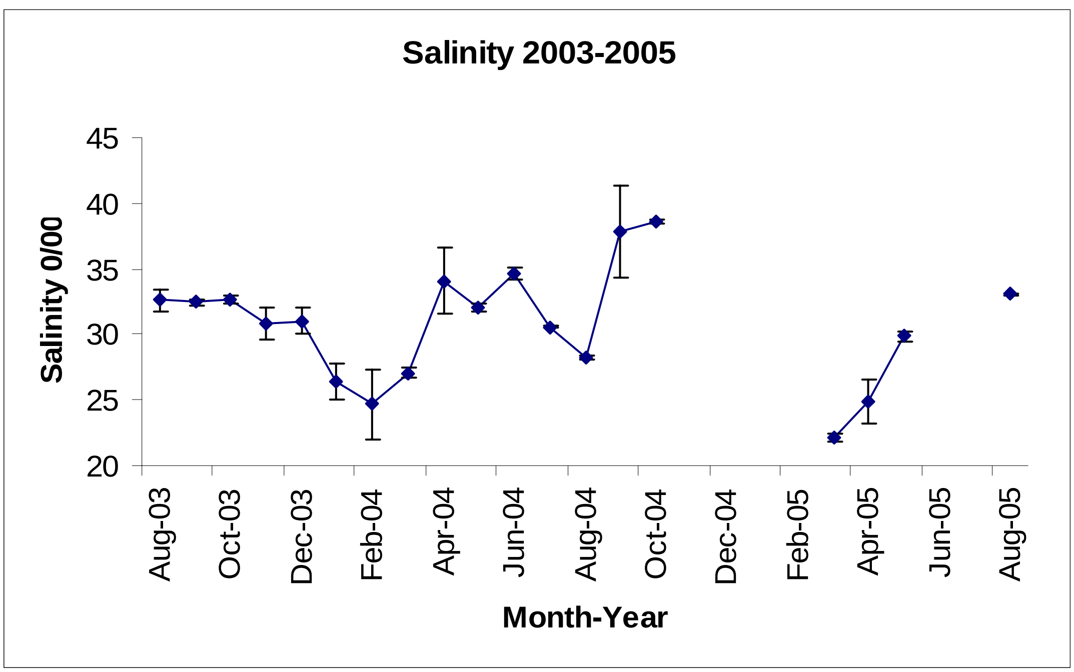


Figure 12. Monthly mean salinity measured at sampling sites in North Humboldt Bay, California, between August 2003 and August 2005. Error bars are equal to one standard deviation of the mean. No sampling was conducted November 2004 through February 2005, and June 2005 through July 2005.

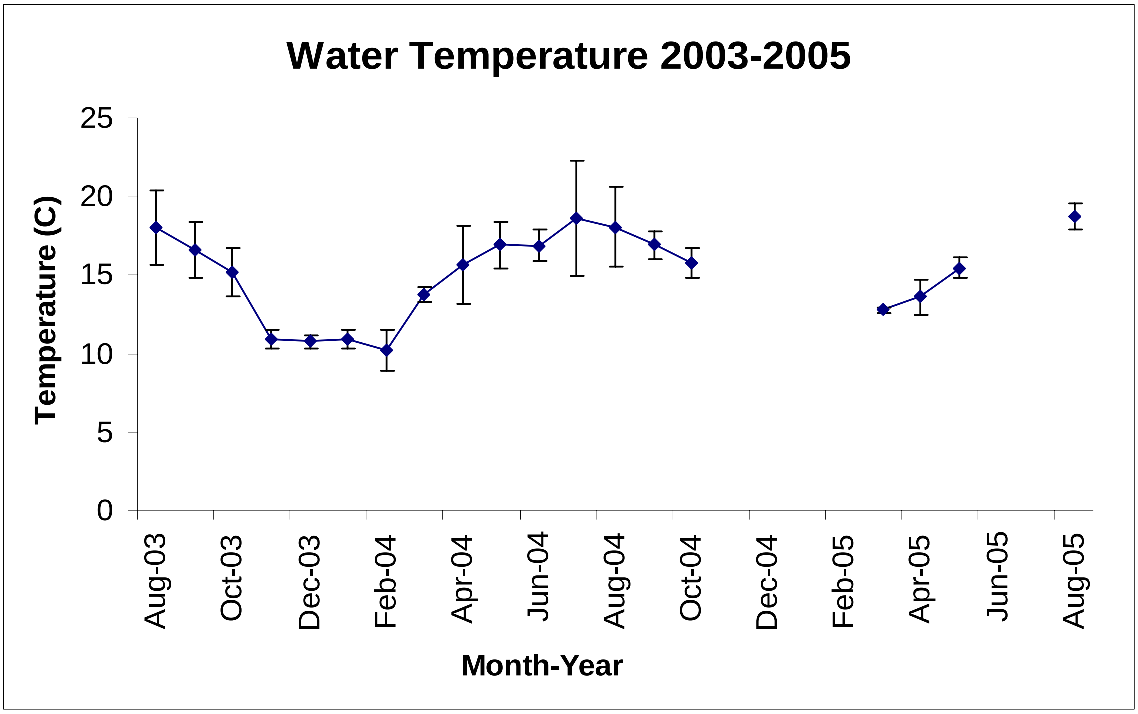


Figure 13. Monthly mean water temperature (C) measured at sampling sites in North Humboldt Bay, California, between August 2003 and August 2005. Error bars are equal to one standard deviation of the mean. No sampling was conducted November 2004 through February 2005, and June 2005 through July 2005.

Sediment

Percent fines in sediment samples ranged from about 43.8% in October 2003 at MR1 and AC2 to 91.9 % in May 2004 at SI3 (Table 4), sediment samples were not collected after July 2004. Mean percent fines for individual sites ranged from 60.4% to 83.7%.

Table 4. Percent fines in sediment samples collected from 20 study sites in North Humboldt Bay, California, from October 2003 to July 2004.

Site	Oct	Dec	Jan	Feb	Apr	May	Jun	Jul	Ave
EB1	70.0	85.0	72.9		83.8	74.8	74.8	82.9	77.4
EB2	57.5	73.8	82.5	61.7		70.4	76.3	67.5	70.7
EB3	65.0	78.8	66.3		57.5	62.5	65.3	62.0	65.4
EB4	85.0	72.5		77.5			73.1	81.3	77.1
MR1	43.8	65.0	49.2		72.1	61.3	65.6	60.8	60.4
MR2	71.3	76.3	82.1	69.2		82.0	71.5	78.8	75.3
MR3	65.0	66.3	69.2	82.9		78.8	49.0	52.9	64.1
MR4	72.5	82.5	85.8	87.1		87.5	68.3	75.0	78.4
MR5	70.0	47.1	88.3	83.3		84.2	73.3	78.8	74.8
MR6	61.3	65.0	62.9	65.4		68.3	54.6	57.1	61.2
MR7	50.0		72.1		70.4	57.1	63.1	61.3	62.4
MR8	58.8	81.3	73.3		75.8	84.2	76.9	69.2	74.5
AC1	67.5	77.5	76.3		68.8	80.0	74.0	79.2	74.6
AC2	43.8	68.8	50.8		50.8	63.8	70.0	70.4	61.0
AC3	71.3	76.3	79.2		67.9	78.8	66.9	82.1	73.7
AC4	75.0	82.5	83.8		87.5	89.0	77.7	77.5	82.2
SI1	59.3	70.0	64.6		62.1	73.7	74.3	61.7	67.9
SI2	62.5	78.8	62.9		62.1	79.2	55.8	72.1	67.6
SI3	75.0	83.8		84.4	90.0	91.9	80.0	84.2	83.7
SI4	85.0	81.3	85.6		83.3	85.0	77.7	82.9	82.3

Discussion

The goal of this study was to describe the fish community structure in eelgrass, mudflat, and oyster culture habitats in the North Bay of Humboldt Bay from August 2003 to August 2005. Specific objectives of this project were to: (1) test the effectiveness of various gear types in sampling fish in different habitats, (2) document baseline fish community composition, and (3) compare fish community structure and abundance in eelgrass, oyster culture, and mud flat habitats in North Humboldt Bay.

Sampling Gear Effectiveness

Sampling fish assemblages in North Humboldt Bay presented several challenges due to the nature of the habitats, the physical characteristics of the North Bay, and the objectives of this study. It was difficult to sample fish in the targeted habitats in the tidal flats due to the shallow and muddy nature of the majority of the North Bay, coupled with rapid tide changes and strong currents. Of all the gear types used during this study, shrimp trawl and fyke nets were most effective at sampling a wide variety of species in the tidal flats and the fyke net was the most effective at sampling somewhat discrete habitats units.

The main limitation of the shrimp trawl net was that it could not be used to sample within oyster culture habitats because of the damage that it would cause to the commercial culture operations. Given this limitation in the gear, shrimp trawl samples from oyster culture habitats were collected adjacent to rather than within the oyster culture operations. This is most likely the reason why there was not a significant habitat influence on species richness or species diversity observed in the shrimp trawl data. While the fyke nets could be set within a specific habitat (eelgrass, mud flat, and oyster culture), the habitats were not "enclosed" to ensure a discreet sample representing only that habitat type. During outgoing tide, fish from other habitats located adjacent to that being sampled by the fyke net could possibly enter that area and become captured in the gear. To obtain discreet habitat samples, a substantially greater effort would be needed to enclose habitat areas during high tide to limit what drains into the fyke net as the tide recedes.

Other sampling techniques, such as beach and purse seines, did not sample as wide a variety of species, could not effectively be used to sample the shallow flat areas of oyster culture and eelgrass habitats, and suffered from the same limitation as the shrimp trawl in not being able to sample within oyster culture habitats without damaging the culture operations. While the minnow trap could be effectively deployed within discrete habitats, catches were very low, highly selective, and did not represent the variety of fish species utilizing the sampled habitats.

Baseline Fish Community

Of the 49 fish species captured during this study, shiner surfperch, English sole, northern anchovy, speckled sanddab, and Pacific herring were captured in largest numbers. Other species captured in significant numbers included topsmelt, Pacific sardine, bay pipefish, walleye surfperch, bay goby, surf smelt and staghorn sculpin. Fish species captured during this study were similar to those captured by Cole (2004), although relative abundances of the most common species were different, likely due to differences in sampling methods and timing of sampling.

Seasonal influences, based on month sampled, were significant on all metrics that were used to describe the fish community composition (species richness, Simpson's Diversity Index, and Shannon-Weiner Diversity Index) and fish abundance (CPUE). The variation in shrimp trawl catches during this study showed a strong seasonal trend with more fishes in the North Bay during late spring and summer months compared to late fall and winter months (Figure 7). This pattern was generally observed in catches of individual species (Figures 3-6) with the exception of the catches of the speckled sanddab (Figure 3), bay goby (Figure 3), and staghorn sculpin (Figure 4), which also had relatively large catches during the winter months. Although fyke data were collected over a shorter period of time (March 2005 to August 2005), they also showed a strong seasonal trend in catch with the peak occurring in August.

Species richness was generally highest during the spring and summer and lowest in the winter (Figure 10). While fyke data did not encompass all seasons, the trend in species richness was similar to that observed in the shrimp trawl data with increasing species richness from March to August (Figure 11). Both diversity indices were variable throughout the seasons, with diversity generally greater in the spring or summer. An anomaly to this general trend was with the February 2004 shrimp trawl catch, which had the greatest monthly diversity indices and the greatest species richness.

While juvenile salmonids are known to inhabit Humboldt Bay (Emmett et al. 1991, Barnhart et al. 1992), none were captured during this study. A possible explanation for this could be the frequency and intensity of sampling, coupled with the low numbers of juvenile salmonids using the North Bay due to low spawning populations in North Bay tributaries. These factors in combination made it unlikely to capture juvenile salmonids. Sampling conducted by California Department of Fish and Game (CDFG unpublished data, Arcata, California) in lower Freshwater Slough during 2004 and 2005 support this assumption in that only 113 and 226 salmonids were captured, respectively, for the period of April through mid-August. Since other highly mobile, pelagic species such as northern anchovy, Pacific herring, and Pacific sardine were captured in the sampling gears used, it is unlikely that salmonids were not captured due to gear avoidance or bias.

Fish Community Structure and Abundance

A dominant feature in the North Bay was the scale at which habitat change occurs due to its bathymetry and the diurnal tidal cycle (two high tides and two low tides per 24 hour period) that exchange an enormous amount of water every tidal cycle. While a high tide will inundate the entire bay, during a lower-low tide water is confined to the major channels pictured in Figure 2. Any fish that occupy habitats in the tidal flats will be forced either into the major channels or into small pockets and depressions that contain enough water and cover (to avoid predation) to sustain them until the water rises with the incoming high tide. This scale of variability due to the tidal cycle can greatly affect fish assemblage distribution directly by limiting habitat suitability on a daily basis. For instance, assessing the fish assemblages in an eelgrass bed that is adjacent to an oyster culture bed will be affected by the amount of mixing of fishes that occurs during low tide in the channel that the two habitats share.

The various habitats that exist do so because of the amount of time that each habitat is inundated; mudflats occur in the shallowest areas of the bay that are dewatered the greatest amount of time during the tidal cycle. Thus, one would expect lower fish numbers in these habitats. Additionally, fishes are attracted to structure and oyster culture and eelgrass habitats in North Humboldt Bay provide structure. The highest catches and diversity of species captured during the course of the study generally occurred in or adjacent to oyster culture and eelgrass habitats in North Humboldt Bay.

While shrimp trawl data indicated that the fish community metrics investigated for this study (species richness, Simpson's diversity index, and Shannon-Weiner diversity index) were not significantly influenced by habitat, data collected with the fyke nets indicate significant differences in fish abundance and species diversity between the three habitat types sampled. The lack of a habitat influence in the shrimp trawl data may be due to the inability to use the shrimp trawl within oyster culture beds. The habitats that were sampled adjacent to the oyster culture sites were more characteristic of mudflat habitats, but with the structure provided by the adjacent oyster culture operation.

Although the fyke data set is limited in duration, there was a significant habitat influence on fish community structure, as indicated by species richness and the two diversity indices. Species richness was greatest in oyster culture habitats, followed by eelgrass habitats, and least in mud flat habitats. These significant differences in species richness between habitat types, especially the difference between oyster culture and eelgrass habitats, are due to the differences that occurred during the spring months because species diversity during the August sample was virtually the same (Figure 11). For both the Simpson and the Shannon-Weiner diversity indices, which take into account the relative abundance of species captured, there was no significant difference in diversity between the oyster culture and eelgrass habitats, while diversity in mudflat habitats was significantly less than both oyster culture and eelgrass habitats (Figure 11).

Both shrimp trawl and fyke catch data indicate that fish abundance as indexed by CPUE, was significantly greater in oyster culture habitats compared to eelgrass and mudflat habitats. There was no difference in abundance between eelgrass and mudflat habitats. This suggests that oyster culture operations may attract a larger number of fish compared to eelgrass and mudflat habitats. It is well established that fish are attracted to structure and the greater abundance in the culture areas may be due to the increased structure in the water column that the culture provides. A similar influence of structure would also be expected in the eelgrass habitats, but was not reflected in the data collected. Additionally, since the shrimp trawl could not be deployed within oyster culture habitats, it may be that fish were more abundant in the transition or edge habitats that exist adjacent to the oyster culture habitats. A possible influence on fish abundance in the fyke data is that most oyster culture areas in Humboldt Bay are at a slightly higher elevation in North Humboldt Bay compared to nearby eelgrass beds, and the higher catches in the culture areas might be explained by the greater proportion of the culture areas being drained on each tidal cycle compared to eelgrass beds.

While day-night sampling was limited to three consecutive days, there were significant differences observed between day and night catch data (for shrimp trawl and fyke data), Shannon-Wiener diversity (for shrimp trawl and fyke data), and Simpson diversity (for shrimp trawl data only), but not in species richness. Neither sampling method showed a significant habitat effect during day-night samples. A lack of significant habitat effect may be due to structure playing a less important role at night for predator avoidance since most fish are visual predators and the need for structure for predator avoidance is reduced during the night. Night catches were greater than day catches for both shrimp trawl and fyke gear types, most likely due to reduced avoidance of the sampling gear by fishes during the night. The lack of a difference in species richness may be due to the limited day-night sampling occurring over a three day period, during which it would be expected that the number of fish species captured would be fairly constant. While the diversity indices indicated some differences between day and night sampling, this is mostly due to the differences in relative catch of the different species, since species richness was similar for both day and nigh sampling.

Summary

The physical characteristics of North Humboldt Bay pose unique challenges in sampling discreet habitats, especially within oyster culture beds. While sampling discrete habitats was not possible during this study, sampling with shrimp trawl and fyke nets provided valuable information on fish community structure and timing of species presence, while providing some information useful in examining potential differences in fish community structure and abundance associated with the three habitats investigated (eelgrass, oyster culture, and mud flat). A total of 49 different species were captured during this study, with 12 species commonly found in Humboldt Bay dominating the catches. No salmonids were captured, but this may be due to the low probability of encountering a juvenile salmonid given the limited sampling effort and the current low abundance of Humboldt Bay salmonid populations. There were strong seasonal and habitat associated differences observed in fish abundance, with greater numbers of fish associated with eelgrass and oyster culture habitats. Comparisons of fish community structure metrics did not suggest a habitat influence in the shrimp trawl data, but fyke data suggested a strong habitat influence. The lack of a habitat influence in fish community structure in the shrimp trawl data may have been due to the inability to sample directly in the oyster culture habitats, while the fyke data provided a more representative sample of fishes using the specific sampled habitats.

Recommendations

Based on the study of North Humboldt Bay fish communities we recommend the following studies to enhance the information currently collected in this study.

Salmonid Life History and Habitat Use

Chinook and coho salmon and steelhead in the Humboldt Bay drainage are listed as Threatened under the Endangered Species Act of 1973. Juvenile life stages of these species are thought to depend on Humboldt Bay estuary to complete the critical transition between residence in their natal freshwater tributary streams and the Pacific Ocean, but no salmonids were captured in the two years of sampling in this current study. Past sampling efforts in Humboldt Bay have been relatively unsuccessful at capturing juvenile salmonids as well, making it difficult to determine estuarine residence time and habitat preferences within the estuary. A focused effort on tracking individual fish using a combination of juvenile out-migration traps and sonic radio tracking technologies could help answer key questions about use and relative importance of specific habitats present in Humboldt Bay to listed salmonids species. Current juvenile salmonid sampling efforts by the California Department of Fish and Game in Freshwater slough, a tributary to North Humboldt Bay, provide an excellent opportunity for inter-agency cooperation and cost sharing.

South Bay, Central Bay, and North Bay Species Diversity Comparisons

Sampling efforts in this study focused on comparisons of fish diversity between sites with and without eelgrass and oyster culture. A major concern with regard to this study design is that North Humboldt Bay has limited sites that have not been altered by past and present oyster culture (dredging, long lines, etc.), or that were recently abandoned that are repopulating with native eelgrass. There is a need to incorporate natural slough and eelgrass habitats into the study, like those in South Humboldt Bay, as well as eelgrass beds on the periphery of Central Humboldt Bay, to make comparisons of species diversity in disturbed and undisturbed portions of Humboldt Bay.

Acknowledgements

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Appendices

Appendix A. Date, location, gear type and tide conditions during fish community sampling in North Humboldt Bay, California, between August 2003 and August 2005.

Date	Start Time	Sets	Site	Method	Tide	Longitude	Latitude	Flats_Channel
8/6/2003	12:12	3	EB1	Trawl	Flood	-124.148	40.8193	In Main Channel
8/6/2003	13:28	3	EB2	Trawl	Slack	-124.142	40.82028	In Main Channel
8/14/2003	11:19	1	EB3	Trawl	Flood	-124.133	40.82523	In Main Channel
8/21/2003	12:50	3	EB3	Trawl	Slack	-124.133	40.82523	In Main Channel
8/21/2003	9:15	3	AC1	Trawl	Slack	-124.139	40.8299	In Main Channel
8/21/2003	11:37	3	AC2	Trawl	Ebb	-124.137	40.82848	In Main Channel
8/21/2003	10:30	3	AC3	Trawl	Ebb	-124.122	40.83685	In Main Channel
8/22/2003	10:31	3	EB4	Trawl	Slack	-124.117	40.8292	In Main Channel
8/22/2003	12:21	3	AC4	Trawl	Ebb	-124.118	40.83704	In Main Channel
8/27/2003	9:38	3	MR2	Trawl	Flood	-124.153	40.83577	In Main Channel
8/27/2003	11:19	3	MR3	Trawl	Flood	-124.148	40.84093	In Main Channel
8/27/2003	12:39	3	MR4	Trawl	Flood	-124.145	40.84849	In Main Channel
8/27/2003	13:19	3	MR5	Trawl	Slack	-124.142	40.84441	In Main Channel
8/27/2003	12:10	3	MR6	Trawl	Ebb	-124.147	40.84261	In Main Channel
8/28/2003	15:20	3	SI1	Trawl	Ebb	-124.143	40.83069	In Main Channel
8/28/2003	12:35	3	SI2	Trawl	Flood	-124.142	40.83162	In Main Channel
8/28/2003	14:33	3	SI3	Trawl	Slack	-124.138	40.83745	In Main Channel
8/28/2003	13:33	3	SI4	Trawl	Flood	-124.135	40.83794	In Main Channel
8/28/2003	11:09	3	MR7	Trawl	Flood	-124.156	40.83603	In Main Channel
8/29/2003	9:13	3	MR1	Trawl	Flood	-124.158	40.83216	In Main Channel

Date	Start Time	Sets	Site	Method	Tide	Longitude	Latitude	Flats_Channel
8/29/2003	8:39	3	MR8	Trawl	Slack	-124.16	40.83302	In Main Channel
9/22/2003	13:05	3	AC3	Trawl	Ebb	-124.122	40.83685	In Main Channel
9/22/2003	12:10	3	AC4	Trawl	Ebb	-124.118	40.83704	In Main Channel
9/22/2003	14:17	3	EB4	Trawl	Ebb	-124.117	40.8292	In Main Channel
9/23/2003	13:30	3	MR4	Trawl	Ebb	-124.145	40.84849	In Main Channel
9/23/2003	12:45	3	MR5	Trawl	Ebb	-124.142	40.84441	In Main Channel
9/23/2003	11:55	3	SI3	Trawl	Slack	-124.138	40.83745	In Main Channel
9/23/2003	11:07	3	SI4	Trawl	Flood	-124.135	40.83794	In Main Channel
9/24/2003	8:56	3	EB1	Trawl	Flood	-124.148	40.8193	In Main Channel
9/24/2003	9:46	3	EB2	Trawl	Flood	-124.142	40.82028	In Main Channel
9/24/2003	10:35	3	AC1	Trawl	Flood	-124.139	40.8299	In Main Channel
9/24/2003	11:38	3	AC2	Trawl	Slack	-124.137	40.82848	In Main Channel
9/24/2003	13:20	3	SI1	Trawl	Slack	-124.143	40.83069	In Main Channel
9/24/2003	12:25	3	SI2	Trawl	Slack	-124.142	40.83162	In Main Channel
9/29/2003	10:13	3	MR6	Trawl	Flood	-124.147	40.84261	In Main Channel
9/29/2003	11:09	3	MR7	Trawl	Flood	-124.156	40.83603	In Main Channel
9/29/2003	11:50	3	MR8	Trawl	Flood	-124.16	40.83302	In Main Channel
9/30/2003	12:01	3	MR1	Trawl	Ebb	-124.158	40.83216	In Main Channel
9/30/2003	13:11	3	MR2	Trawl	Flood	-124.153	40.83577	In Main Channel
10/1/2003	12:46	3	EB3	Trawl	Flood	-124.133	40.82523	In Main Channel
10/20/2003	13:34	3	EB4	Trawl	Ebb	-124.117	40.8292	In Main Channel
10/21/2003	12:12	3	AC1	Trawl	Ebb	-124.139	40.8299	In Main Channel
10/21/2003	14:17	3	AC2	Trawl	Ebb	-124.137	40.82848	In Main Channel

Date	Start Time	Sets	Site	Method	Tide	Longitude	Latitude	Flats_Channel
10/21/2003	14:29	2	AC3	Trawl	Ebb	-124.122	40.83685	In Main Channel
10/21/2003	11:03	3	AC4	Trawl	Slack	-124.118	40.83704	In Main Channel
10/22/2003	12:22	3	SI1	Trawl	Ebb	-124.143	40.83069	In Main Channel
10/22/2003	13:10	3	SI2	Trawl	Ebb	-124.142	40.83162	In Main Channel
10/22/2003	10:13	3	SI3	Trawl	Flood	-124.138	40.83745	In Main Channel
10/22/2003	11:11	3	SI4	Trawl	Slack	-124.135	40.83794	In Main Channel
10/27/2003	13:30	3	MR2	Trawl	Slack	-124.153	40.83577	In Main Channel
10/27/2003	11:20	3	MR3	Trawl	Flood	-124.148	40.84093	In Main Channel
10/27/2003	10:29	3	MR4	Trawl	Flood	-124.145	40.84849	In Main Channel
10/27/2003	9:41	3	MR5	Trawl	Flood	-124.142	40.84441	In Main Channel
10/27/2003	12:03	3	MR6	Trawl	Flood	-124.147	40.84261	In Main Channel
11/3/2003	13:25	3	EB2	Trawl	Ebb	-124.142	40.82028	In Main Channel
11/3/2003	12:44	3	EB3	Trawl	Ebb	-124.133	40.82523	In Main Channel
11/4/2003	11:52	2	MR8	Trawl	Ebb	-124.16	40.83302	In Main Channel
11/22/2003	11:17	3	EB3	Trawl	Ebb	-124.133	40.82523	In Main Channel
11/22/2003	10:13	3	EB4	Trawl	Slack	-124.117	40.8292	In Main Channel
11/25/2003	11:19	3	AC1	Trawl	Flood	-124.139	40.8299	In Main Channel
11/25/2003	10:27	3	AC2	Trawl	Flood	-124.137	40.82848	In Main Channel
12/1/2003	13:41	3	MR2	Trawl	Slack	-124.153	40.83577	In Main Channel
12/1/2003	12:51	3	MR3	Trawl	Slack	-124.148	40.84093	In Main Channel
12/1/2003	11:22	3	MR4	Trawl	Ebb	-124.145	40.84849	In Main Channel
12/1/2003	10:29	3	MR5	Trawl	Ebb	-124.142	40.84441	In Main Channel
12/1/2003	12:09	3	MR6	Trawl	Ebb	-124.147	40.84261	In Main Channel

Date	Start Time	Sets	Site	Method	Tide	Longitude	Latitude	Flats_Channel
12/1/2003	14:23	3	MR7	Trawl	Flood	-124.156	40.83603	In Main Channel
12/2/2003	12:37	2	MR7	Trawl	Ebb	-124.156	40.83603	In Main Channel
12/3/2003	12:30	3	SI1	Trawl	Ebb	-124.143	40.83069	In Main Channel
12/3/2003	13:13	3	SI2	Trawl	Ebb	-124.142	40.83162	In Main Channel
12/3/2003	11:38	3	MR1	Trawl	Ebb	-124.158	40.83216	In Main Channel
12/3/2003	10:32	3	MR8	Trawl	Ebb	-124.16	40.83302	In Main Channel
12/8/2003	14:15	3	SI4	Trawl	Ebb	-124.135	40.83794	In Main Channel
12/8/2003	13:36	3	SI3	Trawl	Ebb	-124.138	40.83745	In Main Channel
12/8/2003	12:51	3	AC3	Beam Trawl	Slack	-124.122	40.83685	In Main Channel
12/8/2003	10:53	3	AC4	Trawl	Slack	-124.118	40.83704	In Main Channel
12/10/2003	12:25	3	EB2	Trawl	Slack	-124.142	40.82028	In Main Channel
12/10/2003	11:26	3	EB1	Trawl	Slack	-124.148	40.8193	In Main Channel
1/13/2004	12:26	3	EB2	Trawl	Flood	-124.142	40.82028	In Main Channel
1/13/2004	10:47	3	EB1	Trawl	Flood	-124.148	40.8193	In Main Channel
1/15/2004	12:22	3	MR6	Trawl	Slack	-124.147	40.84261	In Main Channel
1/15/2004	9:59	3	MR5	Trawl	Ebb	-124.142	40.84441	In Main Channel
1/15/2004	10:59	3	MR4	Trawl	Ebb	-124.145	40.84849	In Main Channel
1/15/2004	13:18	3	MR3	Trawl	Flood	-124.148	40.84093	In Main Channel
1/16/2004	11:59	3	MR8	Trawl	Ebb	-124.16	40.83302	In Main Channel
1/16/2004	10:11	3	MR7	Trawl	Ebb	-124.156	40.83603	In Main Channel
1/16/2004	10:59	3	MR2	Trawl	Ebb	-124.153	40.83577	In Main Channel
1/16/2004	12:55	3	MR1	Trawl	Slack	-124.158	40.83216	In Main Channel
1/23/2004	12:22	3	SI2	Trawl	Slack	-124.142	40.83162	In Main Channel

Date	Start Time	Sets	Site	Method	Tide	Longitude	Latitude	Flats_Channel
1/23/2004	11:29	3	SI3	Trawl	Flood	-124.138	40.83745	In Main Channel
1/23/2004	10:29	3	SI4	Trawl	Flood	-124.135	40.83794	In Main Channel
1/28/2004	12:39	3	EB3	Trawl	Flood	-124.133	40.82523	In Main Channel
1/28/2004	11:39	3	EB4	Trawl	Slack	-124.117	40.8292	In Main Channel
1/28/2004	9:49	3	AC4	Trawl	Ebb	-124.118	40.83704	In Main Channel
1/28/2004	10:41	3	AC3	Trawl	Slack	-124.122	40.83685	In Main Channel
1/29/2004	9:45	3	AC1	Trawl	Ebb	-124.139	40.8299	In Main Channel
1/29/2004	12:00	3	SI1	Trawl	Slack	-124.143	40.83069	In Main Channel
1/29/2004	10:43	3	AC2	Trawl	Slack	-124.137	40.82848	In Main Channel
2/3/2004	14:58	3		Beach Seine	Ebb	-124.153	40.81482	Over Flats
2/3/2004	13:50	3		Trawl	Ebb	-124.154	40.81455	In Main Channel
2/4/2004	11:36	3	AC3	Trawl	Ebb	-124.122	40.83685	In Main Channel
2/4/2004	10:27	3	AC4	Trawl	Slack	-124.118	40.83704	In Main Channel
2/5/2004	12:30	3	SI1	Trawl	Ebb	-124.143	40.83069	In Main Channel
2/5/2004	13:30	3	SI2	Trawl	Ebb	-124.142	40.83162	In Main Channel
2/5/2004	11:39	3	SI3	Trawl	Ebb	-124.138	40.83745	In Main Channel
2/5/2004	10:33	3	SI4	Trawl	Slack	-124.135	40.83794	In Main Channel
2/10/2004	12:17	3	MR4	Trawl	Flood	-124.145	40.84849	In Main Channel
2/10/2004	11:19	3	MR5	Trawl	Flood	-124.142	40.84441	In Main Channel
2/19/2004	9:51	3	MR1	Trawl	Flood	-124.158	40.83216	In Main Channel
2/19/2004	12:25	3	MR7	Trawl	Ebb	-124.156	40.83603	In Main Channel
2/19/2004	11:22	3	MR8	Trawl	Slack	-124.16	40.83302	In Main Channel
2/24/2004	12:04	1	EB4	Trawl	Flood	-124.117	40.8292	In Main Channel

Date	Start Time	Sets	Site	Method	Tide	Longitude	Latitude	Flats_Channel
2/27/2004	13:47	3	AC1	Trawl	Flood	-124.139	40.8299	In Main Channel
2/27/2004	9:46	3	EB1	Trawl	Ebb	-124.148	40.8193	In Main Channel
2/27/2004	10:42	3	EB2	Trawl	Slack	-124.142	40.82028	In Main Channel
2/27/2004	12:30	3	EB3	Trawl	Slack	-124.133	40.82523	In Main Channel
2/27/2004	11:38	3	EB4	Trawl	Slack	-124.117	40.8292	In Main Channel
2/28/2004	13:49	3	AC2	Trawl	Slack	-124.137	40.82848	In Main Channel
2/28/2004	12:39	3	MR2	Trawl	Slack	-124.153	40.83577	In Main Channel
2/28/2004	11:52	3	MR3	Trawl	Ebb	-124.148	40.84093	In Main Channel
2/28/2004	10:20	3	MR6	Trawl	Ebb	-124.147	40.84261	In Main Channel
3/10/2004	10:23	3	EB1	Trawl	Flood	-124.148	40.8193	In Main Channel
3/10/2004	10:23	3	EB1	Trawl	Flood	-124.148	40.8193	In Main Channel
3/12/2004	11:14	3	EB3	Trawl	Flood	-124.133	40.82523	In Main Channel
3/12/2004	11:14	3	EB3	Trawl	Flood	-124.133	40.82523	In Main Channel
4/15/2004	10:04	3	EB1	Trawl	Flood	-124.148	40.8193	Over Flats
4/15/2004	10:53	3	EB2	Trawl	Slack	-124.142	40.82028	In Main Channel
4/16/2004	9:25	3	MR2	Trawl	Flood	-124.153	40.83577	Over Flats
4/16/2004	15:08	3	MR2	Trawl	Ebb	-124.153	40.83577	In Main Channel
4/16/2004	10:24	3	MR8	Trawl	Flood	-124.16	40.83302	Over Flats
4/16/2004	14:09	3	MR8	Trawl	Ebb	-124.16	40.83302	In Main Channel
4/16/2004	11:23	6	MR	Minnow Trap	Flood	-124.14	40.84597	Over Culture
4/27/2004	10:37	3	EB4	Trawl	Ebb	-124.117	40.8292	In Main Channel
4/27/2004	10:16	6	EB	Minnow Trap	Ebb	-124.132	40.81854	Over Culture
4/30/2004	13:10	3	AC4	Trawl	Ebb	-124.118	40.83704	In Main Channel
4/30/2004	15:09	3	EB2	Trawl	Slack	-124.142	40.82028	In Main Channel

Date	Start Time	Sets	Site	Method	Tide	Longitude	Latitude	Flats_Channel
4/30/2004	16:14	3	AC1	Trawl	Flood	-124.139	40.8299	In Main Channel
4/30/2004	12:17	3	SI1	Trawl	Ebb	-124.143	40.83069	In Main Channel
4/30/2004	11:15	3	SI3	Trawl	Ebb	-124.138	40.83745	In Main Channel
5/5/2004	10:18	3	EB4	Trawl	Flood	-124.117	40.8292	In Main Channel
5/5/2004	8:44	3	EB2	Trawl	Flood	-124.142	40.82028	In Main Channel
5/12/2004	11:44	3	SI2	Trawl	Slack	-124.142	40.83162	In Main Channel
5/12/2004	8:43	3	AC4	Trawl	Slack	-124.118	40.83704	In Main Channel
5/12/2004	10:05	3	SI4	Trawl	Ebb	-124.135	40.83794	In Main Channel
5/13/2004	10:26	2	MR8	Trawl	Ebb	-124.16	40.83302	In Main Channel
5/13/2004	9:23	3	MR5	Trawl	Ebb	-124.142	40.84441	In Main Channel
5/19/2004	10:23	3	MR8	Trawl	Flood	-124.16	40.83302	In Main Channel
5/19/2004	9:25	3	AC2	Trawl	Flood	-124.137	40.82848	In Main Channel
5/25/2004	12:40	3	EB	Purse Seine	Flood	-124.143	40.81867	In Main Channel
5/26/2004	10:30	3	MR	Purse Seine	Ebb	-124.154	40.83491	In Main Channel
5/27/2004	8:00	3	SI	Purse Seine	Ebb	-124.14	40.83312	In Main Channel
5/27/2004	11:25	3	Eureka	Purse Seine	Ebb	-124.145	40.80893	In Main Channel
5/27/2004	10:15	3	AC	Purse Seine	Ebb	-124.124	40.8328	In Main Channel
5/28/2004	10:19	12	AC	Cast Net	Ebb	-124.14	40.82688	In Main Channel
6/2/2004	12:27	3	AC2	Trawl	Slack	-124.137	40.82848	In Main Channel
6/2/2004	10:43	3	MR2	Trawl	Flood	-124.153	40.83577	In Main Channel
6/2/2004	9:28	3	MR5	Trawl	Flood	-124.142	40.84441	In Main Channel
6/8/2004	8:43	3	EB1	Trawl	Ebb	-124.148	40.8193	In Main Channel
6/8/2004	10:45	1	EB4	Trawl	Slack	-124.117	40.8292	In Main Channel

Date	Start Time	Sets	Site	Method	Tide	Longitude	Latitude	Flats_Channel
6/9/2004	10:35	3	SI2	Trawl	Ebb	-124.142	40.83162	In Main Channel
6/10/2004	10:03	3	AC4	Trawl	Ebb	-124.118	40.83704	In Main Channel
6/10/2004	8:47	3	SI4	Trawl	Ebb	-124.135	40.83794	In Main Channel
6/15/2004	8:24	3	EB4	Trawl	Flood	-124.117	40.8292	In Main Channel
7/12/2004	12:10	3	MR8	Trawl	Flood	-124.16	40.83302	In Main Channel
7/12/2004	10:48	3	MR5	Trawl	Flood	-124.142	40.84441	In Main Channel
7/13/2004	10:29	3	SI2	Trawl	Flood	-124.142	40.83162	In Main Channel
7/13/2004	12:09	3	AC4	Trawl	Slack	-124.118	40.83704	In Main Channel
7/13/2004	9:07	3	SI4	Trawl	Flood	-124.135	40.83794	In Main Channel
7/14/2004	8:16	3	AC2	Trawl	Flood	-124.137	40.82848	In Main Channel
7/14/2004	9:17	3	EB4	Trawl	Flood	-124.117	40.8292	In Main Channel
7/14/2004	10:38	3	EB1	Trawl	Flood	-124.148	40.8193	In Main Channel
7/20/2004	11:01	3	MR2	Trawl	Flood	-124.153	40.83577	In Main Channel
7/20/2004	9:47	3	MR6	Trawl	Flood	-124.147	40.84261	In Main Channel
7/20/2004	8:42	3	MR4	Trawl	Slack	-124.145	40.84849	In Main Channel
7/21/2004	9:01	3	AC3	Trawl	Slack	-124.122	40.83685	In Main Channel
7/21/2004	10:18	3	AC1	Trawl	Flood	-124.139	40.8299	In Main Channel
7/21/2004	12:16	3	EB2	Trawl	Flood	-124.142	40.82028	In Main Channel
7/23/2004	8:40	3	SI3	Trawl	Ebb	-124.138	40.83745	In Main Channel
7/23/2004	10:06	3	SI1	Trawl	Ebb	-124.143	40.83069	In Main Channel
7/26/2004	12:04	3	AC	Purse Seine	Ebb	-124.12	40.8356	In Main Channel
7/26/2004	9:30	3	EB	Purse Seine	Ebb	-124.135	40.82224	In Main Channel
7/27/2004	9:14	3	MR	Purse Seine	Slack	-124.149	40.83892	In Main Channel

Date	Start Time	Sets	Site	Method	Tide	Longitude	Latitude	Flats_Channel
7/27/2004	11:05	3	SI	Purse Seine	Ebb	-124.136	40.83016	In Main Channel
8/3/2004	8:47	3	MR7	Trawl	Slack	-124.1561559	40.83603	In Main Channel
8/3/2004	11:20	3	SI1	Trawl	Flood	-124.14336	40.83069	In Main Channel
8/3/2004	10:00	3	MR5	Trawl	Flood	-124.14229	40.84441	In Main Channel
8/4/2004	11:09	3	AC2	Trawl	Flood	-124.1371366	40.82848	In Main Channel
8/4/2004	9:22	3	SI4	Trawl	Slack	-124.1351346	40.83794	In Main Channel
8/4/2004	10:06	3	AC4	Trawl	Slack	-124.1181176	40.83704	In Main Channel
8/5/2004	8:51	3	EB4	Trawl	Ebb	-124.11728	40.8292	In Main Channel
8/5/2004	7:50	3	EB1	Trawl	Ebb	-124.14838	40.8193	In Main Channel
8/17/2004	9:06	3	MR4	Trawl	Slack	-124.1451447	40.84849	In Main Channel
8/17/2004	11:26	3	MR2	Trawl	Flood	-124.15317	40.83577	In Main Channel
8/18/2004	9:59	3	SI1	Trawl	Flood	-124.14336	40.83069	In Main Channel
8/18/2004	8:45	3	SI3	Trawl	Slack	-124.1381379	40.83745	In Main Channel
8/19/2004	11:45	3	AC3	Trawl	Flood	-124.1221215	40.83685	In Main Channel
8/20/2004	11:21	3	EB2	Trawl	Flood	-124.1421415	40.82028	In Main Channel
8/20/2004	10:14	3	EB3	Trawl	Flood	-124.13344	40.82523	In Main Channel
8/20/2004	8:23	3	AC1	Trawl	Slack	-124.13904	40.8299	In Main Channel
8/25/2004	11:38	3	MR3	Trawl	Ebb	-124.1481476	40.84093	In Main Channel
8/25/2004	9:41	3	EB2	Trawl	Slack	-124.1421415	40.82028	Over Flats
8/25/2004	9:30	1	EB2	Fyke Net	Ebb	-124.14322	40.81857	Rivulet Draining Flats
8/25/2004	12:28	4	MR8	Trawl	Ebb	-124.16033	40.83302	In Main Channel
9/13/2004	11:10	3	EB2	Trawl	Flood	-124.1421415	40.82028	In Main Channel
9/13/2004	9:25	5	EB1	Trawl	Ebb	-124.14838	40.8193	In Main Channel

Date	Start Time	Sets	Site	Method	Tide	Longitude	Latitude	Flats_Channel
9/14/2004	9:41	3	MR5	Trawl	Flood	-124.14229	40.84441	In Main Channel
9/15/2004	10:17	3	MR6	Trawl	Flood	-124.14747	40.84261	In Main Channel
9/15/2004	8:49	6	MR4	Trawl	Flood	-124.1451447	40.84849	In Main Channel
9/15/2004	11:16	3	MR2	Trawl	Flood	-124.15317	40.83577	In Main Channel
9/20/2004	11:09	3	MR7	Trawl	Ebb	-124.1561559	40.83603	In Main Channel
9/20/2004	12:14	3	SI4	Trawl	Ebb	-124.1351346	40.83794	In Main Channel
9/22/2004	8:47	3	SI1	Trawl	Slack	-124.14336	40.83069	In Main Channel
9/22/2004	9:46	3	AC4	Trawl	Ebb	-124.1181176	40.83704	In Main Channel
9/23/2004	9:38	3	EB4	Trawl	Ebb	-124.11728	40.8292	In Main Channel
9/23/2004	8:40	3	AC2	Trawl	Slack	-124.1371366	40.82848	In Main Channel
9/23/2004	10:21	3	EB3	Trawl	Ebb	-124.13344	40.82523	In Main Channel
9/24/2004	10:49	1	MR8	Fyke Net	Ebb	-124.16249	40.83776	Rivulet Draining Flats
9/24/2004	10:58	3	MR8	Trawl	Ebb	-124.16033	40.83302	Over Flats
9/24/2004	12:02	3	MR1	Trawl	Ebb	-124.15821	40.83216	In Main Channel
9/24/2004	13:39	3	MR3	Trawl	Ebb	-124.1481476	40.84093	In Main Channel
9/28/2004	10:21	3	AC1	Trawl	Flood	-124.13904	40.8299	In Main Channel
9/28/2004	8:33	3	AC3	Trawl	Ebb	-124.1221215	40.83685	In Main Channel
9/30/2004	9:51	3	SI2	Trawl	Flood	-124.1421418	40.83162	In Main Channel
9/30/2004	10:53	3	MR8	Trawl	Flood	-124.16033	40.83302	In Main Channel
9/30/2004	8:45	3	SI3	Trawl	Flood	-124.1381379	40.83745	In Main Channel
10/6/2004	12:06	3	MR2	Trawl	Ebb	-124.15317	40.83577	In Main Channel
10/6/2004	9:16	3	MR5	Trawl	Slack	-124.14229	40.84441	In Main Channel
10/6/2004	10:15	3	MR6	Trawl	Slack	-124.14747	40.84261	In Main Channel

Date	Start Time	Sets	Site	Method	Tide	Longitude	Latitude	Flats_Channel
10/6/2004	11:09	3	MR7	Trawl	Slack	-124.1561559	40.83603	In Main Channel
10/8/2004	8:40	4	SI4	Trawl	Flood	-124.1351346	40.83794	In Main Channel
10/8/2004	10:05	3	SI2	Trawl	Slack	-124.1421418	40.83162	In Main Channel
10/15/2004	10:47	3	EB4	Trawl	Flood	-124.11728	40.8292	In Main Channel
10/15/2004	11:35	3	EB1	Trawl	Flood	-124.14838	40.8193	In Main Channel
10/15/2004	9:56	3	AC4	Trawl	Flood	-124.1181176	40.83704	In Main Channel
10/15/2004	9:02	3	AC2	Trawl	Flood	-124.1371366	40.82848	In Main Channel
3/24/2005	14:33	3	MR Oyster Culture	Trawl		-124.141399	40.85133	Over Flats
3/24/2005	13:49	3	MR Mudflat	Trawl	Ebb	-124.16348	40.83748	Over Flats
3/24/2005	15:26	3	MR Eelgrass	Trawl	Ebb	-124.1561558	40.83232	Over Flats
3/24/2005	11:40	1	MR Mudflat	Fyke Net	Slack	-124.16348	40.83748	Over Flats
3/24/2005	13:00	1	MR Eelgrass	Fyke Net	Ebb	-124.1561558	40.83232	Over Flats
3/24/2005	12:20	1	MR Oyster Culture	Fyke Net	Slack	-124.141399	40.85133	Over Flats
3/25/2005	12:37	1	AC Oyster Culture	Fyke Net	Slack	-124.12629	40.83876	Over Flats
3/25/2005	15:55	3	AC Oyster Culture	Trawl	Ebb	-124.12817	40.83631	Over Flats
3/25/2005	12:07	1	AC Eelgrass	Fyke Net	Slack	-124.1171166	40.83622	Over Flats
3/25/2005	14:37	3	AC Eelgrass	Trawl	Slack	-124.1181179	40.8353	Over Flats
3/25/2005	11:25	1	AC Mudflat	Fyke Net	Slack	-124.10547	40.84049	Over Flats
3/25/2005	13:33	3	AC Mudflat	Trawl	Ebb	-124.1071066	40.84208	Over Flats
4/5/2005	9:49	1	EB Eelgrass	Fyke Net	Slack	-124.14705	40.81818	Over Flats
4/5/2005	10:24	1	EB Oyster Culture	Fyke Net	Slack	-124.1351347	40.82097	Over Flats

Date	Start Time	Sets	Site	Method	Tide	Longitude	Latitude	Flats_Channel
4/5/2005	10:45	3	EB Mudflat	Fyke Net		-124.15304	40.81488	Over Flats
4/5/2005	10:57	3	EB Eelgrass	Trawl	Ebb	-124.14705	40.81818	Over Flats
4/5/2005	12:29	3	EB Mudflat	Trawl	Ebb	-124.15304	40.81488	Over Flats
4/5/2005	11:30	3	EB Oyster Culture	Trawl	Ebb	-124.1351347	40.82097	Over Flats
4/5/2005	10:45	1	EB Mudflat	Fyke Net		-124.1514958	40.81568	Over Flats
4/20/2005	11:39	3	AC Mudflat	Trawl	Slack	-124.1011006	40.83645	Over Flats
4/20/2005	12:23	3	AC Eelgrass	Trawl	Ebb	-124.1261	40.83212	Over Flats
4/20/2005	13:17	3	AC Oyster Culture	Trawl	Ebb	-124.1261	40.83822	Over Flats
4/20/2005	11:25	1	AC Oyster Culture	Fyke Net	Slack	-124.1261	40.83822	Over Flats
4/20/2005	10:27	1	AC Mudflat	Fyke Net	Flood	-124.1011006	40.83645	Over Flats
4/20/2005	11:08	1	AC Eelgrass	Fyke Net	Slack	-124.1261	40.83212	Over Flats
4/21/2005	10:57	1	EB Mudflat	Fyke Net	Slack	-124.15211	40.81399	Over Flats
4/21/2005	11:18	1	EB Eelgrass	Fyke Net	Slack	-124.1081078	40.82797	Over Flats
4/21/2005	11:43	1	EB Oyster Culture	Fyke Net	Ebb	-124.1381375	40.8199	Over Flats
4/21/2005	11:13	3	EB Mudflat	Trawl	Ebb	-124.15141	40.81538	Over Flats
4/21/2005	12:20	3	EB Eelgrass	Trawl	Ebb	-124.1081078	40.82797	Over Flats
4/21/2005	13:14	3	EB Oyster Culture	Trawl	Ebb	-124.1381375	40.8199	Over Flats
4/22/2005	14:12	3	SI Oyster Culture	Trawl	Ebb	-124.12939	40.84883	Over Flats
4/22/2005	13:17	3	SI Mudflat	Trawl	Ebb	-124.11531	40.84937	Over Flats
4/22/2005	14:50	3	SI Eelgrass	Trawl	Ebb	-124.12712	40.84082	Over Flats

Date	Start Time	Sets	Site	Method	Tide	Longitude	Latitude	Flats_Channel
4/22/2005	11:40	1	SI Mudflat	Fyke Net	Flood	-124.11531	40.84937	Over Flats
4/22/2005	12:22	1	SI Oyster Culture	Fyke Net	Slack	-124.12939	40.84883	Over Flats
4/22/2005	13:05	1	SI Eelgrass	Fyke Net		-124.12712	40.84082	Over Flats
5/2/2005	9:13	3	MR Mudflat	Trawl	Ebb	-124.14634	40.85643	Over Flats
5/2/2005	9:54	3	MR Oyster Culture	Trawl	Ebb	-124.13901	40.8502	Over Flats
5/2/2005	10:39	3	MR Eelgrass	Trawl	Ebb	-124.1461456	40.84081	Over Flats
5/2/2005	8:58	1	MR Eelgrass	Fyke Net	Ebb	-124.1461456	40.84081	Over Flats
5/2/2005	7:53	1	MR Mudflat	Fyke Net	Flood	-124.14634	40.85643	Over Flats
5/2/2005	8:30	1	MR Oyster Culture	Fyke Net	Ebb	-124.13901	40.8502	Over Flats
5/3/2005	9:50	1	SI Eelgrass	Fyke Net		-124.1271269	40.84285	Over Flats
5/3/2005	9:35	1	SI Oyster Culture	Fyke Net	Ebb	-124.131296	40.84881	Over Flats
5/3/2005	8:55	1	SI Mudflat	Fyke Net	Ebb	-124.1181175	40.84985	Over Flats
5/3/2005	12:32	3	SI Eelgrass	Trawl	Ebb	-124.1271269	40.84285	Over Flats
5/3/2005	10:56	3	SI Oyster Culture	Trawl	Ebb	-124.131296	40.84881	Over Flats
5/3/2005	10:06	3	SI Mudflat	Trawl	Ebb	-124.1181176	40.84985	Over Flats
5/4/2005	10:40	1	EB Eelgrass	Fyke Net		-124.1181178	40.82513	Over Flats
5/4/2005	10:00	1	EB Oyster Culture	Fyke Net	Slack	-124.14131	40.81895	Over Flats
5/4/2005	9:40	1	EB Mudflat	Fyke Net	Slack	-124.15015	40.81682	Over Flats
5/4/2005	10:51	2	EB Mudflat	Trawl	Ebb	-124.15015	40.81682	Over Flats
5/4/2005	11:20	3	EB Oyster Culture	Trawl	Ebb	-124.14131	40.81895	Over Flats

Date	Start Time	Sets	Site	Method	Tide	Longitude	Latitude	Flats_Channel
5/4/2005	12:24	3	EB Eelgrass	Trawl	Ebb	-124.1181178	40.82513	Over Flats
8/1/2005	14:31	3	EB Oyster Culture	Trawl	Ebb	-124.1351347	40.821	Over Flats
8/1/2005	13:36	3	EB Mudflat	Trawl	Ebb	-124.15344	40.8151	Over Flats
8/1/2005	15:21	3	EB Eelgrass	Trawl	Ebb	-124.1051047	40.82821	Over Flats
8/1/2005	12:20	1	EB Mudflat	Fyke Net	Ebb	-124.15344	40.8151	Over Flats
8/1/2005	12:55	1	EB Oyster Culture	Fyke Net	Ebb	-124.1351346	40.821	Over Flats
8/1/2005	13:15	1	EB Eelgrass	Fyke Net	Ebb	-124.1051047	40.82821	Over Flats
8/1/2005	11:40	3	AC Mudflat Night	Trawl	Slack	-124.1193	40.83848	Over Flats
8/2/2005	10:53	1	AC Mudflat Night	Fyke Net	Ebb	-124.1193	40.83848	Over Flats
8/2/2005	10:53	1	AC Eelgrass Night	Fyke Net	Ebb	-124.12304	40.83419	Over Flats
8/2/2005	10:53	1	AC Oyster Culture Night	Fyke Net	Ebb	-124.1263	40.83824	Over Flats
8/2/2005	2:24	3	AC Eelgrass Night	Trawl	Ebb	-124.12304	40.83419	Over Flats
8/2/2005	12:47	3	AC Oyster Culture Night	Trawl	Ebb	-124.1263	40.83824	Over Flats
8/2/2005	12:38	3	EB Eelgrass Night	Trawl	Ebb	-124.1051047	40.82821	Over Flats
8/2/2005	11:38	1	EB Mudflat Night	Fyke Net	Ebb	-124.15344	40.8151	Over Flats
8/2/2005	12:47	1	AC Eelgrass	Fyke Net		-124.12304	40.83419	Over Flats
8/2/2005	12:20	1	AC Oyster Culture	Fyke Net		-124.1263	40.83824	Over Flats
8/2/2005	11:58	1	AC Mudflat	Fyke Net		-124.1193	40.83848	Over Flats

Date	Start Time	Sets	Site	Method	Tide	Longitude	Latitude	Flats_Channel
8/2/2005	14:42	3	AC Eelgrass	Trawl	Ebb	-124.12304	40.83419	Over Flats
8/2/2005	13:46	3	AC Oyster Culture	Trawl	Ebb	-124.1263	40.83824	Over Flats
8/2/2005	13:02	3	AC Mudflat	Trawl	Slack	-124.1193	40.83848	Over Flats
8/2/2005	11:38	1	EB Oyster Culture Night	Fyke Net	Ebb	-124.1351346	40.821	Over Flats
8/3/2005	1:52	3	AC Oyster Culture Night	Trawl		-124.1263	40.83824	Over Flats
8/3/2005	15:31	3	MR Oyster Culture	Trawl	Ebb	-124.14823	40.85171	Over Flats
8/3/2005	14:46	3	MR Eelgrass	Trawl		-124.1421417	40.84947	Over Flats
8/3/2005	14:06	3	MR Mudflat	Trawl		-124.141399	40.85028	Over Flats
8/3/2005	13:583:43	13	MR Eelgrass	Fyke Net	Slack	-124.1421193	40.8494783848	Over Flats
8/3/2005	13:3758	1	MR Mudflat	Fyke Net	Slack	-124.14179	40.8502884947	Over Flats

Appendix B. Water quality measurements taken during course of study. NA= measurements not collected.

Date	Location (Site)	Temp (C.)	Secchi (ft)	Turbidity (NTU)	DO (mgL)	DO %	Sp Cond. (mS)	pH	Salinity (ppt)
8/6/2003	EB1	NA	NA	NA	NA	NA	NA	NA	NA
8/21/2003	EB3	NA	NA	NA	6.77	89.4	52	NA	NA
8/21/2003	EB3	19.82	NA	NA	7	92.6	52.3	7.81	34.28
8/22/2003	EB4	19.67	NA	NA	6.77	89.4	52	NA	NA
8/21/2003	AC1	19.18	NA	NA	6.73	89.7	52.1	7.73	33.87
8/21/2003	AC1	19.18	NA	NA	6.73	89.7	52.1	7.73	33.87
8/21/2003	AC2	19.48	NA	NA	6.69	89.7	52.1	7.71	33.89
8/21/2003	AC3	19.51	NA	NA	6.74	89.5	52.3	7.77	NA
8/21/2003	AC3	19.51	NA	NA	6.74	89.5	52.3	7.77	NA
8/22/2003	AC4	19.85	NA	NA	7.4	99.2	52.1	NA	33.91
8/28/2003	SI1	16.84	NA	NA	7.71	97	49.6	NA	31.93
8/28/2003	SI2	17.23	NA	NA	7.37	91.6	49.5	NA	32.1
8/28/2003	SI3	18.44	NA	NA	7.17	94.1	49.5	8.05	32.09
8/28/2003	SI4	19.25	NA	NA	7.12	94.4	49.8	8.06	32.21
8/29/2003	MR1	18.35	NA	NA	6.67	86.6	49.9	NA	32.23
8/27/2003	MR2	19.2	2.8	NA	6.91	91.2	49.6	8.07	31.84
8/27/2003	MR3	18.4	4.6	NA	7.33	95.1	49.7	8.09	32.16
8/27/2003	MR4	18.16	4.5	NA	7.37	96	49.6	8.06	32.08
8/27/2003	MR5	18.45	NA	NA	7.56	95.9	49.6	NA	32.09
8/27/2003	MR5	18.45	NA	NA	7.56	95.9	49.6	NA	32.09
8/27/2003	MR6	15.21	NA	NA	8.27	99	49.3	NA	31.83
8/28/2003	MR7	18.56	NA	NA	7.15	93.1	48.9	7.99	32.17
8/29/2003	MR8	18.49	NA	NA	6.51	83.3	49.9	7.98	32.31
9/24/2003	EB1	16.4	NA	NA	7.83	96.9	41.5	8.25	32.6
9/24/2003	EB1	16.4	NA	NA	7.83	96.9	41.5	8.25	32.6
9/24/2003	EB2	15.9	NA	NA	7.84	96.7	41.06	8.26	32.6
10/1/2003	EB3	15.09	6	NA	8.41	107.9	52.3	8.3	33.84
9/22/2003	EB4	18.3	7	NA	NA	NA	NA	8.34	NA
9/30/2003	MR1	15	1.2	NA	7.56	91.4	39.78	8.17	32.1
9/30/2003	MR2	14.5	5	NA	7.77	73.2	39.24	8.22	32.1
9/23/2003	MR3	17.1	NA	NA	8.77	0	41.53	8.32	32.2
9/23/2003	MR4	17.7	NA	NA	8.15	104.6	42.64	8.31	32.5
9/29/2003	MR6	NA	2	NA	NA	NA	NA	NA	NA

Date	Location (Site)	Temp (C.)	Secchi (ft)	Turbidity (NTU)	DO (mgL)	DO %	Sp Cond. (mS)	pH	Salinity (ppt)
9/29/2003	MR7	NA	4	NA	NA	NA	NA	NA	NA
9/29/2003	MR8	NA	2	NA	NA	NA	NA	NA	NA
9/24/2003	AC1	15.6	3	NA	7.67	91.9	40.8	8.26	32.5
9/24/2003	AC2	13.9	5	NA	8.55	101.1	39.09	8.24	32.5
9/22/2003	AC3	21.3	4	NA	NA	NA	NA	8.28	NA
9/22/2003	AC4	16.5	NA	NA	NA	NA	NA	8.18	NA
9/24/2003	SI1	16.8	3	NA	7.92	99.2	41.95	8.3	32.6
9/24/2003	SI2	15.2	4.5	NA	7.09	97	40.37	8.28	32.5
9/23/2003	SI3	17.1	5.2	NA	7.64	NA	42.14	8.3	32.5
9/23/2003	SI4	17.1	5	NA	7.8	NA	42.85	8.26	32.7
11/3/2003	EB2	11.61	NA	1.34	9.71	9.71	47.3	8.54	30.06
11/3/2003	EB3	11.67	NA	0.97	10.02	112.4	47.3	8.52	30.06
10/20/2003	EB4	17.15	NA	2.01	9.34	117.4	50.4	8.28	32.59
10/21/2003	AC1	15.8	NA	1.68	8.95	109.1	50.5	8.25	32.6
10/21/2003	AC2	15.95	NA	2.01	9.41	115.3	50.5	8.25	32.6
10/21/2003	AC3	17.23	NA	2.21	10.16	127.8	50.4	8.31	32.6
10/21/2003	AC4	15.48	NA	1.9	8.86	108.1	50.5	8.23	32.57
10/22/2003	SI1	16.43	NA	2.98	8.15	101.6	50.4	8.23	32.63
10/22/2003	SI2	16.34	NA	1.63	9.07	112.3	50.4	8.28	32.54
10/22/2003	SI3	16.1	NA	3.05	8.13	100.8	50.5	8.34	32.61
10/22/2003	SI4	16.17	NA	1.88	7.84	98.6	50.4	8.26	32.61
10/27/2003	MR2	13.56	NA	3	8.44	99.6	50.6	8.16	32.53
10/27/2003	MR3	12.87	NA	3.06	8.05	93.2	50.7	8.13	32.56
10/27/2003	MR4	13.92	NA	2.83	7.91	93.7	50.6	8.13	32.47
10/27/2003	MR5	15.48	NA	4.37	8.04	98.7	50.4	8.14	32.5
10/27/2003	MR6	12.39	NA	2.02	8.03	87.6	50.8	8.13	32.59
10/27/2003	MR7	12.9	NA	2.55	8.25	95.5	50.7	8.13	32.55
11/4/2003	MR8	11.21	NA	NA	9.56	105.7	47.5	8.45	30.18
12/10/2003	EB2	10.94	NA	NA	8.62	92.7	47.6	8.11	30.59
12/10/2003	EB1	11.06	NA	NA	9.06	98	48.2	8.08	30.66
12/8/2003	SI4	11.14	NA	NA	8.68	94	45.7	8.01	28.91
12/8/2003	SI3	11.03	NA	NA	8.36	90.8	45.8	7.99	29.04
12/8/2003	AC3	11.51	NA	NA	8.79	96.5	47.2	8.05	29.98
12/8/2003	AC4	11.3	NA	NA	8.49	93.3	47.5	7.99	30.18
12/3/2003	SI1	10.88	NA	1.66	8.49	93.1	49.5	8.08	31.57

Date	Location (Site)	Temp (C.)	Secchi (ft)	Turbidity (NTU)	DO (mgL)	DO %	Sp Cond. (mS)	pH	Salinity (ppt)
12/3/2003	SI2	11.01	NA	1.98	8.61	94.4	49.3	8.09	31.43
11/22/2003	EB3	10.93	NA	2.68	8.37	92.4	48.6	8.1	30.94
11/22/2003	EB4	10.8	NA	2.22	8.45	92.1	48.3	8.09	31.2
11/25/2003	AC1	10.25	NA	NA	8.51	92.8	52	8.12	30.3
11/25/2003	AC2	10.2	NA	NA	8.47	93	51.8	8.07	33.16
12/3/2003	MR1	10.68	NA	2.24	8.22	90.4	50.1	8.04	31.98
12/1/2003	MR2	10.35	NA	2.23	7.98	86.2	49.6	8.05	31.61
12/1/2003	MR3	10.38	NA	2.41	8.17	88.2	49.4	8.06	31.46
12/1/2003	MR4	10.29	NA	2.19	8.26	88.8	49.4	8.04	31.46
12/1/2003	MR5	10.27	NA	1.9	7.75	85.2	49.6	7.98	31.6
12/1/2003	MR6	10.3	NA	2.18	8.29	90.9	49.6	8.07	31.6
12/1/2003	MR7	10.35	NA	2.52	8.31	91.1	49.7	8.07	31.67
12/2/2003	MR7	10.49	NA	2.52	8.41	92.5	49.4	8.04	31.47
12/3/2003	MR8	10.67	NA	2.4	8.21	90.1	50	7.99	31.91
1/28/2004	EB3	10.11	NA	6.4	8.66	90.8	42	8.04	26.28
1/28/2004	EB4	10.12	NA	6.77	8.64	90.3	40.7	8.05	25.38
1/28/2004	AC4	10.3	NA	9.95	8.55	89.6	40.2	8.05	25.04
1/23/2004	SI2	11.11	NA	3.25	7.92	87.5	47.2	8.13	29.89
1/23/2004	SI3	11.02	NA	3.87	8.04	88.2	45.7	8.1	28.83
1/23/2004	SI4	10.94	NA	4.6	8.62	92.4	45.6	8.11	28.83
1/13/2004	EB2	10.85	NA	4.97	8.8	96	42.6	7.98	26.73
1/13/2004	EB1	10.76	NA	2.92	8.41	89.1	41.9	7.95	26.21
1/16/2004	MR8	11.38	NA	8.44	7.91	84.8	41.4	7.97	25.93
1/16/2004	MR7	11.32	NA	4.46	8.29	89.4	42.2	8.08	26.48
1/15/2004	MR6	11.62	NA	5.24	7.84	85.2	39.3	7.85	24.56
1/15/2004	MR5	11.36	NA	5.49	8.12	87.3	41.6	7.93	26
1/15/2004	MR4	11.46	NA	7.47	8.41	90.3	40.7	7.94	25.45
1/15/2004	MR4	11.46	NA	NA	8.41	90.3	40.7	7.94	25.45
1/15/2004	MR3	11.89	NA	5.55	8.09	87	40.5	8	25.25
1/16/2004	MR2	11.47	NA	4.62	8.48	91.6	42	8.06	26.49
1/16/2004	MR1	11.52	NA	6.51	8.02	87.3	41.4	8.02	25.93
1/29/2004	AC1	10.2	NA	4.2	8.63	91.2	42.3	8.04	26.49
1/29/2004	SI1	10.32	NA	4.11	8.37	87.9	41.1	8.04	25.67
1/28/2004	AC3	10.12	NA	10.78	8.47	88.3	42.7	8.09	26.76
1/28/2004	AC3	10.12	NA	NA	8.47	88.3	42.7	8.09	26.76

Date	Location (Site)	Temp (C.)	Secchi (ft)	Turbidity (NTU)	DO (mgL)	DO %	Sp Cond. (mS)	pH	Salinity (ppt)
1/29/2004	AC2	10.16	NA	6.43	8.24	86.9	41.2	8.02	25.8
2/5/2004	SI1	10.78	NA	2.91	8.74	95.3	43.8	8.17	27.56
2/27/2004	AC1	10.38	NA	6.84	8.63	90.5	36.7	8	22.66
2/28/2004	AC2	10.86	NA	7.41	8.92	94.1	36.7	7.97	22.69
2/4/2004	AC3	10.54	NA	3.73	9.04	97.9	43.6	8.15	27.62
2/4/2004	AC4	10.49	NA	4.93	8.8	92.2	43.8	8.1	27.54
2/27/2004	EB1	10.13	NA	89.7	8.53	89.7	40	7.93	24.97
2/27/2004	EB2	10.1	NA	7.62	8.84	92.8	39.9	7.98	21.83
2/27/2004	EB3	10.15	NA	5.18	9.03	94.4	40	8.02	24.9
2/27/2004	EB4	10.06	NA	5.36	8.69	91.6	39.4	8.01	24.42
2/24/2004	EB4	11.56	NA	NA	9.29	100.3	71	7.88	25.66
2/19/2004	MR1	NA	NA	7.29	NA	NA	NA	NA	NA
2/28/2004	MR2	10.15	NA	7.41	9.33	96.6	33.2	7.87	20.32
2/28/2004	MR3	10.55	NA	8.05	8.98	91.9	32.7	7.9	20.04
2/10/2004	MR4	10.5	NA	NA	10.95	98.5	NA	8.01	NA
2/10/2004	MR5	NA	NA	NA	NA	NA	NA	NA	NA
2/10/2004	MR5	10.1	NA	NA	10.93	97	NA	7.93	NA
2/28/2004	MR6	10.49	NA	10.99	9.18	95.7	35.3	8.12	21.99
2/19/2004	MR7	NA	NA	5.74	NA	NA	NA	NA	NA
2/19/2004	MR8	NA	NA	5.79	NA	NA	NA	NA	NA
2/5/2004	SI2	10.82	NA	3.36	8.84	96	42.5	8.15	26.59
2/5/2004	SI3	10.64	NA	3.03	8.51	95	42.9	8.16	26.86
2/5/2004	SI4	10.53	NA	3.28	8.13	86.9	42	8.11	26.3
3/10/2004	EB1	13.39	2.2	NA	8.67	97.2	42.6	8.09	26.86
3/12/2004	EB3	14.08	3.8	NA	8.7	99.6	43.3	8.18	27.31
3/10/2004	EB1	13.39	2.2	NA	8.67	97.2	42.6	8.09	26.86
3/12/2004	EB3	14.08	3.8	NA	8.7	99.6	43.3	8.18	27.31
4/30/2004	AC4	18.44	2	15.33	9.27	118.8	47.78	8.18	31.2
4/30/2004	EB2	18.88	3	8.9	9.25	120	47.41	8.34	30.91
4/27/2004	EB4	17.98	4	3.91	8.5	104.3	53.08	8.4	35.07
4/30/2004	AC1	17.97	3.5	10.81	8.6	109.3	47.6	8.2	31.05
4/30/2004	SI1	16.56	3	4.67	8.91	110.6	47.82	8.14	31.2
4/30/2004	SI3	16.68	3	4.64	8.07	100	47.67	8.08	31.09
4/16/2004	MR2	12.01	3.5	4.01	7.8	91.3	55.28	8.1	36.53
5/12/2004	SI2	16.38	1	7.78	9.14	113.2	49.41	8.22	32.35

Date	Location (Site)	Temp (C.)	Secchi (ft)	Turbidity (NTU)	DO (mgL)	DO %	Sp Cond. (mS)	pH	Salinity (ppt)
5/12/2004	AC4	14.98	3.5	4.37	8.12	97.9	49.4	8.05	32.32
4/16/2004	MR2	13.92	3	4.82	9.35	113	54.49	8.33	36.03
4/16/2004	MR8	11.78	3.5	3.71	8.42	98.1	55.59	8.22	36.75
4/16/2004	MR8	14.59	2.5	3.71	8.77	107.9	54.78	8.25	36.22
4/15/2004	EB1	11.57	3	NA	8.47	98.3	55.93	8.17	36.98
4/15/2004	EB2	11.72	3	NA	8.56	99.1	54.75	8.21	36.11
5/5/2004	EB4	16.99	1	24.3	7.52	94.3	48.42	8.09	31.64
5/5/2004	EB2	17.09	1.5	7.24	7.22	90.5	48.2	8.08	31.49
5/12/2004	SI4	15.33	3	6.36	7.75	94.1	49.34	8.07	32.29
5/13/2004	MR8	15	3.5	NA	8.32	100.6	49.5	8.13	32.39
5/13/2004	MR5	15.23	3.5	NA	8.39	102.1	49.44	8.15	32.35
5/19/2004	MR8	16.8	2.5	6.02	7.89	98.9	49.55	8.23	32.46
5/19/2004	AC2	16.92	3	6.9	7.9	99.2	49.53	8.01	32.46
5/26/2004	MR8	18.09	NA	6.02	7.27	93.6	50.14	8.29	32.92
5/25/2004	EB2	18.99	4	5.22	8.25	108	50	8.38	32.81
5/27/2004	SI4	18.31	4	3.88	7.69	99.6	50.09	8.32	32.88
5/27/2004	Eureka Sl	19.93	2.5	7.21	6.8	87.8	42.64	8.17	27.48
5/27/2004	AC2	17.62	2	7.87	6.42	81.9	50.11	8.2	32.89
6/2/2004	AC2	15.15	4	4.88	7.52	92.1	51.59	8.07	33.87
6/2/2004	MR2	16.3	2	10.75	7.05	88.4	51.97	8.09	34.24
6/2/2004	MR5	17.63	2.5	8.52	6.9	88.7	52.16	8	34.39
6/10/2004	AC4	16.2	3	7.57	8.12	101.9	52.87	8.15	34.9
6/10/2004	SI4	16.44	3.5	4.46	7.09	89.2	52.85	8.07	34.89
6/9/2004	SI2	17.32	3	5.57	7.9	103.9	52.82	8.22	34.88
6/8/2004	EB1	17.37	3.5	NA	7.31	94.9	52.66	8.04	34.76
6/8/2004	EB4	19.02	2.25	NA	8.04	106.2	52.81	8.17	34.88
6/15/2004	EB4	17.62	1.5	16.93	5.68	73.2	52.89	7.67	34.93
7/12/2004	MR8	18.28	3.8	3.91	96.8	7.63	46.73	8.1	30.43
7/12/2004	MR8	NA	NA	NA	NA	NA	NA	NA	NA
7/13/2004	SI2	18.38	3.8	5.32	6.51	82.1	46.8	8.05	30.48
7/12/2004	MR5	18.81	3.8	4.25	7.6	97.9	46.82	8.03	30.49
7/13/2004	AC4	18.34	NA	4.58	6.58	84	46.79	8.05	30.46
7/13/2004	SI4	19.18	3.8	4.28	5.65	73.3	47.04	8.05	30.63
7/14/2004	AC2	18.8	NA	3.2	5.94	76.5	47	7.94	30.62
7/14/2004	EB4	18.85	NA	6.04	6.11	78.7	47	7.95	30.61

Date	Location (Site)	Temp (C.)	Secchi (ft)	Turbidity (NTU)	DO (mgL)	DO %	Sp Cond. (mS)	pH	Salinity (ppt)
7/14/2004	EB1	17.21	NA	4.72	6.59	82.2	46.67	7.98	30.39
7/20/2004	MR2	20.9	3	4.95	6.25	83.6	46.87	8.04	30.52
7/20/2004	MR6	21.38	3	8.74	5.82	78.5	46.96	7.91	30.58
7/20/2004	MR4	21.61	3	4.84	5.49	74.5	47.01	7.85	30.61
7/21/2004	AC3	20.46	2.5	8.73	5.25	69.8	46.99	7.9	30.61
7/21/2004	AC1	21.01	3	5.43	5.97	80.1	46.91	8.01	30.55
7/21/2004	EB2	21.07	3	3.96	6	80.6	46.92	8.06	30.55
7/23/2004	SI3	20.65	4.21	5.33	6.1	81.3	46.97	7.98	30.6
7/27/2004	AC	19.57	3.5	5	5.92	77.3	46.81	7.86	30.48
7/27/2004	EBC	19.66	3.5	3.16	6.07	78.4	46.67	7.89	30.39
7/23/2004	SI1	20.81	4.2	4.63	5.8	77.7	47.05	7.99	30.63
7/26/2004	SIC	NA	3.5	5.33	NA	NA	NA	NA	NA
7/26/2004	MRC	NA	3.2	4.3	NA	NA	NA	NA	NA
8/3/2004	MR7	17.43	2.5	6.73	6.58	81.8	43.8	7.81	28.3
8/3/2004	SI1	17.41	3.5	8	6.92	85.6	43.71	7.93	28.23
8/3/2004	MR5	17.99	3	10.26	6.45	80.5	43.88	7.87	28.36
8/4/2004	AC2	18.4	3.2	4.16	6.97	87.7	43.65	7.89	28.2
8/4/2004	SI4	18.32	4	8.05	7.62	95.6	43.67	7.94	28.21
8/4/2004	AC4	18.95	2.5	3.83	6	76.5	43.64	7.83	28.19
8/5/2004	EB4	18.57	4.2	3.46	6.74	85.2	43.76	7.98	28.28
8/5/2004	EB1	17.17	3.8	3.93	7.04	87.1	43.52	7.95	28.09
8/17/2004	MR4	20.36	2.5	5.5	6.39	87.3	43.94	7.97	28.4
8/20/2004	EB2	18.54	3.9	4.4	6.8	86	43.7	7.94	28.23
8/20/2004	EB3	19.12	4	3.96	6.89	88.3	43.81	8.01	28.31
8/20/2004	AC1	19.15	4.2	3.73	6.21	77.7	43.71	7.89	28.24
8/19/2004	AC3	19.27	4	5.43	6.83	87.3	43.72	7.88	28.25
8/18/2004	SI1	19.32	3.5	3.26	6.96	89.1	43.74	7.94	28.26
8/17/2004	MR2	19.23	3	6.1	7.19	92	43.67	7.97	28.21
8/18/2004	SI3	19.33	3.5	3.6	6.6	84.7	43.82	7.89	28.32
8/25/2004	MR3	8.76	4	3.93	7.96	100.5	43.32	8.04	27.97
8/25/2004	EB2	17.99	8	4.46	8.16	101.6	43.2	7.99	27.88
8/25/2004	EB2	17.99	8	4.46	8.16	101.6	43.2	7.99	27.88
8/25/2004	MR8	18.35	3.5	4.26	8.6	107.2	43.05	8.13	27.77
2/3/2004	EB	10.59	NA	NA	9.09	96.6	41.2	8.02	25.89
2/3/2004	EB	10.59	NA	NA	9.09	96.6	41.2	8.02	25.89

Date	Location (Site)	Temp (C.)	Secchi (ft)	Turbidity (NTU)	DO (mgL)	DO %	Sp Cond. (mS)	pH	Salinity (ppt)
9/15/2004	MR6	17.4	2.5	7.16	7.02	92.8	58.43	7.89	39.06
9/15/2004	MR4	17.33	3	6.1	6.32	84.3	58.49	7.74	39.11
9/15/2004	MR2	16.67	3	7.73	7.25	94.3	58.36	7.89	39
9/14/2004	MR5	18.71	3.5	5.5	6.97	94.3	58.44	7.88	39.09
9/20/2004	MR7	17.18	4	6.1	6.22	81.5	58.16	7.75	38.86
9/20/2004	SI4	17.75	4.5	3.23	7	92.8	58.19	7.86	38.9
9/28/2004	AC1	NA	2.5	9.93	NA	NA	NA	NA	NA
9/28/2004	AC3	NA	2.5	8.26	NA	NA	NA	NA	NA
9/13/2004	EB2	17.22	3	5.56	9.74	119.4	43.47	7.9	28.07
9/13/2004	EB1	18.29	4	4.13	8.84	112	43.55	7.86	28.12
9/24/2004	MR8	16.88	3.5	5.5	8.24	107.7	58.2	7.91	38.89
9/24/2004	MR8	16.88	3.5	5.5	8.24	107.7	58.2	7.91	38.89
9/23/2004	EB4	16.65	3.9	4.13	7.08	91.7	58.14	7.86	38.84
9/22/2004	SI1	16.65	3.5	4.1	6.91	89.7	58.18	7.84	38.87
9/24/2004	MR1	15.73	4	4.16	7.23	92.9	58.12	7.84	38.79
9/24/2004	MR3	17.72	3	5.16	8.01	106.1	58.26	7.93	38.94
9/23/2004	AC2	15.74	5.5	4.33	7.23	92.4	58.07	7.82	38.75
9/22/2004	AC4	16.79	3.5	5.2	7	91.1	58.15	7.84	38.85
9/23/2004	EB3	16.51	4	4.33	7.41	96.3	58.1	7.87	38.84
9/30/2004	SI2	15.63	3.5	NA	6.24	79.5	58.13	7.78	38.8
9/30/2004	MR8	15	3.5	NA	6.06	76.2	58.09	7.75	38.76
9/30/2004	SI3	16.07	3.5	NA	6.3	80.9	58.23	7.75	38.89
10/6/2004	MR2	15.98	4.5	NA	7.15	91.9	58.16	7.98	38.84
10/6/2004	MR5	15.76	5.5	NA	7.11	90.7	57.96	7.81	38.68
10/6/2004	MR6	15.88	4.5	NA	7.19	92.1	58.1	7.85	38.79
10/6/2004	MR7	16.1	4	NA	6.98	89.7	58.19	7.91	38.86
10/8/2004	SI4	NA	4	NA	NA	NA	NA	NA	NA
10/8/2004	SI2	NA	5	NA	NA	NA	NA	NA	NA
10/15/2004	EB4	16.01	3.5	NA	7.04	90.3	57.6	7.85	38.42
10/15/2004	EB1	13.41	4	NA	7.03	85.6	57.89	7.42	38.53
10/15/2004	AC4	16.41	3	NA	7.11	91.8	57.58	7.9	38.41
10/15/2004	AC2	16.37	4	NA	7.1	91.6	57.59	7.68	38.41
3/24/2005	MR Mud	12.94	2.5	NA	9.59	104.3	35.153	7.76	22.15
3/24/2005	MR Eel	12.61	1.5	NA	9.79	105.8	35.35	7.91	22.27
3/24/2005	MR Oyster	12.75	1.5	NA	9.66	104.1	34.237	7.75	21.5

Date	Location (Site)	Temp (C.)	Secchi (ft)	Turbidity (NTU)	DO (mgL)	DO %	Sp Cond. (mS)	pH	Salinity (ppt)
4/5/2005	EB Eel	12.15	NA	NA	9.13	98.6	37.37	7.8	23.6
4/5/2005	EB Oyster	12.23	5.5	NA	9.2	99.4	37.494	7.87	23.8
4/5/2005	EB Mud	12.44	NA	NA	9.16	99.9	37.69	7.94	23.95
4/22/2005	SI Mud	14.92	4	NA	8.09	94.6	42.444	7.73	27.29
4/22/2005	SI Oyster Culture	14.81	4.5	NA	8.53	99.8	42.951	7.82	27.67
4/22/2005	SI Eel	15.03	3	NA	8.74	102.7	42.857	7.84	27.61
5/2/2005	MR Eel	14.85	4	NA	8.12	96.3	46.14	8	29.94
5/2/2005	MR Mud	15.04	4	NA	7.73	92	45.738	7.73	29.67
5/2/2005	MR Oyster	16.26	2	NA	7.73	94	45.395	7.92	29.43
5/3/2005	SI Eel	15.85	3	NA	7.53	91	45.639	7.93	29.61
5/3/2005	SI Oyster	15.65	4	NA	7.73	93.2	45.954	7.92	29.84
5/3/2005	SI Mud	15.38	3	NA	7.14	85.7	45.922	7.9	29.77
5/4/2005	EB Eel	16.21	NA	NA	7.96	96.4	45.938	7.93	29.83
5/4/2005	EB Oyster	15.14	3.5	NA	8.19	98.3	46.588	8.01	30.29
5/4/2005	EB Mud	14.33	3	NA	8.67	101.8	47.126	8.02	30.66
4/20/2005	AC Mud	14.55	3	NA	8.43	96.1	38.204	7.81	24.3
4/20/2005	AC Oyster	13.56	4	NA	8.7	97.7	38.947	7.93	24.83
4/20/2005	AC Mud	13.26	2.5	NA	7.94	88	37.831	7.86	24.02
4/20/2005	AC Eel	13.15	NA	NA	8.54	94.6	38.925	7.86	24.8
8/2/2005	AC Eel	18.07	NA	NA	7.68	99.3	50.29	8.02	33.02
8/2/2005	AC Oyster	18.95	NA	NA	7.37	96.8	50.37	8.02	33.08
8/2/2005	AC Mud	18.25	NA	NA	7.24	93.8	50.31	7.99	33.04
8/2/2005	AC Mud	NA	NA	NA	NA	NA	NA	NA	NA
8/1/2005	EB Mud	17.96	NA	NA	8.5	100.2	70.14	7.9	32.94
8/1/2005	EB Oyster	19.04	NA	NA	8.89	116.7	50.3	8.05	33.03
8/1/2005	EB Eel	19.51	NA	NA	8.32	110.2	50.38	8.05	33.09
8/3/2005	AC Oyster Nt	18.72	NA	NA	7.18	93.6	50.36	7.98	33.07
8/3/2005	AC Mud Nt	19.92	NA	NA	7.37	98.4	50.45	8	33.14
4/5/2005	EB Mud	12.44	NA	NA	9.16	99.9	37.69	7.94	23.95
8/3/2005	MR Eel	19.34	NA	NA	7.97	105.2	50.4	7.98	33.1
8/3/2005	MR Mud	20.16	NA	NA	7.95	106.6	50.45	8.01	33.14
8/3/2005	MR Oyster Nt	18.55	NA	NA	7.87	102.7	50.37	8	33.07
8/2/2005	AC Mud Nt	17.1	NA	NA	7.1	89.7	50.21	7.92	32.96

Date	Location (Site)	Temp (C.)	Secchi (ft)	Turbidity (NTU)	DO (mgL)	DO %	Sp Cond. (mS)	pH	Salinity (ppt)
8/2/2005	AC Eel Nt	19.53	NA	NA	7.47	99.1	50.42	8.03	33.12
8/2/2005	AC Oyster Nt	18.89	NA	NA	9.18	123	50.36	8	33.07
8/2/2005	AC Eel Nt	19.53	NA	NA	7.47	99.1	50.42	8.03	33.12
8/2/2005	AC Oyster Nt	18.96	NA	NA	9.18	123	50.36	8	33.07
8/2/2005	EB Eel Nt	17.39	NA	NA	6.58	83.8	50.29	7.91	33
8/1/2005	AC Mud Nt	17.1	NA	NA	7.1	89.7	50.21	7.92	32.96
3/25/2005	AC Oyster	12.98	NA	NA	9.62	101.7	35.302	7.78	22.29
3/25/2005	AC Eel	13.05	NA	NA	9.68	102.9	35.498	7.84	22.32
3/25/2005	AC Mud	13.02	3.1	NA	9.52	103.7	36.002	7.78	22.13
4/21/2005	EB Mud	13.31	2.6	NA	8.02	92.4	37.926	7.92	24.11
4/21/2005	EB Eel	13.4	NA	NA	8.12	93.8	37.981	7.9	24.14
4/21/2005	EB Oyster	13.38	NA	NA	8.06	92.9	37.931	7.9	24.13

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