Benthic Macrofauna, Sediment and Water Quality near Seafood Cannery Outfalls in Yaquina Bay, Oregon

by

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ABSTRACT

Seafood canneries in lower Yaquina Bay, Oregon process shrimp (*Pandalus jordani*), Dungeness crab (*Cancer magister*), a variety of bottom fish and several salmon species. The shrimp wastes are screened and discharged directly into the Bay beneath the cannery docks. During the shrimp processing season about 3.8 million liters of wastes are discharged daily.

We conducted a survey of the macrobenthos, sediment, and water quality in Yaquina Bay in May 1978. The effects of the cannery wastes were restricted to the immediate vicinity of the cannery docks. The effluent plume was quite turbid and had high nutrient concentrations. Because of its initial low salinity it was restricted to the surface layer where it mixed with estuarine water and was rapidly dispersed by strong tidal currents. Dissolved oxygen concentrations were 7.0 mg/l or greater in the plume. The strong currents and screening treatment of the effluent minimized deposition of solids on the sea bed. Bottom water quality was not adversely affected.

A very diverse and abundant macrofaunal benthic community was present along the cannery docks. The community structure of the benthos near the cannery outfalls was very similar to that at the Marine Science Center docks across the Bay. Difference in species composition of benthic assemblages in lower Yaquina Bay were strongly correlated with sediment composition.

INTRODUCTION

The environmental impact of seafood cannery effluents has received relatively little attention by marine ecologists. On the west coast of the United States environmental conditions in the vicinity of cannery outfalls in Los Angeles Harbor have been examined by Soule and Oguri (1976) and Reish (1959); in Dutch Harbor, Alaska by Stewart and Tangarone (1977) and Karna (1978); at Petersburg, Alaska by Beyer, Nakatani, and Staude (1975), and at sixteen Alaskan sites by the Environmental Protection Agency (EPA) (1975). To our knowledge the effects of seafood cannery effluents have never been examined on the Oregon coast.

Section 74 of the Clean Water Act of 1977 (Public Law 95-217) required the EPA to conduct a study of the ecological effects of seafood cannery wastes. As part of that study we have examined biological sediment and water conditions in the vicinity of cannery outfalls in lower Yaquina Bay near Newport, Oregon (Fig. 1). Cannery operations in Yaquina Bay are representative of those throughout the Pacific Northwest. The principal species processed include shrimp (Pandalus jordani), Dungeness crab (Cancer magister), a variety of bottom fish and several salmon species. The shrimp cannery effluents in Yaquina Bay are screened, thus removing crustacean shells.

The macrofaunal benthos was selected as the most appropriate indicator assemblage for determining the effects of cannery effluents because benthic animals are relatively long lived and permanent residents of a given habitat. Thus, they are sensitive to the chronic effects of environmental perturbations. The structure of benthic communities should reflect changes in sediment or bottom water quality that might result from cannery effluents.

Our principal objective was to assess the ecological impacts, if any existed, through a comparison of biological, sediment and water quality at control and cannery sampling sites.

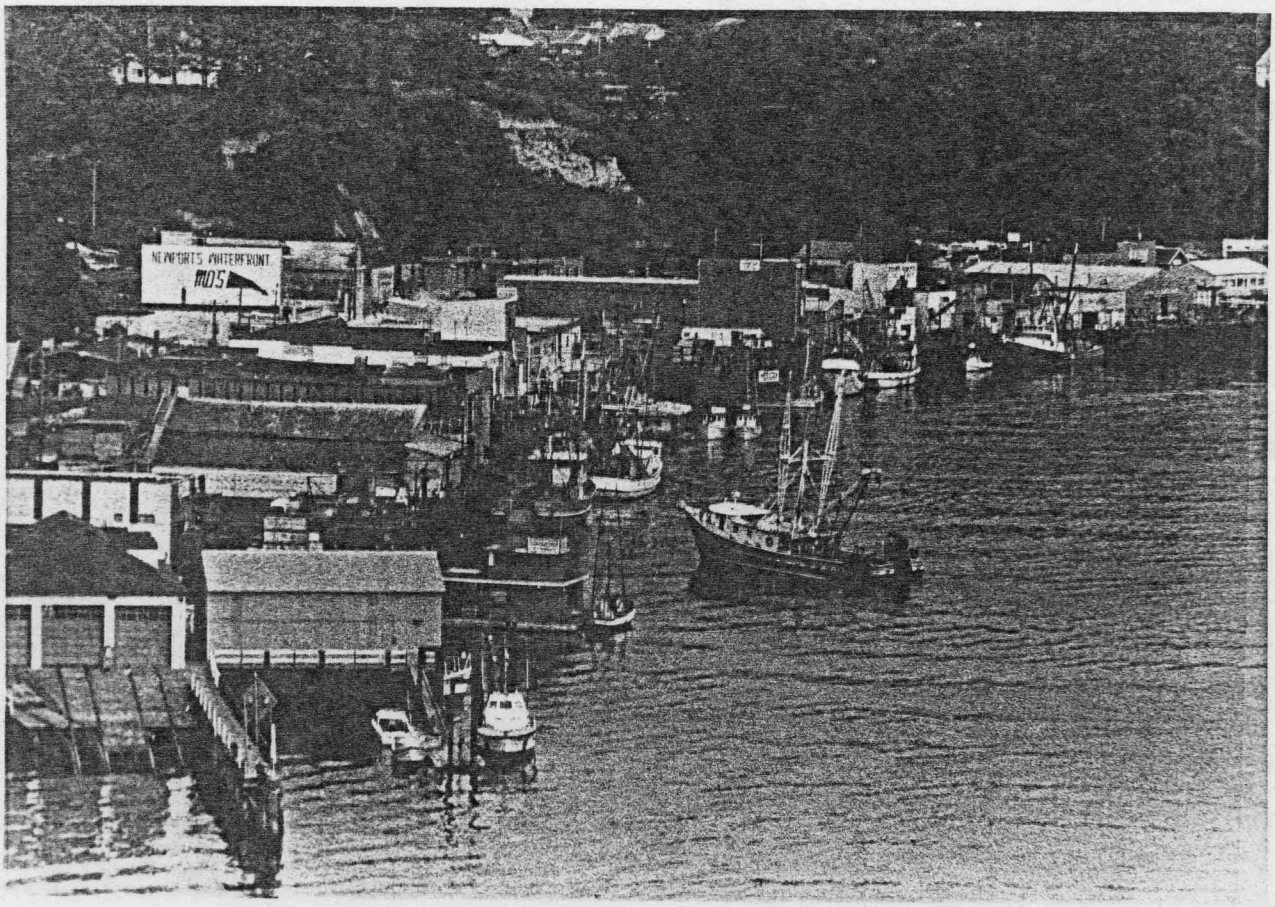


Fig. 1. Cannery row in Yaquina Bay, Newport, Oregon.

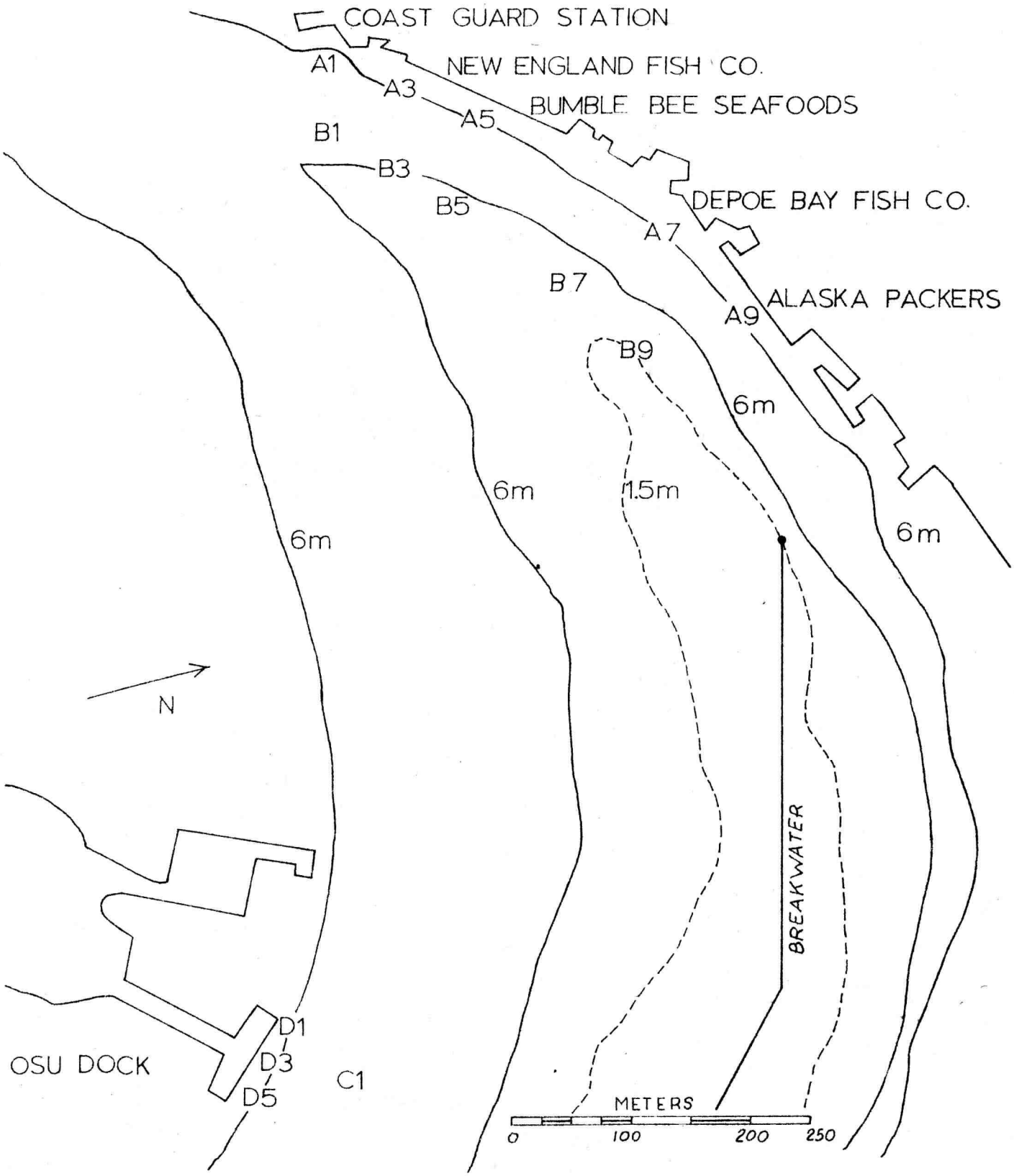
MATERIALS AND METHODS

Stations were located along four transects (Fig. 2). Transect A was immediately adjacent to the docks along cannery row and transect B was parallel to A, 100 m offshore. Five stations were occupied on each of these transects. Transect D included three stations adjacent to the docks for the three oceanographic vessels of Oregon State University. Three stations were originally designated along transect C, 100 m off the OSU docks. However, because of the difficulty in obtaining sediment samples at C, collections were made at only one C station.

The major survey was conducted on 9-10 May 1978. Initially we attempted to collect benthic samples with a 0.1 m^2 Smith-McIntyre grab. Adequate samples could not be obtained with this device because of the shells and coarse sediments found along the A and C transects. Sediment samples were therefore collected with a dredge (mouth: 16.5 x 30 cm, depth: 15 cm, lining: 1 mm mesh screen, (Fig. 3). The dredge was towed for approximately 100 m along the transect to obtain a single sample. Replicate dredge samples were taken at each station for faunal analysis. In the notation used in this report the second replicate collected at the seventh station on transect B is designated sample B7-2. Animals were removed by sieving the sediments through a 1 mm screen, preserved in 10% buffered formalin, later transferred to 70% ETOH, identified to the species level and enumerated. A third dredge sample was taken for sediment chemistry and particle size analyses.

Water samples were collected at the bottom with a 5 l Niskin bottle and at the surface with a bucket. Temperature, salinity, and dissolved oxygen concentration were determined at the surface, 1 meter depth, and bottom with an RS-5 salinometer (Beckman Instr.) and Model 57 DO meter (Yellow Springs Instr.). Surface water clarity was estimated with a standard Secchi disc. Turbidity of the water sample was measured with a Model 2100 Hach turbidi-

Fig. 2. Location of Yaquina Bay stations.


COAST GUARD STATION
A1
NEW ENGLAND FISH CO.
A3
BUMBLE BEE SEAFOODS
A5
B1
B3
DEPOE BAY FISH CO.
B5
A7
B7
ALASKA PACKERS
A9
B9
6m
6m
1.5m
6m
6m
N
BREAKWATER
D1
D3
D5
OSU DOCK
C1
METERS
0
100
200
250

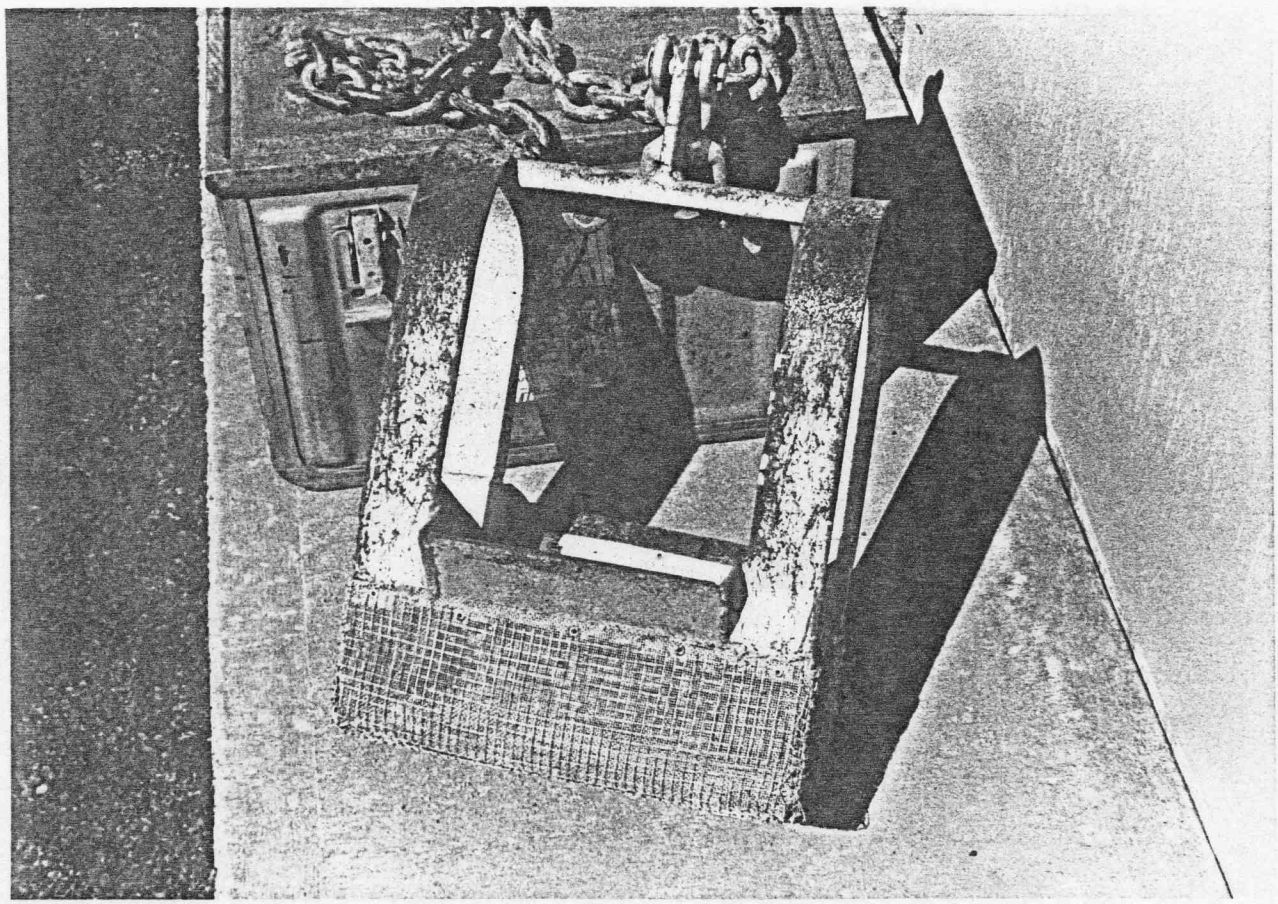


Fig. 3. Dredge used to collect Yaquina Bay sediment samples.

meter and the results expressed in nephelometric turbidity units (NTU).

On 12 May 1978 sediment traps were placed at stations A5, A7, D1 and D5. The traps were aluminum cylinders (diameter 15.2 cm, height 63.5 cm, capacity 11.5 l) covered with a flow straightener. They were strapped to the shoreward side of the most seaward piling beneath the docks. Their bottoms were 1 m above the sea bed. Their contents were retrieved after one week and filtered through a glass fiber filter. The filtrate was preserved with 80 mg/l $H_g\ Cl_2$ and the residue frozen until the chemical analyses were conducted.

On 18 July 1978 divers collected a second series of sediment samples for physical and chemical analyses. One core sample was taken at each station on transects A and D. The cores were 14 cm deep and 10 cm in diameter.

The sediment particle size distribution was determined for sand by sieving through a Wentworth scale screen series and for the silt-clay fractions by the pipette method (Buchanan, 1971). Sediment samples for bulk chemical analyses were freeze dried and finely ground using a Mullite mortar and pestle. Interstitial water was obtained by centrifuging the sediment under a nitrogen atmosphere at 9000 rpm at 5°C for 10 minutes and filtering the water through a 0.45μ millipore filter. Interstitial nutrients were preserved with 40 mg $HgCl_2$ per liter of sample. Sediment samples for sulfides were collected in 10 cc open barrel syringes; the open end was sealed after sample collection with plastic film and the contents frozen until analyzed. Grease and oil samples were collected in clean (hexane washed) glass bottles with aluminum foil lined lids and kept at 5°C until analyzed.

Bulk organic carbon was determined by subtracting the total inorganic carbon concentration (measured on an OIC model 303 carbon analyzer) from the total carbon concentration (measured on a Hewlett Packard C-H-N analyzer. Sediments for total Kjeldahl nitrogen were digested with H_2SO_4 and persulfate and analyzed with a Technicon autoanalyzer using the automated phenate

method (EPA, 1974). Total grease and oil in sediments were determined by the Soxhlet extraction method 502D (APHA, 1975). The hydrocarbon portion of the extracted grease and oil was determined by infrared analysis for hydrocarbons after removal of polar material by silica gel (Method 502E, APHA, 1975). Alkaline soluble sulfide was determined by the method of Green and Schnitker (1974). Total sulfide was also determined by the Green and Schnitker method after the sulfides were liberated with H_2SO_4 and trapped in sulfide antioxidant buffer. Nutrients (organic nitrogen, ammonia, nitrate plus nitrite, total soluble phosphate and orthophosphate) were analyzed on a Technicon autoanalyzer according to EPA methods (1974).

Biological Indices

Specimens which could not be identified to the species level were excluded from the community structure analysis. Replicates taken at each station were not pooled for quantitative faunal analyses. Thus the data set included 28 biological samples. Faunal density was calculated as the number of individuals of all species (N) collected per dredge sample. Areal species richness was estimated as the number of species (S) collected per dredge sample. H' diversity and the complement of Simpson's Index of dominance were calculated as follows:

$$H' = \frac{1}{N}\left(N \log N - \sum_{i=1}^{S} n_i \log n_i\right)$$

$$1 - \text{Simpson's Index} = 1 - \sum_{i=1}^{S} \frac{n_i(n_i-1)}{N(N-1)}$$

where n_i = number of individuals belonging to the i^{th} species.

The statistical significance of differences in mean values of density, richness, diversity and dominance were tested by analysis of variance and Student-Newman-Keuls multiple range test (Sokal and Rohlf, 1969).

Both normal and inverse numerical classifications were applied to the data set (Boesch, 1977). The normal classification clusters samples on the basis of similarity in the composition and relative abundance of species. Inverse classification clusters species on the basis of similarity in distribution among samples. The distribution and characteristics of the collection and species groups formed by numerical classification can be correlated with environmental factors including stress from pollution.

The classificatory procedures we used are described in detail by Boesch (1977). To reduce the data set to a manageable size, rare species represented by less than ten individuals were excluded from the classification. A square root transformation was applied in both normal and inverse analyses. The Bray-Curtis dissimilarity coefficient (D_{jk}) was used in the normal classification:

$$D_{jk} = \frac{\sum_{i}^{S} |x_{ij} - x_{ik}|}{\sum_{i}^{S} (x_{ij} + x_{ik})}$$

where: D_{jk} = dissimilarity between collections j and k

$x_{ij(k)}$ = square root of the number of individuals of the i^{th} species in the j(k) collection

S = number of species.

Prior to the inverse classification the square root of the abundance of species in each collection was standardized by dividing it by the sum of the square roots of the abundance in all collections. This standardization

permits a close affinity between species which differ in abundance but have similar distributions among the collections. The Manhattan metric dissimilarity coefficient (D_{ab}) was used in the inverse classification:

$$D_{ab} = 1/2\sum_{c}^{E}|x_{ca}-x_{cb}|$$

where: D_{ab} = dissimilarity between species a and b

$x_{ca(b)}$ = standardized square root of the abundance in the c^{th} collection of species a(b)

E = number of collections.

Once the matrix of dissimilarity values is generated, the collections (or species) are clustered to form a dendrogram. In this process all entities beginning with the least dissimilar are combined in an hierarchial fashion. This procedure requires a sorting strategy to determine the dissimilarity between a newly combined pair of entities and all other entities remaining in the matrix. The method we used is the flexible sorting strategy of Lance and Williams (1967):

$$D_{hk} = 0.625(D_{hi}+D_{hj})-0.25D_{ij}$$

where: entities i and j are fused to form group k

D_{hk} = dissimilarity between group k and entity h

$D_{hi(j)}$ = dissimilarity between entities h and i(j) in the matrix prior to fusion of i and j

D_{ij} = dissimilarity between i and j before they were combined.

Relationships between collection groups and species groups can be examined in two-way tables in which the original data matrix is reduced according to the normal and inverse classification results. We calculated the mean number of individuals of each species group within the samples of each collection group. We also determined the constancy of each species group in each collection group. Constancy is the observed number of occurrences of a species group in a collection group divided by the number of possible occurrences. Thus, if a species group includes 6 species and a collection group has 5 samples, 30 occurrences are possible. If every species occurs in every sample, the constancy index would be 1.0. If none of the species occur in the collection group, the index would be 0.

RESULTS

Cannery Effluents

The principal species processed by seafood canneries in Yaquina Bay are shrimp (Pandalus jordani), Dungeness crab (Cancer magister), a variety of bottom fish, and several salmon species. By July 1977 all of the Yaquina canneries had installed forty mesh screens which retain fish carcasses and shrimp and crab shells. These materials are used either as agricultural fertilizer or mink food. The canneries are constructed on docks and the effluent passing through the screens is discharged directly into the bay beneath the docks.

Although the canneries operate throughout the year, the effluent volume increases substantially during the shrimp season, April to October. During the 1978 season the Yaquina canneries operated fourteen machines for peeling shrimp, two at the New England Fish Co. near station A3, and four each at Bumble Bee Seafoods (A5), Depoe Bay Fish Co. (A7), and Alaska Packers Association (A9) (Fig. 2). At peak production approximately one million gallons (3.8×10^6 l) of shrimp processing effluent are discharged each day into Yaquina Bay. The BOD of this effluent is 1000-1500 mg/l (David Ertz, pers. comm.).

The shrimp processing effluent resulted in a patchy, whitish discoloration of the water beneath the docks along the bayfront and extending a short distance (10-30 m) into the bay (Fig. 4). This plume was most evident during slack water and was rapidly dispersed by tidal currents which are rather strong (100 cm/sec) in the vicinity of the canneries. Because of its buoyant freshwater nature, the plume was restricted to a relatively thin (<1 m) surface lens. During our surveys we observed large numbers of small fish (probably whitebait smelt, Allosmerus elongatus) apparently filter feeding within the plume.

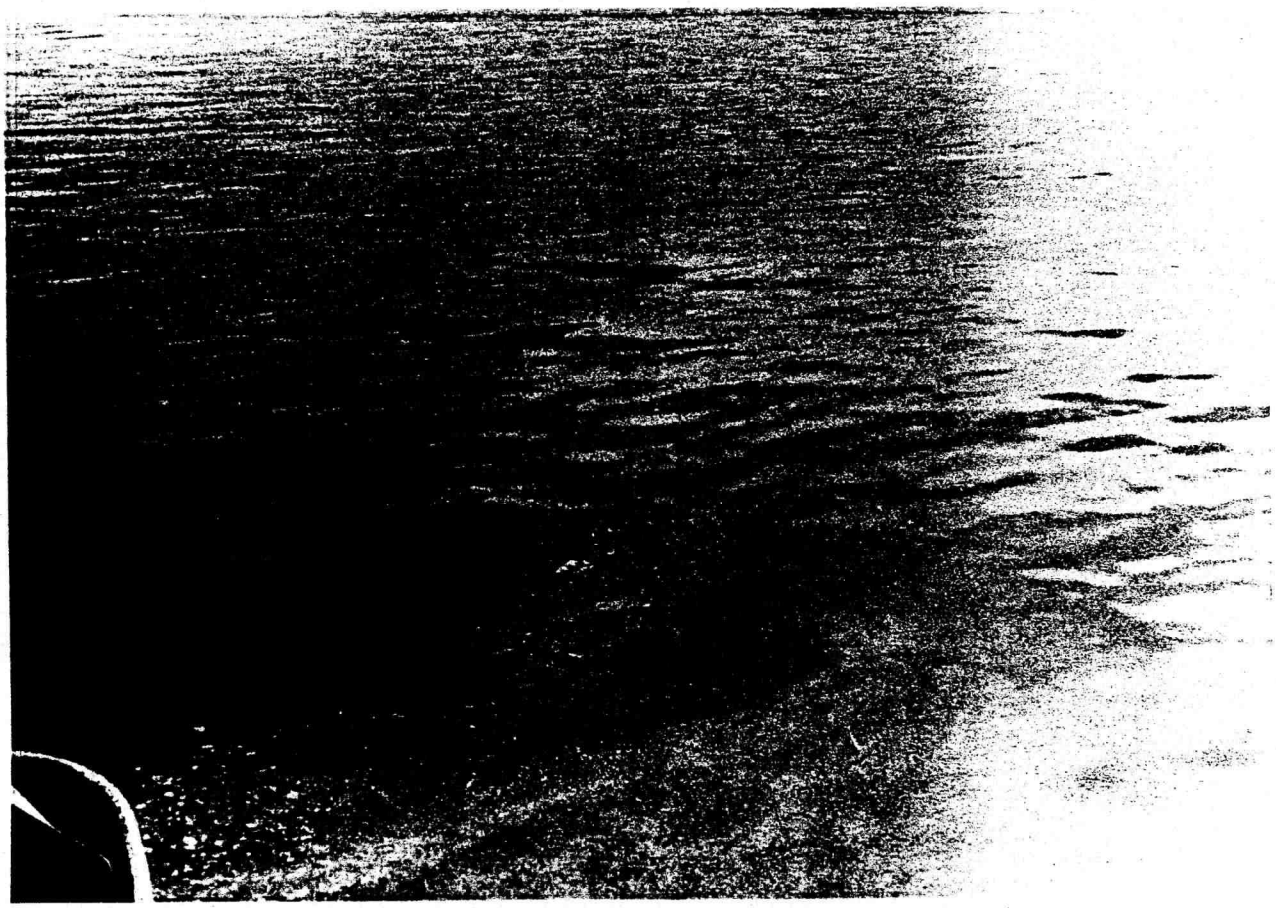


Fig. 4. Seafood cannery effluent plume in Yaquina Bay.

Water Quality and Depth

Stations A1, B1, and C1 were located in channels and were deeper (8 - 13 m) than the other stations (3.5 -6.5 m) (Fig. 2, Table 1). Stations B3 and B5 were at the edge of the channel. Stations B7 and B9 were out of the channel and very near an eelgrass (Zostera marina) bed.

The discoloration of the surface water was evident in secchi disc depths and surface turbidity (Table 1). At transect B, C, and D secchi disc depths ranged from 1.25 to 1.60 m. The secchi depth at stations A1, 3, 7, and 9 ranged from 0.83 to 1.17 m. The highest secchi depth of the survey (1.78 m) was recorded at station A5, indicating the patchy nature of the effluent plume. Surface turbidity showed exactly the same pattern as the secchi depths (Table 1). However, turbidity in bottom water along the A transect (1.3 - 2.1 NTU) was actually less than along the B, C and D transects (2.1 - 3.9 NTU) (Table 1). This reflects the restriction of the plume to the surface layer.

There was very little difference between the four transects in salinity and temperature at the surface, 1 m, and bottom (Table 1). Salinities ranged from 25.4 °/₀₀ on the surface at C1 to 33.4 on the bottom at A3. Temperature ranged from 13.2°C on the surface at A9 and C1 to 10.0°C on the bottom at A1 and A3. At most stations the bottom water salinity was 2 - 3 °/₀₀ greater and the temperature 1-2°C less than at the surface indicating slight stratification of the water column. A slight depression in surface salinity due to the cannery effluents is evident from a comparison of the difference in salinity between the surface and 1 m (Table 1). This difference was considerably higher along the A transect ($\bar{x}$ = 2.1 °/₀₀, range : 0.9 to 3.8 °/₀₀) than at the B, C, and D transects ($\bar{x}$ = 0.5, range : -0.1 to 1.4 °/₀₀). The dissolved oxygen concentration was $\geq$ 7.0 mg/l at all stations and depths

Table 1. Water quality and depth at the Yaquina Bay stations.

Parameter		Station													
		A1	A3	A5	A7	A9	B1	B3	B5	B7	B9	C1	D1	D3	D5
Depth (m)		8.0	5.5	5.5	3.5	4.0	13.0	6.5	4.0	4.5	4.5	10.5	5.0	6.5	6.0
Salinity (°/₀₀)	Surface	30.2	27.1	29.1	26.4	26.1	27.1	26.6	26.1	26.2	26.0	25.4	29.4	26.1	27.8
	1 m	31.6	30.9	31.0	28.6	28.1	27.4	27.1	26.6	26.7	26.5	26.8	29.3	26.9	27.7
	Bottom	33.0	33.4	32.4	28.6	30.1	31.1	30.2	29.4	30.2	31.1	31.2	30.4	29.9	28.3
Temperature (°C)	Surface	12.2	12.8	12.3	12.8	13.2	12.9	13.0	13.1	13.1	13.1	13.2	12.2	13.0	12.8
	1 m	11.4	11.9	11.7	12.5	12.7	12.8	12.9	13.0	12.9	12.9	13.0	12.4	13.0	12.8
	Bottom	10.0	10.0	10.8	12.5	12.0	11.4	11.8	12.2	11.8	11.6	11.8	12.0	12.1	12.5
Dissolved Oxygen (mg/l)	Surface	7.2	7.2	7.9	7.0	7.9	8.2	8.2	8.3	8.2	8.4	8.5	8.2	8.4	8.3
	1 m	7.3	7.2	7.7	7.1	7.9	8.2	8.1	8.1	8.0	8.2	8.3	8.0	8.2	8.2
	Bottom	7.4	7.3	7.8	7.3	7.9	7.7	7.9	8.0	7.8	7.9	7.7	7.8	7.7	8.1
Secchi Depth (m)		1.17	1.07	1.78	0.83	1.06	1.59	1.60	1.53	1.57	1.56	1.45	1.38	1.33	1.25
Turbidity (NTU)	Surface	3.8	3.7	1.5	140.0	8.0	2.5	2.4	2.4	2.4	2.1	2.5	3.5	3.3	3.5
	Bottom	2.1	2.1	2.0	1.3	1.6	2.5	2.4	2.3	2.5	2.4	3.0	3.9	3.6	3.5
Organic Nitrogen (mg/l)	Surface	6.18	2.68	3.30	88.74	3.84	0.14	0.12	0.21	0.15	0.12	0.19	0.15	0.24	0.23
	Bottom	0.20	0.24	0.13	0.59	0.28	0.20	0.16	0.19	0.20	0.16	0.26	0.18	0.46	0.29
Ammonia (mg/l)	Surface	0.37	0.14	0.13	3.46	0.24	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	Bottom	0.04	0.08	0.03	0.06	0.04	0.02	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.04
Nitrate + Nitrite (mg/l)	Surface	0.16	0.17	0.18	0.31	0.18	0.17	0.18	0.18	0.18	0.19	0.20	0.13	0.19	0.14
	Bottom	0.14	0.12	0.12	0.15	0.14	0.15	0.12	0.12	0.15	0.17	0.14	0.11	0.12	0.16
Total Phosphate (mg/l)	Surface	0.48	0.21	0.26	6.23	0.39	0.06	0.08	0.04	0.04	0.05	0.06	0.09	0.08	0.06
	Bottom	0.05	0.10	0.07	0.12	0.09	0.04	0.06	0.04	0.07	0.06	0.06	0.09	0.09	0.06
Orthophosphate (mg/l)	Surface	0.37	0.16	0.17	5.72	0.29	0.04	0.03	0.03	0.03	0.03	0.03	0.05	0.04	0.04
	Bottom	0.05	0.05	0.05	0.06	0.04	0.04	0.04	0.03	0.04	0.03	0.04	0.04	0.04	0.04

(Table 1). DO concentrations at the surface were slightly less along the A transect (7.0 - 7.9 mg/l) than at the B, C and D transects (8.2 - 8.5 mg/l). This difference was less pronounced at 1 m and on the bottom.

The surface concentration of organic nitrogen along the A transect (2.7 - 88.7 mg/l) was more than an order of magnitude greater than surface values at the other transects (0.11 - 0.24 mg/l) (Table 1). However, organic nitrogen concentration at the bottom was very similar at the A (0.13 - 0.59 mg/l) and B, C, and D transects (0.16 - 0.45 mg/l). This same pattern was found for ammonia, total phosphate and orthophosphate (Table 1). Except for the surface concentration of nitrite plus nitrate at station A7 (0.31 mg/l), there was very little variation in this parameter between stations although surface concentrations (0.13 - 0.22 mg/l) were slightly higher than at the bottom (0.11 - 0.17 mg/l).

Sediment Characteristics

Particle Size Distribution

There were substantial differences in the particle size distribution of sediments between and within transects (Table 2). With the exception of samples A1 and A9. sediments along the A transect were poorly sorted and contained a much larger proportion of coarse sands and larger particles (> 20%) than any of the samples collected on the B and D transects. A particle size analysis was not conducted for the sample from the C transect because it contained only large shells and gravel. The only samples with a large proportion (> 40%) of very fine sands or smaller particles were collected at stations B7 and B9. The other samples collected on the B transect were very well sorted fine sands. The D transect sediments were characterized by a large proportion of both fine and medium sands. Human artifacts on the bottom along the A transect were much more numerous than at any of the other stations (Fig. 5).

Table 2. Mean size distribution (percent weight) of Yaquina Bay sediment samples.

Size Class	Station												
	A1	A3	A5	A7	A9	B1	B3	B5	B7	B9	D1	D3	D5
Coarse sands or larger	8.5	62.4	51.5	21.8	2.9	0.5	0	0	0.8	1.2	3.7	7.2	3.2
Medium sands	11.8	10.5	6.2	35.2	27.0	16.1	17.7	9.2	2.4	3.1	23.8	42.0	44.6
Fine sands	73.9	23.6	26.6	34.8	55.9	83.1	79.4	87.0	54.5	39.4	63.0	47.4	49.4
Very fine sands or smaller	5.8	3.5	15.7	8.2	14.3	0.4	3.0	3.7	42.3	56.3	9.6	3.4	2.8

Fig. 5. Human artifacts collected in one dredge sample at Yaquina Bay station A3.

Sediment Chemistry

The results of the chemical analyses performed on sediments collected by dredging and by divers are given in Tables 3 and 4 respectively. Comparison of values between these tables may not be valid because of the difference in collection technique. There was no evidence for a major increase in the concentration of any chemical parameter along the A transect. Concentrations of organic nitrogen, nitrate plus nitrite, and total soluble phosphate in interstitial water at station A9 were within the ranges recorded at the B and D transects. Interstitial concentrations of ammonia and orthophosphate at A9 were slightly higher than in the B and D samples. Organic carbon concentrations in bulk sediment samples were inversely related to particle size and reached a maximum at station B9. Total Kjeldahl nitrogen and total oil and grease concentrations were relatively high along the A transect although the ranges overlapped values for the B and D samples. With few exceptions, concentrations of hydrocarbon oil and grease, total sulfides and alkaline soluble sulfides were higher in the A samples.

Characteristics of the material deposited in the sediment traps placed on pilings under the dock opposite stations A5, A7, D1, and D5 are given in Table 5. The greatest weight of sediment was found in the traps at A7 and D5. The concentration of total nitrogen and organic carbon was slightly greater in the residue collected at A5. The organic nitrogen content of the filtrate was similar in all samples. Nutrients were higher in the filtrate obtained from traps on the A transect.

Macrobenthos

Density, Diversity, and Species Composition

The structure of the benthic assemblage was very similar at each of the four transects (Table 6). Analysis of variance showed no significant

Table 3. Chemical analyses of sediment samples collected by dredging, 10 May 1978.

Parameter	Station								
	A9	B1	B3	B5	B7	B9	D1	D3	D5
Interstitial water (mg/l)									
Organic nitrogen	1.27	0.62	0.00	0.88	5.59	1.43	5.01	5.40	2.31
Ammonia	2.89	0.63	1.26	1.70	2.48	1.91	1.96	2.28	1.31
Nitrate + nitrite	0.23	0.25	0.25	<0.05	0.23	0.10	0.22	0.18	0.25
Total soluble phosphate	0.65	<0.25	<0.25	0.37	0.52	0.42	0.77	0.40	0.26
Orthophosphate	0.45	0.15	0.26	0.28	0.36	0.39	0.17	0.25	0.18
Bulk sediment (mg/kg)									
Total organic carbon	3900	<2000	<3100	<2600	12450	29300	5640	1900	<1000
Total Kjeldahl nitrogen	2100	<200	<200	<500	1300	2300	710	1000	<200
Total oil/grease	790	770	180	420	490	290	380	650	22
Hydrocarbon oil/grease	100	180	<5	19	<5	<5	14	43	28
Total sulfides	360	<1	<2	18	95	31	29	12	15
Alkaline soluble sulfides	8	0	0	<2	4	3	3	2	<1

Table 4. Chemical analyses of sediment samples collected by divers, 18 July 1978.

Parameter	Station A1	A3	A5	A7	A9	D1	D3	D5
Bulk Sediment (mg/kg)								
Total organic carbon	5400	5600	18100	9500	-	12200	12700	3400
Total Kjeldahl nitrogen	440	1250	1700	650	2900	520	<125	<100
Total oil/grease	1950	2120	2110	6620	3590	560	560	4060
Hydrocarbon oil/grease	123	230	554	261	219	79	93	107
Total sulfides	330	700	810	1400	520	350	19	23
Alkaline soluble sulfides	6	11	12	24	27	16	3	2

Table 5. Chemical analyses of Yaquina Bay sediment trap samples.

Parameter	Station A5	A7	D1	D5
Residue				
Weight (gm)	36.2	141.3	21.4	88.3
Total nitrogen (gm/kg)	7.4	6.1	6.2	6.3
Total organic carbon (gm/kg)	52.2	44.1	39.9	41.5
Filtrate (mg/l)				
Organic nitrogen	0.24	0.20	0.27	0.18
Ammonia	0.69	0.76	0.07	0.10
Nitrate + nitrite	0.08	0.14	0.06	0.06
Total phosphate	0.31	0.10	0.05	0.05
Orthophosphate	0.29	0.08	0.04	0.04

Table 6. Mean richness, density, dominance, and diversity of benthic samples at Yaquina Bay transects.

Parameter		Transect A	Transect B	Transect C	Transect D	Analysis of Variance
Areal Richness (S/Dredge)	$\bar{x}$	33.1	31.3	32.0	36.5	F = 0.23 n.s.
	Range	10-50	11-53	24-40	29-48	
Density of Individuals (N/Dredge)	$\bar{x}$	385.3	711.0	129.5	255.2	F = 3.35*
	Range	30-842	43-1283	78-181	104-382	
Dominance (1-Simpson's Index)	$\bar{x}$	0.85	0.81	0.91	0.89	F = 1.64 n.s.
	Range	0.74-0.91	0.54-0.93	0.89-0.92	0.82-0.91	
Diversity (H')	$\bar{x}$	1.04	0.94	1.21	1.20	F = 3.18*
	Range	0.84-1.19	0.49-1.18	1.13-1.28	1.08-1.37	

n.s. not significant; $^{*}F_{0.05(24,3)} = 3.01$; $^{**}F_{0.01(24,3)} = 4.72$

differences in either areal species richness or dominance between the four transects. The mean number of species collected in a dredge sample varied between 31.3 at transect B and 36.5 at transect D. Values for the complement of Simpson's Index varied between 0.81 at transect B and 0.91 at transect C. The range for both of these parameters was much greater at transects A and B than at C or D, indicating greater heterogeneity in benthic community structure at the stations closest to cannery row.

Significant differences were observed between the four transects for mean values of both density of individuals and H' diversity (Table 6). The mean density at transect B (711.0 individuals/dredge) was statistically greater than at any of the other transects. Although the mean density at transect C (129.5) was substantially less than at A (385.3) or D (255.2), the difference was not significant. Mean H' diversity at B (0.94) was signigicantly less than at D (1.20), but not significantly different from H' at C (1.21). This apparent contradiction is due to the sensitivity of the multiple range test to differences in sample size which was greater at D than at C. There were no other significant differences in mean H' between the transects.

The similarity in the structure of the benthic assemblage is also reflected in the nearly ubiquitous presence of dominant species among the four transects. Table 7 includes all species which ranked within the ten most abundant species at any one of the four transects. Of the 24 species selected by this criterion, all 24 were found at transect B, 22 at both B and D, and 21 at C. Despite this ubiquitous pattern, no single species ranked within the 10 most abundant species at all four stations. The differences between the transects are obviously due to the relative abundance of dominants rather than qualitative differences in species composition.

Table 7. Mean density of species which ranked within the ten most abundant species at one or more Yaquina Bay transects. Ranks are given in parentheses.

Species	Transect A	B	C	D
Macoma inquinata	63.5 (1)	133.2 (1)	1.5	44.8 (1)
Melita dentata	48.3 (2)	1.4	23.0 (1)	3.7
Anisogammarus pugettensis	44.0 (3)	.3	0	2.5
Capitella capitata	31.0 (4)	5.8	.5	.8
Anaitides williamsi	30.5 (5)	.4	8.5 (4)	.7
Protothaca staminea	24.6 (6)	36.6 (7)	.5	14.3 (6)
Photis brevipes	22.2 (7)	30.1 (9)	1.0	13.5 (7)
Heptacarpus paludicola	16.2 (8)	.2	8.0 (5)	.5
Crangon nigricauda	12.0 (9)	5.0	20.5 (2)	.7
Platynereis bicanaliculata	9.9 (10)	1.3	2.0	3.5
Orchomenella sp. 1	.3	74.1 (2)	1.5	14.8 (5)
Olivella pycna	.7	71.0 (3)	.5	7.3 (8)
Paraphoxus epistomus	.2	61.6 (4)	10.5 (3)	30.3 (2)
Owenia collaris	1.4	42.7 (5)	.5	16.3 (3)
Olivella biplicata	.1	38.2 (6)	1.0	.2
Aglaja diomedea	.2	32.0 (8)	0	2.8
Glycinde picta	8.0	24.2 (10)	.5	7.0 (9)
Pontogeneia inermis	3.1	.4	4.0 (6)	0
Podocerus sp. 1	0	.1	4.0 (6)	0
Caprella laeviuscula	.1	1.4	4.0 (6)	.2
Paleanotus bellis	2.3	.2	3.5 (9)	.2
Archaeomysis grebnitzkii	0	2.5	3.5 (9)	.7
Cryptomya californica	6.1	22.6	1.0	16.3 (3)
Amphissa columbiana	.2	10.3	0	5.8 (10)

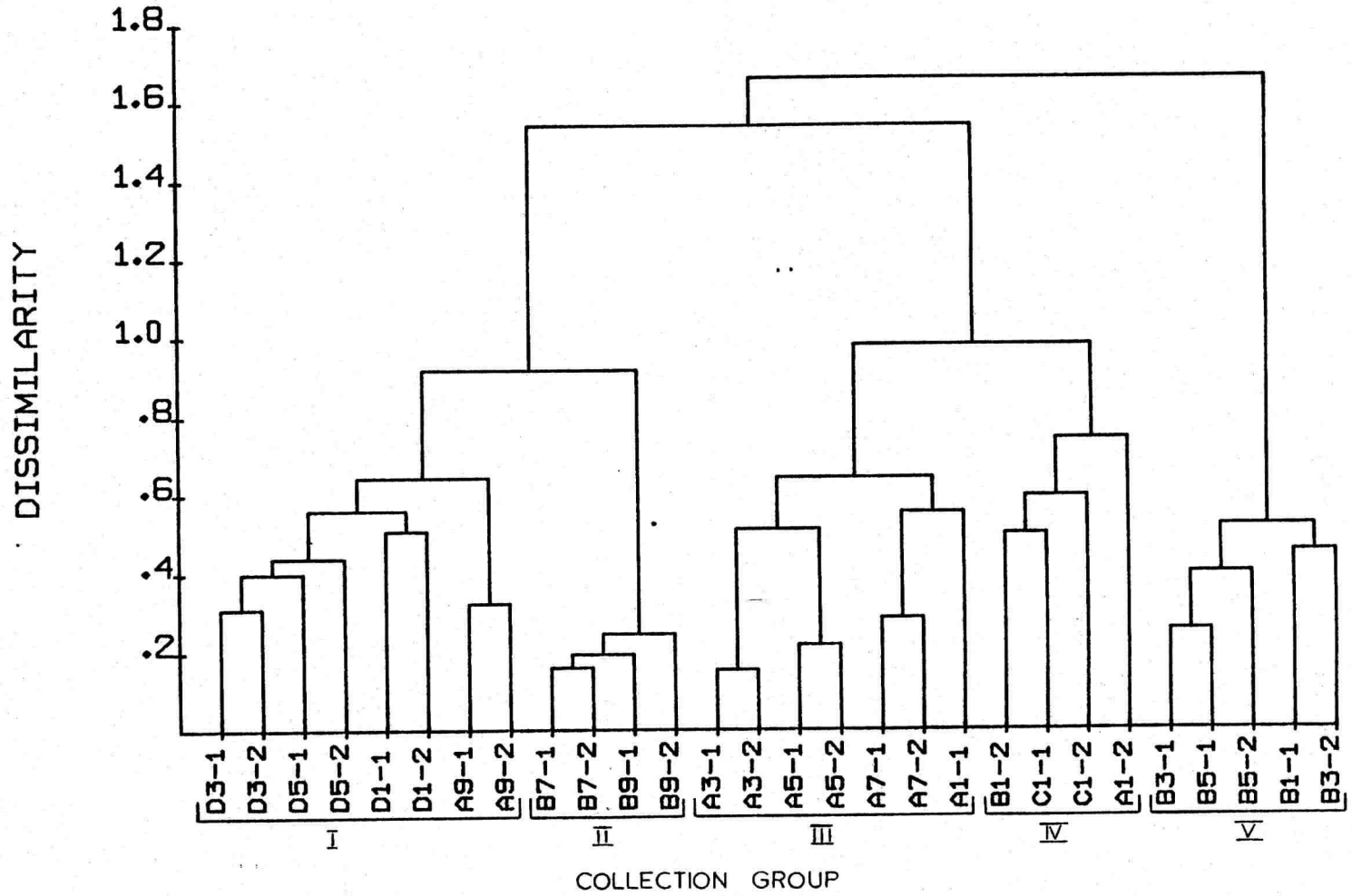
The dominant species were most similar at transects B and D (Table 7). The following eight species were among the ten most abundant at both of these transects: Macoma inquinata, Protothaca staminea, Photis brevipes, Orchomenella sp. 1, Olivella pycna, Paraphoxus epistomus, Owenia collaris, and Glycinde picta. Cryptomya californica and Amphissa columbiana ranked within the top ten at D, but not at B although the mean catch of both species per dredge sample was actually greater at B. The mean catch of all ten of the most abundant species at B was greater than at any other transect. The sixth and eighth most abundant species at B, Olivella biplicata and Aglaja diomedea, were relatively rare at the other transects.

The dominant fauna at transect C was not closely related to that of any other transect. The five least abundant dominants at C (Pontogeneia inermis, Podocerus sp. 1, Caprella laeviuscula, Paleanotus bellis, and Archaeomysis grebnitzki) did not rank within the top ten at any other transect and had rather low densities ($\leq$ 4 individuals/dredge). Four of the five most abundant species at C were also dominants at A: Melita dentata, Anaitides williamsi, Heptacarpus poludicola, and Crangon nigracauda. Paraphoxus epistomus was a dominant at C, B, and D. Transect A shared the four dominant species listed above with C, and three species (Macoma inquinata, Protothaca staminea, and Photis brevipes) with both B and D. Two of the most abundant species at A (Capitella capitata and Platynereis bicanaliculata) were present, but not dominant at B, C, or D.

Numerical Classification

The pattern of overlap between transects in the composition of the dominant species suggests a lack of faunal homogeneity within the transects. The normal classification of the data set resulted in five reasonably well-defined collection groups (Fig. 6). Twelve of the 14 station replicate pairs

Fig. 6. Collection group clusters of Yaquina Bay benthic samples.


DISSIMILARITY
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
D3-1
D3-2
D5-1
D5-2
D1-1
D1-2
A9-1
A9-2
B7-1
B7-2
B9-1
B9-2
A3-1
A3-2
A5-1
A5-2
A7-1
A7-2
A1-1
B1-2
C1-1
C1-2
A1-2
B3-1
B5-1
B5-2
B1-1
B3-2
I
II
III
IV
V
COLLECTION GROUP

of samples fell within the same collection group and 11 of these were "nearest neighbors." That result lends credence to a quantitative analysis of dredge samples which are often considered qualitative at best.

Samples taken along individual transects did not always fall into the same collection group (Fig. 6). Group I includes all transect D samples plus the replicates taken at station A9. Group II includes all samples from stations B7 and B9 and possesses the lowest within group faunal dissimilarity. Group III is restricted to the A transect and includes sample A1-1 and both replicates at stations A3, A5 and A7. The two replicates at C1 and samples A1-2 and B1-2 are included in Group IV which has the highest within group dissimilarity. Group V inclues sample B1-1 and the replicates at stations B3 and B5. At higher hierarchical levels, Group I is most closely related to II, and III to IV. Group V is quite distinct from the other collection groups.

In contrast to the statistical comparison of community structure parameters between transects, there were highly significant differences in areal richness, density of individuals, dominance, and H' diversity between the five collection groups (Table 8). Student-Newman-Keule multiple range test at the 0.05 probability level showed that mean areal richness of Group V (21.0 species) was not different from Group IV (23.2), but both means were less than in the other groups. Richness at III (34.1 species) and I (37.6) were not different. Richness at II (47.2 species) was greater than at III, but the difference between II and I was barely insignificant. The mean density of individuals was greater at II (1245.0 individuals) and less at IV (83.0) than at any other groups. Density at I (347.8 individuals), III (367.4), and V (417.4) were not different from one another. Mean values for the complement of Simpson's Index of dominance and H' diversity were very low at Group V (0.73 and 0.76, respectively) and significantly different from all

Table 8. Mean richness, density, dominance, and diversity of benthic samples in Yaquina Bay Collection Groups.

Parameter		Collection Group I	II	III	IV	V	Analysis of Variance
Areal Richness (S/Dredge)	$\bar{x}$	37.6	47.2	34.1	23.2	21.0	F = 7.59**
	Range	29-50	41-53	22-43	10-40	11-35	
Density of Individuals (N/Dredge)	$\bar{x}$	347.8	1245.0	367.4	83.0	417.4	F = 25.95**
	Range	104-842	1180-1283	80-647	30-181	272-549	
Dominance (1-Simpson's Index)	$\bar{x}$	0.86	0.88	0.87	0.90	0.73	F = 4.76**
	Range	0.74-0.93	0.84-0.90	0.81-0.91	0.87-0.93	0.54-0.86	
Diversity (h')	$\bar{x}$	1.13	1.12	1.09	1.12	0.76	F = 5.50**
	Range	0.84-1.37	1.02-1.18	0.94-1.19	0.90-1.28	0.49-1.04	

*$F_{0.05(23,4)} = 2.80$; **$F_{0.01(23,4)} = 4.26$

other groups. Within the other groups there were no differences in either dominance or H" diversity which varied between 0.86 - 0.90 and 1.09 - 1.13, respectively.

The inverse classification resulted in five species groups (Fig. 7, Table 9). Two way analyses of the mean number of individuals/sample and constancy of species groups in collection groups are shown in Tables 10 and 11, respectively.

One of the major results of the numerical classification was a division of all except one of the B transect samples into collection groups (CG) II and CG V which were distinctly different from one another. Group V included both replicates from stations B3 and B5 plus sample B1-1. It was strongly dominated by Olivella pycna, O. biplicata and Paraphoxus epistomus. These three species had a total mean abundance of 334.8 individuals/sample and accounted for 80% of the individuals collected in CG V. Their dominance accounts for the very low mean values for H' diversity (0.76) and the complement of Simpson's Index (0.73). None of the other species collected in these samples were very abundant. The high constancy and abundance of species group (SG) 5 in CG V merely reflects the ubiquity and density of the three dominants. The other ten species in SG 5 had only a moderate constancy (0.36) and low mean density (2.1 individuals/species/sample). Glycinde picta was the only species other than the dominants that appeared in all five samples. CG V had the lowest areal richness ($\bar{x}$ S/sample = 21.0) and, excluding the three dominants, the lowest mean density (82.6 individuals/sample) of any collection group.

The replicates from stations B7 and B9 constituted collection Group II which had the highest density of individuals, areal species richness, and within group faunal homogeneity of any of the collection groups. Species

Fig. 7. Species group clusters for Yaquina Bay samples.

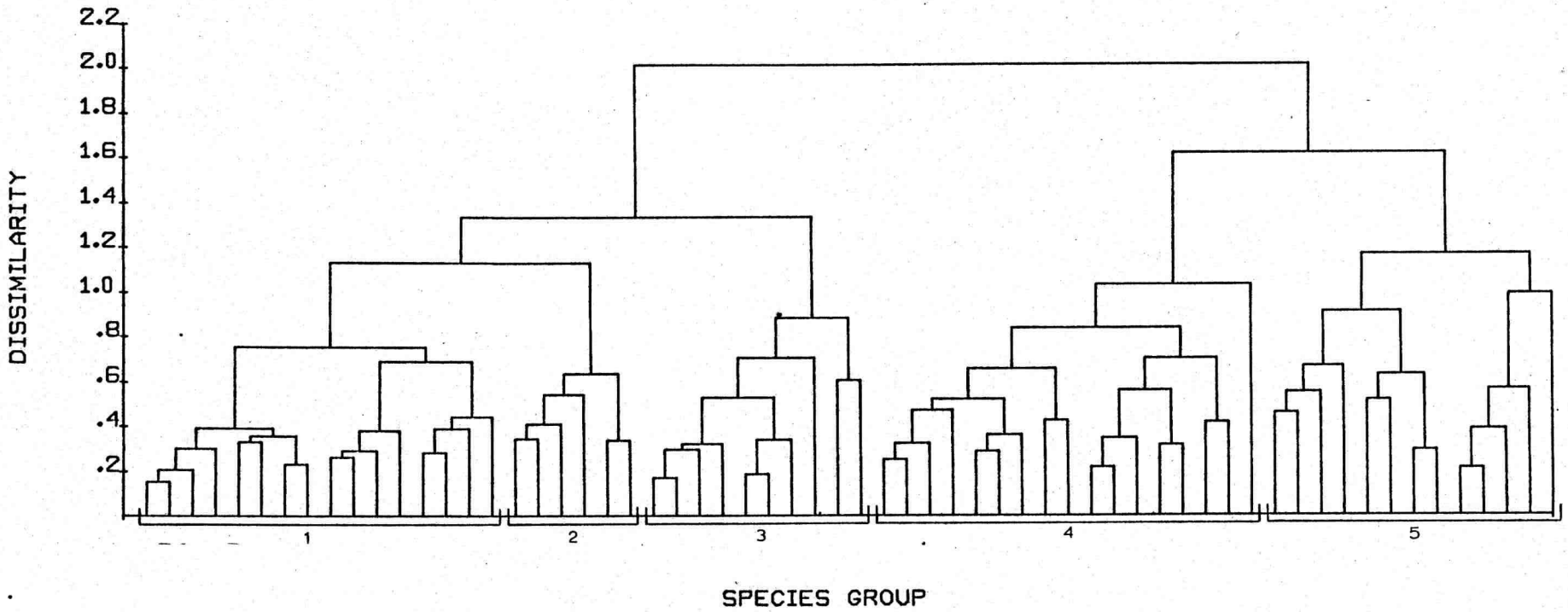

DISSIMILARITY
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
1
2
3
4
5
SPECIES GROUP

Table 9. Mean density of individuals in dredge samples within each collection group for members of each species group. Rank of the ten most abundant species within each collection group is given in parentheses.

	Collection Group				
	I	II	III	IV	V
Species Group 1					
Glycinde picta	12.8 (7)	56.0 (8)	2.7	.5	3.6
Macoma inquinata	96.2 (1)	331.5 (1)	19.2 (6)	.8	1.2
Protothaca staminea	36.6 (2)	89.2 (4)	5.6	.2	1.8
Haploscoloplos elongatus	6.4	11.0	.4	0	.2
Sphaerosyllis californiensis	1.5	7.8	2.0	0	0
Diastylis alaskensis	4.4	8.8	1.3	.2	1.0
Photis brevipes	12.5 (8)	74.8 (6)	28.7 (4)	1.2	.2
Cryptomya californica	13.9 (6)	56.5 (7)	6.3	1.5	0
Mediomastus californiensis	4.5	11.5	.4	0	2.2
Owenia collaris	14.0 (5)	90.5 (3)	0	.2	13.0 (4)
Protomedeia zotea	1.8	12.5	0	0	.2
Prionospio malmgreni	1.5	1.2	0	0	.8
Odostomia phanea	2.2	20.5	.6	0	2.4
Lamprops quadriplicata	2.8	30.8 (9)	0	.2	3.8 (9)
Tellina modesta	3.1	10.0	0	0	8.2 (5)
Amphissa columbiana	4.4	17.2	.3	0	6.8 (7)
Species Group 2					
Mytilus edulis	5.0	2.2	1.0	.5	0
Cancer magister	6.5 (10)	1.2	1.6	1.8	1.4
Pinnixia schmitti	6.4	1.0	.3	0	0
Gemma gemma	3.8	.5	.9	0	0
Cirratulus cirratus	6.2	.5	.7	0	0
Eupolymnia crescentis	1.8	0	0	.5	0
Species Group 3					
Tharyx parvus	0	30.5 (10)	0	0	0
Mitrella tuberosa	0	27.5	0	0	0
Ampharete arctica	0	3.2	.4	0	0
Dendraster excentricus	.1	3.0	0	0	.2
Aglaja diomedea	2.2	80.0 (5)	.1	0	0
Orchomenella sp. 1	11.2 (9)	184.8 (2)	.3	.8	.4
Nassarius mendicus	.5	27.2	0	0	.2
Nephtys caecoides	.6	1.2	0	0	0
Rhyncospio arenicola	.2	1.8	.3	0	0
Epitonium indianorum	0	4.5	0	0	0
Species Group 4					
Crangon nigricauda	1.1	1.8	16.1 (8)	12.5 (2)	7.2 (6)
Pontogeneia inermis	.1	0	4.1	2.5 (7)	.6
Melita dentata	3.6	1.0	67.6 (1)	13.0 (1)	1.4
Gnorimosphaeroma oregonensis	.1	0	1.4	.2	0
Cancer productus	.4	0	7.4	.2	.2
Cancer oregonensis	.2	0	3.3	.2	0
Paleanotus bellis	.4	.2	3.0	2.0	0
Heptacarpus paludicola	.6	0	22.3 (5)	5.2 (4)	.2
Pholis ornata	.1	0	2.3	0	0
Anaitides williamsi	.9	0	42.7 (3)	5.0 (5)	.8
Lumbrineris zonata	.5	0	7.9 (10)	.2	0
Anisogammarus pugettensis	3.6	.8	59.6 (2)	2.2 (9)	0
Harmothoe imbricata	1.1	1.5	6.1	.2	0
Platynereis bicanaliculata	3.9	2.8	12.7 (9)	1.0	.4
Armandia brevis	1.1	0	.7	0	.4
Capitalla capitata	24.4 (3)	14.2	17.1 (7)	.2	.2
Petrolisthes eriomerus	0	.2	6.0	0	0
Species Group 5					
Clinocardium nuttalli	1.0	1.0	.1	.8	.4
Parapleustes pugettensis	.9	.2	0	2.2 (9)	.6
Paraphoxus spinosus	2.1	.2	.9	2.5 (7)	1.6
Caprella laeviuscula	.1	0	.1	3.8 (6)	1.4
Archaeomysis grebnitzkii	.5	0	0	1.8	5.0 (8)
Mandibulophoxus gilesi	0	0	0	0	2.2
Hippomedon denticula	0	0	0	.5	2.0
Eohaustorius estuarius	.2	0	0	0	3.8 (9)
Olivella pycna	5.5	5.5	1.0	.5	137.4 (1)
Olivella biplicata	.1	.5	.1	1.0	75.6 (3)
Paraphoxus epistomus	22.8 (4)	1.0	.3	6.0 (3)	121.8 (2)
Parophrys vetulus	0	1.2	.6	0	3.6
Caprella californica	.1	0	1.4	.8	.2

Table 10. Mean density of species groups in dredge samples within Yaquina Bay collection groups.

	Species Group				
Collection Group	1	2	3	4	5
I	218.5	29.6	15.0	42.2	33.4
II	829.8	5.5	363.8	22.5	9.8
III	67.4	4.4	1.1	280.4	4.6
IV	5.0	2.8	0.8	45.0	19.8
V	45.4	1.4	0.8	11.4	355.6

Table 11. Constancy of species groups within Yaquina Bay collection groups. Very high values (>.75) are underlined twice, high values (.50-.74), once.

	Species Group				
Collection Group	1	2	3	4	5
I	.78	.77	.24	.43	.28
II	.97	.62	.85	.26	.31
III	.44	.43	.09	.80	.19
IV	.20	.29	.03	.41	.38
V	.40	.13	.06	.18	.51

Groups 1 and 3 are dominant (Tables 9, 10). Constancy was high or very high for both of these species groups plus SG 2, although the latter was represented by very few individuals (Table 11). SG 3 was almost entirely restricted to CG II. SG 1 reached its maximum abundance in CG II, but it was also the dominant species group in CG I.

Macoma inquinata and Orchomenella sp. 1 were the first and second most abundant species in each of the four CG II samples. The tremendous faunal homogeneity of this group was also due to the ubiquitous presence of 25 species in all samples. The other dominants include Owenia collaris, Protothaca staminea, Aglaja diomedea, Photis brevipes, Cryptomya californica, Glycinde picta, Lamprops quadriplicata, and Tharyx parvus. All of these species reached their maximum abundance in this collection group.

The benthos at B7 and B9 was very different from that at the other B transect stations, especially CG V. Only two species, Owenia collaris and Glycinde picta, ranked within the ten most abundant species in both CG II and CG V. The three dominants at CG V, Olivella pycna, O. biplicata and Paraphoxus epistomus had a total mean abundance per dredge sample of only 7.0 individuals within CG II.

Numerical classification also subdivided the A transect stations. The replicates at A9 clustered with all D transect samples in collection Group I. The remainder of the A samples (except for A1-2) formed collection Group III. The structure of the benthos in these groups is very similar, but the dominant species are rather different (Table 9). Only three species (Macoma inquinata, Capitella capitata, and Photis brevipes) appear within the ten most abundant species in both collection groups. The dominants in CG III (Melita dentata, Anisogammarus pugettensis, and Anaitides williamsi) were not abundant in CG I. CG I was much more closely related to CG II (stations B7, 9) in dominant species composition. Species groups 1 and 2 were abundant and had very high

constancy within CG I (Tables 10, 11). Species group 4 was most abundant and ubiquitous in CG III.

The distribution of the opportunistic polychaete Capitella capitata is shown in Table 12. Although C. capitata ranks as the third most abundant species in CG I, it was present in only three (D3-1, A9-1, A9-2) of the eight CG I samples. Its spatial distribution indicates a gradient of increasing density along both the A and B transects. It reached its maximum abundance at stations A7, A9, and B9. These collections contained a great variety of other species and relatively high faunal densities.

The two replicates taken on the C transect and samples A1-2 and B1-2 form collection Group IV. These samples contained relatively few species and individuals. The lack of any real dominant species resulted in relatively high values of H' diversity and the complement of Simpson's Index (Table 8). The constancy and abundance of all species groups was low in CG IV (Table 10, 11). Melita dentata was the most abundant species, but its mean density/sample was only 13.0 individuals. The composition of the "dominant" species in CG IV most closely resembles that of CG III.

Unidentified Species

The preceding results are based on those individuals which were identified to the species level. Specimens which could be identified only at higher taxonomic levels are listed in Table 13 for both transects and collection groups. The highest density of unidentified individuals was found at the A transect and in collection Group III which includes 7 of the 10 A transect samples. A relatively high abundance of anomuran megalopae is evident in CG III and of ophiuroideans in CG II (stations B7 and B9).

Table 12. Distribution of Capitella capitata in Yaquina Bay samples.

	Number of Individuals									
	Dredge Sample									
Transect	1-1	1-2	3-1	3-2	5-1	5-2	7-1	7-2	9-1	9-2
A	2	0	19	8	7	15	46	23	25	165
B	1	0	0	0	0	0	5	3	41	8
C	1	0								
D	0	0	5	0	0	0				

Table 13. Distribution of taxa not identified to the species level in Yaquina Bay transects and collection groups.

Taxon	Transect				Collection Group				
	A	B	C	D	I	II	III	IV	V
Anomuran megalopae	10.7	.1	0	1.3	1.9	.2	10.4	.8	0
Pycnogonida	3.2	5.2	8.5	2.5	2.1	1.2	4.3	6.2	7.8
Ophiuroidea	1.4	7.7	.5	0	0	18.5	2.0	.2	.6
Nudibranchia	4.8	1.7	2.0	.3	.2	0	6.7	1.2	3.4
Brachyuran megalopae	3.2	.5	3.0	3.8	3.0	.5	4.3	1.8	.6
Nemertea	2.5	.3	0	1.0	1.5	.8	2.7	0	0
Polycladida	.1	.1	5.5	0	0	0	.1	2.8	.2
Anthozoa	.3	0	.5	0	0	0	.3	.2	.2
TOTAL	26.2	15.6	20.0	8.9	8.7	21.2	30.8	13.2	12.8

DISCUSSION AND CONCLUSIONS

Cannery Effluents

The effects of seafood cannery effluents on water and sediment quality in Yaquina Bay are restricted to the immediate vicinity of the cannery docks. The effluent plume is quite turbid and has high nutrient concentrations. Because of its initial low salinity it is restricted to the surface layer where it mixes rapidly with estuarine water and is dispersed by strong tidal currents. The quality of water at the bottom along the A transect was comparable to that at other stations in the Bay. The dissolved oxygen concentration at both the surface and bottom was not less than 7 mg/l.

The strength of the currents along cannery row and the screening treatment of the effluents minimize the deposition of waste materials on the sea bed. There was no evidence for a major increase in the concentration of any chemical parameter in the sediments along the A transect. However, concentrations of Kjeldahl nitrogen, total and hydrocarbon oil and grease, and total and alkaline soluble sulfides were generally higher than at the other transects although the ranges often overlapped. Television observations and the dredged samples did not indicate the accumulation of shells or other waste products on the bottom. There was, however, a greatly increased incidence of human artifacts on the bottom at the A stations.

A very diverse and abundant macrofaunal benthic community was found immediately adjacent to the cannery outfalls (transect A). Although this assemblage differed in species composition from the benthos collected across the Bay at the Oregon State University docks (transect D), there were no statistical differences in community structure parameters of density, dominance, diversity or richness.

Tidal or current dispersion of wastes seems to be the major factor determining the impact of cannery effluents. Beyer, Nakatani and Staude (1975)

examined environmental conditions near salmon cannery outfalls in an area of strong tidal action at Petersburg, Alaska. Their results are similar to ours. DO concentrations near the Petersburg canneries were not lower than ambient values. Turbidity was high only in the immediate vicinity of the outfalls. Their analysis of intertidal communities indicated that spatial differences could not be attributed to outfall effects. The Petersburg effluents were not screened, resulting in temporary accumulations of heads, tails and viscera in a small area north of the outfalls. The subtidal benthos was less diverse beneath these accumulations. Beyer et al. (1975) believed that grinding wastes would alleviate this problem.

Cannery effluents can cause major environmental degradation if flushing is inadequate. Stewart and Tangarone (1977) and Karna (1978) examined water and sediment quality in the vicinity of seafood cannery outfalls in Dutch Harbor, Alaska. They found that DO concentrations in bottom water were often less than 6 mg/l and in one instance the bottom water was anaerobic. Concentrations of ammonia and total phosphorus at the bottom were substantially greater than at control locations. Most of the shells and heavier wastes accumulated on the bottom within a 30 m radius of the outfalls. Deposits of less dense material extended well beyond the 30 m radius. These deposits resulted in high concentrations of hydrogen sulfides and organic matter in the sediments. Qualitative observations during diving surveys indicated a greatly reduced richness of benthic species in the area of waste deposits.

Reish (1959) and Barnard and Reish (1959) reported a tremendous degradation of the macrobenthos in poorly flushed embayments next to fish canneries in Los Angeles Harbor and Newport Bay, California. Only 7 species and 134 individuals were collected from the cannery area in Newport Bay, and 3 species and 88 individuals in Los Angeles Harbor. The widely recognized pollution indicator species, Capitella capitata, accounted for about 90% of

the individuals in both cases. This polychaete reached its maximum density in our survey at stations A7, A9, and B9. The collections at these stations contained an average of 45 species and 715 individuals per dredge sample. C. capitata accounted for about 7% of the individuals. We do not believe that a significant ecological alteration is indicated by the presence of an opportunistic species in the midst of such an abundance and variety of other benthic invertebrates.

This report concerns cannery effluent impacts on the macrobenthos, sediment and water quality as determined from a single ecological survey. Limitations in time and resources prevented an analysis of temporal changes or effects on other biological communities. One assemblage that certainly warrants additional study is the intertidal fauna and flora on the pilings and rocks beneath the cannery docks. Michael Mix (personal communication) has observed a high incidence of mortality, abnormal and possibly neoplastic cells, and inhibited gametogenesis in mussels, Mytilus edulis, collected from the cannery dock pilings in Yaquina Bay. These disorders were correlated with increased body burdens of benzo(α)pyrene, a carcinogenic petroleum hydrocarbon. The source of the benzo(α)pyrene is uncertain. Dunn and Stich (1976) attributed elevated levels of benzo(α)pyrene in mussels growing near pilings in Vancouver harbor to the creosote used as a piling preservative.

Spatial Heterogeneity in Yaquina Bay Benthos

We observed substantial within and between transect variations in the structure and species composition of Yaquina Bay benthic assemblages. The characteristics of the benthos on the A transect do not seem to be attributable to cannery outfall effects. There were no substantial differences between any of the stations in the temperature, salinity or dissolved oxygen in water near the bottom. Water depth was slightly greater at the channel stations (A1, B1, C1), but major differences in the benthos were found

between stations of comparable depth. Sediment particle size distribution is the only environmental factor that was closely related to spatial changes in the benthos.

The numerical classification of the Yaquina Bay samples produced five collection groups. The stations which clustered together on the basis of faunal similarity are also similar in sediment characteristics. In Table 14 the sediment preferences as described in the scientific literature are given for benthic species collected in Yaquina Bay. Species are listed in Table 14 within the collection group in which they achieved their maximum abundance (see Table 9 for density data).

Most of the species reached maximum density in collection groups II or III. Sediments at these two groups of collections were distinctly different. CG II includes stations B7 and B9 which were the only stations in which the sediment contained a large proportion of fine particles. Almost all species which were most abundant at CG II are described in the literature as having a preference for muddy sand or similar fine sediment types (Table 14). All species which reached their maximum abundance in CG II were clustered in species groups 1 and 3 by the inverse numerical classification. The distinction between these two species groups is that the members of SG 3 have a stronger preference for muds and were almost entirely restricted to CG II (Tables 14, 9). SG 1 however was more tolerant of sandier sediments and therefore had a wider spatial distribution in the Bay.

In contrast to the muddy sediments at CG II, the sediments at CG III (sample A1-1 and both replicates at A3, 5, 7) were poorly sorted and contained a large proportion of coarse sands, gravel and shells. The literature indicates that the species with a maximum density at CG III had a preference for coarse sediment types (Table 14). These species were restricted to SG 4 which was also present, but much less abundant in CG IV

Table 14. Sediment preference of Yaquina Bay macrobenthos as described in the scientific literature. Species are assigned to the collection group in which they achieved their maximum density.

Collection Group Stations Sediment Type	Species	Species Group	Sediment Preference	Reference
Collection Group II Stations B7, B9 Fine sand, silt and clay.	Glycinde picta	1	sandy mud	1,2
	Macoma inquinata	1	silt and mud	1
	Protothaca staminea	1	sandy mud, sands, gravel, rocks	1,3,4
	Haploscoloplos elongatus	1	very fine sands, muddy sand	5,6,7
	Sphaerosyllis californiensis	1	silt, mud, and mixed sediment	1,7
	Cryptomya californica	1	mud or sand	1
	Mediomostus californiensis	1	mud, fine or very fine sand	1,2,6,8
	Owenia collaris	1	muddy sand, fine sand	1,9,10,11
	Lamprops quadriplicata	1	fine sand	12
	Tellina modesta	1	silty sand, sand	1,13
	Amphissa columbiana	1	sand, gravel, rocks	1
	Tharyx parvus	3	fine silty muds, muddy sands	1,8,14
	Mitrella tuberosa	3	sand and gravel	1
	Ampharete arctica	3	mud	15
	Aglaja diomedea	3	mudflats	1,3,16
	Nassarius mendicus	3	mud, sand, rocks	1
	Rhyncospio arenicola	3	muddy sand	17
	Orchomenella sp.	3	sandy mud	18
Collection Group III Stations A1,3,5,7 Poorly sorted sands, gravel and shell.	Crangon nigricauda	4	rocks, sand	1
	Melita dentata	4	rocks, stones	19
	Gnorimosphaeroma oregonensis	4	sand, stones, gravel, rocks	20
	Anisogammarus pugettensis	4	marshes	1
	Cancer productus	4	coarse sands, gravel, rocks	21
	Heptacarpus paludicola	4	pools on mudflats and rocky intertidal	1
	Anaitides williamsi	4	muddy sand, shell fragments	1,14
	Lumbrineris zonata	4	mixed sediments or clean sand	7
	Harmothoe imbricata	4	rocks	1
	Platynereis bicanaliculata	4	sand, shells, rocks	1,14
	Petrolisthes eriomerus	4	rocks	22,23
Collection Group V Stations B1,3,5 Very well sorted fine sands	Eohaustorius estuarius	5	clean, medium sand	24
	Paraphoxus epistomus	5	medium fine unstable sand	19,25
	Olivella biplicata	5	clean sand	1
Collection Group I Stations A9, D1,3,5 Fine and medium sands	Cancer magister	2	sand	1,21
	Gemma gemma	2	sands or muddy sands	26
	Cirratulus cirratus	2	sand, rocks	1,27
	Eupolymnia crescentis	2	sandy mud	1
	Capitella capitata	1	organically enriched fine sediments	1,14,28

1 Smith and Carlton (1975), 2 Barnes (1966), 3 Ricketts and Calvin (1952), 4 Fitch (1953), 5 Reish (1963), 6 Reish (1964), 7 Hartman (1968), 8 Vassallo(1970), 9 Perkins (1974), 10 Hartman (1969), 11 Fager (1964), 12 Given (1965), 13 Maurer (1967), 14 Barnard and Reish (1959), 15 Sanders (1960), 16 Abbott (1974), 17 Wieser (1959), 18 Hurley (1963), 19 Bousfield (1973), 20 Rees (1975), 21 Schmitt (1921), 22 Gonor and Gonor (1973), 23 Knudsen (1964), 24 Bosworth (1973), 25 Maurer et al. (1974), 26 Narchi (1971), 27 Reish (1949), 28 Warren (1977).

(samples A1-2, B1-2, C1-1 and 2). The sediments at CG IV were shells and gravel [sediment data given in Table 2 are representative of the first replicate taken at stations A1 and B1]. The depauperate fauna in CG IV may be related to the location of these stations in channels where they are subjected to dredging and a great deal of ship activity.

Very well sorted fine sands occurred in sample B1-1 and both replicates at stations B3 and B5 (CG V). Species group 5 was dominant and its members are known to prefer clean fine or medium sands (Table 14). Medium and fine sands are present at CG V (the D transect and station A9). Species group 2 reached its maximum abundance at CG V and with the exception of Mytilus edulis, it is a sand dwelling assemblage.

In summary, sediment composition is a major factor controlling the distribution of subtidal benthic invertebrates in Yaquina Bay. Two major assemblages were encountered in our survey. The muddy sands at stations B7 and 9 support a very abundant and diverse benthic community dominated by Macoma inquinata, Orchomenella sp. 1, and Owenia collaris. The more psammophilic species in this community were also abundant in the medium and fine sands at station A9 and the D transect. The second major assemblage was found in the coarser sediments along most of the A transect. The more abundant species there were Melita dentata, Anisogammarus pugettensis, and Anaitides williamsi. A depauperate example of this community was encountered in coarse channel sediments. The fine clean sands along channel banks were densely populated by only three species, Olivella pycna, O. biplicata, and Paraphoxus epistomus.

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Appendix 1. Raw data set for the macrofaunal benthic collections made in Yaquina Bay, Oregon on 9-10 May 1978.

	A1-1	A1-2	A3-1	A3-2	A5-1	A5-2	A7-1	A7-2	A9-1	A9-2
ACMAEA SP	1									
ACTEOCINA CULCITELLA									1	
AGLAJA DIOMEDEA			1						1	
AMAENA OCCIDENTALIS	1									
AMPHARETE ARCTICA								3		
AMPHISSA COLUMBIANA	1					1				
AMPITHOE LACERTOSA				1						
ANAITIDES WILLIAMSI	6	3	74	93	4	27	35	60	1	2
ANISOGAMMARUS CONFERVICOLUS					2					
ANISOGAMMARUS PUGETTENSIS	6	9	162	232		2	7	8	2	12
ANOMURAN MEGALOPA	3	1	28	19	17	5	18	9	1	6
ANTHOZOAN UNID		1						2		
ARMANDIA BREVIS			2			1	2		1	7
BARNEA SUBTRUNCATA				1						
CANCER MAGISTER	2		3	3	1	1		1	5	14
CANCER OREGONENSIS			8	1	3	2	6	3		1
CANCER PRODUCTUS	4		14	11	8	7	4	4		3
CAPITELLA CAPITATA	2		19	8	7	15	46	23	25	165
CAPRELLA CALIFORNICA					1		9			
CAPRELLA LAEVIUSCULA					1					
CIRRATULUS CIRRATUS					1	3		1	8	8
CISTENIDES BREVICOMA						1			1	
CLINOCARDIUM NUTTALLI			1						1	2
COROPHIUM OAKLANDENSE			3							
CRAB MEGALOPA	1	1	10	6		7	1	5	1	
CRANGON NIGRICAUDA		2	11	12	29	58		3		5
CRYPTOMYA CALIFORNICA	2	4	6	5	3	7	12	9	6	7
DIASTYLIS ALASKENSIS			2	3		1	3		6	9
DYNAMENELLA SHEARERI			2			1				
ENOPHRYS BISON			1		1			1		
EOHAUSTORIUS ESTUARIUS										1
EULALIA AVICULISETA				2			1			
EUPOLYMNIA CRESCENTIS									1	2
EUSYLLIS BLOMSTRANDI			2			2				
GEMMA GEMMA			2	4					5	9
GLYCINDE PICTA		1	2	1	1	2	6	7	12	48
GNORIMOSPHAEROMA OREGONENSIS	1		4	1	3	1				
GYPTIS BREVIPALPA										1
HAPLOSCOLOPLOS ELONGATUS						3			7	20
HARMOTHOE IMBRICATA			12	8	4	15	3	1	2	
HEPTACARPUS PALUDICOLA	1	4	4	1	71	77	1	1	1	1
HETEROMASTUS FILOBRANCHUS							1			1
HIATELLA ARCTICA					1					
IDOTEA FEWKESI				1		2	1			
ISOPOD A				1						
JASSA FALCATA									2	
LACUNA MARMORATA						1	1			
LAMPROPS QUADRIPLICATA									7	1
LETOCHELIA DUBIA										2
LIMNORIA LIGNORUM								1		
LUMBRINERIS ZONATA	1		20	19	1	1	5	8		2
MACOMA INQUINATA	11		20	14	21	24	29	15	172	329
MACOMA NASUTA							1			
MEDIOMASTUS CALIFORNIENSIS								3	3	6
MELITA DENTATA	27	3	121	119	83	106	4	6	1	6
MICROPODARKE DUBIA			2	2		2				2
MIMULUS FOLIATUS			1							
MYTILUS EDULIS			•	1	1	1	2	2		9
NEMERTEAN UNID					12	3		4	1	5
NEPHTYS CAECOIDES										1
NEPHTYS FERRUGINEA										2
NUDIBRANCH UNID	1	1	15	14	3	5	5	4		
ODONTOSYLLIS PARVA							1			
ODOSTOMA SP					1	4				
ODOSTOMIA PHANEA	1				1	2			2	3
OLIVELLA BIPLICATA			1							
OLIVELLA PYCNA	1		3		2			1		
OPHIUROIDEA UNID			1	1	2	7	2	1		
ORCHOMENELLA SP I				1			1			1
OWENIA COLLARIS									1	13
PAGURUS SAMUELIS	1									2
PALEANOTUS BELLIS			10		3	4	1	3		2
PARAPHOXUS EPISTOMUS					1	1				
PARAPHOXUS SPINOSUS			4	1				1		
PARAPLEUSTES PUGETTENSIS										2
PAROPHRYS VETULUS			1	1	2					
PEISIDICE ASPERA					1					
PETROLISTHES ERIOMERUS			29	13						
PHOLIS ORNATA			4		7	4	1		1	
PHOTIS BREVIPES	2	2	53	61	28	26	21	10	8	11
PINNIXIA SCHMITTI			1	1					6	10
PIONOSYLLIS GIGANTEA						1				
PISASTER BREVISPINUS										1
PLATYNEREIS BICANALICULATA	1		12	13		19	36	8	1	9
POLYCLADIDA UNID				1						
POLYNOID SP A			2							
POLYNOID SP B			1	1						
PONTOGENEIA INERMIS		1	5	5	12	6		1		1
PRIONOSPIO CIRRIFERA			1							2
PRIONOSPIO MALMGRENI									1	1
PROTOTHACA STAMINEA	6		12.	2	2	3	5	9	117	90
PSEUDOPOTAMILLA SOCIALIS								2		
PUGETTIA PRODUCTA							2			
PYCNOGONID UNID	1		4	12	3	4	6		1	1
PYCNOPODIA HELIANTHOIDES	1	1					1			
RHOMBOIDELLA COLUMBIANA								1		
RHYNCOSPIO ARENICOLA							1	1	1	
SAXIDOMUS GIGANTIUS				1						1
SCYRA ACUTIFRONS						1				
SPHAEROSYLLIS CALIFORNIENIS			3	2		4	5			9
SPIOPHANES FIMBRIATA										1
SYLLIS SP (BANSE)				1			2	2		2
TELLINA MODESTA										2
TIRON BIOCELLATA					1		1			
TRANSENNELLA TANTILLA										1
TRITELLA LAEVIS	1									
VENERUPIS PHILIPPINARUM			1							

	B1-1	B1-2	B3-1	B3-2	B5-1	B5-2	B7-1	B7-2	B9-1	B9-2
ACTEOCINA CULCITELLA								1		
ACTEOCINA HARPA							2	1	2	1
AGLAJA DIOMEDEA							79	79	34	128
AMPHARETE ARCTICA							5	2	6	
AMPHISSA COLUMBIANA					6	28		2	23	44
ANAITIDES WILLIAMSI	2									
ANISOGAMMARUS PUGETTENSIS								3		
ANOMURAN MEGALOPA										1
ARCHAEOMYSIS GREBNITZKII	25									
ARMANDIA BREVIS	1					1				
CALIANASSA CALIFORNIENSIS										1
CANCER MAGISTER	3	1	1	1		2	1	1	1	1
CANCER OREGONENSIS		1								
CANCER PRODUCTUS						1				
CAPITELLA CAPITATA	1						5	3	41	8
CAPRELLA CALIFORNICA						1				
CAPRELLA LAEVIUSCULA	7	7								
CIRRATULUS CIRRATUS								1	1	
CISTENIDES BREVICOMA								1	1	1
CITHARICHTHYS SORDIDUS						1				
CLINOCARDIUM NUTTALLI	1			1			2		1	1
COROPHIUM OAKLANDENSE										1
CRAB MEGALOPA	2				1			1		
CRANGON NIGRICAUDA	27	7	1		5	3	5	1	1	
CRYPTOMYA CALIFORNICA							50	18	90	68
CUMELLA VULGARIS									1	
DENDRASTER EXCENTRICUS	1						3	4	5	
DIASTYLIS ALASKENSIS						5	11	13	2	9
ENOPHRYS BISON		1								
EOHAUSTORIUS ESTUARIUS	14		2	3						
EPITONIUM INDIANORUM									8	10
EUSYLLIS BLOMSTRANDI	1									
GEMMA GEMMA							1			1
GLYCINDE PICTA	1		1	1	6	9	56	70	58	40
HALOSYDNA BREVITOSA	1									
HAPLOSCOLOPLOS ELONGATUS					1		18	9	11	6
HARMOTHOE IMBRICATA							4		2	
HEPTACARPUS BREVIROSTRIS	1	1								
HEPTACARPUS PALUDICOLA	1	1								
HETEROMASTUS FILOBRANCHUS					1			1	3	1
HIATELLA STRIATA								1	1	
HIPPOMEDON DENTICULATUS	8	1	1	1						
IDOTEA FEWKESI								1		
LACUNA MARMORATA			1							
LAMPROPS QUADRIPLICATA			2		5	12	60	15	7	41
LETOCHELIA DUBIA								3		
LITTORINA SCUTULATA										1
LOXORHYNCHUS CRISPATUS									1	
LUMBRINERIS CALIFORNIENSIS								1		
LUMBRINERIS CRUZENSIS									1	
LYONSIA CALIFORNICA									1	
MACOMA INQUINATA					3	3	356	401	318	251
MANDIBULOPHOXUS GILESI	11									
MEDIOMASTUS CALIFORNIENSIS					10	1	6	7	16	17
MELITA DENTATA	4	3			1	2	1	1	1	1
MITRELLA TUBEROSA							46	17	45	2
MONOCULODES SPINIPES	3					1				
MYRIOCHELE HEERI								1	3	2
MYTILUS EDULIS							2	1	3	3
NASSARIUS MENDICUS					1		30	5	29	45
NEMERTEAN UNID								1	2	
NEPHTYS CAECA										1
NEPHTYS CAECOIDES							2	2		1
NEPHTYS CILIATA	4		1	1						
NEPHTYS FERRUGINEA								1		
NUDIBRANCH UNID	13		2		1	1				
ODOSTOMIA PHANEA						12	26	15	8	33
OLIVELLA BIPLICATA	68	2	133	25	105	47		1	1	
OLIVELLA PYCNA	88	1	202	55	207	135	2	3	5	12
OPHIUROIDEA UNID	1				1	1	20	13	22	10
ORCHOMENELLA SP I						2	160	243	151	185
OWENIA COLLARIS			4	1	41	19	81	75	112	94
PAGURUS SAMUELIS		1								
PALEANOTUS BELLIS		1							1	
PANDORA GLACIALIS									1	
PARAPHOXUS EPISTOMUS	98	3	146	179	138	48				4
PARAPHOXUS SPINOSUS	6	4								1
PARAPLEUSTES FUGETTENSIS	3	4					1			
PAROPHRYS VETULUS	7		1		7	3	1	1	1	2
PETROLISTHES ERIOMERUS							1			
PHOLOE TUBERCULATA								1		
PHOTIS BREVIPES	1	1					111	88	50	50
PINNIXIA SCHMITTI							1	2		1
PLATYNEREIS BICANALICULATA						2	8		3	
PODOCERUS SP I	1									
POLYCIRRUS SPI						1				
POLYCLADIDA UNID						1				
PONTOGENEIA INERMIS	3	1								
PRIONOSPIO CIRRIFERA							1		1	
PRIONOSPIO MALMGRENI			2		2		1	2	2	
PROTOMEDEIA ZOTEA					1		3	5	7	35
PROTOTHACA STAMINEA	1		1			7	63	128	140	26
PSEUDOPOTAMILLA SOCIALIS	1									
PYCNOGONID UNID	37	8	1		1		1	1	2	1
PYCNOPODIA HELIANTHOIDES	1									
RHYNCOSPIO ARENICOLA							1		1	5
SABELLARIA CEMENTARIUM	1									
SAXIDOMUS GIGANTIUS						1			1	1
SILIQUA PATULA									1	
SPHAEROSYLLIS CALIFORNIENIS							5	10	8	8
SPIONIDAE SP B								1		
SPIOPHANES BOMBYX								1		1
SPIOPHANES FIMBRIATA								2		1
SPIOPHANES SP A							1			
SYLLIS ELONGATA		2								
TELLINA BODEGENSIS									1	2
TELLINA MODESTA	5			11	9	16	9	8	9	14
TELLINA NUCULOIDES	1									
THARYX PARVUS							15	30	58	19
TRANSENNELLA TANTILLA									2	

	C1-1	C1-2	D1-1	D1-2	D3-1	D3-2	D5-1	D5-2
ACTEOCINA HARPA	1				1			
AGLAJA DIOMEDEA			5	7	1	4		
AMAENA OCCIDENTALIS					1	1		1
AMPHISSA COLUMBIANA			1	25	2	7		
AMPITHOE LACERTOSA						1		
ANAITIDES SP A				1			2	
ANAITIDES WILLIAMSI	17			1	1		1	1
ANISOGAMMARUS PUGETTENSIS			1	2	2	7	1	2
ANOMURAN MEGALOPA			3		3	2		1
ANTHOZOAN UNID	1							
ARCHAEOMYSIS GREBNITZKII	7		3				1	
ARCHIDORIS ODHNERI	1							
ARMANDIA BREVIS					1			
AUTOLYTUS VERRILLI	2							
CALLIOSTOMA LIGATUM		1						
CANCER MAGISTER	4	2	3	1	3	24	1	1
CANCER OREGONENSIS					1			
CANCER PRODUCTUS		1						
CAPITELLA CAPITATA	1				5			
CAPRELLA CALIFORNICA		3	1					
CAPRELLA LAEVIUSCULA	6	2						1
CIRRATULUS CIRRATUS				1	18	3	12	
CLINOCARDIUM NUTTALLI	2	1	2	1		1	1	
COROPHIUM BREVIS				3				
CRAB MEGALOPA	5	1	2	4		7	6	4
CRANGON NIGRICAUDA	31	10	2		2			
CRYPTOMYA CALIFORNICA		2	8	59	3	17	5	6
DENDRASTER EXCENTRICUS				1				
DIASTYLIS ALASKENSIS		1		12	2	1		5
DIASTYLOPSIS DAWSONI					1			
DORIDELLA STEINBERGAE	1							
EOHAUSTORIUS ESTUARIUS				1				
ETEONE LACTEA							1	
ETEONE LONGA							1	
EUCALIA AVICULISETA	3				1			
EUPOLYMNIA CRESCENTIS	1	1			4	2	5	
EXOGENE LOUREI	2							
GEMMA GEMMA						15	1	
GLYCINDE PICTA	1		2	6	10	10	13	1
GNORIMOSPHAEROMA OREGONENSIS	1		1					
HAPLOSCOLOPLOS ELONGATUS			2	3	9	5	4	1
HARMOTHOE IMBRICATA	1		1		4	1		1
HARMOTHOE LUNULATA					1		1	
HEPTACARPUS BREVIROSTRIS		3						
HEPTACARPUS PALUDICOLA		16	1		1			1
HIPPOMEDON DENTICULATUS	1							
IDOTEA FEWKESI	1							
ISCHYROCERUS ANGUIPES			2					
LACUNA MARMORATA		1		1				1
LAMPROPS QUADRIPLICATA	1		9	5				
LIMNORIA ALGARUM								1
LITTORINA SCUTULATA		2						
LOPHOPANOPEUS BELLUS		1			1			
LOXORHYNCHUS CRISPATUS		1						
LUMBRINERIS CRUZENSIS					1			
LUMBRINERIS ZONATA	1					1		1
MACOMA INQUINATA	2	1	10	82	45	80	22	30
MAGELONA SACCULATA					1			
MEDIOMASTUS CALIFORNIENSIS			1		12	1	10	3
MELITA DENTATA	29	17	5		3	4		10
MESOCHAETOPTERUS TAYLORI						3	1	
MONOCULODES SPINIPES	2							
MYTILUS EDULIS	1	1	3		10	14	2	2
NAINERIS UNCINATA						1	1	
NASSARIUS MENDICUS				4				
NEMERTEAN UNID					3		3	
NEOAMPHITRITE ROBUSTA					1			
NEPHTYS CAECOIDES			3				1	
NUCELLA LAMELLOSA						1	1	
NUDIBRANCH UNID	3	1				1		1
ODOSTOMIA PHANEA				8	1	4		
OLIVELLA BIPLICATA	2		1					
OLIVELLA PYCNA	1		27	14		3		
OPHIUROIDEA UNID	1							
ORCHOMENELLA SP I	3		17	36	15	10	8	3
OWENIA COLLARIS	1			26	5	18	44	5
PALEANOTUS BELLIS	7		1					
PARAPHOXUS EPISTOMUS	21		108	1	27	33	10	3
PARAPHOXUS SPINOSUS	6			11	3	3		
PARAPLEUSTES PUGETTENSIS	2	3	2	2	1			
PHOTIS BREVIPES	2		8	22	8	13	15	15
PINNIXIA SCHMITTI			3	16	3	8	4	1
PIONOSYLLIS GIGANTEA	1							
PISASTER OCHRACEUS					1			
PLATYNEREIS BICANALICULATA	3	1	6	3	5	4	1	2
PODOCERUS SP I	5	3						
POLYCLADIDA UNID	6	5						
PONTOGENEIA INERMIS	5	3						
PRIONOSPIO CIRRIFERA								1
PRIONOSPIO MALMGRENI					3	3	3	1
PROTOMEDEIA ZOTEA				1	4	1	7	1
PROTOTHACA STAMINEA		1	9	21	5	49		2
PSEUDOPOTAMILLA SOCIALIS			1		1			
PYCNOGONID UNID	15	2	8		2	5		
PYCNOPODIA HELIANTHOIDES								1
RHYNCOSPIO ARENICOLA					1			
SABELLARIA SPINULOSA	1							
SAXIDOMUS GIGANTIUS				1				
SCOLOPLOS ARMIGER	1							
SPHAEROSYLLIS CALIFORNIENIS				1	1		1	
SYLLIS SP A			1			1	1	
TELLINA MODESTA			16	2	2	3		
TIRON BIOCELLATA			1					
TRANSENNELLA TANTILLA			1	1		2	1	