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Fish Communities in Eelgrass, Oyster Culture, and Mud Flat Habitats of North Humboldt Bay, California
Progress Report

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This progress report provides an update for an on-going project. Information presented in this interim report is preliminary and analyses are incomplete. As such, this annual progress report has received limited internal review prior to its release and will be finalized in more formal literature in the future. Consequently, this progress report should not be cited without approval of the author or the Arcata Fish and Wildlife Office.

Key words: fish, community structure, estuary, Humboldt Bay, eelgrass, oyster culture, mud flat

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Abstract. Fish communities were surveyed in eelgrass, oyster culture, and mud flat habitats in North Humboldt Bay, California from August 2003 to July 2004 using a variety of gears. 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. Species diversity indices and catch rates were calculated from catch data to compare seasonal distributions and relative abundance of fishes between channels and habitat types and to assess gear selectivity.

Forty-seven fish species representing 22 families were collected during the study. Trawl catch rates for all fishes combined changed seasonally, ranging from 1.3 fish/set in December 2003 to 103.2 fish/set in June 2004. In general, changes in trawl catch rates coincided with seasonal changes in salinity and water temperature. Species richness (total number of species) also varied by month, with the greatest diversity in catches occurring in May 2004 and the lowest richness observed in December 2003. There was no significant difference in Shannon-Wiener diversity or Simpson diversity indices between trawl sets and purse seine hauls. There was also no significant difference between diversity indices generated from fyke net and trawl catches. Minnow traps, however, appeared to be highly selective.

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. 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).

Three species of salmonids and the tidewater goby (*Eucyclogobius newberryi*) that inhabit Humboldt Bay and its tributaries are listed as threatened under the Endangered Species Act of 1973. Coho salmon (*Oncorhynchus kisutch*) is listed for the Southern Oregon/Northern California Coasts Evolutionarily Significant Unit (ESU) (May 1997), Chinook salmon (*O. tshawytscha*) is listed for the California Coastal ESU (September 1999) and Steelhead *O. mykiss* is listed for the Northern California ESU (June 2000). 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 as estuaries as nursery areas after out-migrating from natal streams as smolts. Estuarine residence by juvenile salmonids is important to protection and recovery efforts as research indicates it is a critical period 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, and Chinook salmon have been captured in Humboldt Bay, but specific data on habitat use are limited (Barnhart et al. 1992, Emmett et al. 1991). 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, again based on beach seine catches. 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 using fyke nets equipped with 19.7 m leads.

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 quantifiably measured. 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 having eelgrass beds.

Studies in other estuaries in the Pacific Northwest have documented the use of eelgrass by various marine species. Adults and juveniles from more than 75 different species have been observed in eelgrass habitats. Over 50% of these species were 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 on-going study is to describe the fish community structure in eelgrass and non-eelgrass (e.g. mud flats, oyster culture beds) sites in the North Bay area of Humboldt Bay from August 2003 to July 2004. Specific objectives of this project are to:

1. Test the effectiveness and selectivity of various gear types in sampling fish communities in different habitats present in North Humboldt Bay.
2. Document baseline fish community composition, including seasonal and spatial distribution of fishes in North Humboldt Bay.
3. Compare fish community structure and catch rates of fishes in eelgrass, oyster culture, and mud flat habitats in North Humboldt Bay.

Study Area

Humboldt Bay is located along the Pacific coastline in Humboldt County near the town of Eureka in northern California. The bay is about 22 km long, 7 km across at it widest point, and is the second largest estuary in California, encompassing over 17,000 acres.

We defined the study area to include the northern portion of Humboldt Bay, landward of the California State Highway 255 bridge. Six major channels were identified in North Humboldt Bay and sample sites were stratified and assigned names based on these channels (Figure 1). 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 it's 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 four predefined habitat categories based on the presence or absence of mariculture and/or eelgrass. The four categories were mariculture with eelgrass (MCEG); mariculture with no eelgrass (MCNG), no mariculture with eelgrass (NCEG); and no mariculture with no eelgrass (NCNG).

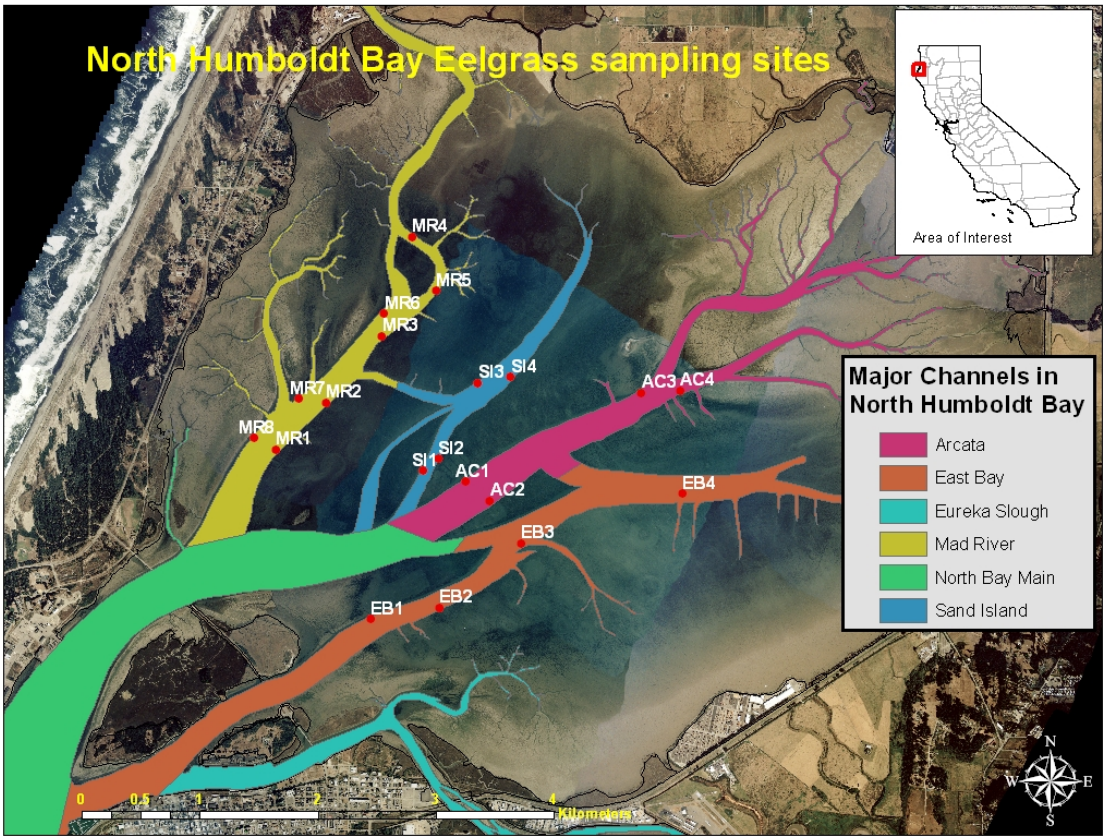

Figure 1. Major channels and locations of sample sites in North Humboldt Bay, California.

Methods

Sampling Gear

Different gear types were tested to qualitatively determine their effectiveness and selectivity in sampling fish communities in different habitats present in 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 four different habitat types because of limitations specific to each of the gear types.

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. Trawl samples were not collected in mariculture areas. A trawl set consisted of towing the 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 trawl fished correctly and consistently between sets. Catch per unit of effort of 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 prior to analyses because catch per unit effort (CPUE) data were log-normal distributed.

Beach seine hauls were conducted using a 36.6 m long 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.

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.

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.

A 1.22 m Maine fyke net with 30.48 m leads 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 four hours after high tide.

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 four-hour sample periods.

Fish captured by the various gears 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 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. Diversity indices were calculated by month for each site, channel, and habitat type. 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 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, temperature, conductivity, and pH were measured monthly at the beginning of each sampling set using a YSI 556 MPS multi-meter. Water samples were collected 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). Eighty 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 inverse of the percentage of coarse material. Percent fines from the three samples were then averaged for each site.

Results

Sampling Gear

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*).

For this progress report, only the trawl data were analyzed and presented. Analyses of all data for all gear types will be presented in the final report. As of July 31 2004, a total of 172 trawl sample (3 sets per sample = 516 individual trawl sets) were made in the study area (Table 1, Appendix 1). Due to boat problems and inclement weather, sampling during November 2003 and March 2004 was infrequent. As such, data from these two months were not included in analyses (Table 1).

Table 1. List of sites sampled during the first year of study. An X denotes a site that was sampled with shrimp trawl. Habitat types are as follows: MCEG = mariculture with eelgrass; MCNG = mariculture with no eelgrass; NCEG = no mariculture with eelgrass; NCNG = no mariculture no eelgrass.

Site	Habitat	Sampling Effort (August 2003 – July 2004)											
		A	S	O	N	D	J	F	M	A	M	J	J
MR1	NCNG	X	X			X	X	X					
MR2	NCEG	X	X	X		X	X	X		X		X	X
MR3	NCEG	X	X	X		X	X	X					
MR4	MCEG	X	X	X		X	X	X					X
MR5	MCEG	X	X	X		X	X	X			X	X	X
MR6	MCEG	X	X	X		X	X	X					X
MR7	NCEG	X	X	X		X	X	X					
MR8	NCNG	X	X	X		X	X	X		X	X		X
SI1	NCEG	X	X	X		X	X	X		X			X
SI2	MCEG	X	X	X		X	X	X			X	X	X
SI3	NCEG	X	X	X		X	X	X		X			X
SI4	MCEG	X	X	X		X	X	X			X	X	X
AC1	MCEG	X	X	X	X		X	X		X			X
AC2	MCEG	X	X	X	X		X	X			X	X	X
AC3	MCEG	X	X	X		X	X	X					X
AC4	NCEG	X	X	X		X	X	X		X	X	X	X
EB1	NCNG	X	X			X	X	X	X	X		X	X
EB2	MCNG	X	X	X		X	X	X		X	X		X
EB3	MCEG	X	X	X	X		X	X	X				
EB4	NCEG	X	X	X	X		X	X			X	X	X

Species Captured

A total of 47 fish species representing 22 families were collected during the study (Table 2), including juveniles from many of the taxa captured (Table 2). Most of the species captured, 62% by number of species and 50% by number of individuals, were classified as resident species based on information reported by Gotshall et al. (1982). Forty-nine percent of the total number of individuals captured was considered to be using Humboldt Bay as a nursery (Gotshall et al. 1982), representing only 4% of the total number of species captured.

The dominant resident species in trawl catches was English sole *Parophrys vetulus* (49% of the total catch), shiner surfperch *Cymatogaster aggregata* (27% of the total catch), speckled sanddab *Citharichthys stigmaeus* (8% of the total catch), bay goby *Lepidogobius lepidus* (3% of the total catch), and walleye surfperch *Hyperprosopon argenteum* (3% of the total catch), totaling 90% of the individual fish captured.

Table 2. List of fish species collected in trawl samples from Humboldt Bay as of July 31, 2004. 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	2
	Jacksmelt	*Atherinops californiensis*	Feeding	Adult	1
Aulorhynchidae	Tubesnout	*Aulorhynchus flavidus*	Resident	Adult, Juvenile	33
Batrachoididae	Plainfin midshipman	*Porichthys notatus*	Resident	Adult, Juvenile	29
Bothidae	Speckled Sanddab	*Citharichthys stigmaeus*	Resident	Adult, Juvenile	763
	California Halibut	*Paralichthys californicus*	Occasional Visitor	Juvenile	1
Carcharhinidae	Brown Smoothhound	*Mustelus henlei*	Resident	Adult	2
	Leopard Shark	*Triakis semifasciata*	Resident	Adult	1
Clupeidae	Pacific Herring	*Clupea harengus*	Resident	Adult, Juvenile	78
	American Shad	*Alosa sapidissima*	Occasional Visitor	Juvenile	3
	Pacific Sardine	*Sardinops sagax caeruleus*	Occasional Visitor	Juvenile	2
Cottidae	Staghorn Sculpin	*Leptocottus armatus*	Resident	Adult, Juvenile	96
	Cabezon	*Scorpaenichthys marmoratus*	Resident	Juvenile	6
	Buffalo Sculpin	*Enophrys bison*	Resident	Adult, Juvenile	2
Cynoglossidae	California Tonguefish	*Symphurus atricauda*	Occasional Visitor	Adult	1
Embiotocidae	Redtail Surfperch	*Amphistichus rhodoterus*	Feeding	Adult	3
	Shiner Surfperch	*Cymatogaster aggregate*	Resident	Adult, Juvenile	2,467
	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	233
	White Surfperch	*Phanerodon furcatus*	Spawning	Adult	17
	Pile Surfperch	*Damalichthys vacca*	Resident	Adult, Juvenile	56
Engraulididae	Northern Anchovy	*Engraulis mordax*	Resident	Adult, Juvenile	155
Gadidae	Pacific Tomcod	*Microgadus proximus*	Feeding	Adult	6
Gasterosteidae	Threespine Stickleback	*Gasterosteus aculeatus*	Resident	Adult, Juvenile	5
Gobiidae	Bay Goby	*Lepidogobius lepidus*	Resident	Adult, Juvenile	243
	Arrow Goby	*Clevelandia ios*	Resident	Adult, Juvenile	3
	Blackeye Goby	*Coryphopterus nicholsii*	Resident	Adult	3
Hexagrammidae	Kelp Greenling	*Hexagrammos decagrammus*	Spawning	Adult	2
	Lingcod	*Ophiodon elongates*	Feeding, Nursery	Juvenile	14
Liparididae	Slimy snailfish	*Liparis mucosus*	Resident	Adult	2
Myliobatididae	Bat Ray	*Myliobatis californica*	Feeding, Nursery, Spawning	Adult	8
Osmeridae	Night Smelt	*Spirinchus starksi*	Feeding	Adult	1
	Surf Smelt	*Hypomesus pretiosus*	Feeding	Adult, Juvenile	3
	Longfin Smelt	*Spirinchus thaleichthys*	Feeding	Adult	8
Pholidae	Saddleback Gunnel	*Pholis ornate*	Resident	Adult, Juvenile	28
	Penpoint Gunnel	*Apodichthys flavidus*	Resident	Adult	1
Pleuronectidae	Curlfin Turbot	*Pleuronichthys decurrens*	Nursery	Juvenile	2
	English sole	*Parophrys vetulus*	Nursery	Juvenile	4,511
	Starry Flounder	*Platichthys stellatus*	Resident	Adult, Juvenile	23
Scorpaenidae	Juvenile Rockfish Species	*Sebastes* spp.	Resident	Juvenile	27
	Copper rockfish	*Sebastes caurinus*	Resident	Juvenile	18
	Black Rockfish	*Sebastes melanops*	Resident	Juvenile	36
	Grass Rockfish	*Sebastes rastrelliger*	Resident	Juvenile	2
	Bocaccio Rockfish	*Sebastes paucispinis*	Feeding	Juvenile	1
Syngnathidae	Bay Pipefish	*Syngnathus leptorhynchus*	Resident	Adult, Juvenile	152

Catch per Unit Effort

A seasonal change in the CPUE for the trawl data was observed, ranging from 1.3 fish/trawl set in December 2003 to 103.2 fish/trawl set in June 2004 (Figure 2). Catch per unit effort also varied by habitat type (Figure 3).

Fish Community Analyses

Species Richness pooled by month ranged from 13 species in December 2003 to 27 species in May 2004 (Figure 4) and varied by habitat type (Table 3). Species richness data from individual sites pooled over the course of the study ranged from 8 species at MR3 to 25 species at MR8 (Figure 5).

Both the Simpson (Figure 6) and Shannon-Wiener (Figure 7) diversity indices varied by habitat type and month. Paired t-tests showed no significant difference ($p = 0.011$) in the H' index between trawl and purse seine hauls, and no significant difference ($p=0.065$) in the D index between trawl and purse seine hauls. There were no significant differences ($p=0.132$) between fyke net and trawl diversity indices.

Water Quality

Over the course of study, salinity ranged from 20.04 ppt in February 2004 to 36.98 ppt in April 2004 (Figure 8). Water temperature ranged 10°C in February 2004 to 21°C in July 2004 (Figure 9). Turbidity ranged from 1.34 ntu in November 2003 to 24.3 ntu in May 2004 (Figure 10).

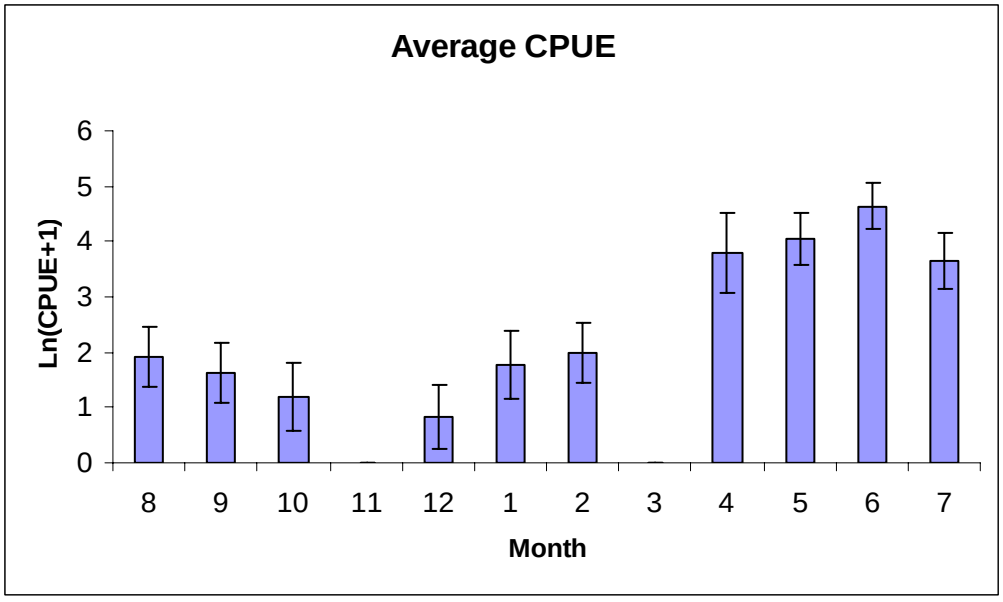

Figure 2. Monthly mean natural log of catch per unit effort (CPUE) of shrimp trawls conducted in North Humboldt Bay, California between August 2003 and July 2004. Error bars are equal to one standard deviation of the mean.

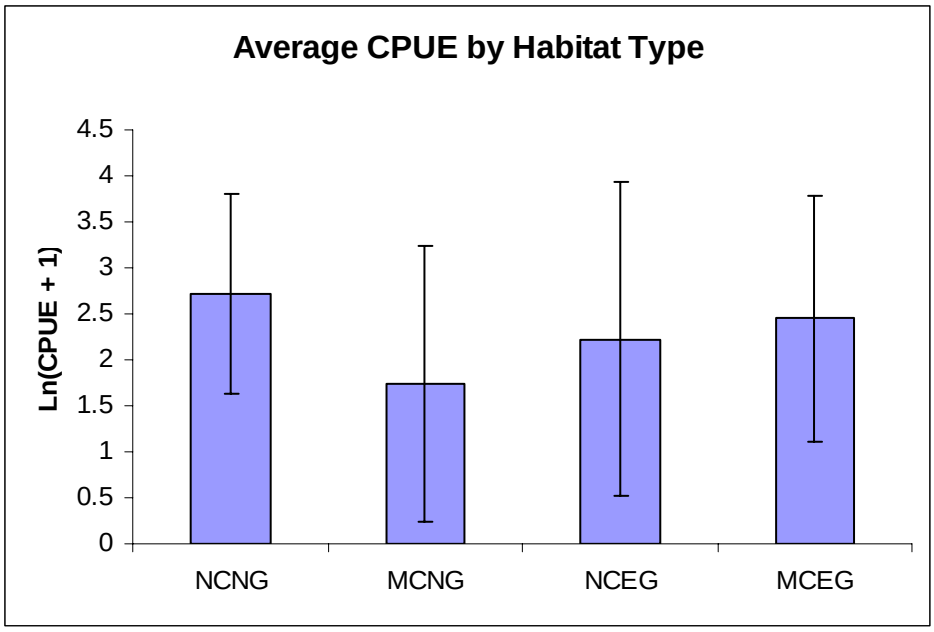

Figure 3. Mean natural log of shrimp trawl catch per unit effort (CPUE) by habitat type on North Humboldt Bay, California between August 2003 and July 2004. Error bars equal to one standard deviation of the mean. Habitat types are indicated by: NCNG = no mariculture, no eelgrass; MCNG = mariculture, no eelgrass; NCEG = no mariculture, with eelgrass; and MCEG = mariculture with eelgrass.

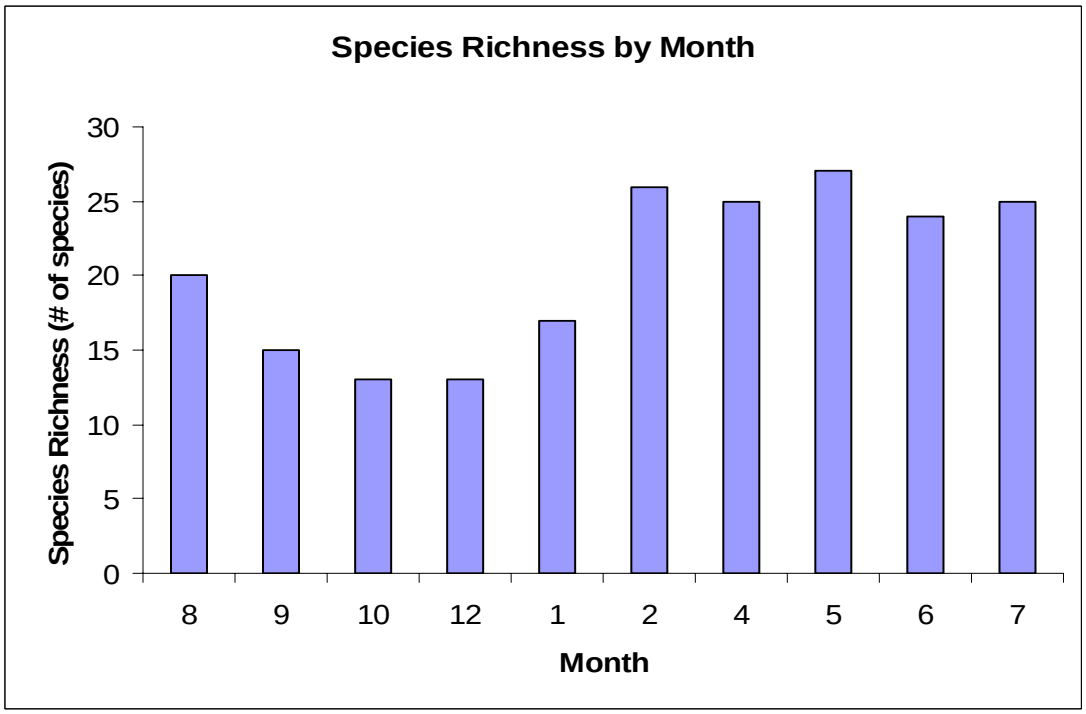

Figure 4. Monthly species richness (number of species) from shrimp trawl catches conducted on North Humboldt Bay, California between August 2003 and July 2004.

Table 3. Species Richness (number of species) by habitat type from shrimp trawl catches conducted on North Humboldt Bay, California between August 2003 and July 2004.

Habitat Type	Number of Fish Species
No Mariculture, No Eelgrass	34
Mariculture, No Eelgrass	26
No Mariculture, Eelgrass	35
Mariculture, Eelgrass	40

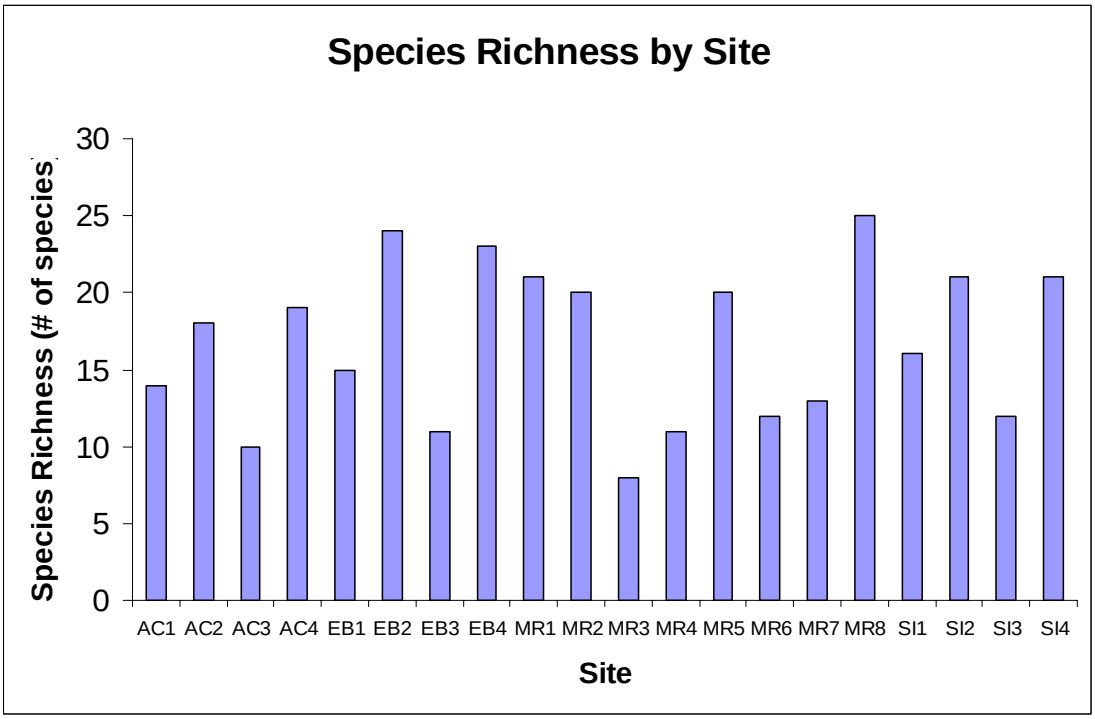

Figure 5. Species richness (number of species) from shrimp trawl catches for sampling sites on Humboldt Bay, California between August 2003 and July 2004.

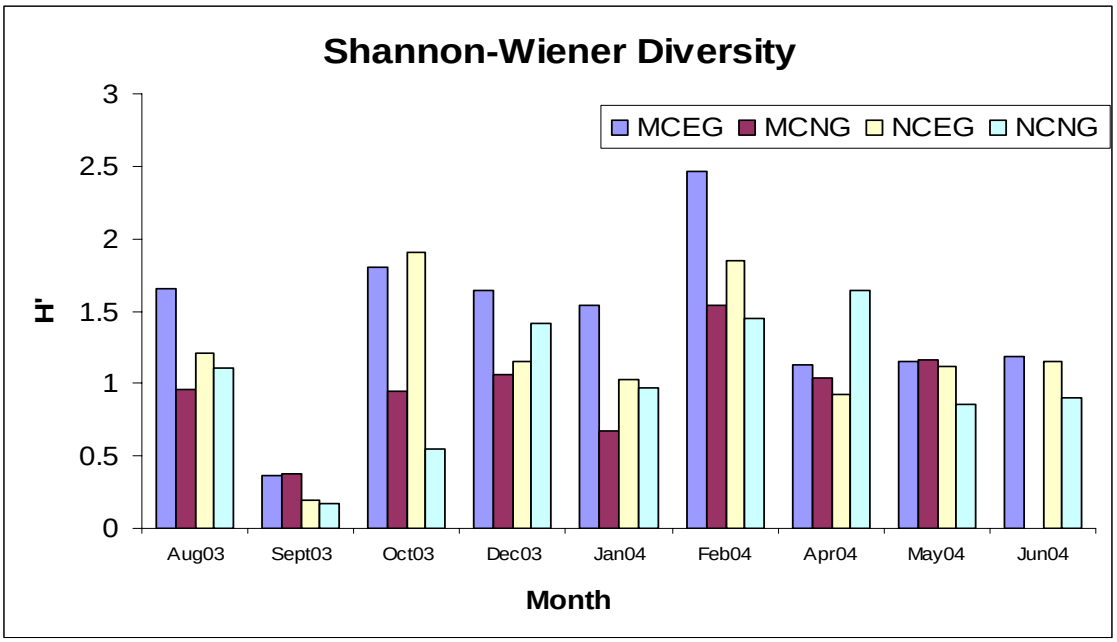

Figure 6. Monthly Shannon-Wiener diversity indices (H') of fish species from shrimp trawls catches conducted in different habitat types in Humboldt Bay, California between August 2003 and July 2004. Habitat types are indicated by: MCEG = mariculture with eelgrass; MCNG = mariculture, no eelgrass; NCEG = no mariculture, with eelgrass; and NCNG = no mariculture, no eelgrass.

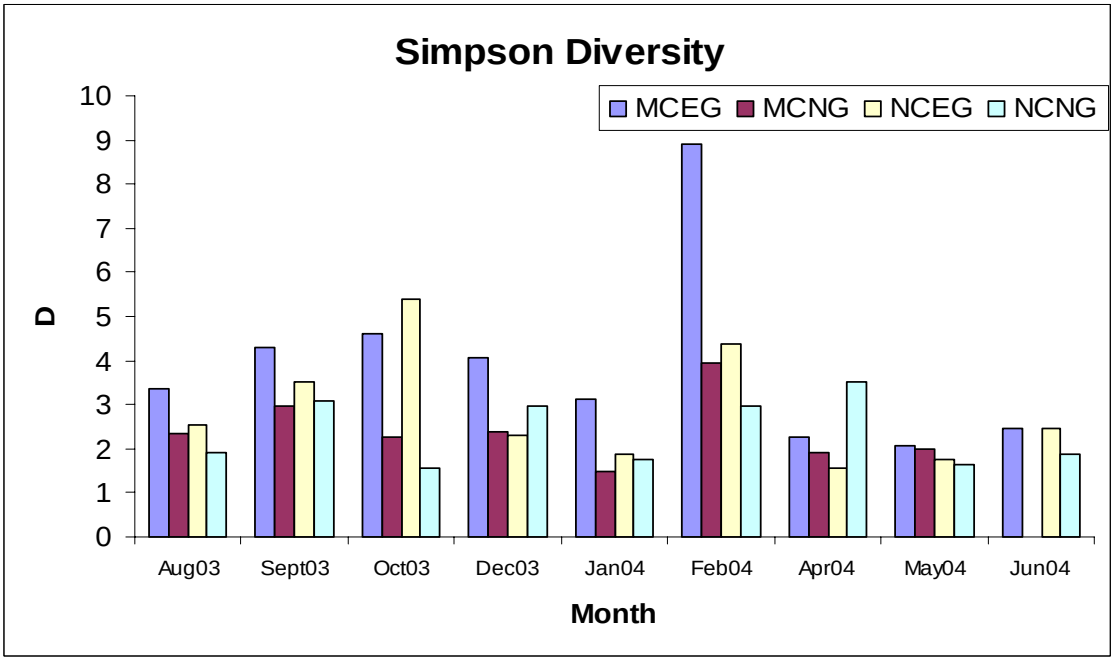

Figure 7. Monthly Simpson diversity indices (D) of fish species from shrimp trawl catches conducted in different habitat types in Humboldt Bay, California between August 2003 and July 2004. Habitat types are indicated by: MCEG = mariculture with eelgrass; MCNG = mariculture, no eelgrass; NCEG = no mariculture, with eelgrass; and NCNG = no mariculture, no eelgrass.

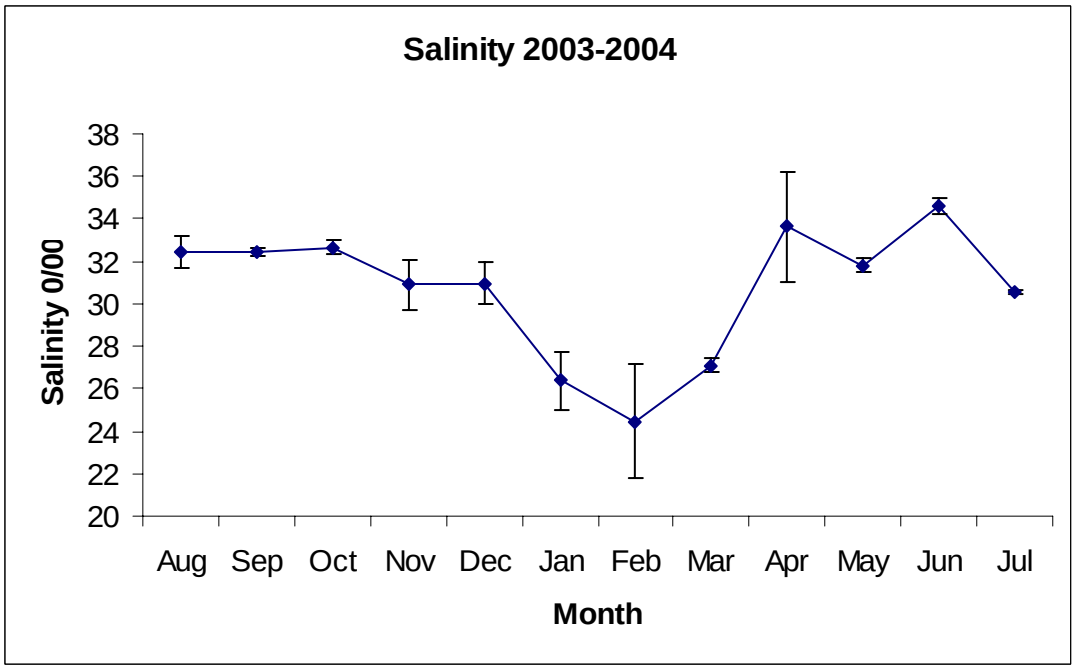

Figure 8. Monthly mean salinity measured at 20 shrimp trawl sampling sites on Humboldt Bay, California between August 2003 and July 2004. Error bars are equal to one standard deviation of the mean.

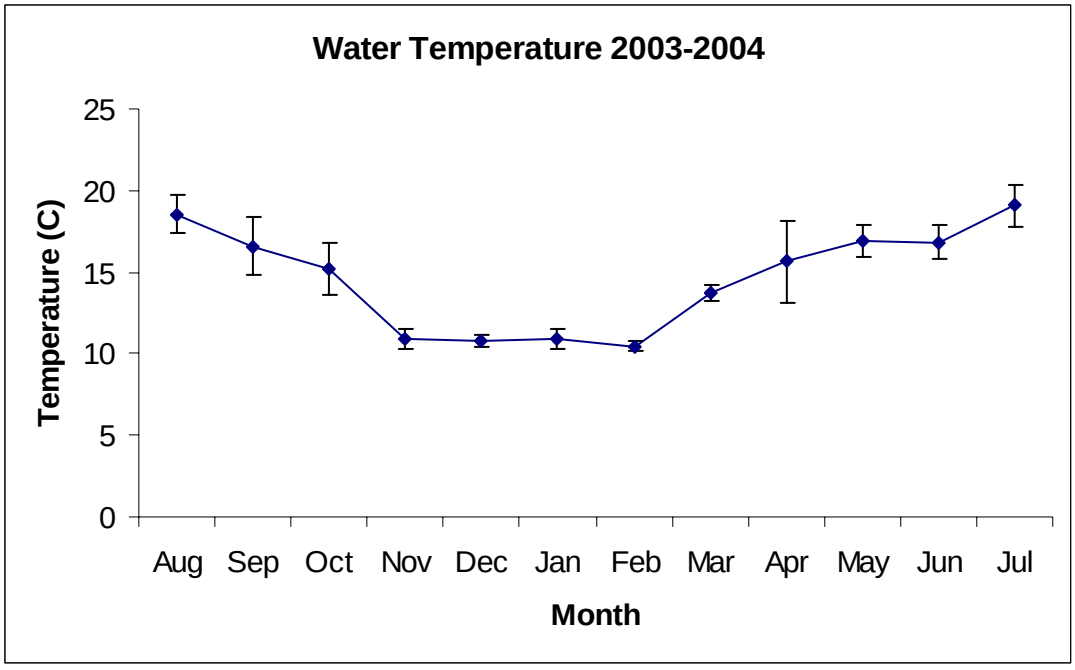

Figure 9. Monthly mean water temperature (C) measured at 20 shrimp trawl sampling sites on Humboldt Bay, California between August 2003 and July 2004. Error bars are equal to one standard deviation of the mean.

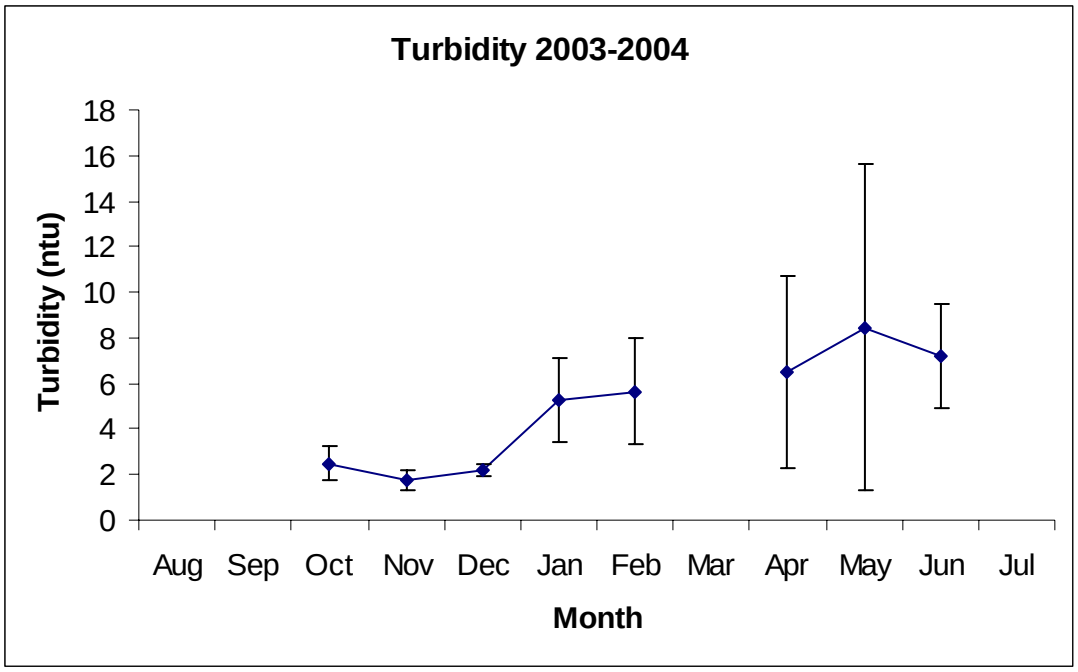

Figure 10. Monthly mean turbidity measured at 20 shrimp trawl sampling sites on Humboldt Bay, California between August 2003 and July 2004. Error bars are equal to one standard deviation of the mean.

Sediment

Percent fines in sediment samples ranged from about 44% in October 2003 at MR1 and AC2 to 92 % in May 2004 at SI3 (Table 4).

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

It was difficult to collect fish samples in shallow areas of Humboldt Bay, which included all oyster culture sites. Mud in North Humboldt Bay made sampling outside of a boat both hazardous and time consuming. The shallow nature of the majority of North Humboldt Bay coupled with rapid tide changes and strong currents hampered sampling over flats. The shrimp trawl proved to be the easiest gear type to deploy and could be retrieved with two crew members. Other sampling gears (purse seine, beach seine, and fyke net) required three to four persons to set and retrieve. The beach seine was an effective gear at low tides, but was cumbersome to operate because of the thick mud on the edges of the channels. Although the beach seine was effective, it resulted in some mortality to fishes as mud was also collected in the net when it was retrieved. The purse seine was effective at capturing schooling mid-water fish species but captured benthic species only when deployed in shallow water due to the limited depth of the net. The cast

net was one of the least effective of the gears used. Deployment of the cast net was difficult and required a considerable skill. The Maine fyke net proved to be an effective sampling device over flats, but could not be deployed in water deeper than 2 m. The fyke net required three crew members to deploy and retrieve and captured both benthic and mid-water species. Unbaited minnow traps were easy to deploy and retrieve, but were selective.

Recommendations

Based on the first year of sampling we recommend the following studies that would enhance the information currently collected in this study.

Fyke Nets in Sites Draining Eelgrass Bed

Experimental sampling techniques used within North Humboldt Bay during the 2004 field season revealed that fyke nets with wings effectively sampled fish exiting flats during ebb tides. Additional effort using this technique, throughout the year, would improve our understanding of the role of eelgrass and potential benefits or detriments of oyster culture operations on fish habitats.

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. Past sampling efforts in Humboldt Bay have been relatively unsuccessful at capturing juvenile salmonids, 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

We would like to thank the Humboldt Bay Harbor, Recreation and Conservation District and NOAA Fisheries for providing the funding to conduct this study. We would also like to thank Kirsten Acker, Forrest Cottrell, Anthony Heacock, Cornelius Hughey, Michael Reichmuth, and Anthony Scheiff for their field work.

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Appendix

Appendix A. Date, location, gear type and tide conditions during fish community sampling on North Humboldt Bay, California between August 2003 and July 2004.

Date	Start Time	Sets	Site	Method	Tide	Longitude	Latitude	Flats_Channel
8/6/2003	12:12	3	EB1	Trawl	Flood	-124.148375255367	40.8193000754906	In Main Channel Adjacent
8/6/2003	13:28	3	EB2	Trawl	Slack	-124.141577847619	40.8202811251177	In Main Channel Adjacent
8/14/2003	11:19	1	EB3	Trawl	Flood	-124.133444882069	40.8252337591523	In Main Channel Adjacent
8/21/2003	12:50	3	EB3	Trawl	Slack	-124.133444882069	40.8252337591523	In Main Channel Adjacent
8/22/2003	10:31	3	EB4	Trawl	Slack	-124.117276060519	40.829198088562	In Main Channel Adjacent
8/21/2003	9:15	3	AC1	Trawl	Slack	-124.139036710822	40.8298988468258	In Main Channel Adjacent
8/21/2003	11:37	3	AC2	Trawl	Ebb	-124.13660701282	40.8284763106435	In Main Channel Adjacent
8/21/2003	10:30	3	AC3	Trawl	Ebb	-124.121514135874	40.8368462663624	In Main Channel Adjacent
8/22/2003	12:21	3	AC4	Trawl	Ebb	-124.117608133923	40.8370364413526	In Main Channel Adjacent
8/28/2003	15:20	3	SI1	Trawl	Ebb	-124.143360046737	40.8306935233796	In Main Channel Adjacent
8/28/2003	12:35	3	SI2	Trawl	Flood	-124.141872577485	40.831621837781	In Main Channel Adjacent
8/28/2003	14:33	3	SI3	Trawl	Slack	-124.137963062713	40.837446477822	In Main Channel Adjacent
8/28/2003	13:33	3	SI4	Trawl	Flood	-124.13466359803	40.8379357715106	In Main Channel Adjacent
8/29/2003	9:13	3	MR1	Trawl	Flood	-124.15820540966	40.8321643945226	In Main Channel Adjacent
8/27/2003	9:38	3	MR2	Trawl	Flood	-124.153170016206	40.8357728183475	In Main Channel Adjacent
8/27/2003	11:19	3	MR3	Trawl	Flood	-124.147645836985	40.8409287279242	In Main Channel Adjacent
8/27/2003	12:39	3	MR4	Trawl	Flood	-124.144768769356	40.8484943356224	In Main Channel Adjacent
8/27/2003	13:19	3	MR5	Trawl	Slack	-124.142292513321	40.8444077864745	In Main Channel Adjacent
8/27/2003	12:10	3	MR6	Trawl	Ebb	-124.147474270293	40.8426053282299	In Main Channel Adjacent
8/28/2003	11:09	3	MR7	Trawl	Flood	-124.155935885362	40.8360328272903	In Main Channel Adjacent
8/29/2003	8:39	3	MR8	Trawl	Slack	-124.16033213272	40.8330172414492	In Main Channel Adjacent
9/24/2003	8:56	3	EB1	Trawl	Flood	-124.148375255367	40.8193000754906	In Main Channel Adjacent
9/24/2003	9:46	3	EB2	Trawl	Flood	-124.141577847619	40.8202811251177	In Main Channel Adjacent
10/1/2003	12:46	3	EB3	Trawl	Flood	-124.133444882069	40.8252337591523	In Main Channel Adjacent
9/22/2003	14:17	3	EB4	Trawl	Ebb	-124.117276060519	40.829198088562	In Main Channel Adjacent
9/30/2003	12:01	3	MR1	Trawl	Ebb	-124.15820540966	40.8321643945226	In Main Channel Adjacent
9/30/2003	13:11	3	MR2	Trawl	Flood	-124.153170016206	40.8357728183475	In Main Channel Adjacent

Appendix A, continued. Date, location, gear type and tide conditions during fish community sampling on North Humboldt Bay, California between August 2003 and July 2004.

Date	Start Time	Sets	Site	Method	Tide	Longitude	Latitude	Flats_Channel
9/23/2003	13:30	3	MR4	Trawl	Ebb	-124.144768769356	40.8484943356224	In Main Channel Adjacent
9/23/2003	12:45	3	MR5	Trawl	Ebb	-124.142292513321	40.8444077864745	In Main Channel Adjacent
9/29/2003	10:13	3	MR6	Trawl	Flood	-124.147474270293	40.8426053282299	In Main Channel Adjacent
9/29/2003	11:09	3	MR7	Trawl	Flood	-124.155935885362	40.8360328272903	In Main Channel Adjacent
9/29/2003	11:50	3	MR8	Trawl	Flood	-124.16033213272	40.8330172414492	In Main Channel Adjacent
9/24/2003	10:35	3	AC1	Trawl	Flood	-124.139036710822	40.8298988468258	In Main Channel Adjacent
9/24/2003	11:38	3	AC2	Trawl	Slack	-124.13660701282	40.8284763106435	In Main Channel Adjacent
9/22/2003	13:05	3	AC3	Trawl	Ebb	-124.121514135874	40.8368462663624	In Main Channel Adjacent
9/22/2003	12:10	3	AC4	Trawl	Ebb	-124.117608133923	40.8370364413526	In Main Channel Adjacent
9/24/2003	13:20	3	SI1	Trawl	Slack	-124.143360046737	40.8306935233796	In Main Channel Adjacent
9/24/2003	12:25	3	SI2	Trawl	Slack	-124.141872577485	40.831621837781	In Main Channel Adjacent
9/23/2003	11:55	3	SI3	Trawl	Slack	-124.137963062713	40.837446477822	In Main Channel Adjacent
9/23/2003	11:07	3	SI4	Trawl	Flood	-124.13466359803	40.8379357715106	In Main Channel Adjacent
11/3/2003	13:25	3	EB2	Trawl	Ebb	-124.141577847619	40.8202811251177	In Main Channel Adjacent
11/3/2003	12:44	3	EB3	Trawl	Ebb	-124.133444882069	40.8252337591523	In Main Channel Adjacent
10/20/2003	13:34	3	EB4	Trawl	Ebb	-124.117276060519	40.829198088562	In Main Channel Adjacent
10/21/2003	12:12	3	AC1	Trawl	Ebb	-124.139036710822	40.8298988468258	In Main Channel Adjacent
10/21/2003	14:17	3	AC2	Trawl	Ebb	-124.13660701282	40.8284763106435	In Main Channel Adjacent
10/21/2003	14:29	2	AC3	Trawl	Ebb	-124.121514135874	40.8368462663624	In Main Channel Adjacent
10/21/2003	11:03	3	AC4	Trawl	Slack	-124.117608133923	40.8370364413526	In Main Channel Adjacent
10/22/2003	12:22	3	SI1	Trawl	Ebb	-124.143360046737	40.8306935233796	In Main Channel Adjacent
10/22/2003	13:10	3	SI2	Trawl	Ebb	-124.141872577485	40.831621837781	In Main Channel Adjacent
10/22/2003	10:13	3	SI3	Trawl	Flood	-124.137963062713	40.837446477822	In Main Channel Adjacent
10/22/2003	11:11	3	SI4	Trawl	Slack	-124.13466359803	40.8379357715106	In Main Channel Adjacent
10/27/2003	13:30	3	MR2	Trawl	Slack	-124.153170016206	40.8357728183475	In Main Channel Adjacent
10/27/2003	11:20	3	MR3	Trawl	Flood	-124.147645836985	40.8409287279242	In Main Channel Adjacent
10/27/2003	10:29	3	MR4	Trawl	Flood	-124.144768769356	40.8484943356224	In Main Channel Adjacent
10/27/2003	9:41	3	MR5	Trawl	Flood	-124.142292513321	40.8444077864745	In Main Channel Adjacent
10/27/2003	12:03	3	MR6	Trawl	Flood	-124.147474270293	40.8426053282299	In Main Channel Adjacent

Appendix A, continued. Date, location, gear type and tide conditions during fish community sampling on North Humboldt Bay, California between August 2003 and July 2004.

Date	Start Time	Sets	Site	Method	Tide	Longitude	Latitude	Flats_Channel
11/4/2003	11:52	2	MR8	Trawl	Ebb	-124.16033213272	40.8330172414492	In Main Channel Adjacent
12/10/2003	12:25	3	EB2	Trawl	Slack	-124.141577847619	40.8202811251177	In Main Channel Adjacent
12/10/2003	11:26	3	EB1	Trawl	Slack	-124.148375255367	40.8193000754906	In Main Channel Adjacent
12/8/2003	14:15	3	SI4	Trawl	Ebb	-124.13466359803	40.8379357715106	In Main Channel Adjacent
12/8/2003	13:36	3	SI3	Trawl	Ebb	-124.137963062713	40.837446477822	In Main Channel Adjacent
12/8/2003	12:51	3	AC3	Beam Trawl	Slack	-124.121514135874	40.8368462663624	In Main Channel Adjacent
12/8/2003	10:53	3	AC4	Trawl	Slack	-124.117608133923	40.8370364413526	In Main Channel Adjacent
12/3/2003	12:30	3	SI1	Trawl	Ebb	-124.143360046737	40.8306935233796	In Main Channel Adjacent
12/3/2003	13:13	3	SI2	Trawl	Ebb	-124.141872577485	40.831621837781	In Main Channel Adjacent
11/22/2003	11:17	3	EB3	Trawl	Ebb	-124.133444882069	40.8252337591523	In Main Channel Adjacent
11/22/2003	10:13	3	EB4	Trawl	Slack	-124.117276060519	40.829198088562	In Main Channel Adjacent
11/25/2003	11:19	3	AC1	Trawl	Flood	-124.139036710822	40.8298988468258	In Main Channel Adjacent
11/25/2003	10:27	3	AC2	Trawl	Flood	-124.13660701282	40.8284763106435	In Main Channel Adjacent
12/3/2003	11:38	3	MR1	Trawl	Ebb	-124.15820540966	40.8321643945226	In Main Channel Adjacent
12/1/2003	13:41	3	MR2	Trawl	Slack	-124.153170016206	40.8357728183475	In Main Channel Adjacent
12/1/2003	12:51	3	MR3	Trawl	Slack	-124.147645836985	40.8409287279242	In Main Channel Adjacent
12/1/2003	11:22	3	MR4	Trawl	Ebb	-124.144768769356	40.8484943356224	In Main Channel Adjacent
12/1/2003	10:29	3	MR5	Trawl	Ebb	-124.142292513321	40.8444077864745	In Main Channel Adjacent
12/1/2003	12:09	3	MR6	Trawl	Ebb	-124.147474270293	40.8426053282299	In Main Channel Adjacent
12/1/2003	14:23	3	MR7	Trawl	Flood	-124.155935885362	40.8360328272903	In Main Channel Adjacent
12/2/2003	12:37	2	MR7	Trawl	Ebb	-124.155935885362	40.8360328272903	In Main Channel Adjacent
12/3/2003	10:32	3	MR8	Trawl	Ebb	-124.16033213272	40.8330172414492	In Main Channel Adjacent
1/28/2004	12:39	3	EB3	Trawl	Flood	-124.133444882069	40.8252337591523	In Main Channel Adjacent
1/28/2004	11:39	3	EB4	Trawl	Slack	-124.117276060519	40.829198088562	In Main Channel Adjacent
1/28/2004	9:49	3	AC4	Trawl	Ebb	-124.117608133923	40.8370364413526	In Main Channel Adjacent
1/23/2004	12:22	3	SI2	Trawl	Slack	-124.141872577485	40.831621837781	In Main Channel Adjacent
1/23/2004	11:29	3	SI3	Trawl	Flood	-124.137963062713	40.837446477822	In Main Channel Adjacent
1/23/2004	10:29	3	SI4	Trawl	Flood	-124.13466359803	40.8379357715106	In Main Channel Adjacent
1/13/2004	12:26	3	EB2	Trawl	Flood	-124.141577847619	40.8202811251177	In Main Channel Adjacent

Appendix A, continued. Date, location, gear type and tide conditions during fish community sampling on North Humboldt Bay, California between August 2003 and July 2004.

Date	Start Time	Sets	Site	Method	Tide	Longitude	Latitude	Flats_Channel
1/13/2004	10:47	3	EB1	Trawl	Flood	-124.148375255367	40.8193000754906	In Main Channel Adjacent
1/16/2004	11:59	3	MR8	Trawl	Ebb	-124.16033213272	40.8330172414492	In Main Channel Adjacent
1/16/2004	10:11	3	MR7	Trawl	Ebb	-124.155935885362	40.8360328272903	In Main Channel Adjacent
1/15/2004	12:22	3	MR6	Trawl	Slack	-124.147474270293	40.8426053282299	In Main Channel Adjacent
1/15/2004	9:59	3	MR5	Trawl	Ebb	-124.142292513321	40.8444077864745	In Main Channel Adjacent
1/15/2004	10:59	3	MR4	Trawl	Ebb	-124.144768769356	40.8484943356224	In Main Channel Adjacent
1/15/2004	13:18	3	MR3	Trawl	Flood	-124.147645836985	40.8409287279242	In Main Channel Adjacent
1/16/2004	10:59	3	MR2	Trawl	Ebb	-124.153170016206	40.8357728183475	In Main Channel Adjacent
1/16/2004	12:55	3	MR1	Trawl	Slack	-124.15820540966	40.8321643945226	In Main Channel Adjacent
1/29/2004	9:45	3	AC1	Trawl	Ebb	-124.139036710822	40.8298988468258	In Main Channel Adjacent
1/29/2004	12:00	3	SI1	Trawl	Slack	-124.143360046737	40.8306935233796	In Main Channel Adjacent
1/28/2004	10:41	3	AC3	Trawl	Slack	-124.121514135874	40.8368462663624	In Main Channel Adjacent
1/29/2004	10:43	3	AC2	Trawl	Slack	-124.13660701282	40.8284763106435	In Main Channel Adjacent
2/5/2004	12:30	3	SI1	Trawl	Ebb	-124.143360046737	40.8306935233796	In Main Channel Adjacent
2/27/2004	13:47	3	AC1	Trawl	Flood	-124.139036710822	40.8298988468258	In Main Channel Adjacent
2/28/2004	13:49	3	AC2	Trawl	Slack	-124.13660701282	40.8284763106435	In Main Channel Adjacent
2/4/2004	11:36	3	AC3	Trawl	Ebb	-124.121514135874	40.8368462663624	In Main Channel Adjacent
2/4/2004	10:27	3	AC4	Trawl	Slack	-124.117608133923	40.8370364413526	In Main Channel Adjacent
2/27/2004	9:46	3	EB1	Trawl	Ebb	-124.148375255367	40.8193000754906	In Main Channel Adjacent
2/27/2004	10:42	3	EB2	Trawl	Slack	-124.141577847619	40.8202811251177	In Main Channel Adjacent
2/27/2004	12:30	3	EB3	Trawl	Slack	-124.133444882069	40.8252337591523	In Main Channel Adjacent
2/27/2004	11:38	3	EB4	Trawl	Slack	-124.117276060519	40.829198088562	In Main Channel Adjacent
2/24/2004	12:04	1	EB4	Trawl	Flood	-124.117276060519	40.829198088562	In Main Channel Adjacent
2/19/2004	9:51	3	MR1	Trawl	Flood	-124.15820540966	40.8321643945226	In Main Channel Adjacent
2/28/2004	12:39	3	MR2	Trawl	Slack	-124.153170016206	40.8357728183475	In Main Channel Adjacent
2/28/2004	11:52	3	MR3	Trawl	Ebb	-124.147645836985	40.8409287279242	In Main Channel Adjacent
2/10/2004	12:17	3	MR4	Trawl	Flood	-124.144768769356	40.8484943356224	In Main Channel Adjacent
2/10/2004	11:19	3	MR5	Trawl	Flood	-124.142292513321	40.8444077864745	In Main Channel Adjacent

Appendix A, continued. Date, location, gear type and tide conditions during fish community sampling on North Humboldt Bay, California between August 2003 and July 2004.

Date	Start Time	Sets	Site	Method	Tide	Longitude	Latitude	Flats_Channel
2/28/2004	10:20	3	MR6	Trawl	Ebb	-124.147474270293	40.8426053282299	In Main Channel Adjacent
2/19/2004	12:25	3	MR7	Trawl	Ebb	-124.155935885362	40.8360328272903	In Main Channel Adjacent
2/19/2004	11:22	3	MR8	Trawl	Slack	-124.16033213272	40.8330172414492	In Main Channel Adjacent
2/5/2004	13:30	3	SI2	Trawl	Ebb	-124.141872577485	40.831621837781	In Main Channel Adjacent
2/5/2004	11:39	3	SI3	Trawl	Ebb	-124.137963062713	40.837446477822	In Main Channel Adjacent
2/5/2004	10:33	3	SI4	Trawl	Slack	-124.13466359803	40.8379357715106	In Main Channel Adjacent
3/10/2004	10:23	3	EB1	Trawl	Flood	-124.148375255367	40.8193000754906	In Main Channel Adjacent
3/12/2004	11:14	3	EB3	Trawl	Flood	-124.133444882069	40.8252337591523	In Main Channel Adjacent
3/10/2004	10:23	3	EB1	Trawl	Flood	-124.148375255367	40.8193000754906	In Main Channel Adjacent
3/12/2004	11:14	3	EB3	Trawl	Flood	-124.133444882069	40.8252337591523	In Main Channel Adjacent
4/30/2004	13:10	3	AC4	Trawl	Ebb	-124.117608133923	40.8370364413526	In Main Channel Adjacent
4/30/2004	15:09	3	EB2	Trawl	Slack	-124.141577847619	40.8202811251177	In Main Channel Adjacent
4/27/2004	10:37	3	EB4	Trawl	Ebb	-124.117276060519	40.829198088562	In Main Channel Adjacent
4/30/2004	16:14	3	AC1	Trawl	Flood	-124.139036710822	40.8298988468258	In Main Channel Adjacent
4/30/2004	12:17	3	SI1	Trawl	Ebb	-124.143360046737	40.8306935233796	In Main Channel Adjacent
4/30/2004	11:15	3	SI3	Trawl	Ebb	-124.137963062713	40.837446477822	In Main Channel Adjacent
4/16/2004	9:25	3	MR2	Trawl	Flood	-124.153170016206	40.8357728183475	Over Flats
5/12/2004	11:44	3	SI2	Trawl	Slack	-124.141872577485	40.831621837781	In Main Channel Adjacent
5/12/2004	8:43	3	AC4	Trawl	Slack	-124.117608133923	40.8370364413526	In Main Channel Adjacent
4/16/2004	15:08	3	MR2	Trawl	Ebb	-124.153170016206	40.8357728183475	In Main Channel Adjacent
4/16/2004	10:24	3	MR8	Trawl	Flood	-124.16033213272	40.8330172414492	Over Flats
4/16/2004	14:09	3	MR8	Trawl	Ebb	-124.16033213272	40.8330172414492	In Main Channel Adjacent
4/15/2004	10:04	3	EB1	Trawl	Flood	-124.148375255367	40.8193000754906	Over Flats
4/15/2004	10:53	3	EB2	Trawl	Slack	-124.141577847619	40.8202811251177	In Main Channel Adjacent
5/5/2004	10:18	3	EB4	Trawl	Flood	-124.117276060519	40.829198088562	In Main Channel Adjacent
5/5/2004	8:44	3	EB2	Trawl	Flood	-124.141577847619	40.8202811251177	In Main Channel Adjacent
5/12/2004	10:05	3	SI4	Trawl	Ebb	-124.13466359803	40.8379357715106	In Main Channel Adjacent
5/13/2004	10:26	2	MR8	Trawl	Ebb	-124.16033213272	40.8330172414492	In Main Channel Adjacent
5/13/2004	9:23	3	MR5	Trawl	Ebb	-124.142292513321	40.8444077864745	In Main Channel Adjacent

Appendix A, continued. Date, location, gear type and tide conditions during fish community sampling on North Humboldt Bay, California between August 2003 and July 2004.

Date	Start Time	Sets	Site	Method	Tide	Longitude	Latitude	Flats_Channel
5/19/2004	10:23	3	MR8	Trawl	Flood	-124.16033213272	40.8330172414492	In Main Channel Adjacent
5/19/2004	9:25	3	AC2	Trawl	Flood	-124.13660701282	40.8284763106435	In Main Channel Adjacent
5/26/2004	10:30	3	MR	Purse Seine	Ebb	-124.15358566799600	40.83490685786260	In Main Channel Adjacent
5/25/2004	12:40	3	EB	Purse Seine	Flood	-124.14334292626100	40.81867219579110	In Main Channel Adjacent
5/27/2004	8:00	3	SI	Purse Seine	Ebb	-124.13995362659300	40.83312042395070	In Main Channel Adjacent
5/27/2004	11:25	3	Eureka	Purse Seine	Ebb	-124.14507272351600	40.80892510814040	In Main Channel Adjacent
5/27/2004	10:15	3	AC	Purse Seine	Ebb	-124.12413291948900	40.83279519307830	In Main Channel Adjacent
6/2/2004	12:27	3	AC2	Trawl	Slack	-124.13660701282	40.8284763106435	In Main Channel Adjacent
6/2/2004	10:43	3	MR2	Trawl	Flood	-124.153170016206	40.8357728183475	In Main Channel Adjacent
6/2/2004	9:28	3	MR5	Trawl	Flood	-124.142292513321	40.8444077864745	In Main Channel Adjacent
6/10/2004	10:03	3	AC4	Trawl	Ebb	-124.117608133923	40.8370364413526	In Main Channel Adjacent
6/10/2004	8:47	3	SI4	Trawl	Ebb	-124.13466359803	40.8379357715106	In Main Channel Adjacent
6/9/2004	10:35	3	SI2	Trawl	Ebb	-124.141872577485	40.831621837781	In Main Channel Adjacent
6/8/2004	8:43	3	EB1	Trawl	Ebb	-124.148375255367	40.8193000754906	In Main Channel Adjacent
6/8/2004	10:45	1	EB4	Trawl	Slack	-124.117276060519	40.829198088562	In Main Channel Adjacent
5/28/2004	10:19	12	AC	Cast Net	Ebb	-124.13984666144100	40.82687512081830	In Main Channel Adjacent
4/27/2004	10:16	6	EB	Minnow Trap	Ebb	-124.13227245495200	40.81854113753470	Over Culture
4/16/2004	11:23	6	MR	Minnow Trap	Flood	-124.14017383358700	40.84597131408280	Over Culture
6/15/2004	8:24	3	EB4	Trawl	Flood	-124.117276060519	40.829198088562	In Main Channel Adjacent
7/12/2004	12:10	3	MR8	Trawl	Flood	-124.16033213272	40.8330172414492	In Main Channel Adjacent
7/13/2004	10:29	3	SI2	Trawl	Flood	-124.141872577485	40.831621837781	In Main Channel Adjacent
7/12/2004	10:48	3	MR5	Trawl	Flood	-124.142292513321	40.8444077864745	In Main Channel Adjacent
7/13/2004	12:09	3	AC4	Trawl	Slack	-124.117608133923	40.8370364413526	In Main Channel Adjacent
7/13/2004	9:07	3	SI4	Trawl	Flood	-124.13466359803	40.8379357715106	In Main Channel Adjacent
7/14/2004	8:16	3	AC2	Trawl	Flood	-124.13660701282	40.8284763106435	In Main Channel Adjacent
7/14/2004	9:17	3	EB4	Trawl	Flood	-124.117276060519	40.829198088562	In Main Channel Adjacent
7/14/2004	10:38	3	EB1	Trawl	Flood	-124.148375255367	40.8193000754906	In Main Channel Adjacent
7/20/2004	11:01	3	MR2	Trawl	Flood	-124.153170016206	40.8357728183475	In Main Channel Adjacent

Appendix A, continued. Date, location, gear type and tide conditions during fish community sampling on North Humboldt Bay, California between August 2003 and July 2004.

Date	Start Time	Sets	Site	Method	Tide	Longitude	Latitude	Flats_Channel
7/20/2004	9:47	3	MR6	Trawl	Flood	-124.147474270293	40.8426053282299	In Main Channel Adjacent
7/20/2004	8:42	3	MR4	Trawl	Slack	-124.144768769356	40.8484943356224	In Main Channel Adjacent
7/21/2004	9:01	3	AC3	Trawl	Slack	-124.121514135874	40.8368462663624	In Main Channel Adjacent
7/21/2004	10:18	3	AC1	Trawl	Flood	-124.139036710822	40.8298988468258	In Main Channel Adjacent
7/21/2004	12:16	3	EB2	Trawl	Flood	-124.141577847619	40.8202811251177	In Main Channel Adjacent
7/23/2004	8:40	3	SI3	Trawl	Ebb	-124.137963062713	40.837446477822	In Main Channel Adjacent
7/27/2004	9:14	3	MR	Purse Seine	Slack	-124.14859395433100	40.83892069939020	In Main Channel Adjacent
7/27/2004	11:05	3	SI	Purse Seine	Ebb	-124.13579112020400	40.83015842606980	In Main Channel Adjacent
7/23/2004	10:06	3	SI1	Trawl	Ebb	-124.143360046737	40.8306935233796	In Main Channel Adjacent
7/26/2004	12:04	3	AC	Purse Seine	Ebb	-124.11975188499800	40.83560061711150	In Main Channel Adjacent
7/26/2004	9:30	3	EB	Purse Seine	Ebb	-124.13518157316600	40.82223634665420	In Main Channel Adjacent

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