FRI-UW-8014
August 1980

FISHERIES RESEARCH INSTITUTE
College of Fisheries
University of Washington
Seattle, Washington 98195

SURVEY OF RESIDENT MARINE FISHES AT TERMINALS 91 AND 37 (ELLIOTT BAY, SEATTLE, WASHINGTON)

by

Bruce S. Miller

FINAL REPORT

April-July 1980

to

Port of Seattle
P.O. Box 1209
Seattle, Washington 98111
Contract No. P-03035

Approved

Submitted August 27, 1980

O. A. Mathisen
Acting for the Director

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INTRODUCTION

The Port of Seattle is considering a number of significant construction alterations to the Terminal 91 area (Piers 90 and 91). A number of these alterations require filling or structural additions to marine waters around Piers 90 and 91 that are presently open. The primary purpose of this study was to assess the kinds and abundance of resident marine fishes at Terminal 91 and to evaluate the impact of the proposed construction alterations on resident marine fishes. In addition, Terminal 37 was surveyed as a similar post-construction site to compare with Terminal 91.

I would like to acknowledge a number of people who helped me in this project. Wayne Palsson was the lead diver for the diving studies and was assisted by Lynde McGill, Jeff Lauffle, and Dave Urquhart; Dale Griggs skippered the research vessel MALKA and was assisted by Gary Walters; the trawling studies were carried out by the 1980 "Ecology of Marine Fishes" graduate students--Jack Word, Dan Grosse, Paula Cullenberg, Bernie Megrey, Cleve Steward, Greg Ruggerone, Robert Walker, Gary Glodek, Ed Cohen, Bob Crittenden, and Scott Becker; John Dohrman and Bob Wells provided reference materials and answered all questions, and Bob ran the dive boat for us; Marie Miller did most of the typing of the report; I sincerely thank all of these people.

METHODS AND MATERIALS

Trawling

Trawling for fishes consisted of a 24-hr sampling series during May 2 and 3, 1980 at Terminals 37 and 91. One station (A) was located at Terminal 37 and four stations (B, C, D, E) were located at Terminal 91 (Fig. 1). The original sampling plan called for at least one tow at each station during the following time periods: afternoon (1430-1700), dusk (2030-2300), night (0100-0300), and dawn (0500-0730). However, at some stations trawling proved to be very difficult and hazardous (especially at night) due to litter (cables, scrap metal, pieces of concrete) which resulted in breaking off our trawl about a dozen times, and eventually in the entire loss of a trawl. Consequently, the sampling finally accomplished was as follows:

	Time			
Station	Afternoon	Dusk	Night	Dawn
Terminal 37 A	++(2 tows)	+	0	+
Terminal 91 B	+	+	0	+
Terminal C	+	+	+	+
Terminal D	+	+	+	+
Terminal E	+	0	0	0

Trawls were made with a 7.6 m (25 ft) otter trawl ("shrimp trawl," "try net") with 6.35 mm (1/4 inch) mesh in the cod end; except for the smaller cod end mesh, this net is nearly identical to the Southern California Coastal Water Research Project standardized trawl from which it was copied and is identical to the trawl presently being used by the National Marine Fisheries Service (Dr. Bruce McCain) in Puget Sound as part of the Marine Ecosystem Analysis program directed by the National Oceanic and Atmospheric Administration. Towing speed of the trawl was about 77 m/min (2.5 knots) and each tow lasted for about 5 min; however, the skipper paid particular attention to trying to make the tows cover the same distance (i.e., 385 m) by utilizing markers (pilings, etc.) to mark the beginning and end of each tow.

Fish brought aboard in the trawl were separated by species, weighed by species, and then individuals of a species counted and measured (total length). Individuals of a fish species selected for stomach analysis were preserved by injecting the coelomic cavity with 10% formalin and then storing the entire fish in plastic bags with a small amount of formalin, and then kept cool until stomachs could be removed and the contents identified.

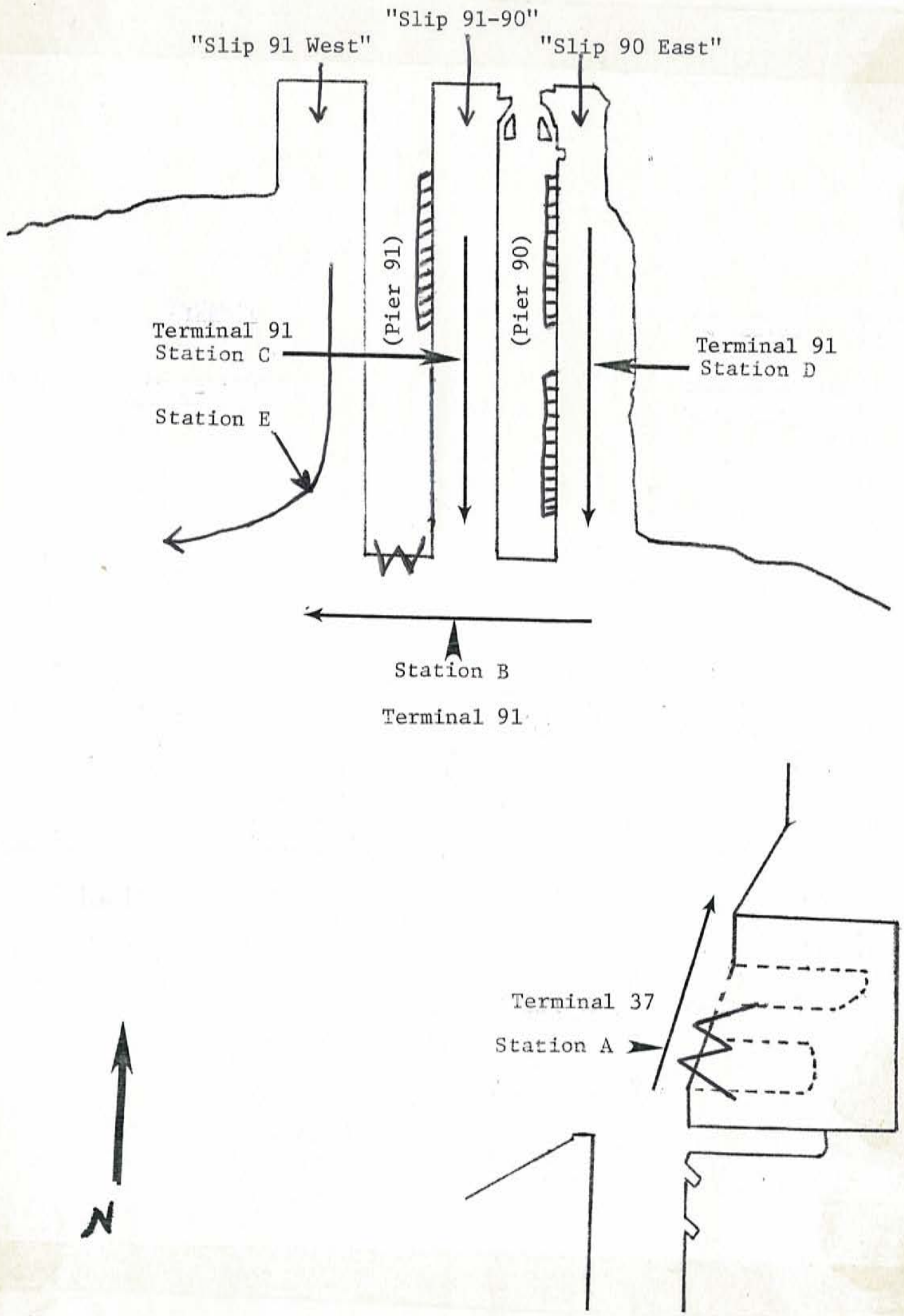

Figure 1. Location of trawls (⟶) and diving stations (▧ = straight line transects, and W = zig-zag transects).

Diving

Four SCUBA surveys were made at the study sites (Fig. 1), one each on 19 June, and 3, 11, and 18 July 1980. All dives were made in the late morning (ca 11 a.m.).

The survey on 19 June was made west of Pier 91, partially in order to recover the trawl lost in the area, but also to observe and record the fish in the search area.

The remaining three surveys were specifically designed to census the fish found among the pilings and riprap associated with Terminals 91 and 37 and as such the dives were made in, on, or around the pilings and riprap.

The survey of 3 July consisted of one straight line transect series landward and on the east side of Pier 91, one straight line transect series seaward and on the west side of Pier 90, and one straight line transect series landward and on the east side of Pier 90. The survey of 11 July consisted of one straight line transect series seaward and on the east side of Pier 90 and a zigzag transect off the end (seaward) of Pier 91. On 18 July a zigzag transect was made off Terminal 37.

Straight line transect series (Fig. 1) were made under the docks among the pilings. The sampling plan was to make both a landward and seaward transect series for Slip 91-90 and Slip 90 east. A transect series was made by swimming three straight line transects which were between the pilings and parallel to the dock: one transect was shallow (ca 3 m water depth) next to the center fill riprap--and two transects were near the outside pilings (ca 9 m water depth) where one transect was made between the pilings near the surface and one transect was made between the pilings on the bottom. At the beginning of each transect an underwater and horizontal visibility measurement at the transect depth was made by the divers recording the distance that the white recording slate (20 cm x 30 cm) disappeared from view. The length of the transect was measured by noting the starting and ending pilings and measuring the distance between these pilings. In order to minimize fish disturbance by divers swimming along one transect (e.g., the surface deep transect), the transects in a series were not overlapping in location--i.e., the following transect was begun where the previous one left off. During the straight line transect surveys fish species were identified, life history stage was noted (juvenile or adult), and the number of individuals was counted.

Zigzag transects (Fig. 1) were made off the end of Pier 91 and off Terminal 37 among the pilings and/or riprap. Visibility measurements and recording of fishes were done in the same manner as for straight line transects except depth was also recorded for each fish sighting. Zigzag transects started at the waterline (i.e., 0 depth), angled down to the end of the riprap (ca 17 m maximum water depth), angled back up to the waterline and then repeated this sequence. Markers were left at the waterline points and at the maximum depth points (which were anchored and released to the surface); after the zigzag transect was completed, the distances were measured between the buoys at the surface.

Data Analysis

Diversity

Species diversity was indicated by adding up the total number of species collected at Terminal 91 and at Terminal 37, and by calculating for the trawl data Shannon's index of diversity (Zar 1974):

$$H = \sum_{i=1}^{s} (n_i/N) \ln (n_i/N)$$

where n_i = number of individuals caught in species i,
N = total number of individuals caught, and
s = total number of species.

Recurrent Group Analysis

A calculation developed by Fager (1957) and Fager and Longhurst (1968) and for grouping together species having an affinity for each other was done for the trawl data at Terminals 91 and 37. An index of affinity (IA) is calculated for every possible species pair under consideration by the following formula:

$$IA = \frac{C}{\sqrt{AB}} - \frac{1}{2\sqrt{B}}$$

where A = number of occurrences of species A,
B = number of occurrences of species B, and
C = number of AB occurrences.

An assemblage was constructed from species pairs with an IA > .5.

Abundance

Calculations for number of fish per 100 m^2 of bottom were made for trawl-caught fish by dividing the area (m^2) covered by the trawl (i.e., length of bottom covered x trawl mouth opening) into 2 x number of fish caught during the trawl and multiplied by 100. The reason that the number of fish caught in the trawl was doubled is that, based on previous studies (Riley and Corlett 1965; Edwards and Steele 1968; Walton 1979), the assumption was made that the trawl is only 50% efficient at catching the fish (primarily flatfish) in its path.

In presenting the trawl-caught fish data by sampling site, the maximum abundance is presented--i.e., the data for each species from the trawl sample that caught the most individuals of that species. This is done out of recognition that the different species have different trawl vulnerability at different times of the day (e.g., some flatfish are known to be passed over by a trawl during certain periods because they are buried in the bottom sediment) and that species may be utilizing (e.g., foraging) an area only at certain times of the day. By using the maximum abundance from the 24 hr trawl samples it is believed that a more realistic evaluation of the importance of an area to a fish species will be made.

Abundance values for fish observed while diving were also calculated in terms of fish per 100 m^2 of area. These calculations were made by using the data obtained (Appendix 1) on the length of the transect and the width of the transect (value used was one-half of the visibility measurement) to give the total area covered by the transect (in m^2); the total area covered by the transect was then divided into the number of fish observed and multiplied by 100.

For the two zigzag transects off the end of Pier 91 and off Terminal 37, no correction was made for the fact that the transect path sloped down from the shoreline while what is actually being measured is a nonsloping transect at the surface. However, to correct accurately for this factor would be time-consuming and would only be a slight correction in the direction of slightly lowering the fish abundance values on those two transects. If preferred, the values given for the zigzag transects can be thought of as the number of fish associated with the bottom under 100 m^2 of surface water.

Names of Fishes

Common names of fishes have been used throughout this report. However, an alphabetical listing (Appendix 2) gives the common and scientific names of all fish referred to in this report.

RESULTS

Temperature and salinity were recorded at each trawling station (Table 1) primarily as a check to assure us that peculiar conditions were not occurring at the time of trawling, but also to serve as a comparison of the Terminals 91 and 37 sites.

Bottom temperatures and salinities presumably correlate better than surface temperatures and salinities to the distribution and abundance of bottom-trawled fishes; bottom temperatures and salinities recorded (Table 1) are not considered to be significantly different between trawling sites. Surface salinities were more variable and in a couple of cases were fairly low at Terminal 37, presumably due to the freshwater influence of the Duwamish River.

Trawling

Diversity

The total number of species found at Terminals 91 and 37 was essentially the same, namely 20. However, if all four stations sampled at Terminal 91 are combined, there are a few more species at Terminal 91. The single station (B) off the ends of Piers 91 and 90 recorded 20 species, and none of the other individual stations at Terminal 91 had more than 15 species.

Shannon's diversity indices also showed no difference between Terminals 91 and 37. Values (H) calculated for both Terminals 91 and 37 were for all practical purposes identical at 1.5; if shiner perch were removed from the data (shiner perch were caught in much larger numbers than other species, which tends to overly influence "diversity" calculations) the values calculated are still essentially identical at about 2.2.

Other "diversity" indices (i.e., richness, evenness, dominance) were also calculated (University of Washington Fisheries 525 papers 1980) and no significant difference was detectable between Terminals 91 and 37.

Recurrent Group Analysis

It is reasonably clear from an examination of the basic fish data obtained (Appendix 3) that shiner perch and flatfish are the principal species assemblage occurring at both Terminals 91 and 37. Recurrent group analysis also resulted in the finding that the representative species assemblage at both Terminals would consist of shiner perch, English sole, rock sole, and flathead sole; other species also likely to be found with this group are Dover sole, speckled sanddab, and snake

Table 1. Environmental data collected during trawl surveys at Terminals 91 and 37.

	Depth M	Surface T°	Bottom T°	Surface S°/oo	Bottom S°/oo
AFTERNOON SERIES (1430-1647)					
Terminal 91, Station C	13	10.5	9.5	26.9	28.3
Station D	11	10.3	9.7	31.6	28.1
Station E	13	--	--	--	--
Station B	18	10.4	9.5	28.6	28.1
Terminal 37, Station A (2 tows)	18	10.7	9.6	20.6	28.5
DUSK SERIES (2032-2250)					
Terminal 91, Station C	15	10.3	9.3	27.0	28.2
Station D	11	10.2	9.7	27.1	28.2
Station B	18	10.3	9.4	26.8	28.4
Terminal 37, Station A	15	10.3	9.3	23.1	28.8
NIGHT SERIES (0115-0144)					
Terminal 91, Station C	13	10.0	9.3	27.6	28.7
Station D	11	9.6	9.3	27.8	28.0
DAWN SERIES (0515-0730)					
Terminal 91, Station C	15	9.3	9.0	24.7	25.0
Station D	13	9.7	9.1	26.0	28.6
Station B	22	9.7	9.1	25.7	29.0
Terminal 37, Station A	21	9.9	9.5	25.9	28.8

Weather

Afternoon: 0 precipitation, air temp 15.1-16.2°, winds 5-10 mph, water slightly choppy.
Dusk: 0 precipitation, air temp 10.0-11.0°, winds <5 mph, calm seas.
Night: 0 precipitation, air temp 8.5°, no wind, calm.
Dawn: 0 precipitation, air temp 6.5-7.5°, winds <5 mph, calm.

prickleback. All of these species, except snake prickleback, are potentially economically important species (i.e., commercial or recreational use).

Abundance

The compilation of the maximum abundance of bottom-associated marine fish at Terminals 91 and 37 (Table 2) indicated a similar number of fish at all study sites except perhaps off the end of Piers 90-91. However, it is also readily apparent that shiner perch alone, at all sites, dominate the abundance calculations and the fact that they were caught in lesser numbers off the end of Piers 90-91 was enough to lower the abundance value for that site. Nevertheless, it is very consistent that at each study site shiner perch during at least one haul (i.e., time of day) was clearly the most abundant fish species caught by the otter trawl and must be represented in the abundance calculations. In fact, considering the objectives of this study (i.e., to assess potential loss of resident marine fish to various construction proposals at Terminal 91), the conservative use of the abundance data (Table 2) would be to use the maximum values (omitting Terminal 37) for each species as an estimate of the abundance of that particular species. If this approach is used the maximum abundance value for all economically important fishes would be 35.16 fish per 100 m^2 of bottom substrate.

The emphasis on "economically important fishes" is made easier to justify by the fact that such fishes, in terms of total number caught, represent 97% of the fish in our survey. Surely other species may have important ecological significance, but in our survey the number caught was so few that it seemed particularly appropriate to separate out economically important fishes. Other species caught in this survey which were not considered economically important were (in order of frequency of occurrence): snake prickleback, roughback sculpin, ratfish, bay goby, midshipman, blackbelly eelpout, northern ronquil, buffalo sculpin, and staghorn sculpin. Two species caught (one specimen of each), Pacific herring and longfin smelt, were omitted from the trawl analysis because they were considered to be particularly unlikely to be resident species.

The length (Appendix 3) and weight data taken indicated that the majority of fish caught was juveniles or subadults--very few adult size fish were caught.

Food Studies

Two graduate students in the Fisheries 525 class examined the stomachs of some of the fishes caught at Terminals 91 and 37. The results will be summarized in this section but for additional information, see G. Ruggerone and R. Walker (University of Washington 1980).

Table 2. Maximum abundance (fish/100 m^2) of fish species caught trawling at Terminals 91 and 37. Individual and total abundance values are given for economically valuable species and total abundance values are given for all species. Note that the economically valuable species are listed in the order of the frequency the species occurred at all sites.

Species	Slip 91 West	Slip 91 -90	Slip 90 East	Piers 90 -91 End	Terminal 37 End
Shiner perch	24.67	16.13	11.25	6.09	15.10
English sole	1.22	0.94	4.13	0.75	0.47
Rock sole	0.19	0.19	1.41	0.84	1.31
Flathead sole	0.28	0.56	0.28	0.28	0.47
Dover sole	0.0	0.09	0.56	0.75	2.34
Sand sole	0.19	0.0	0.09	0.66	0.38
Speckled sanddab	0.0	0.56	0.47	0.28	0.47
Tomcod	0.0	0.38	0.94	0.09	0.19
Pacific cod	0.0	0.19	0.19	0.0	0.19
Quillback rockfish	0.19	0.09	0.0	0.38	0.0
Brown rockfish	0.0	0.19	0.0	0.19	0.0
Whitespotted greenling	0.0	0.0	0.09	0.19	0.0
C-O Sole	0.09	0.0	0.0	0.09	0.0
Copper rockfish	0.0	0.0	0.0	0.19	0.0
Pile perch	0.0	0.0	0.0	0.09	0.0
Pacific sanddab	0.0	0.0	0.0	0.19	0.0
Slender sole	0.0	0.0	0.0	0.0	0.19
Starry flounder	0.0	0.0	0.0	0.0	0.19
All Econ. Impt. Fish Species	26.82	19.32	19.41	11.06	21.00
All Fish Species Caught	26.82	19.88	19.88	11.72	22.13

Stomach contents of 17 rock sole (Table 3), ranging in size from 158-269 mm TL, indicated that polychaetes and bivalves were most frequently consumed and crustaceans less frequently. Five stomachs were empty. Twenty-one English sole, ranging in size from 193-310 mm, also primarily consumed polychaetes and bivalves (Table 3). In comparison to rock sole, English sole stomachs contained more polychaete families and fewer categories of bivalves.

In order to look at which fish might be utilizing epibenthic and pelagic organisms in the study area, ten species of presumably pelagic-epibenthic-feeding fishes were chosen for stomach analysis (Table 4). The results are summarized (Fig. 2) and indicate that decapod crustaceans, particularly caridean shrimp, were a major source of food for most of this group of fish. Fish were also an important diet item for several species. Inspection of the stomach content data did not indicate any significant differences between Terminal 91 and Terminal 37 - basically, the same fish species were present feeding on the same organisms.

Parasite Incidence

One graduate student (G. Glodek) in the Fisheries 525 class externally examined the gills, fins, and body surface of shiner perch, English sole, and rock sole at Terminal 91 for parasite incidence (University of Washington 1980).

English sole and rock sole were found to be about equally infested with the parasitic nematode, *Philometra* ("blood worm")--the combined incidence was 56%. Shiner perch were infested in the gills with *Caligus rapax* ("gill lice")--the incidence was 71%.

Diving

Diversity

Species of fish seen while diving (Appendices 4 and 5) had also been caught while trawling except for the following: walleye pollock, striped seaperch, black rockfish, painted greenling, and sturgeon poacher. The total number of species seen during the straight line transects along the sides of Piers 91 and 90 was 12, and the total number seen off the end of Pier 91 and off Terminal 37 was 10 (7 off Pier 91 and 6 off Terminal 37).

The characteristic Terminals 91 and 37 riprap-pilings fish assemblage was also dominated by surfperch (but pile perch rather than shiner perch), but rockfish were much more important while flatfish assumed much less importance than they did in the trawl-sampled soft bottom areas.

Table 3. Stomach contents of English sole and rock sole (+ = item present, blank = absent, UID = unidentified).

Food Item	Rock Sole	English Sole
Crustacea		
Pinnotheridae	+	
Cancer gracilis	+	
Brachyrhyncha	+	
Isopod		+
Pelecypoda		
Axinospida serricata	+	+
Nucula tenuis	+	
Nemocardium centifilosum	+	
Psephida lordi	+	
Cuspidaridae	+	
Tellinidae	+	+
UID bivalve	+	+
Bivalve siphon	+	+
Polychaeta		
Amphaeridae	+	
Cirratulidae	+	+
Goniadidae	+	+
Glyceridae		+
Lumbriniridae	+	+
Maldanidae		+
Opheliidae	+	+
Pectinaridae	+	+
Phyllodocidae		+
Terebellidae		+
Spionidae ?	+	
UID Polychaete	+	+

Table 4. Pelagic-epibenthic-feeding fishes from Terminals 91 and 37 analyzed for stomach contents.

Species	Total sample	Contents in stomach	Contents identified from intestine	Empty
Ratfish *Hydrolagus colliei*	8	3	4	1
Plainfin midshipman *Porichthys notatus*	3	1	0	2
Pacific cod *Gadus macrocephalus*	6	6	0	0
Pacific tomcod *Microgadus proximus*	14	11	1	2
Brown rockfish *Sebastes auriculatus*	6	3	2	1
Quillback rockfish *Sebastes maliger*	7	1	2	4
Copper rockfish *Sebastes caurinus*	4	2	0	2
Whitespotted greenling *Hexagrammos stelleri*	3	3	0	0
Buffalo sculpin *Enophrys bison*	1	1	0	0
Sand sole *Psettichthys melanostictus*	7	2	0	5
	59	33	9	17

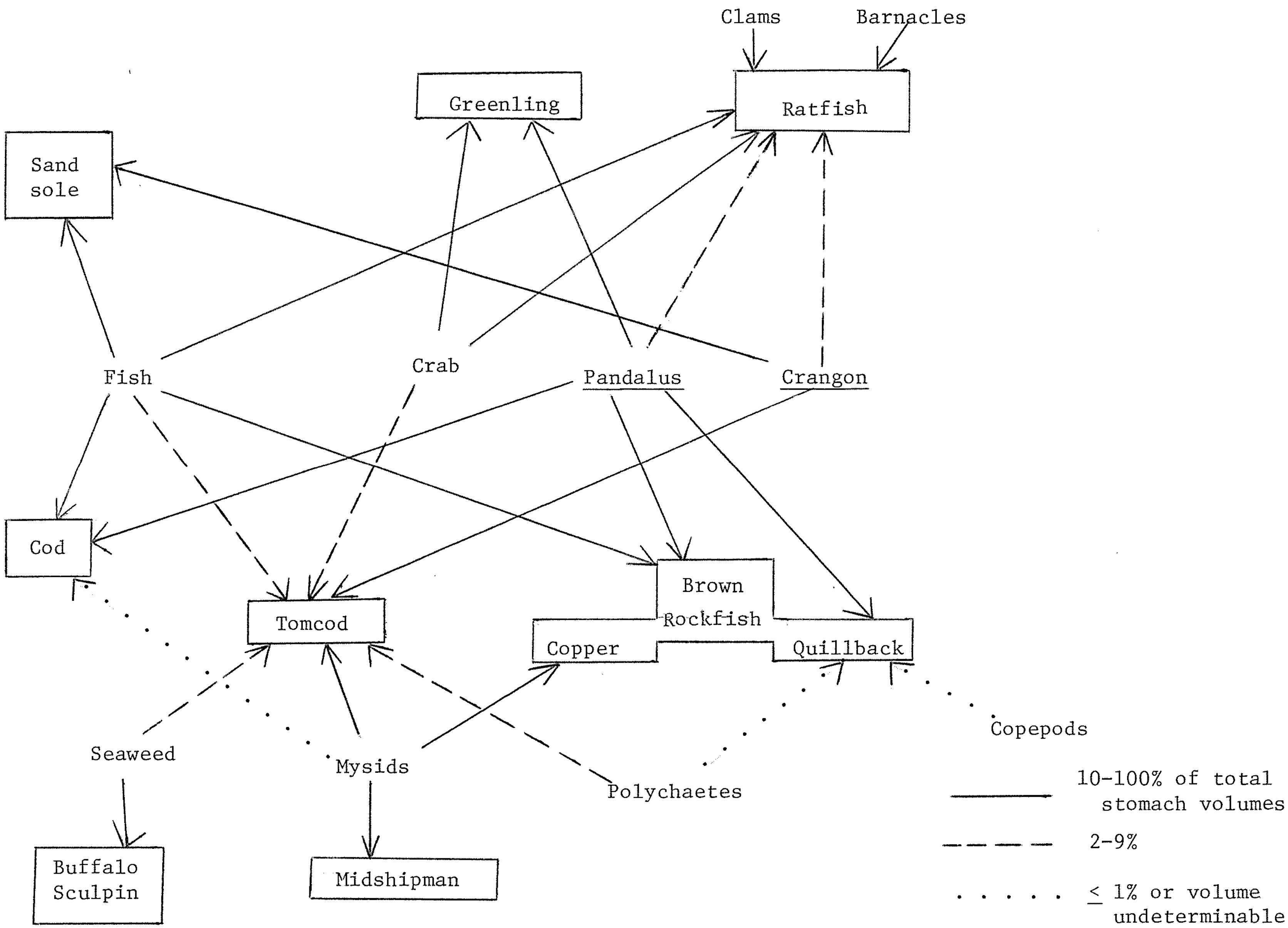

Figure 2. Food web diagram of the pelagic-epibenthic-feeding fishes sampled at Terminals 91 and 37.

Fish observed while diving immediately west of the center of Pier 91 (soft, silty bottom) were 1 ratfish, 1 Pacific cod, 3 copper rockfish, and 2 English sole. This dive was most noteworthy for the fact that bottom visibility was very poor (1-2 m) and the bottom was littered with large cables, rolls of wire, large chunks of scrap metal, concrete blocks, concrete pieces, barrels, ladders, etc.--this same situation also existed off the end of Pier 91. Rockfish, in particular, were often observed associated with debris.

Abundance

Fish abundance along the sides of Piers 91 and 90 was most notable for the much larger abundance calculated for the east side of Pier 90 (Table 5). Again, as with the trawl-caught fish calculations, surfperch account for the large difference in abundance values. Without the large surfperch values, the fish abundance would be similar at Slips 91-90 and 90 east.

There was also a large difference between total fish abundance off the end of Pier 91 and off Terminal 37 (Table 6)--and again the difference was attributable to a much larger number of pile perch sighted off Pier 91 compared to Terminal 37. However, there was also a clear difference in depth distribution of fish off the end of Pier 91 and off Terminal 37 (Appendix 5). Of 38 fish seen during the zigzag transect at Pier 91, 36 fish were seen in water $\leq$10 m depth (24 fish in 6-10 m, 12 fish in 0-5 m); at Terminal 37, of the 14 fish seen, only 1 fish was in 6-10 m of water and all the rest were in water 11-18 m deep.

Table 5. Abundance of fish (number fish/100 m^2) in pilings and riprap along sides of Piers 91 and 90.

Species Group	Slip 91-90 Transects Landward	Slip 91-90 Transects Seaward	Slip 90 East Transects Landward	Slip 90 East Transects Seaward
Pacific cod	1.23	0.0	0.49	0.0
Surfperch	2.46	1.18	15.29	44.40
Rockfish	3.28	1.18	0.99	1.93
Flatfish	1.23	0.79	0.99	1.16
Misc. other	0.0	0.39	1.97	* 0.0
Total Fish	8.20	3.53	19.72	*47.49

*These values do not include a school of 50 juvenile fish (which were probably herring, smelt, or sand lance) seen in the surface waters under Pier 90.

Table 6. Abundance of fish (number of fish/100 m^2) associated with pilings and riprap at the end of Pier 91 and Terminal 37.

Species Group	Pier 91 Transect	Terminal 37 Transect
Walleye pollock	0.0	0.58
Surfperch	15.23	1.73
Rockfish	2.03	0.87
Flatfish	1.02	0.28
Misc. other	1.02	*0.58
Total Fish	19.29	*4.05

*These values do not include several thousand juvenile herring seen in the surface waters of Terminal 37 after the transect dive was completed.

DISCUSSION

General Considerations

This survey of potentially resident marine fish did not reveal any species that were endangered, rare, or unusual in Puget Sound.

The two species assemblages identified are typical and common for protected, shallow soft bottom, and riprap-pilings habitats. The common species found--English sole, rock sole, flathead sole, Dover sole, speckled sanddab, shiner perch, pile perch, brown rockfish, quillback rockfish--are all common in central Puget Sound (DeLacy et al. 1972).

The abundance of fishes in the Terminal 91 area is not large. If the maximum abundance estimate of 35 fish per 100 m^2 of soft bottom is used, this is only about one-fifth of the estimates made for other comparable shallow mud-sand habitats in central and northern Puget Sound (Miller et al. 1977, 1978, in press).

About half of the predominant species, English sole and rock sole, was infested with the "blood worm," Philometra. This is a common occurrence in southern and central Puget Sound and is not related to pollution (Amish 1976), but essentially destroys the value of these species for commercial or recreational use.

It is not meaningful to compare the abundance estimates of riprap-pilings fish at Terminal 91 to other estimates because the habitat which is attracting these fishes--riprap, pilings, debris--is man-made. In fact, the Washington State Department of Fisheries suggests that there is too much low relief, shallow sand, and mud bottom in central and southern Puget Sound and that artificial reefs are needed to attract such fishes as rockfish and surfperch (Walton 1979, Hueckel 1980). For example, construction has begun on a fishing pier just east of Terminal 91 which will have its own artificial reef to provide more continuous recruitment of recreational fishes to the pier fishery; Walton (1979) has shown that artificial reefs in central Puget Sound considerably increase the number of rockfish and surfperch per unit area. Man-made riprap and pilings act as artificial reefs which attract surfperch and rockfish and indeed this is the case at Terminal 91 where the fish fauna is dominated by surfperch.

Evaluation of Construction Alternatives

In a draft memo of 30 June 1980 from the Port of Seattle (John Dohrman), 14 alternatives for expanded use of Terinal 91 were outlined and illustrated. In evaluating these alternatives, I am assuming that water quality will remain as good or better than the present situation.

Of the 14 alternatives, only 4 would appear to probably change the present situation in regard to resident marine fish; these are: Alternatives 1B Small and 1B Large (proposals for a yard crane terminal facility), 4C (auto importing expansion), and 7 (a marina). I do not believe the other alternatives will have any noticeable effect on the resident marine fishes.

Alternative 1B Small would fill in the entire waterway east of Pier 90. This waterway, at least the east side of it, may be an English sole nursery area, where the recently metamorphosed juveniles spend the first year of their lives. This waterway had the highest abundance of English sole, including many juveniles, of any of the sampling sites. However, about half of the English sole were externally parasitized with nematodes, which essentially eliminates their value to recreational or commercial fishing, although presumably they are available as food items to other marine-oriented fish, birds, and mammals. This waterway also had the highest abundance of surfperch in any of the areas surveyed--pile perch, striped seapearch, and shiner perch. Alternative 1B Small would result in the loss of surfperch by destroying the habitat (admittedly man-made) that they need. From the fish surveys we have done, both trawling and diving, my opinion is that the waterway next to Pier 90 is presently the most valuable fish habitat and consequently I would rate Alternative 1B Small the <u>least</u> desirable alternative.

Alternative 1B Large would fill in the entire waterway between Piers 90 and 91. This would principally eliminate shiner perch habitat. However, Alternative 1B Large would appear to be similar to the construction which took place at Terminal 37; if this is the case, our present studies indicate that species composition and abundance off the end of Piers 91-90 should remain essentially the same as it is now although undeniably there will be some loss in number of fish because of the decreased bottom area and riprap-pilings habitat presently between the piers. It is my opinion that this decrease in fish is not significant in either the kinds or abundance of fish.

Alternative 4C is commented on only in passing. This alternative fills in the area called Smith Cove Park and as such was not sampled during our survey since it was understood that the appropriate sampling technique, beach seining, was being done by others. However, my strictly qualitative observations of the habitat type make me wonder if it might not be fairly significant as a nursery area for juvenile fishes.

Alternative 7 is a marina which would utilize the water from the east side of Pier 91 to the east side of Pier 90. There would be floating slips and a breakwater at the entrance. Such marinas may reduce the soft bottom fish assemblages due to shading and fuel contamination, but surfperches, rockfish, and some pelagic fishes are often enhanced due to increased habitat (floating slips, pilings, riprap, etc.). However, if water circulation is poor in marinas, all but the hardiest fishes (e.g., staghorn sculpins) usually disappear, presumably due to oil and gas pollution.

Conclusions

In terms of resident marine fish, I consider Alternative 1B Small the least desirable of all the alternatives. Alternative 7 may rank the same as 1B Small if water circulation is predicted to be poor. Alternative 4C needs to be evaluated by the people doing the fish work in the Smith Cove Park area.

Alternative 1B Large would result in the loss of some fish habitat but I do not consider the loss significant.

I believe all other alternatives would result in no noticeable change to fishes in the area (assuming the present water quality is maintained).

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Appendix 1. Data on visibility, depth, and length of diving transects. E = east, W = west.

Transect	Visibility(m)	Survey Depth(m)	Transect Length(m)
Pier 91E Landward Shallow	3	3	51
Pier 91E Landward Bottom Deep	4	9	52
Pier 91E Landward Surface Deep	4	4(9)*	32.5
Pier 90W Seaward Shallow	3	3	45
Pier 90W Seaward Bottom Deep	4	8	47.5
Pier 90W Seaward Surface Deep	4	4(8)*	49
Pier 90E Landward Shallow	2	3	48
Pier 90E Landward Bottom Deep	3	6	49
Pier 90E Landward Surface Deep	3	4(6)*	59
Pier 90E Seaward Shallow	4	3	40.5
Pier 90E Seaward Bottom Deep	4	8	46
Pier 90E Seaward Surface Deep	4	3(8)*	43
Pier 91 end: zig-zag	2	0-14	197
Terminal 37: zig-zag	4.5	0-18	173

*( ) = bottom depth

Appendix 2. Common and scientific names of fishes collected during the Terminal 91-37 resident marine fish survey.

Common name	Scientific name
Bay goby	*Lepidogobius lepidus*
Black rockfish	*Sebastes melanops*
Blackbelly eelpout	*Lycodopsis pacifica*
Brown rockfish	*Sebastes auriculatus*
Buffalo sculpin	*Enophrys bison*
C-O sole	*Pleuronichthys coenosus*
Copper rockfish	*Sebastes caurinus*
Dover sole	*Microstomus pacificus*
English sole	*Parophrys vetulus*
Flathead sole	*Hippoglossoides elassodon*
Longfin smelt	*Spirinchus thaleichthys*
Midshipman	*Porichthys notatus*
Northern ronquil	*Ronquilus jordani*
Pacific cod	*Gadus macrocephalus*
Pacific herring	*Clupea harengus pallasi*
Pacific sanddab	*Citharichthys sordidus*
Painted greenling	*Oxylebius pictus*
Pile perch	*Rhacochilus vacca*
Quillback rockfish	*Sebastes maliger*
Ratfish	*Hydrolagus colliei*
Rock sole	*Lepidopsetta bilineata*
Roughback sculpin	*Chitonotus pugetensis*
Sand lance	*Ammodytes hexapterus*
Sand sole	*Psettichthys melanostictus*
Shiner perch	*Cymatogaster aggregata*
Slender sole	*Lyopsetta exilis*
Snake prickleback	*Lumpenus sagitta*
Speckled sanddab	*Citharichthys stigmaeus*
Staghorn sculpin	*Leptocottus armatus*
Starry flounder	*Platichthys stellatus*
Striped seaperch	*Embiotoca lateralis*
Sturgeon poacher	*Agonus acipenserinus*
Tomcod	*Microgadus proximus*
Walleye pollock	*Theragra chalcogramma*
Whitespotted greenling	*Hexagrammos stelleri*

Appendix 3. Species abundance and size range (TL) of fishes collected during trawling at Terminals 91 and 37.

	Afternoon -- Terminal 91					
	Station C		Station D		Station E	
	#	Range (mm)	#	Range (mm)	#	Range (mm)
Midshipman						
Rock sole	2	45-174	4	169-225	2	122-213
Flathead sole	3	176-249	3	170-257	3	157-285
C-O sole					1	290
Dover sole			1	142		
Sand sole			1	301	2	174-320
English sole	5	87-245	44	97-367	13	175-356
Slender sole						
Speckled sanddab	3	70-146	5	120-167		
Pacific sanddab						
Snake prickleback	2	153-220	4	170-239	1	170
Staghorn sculpin			1	52		
Buffalo sculpin						
Roughback sculpin	1	63				
Northern ronquil						
Whitespotted greenling			1	123		
Quillback rockfish	1	111				
Copper rockfish					2	142-270
Brown rockfish						
Pile perch						
Shiner perch					263	80-151
Longfin smelt						
Pacific herring					1	126
Tomcod						
Pacific cod						
Bay goby						
Ratfish	2	360-390				
Blackbelly eelpout						
Starry flounder						

Appendix 3. Species abundance and size range (TL) of fishes collected during trawling at Terminals 91 and 37 - continued.

	Afternoon					
	Terminal 91		Terminal 37			
	Station B		Station A (1st haul)		Station A (2nd haul)	
	#	Range (mm)	#	Range (mm)	#	Range (mm)
Rock sole	1	121	3	222-245	8	76-247
Flathead sole	1	144	3	148-159		
C-O sole	1	193				
Dover sole						
Sand sole	7	73-171	1	325	4	84-366
English sole			2	153-252	3	141-222
Slender sole						
Speckled sanddab			1	138	5	109-252
Pacific sanddab	2	56-78				
Snake prickleback			1	106	1	116
Staghorn sculpin						
Buffalo sculpin					1	265
Roughback sculpin					1	25
Northern ronquil						
Whitespotted greenling	1	250				
Quillback rockfish	4	114-241				
Copper rockfish	2	131-190				
Brown rockfish	2	229-265				
Pile perch	1	95				
Shiner perch						
Longfin smelt			1	98		
Pacific herring						
Tomcod						
Pacific cod						
Bay goby						
Ratfish					1	459
Blackbelly eelpout						
Starry flounder					1	243

Appendix 3. Species abundance and size range (TL) of fishes collected during trawling at Terminals 91 and 37 - continued.

	Dusk Terminal 91						Terminal 37	
	Station C		Station D		Station B		Station A	
	#	Range (mm)	#	Range (mm)	#	Range (mm)	#	Range (mm)
Midshipman							1	201
Rock sole	1	222	15	71-213	9	76-250	5	111-212
Flathead sole	6	155-196	2	149-190	2	78-173	5	110-150
C-O sole								
Dover sole	1	125	6	127-140	8	116-215	25	113-298
Sand sole							2	255-369
English sole	10	51-278	17	136-314	3	198-313	1	236
Slender sole								
Speckled sanddab	6	115-156	4	112-173				
Pacific sanddab								
Snake prickleback	1	40	1	213	1	171	1	101
Staghorn sculpin								
Buffalo sculpin								
Roughback sculpin			1	74				
Northern ronquil								
Whitespotted greenling								
Quillback rockfish					2	121-174		
Copper rockfish								
Brown rockfish	1	63						
Pile perch					1	107		
Shiner perch	172	75-126	120	78-127	65	78-116	161	77-145
Longfin smelt								
Pacific herring								
Tomcod	4	117-148					1	160
Pacific cod	2	276-277	2	81-180			1	289
Bay goby	1	93					2	88-90
Ratfish					1	432	3	227-375
Blackbelly eelpout					5	106-206	3	97-205

Appendix 3. Species abundance and size range (TL) of fishes collected curing trawling at Terminals 91 and 37 - continued.

	Night - Terminal 91 Station C		Station D	
	#	Range (mm)	#	Range (mm)
Midshipman				
Rock sole	1	198		
Flathead sole			1	151
C-O sole				
Dover sole			2	265-305
Sand sole				
English sole	1	212	4	175-230
Slender sole				
Speckled sanddab	2	112-132	3	70-130
Pacific sanddab				
Snake prickleback			1	104
Staghorn sculpin				
Buffalo sculpin				
Roughback sculpin				
Northern ronquil				
Whitespotted greenling				
Quillback rockfish				
Copper rockfish				
Brown rockfish	1	94		
Pile perch				
Shiner perch	12	64-91	14	82-108
Longfin smelt				
Pacific herring				
Tomcod			10	106-150
Pacific cod			1	250
Bay goby				
Ratfish	1	474		
Blackbelly eelpout				

Appendix 3. Species abundance and size range (TL) of fishes collected furing trawling at Terminals 91 and 37 - continued.

	Dawn Terminal 91						Terminal 37	
	Station C		Station D		Station B		Station A	
	#	Range (mm)	#	Range (mm)	#	Range (mm)	#	Range (mm)
Midshipman							2	130-248
Rock sole	2	195-253	5	127-221	8	73-328	14	72-265
Flathead sole	1	142			3	126-160		
C-O sole								
Dover sole	1	178	1	85	3	125-162		
Sand sole								
English sole	6	188-247	24	95-318	8	131-310	5	100-265
Slender sole							2	81-86
Speckled sanddab	2	145-163			3	141-154	1	135
Pacific sanddab								
Snake prickleback			1	217			1	202
Staghorn sculpin								
Buffalo sculpin								
Roughback sculpin	1	65			1	75		
Northern ronquil							1	106
Whitespotted greenling			1	325				
Quillback rockfish								
Copper rockfish					1	126		
Brown rockfish	2	190-220						
Pile perch					1	97		
Shiner perch	8	80-130	2	78-85	5	76-92	1	86
Longfin smelt								
Pacific herring								
Tomcod					1	124		
Pacific cod								
Bay goby							2	65-86
Ratfish								
Blackbelly eelpout								

Appendix 4. Species and numbers of fish sighted during diving straightline transect series surveys at Pier 91 and 90 (ad = adult, juv = juvenile, UID = unidentified).

	Slip 91-90						Slip 90 East					
	Landward			Seaward			Landward			Seaward		
Species	Shallow	Bottom Deep	Surface Deep	Shallow	Bottom Deep	Surface Deep	Shallow	Bottom Deep	Surface Deep	Shallow	Bottom Deep	Surface Deep
Sand lance ad							1					
UID juvs (prob. herring, smelt or sand lance)												(50)
Pacific cod ad	3											
Shiner perch											70	
Pile perch			1	2			5	1	25	1	20	4
Striped seaperch		4				1					20	
Copper rockfish ad	1											
Copper rockfish juv	1											
Brown rockfish ad	1					3				3		
Brown rockfish juv	2									2		
Quillback rockfish ad								1				
UID rockfish ad							1					
UID rockfish juv		3										
English sole ad		1						1		1	2	
Rock sole ad	1				2							
UID flatfish ad	1						1					
Painted greenling ad				1								
UID sculpins							2					
Sturgeon poacher ad								1				
UID fish								1				

Appendix 5. Species and numbers of fish sighted during diving zig-zag transect surveys at the end of Pier 91 and off Terminal 37.

	Pier 91			Terminal 37		
	Depth(m)			Depth(m)		
Species	0-5	6-10	>10(11-14)	0-5	6-10	>10(11-18)
Herring juv				*		
Walleye pollock						2
Pile perch	10	20				6
Copper rockfish ad						1
Brown rockfish ad		1				2
Quillback rockfish ad			1			
Quillback rockfish juv			1			
Black rockfish ad	1					
English sole ad						1
Rock sole ad		1				
UID flatfish		1				
Painted greenling ad		1				1
Sturgeon poacher	1					
UID sculpin (Artedius sp.)					1	

* Several thousand juvenile herring were seen at the surface waters at Terminal 37--some were seen outside the pier and some underneath the pier. These juvenile herring were not seen until after the transect had been completed.