Benthic and Epibenthic Invertebrates, Demersal Fishes, and Sediment Structure off Tillamook Bay, Oregon, September 1990,

with Comparisons to Previous Surveys

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INTRODUCTION

Biological surveys conducted by the National Marine Fisheries Service (NMFS) in 1984 and 1985 at the interim Ocean Dredged-Material Disposal Site (ODMDS) offshore from Tillamook Bay, Oregon, revealed extremely high densities of benthic invertebrates (Emmett et al. 1987, 1988). As a result, the U.S. Army Corps of Engineers (COE), Portland District, requested NMFS to sample deeper areas in an attempt to find an area that was biologically less active. In October 1988, benthic invertebrate and sediment samples were collected along a transect originating in the interim ODMDS [35-m (115-ft) depth contour] and ending at the 73-m (240-ft) depth contour. Results from the September 1988 survey revealed that benthic invertebrate densities at the deeper stations were lower than those at the interim ODMDS; however, benthic invertebrate densities may have been underestimated because of sampling problems (Emmett et al. 1990).

To verify benthic invertebrate densities off Tillamook Bay, NMFS conducted a fifth biological survey during September 1990; all previous benthic invertebrate sampling stations (34) and 10 trawling stations were reoccupied. This report presents the information collected during the September 1990 survey and compares it to previous surveys.

METHODS

Benthic Invertebrates and Sediments

Benthic invertebrates and sediments were collected at 34 stations, primarily located along three transects (Fig. 1). The first transect contained six stations (T11-T16) and ran perpendicular from shore north of the interim ODMDS, starting at the 18-m depth contour and ending at the 35-m contour. The second transect had 14 stations (T21-T240) and also ran perpendicular from shore, starting near the center of the interim ODMDS at the 18-m depth contour and ending at the 73-m contour. The third transect contained six stations (T31-T36) and was located south of the interim ODMDS, running from the 18-m depth contour to the 35-m depth contour. Eight other stations were also sampled, four north of the second transect (TR1, TR2, TN200, TN240) at the 18-, 30-, 61-, and 73-m depth contours and four south of the second

transect (TR3, TR4, TS200, TS240) at similar depths. We used Loran-C navigational readings to return to previous sampling stations (Appendix Table 1).

A 0.96-m^2 Gray-O'Hara box corer (Pequegnat et al. 1981) was used to collect six samples at each station. Five of these samples were individually sieved through a 0.5-mm mesh screen, and the residue placed in jars with a buffered 5% formaldehyde solution containing Rose Bengal (a protein stain). The sixth sample was used for sediment analysis. Sediment grain size was determined by sieving, and total volatile solids were determined by burning for 1 hour at 600°C. Sediment particle sizes are presented using the phi scale where phi=$-\log_2$ of the particle diameter in millimeters. Sediment analysis was done by the COE, North Pacific Division Materials Laboratory at Troutdale, Oregon. Benthic organisms were sorted from the preserved samples, identified to the lowest possible taxonomic level (usually species), and counted. All identified specimens were archived in vials containing 70% ethyl alcohol and stored at the NMFS Point Adams Biological Field Station, Hammond, Oregon.

Trawling (Fishes and Large Epibenthic Invertebrates)

We bottom-trawled at 10 stations (Fig. 2): 3 stations (T1, T4, T110) within the interim ODMDS at depth contours of 20, 28, and 34 m; 3 stations (T180, T200, T220) directly west of the interim ODMDS at depth contours of 55, 61, and 66 m; and 2 stations each (TN200, TN220, TS200, TS220) north and south of these westerly stations along the 61- and 67-m depth contours. Bottom trawling was done with an 8-m semiballoon shrimp trawl that had overall mesh size of 38.1 mm (stretched); a 12.7-mm mesh liner was inserted in the cod end to ensure retention of small fishes and invertebrates. Fishing width of the trawl was estimated to be 5 m. Each trawling effort lasted 10 minutes. We determined position fixes using Loran-C navigational equipment (see Appendix Table 1 for Loran-C readings for each station).

All captured fishes, crabs, shrimps, and large invertebrates were placed in labeled 19-L (5-gal) buckets containing a buffered solution of 5% formaldehyde and seawater. In the laboratory, fishes and large invertebrates were rinsed in fresh water, measured [total and standard lengths (mm)], and weighed (g). Crabs were measured across the carapace just anterior to the tenth anterolateral spines. Shrimps were identified, measured (tip of rostrum to end of telson), counted, and weighed. For each trawling effort, a subsample of up to 50 individuals of a species

was measured and weighed. When more than 50 individuals of a species were captured, the remainder was counted and weighed as a group.

Data Analysis

Benthic Invertebrates

The five benthic invertebrate replicates from each station allowed us to calculate a mean number/m^2 and a standard deviation for each species. Two community structure indices were also calculated for each station.

1) Diversity was described by the Shannon-Wiener function (H) (Krebs 1978):

$$H = -\sum_{i=1}^{s} p_i \log_2 p_i$$

where $p_i = Xa/n$ (Xa is the number of individuals of a particular species in the sample and n is the total number of individuals in the sample) and s = number of species.

2) Equitability (E) measures the proportional abundances among the various species in a sample (Krebs 1978):

$$E = H/\log_2 s$$

where H = Shannon-Wiener function and s = number of species.

A paired t-test (Wilkinson 1989) was used to identify significant differences between the number of taxa and invertebrate densities of the September 1990 data and similar data from September 1984 (Stations TR1-T36), and October 1988 (T115-TS240). Benthic invertebrate densities were $\log_{10}$ transformed before statistical analysis.

Fishes and Large Epibenthic Invertebrates

By using distance fished (calculated from Loran-C fixes), fishing width of the trawl (5 m), and catch data, we estimated densities of fishes and large epibenthic invertebrates [number/hectare (ha)]. A descriptive summary of each trawling effort included a species list, the numbers and weights of fishes and epibenthic invertebrates captured (total and by species), numbers/ha (total and by species),

Table 1.--Number of taxa found off Tillamook Bay during five benthic invertebrate surveys.

Station	Depth (ft)	Depth (m)	Sep 84	Jan 85	Jul 85	Oct 88	Sep 90
TR1	60	18	59	47	*	*	93
TR2	100	30	65	55	*	*	115
TR3	60	18	49	38	*	*	90
TR4	100	30	50	52	*	*	131
T11	60	18	52	39	36	*	104
T12	70	21	62		62	*	89
T13	80	24	74	46	60	*	116
T14	90	27	62	38	53	*	140
T15	100	30	67	46	57	*	114
T16	116	35	69	45	42	*	109
T21	66	20	63	28	33	*	103
T22	70	21	61	28	34	*	82
T23	80	24	86	42	37	*	117
T24	93	28	66	42	63	*	140
T25	100	30	65	45	52	*	146
T26	115	35	65	44	49	*	120
T31	60	18	47	37	44	*	79
T32	70	21	52	43	46	*	120
T33	77	23	39	49	48	*	105
T34	87	27	38	47	56	*	117
T35	97	30	41	49	49	*	121
T36	111	34	66	52	42	*	122
T115	115	35	*	*	*	55	116
T120	120	37	*	*	*	46	125
T140	141	43	*	*	*	63	145
T160	160	49	*	*	*	44	163
T180	183	56	*	*	*	61	161
T200	204	62	*	*	*	67	159
T220	222	68	*	*	*	68	151
T240	246	75	*	*	*	58	153
TN200	200	61	*	*	*	77	147
TN240	242	74	*	*	*	92	170
TS200	207	63	*	*	*	70	137
TS240	246	75	*	*	*	58	173
Mean			59	43	48	63	126
S.D.			12	7	9	13	25

* Station not sampled during this survey.

In 1990, diversity (H) was highest at Station T31 (4.36) and lowest at Station T25 (1.26) (Table 3). Interestingly, this corresponds to the stations with the lowest and highest benthic invertebrate densities (Table 2). This reflects how evenly the proportional abundances of the taxa were distributed at each station, which in turn is reflected in the equitability (E) values (Table 4). Station T31 had low densities, but the taxa present at this station had relatively even proportional abundances, thus high diversity and equitability, while Station T25 had high invertebrate densities, represented by only a few taxa, resulting in low diversity and low equitability. Overall, lower diversity (H) and equitability (E) occurred during the September 1990 survey than during any previous survey (Tables 3-4). Although we identified more taxa during this survey than during any previous survey, only a few taxa were abundant.

Polychaetes were the dominant invertebrates during September 1990, composing 91% of the invertebrate density (Table 5). Three species (*Owenia fusiformis, Spiophanes bombyx, and Prionospio lighti*) made up 76% of the polychaete densities. Other dominant species by major taxonomic category included the molluscs *Olivella* spp., *Olivella pycna*, and *Macoma* spp.; the cumaceans *Diastylopsis dawsoni* and *Colurostylis occidentalis;* the amphipods *Photis macinerneyi* and *Eohaustorius sencillus;* and the echinoderm *Dendraster excentricus*.

Fishes and Large Epibenthic Invertebrates

In September 1990, 48 fish and large epibenthic invertebrate taxa were captured in 10 trawling efforts (Table 6, Appendix Table 2). Pacific sanddab, *Citharichthys sordidus,* comprised 46% of the total catch for the survey (Table 6). Other numerically dominant species included northern crangon, *Crangon alaskensis;* speckled sanddab, *Citharichthys stigmaeus;* and English sole, *Pleuronectes vetulus*. Additional species, important by weight (few in number but large in size), included spotted ratfish, *Hydrolagus colliei;* rex sole, *Errex zachirus;* and sand sole, *Psettichthys melanostictus*.

The most taxa (24) were captured at Stations T110 and T180; the fewest taxa (10) were captured at Station T220 (Table 7, Appendix Table 4). During previous surveys, no more than 18 taxa/trawl were captured. Interestingly, the stations with the previous lowest number of taxa/trawl (four at Stations

Table 4.--Equitability (E) of benthic invertebrates found off Tillamook Bay, Oregon, during five benthic invertebrate surveys.

Station	Depth (ft)	Depth (m)	Sep 84	Jan 85	Jul 85	Oct 88	Sep 90
TR1	60	18	0.77	0.27	*	*	0.39
TR2	100	30	0.15	0.14	*	*	0.43
TR3	60	18	0.84	0.83	*	*	0.65
TR4	100	30	0.13	0.13	*	*	0.58
T11	60	18	0.64	0.85	0.62	*	0.35
T12	70	21	0.25		0.34	*	0.34
T13	80	24	0.23	0.78	0.31	*	0.40
T14	90	27	0.20	0.78	0.30	*	0.46
T15	100	30	0.14	0.23	0.18	*	0.42
T16	116	35	0.25	0.36	0.38	*	0.48
T21	66	20	0.75	0.66	0.77	*	0.41
T22	70	21	0.78	0.76	0.73	*	0.52
T23	80	24	0.42	0.85	0.51	*	0.57
T24	93	28	0.35	0.45	0.24	*	0.23
T25	100	30	0.12	0.79	0.33	*	0.18
T26	115	35	0.26	0.42	0.56	*	0.42
T31	60	18	0.77	0.79	0.75	*	0.69
T32	70	21	0.82	0.79	0.78	*	0.61
T33	77	23	0.84	0.73	0.79	*	0.59
T34	87	27	0.82	0.64	0.53	*	0.58
T35	97	30	0.72	0.54	0.73	*	0.58
T36	111	34	0.34	0.71	0.68	*	0.55
T115	115	35	*	*	*	0.79	0.47
T120	120	37	*	*	*	0.80	0.46
T140	141	43	*	*	*	0.77	0.39
T160	160	49	*	*	*	0.82	0.47
T180	183	56	*	*	*	0.82	0.43
T200	204	62	*	*	*	0.73	0.34
T220	222	68	*	*	*	0.72	0.35
T240	246	75	*	*	*	0.83	0.42
TN200	200	61	*	*	*	0.79	0.35
TN240	242	74	*	*	*	0.83	0.55
TS200	207	63	*	*	*	0.69	0.38
TS240	246	75	*	*	*	0.83	0.56
Mean			0.48	0.60	0.53	0.79	0.46
S.D.			0.29	0.25	0.21	0.05	0.12

* Station not sampled during this survey.

Table 6.--Catch summary for demersal fishes and large epibenthic invertebrates captured by 8-m trawl off Tillamook Bay, Oregon, during September 1990.

Taxon	Total number captured	Total weight (g)	Number per hectare	Weight (g) per hectare
Spotted ratfish[a/]	20	6,457	10	3,087
Longfin smelt	1	10	<1	5
Whitebait smelt	15	114	7	54
Pacific tomcod	32	280	15	134
Tube-snout	7	19	3	9
Bay pipefish	1	1	<1	0
Shiner perch	8	78	4	37
Unidentified rockfish	2	13	1	6
Sablefish	2	348	1	166
Lingcod	21	668	10	319
Roughback sculpin	3	33	1	16
Red Irish lord	1	72	<1	34
Brown Irish lord	12	330	6	158
Spotfin sculpin	3	44	1	21
Pacific staghorn sculpin	5	290	2	139
Slim sculpin	28	65	13	31
Cabezon	1	51	<1	24
Unidentified sculpin	1	4	<1	2
Northern spearnose poacher	3	6	1	3
Warty poacher	3	6	1	3
Pricklebreast poacher	13	29	6	14
Spinycheek starsnout	2	6	1	3
Showy snailfish	10	20	5	10
Bathymasteridae	2	17	1	8
Pacific sanddab	1,205	19,918	576	9,521
Speckled sanddab	153	1,668	73	797
Petrale sole	7	435	3	208
Rex sole	97	5,286	46	2,527
Butter sole	11	1,254	5	599
Arrowtooth flounder	46	1,278	22	611
English sole	150	5,439	72	2,600
Sand sole	24	2,420	11	1,157
Dover sole	60	1,800	29	860
Dungeness crab	87	90	42	43
Pygmy rock crab	1	2	<1	1
Red rock crab	6	29	3	14
Furrowed rock crab	3	3	1	2
Longhorn decorator crab	2	1	1	1
Northern crangon	361	569	173	272
California bay shrimp	60	44	29	21
Blacktail bay shrimp	18	8	9	4
Smooth crangon	91	12	43	6
Stout coastal shrimp	21	5	10	3
Prawn	14	18	7	9
Sand star	10	801	5	383
Pacific sea star	4	444	2	212
Sunflower star	2	935	1	447
Sand dollar	7	461	3	220
Totals	2,636	51,885	1,255	24,801

[a/] For scientific names see Appendix Table 2.

T110 and T180 during October 1986) had the most taxa during September 1990 (Table 7). There was no obvious relationship between depth and number of taxa captured during the present survey.

Fish and large epibenthic invertebrate densities during September 1990 were highest at Station TS220 (5,476/ha) and lowest at Station T1 (576/ha) (Table 7). Station TS220 had the highest fish and epibenthic invertebrate density reported from any of the five surveys (Table 7). Generally, 1990 trawl catch densities were similar to densities in September 1984.

Length and carapace-width frequency distributions of some numerically and commercially important fishes and Dungeness crab indicated that catches for some species were almost all juveniles (Figs. 3-4). For example, lingcod, *Ophiodon elongatus*, were probably age-1 or age-2; Dover sole, *Microstomus pacificus*, were primarily subyearlings and yearlings, and Dungeness crab were all subyearlings (recently settled), while both juvenile and adult Pacific sanddab, speckled sanddab, and rex sole were captured.

Trawl station diversity (H) in September 1990 was highest at Station T110 (3.63) (Table 8). This was higher than any previously sampled Tillamook trawl station and was due to the large number of taxa captured and the relatively equal proportional abundances of the taxa (E = 0.79) (Table 8). Lowest trawl station diversity during 1990 was at Station TS200 (1.76), and this was reflected in the low equitability value (0.48). Although 13 taxa were captured at Station TS200, 68% of the catch was composed of Pacific sanddab (Appendix Table 4).

Sediments

Median grain size during this survey ranged from 2.90 phi (fine sand) to 4.0 phi (very fine sand), with all but six stations having a median grain size of very fine sand (>3.0-4.0 phi) (Table 9). Overall, the median grain size for the 34 stations sampled in September 1990 was slightly finer (mean = 3.18 phi) than any of the previous surveys (Table 9). Similar to previous surveys, the September 1990 survey revealed very little median grain size variation between stations. In September 1990, median grain size was significantly finer than similar stations in September 1984 (paired t-test, $P < 0.05$), but not significantly different from October 1988 (paired t-test, $P > 0.05$).

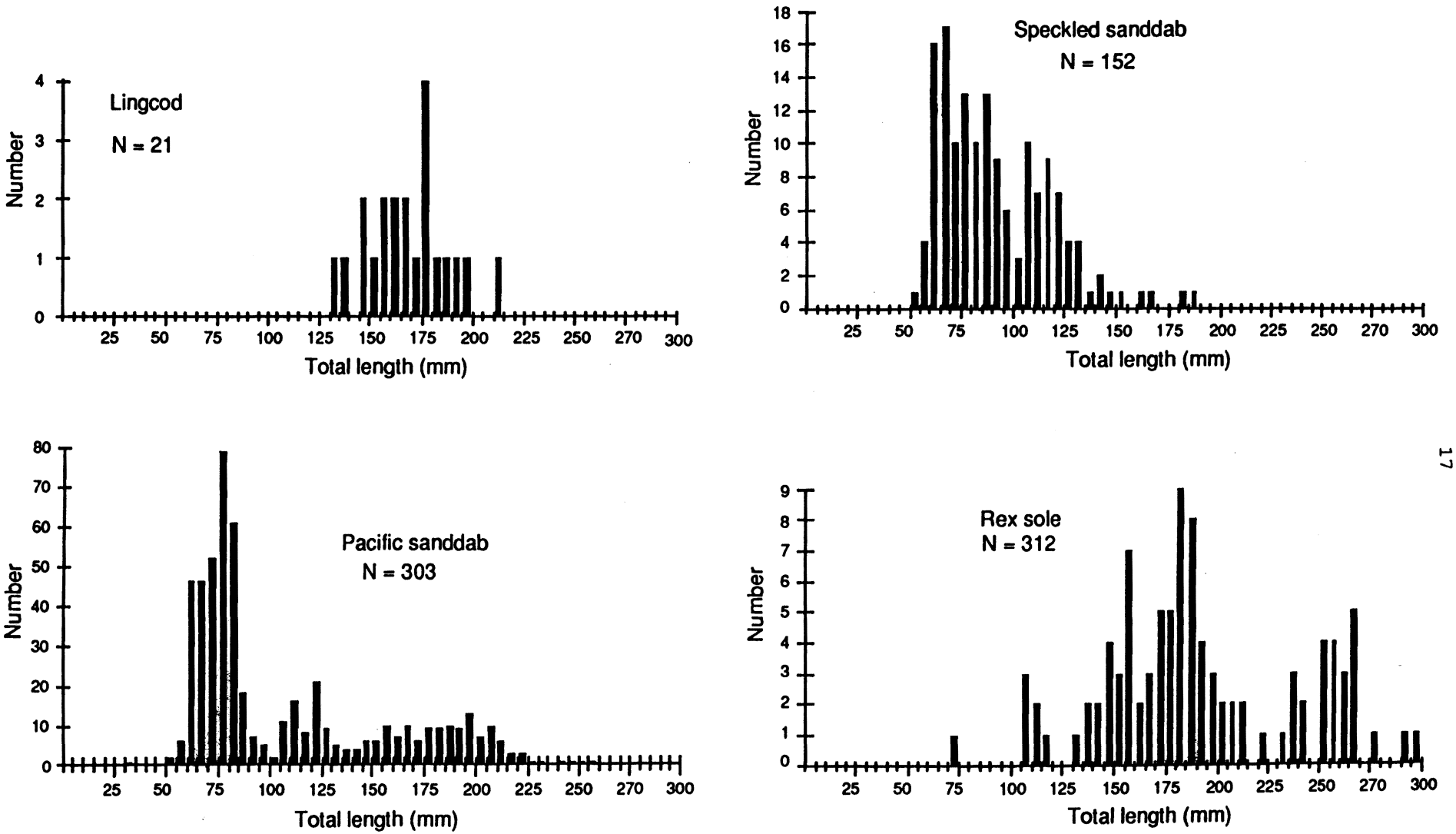

Figure 3.--Length-frequency distributions of lingcod, speckled sanddab, Pacific sanddab, and rex sole captured at 10 trawling stations off Tillamook Bay, Oregon, September 1990. Fish >300 mm long are included in the 296- to 300-mm size interval.

Table 9.--Median grain size (phi) found at benthic stations sampled during five surveys off Tillamook Bay, Oregon.

Station	Depth (ft)	Depth (m)	Sep 84	Jan 85	Jul 85	Oct 88	Sep 90
TR1	60	18	3.00	3.10	*	*	4.00
TR2	100	30	3.10	3.20	*	*	3.30
TR3	60	18	3.10	2.90	*	*	3.30
TR4	100	30	3.10	3.00	*	*	3.20
T11	60	18	3.00	2.80	2.70	*	2.90
T12	70	21	3.00	3.10	3.00	*	3.10
T13	80	24	3.10	2.90	3.00	*	3.10
T14	90	27	3.10	3.00	3.10	*	3.30
T15	100	30	3.00	2.90	3.10	*	3.10
T16	116	35	3.00	3.00	3.20	*	3.30
T21	66	20	2.70	2.70	2.90	*	3.20
T22	70	21	2.90	2.80	3.00	*	3.00
T23	80	24	3.00	2.80	3.00	*	3.00
T24	93	28	3.00	3.00	3.00	*	3.00
T25	100	30	3.10	2.90	3.00	*	3.20
T26	115	35	3.00	2.90	3.10	*	3.10
T31	60	18	3.00	3.00	3.00	*	3.20
T32	70	21	3.00	3.00	3.00	*	3.20
T33	77	23	3.00	3.00	3.00	*	3.20
T34	87	27	3.00	3.10	3.00	*	3.00
T35	97	30	3.10	3.10	3.10	*	3.20
T36	111	34	3.10	3.10	3.10	*	3.10
T115	115	35	*	*	*	3.10	3.10
T120	120	37	*	*	*	3.10	3.10
T140	141	43	*	*	*	3.20	3.40
T160	160	49	*	*	*	3.10	3.10
T180	183	56	*	*	*	3.10	3.30
T200	204	62	*	*	*	3.10	3.10
T220	222	68	*	*	*	3.10	3.30
T240	246	75	*	*	*	3.10	3.20
TN200	200	61	*	*	*	2.10	3.20
TN240	242	74	*	*	*	3.10	3.00
TS200	207	63	*	*	*	3.10	3.10
TS240	246	75	*	*	*	3.20	3.10
Mean			3.02	2.97	3.02	3.03	3.18
S.D.			0.09	0.12	0.10	0.30	0.18

* Station not sampled during this survey.

Table 10.--Percent silt/clay of sediments found at benthic stations sampled during five surveys off Tillamook Bay, Oregon.

Station	Depth (ft)	Depth (m)	Sep 84	Jan 85	Jul 85	Oct 88	Sep 90
TR1	60	18	0.60	1.00	*	*	6.40
TR2	100	30	0.40	2.00	*	*	1.20
TR3	60	18	0.80	0.10	*	*	0.40
TR4	100	30	1.00	1.00	*	*	1.20
T11	60	18	0.60	0.10	0.00	*	0.20
T12	70	21	0.40	1.00	0.00	*	0.20
T13	80	24	1.00	0.10	0.00	*	0.10
T14	90	27	0.80	1.00	1.00	*	0.20
T15	100	30	0.30	0.10	1.00	*	0.50
T16	116	35	0.70	1.00	0.00	*	1.60
T21	66	20	0.70	0.10	1.00	*	0.20
T22	70	21	0.20	0.10	1.00	*	0.30
T23	80	24	0.20	0.10	1.00	*	0.60
T24	93	28	0.50	1.00	1.00	*	0.30
T25	100	30	1.30	0.10	0.00	*	1.60
T26	115	35	0.50	0.10	1.00	*	0.90
T31	60	18	0.50	0.10	1.00	*	0.20
T32	70	21	0.40	0.10	0.00	*	0.10
T33	77	23	0.30	1.00	1.00	*	0.30
T34	87	27	1.30	1.00	0.00	*	2.30
T35	97	30	3.80	1.00	1.00	*	0.70
T36	111	34	0.60	1.00	1.00	*	1.00
T115	115	35	*	*	*	0.60	1.50
T120	120	37	*	*	*	0.50	0.80
T140	141	43	*	*	*	0.80	1.20
T160	160	49	*	*	*	0.40	0.80
T180	183	56	*	*	*	0.90	1.10
T200	204	62	*	*	*	0.90	1.00
T220	222	68	*	*	*	1.10	1.10
T240	246	75	*	*	*	3.10	1.10
TN200	200	61	*	*	*	0.30	1.40
TN240	242	74	*	*	*	1.70	0.90
TS200	207	63	*	*	*	0.90	0.80
TS240	246	75	*	*	*	1.90	1.10
Mean			0.77	0.60	0.61	1.09	0.98
S.D.			0.75	0.55	0.50	0.79	1.09

* Station not sampled during this survey.

The high benthic invertebrate densities (relative to other Oregon coastal areas) at the shallow-water stations (TR1 through T36) during September 1990 correspond closely to the September 1984 survey (Table 2). The benthic invertebrate density at Station T25 (145,582/m^2 in September 1990) is the highest density reported for the Oregon/Washington coast. This station is located in the interim ODMDS. Some of the lowest densities occurred at the stations just south of the interim ODMDS (Stations T31, T32, T33, and T34). However, these densities are still higher than are typically found in similar areas along the Oregon coast (Emmett et al. 1987).

At least twice the number of invertebrate taxa were reported from the September 1990 survey than from previous surveys (Table 1, Appendix Table 2). In part, there appeared to be more species inhabiting the area off Tillamook Bay in late 1990. The larger number of taxa identified in 1990 was also due to identification of more taxa to species than occurred for previous surveys. Nevertheless, many specimens in the 1990 collection could not be identified to species, some of which we suspect may not yet be described in the scientific literature.

Although benthic invertebrate densities from the September 1990 survey varied widely, the sediment structure did not (Tables 6-8). This indicates that different factors (biological and physical processes) are probably more important in controlling benthic invertebrate densities.

During the October 1988 sampling, most of the trawls filled with macroalgae and blades of *Zostera* spp. (Emmett et al. 1990), which may have directly affected catch rates. In 1990, few macroalgae were collected in the trawls and were not suspected of reducing trawl efficiencies. Fish and epibenthic densities in September 1990 were much higher than October 1986 densities, but similar to September 1984. We believe the trawl data in this report accurately describe the fish and epibenthic invertebrate community offshore from Tillamook Bay.

Most of the fishes and Dungeness crabs captured during the September 1990 survey were juveniles, similar to previous findings. Whether the area off Tillamook Bay is particularly important for some fish and crab species is unknown, since most of the nearshore waters off Oregon and Washington have not been surveyed.

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Appendix Table 1.--Continued.

Station	Depth (ft)	Depth (m)	Loran Readings Beginning		Loran Readings Ending	
			TRAWL STATIONS			
T1	61	19	12378.8	28006.2	12376.7	28006.8
T4	91	28	12381.1	28005.3	12379.4	28005.7
T110	110	34	12380.2	28004.9	12378.5	28005.5
T180	180	55	12381.2	28001.7	12379.3	28002.1
T200	201	61	12382.0	28000.4	12380.2	28000.8
T220	217	66	12383.9	27998.9	12382.0	27999.1
TN200	198	60	12372.9	28001.7	12371.4	28002.0
TN220	217	66	12379.1	27999.7	12377.3	27999.8
TS200	199	61	12393.9	27998.4	12391.5	27998.9
TS220	222	68	12391.5	27997.4	12392.5	27997.2

Appendix Table 2.--Continued.

Phyllodoce maculata
Phyllodoce multipapillata
Hesionidae
Gyptis spp.
Hesionella mccullochae
Heteropodarke heteromorpha
Kefersteinia cirrata
Microphthalmus spp.
Microphthalmus sczelkowii
Micropodarke dubia
Ophiodromus pugettensis
Parandalia fauveli
Podarkeopsis glabrus
Syllidae
Autolytus (=*Proceraea*) spp.
Autolytus cornutus
Exogone lourei
Pionosyllis uraga
Sphaerosyllis brandhorsti
Streptosyllis latipalpa
Syllis spp.
Syllis hyperioni
Typosyllis spp.
Nereidae
Cheilonereis cyclurus
Nereis spp.
Nereis procera
Nereis zonata
Platynereis bicanaliculata
Nephtyidae
Nephtys spp.
Nephtys caeca
Nephtys caecoides
Nephtys ferruginea
Nephtys longosetosa
Nepthys punctata
Sphaerodoridae
Sphaerodoropsis spaerulifer
Glyceridae
Glycera spp.
Glycera americana
Glycera capitata
Glycera convoluta
Glycera tenuis
Goniadidae
Glycinde spp.
Glycinde armigera
Glycinde picta
Goniada brunnea
Goniada maculata
Onuphidae
Diopatra ornata
Onuphis spp.
Onuphis sp. (intermediates)
Onuphis elegans
Onuphis iridescens

Appendix Table 2.--Continued.

Magelonidae
- *Magelona* spp.
- *Magelona hartmanae*
- *Magelona hobsonae*
- *Magelona longicornis*
- *Magelona sacculata*

Chaetopteridae
- *Chaetopterus variopedatus*
- *Mesochaetopterus taylori*
- *Phyllochaetopterus* spp.
- *Phyllochaetopterus prolifica*
- *Spiochaetopterus costarum*

Cirratulidae
- *Aphelochaeta* (=*Tharyx*) *secundus*
- *Aphelochaeta multifilis*
- *Caulleriella alata*
- *Chaetozone* spp.
- *Chaetozone setosa*
- *Chaetozone spinosa*
- *Cirratulus* spp.
- *Cirratulus cirratus*
- *Tharyx* spp.

Flabelligeridae
- *Flabelligera affinis*
- *Pherusa* spp.
- *Pherusa neopapillata*
- *Pherusa plumosa*

Scalibregmidae
- *Scalibregma inflatum*

Opheliidae
- *Armandia brevis*
- *Ophelia* spp.
- *Ophelia limacina*
- *Ophelina* spp.
- *Ophelina acuminata*
- *Polyopthalmus* spp.
- *Travisia brevis*
- *Travisia pupa*

Capitellidae
- *Capitella capitata* complex
- *Barantolla americana*
- *Decamastus gracilis*
- *Heteromastus filiformis*
- *Notomastus* spp.
- *Notomastus tenuis*
- *Notomastus lineatus*
- *Mediomastus* spp.
- *Mediomastus acutus*
- *Mediomastus californiensis*

Maldanidae
- *Asychis* spp.
- *Axiothella rubrocincta*
- *Euclymene* spp.
- *Isocirrus longiceps*
- *Rhodine bitorquata*

Appendix Table 2.--Continued.

Bittium cf. *subplanatum*
Epitonium
Epitonium indianorum
Naticidae
Polinices spp.
Muricidae
Columbellidae
Amphissa columbiana
Mitrella gouldi
Buccinidae
Searlesia dira
Nassariidae
Nassarius spp.
Nassarius fossatus
Nassarius mendicus
Olividae
Olivella spp.
Olivella baetica
Olivella biplicata
Olivella pycna
Turridae
Kurtziella plumbea
Pyramidellidae
Odostomia spp.
Turbonilla spp.
Cephalaspidea
Cylichnidae
Cylichna spp.
Cylichna alba
Cylichnella culcitella
Scaphander willetti
Aglajidae
Aglaja spp.
Aglaja diomedeum
Gastropteridae
Gastropteron pacificum
Diaphanidae
Diaphana spp.
Clionidae
Clione spp.
Nudibranchia
Pelecypoda
Nuculidae
Acila castrensis
Nucula tenuis
Nuculanidae
Yoldia scissurata
Mytilidae
Modiolus spp.
Pectenidae
Thyasiridae
Axinopsida serricata
Montacutidae
Mysella tumida
Cardiidae
Clinocardium spp.

Appendix Table 2.--Continued.

Neomysis rayii
Pacifacanthomysis nephrophthalma
Cumacea
Lampropidae
Hemilamprops spp.
Hemilamprops californica
Lamprops tomalesi
Leuconidae
Leucon spp.
Epileucon sp. A
Eudorella pacifica
Diastylidae
Colurostylis occidentalis
Diastylis spp.
Diastylis abbotti
Diastylopsis spp.
Diastylopsis dawsoni
Diastylopsis tenuis
Nannastacidae
Campylaspis sp. D
Cumella vulgaris
Tanaidacea
Paratanaidae
Leptochelia dubia
Leptognathia spp.
Isopoda
Anthuridea
Haliophasma geminata
Flabellifera
Bathycopea daltonae
Exosphaeroma amplicauda
Gnorimosphaeroma spp.
Gnorimosphaeroma noblei
Gnorimosphaeroma oregonensis
Idoteidae
Edotea sublittoralis
Idotea spp.
Idotea fewkesi
Synidotea spp.
Synidotea angulata
Synidotea bicuspida
Janiridae
Ianiropsis spp.
Ianiropsis kincaidi
Ianiropsis kincaidi kincaidi
Munnidae
Munnogonium waldronense
Amphipoda
Gammaridea
Ampeliscidae
Ampelisca spp.
Ampelisca agassizi
Ampelisca macrocephala
Ampelisca careyi
Haploops spp.

Appendix Table 2.--Continued.

- Oedicerotidae
  - *Monoculodes spinipes*
  - *Synchelidium shoemakeri*
  - *Westwoodilla caecula*
- Phoxocephalidae
  - *Metaphoxus frequens*
  - *Foxiphalus obtusidens*
  - *Mandibulophoxus uncirostratu*
  - *Rhepoxynius* spp.
  - *Rhepoxynius abronius*
  - *Rhepoxynius daboius*
  - *Rhepoxynius lucubrans*
  - *Rhepoxynius vigitegus*
  - *Rhepoxynius menziesi*
  - *Grandifoxus grandis*
  - *Eobrolgus spinosus*
- Pleustidae
  - *Pleusmytes* spp.
  - *Pleusmytes subglaber*
  - *Parapleustes den*
- Podoceridae
  - *Dulichia* spp.
- Stenothoidae
- Synopiidae
  - *Tiron biocellata*

Hyperiidea
- Hyperiidae
  - *Hyperoche* spp.
  - *Hyperoche medusarium*

Caprellidea
- Caprellidae

Decapoda
- Hippolytidae
  - *Heptacarpus* spp.
- Crangonidae
  - *Crangon* spp.
  - *Crangon alaskansis*
  - *Lissocrangon stylirostris*
- Callianassidae
  - *Callianassa* spp.
  - *Callianassa californiensis*
- Paguridae
  - *Pagurus* spp.
  - *Pagurus armatus*
  - *Pagurus setosa*
- Porcellanidae

Brachyura
- Majidae
  - *Pugettia* spp.
- Cancridae
  - *Cancer* spp.
  - *Cancer gracilis*
  - *Cancer magister*
- Grapsidae

Appendix Table 2.--Continued.

Echinodermata	
Asteroidea	
Platyasterida	
Luidiidae	
Luidia foliolata	sand star
Forcipulatida	
Asteriidae	
Pisaster ochraceus	Pacific sea star
Pycnopodia helianthoides	sunflower star
Echinoidea	
Clypeasteroida	
Dendrasteridae	
Dendraster excentricus	sand dollar
Chordata	
Elasmobranchiomorphi	
Chimaeriformes	
Chimaeridae	
Hydrolagus colliei	spotted ratfish
Osteichthyes	
Salmoniformes	
Osmeridae	
Allosmerus elongatus	whitebait smelt
Spirinchus thaleichthys	longfin smelt
Gadiformes	
Gadidae	
Microgadus proximus	Pacific tomcod
Gasterosteiformes	
Gasterosteidae	
Aulorhynchus flavidus	tube-snout
Syngnathidae	
Syngnathus leptorhynchus	bay pipefish
Perciformes	
Embiotocidae	
Cymatogaster aggregata	shiner perch
Bathymasteridae	
Scorpaeniformes	
Scorpaenidae	unidentified rockfish
Anoplopomatidae	
Anoplopoma fimbria	sablefish
Hexagrammidae	
Ophiodon elongatus	lingcod
Cottidae	
Chitonotus pugetensis	roughback sculpin
Hemilepidotus hemilepidotus	red Irish lord
Hemilepidotus spinosus	brown Irish lord
Icelinus tenius	spotfin sculpin
Leptocottus armatus	Pacific staghorn sculpin
Radulinus asprellus	slim sculpin
Scorpaenichthys marmoratus	cabezon
Agonidae	
Agonopsis vulsa	northern spearnose poacher
Occella verrucosa	warty poacher
Stellerina xyosterna	pricklebreast poacher
Bathyagonus infraspinatus	spinycheek starsnout

Appendix Table 3.--Summaries of benthic invertebrate collections (by station) off Tillamook Bay, Oregon, September 1990.

(Because of its length, this Appendix Table was not included in this report but can be obtained by writing to the authors.)

Appendix Table 4.--Continued.

Station: T4

Gear: 8-m Trawl
Date: 12 Sep 1990
Depth: 28.3 m
Distance traveled: 389 m

Taxon	No. captured	Total wt.(g)	No. per hectare	Wt. per hectare
Spotted ratfish	3	1,013	15	5,208
Longfin smelt	1	10	5	51
Pacific tomcod	8	100	41	514
Tube-snout	2	8	10	41
Lingcod	12	317	62	1,630
Pacific staghorn sculpin	2	78	10	401
Warty poacher	2	3	10	15
Pricklebreast poacher	3	8	15	41
Pacific sanddab	8	634	41	3,260
Speckled sanddab	55	639	283	3,285
Butter sole	5	619	26	3,183
English sole	41	365	211	1,877
Sand sole	15	1,308	77	6,725
Dungeness crab	3	3	15	15
Northern crangon	54	14	278	77
California bay shrimp	15	14	77	75
Blacktail bay shrimp	9	4	46	22
Smooth bay shrimp	50	5	257	30
Pacific sea star	1	57	5	293
TOTALS	289	5,201	1,484	26,743

H = 3.33 E = 0.78

Appendix Table 4.--Continued.

Station: T180

Gear: 8-m Trawl
Date: 13 Sep 1990
Depth: 54.3 m
Distance traveled: 426 m

Taxon	No. captured	Total wt.(g)	No. per hectare	Wt. per hectare
Spotted ratfish	2	157	9	737
Pacific tomcod	4	50	19	235
Lingcod	1	33	5	155
Roughback sculpin	3	33	14	155
Brown Irish lord	2	9	9	42
Spotfin sculpin	3	44	14	207
Pacific staghorn sculpin	1	45	5	211
Northern spearnose poacher	2	4	9	19
Showy snailfish	2	4	9	19
Pacific sanddab	146	2,243	685	10,531
Speckled sanddab	7	277	33	1,300
Petrale sole	1	34	5	160
Rex sole	3	79	14	371
Arrowtooth flounder	3	146	14	685
English sole	14	488	66	2,291
Dover sole	1	29	5	136
Dungeness crab	17	20	80	94
Red rock crab	6	29	28	136
Longhorn decorator crab	1	<1	5	1
Northern crangon	13	4	61	21
Stout coastal shrimp	6	3	28	14
Prawn	9	15	42	75
Sand star	1	63	5	296
Sand dollar	2	139	9	653
TOTALS	250	3,949	1,173	18,544

H = 2.62 E = 0.57

Appendix Table 4.--Continued.

Station: T220

Gear: 8-m Trawl
Date: 13 Sep 1990
Depth: 66.8 m
Distance traveled: 444 m

Taxon	No. captured	Total wt.(g)	No. per hectare	Wt. per hectare
Spotted ratfish	1	82	5	369
Slim sculpin	3	8	14	36
Pacific sanddab	107	2,500	482	11,261
Petrale sole	2	78	9	351
Rex sole	9	494	41	2,225
Arrowtooth flounder	5	137	23	617
English sole	4	353	18	1590
Dover sole	6	170	27	766
Northern crangon	35	16	158	74
Sand star	1	66	5	297
TOTALS	173	3,904	782	17,586

H = 1.82 E = 0.55

Appendix Table 4.--Continued.

Station: TN220

Gear: 8-m Trawl
Date: 13 Sep 1990
Depth: 66.8 m
Distance traveled: 463 m

Taxon	No. captured	Total wt.(g)	No. per hectare	Wt. per hectare
Spotted ratfish	1	164	4	708
Slim sculpin	2	1	9	5
Spinycheek starsnout	1	4	4	17
Showy snailfish	3	3	13	13
Bathymasteridae	1	13	4	56
Pacific sanddab	63	1,560	272	6,739
Rex sole	14	747	60	3,227
Arrowtooth flounder	9	363	39	1,568
Dover sole	3	58	13	251
Dungeness crab	39	39	168	168
Furrowed rock crab	3	3	13	16
Northern crangon	24	11	104	51
California bay shrimp	1	<1	4	3
Stout coastal shrimp	8	1	35	7
Prawn	2	1	9	5
TOTALS	174	2,971	751	12,834

H = 2.75 E = 0.70

Appendix Table 4.--Continued.

Station: TS220

Gear: 8-m Trawl
Date: 12 Sep 1990
Depth: 68.6 m
Distance traveled: 222 m

Taxon	No. captured	Total wt.(g)	No. per hectare	Wt. per hectare
Lingcod	2	118	18	1,063
Pacific staghorn sculpin	1	94	9	847
Slim sculpin	21	49	189	441
Spinycheek starsnout	1	2	9	18
Showy snailfish	3	11	27	99
Bathymasteridae	1	4	9	36
Pacific sanddab	377	3,880	3,396	34,955
Rex sole	28	1,618	252	14,577
Arrowtooth flounder	10	154	90	1,387
English sole	19	1,709	171	15,396
Dover sole	22	670	198	6,036
Pygmy rock crab	1	2	9	18
Longhorn decorator crab	1	0	9	8
Northern crangon	113	477	1,018	4,303
California bay shrimp	1	1	9	9
Stout coastal shrimp	4	0	36	4
Sand star	2	183	18	1,649
Sunflower star	1	357	9	3,216
TOTALS	608	9,330	5,476	84,062

H = 1.92 E = 0.46