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DUWAMISH RIVER COASTAL AMERICA RESTORATION AND REFERENCE SITES: RESULTS FROM 1995 MONITORING STUDIES

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Approved

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Director

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KEY WORDS

Duwamish River estuary, restoration, reference sites, benthic and meiobenthic invertebrates, avifauna, insects, emergent vegetation.

OBJECTIVES

This report describes the results of the 1995 sampling, which is part of ongoing biological monitoring at three wetland restoration sites in the Duwamish River estuary, Seattle, Washington. Restoration at these sites was originally funded by Coastal America, a federal intergovernmental program initiated by US President Bush's administration. Two of these sites are in the middle portion of the Duwamish Waterway in a region dominated by tidal influence and mixed fresh- and marine water. The first of these two downstream sites is the General Service Administration (GSA) site, which is a long, narrow intertidal strip running parallel to the east bank of the Duwamish Waterway adjacent to the US Army Corps of Engineers, Seattle District. Restoration at this site included the removal of rock riprap and a large overwater wharf structure to allow natural colonization by existing wetland plants, and the construction of a sediment "bench" at 0.0-m elevation to promote usage by juvenile salmon (*Oncorhynchus* spp.). The second downstream site is at Terminal 105; this site originally consisted of a vacated street end and a large pipe that drained a small, degraded wetland area. Restoration included removal of debris and replacement of the pipe with an estuarine channel that restored tidal flow to the area. The third Coastal America restoration site is at the upper turning basin at the head of the Duwamish Waterway. This site comprises an upland riparian buffer that has been planted with native vegetation and a small regraded upper intertidal basin that has been planted with the native sedge *Carex lyngbei*.

Initial baseline and pilot studies of benthic invertebrates, insects, emergent vegetation, and sediment grain size took place in 1993, prior to restoration (Cordell et al. 1994). During these baseline studies, appropriate reference sites in the vicinity of the restoration sites were also chosen and sampled. In late 1993 and early 1994, construction and planting of restoration sites took place. The purpose of the present study was to conduct the first post-restoration sampling of the restoration and reference sites. The overall objectives of this study were as follows:

1. Conduct systematic biological sampling of long-term reference and restored sites.
2. Enumerate attribute species, as defined by the Estuarine Habitat Assessment Protocol (Simenstad et al. 1991; henceforth referred to as the "Protocol") and important non-attribute species at restoration and reference sites in order to make between-site comparisons.
3. Evaluate future sampling options based on the results of (1) and (2).

It is intended that the results of this study will be used in concert with results of the previous pilot and monitoring studies in formulating future monitoring strategies at Duwamish River sites.

Our original Scope of Work included a component to analyze juvenile salmon stomachs collected from the Duwamish Waterway and provided by Muckleshoot Tribal Fisheries. However, inadequate preservation of fish samples made diet analysis impossible. Therefore, juvenile salmon stomachs will be collected and analyzed in spring 1996 and results will be presented in the final report on the 1996 monitoring activities.

SPECIFIC TASKS AND METHODS

BENTHIC INVERTEBRATES

Benthic macro- and meiofauna and sediment grain size sampling was conducted at 0.0-m elevation reference sites located in the Duwamish Waterway at Kellogg Island and the turning basin (Cordell et al. 1994) (Fig. 1). Samples were also taken at four restoration sites, including the turning basin on the mudflat just below high-intertidal transplanted *Carex lyngbei*, a sandflat at the foot of riprap forming the seaward end of a constructed channel at Terminal 105 (T-105), a constructed sand bench near the GSA, and the lower of two constructed sand benches on the east bank near the West Seattle freeway bridge (Duwamish Bench).

Benthic sampling was conducted one time (15 May 1995). We chose this date because highest combined infaunal densities were found in the May–June period in 1993 (Cordell et al. 1994). At the previously established reference transects, we sampled along the same transects that had been randomly established in 1993, avoiding any areas of scour around the stakes. At each restoration site, we established one 50-m transect and took 15 samples at random intervals along each transect. As in 1993, we used a PVC core that sampled an area of 0.0024 m^2 as recommended by Cordell et al. (1994). Cores were taken to a depth of 10 cm and were fixed in the field in a 5% buffered formaldehyde solution.

After ~1 wk of fixation in the formaldehyde solution, benthic core samples were washed through two sieve sizes: macrofauna was retained on a 0.5-mm sieve, and meiofauna on a 0.153-mm sieve. Samples were then transferred to 50% isopropanol. If subsampling was necessary, samples were split to manageable fractions. Macrofauna samples were split in a Folsom plankton splitter (Wickstead 1976) until at least 100 organisms were obtained. Meiofauna samples were subsampled as for the macrofauna using a Hensen's Stemple pipette (Hensen 1895) (Wildco, 301 Cass Street, Saginaw, Michigan 48602): samples were thoroughly stirred, and a known volume removed with the pipette. All organisms were identified using dissection, and when necessary, compound microscopes. Taxa occurring as attributes in the Protocol were identified to species. Taxa not listed as attributes in the Protocol were not identified to species unless they were particularly abundant or previously had been identified or hypothesized as being prey for fishes or birds.

INSECTS

Insects were sampled at two reference vegetation patches and three restoration sites. The reference sites included *Carex* site 2 and the small *Scirpus* patch across the channel from the northeast tip of Kellogg Island (Fig. 1). These sites were chosen because they are among the only emergent vegetation remaining in the Duwamish Waterway, and because they serve as references for vegetation at restoration sites in their immediate vicinity. The three restoration sites were the *Carex* transplants at the turning basin, the small, naturally recruiting patch of *Scirpus* at the GSA site, and along the margins of the constructed channel at the T-105 site (Fig. 1).

Beginning on 28 July 1995, insects were collected in rectangular fallout traps (55-cm x 38-cm plastic storage bins), which have been successfully deployed in other estuarine emergent vegetation habitats in the Pacific Northwest (J.R. Cordell and W.G. Hood, unpubl. data). These floating traps rise and fall with the tide and are kept in place by four vertical PVC pipes. They are designed to catch insects that fall from the air or from riparian vegetation and, as such, measure direct input of insects to the aquatic system. The traps were filled with a preservative (antifreeze) to ~4-cm depth. They were placed haphazardly in the vegetation or proposed transplant zones at each site and left for 4 consecutive days until 1 August. Five traps were placed at each site, except the *Scirpus* patch near Kellogg Island, which could only accommodate three traps. Some traps capsized; only four traps were recovered from *Carex* site number 2 and three traps were recovered from the T-105 site. At the end of the sampling period, the preservative in each trap was drained through a 0.153-mm sieve, and the insects were removed and placed in sample jars with 50% isopropyl alcohol.

AVIFAUNA

Avifauna were observed at two restoration and two reference sites on the west side of the Duwamish river. One pair of sites in the lower waterway consists of the T-105 restoration site and Kellogg Island reference site. T-105 serves as a public park and a launch for hand-carried boats. Because it is located next to a gravel plant served by barges, across from a marina for recreational boats and is the site closest to the river's mouth and Elliot Bay, T-105 sees regular motorized boat traffic. The area observed was ~84 m of shoreline with a channel extending inland about 240 m to the east. Counts were made of birds in the intertidal area of the shoreline and of the channel. Kellogg Island is a relatively undisturbed reference site upriver from T-105, 1 km to the south, and is the largest of the sites. Observations were made along 430 m of shoreline on the east side of the island and 360 m on the shore to the west of the island. The passage between the bank and the island received no boat traffic when observed and does not appear to have many recent industrial or recreational influences. The other pair of sites was located at the turning basin, ~6 km south of Kellogg Island. The reference area is bounded by a bridge to the south and a channel containing the partially burned wreck of a ship to the north. The restored area is bounded by the channel to the south and the river shore to the north of the site.

Avifauna observations were made from June through September 1995. A pair of 7x35 mm binoculars was used to take scan samples in half-hour periods during daylight hours from 0700 to 1900 PST. This involved observing each site for a fixed period of time and recording all birds using the site by species, abundance, and behavior. Scan sampling was chosen because birds tended to display one primary behavior when at a site, making focal animal sampling (recording the behaviors of a single animal over a period of time) unnecessary. Observation times were spread throughout the day. On the first scan, the number of each species present and the behavior of individuals were recorded. As new individuals arrived, their arrival, identification, and behavior were noted.

Behaviors were classified as foraging, resting, and transit. Transit consisted almost exclusively of swimming because land transit was usually observed while birds were either foraging or on their way to the water. Birds flying by were not counted unless they landed and made contact with the intertidal area. Birds on the water were included when they were within a rectangle bounded by the extent of the site shorelines and the midline of the river. Tides, wind speed and direction, and general weather conditions were also recorded, as were obvious disturbances such as boat traffic that caused birds to move or change behaviors.

Most of the data were collected from one location on the bank of the river or upper part of the intertidal area where birds could be seen with minimum disturbance. To reduce the impact of observer presence on the bird count, the observer quietly approached the site, immediately noted any birds present, then remained in the upland area for the first 15 minutes of observation. If the tide was not visible owing to low water, the observer moved toward the water's edge to record any birds otherwise out of sight, then returned to the upland location. Most observations were made during relatively low tides when more intertidal area was exposed. One site (turning basin reference) was completely submerged and unapproachable during high tides. All species of birds that landed on the intertidal region were recorded, as well as those on pilings and posts set in the region. The tally of birds present was sorted by species and primary behavior (e.g., for mallard ducks: "MD resting: 5, foraging: 4, transit: 2, other: 0").

Data were sorted by species, abundance, and behavior. Abundance was expressed as the mean number of birds present across all observation periods for each site. In addition to total numbers of birds present being compared, abundances were also compared without three common flocking species: European starlings, Canada geese, and glaucous-winged gulls. These birds were often seen in groups of ≥50, in contrast to other species, which were present in much smaller groups ranging from 1 to 38 in number. Richness, or the mean number of species present across all observations, was also calculated by site. A measure of birds actually using each site was provided by calculating richness with the full dataset as well as with a smaller dataset minus the transit observations. Finally, richness was calculated without flockers (see preceding text). Behavioral observations were also calculated as a percentage of all sightings within each site in order to compare relative use patterns regardless of species.

Data were also expressed as percent occurrence of all species observed across the four sites as a function of the total number of 1/2-h observation periods. For this analysis, species were grouped loosely by guild: passerines, raptors, shorebirds, waterfowl, and seabirds. Because restoration success may be gauged not only by values such as abundance and richness, but also by the particular type of species observed, data were further subdivided into three conservation categories: indigenous/native species were defined as resident birds of western Washington, non-native species were defined as known exotics, and native, human-associated species were defined as resident birds whose populations have grown as a consequence of their interaction with humans (e.g., barn swallows nest only in man-made structures, glaucous-winged gulls forage in garbage dumps).

Emergent Vegetation

Five sites were sampled for emergent vegetation shoot density. Reference sites included the three largest *Carex* benches of the six sampled in 1994 (Site 1, Site 2, and Site 3; Fig. 1) and the *Scirpus* patch across the channel from the northeast end of Kellogg Island (Fig. 2). The *Carex* patches were intended as references for *Carex* transplants at the T-105 and turning basin sites. The Kellogg Island *Scirpus* patch provided a reference for the small naturally recruiting *Scirpus* patch at the GSA site (the fifth site). Other species present in the quadrats were also noted; species abbreviations are listed in Appendix 1. In addition, at the turning basin restoration site, the condition of any remaining vegetation that had been planted in the upland area was assessed by noting the species code (name and number) that had been written on a tag on each plant and the condition of the plant (dead, alive, almost dead). Because different sections of the upland seemed to have different rates of success, we subdivided the site into five strata and summarized data by stratum (see Fig. 1). Transplanted emergent vegetation at restoration sites was not sampled because of transplant failure (turning basin) or postponement (T-105).

Shoot height and density at the three *Carex* benches were compared using one-way ANOVA. Shoot height and density at the two *Scirpus* sites were compared using the Student's t-test. Both of these parametric tests are robust to non-normalities in the data when the design is balanced (equal sample sizes at all sites).

Sediment Grain Size

Sediment grain-size samples were collected at 10 randomly selected locations along each benthic transect with a 0.0024-m^2 core to a depth of 10 cm, placed in plastic bags, iced, and frozen upon return to the laboratory. Cores were processed in the laboratory according to the methods of Folk (1968). They were washed in freshwater to solubilize salts and then oven-dried at 60°C. Sediment samples were then mechanically shaken through nested #10, #18, #35, #60, #120, and #230 sieves. The residual fines were added to the original liquid fraction and analyzed by pipet analysis.

RESULTS

Benthic Macroinvertebrates

Taxa Richness

Relatively few benthic macroinvertebrate taxonomic categories were found at the turning basin restoration and reference sites and at the T-105 site, with 18, 16, and 18 taxa, respectively (Appendix 1). Relatively high numbers of taxa were found at Kellogg Island (27 categories) and at the constructed intertidal bench at the GSA site (29 categories). An intermediate number of taxa (22 categories) was found at the Duwamish Bench.

Assemblage Compositions

The composition of benthic macrofauna at all sites was numerically dominated by four major invertebrate categories: nematode, oligochaete, and polychaete worms, and the gammarid amphipods *Corophium* spp. (Fig. 3). Nematodes made up a relatively constant 20–25% of the composition; the proportion of other taxa varied considerably among the sites. The turning basin restoration site had a high proportion of *Corophium* spp. while the other sites were dominated by either polychaete or oligochaete worms (Fig. 3).

Densities

For all benthic macrofauna invertebrates combined, densities were similar (9–15 x 10^4 individuals per m^2) except at two sites: densities were relatively low at the turning basin reference site (4.6 x 10^4 individuals per m^2) and high at the Kellogg Island site (35 x 10^4 individuals m^{-2}) (Fig. 4). Densities of most prominent macroinvertebrate taxa were also highest at Kellogg Island. In particular, mean numbers of nematode and oligochaete worms, the polychaete *Manayunkia aesturina*, and the cumacean crustaceans *Cumella vulgaris* and *Nippoleucon hinumensis* were more than twice as high at Kellogg Island than at any other site (Figs. 4–6). One notable exception was for the amphipods *Corophium* spp., which were 3X more abundant at the turning basin restoration site than at the next highest site and ~6X more dense than at the turning basin reference site.

Some prominent taxa were absent or present only in very low numbers at some sites: (1) the bivalves *Macoma* spp. were not present at the GSA bench or at T-105 (Fig. 4); (2) the polychaete worms *Polydora* sp. and *Capitella* sp. occurred only in the lower waterway, but were absent from the two turning basin sites; (3) the polychaete worms *Hobsonia florida* and *Manayunkia aesturina* were not found at the T-105 or Duwamish bench sites, and *Manayunkia* was also absent from the GSA Bench site (Fig. 5); (4) the gammarid amphipods *Corophium* spp. and *Eogammarus confervicolus* were very sparse at the Duwamish Bench site, and *Eogammarus* was also absent or rare at the T-105 and turning basin reference sites (Fig. 6); (5) the cumacean *Cumella vulgaris* occurred in very low numbers at the two turning basin sites and T-105 (Fig. 6); and (6) the cumacean *Nippoleucon hinumensis* was relatively rare at all sites except Kellogg Island (Fig. 6).

BENTHIC MEIOFAUNA

Taxa Richness

Similarly to benthic macrofauna, relatively low numbers of benthic meiofauna taxa were found at the turning basin restoration and reference sites, which had 21 and 19 taxa, respectively (Appendix 2). Relatively high numbers of taxa were found at the T-105 site and at the constructed intertidal bench at the GSA site (41 categories each). An intermediate number of taxa was found at the Duwamish intertidal bench and Kellogg Island sites (34 and 32 taxa, respectively).

Assemblage Compositions

Nematode worms and harpacticoid copepods numerically dominated the meiofauna at all sites, consisting of between ~60 and nearly 100% of the total numbers at each site, and harpacticoids outnumbered nematodes at all but the T-105 site. Foraminiferans, turbellarian flatworms, polychaetes, and other taxa made up the relatively small remainder (Fig. 7, top).

The harpacticoid copepod fauna was usually numerically dominated by unidentified juvenile copepodids and nauplii. For identifiable harpacticoids, one or two taxa dominated the numbers at each site except T-105, where harpacticoid numbers were more evenly distributed among a number of taxa (Fig. 7, bottom). The most abundant harpacticoid at the two turning basin sites and Kellogg Island was *Leimia vaga*; the GSA bench was dominated by *Schizopera* sp., and the Duwamish bench harpacticoid fauna consisted primarily of the family Laophontidae and *Harpacticus* spp. in the *Uniremis* group (Fig. 7, bottom panel).

Densities

For all benthic meiofauna combined, mean density at the turning basin restoration site (7.2 x 10^6 individuals m^{-2}) was over twice as high as at any other site (Fig. 8). Total mean density at other sites ranged from 4.4 x 10^5 individuals m^{-2} at T-105 to 2.7 x 10^6 individuals m^{-2} at Kellogg Island (Appendix 1).

Among non-harpacticoid meiofauna taxa, lowest abundances were always found at T-105 (Fig. 8). Ostracods and nematodes were most abundant at the turning basin restoration site, and turbellarian flatworms were most numerous at the Duwamish Bench. Foraminiferans were relatively abundant only at the Kellogg Island site (Fig. 8).

As was the case with non-harpacticoid taxa, all harpacticoid copepods combined and harpacticoid nauplii plus juvenile copepodids were more than twice as abundant at the turning basin restoration site than at any other site, and were the least abundant at T-105 (Fig. 9). Five species of harpacticoids—*Coullana canadensis*, *Pseudobradya* sp., *Microarthridion littorale*, *Leimia vaga*, and *Huntemannia jadensis*—were mostly confined to the two turning basin sites (Figs. 9 and 10). Two other species—*Tachidius triangularis* and *Schizopera knabeni*—were relatively abundant at both the turning basin restoration site and at least one other downriver site (Figs. 10 and 11). Another, unidentified species of *Schizopera*, a species of *Mesochra*, and the family Laophontidae were abundant only at Kellogg Island or the created benches or both (Fig. 11). *Harpacticus* spp. in the *Uniremis* group, an important juvenile salmon prey taxon, were abundant only at the created intertidal benches at the GSA and lower Duwamish sites.

INSECTS

Many fewer types (5 categories) of insects were found at the T-105 site than at any other site. Relatively high numbers of taxa were found at the Kellogg Island *Scirpus* patch (18 categories) and at the turning basin restoration site (16 categories). Intermediate numbers of taxa were found at the GSA *Scirpus* patch and *Carex* site 2 (10 and 13 categories, respectively).

On the basis of total mean number of insects per fallout trap, the sites that we sampled fell into three categories. First, the *Carex* site and turning basin transplant area had the highest mean densities with 139.9 and 262.4 insects per trap, respectively. Second, the *Scirpus* patches across from Kellogg Island and at the GSA site had much lower average numbers of insects (18.1 and 13.8 per trap), respectively. Third, the T-105 channel margin had extremely low insect density, at 3.6 individuals per trap.

The sites also form three groups on the basis of their insect compositions. The turning basin transplant site and the *Carex* bench site both had relatively high numbers of ephydrid flies (an average of 243 per trap for turning basin transplant site and 118 for the *Carex* site). In contrast, the other sites had three or less of this taxon per trap (Fig. 12). They also had similarly high numbers of chironomid flies (6.6 per trap for turning basin transplant site and 10.0 for the *Carex* site) as compared with the other sites (one or less per trap). The *Scirpus* patches near Kellogg Island and at GSA site resembled each other in having relatively few ephydrid and chironomid flies, and in having the insects distributed more evenly throughout different groups. These two sites differed substantially in insect fauna in only one category: the Kellogg Island site had twice as many individuals in the "other insects" category (consisting of Homoptera, Hemiptera, Coleoptera, Lepidoptera, and Collembola) than any other site. The Kellogg Island *Scirpus* patch also differed from every other site in having a large number of the beachhopper amphipod *Traskorchestia traskiana*: amphipods did not occur in fallout traps from any other site. The T-105 channel margin was remarkable in the low number of insects that were collected there. Far fewer insects were collected in each category at this site than at any other site.

AVIFAUNA

As would be expected, average taxa richness was much lower than abundance (Fig. 13, middle panel), indicating that many species were sighted as single individuals more than once or some species were gregarious. On average, 6–8 species could be seen within a 1/2-h observation period although this figure was again lower for the T-105 site (~4 species). Because birds in transit across a site may not actually be using that site, richness was recalculated after subtracting all transit observations to investigate whether there were significant differences in species use patterns. Although this lowered richness slightly, the difference was small. Subtracting flocking species (see previous text) also lowered richness slightly, as would be expected.

Site-specific abundance (Fig. 13, bottom panel) was fairly high and even across three of the four sites (turning basin reference and restoration sites and Kellogg Island; 60–70 birds seen per 1/2-h observation period) and much lower at T-105 (~30 birds). However, the majority of these sightings were composed of three flocking species: European starlings, Canada geese, and glaucous-winged gulls. When these species are removed, abundance falls dramatically although the general pattern is preserved (Fig. 13, bottom panel). Variance was high at all sites, indicating that there were probably influences of time of season, day, and tide, as well as weather. However, limited sample sizes (maximum number of 1/2-h observations at any one site was 14) precluded a detailed multivariate analysis.

Birds used each site differently (Fig. 13, top panel). Resting and foraging behavior accounted for 80–85% of all observations at the turning basin reference and restored sites and the Kellogg Island reference site. Of these sites, proportionally more of the behavior at the two latter sites consisted of resting, ~3–4X that observed at the turning basin reference site. At the T-105 site, ~2–3X more birds were in transit than at the other sites.

Twenty-seven bird species were observed across all four sites (Table 1), the majority of which were passerines (14 species). Only three shore/wading birds (i.e., mudflat foraging species) were seen, although an additional six species of waterfowl were observed. Turning basin reference and restoration sites and the Kellogg Island site each had 21 taxa although species composition differed. Only 16 different species were seen at T-105. Of the 27 total taxa observed, 3 passerines and 2 waterfowl were non-indigenous introduced species. Of the non-native waterfowl, domestic ducks and geese were seen only at a single or linked (i.e., turning basin) site or sites, indicating a local, perhaps even single domestic animal release. On the other hand, the passerines are known invaders across broad regions and diverse habitats in the United States. The three species in this group occurred at all four sites. In addition, seven species were native but positively influenced by association with humans such as to be considered pests. At least five of these species occurred across all four sites and one site, Kellogg Island, contained all seven (Table 1). At the Kellogg Island and two turning basin sites, species composition was dominated by indigenous species that are not known to be enhanced by human impacts; these species constituted 52–57% of the total species seen. In contrast, the species composition at the T-105 site was made up of only 36% indigenous non-human associated species (Table 1).

In order to rank restored sites relative to each other as well as to the reference areas, we calculated a pairwise index of association: species present at both sites/species present at either site (Table 2). The predominant pattern evident from this analysis is that all site pairings are most similar in introduced and human-associated species. Overlap of indigenous species between sites was usually relatively low.

Emergent Vegetation

Turning Basin

No signs of *Carex* species were found at the site. In the intertidal area that was planted with *Carex*, *Scirpus cernuus* was growing in mats and small, sparse clumps of *Cotula coronopofila* also dotted the area. In Areas 1 and 2 (Fig. 2), 175 dead clumps of *Elymus mollis*, with many empty spaces, were counted. On the river side of the site (Area 1), 65 live clumps were found on the river side of a berm and 66 inside of the berm. The *Typha angustifolia* patch adjacent to and slightly downstream from the site seemed intact, with *Atriplex patula* and *Cotula coronopofila* in the understory. Most other planted vegetation had been marked although it was not always possible to determine, either from the name code or from the plant itself, what the species was. Nevertheless, it was clear that percent survival of planted vegetation varied by area and species (Table 3). Plants marked NR (Nootka Rose), VM (vine maple), W? (Willow?), RE (red elderberry), SB (service berry), and OA (Oregon ash) appeared to have 100% survival in all areas (no dead remains were noted). Species marked PW (Pacific willow?) and SW (*Salix lasiandra* or *sitchensis*?) had 100% survival in all areas except Area 4 where 90% (7 of 8) and 70% (2 of 3) survived. An unidentifiable species (no mark and unidentifiable) had 100% survival in 2 of the 3 areas in which it was found; in the third area, none survived. Species marked W, WR, WS (all willows?), RC (red currant?), and an unmarked species had the lowest survival rates.

Carex lyngbyei *Benches*

Boeing Sedge Bench (Site #1)

This bench is the farthest upriver, above the turning basin and just upstream of the foot bridge connecting the Boeing parking lot to the plant. Netting from the previous year's goose exclosure experiments was removed, but it did not appear to have provided any protection against grazing during the 1995 season. Most plants were senescing and heavily grazed, and *Cotula coronopofila* was covering many previously bare areas. The long axis of the patch was 26 m, average shoot density was 32 shoots per quadrat, and the maximum shoot height was 91 cm.

Delightful Sedge Bench (Site #2)

Just below the turning basin, this site was 28 m along its long axis. Average shoot density was 46.8 shoots per quadrat (the highest of the three *Carex* sites) and maximum shoot height was 93.7 cm (similar to Site 1).

Lombardi Bench (Site #3)

The most downstream of the three benches, this bench is divided into two sections. The upstream portion had a long axis of 4 m and the downstream portion had a long axis of 10 m. The water side of the downstream patch was heavily grazed, but the landward side of the patch and the entire upstream patch were not grazed at all. Average shoot density was 38.1 shoots per quadrat and maximum shoot height was 123.6 cm (the tallest of the three sites). *Atriplex patula*, *Aster subspicatus*, *Spergularia marina*, *Scirpus cernuus* and *Triglochin maritima* appear to be colonizing these areas; *Atriplex patula*, *Scirpus cernuus*, and *Spergularia marina* were each found in 3 of the 10 quadrats; *Aster subspicatus* and *Triglochin maritima* were each found in one.

Comparison of Sites

Average number of shoots was not significantly different at the three sites ($p = .144$) and ranged between 32 and 46 shoots per .0625 m^2 (Table 4). The coefficient of variation for shoot density was relatively low at all sites, but the shoots were patchily distributed even in the center of the benches.

Maximum shoot height was not equal at the three sites ($p = .004$). Shoot height at Site 3 was greater than at the other two sites.

Change Over Time

No general trends could be detected at this point in average shoot density or maximum shoot height at the three *Carex* benches (Fig. 14). Maximum shoot height at sites 1 and 3 appear to be significantly higher in 1994 than in 1995.

Scirpus validus

Reference Site Adjacent to Kellogg Island

The patch was 10 m long with average shoot density of 16.2 shoots per quadrat. Average shoot height was 18.4 cm, but the upland half of the patch was noticeably taller than the water side (the tallest plant in the upland half of the patch was measured at 211 cm). The upstream and downstream halves differed in species composition; along the upstream 5 m of the transect, each quadrat contained three to four other species (*Carex lyngbyei* and *Spergularia marina* each occurred in four of the initial five quadrats; *Potentilla pacifica*, *Atriplex patula*, and *Ranunculus repens* each occurred in two of the initial five quadrats, and *Cotula coronopofila* was found in one of the initial 5 quadrats). A large log and cement block in the center of the patch create large bare areas in the patch.

Species surrounding the reference patch include *Potentilla pacifica*, *Juncus* sp., *Distichlis spicata, Aster subspicatus*, and *Carex lyngbyei.* Although no sampling was conducted in the surrounding area, the *Carex* there appeared younger (shorter, fresher, green) and less grazed than in upstream areas.

GSA Site

The *Scirpus* at the GSA site consists of a naturally recruited patch where pilings and overwater structure have been removed. The long axis of the patch was 38 m with breaks from 29.0–30.6 and 22.4–23.3 m. Average shoot density was 37.8 shoots per quadrat and average maximum shoot height was 73.7 cm. Other species in the patch included *Spergularia marina* (in 9 out of 10 quadrats), *Scirpus cernuus* (6 out of 10 quadrats), *Cotula coronopofila* (6 out of 10 quadrats), *Lilaeopsis* sp. (3 out of 10 quadrats), *Salicornia virginica* (1 out of 10 quadrats), and *Atriplex patula* (1 out of 10 quadrats).

Comparison of Sites

Shoot density and maximum shoot height were significantly different at the reference and GSA *Scirpus* patches ($p = .029$, $p = .011$). Shoot height was greater at the reference site and shoot density was greater at the GSA site. (Table 5).

SEDIMENT GRAIN SIZE

Sediment grain size distribution differed greatly among the three benthic sites (Fig. 15, Appendix 2). As in 1993, the Kellogg Island and both turning basin sites had a high proportion of fines, >40% of the sediment in each case. In contrast, the sediment from the T-105 and intertidal bench sites consisted of <10% fines. At the T-105 site, the sediment fell mostly into the 0.25-mm size class (44%) with most of the remainder distributed into the 0.5-mm (17%) and 0.125-mm (18%) size classes. The Duwamish Bench sediments consisted mostly of particles in the 0.25-mm (37%) and 0.125-mm (42%) size classes. At the GSA Bench, sediments were more evenly distributed, with 18–25% in each of the 0.125-, 0.25-, 0.5-, 1-, and 2-mm fractions.

DISCUSSION AND RECOMMENDATIONS

BENTHIC STUDIES

For macrobenthic invertebrates, the Kellogg Island reference site stood out from the other sites in having high taxa richness, much higher overall density, and the highest density for 8 of the 13 species examined. This is probably due to one or a combination of the following three factors: first, Kellogg Island probably has higher species diversity and abundance of some species as compared with the turning basin sites because the latter sites experience much lower average salinity and much higher daily fluctuations in salinity than does Kellogg Island (Warner and Fritz 1995). Species that are not tolerant of these conditions are absent or rare at the turning basin sites. Second, Kellogg Island had the highest proportion of fine sediments while the other, lower waterway sites had the highest percentages of medium to coarse sand. Because coarser sediments drain faster and retain less water and organic matter, muds have more organic matter per unit area and faunal densities are frequently highest there (Gray 1981). Finally, the Kellogg Island site is located in an area in which the intertidal has remained relatively undeveloped and is not disturbed by boat traffic or dredging. A great deal of settled organic material is evident at this site, ranging from buried woody debris to fine flocculent particles on the sediment surface.

We noted relatively high densities of the Asian cumacean crustacean *Nippoleucon hinumensis* in the Kellogg Island macrobenthos samples—it also occurred at the two turning basin sites. This cumacean has recently invaded a number of estuaries in Washington and Oregon: in Willapa and Commencement bays, it is sometimes the most abundant benthic macrocrustacean and is a significant prey item for intertidal foraging small fishes (J. Cordell and V. Zipperer, University of Washington, and D. Stouder, Ohio State University Fisheries Cooperative Unit, unpubl. data). We expect this species to become increasingly abundant and prominent in fish diets in the Duwamish River estuary in the future.

Like the macrobenthos, the turning basin meiofauna assemblages were characterized by low taxa richness. However, these sites had much higher (restoration site) or comparable (reference site) densities as compared with the downriver sites. This was due mainly to the epibenthic harpacticoid copepod *Leimia vaga*, which reached densities exceeding 2.0×10^6 m^{-2}. These and several other species of oligohaline harpacticoids that were abundant at the turning basin sites have been recorded as prey of juvenile flatfish and other estuarine fish (Haertel and Osterberg 1967; J. Cordell, unpubl. data). These taxa may also be important as prey for juvenile outmigrating chum salmon in the Duwamish Waterway, but feeding habits of these fish are little studied in the oligohaline portions of estuaries. Studies of salmon diets from fish collected in spring 1996 will provide more information on this subject.

It is notable that the harpacticoid copepod genus *Harpacticus*, an important juvenile salmon prey taxon, was absent from the turning basin sites and relatively abundant only at the two constructed intertidal benches. *Harpacticus* are probably not present at the turning basin because of low average and highly fluctuating salinities. For the lower waterway sites, based on our (one-time) sampling, we cannot say definitively that the bench sites are more productive of *Harpacticus*. For example, an alternative hypothesis is that our data are a result of differences in timing of peak abundances among the sites. We can say, however, that in our May 1995 sampling the intertidal benches produced densities of *Harpacticus* that were high compared with other sites sampled and compared with densities of this taxon from a number of other studies. For instance, densities of *Harpacticus* from the intertidal benches found in this study were higher than densities found for all juvenile salmon prey taxa combined from a variety of similar habitats sampled for epibenthic harpacticoids in Commencement Bay (Simenstad et al. 1993).

The difference between the turning basin reference and restoration sites, where the restoration site had much higher densities for all invertebrates combined and for most individual taxa in both macrofauna and meiofauna fractions, calls into question the suitability of the reference site. The differences were probably caused by the different hydrographic regimes of the two sites. The restoration site is just downstream from a slight bend in the river, and appears to have lower current velocities than the reference site, which is located just upstream on the river channel proper. Therefore, the restoration site may experience more deposition of organic matter and less disturbance of the invertebrates by current scour. While it may be desirable in the future to add another benthic reference site in the vicinity of the turning basin, we do not recommend dropping the current reference site. It is physically close to the restoration site, and there is a chance that between-site variation will be even larger at a new site that is farther away. Also, we have 2 years of monitoring data that may form the basis of a valuable long-term data set. These benthic invertebrate data, while perhaps not being directly comparable to the restoration site on a year-by-year basis, will nonetheless be valuable in comparing trajectories of benthic populations across multi-year time scales. The ideal situation would be to add several reference sites in order to characterize intersite variation and understand where the restoration site fits in to this range.

Sampling of benthic macro- and meiofauna has thus far been conducted at the 0.0-m tidal elevation. This method presents several problems for monitoring of Duwamish Waterway restoration sites and interpretation of results. First, restoration efforts to date have been focused on higher intertidal areas and emphasized planting of emergent vegetation rather than creation of lower elevation mudflat habitats. While these areas may in fact eventually benefit adjacent lower intertidal areas because of export of detritus, any such effects may not be detectable for many years. In addition, it should be pointed out that monitoring benthos at 0.0 m does not provide information about direct trophic linkages between the specific restored habitats and species of interest. In these cases, 0.0-m benthic monitoring is probably not as good a strategy as sampling in the restoration area per se. But it should be noted that if intertidal mudflat creation is included in future restoration efforts, as we have recommended (see following text under Avifauna), both preexisting and ongoing lower intertidal benthic data will be invaluable. It is evident that thought needs to be given to prioritizing which species (and the habitat attributes that they use) are most important and most likely to be affected by restoration in the design of future monitoring studies.

INSECTS

The most abundant insects found at the upriver turning basin restoration and reference *Carex* sites were ephydrid flies. Ephydrids, commonly known as brine or shore flies, are an important insect family found in oligohaline and euryhaline littoral habitats. They are found in marshes, tide pools, and alkaline lakes. Most species feed as adults and larvae on microalgae, bacteria, yeasts, and other unicellular organisms (Wirth et al. 1987). They have been known to be an important food source for waterfowl. However, to our knowledge they have not been demonstrated to be important in the diets of juvenile salmon. Nevertheless, drift-feeding juvenile salmon are opportunistic feeders and might feed on ephydrids if they were encountered. The large number of ephydrids collected from fallout traps suggests a high input of these insects into the aquatic environment, which may be beneficial to salmon. However, given a one-time only sample and without salmon diet data, it is impossible to know whether or not any insect taxon will be available when juvenile salmon are feeding. The three other sites had approximately two orders of magnitude fewer ephydrids per trap. With this taxon subtracted, the turning basin reference and *Carex* Bench sites still had ~60% more insects per trap than the *Scirpus* patch near Kellogg Island and GSA *Scirpus* patch sites and 1,000% more insects per trap than the T-105 channel margin.

The *Carex* bench site appears to be an appropriate reference site for the turning basin restoration site, given their similarities in insect composition. It is notable, however, that the two sites have similar insect compositions and densities even though the *Carex* bench site had dense vegetation and the turning basin restoration site was virtually unvegetated. This suggests that either intertidal vegetation did not contribute greatly to insect input as measured by the fallout traps at these sites because it was overwhelmed by insect outfall from other sources, or relatively high insect production at the turning basin restoration site was a result of decaying plants from the failed transplants. It is also possible that the fallout traps selectively undersample insects that are washed directly off plants into the water by tidal action.

Similarities between the established *Scirpus* patch near Kellogg Island and the recruiting *Scirpus* patch at the GSA site suggest that the former is an appropriate reference site. Because there are no remaining naturally occurring estuarine sloughs in the Duwamish Waterway, there is no clearly appropriate reference site for the T-105 channel. However, in comparing this site with all other sites sampled, it is clear that insect fallout and taxa richness there was extremely low. The T-105 channel margin had no intertidal vegetation and very little established riparian vegetation, and these factors likely contributed to the low insect production. Both insect densities and assemblage composition are expected to change as restoration sites are replanted and mature.

Future insect sampling should take place during the spring and early summer during juvenile salmon outmigration. Concurrent collection of fish for diet analysis is advisable to allow comparison of prey spectra with insect fallout composition and thus provide a more useful measure of habitat quality. It would also be advisable to sample on more than one occasion, if sufficient funds are available, because insect assemblages in the Duwamish River estuary appear to be very patchy in time as well as space (Cordell et al. 1994). Insect outfall traps are an inexpensive, reliable, and simple technique for the measurement of drift insect input, and we recommend their continued use in Duwamish Waterway restoration monitoring.

AVIFAUNA

Bird habitat in the Duwamish Waterway is restricted to small, isolated patches. In addition, these sites are subject in varying degrees to anthropogenic factors including pollution, noise, boat traffic, visitation by humans, and introduced species. Given these constraints, it is not surprising that there is little difference among three of the four sites. On the basis of our limited preliminary studies, none of the sites appeared to act as attractants to the shore/wading birds that typically forage on exposed mudflats. All of the sites had high proportions of non-native or human-associated pest species, and indigenous species were sparsely scattered throughout the sites. In addition, indigenous species between-site overlap was low, indicating that these species may be rare or marginalized. However, because our observations were limited to the summer, they did not encompass early spring feeding and courtship behaviors or fall migrations that are regularly observed in the Duwamish Waterway (P. Cagney, US Army Corps of Engineers, pers. comm.). Future monitoring should include observations made during these times.

Three factors may be particularly important in effecting increased bird use of aquatic and shore habitats in the Duwamish estuary. First, as more areas are made available for restoration, habitat patches will become less isolated and more physically linked. At some point, a "critical mass" may be reached where there is enough interconnected habitat to attract foraging and nesting birds. Second, as existing restoration habitat matures, it may provide forage (both directly, and indirectly as detritus input to mudflats) and refuge as transplanted vegetation becomes established. This may be the case at both of the restoration sites that we observed: neither of them had any established transplanted emergent vegetation. Third, future restoration that specifically creates intertidal mudflat habitat may be particularly important in attracting shorebirds, and should be seriously considered if these species are a priority. Continued monitoring of bird use of a variety of habitats in the waterway in different seasons will be important in establishing the importance of these factors.

EMERGENT VEGETATION

Although the three *Carex* benches that were sampled had similar shoot density, the Lombardi patch (site #3) had greater average maximum shoot height. The difference in shoot height may occur because downstream patches are less heavily grazed than upstream patches (especially if the condition of the bench near the reference *Scirpus* patch is considered). Downstream patches may also mature later in the season. Higher salinity, colder temperatures, and greater disturbance from boat wake in downstream patches might contribute to delayed initiation of growing season for downstream patches. These physical factors, and even timing of first shoots, may affect the amount of goose traffic at downstream benches and allow them to escape the heavy grazing pressures experienced by upstream patches.

While the upland plantings at the turning basin restoration site experienced high survival rates, lack of any *Carex lyngbei* at the site indicates that transplanting efforts for this species failed there. Failure was largely due to goose grazing activity, during which transplants were pulled out of the sediment, and the problem was possibly compounded by boat wakes: placement of straw bales as protection appeared to have no impact (C. Tanner, US Fish and Wildlife Service, Olympia, pers. comm.). Because of this and the fact that no planting was done at the T-105 site, 1995 studies should be regarded as pre-transplant monitoring. We recommend that steps be taken to protect future *Carex* transplants from goose grazing and wave action.

The *Scirpus* patch near Kellogg Island is small and infiltrated by heavy rubble. It is advisable to remove some of the rubble and provide protection from boat wake to encourage spreading of the patch. A patch on Kellogg Island is also small, but if conditions for *Scirpus* could be improved in these areas, the existing patches may be able to expand. It is difficult to assess reasons for the patchy condition of the *Scirpus* at the GSA site. It will be interesting to observe whether some of the breaks in the patch begin to fill in or whether the total length of the patch grows.

SUMMARY

1. Benthic macro- and meiofauna and grain size core samples were collected on 15 May 1995 from 0.0-m elevation reference sites at Kellogg Island and the turning basin, from restoration sites at the turning basin and Terminal 105, and from created intertidal benches at GSA and lower Duwamish sites. Insect fallout was sampled between 28 July and 1 August 1995 at reference *Carex lyngbei* and *Scirpus* sites, and at restoration sites at the turning basin and along the margins of a created channel at Terminal 105. Observations of avifauna were made from June through September 1995 at reference sites at the Kellogg Island and the turning basin and at restoration sites at the turning basin and Terminal 105. On 1 August 1995, shoot density and height were measured from three *Carex lyngbei* benches in the vicinity of the turning basin and from *Scirpus* patches at Kellogg Island and GSA sites. Percent survival of all intertidal and upland plantings was recorded at the turning basin restoration site.

2. Densities of combined benthic macroinvertebrates were highest at the Kellogg Island reference site and lowest at the Terminal 105 restoration site. This pattern held true for most individual taxa as well. However, *Corophium* spp. were most abundant at the turning basin restoration site. High densities at Kellogg Island may be a result of its sheltered location, lower grain size, higher salinity regime, and abundance of organic matter. Low densities at the Terminal 105 site may be a result of coarser grain size and exposure to disturbance from river scour and boat traffic.

3. Meiofauna assemblages were dominated by harpacticoid copepods at all sites except Terminal 105. However, harpacticoid species composition differed greatly among the sites. Highest harpacticoid densities were found at the turning basin restoration site, owing to large numbers of the epibenthic species *Leimia vaga.* This species also dominated the fauna

at the turning basin reference and Kellogg Island sites. The juvenile chum salmon prey taxa *Harpacticus* spp. were abundant only at the two created intertidal benches in the lower, more saline part of the waterway.

4. For both macro- and meiofauna, taxa richness was much lower at the turning basin sites, where the fauna consisted mainly of species that are tolerant of highly fluctuating and low average salinities.

5. The upriver *Carex lyngbei* bench and turning basin restoration sites had highest insect fallout densities, followed by the two *Scirpus* sites. The channel margin at Terminal 105 had very low insect densities. The upriver sites were dominated by ephydrid flies and at the downriver sites, insects were distributed more evenly into several groups. Large numbers of the beachhopper amphipod *Traskorchestia traskiana* were caught in fallout traps at the *Scirpus* site near Kellogg Island.

6. Twenty-seven bird species were observed from June through September 1995. There were no substantial differences among the sites, and none of the sites appeared to be attractants to wading or shorebirds. All sites had large proportions of non-indigenous invasive or indigenous pest species. Increasing the physical linkages among restoration sites and creation of intertidal mudflat habitat may be important in increasing shorebird use of the Duwamish River estuary. Future monitoring of birds should take place during periods of spring feeding/courtship and fall migration.

7. The three *Carex lyngbei* benches sampled had shoot densities and heights similar to those in previous years. It appeared that upriver *Carex* patches were more heavily grazed and had earlier growth peaks than downriver patches. Shoot density and maximum shoot height were significantly different at the reference and GSA *Scirpus* patches, with shoot height greater at the reference site and shoot density greater at the GSA site. While intertidal *Carex* plantings at the turning basin restoration site failed, upland planting at this same site has been highly successful.

8. In future monitoring efforts, consideration should be given to prioritizing which sampling locations, elevations, and methodologies yield the most useful information. Benefits of gaining long-term valuable data sets (e.g., continued benthic sampling at 0.0-m elevations) must be weighed against those of acquiring specific information in a given year (e.g., identifying trophic linkages between emergent vegetation and juvenile chinook salmon).

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FIGURES

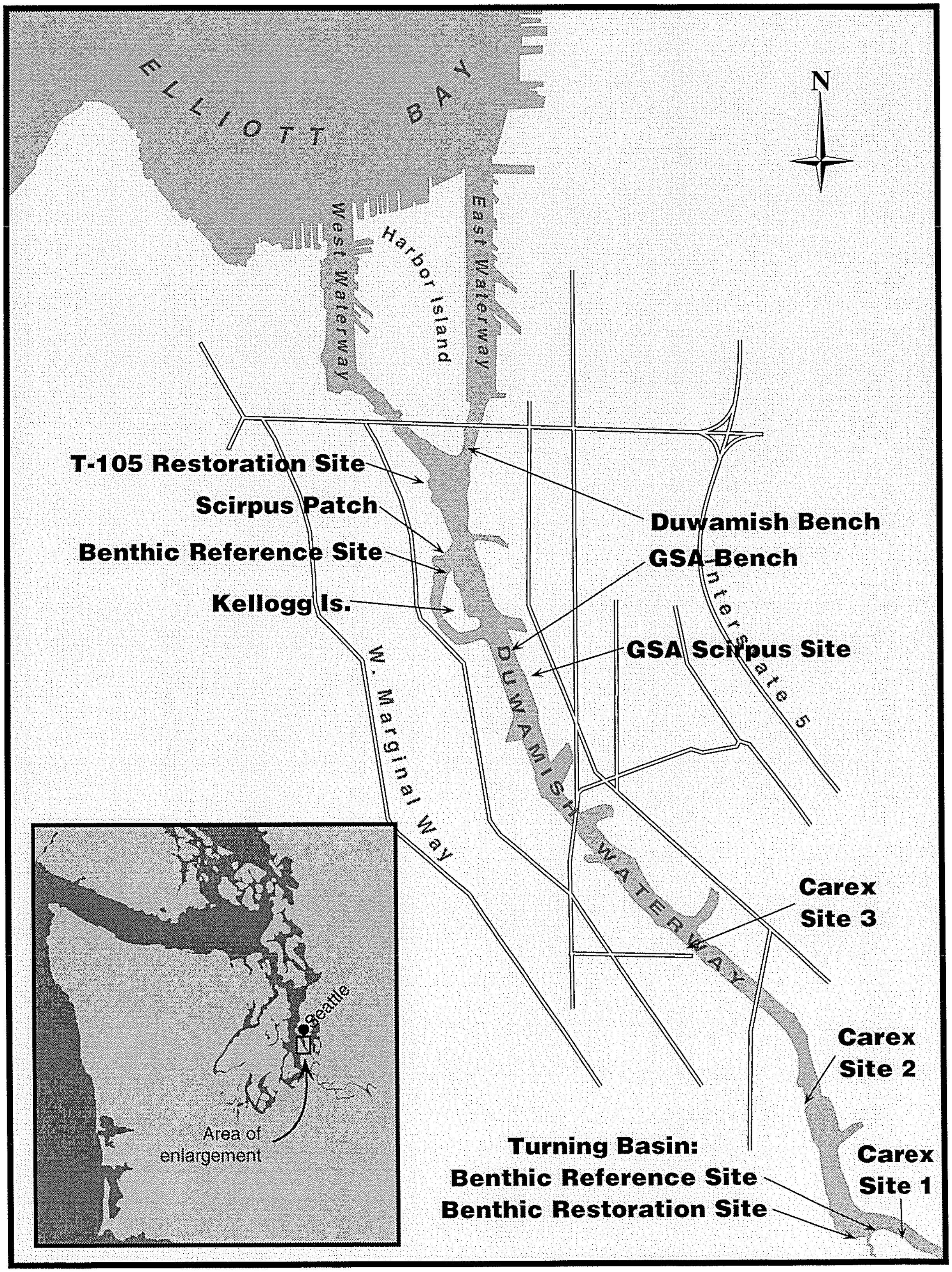


Figure 1. Location of 1995 sampling sites in the Duwamish Waterway.

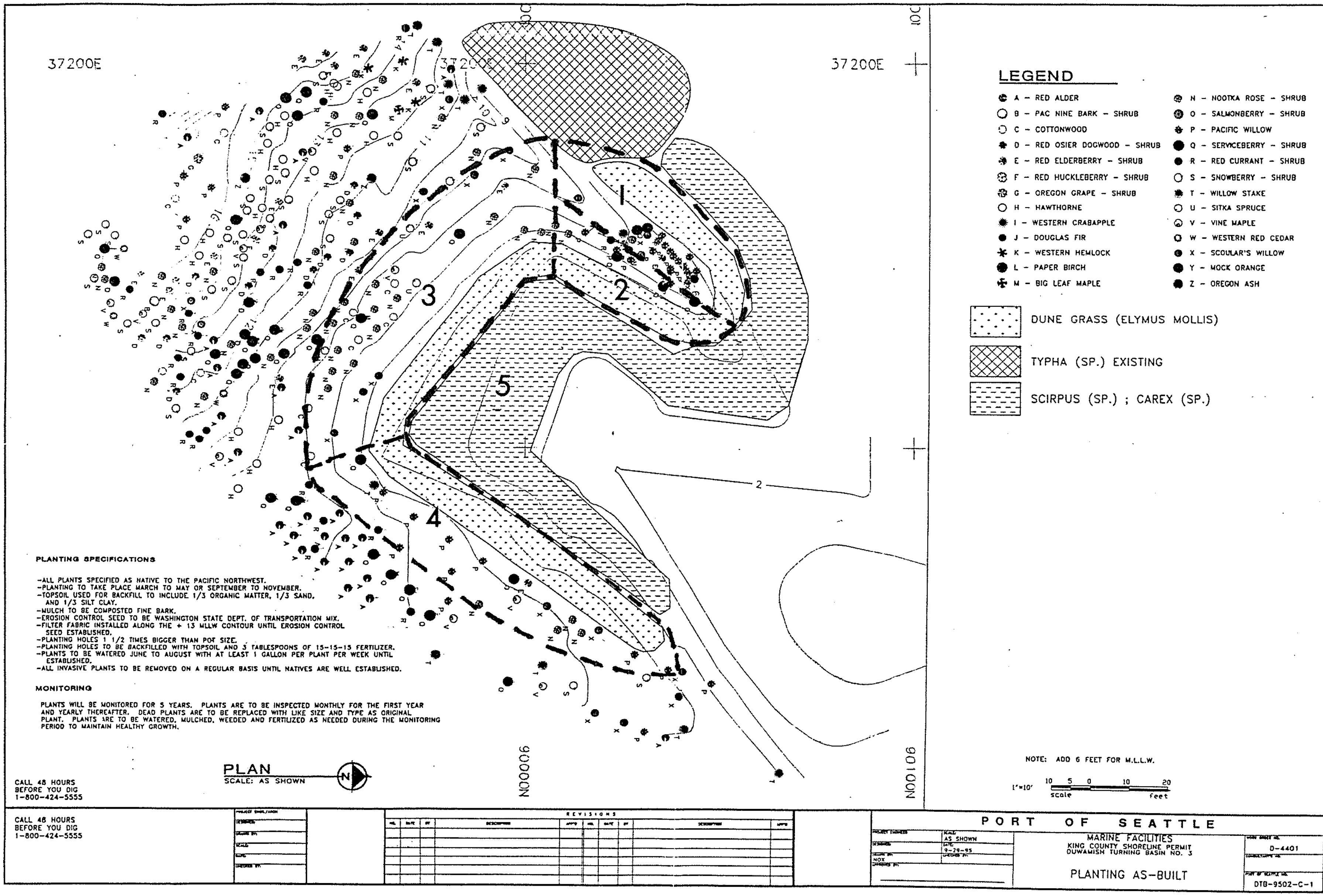


Figure 2. Areas sampled for percent survival of plantings at turning basin restoration site, Duwamish Waterway, August, 1995.

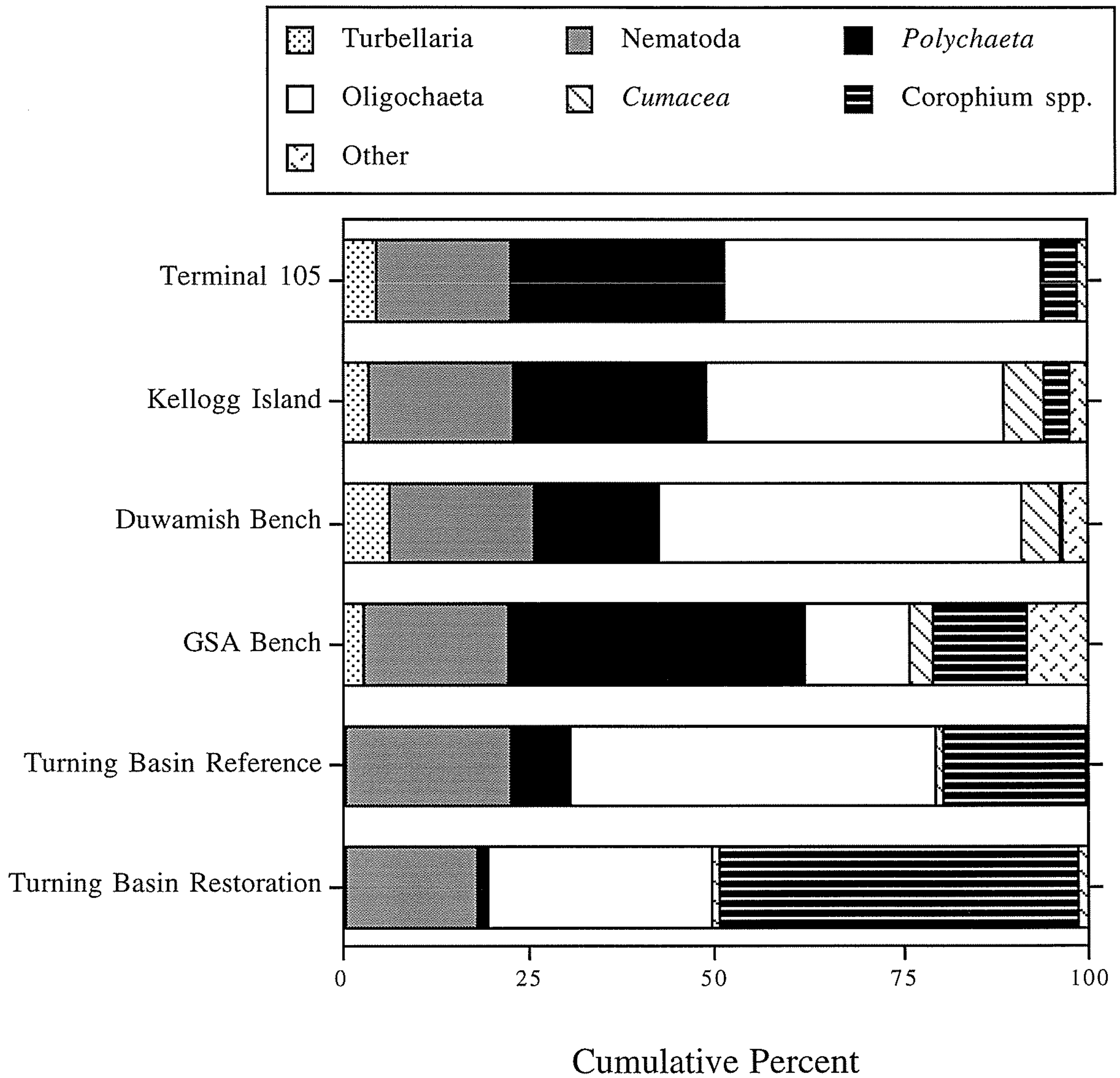


Figure 3. Numerical percentage composition of benthic macroinvertebrates by major taxonomic groupings at six sites in the Duwamish Waterway, 15 May, 1995.

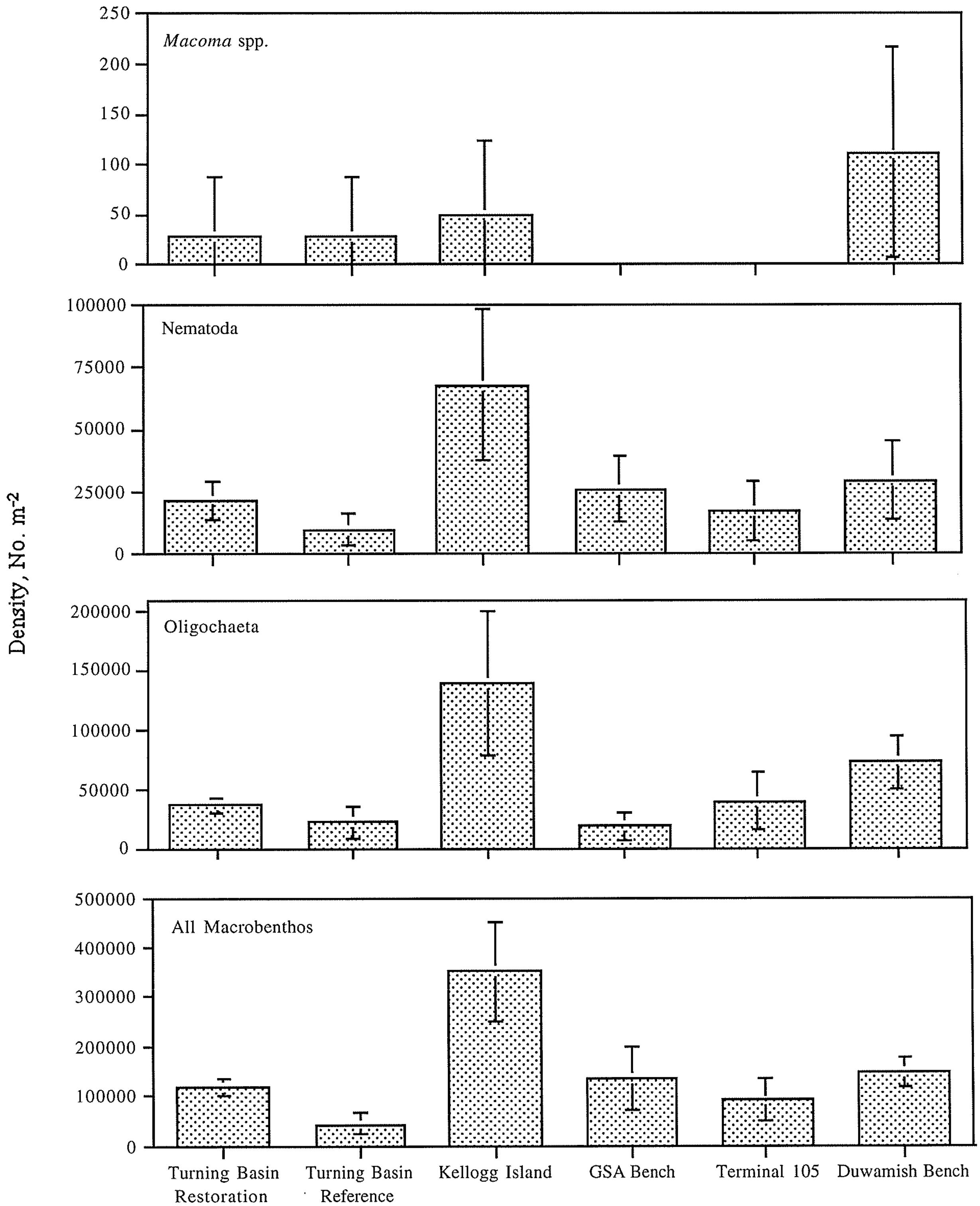


Figure 4. Numerical percentage composition of benthic macroinvertebrates by major taxonomic groupings at six sites in the Duwamish Waterway, 15 May, 1995.

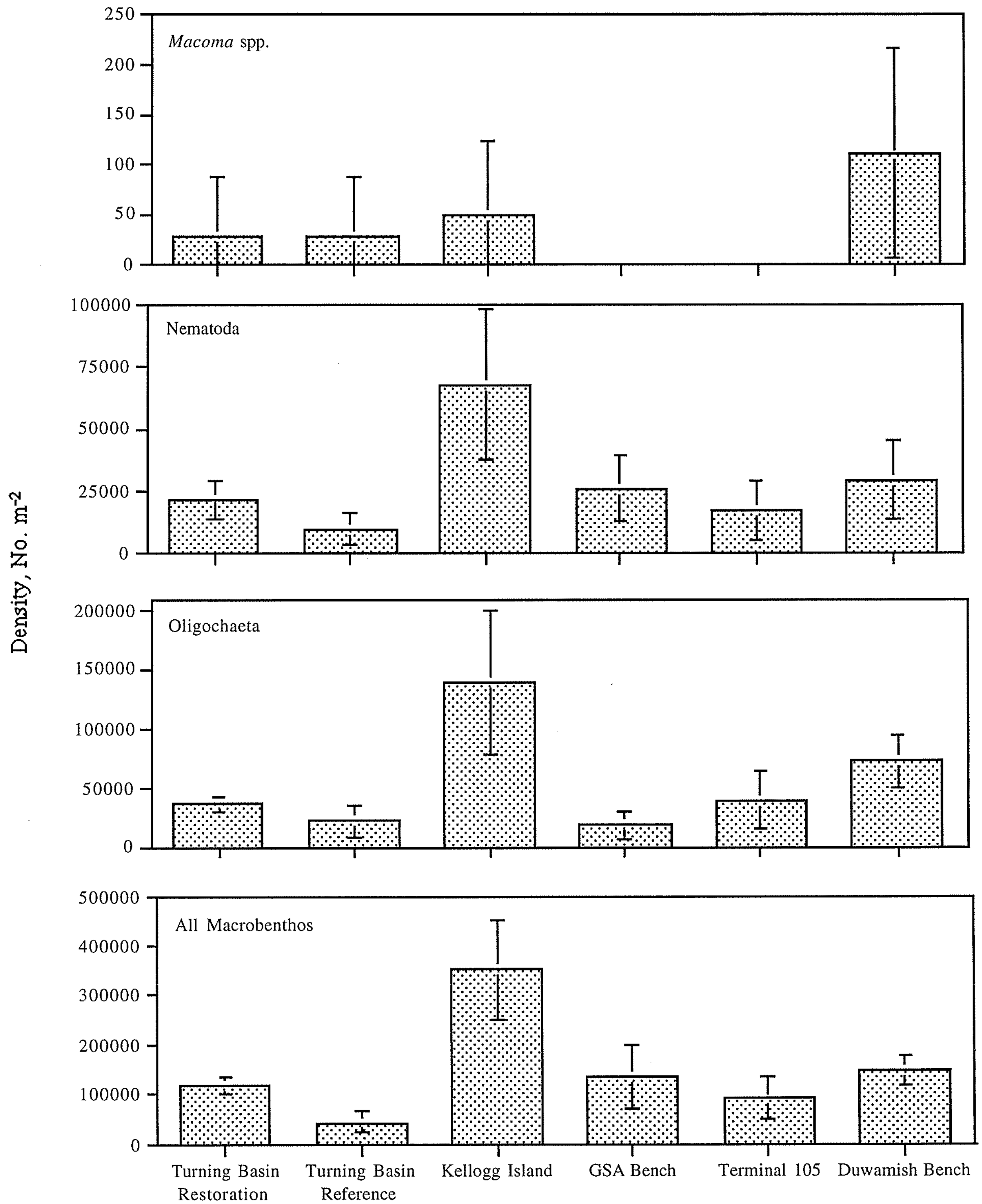


Figure 5. Densities of prominent macrobenthic polychaete worms at six sites in the Duwamish Waterway, 15 May, 1995. Vertical lines represent 95% confidence intervals.

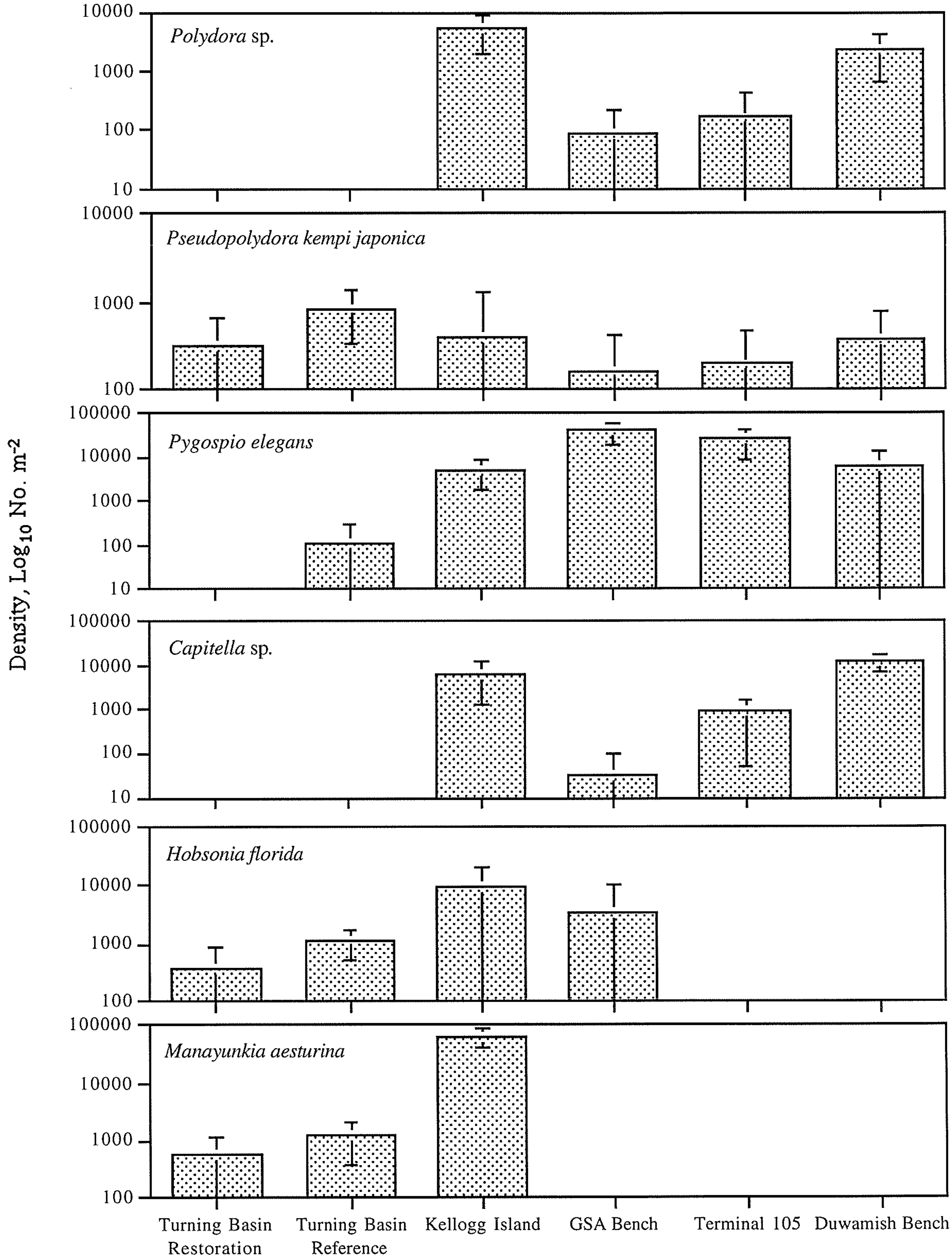
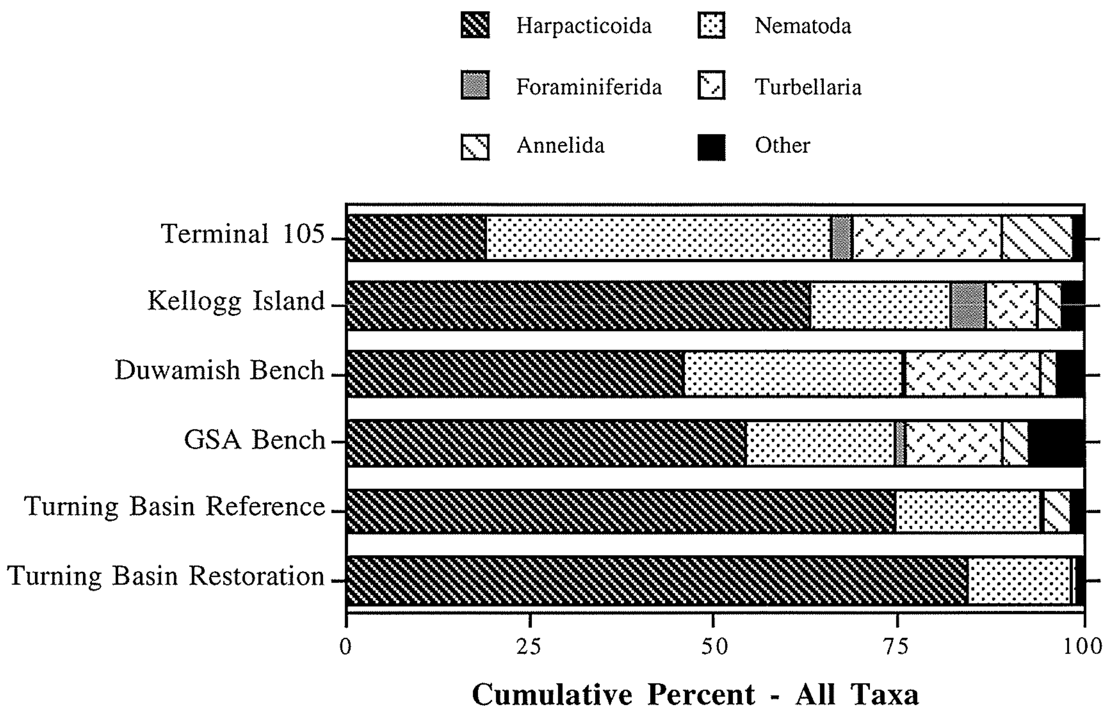


Figure 6. Densities prominent macrobenthic crustaceans at six sites in the Duwamish Waterway, 15 May, 1995. Vertical lines represent 95% confidence intervals.



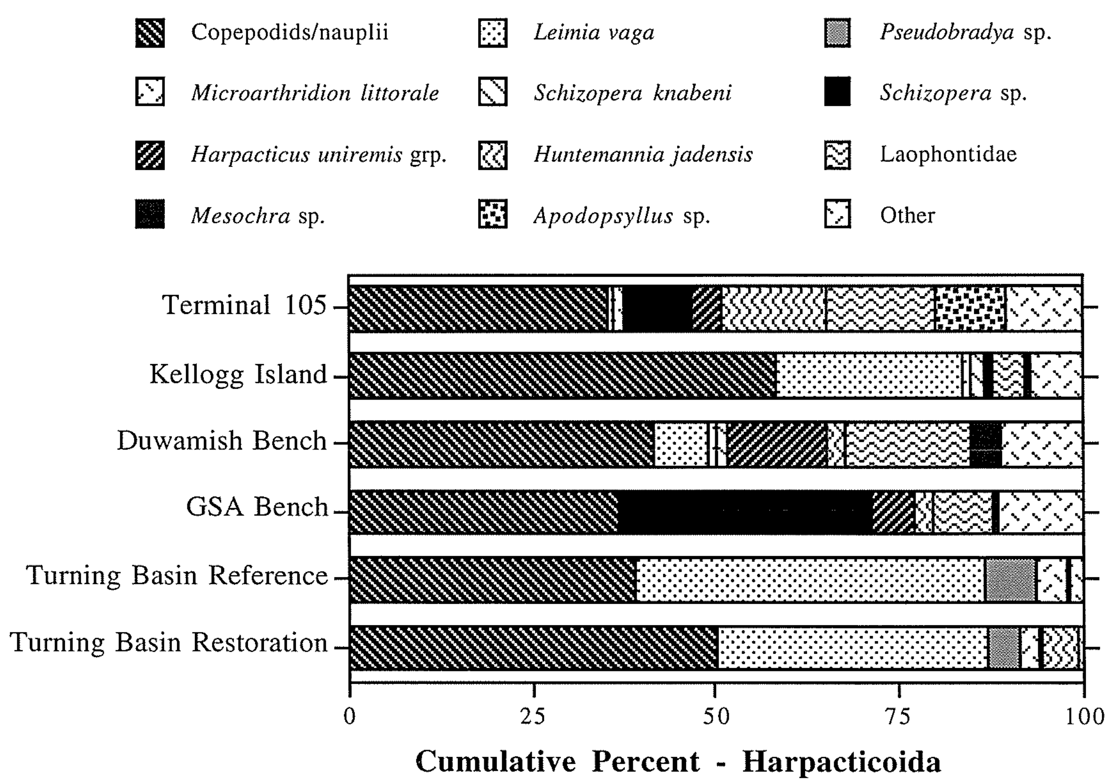


Figure 7. Densities prominent macrobenthic crustaceans at six sites in the Duwamish Waterway, 15 May, 1995. Vertical lines represent 95% confidence intervals.

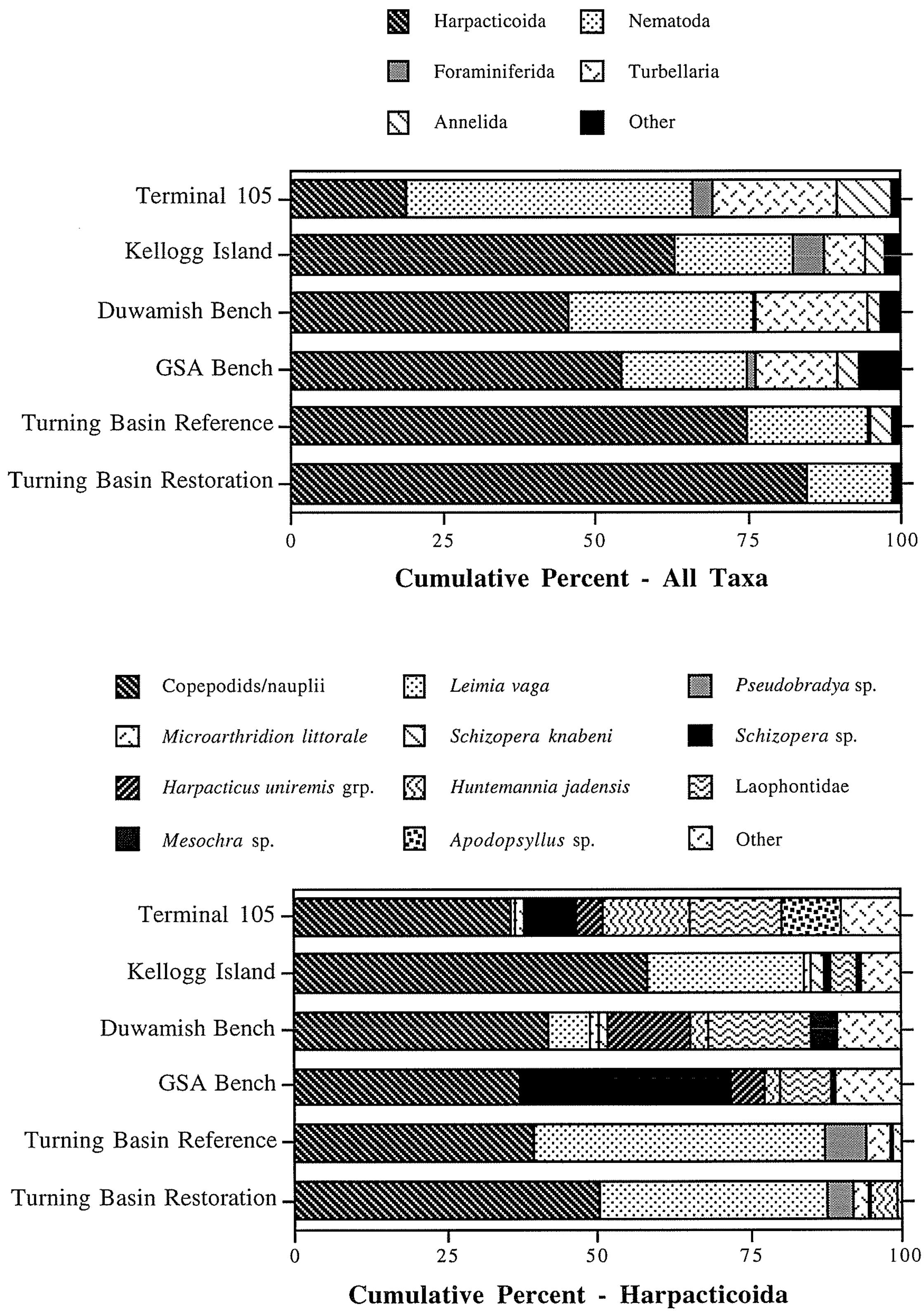


Figure 8. Densities of prominent meiobenthic non-harpacticoid invertebrates at six sites in the Duwamish Waterway, 15 May, 1995. Vertical lines represent 95% confidence intervals.

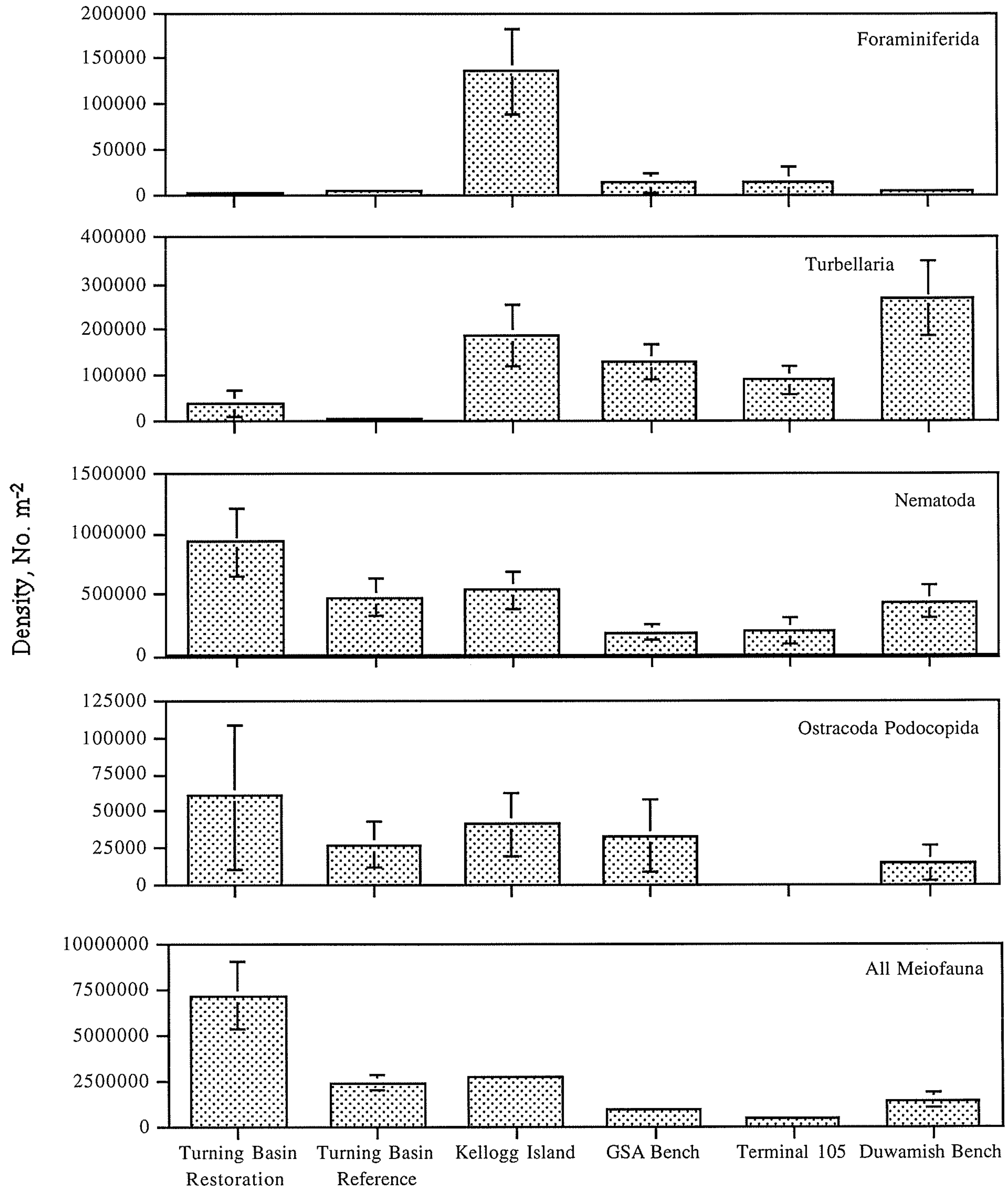


Figure 9. Densities of prominent meiobenthic harpacticoid copepods at six sites in the Duwamish Waterway, 15 May, 1995. Vertical lines represent 95% confidence intervals.

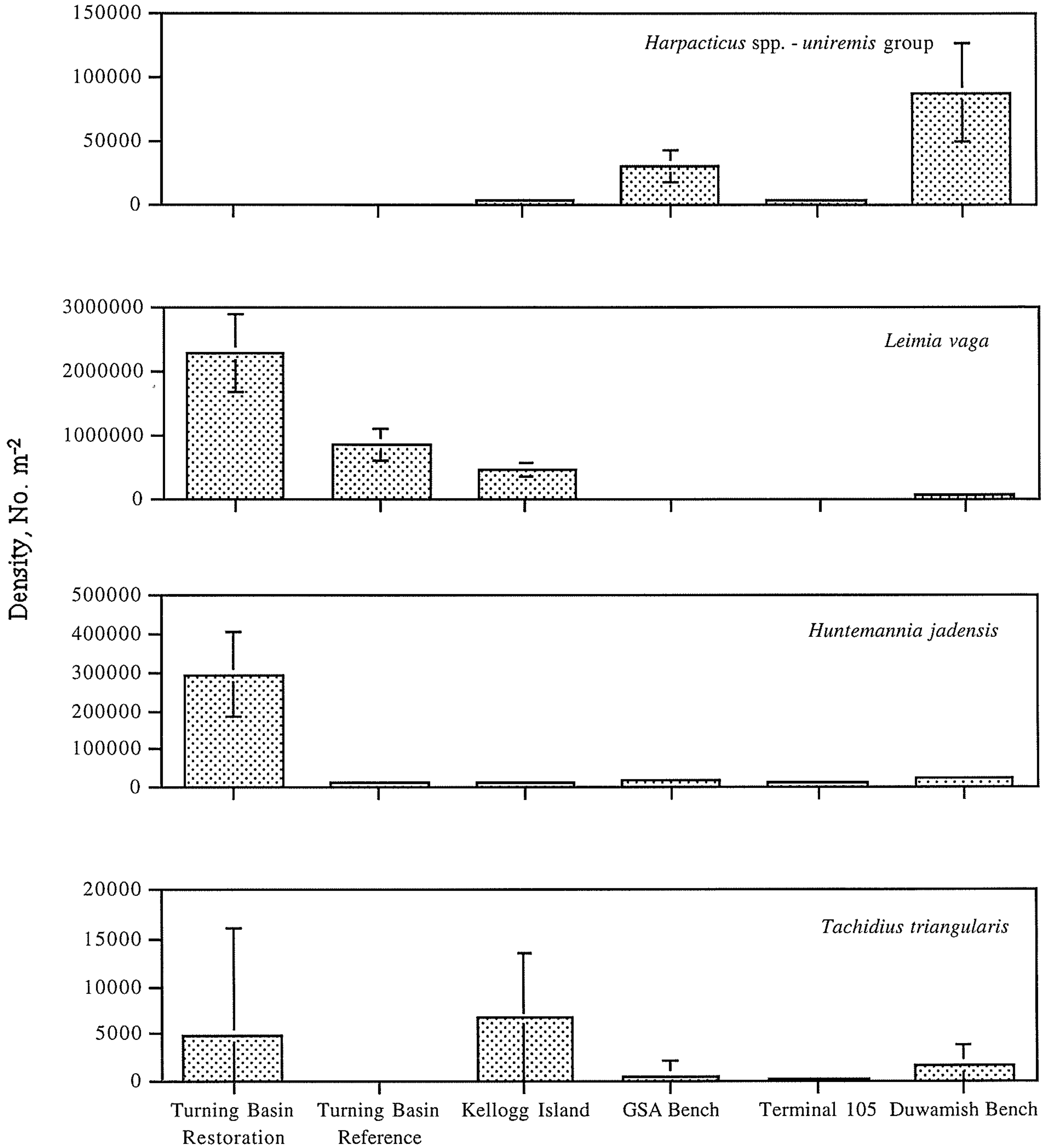


Figure 10. Densities of prominent meiobenthic harpacticoid copepods at six sites in the Duwamish Waterway, 15 May, 1995, continued. Vertical lines represent 95% confidence intervals.

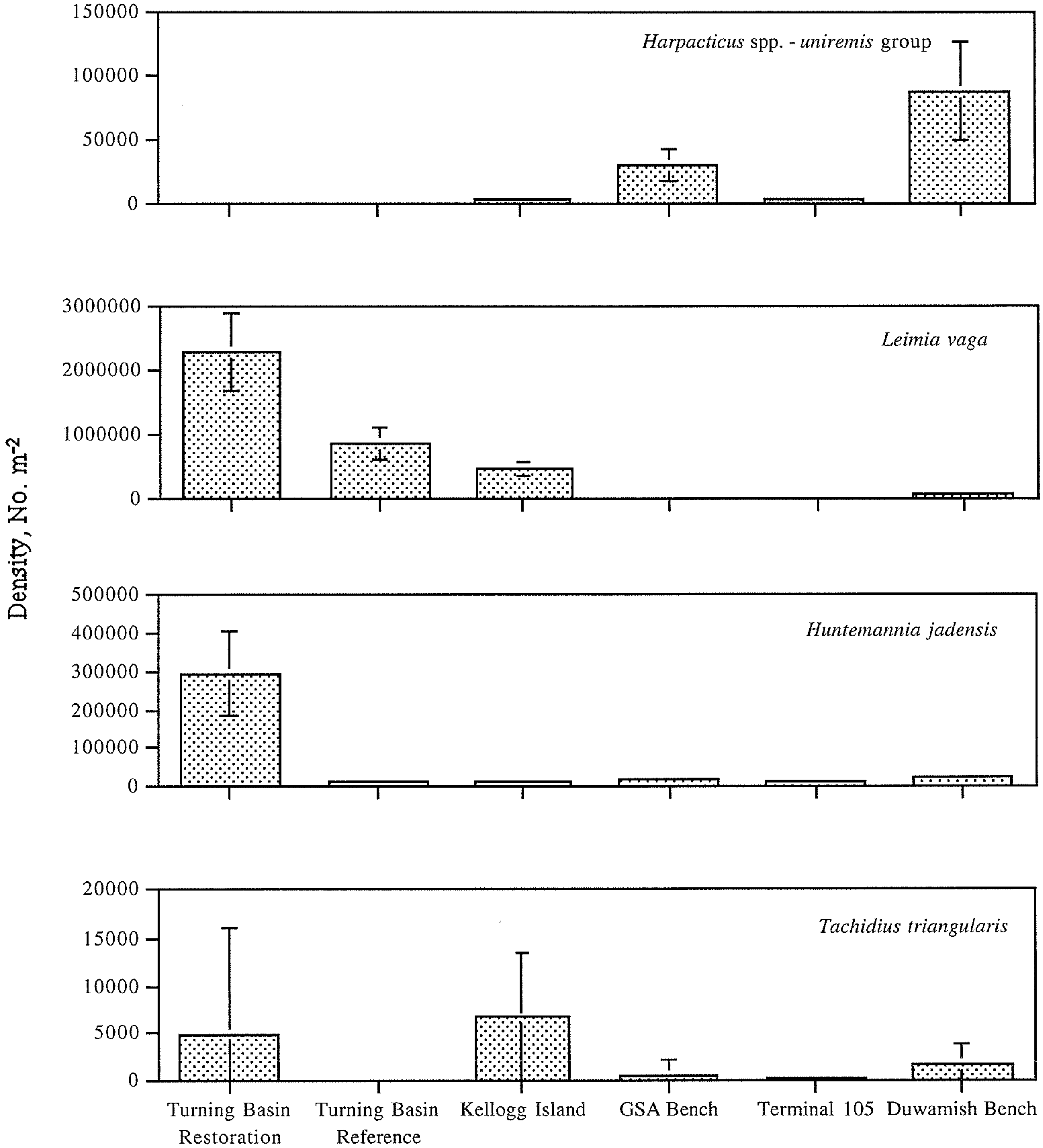


Figure 11. Densities of prominent meiobenthic harpacticoid copepods at six sites in the Duwamish Waterway, 15 May, 1995, continued. Vertical lines represent 95% confidence intervals.

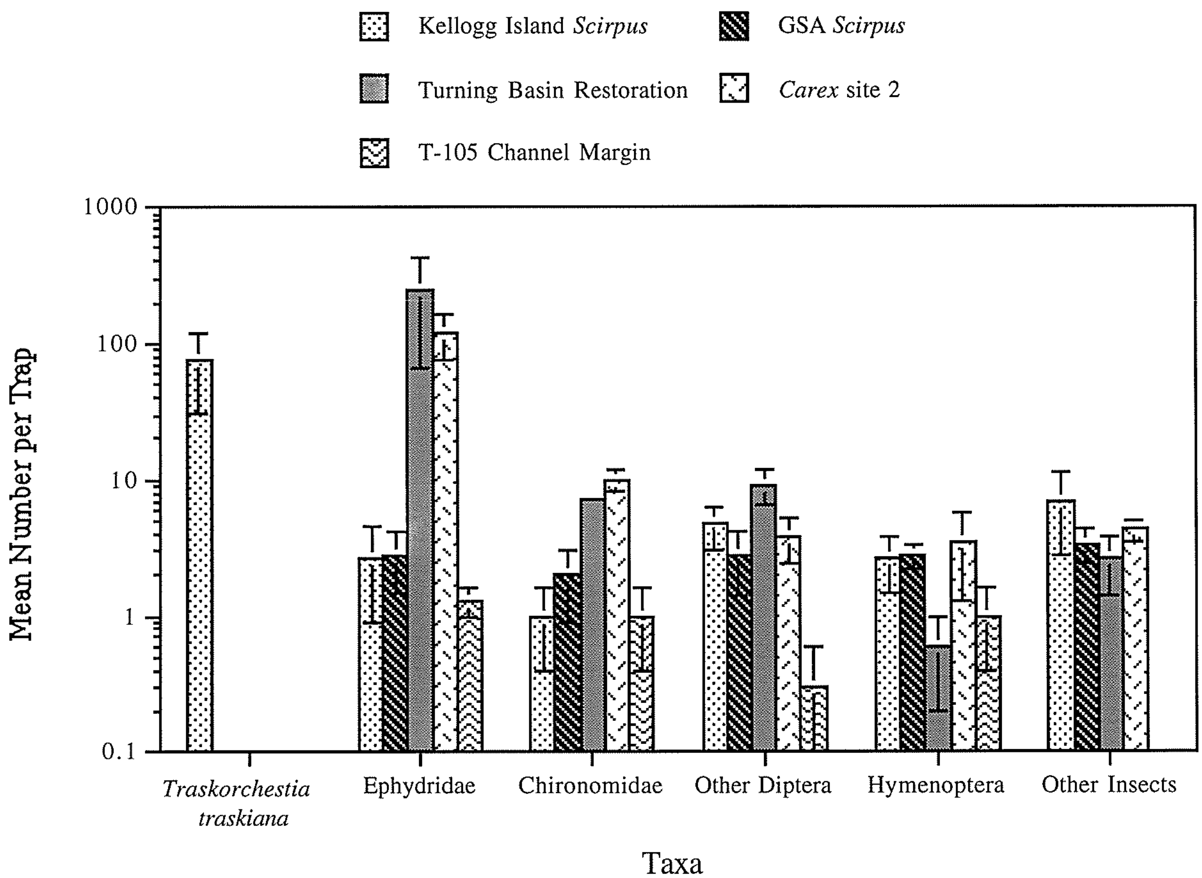


Figure 12. Insect abundances from fallout traps at four sites in the Duwamish Waterway, 28 July-1 August, 1995. Vertical lines represent standard deviation.

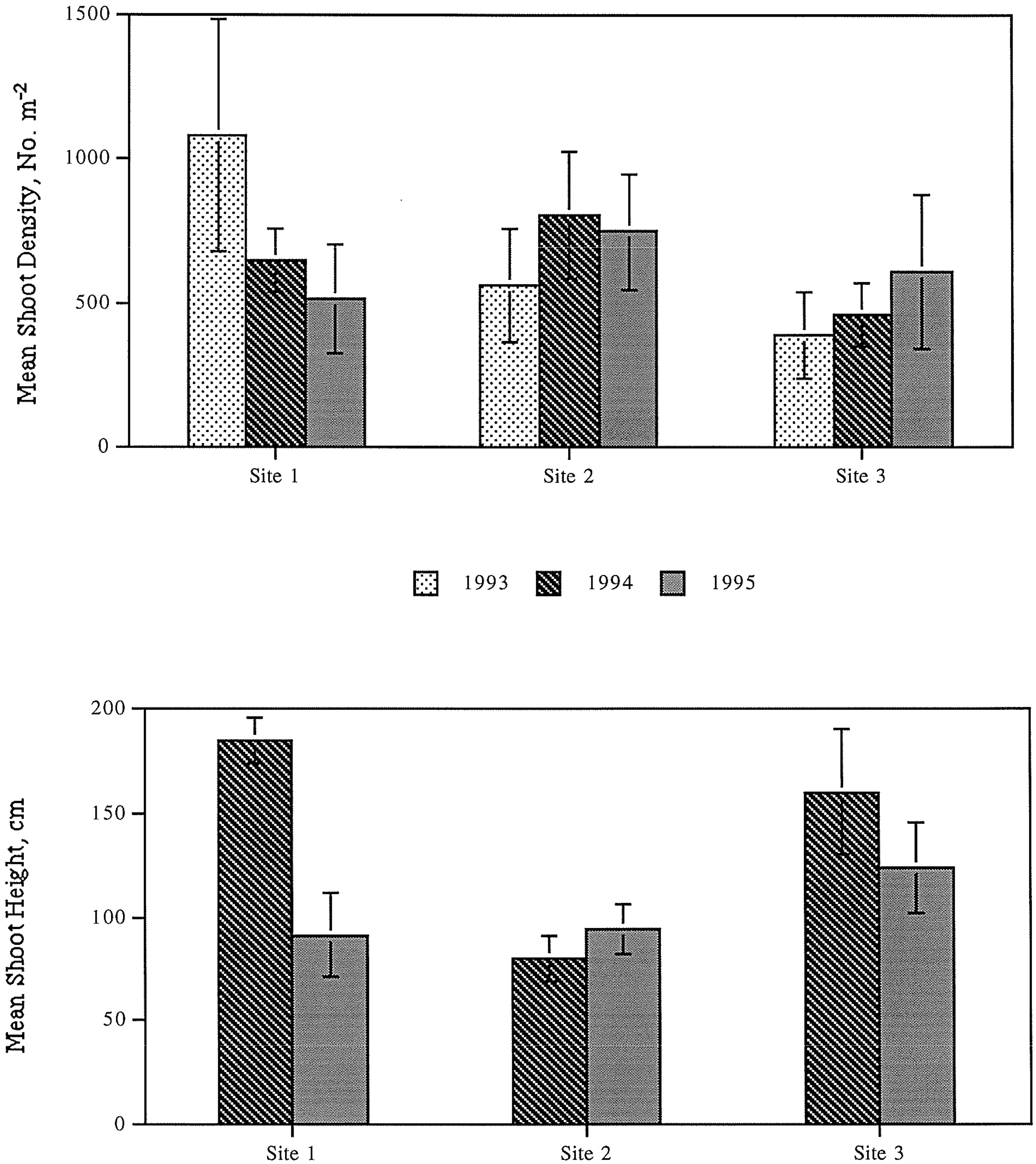


Figure 13. Abundance (bottom), species richness (middle), and behavior (top) of birds observed at four sites in the Duwamish Waterway, June-September, 1995. Vertical lines represent standard deviation: standard deviation of "all birds" category in bottom graph were very large and are not shown.

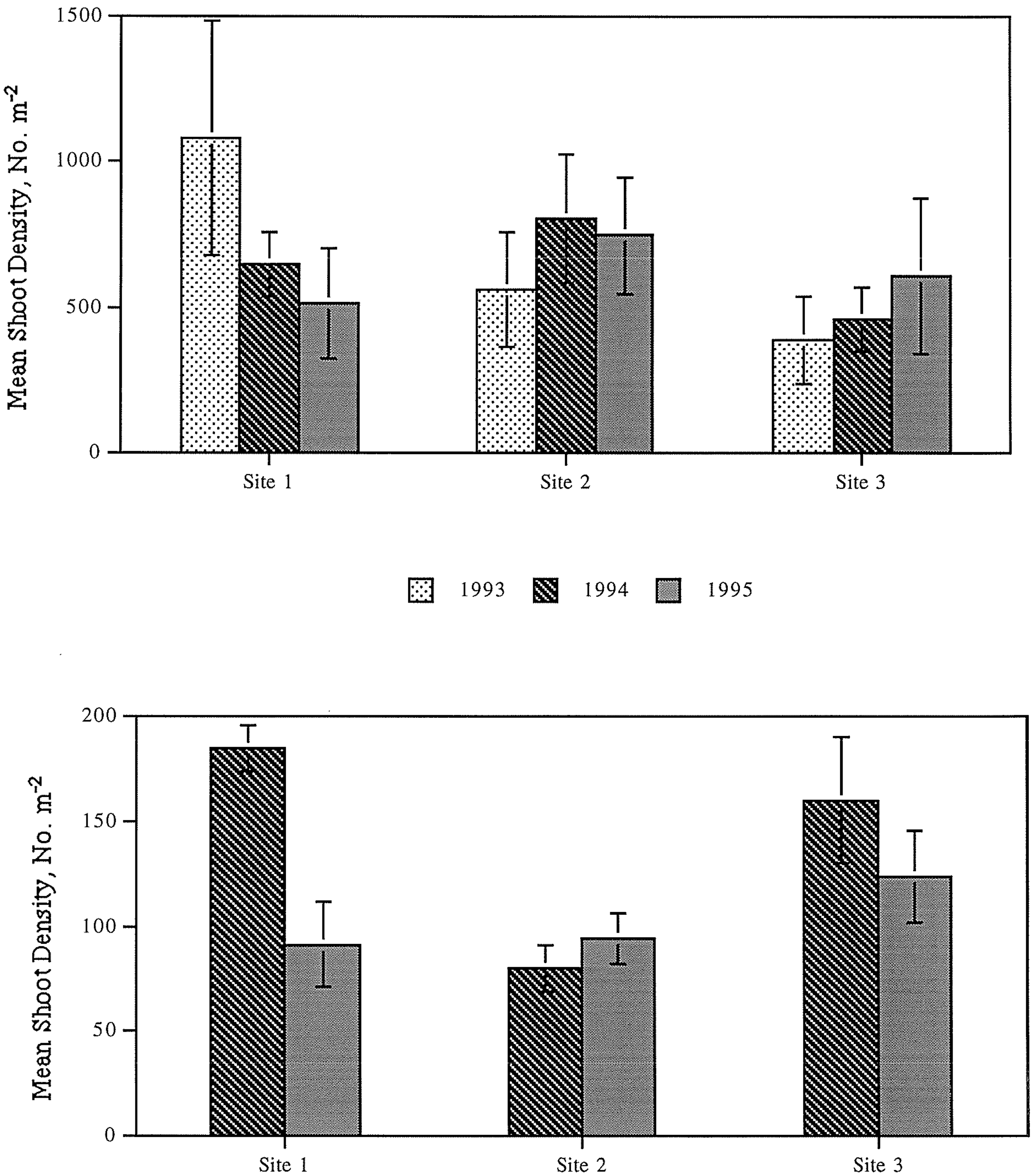


Figure 14. Estimates of average shoot density (top) per 0.0625 m^2 quadrat and average maximum shoot height (bottom) at three *Carex lyngbei* benches in the Duwamish Waterway, 1 August, 1995. Vertical lines represent 95% confidence intervals.

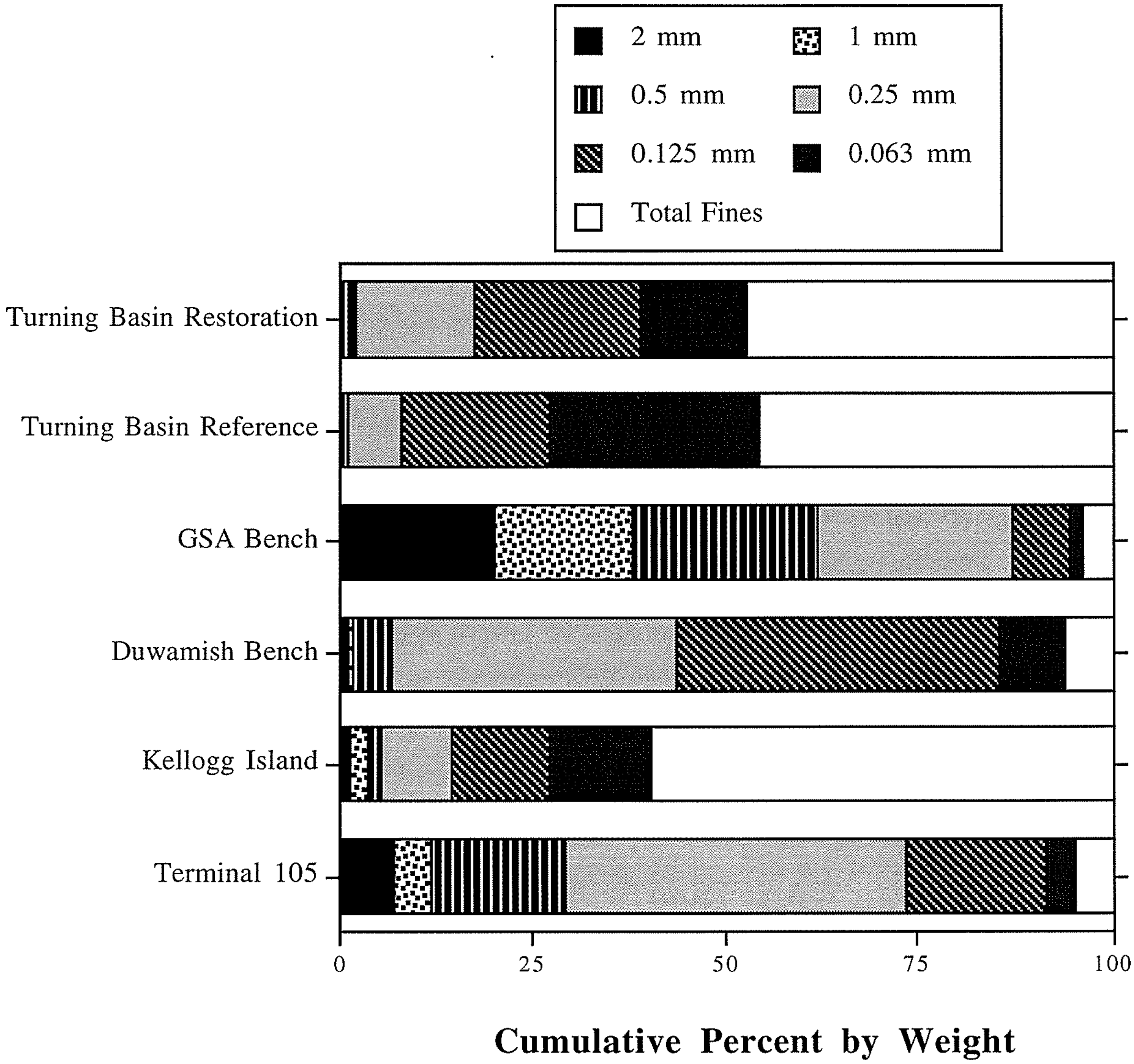


Figure 15. Sediment grain size composition at six sites in the Duwamish Waterway, November, 1995.

TABLES

Table 1. Bird species observed at four sites in the Duwamish Waterway, June-September, 1995. Numbers = percent of total observations for each species. Species are grouped loosely by guild in the following order: passerines, raptors, shore/wading birds, waterfowl, and seabirds. * = nonnative species; † = native species likely to occur in association with human disturbance.

Species	TB reference	TB restored	Kellogg Island	T-105
Number of 1/2H obs.	12	13	14	12
House finch*	25	8	14	8
Gold finch	17	0	0	8
Song sparrow	8	0	0	0
Fox sparrow	33	8	21	0
House sparrow*	8	15	7	17
Barn swallow†	17	0	14	25
Tree swallow	0	0	7	0
Cliff swallow	25	61	14	8
Violet-green swallow	8	8	0	0
American robin†	0	0	14	0
European starling*	33	23	79	58
Rock dove†	42	61	7	8
Belted kingfisher	8	15	64	33
Northwestern crow†	8	23	71	50
Osprey	0	8	14	0
Killdeer	83	85	93	67
Spotted sandpiper	33	69	29	8
Great blue heron	17	23	93	33
Common merganser	8	46	36	0
Mallard duck†	100	85	79	17
Gadwall	0	8	7	0
Domestic duck*	0	0	0	17
Canada goose†	33	54	64	67
Domestic goose*	8	15	0	0
Glaucous-winged gull†	42	61	100	58
Mew gull	17	8	7	0
Double-crested cormorant	0	8	29	0
Total species seen	21	21	21	16
Percent of all species seen	78	78	78	59
Number of indigenous species	11	12	11	6
Number of introduced species	4	4	3	4
Number of human-associated species	6	5	7	6

Table 2. Summary statistics for shoot density and maximum shoot height at *Carex* benches, Duwamish River, 1995.

Species	TB reference/ TB restoration	TB reference/ Kellogg Island	TB reference/ Kellogg Island	TB reference/ T-105	TB reference/ T-105	Kellogg Island/ T-105
Indigenous species						
Gold finch Song sparrow Fox sparrow Tree swallow Cliff swallow Violet-green swallow American kingfisher						
Osprey	60	53	73	40	33	33
Killdeer Spotted sandpiper Great blue heron						
Common merganser Gadwall						
Mew gull Double-crested cormorant						
Introduced species						
House finch House sparrow European starling	100	100	100	100	100	100
Domestic duck Domestic goose	50	0	0	0	0	0
Native human-associated						
Barn swallow American robin Rock dove Northwestern crow						
Canada goose Mallard duck	100	100	100	100	100	100
Glaucous-winged gull	100	100	100	100	100	100

Table 3. Survival of plantings at turning basin by species and area.

species		*Counts* per area				*Percent survival* per area			
		1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
?	live	0	0	1	1	0	*	100	100
	total	3	0	1	1				
NR	live	1	3	5	2	100	100	100	100
Nootka Rose	total	1	3	5	2				
OA	live	1	0	0	0	100	*	*	*
Oregon ash	total	1	0	0	0				
PW	live	1	4	0	7	100	100	*	90
Pacific Willow	total	1	4	0	8				
RC	live	0	1	0	0	*	20	*	*
Red Currant	total	0	6	0	0				
RE	live	1	1	0	1	100	100	*	100
Red Elderberry	total	1	1	0	1				
SB	live	0	0	0	1	*	*	*	100
Service berry	total	0	0	0	1				
SW	live	0	0	2	2	0	*	100	70
Scouler's willow?	total	5	0	2	3				
VM	live	0	2	1	1	*	100	100	100
Vine maple	total	0	2	1	1				
W	live	9	0	0	0	50	*	*	*
Willow	total	19	0	0	0				
W?	live	1	1	0	0	100	100	*	*
Willow?	total	1	1	0	0				
WR	live	0	0	0	0	0	*	*	*
Willow?	total	1	0	0	0				
WS	live	0	0	0	0	*	*	*	0
Willow (*sitchensis*?)	total	0	0	0	1				
No #	live	3	2	0	0	40	50	*	*
	total	8	4	0	0				

Table 4. Summary statistics for shoot density and maximum shoot height at *Carex* Benches, Duwamish River, 1995.

	Site 1	Site 2	Site 3
Shoot density			
Average	32	46.8	38.1
Max	60	76	75
Min	17	28	20
Std Dev	13.86	14.81	19.60
CV	0.43	0.32	0.51
Maximum shoot height			
Average	91	93.7	123.6
Max	138	120	158
Min	46	78	81
Std Dev	24.00	14.37	25.54
CV	0.26	0.15	0.21

Table 5. Summary statistics for shoot density and maximum shoot height at *Scirpus* benches, Duwamish River, 1995. Data from Kellogg Island, 1993, are included for comparison.

	Reference	GSA	KI, 1993
Shoot density			
Average	16.2	37.8	22.8
Max	34	91	34
Min	6	8	13
Std Dev	9.26	25.65	6.83
CV	0.57	0.68	0.30

Maximum shoot height		
Average	118.4	73.2
Max	171	110
Min	58	28
Std Dev	42.71	22.99
CV	0.36	0.31

APPENDICES

APPENDIX 1: SUMMARY DATA FROM BENTHIC MACROFAUNA SAMPLES AT SIX SITES IN THE DUWAMISH WATERWAY, 15 MAY, 1995

BENTHIC PLANKTON ANALYSIS   SITE TABLE, PAGE 1

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****
* SITE SUMMARY *
****

IDENTIFICATION 95MY15
STATION 10075 - TURNING BASIN
FROM SAMPLES B 1 B 2 B 3 B 4 B 5 B 6 B 7 B 8 B 9 B10 B11 B12 B13 B14 B15

SPECIES DEFINITION -
TRUNCATED = NO
LH-STAGE = EGGORNOT
PARTS CODE EXCLUDED

ABUNDANCES AND WEIGHTS ARE ADJUSTED TO AN AREA OF 1.0 SQUARE METERS

	MEAN	RANGE	S.D.	COEF.VAR
SAMPLE AREA (M**2)	.002	.002- .002	.000	.000
TOTAL WET WEIGHT (PER M**2)	.000	.000- .000	.000	.000
TOTAL ABUNDANCE (PER M**2)	122435.20	81111.10- 180416.70	29246.06	.24
SAMPLE WET WEIGHT (PER M**2)	.000	.000- .000	.000	.000
SAMPLE DRY WEIGHT (PER M**2)	.000	.000- .000	.000	.000

ORGANISM NAME / PARTS CODE	LH-STAGE	NUMBERS/M**2 TOTAL	MEAN	RANGE	S.D.	WET WEIGHT,GRAMS/M**2 TOTAL	MEAN	RANGE	S.D.	AVG. BIOMASS MEAN	S.D.	PERCENTAGES ABUN-DANCE	BIO-MASS
Hydroida	C	416.7	27.8	416.7 - 416.7	107.6	.000	.000	.000 - .000	.00	.0000	.0000	.02	.00
Turbellaria	C	10000.0	666.7	3333.3 - 3333.3	1380.1	.000	.000	.000 - .000	.00	.0000	.0000	.54	.00
Nematoda	A	323888.9	21592.6	6666.7 - 46666.7	14008.8	.000	.000	.000 - .000	.00	.0000	.0000	17.64	.00
Nereidae	7	3333.3	222.2	416.7 - 833.3	309.7	.000	.000	.000 - .000	.00	.0000	.0000	.18	.00
Pseudopolydora kempi japonica	A	4722.2	314.8	416.7 - 2222.2	608.7	.000	.000	.000 - .000	.00	.0000	.0000	.26	.00
Hobsonia florida	A	5416.7	361.1	416.7 - 3333.3	929.9	.000	.000	.000 - .000	.00	.0000	.0000	.29	.00
Manayunkia aestuarina	A	8333.3	555.6	1666.7 - 3333.3	1206.2	.000	.000	.000 - .000	.00	.0000	.0000	.45	.00
Oligochaeta	A	555555.5	37037.0	20000.0 - 60000.0	10804.6	.000	.000	.000 - .000	.00	.0000	.0000	30.25	.00
Macoma sp.	A	416.7	27.8	416.7 - 416.7	107.6	.000	.000	.000 - .000	.00	.0000	.0000	.02	.00
Balanomorpha	7	1666.7	111.1	1666.7 - 1666.7	430.3	.000	.000	.000 - .000	.00	.0000	.0000	.09	.00

BENTHIC PLANKTON ANALYSIS
****

SITE TABLE, PAGE 2

IDENTIFICATION 95MY15
STATION 10075 - TURNING BASIN
FROM SAMPLES B 1 B 2 B 3 B 4 B 5 B 6 B 7 B 8 B 9 B10 B11 B12 B13 B14 B15

ORGANISM NAME / PARTS CODE	LH-STAGE	NUMBERS/M**2 TOTAL	NUMBERS/M**2 MEAN	NUMBERS/M**2 RANGE	NUMBERS/M**2 S.D.	WET WEIGHT,GRAMS/M**2 TOTAL	WET WEIGHT,GRAMS/M**2 MEAN	WET WEIGHT,GRAMS/M**2 RANGE	WET WEIGHT,GRAMS/M**2 S.D.	AVG. BIOMASS MEAN	AVG. BIOMASS S.D.	PERCENTAGES ABUN-DANCE	PERCENTAGES BIO-MASS
Leuconidae	A	11111.1	740.7	1111.1 - 3333.3	1218.4	.000	.000	.000 - .000	.00	.0000	.0000	.61	.00
Cumella vulgaris	A	6666.7	444.4	3333.3 - 3333.3	1172.9	.000	.000	.000 - .000	.00	.0000	.0000	.36	.00
Tanais sp.	A	10000.0	666.7	3333.3 - 3333.3	1380.1	.000	.000	.000 - .000	.00	.0000	.0000	.54	.00
Corophium sp.	7	643888.9	42925.9	16666.7 - 96666.7	20012.6	.000	.000	.000 - .000	.00	.0000	.0000	35.06	.00
Corophium salmonis	A	183888.9	12259.3	3333.3 - 26666.7	6792.7	.000	.000	.000 - .000	.00	.0000	.0000	10.01	.00
Corophium spinicorne	A	50555.6	3370.4	3333.3 - 13333.3	4149.3	.000	.000	.000 - .000	.00	.0000	.0000	2.75	.00
Eogammarus confervicolus	A	13333.3	888.9	13333.3 - 13333.3	3442.7	.000	.000	.000 - .000	.00	.0000	.0000	.73	.00
Diptera-chironomidae	6	3333.3	222.2	3333.3 - 3333.3	860.7	.000	.000	.000 - .000	.00	.0000	.0000	.18	.00

TOTAL NUMBER OF PLANKTON CATEGORIES 18

SHANNON-WEINER DIVERSITY INDEX NUMBERS 2.31
BIOMASS .00
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS 2.31

BENTHIC PLANKTON ANALYSIS SITE TABLE, PAGE 1
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****
* SITE SUMMARY *
****

IDENTIFICATION 95MY15
STATION 10074 - TURNING BASIN REFERENCE
FROM SAMPLES B 1 B 2 B 3 B 4 B 5 B 6 B 7 B 8 B 9 B10 B11 B12 B13 B14 B15

SPECIES DEFINITION -
TRUNCATED = NO
LH-STAGE = EGGORNOT
PARTS CODE EXCLUDED

ABUNDANCES AND WEIGHTS ARE ADJUSTED TO AN AREA OF 1.0 SQUARE METERS

	MEAN	RANGE	S.D.	COEF.VAR
SAMPLE AREA (M**2)	.002	.002-.002	.000	.000
TOTAL WET WEIGHT (PER M**2)	.000	.000-.000	.000	.000
TOTAL ABUNDANCE (PER M**2)	45777.77	9583.33-160000.00	40429.50	.88
SAMPLE WET WEIGHT (PER M**2)	.000	.000-.000	.000	.000
SAMPLE DRY WEIGHT (PER M**2)	.000	.000-.000	.000	.000

ORGANISM NAME		NUMBERS/M**2				WET WEIGHT,GRAMS/M**2				AVG. BIOMASS		PERCENTAGES	
PARTS CODE	LH-STAGE	TOTAL	MEAN	RANGE	S.D.	TOTAL	MEAN	RANGE	S.D.	MEAN	S.D.	ABUN-DANCE	BIO-MASS
Turbellaria	C	3750.0	250.0	416.7 - 1666.7	585.0	.000	.000	.000 - .000	.00	.0000	.0000	.55	.00
Nematoda	A	150833.3	10055.6	1250.0 - 46666.7	11741.8	.000	.000	.000 - .000	.00	.0000	.0000	21.97	.00
Nereidae	7	3333.3	222.2	833.3 - 1666.7	494.7	.000	.000	.000 - .000	.00	.0000	.0000	.49	.00
Pseudopolydora kempi japonica	A	12500.0	833.3	416.7 - 3333.3	918.3	.000	.000	.000 - .000	.00	.0000	.0000	1.82	.00
Pygospio elegans	A	1666.7	111.1	416.7 - 1250.0	332.8	.000	.000	.000 - .000	.00	.0000	.0000	.24	.00
Hobsonia florida	A	16666.7	1111.1	416.7 - 3333.3	1098.6	.000	.000	.000 - .000	.00	.0000	.0000	2.43	.00
Manayunkia aestuarina	A	18750.0	1250.0	833.3 - 5416.7	1582.7	.000	.000	.000 - .000	.00	.0000	.0000	2.73	.00
Oligochaeta	A	334999.9	22333.3	1666.7 - 73333.3	23958.4	.000	.000	.000 - .000	.00	.0000	.0000	48.79	.00
Macoma sp.	A	416.7	27.8	416.7 - 416.7	107.6	.000	.000	.000 - .000	.00	.0000	.0000	.06	.00
Leuconidae	A	6250.0	416.7	416.7 - 2500.0	862.6	.000	.000	.000 - .000	.00	.0000	.0000	.91	.00

BENTHIC PLANKTON ANALYSIS
****

SITE TABLE, PAGE 2

IDENTIFICATION 95MY15
STATION 10074 - TURNING BASIN REFERENCE
FROM SAMPLES B 1 B 2 B 3 B 4 B 5 B 6 B 7 B 8 B 9 B10 B11 B12 B13 B14 B15

ORGANISM NAME		NUMBERS/M**2				WET WEIGHT,GRAMS/M**2				AVG. BIOMASS		PERCENTAGES	
												ABUN-	BIO-
PARTS CODE	LH-STAGE	TOTAL	MEAN	RANGE	S.D.	TOTAL	MEAN	RANGE	S.D.	MEAN	S.D.	DANCE	MASS
Cumella vulgaris		2083.3	138.9	416.7 -	257.2	.000	.000	.000 -	.00	.0000	.0000	.30	.00
	A			833.3				.000					
Tanais sp.		3333.3	222.2	3333.3 -	860.7	.000	.000	.000 -	.00	.0000	.0000	.49	.00
	A			3333.3				.000					
Corophium sp.		40000.0	2666.7	416.7 -	5090.5	.000	.000	.000 -	.00	.0000	.0000	5.83	.00
	7			20000.0				.000					
Corophium salmonis		87500.0	5833.3	1666.7 -	4761.2	.000	.000	.000 -	.00	.0000	.0000	12.74	.00
	A			15833.3				.000					
Corophium spinicorne		4166.7	277.8	1666.7 -	749.8	.000	.000	.000 -	.00	.0000	.0000	.61	.00
	A			2500.0				.000					
Eogammarus confervicolus		416.7	27.8	416.7 -	107.6	.000	.000	.000 -	.00	.0000	.0000	.06	.00
	A			416.7				.000					

TOTAL NUMBER OF PLANKTON CATEGORIES 16

SHANNON-WEINER DIVERSITY INDEX NUMBERS 2.26
BIOMASS .00
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS 2.26

BENTHIC PLANKTON ANALYSIS SITE TABLE, PAGE 1
****

****
* SITE SUMMARY *
****

IDENTIFICATION 95MY15
STATION 10070 - KELLOGG ISLAND
FROM SAMPLES B 1 B 2 B 3 B 4 B 1 B 4 B 5 B 6 B 7 B 8 B 9 B10 B11 B12 B13 B14 B15

SPECIES DEFINITION -
TRUNCATED = NO
LH-STAGE = EGGORNOT
PARTS CODE EXCLUDED

ABUNDANCES AND WEIGHTS ARE ADJUSTED TO AN AREA OF 1.0 SQUARE METERS

	MEAN	RANGE	S.D.	COEF.VAR
SAMPLE AREA (M**2)	.002	.002- .002	.000	.000
TOTAL WET WEIGHT (PER M**2)	.000	.000- .000	.000	.000
TOTAL ABUNDANCE (PER M**2)	352892.20	23333.33- 793750.00	179085.10	.51
SAMPLE WET WEIGHT (PER M**2)	.000	.000- .000	.000	.000
SAMPLE DRY WEIGHT (PER M**2)	.000	.000- .000	.000	.000

ORGANISM NAME / PARTS CODE	LH-STAGE	NUMBERS/M**2 TOTAL	MEAN	RANGE	S.D.	WET WEIGHT,GRAMS/M**2 TOTAL	MEAN	RANGE	S.D.	AVG. BIOMASS MEAN	S.D.	PERCENTAGES ABUN-DANCE	BIO-MASS
Cnidaria	C	10000.0	588.2	10000.0 - 10000.0	2425.4	.000	.000	.000 - .000	.00	.0000	.0000	.17	.00
Hydroida	C	60000.0	3529.4	6666.7 - 26666.7	8856.1	.000	.000	.000 - .000	.00	.0000	.0000	1.00	.00
Turbellaria	C	218333.3	12843.1	1666.7 - 80000.0	19236.9	.000	.000	.000 - .000	.00	.0000	.0000	3.64	.00
Nemertea	C	13333.3	784.3	3333.3 - 6666.7	1874.3	.000	.000	.000 - .000	.00	.0000	.0000	.22	.00
Nematoda	AC	********	67843.1	13333.3 - 173333.3	54300.4	.000	.000	.000 - .000	.00	.0000	.0000	19.22	.00
Eteone sp.	C	10000.0	588.2	3333.3 - 6666.7	1762.0	.000	.000	.000 - .000	.00	.0000	.0000	.17	.00
Nereidae	7	3333.3	196.1	3333.3 - 3333.3	808.5	.000	.000	.000 - .000	.00	.0000	.0000	.06	.00
Goniada sp.	C	3333.3	196.1	3333.3 - 3333.3	808.5	.000	.000	.000 - .000	.00	.0000	.0000	.06	.00
Spionidae	7	6666.7	392.2	6666.7 - 6666.7	1616.9	.000	.000	.000 - .000	.00	.0000	.0000	.11	.00
Polydora sp.	A7	90000.0	5294.1	3333.3 - 20000.0	5899.5	.000	.000	.000 - .000	.00	.0000	.0000	1.50	.00

BENTHIC PLANKTON ANALYSIS
****

SITE TABLE, PAGE 2

IDENTIFICATION 95MY15
STATION 10070 - KELLOGG ISLAND
FROM SAMPLES B 1 B 2 B 3 B 4 B 1 B 4 B 5 B 6 B 7 B 8 B 9 B10 B11 B12 B13 B14 B15

ORGANISM NAME / PARTS CODE	LH-STAGE	NUMBERS/M**2 TOTAL	NUMBERS/M**2 MEAN	NUMBERS/M**2 RANGE	NUMBERS/M**2 S.D.	WET WEIGHT,GRAMS/M**2 TOTAL	WET WEIGHT,GRAMS/M**2 MEAN	WET WEIGHT,GRAMS/M**2 RANGE	WET WEIGHT,GRAMS/M**2 S.D.	AVG. BIOMASS MEAN	AVG. BIOMASS S.D.	PERCENTAGES ABUN-DANCE	PERCENTAGES BIO-MASS
Pseudopolydora kempi japonica	7	6666.7	392.2	6666.7 - 6666.7	1616.9	.000	.000	.000 - .000	.00	.0000	.0000	.11	.00
Pygospio elegans	A	80000.0	4705.9	3333.3 - 13333.3	5408.2	.000	.000	.000 - .000	.00	.0000	.0000	1.33	.00
Capitellidae	A	6666.7	392.2	6666.7 - 6666.7	1616.9	.000	.000	.000 - .000	.00	.0000	.0000	.11	.00
Capitella capitata	A	110000.0	6470.6	3333.3 - 26666.7	9389.0	.000	.000	.000 - .000	.00	.0000	.0000	1.83	.00
Hobsonia florida	A	155000.0	9117.6	1666.7 - 83333.3	19738.9	.000	.000	.000 - .000	.00	.0000	.0000	2.58	.00
Manayunkia aestuarina	A	********	65000.0	36666.7 - 140000.0	41641.7	.000	.000	.000 - .000	.00	.0000	.0000	18.42	.00
Oligochaeta	A	********	138921.6	33333.3 - 453333.3	*******	.000	.000	.000 - .000	.00	.0000	.0000	39.37	.00
Macoma sp.	A	833.3	49.0	416.7 - 416.7	138.4	.000	.000	.000 - .000	.00	.0000	.0000	.01	.00
Halacaridae	C	6666.7	392.2	3333.3 - 3333.3	1107.0	.000	.000	.000 - .000	.00	.0000	.0000	.11	.00
Balanomorpha	7	3333.3	196.1	3333.3 - 3333.3	808.5	.000	.000	.000 - .000	.00	.0000	.0000	.06	.00
Neomysis mercedis	7	3333.3	196.1	3333.3 - 3333.3	808.5	.000	.000	.000 - .000	.00	.0000	.0000	.06	.00
Leuconidae	A	101666.7	5980.4	1666.7 - 16666.7	5745.1	.000	.000	.000 - .000	.00	.0000	.0000	1.69	.00
Cumella vulgaris	A	236666.7	13921.6	3333.3 - 50000.0	14588.6	.000	.000	.000 - .000	.00	.0000	.0000	3.94	.00
Corophium sp.	7	143333.3	8431.4	3333.3 - 33333.3	9213.3	.000	.000	.000 - .000	.00	.0000	.0000	2.39	.00
Corophium salmonis	A	58333.3	3431.4	1666.7 - 13333.3	4016.9	.000	.000	.000 - .000	.00	.0000	.0000	.97	.00
Corophium insidiosum	A	10000.0	588.2	3333.3 - 6666.7	1762.0	.000	.000	.000 - .000	.00	.0000	.0000	.17	.00
Eogammarus confervicolus	A	41666.7	2451.0	1666.7 - 23333.3	5593.8	.000	.000	.000 - .000	.00	.0000	.0000	.69	.00

TOTAL NUMBER OF PLANKTON CATEGORIES 27

SHANNON-WEINER DIVERSITY INDEX NUMBERS 2.76
BIOMASS .00
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS 2.76

BENTHIC PLANKTON ANALYSIS ****************************** SITE TABLE, PAGE 1

****
* SITE SUMMARY *
****

IDENTIFICATION 95MY15
STATION 10064 - GSA INTERTIDAL BENCH
FROM SAMPLES B 1 B 2 B 3 B 4 B 5 B 6 B 7 B 9 B10 B11 B12 B13 B14 B15

SPECIES DEFINITION -
TRUNCATED = NO
LH-STAGE = EGGORNOT
PARTS CODE EXCLUDED

ABUNDANCES AND WEIGHTS ARE ADJUSTED TO AN AREA OF 1.0 SQUARE METERS

	MEAN	RANGE	S.D.	COEF.VAR
SAMPLE AREA (M**2)	.002	.002- .002	.000	.000
TOTAL WET WEIGHT (PER M**2)	.000	.000- .000	.000	.000
TOTAL ABUNDANCE (PER M**2)	135644.80	13333.33- 363333.30	116374.00	.86
SAMPLE WET WEIGHT (PER M**2)	.000	.000- .000	.000	.000
SAMPLE DRY WEIGHT (PER M**2)	.000	.000- .000	.000	.000

ORGANISM NAME / PARTS CODE	LH-STAGE	NUMBERS/M**2 TOTAL	MEAN	RANGE	S.D.	WET WEIGHT,GRAMS/M**2 TOTAL	MEAN	RANGE	S.D.	AVG. BIOMASS MEAN	S.D.	PERCENTAGES ABUN-DANCE	BIO-MASS
Cnidaria	C	25833.3	1845.2	833.3 - 10000.0	3700.6	.000	.000	.000 - .000	.00	.0000	.0000	1.36	.00
Turbellaria	C	52361.1	3740.1	416.7 - 13333.3	4769.6	.000	.000	.000 - .000	.00	.0000	.0000	2.76	.00
Nemertea	C	28194.4	2013.9	416.7 - 5000.0	1417.2	.000	.000	.000 - .000	.00	.0000	.0000	1.48	.00
Nematoda	A	365833.3	26131.0	833.3 - 76666.7	24194.0	.000	.000	.000 - .000	.00	.0000	.0000	19.26	.00
Anaitides sp.	A	1666.7	119.0	1666.7 - 1666.7	445.4	.000	.000	.000 - .000	.00	.0000	.0000	.09	.00
Eteone sp.	A	1666.7	119.0	1666.7 - 1666.7	445.4	.000	.000	.000 - .000	.00	.0000	.0000	.09	.00
Nereidae	7	833.3	59.5	416.7 - 416.7	151.3	.000	.000	.000 - .000	.00	.0000	.0000	.04	.00
Nereis sp.	7	151666.7	10833.3	1666.7 - 150000.0	40057.4	.000	.000	.000 - .000	.00	.0000	.0000	7.99	.00
Polydora sp.	7	1250.0	89.3	416.7 - 833.3	241.2	.000	.000	.000 - .000	.00	.0000	.0000	.07	.00
Pseudopolydora kempi japonica	A	2222.2	158.7	555.6 - 1666.7	458.6	.000	.000	.000 - .000	.00	.0000	.0000	.12	.00

BENTHIC PLANKTON ANALYSIS
****

SITE TABLE, PAGE 2

IDENTIFICATION 95MY15
STATION 10064 - GSA INTERTIDAL BENCH
FROM SAMPLES B 1 B 2 B 3 B 4 B 5 B 6 B 7 B 9 B10 B11 B12 B13 B14 B15

ORGANISM NAME / PARTS CODE	LH-STAGE	NUMBERS/M**2 TOTAL	MEAN	RANGE	S.D.	WET WEIGHT,GRAMS/M**2 TOTAL	MEAN	RANGE	S.D.	AVG. BIOMASS MEAN	S.D.	PERCENTAGES ABUN-DANCE	BIO-MASS
Pygospio elegans	A	551250.0	39375.0	1666.7 - 96666.7	36973.1	.000	.000	.000 - .000	.00	.0000	.0000	29.03	.00
Capitella capitata	A	416.7	29.8	416.7 - 416.7	111.4	.000	.000	.000 - .000	.00	.0000	.0000	.02	.00
Hobsonia florida	A	46666.7	3333.3	46666.7 - 46666.7	12472.2	.000	.000	.000 - .000	.00	.0000	.0000	2.46	.00
Sabellidae	7	416.7	29.8	416.7 - 416.7	111.4	.000	.000	.000 - .000	.00	.0000	.0000	.02	.00
Oligochaeta	A	263611.1	18829.4	833.3 - 75000.0	21451.9	.000	.000	.000 - .000	.00	.0000	.0000	13.88	.00
Halacaridae	C	38611.1	2757.9	833.3 - 13333.3	3793.8	.000	.000	.000 - .000	.00	.0000	.0000	2.03	.00
Balanomorpha	E7	11527.8	823.4	416.7 - 3333.3	1270.0	.000	.000	.000 - .000	.00	.0000	.0000	.61	.00
Cumella vulgaris	A	58750.0	4196.4	416.7 - 16666.7	6542.2	.000	.000	.000 - .000	.00	.0000	.0000	3.09	.00
Tanais sp.	A	6388.9	456.3	555.6 - 3333.3	959.8	.000	.000	.000 - .000	.00	.0000	.0000	.34	.00
Gnorimosphaeroma oregonensis	A	2083.3	148.8	833.3 - 1250.0	387.0	.000	.000	.000 - .000	.00	.0000	.0000	.11	.00
Ampithodae	7	3333.3	238.1	3333.3 - 3333.3	890.9	.000	.000	.000 - .000	.00	.0000	.0000	.18	.00
Ampithoe sp.	7	11666.7	833.3	11666.7 - 11666.7	3118.0	.000	.000	.000 - .000	.00	.0000	.0000	.61	.00
Corophium sp.	7	195833.3	13988.1	416.7 - 63333.3	19345.4	.000	.000	.000 - .000	.00	.0000	.0000	10.31	.00
Corophium salmonis	A	14305.6	1021.8	555.6 - 3333.3	1399.1	.000	.000	.000 - .000	.00	.0000	.0000	.75	.00
Corophium spinicorne	A	27083.3	1934.5	1666.7 - 10000.0	3124.9	.000	.000	.000 - .000	.00	.0000	.0000	1.43	.00
Eogammarus confervicolus	A	27083.3	1934.5	416.7 - 16666.7	4459.6	.000	.000	.000 - .000	.00	.0000	.0000	1.43	.00
Diptera	G	416.7	29.8	416.7 - 416.7	111.4	.000	.000	.000 - .000	.00	.0000	.0000	.02	.00
Diptera-chironomidae	6	7638.9	545.6	416.7 - 2500.0	944.3	.000	.000	.000 - .000	.00	.0000	.0000	.40	.00
Empididae	6	416.7	29.8	416.7 - 416.7	111.4	.000	.000	.000 - .000	.00	.0000	.0000	.02	.00

TOTAL NUMBER OF PLANKTON CATEGORIES 29

SHANNON-WEINER DIVERSITY INDEX NUMBERS 3.17
BIOMASS .00
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS 3.17

BENTHIC PLANKTON ANALYSIS
****

SITE TABLE, PAGE 1

****
* SITE SUMMARY *
****

IDENTIFICATION 95MY15
STATION 10068 - TERMINAL 105
FROM SAMPLES B 1 B 2 B 3 B 4 B 5 B 6 B 7 B 8 B 9 B10 B11 B12 B13 B14 B15

SPECIES DEFINITION -
TRUNCATED = NO
LH-STAGE = EGGORNOT
PARTS CODE EXCLUDED

ABUNDANCES AND WEIGHTS ARE ADJUSTED TO AN AREA OF 1.0 SQUARE METERS

	MEAN	RANGE	S.D.	COEF.VAR
SAMPLE AREA (M**2)	.002	.002- .002	.000	.000
TOTAL WET WEIGHT (PER M**2)	.000	.000- .000	.000	.000
TOTAL ABUNDANCE (PER M**2)	94500.01	3333.33- 216666.70	74814.11	.79
SAMPLE WET WEIGHT (PER M**2)	.000	.000- .000	.000	.000
SAMPLE DRY WEIGHT (PER M**2)	.000	.000- .000	.000	.000

ORGANISM NAME / PARTS CODE	LH-STAGE	NUMBERS/M**2 TOTAL	MEAN	RANGE	S.D.	WET WEIGHT,GRAMS/M**2 TOTAL	MEAN	RANGE	S.D.	AVG. BIOMASS MEAN	S.D.	PERCENTAGES ABUN-DANCE	BIO-MASS
Hydroida	C	6666.7	444.4	6666.7 - 6666.7	1721.3	.000	.000	.000 - .000	.00	.0000	.0000	.47	.00
Turbellaria	C	64722.2	4314.8	1250.0 - 13333.3	4373.3	.000	.000	.000 - .000	.00	.0000	.0000	4.57	.00
Nemertea	C	5833.3	388.9	416.7 - 3333.3	924.6	.000	.000	.000 - .000	.00	.0000	.0000	.41	.00
Nematoda	A	255000.0	17000.0	1250.0 - 64166.7	21262.4	.000	.000	.000 - .000	.00	.0000	.0000	17.99	.00
Eteone sp.	A	1250.0	83.3	416.7 - 833.3	233.6	.000	.000	.000 - .000	.00	.0000	.0000	.09	.00
Polydora sp.	7	2500.0	166.7	833.3 - 1666.7	467.2	.000	.000	.000 - .000	.00	.0000	.0000	.18	.00
Pseudopolydora kempi japonica	A7	2916.7	194.4	416.7 - 1666.7	468.9	.000	.000	.000 - .000	.00	.0000	.0000	.21	.00
Pygospio elegans	A	383750.0	25583.3	416.7 - 101666.7	30713.2	.000	.000	.000 - .000	.00	.0000	.0000	27.07	.00
Capitella capitata	A	13194.4	879.6	1111.1 - 5000.0	1515.7	.000	.000	.000 - .000	.00	.0000	.0000	.93	.00
Fabricia sp.	C	5000.0	333.3	1666.7 - 1666.7	690.1	.000	.000	.000 - .000	.00	.0000	.0000	.35	.00

BENTHIC PLANKTON ANALYSIS SITE TABLE, PAGE 2
****

IDENTIFICATION 95MY15
STATION 10068 - TERMINAL 105
FROM SAMPLES B 1 B 2 B 3 B 4 B 5 B 6 B 7 B 8 B 9 B10 B11 B12 B13 B14 B15

ORGANISM NAME PARTS CODE	LH-STAGE	NUMBERS/M**2 TOTAL	MEAN	RANGE	S.D.	WET WEIGHT,GRAMS/M**2 TOTAL	MEAN	RANGE	S.D.	AVG. BIOMASS MEAN	S.D.	PERCENTAGES ABUN-DANCE	BIO-MASS
Archianellida		833.3	55.6	833.3 -	215.2	.000	.000	.000 -	.00	.0000	.0000	.06	.00
	C			833.3				.000					
Oligochaeta		598333.3	39888.9	833.3 -	44771.9	.000	.000	.000 -	.00	.0000	.0000	42.21	.00
	A			158333.3				.000					
Halacaridae		1666.7	111.1	1666.7 -	430.3	.000	.000	.000 -	.00	.0000	.0000	.12	.00
	C			1666.7				.000					
Balanomorpha		4027.8	268.5	416.7 -	476.7	.000	.000	.000 -	.00	.0000	.0000	.28	.00
	7			1666.7				.000					
Cumella vulgaris		6250.0	416.7	416.7 -	686.5	.000	.000	.000 -	.00	.0000	.0000	.44	.00
	A			1666.7				.000					
Corophium sp.		51666.7	3444.4	3333.3 -	8176.3	.000	.000	.000 -	.00	.0000	.0000	3.64	.00
	7			30000.0				.000					
Corophium salmonis		12222.2	814.8	555.6 -	1838.0	.000	.000	.000 -	.00	.0000	.0000	.86	.00
	A			6666.7				.000					
Corophium spinicorne		1666.7	111.1	1666.7 -	430.3	.000	.000	.000 -	.00	.0000	.0000	.12	.00
	A			1666.7				.000					

TOTAL NUMBER OF PLANKTON CATEGORIES 18

SHANNON-WEINER DIVERSITY INDEX NUMBERS 2.21
BIOMASS .00
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS 2.21

BENTHIC PLANKTON ANALYSIS SITE TABLE, PAGE 1
****

****
* SITE SUMMARY *
****

IDENTIFICATION 95MY15
STATION 10060 - DUWAMISH LOWER BENCH
FROM SAMPLES B 1 B 2 B 3 B 4 B 5 B 6 B 7 B 8 B 9 B10 B11 B12 B13 B14 B15

SPECIES DEFINITION -
TRUNCATED = NO
LH-STAGE = EGGORNOT
PARTS CODE EXCLUDED

ABUNDANCES AND WEIGHTS ARE ADJUSTED TO AN AREA OF 1.0 SQUARE METERS

	MEAN	RANGE	S.D.	COEF.VAR
SAMPLE AREA (M**2)	.002	.002- .002	.000	.000
TOTAL WET WEIGHT (PER M**2)	.000	.000- .000	.000	.000
TOTAL ABUNDANCE (PER M**2)	149666.70	59583.34- 270833.30	54644.46	.37
SAMPLE WET WEIGHT (PER M**2)	.000	.000- .000	.000	.000
SAMPLE DRY WEIGHT (PER M**2)	.000	.000- .000	.000	.000

ORGANISM NAME / PARTS CODE	LH-STAGE	NUMBERS/M**2 TOTAL	MEAN	RANGE	S.D.	WET WEIGHT,GRAMS/M**2 TOTAL	MEAN	RANGE	S.D.	AVG. BIOMASS MEAN	S.D.	PERCENTAGES ABUN-DANCE	BIO-MASS
Cnidaria	C	33333.3	2222.2	1666.7 - 13333.3	4528.0	.000	.000	.000 - .000	.00	.0000	.0000	1.48	.00
Turbellaria	C	138333.3	9222.2	3333.3 - 20000.0	6632.9	.000	.000	.000 - .000	.00	.0000	.0000	6.16	.00
Nemertea	C	24166.7	1611.1	1666.7 - 6666.7	2324.5	.000	.000	.000 - .000	.00	.0000	.0000	1.08	.00
Nematoda	A	437500.0	29166.7	3333.3 - 108333.3	28370.1	.000	.000	.000 - .000	.00	.0000	.0000	19.49	.00
Eteone sp.	CA	20833.3	1388.9	1666.7 - 4166.7	1532.3	.000	.000	.000 - .000	.00	.0000	.0000	.93	.00
Platynereis bicanaliculata	A	416.7	27.8	416.7 - 416.7	107.6	.000	.000	.000 - .000	.00	.0000	.0000	.02	.00
Glyceridae	A	2083.3	138.9	416.7 - 1666.7	436.1	.000	.000	.000 - .000	.00	.0000	.0000	.09	.00
Goniadidae	A	1666.7	111.1	1666.7 - 1666.7	430.3	.000	.000	.000 - .000	.00	.0000	.0000	.07	.00
Polydora sp.	7A	36666.7	2444.4	1666.7 - 10000.0	3203.8	.000	.000	.000 - .000	.00	.0000	.0000	1.63	.00
Pseudopolydora kempi japonica	A	5416.7	361.1	416.7 - 1666.7	684.0	.000	.000	.000 - .000	.00	.0000	.0000	.24	.00

BENTHIC PLANKTON ANALYSIS
****

SITE TABLE, PAGE 2

IDENTIFICATION 95MY15
STATION 10060 - DUWAMISH LOWER BENCH
FROM SAMPLES B 1 B 2 B 3 B 4 B 5 B 6 B 7 B 8 B 9 B10 B11 B12 B13 B14 B15

ORGANISM NAME / PARTS CODE	LH-STAGE	NUMBERS/M**2 TOTAL	NUMBERS/M**2 MEAN	NUMBERS/M**2 RANGE	NUMBERS/M**2 S.D.	WET WEIGHT,GRAMS/M**2 TOTAL	WET WEIGHT MEAN	WET WEIGHT RANGE	WET WEIGHT S.D.	AVG. BIOMASS MEAN	AVG. BIOMASS S.D.	PERCENTAGES ABUN-DANCE	PERCENTAGES BIO-MASS
Pygospio elegans	A	89583.3	5972.2	1250.0 - 45000.0	13883.4	.000	.000	.000 - .000	.00	.0000	.0000	3.99	.00
Capitella capitata	A	185833.3	12388.9	1666.7 - 40000.0	9443.2	.000	.000	.000 - .000	.00	.0000	.0000	8.28	.00
Arenicolidae	A	23333.3	1555.6	1666.7 - 6666.7	2311.7	.000	.000	.000 - .000	.00	.0000	.0000	1.04	.00
Fabricia sp.	A	11666.7	777.8	1666.7 - 6666.7	1875.8	.000	.000	.000 - .000	.00	.0000	.0000	.52	.00
Oligochaeta	A	********	72388.9	13333.3 - 143333.3	40584.6	.000	.000	.000 - .000	.00	.0000	.0000	48.37	.00
Mysella sp.	CA	833.3	55.6	416.7 - 416.7	146.6	.000	.000	.000 - .000	.00	.0000	.0000	.04	.00
Macoma sp.	A	1666.7	111.1	416.7 - 416.7	190.7	.000	.000	.000 - .000	.00	.0000	.0000	.07	.00
Cumella vulgaris	A	112500.0	7500.0	1666.7 - 16666.7	5354.5	.000	.000	.000 - .000	.00	.0000	.0000	5.01	.00
Tanais sp.	A	18333.3	1222.2	1666.7 - 6666.7	2038.0	.000	.000	.000 - .000	.00	.0000	.0000	.82	.00
Ampithodae	7	3333.3	222.2	3333.3 - 3333.3	860.7	.000	.000	.000 - .000	.00	.0000	.0000	.15	.00
Corophium sp.	7	10000.0	666.7	1666.7 - 6666.7	1759.3	.000	.000	.000 - .000	.00	.0000	.0000	.45	.00
Eogammarus confervicolus	A	1666.7	111.1	1666.7 - 1666.7	430.3	.000	.000	.000 - .000	.00	.0000	.0000	.07	.00

TOTAL NUMBER OF PLANKTON CATEGORIES 22

SHANNON-WEINER DIVERSITY INDEX NUMBERS 2.51
BIOMASS .00
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS 2.51

APPENDIX 2: SUMMARY DATA FROM BENTHIC MEIOFAUNA SAMPLES AT SIX SITES IN THE DUWAMISH WATERWAY, 15 MAY, 1995

BENTHIC PLANKTON ANALYSIS
****

SITE TABLE, PAGE 1

****
* SITE SUMMARY *
****

IDENTIFICATION 95MY15
STATION 10075 - TURNING BASIN
FROM SAMPLES M 1 M 2 M 3 M 4 M 5 M 6 M 7 M 8 M 9 M10 M11 M10 M11 M12 M13 M14 M15

SPECIES DEFINITION -
TRUNCATED = NO
LH-STAGE = EGGORNOT
PARTS CODE EXCLUDED

ABUNDANCES AND WEIGHTS ARE ADJUSTED TO AN AREA OF 1.0 SQUARE METERS

	MEAN	RANGE	S.D.	COEF.VAR
SAMPLE AREA (M**2)	.240	.240- .240	.000	.000
TOTAL WET WEIGHT (PER M**2)	.000	.000- .000	.000	.000
TOTAL ABUNDANCE (PER M**2)	71862.65	69.44- 117458.30	33234.54	.46
SAMPLE WET WEIGHT (PER M**2)	.000	.000- .000	.000	.000
SAMPLE DRY WEIGHT (PER M**2)	.000	.000- .000	.000	.000

ORGANISM NAME / PARTS CODE	LH-STAGE	NUMBERS/M**2 TOTAL	MEAN	RANGE	S.D.	WET WEIGHT, GRAMS/M**2 TOTAL	MEAN	RANGE	S.D.	AVG. BIOMASS MEAN	S.D.	PERCENTAGES ABUN-DANCE	BIO-MASS
Rhizopodea-foraminiferida	C	347.2	20.4	347.2 - 347.2	84.2	.000	.000	.000 - .000	.00	.0000	.0000	.03	.00
Hydrozoa	C	520.8	30.6	520.8 - 520.8	126.3	.000	.000	.000 - .000	.00	.0000	.0000	.04	.00
Turbellaria	C	6684.0	393.2	208.3 - 1736.1	512.2	.000	.000	.000 - .000	.00	.0000	.0000	.55	.00
Nematoda	C	158090.3	9299.4	4583.3 - 18750.0	5176.7	.000	.000	.000 - .000	.00	.0000	.0000	12.94	.00
Polychaeta	6	208.3	12.3	208.3 - 208.3	50.5	.000	.000	.000 - .000	.00	.0000	.0000	.02	.00
Oligochaeta	7	416.7	24.5	416.7 - 416.7	101.1	.000	.000	.000 - .000	.00	.0000	.0000	.03	.00
Podocopida	C	10260.4	603.6	416.7 - 3472.2	892.3	.000	.000	.000 - .000	.00	.0000	.0000	.84	.00
Harpacticoida	AF2	523635.5	30802.1	4854.2 - 79618.1	23152.5	.000	.000	.000 - .000	.00	.0000	.0000	42.86	.00
Coullana canadensis	A	4694.4	276.1	41.7 - 687.5	249.3	.000	.000	.000 - .000	.00	.0000	.0000	.38	.00
Pseudobradya sp.	A	43072.9	2533.7	1458.3 - 4583.3	1303.7	.000	.000	.000 - .000	.00	.0000	.0000	3.53	.00

BENTHIC PLANKTON ANALYSIS SITE TABLE, PAGE 2
****

IDENTIFICATION 95MY15
STATION 10075 - TURNING BASIN
FROM SAMPLES M 1 M 2 M 3 M 4 M 5 M 6 M 7 M 8 M 9 M10 M11 M10 M11 M12 M13 M14 M15

ORGANISM NAME / PARTS CODE	LH-STAGE	NUMBERS/M**2 TOTAL	MEAN	RANGE	S.D.	WET WEIGHT,GRAMS/M**2 TOTAL	MEAN	RANGE	S.D.	AVG. BIOMASS MEAN	S.D.	PERCENTAGES ABUN-DANCE	BIO-MASS
Microarthridion littorale		28559.0	1679.9	666.7 -	1093.3	.000	.000	.000 -	.00	.0000	.0000	2.34	.00
A				4166.7				.000					
Tachidius triangularis		833.3	49.0	833.3 -	202.1	.000	.000	.000 -	.00	.0000	.0000	.07	.00
A				833.3				.000					
Tachidius discipes		208.3	12.3	208.3 -	50.5	.000	.000	.000 -	.00	.0000	.0000	.02	.00
8				208.3				.000					
Huntemannia jadensis		50270.8	2957.1	645.8 -	1962.7	.000	.000	.000 -	.00	.0000	.0000	4.11	.00
A				6500.0				.000					
Leimia vaga		387925.4	22819.1	16166.7 -	10683.3	.000	.000	.000 -	.00	.0000	.0000	31.75	.00
A				41312.5				.000					
Schizopera sp.		208.3	12.3	208.3 -	50.5	.000	.000	.000 -	.00	.0000	.0000	.02	.00
A				208.3				.000					
Schizopera knabeni		3090.3	181.8	208.3 -	207.4	.000	.000	.000 -	.00	.0000	.0000	.25	.00
A				625.0				.000					
Canthocamptidae		208.3	12.3	208.3 -	50.5	.000	.000	.000 -	.00	.0000	.0000	.02	.00
8				208.3				.000					
Mesochra sp.		625.0	36.8	208.3 -	81.9	.000	.000	.000 -	.00	.0000	.0000	.05	.00
A				208.3				.000					
Corophium sp.		1597.2	94.0	208.3 -	159.0	.000	.000	.000 -	.00	.0000	.0000	.13	.00
7				416.7				.000					
Diptera-chironomidae		208.3	12.3	208.3 -	50.5	.000	.000	.000 -	.00	.0000	.0000	.02	.00
6				208.3				.000					

TOTAL NUMBER OF PLANKTON CATEGORIES 21

SHANNON-WEINER DIVERSITY INDEX NUMBERS 2.12
BIOMASS .00
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS 2.12

BENTHIC PLANKTON ANALYSIS ******************************

SITE TABLE, PAGE 1

****
* SITE SUMMARY *
****

IDENTIFICATION 95MY15
STATION 10074 - TURNING BASIN REFERENCE
FROM SAMPLES M 1 M 2 M 3 M 4 M 5 M 6 M 7 M 8 M 9 M10 M11 M12 M13 M14 M15

SPECIES DEFINITION -
TRUNCATED = NO
LH-STAGE = EGGORNOT
PARTS CODE EXCLUDED

ABUNDANCES AND WEIGHTS ARE ADJUSTED TO AN AREA OF 1.0 SQUARE METERS

	MEAN	RANGE	S.D.	COEF.VAR
SAMPLE AREA (M**2)	.240	.240- .240	.000	.000
TOTAL WET WEIGHT (PER M**2)	.000	.000- .000	.000	.000
TOTAL ABUNDANCE (PER M**2)	23985.30	10395.83- 38515.63	7551.20	.31
SAMPLE WET WEIGHT (PER M**2)	.000	.000- .000	.000	.000
SAMPLE DRY WEIGHT (PER M**2)	.000	.000- .000	.000	.000

ORGANISM NAME / PARTS CODE	LH-STAGE	NUMBERS/M**2 TOTAL	MEAN	RANGE	S.D.	WET WEIGHT,GRAMS/M**2 TOTAL	MEAN	RANGE	S.D.	AVG. BIOMASS MEAN	S.D.	PERCENTAGES ABUN-DANCE	BIO-MASS
Rhizopodea-foraminiferida	C	555.6	37.0	208.3 - 347.2	101.2	.000	.000	.000 - .000	.00	.0000	.0000	.15	.00
Hydrozoa	C	1857.6	123.8	208.3 - 625.0	201.1	.000	.000	.000 - .000	.00	.0000	.0000	.52	.00
Turbellaria	C	208.3	13.9	208.3 - 208.3	53.8	.000	.000	.000 - .000	.00	.0000	.0000	.06	.00
Rotifera	C	208.3	13.9	208.3 - 208.3	53.8	.000	.000	.000 - .000	.00	.0000	.0000	.06	.00
Nematoda	C	71059.0	4737.3	1250.0 - 8333.3	2692.2	.000	.000	.000 - .000	.00	.0000	.0000	19.75	.00
Polychaeta	6	416.7	27.8	208.3 - 208.3	73.3	.000	.000	.000 - .000	.00	.0000	.0000	.12	.00
Spionidae	6	12343.8	822.9	416.7 - 5833.3	1749.3	.000	.000	.000 - .000	.00	.0000	.0000	3.43	.00
Podocopida	C	4149.3	276.6	104.2 - 781.2	278.9	.000	.000	.000 - .000	.00	.0000	.0000	1.15	.00
Harpacticoida	A2F	105382.0	7025.5	2083.3 - 12152.8	2688.7	.000	.000	.000 - .000	.00	.0000	.0000	29.29	.00
Coullana canadensis	A	3706.6	247.1	34.7 - 1333.3	343.8	.000	.000	.000 - .000	.00	.0000	.0000	1.03	.00

BENTHIC PLANKTON ANALYSIS
****

SITE TABLE, PAGE 2

IDENTIFICATION 95MY15
STATION 10074 - TURNING BASIN REFERENCE
FROM SAMPLES M 1 M 2 M 3 M 4 M 5 M 6 M 7 M 8 M 9 M10 M11 M12 M13 M14 M15

ORGANISM NAME	PARTS CODE	LH-STAGE	NUMBERS/M**2 TOTAL	NUMBERS/M**2 MEAN	NUMBERS/M**2 RANGE	NUMBERS/M**2 S.D.	WET WEIGHT,GRAMS/M**2 TOTAL	WET WEIGHT,GRAMS/M**2 MEAN	WET WEIGHT,GRAMS/M**2 RANGE	WET WEIGHT,GRAMS/M**2 S.D.	AVG. BIOMASS MEAN	AVG. BIOMASS S.D.	PERCENTAGES ABUN-DANCE	PERCENTAGES BIO-MASS
Pseudobradya sp.		A	18593.8	1239.6	104.2 - 2343.8	708.7	.000	.000	.000 - .000	.00	.0000	.0000	5.17	.00
Microarthridion littorale		A	10555.6	703.7	208.3 - 1666.7	462.4	.000	.000	.000 - .000	.00	.0000	.0000	2.93	.00
Tachidius discipes		A	312.5	20.8	104.2 - 208.3	58.4	.000	.000	.000 - .000	.00	.0000	.0000	.09	.00
Huntemannia jadensis		A	1217.0	81.1	26.0 - 479.2	143.3	.000	.000	.000 - .000	.00	.0000	.0000	.34	.00
Leimia vaga		A	127390.6	8492.7	2531.3 - 17354.2	4431.3	.000	.000	.000 - .000	.00	.0000	.0000	35.41	.00
Schizopera knabeni		A	885.4	59.0	208.3 - 260.4	102.0	.000	.000	.000 - .000	.00	.0000	.0000	.25	.00
Mesochra sp.		A	312.5	20.8	104.2 - 208.3	58.4	.000	.000	.000 - .000	.00	.0000	.0000	.09	.00
Cumella vulgaris		7	208.3	13.9	208.3 - 208.3	53.8	.000	.000	.000 - .000	.00	.0000	.0000	.06	.00
Diptera-chironomidae		6	416.7	27.8	416.7 - 416.7	107.6	.000	.000	.000 - .000	.00	.0000	.0000	.12	.00

TOTAL NUMBER OF PLANKTON CATEGORIES 19

SHANNON-WEINER DIVERSITY INDEX NUMBERS 2.35
BIOMASS .00
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS 2.35

BENTHIC PLANKTON ANALYSIS
****

SITE TABLE, PAGE 1

****
* SITE SUMMARY *
****

IDENTIFICATION 95MY15
STATION 10070 - KELLOGG ISLAND
FROM SAMPLES M 1 M 2 M 3 M 4 M 5 M 6 M 7 M 8 M 9 M10 M11 M12 M13 M14 M15

SPECIES DEFINITION -
TRUNCATED = NO
LH-STAGE = EGGORNOT
PARTS CODE EXCLUDED

ABUNDANCES AND WEIGHTS ARE ADJUSTED TO AN AREA OF 1.0 SQUARE METERS

	MEAN	RANGE	S.D.	COEF.VAR
SAMPLE AREA (M**2)	.240	.240- .240	.000	.000
TOTAL WET WEIGHT (PER M**2)	.000	.000- .000	.000	.000
TOTAL ABUNDANCE (PER M**2)	27427.54	12645.83- 39583.33	6078.84	.22
SAMPLE WET WEIGHT (PER M**2)	.000	.000- .000	.000	.000
SAMPLE DRY WEIGHT (PER M**2)	.000	.000- .000	.000	.000

ORGANISM NAME / PARTS CODE	LH-STAGE	NUMBERS/M**2 TOTAL	MEAN	RANGE	S.D.	WET WEIGHT,GRAMS/M**2 TOTAL	MEAN	RANGE	S.D.	AVG. BIOMASS MEAN	S.D.	PERCENTAGES ABUN-DANCE	BIO-MASS
Rhizopodea-foraminiferida	C	20243.1	1349.5	520.8 - 3958.3	858.9	.000	.000	.000 - .000	.00	.0000	.0000	4.92	.00
Hydrozoa	C	2812.5	187.5	173.6 - 625.0	234.0	.000	.000	.000 - .000	.00	.0000	.0000	.68	.00
Turbellaria	C	27916.7	1861.1	277.8 - 4583.3	1228.9	.000	.000	.000 - .000	.00	.0000	.0000	6.79	.00
Nematoda	C	79861.1	5324.1	2777.8 - 10833.3	2711.5	.000	.000	.000 - .000	.00	.0000	.0000	19.41	.00
Polychaeta	6	3784.7	252.3	173.6 - 1041.7	286.5	.000	.000	.000 - .000	.00	.0000	.0000	.92	.00
Spionidae	7	763.9	50.9	138.9 - 625.0	162.8	.000	.000	.000 - .000	.00	.0000	.0000	.19	.00
Capitella sp.	7	625.0	41.7	208.3 - 416.7	116.8	.000	.000	.000 - .000	.00	.0000	.0000	.15	.00
Manayunkia aestuarina	7	8125.0	541.7	208.3 - 1458.3	420.9	.000	.000	.000 - .000	.00	.0000	.0000	1.97	.00
Oligochaeta	C	590.3	39.4	173.6 - 208.3	81.8	.000	.000	.000 - .000	.00	.0000	.0000	.14	.00
Halacaridae	C	208.3	13.9	208.3 - 208.3	53.8	.000	.000	.000 - .000	.00	.0000	.0000	.05	.00

BENTHIC PLANKTON ANALYSIS
****

SITE TABLE, PAGE 2

IDENTIFICATION 95MY15
STATION 10070 - KELLOGG ISLAND
FROM SAMPLES M 1 M 2 M 3 M 4 M 5 M 6 M 7 M 8 M 9 M10 M11 M12 M13 M14 M15

ORGANISM NAME / PARTS CODE	LH-STAGE	NUMBERS/M**2 TOTAL	NUMBERS/M**2 MEAN	NUMBERS/M**2 RANGE	NUMBERS/M**2 S.D.	WET WEIGHT,GRAMS/M**2 TOTAL	WET WEIGHT MEAN	WET WEIGHT RANGE	WET WEIGHT S.D.	AVG. BIOMASS MEAN	AVG. BIOMASS S.D.	PERCENTAGES ABUN-DANCE	PERCENTAGES BIO-MASS
Podocopida	C	6145.8	409.7	138.9 - 1250.0	382.2	.000	.000	.000 - .000	.00	.0000	.0000	1.49	.00
Harpacticoida	2F	150729.2	10048.6	3958.3 - 14166.7	3027.5	.000	.000	.000 - .000	.00	.0000	.0000	36.64	.00
Ectinosomatidae	A	8006.9	533.8	208.3 - 1583.3	473.1	.000	.000	.000 - .000	.00	.0000	.0000	1.95	.00
Harpacticus uniremis	8	62.5	4.2	62.5 - 62.5	16.1	.000	.000	.000 - .000	.00	.0000	.0000	.02	.00
Harpacticus arcticus	8A	104.2	6.9	20.8 - 41.7	15.1	.000	.000	.000 - .000	.00	.0000	.0000	.03	.00
Harpacticus sp.-uniremis group	F	312.5	20.8	20.8 - 208.3	54.0	.000	.000	.000 - .000	.00	.0000	.0000	.08	.00
Tisbe sp.	A	645.8	43.1	41.7 - 333.3	97.2	.000	.000	.000 - .000	.00	.0000	.0000	.16	.00
Microarthridion littorale	A	2083.3	138.9	41.7 - 520.8	164.4	.000	.000	.000 - .000	.00	.0000	.0000	.51	.00
Tachidius triangularis	A	1006.9	67.1	173.6 - 416.7	126.2	.000	.000	.000 - .000	.00	.0000	.0000	.24	.00
Tachidius discipes	A	208.3	13.9	208.3 - 208.3	53.8	.000	.000	.000 - .000	.00	.0000	.0000	.05	.00
Laophontidae	F	2986.1	199.1	208.3 - 625.0	230.1	.000	.000	.000 - .000	.00	.0000	.0000	.73	.00
Heterolaophonte discophora	A	8430.6	562.0	125.0 - 1687.5	458.0	.000	.000	.000 - .000	.00	.0000	.0000	2.05	.00
Ameiridae	A	416.7	27.8	208.3 - 208.3	73.3	.000	.000	.000 - .000	.00	.0000	.0000	.10	.00
Huntemannia jadensis	A	1368.1	91.2	20.8 - 416.7	133.0	.000	.000	.000 - .000	.00	.0000	.0000	.33	.00
Leimia vaga	A8F	66274.3	4418.3	708.3 - 7187.5	1942.9	.000	.000	.000 - .000	.00	.0000	.0000	16.11	.00
Schizopera sp.	A	1250.0	83.3	208.3 - 625.0	172.5	.000	.000	.000 - .000	.00	.0000	.0000	.30	.00
Schizopera knabeni	A	5652.8	376.9	27.8 - 1520.8	397.2	.000	.000	.000 - .000	.00	.0000	.0000	1.37	.00
Stenhelia sp.	A	7618.1	507.9	41.7 - 2125.0	624.1	.000	.000	.000 - .000	.00	.0000	.0000	1.85	.00
Mesochra sp.	A	1513.9	100.9	41.7 - 458.3	172.3	.000	.000	.000 - .000	.00	.0000	.0000	.37	.00
Parastenhelia hornelli	8	208.3	13.9	208.3 - 208.3	53.8	.000	.000	.000 - .000	.00	.0000	.0000	.05	.00
Halicyclops sp.	A	208.3	13.9	208.3 - 208.3	53.8	.000	.000	.000 - .000	.00	.0000	.0000	.05	.00
Cumella vulgaris	A	1250.0	83.3	208.3 - 416.7	131.8	.000	.000	.000 - .000	.00	.0000	.0000	.30	.00

BENTHIC PLANKTON ANALYSIS

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IDENTIFICATION 95MY15
STATION 10070 - KELLOGG ISLAND
FROM SAMPLES M 1 M 2 M 3 M 4 M 5 M 6 M 7 M 8 M 9 M10 M11 M12 M13 M14 M15

TOTAL NUMBER OF PLANKTON CATEGORIES 32

SHANNON-WEINER DIVERSITY INDEX	NUMBERS	2.95
	BIOMASS	.00
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS		2.95

BENTHIC PLANKTON ANALYSIS
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****
* SITE SUMMARY *
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IDENTIFICATION 95MY15
STATION 10064 - GSA INTERTIDAL BENCH
FROM SAMPLES M 1 M 2 M 3 M 4 M 5 M 6 M 7 M 8 M 9 M10 M11 M12 M13 M14 M15

SPECIES DEFINITION -
TRUNCATED = NO
LH-STAGE = EGGORNOT
PARTS CODE EXCLUDED

ABUNDANCES AND WEIGHTS ARE ADJUSTED TO AN AREA OF 1.0 SQUARE METERS

	MEAN	RANGE	S.D.	COEF.VAR
SAMPLE AREA (M**2)	.240	.240-.240	.000	.000
TOTAL WET WEIGHT (PER M**2)	.000	.000-.000	.000	.000
TOTAL ABUNDANCE (PER M**2)	9648.61	2350.00-15937.50	4087.71	.42
SAMPLE WET WEIGHT (PER M**2)	.000	.000-.000	.000	.000
SAMPLE DRY WEIGHT (PER M**2)	.000	.000-.000	.000	.000

ORGANISM NAME		NUMBERS/M**2				WET WEIGHT,GRAMS/M**2				AVG. BIOMASS		PERCENTAGES	
PARTS CODE	LH-STAGE	TOTAL	MEAN	RANGE	S.D.	TOTAL	MEAN	RANGE	S.D.	MEAN	S.D.	ABUN-DANCE	BIO-MASS
Rhizopodea-foraminiferida	C	1875.0	125.0	41.7 - 729.2	195.1	.000	.000	.000 - .000	.00	.0000	.0000	1.30	.00
Hydrozoa	C	604.2	40.3	83.3 - 208.3	75.7	.000	.000	.000 - .000	.00	.0000	.0000	.42	.00
Turbellaria	C	19500.0	1300.0	541.7 - 2291.7	706.3	.000	.000	.000 - .000	.00	.0000	.0000	13.47	.00
Nematoda	C	29260.4	1950.7	208.3 - 3916.7	1133.4	.000	.000	.000 - .000	.00	.0000	.0000	20.22	.00
Polychaeta	6	4062.5	270.8	104.2 - 3958.3	1020.5	.000	.000	.000 - .000	.00	.0000	.0000	2.81	.00
Spionidae	7	145.8	9.7	41.7 - 104.2	28.2	.000	.000	.000 - .000	.00	.0000	.0000	.10	.00
Archianellida	A	83.3	5.6	83.3 - 83.3	21.5	.000	.000	.000 - .000	.00	.0000	.0000	.06	.00
Oligochaeta	C	916.7	61.1	41.7 - 312.5	88.9	.000	.000	.000 - .000	.00	.0000	.0000	.63	.00
Halacaridae	C	3385.4	225.7	41.7 - 916.7	268.6	.000	.000	.000 - .000	.00	.0000	.0000	2.34	.00
Podocopida	C	5020.8	334.7	83.3 - 1562.5	449.1	.000	.000	.000 - .000	.00	.0000	.0000	3.47	.00

BENTHIC PLANKTON ANALYSIS
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IDENTIFICATION 95MY15
STATION 10064 - GSA INTERTIDAL BENCH
FROM SAMPLES M 1 M 2 M 3 M 4 M 5 M 6 M 7 M 8 M 9 M10 M11 M12 M13 M14 M15

ORGANISM NAME		NUMBERS/M**2				WET WEIGHT,GRAMS/M**2				AVG. BIOMASS		PERCENTAGES	
PARTS CODE	LH-STAGE	TOTAL	MEAN	RANGE	S.D.	TOTAL	MEAN	RANGE	S.D.	MEAN	S.D.	ABUN-DANCE	BIO-MASS
Harpacticoida	2F	28927.1	1928.5	208.3 - 5000.0	1488.4	.000	.000	.000 - .000	.00	.0000	.0000	19.99	.00
Ectinosomatidae	A	3291.7	219.4	41.7 - 520.8	195.4	.000	.000	.000 - .000	.00	.0000	.0000	2.27	.00
Pseudobradya sp.	A	104.2	6.9	104.2 - 104.2	26.9	.000	.000	.000 - .000	.00	.0000	.0000	.07	.00
Harpacticus sp. a-uniremis gro	FA8	1318.8	87.9	31.3 - 208.3	74.5	.000	.000	.000 - .000	.00	.0000	.0000	.91	.00
Harpacticus sp.-uniremis group	FA	3201.0	213.4	4.2 - 493.8	164.8	.000	.000	.000 - .000	.00	.0000	.0000	2.21	.00
Tisbe sp.	A	458.3	30.6	41.7 - 416.7	107.4	.000	.000	.000 - .000	.00	.0000	.0000	.32	.00
Tachidius triangularis	A	104.2	6.9	104.2 - 104.2	26.9	.000	.000	.000 - .000	.00	.0000	.0000	.07	.00
Laophontidae	FA	2747.9	183.2	83.3 - 633.3	193.6	.000	.000	.000 - .000	.00	.0000	.0000	1.90	.00
Laophonte sp.	A	270.8	18.1	83.3 - 104.2	37.7	.000	.000	.000 - .000	.00	.0000	.0000	.19	.00
Heterolaophonte discophora	AF	2289.6	152.6	4.2 - 1041.7	270.7	.000	.000	.000 - .000	.00	.0000	.0000	1.58	.00
Heterolaophonte longisetigera	A	33.3	2.2	33.3 - 33.3	8.6	.000	.000	.000 - .000	.00	.0000	.0000	.02	.00
Heterolaophonte hamondi	AF	1137.5	75.8	20.8 - 208.3	73.0	.000	.000	.000 - .000	.00	.0000	.0000	.79	.00
Cyllindropsyllidae	A	854.2	56.9	104.2 - 250.0	87.8	.000	.000	.000 - .000	.00	.0000	.0000	.59	.00
Ameiridae	A	104.2	6.9	104.2 - 104.2	26.9	.000	.000	.000 - .000	.00	.0000	.0000	.07	.00
Nitocra sp.	A	3052.1	203.5	52.1 - 750.0	226.0	.000	.000	.000 - .000	.00	.0000	.0000	2.11	.00
Huntemannia jadensis	A	2154.2	143.6	8.3 - 416.7	130.6	.000	.000	.000 - .000	.00	.0000	.0000	1.49	.00
Leimia vaga	A	250.0	16.7	41.7 - 104.2	37.1	.000	.000	.000 - .000	.00	.0000	.0000	.17	.00
Schizopera sp.	A	26787.5	1785.8	83.3 - 3500.0	1067.2	.000	.000	.000 - .000	.00	.0000	.0000	18.51	.00
Schizopera knabeni	A	208.3	13.9	104.2 - 104.2	36.7	.000	.000	.000 - .000	.00	.0000	.0000	.14	.00
Mesochra sp.	A	479.2	31.9	83.3 - 208.3	61.4	.000	.000	.000 - .000	.00	.0000	.0000	.33	.00
Thalestridae	F	416.7	27.8	416.7 - 416.7	107.6	.000	.000	.000 - .000	.00	.0000	.0000	.29	.00
Dactylopodia crassipes	8	288.5	19.2	10.4 - 104.2	32.3	.000	.000	.000 - .000	.00	.0000	.0000	.20	.00
Diarthrodes sp.	A	125.0	8.3	41.7 - 83.3	23.4	.000	.000	.000 - .000	.00	.0000	.0000	.09	.00

BENTHIC PLANKTON ANALYSIS ***************************** SITE TABLE, PAGE 3

IDENTIFICATION 95MY15
STATION 10064 - GSA INTERTIDAL BENCH
FROM SAMPLES M 1 M 2 M 3 M 4 M 5 M 6 M 7 M 8 M 9 M10 M11 M12 M13 M14 M15

ORGANISM NAME / PARTS CODE	LH-STAGE	NUMBERS/M**2 TOTAL	MEAN	RANGE	S.D.	WET WEIGHT,GRAMS/M**2 TOTAL	MEAN	RANGE	S.D.	AVG. BIOMASS MEAN	S.D.	PERCENTAGES ABUN-DANCE	BIO-MASS
Parastenhelia spinosa		104.2	6.9	104.2 -	26.9	.000	.000	.000 -	.00	.0000	.0000	.07	.00
8				104.2				.000					
Cyclopoida		104.2	6.9	104.2 -	26.9	.000	.000	.000 -	.00	.0000	.0000	.07	.00
F				104.2				.000					
Halicyclops sp.		41.7	2.8	41.7 -	10.8	.000	.000	.000 -	.00	.0000	.0000	.03	.00
A				41.7				.000					
Cumella vulgaris		312.5	20.8	104.2 -	58.4	.000	.000	.000 -	.00	.0000	.0000	.22	.00
7				208.3				.000					
Corophium sp.		208.3	13.9	208.3 -	53.8	.000	.000	.000 -	.00	.0000	.0000	.14	.00
7				208.3				.000					
Anisogammarus sp.		41.7	2.8	41.7 -	10.8	.000	.000	.000 -	.00	.0000	.0000	.03	.00
7				41.7				.000					
Collembola		291.7	19.4	41.7 -	64.7	.000	.000	.000 -	.00	.0000	.0000	.20	.00
C				250.0				.000					
Diptera-chironomidae		166.7	11.1	166.7 -	43.0	.000	.000	.000 -	.00	.0000	.0000	.12	.00
6				166.7				.000					

TOTAL NUMBER OF PLANKTON CATEGORIES 41

SHANNON-WEINER DIVERSITY INDEX NUMBERS 3.46
BIOMASS .00
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS 3.46

BENTHIC PLANKTON ANALYSIS

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SITE TABLE, PAGE 1

****
* SITE SUMMARY *
****

IDENTIFICATION 95MY15
STATION 10068 - TERMINAL 105
FROM SAMPLES M 1 M 2 M 3 M 4 M 5 M 6 M 7 M 8 M 9 M10 M11 M12 M13 M14 M15

SPECIES DEFINITION -
TRUNCATED = NO
LH-STAGE = EGGORNOT
PARTS CODE EXCLUDED

ABUNDANCES AND WEIGHTS ARE ADJUSTED TO AN AREA OF 1.0 SQUARE METERS

	MEAN	RANGE	S.D.	COEF.VAR
SAMPLE AREA (M**2)	.240	.240- .240	.000	.000
TOTAL WET WEIGHT (PER M**2)	.000	.000- .000	.000	.000
TOTAL ABUNDANCE (PER M**2)	4425.97	1120.83- 11450.00	2753.65	.62
SAMPLE WET WEIGHT (PER M**2)	.000	.000- .000	.000	.000
SAMPLE DRY WEIGHT (PER M**2)	.000	.000- .000	.000	.000

ORGANISM NAME / PARTS CODE	LH-STAGE	NUMBERS/M**2 TOTAL	MEAN	RANGE	S.D.	WET WEIGHT,GRAMS/M**2 TOTAL	MEAN	RANGE	S.D.	AVG. BIOMASS MEAN	S.D.	PERCENTAGES ABUN-DANCE	BIO-MASS
Rhizopodea-foraminiferida	C	2187.5	145.8	41.7 - 1250.0	314.1	.000	.000	.000 - .000	.00	.0000	.0000	3.29	.00
Hydrozoa	C	125.0	8.3	41.7 - 83.3	23.4	.000	.000	.000 - .000	.00	.0000	.0000	.19	.00
Turbellaria	C	13466.7	897.8	50.0 - 2291.7	547.3	.000	.000	.000 - .000	.00	.0000	.0000	20.28	.00
Nematoda	C	31058.3	2070.6	458.3 - 6333.3	1802.8	.000	.000	.000 - .000	.00	.0000	.0000	46.78	.00
Polychaeta	A	83.3	5.6	83.3 - 83.3	21.5	.000	.000	.000 - .000	.00	.0000	.0000	.13	.00
Spionidae	76	208.3	13.9	41.7 - 83.3	25.7	.000	.000	.000 - .000	.00	.0000	.0000	.31	.00
Capitella sp.	7	83.3	5.6	41.7 - 41.7	14.7	.000	.000	.000 - .000	.00	.0000	.0000	.13	.00
Manayunkia aestuarina	7	125.0	8.3	41.7 - 83.3	23.4	.000	.000	.000 - .000	.00	.0000	.0000	.19	.00
Archianellida	A	83.3	5.6	83.3 - 83.3	21.5	.000	.000	.000 - .000	.00	.0000	.0000	.13	.00
Archianellida	C	41.7	2.8	41.7 - 41.7	10.8	.000	.000	.000 - .000	.00	.0000	.0000	.06	.00

BENTHIC PLANKTON ANALYSIS SITE TABLE, PAGE 2
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IDENTIFICATION 95MY15
STATION 10068 - TERMINAL 105
FROM SAMPLES M 1 M 2 M 3 M 4 M 5 M 6 M 7 M 8 M 9 M10 M11 M12 M13 M14 M15

ORGANISM NAME / PARTS CODE	LH-STAGE	NUMBERS/M**2 TOTAL	MEAN	RANGE	S.D.	WET WEIGHT,GRAMS/M**2 TOTAL	MEAN	RANGE	S.D.	AVG. BIOMASS MEAN	S.D.	PERCENTAGES ABUN-DANCE	BIO-MASS
Oligochaeta	C	5658.3	377.2	33.3 - 2666.7	728.5	.000	.000	.000 - .000	.00	.0000	.0000	8.52	.00
Halacaridae	C	83.3	5.6	41.7 - 41.7	14.7	.000	.000	.000 - .000	.00	.0000	.0000	.13	.00
Podocopida	C	125.0	8.3	41.7 - 83.3	23.4	.000	.000	.000 - .000	.00	.0000	.0000	.19	.00
Eurytemora sp.	F	41.7	2.8	41.7 - 41.7	10.8	.000	.000	.000 - .000	.00	.0000	.0000	.06	.00
Harpacticoida	2F	4456.2	297.1	41.7 - 1083.3	277.4	.000	.000	.000 - .000	.00	.0000	.0000	6.71	.00
Ectinosomatidae	A	333.3	22.2	41.7 - 83.3	31.0	.000	.000	.000 - .000	.00	.0000	.0000	.50	.00
Harpacticus sp. a-uniremis gro	8	400.0	26.7	4.2 - 300.0	77.6	.000	.000	.000 - .000	.00	.0000	.0000	.60	.00
Harpacticus sp.-uniremis group	F	112.5	7.5	4.2 - 100.0	25.7	.000	.000	.000 - .000	.00	.0000	.0000	.17	.00
Tisbe sp.	A	41.7	2.8	41.7 - 41.7	10.8	.000	.000	.000 - .000	.00	.0000	.0000	.06	.00
Microarthridion littorale	A	177.1	11.8	41.7 - 83.3	25.8	.000	.000	.000 - .000	.00	.0000	.0000	.27	.00
Tachidius triangularis	A	41.7	2.8	41.7 - 41.7	10.8	.000	.000	.000 - .000	.00	.0000	.0000	.06	.00
Tachidius discipes	A	183.3	12.2	16.7 - 166.7	42.9	.000	.000	.000 - .000	.00	.0000	.0000	.28	.00
Laophontidae	FA	133.3	8.9	41.7 - 91.7	25.3	.000	.000	.000 - .000	.00	.0000	.0000	.20	.00
Laophonte sp.	A	1677.1	111.8	41.7 - 666.7	182.0	.000	.000	.000 - .000	.00	.0000	.0000	2.53	.00
Heterolaophonte discophora	A	70.8	4.7	4.2 - 66.7	17.2	.000	.000	.000 - .000	.00	.0000	.0000	.11	.00
Cyllindropsyllidae	A	141.7	9.4	16.7 - 83.3	23.3	.000	.000	.000 - .000	.00	.0000	.0000	.21	.00
Ameiridae	A	250.0	16.7	83.3 - 166.7	46.7	.000	.000	.000 - .000	.00	.0000	.0000	.38	.00
Nitocra sp.	A	62.5	4.2	20.8 - 41.7	11.7	.000	.000	.000 - .000	.00	.0000	.0000	.09	.00
Apodopsyllus sp.	A	1208.3	80.6	416.7 - 791.7	224.1	.000	.000	.000 - .000	.00	.0000	.0000	1.82	.00
Huntemannia jadensis	A	1768.8	117.9	4.2 - 541.7	171.9	.000	.000	.000 - .000	.00	.0000	.0000	2.66	.00
Leimia vaga	A	95.8	6.4	4.2 - 41.7	14.4	.000	.000	.000 - .000	.00	.0000	.0000	.14	.00
Diosaccidae	A	41.7	2.8	41.7 - 41.7	10.8	.000	.000	.000 - .000	.00	.0000	.0000	.06	.00
Schizopera sp.	A	1108.3	73.9	41.7 - 525.0	157.3	.000	.000	.000 - .000	.00	.0000	.0000	1.67	.00

BENTHIC PLANKTON ANALYSIS
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SITE TABLE, PAGE 3

IDENTIFICATION 95MY15
STATION 10068 - TERMINAL 105
FROM SAMPLES M 1 M 2 M 3 M 4 M 5 M 6 M 7 M 8 M 9 M10 M11 M12 M13 M14 M15

ORGANISM NAME / PARTS CODE	LH-STAGE	NUMBERS/M**2 TOTAL	MEAN	RANGE	S.D.	WET WEIGHT,GRAMS/M**2 TOTAL	MEAN	RANGE	S.D.	AVG. BIOMASS MEAN	S.D.	PERCENTAGES ABUN-DANCE	BIO-MASS
Schizopera knabeni	A	37.5	2.5	16.7 - 20.8	6.6	.000	.000	.000 - .000	.00	.0000	.0000	.06	.00
Stenhelia sp.	F	41.7	2.8	41.7 - 41.7	10.8	.000	.000	.000 - .000	.00	.0000	.0000	.06	.00
Thalestridae	F	41.7	2.8	41.7 - 41.7	10.8	.000	.000	.000 - .000	.00	.0000	.0000	.06	.00
Dactylopodia crassipes	A8	108.3	7.2	4.2 - 66.7	17.4	.000	.000	.000 - .000	.00	.0000	.0000	.16	.00
Cyclopoida	F	41.7	2.8	41.7 - 41.7	10.8	.000	.000	.000 - .000	.00	.0000	.0000	.06	.00
Oncaea sp.	A	16.7	1.1	16.7 - 16.7	4.3	.000	.000	.000 - .000	.00	.0000	.0000	.03	.00
Cumella vulgaris	A	52.1	3.5	52.1 - 52.1	13.4	.000	.000	.000 - .000	.00	.0000	.0000	.08	.00
Corophium sp.	7	375.0	25.0	41.7 - 333.3	86.0	.000	.000	.000 - .000	.00	.0000	.0000	.56	.00

TOTAL NUMBER OF PLANKTON CATEGORIES 41

SHANNON-WEINER DIVERSITY INDEX NUMBERS 2.68
BIOMASS .00
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS 2.68

BENTHIC PLANKTON ANALYSIS
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SITE TABLE, PAGE 1

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* SITE SUMMARY *
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IDENTIFICATION 95MY15
STATION 10060 - DUWAMISH LOWER BENCH
FROM SAMPLES M 1 M 2 M 3 M 4 M 5 M 4 M 5 M 6 M 7 M 8 M 9 M10 M11 M12 M13 M14 M15

SPECIES DEFINITION -
TRUNCATED = NO
LH-STAGE = EGGORNOT
PARTS CODE EXCLUDED

ABUNDANCES AND WEIGHTS ARE ADJUSTED TO AN AREA OF 1.0 SQUARE METERS

	MEAN	RANGE	S.D.	COEF.VAR
SAMPLE AREA (M**2)	.240	.240- .240	.000	.000
TOTAL WET WEIGHT (PER M**2)	.000	.000- .000	.000	.000
TOTAL ABUNDANCE (PER M**2)	14598.77	312.50- 30552.08	6888.34	.47
SAMPLE WET WEIGHT (PER M**2)	.000	.000- .000	.000	.000
SAMPLE DRY WEIGHT (PER M**2)	.000	.000- .000	.000	.000

ORGANISM NAME / PARTS CODE	LH-STAGE	NUMBERS/M**2 TOTAL	MEAN	RANGE	S.D.	WET WEIGHT,GRAMS/M**2 TOTAL	MEAN	RANGE	S.D.	AVG. BIOMASS MEAN	S.D.	PERCENTAGES ABUN-DANCE	BIO-MASS
Rhizopodea-foraminiferida	C	625.0	36.8	104.2 - 208.3	73.1	.000	.000	.000 - .000	.00	.0000	.0000	.25	.00
Hydrozoa	C	3854.2	226.7	104.2 - 625.0	188.6	.000	.000	.000 - .000	.00	.0000	.0000	1.55	.00
Turbellaria	C	45500.0	2676.5	1250.0 - 5208.3	1484.4	.000	.000	.000 - .000	.00	.0000	.0000	18.33	.00
Rotifera	C	104.2	6.1	104.2 - 104.2	25.3	.000	.000	.000 - .000	.00	.0000	.0000	.04	.00
Nematoda	C	74791.7	4399.5	2708.3 - 8958.3	2330.6	.000	.000	.000 - .000	.00	.0000	.0000	30.14	.00
Polychaeta	7	104.2	6.1	104.2 - 104.2	25.3	.000	.000	.000 - .000	.00	.0000	.0000	.04	.00
Spionidae	76	1125.0	66.2	83.3 - 729.2	176.2	.000	.000	.000 - .000	.00	.0000	.0000	.45	.00
Capitella sp.	7	312.5	18.4	104.2 - 208.3	55.1	.000	.000	.000 - .000	.00	.0000	.0000	.13	.00
Oligochaeta	C	3458.3	203.4	104.2 - 625.0	197.3	.000	.000	.000 - .000	.00	.0000	.0000	1.39	.00
Halacaridae	C	208.3	12.3	104.2 - 104.2	34.6	.000	.000	.000 - .000	.00	.0000	.0000	.08	.00

BENTHIC PLANKTON ANALYSIS ***************************** SITE TABLE, PAGE 2

IDENTIFICATION 95MY15
STATION 10060 - DUWAMISH LOWER BENCH
FROM SAMPLES M 1 M 2 M 3 M 4 M 5 M 4 M 5 M 6 M 7 M 8 M 9 M10 M11 M12 M13 M14 M15

ORGANISM NAME	PARTS CODE	LH-STAGE	NUMBERS/M**2 TOTAL	NUMBERS/M**2 MEAN	NUMBERS/M**2 RANGE	NUMBERS/M**2 S.D.	WET WEIGHT,GRAMS/M**2 TOTAL	WET WEIGHT MEAN	WET WEIGHT RANGE	WET WEIGHT S.D.	AVG. BIOMASS MEAN	AVG. BIOMASS S.D.	PERCENTAGES ABUN-DANCE	PERCENTAGES BIO-MASS
Podocopida		C	2666.7	156.9	104.2 - 833.3	217.9	.000	.000	.000 - .000	.00	.0000	.0000	1.07	.00
Harpacticoida		2F	46958.3	2762.3	729.2 - 7812.5	1992.8	.000	.000	.000 - .000	.00	.0000	.0000	18.92	.00
Coullana canadensis		A	520.8	30.6	520.8 - 520.8	126.3	.000	.000	.000 - .000	.00	.0000	.0000	.21	.00
Ectinosomatidae		A	9458.3	556.4	104.2 - 1145.8	397.9	.000	.000	.000 - .000	.00	.0000	.0000	3.81	.00
Harpacticus arcticus		F	31.3	1.8	31.3 - 31.3	7.6	.000	.000	.000 - .000	.00	.0000	.0000	.01	.00
Harpacticus sp. a-uniremis gro		8	4968.8	292.3	93.8 - 968.8	285.4	.000	.000	.000 - .000	.00	.0000	.0000	2.00	.00
Harpacticus sp.-uniremis group		F	9968.8	586.4	125.0 - 1645.8	474.5	.000	.000	.000 - .000	.00	.0000	.0000	4.02	.00
Tisbe sp.		A	1552.1	91.3	104.2 - 437.5	123.7	.000	.000	.000 - .000	.00	.0000	.0000	.63	.00
Microarthridion littorale		A	1656.3	97.4	31.3 - 312.5	98.3	.000	.000	.000 - .000	.00	.0000	.0000	.67	.00
Tachidius discipes		A	291.7	17.2	83.3 - 104.2	38.4	.000	.000	.000 - .000	.00	.0000	.0000	.12	.00
Laophontidae		AF8	4791.7	281.9	104.2 - 1041.7	273.3	.000	.000	.000 - .000	.00	.0000	.0000	1.93	.00
Laophonte sp.		A	3572.9	210.2	62.5 - 645.8	186.6	.000	.000	.000 - .000	.00	.0000	.0000	1.44	.00
Heterolaophonte discophora		A	10412.5	612.5	229.2 - 1593.8	482.5	.000	.000	.000 - .000	.00	.0000	.0000	4.20	.00
Heterolaophonte longisetigera		A	385.4	22.7	20.8 - 104.2	38.3	.000	.000	.000 - .000	.00	.0000	.0000	.16	.00
Nitocra sp.		A	104.2	6.1	104.2 - 104.2	25.3	.000	.000	.000 - .000	.00	.0000	.0000	.04	.00
Huntemannia jadensis		A	3381.3	198.9	20.8 - 770.8	200.5	.000	.000	.000 - .000	.00	.0000	.0000	1.36	.00
Leimia vaga		A	8229.2	484.1	83.3 - 1385.4	434.9	.000	.000	.000 - .000	.00	.0000	.0000	3.32	.00
Schizopera knabeni		A	1645.8	96.8	104.2 - 312.5	111.4	.000	.000	.000 - .000	.00	.0000	.0000	.66	.00
Mesochra sp.		A	4750.0	279.4	104.2 - 729.2	236.2	.000	.000	.000 - .000	.00	.0000	.0000	1.91	.00
Diarthrodes sp.		A	520.8	30.6	104.2 - 208.3	61.2	.000	.000	.000 - .000	.00	.0000	.0000	.21	.00
Halicyclops sp.		A	625.0	36.8	104.2 - 312.5	81.9	.000	.000	.000 - .000	.00	.0000	.0000	.25	.00
Balanomorpha		2	291.7	17.2	83.3 - 208.3	53.2	.000	.000	.000 - .000	.00	.0000	.0000	.12	.00
Cumella vulgaris		A	1208.3	71.1	104.2 - 312.5	85.0	.000	.000	.000 - .000	.00	.0000	.0000	.49	.00

BENTHIC PLANKTON ANALYSIS
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SITE TABLE, PAGE 3

IDENTIFICATION 95MY15
STATION 10060 - DUWAMISH LOWER BENCH
FROM SAMPLES M 1 M 2 M 3 M 4 M 5 M 4 M 5 M 6 M 7 M 8 M 9 M10 M11 M12 M13 M14 M15

ORGANISM NAME PARTS CODE	LH-STAGE	NUMBERS/M**2 TOTAL	MEAN	RANGE	S.D.	WET WEIGHT,GRAMS/M**2 TOTAL	MEAN	RANGE	S.D.	AVG. BIOMASS MEAN	S.D.	PERCENTAGES ABUN-DANCE	BIO-MASS
Corophium sp. 7		104.2	6.1	104.2 - 104.2	25.3	.000	.000	.000 - .000	.00	.0000	.0000	.04	.00

TOTAL NUMBER OF PLANKTON CATEGORIES 34

SHANNON-WEINER DIVERSITY INDEX NUMBERS 3.27
BIOMASS .00
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS 3.27

APPENDIX 3: SUMMARY DATA FROM BENTHIC GRAIN SIZE SAMPLES AT SIX SITES IN THE DUWAMISH WATERWAY, NOVEMBER,

Terminal 105

Phi	Mean %	Std. deviation	Cum. %
2mm	6.99%	8.83%	6.99%
1mm	4.86%	3.33%	11.84%
0.5 mm	17.43%	3.68%	29.27%
0.25 mm	44.34%	7.35%	73.61%
0.125 mm	17.69%	5.05%	91.30%
0.063 mm	3.95%	2.26%	95.25%
total fines	4.75%	2.03%	100.00%

Kellogg Island

Phi	Mean %	Std. deviation	Cum. %
2mm	1.37%	0.92%	1.37%
1mm	2.14%	2.65%	3.51%
0.5 mm	1.82%	0.60%	5.32%
0.25 mm	9.01%	3.07%	14.33%
0.125 mm	12.97%	3.82%	27.30%
0.063 mm	13.02%	4.98%	40.32%
total fines	59.68%	11.82%	100.00%

Duwamish Bench

Phi	Mean %	Std. deviation	Cum. %
2mm	0.91%	0.92%	0.91%
1mm	0.72%	0.15%	1.63%
0.5 mm	4.82%	0.43%	6.45%
0.25 mm	37.29%	0.86%	43.74%
0.125 mm	41.62%	0.70%	85.36%
0.063 mm	8.31%	0.65%	93.67%
total fines	6.33%	0.85%	100.00%

GSA Bench

Phi	Mean %	Std. deviation	Cum. %
2mm	20.18%	2.22%	20.18%
1mm	18.00%	0.60%	38.18%
0.5 mm	23.82%	1.19%	62.00%
0.25 mm	24.99%	2.03%	86.99%
0.125 mm	7.59%	0.76%	94.58%
0.063 mm	1.46%	0.55%	96.04%
total fines	3.96%	1.43%	100.00%

Turning Basin Reference

Phi	Mean %	Std. deviation	Cum. %
2mm	0.07%	0.11%	0.07%
1mm	0.12%	0.06%	0.19%
0.5 mm	0.61%	0.37%	0.80%
0.25 mm	7.22%	1.62%	8.03%
0.125 mm	19.35%	4.29%	27.38%
0.063 mm	26.86%	4.10%	54.24%
total fines	45.76%	8.07%	100.00%

Turning Basin

Phi	Mean %	Std. deviation	Cum. %
2mm	0.05%	0.09%	0.05%
1mm	0.15%	0.14%	0.21%
0.5 mm	1.72%	2.50%	1.93%
0.25 mm	15.52%	11.50%	17.45%
0.125 mm	21.68%	10.77%	39.14%
0.063 mm	13.65%	5.31%	52.78%
total fines	47.22%	14.33%	100.00%