Distribution of fish species in Humboldt Bay, Humboldt County, California, USA: A GIS Perspective

by

Mary Erin Cole

A Thesis

Presented to

The Faculty of Humboldt State University

In Partial Fulfillment

Of the Requirements for the Degree

Masters of Science

In Natural Resources: Fisheries Biology

May, 2004

ABSTRACT

Fish species distribution of Humboldt Bay, Humboldt County, California, USA: A GIS Perspective

Mary Erin Cole

In recent years, GIS analysis has become very important to the natural and physical sciences. Fisheries biologists have been employing GIS in many aspects of fish management. Analyses in estuarine systems that contain commercially and recreationally important fish species are increasing in scope and value. Fish abundance and diversity in Humboldt Bay, Humboldt County, California, were examined from 15 September 2000 to 30 November 2001. Sixty-seven fish species from 25 families were documented. Water quality parameters were also collected throughout the bay. These data were used to create several GIS coverages that can be used to analyze fish distribution with respect to habitat type within Humboldt Bay.

ACKNOWLEDGEMENTS

Funding for this study was provided by a grant from the California Department of Fish and Game, Golden West Women's Fly-Flyfishers, and Marin Rod and Gun Club. I must also extend my gratitude to Dr. Tim Mulligan for the wonderful advice and assistance he gave over these past few years. His commitment to excellence has been apparent in everything from his guidance in the field to his revision of thesis drafts. I also wish to thank the other members of my committee, Dr. Terry Roelofs, and Dr. Steven Steinberg. They have both offered me valuable direction with regards to both my thesis and my life in general. Dr. Helen Mulligan offered much needed help with larval and juvenile fish identification; her attention to detail was a great benefit to me.

Of course, there have been many people who graciously gave of their time to help me in the field and with fish identification. These were Gisela Fritz, Daniel Norman, Debra Parthree, Joseph Pecharich, Rebecca Quiñones, Tara Smith, Susan Tharratt, Gus Theisfeld, Jolyon Walkley, and Jason Weber. Thanks to them, this study covered more of Humboldt Bay in terms of area than any other. Lastly, I thank friends and family for their dearly cherished support, including Drew, who put up with all the Humboldt Bay mud, and the long rants about fish identification, and married me anyway.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF TABLES (continued)

Table Page

LIST OF TABLES (continued)

LIST OF TABLES (continued)

Table Page

LIST OF TABLES (continued)

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF FIGURES (continued)

LIST OF FIGURES (continued)

Figure Page

LIST OF APPENDICES

LIST OF APPENDICES

INTRODUCTION

Humboldt Bay is second largest coastal estuary in California. In terms of its diversity and abundance of estuarine fauna, it is second only to San Francisco Bay (United States Department of Army 1977). Its importance as a spawning, nursery and feeding ground for both estuarine and oceanic fishes has been established (Barnhart et al. 1992). It supports both commercial and sport fisheries for Pacific herring, Northern anchovy, and California halibut, as well as shark and surfperch (Warner 1982). Because of its ecological importance, studies of fish, bird, and plant species inhabiting the bay are numerous.

Most fish studies involving Humboldt Bay have concentrated on commercially or recreationally important species. For example, Misitano (1970, 1976) studied the early life history stages of English sole, *Parophrys vetulus*. Misitano found that English sole enter Humboldt Bay at approximately the same time that it begins settling to the bottom. Anderson and Bryan (1970) described growth of surfperches in Humboldt Bay. They detailed length-weight relationships between males and females by studying scales from three species of surfperch collected in the bay. Rabin and Barnhart (1977, 1986) studied the fecundity and population characteristics of Pacific herring, *Clupea pallasi*, in Humboldt Bay. Through their research, eelgrass beds near freshwater creeks were determined to be the primary spawning areas. In 1978 Collins described feeding behavior of both English sole and speckled sanddab, *Citharichthys stigmaeus*. Collins discussed and modeled feeding strategies and food selection of the two species. Toole

(1980) expanded on earlier English sole studies by describing the relationship between life stage and feeding behavior as it pertained to specific locations within Humboldt Bay. Bloeser (2000) described the biology of adult California halibut, *Paralichthys californicus*, in Humboldt Bay. Hers was the first study to research this species' use of Humboldt Bay and the effect of an El Niño event on the population's presence in the bay.

Much of the current knowledge of fish species known to use Humboldt Bay comes from Master's theses conducted at Humboldt State University. Eldridge (1970) found that the abundance of larval fishes increased with increasing distance from the mouth of Humboldt Bay. His study found a total of 37 species of larval fish. DeGeorges (1972) also collected a number of fish species in Humboldt Bay that had not yet been documented during his study of artificial reefs in South Bay. Samuelson (1973) and Sopher (1974) each conducted trawl surveys in South and North Bay, respectively, to determine species composition. These two studies are commonly sited in other publications describing the fish composition in Humboldt Bay. Waldvogel (1977) studied the distribution and age structure of Northern anchovy, *Engraulis mordax*, in Humboldt Bay. In the process, he documented 16 incidentally collected species. Other studies that provide information regarding species composition can be found in Prince and Gotshall (1976), Hill and Hendrickson (1991) and Chamberlain and Barnhart (1993), among others. Each of these has documented the presence of specific fish and added to the current information of species composition in Humboldt Bay.

Further information on the fish species inhabiting Humboldt Bay is often based on summary reports, both published and unpublished (Gotshall 1966, Monroe 1973, Shapiro

and Associates 1980, Gotshall et al. 1980, Barnhart et al. 1992, Fritzsche and Cavanagh 1995). These papers reference the research of Humboldt State University, Master's theses, historical records and personal communications. Because of this, determination of dates and locations of fish species collected in Humboldt Bay are often difficult to ascertain. A majority of the data presented in these papers was collected in the 1970s.

These studies are also limited in application because only certain habitats within Humboldt Bay were sampled. Examination of many habitats would allow for a new understanding of fish distribution as it relates to habitat type, and provide detailed information for geographic information systems (GIS) analyses regarding ecological relationships within Humboldt Bay. It would also produce a database of current information regarding fish species and their distribution in Humboldt Bay.

Geographic information systems technology allows for complex spatial analyses to be conducted. Its capabilities allow scientists to examine ecological relationships to improve fisheries management decisions. For example, established characteristics for suitable salmon spawning habitat were entered into GIS in order to determine possible locations that met these criteria (Dauble et al. 1999). The health of fish habitat can also be determined using GIS. Hawks et al. (2000) used GIS as an aid in the development of watershed interactions, and determined appropriate acquisition areas based on human impacts, percentage public land, species richness and habitat characteristics

Geographic information systems can also be very useful for predictive analyses. Keleher and Rahel (1996) were able to model potential fish habitat loss based on gradual increases in temperature over time. Many variables affect the distribution of fish and

habitat utilization. Geographic information systems allow a number of environmental factors to be analyzed. Zheng et al. (2002) found that statistical analyses used to describe spatial patterns of whiting, *Merlangius merlangus,* were limited and potentially incorrect. Subsequently, in order to accurately model the relationship between environmental conditions and abundance of whiting, GIS was used.

The ability of GIS to query spatial data and produce maps of species distribution makes it highly practical for analyzing fish habitat data. Fortunati et al. (2002) recognized the importance of analyzing and depicting trawl data using GIS, and therefore described the Trawl Survey Data Viewer (TSDV), a new GIS tool. This tool allows researchers to apply the graphic capabilities of GIS to the large amounts of data collected during trawl surveys. Singh et al. (2000) used maps created in GIS to support a proposal to include Musquash Estuary in New Brunswick, Canada, as a Marine Protected Area (MPA). The capabilities of GIS allowed clear representation of fish habitat and distribution.

Several physical and biological features of Humboldt Bay are currently being mapped using GIS. Many of these are available from the Humboldt Bay Harbor, Recreation and Conservation District at http://www.humboldtbay.org. Several of the maps describe the infrastructure surrounding the bay, including property lines and roads. There are also maps depicting bird habitat, oyster culture beds, and historic and current eel grass bed locations. The capabilities of GIS are useful to the Humboldt Bay Harbor, Recreation and Conservation District because it is responsible for the management of the port of Humboldt Bay. Consequently, it maintains the many GIS coverages of the bay.

However, there is no coverage available that describes the location of finfish in Humboldt Bay.

This study is important because fish distribution data have never been collected over such a large scope of locations within Humboldt Bay. Physical-chemical parameters have also been recorded at many sampling locations. These data can easily be combined with habitat type data in GIS, allowing specific queries of the data. For this study, GIS will be used to determine habitat utilization by fishes of Humboldt Bay, and primarily for its ability to graphically depict fish distribution within Humboldt Bay.

SITE DESCRIPTION

Humboldt Bay is located 372 kilometers north of San Francisco Bay at latitude 40°46′N and longitude 124°14′W (Figure 1). The bay is composed of three subbays: North Bay, Entrance Bay and South Bay. Collectively, the bay measures 22.5 km in length, with an area of 62.4 km^2 at mean high tide (MHW), and 28.0 km^2 at mean low tide (MLLW) (Proctor et al. 1980). Humboldt Bay is primarily exposed at low tide, with 65-70 percent of the entire bay made up of mudflats, the dominant habitat in both North and South Bays (Barnhart et al. 1992).

The bay is considered an atypical estuary because true estuarine conditions rarely occur due to limited freshwater input. There is also little mixing in the bay. At low tide, water that was covering the mudflats and present in the channels at high tide moves into the deeper channels and near shore waters, respectively (Pequegnat and Butler 1982). A descriptive classification of Humboldt Bay was given by Costa (1982) when he described it as a tide driven, multibasin coastal lagoon.

North Bay, also called Arcata Bay, is the largest of the three subbays, with a surface area of 8000 acres (Monroe 1973). Jacoby Creek in the northeast, and Freshwater Creek and Elk River in the southeast provide freshwater to North Bay. Seventy-seven percent of the MHW area of North Bay is made up of intertidal mudflats, which are segmented by channels (Figure 2). North Bay Channel, Samoa Channel, and Eureka Channel are deepwater channels that extend from Entrance Channel, at the entrance of

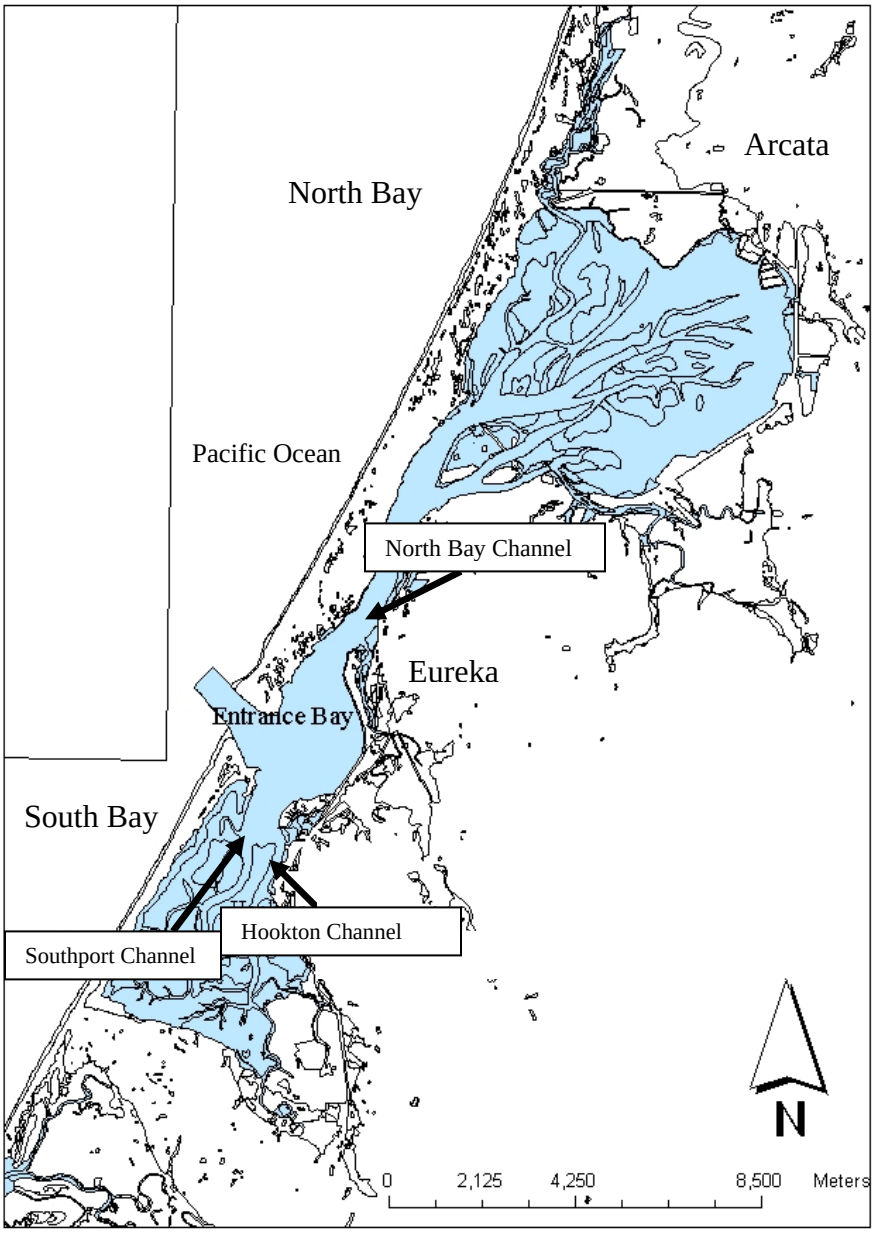

Figure 1. Humboldt Bay, Humboldt County, California. Map modified from National Wetlands Inventory Data, United States Fish and Wildlife Service, 1987.

Figure 2. Intertidal mudflats in North Bay of Humboldt Bay, Humboldt County, California. These flats, located near the Arcata Marsh of northern North Bay, are segmented by tidal gullies.

the bay, into North Bay. Mad River Slough Channel and Arcata Channel are shallower tidal channels that branch from deeper channels and segment into several tidal gullies.

South Bay is approximately 4600 acres in area (Monroe 1973). Mudflats are the major habitat type, making up 81 percent of the MHW area in this subbasin. Freshwater input comes from Salmon Creek, which flows into the southeastern portion of South Bay. Two channels, Hookton Channel and Southport Channel, extend from Entrance Channel into South Bay. Because the tidal prism, MHW to MLLW, of South Bay is 68 percent (higher than the 44 percent tidal prism of North Bay), the water in this bay is much closer in character to nearshore water (Pequegnat and Butler 1982).

Eelgrass, *Zostera marina*, is commonly found on the low mud flats near tidal gullies of both North and South Bays. Harding and Butler (1979) estimated the combined area of eelgrass cover in both North and South Bays to be 1221 hectares, with a higher biomass in South Bay. Current mapping of eelgrass beds in Humboldt Bay is being carried out (McBride 2003, personal communication). Based on digital images taken in October 2000 by the California Department of Fish and Game, the area of eelgrass in all of Humboldt Bay was determined to be 1951 hectares, with North Bay possessing a larger area of eelgrass than South Bay (McBride 2003, personal communication).

Entrance Bay connects North and South Bays and is essentially a deep channel that includes the mouth of Humboldt Bay. The area covered by water remains relatively constant throughout the tidal cycle, with only 10 percent of its area considered tidal flat (Barnhart et al. 1992). Two jetties, approximately 2 kilometers long, were constructed at

the entrance of the bay in 1889-1899. The entrance to Humboldt Bay increased in depth from 12 to 27 feet due to this construction (Tuttle 1982). The addition of the jetties caused an increase in wave energy entering the bay (Costa 1982), and lead to the complete rebuilding of the jetties between 1911 and 1925 (Tuttle 1982). Much of the shore of Entrance Bay is lined with rip-rap due to this increased wave action (Figure 3).

In order to maintain channel depths, the Army Corps of Engineers is required to dredge Humboldt Bay channels annually. Entrance Channel, North Bay Channel, Samoa Channel, Eureka Channel and Hookton Channel are dredged to depths of 7.9 to 10.7 meters (Barnhart et al. 1992). Major modifications of channels require sponsorship from the local Humboldt Bay Harbor District, which sponsored Army Corps projects to deepen Entrance Channel, North Bay Channel and Samoa Channel in April 2000 to improve navigation (Humboldt Bay Harbor District; http://www.humboldtbay.org). In addition to dredging, other modifications such as diking, draining and filling have changed the morphology of Humboldt Bay remarkably (Glatzel 1982).

The National Wetlands Inventory (NWI) of the United States Fish and Wildlife Service is responsible, under the 1986 Emergency Wetlands Resource Act, for characterizing and sizing the country's wetlands and deepwater habitats. The agency has mapped approximately 90% of the wetlands in the continental United States, 44% of the maps are available in digital format (http://wetlands.fws.gov). They have distributed over one million digital wetland files; all are available for use by the private sector.

Figure 3. The shore of Entrance Bay of Humboldt Bay, Humboldt County, California is lined with rip-rap due to increased wave action. This photo was taken near the town of King Salmon, along the eastern shore of Entrance Bay.

The NWI uses Cowardin et al. (1979) for classification of wetlands and deepwater habitats (Appendix 1). This scheme is widely used, and serves as a consistent system for describing wetland habitat. The hierarchical system begins with five major categories: Estuarine (E), Lacustrine (L), Marine (M), Palustrine (M), and Riverine (R). The digital map of Humboldt Bay, available through the NWI, is used as the base habitat map in this GIS study.

METHODS AND MATERIALS

Field sampling of fishes in Humboldt Bay began on 15 September 2000, with surveys continuing until 30 November 2001. A major objective of the field sampling was to increase effort in areas that had not been typically investigated in past studies. Many locations along the periphery of the bay, as well as sloughs, channels, beach and rubble areas, mud flats and eelgrass beds were selected by reviewing a National Oceanic and Atmospheric Administration (NOAA) navigational chart. Some sampled areas not evident on the chart were detected through examination in the field.

Coordinates

Geographic coordinates were collected at each site in order to accurately record the location. Points for many intertidal and subtidal locations were collected on the shore adjacent to the wetted area sampled. Locations were recorded as geographic coordinates in degrees, minutes and seconds, using a Trimble GeoExplorer II hand held Global Positioning System (GPS) unit. The GPS points were collected instantaneously, and not averaged or corrected. A total of 280 points was collected using this GPS unit. Forty-nine trawling locations, sampled using the R/V *The Coral Sea*, were collected via a Furuno GPS 80 unit. Because the base layer map of Humboldt Bay was projected in Universal Transverse Mercator (UTM), these coordinates were then converted using Corpscon for Windows Version 5.11.08.

Fishes

The focus of fish sampling was in areas that had not been thoroughly sampled in the past, including small channels, sloughs, rip rap areas in the vicinity of the jetties and flocculent mud flats. Sampling techniques varied with habitat type. Much of the sampling was completed from the shore using pole seines, which varied in size from 8 to 50 feet long by 4 to 6 feet deep with a mesh size of 0.25 inch. Two to four crewmembers pulled the pole seine either parallel to shore or at a slight angle towards the shore. Beach seines were also used, and ranged in size from 120 to 150 feet long by 6 to 8 feet deep with a mesh size of 0.25 inch. One end of a beach seine was stacked on shore while the free end was attached to a small aluminum skiff. The skiff was then used to deploy the seine in order to make a half circle from the shore. Once the skiff had completed the set, crewmembers would pull the net onto the shore.

Sampling of the major channels in the bay was conducted from the R/V *Coral Sea* using a 32-foot epibenthic otter trawl with a stretch mesh size of 2 inches in the body and 1-inch stretch mesh in the cod end. Seventeen trawls were completed using this trawl net. Trawling over eel grass beds was done using a 16-foot epibenthic otter trawl with a 1-inch stretch mesh in the body and 0.25-inch stretch mesh in the cod end. Sixteen trawls were done with this net from Humboldt State University's 27 foot aluminum pontoon boat. The tow speed and length of each trawl was dependent upon location, and was recorded to the nearest minute. On most occasions, geographical coordinates were taken once the trawl entered the water and again when the net was pulled out of the water.

The pontoon boat was also used to deploy a 6 foot modified beam trawl with 3-millimeter mesh to collect juvenile fishes a total of eight times. Standard minnow traps were also used in areas were nets could not be easily deployed. For example, minnow traps were attached to riprap at the entrance to the bay, which is a deep channel with very steep sides. A total of 30 traps were set in Humboldt Bay.

All fishes were identified, enumerated, measured to the nearest millimeter (total length, TL), and released at the site of capture. Fish that could not be identified in the field were fixed in either 5 or 10 percent formalin, depending on life history stage. These specimens were brought back to the laboratory where they were subsequently transferred to 40 percent isopropyl alcohol and identified. An approved protocol was obtained under the Institutional Animal Care and Use Protocol #00/01.F.104.A. Fishes were primarily identified using Miller and Lea (1972). Other keys used were Tarp (1952), Hitz (1965), and Materese (1989).

Water Quality

Temperature, salinity and dissolved oxygen were measured concurrently with fish sampling with either a Yellow Springs Instrument (YSI) model 85 or model 33. Location and number of readings were contingent upon the nature of the sample site. For example, a slough would require readings to be taken at the mouth where salinities might be higher, and also at the terminus, where salinities might be lower. In order to accurately represent changes in water quality over area, readings were taken as frequently as possible.

GIS Analysis

A digital habitat map of Humboldt Bay was obtained from the NWI website (http://www.nwi.fws.gov). Seven separate ARC/INFO export files corresponding with the United States Geological Service 7.5 minute topographic quadrangles, were downloaded to obtain a complete coverage of Humboldt Bay (Environmental Systems Research Institute, 1999a). These coverages were joined into one contiguous coverage and then the dissolve command was used to combine the attribute tables into one database table.

The polygons of the resulting coverage included habitat types as well as their area. The habitat types included estuarine, marine, palustrine, and riverine. For each of these high level categories, many subsystems were defined. A new column was added into the attribute table to condense the habitat code for all but the estuarine type into one code for each. For example, instead of including all three marine habitats: M1UBL, M2US2N, and M2US2P, polygons were merged to include all subcategories under the single heading “Marine.” This coverage was used as the base layer for fish and water quality data.

Two separate tables were created in Microsoft Excel to include spatial information for each sample location. Most sites were represented by points. Most trawl sites were represented by a pair of points representing the start and end of the trawl. Each point in both tables was given a unique number based on sampling order. These tables were saved as dBASE IV files, and imported as shapefiles using ArcView 3.2

(Environmental Systems Research Institute, 1999b). These shapefiles were then converted to coverages.

The point shapefile depicting trawl locations was edited in ArcMap to create lines (Environmental Systems Research Institute, 2000). For trawls with a start and end point, lines were digitized connecting the two. Trawl lines that crossed an upland polygon when a straight line was digitized were given a central vertex outside of the upland polygon. For trawls with only a start point, trawl length was determined using the equation: d = vt, where d = distance, v = velocity and t = time, as both the speed of the boat as well as the length of time for each trawl were known. Once the distance was obtained, lines were digitized to the specific length. The appropriate azimuth was retained for all lines. These trawls were saved as a line shapefile. A column was added to the attribute table to give each line a new, unique identification number.

With the creation of the line shapefile, a completely new set of unique identifying numbers was created for the point shapefile. This was necessary, as the original point shapefile included all sampling events in one series of numbers. Because there were two separate shapefiles, new numbers were needed. The attribute table reflects the addition of new numbers with the original number identified as “Sample_#,” and the new number identified as “ID.” The sample number was retained in the attribute table to allow easy cross-referencing with originally collected tabular data.

Two tables were created in Excel to include fish data collected at each site: one for point locations and one for line locations. The tables included, for each feature, the common name of the fish species collected, the maximum, minimum and average length

and abundance for each species. The table also included the respective identification number (ID) for each sampling site. Similarly, two water quality data tables were created. These tables were saved as dBASE IV files.

Upon viewing the point shapefile with the habitat map shapefile in ArcMap, it was apparent that many points did not fall within the correct known habitat polygon. This was primarily due to established, inherent error in both the GPS units and the map data, but also the nature of GPS point collection. Therefore, many points appeared to fall on land. Other inaccuracies were noticeable when points fell just outside the respective channel sampled (Figure 4).

Point-in-polygon and line-in-polygon intersections were performed between the sample location files to allow easy examination of what habitat type contained points and transects by searching only the attribute table. A considerable number of locations that were, in actuality, sampled in estuarine habitat appeared to fall within upland or palustrine habitat polygons. These points were selected from the attribute table. An export file was created that contained only these points.

In order to move these points into the correct habitat polygons, the editing function in ArcMap was used. The original point shapefile was used as the editing layer. Each point from the export file was examined individually while reviewing raw data sheets for accuracy of location. Points that fell outside the actual areas sampled were mapped to an appropriate, nearby location. These included points in both estuarine and palustrine habitat polygons. Points that fell in the sloughs and channels that were not

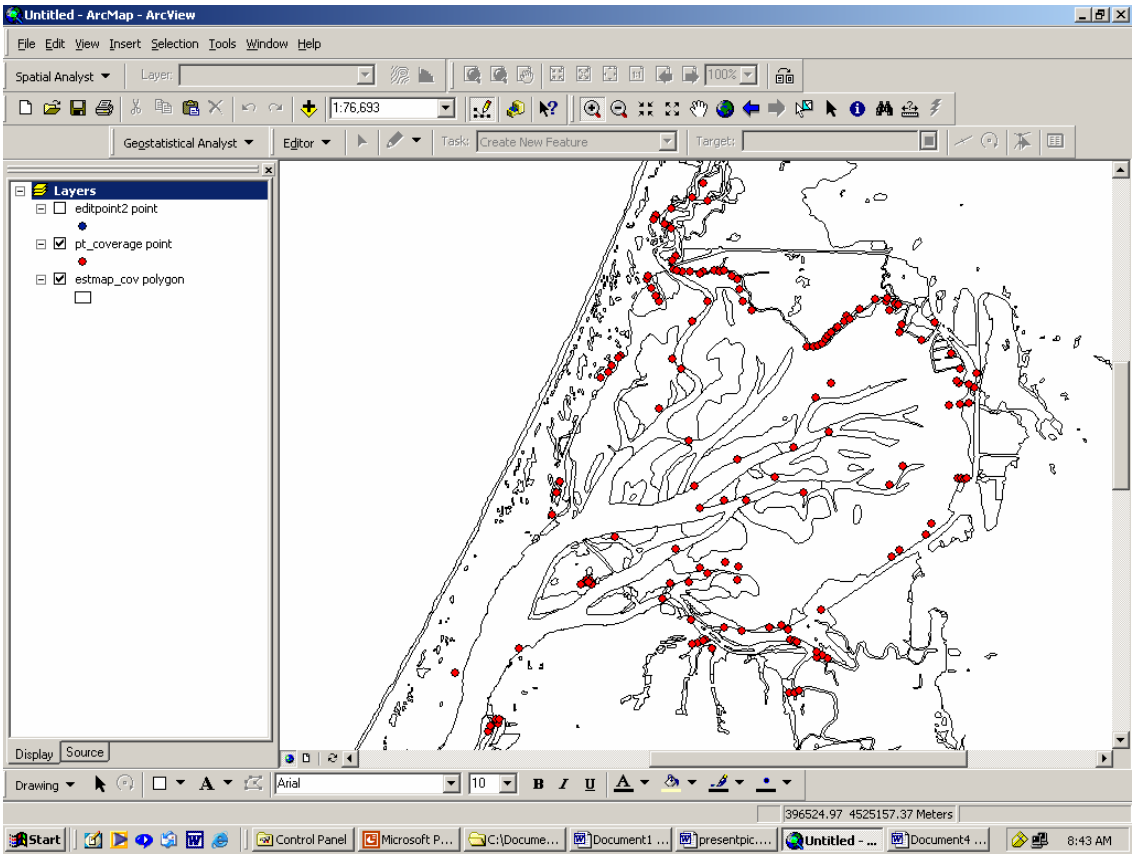

Figure 4. The habitat coverage of Humboldt Bay, Humboldt County California with associated sample points coverage. The red point layer entitled “pt_coverage” represents the sampling locations between the months of September 2000, and November 2001 before editing occurred. Notice that many of the points fall outside of narrow channels, and onto land.

evident on the map were not edited. The newly edited points were saved as a separate shapefile (Figure 5).

The edited point coverage was intersected in ARC/INFO. After this intersection, the only points that fell within upland polygons were the unedited points from sloughs and channels not detectable on the map. The original intersected line shapefile was free of discrepancies. Any further editing of points was made directly to the new intersected coverage.

The fish and water quality data tables were related to the intersected point and line coverages on the common ID field in the attribute tables in ArcMap. Because dBASE IV files created in Excel do not maintain cell formatting, columns containing text were not recognized in ArcMap. A new text column was added to the fish data tables in ArcMap, and the field calculator was used to copy the original species column, "Fish_Sp," to the new column, "Species".

After the finished tables were related to the spatial data, specific data were queried for all habitat analyses. Specific habitat types were selected from the intersected coverages. Because the fish data tables were related, statistics for all species collected in a selected habitat were easily queried. For example, searches for specific fish species were easily conducted to determine locations within the bay where these species were captured. (Figure 6). Likewise, the average length for a particular species was obtained by averaging the average length column; overall maximum lengths were obtained from the maximum length column.

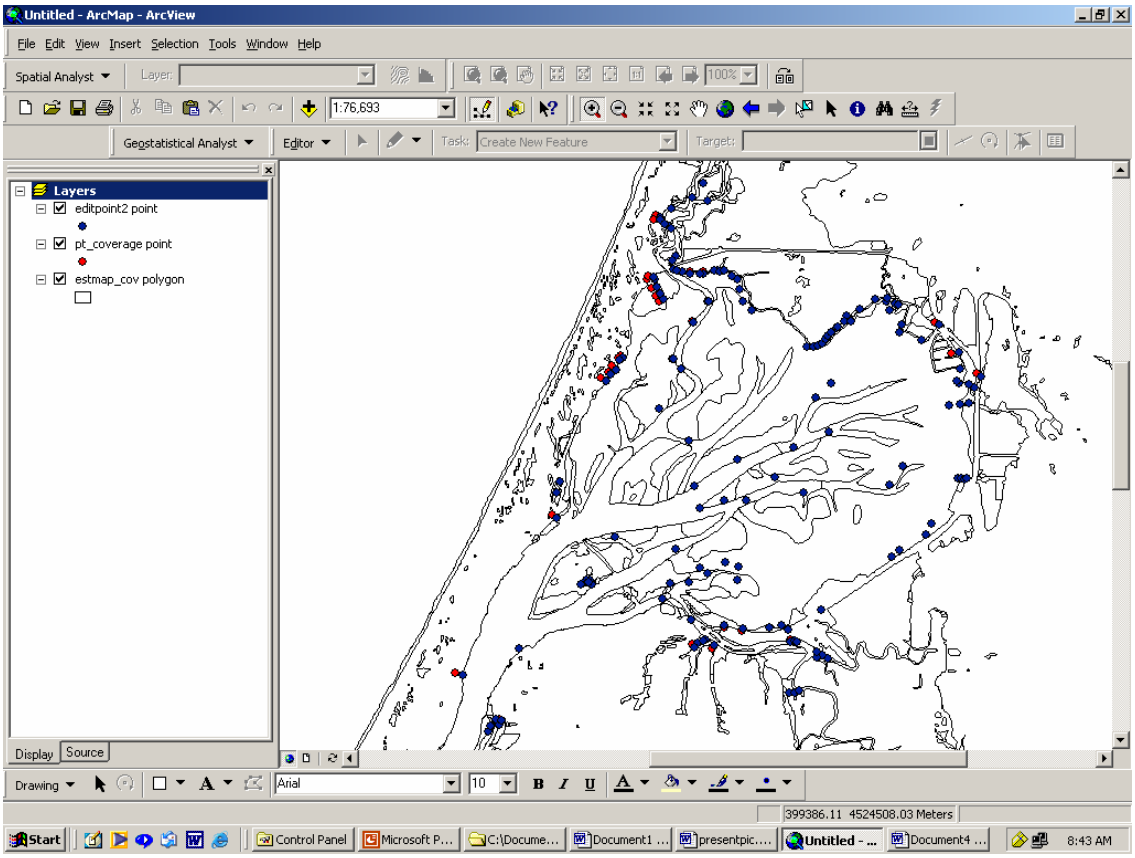

Figure 5. The habitat coverage of Humboldt Bay, Humboldt County California with associated sample points coverage. The red point layer entitled “pt_coverage” represents the sampling locations between the months of September 2000, and November 2001 before editing occurred. The blue point layer entitled “editpoint2” reflects the revised points.

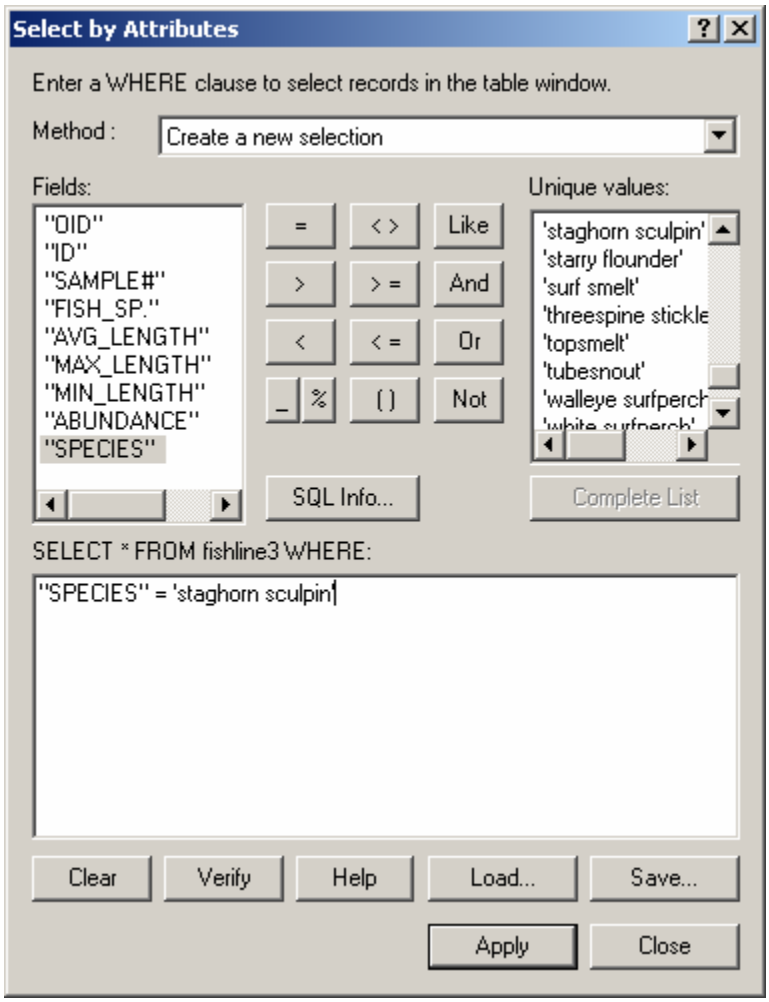

Figure 6. Locating particular species collected within Humboldt Bay, Humboldt County, California between the months of September 2000 and November 2001 using ArcView ArcGIS 8.3 was done by performing a query in ArcMap. Certain attributes were selected to fit the search criteria.

RESULTS

Point and line coverages were created to depict sampling locations in Humboldt Bay (Figure 7). Before the marine, palustrine and riverine habitat types were condensed into one, the Humboldt Bay coverage contained a total of 89 habitat types, under the five major headings: estuarine, marine, palustrine, and riverine, and uplands (Table 1). For a complete description of habitat types see Appendix 1. For a specific example, the first habitat type in Figure 7, E1AB3L, describes a habitat type where E = Estuarine, 1= Subtidal, AB = Aquatic Bed, 3 = Rooted Vascular, L = Subtidal. Upland habitat made up most of the area of the coverage, followed by the three marine habitat types. There were 1022 palustrine habitat polygons making up 60 different habitat types. The entire coverage was made up of 19 estuarine habitat types. Within the coverage, Humboldt Bay and immediately surrounding wetted areas contained 16 estuarine habitat types. Of these estuarine habitats, 12 were sampled during the study (Table 2).

A total of 67 fish species from 25 families was collected in Humboldt Bay using all methods between 15 September 2000 and 30 November 2001 (Table 3). The 10 most abundant species accounted for 94.75 % of the total catch; the three most abundant made up over 55 %. The threespine stickleback, *Gasterosteus aculeatus*, was the most abundant species collected, with 15,655 individuals captured at 108 separate sites. Shiner surfperch, *Cymatogaster aggregata*, and topsmelt, *Atherinops affinis*, were the second and third most abundant, respectively.

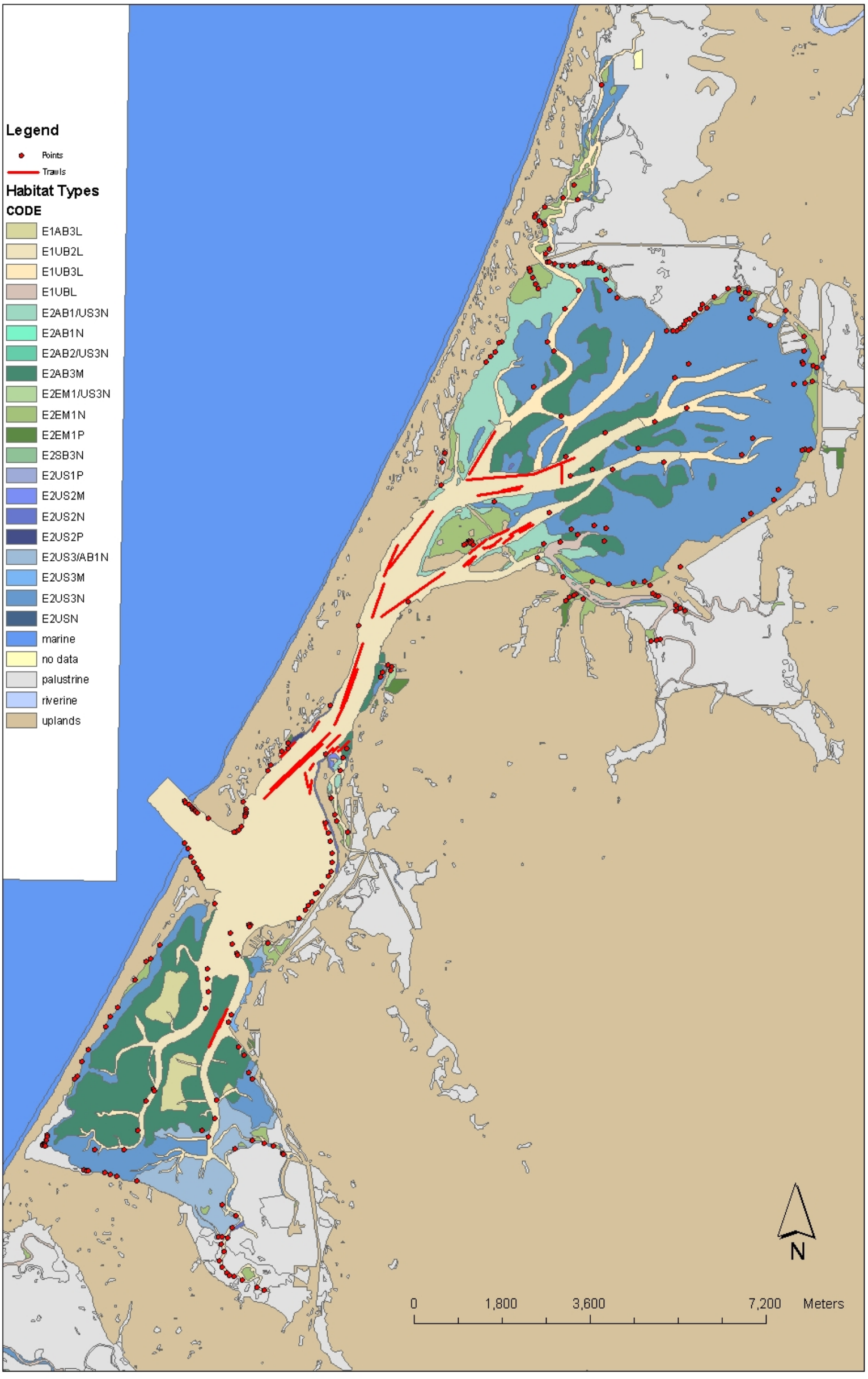

Figure 7. Sample locations within Humboldt Bay, Humboldt County, California between the months of September 2000 and November 2001. Habitat map digitized by National Wetlands Inventory.

Table 1. Habitat types in the coverage of Humboldt Bay, Humboldt County, California, before marine, palustrine and riverine habitats were condensed into one habitat type for each. For description of habitat types see Appendix 1.

Habitat Type	# of polygons	Total Area (m^2)
E2US1P	1	15347
E2AB1N	2	23855
E2SB3N	1	39234
E2EM1/US3N	1	52021
E2AB2/US3N	1	61538
E2US3M	3	101458
E2US2M	2	186062
E2EM1P	15	345227
E1AB3L	3	1068204
E2US2N	22	1150698
E2US2P	17	1373438
E2US3/AB1N	10	2702989
E1UB3L	12	3830974
E2AB1/US3N	24	3996251
E2EM1N	86	4581905
E1UBL	8	4868397
E2AB3M	28	12019885
E1UB2L	3	19082203
E2US3N	35	23617745
M2US2P	1	112015
M2US2N	4	3170451
M1UBL	1	305884320
PUSCH	1	607
PUBGX	1	1734
PEM1CF	1	1997
PAB4HH	1	2051
PSS2C	1	2361
PEM1CX	1	2419
PEM1/UBFH	1	2972
PSS1/4A	1	3054
PSS1CD	1	3204
PUSCX	2	4131
PEM1B	3	5136
PAB3HX	1	6308
PEM/UBHH	1	6733
PUBFH	6	7418
PEMC	2	9768
PEM1R	1	9951

Table 1. All habitat types in the entire coverage of Humboldt Bay, Humboldt County, California, before marine, palustrine and riverine habitats were condensed into one habitat type for each. For description of habitat types see Appendix 1. (continued).

Habitat Type	# of polygons	Total Area (m^2)
PSS1A	3	10293
PSS1B	1	11533
PUSA	2	12315
PUBKHX	1	13594
PSS/EM1FH	1	17651
PEM1FX	2	19271
PFO/SS1C	5	19689
PFO/SS1R	1	21956
PAB3HH	1	22073
PFO4C	1	22392
PEM1/AB3HX	1	23470
PFO/EM1F	1	23853
PUBF	8	28562
PUBFX	11	29615
PAB3H	1	30060
PEM1/UBHX	1	34273
PEM1HX	1	39717
PEM1/AB3F	1	43916
PUB/EM1F	1	47914
PEM1/UBHH	2	51869
PEM1FH	4	67168
PUBHX	24	67983
PAB4H	1	71004
PSS1/USS	1	71441
PAB3F	3	91755
PEM/SS1C	7	107965
PUSC	8	127571
PSS/EM1F	7	152161
PEM1/USA	3	156827
PEM1/UBF	11	183020
PSS/EM1C	23	230271
PSS/EM1A	4	253513
PUBH	19	285531
PEM1A	15	331971
PUBHH	20	353460
PSS1/USA	6	606507
PEM1CH	2	637004

Table 1. All habitat types in the entire coverage of Humboldt Bay, Humboldt County, California, before marine, palustrine and riverine habitats were condensed into one habitat type for each. For description of habitat types see Appendix 1. (continued).

Habitat Type	# of polygons	Total Area (m^2)
PFO1C	53	644714
PEM1F	56	1146969
PEM1AD	3	1222171
PSS1C	235	1827335
PFO1A	20	1988493
PEM1C	379	8540953
PEM1CD	47	47022343
R2UBH	1	33999
R1UBV	2	189113
R3UBH	12	428275
R1USR	2	565004
R3USA	4	595855
R3USC	11	1683454
UPLAND	27	565901526
No data	1	62348

Table 2. Estuarine habitats of Humboldt Bay, Humboldt County, California and the surrounding wetted areas. The codes are listed in order of area, which is given in meters squared. The number of habitat polygons of the coverage is given, as well as the number of sampling locations in the form of points and lines. Four estuarine habitat types in Humboldt Bay were not sampled.

Code	Area	Percent Area	# of Polygons	# Points	# Lines
E2AB1N	23855	< 0.1	2	0	0
E2US2M	31773	< 0.1	1	0	0
E2US2P	36177	< 0.1	1	0	1
E2EM1/US3N	52021	< 0.1	1	2	0
E2US3M	101458	0.1	3	0	0
E2US2N	175368	0.2	6	4	0
E2EM1P	324165	0.5	14	5	0
E1UBL	966043	1.4	5	8	0
E1AB3L	1068204	1.5	3	0	0
E2US3/AB1N	2702989	3.8	10	6	0
E2EM1N	3547248	5.0	80	26	0
E1UB3L	3830974	5.4	12	17	0
E2AB1/US3N	3996251	5.6	24	22	0
E2AB3M	12019885	16.8	28	10	1
E1UB2L	19082203	26.7	3	89	47
E2US3N	23423963	32.8	26	70	0

Table 3. Sixty-seven identified species were collected in Humboldt Bay, Humboldt County, California between 15 September 2000 and 30 November 2001. Species are ordered by number of sites where collection occurred. Rank of abundance is given for the 25 most abundant species.

Fish Sp.	# of sites	Abundance	Abundance Rank for top 25 species	% Abundance	% of sites
boneyhead sculpin	1	2		<0.01	<1
brown smoothhound	1	1		<0.01	<1
calico surfperch	1	1		<0.01	<1
copper rockfish	1	1		<0.01	<1
curlfin turbot	1	1		<0.01	<1
cutthroat trout	1	2		<0.01	<1
gopher rockfish	1	1		<0.01	<1
lingcod	1	1		<0.01	<1
longjaw mudsucker	1	1		<0.01	<1
medusa fish	1	1		<0.01	<1
red Irish lord	1	2		<0.01	<1
ringtail snailfish	1	1		<0.01	<1
rock greenling	1	2		<0.01	<1
steelhead	1	1		<0.01	<1
fluffy sculpin	2	2		<0.01	<1
mosquito fish	2	10		<0.1	<1
petrale sole	2	2		<0.01	<1
showy snailfish	2	5		<0.1	<1
spiny dogfish	2	5		<0.1	<1
brown Irish lord	3	7		<0.1	<1
California halibut	3	3		<0.1	<1
whitebait smelt	3	5		<0.1	<1
buffalo sculpin	4	5		<0.1	1.2
coho salmon	4	5		<0.1	1.2
leopard shark	4	88	22	<1	1.2

Table 3. Sixty-seven identified species were collected in Humboldt Bay, Humboldt County, California between 15 September 2000 and 30 November 2001. Species are ordered by number of sites where collection occurred. Rank of abundance is given for the 25 most abundant species (continued).

Fish Sp.	# of sites	Abundance	Abundance Rank for top 25 species	% Abundance	% of sites
longfin smelt	4	11		<0.1	1.2
Pacific tomcod	4	9		<0.1	1.2
sharpnose sculpin	4	4		<0.1	1.2
Pacific sanddab	5	15		<0.1	1.6
striped surfperch	5	10		<0.1	1.6
juvenile rockfish	6	14		<0.1	1.9
kelp greenling	6	15		<0.1	1.9
Pacific sardine	6	46	25	<0.1	1.9
penpoint gunnel	6	7		<0.1	1.9
pile surfperch	6	14		<0.1	1.9
spotfin surfperch	6	24		<0.1	1.9
silver surfperch	7	121	17	<1	2.2
juvenile flatfish	8	25		<0.1	2.5
night smelt	8	11		<0.1	2.5
plainfin midshipman	8	68	23	<1	2.5
tidewater goby	8	26		<0.1	2.5
bat ray	9	33		<0.1	2.8
butter sole	10	98	20	<1	3.1
sandsole	10	15		<0.1	3.1
Pacific sandlance	11	234	15	<1	3.4
bay goby	12	34		<0.1	3.7
white surfperch	12	35		<0.1	3.7
cabezon	13	23		<0.1	4
prickly sculpin	13	34		<0.1	4
redtail surfperch	13	101	19	<1	4

Table 3. Sixty-seven identified species were collected in Humboldt Bay, Humboldt County, California between 15 September 2000 and 30 November 2001. Species are ordered by number of sites where collection occurred. Rank of abundance is given for the 25 most abundant species (continued).

Fish Sp.	# of sites	Abundance	Abundance Rank for top 25 species	% Abundance	% of sites
chinook salmon	14	89	21	<1	4.4
black rockfish	17	139	16	<1	5.3
walleye surfperch	17	62	24	<1	5.3
tubesnout	20	312	12	<1	6.2
jacksmelt	21	287	13	<1	6.5
saddleback gunnel	21	44		<0.1	6.5
Pacific herring	24	444	10	<1	7.5
Northern anchovy	33	4499	6	8.2	10.3
speckled sanddab	39	270	14	<1	12.1
starry flounder	39	104	18	<1	12.1
English sole	61	1616	8	2.9	19
arrow goby	72	474	9	<1	22.4
bay pipefish	72	392	11	<1	22.4
Osmerid sp	86	5201	4	9.5	26.8
shiner surfperch	103	8152	2	14.9	32.1
threespine stickleback	108	15655	1	28.5	33.6
topsmelt	122	6805	3	12.4	38
surf smelt	123	5009	5	9.1	38.3
staghorn sculpin	194	4152	7	7.6	60.4
total # of sites	321	54888			

The seventh most abundant species, the Pacific staghorn sculpin, *Leptocottus armatus*, was collected at 60.44 % of the sites, the most of all species. Similarly, the fifth most abundant species, surf smelt, *Hypomesus pretiosis*, was collected at 38.32 % of all sites. Topsmelt, the third most abundant species, was also the third most commonly collected species, closely following surf smelt with 38.01 %. Juveniles of the family Osmeridae were not identified to species. In the results, these are counted as a separate species. One green sturgeon was collected in Samoa Channel outside these survey dates.

Eight of the survey points fell within the upland polygons, and 12 fell in palustrine. All but two of these points were actually in a narrow drainage ditch that runs alongside a diked area of North Bay. Based on personal observation, the habitat type of this channel is most likely E2US3N as it is: estuarine (E), intertidal (2), with an unconsolidated shore (US), made up of predominately muddy sediment (3), and is regularly flooded (N). Therefore, the 18 sample points within this channel were assigned habitat type E2US3N. The other two points were assigned to habitat type E2EM1N, where E = estuarine, 2 = intertidal, EM = emergent, 1 = persistent, meaning emergent vegetation that remains rather than fall to the surface at the end of the growing season, and N = regularly flooded.

All trawls were focused within the deeper portions of the bay. Therefore, the majority of lines fall within the habitat E1UB2L, where E = estuarine, 1 = subtidal, UB = unconsolidated bottom, 2 = sand, and L = subtidal. However, two trawls entered more than one habitat type while sampling. It is impractical to separate the catch of these trawls by habitat type because the particular habitat the species were collected in is

unknown. These two trawls and resulting fish collected are listed at the end of this section. The following results are listed separately by habitat type in order of area, largest to smallest.

Estuarine, Intertidal, Unconsolidated Shore, Mud, Regularly Flooded (E2US3N)

This habitat type has the largest area of estuarine habitat in Humboldt Bay at 32.81 percent. Twenty-five percent of the sampling points fell in this habitat type (Table 4). A total of 19,425 individuals from 28 identified species including juveniles from the family Osmeridae were collected; nearly half of these were threespine stickleback (48.93 %). Northern anchovy and Pacific staghorn sculpin followed in abundance. Forty plainfin midshipman, *Porichthys notatus*, averaging 36.60 mm in size were also collected at three points. Eighty-six leopard sharks, *Triakis semifasciata*, were also collected at two points in this habitat type. The largest was approximately 1219 mm. Seven tidewater gobies, *Eucyclogobius newberyii*, and three unidentified juvenile rockfish were also collected in habitat type E2US3N.

Eighteen points that fell in both in upland and palustrine habitat polygons on the map were assigned this habitat type for purpose of analysis. These fish were collected in a narrow channel that parallels the contour of the bay along both the northern and western border. The map depicts this slough as a line, and therefore has no associated habitat data. A total of 3,532 fish were collected (Table 5). Threespine stickleback were collected at 12 points, Pacific staghorn sculpin were collected at 11 of the points.

Table 4. Fish species collected in habitat type E2US3N, where E = estuarine, 2 = intertidal, US = unconsolidated shore, 3 = mud, N = regularly flooded, of Humboldt Bay, Humboldt County, California between the months of September 2000 to November 2001. Average, maximum and minimum lengths were obtained using table queries in ArcMap and are given here under columns Average AVG, Maximum MAX and Minimum MIN. All measurements are total length in millimeters.

SPECIES	*# of points*	*Abundance*	*Average AVG*	*Maximum MAX*	*Minimum MIN*
pile surfperch	1	1	324	324	324
sharpnose sculpin	1	1	57	57	57
redtail surfperch	1	2	92	92	91
speckled sanddab	1	2	55	65	45
white surfperch	1	2	76	79	72
bat ray	1	3	759	900	620
black rockfish	2	3	55	68	43
saddleback gunnel	4	7	84	141	71
tidewater goby	1	7	46	64	37
bay goby	2	9	51	96	25
prickly sculpin	6	10	70	103	44
starry flounder	8	13	105	246	33
tubesnout	1	20	138	149	124
jacksmelt	5	27	232	346	39
walleye surfperch	5	28	67	211	23
English sole	10	29	65	108	35
plainfin midshipman	3	40	37	60	28
butter sole	1	60	23	32	8
bay pipefish	14	71	172	265	40
leopard shark	2	86	683	1219	300
arrow goby	24	142	51	66	20
Pacific herring	5	173	62	92	25
surf smelt	38	912	76	167	47
shiner surfperch	23	994	75	155	40
Osmerid sp.	26	1274	50	67	12
Topsmelt	38	1455	89	262	20
staghorn sculpin	54	1507	53	130	12
Northern anchovy	7	3042	69	111	32
threespine stickleback	27	9505	53	86	11
total		19425			

Table 5. Fish species collected in the habitat type E2US3N, where E = estuarine, 2 = intertidal, US = unconsolidated shore, 3 = mud, N = Regularly Flooded, of the narrow channels of Humboldt Bay, Humboldt County, California, between the months of September 2000 to November 2001. Average, maximum and minimum lengths were obtained using table queries in ArcMap and are given here under columns Average AVG, Maximum MAX and Minimum MIN. All measurements are total length in millimeters.

SPECIES	*# of points*	*Abundance*	*Average AVG*	*Maximum MAX*	*Minimum MIN*
coho salmon	1	1	127	127	127
starry flounder	1	1	24	24	24
bay pipefish	2	2	174	211	136
cutthroat trout	1	2	276	370	182
surf smelt	2	2	58	62	54
shiner surfperch	1	3	123	137	101
jacksmelt	3	6	19	22	17
prickly sculpin	2	6	84	130	57
Pacific herring	3	7	33	38	27
tidewater goby	2	8	30	48	20
Northern anchovy	4	9	53	96	44
mosquito fish	2	10	27	41	13
Osmerid sp.	6	24	51	58	46
arrow goby	9	51	49	62	36
topsmelt	4	165	119	140	62
staghorn sculpin	11	174	66	150	24
threespine stickleback	12	3061	39	65	12
total		3532			

However, threespine stickleback made up 86.66 % of the total catch. Pacific staghorn sculpin and topsmelt each made up less than 5 % of the total catch. The remaining 3.74 % included 14 other species, including juveniles of the family Osmeridae.

Estuarine, Subtidal, Unconsolidated Bottom, Sand, Subtidal (E1UB2L)

This habitat type constituted 26.73 % of all the estuarine habitat within the bay. Thirty-two percent of all points fell in this habitat. Forty-eight identified species, including juveniles of the family Osmeridae, were collected by methods other than trawl in habitat type E1UB2L (Table 6). The most abundant species was topsmelt, followed by surf smelt and Pacific staghorn sculpin, respectively. One medusa fish, *Icichthys lockingtoni*, was collected in this habitat type, as well as two coho salmon, *Oncorhynchus kisutch*. A single gopher rockfish, *Sebastes carnatus*, was also found in this habitat type in South Bay.

Thirty-eight identified species, including juveniles of the family Osmeridae, were collected during the thirty-nine trawls that were concentrated within this habitat (Table 7). Juveniles of the family Osmeridae were the most abundant group collected by trawl. Shiner surfperch and English sole were the second and third most abundant. Plainfin midshipmen were represented in both the point and line coverages. In all, 17,080 individuals from sixty identified species, including juveniles of the family Osmeridae, were collected in habitat type E1UB2L.

Table 6. Fish species collected by methods other than trawl in habitat type E1UB2L, where E = estuarine, 1 = subtidal, UB = unconsolidated bottom, 2 = sand, L = subtidal, of Humboldt Bay, Humboldt County, California between the months of September 2000 to November 2001. Average, maximum and minimum lengths were obtained using table queries in ArcMap and are given here under columns Average AVG, Maximum MAX and Minimum MIN. All measurements are total length in millimeters.

SPECIES	*# of points*	*Abundance*	*Average AVG*	*Maximum MAX*	*Minimum MIN*
Pacific sanddab	1	1	20	20	20
buffalo sculpin	1	1	151	151	151
calico surfperch	1	1	179	179	179
copper rockfish	1	1	36	36	36
gopher rockfish	1	1	76	76	76
medusa fish	1	1	79	79	79
steelhead	1	1	126	126	126
Pacific sandlance	2	2	88	99	76
coho salmon	1	2	102	105	98
fluffy sculpin	2	2	44	53	34
juvenile rockfish	1	2	32	34	30
petrale sole	2	2	35	36	34
pile surfperch	2	2	265	330	200
red Irish lord	1	2	62	64	60
rock greenling	1	2	76	84	67
sharpnose sculpin	2	2	51	61	40
white surfperch	2	2	144	196	91
brown Irish lord	1	5	62	79	48
penpoint gunnel	4	5	129	162	105
walleye surfperch	4	5	70	78	61
plainfin midshipman	2	6	44	54	33
arrow goby	3	8	53	58	46
cabezon	5	8	126	214	80
sandsole	7	9	73	95	32
saddleback gunnel	6	10	98	147	70.5
striped surfperch	5	10	101	200	51
Northern anchovy	6	11	50	55	44
bay goby	5	13	59	94	17
butter sole	2	14	41	50	20
kelp greenling	5	14	108	183	79
spotfin surfperch	6	24	151	189	54
jacksmelt	5	30	251	372	143
Pacific sardine	2	38	102	132	95

Table 6. Fish species collected by methods other than trawl in habitat type E1UB2L, where E = estuarine, 1 = subtidal, UB = unconsolidated bottom, 2 = sand, L = subtidal, of Humboldt Bay, Humboldt County, California between the months of September 2000 to November 2001. Average, maximum and minimum lengths were obtained using table queries in ArcMap and are given here under columns Average AVG, Maximum MAX and Minimum MIN. All measurements are total length in millimeters (continued).

SPECIES	*# of points*	*Abundance*	*Average AVG*	*Maximum MAX*	*Minimum MIN*
starry flounder	13	44	116	212	36
speckled sanddab	11	55	63	104	35
chinook salmon	13	87	96	119	70
redtail surfperch	11	96	131	212	56
silver surfperch	7	121	61	82	52
black rockfish	11	132	57	74	44
bay pipefish	19	134	174	324	67
Pacific herring	9	198	46	81	28
English sole	20	221	68	117	32
tubesnout	10	254	127	219	93
shiner surfperch	18	423	76	141	37
threespine stickleback	22	492	53	84	15
Osmerid sp.	14	635	50	62	32
staghorn sculpin	35	1279	80	242	14
surf smelt	43	3106	77	428	25
topsmelt	32	3592	103	337	24
total		11106			

Table 7. Fish species collected by trawl in habitat type E1UB2L, where E = estuarine, 1 = subtidal, UB = unconsolidated bottom, 2 = sand, L = subtidal, of Humboldt Bay, Humboldt County, California between the months of September 2000 to November 2001. Average, maximum and minimum lengths were obtained using table queries in ArcMap and are given here under columns Average AVG, Maximum MAX and Minimum MIN. All measurements are total length in millimeters.

SPECIES	*# of lines*	*Abundance*	*Average AVG*	*Maximum MAX*	*Minimum MIN*
Pacific herring	1	1	213	213	213
brown Irish lord	1	1	125	125	125
brown smoothhound	1	1	600	600	600
curlfin turbot	1	1	101	101	101
plainfin midshipman	1	1	50	50	50
ringtail snailfish	1	1	42	42	42
sharpnose sculpin	1	1	54	54	54
Pacific sardine	2	2	132	148	116
California halibut	3	3	591	760	473
buffalo sculpin	2	3	79	117	65
redtail surfperch	1	3	241	281	180
butter sole	1	4	96	109	82
juvenile rockfish	3	4	83	105	67
starry flounder	3	4	229	372	112
Northern anchovy	2	5	113	142	97
saddleback gunnel	4	5	99	115	85
showy snailfish	2	5	98	165	70
spiny dogfish	2	5	419	462	395
whitebait smelt	3	5	109	143	90
sandsole	3	6	75	100	30
threespine stickleback	5	6	67	75	45
cabezon	5	7	120	282	41
surf smelt	2	8	40	125	65
Pacific tomcod	4	9	155	215	96
longfin smelt	4	11	126	131	120
night smelt	8	11	121	136	102
Pacific sanddab	4	14	81	114	42
tubesnout	6	18	125	165	103
walleye surfperch	3	19	128	191	101
white surfperch	5	19	145	160	133
bat ray	3	22	294	463	265
topsmelt	4	23	82	99	47
juvenile flatfish	7	24	29	39	12
bay pipefish	14	67	158	298	69

Table 7. Fish species collected by trawl in habitat type E1UB2L, where E = estuarine, 1 = subtidal, UB = unconsolidated bottom, 2 = sand, L = subtidal, of Humboldt Bay, Humboldt County, California between the months of September 2000 to November 2001. Average, maximum and minimum lengths were obtained using table queries in ArcMap and are given here under columns Average AVG, Maximum MAX and Minimum MIN. All measurements are total length in millimeters (continued).

SPECIES	# of lines	Abundance	Average AVG	Maximum MAX	Minimum MIN
speckled sanddab	20	83	76	117	27
staghorn sculpin	17	195	104	207	21
Pacific sandlance	8	231	84	99	76
English sole	16	1182	92	230	18
shiner surfperch	16	1474	99	147	75
Osmerid sp.	15	2490	42	69	10
total		5974			

Estuarine, Intertidal, Aquatic Bed, Rooted Vascular, Irregularly Exposed (E2AB3M)

Four percent of points fell within this habitat type, which makes up 16.84 percent of estuarine habitat in Humboldt Bay. Fifteen identified species, including juveniles of the family Osmeridae, were collected (Table 8). Of these, the most abundant was shiner surfperch at 46.66 % of the entire catch. The second and third most abundant species were surf smelt and threespine stickleback making up 30.41 %, combined. One leopard shark measuring 281 millimeters was collected in this habitat type near Daby Island, which is just northeast of Woodley Island in North Bay.

Estuarine, Intertidal, Aquatic Bed, Algal / Unconsolidated Shore, Mud, Regularly Flooded (E2AB1/US3N)

Two percent of all points fell in this habitat type, which makes up 5.60 % of estuarine habitat in Humboldt Bay. Of the 20 identified species collected, including juveniles of the family Osmeridae, the most abundant was threespine stickleback at 54.52 % of the entire catch (Table 9). Shiner surfperch was the second most abundant species at 19.73 percent, followed by staghorn sculpin at 5.37 %. Pacific sardine, *Sardinops sagax*, and one longjaw mudsucker, *Gillichthys mirabilis*, were also collected here.

Estuarine, Subtidal, Unconsolidated Bottom, Mud, Subtidal (E1UB3L)

Habitat type E1UB3L makes up 5.37 % of estuarine habitat in the bay; six percent of all points were in this habitat type. A total of 4,567 fish were collected, representing twenty-four identified species, including juveniles of the Osmeridae family

Table 8. Fish species collected in habitat type E2AB3M, where E = estuarine, 2 = intertidal, AB = aquatic bed, 3 = rooted vascular, M = irregularly exposed, of Humboldt Bay, Humboldt County, California between the months of September 2000 to November 2001. Average, maximum and minimum lengths were obtained using table queries in ArcMap and are given here under columns Average AVG, Maximum MAX and Minimum MIN. All measurements are total length in millimeters.

SPECIES	*# of points*	*Abundance*	*Average AVG*	*Maximum MAX*	*Minimum MIN*
arrow goby	1	1	62	62	62
bat ray	1	1	352	352	352
black rockfish	1	1	64	64	64
leopard shark	1	1	281	281	281
walleye surfperch	1	2	120	148	91
starry flounder	2	3	79	86	76
Northern anchovy	1	4	97	113	80
Osmerid sp.	1	12	53	65	47
bay pipefish	3	18	164	281	62
topsmelt	3	19	90	204	48
jacksmelt	1	39	265	322	178
staghorn sculpin	8	43	73	142	33
threespine stickleback	5	60	63	79	31
surf smelt	6	131	73	111	54
shiner surfperch	7	293	74	138	43
total		628			

Table 9. Fish species collected in habitat type E2AB1/US3N, where E = estuarine, 2 = intertidal, AB = aquatic bed, 1 = algal / US = unconsolidated shore, 3 = mud, N = regularly flooded, of Humboldt Bay, Humboldt County, California between the months of September 2000 to November 2001. Average, maximum and minimum lengths were obtained using table queries in ArcMap and are given here under columns Average AVG, Maximum MAX and Minimum MIN. All measurements are total length in millimeters.

SPECIES	*# of points*	*Abundance*	*Average AVG*	*Maximum MAX*	*Minimum MIN*
bay goby	1	1	0	0	0
black rockfish	1	1	51	51	51
longjaw mudsucker	1	1	93	93	93
speckled sanddab	1	1	49	49	49
tidewater goby	1	1	43	43	43
chinook salmon	1	2	103	104	102
walleye surfperch	2	2	60	67	53
Pacific sardine	1	4	105	112	96
prickly sculpin	2	4	85	126	35
saddleback gunnel	2	16	90	133	49
jacksmelt	3	20	53	107	25
bay pipefish	6	29	139	265	40
surf smelt	4	62	70	88	51
Northern anchovy	4	156	75	116	41
arrow goby	15	184	51	69	21
Osmerid sp.	4	201	49	60	32
topsmelt	15	208	79	237	21
staghorn sculpin	19	235	63	166	16
shiner surfperch	12	864	56	150	36
threespine stickleback	15	2388	41	76	21
total		4380			

(Table 10). Shiner surfperch made up 56.8 % of entire catch. Northern anchovy was the second most abundant species comprising just over a quarter of the remaining individuals. Topsmelt was the third most abundant species. Other species collected in this habitat type were tidewater goby and plainfin midshipmen. One juvenile flatfish was not identified to species.

Estuarine, Intertidal, Emergent, Persistent (Emergent Vegetation that Remains into the Next Growing Season), Regularly Flooded (E2EM1N)

Nine percent of the points fell within this habitat type, which is 4.97 % of the bay. A total of 2,395 individuals from 15 species, including juveniles of the family Osmeridae, were collected (Table 11). The most abundant species was shiner surfperch at 35.99 %. Topsmelt comprised 23.13 % of the catch; surf smelt comprised 12.61 %. Two coho salmon were collected in habitat type E2EM1N in small channels segmenting the mudflats in the northeast corner of North Bay

One point that fell in habitat type uplands and another that fell in palustrine on the map were assigned this habitat type for purposes of analysis. These points are located in western North Bay near the town of Manila. Only six individuals from two species were collected at these two points: shiner surfperch and topsmelt (Table 12). These two species are representative of the overall abundance for this habitat type. The combined total number of individuals for all sampling within this habitat type was 2,401 from 15 species.

Table 10. Fish species collected in habitat type E1UB3L, where E = estuarine, 1 = subtidal, UB = unconsolidated bottom, 3 = mud, L = subtidal, of Humboldt Bay, Humboldt County, California between the months of September 2000 to November 2001. Average, maximum and minimum lengths were obtained using table queries in ArcMap and are given here under columns Average AVG, Maximum MAX and Minimum MIN. All measurements are total length in millimeters.

SPECIES	*# of points*	*Abundance*	*Average AVG*	*Maximum MAX*	*Minimum MIN*
unidentified juvenile flatfish	1	1	40	40	40
pile surfperch	1	1	378	378	378
Pacific sardine	1	2	82	82	81
black rockfish	2	2	56	56	55
tidewater goby	1	2	21	23	18
Osmerid sp.	1	3	38	40	35
saddleback gunnel	3	3	67	81	45
bat ray	2	4	252	386	150
bay goby	3	5	72	84	51
white surfperch	3	5	75	91	61
walleye surfperch	2	6	150	213	82
threespine stickleback	3	9	34	50	21
Pacific herring	3	10	74	92	49
speckled sanddab	2	10	55	89	45
starry flounder	5	13	156	291	59
plainfin midshipman	2	21	37	101	31
bay pipefish	5	29	146	268	37
surf smelt	3	30	83	103	71
arrow goby	9	53	50	66	24
English sole	4	61	81	153	38
staghorn sculpin	11	117	81	162	28
jacksmelt	4	165	131	340	60
topsmelt	10	254	71	178	37
Northern anchovy	2	1167	102	127	81
shiner surfperch	14	2594	65	144	40
total		4567			

Table 11. Fish species collected in habitat type E2EM1N, where E = estuarine, 2 = intertidal, EM = emergent, 1 = persistent, N = regularly flooded, of Humboldt Bay, Humboldt County, California between the months of September 2000 to November 2001. Average, maximum and minimum lengths were obtained using table queries in ArcMap and are given here under columns Average AVG, Maximum MAX and Minimum MIN. All measurements are total length in millimeters.

SPECIES	*# of points*	*Abundance*	*Average AVG*	*Maximum MAX*	*Minimum MIN*
coho salmon	2	2	96	99	93
starry flounder	1	2	66	67	65
butter sole	2	3	35	45	22
tidewater goby	1	6	31	43	21
arrow goby	5	9	51	59	42
speckled sanddab	1	10	35	50	22
bay pipefish	2	11	192	240	162
English sole	2	77	37	63	21
threespine stickleback	8	88	42	70	14
Osmerid sp.	10	91	55	65	44
Northern anchovy	5	99	50	69	42
staghorn sculpin	19	279	45	102	14
surf smelt	12	302	67	141	48
topsmelt	4	554	86	170	29
shiner surfperch	4	862	73	97	46
total		2395			

Table 12. Fish species collected in west North Bay, habitat type E2EM1N, where E = estuarine, 2 = intertidal, EM = emergent, 1 = persistent, N = regularly flooded, of Humboldt Bay, Humboldt County, California between the months of September 2000 to November 2001. Average, maximum and minimum lengths were obtained using table queries in ArcMap and are given here under columns Average AVG, Maximum MAX and Minimum MIN. All measurements are total length in millimeters.

SPECIES	*# of Points*	*Abundance*	*Average AVG*	*Maximum MAX*	*Minimum MIN*
shiner surfperch	1	1	85	85	85
topsmelt	2	5	91	100	81
Total		6			

Estuarine, Intertidal, Unconsolidated Shore, Mud / Aquatic Bed, Algal, Regularly Flooded (E2US3/AB1N)

This habitat type makes up 3.79 % of all estuarine habitat in the bay. Two percent of sample points fell within this type. From these points, 17 identified species, including juveniles of the family Osmeridae, totaling 1208 individuals were collected (Table 13). The three most abundant species made up nearly three quarters of the entire catch. These were juveniles of the Osmeridae family with 339 individuals, topsmelt with 323 individuals and surf smelt with 235 individuals. One 850 millimeter, total length, leopard shark was collected in this habitat type in Hookton Slough in South Bay. An unidentified juvenile rockfish was also collected in habitat type E2US3/AB1N.

Estuarine, Subtidal, Unconsolidated Bottom, Subtidal (E1UBL)

Three percent of points fell in this habitat type, which made up 1.35 % of estuarine habitat within Humboldt Bay. From those points, 16 species, including juveniles of the family Osmeridae, were collected (Table 14). Of the 803 individuals collected, shiner surfperch was the most abundant making up just over half the entire catch at 57.91 %. Topsmelt was the second most abundant species at 13.08 %, followed by surfsmelt at 12.08 %. One tidewater goby was also found in habitat type E1UBL.

Table 13. Fish species collected in habitat type E2US3/AB1N, where E = estuarine, 2 = intertidal, US = unconsolidated shore, 3 = mud / AB = aquatic bed, 1 = algal, N = regularly flooded, of Humboldt Bay, Humboldt County, California between the months of September 2000 to November 2001. Average, maximum and minimum lengths were obtained using table queries in ArcMap and are given here under columns Average AVG, Maximum MAX and Minimum MIN. All measurements are total length in millimeters.

SPECIES	*# of points*	*Abundance*	*Average AVG*	*Maximum MAX*	*Minimum MIN*
Pacific herring	1	1	47	47	47
bat ray	1	1	335	335	335
juvenile rockfish	1	1	28	28	28
kelp greenling	1	1	64	64	64
leopard shark	1	1	850	850	850
saddleback gunnel	1	1	69	69	69
English sole	2	2	58	71	45
threespine stickleback	3	7	55	77	50
white surfperch	1	7	69	77	62
arrow goby	2	8	56	59	52
pile surfperch	1	9	83	88	60
starry flounder	3	10	109	227	36
bay pipefish	3	12	147	227	58
staghorn sculpin	5	90	64	107	23
shiner surfperch	4	160	58	122	41
surf smelt	3	235	69	120	52
topsmelt	6	323	59	161	17
Osmerid sp.	1	339	54	100	42
total		1208			

Table 14. Fish species collected in habitat type E1UBL, where E = estuarine, 1 = subtidal, UB = unconsolidated bottom, L = subtidal, of Humboldt Bay, Humboldt County, California between the months of September 2000 to November 2001. Average, maximum and minimum lengths were obtained using table queries in ArcMap and are given here under columns Average AVG, Maximum MAX and Minimum MIN. All measurements are total length in millimeters.

SPECIES	*# of Points*	*Abundance*	*Average AVG*	*Maximum MAX*	*Minimum MIN*
starry flounder	1	1	85	85	85
tidewater goby	1	1	30	30	30
English sole	2	2	113	131	95
bat ray	1	2	343	427	258
bay pipefish	1	2	102	116	88
saddleback gunnel	1	2	85	88	81
arrow goby	1	3	34	39	29
threespine stickleback	3	4	41	43	39
Northern anchovy	1	5	83	85	79
bay goby	1	6	74	86	58
butter sole	3	9	26	32	18
Osmerid sp.	4	37	57	82	48
staghorn sculpin	6	62	47	112	11
surf smelt	4	97	68	128	58
topsmelt	2	105	75	137	59
shiner surfperch	1	465	75	119	53
total		803			

Estuarine, Intertidal, Emergent, Persistent (Emergent Vegetation that Remains into the Next Growing Season), Irregularly Flooded (E2EM1P)

This habitat type makes up 0.45 % of the entire estuarine habitat of the bay. Two percent of the sample points fell within this habitat type. Seventeen species, including juveniles of the family Osmeridae, representing a total of 287 individuals were collected (Table 15). Over half of the total catch was made up of Pacific staghorn sculpin, and speckled sanddab, each totaling approximately 30% of the entire catch. A total of 99 sculpins of four different species were collected in this habitat type, eight-six of which were Pacific staghorn sculpin. Ten prickly sculpin, *Cottus asper*, two boneyhead sculpin, *Artedius notospilotus*, and one buffalo sculpin, *Enophrys bison*, were also collected.

Estuarine, Intertidal, Unconsolidated Shore, Sand, Regularly Flooded (E2US2N)

A total of 19 species, including juveniles of the family Osmeridae, were collected in habitat type E2US2N (Table 16). Of the 461 individuals, the three most abundant each comprised approximately 20 % of the total catch. Surf smelt were the most abundant at 22.99 %, followed by topsmelt at 22.13 % and juveniles from the Osmeridae family at 19.52 %. One percent of all sample points were within this habitat, which makes up 0.25 % of estuarine habitat in the bay. One tidewater goby was found in this habitat type in Hookton Slough in South Bay. Seven juvenile rockfish were not identified to species.

Table 15. Fish species collected in habitat type E2EM1P, where E = estuarine, 2 = intertidal, EM = emergent, 1 = persistent, P = irregularly flooded, of Humboldt Bay, Humboldt County, California between the months of September 2000 to November 2001. Average, maximum and minimum lengths were obtained using table queries in ArcMap and are given here under columns Average AVG, Maximum MAX and Minimum MIN. All measurements are total length in millimeters.

SPECIES	*# of points*	*Abundance*	*Average AVG*	*Maximum MAX*	*Minimum MIN*
Osmerid sp.	1	1	58	58	58
bay pipefish	1	1	192	192	192
buffalo sculpin	1	1	55	55	55
penpoint gunnel	1	1	105	105	105
pile surfperch	1	1	285	285	285
boneyhead sculpin	1	2	82	88	75
tubesnout	1	2	130	145	114
cabezon	1	6	81	163	45
butter sole	1	8	34	47	27
threespine stickleback	1	9	42	66	21
prickly sculpin	2	10	65	89	47
starry flounder	1	10	129	156	112
arrow goby	2	12	35	54	30
surf smelt	2	18	80	142	61
English sole	3	34	63	128	44
speckled sanddab	1	85	66	110	22
staghorn sculpin	4	86	67	240	23
total		287			

Table 16. Fish species collected in habitat type E2US2N, where E = estuarine, 2 = intertidal, US = unconsolidated shore, 2 = sand, N = regularly flooded, of Humboldt Bay, Humboldt County, California between the months of September 2000 to November 2001. Average, maximum and minimum lengths were obtained using table queries in ArcMap and are given here under columns Average AVG, Maximum MAX and Minimum MIN. All measurements are total length in millimeters.

SPECIES	*# of Points*	*Abundance*	*Average AVG*	*Maximum MAX*	*Minimum MIN*
Northern anchovy	1	1	121	121	121
Pacific sandlance	1	1	131	131	131
cabezon	1	1	126	126	126
lingcod	1	1	78	78	78
penpoint gunnel	1	1	118	118	118
tidewater goby	1	1	49	49	49
arrow goby	1	3	45	55	38
bay pipefish	1	3	214	280	161
starry flounder	1	3	160	285	90
prickly sculpin	1	4	50	54	47
English sole	1	7	104	150	78
juvenile rockfish	1	7	79	86	67
threespine stickleback	2	15	61	137	28
speckled sanddab	1	16	87	105	50
shiner surfperch	2	19	57	142	39
staghorn sculpin	3	26	88	129	51
Pacific herring	2	54	55	66	45
Osmerid sp.	1	90	55	64	50
topsmelt	2	102	102	176	26
surf smelt	4	106	102	148	60
total		461			

Estuarine, Intertidal, Emergent, Persistent (Emergent Vegetation that Remains into the Next Growing Season) / Unconsolidated Shore, Mud, Regularly Flooded (E2EM1/US3N)

This habitat type makes up 0.073 % of the entire estuarine area of Humboldt Bay. Only two species, comprising 64 individuals, were collected from 1 % of all points (Table 17). Pacific staghorn sculpins made up 92.19 % of the entire catch, with the remaining percentage represented by threespine sticklebacks.

E1UB2L-Estuarine, Intertidal, Unconsolidated Shore, Sand, Irregularly Flooded (E2US2P)

A 36.80-meter section of one juvenile sampling trawl entered the habitat type E2US2P. The remainder of the trawl, 302.32 meters, fell in the E1UB2L habitat type. Habitat type E2US2P makes up 0.05 % of estuarine habitat in Humboldt Bay. A total of 23 individuals from six species, including juveniles of the family Osmeridae, was collected (Table 18). The most abundant was the tubesnout, *Aulorhynchus flavidus*, followed by speckled sanddab.

E1UB2L-E2AB3M

Another trawl that sampled in two habitat types occurred when using the 16-foot trawl. Most of this trawl sampled habitat type E2AB3M with 249.68 meters of the entire 309.03-meter trawl. Twenty-nine individuals from 4 species, including juveniles of the

Table 17. Fish species collected in habitat type E2EM1/US3N, where E = estuarine, 2 = intertidal, EM = emergent, 1 = persistent / US = unconsolidated shore, 3 = mud, N = regularly flooded of Humboldt Bay, Humboldt County, California between the months of September 2000 to November 2001. Average, maximum and minimum lengths were obtained using table queries in ArcMap and are given here under columns Average AVG, Maximum MAX and Minimum MIN. All measurements are total length in millimeters.

SPECIES	*# of points*	*Abundance*	*Average AVG*	*Maximum MAX*	*Minimum MIN*
threespine stickleback	1	5	28	51	16
staghorn sculpin	2	59	34	65	15
total		64			

Table 18. Fish species collected by trawl entering habitat types E2US2P, where E = estuarine, 2 = intertidal, US = unconsolidated shore, 2 = sand, P = irregularly flooded, and E1UB2L, where E = estuarine, 1 = subtidal, UB = unconsolidated bottom, 2 = sand, L = subtidal, of Humboldt Bay, Humboldt County, California between the months of September 2000 to November 2001. Average, maximum and minimum lengths were obtained using table queries in ArcMap and are given here under columns Average AVG, Maximum MAX and Minimum MIN. All measurements are total length in millimeters.

SPECIES	*# of trawls*	*Abundance*	*Average AVG*	*Maximum MAX*	*Minimum MIN*
English sole	1	1	19	19	19
brown Irish lord	1	1	96	96	96
cabezon	1	1	51	51	51
Osmerid sp.	1	3	36	39	32
speckled sanddab	1	8	42	61	35
tubesnout	1	9	128	152	102
total		23			

family Osmeridae, were collected (Table 19). Bay pipefish, *Syngnathus leptorhynchus*, was the most abundant with 13 individuals, followed by tubesnout.

Table 19. Fish species collected by trawl entering habitat types E2AB3M, where E = estuarine, 2 = intertidal, AB = aquatic bottom, 3 = rooted vascular, M = irregularly exposed, and E1UB2L, where E = estuarine, 1 = subtidal, UB = unconsolidated bottom, 2 = sand, L = subtidal, of Humboldt Bay, Humboldt County, California between the months of September 2000 to November 2001. Average, maximum and minimum lengths were obtained using table queries in ArcMap and are given here under columns Average AVG, Maximum MAX and Minimum MIN. All measurements are total length in millimeters.

SPECIES	*# of trawls*	*Abundance*	*Average AVG*	*Maximum MAX*	*Minimum MIN*
Osmerid sp.	1	1	38	38	38
threespine stickleback	1	6	54	81	45
tubesnout	1	9	126	139	97
bay pipefish	1	13	155	210	83
total		29			

DISCUSSION

Of the 67 species collected during this study, all but five have been previously documented in Humboldt Bay. Locations of the 15 most abundant species can be viewed in Figures 8-22. The most abundant fish collected over the course of this study was threespine stickleback, *G. aculeatus*. This species was collected at 108 points, or approximately one-third of all sampling locations. *Gasterosteus aculeatus* can be found in freshwater as well as coastal marine environments. It is regularly found in bays, backwaters, river tributaries and other areas with low flows (Wootton 1976). Salinities where threespine sticklebacks were collected ranged from 16 parts per thousand to 36 parts per thousand (Appendix C). Gotshall et al (1980) and Shapiro and Associates (1980) noted year-round presence of *G. aculeatus* in Humboldt Bay.

While threespine stickleback was the most abundant species, the Pacific staghorn sculpin was the most commonly captured species. Previous studies of Humboldt Bay support this extensive distribution of staghorn sculpin. Shapiro and Associates (1980) claimed staghorn sculpin was one of the most abundant and widely distributed fish in Humboldt Bay. Barnhart et al. (1992) listed staghorn sculpins as abundant, and strongly euryhaline allowing the species to live in both fresh and saltwater habitats.

Found at just over 60 percent of all locations, staghorn sculpins were collected in all but one habitat type sampled in the bay. Water quality readings taken both during trawls and other sampling methods ranged from 0.6 parts per thousand to 37 parts per thousand (Appendix D).

Figure 8. Locations within Humboldt Bay, Humboldt County, California where threespine stickleback were collected between the months of September 2000 and November 2001. Threespine stickleback ranged in length from 11mm to 137mm. The overall average length was 49.17mm. Habitat map digitized by National Wetlands Inventory.

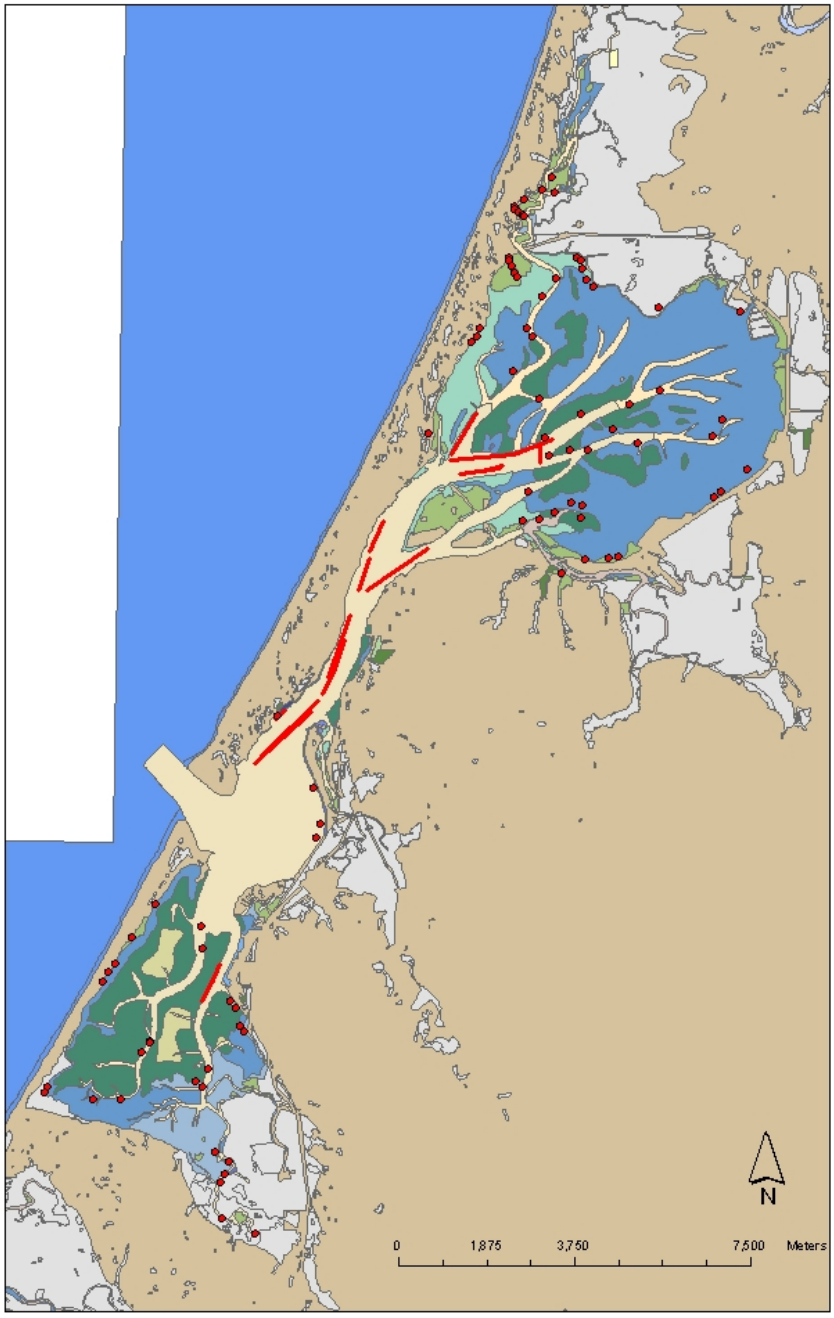

Figure 9. Locations within Humboldt Bay, Humboldt County, California where shiner surfperch were collected between the months of September 2000 and November 2001. Shiner surfperch ranged in length from 36mm to 155mm. The overall average length was 75mm. Habitat map digitized by National Wetlands Inventory.

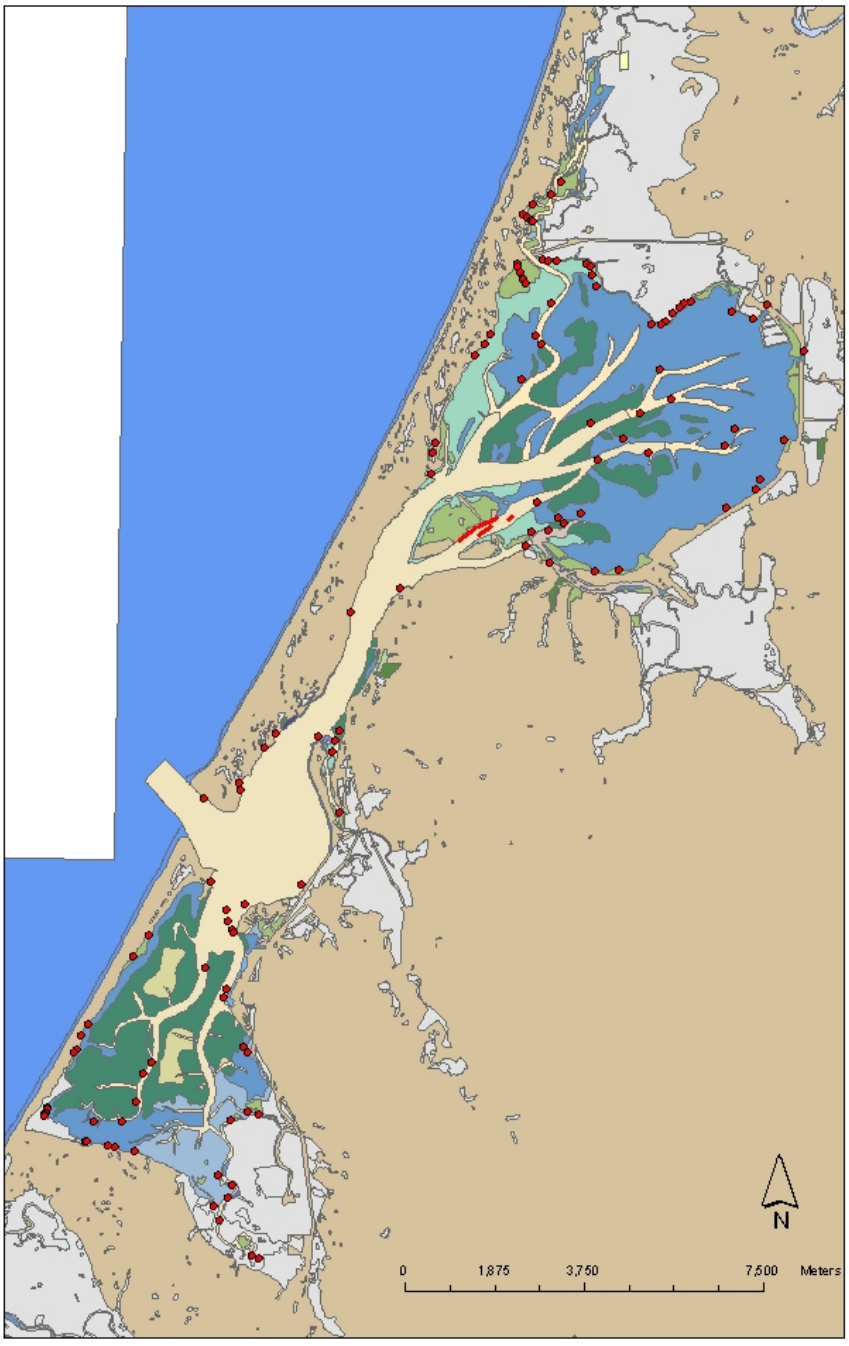

Figure 10. Locations within Humboldt Bay, Humboldt County, California where topsmelt were collected between the months of September 2000 and November 2001. Topsmelt ranged in length from 17mm to 337 mm. The overall average length was 89.43mm. Habitat map digitized by National Wetlands Inventory.

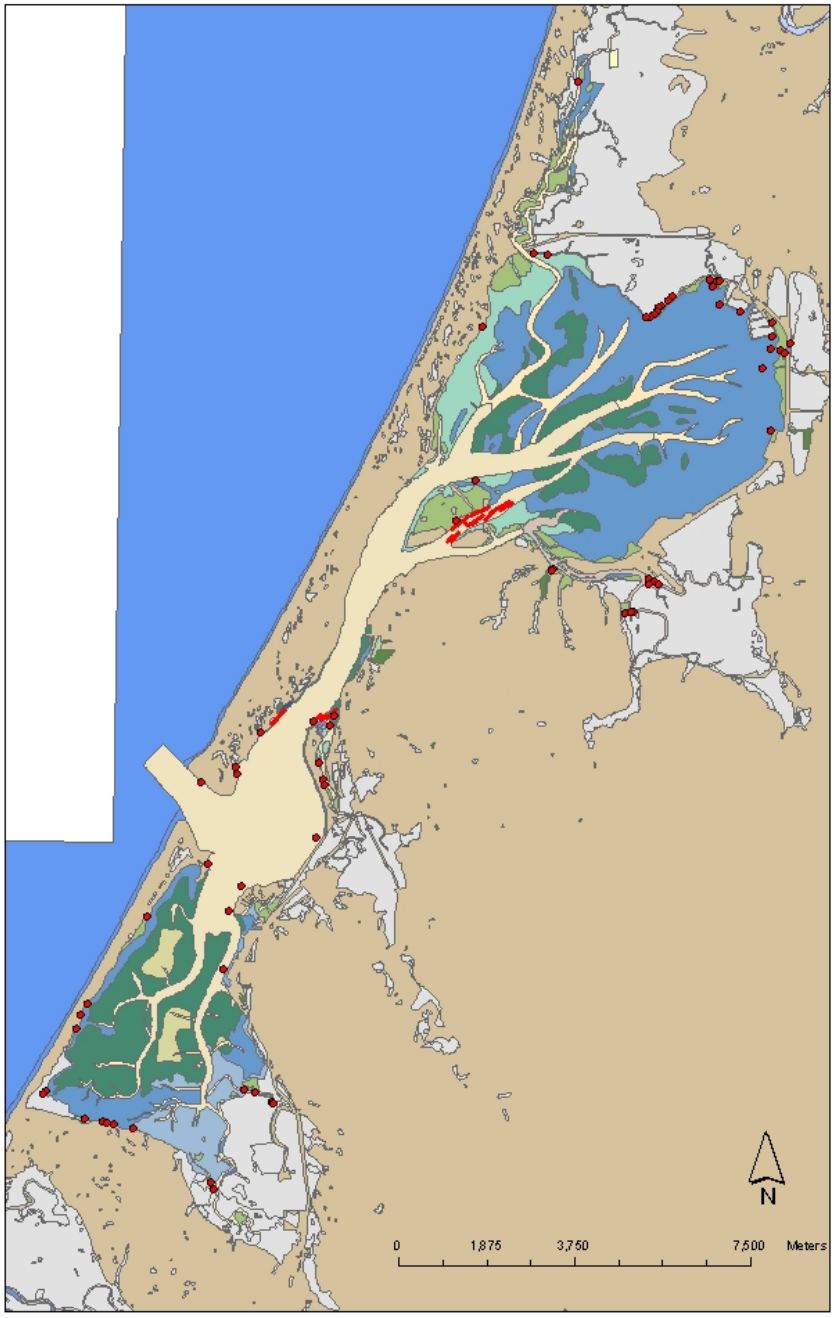

Figure 11. Locations within Humboldt Bay, Humboldt County, California where juveniles of the family Osmeridae were collected between the months of September 2000 and November 2001. Juveniles of the family Osmeridae ranged in length from 10mm to 100mm. The overall average length was 49.59mm. Habitat map digitized by National Wetlands Inventory.

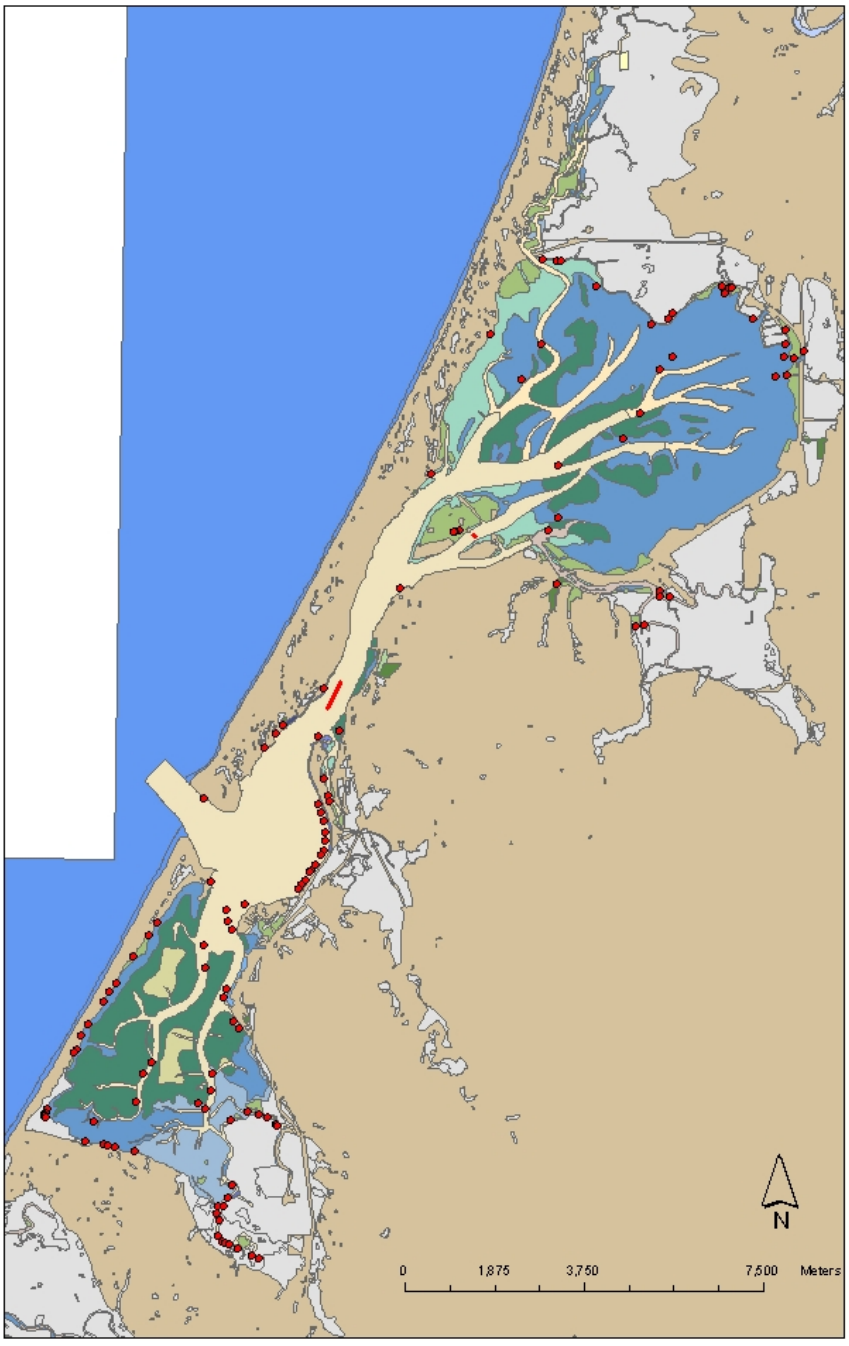

Figure 12. Locations within Humboldt Bay, Humboldt County, California where surfsmelt were collected between the months of September 2000 and November 2001. Surfsmelt ranged in length from 25mm to 428mm. The overall average length was 75.24mm. Habitat map digitized by National Wetlands Inventory.

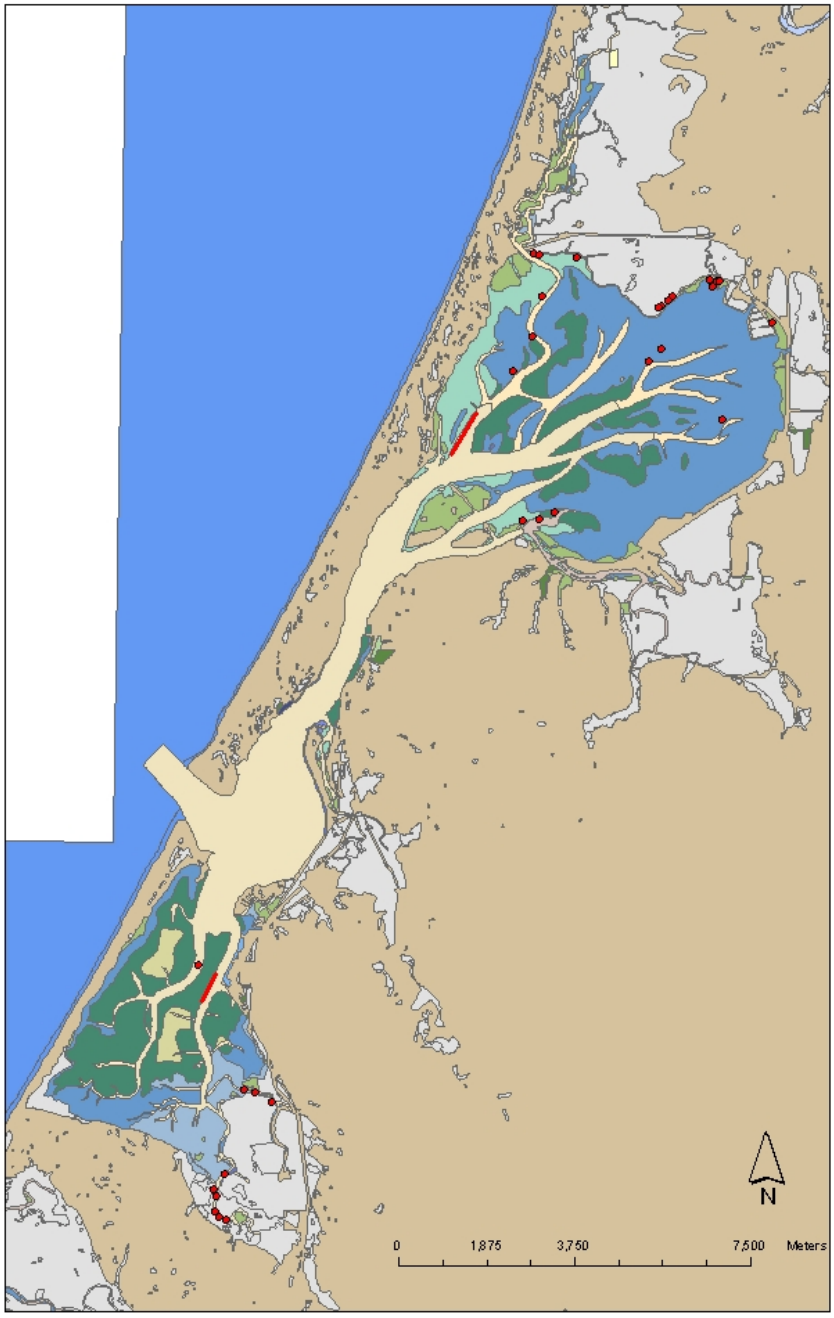

Figure 13. Locations within Humboldt Bay, Humboldt County, California where Northern anchovy were collected between the months of September 2000 and November 2001. Northern anchovy ranged in length from 31mm to 142mm. The overall average length was 69.51mm. Habitat map digitized by National Wetlands Inventory.

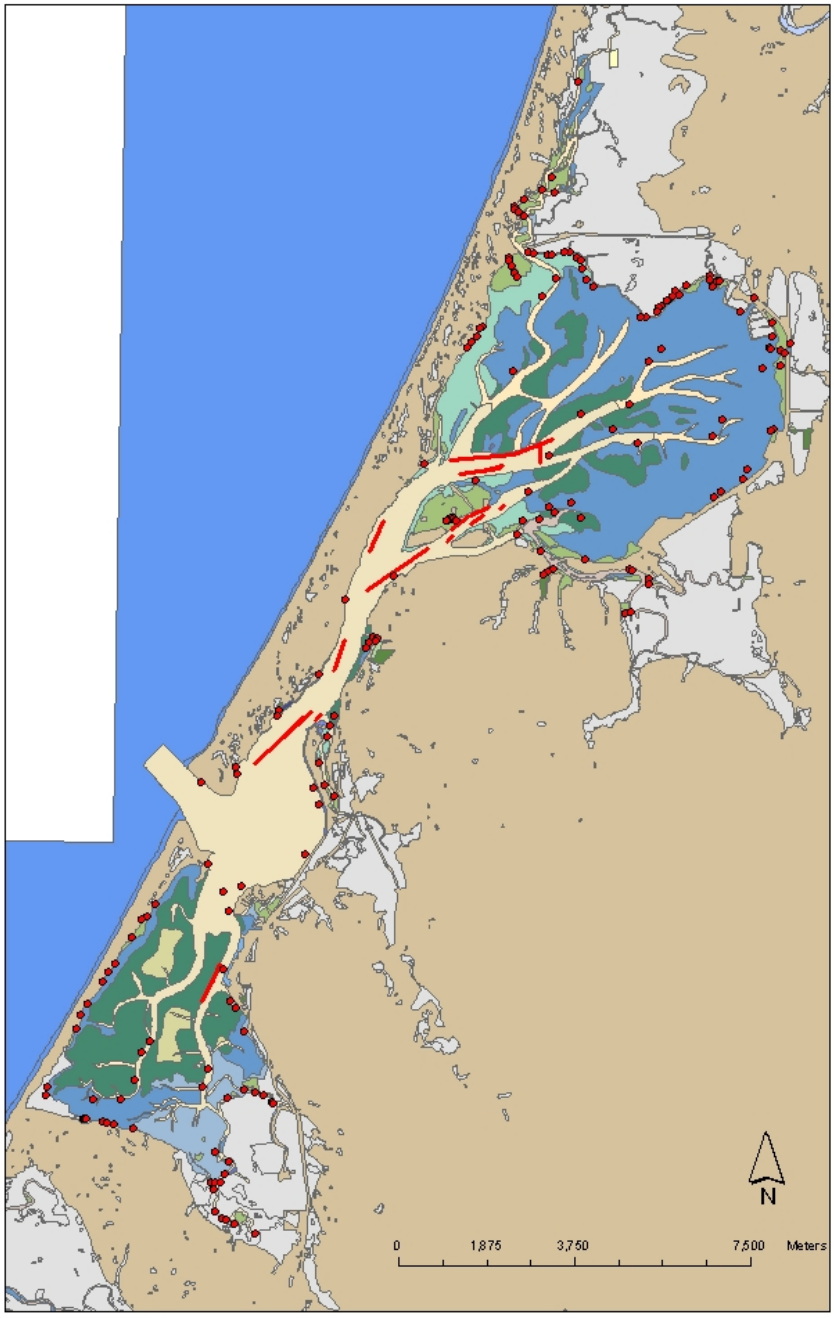

Figure 14. Locations within Humboldt Bay, Humboldt County, California where staghorn sculpin were collected between the months of September 2000 and November 2001. Staghorn sculpin ranged in length from 11mm to 242mm. The overall average length was 66.27mm. Habitat map digitized by National Wetlands Inventory.

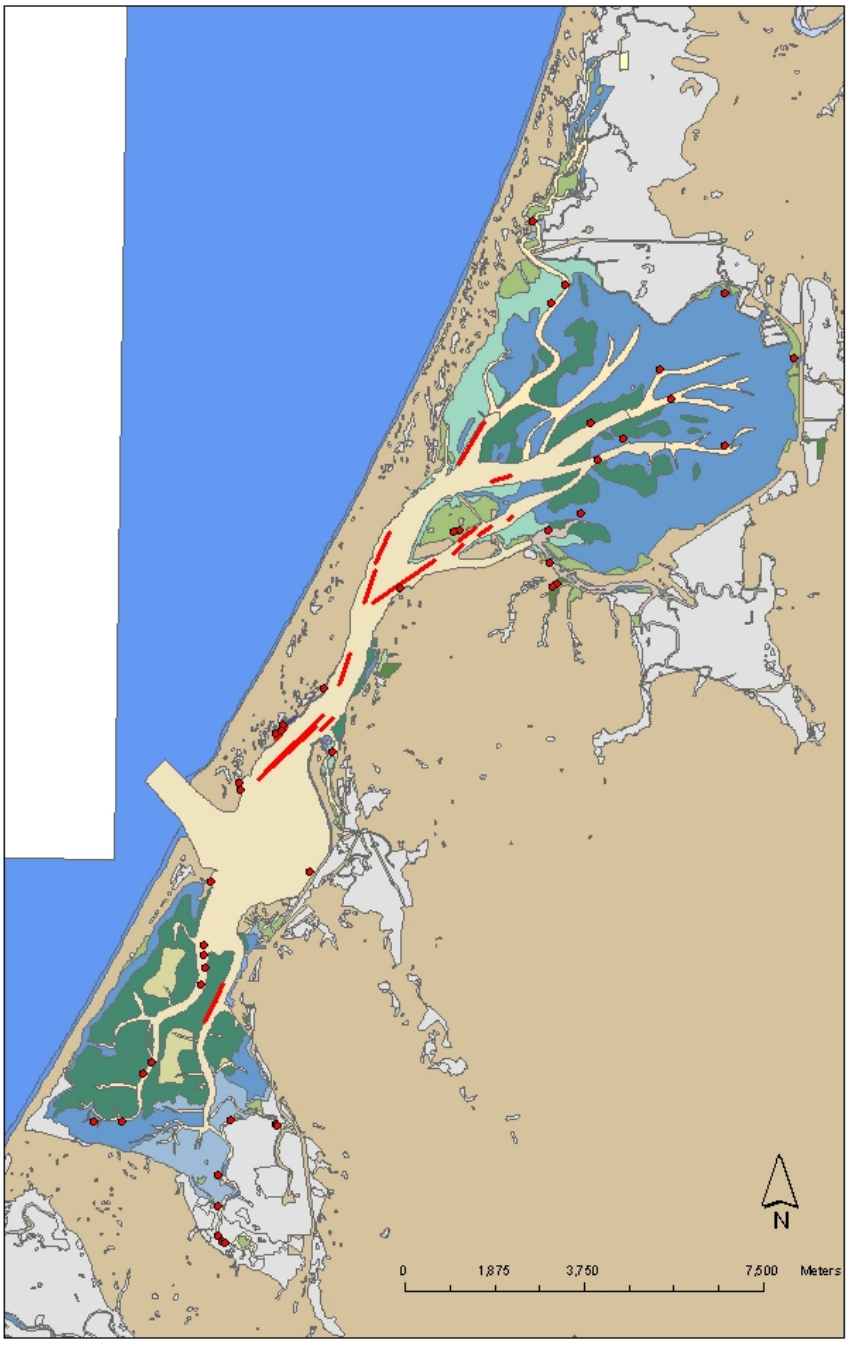

Figure 15. Locations within Humboldt Bay, Humboldt County, California where English sole were collected between the months of September 2000 and November 2001. English sole ranged in length from 18mm to 230mm. The overall average length was 74.34mm. Habitat map digitized by National Wetlands Inventory.

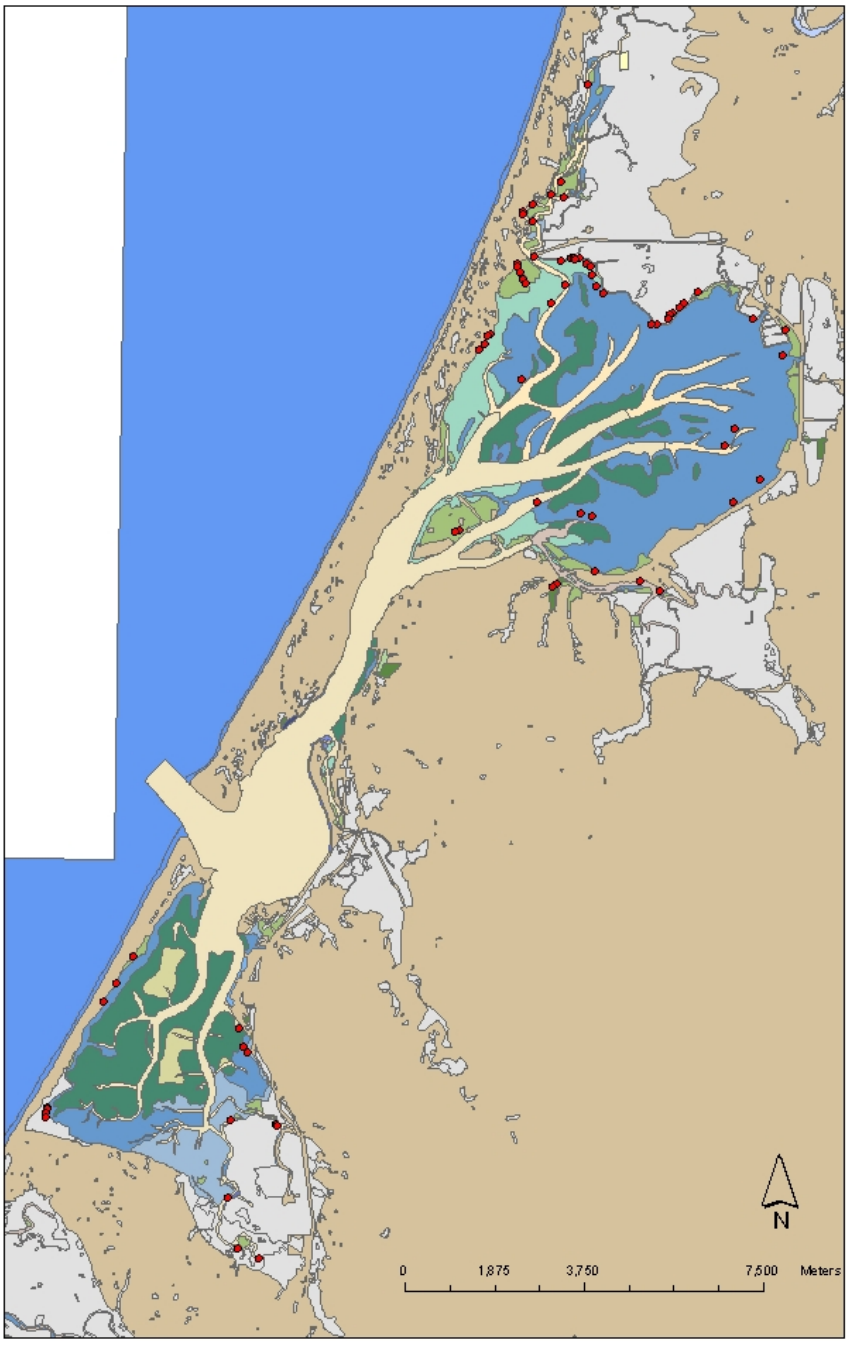

Figure 16. Locations within Humboldt Bay, Humboldt County, California where arrow goby were collected between the months of September 2000 and November 2001. Arrow goby ranged in length from 20mm to 69mm. The overall average length was 50.26mm. Habitat map digitized by National Wetlands Inventory.

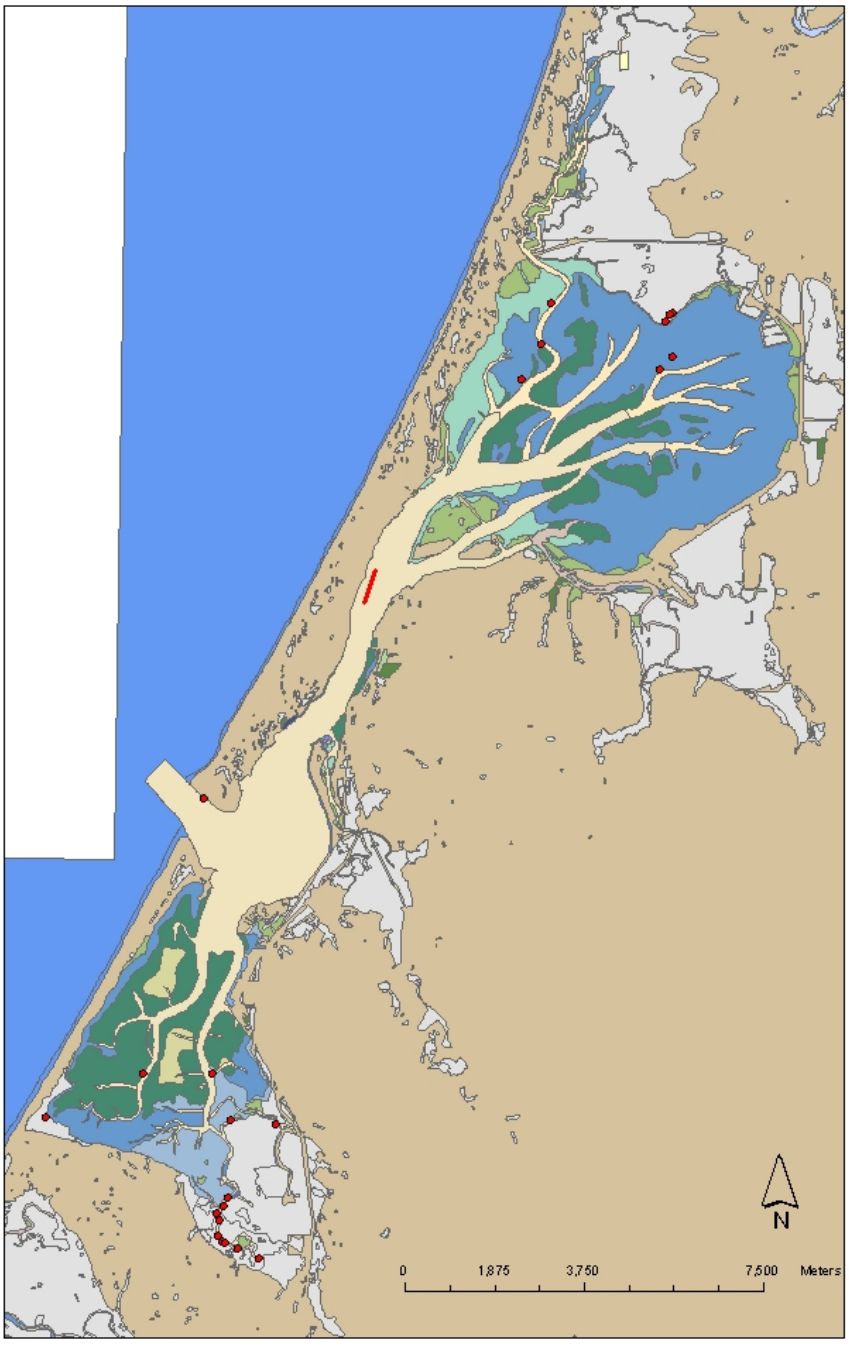

Figure 17. Locations within Humboldt Bay, Humboldt County, California where Pacific herring were collected between the months of September 2000 and November 2001. Pacific herring ranged in length from 25mm to 213mm. The overall average length was 58.91mm. Habitat map digitized by National Wetlands Inventory.

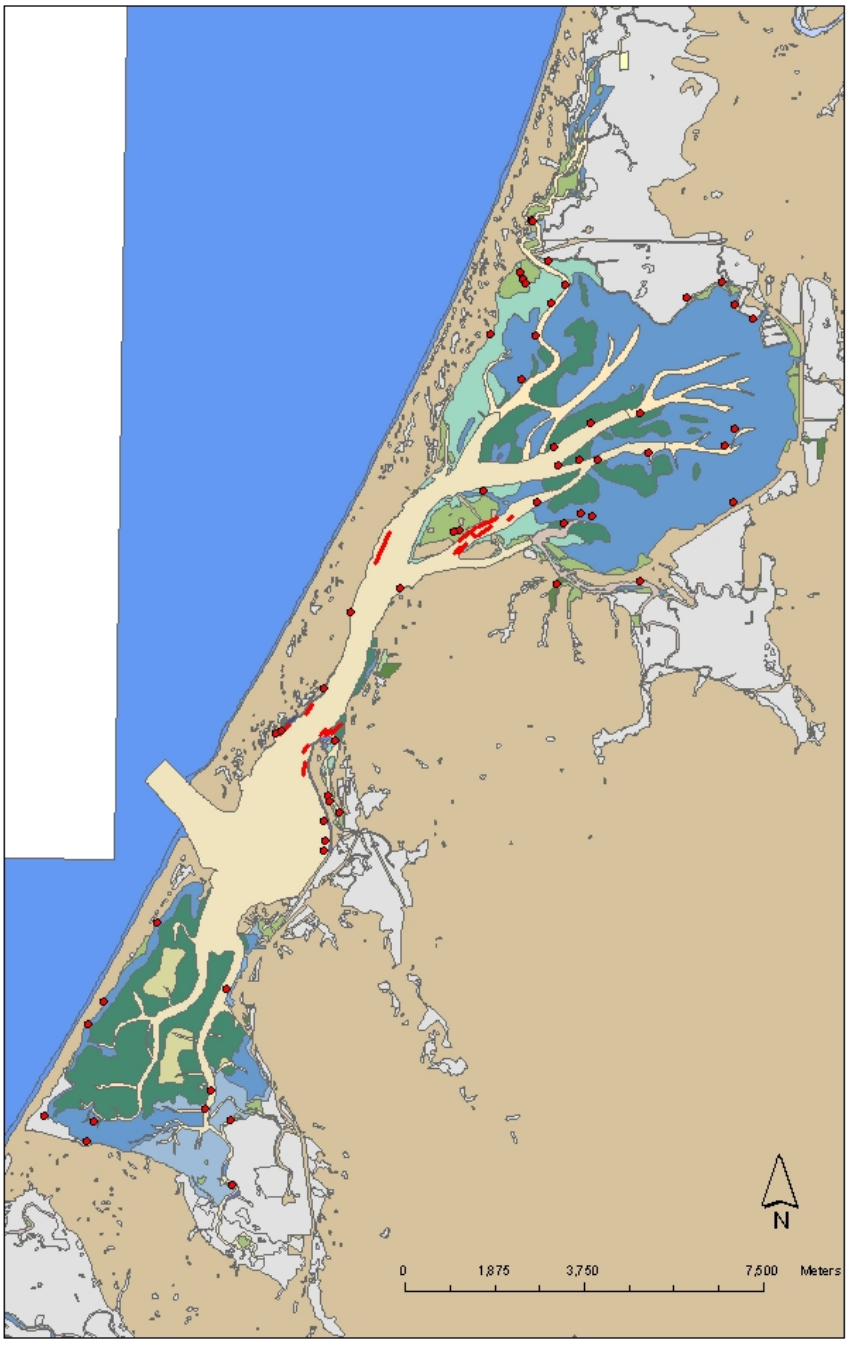

Figure 18. Locations within Humboldt Bay, Humboldt County, California where bay pipefish were collected between the months of September 2000 and November 2001. Bay pipefish ranged in length from 37mm to 324mm. The overall average length was 164.08mm. Habitat map digitized by National Wetlands Inventory.

Figure 19. Locations within Humboldt Bay, Humboldt County, California where tubesnout were collected between the months of September 2000 and November 2001. Tubesnout ranged in length from 93mm to 219mm. The overall average length was 127.32mm. Habitat map digitized by National Wetlands Inventory.

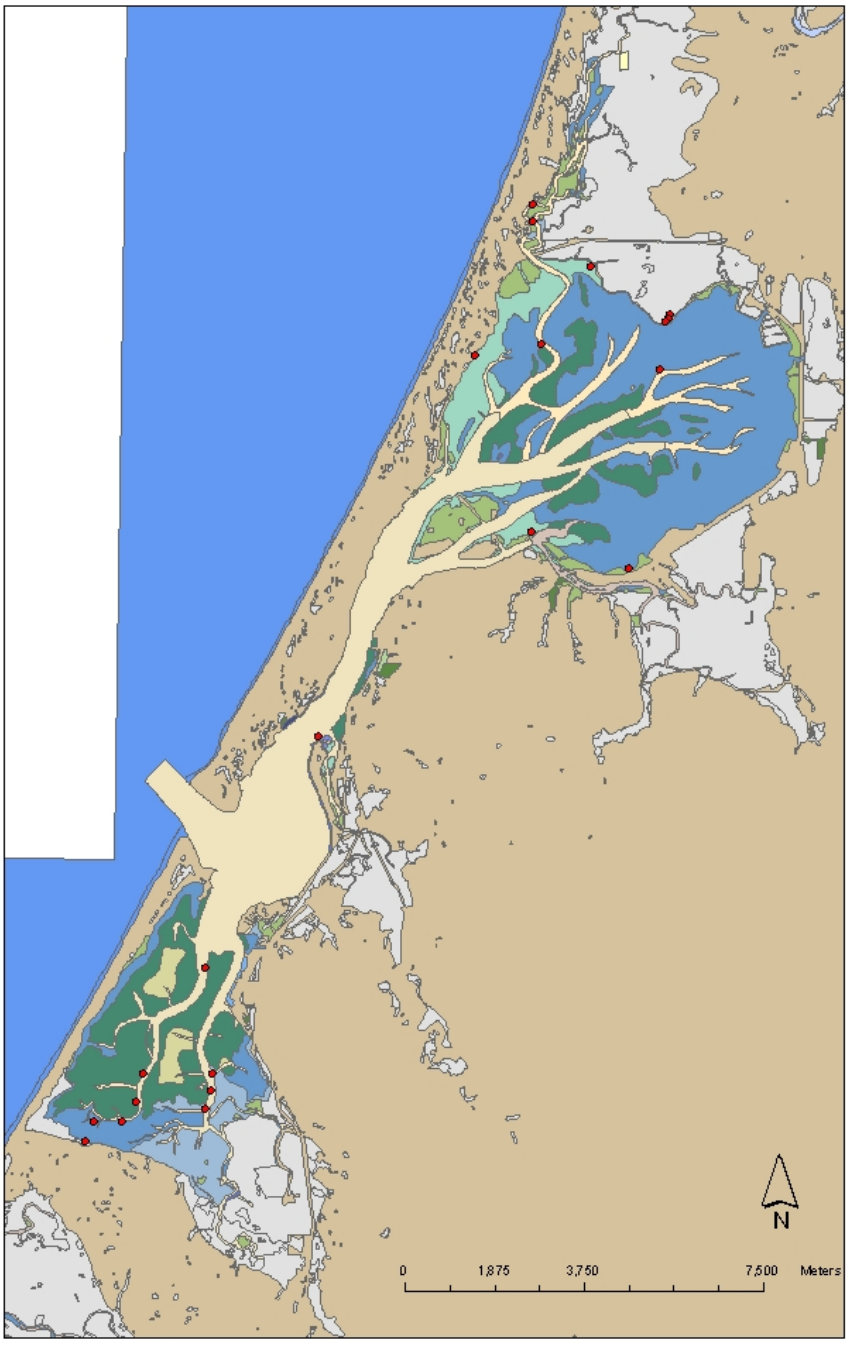

Figure 20. Locations within Humboldt Bay, Humboldt County, California where jacksmelt were collected between the months of September 2000 and November 2001. Jacksmelt ranged in length from 17mm to 372mm. The overall average length was 162.70mm. Habitat map digitized by National Wetlands Inventory.

Figure 21. Locations within Humboldt Bay, Humboldt County, California where speckled sanddab were collected between the months of September 2000 and November 2001. Speckled sanddab ranged in length from 22mm to 117mm. The overall average length was 68.16mm. Habitat map digitized by National Wetlands Inventory.

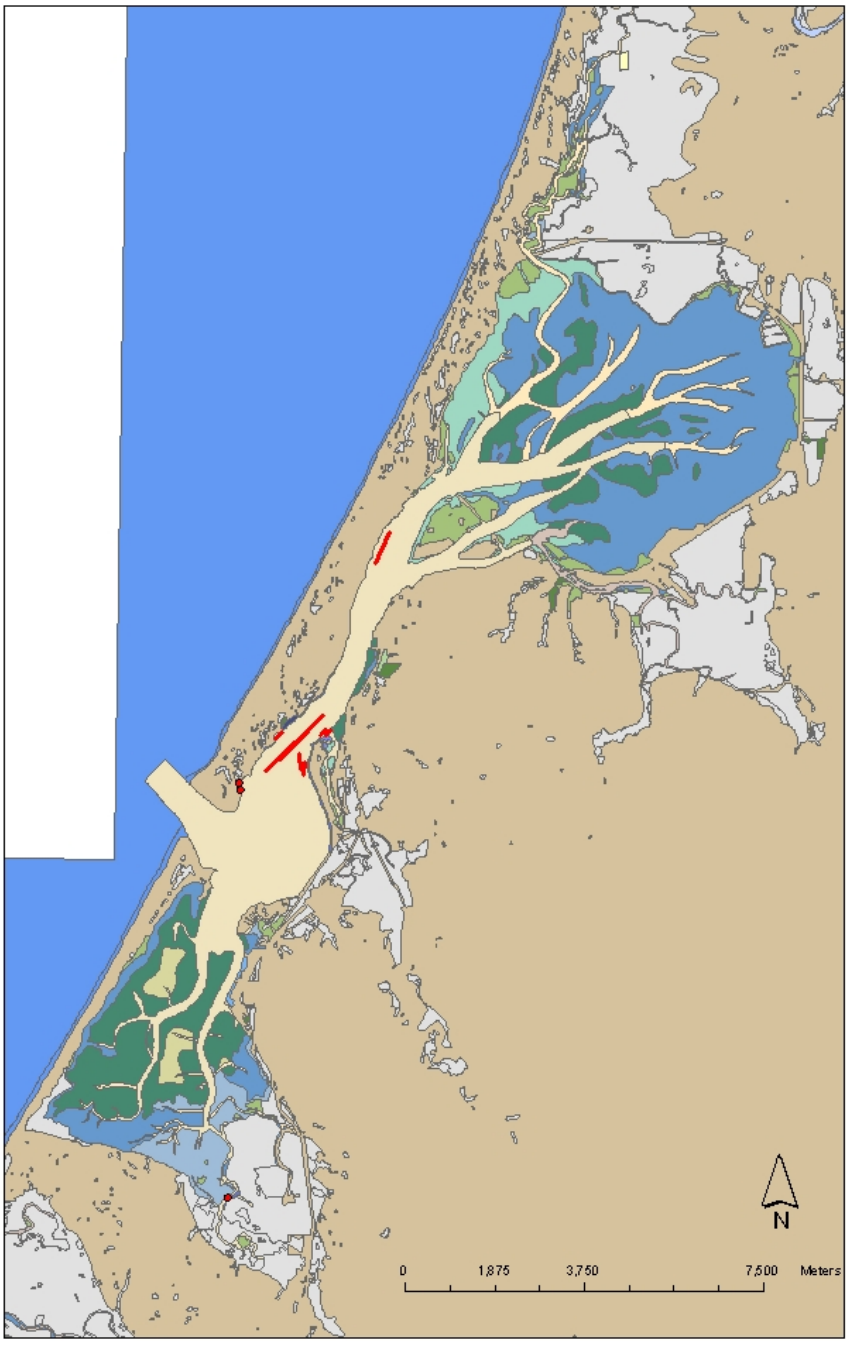

Figure 22. Locations within Humboldt Bay, Humboldt County, California where Pacific sandlance were collected between the months of September 2000 and November 2001Pacific sandlance ranged in length from 76mm to 131mm. The overall average length was 88.73mm. Habitat map digitized by National Wetlands Inventory.

Lengths of staghorn sculpins ranged from 11 millimeters TL in habitat type E1UBL to 242 millimeters TL in habitat type E1UB2L.

Shiner surfperch was the most abundant species collected in both Samuelson's (1973) South Bay study and Sopher's (1974) study of North Bay. Because Sopher found no females carrying young after May and no individuals less than 85 millimeters TL between January and May, he determined that spawning in Humboldt Bay must occur between May and June. The highest numbers of smaller individuals occurred between the months of June and July. Similarly, Samuelson found that between the months of February and April, *C. aggregata* ranged in total length from 73 millimeters to 225 millimeters. However, between the months of June and October, total lengths ranged from 50 millimeters to 132 millimeters.

In this study of Humboldt Bay, shiner surfperch, collected from 25 September 2000 to 30 November 2001, was the second most abundant species. The highest numbers were collected during the summer months of June through September (Appendix E). Shiner surfperch were primarily collected by seine during these months. No trawl samples were collected. The smallest individual measured 36 millimeters TL, and was collected in July. Most of the smaller individuals were collected in July with the average TL being lowest between the months of June through August. The higher number of individuals collected in the month of September is a reflection of the over one thousand shiner surfperch caught by trawl in Eureka Channel.

Collected at only 33 sites, northern anchovy was the sixth most abundant species collected. Waldvogel (1977) found that Northern anchovy entered Humboldt Bay in

April, and remained until the first week of November. Samuelson (1973) and Sopher (1974) found northern anchovies in Humboldt Bay from April to October, and March to September, respectively. Eldridge and Bryan (1972) found *E. mordax* larvae in the months of March, August, September, and December.

These results are consistent with the present study, as anchovies were found in the bay from March to October. Anchovies were most abundant from June to August. Northern anchovy are abundant in other California coastal estuaries. Northern anchovy was the most abundant species in August and September. Northern anchovies were also the most abundant species overall in a study of Colorado Lagoon (Allen and Horn 1975). Northern anchovy are thought to bring coho salmon, and chinook salmon, *Oncorhynchus tshawytscha*, into Humboldt Bay, as they are a major food source for both.

English sole was the eighth most abundant species for this study. This is consistent with results from other published studies of Humboldt Bay (Samuelson 1973, Sopher 1974, Shapiro and Associates 1980, Chamberlain and Barnhart 1993), where English sole were among the most commonly collected species. Misitano (1970, 1976) found that English sole use Humboldt Bay as a nursery area, and that entry into the bay occurs when they are between 19 to 26 millimeters total length. Toole (1980) determined young-of-the-year English sole to be present in Humboldt Bay between the months of February and April, when they became abundant until the emigration of yearlings from the bay.

The smallest English sole collected in this study were found on 13 March 2001. For this one sampling date, mean lengths of each trawl ranged from 19 millimeters to 34

millimeters TL. The smallest individual was 18 millimeters TL. These were collected in North Bay channel and the channel between Indian and Woodley Islands while sampling for juvenile fishes with the 16 foot modified beam trawl.

Over the entire study, the mean lengths of English sole were from 37.39 millimeters to 104.29 millimeters TL at each site where they were collected. The largest specimen collected in this study was 230 millimeters TL. This individual was taken in North Bay Channel, northwest of the Elk River slough mouth on 30 November 2001. Based on Ketchen (1956), this individual would be considered near sexually maturity, and was collected during the English sole spawning season between October and May (Matarese et al. 1989). Because no sexually mature English sole have been collected in Humboldt Bay, spawning is believed to occur in ocean waters.

The presence of leopard sharks in Humboldt Bay has been noted by several researchers (Samuelson 1973, Sopher 1974, Gotshall et al. 1980, Shapiro and Associates 1980, Fritzsche and Cavanagh 1995). A 1975 study of food habits of leopard sharks in San Francisco and Tomales Bays noted that *Callianasa* shrimp, crabs of the genus *Cancer*, and an echiuran worm, *Urechis caupo*, were most frequently fed upon (Russo 1975). Each of these is a demersal invertebrate, which supports the claim that leopard sharks are benthic feeders on mud flats.

Although leopard sharks were found in North Bay and Hookton Slough, they were collected in abundance in the southwestern portion of South Bay on 8 May 2001 (Figure 23). On this day, a total of 86 individuals were collected on an incoming tide. The habitat at this location is E2US3N, and is best described as mudflat segmented by

narrow channels. Miklos et al. (2003) studied leopard sharks in Tomales Bay and found that summer location is greatly affected by tidal stage, with movement into the littoral zones to feed occurring at high tide. The temperatures in the intertidal areas of Tomales Bay during the study often reached 25 ºC. Water temperatures recorded on 8 May 2001 in Humboldt Bay reached 21 ºC, with a salinity of 34 parts per thousand.

One medusafish, *Icichthys lockingtoni*, family Centrolophidae, was collected in eelgrass beds near Southport Channel in South Bay. Gotshall et al. (1980) stated that a medusafish had been collected in Humboldt Bay by trawl in September of 1968. Fritzsche and Cavanagh (1995) reiterated that this was the only medusafish recorded from Humboldt Bay, and that they are rarely found in shallow water. The individual found in this study measured 79 millimeters TL. It was collected on 12 July 2001 on an out going tide.

Twenty-six tidewater gobies were collected in six habitat types in Humboldt Bay, including the assigned habitat type of E2US3N for the drainage ditch in North Bay (Figures 24 and 25). Gobies were collected on both sides of the tide gate between the drainage ditch (nine gobies) and Eureka Slough (one goby). Tidewater gobies were also collected near and in Mad River Slough in the northwest corner of North Bay, and Hookton and White Sloughs in the southeast corner of South Bay.

Figure 23. Locations within Humboldt Bay, Humboldt County, California where leopard sharks were collected between the months of September 2000 and November 2001. Leopard shark ranged in length from 281mm to 1219mm. The overall average length was 624.31mm. Habitat map digitized by National Wetlands Inventory.

Figure 24. Tide gate separating Eureka Slough, Humboldt Bay, Humboldt County, California and the drainage ditch that parallels California State Highway 101. The drainage ditch is in the foreground.

Figure 25. Tide gate separating Eureka Slough, Humboldt Bay, Humboldt County, California and the drainage ditch that parallels California State Highway 101. Eureka Slough is in the background.

During the course of this study, five species not documented in Humboldt Bay were collected. These were gopher rockfish, *Sebastes carnatus,* Pacific sardine, *Sardinops sagax*, mosquitofish, *Gambusia affinis,* longjaw mudsucker, *Gillichthys mirabilis*, and petrale sole, *Eopsetta jordani*. These species are not uncommon to the northeast Pacific Ocean, however, no studies have noted their presence in Humboldt Bay.

Due to our sampling techniques, only juvenile rockfish were collected in this study. Most of the 155 individuals were black rockfish, a species known to reside in Humboldt Bay (Gotshall et al. 1980). Juvenile rockfish have been shown to reside in other California bays and estuaries (Moring 1972, Yoclavich et al. 1991, 1996). The single copper rockfish collected on 14 August 2001 at the mouth of Hookton Slough in South Bay is also considered to be resident in Humboldt Bay (Gotshall et al. 1980). One gopher rockfish was collected in the southern end of Southport Channel in South Bay on 11 July 2001. While copper rockfish are considered residents of Humboldt Bay (Gotshall et al 1980), gopher rockfish have never been noted in Humboldt Bay. Their range is described as San Roque, Baja California to Eureka, California (Miller and Lea 1972). However, rockfish of the subgenus *Pteropodus*, the "copper complex," which include the gopher rockfish, were thought to be common near Monterey Bay (Yocklavich et al. 1996).

Pacific sardine are range from Guaymas, Mexico, to Kamchatka, Russia (Miller and Lea 1972). While common within this range, this species has never been documented in Humboldt Bay. Pacific sardines may be identified by the striations on the operculum, and black spots on their sides. These two characteristics differentiate them

from other common Clupeioid fishes such as the Pacific herring. The Pacific sardine spawns from January to June, with northward migrations beginning in early summer (Hart 1973). In the present study, forty-six sardines were collected at six separate sites on four different dates. Collection occurred between 12 July and 30 November 2001, with 37 individuals being collected on 14 August 2001. The smallest sardine collected was 81 millimeters TL, the largest was 148 millimeters TL. Based on the age description of sardines off Central California given by Hart (1973), the individuals collected over the course of this study were approximately one year old.

Mosquitofish were collected in the drainage ditch near the Eureka Airport. There is a tide gate located at this location on Eureka slough, as noted on the USGS topoquad. This gate separates the slough from the drainage ditch that follows the outline of the bay (Figures 24 and 25). The mosquitofish were found on only one side of this disconnect, in the direction of the drainage ditch. Ten mosquitofish varying in size from 13 to 41 millimeters TL were collected. This species is considered a freshwater or brackish fish and is not native to Humboldt Bay.

The California Department of Fish and Game has no historical record of when mosquitofish may have planted into Eureka Slough or the drainage ditch, however, a 2001 United States Fish and Wildlife study of the drainage ditch found mosquitofish, and threespine stickleback (Goldsmith 2003, personal communication). Mosquitofish are found in other California bays and estuaries. In San Francisco Bay it is considered an introduced species, were it was found in less than 1 % of both otter trawls and beach seines during a 20-year study of Suisun Marsh (Matern et al. 2002). However,

mosquitofish were abundant in a study of a more southern estuary, Mugu Lagoon, the largest estuarine lagoon in southern California, located at Point Mugu, Ventura County (Saiki 1997).

One longjaw mudsucker, *G. mirabilis*, was collected in a small channel that dead-ends just west of the mouth of Mad River Slough. Salinities on the day of capture ranged from 33 to 34 parts per thousand. This is consistent with what is considered typical habitat of the longjaw mudsucker: shallow backwater with soft, muddy substrate and moderate to high salinities (Barlow 1961). Its geographical range is Tomales Bay just north of Point Reyes to the Gulf of California(Miller and Lea 1972). Although Barlow (1961) gives the same northern limit, he notes that the northernmost "permanent" population may be in San Francisco Bay, due to the abundance of the species there.

Longjaw mudsuckers were present and found to be tolerant to the fluctuating conditions of tidal marshes in San Francisco Bay estuary (Josselyn 1983). A study in the Sweetwater Marsh National Wildlife Refuge in San Diego, California found juvenile *G. mirabilis* to be abundant in spring and summer, with adults present in most samples throughout the study (West and Zedler 2000). In this study, juveniles were determined to be those individuals less than 100 millimeters. The individual collected in Humboldt Bay would, therefore, be considered a juvenile at 93 millimeters TL.

Two juvenile petrale sole were collected near the eastern shore in Entrance Bay. This area is characterized by high wave action, and sandy beaches. None of the identified specimens in the larval fish studies of Humboldt Bay by Eldridge (1970) or Eldridge and Bryan (1972) was petrale sole. There are no publications that have

documented petrale sole in Humboldt Bay. Miller and Lea (1972) define the range of petrale sole from Islas Los Coronados, Baja California, to northern Gulf of Alaska. Petrale sole are found in near shore waters near Humboldt Bay.

Juvenile fishes use Humboldt Bay as a refuge from predators, and as a nursery area. Mature fishes use its many habitats for both feeding and spawning. A study in the Kariega Estuary in South Africa (Paterson and Whitfield 2000) supports the supposition that juvenile fishes seek out the shallower habitats of estuaries to avoid predation. Similarly, many of the same species found in Humboldt Bay were also found during an ecological profile of San Francisco Bay (Josselyn 1983). These fishes were abundant in shallow tidal sloughs. Spatial analyses of fish distribution within Humboldt Bay using GIS have shown that fish utilize many habitats in the bay, and that juvenile fishes are abundant in shallow areas.

Geographic information systems are useful in the field of fisheries. It allows for comprehensive spatial analyses, and generates descriptive graphical output. It is this output that provided an updated display of finfish distribution in Humboldt Bay for this study. However, by entering the fish data into GIS, additional advantages were provided. For example, simple analyses of fish species by habitat type were easy to perform, and meaningful to obtain. Likewise, water quality data were easily added to the spatial database.

Collected data like these may be used in many ways because they are displayed visually. Other studies have used GIS to present data for use in both conservation and management. Lunetta et al. (1997) used GIS to combine aspects of salmon spawning

habitat such as stream bank vegetation and gradient to identify particular areas in a stream. By using GIS and other remotely sensed data, suitable habitat locations were predicted before attempting to find then in the field. Fish abundance and habitat usage are not often described using GIS. This was the reason for the study of whitefish in a boreal lake in Ontario, Canada (Bégout Anras et al. 1999). Location of the whitefish was tracked over two spawning seasons. These data were combined with detailed habitat data to determine patterns of whitefish spawning behavior.

The habitat type data layer used here was digitized from USGS topographic maps, which were photorevised in the 1970's. Because not all of the small sloughs were apparent on the habitat map, sample points appeared to fall on land. Similarly, points that landed in palustrine habitats were inaccurate as none of the sites sampled were non-tidal. Clearly there is a need for new cartographic media to describe wetland habitats of North America.

The Humboldt Bay Harbor, Recreation and Conservation District maintains a current Humboldt Bay atlas of GIS coverages. Of these, several map biological characters. These coverages can be intersected with our new fish distribution coverage to perform analyses similar to the fish by habitat analysis in this study. One of the available coverages of Humboldt Bay is a 1980 sediment layer. This layer was hand digitized in 2000 from two paper maps (Shapiro and Associates 1980). The coverage gives a description of sediments from clay to sand and silt, as well as a coarseness category (Figure 26). When this coverage is intersected with our fish distribution layer, a

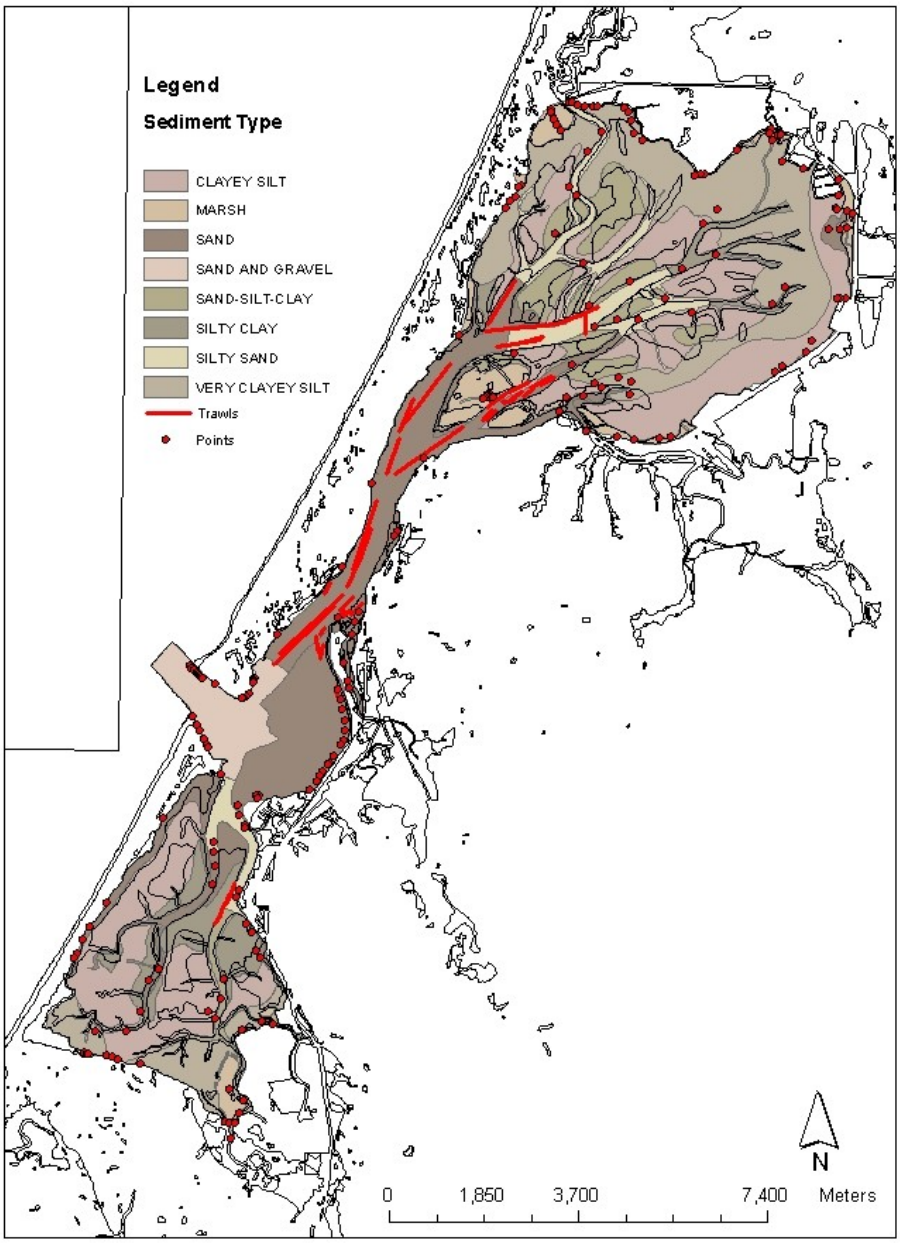

Figure 26. Sediment types of Humboldt Bay, Humboldt County, California and the locations sampled between the months of September 2000 and November 2001. Sediment coverage is available from the Humboldt Bay Harbor, Recreation and Conservation District at http://www.humboldtbay.org.

list of the detected species can be queried by sediment type. For example, at least 18 species, including juveniles of the family Osmeridae, were collected by methods other than trawl over the sediment type described as marsh (Table 20). Topsmelt accounted for over one half of the total number of fishes collected in marshy sediment type. A total of 42 species collected by methods other than trawls were associated with the sandy sediment type when the coverages were intersected (Table 21).

There is also a coverage depicting eelgrass beds in Humboldt Bay from 1997. Because eelgrass beds are known to be very productive areas in the bay, and provide habitat for shelter, feeding and spawning, the results from intersecting this coverage with the fish distribution layer are worthy of note (Figure 27). A total of 22 species were collected in eelgrass beds throughout the entire study (Table 22). Shiner surfperch were the most abundant species; two other surfperch species were also collected. Just as a substantial amount of editing was required for this study to assure that sampling locations fell within the correct habitat type, further editing would be required for this analysis. Bay pipefish, which are known to reside in eelgrass beds are clearly underrepresented as the majority of the bay pipefish collected in this study were in fact collected in this habitat. Most likely points from fish sampling areas either fell among the fringe of the defined eelgrass beds or the current eelgrass coverage needs further updating.

The Humboldt Bay Harbor, Recreation and Conservation District updates coverages as they are created. Both the sediment coverage and eelgrass coverage are several years old as was the habitat map used for this study. Because of this, slight

Table 20. Fish species collected by methods other than trawl over the marshy sediment of Humboldt Bay, California between the months of September 2000 to November 2001.

SPECIES	*# of points*	*Abundance*
Pacific herring	1	1
juvenile rockfish	1	1
kelp greenling	1	1
leopard shark	1	1
saddleback gunnel	1	1
English sole	2	2
bay pipefish	2	2
coho salmon	2	2
prickly sculpin	1	2
starry flounder	2	8
threespine stickleback	5	16
arrow goby	4	19
shiner surfperch	4	43
Osmerid sp	5	58
staghorn sculpin	12	81
Northern anchovy	4	98
surf smelt	5	198
topsmelt	5	718
total		1252

Table 21. Fish species collected by methods other than trawl over sandy sediment in Humboldt Bay, California between the months of September 2000 to November 2001.

SPECIES	*# of points*	*Abundance*
Pacific sardine	1	1
buffalo sculpin	1	1
calico surfperch	1	1
gopher rockfish	1	1
medusa fish	1	1
sharpnose sculpin	1	1
white surfperch	1	1
Pacific herring	1	2
bat ray	1	2
cabezon	2	2
coho salmon	1	2
kelp greenling	2	2
petrale sole	2	2
red Irish lord	1	2
rock greenling	1	2
penpoint gunnel	3	4
walleye surfperch	4	5
Northern anchovy	2	6
bay goby	1	6
juvenile rockfish	1	7
saddleback gunnel	4	7
sandsole	6	8
arrow goby	4	9
striped surfperch	4	9
starry flounder	7	13
speckled sanddab	6	22
spotfin surfperch	6	24
jacksmelt	3	25
bay pipefish	13	28
English sole	11	33
butter sole	1	60
chinook salmon	13	87
redtail surfperch	11	96
black rockfish	7	107
silver surfperch	7	121
tubesnout	4	132
threespine stickleback	15	143
staghorn sculpin	29	612
Osmerid sp	12	658

Table 21. Fish species collected by methods other than trawl over sandy sediment in Humboldt Bay, California between the months of September 2000 to November 2001 (continued).

SPECIES	*# of points*	*Abundance*
shiner surfperch	13	882
topsmelt	23	890
surf smelt	34	2563
total		6580

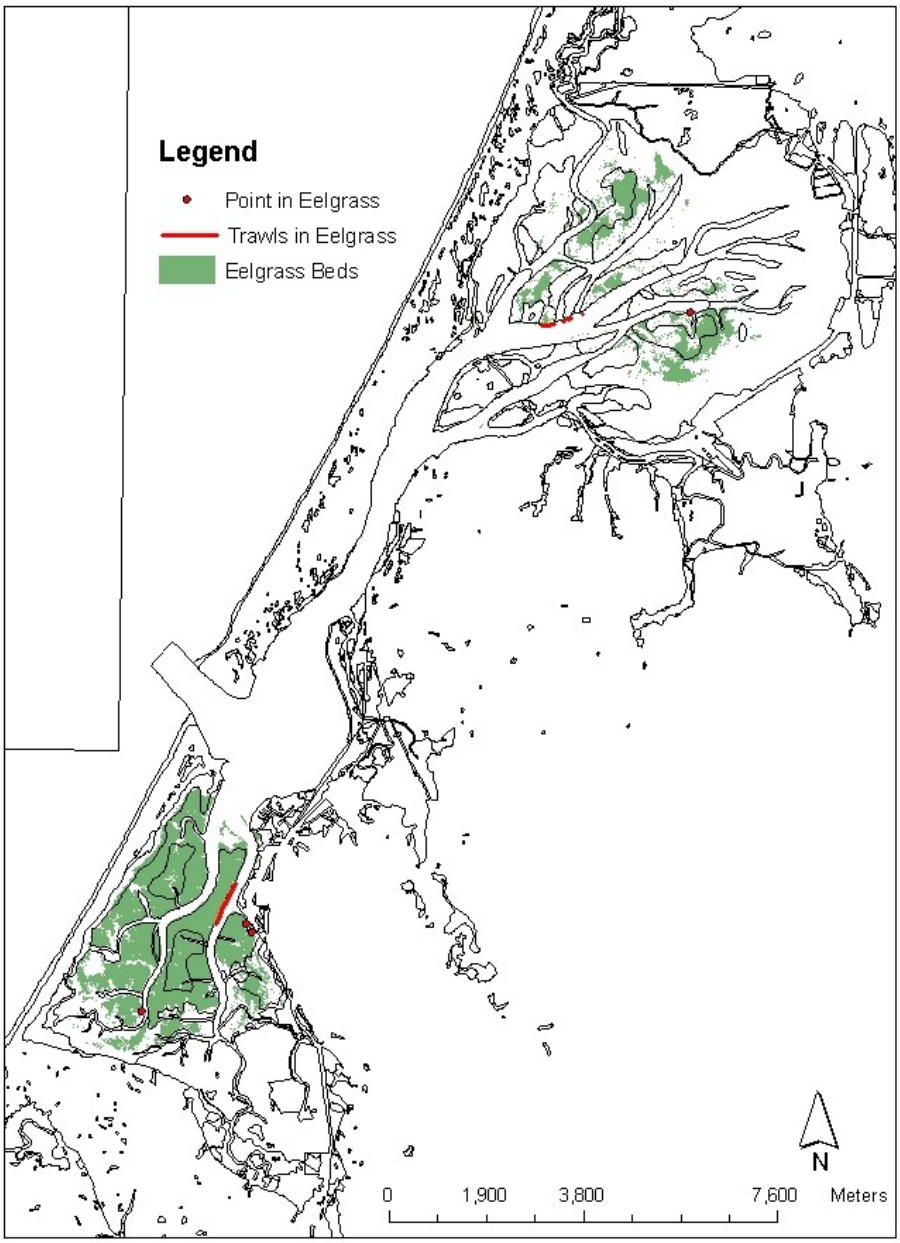

Figure 27. Eelgrass beds of Humboldt Bay, Humboldt County, California and the locations sampled between the months of September 2000 and November 2001. Eelgrass coverage is available from the Humboldt Bay Harbor, Recreation and Conservation District at http://humboldtbay.org.

Table 22. Fish species collected by all methods in eelgrass beds of Humboldt Bay, California between the months of September 2000 to November 2001.

Species	*# of points*	*Abundance*
arrow goby	1	1
black rockfish	1	1
brown smoothhound	1	1
saddleback gunnel	1	1
tubesnout	1	1
Northern anchovy	1	2
juvenile rockfish	1	2
starry flounder	2	2
spiny dogfish	1	4
bat ray	2	5
night smelt	2	5
speckled sanddab	3	5
bay pipefish	1	6
white surfperch	2	6
walleye surfperch	3	19
staghorn sculpin	7	26
threespine stickleback	3	35
jacksmelt	1	39
English sole	2	40
topsmelt	2	41
surf smelt	3	109
shiner surfperch	6	143
total		494

discrepancies, like changes in tidal sloughs are apparent when the coverages are used as a base layer for current fish data.

This study of Humboldt Bay fishes has accomplished several goals. The need for current fish species data was apparent, as most of the published data is vague in terms of location and comes from the 1970s. It has also created a new GIS coverage for Humboldt Bay that can be layered with other available GIS coverages. For this study, the creation of this fish species coverage has offered a new understanding of fish distribution by Humboldt Bay habitat type. The addition of this new coverage will also allow for future analyses to be preformed as more GIS coverages of the natural resources of Humboldt Bay are created.

LITERATURE CITED

Allen, L. G. and M. H. Horn. 1975. Abundance, diversity and seasonality of fishes in Colorado Lagoon, Alamitos Bay, California. Estuarine and Coastal Marine Science 3: 371-380.

Anderson, R.D., and C.F. Bryan. 1970. Age and growth of three surfperches (Embiotocidae) from Humboldt Bay, California. Transactions of the American Fisheries Society 3: 475-482.

Barlow, G.W. 1961. Gobies of the genus *Gillichthys*, with comments on the sensory canals as a taxonomic tool. Copeia 4: 423-437.

Barnhart, R.A., M.J. Boyd, and J.E. Pequegnat. 1992. The ecology of Humboldt Bay, California: an estuarine profile. United States Department of the Interior Fish and Wildlife Service, Biological Report 1:1-121.

Bégout Anras, M.L., P.M. Cooley, R.A. Bodaly, L. Anras, and R.J.P. Fudge. 1999. Movement and habitat use by lake whitefish during spawning in a boreal lake: integrating acoustic telemetry and geographic information systems. Transactions of the American Fisheries Society 128: 939-952.

Bloeser, J. 2000. Biology and population structure of California halibut, *Paralichthys californicus*, in Humboldt Bay. Master's Thesis. Department of Fisheries, Humboldt State University, Arcata, California.

Chamberlain, R.H. and R.A. Barnhart. 1993. Early use by fish of a mitigation salt marsh, Humboldt Bay, California. Estuaries 16: 769-783.

Collins, P. 1978. Feeding and food resource utilization of juvenile English sole and speckled sanddab in the central portion of Humboldt Bay, California. Master's Thesis. Department of Fisheries, Humboldt State University, Arcata, California.

Costa, S.L. 1982. The physical oceanography of Humboldt Bay. Pages 2-31 *in* C. Toole and C. Diebel, editor. Humboldt Bay symposium proceedings. Center for Community Development, Humboldt State University, Arcata, California.

Cowardin L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service, Washington D.C. Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/1998/classwet/classwet.htm (Version 04DEC98)

Dauble, D.D., R.L. Johnson, and A.P. Garcia. 1999. Fall Chinook salmon spawning in tailraces of Lower Snake River hydroelectric projects. Transactions of the American Fisheries Society 128: 672-679.

DeGeorges, A. 1972. Feasibility of artificial reefs in intertidal waters. Master's Thesis. Department of Fisheries, Humboldt State University, Arcata, California.

Eldridge, M.B. 1970. Larval fish survey of Humboldt Bay. Master's Thesis. Department of Fisheries, Humboldt State University, Arcata, California.

Eldridge, M.B. and C.F. Bryan. 1972. Larval fish survey of Humboldt Bay, California. United States Department of Commerce NOAA Technical Report NMFS SSRF-665: 1-8

Environmental Systems Research Institute, Inc. (ESRI). 1999a. Arc/Info version 7.1. Computer software. Redlands, California.

Environmental Systems Research Institute, Inc. (ESRI). 1999b. ArcView version 3.2. Computer software. Redlands, California.

Environmental Systems Research Institute, Inc. (ESRI). 2000. ArcView ArcGIS 8.3. Computer software. Redlands, California.

Fortunati, L., G. Garofalo, and R. Demontis. 2002. TSDV: a GIS tool for inspection trawl survey data. ICES Journal of Marine Science 59: 168-178.

Fritzsche, RA, and J.W. Cavanagh. 1995. A guide to the fishes of Humboldt Bay. Humboldt State University, Arcata, California.

Glatzel, K.A. 1982. An historical overview of land use surrounding Humboldt Bay. Pages 68-76 *in* Humboldt Bay symposium proceedings. Center for Community Development, Humboldt State University, Arcata, California.

Gotshall,D.W. 1966. Marine resources of Humboldt Bay. Pages 23-36 *in* A symposium on Humboldt Bay. Center for Community Development, Humboldt State College, Arcata, California.

Gotshall, D.W., G.H. Allen, R. Barnhart. 1980. An annotated checklist of fishes from Humboldt Bay, California. California Department of Fish and Game 66: 220-232.

Harding, Jr. L.W., and J.H. Butler. 1979. The standing stock and production of eelgrass *Zostera marina*, in Humboldt Bay, California. California Department of Fish and Game 65: 151-158.

Hart, J.L. 1973. Pacific fishes of Canada. Bulletin Fisheries Research Board Canada 180: 1-740.

Hawks, M. M., J. S. Stanovick, and M.L. Caldwell. 2000. Demonstration of GIS capabilities for fisheries management decisions: analysis of acquisition potential within the Meramec River Basin. Environmental Management 26(1): 25-34.

Hill, J.P. and G.L. Hendrickson. 1991. Haematozoa of fishes in Humboldt Bay, California. Journal of Wildlife Diseases 27(4): 701-705.

Hitz, C.R. 1965. Field identification of the northeastern Pacific rockfish (Sebastodes). United States Department of the Interior, Fish and Wildlife Service, circular 203. 1-61.

Josselyn, M. 1983. The ecology of San Francisco Bay tidal marshes: a community profile. United States Department of the Interior, Fish and Wildlife Service, FWS/OBS – 83/23.

Keleher, C.L. and F.J. Rahel. 1996. Thermal limits to salmonid distributions in the Rocky Mountain region and potential habitat loss due to global warming: a Geographic information system approach. Transactions of the American Fisheries Society 125: 1-13.

Ketchen, K.S. 1956. Factors influencing the survival of the lemon sole (*Parophrys vetulus*) in Hecate Strait, British Columbia. Journal of the Research Board of Canada 13: 647-693.

Lunetta, R.S., B.L. Cosemtino, D.R. Montgomery, E. M. Beamer, and T.J. Beechie. 1997. GIS-based evaluation of salmon habitat in the Pacific Northwest. Photogrammetric Engineering & Remote Sensing 63: 1219-1229.

Matarese, A.C., A.W. Kendall Jr., D.M. Blood, and B.M. Vinter. 1989. Laboratory guide to early life history stages of northeast Pacific fishes. NOAA Technical Report. NMFS 80. Seattle.

Matern, S.A., P.B. Moyle, and L.C. Pierce. 2002. Native and alien fishes in a California estuarine marsh: twenty-one years of changing assemblages. Transactions of the American Fisheries Society 131: 797-816.

Miklos, P., S.M. Katzman, J.J. Cech Jr. 2003. Effect of temperature on oxygen consumption of the leopard shark, *Triakis semifasciata*. Environmental Biology of Fishes 66:26-18.

Miller, D.J. and R.N. Lea 1972. Guide to the coastal marine fishes of California. California Department of Fish and Game, Fish Bulletin 157: 1-249.

Misitano, D.A. 1970. Aspects of the early life history of English sole in Humboldt Bay, California. Master's Thesis. Department of Fisheries, Humboldt State University, Arcata, California.

Misitano, D.A. 1976 Size and stage of development of larval English sole, *Parophrys vetulus*, at time of entry into Humboldt Bay. California Department of Fish and Game 62: 93-98.

Monroe, G.W. 1973. The natural resources of Humboldt Bay. California Department of Fish and Game Coastal Wetland Series 6. 160 p.

Moring, J.R. 1972. Check list of intertidal fishes of Trinidad Bay, California, and adjacent areas. California Department of Fish and Game 58: 315-320.

Paterson, A.W. and A.K. Whitfield. 2000. Do shallow-water habitats function as refugia for juvenile fishes? Estuarine, Coastal and Shelf Science 51: 359-364.

Pequegnat, J.E. and J.H. Butler 1982. The biological oceanography of Humboldt Bay. Pages 39-51 *in* C. Toole and C. Diebel, editor. Humboldt Bay symposium proceedings. Center for Community Development, Humboldt State University, Arcata, California.

Prince, E. D. and D. Gotshall. 1976. Food of the copper rockfish, *Sebastes caurinus* Richardson, associated with and artificial reef in south Humboldt Bay, California. California Department of Fish and Game 62: 274-285.

Proctor, C.M., J.C. Garcia, D.V. Galvin, G.B. Lewis, L.C. Loehr, and A.M. Massa. 1980. An ecological characterization of the Pacific Northwest coastal region. United States Department of the Interior, Fish and Wildlife Service, FWS/OBS-79/11-15.

Rabin, D.J., and R.A. Barnhart. 1977. Fecundity of Pacific herring, *Clupea harangus pallasi*, in Humboldt Bay. California Department of Fish and Game 63(3):193-196.

Rabin, D.J., and R.A. Barnhart. 1986. Population characteristics of Pacific herring, *Clupea harengus pallasi*, in Humboldt Bay, California. California Department of Fish and Game 72: 4-16

Russo, R.A. 1975. Observations on the food habits of leopard shark (*Triakis semifasciata*) and brown smoothhounds (*Mustelus henlei*). California Department of Fish and Game 61: 95-103.

Saiki, M.K. 1997. Survey of small fishes and environmental conditions in Mugu Lagoon, California, and tidally influenced reaches of its tributaries. California Department of Fish and Game 83: 153-167.

Samuelson, C.E. 1973. Fishes of south Humboldt Bay, Humboldt County, California. Master's Thesis. Department of Fisheries, Humboldt State University, Arcata, California.

Shapiro and Associates, Inc. 1980. Humboldt Bay wetlands review and baylands analysis, final report. United States Army Corps of Engineers, San Francisco, California. 668 pp.

Singh, R., M. Buzeta, M. Dowd, J.L. Martin, and M. LeGresley. 2000. Ecological overview of Musquash Estuary: a proposed marine protected area. Fisheries and Oceans Canada, Canadian Manuscript Report of Fisheries and Aquatic Sciences 2538: 1-39.

Sopher, T.R. 1974. A trawl survey of the fishes of Arcata Bay, California. Master's Thesis. Department of Fisheries, Humboldt State University, Arcata, California.

Tarp, F.H. 1952. A revision of the family Embiotocidae. California Department of Fish and Game, Fisheries Bulletin 88: 1-99.

Toole, C.L. 1980. Intertidal recruitment and feeding in relation to optimal utilization of nursery areas by juvenile English sole (*Parophrys vetulus*: Pleuronectidae). Environmental Biology of Fishes 5(4): 383-390.

Tuttle, D. 1982. The history of erosion at King Salmon – Buhne Point from 1854 to 1982. Pages 32-38 *in* C. Toole and C. Diebel, editor. Humboldt Bay symposium proceedings. Center for Community Development, Humboldt State University, Arcata, California.

U.S. Department of the Army. 1977. Final environmental statement: Humboldt Bay harbor marina regulatory permit application Humboldt County, California. United States Army Corps of Engineers District, Public Notice 10643-21, San Francisco, California.

U.S. Fish and Wildlife Service. 1987. National Wetlands Inventory website. United States Department of the Interior, Fish and Wildlife Service, St. Petersburg. Florida. http://www.nwi.fws.gov.

Waldvogel, J.B. 1977. Age, maturity and distribution of northern anchovy, *Engraulis mordax,* in Humboldt Bay, California. Master's Thesis. Department of Fisheries, Humboldt State University, Arcata, California.

Warner, R. 1982. Overview of commercial and sport fisheries in Humboldt Bay. Page 107 *in* Humboldt Bay symposium proceedings. Center for Community Development, Humboldt State University, Arcata, California.

West, J.M., and J.B. Zedler. 2000. Marsh-creek connectivity: fish use of a tidal salt marsh in southern California. Estuaries 23: 699-710.

Wootton, R.J. 1976. The biology of the sticklebacks. Academic Press Inc., New York, New York.

Yocklavich, M.M., G.M. Cailliet, J.P. Barry, D.A. Ambrose, B.S. Antrim. 1991. Temporal and spatial patterns in abundance and diversity of fish assemblages in Elkhorn Slough, California. Estuaries 14: 465-480.

Yocklavich, M.M., V.J. Loeb, M. Nishimoto, and B. Daly. 1996. Nearshore assemblages of larval rockfishes and their physical environment off central California during an extended El Niño event, 1991-1993. Fishery Bulletin 94: 766-782.

Zheng, X., G.J. Pierce, D.G. Reid, and I.T. Jolliffe. 2002. Does the North Atlantic current affect spatial distribution of whiting? Testing environmental hypotheses using statistical and GIS techniques. ICES Journal of Marine Science 59: 239-253.

PERSONAL COMMUNICATIONS

Golsmith, G. 2003. Personal Communication. United States Fish and Wildlife Service, 1655 Heindon Road, Arcata, CA 95521.

McBride, S. 2003. Personal Communication. University of California Sea Grant Extension Program, #1 Commercial Street, Suite 4, Eureka, CA 95501.

Appendix A. Habitat classification from The National Wetlands Inventory Wetland and Deepwater Habitat mapping code. Estuarine habitats have a tidal flooding classification beyond subclass, where: L = Subtidal, M = Irregularly Exposed, N = Regularly Flooded and P = Irregularly Flooded. (Classification definitions derived from: Cowardin, et al.)

U=Uplands

System	Subsystem	Class	Subclass
M=Marine	1=Subtidal	RB=Rock Bottom	1=Bedrock
			2=Rubble
		UB=Unconsolidated Bottom	1=Cobble-Gravel
			2=Sand
			3=Mud
			4=Organic
		AB=Aquatic Bottom	1=Algal
			3=Rooted Vascular
			5=Unknown Submergent
		RF=Reef	1=Coral
			3=Worm
		OW=Open Water	Unknown Bottom
	2=Intertidal	AB= Aquatic Bed	1=Algal
			3=Rooted Vascular
			5=Unknown Submergent
		RF=Reef	1=Coral
			3=Worm
		RS=Rocky Shore	1=Bedrock
			2=Rubble
		US=Unconsolidated Shore	1=Cobble-Gravel
			2=Sand
			3=Mud
			4=Organic

Appendix A. Habitat classification from The National Wetlands Inventory Wetland and Deepwater Habitat mapping code. Estuarine habitats have a tidal flooding classification beyond subclass, where: L = Subtidal, M = Irregularly Exposed, N = Regularly Flooded and P = Irregularly Flooded. (Classification definitions derived from: Cowardin, et al.)(continued)

System	Subsystem	Class	Subclass
E=Estuarine	1=Subtidal	RB=Rock Bottom	1=Bedrock
			2=Rubble
		UB=Unconsolidated Bottom	1=Cobble-Gravel
			2=Sand
			3=Mud
			4=Organic
		AB=Aquatic Bed	1=Algal
			3=Rooted Vascular
			4=Floating Vascular
			5=Unknown Submergent
			6=Unknown Surface
		RF=Reef	2=Mollusc
			3=Worm
		OW=Open Water	Unknown Bottom
	2=Intertidal		
		AB=Aquatic Bed	1=Algal
			3=Rooted Vascular
			4=Floating Vascular
			5=Unknown Submergent
			6=Unknown Surface
		RF=Reef	2=Mollusc
			3=Worm
		SB=Streambed	3=Cobble-Gravel
			4=Sand
			5=Mud
			6=Organic
		RS=Rocky Shore	1=Bedrock
			2=Rubble
		US=Unconsolidated Shore	1=Cobble-Gravel
			2=Sand
			3=Mud
			4=Organic
		EM=Emergent	1=Persistent
			2=Nonpersistent

Appendix A. Habitat classification from The National Wetlands Inventory Wetland and Deepwater Habitat mapping code. Estuarine habitats have a tidal flooding classification beyond subclass, where: L = Subtidal, M = Irregularly Exposed, N = Regularly Flooded and P = Irregularly Flooded. (Classification definitions derived from: Cowardin, et al.)(continued)

System	Subsystem	Class	Subclass
E=Estuarine	2=Intertidal	SS=Scrub, shrub	1=Broad Leaf Deciduous
			2=Needle Deciduous
			3=Broad Leaf Evergreen
			4=Needle Evergreen
			5=Dead
			6=Indeterminate Deciduous
			7=Indeterminate Evergreen
		FO=Forested	1=Broad Leaf Deciduous
			2=Needle Deciduous
			3=Broad Leaf Evergreen
			4=Needle Evergreen
			5=Dead
			6=Indeterminate Deciduous
			7=Indeterminate Evergreen

Appendix A. Habitat classification from The National Wetlands Inventory Wetland and Deepwater Habitat mapping code. Estuarine habitats have a tidal flooding classification beyond subclass, where: L = Subtidal, M = Irregularly Exposed, N = Regularly Flooded and P = Irregularly Flooded. (Classification definitions derived from: Cowardin, et al.)(continued)

System	Subsystem	Class	Subclass
R=Riverine	1=Tidal	RB=Rock Bottom	1=Bedrock
			2=Rubble
		UB=Unconsolidated Bottom	1=Cobble-Gravel
			2=Sand
			3=Mud
			4=Organic
	2=Lower Perennial	SB=Streambed	1=Bedrock
			2=Rubble
			3=Cobble-Gravel
			4=Sand
			5=Mud
			6=Organic
			7=Vegetated
	3=Upper Perennial	AB=Aquatic Bed	1=Algal
			2=Aquatic Moss
			3=Rooted Vascular
			4=Floating Vascular
			5=Unknown Submergent
			6=Unknown Surface
	4=Intermittent	RS=Rocky Shore	1=Bedrock
			2=Rubble
	5=Unknown Perennial	US=Unconsolidated Shore	1=Cobble-Gravel
			2=Sand
			3=Mud
			4=Organic
			5=Vegetated
		EM=Emergent	2=Nonpersistent

Appendix A. Habitat classification from The National Wetlands Inventory Wetland and Deepwater Habitat mapping code. Estuarine habitats have a tidal flooding classification beyond subclass, where: L = Subtidal, M = Irregularly Exposed, N = Regularly Flooded and P = Irregularly Flooded. (Classification definitions derived from: Cowardin, et al.)(continued)

System	Subsystem	Class	Subclass
L=Lacustrine	1=Limnetic	RB=Rock Bottom	1=Bedrock
			2=Rubble
		UB=Unconsolidated Bottom	1=Cobble-Gravel
			2=Sand
			3=Mud
			4=Organic
		AB=Aquatic Bed	1=Algal
			2=Aquatic Moss
			3=Rooted Vascular
			4=Floating Vascular
			5=Unknown Submergent
			6=Unknown Surface
		OW=Open Water	Unknown Bottom
	2=Littoral	RB=Rock Bottom	1=Bedrock
			2=Rubble
		UB=Unconsolidated Bottom	1=Cobble-Gravel
			2=Sand
			3=Mud
			4=Organic
		AB=Aquatic Bed	1=Algal
			2=Aquatic Moss
			3=Rooted Vascular
			4=Floating Vascular
			5=Unknown Submergent
			6=Unknown Surface
		RS=Rocky Shore	1=Bedrock
			2=Rubble
		US=Unconsolidated Shore	1=Cobble-Gravel
			2=Sand
			3=Mud
			4=Organic
			5=Vegetated
		EM=Emergent	2=Nonpersistent
		OW=Open Water	Unknown Bottom

Appendix A. Habitat classification from The National Wetlands Inventory Wetland and Deepwater Habitat mapping code. Estuarine habitats have a tidal flooding classification beyond subclass, where: L = Subtidal, M = Irregularly Exposed, N = Regularly Flooded and P = Irregularly Flooded. (Classification definitions derived from: Cowardin, et al.)(continued)

System	Subsystem	Class	Subclass
P=Palustrine		RB=Rock Bottom	1=Bedrock
			2=Rubble
		UB=Unconsolidated Bottom	1=Cobble-Gravel
			2=Sand
			3=Mud
			4=Organic
		AB=Aquatic Bed	1=Algal
			2=Aquatic Moss
			3=Rooted Vascular
			4=Floating Vascular
			5=Unknown Submergent
			6=Unknown Surface
		US=Unconsolidated Shore	1=Cobble-Gravel
			2=Sand
			3=Mud
			4=Organic
			5=Vegetated
		ML=Moss/Lichen	1=Moss
			2=Lichen
		EM=Emergent	1=Persistent
			2=Nonpersistent
		SS=Scrub/Shrub	1=Broad Leaf Deciduous
			2=Needle Deciduous
			3=Broad Leaf Evergreen
			4=Needle Evergreen
			5=Dead
			6=Indeterminate Deciduous
			7=Indeterminate Evergreen
		FO=Forested	1=Broad Leaf Deciduous
			2=Needle Deciduous
			3=Broad Leaf Evergreen
			4=Needle Evergreen
			5=Dead
			6=Indeterminate Deciduous
			7=Indeterminate Evergreen
		OW=Open Water	Unknown Bottom

Appendix B. Sampling locations in Humboldt Bay, Humboldt County, California visited between the months of September 2000 and November 2001 including geographic coordinates and converted UTMs with a brief location description. Times of seines and trawls are also given. Minnow traps were set for a period of time, given in hours or cycles (24 hours).

Sample #	*Date*	*Time*	*Latitude*	*Longitude*	*Easting*	*Northing*	*Location*
1	15-Sep-00	1345	40 52' 02.52" N	124 08' 48.65" W	403351.77055	4524454.94712	MR Pond
2	15-Sep-00	1345	40 51' 59.38" N	124 08' 51.94" W	403273.48365	4524359.13237	MR Pond
3	16-Sep-00	940	40 46' 29.42" N	124 12' 38.79" W	397822.36353	4514256.16947	Somoa BR
4	25-Sep-00	1345	40 48' 27.36" N	124 10' 16.86" W	401198.09959	4517847.70816	Eka Channel Trawl Out
5	25-Sep-00	1408	40 47' 57.54" N	124 11' 12.00" W	399893.68430	4516945.57340	Eka Channel Trawl In
6	25-Sep-00	1443	40 49' 07.92" N	124 10' 27.84" W	400957.58819	4519101.83521	Somoa Channel Trawl Out
7	25-Sep-00	1503	40 48' 30.12" N	124 11' 05.10" W	400068.95297	4517948.00380	Somoa Channel Trawl In
8	25-Sep-00	1524	40 47' 39.66" N	124 11' 27.36" W	399526.25506	4516399.11756	N Bay Channel Trawl Out
9	25-Sep-00	1542	40 46' 56.40" N	124 11' 46.02" W	399070.75640	4515071.13361	N Bay Channel Trawl In
10	25-Sep-00	1554	40 46' 40.26" N	124 11' 54.84" W	398857.21803	4514576.27436	Fairhaven Trawl Out
11	25-Sep-00	1612	40 46' 02.28" N	124 12' 46.44" W	397631.45939	4513421.77776	Fairhaven Trawl In
12	25-Sep-00	1622	40 45' 56.10" N	124 12' 52.14" W	397495.18539	4513233.06468	N Bay Trawl Out
13	25-Sep-00	1645	40 46' 32.76" N	124 12' 01.56" W	398696.52820	4514347.16398	N Bay Trawl In
14	1-Oct-00	820	40 43' 23.46" N	124 13' 28.98" W	396565.77740	4508538.39391	Hookton Channel Out
15	1-Oct-00	828	40 43' 36.18" N	124 13' 21.54" W	396745.78453	4508928.18330	Hookton Channel In
16	1-Oct-00	858	40 43' 10.98" N	124 13' 37.44" W	396361.92467	4508156.34353	Hookton Channel Out
17	1-Oct-00	908	40 43' 29.64" N	124 13' 25.98" W	396638.81480	4508727.97318	Hookton Channel In
18	1-Oct-00	1505	40 46' 10.14" N	124 12' 33.6" W	397935.83307	4513659.98710	Entrance Channel Out
19	1-Oct-00	1520	40 46' 28.32" N	124 12' 08.76" W	398525.86958	4514212.56714	Entrance Channel In
20	4-Oct-00	1140	40 48' 15.01" N	124 07' 14.84" W	405458.07933	4517411.13385	Johnson Ranch
21	11-Oct-00	1325	40 48' 09.27" N	124 08' 16.34" W	404014.72357	4517252.70291	Somoa Blvd Pasture
22	11-Oct-00	1105	40 53' 52.23" N	124 08' 05.34" W	404409.50164	4527824.72372	Seahorse Ranch
23	13-Oct-00	1440	40 51' 02.70" N	124 09' 31.46" W	402325.19654	4522623.55429	Manilla Park
24	12-Oct-00	1043	40 49' 46.90" N	124 10' 17.89" W	401206.75462	4520300.68228	Vance Ave
25	12-Oct-00	1043	40 49' 40.49" N	124 10' 19.92" W	401156.56191	4520103.66266	Vance Ave

Appendix B. Sampling locations in Humboldt Bay, Humboldt County, California visited between the months of September 2000 and November 2001 including geographic coordinates and converted UTMs with a brief location description. Times of seines and trawls are also given. Minnow traps were set for a period of time, given in hours or cycles (24 hours) (continued).

Sample #	*Date*	*Time*	*Latitude*	*Longitude*	*Easting*	*Northing*	*Location*
26	19-Oct-00	1100	40 46' 59.40" N	124 11' 57.60" W	398800.59070	4515167.34629	Fairhaven
27	20-Oct-00	1200	40 51' 18.84" N	124 05' 52.62" W	407455.67224	4523055.22442	Arcata Marsh
28	23-Oct-00	1320	40 45' 34.20" N	124 11' 31.20" W	399383.69058	4512531.74798	Elk River Slough
29	23-Oct-00	1520	40 49' 21.66" N	124 09' 28.02" W	402364.57173	4519506.86808	North Bay Trawl Out
30	23-Oct-00	1530	40 49' 25.14" N	124 09' 10.32" W	402780.61232	4519608.70913	North Bay Trawl In
31	23-Oct-00	1538	40 49' 28.86" N	124 09' 58.56" W	401652.11568	4519738.36981	North Bay Trawl Out
32	23-Oct-00	1559	40 49' 44.40" N	124 08' 24.06" W	403871.97969	4520188.42302	North Bay Trawl In
33	23-Oct-00	1610	40 49' 39.60" N	124 08' 35.52" W	403601.61968	4520043.91011	North Bay Trawl Out
34	23-Oct-00	1621	40 49' 27.78" N	124 08' 35.52" W	403596.86473	4519679.43519	North Bay Trawl In
35	23-Oct-00	1635	40 49' 23.58" N	124 09' 12.54" W	402727.97561	4519561.29016	North Bay Trawl Out
36	23-Oct-00	1650	40 49' 18.90" N	124 09' 49.20" W	401867.29234	4519428.33382	North Bay Trawl In
37	23-Oct-00	1720	40 50' 01.56" N	124 09' 34.50" W	402229.05719	4520739.21073	North Bay Trawl Out
38	23-Oct-00	1743	40 49' 33.06" N	124 09' 56.94" W	401691.78663	4519867.37384	North Bay Trawl In
39	26-Oct-00	1425	40 46' 23.49" N	124 11' 43.36" W	399119.27585	4514055.49463	Elk River Slough
40	26-Oct-00	1400	40 46' 25.98" N	124 11' 58.37" W	398768.44898	4514137.07785	Elk River Slough
41	26-Oct-00	1410	40 46' 15.43" N	124 11' 45.47" W	399066.42314	4513807.63676	Elk River Slough
42	27-Oct-00	1350	40 51' 18.86" N	124 05' 52.59" W	407456.38239	4523055.83233	Arcata Marsh
43	27-Oct-00	1350	40 51' 14.15" N	124 05' 34.64" W	407874.84811	4522905.34007	Arcata Marsh
44	29-Oct-00	1500	40 49' 27.36" N	124 10' 23.11" W	401076.42073	4519699.79264	N. Somoa Bridge
45	30-Oct-00	1530	40 51' 24.64" N	124 05' 24.68" W	408112.08098	4523225.89798	Arcata Marsh
46	30-Oct-00	1530	40 51' 23.39" N	124 05' 50.44" W	407508.47240	4523194.88633	Arcata Marsh
47	3-Nov-00	1210	40 48' 25.85" N	124 08' 33.38" W	403622.09861	4517769.14586	Montgomery Wards
48	3-Nov-00	1210	40 48' 37.95" N	124 08' 55.55" W	403107.52723	4518149.04279	Montgomery Wards
49	3-Nov-00	1210	40 48' 56.99" N	124 08' 26.45" W	403796.96976	4518727.24437	Montgomery Wards
50	5-Nov-00	1330	40 49' 14.64" N	124 09' 34.03" W	402220.92136	4519292.26461	Indian Island

Appendix B. Sampling locations in Humboldt Bay, Humboldt County, California visited between the months of September 2000 and November 2001 including geographic coordinates and converted UTMs with a brief location description. Times of seines and trawls are also given. Minnow traps were set for a period of time, given in hours or cycles (24 hours) (continued).

Sample #	*Date*	*Time*	*Latitude*	*Longitude*	*Easting*	*Northing*	*Location*
51	13-Nov-00	1600	40 47' 52.20" N	124 11' 37.80" W	399286.85461	4516789.12022	Tina Town
52	1-Dec-00	1330	40 46' 27.18" N	124 11' 52.75" W	398900.70165	4514172.27971	Eelgrass Beds 1&2
53	1-Dec-00	1400	40 46' 26.69" N	124 11' 57.05" W	398799.69248	4514158.54779	Eelgrass Beds #3
54	1-Dec-00	1410	40 46' 35.00" N	124 11' 38.77" W	399231.70984	4514408.94292	Eelgrass Beds #4
55	1-Dec-00	1434	40 46' 15.51" N	124 12' 12.73" W	398427.38401	4513818.84375	Eelgrass Beds #5
56	1-Dec-00	1447	40 45' 59.71" N	124 12' 12.37" W	398429.14046	4513331.53113	Eelgrass Beds #6
57	1-Dec-00	1458	40 45' 35.86" N	124 11' 57.70" W	398763.02784	4512591.40155	Eelgrass Beds #7
58	1-Dec-00	1509	40 46' 47.81" N	124 12' 05.45" W	398611.69613	4514812.48356	Eelgrass Beds #9
59	7-Dec-00	1310	40 48' 32.10" N	124 10' 00.15" W	401591.57169	4517988.64652	Woodley Island Trawl #1
60	7-Dec-00	1331	40 48' 38.84" N	124 09' 49.94" W	401833.55373	4518193.29692	Woodley Island Trawl #2
61	7-Dec-00	1345	40 48' 44.64" N	124 09' 38.37" W	402107.00187	4518368.54780	Woodley Island Trawl #3
62	7-Dec-00	1401	40 48' 47.68" N	124 09' 26.20" W	402393.37028	4518458.51729	Woodley Island Trawl #4
63	7-Dec-00	1421	40 48' 54.81" N	124 09' 11.76" W	402734.57330	4518673.91459	Woodley Island Trawl #5
64	7-Dec-00	1427	40 49' 00.70" N	124 09' 02.68" W	402949.68397	4518852.73910	Woodley Island Trawl #6
65	7-Dec-00	1449	40 48' 57.46" N	124 09' 08.79" W	402805.22885	4518754.71317	Woodley Island Trawl #7
66	7-Dec-00	1506	40 48' 56.84" N	124 09' 21.61" W	402504.63324	4518739.55050	Woodley Island Trawl #8
67	7-Dec-00	1530	40 48' 49.90" N	124 09' 40.12" W	402068.14980	4518531.28505	Woodley Island Trawl #9
68	17-Jan-01	955	40 46' 33.24" N	124 12' 31.08" W	398004.72639	4514371.46769	Fairhaven
69	17-Jan-01	955	40 46' 21.78" N	124 12' 14.76" W	398382.44726	4514012.83390	Fairhaven
70	23-Jan-01	1210	40 47' 22.59" N	124 11' 03.91" W	400068.70485	4515865.31464	Mudflats EKA garbage
71	23-Jan-01	1235	40 47' 25.44" N	124 11' 05.32" W	400036.84600	4515953.64172	Mudflats EKA garbage
72	23-Jan-01	1310	40 47' 25.22" N	124 11' 03.16" W	400087.37779	4515946.17413	Mudflats EKA garbage
73	23-Jan-01	1415	40 47' 17.85" N	124 11' 11.45" W	399890.01201	4515721.54416	Mudflats EKA garbage
74	23-Jan-01	1430	40 47' 20.97" N	124 11' 09.83" W	399929.28196	4515817.23672	Mudflats EKA garbage
75	28-Jan-01	1035	40 45' 54.99" N	124 13' 13.41" W	396996.02294	4513205.75757	Coast Guard Station

Appendix B. Sampling locations in Humboldt Bay, Humboldt County, California visited between the months of September 2000 and November 2001 including geographic coordinates and converted UTMs with a brief location description. Times of seines and trawls are also given. Minnow traps were set for a period of time, given in hours or cycles (24 hours) (continued).

Sample #	*Date*	*Time*	*Latitude*	*Longitude*	*Easting*	*Northing*	*Location*
76	28-Jan-01	1253	40 45' 47.58" N	124 13' 15.89" W	396934.69771	4512978.07741	Coast Guard Station
77	30-Jan-01	1505	40 46' 30.02" N	124 11' 40.16" W	399197.03476	4514255.82696	Trendsale Ave (Eureka)
78	30-Jan-01	1252	40 48' 07.64" N	124 10' 47.79" W	400465.20371	4517249.35366	Wharfinger Building
79	1-Feb-01	1240	40 43' 32.62" N	124 13' 17.44" W	396840.44008	4508817.07179	Fields Landing
80	1-Feb-01	1322	40 43' 27.49" N	124 13' 19.72" W	396784.75061	4508659.63230	Fields Landing
81	2-Feb-01	937	40 46' 18.67" N	124 12' 47.19" W	397620.86437	4513927.41084	Somoa Beach
82	2-Feb-01	937	40 46' 15.93" N	124 12' 52.50" W	397495.21055	4513844.64471	Somoa Beach
83	10-Feb-01	1242	40 45' 43.10" N	124 13' 39.41" W	396381.30631	4512847.63088	North Spit
84	11-Feb-01	1040	40 44' 19.41" N	124 13' 17.56" W	396857.69958	4510259.88454	King Salmon
85	11-Feb-01	1100	40 44' 13.19" N	124 13' 13.51" W	396950.02576	4510066.76886	King Salmon
86	13-Feb-01	1230	40 44' 30.99" N	124 13' 02.64" W	397212.59994	4510612.09368	King Salmon
87	13-Feb-01	1347	40 44' 26.45" N	124 13' 19.02" W	396826.47721	4510477.44042	King Salmon
88	13-Feb-01	1347	40 44' 11.93" N	124 13' 12.90" W	396963.79360	4510027.71773	King Salmon
89	15-Feb-01	1340	40 43' 08.29" N	124 15' 22.24" W	393901.95432	4508108.16219	South Spit
90	15-Feb-01	1510	40 43' 00.04" N	124 15' 27.30" W	393779.59385	4507855.47201	South Spit
91	16-Feb-01	905	40 49' 51.83" N	124 05' 05.10" W	408535.07338	4520358.36767	Bracut
92	16-Feb-01	1000	40 49' 52.46" N	124 05' 02.78" W	408589.65354	4520377.12143	Bracut
93	20-Feb-01	1252	40 48' 20.94" N	124 07' 16.54" W	405420.58393	4517594.49653	Murray Field
94	20-Feb-01	1416	40 48' 33.06" N	124 06' 51.01" W	406023.53379	4517960.59335	Murray Field
95	20-Feb-01	1553	40 48' 14.37" N	124 07' 11.86" W	405527.65408	4517390.50688	Eka Slough Channel
96	20-Feb-01	1600	40 48' 13.61" N	124 07' 09.77" W	405576.32752	4517366.44660	Eka Slough Channel
97	22-Feb-01	1235	40 42' 51.53" N	124 15' 33.51" W	393630.12733	4507595.15353	South Spit
98	22-Feb-01	1313	40 42' 48.85" N	124 15' 35.69" W	393577.79117	4507513.24920	South Spit
99	22-Feb-01	1425	40 44' 10.33" N	124 14' 30.67" W	395138.94468	4510003.96250	South Spit
100	22-Feb-01	1450	40 44' 07.12" N	124 14' 33.53" W	395070.45973	4509905.93101	South Spit

Appendix B. Sampling locations in Humboldt Bay, Humboldt County, California visited between the months of September 2000 and November 2001 including geographic coordinates and converted UTMs with a brief location description. Times of seines and trawls are also given. Minnow traps were set for a period of time, given in hours or cycles (24 hours) (continued).

Sample #	*Date*	*Time*	*Latitude*	*Longitude*	*Easting*	*Northing*	*Location*
101	27-Feb-01	1307	40 41' 39.81" N	124 14' 37.76" W	394906.90831	4505365.02742	Southport Landing
102	27-Feb-01	1408	40 41' 41.88" N	124 14' 56.68" W	394463.75241	4505435.15559	Southport Landing
103	27-Feb-01	1555	40 41' 43.67" N	124 15' 02.21" W	394334.74687	4505492.19650	Southport Landing
104	5-Mar-01	1430	40 44' 45.19" N	124 13' 38.30" W	396382.35843	4511061.59999	South Spit/Kill Beach
105	8-Mar-01	1210	40 48' 04.11" N	124 06' 45.82" W	406133.80514	4517066.36724	Fay Slough
106	8-Mar-01	1210	40 48' 05.76" N	124 06' 49.81" W	406040.95428	4517118.43268	Fay Slough
107	8-Mar-01	1210	40 48' 04.22" N	124 06' 53.92" W	405944.04185	4517072.17055	Fay Slough
108	8-Mar-01	1210	40 48' 07.95" N	124 06' 53.95" W	405944.80160	4517187.19505	Eureka Slough
109	9-Mar-01	845	40 47' 43.53" N	124 07' 15.14" W	405438.64003	4516440.52943	Freshwater Slough
110	9-Mar-01	905	40 47' 43.15" N	124 07' 11.35" W	405527.30870	4516427.67718	Freshwater Slough
111	9-Mar-01	920	40 47' 44.94" N	124 07' 07.52" W	405617.76879	4516481.72652	Freshwater Slough
112	13-Mar-01	810	40 46' 27.22" N	124 12' 33.77" W	397939.10840	4514186.70842	Bay Plankton Tow Out
113	13-Mar-01	816	40 46' 33.77" N	124 12' 25.55" W	398134.58492	4514386.02530	Bay Plankton Tow In
114	13-Mar-01	824	40 46' 32.13" N	124 12' 28.06" W	398075.04960	4514336.26538	Bay Plankton Tow Out
115	13-Mar-01	830	40 46' 23.63" N	124 12' 37.29" W	397855.06345	4514077.14790	Bay Plankton Tow In
116	13-Mar-01	836	40 46' 24.38" N	124 12' 38.08" W	397836.86277	4514100.52992	Bay Plankton Tow Out
117	13-Mar-01	842	40 46' 28.44" N	124 12' 31.84" W	397984.87081	4514223.70382	Bay Plankton Tow In
118	13-Mar-01	856	40 46' 39.01" N	124 11' 46.25" W	399058.05218	4514534.98147	Bay Plankton Tow Out
119	13-Mar-01	902	40 46' 30.44" N	124 11' 57.43" W	398792.36526	4514274.30183	Bay Plankton Tow In
120	13-Mar-01	915	40 46' 03.73" N	124 12' 14.26" W	398386.53022	4513456.09674	Bay Plankton Tow Out
121	13-Mar-01	920	40 46' 13.89" N	124 12' 16.77" W	398331.98584	4513770.19065	Bay Plankton Tow In
122	13-Mar-01	1037	40 48' 32.44" N	124 10' 00.30" W	401588.19670	4517999.17733	Bay Plankton Tow Out
123	13-Mar-01	1040	40 48' 38.29" N	124 09' 52.24" W	401779.44044	4518177.05317	Bay Plankton Tow In
124	13-Mar-01	1059	40 48' 45.89" N	124 09' 33.40" W	402223.95372	4518405.55107	Bay Plankton Tow Out
125	13-Mar-01	1104	40 48' 43.36" N	124 09' 42.70" W	402005.03117	4518330.42252	Bay Plankton Tow In

Appendix B. Sampling locations in Humboldt Bay, Humboldt County, California visited between the months of September 2000 and November 2001 including geographic coordinates and converted UTMs with a brief location description. Times of seines and trawls are also given. Minnow traps were set for a period of time, given in hours or cycles (24 hours) (continued).

Sample #	*Date*	*Time*	*Latitude*	*Longitude*	*Easting*	*Northing*	*Location*
126	13-Mar-01	1110	40 48' 44.07" N	124 09' 41.45" W	402034.60768	4518351.92751	Bay Plankton Tow Out
127	13-Mar-01	1118	40 48' 44.48" N	124 09' 43.60" W	401984.40285	4518365.23770	Bay Plankton Tow In
128	15-Mar-01	1211	40 45' 40.83" N	124 11' 49.13" W	398966.06337	4512741.90848	Elk River Estuary
129	15-Mar-01	1312	40 45' 45.59" N	124 11' 51.47" W	398913.20085	4512889.43271	Elk River Estuary
130	15-Mar-01	1312	40 45' 56.93" N	124 11' 52.75" W	398887.96383	4513239.51371	Elk River Estuary
131	19-Mar-01	1310	40 48' 12.23" N	124 08' 27.35" W	403757.92047	4517347.32843	Bay Street Slough
132	19-Mar-01	1350	40 48' 11.33" N	124 08' 32.06" W	403647.19355	4517321.01378	Bay Street Slough
133	20-Mar-01	1200	40 48' 14.04" N	124 08' 21.69" W	403891.27167	4517401.41553	Eureka Slough @ Bay St
134	20-Mar-01	1230	40 48' 13.24" N	124 08' 23.38" W	403851.35094	4517377.26204	Eureka Slough @ Bay St
135	20-Mar-01	1230	40 49' 51.80" N	124 04' 59.72" W	408661.07407	4520355.88364	Bracut
136	20-Mar-01	1230	40 49' 52.52" N	124 04' 58.06" W	408700.22949	4520377.60452	Bracut
137	20-Mar-01	930	40 41' 46.33" N	124 15' 22.26" W	393865.34189	4505580.93086	Southport Landing
138	20-Mar-01	1010	40 41' 45.05" N	124 15' 06.68" W	394230.44136	4505536.24285	Southport Landing
139	20-Mar-01	1010	40 41' 46.33" N	124 15' 21.44" W	393884.58725	4505580.65572	Southport Landing
140	20-Mar-01	1135	40 41' 46.58" N	124 15' 24.80" W	393805.83848	4505589.49221	Southport Landing
141	21-Mar-01	855	40 50' 46.23" N	124 04' 53.20" W	408834.50591	4522032.36871	Bracut
142	21-Mar-01	1205	40 50' 55.06" N	124 04' 51.41" W	408879.78246	4522304.12842	Bracut
143	27-Mar-01	1413	40 51' 06.15" N	124 05' 11.09" W	408423.19446	4522651.79542	South G Street Ramp
144	27-Mar-01	1505	40 50' 57.37" N	124 05' 04.59" W	408572.03974	4522379.17357	South G Street Ramp
145	29-Mar-01	1440	40 50' 47.91" N	124 04' 56.92" W	408748.03484	4522085.24828	Gannon Slough
146	29-Mar-01	1555	40 50' 48.93" N	124 05' 05.28" W	408552.65956	4522119.12232	Gannon Slough
147	29-Mar-01	1615	40 50' 49.77" N	124 05' 06.61" W	408521.83618	4522145.40988	Gannon Slough
148	4-Apr-01	755	40 51' 31.51" N	124 06' 00.32" W	407280.29344	4523448.17311	McDaniel Slough
149	4-Apr-01	915	40 51' 36.63" N	124 06' 02.80" W	407224.21477	4523606.78076	McDaniel Slough
150	4-Apr-01	1000	40 51' 35.49" N	124 05' 56.50" W	407371.26979	4523569.77561	McDaniel Slough

Appendix B. Sampling locations in Humboldt Bay, Humboldt County, California visited between the months of September 2000 and November 2001 including geographic coordinates and converted UTMs with a brief location description. Times of seines and trawls are also given. Minnow traps were set for a period of time, given in hours or cycles (24 hours) (continued).

Sample #	*Date*	*Time*	*Latitude*	*Longitude*	*Easting*	*Northing*	*Location*
151	4-Apr-01	1030	40 51' 35.29" N	124 05' 53.74" W	407435.81013	4523562.79781	McDaniel Slough
152	5-Apr-01	1155	40 48' 46.39" N	124 09' 51.58" W	401798.22173	4518426.61450	Indian Island
153	5-Apr-01	1215	40 48' 48.78" N	124 09' 53.36" W	401757.49781	4518500.86522	Indian Island
154	5-Apr-01	1255	40 48' 47.78" N	124 09' 55.43" W	401708.59065	4518470.67447	Indian Island
155	5-Apr-01	1255	40 48' 48.51" N	124 09' 56.05" W	401694.36420	4518493.37747	Indian Island
156	5-Apr-01	1330	40 48' 46.65" N	124 09' 58.25" W	401642.05816	4518436.70921	Indian Island
157	5-Apr-01	1350	40 48' 46.17" N	124 09' 59.77" W	401606.24939	4518422.38210	Indian Island
158	5-Apr-01	1425	40 48' 47.15" N	124 09' 54.34" W	401733.86969	4518450.90867	Indian Island
159	10-Apr-01	1305	40 42' 06.57" N	124 12' 49.10" W	397468.61747	4506154.50290	White Slough
160	10-Apr-01	1430	40 42' 09.34" N	124 12' 57.43" W	397274.31191	4506242.61893	White Slough
161	12-Apr-01	1235	40 41' 59.49" N	124 12' 31.71" W	397873.72064	4505930.56490	NWR-Gold Dredge
162	12-Apr-01	1245	40 42' 00.62" N	124 12' 32.38" W	397858.47618	4505965.62471	NWR-Gold Dredge
163	12-Apr-01	1505	40 42' 05.51" N	124 12' 39.51" W	397693.22428	4506118.71207	NWR-Gold Dredge
164	17-Apr-01	1325	40 40' 38.36" N	124 13' 17.42" W	396766.19454	4503443.77122	Hookton Slough
165	17-Apr-01	1325	40 40' 39.24" N	124 13' 21.27" W	396676.18732	4503472.16256	Hookton Slough
166	17-Apr-01	1500	40 40' 43.33" N	124 13' 26.00" W	396566.89988	4503599.82240	Hookton Slough
167	24-Apr-01	1210	40 41' 04.88" N	124 13' 30.30" W	396475.21581	4504265.71938	Hookton Slough
168	24-Apr-01	1220	40 41' 03.93" N	124 13' 27.31" W	396544.99485	4504235.44815	Hookton Slough
169	24-Apr-01	1330	40 40' 55.34" N	124 13' 26.43" W	396561.96284	4503970.28917	Hookton Slough
170	24-Apr-01	1345	40 41' 00.16" N	124 13' 27.99" W	396527.41279	4504119.42320	Hookton Slough
171	24-Apr-01	1145(2.5hr)	40 40' 49.01" N	124 13' 30.38" W	396466.51616	4503776.39676	Hookton Slough
172	24-Apr-01	1415	40 40' 35.31" N	124 13' 08.42" W	396976.17898	4503346.79161	Hookton Slough
173	24-Apr-01	1415	40 40' 38.80" N	124 13' 12.23" W	396888.22609	4503455.64615	Hookton Slough
174	26-Apr-01	1135	40 50' 37.11" N	124 04' 56.99" W	408742.28019	4521752.24570	North Bay (Red House)
175	26-Apr-01	1159	40 50' 36.29" N	124 05' 03.62" W	408586.70653	4521728.88091	North Bay (Red House)

Appendix B. Sampling locations in Humboldt Bay, Humboldt County, California visited between the months of September 2000 and November 2001 including geographic coordinates and converted UTMs with a brief location description. Times of seines and trawls are also given. Minnow traps were set for a period of time, given in hours or cycles (24 hours) (continued).

Sample #	*Date*	*Time*	*Latitude*	*Longitude*	*Easting*	*Northing*	*Location*
176	26-Apr-01	1225	40 50' 35.51" N	124 05' 12.95" W	408367.91833	4521707.53707	North Bay (Red House)
177	26-Apr-01	1405	40 51' 53.30" N	124 08' 26.87" W	403857.92767	4524163.98161	North Bay near MRS
178	26-Apr-01	1425	40 51' 52.08" N	124 08' 30.12" W	403781.35298	4524127.35381	North Bay near MRS
179	26-Apr-01	1445	40 51' 53.31" N	124 08' 37.73" W	403603.69352	4524167.60677	North Bay near MRS
180	26-Apr-01	1510	40 51' 52.95" N	124 08' 43.74" W	403462.85110	4524158.34524	North Bay near MRS
181	27-Apr-01	850	40 44' 20.12" N	124 12' 46.71" W	397581.58784	4510271.74354	King Salmon Bridge
182	27-Apr-01	850	40 44' 32.47" N	124 13' 02.24" W	397222.61437	4510657.59956	King Salmon Rip-Rap
183	27-Apr-01	850	40 44' 32.29" N	124 13' 03.76" W	397186.88776	4510652.54372	King Salmon Rip-Rap
184	1-May-01	1200	40 51' 53.77" N	124 08' 16.15" W	404109.07666	4524175.20891	Liscom Slough
185	1-May-01	1200	40 51' 54.15" N	124 08' 18.30" W	404058.89652	4524187.58068	Liscom Slough
186	1-May-01	1330	40 51' 53.59" N	124 08' 13.97" W	404160.03938	4524168.99548	Liscom Slough
187	1-May-01	1330	40 51' 53.87" N	124 08' 11.10" W	404227.33951	4524176.75713	Liscom Slough
188	1-May-01	1455	40 51' 54.28" N	124 08' 50.40" W	403307.47422	4524201.39803	Liscom Slough
189	1-May-01	1540	40 51' 53.99" N	124 08' 48.32" W	403356.05078	4524191.81779	Liscom Slough
190	3-May-01	1225	40 51' 20.95" N	124 06' 41.56" W	406310.62466	4523134.74211	Liscom Slough
191	3-May-01	1245	40 51' 21.39" N	124 06' 40.82" W	406328.12293	4523148.08986	Liscom Slough
192	3-May-01	1307	40 51' 32.37" N	124 06' 23.90" W	406728.55945	4523481.64757	Liscom Slough
193	3-May-01	1338	40 51' 27.77" N	124 06' 34.43" W	406480.22840	4523342.92359	Liscom Slough
194	3-May-01	1356	40 51' 38.21" N	124 06' 11.79" W	407014.35385	4523658.14971	Liscom Slough
195	3-May-01	1356	40 51' 38.59" N	124 06' 02.14" W	407240.42636	4523667.02423	Liscom Slough
196	8-May-01	1230	40 42' 02.26" N	124 16' 02.00" W	392939.73090	4506085.52671	South Spit
197	8-May-01	1251	40 42' 03.20" N	124 16' 04.24" W	392887.57996	4506115.27012	South Spit
198	8-May-01	1314	40 42' 05.05" N	124 16' 01.89" W	392943.55340	4506171.51913	South Spit
199	8-May-01	1409	40 42' 02.91" N	124 16' 02.11" W	392937.43850	4506105.60670	South Spit
200	8-May-01	1409	40 42' 05.90" N	124 16' 01.10" W	392962.47124	4506197.46147	South Spit

Appendix B. Sampling locations in Humboldt Bay, Humboldt County, California visited between the months of September 2000 and November 2001 including geographic coordinates and converted UTMs with a brief location description. Times of seines and trawls are also given. Minnow traps were set for a period of time, given in hours or cycles (24 hours) (continued).

Sample #	*Date*	*Time*	*Latitude*	*Longitude*	*Easting*	*Northing*	*Location*
201	8-May-01	1438	40 42' 07.52" N	124 15' 59.90" W	392991.35318	4506247.00807	South Spit
202	8-May-01	1452	40 42' 09.73" N	124 15' 59.83" W	392993.97850	4506315.12976	South Spit
203	8-May-01	1530	40 42' 11.57" N	124 16' 00.57" W	392977.43063	4506372.11660	South Spit
204	10-May-01	1352	40 51' 09.29" N	124 07' 05.00" W	405757.21878	4522782.18576	North Bay
205	10-May-01	1352	40 51' 09.47" N	124 06' 59.97" W	405875.06594	4522786.23358	North Bay
206	10-May-01	1445	40 51' 09.78" N	124 06' 56.22" W	405962.99309	4522794.67361	North Bay
207	10-May-01	1500	40 51' 11.30" N	124 06' 53.14" W	406035.70706	4522840.62534	North Bay
208	10-May-01	1517	40 51' 13.90" N	124 06' 50.20" W	406105.56568	4522919.92186	North Bay
209	10-May-01	1547	40 51' 16.17" N	124 06' 48.35" W	406149.77210	4522989.36771	North Bay
210	10-May-01	1600	40 51' 17.75" N	124 06' 45.69" W	406212.67264	4523037.29632	North Bay
211	10-May-01	1637	40 51' 21.08" N	124 06' 40.66" W	406331.74781	4523138.48330	North Bay
212	10-May-01	1637	40 51' 24.66" N	124 06' 36.12" W	406439.44492	4523247.52646	North Bay
213	10-May-01	1702	40 51' 26.26" N	124 06' 31.60" W	406545.89758	4523295.52270	North Bay
214	14-May-01	1030(4hr)	40 45' 39.20" N	124 13' 14.61" W	396961.11395	4512719.26051	North Jetty
215	14-May-01	1030(4hr)	40 45' 37.66" N	124 13' 15.20" W	396946.61937	4512671.96673	North Jetty
216	14-May-01	1030(4hr)	40 45' 35.15" N	124 13' 16.77" W	396908.72975	4512595.08262	North Jetty
217	14-May-01	1030(4hr)	40 45' 34.47" N	124 13' 17.65" W	396887.80397	4512574.40190	North Jetty
218	29-May-01	820	40 40' 30.59" N	124 12' 54.87" W	397292.27772	4503196.84628	Hookton Slough
219	29-May-01	945	40 40' 29.24" N	124 12' 46.70" W	397483.51266	4503152.56983	Hookton Slough
220	30-May-01	745	40 42' 03.45" N	124 13' 12.88" W	396909.21380	4506066.02882	South Bay-Gold Dredge
221	30-May-01	930	40 41' 04.15" N	124 13' 14.77" W	396839.45360	4504238.13678	S Bay-Hookton Slough
222	5-Jun-01	1043	40 50' 47.54" N	124 06' 45.58" W	406203.41407	4522105.72244	Arcata Ruins
223	5-Jun-01	1043	40 50' 38.85" N	124 06' 57.48" W	405921.33894	4521841.30696	Arcata Ruins
224	6-Jun-01	0740 (I cyc)	40 45' 46.55" N	124 13' 11.82" W	397029.68280	4512944.98964	Coast Guard
225	6-Jun-01	0740 (I cyc)	40 45' 46.06" N	124 13' 11.98" W	397025.72127	4512929.93253	Coast Guard

Appendix B. Sampling locations in Humboldt Bay, Humboldt County, California visited between the months of September 2000 and November 2001 including geographic coordinates and converted UTMs with a brief location description. Times of seines and trawls are also given. Minnow traps were set for a period of time, given in hours or cycles (24 hours) (continued).

Sample #	*Date*	*Time*	*Latitude*	*Longitude*	*Easting*	*Northing*	*Location*
226	6-Jun-01	0740 (I cyc)	40 45' 45.62" N	124 13' 11.96" W	397026.00155	4512916.35851	Coast Guard
227	6-Jun-01	0740 (I cyc)	40 45' 45.39" N	124 13' 12.07" W	397023.32810	4512909.30227	Coast Guard
228	13-Jun-01	604	40 51' 01.58" N	124 09' 33.31" W	402281.42078	4522589.59166	North Manilla Muni Park
229	13-Jun-01	604	40 50' 56.75" N	124 09' 38.14" W	402166.34992	4522442.15355	North Manilla Muni Park
230	13-Jun-01	604	40 50' 52.73" N	124 09' 40.66" W	402105.69790	4522318.97663	North Manilla Muni Park
231	13-Jun-01	604	40 50' 49.17" N	124 09' 46.46" W	401968.42496	4522211.00390	North Manilla Muni Park
232	18-Jun-01	945	40 51' 30.72" N	124 07' 49.10" W	404733.15492	4523456.24632	North Bay
233	18-Jun-01	945	40 51' 35.52" N	124 07' 55.60" W	404582.88581	4523606.22302	North Bay
234	18-Jun-01	1105	40 51' 43.21" N	124 07' 58.60" W	404515.71704	4523844.25722	North Bay
235	18-Jun-01	1105	40 51' 48.87" N	124 08' 00.59" W	404471.38745	4524019.38975	North Bay
236	18-Jun-01	1230	40 51' 50.84" N	124 08' 04.24" W	404386.72460	4524081.24258	North Bay
237	19-Jun-01	1027	40 43' 23.85" N	124 15' 08.97" W	394220.13796	4508583.50895	South Spit
238	19-Jun-01	1046	40 43' 31.40" N	124 15' 05.24" W	394310.96343	4508815.06624	South Spit
239	19-Jun-01	1106	40 43' 37.14" N	124 14' 58.21" W	394478.40385	4508989.71097	South Spit
240	19-Jun-01	1106	40 43' 54.57" N	124 14' 41.74" W	394872.39664	4509521.67856	South Spit
241	19-Jun-01	1245	40 44' 19.56" N	124 14' 24.55" W	395286.51549	4510286.54154	South Spit
242	25-Jun-01	950	40 44' 54.12" N	124 12' 03.95" W	398598.86505	4511306.34643	Entrance Bay
243	25-Jun-01	950	40 44' 58.32" N	124 12' 00.12" W	398690.45533	4511434.62532	Entrance Bay
244	25-Jun-01	1130	40 45' 08.16" N	124 11' 52.32" W	398877.51570	4511735.54420	Entrance Bay
245	25-Jun-01	1100	40 45' 05.07" N	124 11' 54.42" W	398826.96914	4511640.93594	Entrance Bay
246	25-Jun-01	1210	40 45' 14.44" N	124 11' 51.10" W	398908.76742	4511928.79850	Entrance Bay
247	25-Jun-01	1250	40 45' 20.62" N	124 11' 51.16" W	398909.96098	4512119.37899	Entrance Bay
248	25-Jun-01	1305	40 45' 28.07" N	124 11' 53.28" W	398863.38579	4512349.77960	Entrance Bay
249	25-Jun-01	1330	40 45' 33.65" N	124 11' 54.83" W	398829.39126	4512522.33626	Entrance Bay
250	25-Jun-01	1410	40 45' 40.12" N	124 11' 57.74" W	398763.88549	4512722.77229	Entrance Bay

Appendix B. Sampling locations in Humboldt Bay, Humboldt County, California visited between the months of September 2000 and November 2001 including geographic coordinates and converted UTMs with a brief location description. Times of seines and trawls are also given. Minnow traps were set for a period of time, given in hours or cycles (24 hours) (continued).

Sample #	*Date*	*Time*	*Latitude*	*Longitude*	*Easting*	*Northing*	*Location*
251	26-Jun-01	915	40 50' 31.25" N	124 09' 00.61" W	403034.82989	4521644.25438	North Bay
252	26-Jun-01	1051	40 51' 35.65" N	124 08' 23.07" W	403939.80361	4523618.57431	North Bay
253	26-Jun-01	1200	40 51' 23.46" N	124 08' 35.22" W	403650.43824	4523246.39608	North Bay
254	27-Jun-01	1204	40 41' 19.16" N	124 13' 11.01" W	396934.14017	4504699.74221	Wildlife Refuge
255	27-Jun-01	1100	40 41' 26.18" N	124 13' 23.45" W	396645.15480	4504920.26193	Wildlife Refuge
256	27-Jun-01	1350	40 41' 11.08" N	124 13' 14.10" W	396858.14924	4504451.60375	Wildlife Refuge
257	2-Jul-01	1020	40 51' 35.02" N	124 09' 01.44" W	403041.22061	4523610.89471	MRS side channels
258	2-Jul-01	1053	40 51' 38.14" N	124 09' 04.55" W	402969.67317	4523708.05879	MRS side channels
259	2-Jul-01	1200	40 51' 42.86" N	124 09' 07.75" W	402896.66976	4523854.58836	MRS side channels
260	2-Jul-01	1200	40 51' 47.96" N	124 09' 11.32" W	402815.16156	4524012.95035	MRS side channels
261	2-Jul-01	1200	40 51' 50.43" N	124 09' 10.50" W	402835.36147	4524088.86162	MRS side channels
262	3-Jul-01	1253	40 42' 50.04" N	124 12' 58.28" W	397271.74111	4507497.87756	Kramers Dock
263	3-Jul-01	1320	40 42' 54.11" N	124 13' 01.80" W	397190.88822	4507624.52013	Kramers Dock
264	3-Jul-01	1350	40 43' 05.72" N	124 13' 06.05" W	397096.13573	4507983.89715	Kramers Dock
265	3-Jul-01	1416	40 43' 11.14" N	124 13' 10.65" W	396990.53089	4508152.52102	Kramers Dock
266	11-Jul-01	1137	40 42' 42.57" N	124 14' 24.27" W	395250.84505	4507295.75430	Fields Landing Channel
267	11-Jul-01	1200	40 42' 41.22" N	124 14' 23.60" W	395265.97858	4507253.90509	Fields Landing Channel
268	11-Jul-01	1230	40 42' 34.47" N	124 14' 31.09" W	395087.28574	4507048.25193	Fields Landing Channel
269	12-Jul-01	1024	40 43' 36.13" N	124 13' 40.09" W	396310.59487	4508932.71402	Fields Landing
270	12-Jul-01	1105	40 43' 47.21" N	124 13' 37.70" W	396371.43749	4509273.58281	Fields Landing
271	12-Jul-01	1145	40 43' 56.08" N	124 13' 38.59" W	396354.38343	4509547.38188	Fields Landing
272	12-Jul-01	1222	40 44' 02.49" N	124 13' 39.13" W	396344.48019	4509745.21197	Fields Landing
273	13-Jul-01	1045	40 44' 36.73" N	124 12' 19.83" W	398219.08922	4510775.22953	Entrance Bay
274	13-Jul-01	1105	40 44' 42.14" N	124 12' 14.07" W	398356.46813	4510940.19335	Entrance Bay
275	13-Jul-01	1119	40 44' 45.31" N	124 12' 11.65" W	398414.56376	4511037.16241	Entrance Bay

Appendix B. Sampling locations in Humboldt Bay, Humboldt County, California visited between the months of September 2000 and November 2001 including geographic coordinates and converted UTMs with a brief location description. Times of seines and trawls are also given. Minnow traps were set for a period of time, given in hours or cycles (24 hours) (continued).

Sample #	*Date*	*Time*	*Latitude*	*Longitude*	*Easting*	*Northing*	*Location*
276	13-Jul-01	1119	40 44' 47.85" N	124 12' 08.83" W	398481.77261	4511114.57726	Entrance Bay
277	13-Jul-01	1203	40 44' 53.19" N	124 12' 05.07" W	398572.20675	4511278.02926	Entrance Bay
278	16-Jul-01	850	40 52' 36.93" N	124 08' 37.04" W	403637.41677	4525512.44795	Mad River Slough
279	16-Jul-01	905	40 52' 34.68" N	124 08' 28.25" W	403846.67511	4525779.57543	Mad River Slough
280	16-Jul-01	945	40 52' 35.53" N	124 08' 24.55" W	403929.1985	4525465.465	Mad River Slough
281	16-Jul-01	1020	40 52' 30.35" N	124 08' 53.00" W	403261.1921	4525314.439	Mad River Slough
282	16-Jul-01	1050	40 52' 26.30" N	124 09' 05.14" W	402975.3898	4525193.286	Mad River Slough
283	16-Jul-01	1140	40 52' 24.03" N	124 09' 06.92" W	402932.8038	4525123.837	Mad River Slough
284	16-Jul-01	1140	40 52' 19.82" N	124 08' 54.13" W	403230.483	4524990.086	Mad River Slough
285	16-Jul-01	1200	40 52' 21.48" N	124 08' 57.66" W	403148.5251	4525042.357	Mad River Slough
286	16-Jul-01	1215	40 52' 18.72" N	124 08' 53.00" W	403256.4892	4524955.82	Mad River Slough
287	17-Jul-01	0858(4.5hr)	40 45' 53.81" N	124 14' 01.09" W	395877.62284	4513185.00630	North Jetty
288	17-Jul-01	0858(4.5hr)	40 45' 52.78" N	124 13' 59.77" W	395908.12481	4513152.81087	North Jetty
289	17-Jul-01	0858(4.5hr)	40 45' 51.38" N	124 13' 57.09" W	395970.35329	4513108.75850	North Jetty
290	17-Jul-01	0858(4.5hr)	40 45' 49.56" N	124 13' 54.85" W	396022.08436	4513051.90071	North Jetty
291	17-Jul-01	0858(4.5hr)	40 45' 48.61" N	124 13' 53.52" W	396052.85661	4513022.16943	North Jetty
292	17-Jul-01	0858(4.5hr)	40 45' 47.73" N	124 13' 52.43" W	396078.03226	4512994.67572	North Jetty
293	17-Jul-01	0858(4.5hr)	40 45' 47.02" N	124 13' 51.51" W	396099.29575	4512972.48001	North Jetty
294	17-Jul-01	0858(4.5hr)	40 45' 46.01" N	124 13' 50.03" W	396133.55966	4512940.84962	North Jetty
295	23-Jul-01	1445	40 48' 23.41" N	124 07' 22.10" W	405291.28165	4517672.32719	Brainard
296	23-Jul-01	1515	40 48' 21.94" N	124 07' 31.35" W	405073.96284	4517629.77847	Brainard
297	23-Jul-01	1515	40 48' 19.94" N	124 07' 52.93" W	404567.52235	4517574.61629	Brainard
298	23-Jul-01	1630	40 48' 21.45" N	124 08' 07.37" W	404229.77643	4517625.55198	Brainard
299	30-Jul-01		40 42' 01.37" N	124 15' 15.20" W	394037.66057	4506042.32143	Southport Channel
300	30-Jul-01		40 42' 01.76" N	124 14' 49.18" W	394648.48114	4506045.65392	Southport Channel

Appendix B. Sampling locations in Humboldt Bay, Humboldt County, California visited between the months of September 2000 and November 2001 including geographic coordinates and converted UTMs with a brief location description. Times of seines and trawls are also given. Minnow traps were set for a period of time, given in hours or cycles (24 hours) (continued).

Sample #	*Date*	*Time*	*Latitude*	*Longitude*	*Easting*	*Northing*	*Location*
301	30-Jul-01		40 42' 14.83" N	124 14' 37.50" W	394928.29846	4506444.78107	Southport Channel
302	31-Jul-01	1050(5hr)	40 45' 24.79" N	124 14' 04.91" W	395775.46784	4512291.42708	South Jetty
303	31-Jul-01	1050(5hr)	40 45' 20.46" N	124 14' 01.72" W	395848.39158	4512156.85840	South Jetty
304	31-Jul-01	1050(5hr)	40 45' 15.50" N	124 13' 58.58" W	395919.87265	4512002.88080	South Jetty
305	31-Jul-01	1050(5hr)	40 45' 12.25" N	124 13' 56.13" W	395975.91672	4511901.85939	South Jetty
306	31-Jul-01	1050(5hr)	40 45' 08.40" N	124 13' 54.09" W	396022.08815	4511782.47225	South Jetty
307	31-Jul-01	1050(5hr)	40 45' 06.40" N	124 13' 52.75" W	396052.64613	4511720.36088	South Jetty
308	31-Jul-01	1050(5hr)	40 45' 03.41" N	124 13' 50.81" W	396096.84687	4511627.52545	South Jetty
309	31-Jul-01	1050(5hr)	40 45' 01.81" N	124 13' 49.65" W	396123.35794	4511577.80769	South Jetty
310	6-Aug-01	715	40 48' 49.67" N	124 07' 57.25" W	404478.14345	4518492.65798	North Bay Channels
311	6-Aug-01	720	40 48' 57.99" N	124 07' 56.33" W	404503.01198	4518748.92975	North Bay Channels
312	6-Aug-01	720	40 49' 00.15" N	124 08' 06.72" W	404260.46137	4518818.68288	North Bay Channels
313	6-Aug-01	1041	40 48' 53.73" N	124 08' 20.78" W	403928.49868	4518624.99342	North Bay Channels
314	6-Aug-01	1041	40 48' 48.55" N	124 08' 35.44" W	403582.95983	4518469.73782	North Bay Channels
315	6-Aug-01	1041	40 48' 47.41" N	124 08' 49.91" W	403243.48810	4518439.01482	North Bay Channels
316	7-Aug-01	845	40 49' 47.74" N	124 05' 58.58" W	407280.86409	4520247.86477	North Bay Channels
317	7-Aug-01	915	40 49' 58.79" N	124 05' 48.70" W	407516.54623	4520585.69540	North Bay Channels
318	7-Aug-01	1036	40 49' 07.92" N	124 08' 45.95" W	403344.53576	4519070.23503	North Bay Channels
319	14-Aug-01	1520	40 42' 15.19" N	124 13' 41.55" W	396241.44061	4506437.40743	Hookton Slough Mouth
320	14-Aug-01	1520	40 42' 23.54" N	124 13' 30.67" W	396500.35383	4506691.31378	Hookton Slough Mouth
321	14-Aug-01	1430	40 42' 11.19" N	124 13' 35.80" W	396374.65418	4506312.18221	Hookton Slough Mouth
322	14-Aug-01	1548	40 42' 35.59" N	124 13' 28.99" W	396544.95799	4507062.32533	Hookton Slough Mouth
323	16-Aug-01	1215	40 49' 05.08" N	124 05' 55.96" W	407325.73663	4518931.65834	Spit South of Bracut
324	16-Aug-01	1045	40 49' 24.95" N	124 05' 25.71" W	408042.02441	4519535.50509	Spit South of Bracut
325	16-Aug-01	1045	40 49' 18.31" N	124 05' 29.70" W	407946.00848	4519331.92204	Spit South of Bracut

Appendix B. Sampling locations in Humboldt Bay, Humboldt County, California visited between the months of September 2000 and November 2001 including geographic coordinates and converted UTMs with a brief location description. Times of seines and trawls are also given. Minnow traps were set for a period of time, given in hours or cycles (24 hours) (continued).

Sample #	*Date*	*Time*	*Latitude*	*Longitude*	*Easting*	*Northing*	*Location*
326	16-Aug-01	1215	40 49' 09.09" N	124 05' 49.81" W	407471.36009	4519053.50299	Spit South of Bracut
327	21-Aug-01	855	40 49' 42.20" N	124 07' 06.47" W	405688.51263	4520097.16343	North Bay Channels
328	21-Aug-01	855	40 49' 51.16" N	124 07' 28.87" W	405167.37673	4520380.16473	North Bay Channels
329	21-Aug-01	855	40 49' 37.10" N	124 07' 51.14" W	404640.16352	4519953.33237	North Bay Channels
330	21-Aug-01	855	40 49' 37.06" N	124 08' 08.44" W	404234.91536	4519957.33982	North Bay Channels
331	21-Aug-01	855	40 49' 32.71" N	124 08' 27.46" W	403787.64751	4519828.99323	North Bay Channels
332	22-Aug-01	810	40 50' 18.78" N	124 06' 46.73" W	406165.21717	4521219.23615	North Bay
333	22-Aug-01	842	40 50' 09.40" N	124 07' 14.33" W	405515.13285	4520938.23964	North Bay
334	22-Aug-01	842	40 50' 01.65" N	124 07' 58.05" W	404488.09181	4520712.43326	North Bay
335	22-Aug-01	1012	40 49' 45.51" N	124 08' 31.70" W	403693.47319	4520224.98081	North Bay
336	23-Aug-01	850	40 50' 55.24" N	124 08' 43.83" W	403437.46712	4522378.85004	MRS Channel
337	23-Aug-01	920	40 51' 00.84" N	124 08' 50.19" W	403290.80198	4522553.47846	MRS Channel
338	23-Aug-01	1000	40 50' 12.18" N	124 08' 36.69" W	403587.32575	4521048.88746	MRS Channel
339	30-Nov-01	1336	40 46' 45.24" N	124 11' 51.72" W	398932.45140	4514728.83504	Entrance Bay Trawl Out
340	30-Nov-01	1349	40 47' 03.30" N	124 11' 40.68" W	399198.82204	4515282.19122	Entrance Bay Trawl In
341	30-Nov-01	1402	40 47' 01.26" N	124 11' 41.40" W	399181.08901	4515219.51709	Entrance Bay Trawl Out
342	30-Nov-01	1414	40 47' 22.56" N	124 11' 32.52" W	399398.15854	4515873.47661	Entrance Bay Trawl In
343	30-Nov-01	1430	40 47' 57.30" N	124 11' 19.74" W	399712.20770	4516940.63005	Entrance Bay Trawl Out
344	30-Nov-01	1432	40 48' 19.80" N	124 11' 09.90" W	399952.18123	4517631.30324	Entrance Bay Trawl In
345	30-Nov-01	1520	40 48' 24.42" N	124 11' 09.60" W	399961.13802	4517773.66772	Entrance Bay Trawl Out
346	30-Nov-01	1530	40 48' 45.48" N	124 10' 58.74" W	400224.36265	4518419.62338	Entrance Bay Trawl In

Appendix C. Dates, locations, and water quality measurements for threespine sticklebacks collected within Humboldt Bay, Humboldt County, California between the months of September 2000 and November 2001. ID and Sample # refer to the location (see appendix 2). Dissolved oxygen (DO) readings are in milligrams per liter (mg/L), salinity readings are in parts per thousand (ppt), and temperature is in C°.

Date	*Sample #*	*DO*	*SALINITY*	*TEMPERATURE*
15 Sept	1		28	22
15 Sept	2		28	25
4 Oct	20	11.50	16	18
11 Oct	21	7.80	34	16
13 Oct	23	10.04	35	17
19 Oct	26	9.01	35	13
26 Oct	40	9.45	35	13
27 Oct	43	8.23	34	15
29 Oct	44	6.22	29	15
13 Nov	51	7.78	34	10
1 Feb	79	8.82	31	11
15 Feb	89	8.92	31	10
16 Feb	91	8.02	25	10
20 Feb	94	8.23	24	11
9 March	109	7.89	21	15
27 March	143	7.40	27	16
10 April	160	9.53	31	17
12 April	162	7.10	26	15
17 April	166	8.46	24	15
24 April	167	7.08	31	16
24 April	169	7.08	30	17
26 April	177	7.04	31	18
1 May	184	7.07	32	13
1 May	185	8.04	32	12
1 May	186	9.45	21	18
1 May	187	10.92	22	20
1 May	189	10.30	21	18
3 May	192	10.94	21	20
8 May	197	7.32	31	17
8 May	198	6.85	35	19
8 May	201	7.11	36	22
29 May	218	6.38	35	25
29 May	219	6.26	31	15
13 June	228	5.57	34	16
19 June	237	7.97	33	18
19 June	239	6.65	34	17

Appendix C. Dates, locations, and water quality measurements for threespine sticklebacks collected within Humboldt Bay, Humboldt County, California between the months of September 2000 and November 2001. ID and Sample # refer to the location (see appendix 2). Dissolved oxygen (DO) readings are in milligrams per liter (mg/L), salinity readings are in parts per thousand (ppt), and temperature is in C°. (continued).

Date	*Sample #*	*DO*	*SALINITY*	*TEMPERATURE*
19 June	240	6.60	34	17
27 June	254	6.70	32	182
27 June	256	6.45	32	18
2 July	257	7.12	33	20
2 July	261	6.13	34	23
3 July	262	6.13	34	23
3 July	265	13.36	33	24
11 July	267	5.96	33	15
11 July	268	12.43	33	16
12 July	270	3.19	33	15
12 July	271	7.21	33	15
16 July	284	6.69	34	20
23 July	297	9.66	36	27
30 July	299	9.11	33	19
30 July	301	8.67	33	17
14 August	320	6.36	34	21
22 August	333	5.21	34	19
30 Nov	342	6.00	33	19

Appendix D. Dates, locations, and water quality measurements for staghorn sculpin collected within Humboldt Bay, Humboldt County, California between the months of September 2000 and November 2001. Sample # refers to location of collection (see appendix 2). Dissolved oxygen (DO) readings are given in milligrams per Liter (mg/L), salinity readings are given in parts per thousand (ppt), and temperature readings are given in C°.

Date	*Sample #*	*DO*	*SALINITY*	*TEMPERATURE*
25 Sept	13	7.00	35	16
1 Oct	15	6.00	34	15
11 Oct	22	8.02	34	16
13 Oct	23	10.04	35	17
19 Oct	26	9.01	35	13
23 Oct	28	17.92	34	19
23 Oct	36	9.00	32	15
26 Oct	39	9.5	35	13
27 Oct	43	8.23	34	15
29 Oct	44	6.22	29	15
3 Nov	49	8.43	33	14
5 Nov	50	9.45	34	14
13 Nov	51	7.78	34	10
17 Jan	68	10.24	31	11
23 Jan	73	8.75	31	11
28 Jan	76	8.39	33	10
30 Jan	77	9.11	32	12
30 Jan	78	8.87	31	10
1 Feb	79	8.82	31	11
10 Feb	83	8.84	32	11
11 Feb	85	8.34	32	11
13 Feb	86	8.36	32	12
15 Feb	89	8.92	31	10
16 Feb	91	8.02	25	10
22 Feb	97	8.89	27	11
27 Feb	101	8.54	29	11
27 Feb	103	9.49	28	15
5 March	104	9.55	31	13
8 March	107	8.79	21	12
9 March	109	7.89	21	15
15 March	128	9.00	8	12
15 March	130	9.58	9	13
19 March	131	7.58	15	17
20 March	133	6.97	26	14
20 March	137	5.40	32	16

Appendix D. Dates, locations, and water quality measurements for staghorn sculpin collected within Humboldt Bay, Humboldt County, California between the months of September 2000 and November 2001. Sample # refers to location of collection (see appendix 2). Dissolved oxygen (DO) readings are given in milligrams per Liter (mg/L), salinity readings are given in parts per thousand (ppt), and temperature readings are given in C°. (continued).

Date	*Sample #*	*DO*	*SALINITY*	*TEMPERATURE*
21 March	142	6.31	28	13
27 March	143	7.40	27	16
27 March	144	7.92	28	17
27 March	143	7.32	25	16
4 April	148	6.05	30	11
4 April	151	5.37	30	12
5 April	152	8.80	32	14
10 April	159	7.75	31	13
10 April	160	9.53	31	17
12 April	162	7.10	26	15
17 April	166	8.46	24	15
24 April	167	7.08	31	16
24 April	172	5.62	21	17
26 April	174	9.55	0.6	13
26 April	177	7.04	31	18
1 May	184	7.07	32	13
1 May	187	10.92	22	20
1 May	189	10.3	21	18
3 May	192	10.94	21	20
10 May	205	6.90	35	20
10 May	211	5.87	35	25
29 May	219	6.26	31	15
30 May	220	6.67	33	15
30 May	221	6.77	33	15
5 June	222	6.33	35	16
5 June	223	6.16	36	16
13 June	228	5.57	34	16
13 June	230	5.72	33	15
18 June	232	6.74	37	17
19 June	237	7.97	33	18
19 June	239	6.65	34	17
19 June	240	6.60	34	17
25 June	250	6.70	33	15
26 June	253	5.27	33	18
27 June	254	6.70	32	182

Appendix D. Dates, locations, and water quality measurements for staghorn sculpin collected within Humboldt Bay, Humboldt County, California between the months of September 2000 and November 2001. Sample # refers to location of collection (see appendix 2). Dissolved oxygen (DO) readings are given in milligrams per Liter (mg/L), salinity readings are given in parts per thousand (ppt), and temperature readings are given in C°. (continued).

Date	*Sample #*	*DO*	*SALINITY*	*TEMPERATURE*
27 June	256	6.45	32	18
2 July	257	7.12	33	20
2 July	261	6.13	34	23
3 July	262	6.13	34	23
3 July	265	13.36	33	24
11 July	268	12.43	33	16
16 July	278	7.42	33	15
16 July	280	5.86	34	20
23 July	297	9.66	36	27
30 July	299	9.11	33	19
30 July	301	8.67	33	17
6 August	310	3.89	35	19
6 August	313	5.48	34	21
6 August	315	5.06	34	22
7 August	317	4.13	34	20
14 August	320	6.36	34	21
16 August	326	6.51	34	17
21 August	328	6.13	34	17
22 August	333	5.21	34	19
22 August	334	6.79	33	19
30 Nov	342	6.00	33	19
30 Nov	346	8.00	28	12

Appendix E. Dates, locations, and lengths of shiner surfperch collected within Humboldt Bay, Humboldt County, California between the months of September 2000 and November 2001. Sample # refers to location of collection (see appendix 2). Average lengths were obtained using table queries in ArcMap and are given here under column Average AVG. All measurements are total length in millimeters.

Date	*Sample #*	*Abundance*	*Average AVG*	*Abundance by Month*
25 Sept	5	1025	105.44	
25 Sept	9	16	108.31	
25 Sept	11	11	91.45	
25 Sept	13	11	110.00	1063
1 Oct	15	25	111.64	
1 Oct	17	25	109.96	
11 Oct	21	1	80.00	
12 Oct	24	1	85.00	
23 Oct	30	8	91.25	
23 Oct	32	38	99.22	
23 Oct	34	8	98.88	
23 Oct	36	17	95.18	
23 Oct	38	48	96.32	
27 Oct	43	3	91.67	174
17 Jan	69	1	85.00	1
13 March	113	1	99.00	1
17 April	164	1	132.00	1
8 May	200	34	132.92	
8 May	202	3	103.33	
10 May	209	3	123.33	
29 May	219	6	40.67	
30 May	221	1	44.00	47
13 June	228	12	68.42	
14 June	229	4	51.50	
15 June	230	1	53.00	
18 June	232	80	62.12	
18 June	233	107	53.62	
18 June	234	72	51.28	
18 June	235	59	49.64	
18 June	236	45	50.68	
19 June	237	6	86.00	
19 June	238	1	122.00	
19 June	239	1	57.00	
19 June	240	821	56.20	
19 June	241	13	115.62	

Appendix E. Dates, locations, and lengths of shiner surfperch collected within Humboldt Bay, Humboldt County, California between the months of September 2000 and November 2001. Sample # refers to location of collection (see appendix 2). Average lengths were obtained using table queries in ArcMap and are given here under column Average AVG. All measurements are total length in millimeters (continued).

Date	*Sample #*	*Abundance*	*Average AVG*	*Abundance by Month*
25 June	246	7	126.57	
25 June	250	1	122.00	
26 June	251	207	50.79	
26 June	252	780	59.12	
26 June	253	1188	70.16	
27 June	254	33	52.88	
27 June	255	3	74.00	
27 June	256	18	70.50	3463
2 July	257	156	52.85	
2 July	258	153	56.63	
2 July	259	172	54.12	
2 July	260	30	57.28	
2 July	261	16	54.00	
3 July	262	84	48.28	
3 July	263	11	48.73	
3 July	264	1	100.00	
3 July	265	6	84.00	
11 July	266	1	53.00	
11 July	267	49	54.92	
11 July	268	1	46.00	
12 July	270	1	45.00	
12 July	272	1	113.00	
16 July	278	63	57.93	
16 July	279	39	57.88	
16 July	280	73	67.92	
16 July	281	41	69.24	
16 July	282	111	64.52	
16 July	283	69	67.44	
16 July	284	40	58.68	
16 July	285	49	66.64	
16 July	286	143	53.85	
23 July	295	1	114.00	
23 July	296	1	97.00	
23 July	297	23	68.22	
30 July	299	35	64.42	

Appendix E. Dates, locations, and lengths of shiner surfperch collected within Humboldt Bay, Humboldt County, California between the months of September 2000 and November 2001. Sample # refers to location of collection (see appendix 2). Average lengths were obtained using table queries in ArcMap and are given here under column Average AVG. All measurements are total length in millimeters (continued).

Date	*Sample #*	*Abundance*	*Average AVG*	*Abundance by Month*
30 July	300	4	52.50	1374
6 August	310	18	78.00	
6 August	311	22	54.05	
6 August	312	79	55.68	
6 August	313	218	73.20	
6 August	314	465	74.56	
6 August	315	144	75.52	
7 August	316	56	58.72	
7 August	317	211	63.36	
7 August	318	239	59.16	
14 August	319	5	61.00	
14 August	320	6	82.33	
14 August	321	27	64.44	
16 August	323	36	67.88	
16 August	324	25	76.36	
16 August	326	30	69.40	
21 August	327	48	55.94	
21 August	328	6	58.50	
21 August	329	15	60.73	
21 August	330	4	62.00	
21 August	331	41	61.84	
22 August	332	56	75.00	
22 August	333	11	71.91	
22 August	334	8	59.63	
22 August	335	7	59.29	
23 August	336	3	65.67	
23 August	337	1	56.00	
23 August	338	6	68.33	1787
30 Nov	340	29	96.76	
30 Nov	342	54	95.07	
30 Nov	344	48	92.78	
30 Nov	346	110	89.56	241

Appendix F. Family, specific and common names for all species collected within Humboldt Bay, Humboldt County, California between the months of September 2000 and November 2001.

Family	Species	Common Name
Squalidae	*Squalus acanthias*	Spiny dogfish
Carcharhinidae	*Triakis semifasciata*	Leopard shark
	Mustelus henlei	Brown smoothound
Myliobatididae	*Myliobatis californica*	Bat Ray
Clupeidae	*Clupea harengus*	Pacific herring
	Sardinops sagax	Pacific sardine
Engraulidae	*Engraulis mordax*	Northern anchovy
Salmonidae	*Oncorhynchus clarkii*	Cutthroat trout
	Oncorhynchus mykiss	Steelhead
	Oncorhynchus tshawytscha	Chinook salmon
	Oncorhynchus kisutch	Coho salmon
Osmeridae	*Hypomesus pretiosis*	Surf smelt
	Allosmerus elongatus	Whitebait smelt
	Spirinchus starksi	Night smelt
	Spirinchus thaleichthys	Longfin smelt
		unidentified juveniles
Batrachoididae	*Porichthys notatus*	Plainfin midshipman
Gaddidae	*Microgadus proximus*	Pacific Tomcod
Atherinidae	*Atherinopsis californiensis*	Jacksmelt
	Atherinops affinis	Topsmelt
Poeciliidae	*Gambusia affinis*	Mosquitofish

Appendix F. Family, specific and common names for all species collected within Humboldt Bay, Humboldt County, California between the months of September 2000 and November 2001 (continued).

Family	Species	Common Name
Gasterosteidae	*Aulorhynchus flavidus*	Tubesnout
	Gasterosteus aculeatus	Threespine stickleback
Syngnathidae	*Syngnathus leptorhynchus*	Bay pipefish
Scorpaenidae	*Sebastes caurinus*	Copper rockfish
	Sebastes melanops	Black rockfish
	Sebastes carnatus	Gopher rockfish
	Sebastes sp	unidentified juveniles
Hexagrammidae	*Ophiodon elongatus*	Lingcod
	Hexagrammos decarammus	Kelp greenling
	Hexagrammos superciliosus	Rock greenling
Cottidae	*Scorpaenichthys marmoratus*	Cabezon
	Hemilepidotus spinosus	Brown Irish lord
	Hemilepidotus hemilepidotus	Red Irish lord
	Leptocottus armatus	Pacific staghorn sculpin
	Enophrys bison	Buffalo sculpin
	Artedius notospilotus	Bonyhead sculpin
	Oligocottus snyderi	Fluffy sculpin
	Clinocottus acuticeps	Sharpnose sculpin
	Cottus asper	Prickly sculpin
Liparididae	*Liparis pulchellus*	Showy snailfish
	Liparis rutteri	Ringtail snailfish
Embiotocidae	*Amphistichus koelzi*	Calico surfperch
	Amphistichus rhodoterus	Redtail surfperch
	Hyperprosopon anale	Spotfin surfperch
	Hyperprosopon argenteum	Walleye surfperch

Appendix F. Family, specific and common names for all species collected within Humboldt Bay, Humboldt County, California between the months of September 2000 and November 2001 (continued).

Family	Species	Common Name
Embiotocidae	*Hyperprosopon ellipticum*	Silver surfperch
	Cymatogaster aggregata	Shiner surfperch
	Embiotoca lateralis	Striped surfperch
	Damalichthys vacca	Pile surfperch
	Phanerodon furcatus	White surfperch
Pholidae	*Apodichthys flavidus*	Penpoint gunnel
	Pholis ornata	Saddleback gunnel
Ammodytidae	*Ammodytes hexapterus*	Pacific Sandlance
Gobiidae	*Eucyclogobius newberryi*	Tidewater goby
	Gillichthys mirabilis	Longjaw mudsucker
	Lepidogobius lepidus	Bay goby
	Clevlandia ios	Arrow goby
Centrolophidae	*Icichthys lockingtoni*	Medusafish
Bothidae	*Paralichthys californicus*	California halibut
	Citharichthys sordidus	Pacific sanddab
	Citharichthys stigmaeus	Speckled sanddab
Pleuronectidae	*Pleuronichthys decurrens*	Curlfin turbot
	Psettichthys melanostictus	Sand sole
	Parophrys vetulus	English sole
	Isopsetta isolepis	Butter sole
	Platichthys stellatus	Starry flounder
	Eopsetta jordani	Petrale sole
		unidentified juveniles