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A Plan for Monitoring the Fish Assemblage in Elkhorn Slough

Jennifer Brown

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ABOUT THIS DOCUMENT

J. Brown was invited to prepare this document as a part of her duties as a NOAA Graduate Research Fellow at the Elkhorn Slough National Estuarine Research Reserve.

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AUTHOR AFFLIATION

At the time the report was prepared, Jennifer Brown was a graduate student in the Department of Ecology and Evolutionary Biology, University of California, Santa Cruz, CA 95064.

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The mission of the Elkhorn Slough Foundation and the Elkhorn Slough National Estuarine Research Reserve is conservation of estuarine ecosystems and watersheds, with particular emphasis on Elkhorn Slough, a small estuary in central California. Both organizations practice science-based management, and strongly support applied conservation research as a tool for improving coastal decision-making and management. The Elkhorn Slough Technical Report Series is a means for archiving and disseminating data sets, curricula, research findings or other information that would be useful to coastal managers, educators, and researchers, yet are unlikely to be published in the primary literature.

Background Information - Elkhorn Slough

1. Elkhorn Slough is a tidal lagoon and seasonal estuary.
2. Narrow, shallow embayment extending approximately 6.2 miles inland from the eastern most point in Monterey Bay.
3. "Elkhorn Slough proper" (east of Highway 1 bridge) is adjacent to three other aquatic areas: Moss Landing Harbor, the jetties, and Bennett Slough (together called "greater Elkhorn Slough area").
4. Aquatic habitats include: shallow open water, submerged aquatic vegetation (SAV), sand/mud flats, fresh/salt/brackish marshes, subtidal/intertidal rocks and pilings.
5. Aquatic habitats support a diverse fish fauna – approximately 97 species have been collected in the greater Elkhorn Slough area (Yoklavich et al. (in press)).
6. Surrounding land use is mostly agriculture with associated run-off of nutrients, topsoil, and chemicals.
7. A power plant is located adjacent to Moss Landing Harbor - water intake pipes near mouth of slough entrain and impinge larval and juvenile fishes entering and exiting the Moss Landing Harbor/Elkhorn Slough area.
8. In 1980s dikes and levees were reopened to tidal flow which increased: i) surface wetland area and tidal volume; and ii) velocity of tidal currents and rates of erosion.

Past and Current Monitoring Efforts

Since the 1970's there have been many studies of the fish assemblages in the greater Elkhorn Slough area:

1. Studies examining temporal and spatial trends in abundance of all fish species (see Figure 1 for map of collection sites):
    a. Appiah 1977:
        i. Mostly beach seines (some gill nets)
        ii. 8 stations in Bennett Slough
        iii. Samples collected monthly from September 1975 - August 1976
    b. Nybakken et al. 1977:
        i. Otter trawls used to sample sites in main channel (Bridge, Dairies, Kirby Park) and coastal ocean (North and South Ocean)
        ii. Beach seine used to sample in Bennett Slough
        iii. Samples collected monthly from August 1974 - July 1976
    c. Barry 1983:
        i. Mostly otter trawls (some seines and channel nets)
        ii. Sites in tidal creeks (Long Canyon, Rubis Creek, Hudson's Landing)
        iii. Samples collected monthly from October 1978 - June 1980
    d. King et al. 1986:
        i. Sampling ES NERR South Marsh before and after restoration
        ii. Before restoration - otter trawl and beach seine April and August 1983
        iii. After restoration - otter trawl monthly April 1984 - November 1985
        iv. Comparison sites - otter trawl in Rubis Creek and Kirby Park quarterly from November 1984 - November 1985
    e. Oxman 1995:
        i. Otter trawls
        ii. Sites in main channel (Bridge, Dairies, Kirby Park)
        iii. Samples collected monthly from January - December 1991
        iv. Daytime and nighttime trawls
    f. Lindquist 1998:
        i. Otter trawls (and some beach seines)
        ii. Sites in main channel (Dairies, Kirby Park) and tidal creeks (Long Canyon, Rubis Creek)
        iii. Samples collected eight times between May 1996 - May 1997

g. Brown (unpublished data):
    i. Otter trawls
    ii. Sites in main channel (Bridge, Dairies, Kirby Park) and coastal ocean (North and South Ocean)
    iii. Samples collected summer 1998 - fall 2000

2. Studies examining spatial and temporal trends in abundance of certain species:
    a. Herald 1960:
        i. Summarizes catches from Elkhorn Slough shark derbies 1951-1959
        ii. Samples collected by hook and line
    b. Talent 1973:
        i. Elasmobranchs
        ii. Site in main channel (between Bridge and Dairies)
        iii. Gill net
        iv. Samples collected weekly October 1971 - November 1972
    c. Antrim 1981:
        i. Surfperch (shiner, black and white surfperch)
        ii. Otter trawl
        iii. Sites in main channel (Bridge, Dairies, Kirby Park) and coastal ocean (North and South Ocean)
        iv. Samples collected monthly from August 1974 - October 1975
    d. Ruagh 1976:
        i. Jacksmelt and topsmelt
        ii. Sites main channel (Bridge, Dairies, Kirby Park) and one site in Moss Landing Harbor (Skipper's)
        iii. Gill nets, beach seines, and otter trawls
        iv. Samples collected monthly from August 1974 - August 1975
    g. Cailliet et al. 1990:
        i. Topsmelt and jacksmelt
        ii. Sampling in three habitat types (mudflats, tidal creeks, main channel) at three sites (Rubis Creek, Kirby Park, South Marsh)
        iii. Monofilament gill nets
        iv. Samples collected monthly from November 1987 - January 1989

3. Studies examining spatial and temporal trends in abundance of ichthyoplankton:
    a. Nybakken et al. 1977 (published in Yoklavich et al. 1992):
        i. Collections in Moss Landing Harbor (Harbor Entrance) and main channel (Bridge, Dairies, Red House/ES NERR, Kirby Park)
        ii. Samples collected monthly from September 1974 - September 1976
    b. Tenera 2000:
        i. Sites in main channel (Dairies, Kirby Park), Moss Landing Harbor (Harbor Entrance, Harbor Mouth), and ocean (North One, South One)
        ii. Samples collected monthly from June 1999 - May 2000

Patterns Based on Past Monitoring

1. Fish in Elkhorn Slough can be classified as common (encountered regularly at multiple site in most years) or uncommon (encountered infrequently and/or at a limited number of sites).
    a. Surfperch (Embiotocidae)
        i. 14 species have been collected in the greater Elkhorn Slough area
        ii. 3 species are common in Elkhorn Slough proper (shiner, black and white surfperch)
    b. Sculpin (Cottidae)
        i. At least 4 species have been collected in the greater Elkhorn Slough area
        ii. Pacific staghorn sculpin is the only common species of sculpin

c. Schooling fishes (Atherinidae, Clupeidae, Engraulidae, Osmeridae)
    i. Approximately 10 species of schooling fishes occur in the greater Elkhorn Slough area
    ii. 4 species are common (Northern anchovy, Pacific herring, topsmelt, jacksmelt
d. Flatfish (Bothidae, Pleuronectidae)
    i. Approximately 10 species have been collected in greater Elkhorn Slough area
    ii. 2 species are very common (English sole, speckled sanddab)
    iii. Starry flounder were collected commonly throughout the slough in the 1970s and 1980s; collection of this species has been less common in recent years
e. Elasmobranchs (Carcharhinidae, Myliobatiae, Rhinobatidae, Urolophidae)
    i. 8 species have been collected in the greater Elkhorn Slough area
    ii. 2 species are common (leopard shark, bat ray)
f. Gobies (Gobiidae)
    i. 7 species have been collected in greater Elkhorn Slough area
    ii. 3 species are common (arrow goby, longjaw mudsucker, bay goby)
g. Species that prefer hard substrates (e.g., cabezon, rockfish, greenling) are uncommon because this type of habitat is uncommon in Elkhorn Slough

2. Fish species can be classified based on spatial/temporal patterns of utilization of habitats in Elkhorn Slough (from Yoklavich et al. 1991)
    a. Marine immigrants
        i. Primarily lives in the ocean, but use slough as feeding, spawning and/or juvenile habitat
        ii. Examples include - herring, anchovy, cabezon, flatfishes
    b. Residents
        i. Completes entire life cycle in Elkhorn Slough
        ii. Examples include - gobies, pipefish, black surfperch, staghorn sculpin
    c. Partial residents
        i. Primarily lives in Elkhorn Slough, but exits during certain seasons or life stages
        ii. Examples include - smelts, shiner surfperch, bat rays, leopard sharks
    d. Freshwater species
        i. Found only in fresh or brackish water habitats in Elkhorn Slough
        ii. Examples include - mosquitofish, threespine stickleback, striped bass

3. Temporal changes in abundance and diversity of fish assemblage
    a. Comparisons of diurnal fish assemblage found in 1990s (Oxman 1995, Lindquist 1998) to that found in the 1970s (Nybakken et al. 1977) showed:
        i. Decrease in number of fish per tow
        ii. Decrease diversity at two stations
        iii. Some species in lower abundance or absent
        iv. Other species increased in abundance
        v. In general however, dominant fish species did not change

4. Homogenization of fish assemblages appears to be occurring (Yoklavich et al. (in press)):
    a. upper channel and tidal creeks assemblages becoming more similar to those in the lower channel.
        i. Probably due to erosion and scouring making those shallower areas more similar in habitat type to that found in main channel.
    b. South Marsh (ESNERR) site becoming more similar to tidal creeks and main channel
        i. Probably due to restoration efforts that restored tidal flow to the area – increasing number of marine species and decreasing relative abundance of euryhaline species

5. Diets are changing for some species:
    a. Prey diversity has decreased for eight species of fish examined by Lindquist (1998)

i. Trend primarily due to decreased use of infaunal worms and mollusks and increased use of epifaunal crustaceans
ii. Sediment cores show a similar reduction in prey diversity and abundance in tidal creeks

b. Increasing similarity in diets of fishes in tidal creeks and main channel (Lindquist 1998)
i. Probably due to erosion - causing the sediments in tidal creeks to become more similar to those found in the main channel

c. Diet of large and small leopard sharks becoming more similar (Kao1995)
i. Decreased use of clams in diet of adults
ii. Decreased use of crabs in diet of juveniles
ii. Increased use of fat innkeeper worm by juveniles and adults
iii. Probably due to increasing rates of erosion and increasing number of sea otters in slough (clam and crab predator)

6. There are consistent patterns in abundance and distribution of ichthyoplankton (Nybakken et al. 1977/Yoklavich et al. 1992, Tenera 2000):
a. High abundance of larvae of resident fishes (e.g., gobies)
b. High abundance of larvae of schooling fishes (eggs laid in slough)
c. Power plant entrains many fish larvae as they are being advected into/out of slough waters.
d. Fish larvae can be divided into a winter assemblage and a summer/fall assemblage

Available Monitoring Methods

Although many methods have been used to sample estuarine fish, no single method can effectively sample all species in all habitats. Selecting a method for sampling fish for long-term monitoring involves:

1. Examining the effectiveness of each method for capturing the species of interest (see Table 1)
a. Otter trawl
i. Collects the largest number of species of all methods used in Elkhorn Slough
ii. Good for sampling demersal fishes (flatfish, small elasmobranches, large sculpins, cabezon, lingcod, midshipman)
iii. Okay for fishes associated with submerged aquatic vegetation (surfperch, rockfish, pipefish) – fouling can be a problem
iv. Underestimates fishes that are highly mobile, associated with upper water column, burrowing fishes

b. Beach seine
i. Collects the second largest number of species of all methods used in Elkhorn Slough
ii. Good for sampling demersal fishes (flatfish, small elasmobranches, large sculpins, cabezon, lingcod, midshipman)
iii. Okay for fishes associated with submerged aquatic vegetation (surfperch, rockfish, pipefish) – fouling can be a problem
iv. Underestimates fishes that are highly mobile, associated with upper water column, burrowing fishes

c. Gill nets
i. Collects a low number of species because mesh size limits the size of fish that can be captured
ii. Good for highly mobile fishes (elasmobranches, schooling fishes)
iii. Okay for some gobies, sculpins, and surfperch (if mesh is correct size)

d. Minnow traps
i. Collect a low number of species
ii. Good for sampling small, slow moving fishes (pipefish, sculpin)
iii. Good for fishes that burrow into sediment (gobies)

2. Examining the effectiveness of each method for sampling the habitats of interest:
    a. Otter trawl
        i. Main channel and tidal creeks with water > 4 ft deep
        ii. Samples area between bottom and ~ 4 ft off bottom
    b. Beach seine
        i. Shallow flat areas such as marsh and mud/sand flats
    c. Gill nets
        i. Any unvegetated habitat
        ii. Samples depth range determined by height of net
    d. Minnow traps
        i. Any habitat

3. Determining impacts to wetland habitat/fauna caused by repeated sampling
    a. Otter trawl
        i. Very destructive to benthic habitat structure or vegetation, especially if used repeatedly over same area
        ii. Low rate of injury/death of fish if samples are sorted quickly and properly
    b. Beach seine
        i. Destructive to benthic habitats, especially if used repeatedly over same area
        ii. Amount of destruction determined, to some extent, by size and weight of net
        iii. Death/injury of fish is not expected
    c. Gill nets
        i. Not destructive to benthic habitats unless there is a significant amount of trampling associated with setting and retrieving net
        ii. Death will occur if fish are not freed from net soon after entanglement
        iii. Injury to some fish is expected
    d. Minnow traps
        i. Not destructive benthic habitats unless there is a significant amount of trampling associated with setting and retrieving traps
        ii. No death/injury of fish is expected

4. Other points to consider when designing a monitoring plan:
    a. Simultaneous or near simultaneous monitoring of different areas should be attempted when sampling mobile organisms in order to distinguish between spatial and temporal variability in patterns of abundance.
    b. Need to keep certain factors consistent between sampling events to ensure consistent sampling effort between different areas and times:
        i. time of day - some species have activity patterns that change with time of day (e.g., diurnal vs. nocturnal)
        ii. tidal height – at low tide water is shallow and fish are concentrated into smaller total area
        iii. water flow – can effect catch efficiency of nets

Goals of a Monitoring Plan

I have designed a plan for monitoring the fish assemblage in Elkhorn Slough to address the following questions (listed in order of importance)

1. Are there long-term changes in species composition and relative abundance?
2. Are there changes in spatial distribution of species in Elkhorn Slough?
3. Are there changes in seasonal patterns of species composition and abundance?

This monitoring plan also needs to use methods that meeting the following criteria:

1. Limited amount of time available for sampling effort (minimum level ~ 100 person hrs/yr)
2. Limited amount of money to buy equipment or pay for boat use
3. Field assistants are volunteers without extensive technical skills

4. Minimize damage to benthic habitats caused by sampling gear
5. Minimize by-catch of fish (injury or mortality)

Recommendations for Future Monitoring in Elkhorn Slough

I recommend a three-tiered monitoring plan. The annual sampling schedule for this plan is shown in Table 2 and sampling sites are shown in Figure 1.

1. TIER 1 (~ 120 person hrs/yr): a general snap-shot of overall diversity of fishes in the greater Elkhorn Slough area
    a. Uses sampling methods that collect the largest number of species (see Table 1)
        i. Otter trawls (in the main channel and tidal creeks)
        ii. Beach seines (in shallow marsh)
    b. Focuses on habitats that encompass many of those found in the greater Elkhorn Slough area
        i. Main channel sites – Bridge and Kirby Park
        ii. Shallow marsh sites - Bennett Slough and South Marsh
        iii. Tidal creek site – Rubis Creek
    c. Selected sites that have many species of fish, but are least similar in their fish assemblages (see Table 3)
        i. In main channel - Bridge and Kirby Park are least similar
        ii. Main channel, tidal creek, and marsh sites differ in their fish assemblages
    d. Two time periods each year (see Table 4)
        i. March – samples winter/spring assemblage
        ii. August – samples summer/fall assemblage
    e. Minimizes equipment needed
        i. Need to buy two types of equipment (otter trawl and beach seine)
        ii. Volunteers have to learn two sampling protocols
        iii. Requires a boat and a driver
2. TIER 2 (additional 76 person hrs/yr)
    a. Specialized sampling methods to focus on groups not sampled adequately using otter trawls and beach seines (see Table 1)
        i. Small mesh gill nets for schooling fishes (method recommended in Ruagh 1976)
        ii. Large mesh gill nets for elasmobranches
        iii. Minnow traps for small demersal fish (e.g., gobies)
    b. Targeting habitats preferred by those groups (see Table 3)
        i. Schooling fishes and gobies – upper main channel (Kirby Park) and salt marsh/mud flats (ES NERR South Marsh)
        ii. Elasmobranches – shallow channels and tidal creeks in the ES NERR (see Kao 2000 for description of sites)
    c. Two time periods each year (see Table 4)
        i. Schooling fishes – February (herring, topsmelt, jacksmelt) and May (topsmelt, surfsmelt, anchovy)
        ii. Elasmobranchs – June and July (most species are present during summer and two species are pupping)
        iii. Gobies – February and July to get winter and summer estimates of abundance for these resident species.
    d. Substantially increases equipment and volunteer needs
        i. need two different gill nets and a set of minnow traps
        ii. volunteers have to learn many sampling protocols or need many specialized groups of volunteers

3. TIER 3 (additional person hrs/yr - unknown, but substantial)
    a. specialized method
        i. ichthyoplankton net collects larval fish and eggs

b. areas that have least similar larval fish assemblages (see Table 5)
    i. The Bridge and Kirby Park sites are the least similar
    ii. Bridge – high diversity site
    iii. Kirby – high abundance site
c. Two time periods each year (see Table 6)
    i. January – winter assemblage (staghorn sculpin, Osmeridae, Atherinidae, sandlance, herring)
    ii. September – summer/fall assemblage (anchovy, blennies, gobies)
d. Substantially increases equipment and volunteer needs
    i. Need ichthyoplankton net and frame for mounting net on boat
    ii. Sorting larval samples is very time consuming and requires taxonomic expertise
    iii. Need boat and driver

Details for Monitoring Plan

1. Otter trawl :
    a. Net description: see Barry 1983 (Appendix 1)
    b. Duration of set: 10 minutes tows into current at ~2 knots
    c. Timing of set:
        i. in main channel trawling should occur during extreme low tides if possible (animals will be concentrated into deeper channels)
        ii. in tidal creek trawling needs to occur at high tide to allow boat access into this shallow area
    d. # of field assistants: 3 (one to drive boat, two to operate net)
    e. # of sets: 2-3 per site (tracks of sets should not overlap)
        i. the tracks of sets should not overlap
        ii. the tracks should cover shallower and deeper areas in main channel
    f. Cost of net: approximately $500 (complete with doors and tickle chain)
    g. Sample sites on consecutive days or have two teams sample sites on same day (requires multiple nets)

2. Beach seine:
    a. Net description: smaller than those used in the past (Appendix 1) to minimize damage to benthic habitats and lighter weight will allow for easy transport by two people
        i. 25-30 ft long
        ii. Mesh 0.25 inches
        iii. 4-5 ft tall
        iv. Add tickle chain
        v. Add wooden dowels to ends of net (helps keep net on bottom and assists in carrying net)
    b. Timing of set: seining should occur at low tide (animals will be concentrated into remaining submerged areas)
    c. # of sets: multiple sweeps per site along the shore
        i. Into current if current present
        ii. Sweeps should not overlap
    d. # of field assistants: 2 (with wetsuits)
    e. Cost of net: approximately $50 - 100
    f. Sample sites on consecutive days or have three teams sample sites on same day (requires multiple nets)

3. Large-mesh gill net (for Elasmobranches)
    a. Net description: (see Appendix 1)
        i. 75-100 ft long
        ii. Alternating panels of 4, 6 and 9 inch meshes
        iii. 5 ft tall
    b. Timing of set: gill nets should be set out at low tide
    c. Duration of sets: 2-3 hours while tide is rising
        i. Net should be monitored during entire set to remove animals as they become entangled
    d. # of field assistants: minimum of 2 (with wetsuits)
    e. Cost of net: N/A
    f. Sample sites on consecutive days or have two teams sample sites on same day (requires multiple nets)

4. Small-mesh gill net (for schooling fishes)
    a. Net description: (see Appendix 1)
        i. 75-100 ft long
        ii. Alternating panels of 0.5, 1, and 2 inch meshes
        iii. 5 ft tall
    b. Timing of set: gill nets should be set out during a rising tide
    c. Duration of sets: 4-8 hours
        i. Most fish will be killed or injured with this method, but too time consuming to monitor net constantly
    d. # of field assistants: minimum of 2 (with wetsuits)
    e. Cost of net: N/A
    f. Sample sites on consecutive days or have two teams sample sites on same day (requires multiple nets)

5. Minnow traps:
    a. Trap description:
        i. Many different types available from catalogues
        ii. Recommend collapsible type - less storage space required
        iii. Opening to trap should be small to prohibit large crabs from entering (they can kill and eat fish in traps)
    b. Timing of set: set at low tide (to avoid exposure when tide recedes)
    c. Duration of set: 8-12 hours
    d. # of field assistants: minimum of 1
    e. Cost of traps: approximately $10/each
    f. # of traps per site: 5
    g. Set traps on consecutive days or have two people set traps on same day (requires extra set of traps)

6. Ichthyoplankton:
    a. Push net design - see Nybakken et al. 1977 (Appendix 1)
    b. Gear needed:
        i. small boat
        ii. push-net frame
        iii. ichthyoplankton net
    c. # of people - two (one to drive boat, one to operate net)
    d. # of samples: Two samples @ 2 knot for 10 min each (1 hr/site)
    e. Sorting samples in laboratory
        i. very time consuming
        ii. requires taxonomic expertise

Additional Data or Studies

Interpreting data from this monitoring plan may require additional data or studies:

1. Fisheries data or monitoring data from other central California estuaries.
    a. Is a disappearance/appearance of a species a local or regional phenomena?
2. Water temperature
    a. Are long-term changes in relative abundance due to long-term climate change?
    b. Are short-term changes in relative abundance due to oceanographic changes such as El Niño/ La Niña?
    c. Water temperature is currently monitored by ES NERR volunteers
3. Salinity
    a. Are long-term or seasonal changes in relative abundance due to changes in freshwater input?
    b. Salinity is currently monitored by ES NERR volunteers
4. Rates of erosion
    a. Are temporal or spatial changes in relative abundance due to loss of shallow habitats (e.g., mudflats)?
    b. Requires monitoring of width and depth of channels
5. Invertebrate fauna, especially infauna and epifauna
    a. Are changes in prey availability causing changes in the fish assemblage?
    b. Invertebrates will be monitored in the future according to the ES NERR invertebrate monitoring plan
6. Submerged aquatic vegetation (SAV)
    a. Are changes in fish assemblage due to changes in SAV (e.g., loss of habitat for laying eggs)?
    b. SAV distribution will be monitored in the future according to the ES NERR plant/algae monitoring plan

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TABLE 1. Methods of Collection Used to Sample Fish in the Greater Elkhorn Slough Area.

The fraction in each cell represents the "collection success" of a given method to sample a species of fish: the denominator is the number of research studies that used a given method of collection; the numerator is the number of those research studies in which at least one individual of a given species was collected. Four categories of "collection success" are represented by shading: white = 0%; light gray = 1% - 34%; gray = 35% - 69%; and black = 70% - 100%.

Specific Names	Common Name	beach seine	otter trawl	channel nets	minnow traps	gill nets	trot/long line	hook and line	References
Acanthogobius flavimanus	yellowfin goby	3/4	3/4	2/2	1/1	1/2	0/1	0/1	Nybakken et al. 1977, Barry 1983, Small 1983, King et al. 1986, Cailliet et al. 1990, Yoklavich et al. 1991, Oxman 1995,
Ammodytes hexapterus	Pacific sandlance	0/1	0/1					1/1	Nybakken et al. 1977,
Amphistichus argenteus	barred surfperch	0/1	0/1					1/1	Nybakken et al. 1977,
Artedius harringtoni	scalyhead sculpin	0/1	1/1					0/1	Nybakken et al. 1977,
Atherinops affinis	topsmelt	6/6	5/6	2/2	0/2	4/4	0/1	1/1	Ruagh 1976, Nybakken et al. 1977, Barry 1983, Small 1983, King et al. 1986, Cailliet et al. 1990, Yoklavich et al. 1991, Nerney et al. 1993, Hall 2000
Atherinopsis californiensis	jacksmelt	3/4	4/4	0/2		2/2		1/1	Ruagh 1976, Nybakken et al. 1977, Barry 1983, Cailliet et al. 1990, Yoklavich et al. 1991,
Chilara taylori	spotted cusk-eel	0/1	2/2					0/1	Nybakken et al. 1977, Oxman 1995,
Citharichthys stigmaeus	speckled sanddab	0/4	6/6	0/2		1/1		0/1	Nybakken et al. 1977, Barry 1983, King et al. 1986, Cailliet et al. 1990, Yoklavich et al. 1991, Nerney et al. 1993, Oxman 1995,
Clevelandia ios	arrow goby	5/5	5/6	2/2	0/1	0/1	0/1	0/1	Nybakken et al. 1977, Barry 1983, Small 1983, King et al. 1986, Yoklavich et al. 1991, Nerney et al. 1993, Oxman 1995,
Clupea pallasii	Pacific herring	2/4	6/6	0/2	0/1	2/2		0/1	Nybakken et al. 1977, Barry 1983, King et al. 1986, Cailliet et al. 1990, Yoklavich et al. 1991, Nerney et al. 1993, Oxman 1995, Hall 2000
Coryphopterus nicholsi	blackeye goby	0/1	1/1					0/1	Nybakken et al. 1977,
Cottus asper	prickly sculpin	2/2	0/2	0/1				0/1	Nybakken et al. 1977, Yoklavich et al. 1991,
Cymatogaster aggregata	shiner surfperch	3/4	6/6	2/2	0/1	2/2		1/1	Nybakken et al. 1977, Barry 1983, King et al. 1986, Cailliet et al. 1990, Yoklavich et al. 1991, Nerney et al. 1993, Oxman 1995, Hall 2000
Damalichthys vacca	pile surfperch	0/3	4/4	0/2				1/1	Nybakken et al. 1977, Barry 1983, Yoklavich et al. 1991, Oxman 1995,
Dorosoma petenense	threadfin shad	0/3	3/3	0/2				1/1	Nybakken et al. 1977, Barry 1983, Yoklavich et al. 1991,
Embiotoca jacksoni	black surfperch	3/3	5/5	2/2				1/1	Nybakken et al. 1977, Barry 1983, King et al. 1986, Yoklavich et al. 1991, Oxman 1995,
Embiotoca lateralis	striped surfperch	0/1	0/1					1/1	Nybakken et al. 1977,
Engraulis mordax	Northern anchovy	3/3	5/5	2/2	0/1	2/2		1/1	Nybakken et al. 1977, Barry 1983, King et al. 1986, Cailliet et al. 1990, Yoklavich et al. 1991, Oxman 1995, Hall 2000
Eucyclogobius newberryi	tidewater goby	2/2	0/2	0/1				0/1	Nybakken et al. 1977, Yoklavich et al. 1991,
Gasterosteus aculeatus	threespine stickleback	3/3	2/3	2/2				0/1	Nybakken et al. 1977, Barry 1983, Yoklavich et al. 1991,
Genyonemus lineatus	white croaker	0/1	0/1			1/1		1/1	Nybakken et al. 1977, Cailliet et al. 1990,
Gibbonsia metzi	striped kelpfish	0/2	2/3	0/1				1/1	Nybakken et al. 1977, Barry 1983, Oxman 1995,
Gillichthys mirabilis	longjaw mudsucker	3/3	2/3	2/2	1/1	1/1	1/1		Barry 1983, Small 1983, King et al. 1986, Yoklavich et al. 1991,

TABLE 1. Methods of Collection Used to Sample Fish in the Greater Elkhorn Slough Area (con't).

Specific Names	Common Name	beach seine	otter trawl	channel nets	minnow traps	gill nets	trot/long line	hook and line	References
Girella nigricans	opaleye				0/1	**1/1**			Hall 2000
Gobiidae	gobies	**2/2**	**2/2**	**2/2**					Barry 1983, Yoklavich et al. 1991,
Hexagrammos sp.	greenling	0/1	**2/2**					0/1	Nybakken et al. 1977, Oxman 1995,
Hyperprosopon argenteum	walleye surfperch	**2/3**	**5/5**	0/2				**1/1**	Nybakken et al. 1977, King et al. 1986, Yoklavich et al. 1991, Oxman 1995,
Hyperprosopon ellipticum	silver surfperch	0/1	0/1					**1/1**	Nybakken et al. 1977,
Hypomesus pretiosus	surf smelt	**2/2**	0/2	0/1		**1/1**		0/1	Nybakken et al. 1977, Cailliet et al. 1990, Yoklavich et al. 1991,
Hypsoblennius gentilis	bay blenny		**1/1**						King et al. 1986,
Hypsopsetta guttulata	diamond turbot	**2/3**	**5/5**	**2/2**		**1/1**		0/1	Nybakken et al. 1977, Barry 1983, King et al. 1986, Cailliet et al. 1990, Yoklavich et al. 1991, Oxman 1995,
Hypsurus caryi	rainbow surfperch	0/1	**2/2**					**1/1**	Nybakken et al. 1977, Oxman 1995,
Lepidogobius lepidus	bay goby	**2/3**	**5/5**	0/2				0/1	Nybakken et al. 1977, Barry 1983, King et al. 1986, Yoklavich et al. 1991, Oxman 1995,
Leptocottus armatus	staghorn sculpin	**3/5**	**6/6**	**2/2**	**2/2**	**2/3**	**1/1**	**1/1**	Nybakken et al. 1977, Barry 1983, Small 1983, King et al. 1986, Cailliet et al. 1990, Yoklavich et al. 1991, Nerney et al. 1993, Oxman 1995, Hall 2000
Micrometrus minimus	dwarf surfperch	0/3	**4/4**	0/2				0/1	Nybakken et al. 1977, Barry 1983, Yoklavich et al. 1991, Oxman 1995,
Morone saxatilis	striped bass	0/3	**2/3**	0/2				**1/1**	Nybakken et al. 1977, Barry 1983, Yoklavich et al. 1991,
Mugil cephalus	striped mullet	**1/2**	**1/2**	**1/2**					Barry 1983, Yoklavich et al. 1991,
Mustelus californicus	gray smoothhound	0/3	**4/4**	0/2		**2/2**		**1/2**	Herald 1960, Talent 1973, Nybakken et al. 1977, Barry 1983, King et al. 1986, Cailliet et al. 1990, Yoklavich et al. 1991,
Mustelus henlei	brown smoothhound	0/1	**2/2**	0/1		**2/2**		**1/1**	Herald 1960, Talent 1973, Barry 1983, Cailliet et al. 1990, Oxman 1995,
Myliobatis californica	bat ray	0/3	**5/5**	0/2		**2/2**		**2/2**	Herald 1960, Talent 1973, Nybakken et al. 1977, Barry 1983, King et al. 1986, Cailliet et al. 1990, Yoklavich et al. 1991, Oxman 1995,
Neoclinus uninotatus	onespot fringehead	0/2	**3/3**	0/1				**1/1**	Nybakken et al. 1977, Yoklavich et al. 1991, Oxman 1995,
Ophiodon elongatus	lingcod	0/3	**4/4**	0/2				**1/1**	Nybakken et al. 1977, Barry 1983, Yoklavich et al. 1991, Oxman 1995,
Paralichthys californicus	California halibut	**2/4**	**6/6**	**2/2**				0/1	Nybakken et al. 1977, Barry 1983, King et al. 1986, Yoklavich et al. 1991, Nerney et al. 1993, Oxman 1995,
Phanerodon furcatus	white surfperch	**2/3**	**5/5**	0/2		**1/1**		**1/1**	Nybakken et al. 1977, Barry 1983, King et al. 1986, Cailliet et al. 1990, Yoklavich et al. 1991, Oxman 1995,
Platichthys stellatus	starry flounder	**3/4**	**6/6**	**2/2**				**1/1**	Nybakken et al. 1977, Barry 1983, King et al. 1986, Yoklavich et al. 1991, Nerney et al. 1993, Oxman 1995,
Platyrhinoidis triseriata	thornback		**2/2**			**3/3**		**1/1**	Ackerman 1971, Talent 1973, King et al. 1986, Cailliet et al. 1990, Oxman 1995, Hall 2000
Pleuronectes bilineatus	rock sole	0/1	**1/1**					0/1	Nybakken et al. 1977,
Pleuronectes vetulus	English sole	0/3	**5/5**	0/2		**1/1**		**1/1**	Nybakken et al. 1977, Barry 1983, King et al. 1986, Cailliet et al. 1990, Yoklavich et al. 1991, Oxman 1995,

TABLE 1. Methods of Collection Used to Sample Fish in the Greater Elkhorn Slough Area (con't).

Specific Names	Common Name	beach seine	otter trawl	channel nets	minnow traps	gill nets	trot/long line	hook and line	References
Pleuronichthys decurrens	curlfin turbot	0/2	**3/3**	0/1				0/1	Nybakken et al. 1977, Yoklavich et al. 1991, Oxman 1995,
Porichthys notatus	plainfin midshipman	**3/3**	**5/5**	**2/2**				**1/1**	Nybakken et al. 1977, Barry 1983, King et al. 1986, Yoklavich et al. 1991, Oxman 1995,
Rhacochilus toxotes	rubberlip surfperch	0/2	**3/3**	0/1				**1/1**	Nybakken et al. 1977, Yoklavich et al. 1991, Oxman 1995,
Rhinobatos productus	shovelnose guitarfish	0/1	**2/2**	0/1		**1/1**		**1/1**	Herald 1960, Talent 1973, Barry 1983, King et al. 1986,
Sardinops sagax	Pacific sardine		**1/1**						King et al. 1986,
Scorpaenichthys marmoratus	cabezon	0/2	**4/4**	0/1				**1/1**	Nybakken et al. 1977, King et al. 1986, Yoklavich et al. 1991, Oxman 1995,
Sebastes atrovirens	kelp rockfish	0/1	**1/1**					0/1	Nybakken et al. 1977,
Sebastes auriculatus	brown rockfish	0/3	**5/5**	0/2				**1/1**	Nybakken et al. 1977, Barry 1983, King et al. 1986, Yoklavich et al. 1991, Oxman 1995,
Sebastes carnatus	gopher rockfish	0/1	**1/2**					**1/1**	Nybakken et al. 1977, Oxman 1995,
Sebastes flavidus	yellowtail rockfish	0/1	**1/2**			**1/1**		**1/1**	Nybakken et al. 1977, King et al. 1986, Oxman 1995,
Sebastes melanops	black rockfish	0/1	**2/2**					0/1	Nybakken et al. 1977, Oxman 1995,
Sebastes mystinus	blue rockfish	0/2	**2/2**	0/1				**1/1**	Nybakken et al. 1977, Yoklavich et al. 1991,
Sebastes paucispinis	bocaccio	0/2	**3/3**	0/1				**1/1**	Nybakken et al. 1977, Yoklavich et al. 1991, Oxman 1995,
Sebastes rastrelliger	grass rockfish	0/1	**3/3**					0/1	Nybakken et al. 1977, King et al. 1986, Oxman 1995,
Sebastes sp	rockfish	0/3	**4/4**	0/2				0/1	Nybakken et al. 1977, Barry 1983, Yoklavich et al. 1991, Oxman 1995,
Seriphus politus	queenfish	0/3	**5/5**	0/2				0/1	Nybakken et al. 1977, Barry 1983, King et al. 1986, Yoklavich et al. 1991, Oxman 1995,
Spirinchus starksi	night smelt	0/2	**2/2**	0/1				0/1	Nybakken et al. 1977, Yoklavich et al. 1991,
Symphurus atricauda	California tonguefish	0/3	**5/5**	0/2				0/1	Nybakken et al. 1977, Barry 1983, King et al. 1986, Yoklavich et al. 1991, Oxman 1995,
Syngnathus leptorhynchus	bay pipefish	**2/3**	**5/5**	0/2	**1/1**	0/1		0/1	Nybakken et al. 1977, Barry 1983, King et al. 1986, Yoklavich et al. 1991, Oxman 1995, Hall 2000
Trachurus symmetricus	jack mackerel	0/1	0/1			**1/1**		**1/1**	Nybakken et al. 1977, Cailliet et al. 1990,
Triakis semifaciata	leopard shark	**3/4**	**5/5**	**2/2**		**2/2**	**1/1**	**1/2**	Herald 1960, Ackerman 1971, Talent 1973, Nybakken et al. 1977, Barry 1983, King et al. 1986, Cailliet et al. 1990, Yoklavich et al. 1991, Oxman 1995,
Urolophus halleri	round stingray	**2/2**	**4/4**	0/1		**2/2**		**1/2**	Herald 1960, Talent 1973, Nybakken et al. 1977, King et al. 1986, Yoklavich et al. 1991, Oxman 1995, Hall 2000

TABLE 2. Recommended Three-Tiered Monitoring Program

The annual sampling schedule for the three-tiered program recommended for monitoring the fish assemblage in the greater Elkhorn Slough area. Recommendations include the sites to be sampled using different sampling methods and the months in which sampling should occur. Numbers in parentheses indicate whether a sampling method is included in the first, second, or third tier.

	January	February	March	April	May	June	July	August	September	Oct	Nov	Dec
Bridge	ichthyo-plankton (3)		otter trawl (1)					otter trawl (1)	ichthyo-plankton (3)			
Kirby Park	ichthyo-plankton (3)	small mesh gill net (2), minnow traps (2)	otter trawl (1)		small mesh gill net (2)		minnow traps (2)	otter trawl (1)	ichthyo-plankton (3)			
Bennett Slough			beach seine (1)					beach seine (1)				
ES NERR		small mesh gill net (2), minnow traps (2)	beach seine (1)		small mesh gill net (2)	large mesh gill net (2)	large mesh gill net (2), minnow traps (2)	beach seine (1)				
Rubis Creek			otter trawl (1)					otter trawl (1)				

TABLE 3. Spatial Distribution of Fish in the Greater Elkhorn Slough Area.

The fraction in each cell represents the "frequency of occurrence" of a species at a given site: the denominator is the number of studies that collected fish at a site; the numerator is the number of those studies in which at least one individual of a given species was collected. Four categories of "frequency of occurrence" are represented by shading: white = 0%; light gray = 1% - 35%; gray = 36% - 69%; and black = 70% - 100%.

Specific Names	Common Name	Bennett Slough	North Harbor/ Skipper's	Bridge	Dairy	Kirby Park	Hudson's Landing	Long Canyon	Rubis Creek	NERR/ South Slough	References
Acanthogobius flavimanus	yellowfin goby	3/3	0/1	2/4	1/4	2/6	1/2	1/2	3/4	2/3	Appiah 1977, Nybakken et al. 1977, Barry 1983, Small 1984, King et al. 1986, Schoenherr 1984, Yoklavich et al. 1991, Oxman 1995, Hall 2000, Brown (unpublished data)
Artedius harringtoni	scalyhead sculpin	0/1	0/1	1/1	1/1	0/1					Nybakken et al. 1977
Atherinops affinis	topsmelt	4/4	1/2	3/3	3/3	5/5	2/2	2/2	4/4	4/4	Ruagh 1976, Appiah 1977, Nybakken et al. 1977, Barry 1983, Small 1984, King et al. 1986, Cailliet et al. 1990, Yoklavich et al. 1991, Nerney et al. 1993, Hall 2000
Atherinopsis californiensis	jacksmelt	3/3	1/2	3/3	3/3	4/4	0/2	0/2	3/3	1/1	Ruagh 1976, Appiah 1977, Nybakken et al. 1977, Barry 1983, Cailliet et al. 1990, Yoklavich et al. 1991
Chilara taylori	spotted cusk-eel	0/1	0/1	2/2	1/2	0/2					Nybakken et al. 1977, Oxman 1995
Citharichthys stigmaeus	speckled sanddab	0/2	0/1	4/4	4/4	5/5	2/2	2/2	3/3	3/3	Nybakken et al. 1977, Barry 1983, Small 1984, King et al. 1986, Yoklavich et al. 1991, Nerney et al. 1993, Oxman 1995, Brown (unpublished data)
Clevelandia ios	arrow goby	3/3	0/1	2/3	1/3	1/4	2/2	2/2	3/3	3/4	Appiah 1977, Nybakken et al. 1977, Barry 1983, Small 1984, King et al. 1986, Yoklavich et al. 1991, Nerney et al. 1993, Oxman 1995
Clupea pallasii	Pacific herring	4/4	0/1	0/3	3/3	2/4	2/2	2/2	3/3	3/3	Appiah 1977, Nybakken et al. 1977, Barry 1983, Small 1984, King et al. 1986, Yoklavich et al. 1991, Nerney et al. 1993, Oxman 1995, Hall 2000
Coryphopterus nicholsi	blackeye goby	0/1	0/1	1/1	1/1	0/1					Nybakken et al. 1977
Cottus asper	prickly sculpin	3/3	0/1	0/2	0/2	0/2	0/1	0/1	0/1		Appiah 1977, Nybakken et al. 1977, Yoklavich et al. 1991
Cymatogaster aggregata	shiner surfperch	4/4	0/1	4/4	4/4	6/6	2/2	2/2	4/4	4/4	Appiah 1977, Nybakken et al. 1977, Barry 1983, Small 1984, King et al. 1986, Schoenherr 1984, Yoklavich et al. 1991, Nerney et al. 1993, Oxman 1995, Hall 2000, Brown (unpublished data)
Damalichthys vacca	pile surfperch	1/3	0/1	4/4	3/4	3/4	0/2	0/2	2/2		Nybakken et al. 1977, Barry 1983, Yoklavich et al. 1991, Oxman 1995, Hall 2000, Brown (unpublished data)
Dorosoma petenense	threadfin shad	0/2	0/1	0/2	0/2	2/2	2/2	0/2	2/2		Nybakken et al. 1977, Barry 1983, Yoklavich et al. 1991
Embiotoca jacksoni	black surfperch	3/3	0/1	4/4	4/4	3/5	0/2	2/2	2/2	1/1	Appiah 1977, Nybakken et al. 1977, Barry 1983, King et al. 1986, Yoklavich et al. 1991, Oxman 1995, Brown (unpublished data)
Engraulis mordax	Northern anchovy	4/4	0/1	2/3	2/3	4/4	2/2	2/2	3/3	2/2	Appiah 1977, Nybakken et al. 1977, Barry 1983, Small 1984, King et al. 1986, Yoklavich et al. 1991, Oxman 1995, Hall 2000
Eucyclogobius newberryi	tidewater goby	3/3	0/1	0/2	0/2	0/2	0/1	0/1	0/1		Appiah 1977, Nybakken et al. 1977, Yoklavich et al. 1991
Gasterosteus aculeatus	threespine stickleback	3/3	0/1	0/2	1/2	0/2	1/2	1/2	0/2	1/1	Appiah 1977, Nybakken et al. 1977, Barry 1983, Small 1984, Yoklavich et al. 1991
Gibbonsia sp.	kelpfish			1/1	1/1	0/1	0/1	0/1	1/1		Barry 1983, Oxman 1995
Gillichthys mirabilis	longjaw mudsucker					0/1	1/1	1/1	2/2	2/2	Barry 1983, Small 1984, King et al. 1986

TABLE 3. Spatial Distribution of Fish in the Greater Elkhorn Slough Area (con't).

Specific Names	Common Name	Bennett Slough	North Harbor/ Skipper's	Bridge	Dairy	Kirby Park	Hudson's Landing	Long Canyon	Rubis Creek	NERR/ South Slough	References
Gobiidae	Gobies	0/1		0/2	**1/2**	0/2	**2/2**	**2/2**	**2/2**		Barry 1983, Yoklavich et al. 1991, Brown (unpublished data)
Girella nigricans	opaleye	**1/1**									Hall 2000
Hexagrammos sp.	greenling	0/1	0/1	**2/2**	**1/2**	0/2					Nybakken et al. 1977, Oxman 1995
Hyperprosopon argenteum	walleye surfperch	**3/3**	0/1	**4/4**	**3/4**	**3/5**	**2/2**	0/2	**2/3**	**1/1**	Appiah 1977, Nybakken et al. 1977, Barry 1983, King et al. 1986, Yoklavich et al. 1991, Oxman 1995, Brown (unpublished data)
Hypomesus pretiosus	surf smelt	**3/3**	0/1	0/2	0/2	0/2	0/1	0/1			Appiah 1977, Nybakken et al. 1977, Yoklavich et al. 1991
Hypsoblennius gentilis	bay blenny					0/1			0/1	**2/2**	Small 1984, King et al. 1986
Hypsopsetta guttulata	diamond turbot	0/2	0/1	**1/4**	**2/4**	**5/6**	**2/2**	**2/2**	**4/4**	**2/2**	Nybakken et al. 1977, Barry 1983, King et al. 1986, Schoenherr 1984, Yoklavich et al. 1991, Oxman 1995, Brown (unpublished data)
Hypsurus caryi	rainbow surfperch	0/1	0/1	**2/2**	0/2	0/2					Nybakken et al. 1977, Oxman 1995
Lepidogobius lepidus	bay goby	**3/3**	0/1	**4/4**	**4/4**	**5/5**	0/2	**2/2**	0/3	**2/2**	Appiah 1977, Nybakken et al. 1977, Barry 1983, Small 1984, King et al. 1986, Yoklavich et al. 1991, Oxman 1995, Brown (unpublished data)
Lepidopsetta bilineata	rock sole	0/1	0/1	0/1	**1/1**	0/1					Nybakken et al. 1977
Leptocottus armatus	staghorn sculpin	**4/4**	0/1	**4/4**	**4/4**	**6/6**	**2/2**	**2/2**	**4/4**	**3/3**	Appiah 1977, Nybakken et al. 1977, Barry 1983, Small 1984, King et al. 1986, Schoenherr 1984, Yoklavich et al. 1991, Oxman 1995, Hall 2000, Brown (unpublished data)
Micrometrus minimus	dwarf Surfperch	0/2	0/1	**4/4**	**3/4**	**1/4**	0/2	0/2	**2/2**		Nybakken et al. 1977, Barry 1983, Yoklavich et al. 1991, Oxman 1995, Brown (unpublished data)
Morone saxatilis	striped bass	0/1		0/1	0/1	0/1	**2/2**	**1/2**	0/2		Barry 1983, Yoklavich et al. 1991
Mugil cephalus	striped mullet						**1/1**	0/1	0/1		Barry 1983
Mustelus californicus	gray smoothhound	**1/3**	0/1	0/2	0/2	**3/3**	**2/2**	0/2	**3/3**	**1/1**	Nybakken et al. 1977, Barry 1983, King et al. 1986, Yoklavich et al. 1991, Hall 2000
Mustelus henlei	brown smoothhound			0/1	**1/1**	**1/1**	0/1	0/1	**1/1**		Barry 1983, Oxman 1995
Myliobatis californica	bat ray	0/2	0/1	**3/4**	**3/4**	**5/5**	**2/2**	**2/2**	**3/3**	**1/1**	Nybakken et al. 1977, Barry 1983, King et al. 1986, Yoklavich et al. 1991, Oxman 1995, Brown (unpublished data)
Neoclinus uninotatus	onespot fringehead	0/2	0/1	**3/3**	0/3	0/3	0/1	0/1	0/1		Nybakken et al. 1977, Yoklavich et al. 1991, Oxman 1995
Ophiodon elongatus	lingcod	0/2	0/1	**4/4**	**4/4**	**1/4**	0/2	0/2	**2/2**		Nybakken et al. 1977, Barry 1983, Yoklavich et al. 1991, Oxman 1995, Brown (unpublished data)
Paralichthys californicus	California halibut	0/2	0/1	**4/4**	**2/4**	**6/6**	**2/2**	**2/2**	**4/4**	**4/4**	Nybakken et al. 1977, Barry 1983, Small 1984, King et al. 1986, Schoenherr 1984, Yoklavich et al. 1991, Nerney et al. 1993, Oxman 1995, Brown (unpublished data)
Peprilus simillimus	Pacific pompano	**1/1**									Appiah 1977
Phanerodon furcatus	white surfperch	**3/3**	0/1	**4/4**	**4/4**	**3/6**	0/2	**2/2**	**2/4**	**2/2**	Appiah 1977, Nybakken et al. 1977, Barry 1983, King et al. 1986, Yoklavich et al. 1991, Oxman 1995, Brown (unpublished data)

TABLE 3. Spatial Distribution of Fish in the Greater Elkhorn Slough Area (con't).

Specific Names	Common Name	Bennett Slough	North Harbor/ Skipper's	Bridge	Dairy	Kirby Park	Hudson's Landing	Long Canyon	Rubis Creek	NERR/ South Slough	References
Platichthys stellatus	starry flounder	**3/3**	0/1	**4/4**	**3/4**	**6/6**	**2/2**	**2/2**	**4/4**	**4/4**	Appiah 1977, Nybakken et al. 1977, Barry 1983, Small 1984, King et al. 1986, Schoenherr 1984, Yoklavich et al. 1991, Nerney et al. 1993, Oxman 1995, Brown (unpublished data)
Platyrhinoidis triseriata	thornback	**1/1**		0/2	**2/2**	**3/3**			0/1	0/1	King et al. 1986, Oxman 1995, Hall 2000, Brown (unpublished data)
Pleuronectes vetulus	English sole	0/2	0/1	**4/4**	**4/4**	**5/5**	**2/2**	0/2	**3/3**	**2/2**	Nybakken et al. 1977, Barry 1983, Small 1984, King et al. 1986, Yoklavich et al. 1991, Oxman 1995, Brown (unpublished data)
Pleuronichthys decurrens	curlfin turbot	0/2	0/1	**3/3**	**3/3**	0/3	0/1	0/1	0/1		Nybakken et al. 1977, Yoklavich et al. 1991, Oxman 1995
Porichthys notatus	plainfin midshipman	**4/4**	0/1	**3/4**	**4/4**	**5/5**	**2/2**	**1/2**	**3/3**	**1/1**	Appiah 1977, Nybakken et al. 1977, Barry 1983, King et al. 1986, Yoklavich et al. 1991, Oxman 1995, Hall 2000, Brown (unpublished data)
Rhacochilus toxotes	rubberlip surfperch	0/2	0/1	**3/3**	**2/3**	**1/3**	0/1	0/1	0/1		Nybakken et al. 1977, Yoklavich et al. 1991, Oxman 1995
Rhinobatos productus	shovelnose guitarfish			0/1	0/1	**2/2**	**1/1**	**1/1**	**2/2**	**1/1**	Barry 1983, King et al. 1986, Brown (unpublished data)
Sardinops sagax	Pacific sardine					0/1			0/1	**2/2**	Small 1984, King et al. 1986
Scorpaenichthys marmoratus	cabezon	0/2	0/1	**4/4**	**4/4**	**4/6**	0/1	0/1	**2/3**	**1/2**	Nybakken et al. 1977, Small 1984, King et al. 1986, Yoklavich et al. 1991, Oxman 1995, Brown (unpublished data)
Sebastes auriculatus	brown rockfish	0/2	0/1	**3/3**	**3/3**	**2/4**	0/2	0/2	**3/3**	**1/1**	Nybakken et al. 1977, Barry 1983, King et al. 1986, Yoklavich et al. 1991, Oxman 1995
Sebastes caurinus	copper rockfish	0/1	0/1	**1/1**	**1/1**	0/1					Nybakken et al. 1977
Sebastes melanops	black rockfish	0/1	0/1	0/2	**1/2**	**1/2**					Nybakken et al. 1977, Oxman 1995
Sebastes mystinus	blue rockfish	0/2	0/1	**2/2**	**2/2**	0/2	0/1	0/1	0/1		Nybakken et al. 1977, Yoklavich et al. 1991
Sebastes paucispinis	bocaccio	0/2	0/1	**2/3**	**2/3**	**1/3**	0/1	0/1	0/1		Nybakken et al. 1977, Yoklavich et al. 1991, Oxman 1995
Sebastes rastrelliger	grass rockfish	0/1	0/1	**2/2**	**2/2**	**3/3**			0/1	0/1	Nybakken et al. 1977, King et al. 1986, Oxman 1995
Sebastes sp	rockfish	0/2	0/1	**4/4**	**4/4**	**2/5**	0/2	0/2	**3/3**	**1/2**	Nybakken et al. 1977, Barry 1983, Small 1984, Schoenherr 1984, Yoklavich et al. 1991, Brown (unpublished data)
Seriphus politus	queenfish	0/2	0/1	**1/3**	0/3	**2/5**	**1/2**	**1/2**	**1/4**	**2/2**	Nybakken et al. 1977, Barry 1983, King et al. 1986, Schoenherr 1984, Yoklavich et al. 1991, Oxman 1995
Spirinchus starksi	night smelt	0/2	0/1	**2/2**	0/2	0/2	0/1	0/1	0/1		Nybakken et al. 1977, Yoklavich et al. 1991
Symphurus atricauda	California tonguefish	0/2	0/1	**3/4**	**1/4**	**3/5**	**2/2**	**2/2**	**3/3**	**2/2**	Nybakken et al. 1977, Barry 1983, Small 1984, King et al. 1986, Yoklavich et al. 1991, Oxman 1995, Brown (unpublished data)
Syngnathus leptorhynchus	bay pipefish	**4/4**	0/1	**4/4**	**4/4**	**2/5**	0/2	0/2	**3/3**	**2/2**	Appiah 1977, Nybakken et al. 1977, Barry 1983, Small 1984, King et al. 1986, Yoklavich et al. 1991, Oxman 1995, Hall 2000, Brown (unpublished data)
Triakis semifaciata	leopard shark	0/2	0/1	**2/4**	**4/4**	**4/5**	**2/2**	**2/2**	**3/3**	**1/1**	Nybakken et al. 1977, Barry 1983, King et al. 1986, Yoklavich et al. 1991, Oxman 1995, Brown (unpublished data)
Urolophus halleri	round stingray	**4/4**	0/1	**2/4**	**2/4**	**3/5**	0/1	0/1	0/2	**1/1**	Appiah 1977, Nybakken et al. 1977, King et al. 1986, Yoklavich et al. 1991, Oxman 1995, Hall 2000, Brown (unpublished data)

TABLE 4. Temporal Occurrence of Fish in the Greater Elkhorn Slough Area.

The fraction in each cell represents the '"frequency of occurrence" of a species in a given month: the denominator is the number of sampling events that were examined; the numerator is the number of those sampling events in which at least one individual of a given species was collected. Four categories of "frequency of occurrence" are represented by shading: white = 0%; light gray = 1% - 34%; gray = 35% - 69%; and black = 70% - 100%. This data includes all methods of collection and all locations in the greater Elkhorn Slough area.

Specific Names	Common Name	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	References
Acanthogobius flavimanus	yellowfin goby	0/9	0/11	**2/12**	0/11	**1/11**	0/11	0/8	**1/13**	**3/16**	0/9	**2/10**	0/9	Appiah 1977, Nybakken et al. 1977, Brown (unpublished data)
Artedius harringtoni	scalyhead sculpin	**1/8**	0/7	**2/8**	0/8	0/7	0/7	0/3	0/6	**1/8**	0/8	**1/7**	0/8	Nybakken et al. 1977,
Atherinops affinis	topsmelt	**4/19**	**7/18**	**9/19**	**7/19**	**6/18**	**10/18**	**6/13**	**7/16**	**6/14**	**8/19**	**8/20**	**7/21**	Ruagh 1976, Appiah 1977, Nybakken et al. 1977, Barry 1983, Cailliet et al. 1990, Monaco et al. 1990,
Atherinopsis californiensis	jacksmelt	**4/17**	**6/16**	**8/17**	**7/17**	**9/16**	**8/16**	**4/12**	**1/15**	**3/13**	**1/17**	**6/18**	**3/19**	Ruagh 1976, Appiah 1977, Nybakken et al. 1977, Cailliet et al. 1990, Monaco et al. 1990
Citharichthys stigmaeus	speckled sanddab	**4/8**	**6/10**	**5/11**	**5/10**	**5/10**	**5/10**	**4/7**	**7/12**	**5/15**	**4/8**	**4/9**	**5/8**	Nybakken et al. 1977, Brown (unpublished data)
Clevelandia ios	arrow goby	**2/12**	**1/11**	**2/12**	**6/12**	**3/11**	**3/11**	**2/6**	**3/9**	**5/11**	**5/12**	**2/11**	**3/12**	Appiah 1977, Nybakken et al. 1977, Barry 1983, Monaco et al. 1990,
Clupea pallasii	Pacific herring	**6/13**	**4/14**	**7/13**	**7/13**	**5/14**	**6/12**	**2/7**	**5/13**	**2/12**	**1/13**	**3/17**	**2/13**	Appiah 1977, Nybakken et al. 1977, Barry 1983, King et al. 1986, Monaco et al. 1990,
Coryphopterus nicholsiI	blackeye goby	0/8	0/7	0/8	0/8	0/7	**1/7**	0/3	0/6	0/8	0/8	**1/7**	0/8	Nybakken et al. 1977,
Cymatogaster aggregata	shiner surfperch	**12/16**	**10/20**	**15/19**	**12/18**	**17/20**	**15/18**	**13/14**	**18/25**	**21/25**	**17/19**	**17/22**	**7/16**	Appiah 1977, Nybakken et al. 1977, Antrim 1981, Barry 1983, King et al. 1986, Monaco et al. 1990, Brown (unpublished data)
Damalichthys vacca	pile s urfperch	**3/8**	**2/10**	**4/11**	**6/10**	**4/10**	**4/10**	**3/7**	**2/12**	**2/15**	**2/8**	**1/9**	**1/8**	Nybakken et al. 1977, Brown (unpublished data)
Dorosoma petenense	threadfin shad	0/8	0/7	0/8	0/8	0/7	0/7	0/3	0/6	0/8	0/8	**1/7**	**1/8**	Nybakken et al. 1977,
Embiotoca jacksoni	black surfperch	**9/14**	**10/16**	**10/17**	**9/16**	**12/16**	**11/16**	**8/12**	**13/20**	**15/23**	**15/17**	**11/15**	**11/14**	Appiah 1977, Nybakken et al. 1977, Antrim 1981, Barry 1983, Brown (unpublished data)
Engraulis mordax	Northern anchovy	**2/13**	**2/14**	**3/13**	**5/13**	**7/14**	**6/12**	**4/7**	**7/13**	**5/12**	**2/13**	**6/17**	**1/13**	Appiah 1977, Nybakken et al. 1977, Barry 1983, King et al. 1986, Monaco et al. 1990,
Eucyclogobius newberryi	tidewater goby	0/9	0/8	0/9	0/9	0/8	**2/8**	0/4	0/7	0/9	0/9	0/8	0/9	Appiah 1977, Nybakken et al. 1977,
Gasterosteus aculeatus	threespine stickleback	**1/10**	0/9	**1/10**	**4/10**	**3/9**	**3/9**	**1/5**	**3/8**	**1/10**	**2/10**	0/9	0/10	Appiah 1977, Nybakken et al. 1977, Monaco et al. 1990,
Genyonemus lineatus	white croaker	**1/1**	**1/1**	**1/1**	**1/1**	0/1	0/1	0/1	0/1	**1/1**	**1/1**	**1/1**	**1/1**	Monaco et al. 1990,
Hyperprosopon argenteum	walleye surfperch	**2/9**	**2/11**	**3/12**	**2/11**	**4/11**	**5/11**	**1/8**	**2/13**	**4/16**	**1/9**	**2/10**	**1/9**	Appiah 1977, Nybakken et al. 1977, Brown (unpublished data)
Hypomesus pretiosus	surf smelt	0/9	0/8	0/9	**2/9**	**2/8**	**2/8**	0/4	0/7	0/9	0/9	0/8	0/9	Appiah 1977, Nybakken et al. 1977,
Hypsopsetta guttulata	diamond turbot	**2/10**	**4/14**	**1/13**	**4/12**	**4/14**	**1/12**	**1/9**	**5/17**	**2/17**	**3/10**	**8/16**	**1/10**	Nybakken et al. 1977, King et al. 1986, Monaco et al. 1990, Brown (unpublished data)
Lepidogobius lepidus	bay goby	0/9	0/11	0/12	**4/11**	**1/11**	**4/11**	**2/8**	**3/13**	**3/16**	0/9	0/10	0/9	Appiah 1977, Nybakken et al. 1977, Brown (unpublished data)
Leptocottus armatus	staghorn sculpin	**8/13**	**13/17**	**12/16**	**11/15**	**15/17**	**12/15**	**10/11**	**13/19**	**16/19**	**9/13**	**10/19**	**8/13**	Appiah 1977, Nybakken et al. 1977, Barry 1983, King et al. 1986, Monaco et al. 1990, Brown (unpublished data)

TABLE 4. Temporal Occurrence of Fish in the Greater Elkhorn Slough Area (con't).

Specific Names	Common Name	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	References
Micrometrus minimus	dwarf surfperch	0/8	**1/10**	**1/11**	0/10	0/10	**4/11**	**1/7**	**3/12**	**2/15**	**2/8**	0/9	0/8	Nybakken et al. 1977, Brown (unpublished data)
Mustelus californicus	gray smoothhound	0/9	0/1	**1/9**	0/9	0/10	0/8	**1/4**	0/10	0/9	0/9	0/13	0/9	Nybakken et al. 1977, King et al. 1986,
Myliobatis californica	bat ray	**3/11**	**3/15**	**3/14**	**7/13**	**6/15**	**6/13**	**4/9**	**7/17**	**4/17**	**3/11**	**2/17**	0/11	Nybakken et al. 1977, Barry 1983, King et al. 1986, Brown (unpublished data)
Neoclinus uninotatus	onespot fringehead	0/8	0/7	0/8	0/8	0/7	**1/7**	0/3	**1/6**	**1/8**	0/8	**1/7**	0/8	Nybakken et al. 1977,
Ophiodon elongatus	lingcod	0/8	**1/10**	**1/11**	**3/10**	**3/10**	**1/10**	0/7	**1/12**	**1/15**	**1/8**	**1/9**	0/8	Nybakken et al. 1977, Brown (unpublished data)
Paralichthys californicus	California halibut	**4/12**	**4/16**	**4/15**	**5/14**	**6/16**	**5/14**	**5/10**	**9/18**	**9/18**	**3/12**	**6/18**	**2/12**	Nybakken et al. 1977, Barry 1983, King et al. 1986, Monaco et al. 1990, Brown (unpublished data)
Phanerodon furcatus	white surfperch	**7/12**	**5/14**	**8/15**	**8/14**	**9/14**	**9/14**	**8/11**	**10/19**	**15/22**	**12/15**	**11/13**	**8/12**	Appiah 1977, Nybakken et al. 1977, Antrim 1981, Brown (unpublished data)
Platichthys stellatus	starry flounder	**12/13**	**14/17**	**12/16**	**12/15**	**12/17**	**9/15**	**8/11**	**11/19**	**13/19**	**10/13**	**17/19**	**12/13**	Appiah 1977, Nybakken et al. 1977, Barry 1983, King et al. 1986, Monaco et al. 1990, Brown (unpublished data)
Pleuronectes vetulus	English sole	0/10	**1/14**	**6/13**	**8/12**	**12/14**	**9/12**	**6/9**	**5/16**	**6/17**	**3/10**	**3/16**	0/10	Nybakken et al. 1977, King et al. 1986, Monaco et al. 1990, Brown (unpublished data)
Pleuronichthys decurrens	curlfin turbot	**1/8**	0/7	0/8	0/8	**1/7**	0/7	0/3	0/6	**1/8**	**1/8**	**2/7**	**1/8**	Nybakken et al. 1977,
Porichthys notatus	plainfin midshipman	**1/9**	**2/11**	0/12	**4/11**	**2/11**	**2/11**	0/8	**3/13**	**9/16**	**4/9**	**2/10**	**1/9**	Appiah 1977, Nybakken et al. 1977, Brown (unpublished data)
Rhacochilus toxotes	rubberlip surfperch	0/8	0/7	**1/8**	**1/8**	**1/7**	**2/7**	**1/3**	**1/6**	0/8	**2/8**	0/7	**1/8**	Nybakken et al. 1977,
Scorpaenichthys marmoratus	cabezon	**2/8**	**5/10**	**1/11**	**3/10**	**2/10**	**3/10**	**3/7**	**1/12**	**2/15**	**4/8**	**3/9**	**3/8**	Nybakken et al. 1977, Brown (unpublished data)
Sebastes auriculatus	brown rockfish	**1/8**	**1/7**	**1/8**	0/8	**1/7**	**2/7**	**2/3**	**2/6**	**3/8**	**2/8**	**3/7**	0/8	Nybakken et al. 1977,
Sebastes caurinus	copper rockfish	0/8	0/7	0/8	0/8	0/7	**1/7**	0/3	0/6	0/8	0/8	**1/7**	0/8	Nybakken et al. 1977,
Sebastes mystinus	blue rockfish	**1/8**	**1/7**	0/8	0/8	0/7	**2/7**	0/3	**2/6**	**1/8**	**3/8**	**2/7**	0/8	Nybakken et al. 1977,
Sebastes paucispinis	bocaccio	0/8	0/7	0/8	0/8	0/7	0/7	**2/3**	**2/6**	0/8	0/8	0/7	0/8	Nybakken et al. 1977,
Sebastes rastrelliger	grass rockfish	0/8	0/7	**1/8**	**1/8**	0/7	**2/7**	0/3	0/6	0/8	**1/8**	0/7	0/8	Nybakken et al. 1977,
Sebastes sp.	rockfish	0/8	0/10	0/11	**2/10**	**2/10**	**3/10**	**2/7**	**1/12**	0/15	**1/8**	**2/9**	0/8	Nybakken et al. 1977, Brown (unpublished data)
Seriphus politus	queenfish	0/8	0/7	0/8	0/8	0/7	0/7	0/3	0/6	0/8	**1/8**	**1/7**	0/8	Nybakken et al. 1977,
Symphurus atricauda	California tonguefish	0/8	0/10	0/11	0/10	0/10	**1/10**	0/7	**1/12**	**1/15**	0/8	0/9	0/8	Nybakken et al. 1977, Brown (unpublished data)
Syngnathus leptorhynchus	bay pipefish	**1/9**	**3/11**	**5/12**	**7/11**	0/11	**3/11**	**1/8**	**2/13**	**4/16**	**3/9**	**3/10**	**1/9**	Appiah 1977, Nybakken et al. 1977, Brown (unpublished data)
Triakis semifaciata	leopard shark	**2/12**	**3/16**	**1/15**	**5/14**	**6/16**	**4/14**	**3/10**	**4/18**	**4/18**	**5/12**	**6/18**	**1/12**	Nybakken et al. 1977, Barry 1983, King et al. 1986, Monaco et al. 1990, Brown (unpublished data)
Urolophus halleri	round stingray	**1/9**	**3/11**	0/12	0/11	0/11	0/11	**1/8**	**1/13**	**1/16**	**3/9**	**4/10**	**2/9**	Appiah 1977, Nybakken et al. 1977, Brown (unpublished data)

TABLE 5. Spatial Distribution of Ichthyoplankton in the Greater Elkhorn Slough Area.

The fraction in each cell represents the "frequency of occurrence" of a species at a given site: the denominator is the number of sampling events that were examined; the numerator is the number of those sampling events in which at least one individual of a given species was collected. Four categories of "frequency of occurrence" are represented by shading: white = 0%; light gray = 1% - 34%; gray = 35% - 69%; and black = 70% - 100%.

Specific Names	Common Name	Harbor	Bridge	Dairies	Red House	Kirby Park	References
Ammodytes hexapterus	pacific sandlance	**2/16**	**1/27**	**1/27**	**1/19**	**1/27**	Nybakken et al. 1977, Tenera 2000
Atherinidae	silversides	**4/16**	**2/27**	**6/27**	**4/19**	**3/27**	Nybakken et al. 1977, Tenera 2000
Bathylagus ochotensis	blacksmelt	**1/16**	**1/27**	0/27	0/19	0/27	Nybakken et al. 1977, Tenera 2000
Blenniidae	blennies	**2/5**	**4/8**	**5/8**	n/a	**5/8**	Tenera 2000
Cebidichthys violaceus	monkeyface eel	0/16	**2/27**	0/27	0/19	0/27	Nybakken et al. 1977, Tenera 2000
Citharichthys sp.	sanddabs	**2/16**	**1/27**	**1/27**	0/19	0/27	Nybakken et al. 1977, Tenera 2000
Clevlandia ios	arrow goby	**6/11**	**10/19**	**9/19**	**15/19**	**16/19**	Nybakken et al. 1977
Clinidae	clinids	0/5	0/8	**1/8**	n/a	0/8	Tenera 2000
Clupea pallasii	Pacific herring	**3/16**	**3/27**	**4/27**	**4/19**	**9/27**	Nybakken et al. 1977, Tenera 2000
Coryphopterus nicholsii	blackeye goby	**1/16**	**2/27**	**5/27**	0/19	**2/27**	Nybakken et al. 1977, Tenera 2000
Cottidae	sculpins	**2/5**	**3/8**	**3/8**	n/a	**1/8**	Tenera 2000
Engraulis mordax	Northern anchovy	**8/16**	**10/27**	**12/27**	**10/19**	**16/27**	Nybakken et al. 1977, Tenera 2000
Gillichthys mirabilis	longjawed mudsucker	**8/16**	**10/27**	**12/27**	**15/19**	**25/27**	Nybakken et al. 1977, Tenera 2000
Gobiidae	gobies	**5/5**	**7/8**	**8/8**	n/a	**8/8**	Tenera 2000
Hexagrammidae	greenlings	0/5	0/8	0/8	n/a	**1/8**	Tenera 2000
Lepidogobius lepidus	bay goby	**5/5**	**6/8**	**7/8**	n/a	**3/8**	Tenera 2000
Leptocottus armatus	staghorn sculpin	**8/16**	**10/27**	**8/27**	**7/19**	**7/27**	Nybakken et al. 1977, Tenera 2000
Neoclinus uninotatus	onespot fringehead	**1/11**	0/19	**6/19**	**7/19**	**2/19**	Nybakken et al. 1977
Osmeridae	smelts	**8/16**	**10/27**	**3/27**	**1/19**	0/27	Nybakken et al. 1977, Tenera 2000
Oxyjulis californica	seniorita	0/11	**1/19**	0/19	0/19	0/19	Nybakken et al. 1977
Paralichthys californicus	California halibut	**1/11**	0/19	0/19	0/19	0/19	Nybakken et al. 1977
Pleuronectidae	flounders	**2/16**	**2/27**	**1/27**	0/19	**1/27**	Nybakken et al. 1977, Tenera 2000
Psettichthys melanostictus	sand sole	0/16	0/27	**2/27**	**1/19**	0/27	Nybakken et al. 1977, Tenera 2000
Sciaenidae	croakers	**8/16**	**6/27**	**6/27**	**2/19**	**1/27**	Nybakken et al. 1977, Tenera 2000
Sebastes sps.	rockfish	**3/16**	**3/27**	**5/27**	0/19	**1/27**	Nybakken et al. 1977, Tenera 2000
Sebastolobus sp.	thornyheads	**1/5**	**1/8**	0/8	n/a	0/8	Tenera 2000
Stenobrachius leucopsarus	northern lampfish	**3/16**	**2/27**	**1/27**	0/19	0/27	Nybakken et al. 1977, Tenera 2000
Syngnathus leptorhynchus	bay pipefish	0/16	**2/27**	0/27	0/19	**1/27**	Nybakken et al. 1977, Tenera 2000
Tarletonbeania crenularis	blue lanternfish	**1/5**	**1/8**	0/8	n/a	0/8	Tenera 2000

TABLE 6. Temporal Occurrence of Ichthyoplankton in Elkhorn Slough.

The fraction in each cell represents the "'frequency of occurrence" of a species in a given month: the denominator is the number of sampling events that were examined; the numerator is the number of those sampling events in which at least one individual of a given species was collected. Four categories of "frequency of occurrence" are represented by shading: white = 0%; light gray = 1% - 34%; gray = 35% - 69%; and black = 70% - 100%. This data includes all methods of collection and all locations in Elkhorn Slough. N/A = months that were not sampled.

Specific Names	Common Name	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	References
Ammodytes hexapterus	pacific sandlance	1/14	4/9	1/10	0/10	0/4	0/12	0/7	0/7	0/13	0/13	0/13	0/4	Nybakken et al. 1977, Tenera 2000
Atherinidae	silversides	1/14	3/9	6/10	1/10	0/4	4/12	1/7	0/7	0/13	2/13	0/13	1/4	Nybakken et al. 1977, Tenera 2000
Bathylagus ochotensis	popeye blacksmelt	0/14	0/9	1/10	0/10	0/4	0/12	1/7	0/7	0/13	0/13	0/13	0/4	Nybakken et al. 1977, Tenera 2000
Blennidae	blennies	0/4	1/4	n/a	n/a	n/a	3/3	3/3	2/3	2/4	4/4	1/4	n/a	Tenera 2000
Cebidichthys violaceus	monkeyface eel	0/14	1/9	0/10	0/10	0/4	1/12	0/7	0/7	0/13	0/13	0/13	0/4	Nybakken et al. 1977, Tenera 2000
Citharichthys stigmaeus	speckled sanddab	0/14	3/9	1/10	0/10	0/4	0/12	0/7	0/7	0/13	0/13	0/13	0/4	Nybakken et al. 1977, Tenera 2000
Clevelandia ios	arrow goby	5/10	4/5	8/10	7/10	2/4	5/9	3/4	4/4	7/9	6/9	2/9	3/4	Nybakken et al. 1977
Clinidae	clinids	3/14	0/9	1/10	0/10	0/4	0/12	1/7	1/7	1/13	0/13	0/13	1/4	Nybakken et al. 1977, Tenera 2000
Clupea pallasii	Pacific herring	6/14	6/9	4/10	4/10	1/4	1/12	1/7	0/7	0/13	0/13	0/13	0/4	Nybakken et al. 1977, Tenera 2000
Coryphopterus nicholsiI	blackeye goby	0/14	2/9	0/10	0/10	0/4	2/12	1/7	1/7	2/13	2/13	1/13	0/4	Nybakken et al. 1977, Tenera 2000
Cottidae	sculpins	1/4	2/4	n/a	n/a	n/a	1/3	0/3	0/3	0/4	1/4	1/4	n/a	Tenera 2000
Engraulis mordax	Northern anchovy	9/14	2/9	7/10	4/10	1/4	3/12	2/7	3/7	8/13	8/13	7/13	3/4	Nybakken et al. 1977, Tenera 2000
Gillichthys mirabilis	longjawed mudsucker	7/14	6/9	4/10	6/10	1/4	10/12	5/7	6/7	8/13	7/13	8/13	2/4	Nybakken et al. 1977, Tenera 2000
Gobiidae	gobies	4/14	5/9	1/10	1/10	0/4	3/12	3/7	3/7	3/13	5/13	4/13	0/4	Nybakken et al. 1977, Tenera 2000
Hypomesus pretiosus	surf smelt	3/10	1/5	2/10	1/10	0/4	2/9	0/4	0/4	0/9	0/9	0/9	2/4	Nybakken et al. 1977
Lepidogobius lepidus	bay goby	4/4	4/4	n/a	n/a	n/a	2/3	2/3	1/3	2/4	3/4	4/4	n/a	Tenera 2000
Leptocottus armatus	staghorn sculpin	11/14	8/9	5/10	1/10	0/4	1/12	0/7	0/7	2/13	4/13	4/13	3/4	Nybakken et al. 1977, Tenera 2000
Neoclinus uninotatus	onespot fringehead	0/10	0/5	0/10	2/10	1/4	2/9	1/4	2/4	3/9	2/9	1/9	2/4	Nybakken et al. 1977
Osmeridae	smelts	4/14	5/9	6/10	2/10	0/4	2/12	0/7	0/7	2/13	1/13	0/13	0/4	Nybakken et al. 1977, Tenera 2000
Paralichthys californicus	California halibut	0/10	0/5	0/10	0/10	0/4	0/9	0/4	0/4	1/9	0/9	0/9	0/4	Nybakken et al. 1977
Pleuronectidae	flounders	2/14	3/9	0/10	0/10	0/4	0/12	0/7	0/7	1/13	0/13	0/13	0/4	Nybakken et al. 1977, Tenera 2000
Psettichthys melanostictus	sand sole	0/14	0/9	0/10	0/10	0/4	2/12	0/7	0/7	0/13	0/13	1/13	0/4	Nybakken et al. 1977, Tenera 2000
Sciaenid	croakers	5/14	4/9	4/10	0/10	0/4	0/12	0/7	0/7	3/13	2/13	3/13	1/4	Nybakken et al. 1977, Tenera 2000
Sebastes sp	rockfish	4/14	5/9	0/10	0/10	0/4	0/12	0/7	0/7	1/13	0/13	1/13	1/4	Nybakken et al. 1977, Tenera 2000
Sebastolobus sp.	thornyheads	0/4	2/4	n/a	n/a	n/a	0/3	0/3	0/3	0/4	0/4	0/4	n/a	Tenera 2000
Stenobrachius leucopsarus	northern lampfish	2/14	4/9	0/10	0/10	0/4	0/12	0/7	0/7	0/13	0/13	0/13	0/4	Nybakken et al. 1977, Tenera 2000
Syngnathus leptorhynchus	bay pipefish	0/14	0/9	0/10	0/10	0/4	0/12	0/7	1/7	0/13	0/13	2/13	0/4	Nybakken et al. 1977, Tenera 2000

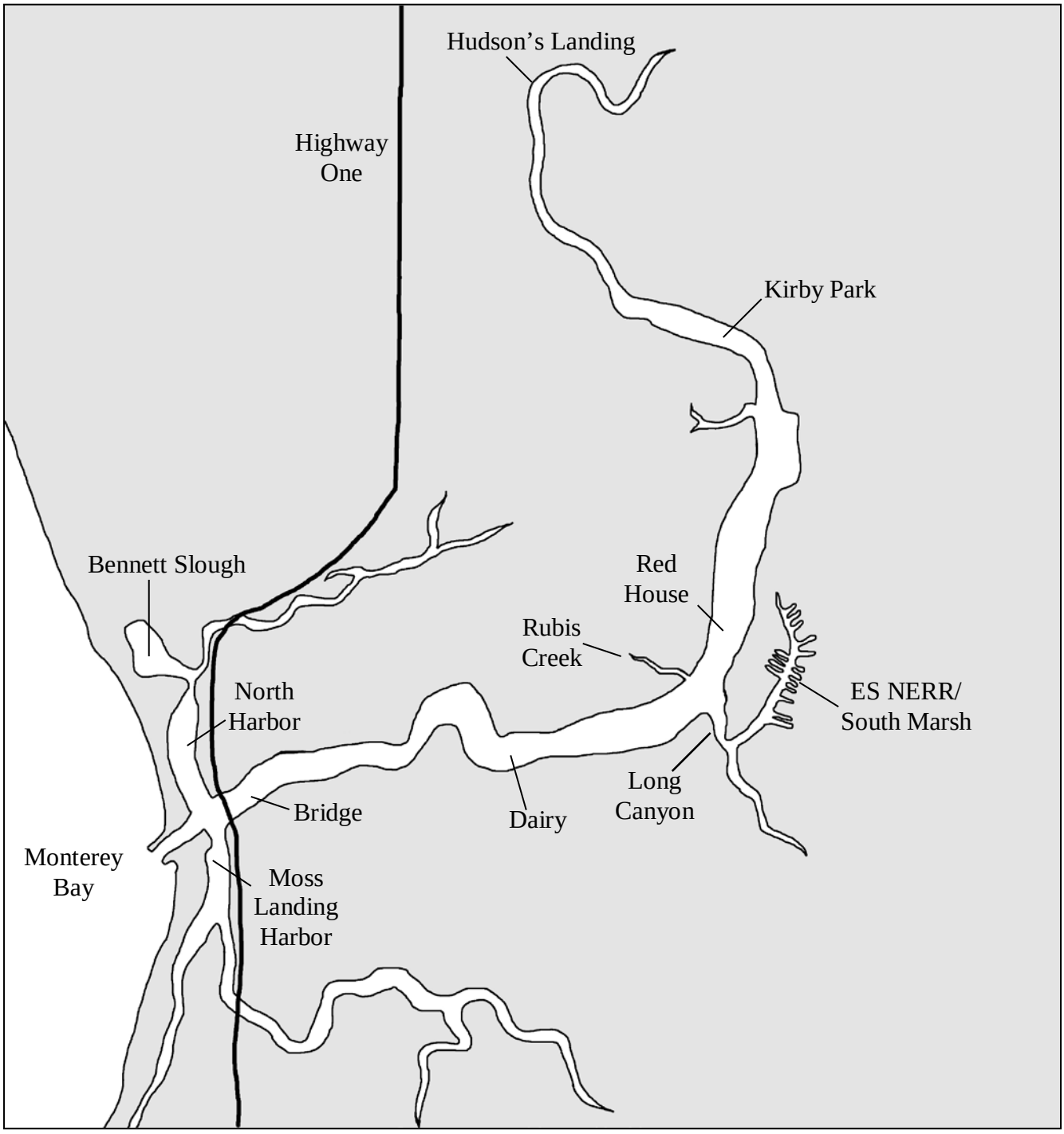

Figure 1. Sampling sites in the greater Elkhorn Slough area. Elkhorn Slough is adjacent to the Monterey Bay on the central California coast.

APPENDIX 1: A Description of Nets Previously Used to Collect Fish in Elkhorn Slough.

Otter Trawl

Headropes	Mesh Size (inches)			Bridles	Speed	References
(feet)	Body	Codend	Codend Liner	(feet)	(knots)	
16	1.5	n/a	0.5	n/a	n/a	Ruagh 1976
16	1.5	1.25	0.5	n/a	3.0-4.0	Nybakken et al. 1977
16	1.5	n/a	0.5	n/a	n/a	Antrim 1981
16	1.5	1	0.5	60	1.5-2.5	Barry 1983
16	1.5	1	0.5	53	n/a	Nerney et al 1983
16	1.5	n/a	0.5	25	1.5-2.0	Schoenherr 1984
10	0.38	0.38	0.25	15	1.5-2.0	Small 1984
10	0.75	n/a	0.25	n/a	1.5-2.0	King 1986
16	1.5	n/a	0.5	n/a	1.5-2.0	King 1986
16	1.5	n/a	0.5	n/a	3.0-4.0	Yoklavich et al. 1991
16	n/a	n/a	n/a	n/a	3.0-4.0	Oxman 1995
16	1.5	n/a	0.5	n/a	1.5-3.0	Lindquist 1998

Ichthyoplankton Nets

Diameter	Length	Mesh Size	Depth	Speed	References
(m)	(m)	(micron)	(m)	(knots)	
0.425	2.2	405	0-1	n/a	Nybakken et al. 1977/Yoklavich et al. 1992
0.71	n/a	335	bottom-surface	n/a	Tenera 2000
0.71	n/a	335	surface	n/a	Tenera 2000

Beach Seines

Length	Height	Mesh Size (inches)		References
(feet)	(feet)	Body	Purse	
60	5	0.75	0.5	Ruagh 1976
260	n/a	1	0.5	Ruagh 1976
50	~4.5	0.75	0.25	Appiah 1977
260	n/a	1	0.5	Nybakken et al. 1977
100	n/a	0.5	0.25	Nybakken et al. 1977
n/a	n/a	0.25	0.13	Barry 1983
15	4	0.25	n/a	Small 1983
50	n/a	0.5	0.25	Yoklavich et al. 1991
15	n/a	small	n/a	Nerney et al. 1993

Gill Nets

Length	Height	Mesh Size	Set Duration	References
(feet)	(feet)	(inches)	(hours)	
300	n/a	4,6,9	overnight	Talent 1973
100	6.66	0.5,1,2	4	Ruagh 1976
100	6.66	0.5,1,2	n/a	Appiah 1977
100	6.66	0.5,1,2	n/a	Nybakken et al. 1977
100	n/a	6,9	8-24	Martin 1982
22	6	1	1.25	Small 1983
33.3	5	0.5-2	n/a	Cailliet et al. 1990
23	6.66	1.63	12	Hall 2000
30	7.3	4	12	Hall 2000