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of Engineers and Columbia River Programs Office

AN INVESTIGATION OF THE BENTHIC INFAUNA AT TWO DREDGE AND FOUR DREDGE DISPOSAL SITES ADJACENT TO THE MOUTH OF THE COLUMBIA RIVER

by

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INTRODUCTION

The Portland District, Corps of Engineers, annually, has the responsibility of dredging and disposing of between 1.5 and 5.9 million cubic yards of dredged material from the channel of the Columbia River estuary. This material is removed by a hopper dredge and is spoiled in areas that have been designated by the Corps in consultation with water use and pollution control agencies. The sites available for the disposal of dredged material within the estuary, and offshore of the mouth of the river are designated as A, B, D, E and F (Fig. 1). During 1974 only sites B, D, E and F were used as disposal sites by the Corps. The site that is used for dredge disposal activity is flexible in that alternate sites are available in the case that inclement weather conditions restricts or prohibits use of specific sites. Other factors important in the selection of a disposal site include where the material is dredged in the estuary, the distance between dredge and dredge disposal sites, and the total quantity of material that has been disposed of on a specific site. An annual project of this type and magnitude potentially has serious implications in a biologically productive estuary.

The National Marine Fisheries Service (NMFS) was requested to enter into a cooperative study with the Corps to develop the techniques for assessing the effects of dredging and spoiling on the benthic fauna of this area, and to make a preliminary or "pilot study" of these effects. The "pilot study" was divided into two parts, i.e., a study of the effects on demersal finfish and shellfish, and a study

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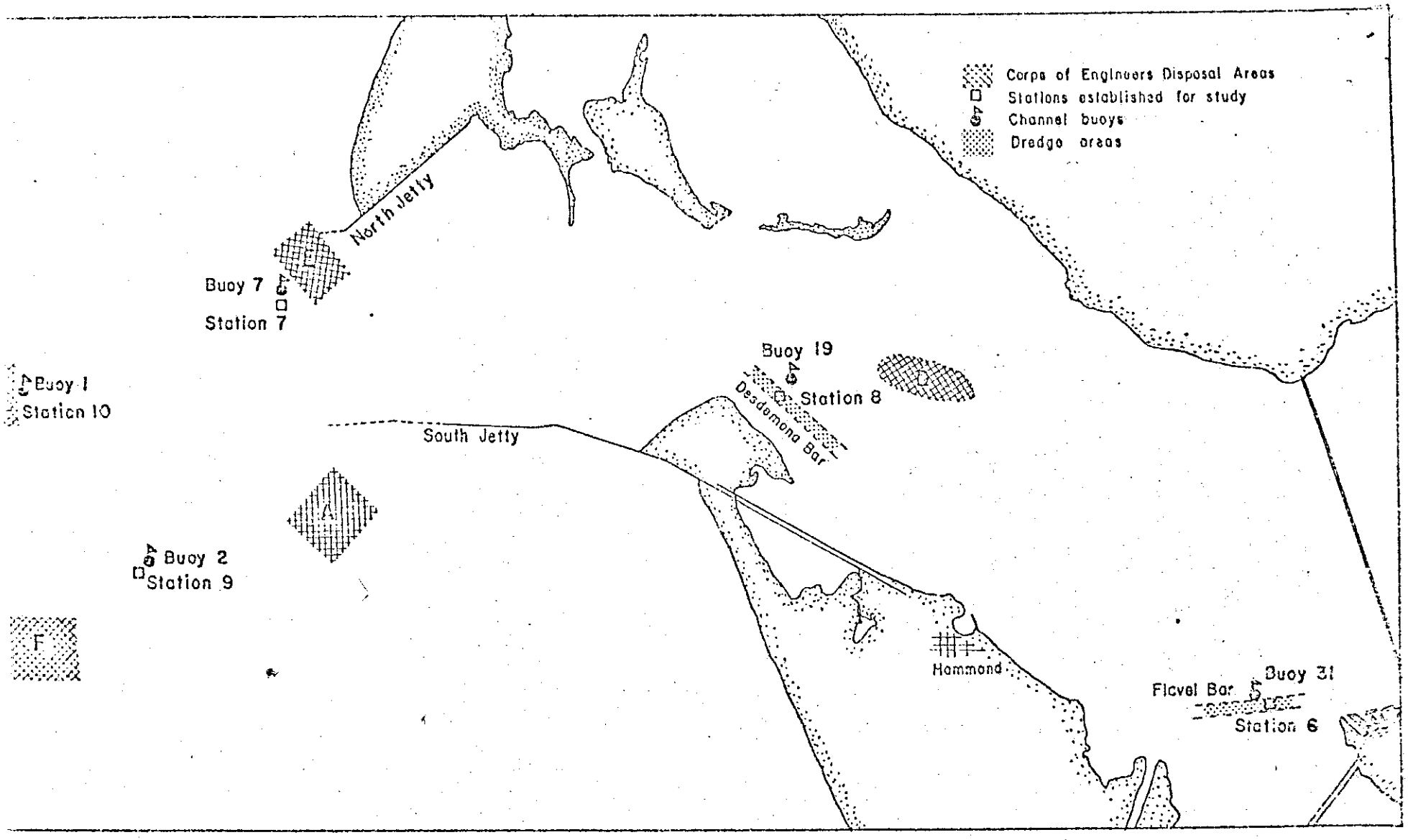

Figure 1.--Study area in lower Columbia River and offshore areas showing Corps of Engineers dredge disposal areas, areas dredged during the study, stations established for the present study, and associated channel buoys.

of the effects on benthic infauna. The results of the "pilot" study on the effects of dredging and dredge disposal on the benthic infauna is presented here.

AREAS STUDIED

Station 6:

Station 6 was approximately at Columbia river mile 12. It was located at the intersection of a line between buoys 33 and 35A and a line between the municipal water tower, the west corner of the most westerly warehouse and buoy 31, in an area known as Flaval bar. From 1968-72 an annual average of 430,938 cubic yards has been dredged from this area. A survey of this area in April, 1974, by the Corps of Engineers showed a depositional site that had formed a bar along the edge of the channel since the conclusion of dredging in November, 1973. This area was large enough for a demersal fish survey (had sufficient length for a 5-minute net tow), was scheduled to be dredged, and thus was chosen for dredging and then upon request the area was dredged. Samples were taken in June and July subsequent to dredging.

Station 7:

Station 7 was located 150 yards southwest of buoy 7, adjacent to the Corps of Engineers spoil site E (Fig. 1) which has been actively used since 1973. During the fiscal years 1973 and 1974 this area received 2,460,077 cubic yards of material. For this study the Corps agreed to deposit the material at the location southwest of the buoy giving

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a good positioning reference for disposal and sampling. This site was in use prior to the initiation of our sampling program. Samples were taken in June and August to assess the effects of a continued disposal program.

Station 8:

Station 8 was located at mile 5 of the Columbia River at the intersection of a line between buoys 14 and 22 and a line between the tower on Clatsop Spit buoy 19 (Desdemona Bar). From 1968 to 1972 an annual average of 178,995 cubic yards of material had been dredged from this area. A Corps of Engineers bottom contour survey in April of 1974 showed an area of deposition in this area. Like station 6 it was chosen as a dredging effects site due to its adequate sampling size and an approved schedule for dredging. The station was sampled in May and early June prior to dredging; samples were taken in late June and August subsequent to dredging.

Station 9:

Station 9 was located 150 yards southwest of buoy 2 to give a good positioning reference for dredge disposal and sampling. This site was adjacent to the Corps of Engineers disposal site F (Fig. 1). Site F has been actively used since fiscal year 1966 but had only received a total of 671,162 cubic yards through FY 1974. This area was sampled in May and August without disposal while the other stations were being used for dredged disposal. The Corps was requested in late August to deposit dredged material at this site and a September sample was taken subsequent to this.

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Station 10:

Station 10 was located 150 yards southwest of buoy 1. This was the most seaward site of active dredge disposal and is designated by the Corps of Engineers as site B. From 1957 through fiscal year 1974, a total of 31,383,444 cubic yards of dredged material have been dumped on this site. The disposal activity was initiated prior to and continued through our sampling program. Samples were taken in May, June and August.

To assure that the dredging and dredged disposal to be done by request was on the chosen sites, observers were placed on the hopper dredge "Biddle" for a 2-day period. The observers were to determine the dredging location, the amount of material dredged from stations 6 and 8, and determine the amount of material depostied on stations 7 and 10. Station 9 was not being used for dredged material disposal at that time. A lack of communication with the Corps of Engineers and mechanical failure of the dredge reduced the effectiveness of this effort considerably.

METHODS

Samples were obtained on a 40-foot boat operated by staff of the Hammond field station, National Marine Fisheries Service. Sampling stations were located by visual sighting of intersecting ranges or by using a compass heading and estimation of distance from buoys. The boat was anchored whenever possible during the sampling procedure. The bottom material was obtained with a 0.2 m^2 van Veen grab. Six

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replicate samples were taken at all stations on all scheduled surveys (except station 6 during the June sample); only 4 replicates were taken on this data due to inclement weather conditions. Six replicates were collected to assure adequate consistancy of the samples to describe the faunal assemblages.

The samples were sieved through a 1 mm stainless steel screen onboard, and preserved in 5-10% formaldehyde solution, buffered with sodium acetate. The samples were sorted under a microscope, in the laboratory, to separate organisms from debris; then the animals were separated into taxonomic groups. The Amphipoda, Cumacea, Isopoda, Pelecypoda, and Gastropoda from each sample were identified to species where possible and counted. The Ophuroidea, Ostracoda, Echinoida and brachyuran decapods were not identified to species, but were counted.

The wet weights of each taxonomic group were determined (samples were dried on filter paper). Tests showed that there was an initial rapid loss of weight during the first 5 minutes of drying which reached an asymptote in 7-10 minutes. Thus, all samples were dried 10 minutes before weighing. All animals were weighed as captured i.e., pelecypods and gastropods in their shells. Three taxonomic groups, nemertina, sipunculida, and polychaeta, were weighed, but were included in the count data only as being present due to the difficulty in classifying them taxonomically, and recognizing parts of animals. The ash-free dry weight of each group was calculated using the wet weight/organic matter relationships suggested by Lie (1968). The factors used were .133 for polychaeta, .150 for crustaceans, .055 for lamillabranchs, .122 for ophuroids, .033 for echinoids, .130 for sipunculoids, and .133 for nemertia.

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Epifaunal forms such as mysids and anomuran shrimp were counted but their numbers are not included in the total. These animals are highly motile and are not sampled with the same efficiency as the infauna. However, the numbers of these animals found on separate dates does indicate their relative abundance (see count tables); the wet weights of these animals were not determined.

RESULTS

Impact of Dredging

Station 6:

A total of 626,766 cubic yards of material was removed from Flavel Bar between March to October, 1974. However, on the station chosen, the specific area was dredged between the May and June sampling dates.

The sediments at this station are primarily fine sand that is easily washed through a 1 mm screen. A high content of wood fiber was noted in the June and July samples.

The benthic infauna is dominated by the amphipod *Eohaustorius washingtonianus* which represented from 80-95% of the animals present (Table 1). Two other amphipods represented between 5-15% of the remaining animals. The total number of animals decreased by 50% between the first and second samples, by 33% between the second and third, and by 33% between the third and fourth samples (Table 2).

The samples show a low diversity of species. A total of 12 taxa were found over all sample dates. The April sample had 9 taxa while the June sample had only 3. However, for the June sample only 4

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Table 1:--Benthic species composing 95% of the number of individuals during each sampling period at station 6, April-July, 1974.

Species	4/18/74 (%)	5/30/74 (%)	6/22/74 (%)	7/16/74 (%)
Eohaustorius washingtonianus	93.8	90.0	80.1	94.2
Anisogammarus confervicolous	2.8	2.4	7.5	2.6
Corophium salmonis		7.1	12.3	2.2

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Table 2:--Abundance (N) and rank (R) of benthic species from station 6, April-July, 1974.

Species	Before Dredging				After Dredging			
	4/13/74		5/30/74		6/22/74		7/16/74	
	1.2 m^2		1.2 m^2		1.2 m^2		1.2 m^2	
	N	R	N	R	N	R	N	R
CRUSTACEA								
Amphipoda								
Eohaustorius washingtonianus	1691	1	862	1	246	1	212	1
Anisogammarus confervicolous	51	2	23	3	23	3	6	2
Corophium salmonis	47	3	68	2	38	2	5	3
Paraphoxus obtusidens	-	-	1	5	-	-	-	-
Paraphoxus sp.	1	5	-	-	-	-	-	-
Isopoda								
Saduria entomon	1	5	4	4	-	-	-	-
Mysidacea *	1	-	-	-	-	-	1	-
MOLLUSCA								
Pelecypoda								
Macoma baltica	6	4	1	5	-	-	-	-
ANNELIDA								
Polychaeta	P	-	-	-	-	-	P	-
NEMERTIA	P	-	-	-	-	-	-	-
INSECTA								
Diptera larvae	1	5	-	-	-	-	-	-
TOTAL	1802		958		307		225	

* Not included in totals

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replicates were taken. The count data has been corrected to represent number of organisms per 1.2 m^2 for comparison with the other data. This does not correct for possible additional species caught due to increased sampling effort. Consequently the June data may underestimate the number of species.

The pelecypods and isopods are not found after dredging. These groups represent about 3% of the total April biomass and 5% of the May biomass. The contribution of these "rare" groups represents a small proportion of the biomass and total number when compared to the dominant amphipods at this station. Biomass decreased from 1,019 milligrams per 1.2 m^2 on the first samples to a low of 164 milligrams per 1.2 m^2 on the fourth sample (Table 3).

Station 8:

The specific area designated as station 8 was dredged between the early and late June samples. However, from the lower Desdemona Bar a total of 398,772 cubic yards of material was dredged from March to October, 1974.

The sediments at station 8 were of a black sandy mud easily sieved through a 1 mm screen. Clay balls from 5-200 mm were intermittently present. Some wood debris was present during all sampled periods.

The benthic infauna at this station is dominated by the amphipods *Anisogammarus confervicolous* and *Paraphoxus milleri* which accounted for 80-98% of the total number of animals (Table 4). In the May and June 21 samples, 95% of the animals were represented by 6 taxonomic categories. The June 11 samples had 95% of the individuals in 4 taxa

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Table 3:--Wet weight (W) and dry weight (D) [1/] of benthic species from station 6 in milligrams per 1.2 m^2, April-July, 1974.

Species	4/18/74		5/30/74		6/22/74		7/16/74	
	W	D	W	D	W	D	W	D
Amphipoda	6574	986	3977	597	1402	210	10920	164
Polychaeta	033	004	>001					
Nemertina	010	001						
Pelecypoda	506	028	625	034				
TOTAL	7123	1019	4602	631	1402	210	10920	164

1/ Calculated from the factors ascertained by Lie (1968).

Table 4:--Benthic species composing 95% of the number of individuals during each sampling period at station 8, April-August, 1974.

Species	5/2/74 (%)	6/11/74 (%)	6/21/74 (%)	8/6/74 (%)
Anisogammarus confervicolous	64.6	2.4	69.4	4.2
Paraphoxus milleri	13.4	82.5	11.1	93.9
Corophium salmonis	6.1		5.5	
Corophium spinicorne	2.4		2.7	
Eohaustorius washingtonianus	2.4	7.9	2.7	
Saduria entomon		2.4		
Macoma baltica	7.3		2.7	

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and in the August samples one species of amphipod accounted for almost 94% of the individuals in the sample. Only during the early June samples were these two not ranked first and second (Table 5); at that date Eohaustorius washingtonianus ranked second to Paraphoxus milleri. The numerical dominance changes at each sampling date between Anisogammarus and Paraphoxus. A total of 14 taxonomic categories were found over all sampling periods. The number of taxa decreased from 10 during May to 6 during August. Only 3 of these taxa are found in all sampling periods.

The total number of individuals increased from the May to June 11 samples, decreased dramatically in the June 21 samples after dredging, and increased to the highest number of animals in August. The biomass follows a similar pattern except that the highest biomass measured (186 mg/1.2 m^2) was in early June (Table 6). This was due to the large contirubtion by nemertine worms.

Impact of Dredge Disposal

Station 7:

Station 7 and the adjacent Corps of Engineers disposal site F were in use prior to the initiation of this study. In the period from March to October, 1974, 3,5000,237 cubic yards of material were disposed of on these sites.

The sediments at this station are of a fine sand that is easily sieved through a 1 mm screen. Wood debris was present in all samples.

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Table 5:--Abundance (N) and rank (R) of benthic species from station 8, April-August, 1974.

Species	Before dredging				After dredging			
	5/2/74		6/11/74		6/21/74		8/6/74	
	1.2 m^2		1.2 m^2		1.2 m^2		1.2 m^2	
	N	R	N	R	N	R	N	R
CRUSTACEA								
Amphipoda								
Anisogammarus confervicolous	53	1	3	3	25	1	7	2
Paraphoxus milleri	11	2	104	1	4	2	155	1
Corophium salmonis	5	4	1	6	2	3	-	-
Corophium spiricorne	2	5	-	-	1	4	-	-
Eohaustorius washingtonianus	2	5	10	2	1	4	-	-
Atylus tridens	1	7	-	-	-	-	-	-
Lysianassidae	-	-	-	-	-	-	1	3
Isopoda								
Saduria entomon	-	-	3	3	-	-	-	-
Mysidacea *	-	-	2	-	-	-	35	-
MOLLUSCA								
Pelecypoda								
Macoma baltica	6	3	2	5	1	4	1	3
Macoma sp.	-	-	1	6	-	-	-	-
Opisthobranchia	1	7	-	-	-	-	-	-
NEMERTIA	P	-	P	-	-	-	P	-
INSECTA								
Diptera larvae	1	7	-	-	1	4	-	-
TOTAL	82		126		36		165	

* Not included in totals

C40329

Table 6.--Wet weight (W) and dry weight [1/] (D) of benthic species from station 8, in milligrams per 1.2 m^2, April-August, 1974.

Species	5/2/74		6/11/74		6/21/74		8/6/74	
	W	D	W	D	W	D	W	D
Amphipoda	328	049	583	088	126	019	617	093
Nemertina	096	013	551	073			135	018
Pelecypoda	087	005	414	023	003		185	010
Isopoda			010	002				
TOTAL	512	067	1548	186	129	019	937	121

1/ Calculated from factors ascertained by Lie (1968).

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There is no single dominant taxa at this station. The amphipods, however, are the most important in number of individuals or species. Six species of amphipods in the June sample, and seven species in the August sample, represent 95% of the individuals (Table 7). There is a decrease in the number of individuals from 542 in June to 115 in the August sample (Table 8). Eight of seventeen taxonomic categories were common to the two sampling dates. A large number of mysids were sampled during both sampling periods. The biomass, however, increases between these dates due to a large increase in polychaete biomass, i.e., from 664 to 713 mg/1.2 m^2 (Table 9).

Station 9:

Station 9 was adjacent to the Corps of Engineers disposal site F. A total of 35,244 cubic yards of material was disposed of on these sites from March to October, 1974. The major portion of this disposal was done between the August and September sampling dates.

The sediments at station 9 were of a fine sand that was easily washed through a 1 mm screen. No wood chips or debris was found at this station.

A total of 45 taxa were found over all sample dates, eleven of which were common to all dates (Table 10). The total number of individuals changed very little between the three sampling dates. The assemblage at this station is characterized by the cumacean *Diastylopsis dawsoni* which ranked first in all sampling periods, and the gastropod *Olivella baetica* which ranked second in the May and August samples and third in the September samples. These two species represent 34

C40331

Table 7.--Benthic species composing 95% of the number of individuals during each sampling period at station 7, June-August, 1974.

Species	6/1/74 (%)	8/6/74 (%)
Paraphoxus obtusidens	18.8	26.1
Mandibulophoxus uncirostratus	40.8	17.4
Monoculodes spinipes	6.6	23.5
Paraphoxus milleri	5.5	6.1
Eohaustorius washingtonianus	15.3	2.6
Hippomedon denticulatus	9.8	9.6
Atylus tridens		12.2

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Table 8.--Abundance (N) and rank (R) of benthic species from station 7, June-August, 1974.

	Continual Dredge Disposal			
	6/1/74		8/6/74	
	1.2 m^2		1.2 m^2	
	N	R	N	R
CRUSTACEA				
Amphipoda				
Monoculodes spinipes	36	5	27	2
Synchelidium shoemakeri	1	-	-	-
Paraphoxus obtusidens	102	2	30	1
Paraphoxus milleri	30	6	7	6
Mandibulophoxus uncirostratus	221	1	20	3
Eohaustorius washingtonianus	83	3	3	7
Hippomedon denticulatus	53	4	11	5
Atylus tridens	-	-	14	4
Photis sp.	-	-	1	8
Cumacea				
Lamprops carinata	6	7	-	-
Diastylopsis dawsoni	5	8	-	-
Isopoda				
Tecticeps convexus	3	9	1	8
Erichsonella sp.	-	-	1	8
Mysidacea*	187	-	110	-
Anomura*	-	-	5	-
MOLLUSCA				
Pelecypoda				
Macoma baltica	1	-	-	-
ANNELIDA				
Polychaeta	1	-		-
TOTAL	542		115	

* Not included in totals.

C40333

Table 9.--Wet weight (W) and dry weight (D) 1/ of benthic species from Station 7 in milligrams per 1.2 m^2, June-August, 1974.

Species	6/1/74		8/6/74	
	W	D	W	D
Amphipoda	3402	510	951	142
Polychaeta	737	098	4291	571
Nemertina	001	>001		
Isopoda	319	048	003	0005
Cumacea	053	008		
TOTAL	4512	664	5245	713

1/ Calculated from factors ascertained by Lie (1968).

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Table 10.--Abundance (N) and rank (R) of benthic species from Station 9, May-September, 1974.

Species	Before Disposal 5/31/74 1.2 m^2 N	R	Before Disposal 8/6/74 1.2 m^2 N	R	After Disposal 9/18/74 1.2 m^2 N	R
CRUSTACEA						
Amphipoda						
Ampelisca macrocephala	34	3	34	4	23	7
Paraphoxus obtusidens	30	4	7	11	67	2
Paraphoxus vigitegus	15	6	13	7	12	10
Paraphoxus epistomus	-	-	4	17	-	-
Paraphoxus sp.	-	-	2	19	-	-
Paraphoxus variatus	1	18	1	23	-	-
Synchelidium shoemakeri	28	5	41	2	16	9
Monoculodes spinipes	9	11	29	5	19	8
Sympleustes subglaber	13	8	6	13	-	-
Eohaustorius washingtonianus	11	9	5	15	-	-
Photis californica	7	12	-	-	6	12
Atylus tridens	-	-	-	-	1	18
Lysianassidae	6	14	7	11	10	11
Anisogammarus confervicolous	1	18	-	-	-	-
Argissidae	2	17	1	23	-	-
Dulichia sp.	1	18	-	-	-	-
Podoceropsis sp.	-	-	1	23	-	-
Hyperidae	-	-	1	23	-	-
Cumacea						
Diastylopsis dawsoni	87	1	105	1	82	1
Hemilamprops californica	14	7	11	8	25	5
Colurostylus occendentalis	10	10	-	-	-	-
Diastylis alaskensis	-	-	5	15	-	-

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Table 10.--Abundance (N) and rank (R) of benthic species from Station 9, May-September, 1974.--Cont.

Species	Before Disposal 5/31/74 1.2 m^2 N	R	Before Disposal 8/6/74 1.2 m^2 N	R	After Disposal 9/18/74 1.2 m^2 N	R
Isopoda						
Tecticeps convexus	7	12	-	-	-	-
Synidotea bicuspida	1	18	1	23	-	-
Synidotea sp.	-	-	-	-	1	18
Ostracoda	-	-	2	19	3	17
Mysidacea	24	-	3	-	1	-
Brachyura	-	-	9	9	-	-
MOLLUSCA						
Pelecypoda						
Macoma calcaria	-	-	1	23	-	-
Macoma sp.	5	15	-	-	-	-
Macoma carilitensis	-	-	15	6	25	5
Tellina modestus	4	16	2	19	4	16
Siliqua patula	-	-	9	9	-	-
Axinopsida serricata	1	18	-	-	-	-
Nucula bellotti	1	18	-	-	-	-
Gastropoda						
Olivella baetica	74	2	41	2	53	3
Olivella biplicata	-	-	-	-	5	13
Nassarius fossatus	-	-	4	17	-	-
Nassarius mendicus	1	18	-	-	-	-
Opisthobranchia	-	-	6	13	5	13
ANNELIDA						
Polychaeta	P		P		P	
NEMERTIA	-		P		P	
SIPUNCULIDA	P		P		-	

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Table 10.--Abundance (N) and rank (R) of benthic species from Station 9, May-September, 1974.--Cont.

Species	Before Disposal 5/31/74 1.2 m^2 N	R	Before Disposal 8/6/74 1.2 m^2 N	R	After Disposal 9/18/74 1.2 m^2 N	R
COELENTERATA						
Anthozoa	1	18	2	19	5	13
ECHINODERMATA						
Ophiuroidea	-	-	-	-	34	4
TOTAL	364		365		396	

* Not included in totals.

to 40% of the total number of individuals (Table 11). An additional 13 to 16 taxa are needed to represent 95% of the organisms. The biomass was the highest in August at 3,144 mg/1.2 m^2 and the lowest in September with 733 mg/1.2 m^2 (Table 12). This change was due to a fourfold decrease in the polychaete biomass and the disappearance of the sipunculids.

Station 10:

Station 10 was actively utilized as a disposal site from March to October, 1974, and received 395,406 cubic yards of dredged material.

The sediment at station 10 during the May and June samples was of a fine sand easily washed through a 1 mm screen. The August sample was a black silty mud with a large wood fiber content. This material did not have any noticeable hydrogen sulfide (H_2S) odor.

The May and June sampling analyses indicate dominance by two and three species respectively. In the May sample, 70% of the individuals found are either the cumacean *Diastylopsis dawsoni* or the gastropod *Olivella baetica* (Table 13). The June sample was dominated by the same species as the May sample with the addition of the amphipod *Paraphexus obtusidens*. In the August sample 92% of the total individuals are the cumacean *Diastylopsis dawsoni*.

A total of 39 taxa are represented during the three sample periods. Five of these organisms are common to the three sample periods. The May samples have 19 taxa represented while the June and August samples have 25 and 24 taxonomic categories respectively (Table 14).

The total biomass of the samples was nearly the same during the May and June samples with 778 and 663 mg/1.2 m^2 respectively. The

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Table 11.--Benthic species composing 95% of the number of individuals during each sampling period at station 9, May-September, 1974.

Species	5/31/74 (%)	8/6/74 (%)	9/18/74 (%)
Ampelisca macrocephala	9.3	9.3	5.8
Paraphoxus obtusidens	8.2	1.9	16.9
Paraphoxus vigitegus	4.1	3.6	3.0
Paraphoxus epistomus		1.1	
Synchelidum shoemakeri	7.7	11.2	4.0
Monoculodes spinipes	2.5	7.9	4.8
Symplustes subglaber	3.6	1.6	
Eohaustorius washingtonianus	3.0	1.4	
Photis californica	1.9		1.5
Lysianassidae	1.6	1.9	2.5
Diastylopsis dawsoni	23.9	28.8	20.7
Hemilamprops californica	3.8	3.1	6.3
Colurostylus occendentalis	2.7		
Diastylis alaskensis		1.4	
Tecticeps convexus	1.9		
Brachyura		2.5	
Macoma sp.	1.4		
Macoma carlitensis		4.1	6.6
Tellina modestus	1.1		
Siliqua patula		2.5	
Olivella baetica	20.3	11.2	13.3
Olivella biplicata			1.3
Nassarius fossatus		1.1	
Opisthobranchia		1.6	1.3
Anthozoa			1.3
Ophuroidea			

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Table 12.--Wet weight (W) and dry weight (D) 1/ of benthic species from Station 9 in milligrams/1.2 m^2, May-September, 1974.

	5/31/74		8/6/74		9/18/74	
	W	D	W	D	W	D
Amphipoda	653	098	738	111	1213	182
Polychaeta	7528	1001	14003	1862	3439	457
Nemertina					038	005
Pelecypoda	026	001	1273	070	135	007
Gastropoda	9312		10500		10460	
Cumacea	819	123	2728	409	284	043
Isopoda	225	034	019	003	010	002
Ophuroidea	301	037	409	050	303	037
Echinodea	004					
Sipunculida	3157	410	4912	639		
Ostracoda	001					
TOTAL	22026	1704	34582	3144	15882	733

1/ Calculated from factors ascertained by Lie (1968).

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Table 13.--Benthic species composing 95% of the number of individuals during each sampling period at station 10, May-August, 1974.

Species	5/3/74 (%)	6/1/74 (%)	8/7/74 (%)
Monoculodes spinipes	3.1	3.3	
Synchelidium shoemakeri		3.9	
Paraphoxus obtusidens	2.4	23.5	
Atylus tridens	1.3		
Eohaustorius washingtonianus		1.3	
Diastylopsis dawsoni	46.9	14.7	91.6
Colurostylis occidentalis	1.8		
Hemilamprops californica		4.2	
Tecticeps convexus	8.4	2.0	
Siliqua patula	2.9		
Tellina modestus		2.6	
Olivella baetica	24.6	29.7	3.7
Olivella biplicata	4.2	5.6	

Table 14.--Abundance (N) and rank (R) of benthic species from station 10, May-August, 1974.

Species	Continual Dredge Disposal 5/3/74 1.2 m^2 N	R	6/1/74 1.2 m^2 N	R	8/7/74 1.2 m^2 N	R
CRUSTACEA						
Amphipoda						
Monoculodes spinipes	12	5	10	7	-	-
Synchelidium shoemakeri	-	-	12	6	3	9
Paraphoxus obtusidens	9	7	72	2	-	-
Paraphoxus milleri	-	-	1	19	-	-
Paraphoxus epistomus	-	-	2	14	-	-
Paraphoxus fatigans	-	-	-	-	1	12
Mandibulophoxus lincirostratus	2	12	2	14	-	-
Atylus tridens	5	9	-	-	43	3
Eohaustorius washingtonianus	-	-	4	10	-	-
Ampelisca macrocephala	-	-	2	14	1	12
Sympleustes subglaber	-	-	2	14	-	-
Photis californica	1	15	-	-	1	12
Photis sp.	-	-	3	11	-	-
Hippomedon denticulatus	-	-	3	11	-	-
Lysianassidae	-	-	1	19	-	-
Argissidae	-	-	1	19	3	9
Isalidae	-	-	-	-	1	12
Cumacea						
Diastylopsis dawsoni	179	1	45	3	2475	1
Colurostylis occidentalis	7	8	3	11	1	-
Hemilamprops californica	4	10	13	5	-	-
Isopoda						
Tecticeps convexus	32	3	6	9	-	-

Table 14.--Abundance (N) and rank (R) of benthic species from station 10, May-August, 1974.--Cont.

Species	Continual Dredge Disposal 5/3/74 1.2 m^2 N	R	6/1/74 1.2 m^2 N	R	8/7/74 1.2 m^2 N	R
Ancinus granulosus	4	10	-	-	1	12
Synidotea bicuspida	2	12	-	-	-	-
Synidotea sp. 1	-	-	-	-	1	12
Synidotea sp. 2	-	-	-	-	1	12
Mysidacea*	62	-	35	-	1	-
Brachyura	1	15	-	-	17	4
MOLLUSCA						
Pelecypoda						
Siliqua patula	11	6	-	-	12	5
Tellina modestus	-	-	8	8	2	11
Gastropoda						
Olivella baetica	94	2	91	1	99	2
Olivella biplicata	16	4	17	4	7	7
Nassarius fossatus	2	12	-	-	-	-
Cylichna sp.	-	-	1	19	1	12
Mitrella sp.	-	-	-	-	1	12
Opisthobranchia	-	-	2	14	6	8
ANNELIDA						
Polychaeta	P		P		P	
SIPUNCULIDA	-	-	P		-	-
ECHINODERMATA						
Echinodea	1	15	-	-	-	-
COELENTERATA						
Anthozoa	-	-	-	-	12	5
Unident	-	-	-	-	1	12
TOTAL	382		306		2703	

*Not included in totals.

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August sample had 3,315 mg/1.2 m^2 (Table 15); the increase in the August sample was attributed to the large number of the cumacean Diastylopsis dawsoni captured.

DISCUSSION

Sherk (1971) states that to assess the effects of sediment deposition on organisms the following system characteristics on processes should be measured.

1. Energy flux and nutrient cycling,
2. Distribution of organisms,
3. Diversity of communities, and
4. Material mortality, migration and predation patterns.

Each of these categories have a spatial component requiring an extensive sampling effort to ascertain. Seasonal variations in abundance of benthic organisms is generally reported to be absent. This is reportedly due to the multi-year life span of the organisms. Lie (1968) found a significant seasonal variation in the number of specimens in Puget Sound. The animals in Columbia River estuary offshore at the mouth of the river are likely to have a seasonal pattern due to the seasonal flucutations in river voluem, velocity and temperature. To properly access these effects, a multi-year study is required.

This study was of short duration and was intended to be a "pilot" study. Only a description of the distribution and diversity of the benthic organisms in relation to pre- and post-dredging and dredge disposal conditions was attempted. The data shows that the dredging

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Table 15.--Wet weight (W) and dry weight (D) 1/ of benthic species from Station 10 in milligrams per 1.2 m^2, May-August, 1974

Species	5/3/74		6/1/74		8/7/74	
	W	D	W	D	W	D
Amphipoda	215	032	524	079	395	059
Polychaeta	3542	471	3340	444	5599	745
Pelecypoda	028	002	006	001	078	004
Gastropoda	32138		21313		12559	
Cumacea	395	059	465	069	16448	2467
Isopoda	1427	214	128	019	264	040
Echinoidea	009	001				
Sipunculida			403	052		
TOTAL	37754	778	26179	663	35343	3315

1/ Calculated by factors ascertained by Lie (1968).

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activity reduced the total number of organisms and eliminated some of the rare species thus reducing diversity. The dredging sites were dominated by amphipods. Since amphipods are motile (free swimming) they might be expected to reestablish an area in a short period of time after the population is inundated by dredging; station 8 has this type of pattern. The immediate post-dredging, surveys show a reduction in total number of individuals. Five weeks later the population is back to the pre-dredging numbers of individuals. The community structure is different with a reduction in the number of species but relative dominance (i.e., the species constituting the majority of the individuals) approximates the immediate pre-dredging condition.

No trend was shown at station 6 that can be directly attributed to dredging. Total numbers of individuals decreased through the sampling period. Relative dominance and species composition changed very little. The cause of the decrease in number of individuals is not known.

The effects of dredge disposal were most definite at stations 7 and 10. A decrease in the number of individuals was apparent at station 7 and some change in relative dominance, but species composition remained nearly the same. However, the biomass increased from the first to second sampling period. This increase was attributed to a large increase in polychaete biomass. Sherk (1971) noted studies which illustrated that polychaetes could dig their way to the surface after being buried by several inches of sediment. However, material deposition at station 7 was of a larger quantity and continued through the sampling periods. The polychaetes could perhaps dig their way out and survive, while amphipods and cumaceans would be inundated

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and reestablishment would have to be accomplished from adjacent communities.

Station 10 changed in total number of individuals, relative dominance, and species composition, between the June and August sampling periods. The cumacean Diastylopsis dawsoni dominated the August sample by contributing almost 92% of the total number of individuals sampled. If the number of Diastylopsis was not considered in the August sample, the relative abundance of the other organisms approximates the May sample, and species composition would have been nearly the same. Lie (1969) found Diastylopsi dawson off the Washington coast in even greater concentrations than was found at station 10. Sherk (1971) noted that shrimp had been found in greater concentrations on dredge disposal sites after dumping. This increase was attributed to the high organic content of the newly deposited material. The August sample was definitely of a different sediment composition than either the May or June samples, and may have had a higher organic matter content.

No discernable trends in numbers of individuals, relative dominance, or species composition, was apparent at station 9. The amount of dredged material disposal on this site was small compared with the other sites. In addition, this station has not been receiving much dredged material in recent years.

This "pilot" study illustrated some basic effects of dredging and dredge disposal on the benthic infauna. Future studies could be enhanced by:

1. taking one core from each station on each sampling period to document a change in sediment composition attributable to dredging or dredge disposal.

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2. using a better method of locating the position of the station such as radar, loran, etc.
3. establishing better communication with the dredge personnel to ascertain exact location of dredging and dredge disposal activity.

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