Report on Ocean Dumping
R and D Pacific Region
Department of Fisheries and Oceans
1983-1984

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REPORT ON OCEAN DUMPING R AND D PACIFIC REGION

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Edited by

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RESUME

Woods, S.M. (ed.). 1985. Report on Ocean Dumping R and D Pacific Region. Department of Fisheries and Oceans, 1983-84. Can. Contract. Rep. Hydrogr. Ocean Sci. 20. 53p.

Les recherches menées en 1983-84 sur les déversements en mer ont été passées en revue au cours d'un atelier tenu à l'Institut des sciences océaniques dont le compte rendu est publié sous forme de résumés étoffés. Les études financées par RODAC et présentées à l'atelier comprennent l'utilisation d'habitat artificiel par le saumon, les effets de déchets ligneux sur le recrutement benthique, une évaluation d'une étude de toxicité à bord d'un navire et l'évaluation de deux importantes séries de données sur les sédiments. Dans le cas des habitats insulaires artificiels, on peut planifier des variations mineures de l'altitude et des caracteristiques de conception de façon à orienter le développement de la communauté faunique benthique, à encourager l'utilisation de l'habitat par les saumons juvéniles migrateurs et à fournir des proies pour ces poissons. L'enrichissement graduel de la communauté benthique s'est produit en présence de faibles quantités de fibres ligneuses tandis que des quantités moderées ou élevées ont entraîné le remplacement des espèces sensibles par des taxons opportunistes. Des algues et des protozoaires ont pu être facilement cultivés en laboratoire compact et pourraient donc être des candidats adéquats pour des analyses biologiques. La comparaison des données recueillies dans chaque laboratoire a donné des résultats utiles et devrait aider à axer la recherche et à répondre à certaines questions sur les analyses chimiques au cours des prochaines années. Une comparaison inter-laboratoires des résultats des tests de toxicité des sédiments a été coordonnée d'un succès remarquable sans problèmes majeur: on a observé une excellente suivie des témoins, une concordance satisfaisante du classement des échantillons et un accord sur les valeurs moyennes finales entre quatre des cinq laboratoires. Une évaluation des études menées dans le Puget Sound a révélé qu'une triade sédimentaire composée de données sur la chimie, la toxicité et l'endofaune fournit les meilleures preuves des dommages biologiques causés dans les sédiments par des quantités excessives de produits chimiques. La présentation des propositions et des rapports de RODAC a été étudiée ainsi que les priorités de recherche en 1985-86.

Mots-clés: Déversements en mer, incidence environnementale

ABSTRACT

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Ocean dumping research conducted during 1983-1984 was reviewed at a workshop held at the Institute of Ocean Sciences; the proceedings have been summarized in extended abstract form for publication. RODAC-funded studies presented at the workshop include the use by salmon of artificial habitat, the effects of wood wastes on benthic recruitment, an assessment of a shipboard toxicity study and an evaluation of two large sediment data sets. Small scale differences in both elevation and design features of artificial island habitat can be planned to direct benthic faunal community development, to promote occupation by migrating juvenile salmon, and to provide feeding opportunities for those fish. Gradual enrichment of a benthic community occurred under low levels of wood fibre, while moderate to high concentrations caused replacement of sensitive species by opportunistic taxa. Both algae and protozoa could be easily maintained in a compact laboratory and may be suitable candidates as bioassay organisms. The interlaboratory data set comparison yielded some very useful results and should help define directions and answer questions regarding chemical analyses in the next few years. An interlaboratory comparison of a sediment toxicity test proved to be remarkably successful, with no major problem, with excellent control survival, with satisfactory agreement on ranking of test samples and with four of five laboratories agreeing on end-point mean values. An assessment of studies conducted in Puget Sound indicated that a Sediment Triad, composed of chemistry, toxicity and infauna data, provides the strongest evidence of biologically-damaging excesses of toxic chemicals in sediments. RODAC proposal and report formats were reviewed along with 1985-86 research priorities.

Key words: Ocean dumping, Environmental effects.

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ACKNOWLEDGEMENTS

I would like to express my gratitude to the speakers and other workshop participants who contributed to the successful outcome of the day's proceedings and to the contents of this report. Special acknowledgement is accorded to R. Kussat (EPS, West Vancouver) and M. Waldichuk (DFO, West Vancouver) for chairing the workshop and to our guest speakers - A.J. Mearns and E.R. Long (Ocean Assessments Division - NOAA, Seattle). My appreciation is extended also to L. Giovando (Ocean Information - IOS) for his review of the report manuscript.

1. SUMMARY AND CONCLUSIONS

RODAC-funded research contracts for 1983-84 were reviewed at a workshop held on 7 December 1984 at the Institute of Ocean Sciences, Sidney, B.C. The studies included the use by salmon of artificial habitat, the effects of wood wastes on benthic recruitment, an assessment of a shipboard toxicity study and an evaluation of two large sediment data sets. Guest presentations discussed aspects of sediment toxicity in the Puget Sound area. To assist with preparing submissions to RODAC, information was provided on RODAC proposal and report formats and on Pacific Region ocean dumping research priorities for 1985-86. This report summarizes the material presented at the workshop.

A study of artificial intertidal islands constructed in the Campbell River Estuary was designed to determine the stage of development of animal communities on the islands, to assess the use of the islands by fish and to evaluate the island communities as food sources for juvenile salmon. It was determined that the upper intertidal platforms were in an early stage of faunal succession while the artificial groove and cove communities had converged toward their natural reference areas. The coarse-grained dredged materials provided habitat which was more attractive to wild chinook fry than to hatchery stocks; possibly the wild chinook were afforded refuge from competition. It was concluded that small differences in elevation and small-scale design features can be planned to direct benthic faunal community development, to promote occupation by migrating juvenile salmon, and to provide feeding opportunities for those fish.

Disruption and redeposition of wood wastes, which accumulate on the sea bottom through routine disposal by coastal forestry operations, generally result in a mixture of wood waste and the underlying sediments of the natural substrate. A study was undertaken to determine the potential for macroinvertebrate recruitment of these organically-rich benthic environments, and to estimate the effects on such recolonization processes within substrates containing varying concentrations of wood waste. Pronounced variability was observed among subsamples for each concentration of wood waste tested, but general trends within the community structural data suggested that a gradual "enrichment" effect occurred under low levels of wood fibre (approximately 5-25%). Moderate to high wood waste concentrations appeared responsible for loss of sensitive species from the community, with subsequent replacement by numerically dominant "opportunistic" taxa.

In an assessment of a proposed shipboard method for evaluating the toxicity of dredge-spoils and sediments, three species of micro-organisms were studied to determine whether elutriates of sediment from the east basin of False Creek, Vancouver, had deleterious effects on their growth rate. Preliminary results indicated that the elutriate tended to enhance growth if seawater only was used to prepare it, but tended to decrease growth if it was prepared using seawater with nutrients, trace metals and EDTA. Both the algae and protozoa could be easily maintained in a compact laboratory and hence could be suitable candidates as bioassay organisms.

To provide minimum specifications for quality control of ocean dumping analyses, statistical analyses were applied to two large data sets of metal levels in marine sediments collected from Alice Arm, B.C. Included among the recommendations resulting from the study were:

- Quality control must continue to be an integral part of every analytical programme.
- Two certified reference materials should be used at any one time so that accuracy may be verified at more than one concentration in the same batch of samples.
- There should be more standardization of methods and closer examination of calibration procedures, including graphing and verification of calibration data on a regular basis.
- More caution should be used in the application of parametric statistical tests to chemical analytical data.
- An effort should be made to identify the major sources of bias between laboratories.
- All interlaboratory data-set comparisons should be evaluated.

As a general conclusion, it was felt that the study yielded some very useful results and that it should help to define directions and answer questions that may arise in regard to chemical analysis over the next few years.

A 10-day static sediment toxicity test proposed for monitoring and assessment was subject to a refereed interlaboratory comparison experiment involving five laboratories. By several standards, the experiment was remarkably successful. It was completed with no major problem, with excellent control survival, with satisfactory interlaboratory agreement on ranking of test samples and, in at least four of five laboratories, with agreement on mean values for survival and for reburial and emergence. However, when mean survival was in the range 15.3 to 16.6 amphipods (76.5 to 83.0%) the experiment failed to confirm interlaboratory agreement on distinguishing toxic from non-toxic samples. It was concluded that survival in the range of 15 to 17 amphipods (75 to 85%) is indicative of marginal toxicity that ought to be verified by other methods, whereas beyond these values (i.e., >17 or <15), the test was robust and comparable among laboratories. Furthermore, data soon to be reported suggest that emergence is a much more sensitive indicator of toxicity than survival and appears to be a responsive index within a few days of the onset of the experiment.

In an assessment of studies conducted since 1978 to characterize the occurrence and concentration of toxic chemicals in Puget Sound, it was concluded that a Sediment Quality Triad, composed of chemistry, toxicity and infauna data, provides the strongest evidence of biologically damaging excesses of toxic chemicals in sediments. The bioassay results are needed to interpret the toxicological meaning of the chemistry data. The infauna results are needed (at least, for now) to interpret the bioassay data. Chemistry data alone provide no indication of biological significance. Infauna data alone (or with the chemical measures) provide little assurance that geographic differences are not caused by subtle variations in sediment properties, recruitment, prey/predator interactions, storm events, depth or natural environmental parameters. This Triad is currently being used in Puget Sound to assign priorities to areas for remedial actions.

Information on recommended reporting format for RODAC and on standard proposal submission forms and scheduling for 1985 was presented for general consideration. This presentation was succeeded by a discussion of the following priority topics for 1985-86 Pacific RODAC research projects:

1) State-of-the-art review of marine sediment bio-assays.
2) Effects of ocean dumping on egg deposition of commercially important fish species.
3) Effects of past and present dumping at the Point Grey Dumpsite.
4) Protocol Development - sediment sample preparation prior to chemical analysis.
5) Effects on colonization of "clean-material capping" of contaminated sediments.

Extended abstracts of the RODAC studies contracted in 1983-1984 are contained in this report. Inquiries regarding the information presented and further publications should be directed to the appropriate scientific authorities at their associated institutes. Appendix I lists the abbreviations and addresses of these institutes.

A list of those who attended the workshop is contained in Appendix II. Appendix III outlines contracts for 1983-1984 while studies contracted for 1984-1985 are listed in Appendix IV.

Copies of this Canadian Report of Hydrography and Ocean Sciences are available for distribution from the Institute of Ocean Sciences, Sidney, B.C.

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2. USE BY JUVENILE CHINOOK SALMON OF ARTIFICIAL HABITAT CONSTRUCTED FROM DREDGED MATERIAL IN THE CAMPBELL RIVER ESTUARY

E.P. Anderson

Contractor: Edward Anderson Marine Sciences
Prepared for: C.D. Levings, DFO/WVL

Numerous potentially conflicting commercial, recreational and wildlife users compete for the resources of the relatively small (about 75 ha) Campbell River Estuary. Two of the largest users are the logging industry[1] and juvenile salmon on their downstream migration (wild juvenile chinook salmon as well as chinook and coho from the Quinsam hatchery). In order to improve the efficiency of log handling and to relieve resource-use conflicts, British Columbia Forest Products (BCFP) dredged a new logpond at the southwestern periphery of the estuary. In cooperation with the Department of Fisheries and Oceans, BCFP rehabilitated the old booming ground and constructed four experimental islands (intertidal gravel platforms at 2-3 m above chart datum) with shorelines which included experimental features such as coves (Islands 1, 2) and narrow grooves (Island 3) (Figure 2.1). The islands were built from materials dredged from the new logpond, which would otherwise have been dumped at sea. They were planted with plugs of the sedge _Carex lyngbyei_ or the rush _Juncus_ sp. salvaged from the dredged area. Construction and planting were completed in February 1982.

The purpose of this study was to determine the stage of development of animal communities on the islands, to assess the use of the islands by fish (in particular relative use by wild and hatchery salmon) and to evaluate the island communities as food sources for juvenile salmon.

The Campbell River, which flows northwestward in this terminal reach, enters Discovery Passage at Tyee Spit. There is little penetration of salt water above Baikie Slough. Much of the shoreline of the estuary is modified by human activity. Nunn's Island, selected as a natural reference area, is a high intertidal marsh which includes a cove of soft silt. South Baikie Slough was chosen as the second natural reference area. At its junction with the Campbell River mainstream, there is a relatively deep pool to the south and a bed of eelgrass (_Zostera_ sp.) to the north. The reference station is located at the edge of the eelgrass.

Sampling procedures carried out during the field study in May 1983 included triplicate samples by quadrat excavation(0.06 m^2, 0.5 mm sieve), triplicates by epibenthic sled (0.01 m^2 mouth, 5m tow, 100 μm mesh) and four hauls by beach seine (15 m long, 6.5 mm stretched mesh) at the stations shown in Figures 2.1, 2.2 and 2.3. Core samples for meiofauna were collected and

[1]Until 1981, British Columbia Forest Products Ltd. operated a log booming ground in the area now occupied by Islands 2,3,4 (Figure 2.1).

delivered to the Pacific Biological Station, Nanaimo, for analysis. Fifty-four wild chinook juveniles were taken for stomach contents analysis, to determine which habitats provided their diets. Identifications were pursued to the species level where practicable.

The 50 quadrat samples contained 39 taxa, of which over half were estuarine to marine, and the remainder freshwater, upper intertidal or indeterminate in association. Principal components analysis (PCA) of quadrat samples divided the samples into six groups, each containing all of the samples from an identifiable station type (Figure 2.4). The PCA plot shows a clear separation along component 1 (26% of variance): all natural stations plus the mid to upper level artificial cove and groove stations lie to the right; those from the upper intertidal platforms lie to the left. There was no significant difference between planted and unplanted stations. Component 2 (16% of variance) appears to represent elevation, or elevation plus correlated factors such as salinity or exposure to air. The PCA plot for epibenthic sled samples is somewhat more diffuse, probably because of the inclusion of pelagic items, but it is similar to the quadrat analysis in its major features (Figure 2.5). The sled and quadrat PCA groups are characterized as follows:

Quadrat Group		Elevation (m)	Corresponding Sled Group	
I	high intertidal natural marsh	3.4	I	
II	high intertidal natural cove	3.0		IIa
III	low intertidal natural silty sand, near eelgrass	.7	II	IIc
IV	upper mid-intertidal artificial coves, silty sand	1.8-2.2		IIa
V	lower mid-intertidal artificial grooves, sand	1.4-1.8		IIb
VI	upper intertidal artificial platform, sand to cobbles, planted or not	2.8-3.6	III	

It is clear that the upper intertidal platforms were in an early stage of faunal succession; there was little difference in community structure between planted and unplanted sites, and a very large difference between the artificial islands and the equivalent natural reference area, Nunn's Island Marsh. In contrast, the intertidal artificial groove and cove communities have converged toward their natural reference areas. These results are supported by cluster analyses and analyses of variance.

The difference in rate of approach to the natural community structure is attributable to the difference between an environment controlled by physical factors (the development of fine-grained sediments with detritus at cove and groove stations) and by biological factors (establishment of marsh macrophyte cover at upper intertidal stations).

The distributions of hatchery chinook and coho juveniles were similar (Figure 2.6 and 2.7). Both preferred relatively deep water, especially at backeddy positions adjacent to stronger currents. Wild chinook were not only similarly abundant at this type of station but were also found dispersed among the shallower island stations (Figure 2.8).

The stomachs of 54 wild chinook juveniles contained 86 taxa, the most diverse assemblage in this study. The most abundant items were small crustacea and insects: Cladocera (freshwater, pelagic), harpacticoid copepods (mostly estuarine-marine, epibenthic), adult chironomid insects (indeterminate) and insects in general (indeterminate or freshwater drift). Clearly marine items (pelagic marine copepods, marine gammarid amphipods) were not particularly abundant in our May stomach contents; other literature indicates that these would be more prominent later in the season. Gammarid amphipods and harpacticoid copepods were most abundant in the environment at the lower intertidal groove stations (Quadrat Group V, Sled IIb). Cladocera and insects were most abundant on the artificial island platforms (Quadrat Group VI, Sled III).

PCA of stomach-content samples grouped within hauls showed a core group of similar samples, dominated by Cladocera and Insecta, from stations at which fish would have had access to both the island platforms and to deeper water nearby (Figure 2.9). The remaining pooled samples were all different in ways which can be attributed to habitat and prey availability. These samples were from shallower stations among the islands, and indicated opportunistic feeding on plankton or on concentrations of epibenthos created by local interactions of topography and current.

This study has shown that coarse-grained dredged materials can be used to provide habitat which is more attractive to wild chinook fry than to hatchery stocks. The manipulated habitat may provide the wild chinook with refuge from competition. Small differences in elevation (<1 m) and small-scale design features (coves, grooves, obstructions causing backeddies) can be planned to direct benthic faunal community development, to promote occupation by migrating juvenile salmon, and to provide feeding opportunities for those fish. Although planted sedge and rush sod plugs were apparently established after 15 months, their cover was as yet thin. This did not reduce the value of the artificial island platforms as a food source for juvenile chinook, for the commonest food items were at least as abundant on the constructed habitat as in the natural marsh.

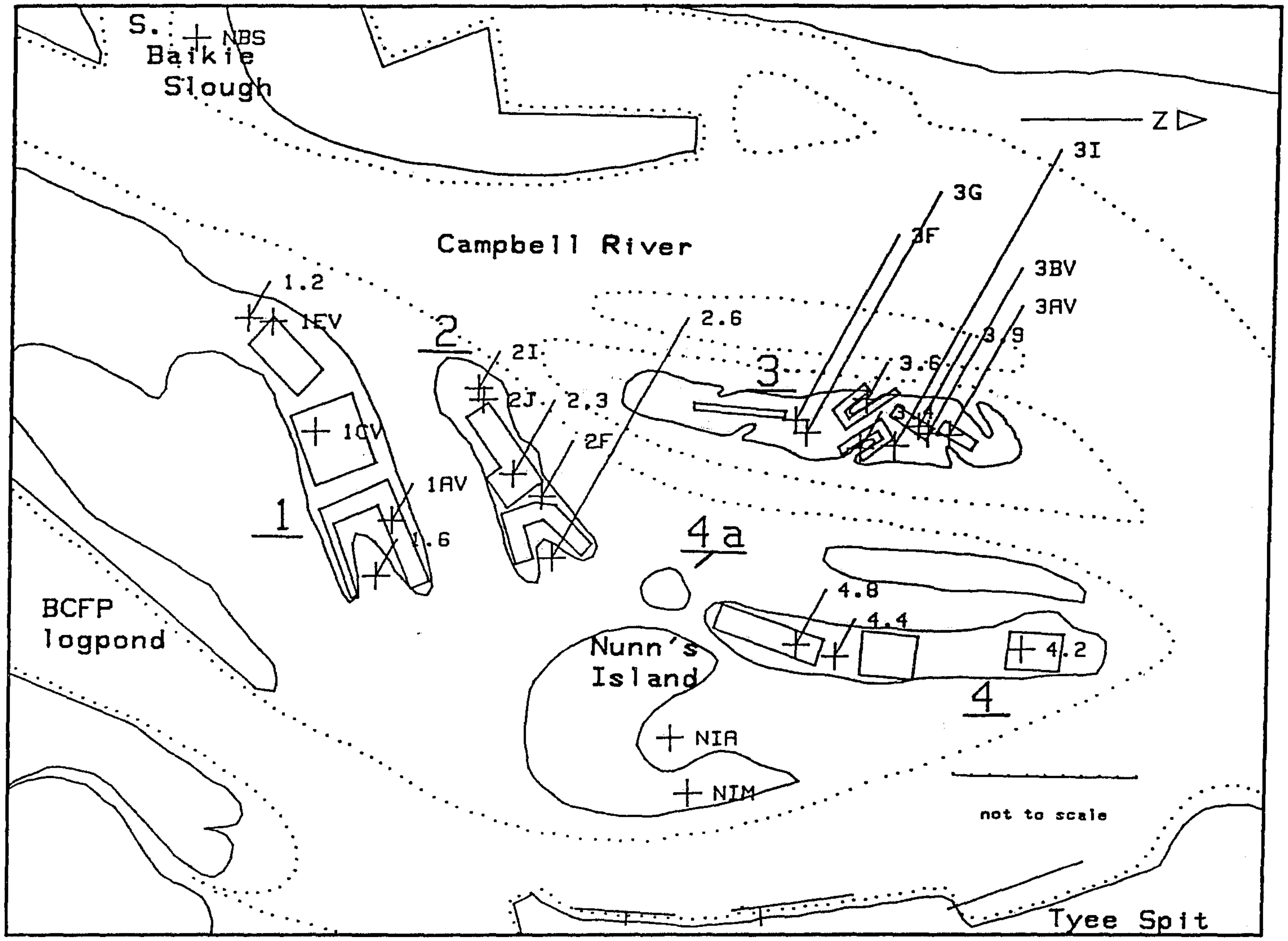


FIGURE 2.1 Locations (+) of quadrat sampling stations in the Campbell River Estuary.

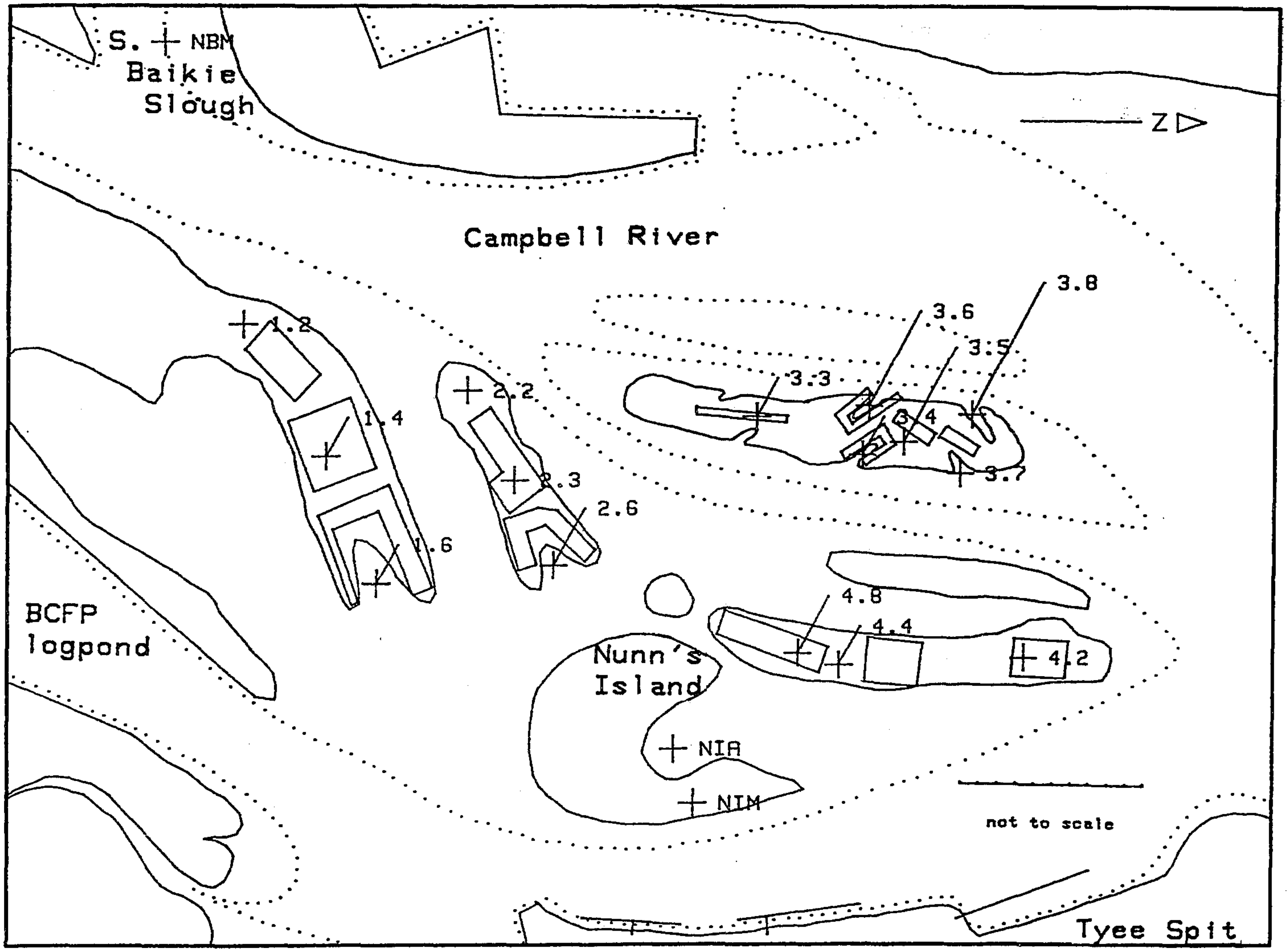


FIGURE 2.2 Locations (+) of epibenthic sled sampling stations in the Campbell River Estuary.

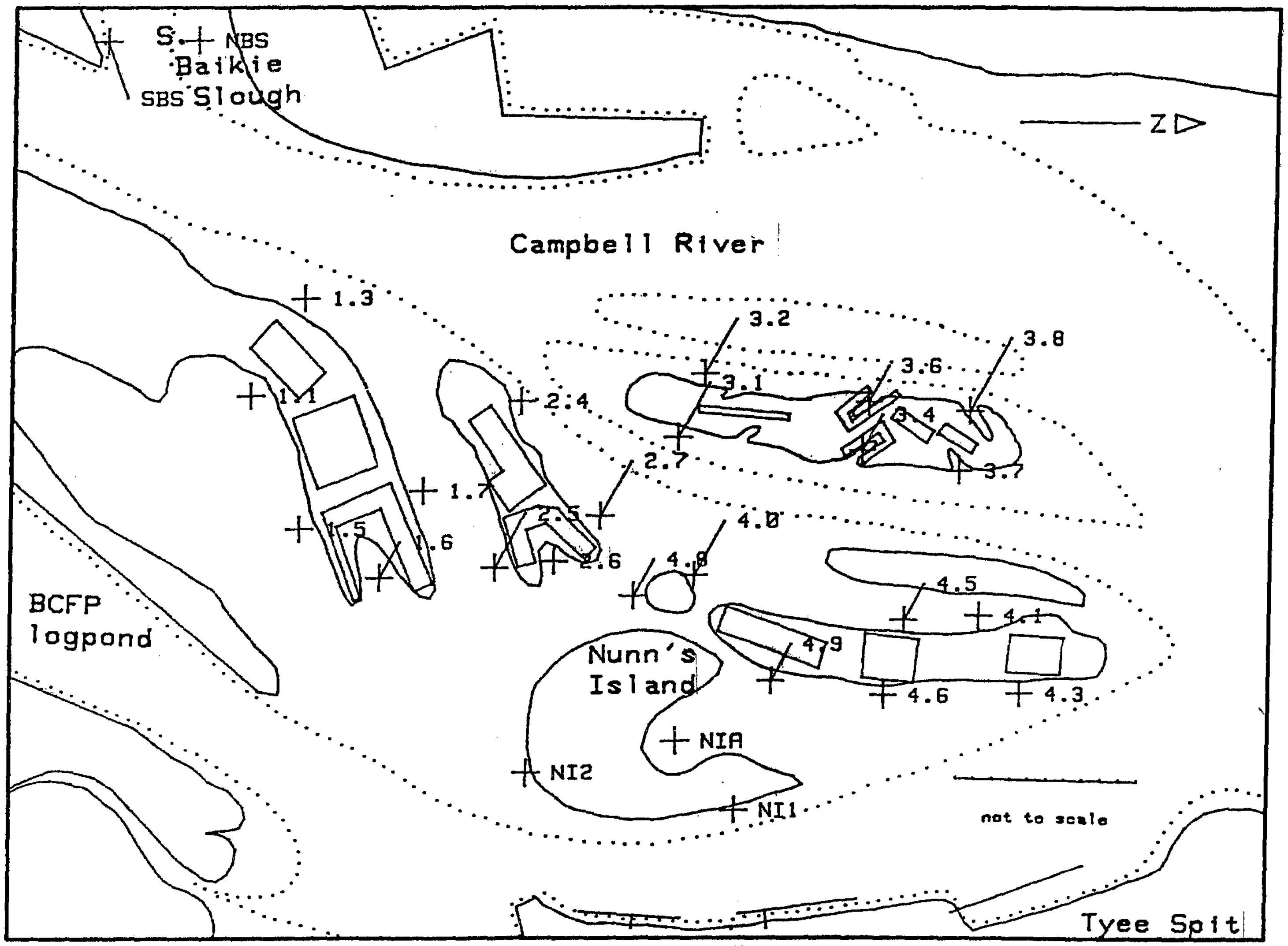


FIGURE 2.3 Locations (+) of beach seine sampling stations in the Campbell River Estuary.

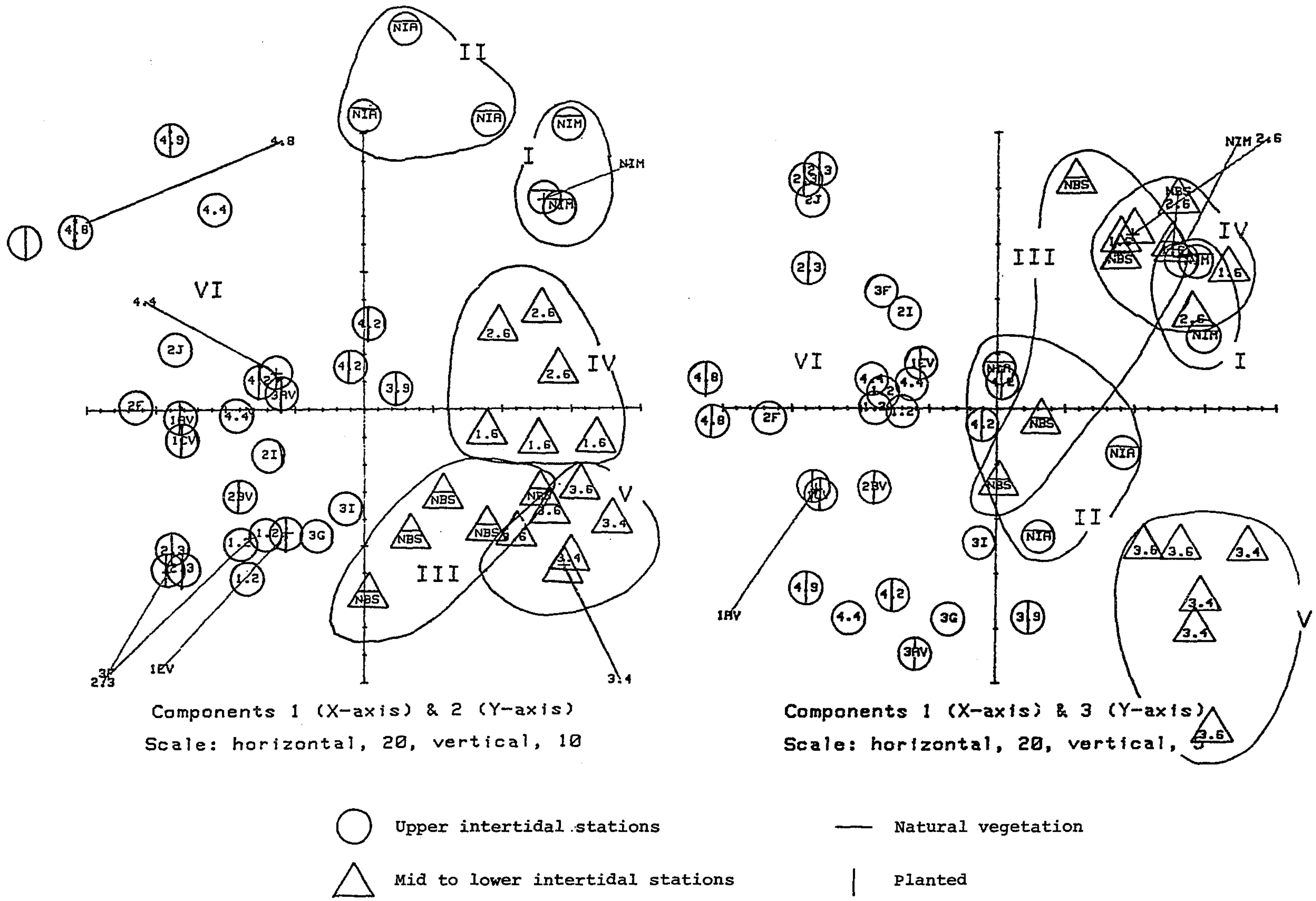


FIGURE 2.4 Principal components plots for quadrat samples.

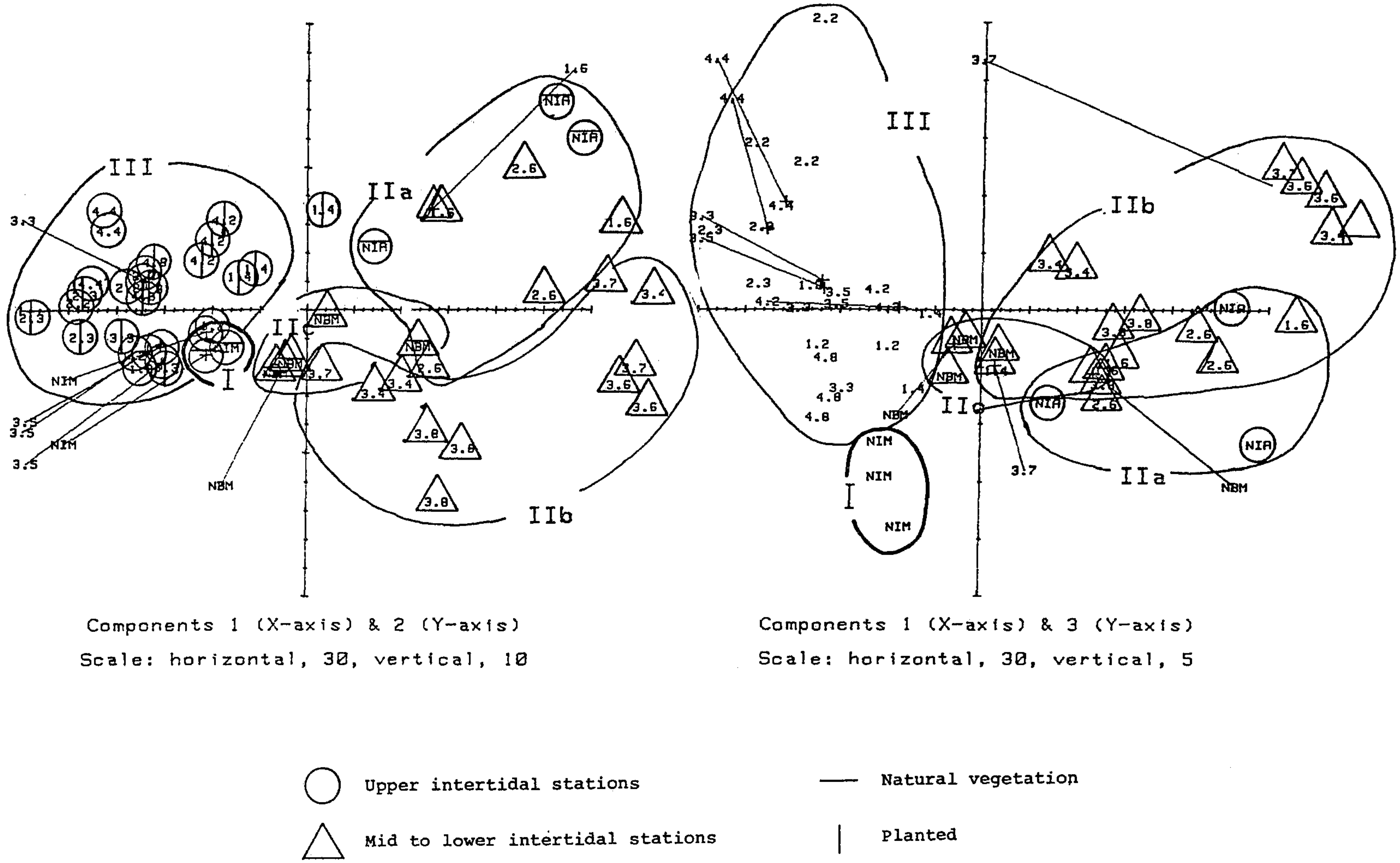


FIGURE 2.5 Principal components plots for epebenthic sled samples.

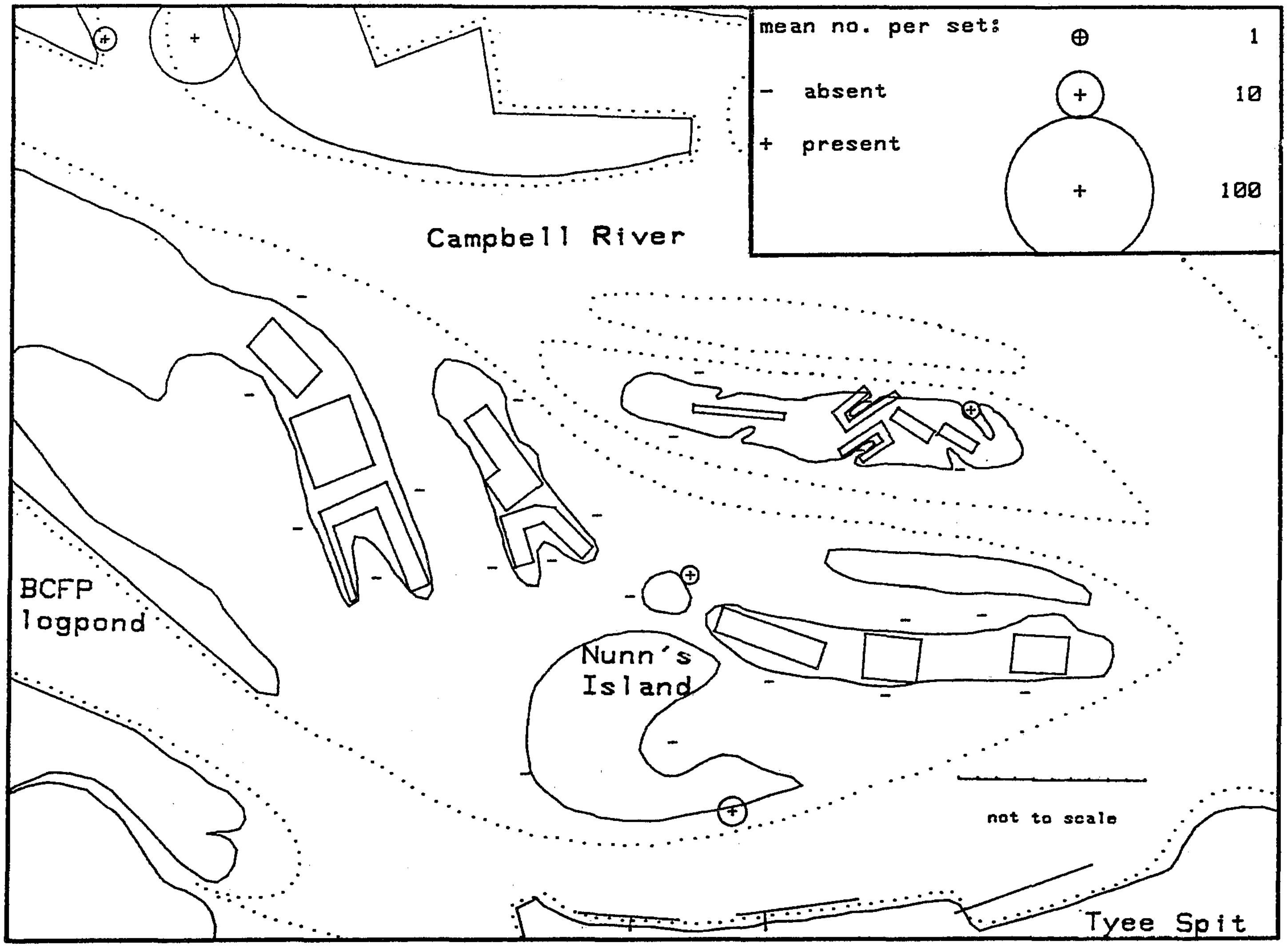


FIGURE 2.6 Distribution of juvenile hatchery chinook salmon.

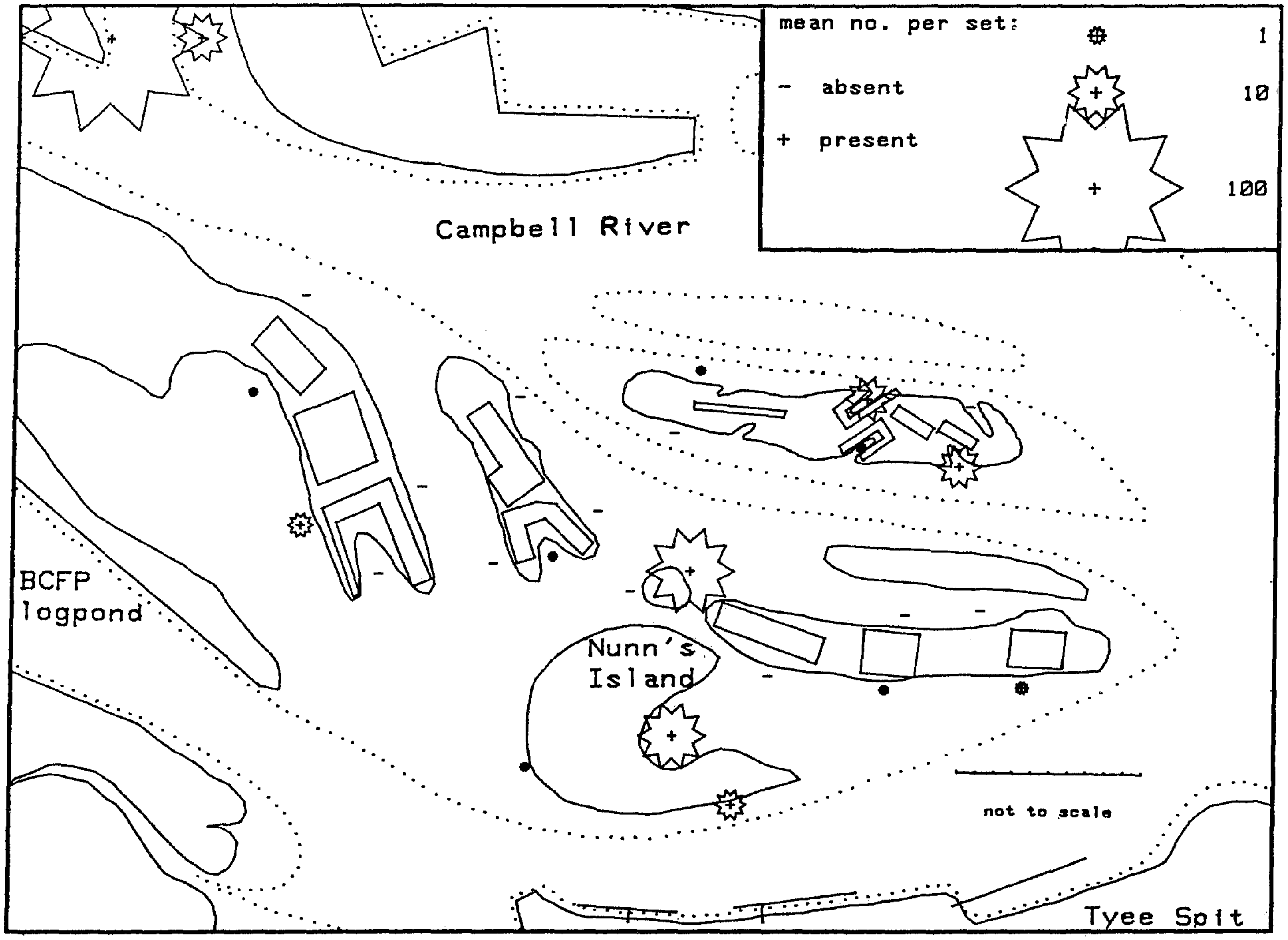


FIGURE 2.7 Distribution of juvenile hatchery coho salmon.

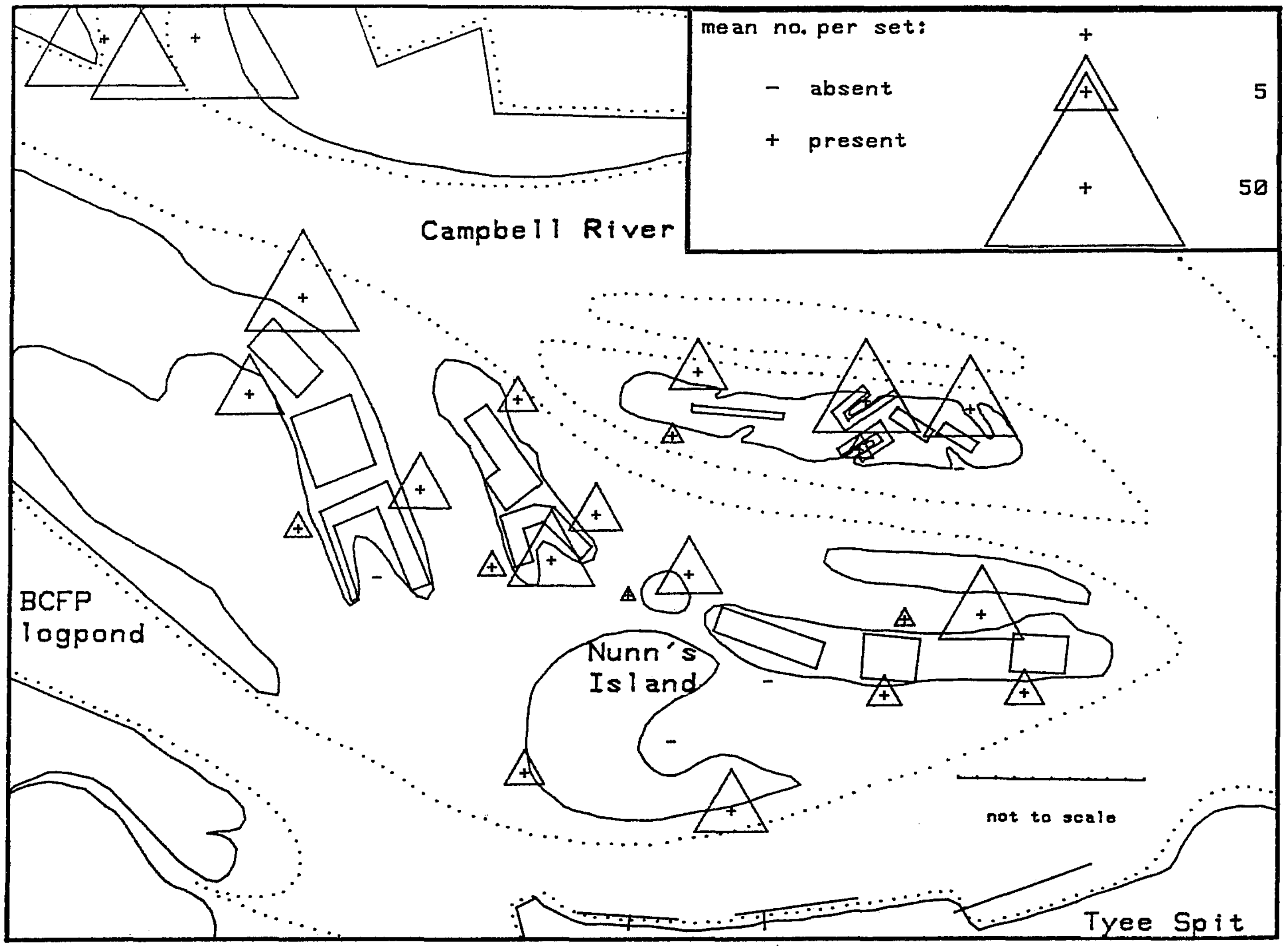
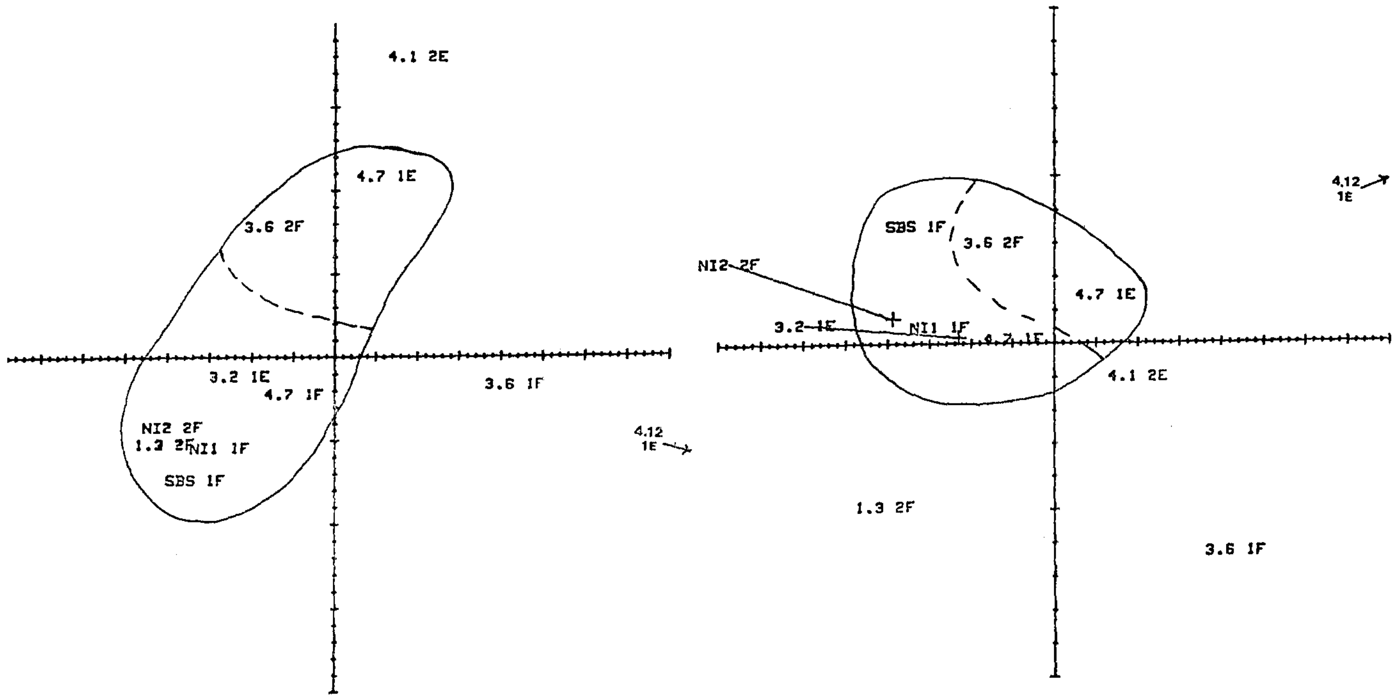


FIGURE 2.8 Distribution of wild chinook salmon.



Components 1 (X-axis) & 2 (Y-axis)
Scale: horizontal, 40, vertical, 20

Components 1 (X-axis) & 3 (Y-axis)
Scale: horizontal, 40, vertical, 10

FIGURE 2.9 Principal components plots for fish stomach contents.

3. EFFECTS OF WOOD WASTES ON THE RECRUITMENT POTENTIAL OF MARINE BENTHIC COMMUNITIES

S.F. Cross

Contractor: E.V.S. Consultants Ltd.
Prepared for: M. Waldichuk, DFO/WVL

Wood wastes, in the form of chips, bark or fibrous material, are routinely disposed of through ocean dumping practices associated with coastal forest products operations. Accumulation of this material can result in thick bottom deposits, which can be subject to disruption and redeposition during dredging activities. Such practices generally result in a mixture of wood waste with the underlying sediments of the natural substrate. This study was designed to determine the potential for macroinvertebrate recruitment of these organically-rich benthic environments, and to estimate the effects on such recolonization processes within substrates containing varying concentrations of wood waste.

Experimental Design

Natural sediment taken from 15-20 m depths in outer Burrard Inlet, B.C. were frozen for several days to kill existing fauna, thawed, homogenized, and mixed with wood wastes in volumetrically-determined proportions approximating 0%, 20%, 50%, and 100% wood fibre and wood by-product materials. These mixtures were placed in two replicate wooden containers (Figure 3.1) and placed in 25 m of water in outer Burrard Inlet for 11 weeks (August-October). Upon retrieval eight subsamples were systematically removed from the two replicate chambers representing each wood waste concentration.

For taxonomic analysis each sample was washed through a 0.5 mm mesh sieve. All macroinvertebrates retained were identified to the lowest possible taxonomic level consistent with presently available literature, and enumerated.

Species/abundance data were examined using a number of different statistical and community descriptive methodologies. In an initial examination, the total and mean number of individuals, and the number of taxa (richness), were compared graphically between the wood waste treatments. Secondly, the distribution of individuals among taxa, which often follows a standard log-normal distribution in unstressed environments, was fitted to the log-normal for each wood waste treatment to determine if deviations from this distribution were evident and a function of wood waste concentrations. Cumulative percent species (on a probit scale) were plotted against geometric class of individuals per species, where geometric class 1 = 1 individual/species; class II = 2-3 individuals/species; class III = 4-7 individuals/species, etc. Finally, an unweighted pair-group hierarchical (cluster) analysis was performed on the species/abundance data matrix in order to compare:

i) samples, based on the similarity of species composition and abundances (Q-type analysis), and

ii) species, based on the similarity of occurrence in samples and their respective abundances (R-type analyses).

The Complement of Bray-Curtis coefficient was employed as the index of similarity in all cases. Prior to this analysis the original data matrix was visually inspected for taxa which could be regarded as rare or incidental. These forms were removed from the original matrix using a number of criteria, one of which will be presented in this abstract, i.e., those taxa with recorded abundances of two or less in approximately 95% (26 of 28) of the treatment subsamples were deleted from the analysis. Results of this analysis, in addition to those employing the original unedited matrix, were displayed on an optimally rotated dendrogram.

Results

Total and mean numbers of taxa were distinctly higher at 20% wood fibre than at the other concentrations (Figure 3.2), and total numbers of organisms were similar between 0% and 50%, and between 20% and 100%,wood fibre. Detailed examination of the actual data shows large variations for most of the major taxonomic groups, especially the polychaetes and bivalve molluscs. Although the 100% wood fibre treatment had fewest species of polychaetes, the number of individuals was almost twice that of the next highest abundance, almost entirely due to large numbers of Capitella capitata and Armandia brevis in the 100% samples. Bivalves showed a similar pattern, with equally high numbers of individuals at all concentrations, but significantly reduced diversity at 100% for which Bankia setacea was heavily dominant.

The log-normal plots presented in Figure 3.3 not only support the phenomenon of increased dominance in the high wood-waste concentrations but also clarify the subtle changes occurring over the entire range of the wood waste proportions tested. The control plot (0%) very closely fits the log-normal, with five geometric classes represented by the taxa present. The 20% and 50% treatments reveal slight decreases in slope corresponding to the addition of one geometric class, suggesting the presence of at least one abundant taxon. The 100% wood-waste treatment data drastically deviates from the log-normal, showing a distinct break in the curve at the third geometric class. The latter portion of this curve maintains a very shallow slope which spans two additional geometric classes. These points are represented entirely by the dominant, "opportunistic" species Capitella capitata, Armandia brevis, and Bankia setacea.

Of the 79 taxa found among all subsamples analysed, 62 met the "incidental" editing criteria, leaving 17 taxa representing the most common/ abundant forms. Sample cluster analysis (Q-type) performed on these data clearly differentiated two distinct groups of samples (Figure 3.4). However, subsamples of each concentration within the two major groups were unevenly distributed, indicating generally inconsistent replication among each of the eight subsamples from a specific concentration.

Cluster analysis by species (R-type) for this matrix differentiated three groups of species as shown in Figure 3.5. Group A taxa were notably more abundant at 20% concentration, suggesting that some enhancement may be occurring due to additional nutrients or bacteria associated with the wood wastes (Figure 3.6). Group B taxa, comprised of one polychaete and four bivalve species, were clearly sensitive to high concentrations of fibre. The last group (Figure 3.6, Group C), comprised of nematodes, three polychaetes, and the wood-burrowing shipworm Bankia setacea, appear to be "opportunistic" and increase substantially in abundance from 0% to 100% concentrations of wood waste.

Conclusions

Pronounced variability was observed among subsamples for each concentration of wood waste tested, but general trends within the community structural data suggest that a gradual "enrichment" effect occurs under low levels of wood fibre (approximately 5-25%). Moderate to high wood-waste concentrations appear responsible for loss of sensitive species from the community, with subsequent replacement by numerically dominant "opportunistic" taxa.

Although this extended abstract provides a somewhat brief overview of the procedures and results of this study, a more explicit account can be found in the following technical report:

Kathman, R.D., S.F. Cross and M. Waldichuk. 1984. Effects of wood waste on the recruitment potential of marine benthic communities. Can. Tech. Rep. Fish. Aquat. Sci. 1284:50 p.

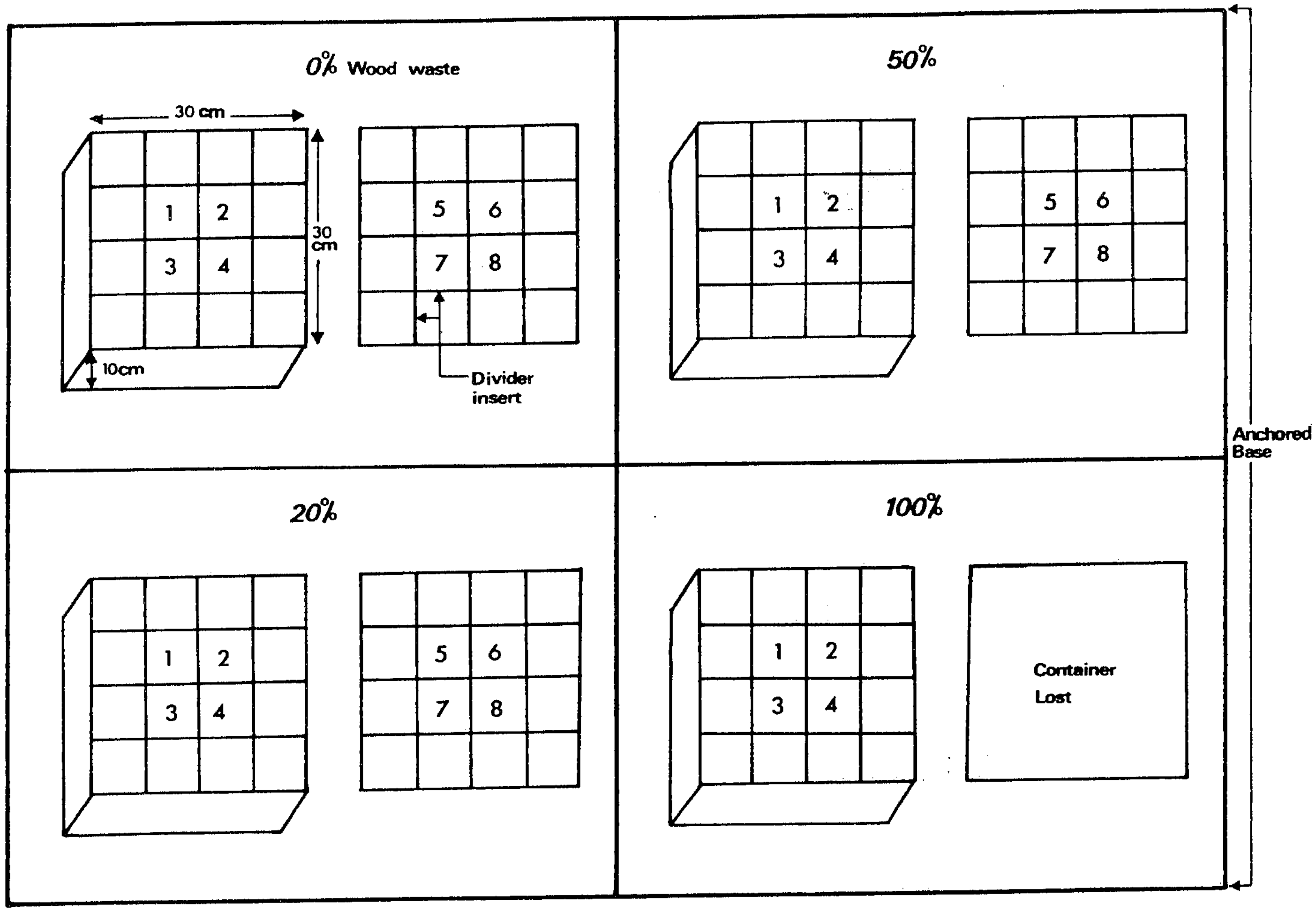


FIGURE 3.1 Base with attached samplers for benthic invertebrate recruitment study.

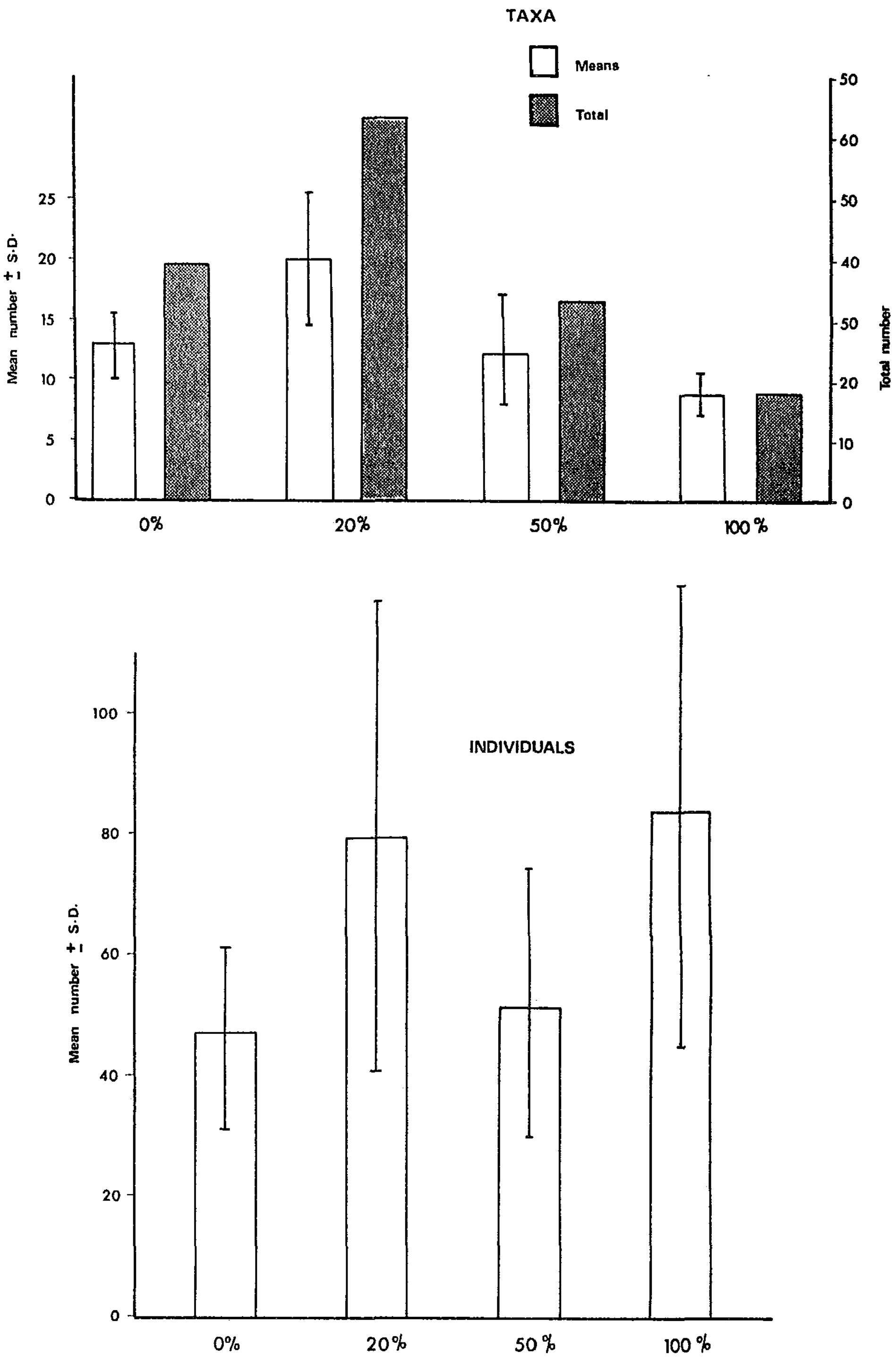


FIGURE 3.2 Numbers of taxa and individuals in original data matrix (28 samples x 81 taxa).

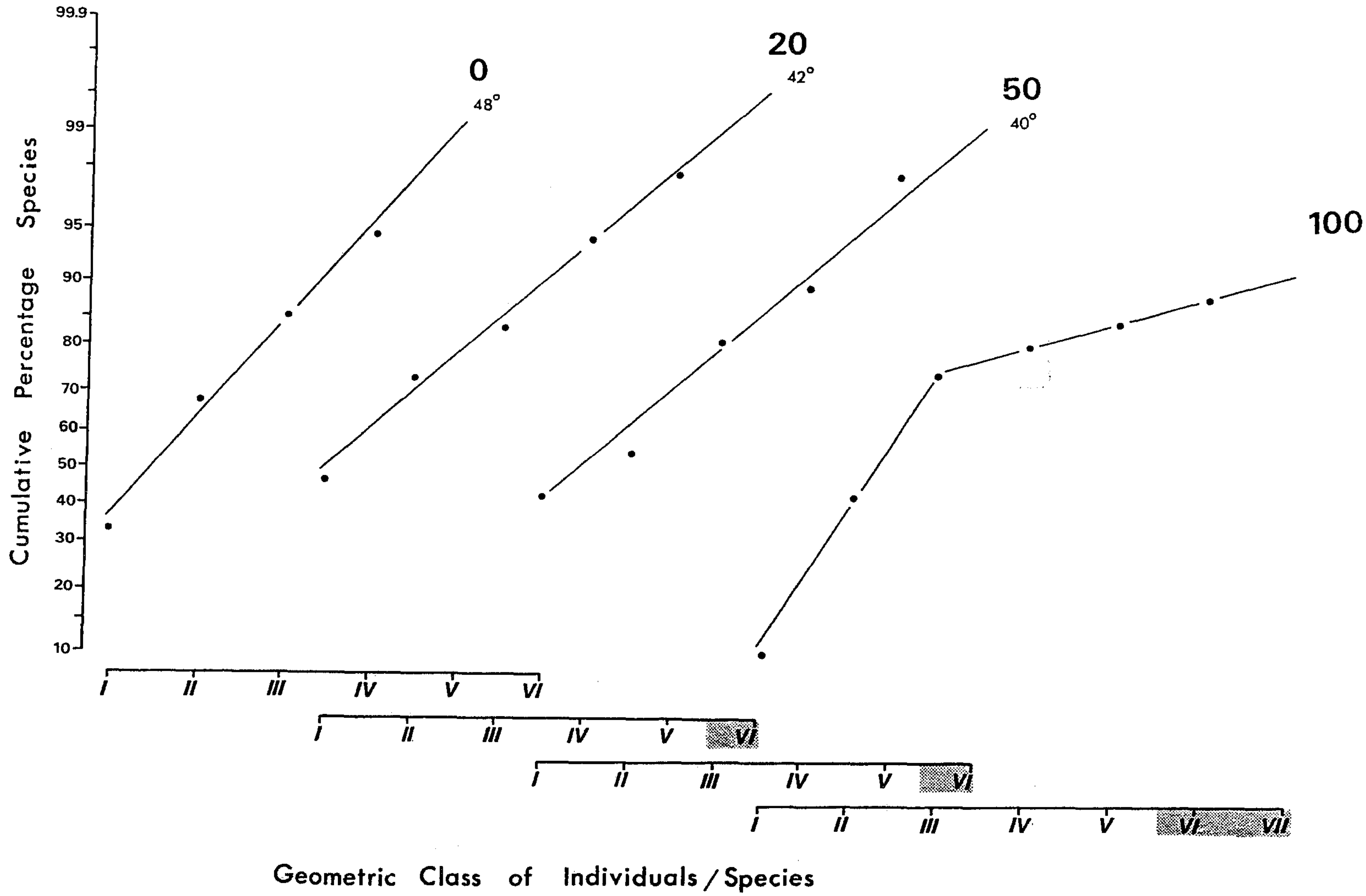


FIGURE 3.3 Linearly transformed plots of the log-normal distribution of individuals among species for each wood waste concentration using original data matrix.

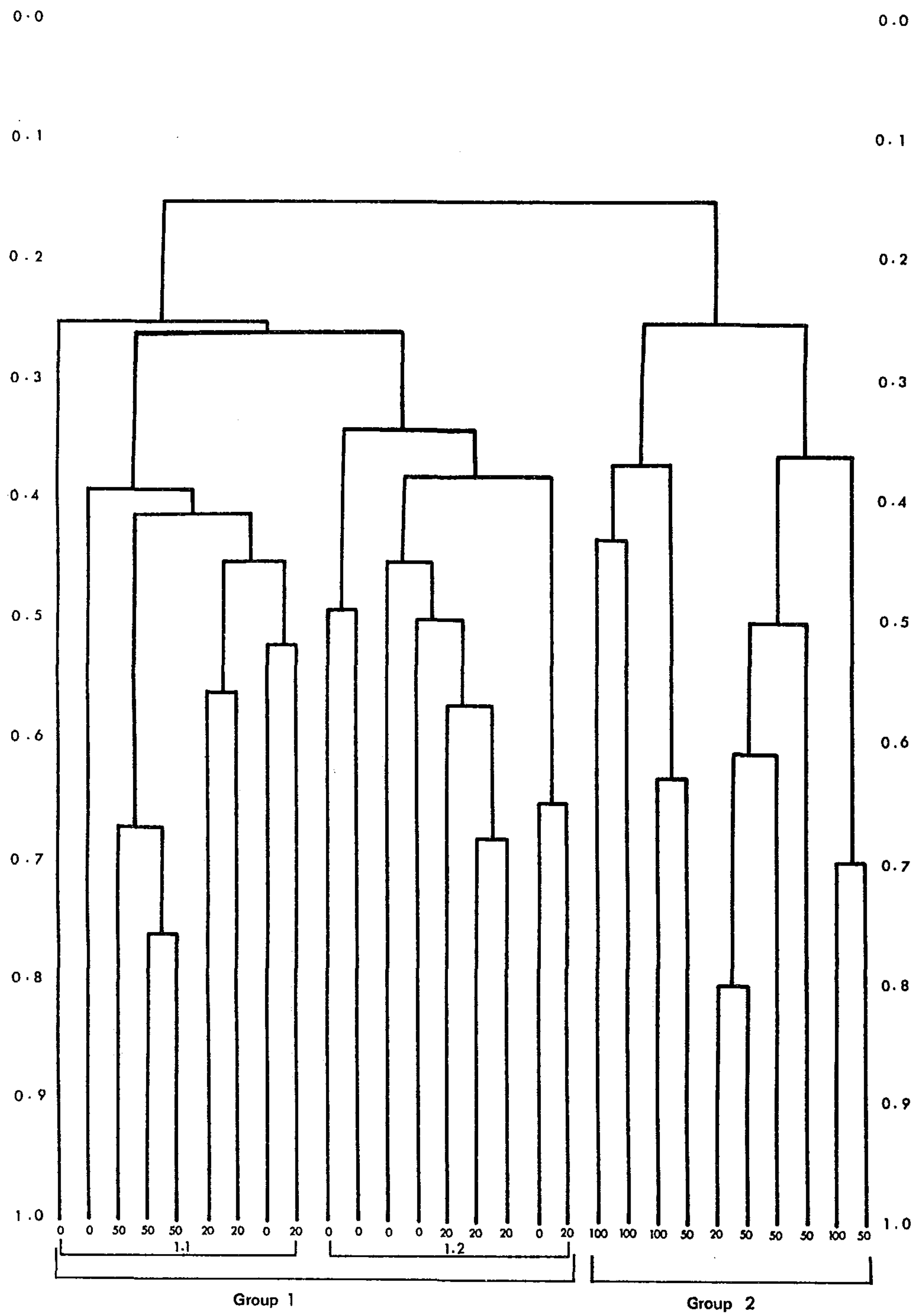


FIGURE 3.4 Q-type cluster analysis treatment groupings derived from original matrix editing procedure (28 samples x 17 taxa).

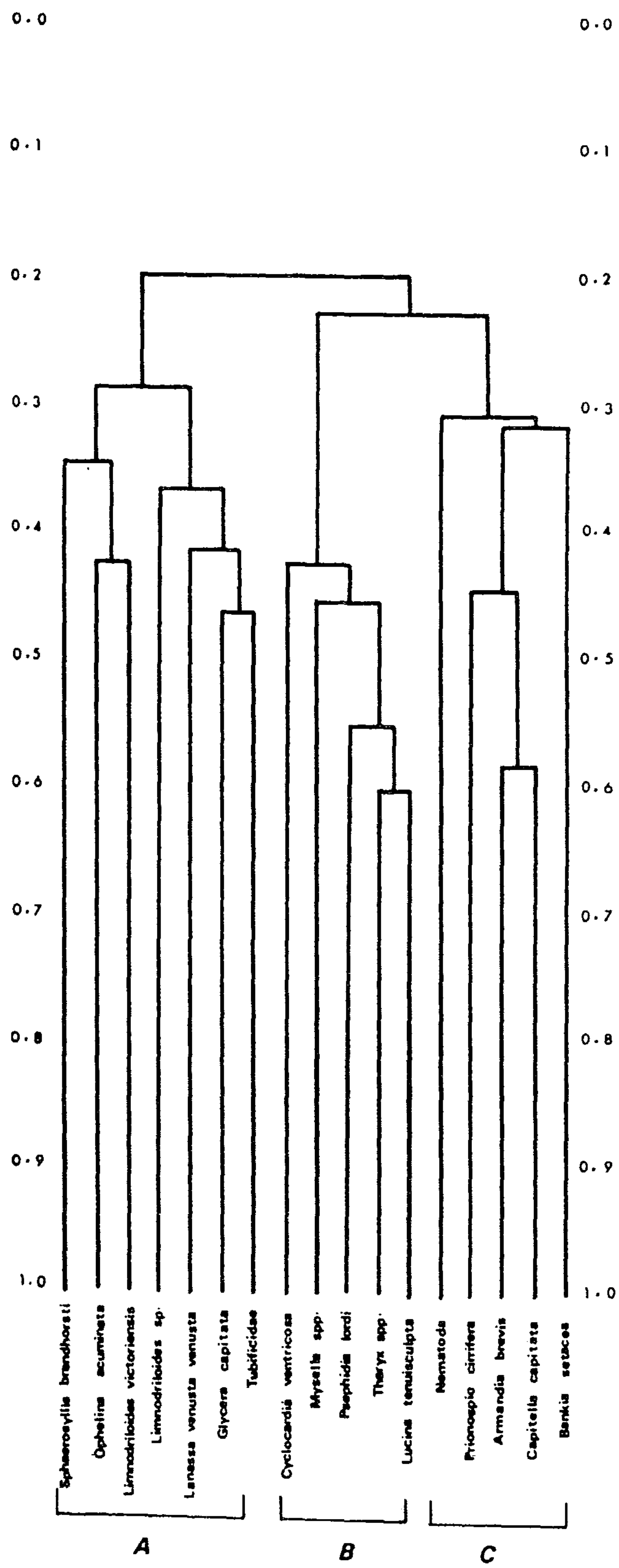


FIGURE 3.5 R-type cluster analysis species groupings derived from original matrix editing procedure (17 taxa x 28 samples).

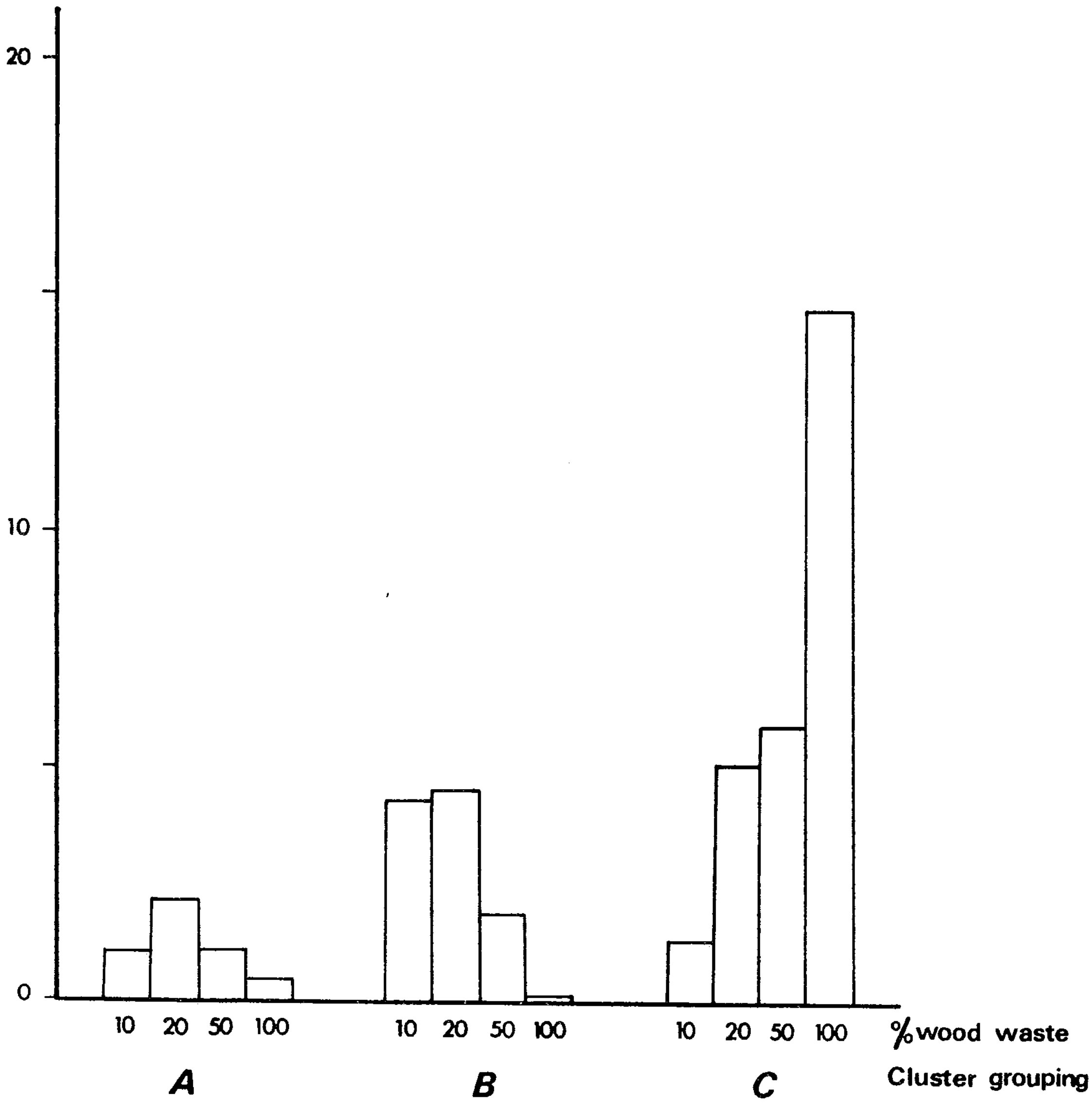


FIGURE 3.6 Mean number of individuals for each cluster analysis species grouping. (Data derived from Figure 3.5.)

4. A SHIPBOARD METHOD FOR EVALUATING THE TOXICITY OF DREDGE-SPOILS AND SEDIMENTS USING MICRO-ORGANISMS

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Contractor : Atlantic Oceanics Company Limited
Prepared for : N. Antia, DFO/WVL

Algae and protozoa have a number of important features which perhaps make them useful organisms for assessing the potential toxicity of elutriates of sediment and dredge-spoils. Firstly, since they have relatively rapid generation times, compared with the metaphyta and metozoa, it should be possible to measure long-term effects (relative to the generation times of the organisms) of low levels of pollutants in the ambient seawater. In addition, algae form the base of the food chain in the pelagic environment so that species alteration at this level could have more profound changes further up the chain.

The objective of this study was to determine whether or not elutriates of sediment from False Creek, Vancouver, had deleterious effects on the growth rate (as measured by the increase in the number of individuals over time) of three species of micro-organisms: the green alga, Dunalliela tertiolecta, the dinoflagellate Amphidinium carteri, and the ciliate Blepharisma sp.

The following combinations of elutriates were used: seawater only; seawater with nutrients, trace metals and EDTA; and seawater with nutrients but no trace metals and no EDTA. The controls were the same combinations but without the addition of sediment.

The algae were cultured in 250 mL polypropylene flasks at 12°C with a 16h/8h light/dark lighting regime,using cool white fluorescent lamps. The protozoa were cultured at room temperature in tissue culture dishes with ambient lighting.

Data were analysed using the logistic growth curve model:

$$Y = \frac{k}{1 + 10^{(a-bx)}}$$ where k is constant

Preliminary results indicate that the elutriates of sediment taken from the east basin of False Creek tend to enhance growth if seawater is used to prepare the elutriate, but tend to decrease growth if the elutriate is prepared using seawater with nutrients, trace metals and EDTA. Both the algae and protozoa could be easily maintained in a compact laboratory and hence may be suitable candidates as bioassay organisms.

5. STATISTICAL ANALYSIS OF TWO LARGE SEDIMENT DATA SETS TO PROVIDE MINIMUM SPECIFICATIONS FOR QUALITY CONTROL OF OCEAN DUMPING ANALYSES

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Contractor: Dobrocky SEATECH Limited
Prepared for: R. Macdonald, DFO/IOS

Investigation of Data Set Properties

This summary describes the results of statistical analyses applied to two data sets of metal levels in marine sediments collected in Alice Arm, B.C. Most of the data examined was produced by Seatech while under contract to AMAX of Canada Limited; the remainder was produced by the Environmental Protection Service (EPS) as part of an interlaboratory comparison with Seatech. Analyses were performed for Cd, Cu, Zn, Mo, Pb and As.

Both Seatech and EPS showed good results for the analyses of certified reference materials. The mean values obtained by both labs were significantly different than the certified value only in a small number of cases. NBS River Sediment (1645) presented the most problems. Detailed analysis of the Seatech results for the certified reference materials and for a sediment composite of material from Alice Arm gave an indication of some year-to-year bias in the Seatech results for some of the metals analysed.

Hindcast performance charts, in the form of control charts for the certified reference materials analysed by Seatech, showed no systematic trends in the results in any given data set from the monitoring programme. Only a few of the values were more than two standard deviations from the mean; this indicates that the Seatech analyses were in control.

The limits of detection and the analytical calibration curves were also examined for the Seatech analyses. The propagation-of-errors method of determining the limit of detection was judged to be the best one available. The suitability of the assumption of linear regression for calibration data was also tested. It was found that, even though the correlation coefficients obtained were excellent, the assumption of linear regression was only statistically justified for half the metals analysed. This was attributed to the calibration curve tailing off at higher concentrations.

EPS supplied no reagent blank data along with their results. All Seatech reagent blanks were below detection except for one Cu value and a number of Zn values. The Zn levels obtained were insignificant in comparison to the lowest sediment Zn value obtained.

Histograms of the metals concentrations obtained were generated for all data sets. No clear patterns were found for any of the metals in any data sets. None of the distributions appeared to be normal; most had the appearance of being skewed or bimodal. Plots of the standard deviation versus the mean showed no trends, with the possible exception of an increase in the standard deviation with the mean. The plots were very scattered and no transformation could be found to stabilize the variances.

Pooled standard deviations were used as a method of predicting the expected precision of metals analyses in different concentration ranges. These deviations were also separated according to the number of replicates. A general increase of the standard deviation with the mean was noted. There was no clear indication as to whether two or three replicate analyses were better.

Comparison of Seatech and EPS Interlaboratory Data Sets

The sediments used for the interlaboratory comparison were dried, sieved (0.15 mm) samples of sediment homogenate. The sediment data sets were identical except for As; since EPS did not perform duplicate analyses for As. The following conclusions do not apply for As unless specifically stated.

In an examination of systematic (laboratory bias) and random errors, EPS was found to have a larger pooled variance for every element except Cd. The variance in the between-laboratory errors was greater than the random errors for all metals except Cd; this indicated that different results were being produced by each laboratory for every element except Cd.

The establishment of a functional relationship between the two data sets also showed a significant interlaboratory bias for every element except Cd.

The assumptions of parametric ANOVA were tested prior to nested ANOVA analysis. The variances between the two data sets were found to be homogeneous only for Cd. For the Seatech data set alone, the Cd and Pb variances were found to be homogeneous; for EPS, Cu variances were found to be homogeneous.

Even though the parametric ANOVA was only appropriate for Cd, it was performed for the other metals also so that it could serve as a guide to others performing similar analyses, and because the mean squares obtained could provide valuable information on the sources of variation between laboratories. The ANOVA showed a significant interlaboratory bias for all metals. A non-parametric Wilcoxon's signed ranks test corroborated this result by also showing such a bias.

The mean squares obtained from the ANOVA analysis were used to break down the sources of variation in the interlaboratory comparison (Table 5.1). The results were used to derive an estimate of the total expected variation between laboratories for each metal. This variation was expressed as the comparability, which was defined as the closeness of agreement between individual results obtained on identical test material but under different conditions i.e. different operator, different apparatus, different methods, different laboratory and/or different time.

Wilcoxon's signed ranks test and pooled variances were used to compare analytical variability of the Seatech and EPS analyses. Both tests showed that the two laboratories were similar in analytical variability.

Arsenic was a difficult element to compare between the two labs since EPS did not perform duplicate analyses for this parameter. The Seatech As results were greater than the EPS As results for all but two of the 53 samples analysed; this indicated a definite interlaboratory bias. Statistical test results were mixed but showed significant differences in the As results for at least some concentration ranges.

Conclusions and Recommendations

The first conclusion that can be drawn from this study is that, although laboratories may demonstrate good accuracy and precision for the analysis of certified reference materials (as both Seatech and EPS did here), this does not necessarily guarantee that two laboratories will obtain the same results. However, this result cannot change the fact that quality control still has to be an integral part of every analytical programme. If both EPS and Seatech had not maintained quality control procedures, a direct comparison of the interlaboratory results would not have been nearly as valid.

It is recommended that laboratories should still continue to use certified reference materials, but two materials should be used at one time so that accuracy may be verified at more than one concentration in the same batch of samples. For large monitoring programmes, a sediment homogenate from the area of interest should be prepared at the beginning of the programme and analysed along with the certified reference materials. Control charts should be an integral part of this use of standard materials.

It is also recommended that there be more standardization of methods. This is not to say that procedures should be restricted to one or two approved methods, but rather that the common methods in use for ocean dumping analyses should be subjected to ruggedness testing (Youdon, 1975). Ensuring that a procedure is reproducible is also important for long term monitoring programmes. In all cases the verification should extend to critical aspects beyond the chemistry, such as hot plates and balances. A protocol should also be established for the use of blanks and reference materials and for the rejection of unsuitable results.

As a result of the evaluation of various methods of detection in this study, it is recommended that all laboratories should examine their calibration procedures more closely. It is highly recommended that they calculate their limits of detection and test their calibrations for linearity. Calibration data should also be graphed and verified regularly.

It was also found that, while individual variances will vary wildly in a set of analytical data, the pooled variances are much more stable, particularly over a narrow range of concentrations. It is felt that pooled standard deviations can be an effective predictive tool for the expected precision of metals analyses in different concentration ranges, providing that a large number of analyses are pooled.

Histograms and regressions of variance versus mean did not indicate that metals distributions were normal or even log normal. A transformation could not be found that would improve the situation by making the variances more homogeneous. More caution is urged in the application of parametric statistical tests to chemical analytical data.

All statistical tests agreed that there was an interlaboratory bias between EPS and Seatech for mean metal concentrations obtained for Cu, Zn, Mo and Pb. For Cd, the finding that random errors were greater than bias errors and the establishment of a functional relationship not significantly different than the ideal 45^{o}-line relationship for results of the two laboratories indicated the lack of interlaboratory bias. However, parametric ANOVA and non-parametric Wilcoxon's signed ranks test indicated a significant interlaboratory bias for Cd. Although the results were mixed, the finding of an indication of the equivalence of results is encouraging for this important parameter. A clear statement could not be made for As due to the lack of duplicate analyses from EPS. The analytical variability was found to be similar for both laboratories for all metals.

It is felt that effort should be spent to identify the major sources of bias between laboratories. The ruggedness testing of procedures recommended above is felt to be a good start along these lines.

As a general conclusion, it is felt that this study has yielded some very useful results and that it should help to define directions and answer questions that may arise in regard to chemical analysis over the next few years. Because this study has been so valuable, it is recommended that all interlaboratory comparisons such as the one studied here should be evaluated.

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TABLE 5.1. A tabulation of the sources of variation in the interlaboratory comparison.

Metal	Standard deviation between replicates for both laboratories combined	Standard deviation between analytical methods	Standard deviation between laboratories	Pooled standard deviation between Seatech replicates	Pooled standard deviation between EPS replicates	Comparability
			(ug/g dry weight)			
Cd	0.29	0.18	0.24	0.30	0.27	0.42
Cu	1.90	2.22	2.32	1.78	2.02	3.73
Zn	7.84	8.14	22.8	6.17	9.21	25.4
Mo	6.23	11.9	27.8	5.93	6.51	30.8
Pb	3.10	5.91	3.83	2.36	3.69	7.69

6. INTERLABORATORY COMPARISON OF A SEDIMENT TOXICITY TEST

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Swartz et al (1985) have proposed for monitoring and assessment a 10-day static sediment toxicity test using the infaunal amphipod Rhepoxynius abronius (Barnard: Phoxocephalidae). The test has been used by five different laboratories to survey for sediment toxicity at several hundred sites in Puget Sound (Long, 1984 and this volume) and elsewhere in the U.S. (Swartz et al, 1985). This test is now being used by a sixth laboratory and it is one of two principal procedures tentatively being used by U.S. EPA as interim criteria for the disposal of dredge material into Puget Sound. Its acceptance beyond this may be contingent on demonstrated reproducibility.

During February, 1984, the Swartz et al (1985) amphipod sediment bioassay was subject to a referred interlaboratory comparison experiment involving five laboratories, four U.S. and one Canadian. This report summarizes some of the results of that experiment, with emphasis on survival, one of three end-points investigated.

Experimental Design and Methods

The experimental design involved the five laboratories each using seven treatments, including six test sediments and a control. Each treatment in each laboratory was replicated six times, with five replicates for end-point monitoring and one for daily water quality monitoring. Each replicate consisted of a 1 L beaker containing a standard amount of sediment and 20 live amphipods. Conditions were as described in Appendix A of Swartz et al (1985). The three end-points tested were mean numbers surviving, reburying and emergent at the end of 10 days.

Collection and preparation of sediments, collection of amphipods and data analysis were cooperative activities not subject to comparison and were coordinated by a non-participating referee. Participants attended a workshop to develop hypotheses and the experimental design, and to assign responsibilities. Laboratories and all materials were coded to maintain anonymity.

Control and test sediments were collected and refrigerated 7 to 14 days prior to the experiment. Portions of the control samples, collected from Yaquina Bay, Oregon, were innoculated with the reference toxicant, cadmium chloride ($CdCl_4$), to achieve three confirmed test concentrations of 4.0, 8.0 and 12.0 mg Cd/kg dry weight. Field samples were taken from three sites in Puget Sound previously determined to represent a gradient of toxic response. Two characteristics of these samples, per cent clay and cadmium content, are shown in Table 6.1 (Columns 1 and 2).

Live amphipods were collected in excess from an abundant population present off West Beach, Whidbey Island on February 12, 1984. All materials (sediments and amphipods) were returned to a central distribution point where they were held until dispersal to each laboratory on February 13, 1984. Following a four-day amphipod acclimation period, the experiment was synchronously initiated at each laboratory on the morning of February 17, 1984 and terminated 10 days later on the morning of February 27, 1984.

Results

The experiment was a complete success in terms of obtaining the required data; all laboratories are credited with reporting positive data in a thorough and timely fashion.

Grand mean survival ranged from 3.8 amphipods in the 12.0 ppm cadmium-dosed sample to 19.3 amphipods in the control samples (Column 3, Table 6.1). Among the three field samples, survival was unexpectedly similar (range 15.8 to 16.6 amphipods) whereas survival appeared to be dose-dependent among the three cadmium-innoculated samples (range 3.8 to 19.2, Table 6.1). Interlaboratory means differed by as little as 1.1 amphipods in control sediments to as much as 8 amphipods for the 8 ppm cadmium-dosed sediments (range 10.0 to 18.0, Column 4, Table 6.1).

A primary criterion of success was that no laboratory produce a mean control survival of less than 90% or 18 amphipods. There were no exceptions to this, as seen in Table 6.1 (top row), and we therefore conclude there is no reason why any laboratory using this test, according to the published protocol, should have difficulty achieving good control response. Incidentally, the end-points "reburial" and "emergence" were equally successful (data are not shown).

A second criterion of success was that the laboratories agree on the relative ranking of samples from least to most toxic. Despite the interlaboratory ranges noted in Table 6.1 for survival, Kendall's Test of Concordance was not significant for any end-point at $p < 0.05$, indicating satisfactory interlaboratory agreement on ranking (individual data are not shown here). Indeed, there was perfect interlaboratory agreement on ranking of the subset of cadmium-dosed sediments but, due to the low range of response values, not for the subset of field samples.

A third criterion for success was interlaboratory agreement on classifying samples as "toxic" or "not toxic", i.e. where mean survival in a test sample is significantly ($p < 0.05$) lower than in respective controls. Dunnett's t procedure indicated perfect agreement for only two of the six test sediments (4.0 ppm cadmium, not toxic and 12.0 ppm cadmium, toxic; Columns 5 and 6, Table 6.1); the test for emergence was only slightly better (three of six perfect, data are not shown). Thus, this test failed, due principally to an inability of laboratories to agree over the narrow range of survival values between 15.3 and 16.6 amphipods (8.0 ppm cadmium and the three field samples, Table 6.1).

A fourth test of success was interlaboratory agreement on absolute means of end-points (independent of controls). For the end-point survival, there was perfect (five of five) interlaboratory agreement only for the control sediments and for the sample from City Waterway (last column, Table 6.1); however, while the test of perfect agreement failed, we note that for six of the seven treatments there was agreement among at least four (or 80%) of the laboratories.

A final criterion for success was interlaboratory agreement on LC50 concentrations for cadmium using the cadmium-dosed sediments. Individual laboratories obtained LC50 concentrations ranging from 8.2 to 11.5 ppm with a grand mean of 9.81 (Table 6.2). There were no significant interlaboratory differences in estimates of LC50 ($p < 0.05$). The interlaboratory coefficient of variation (CV) was 12.0%, a value considerably lower than the range of 21 to 86% reported for other interlaboratory experiments using cadmium (bottom note, Table 6.2).

Conclusion

By several standards, this experiment was remarkably successful. The experiment was completed with no major problem, with excellent control survival, with satisfactory interlaboratory agreement on ranking of test samples and, in at least four of five laboratories (80%), with agreement on mean values for survival and for reburial and emergence (not shown). However, when mean survival was in the range 15.3 to 16.6 amphipods (76.5 to 83.0%), the experiment as performed failed to confirm interlaboratory agreement on distinguishing toxic from non-toxic samples. We have carefully inspected these and other similar data produced by several of these participating laboratories and conclude that survival in the range of 15 to 17 amphipods (75 to 85%) is indicative of marginal toxicity that ought to be verified by other methods whereas, beyond these values (i.e., >17 or <15), the test is robust and comparable among laboratories. Furthermore, data soon to be reported suggest that emergence is a much more sensitive indicator of toxicity than survival and appears to be a responsive index within a few days of the onset of the experiment.

A report describing in detail the conduct and specific results of this experiment is in preparation.

Acknowledgements

For their perseverance and cooperation I thank team leaders Mssrs. R.C. Swartz, U.S. EPA, Newport, Oregon; J. Cummins, U.S. EPA, Manchester, Washington; P. Plesha, NMFS, Mukilteo, Washington; P. Dinnel, University of Washington, Seattle, and P. Chapman, EVS Consultants Ltd., North Vancouver, B.C. On behalf of these gentlemen I also thank the technicians who did most of the work: F. Cole, G. Ditsworth, K. Sercu and J.Lamberson, U.S. EPA, Newport; C. Gangmark, U.S. EPA, Manchester; R. Ott, University of Washington; and D. Mitchell, C. Baslow, K. KcKim and L. Mitchell, EVS Consultants, North Vancouver. Also, on behalf of the team, I thank our respective supervisors.

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TABLE 6.1. Summary of data on sediment characteristics and on mean numbers of amphipods surviving 10-day exposure during sediment bioassay inter-laboratory comparison experiment, February, 1984.

Treatment	Clay (%)	Cadmium (ppm, dry)	$\bar{X}$ Survival	No. surviving (range, diff.)	Laboratory agreement on: Toxic	Not	Means of end-points
Control	1.3	0.2	19.3	18.9 - 20.0 (1.1)	-	-	5
4 ppm Cd	1.3	4.1	19.2	17.8 - 19.8 (2.0)	0	5	4
8 ppm Cd	1.3	8.3	15.3	10.0 - 18.0 (8.0)	3	2	4
12 ppm Cd	1.3	12.2	3.8	1.2 - 8.2 (7.0)	5	0	3
A600E (deep)	60.4	0.4	16.6	13.8 - 18.4 (4.6)	2	3	4
Sinclair Inlet	35.5	4.2	15.8	13.4 - 17.6 (4.2)	2	3	4
City Waterway, Tacoma	40.4	5.6	16.6	14.8 - 17.4 (2.6)	3	2	5

TABLE 6.2. Summary of LC50 concentrations (mg/kg dry weight) of cadmium in sediments used during interlaboratory comparison experiment, February, 1984.

Laboratory	LC50 concentrations $\bar{X}$	95% C.L.
1	9.95	9.68 - 10.23
2	11.45	10.86 - 12.28
3	9.44	9.05 - 9.81
4	8.17	7.53 - 8.67
5	10.02	9.48 - 10.64
	$\bar{X}$ = 9.81	CV = 12.04%*

* Compares with 21% for *Daphnia pulex*, 9 laboratories; 72% for *D. magna*, 8 laboratories; and, 86% for *Pimephales promelas*, 9 laboratories (as cited in Lewis and Dryer, in prep.).

7. GEOGRAPHIC TRENDS IN TOXICITY OF PUGET SOUND SEDIMENTS

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Initial efforts in 1978, 1979 and 1980 to characterize the occurrence and concentration of toxic chemicals in Puget Sound largely involved sampling and analyses of sediments. Sediments in deposition zones accumulate and integrate contaminant inputs from nearby sources. They are the ultimate sink for many toxic chemicals. These initial studies identified distinct trends in the relative concentration of numerous chemicals. Some parts of the bays and waterways located near urban centres were found to be the most contaminated with a wide variety of trace metals and organic compounds. Though several observations (e.g., liver lesions in bottom fish) indicated that adverse biological effects co-occurred with high concentrations of contaminants in sediments, no direct evidence of the toxicological significance of the sediment-associated chemicals was available based upon the chemistry data and field biological observations alone.

To fill this gap, surveys of the Sound initiated in 1981 focused upon testing the toxicity of sediment through use of sediment bioassays. A variety of sublethal end-points were used along with mortality to characterize the toxicological properties of sediment samples. Since those initial surveys, other studies have been conducted by a variety of agencies and investigators. The purpose of this paper is to describe geographic trends in toxicity of Puget Sound sediments and, in so doing, identify those parts of the Sound that are most toxic and most in need of remedial actions.

Sediment bioassays have been performed most often with the amphipod *Rhepoxynius abronius*, with 10-day lethality as the end-point. Many tests have been performed with oyster embryos, with lethality and abnormality as end-points. Tests for altered respiration rates among oligochaetes, anaphase aberrations among cultured trout and bluegill cells, mortality among fish and invertebrates and bacterial activity (Microtox test) have been performed.

Approximately 3.9 square miles are apparently significantly toxic, based upon a review of the available data. That is, compared to remote reference areas, the majority of samples and the majority of the types of tests were positive (toxic) in samples from these 3.9 square miles. Most of these areas were in urban bays or industrial waterways: the mouth of Whatcom Creek Waterway at Bellingham; inner Everett Harbor; off the Denny Way Combined Sewer Overflow at Seattle; the lower Duwamish Channel near Seattle; inner Sinclair Inlet at Bremerton; and upper Hylebos Waterway and City Waterway at Tacoma. Two additional remote areas were relatively toxic in one test: part of Quilcene Bay and part of Case Inlet.

Recent studies have been completed in which sediment chemistry, toxicity and resident infauna data from remote areas were compared with those from parts of urban areas. Samples with similar texture and from comparable depths were compared. Though the available data were from several laboratories and from different years, the results were very encouraging. That is, samples from the remote areas were not contaminated with toxic chemicals, they were not very toxic (most tests were negative), and the infauna were species-rich and dominated by crustaceans (including those known to be contaminant-sensitive). Samples from Elliott and Commencement Bays were contaminated, highly toxic and dominated by molluscs and polychaetes (many of which are pollution-tolerant). The implication of this observation is that the laboratory-derived bioassay data apparently are reflective of in-situ conditions.

Solid-phase sediment bioassays are being used with increasing frequency in regulatory decisions regarding dredge-spoil disposal and assigning priorities to areas for remedial action. The results of bioassays provide answers to the biological "So what?" question regarding sediment chemistry data. They provide meaningful results easily understood by managers and the public. They are considerably less expensive and quicker than complicated chemical analyses. Results are reproducible. They are apparently reflective of in-situ changes in resident infauna.

A Sediment Quality Triad composed of chemistry, toxicity and infauna data provides the strongest evidence of biologically-damaging excesses of toxic chemicals in sediments. The bioassay results are needed to interpret the toxicological meaning of the chemistry data. The infauna results are needed (at least, for now) to interpret the bioassay data. Chemistry data alone provide no indication of biological significance. Infauna data alone (or with the chemical measures) provide little assurance that geographic differences are not caused by subtle variations in sediment properties, recruitment, prey/predator interactions, storm events, depth or natural environmental parameters. This Triad is currently being used in Puget Sound to assign priorities to areas for remedial actions.

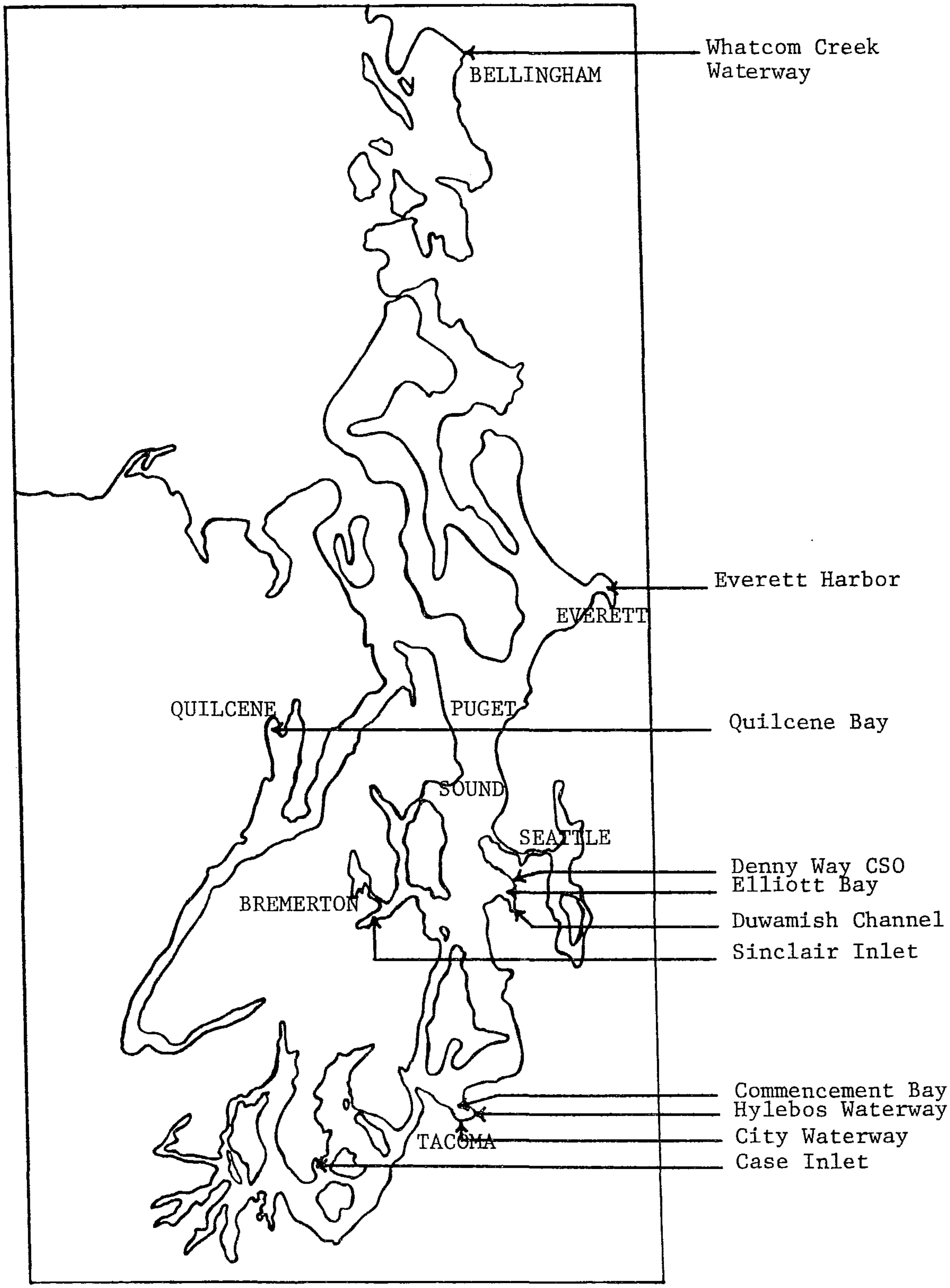

FIGURE 7.1 SAMPLING LOCATIONS IN PUGET SOUND SEDIMENT TOXICITY STUDY

8. RODAC RESEARCH PRIORITIES AND REPORTING FORMATS

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National priorities for 1984-85 ocean dumping research were:

1. quality assurance;
2. sediment transport and/or impact;
3. assessment of disposal options, e.g. capping, landfill;
4. dumpsite selection and assessment; and
5. evaluation of protocols and procedures.

As a complement to these, Pacific Region ocean dumping research priorities for 1985-86 are:

1. marine sediment bioassays,state-of-the-art review;
2. effects of ocean dumping on the egg deposition of commercially important fish species;
3. effects of past and present dumping at the Point Grey dumpsite;
4. protocol development-sediment sample preparation prior to chemical analysis; and
5. effects,on colonization,of "clean material capping" of contaminated sediments.

It is recommended that a consultant interested in submitting a proposal to RODAC discuss the project with a member of the Ocean Dumping Technical Sub-Committee who may act as Scientific Authority for the project if it receives funding. The membership of the Ocean Dumping Technical Sub-Committee, which advises RODAC on the direction of ocean dumping research, is as follows:

Environmental Protection Service	- H. Nelson (Chairman) D. Brothers
Institute of Ocean Sciences	- W. Cretney L. Giovando R. Macdonald J. Thompson C.S. Wong
West Vancouver Laboratory	- C. Levings
Habitat Management Division	- M. Nassichuk M. Flynn

Proposals should be submitted in accordance with the forms presented in Figure 8.1 and should be received by H. Nelson no later than 15 January 1985. The initial screening of the proposals by the Technical Sub-Committee will be completed at a meeting held on 30 January 1985, following which the proposals will be forwarded to RODAC for consideration early in February.

Final submission will be made in late February-early March to the National Research meeting, which allocates research funds to the four regions.

Last year the Ocean Dumping Programme Managers at National Headquarters started a two-phase "Research Roll-up" Exercise. Phase I was an inventory of all research projects funded by RODAC since funding first became available. This amounted to approximately 100 programmes conducted over the last nine years. Phase 2, the results of which are presently in draft form, is the compilation of these studies in a standard format to facilitate comparison. One result of the exercise to date is an as-yet-unofficial, although recommended, standardized reporting format to be followed when submitting reports to RODAC. The suggested format is as follows:

Heading: General classification of subject (i.e. chemical or ecological effects, sampling techniques, dumpsite assessment).

Key Words: Specifies in greater detail the subject of the study.

Reference: Self-explanatory.

Abstract: A brief, general statement of the objectives of the study.

Experimental Information: Provides pertinent details of the experimental method such as:

- concentration of test compounds to be used;
- sampling intervals;
- duration of exposure;
- form of test substance (i.e. organic, inorganic);
- values of pH, temperature, salinity, oxygen, etc.

Sampling Techniques: Statement of techniques used.

Analytical Techniques: Statement of techniques used;
Values of accuracy, precision, detection limit, quantification limit and sensitivity;
Method by which values are determined should be included;
Statement of whether any of the results were confirmed by another method.

Sample Information: Where and when samples were taken;
Number of sites sampled;
Information on replicate and duplicate samples;
Tissue analysed(i.e. muscle or ectoderm);
Dry-weight or wet-weight analysis;
Complete or partial digestion and/or extraction methods;
Weight, condition and life stage of the test organism.

Results: Summary results;
If possible, include overview table of mean result, associated confidence limits, number and type of samples analysed, range and standard deviation.

Conclusions: Conclusions of the study.

Recommendations: Recommendations of the study.

OCEAN DUMPING CONTROL ACT RESEARCH FUND

PROPOSAL SUBMISSION FORM - ______

Department: Region: Date
Service:

Scientific Authority (Responsibility Centre)	Name and Address	Telephone

I - PROPOSAL SUMMARY

Short Title of Project (20 words maximum)

Project Description (250 words maximum)

Starting Date: Duration:

O.D.C.A. Funding:	Year I	Year II	Year III

Proposed Contractor	Name and Address	Telephone

FIGURE 8.1 Proposal submission format.

II - PROPOSAL SPECIFICS

(to be completed in a maximum of 3 pages)

- Objectives (maximum 100 words)
- Project Workplan
- Quality Control
- Expertise of Contractor
- Project Relevance

III - FUNDING 1980 - 81

Estimated total cost of proposal in ______ $ ________

Proposed funding: i) ODCA $ ________ (%)
ii) Responsibility Centre Commitment: $ ________ (%)
iii) Other Sources (specify) $ ________ (%)

[* if multi-year proposal, see note below]

Element of Cost	Contractor	Responsiblity Centre	Other Sources	Total
Salaries	$	$	$	$
Analytical Costs	$	$	$	$
Material & Supplies (expendable/rental)	$	$	$	$
Non-Conference Travel	$	$	$	$
Miscellaneous (specify)	$	$	$	$
TOTAL	$	$	$	$

Note: for multi-year proposal, please provide for each subsequent year the estimated total cost and the proposed funding arrangement

FIGURE 8.1 (cont'd) Proposal submission format.

IV - CONDITIONS GOVERNING SUPPORT

It is agreed that the general conditions as outlined in the "Explanatory Note", re: conditions of support, are hereby accepted by the Scientific Authority.

Signature of Scientific Authority — Date

V - PROPOSAL EVALUATION
(for administrative purposes only)

This proposal has been reviewed at the Regional level, where appropriate

by
Signature of the
R.O.D.A.C. Chairman — Date

FIGURE 8.1 (cont'd) Proposal submission format.

APPENDIX I

LOCATIONS OF PARTICIPANTS 1984

I. Government

CANADA: DFO - Department of Fisheries and Oceans:

Habitat Management Division
Water Quality Unit
1090 West Pender Street
VANCOUVER, B.C. V6E 2P1

South Coast Division
3225 Stephenson Point Road
NANAIMO, B.C. V9T 1T3

IOS - Institute of Ocean Sciences
P.O. Box 6000
SIDNEY, B.C. V8L 4B2

WVL - West Vancouver Laboratory
4160 Marine Drive
WEST VANCOUVER, B.C. V7V 1N6

Environment Canada:

EPS - Environmental Protection Service
Kapilano 100, Park Royal South
WEST VANCOUVER, B.C. V7T 1A2
and
Room 225
Federal Building
WHITEHORSE, Yukon Y1A 2B5

Public Works Canada:

1166 Alberni Street
VANCOUVER, B.C. V6E 3Z3

Ministry of Environment, British Columbia:

Environmental Laboratory
3650 Wesbrook Crescent
VANCOUVER, B.C. V6X 2L2

Marine Resources Branch
Parliament Buildings
VICTORIA, B.C. V8V 1X5

Waste Management Branch
2569 Kenworth Road
NANAIMO, B.C. V9T 4P7

Ministry of Lands, Parks and Housing, British Columbia:

1019 Wharf Street
VICTORIA, B.C. V8W 2Y9

CRD - Capital Regional District:

524 Yates Street
P.O. Box 1000
VICTORIA, B.C. V8W 2S6

U.S.A.: NOAA - National Oceanic and Atmospheric Administration:

Pacific Office
Ocean Assessments Division
7600 Sand Point Way N.E.
SEATTLE, WA. 98115

II. Industry

AMAX of Canada Limited
Box 12525 Oceanic Plaza
Suite 1600 - 1066 West Hastings
VANCOUVER, B.C. V6E 3X1

Analytical Service Laboratories Limited
1650 Pandora Street
VANCOUVER, B.C. V5L 1L6

Arctic Sciences Limited
1986 Mills Road
SIDNEY, B.C. V8L 3S1

B.C. Research
3650 Wesbrook Crescent
VANCOUVER, B.C. V6S 2L2

Can Test Limited
1523 West 3rd Avenue
VANCOUVER, B.C. V6J 1J8

Coastline Environmental Services Limited
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VANCOUVER, B.C. V6J 2C5

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P.O. Box 6500
9865 West Saanich Road
SIDNEY, B.C. V8L 4M7

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10-2614 Bridge Street
VICTORIA, B.C. V8T 4S9

E.V.S. Consultants Limited
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and
2035 Mills Road
SIDNEY, B.C. V8L 3S1

MacLaren Plansearch Incorporated
1100-1140 West Pender Street
VANCOUVER, B.C. V6E 4G1

McLeay, D. and Associates Limited
8320 Rosehill Drive
RICHMOND, B.C. V7A 2J7

Novatec Incorporated
401-2366 Wall Street
VANCOUVER, B.C. V5L 4Y1

Plumper Ocean Projects Limited
319 Stewart Avenue
VICTORIA, B.C. V4R 1R6

Sea-I Research Canada Limited
10992 Madrona Drive (Deep Cove)
P.O. Box 2282
SIDNEY, B.C. V8L 3S8

Seakem Oceanography Limited
2045 Mills Road
SIDNEY, B.C. V8L 3S1

III. <u>University</u>

Department of Biology
University of Victoria
P.O. Box 1700
VICTORIA, B.C. V8W 2Y2

APPENDIX II

OCEAN DUMPING WORKSHOP ATTENDANCE LIST

E.P. Anderson, Edward Anderson Marine Sciences, Victoria, B.C. (604-388-5714)

N.J. Antia, DFO/WVL, West Vancouver, B.C. (604-228-6470)

R. Birch, Arctic Sciences Ltd., Sidney, B.C. (604-656-0177)

D. Bradley, B.C. Research, Vancouver, B.C. (604-224-4331)

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D. Brothers, EPS, West Vancouver, B.C. (604-666-6711)

S. Byers, Environmental Consultant (Polychaete Taxonomist), 6581 Nelson Ave., West Vancouver, B.C. V7W 2A5 (604-921-6944)

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B. Imber, Dobrocky SEATECH Ltd., Sidney, B.C. (604-656-0111)

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C. Kingman, Public Works Canada, Vancouver, B.C. (604-666-3103)

R. Kussat, EPS, West Vancouver, B.C. (604-666-6711)

C.D. Levings, DFO/WVL, West Vancouver, B.C. (604-926-6747)

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E. Long, Ocean Assessments Division, NOAA, Seattle, Washington (206-526-6338)

A.J. Mearns, Ocean Assessments Division, NOAA, Seattle, Washington (206-526-6336)

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R.W. Macdonald, DFO/IOS, Ocean Chemistry, Sidney, B.C. (604-656-8409)

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J.A.J. Thompson, DFO/IOS, Ocean Chemistry, Sidney, B.C. (604-656-8408)

K. Thompson, Seakem Oceanography Ltd., Sidney, B.C. (604-656-0881)

M. Waldichuk, DFO/WVL, West Vancouver, B.C. (604-926-4112)

R. Waters, 891 Seymour Drive, Coquitlam, B.C. (604-461-0563)

K.C. Wiley, MacLaren Plansearch Inc., Vancouver, B.C. (604-684-3216)

S.M. Woods, Sea-I Research Canada Ltd., Sidney, B.C. (604-656-0147)

M. Yunker, Dobrocky SEATECH Ltd., Sidney, B.C. (604-656-0111)

APPENDIX III

1983-1984 CONTRACTS
PACIFIC REGION

1. Use of statistical analyses of large sediment data sets to provide specifications for ocean dumping quality control. $14,000

   Scientific Authority: R.W. Macdonald, DFO /IOS
   Contractor: Dobrocky SEATECH Limited
   DSS File No.: 06SB. FP 941-3-1200

2. Effect of wood wastes on the recruitment potential of marine benthic communities. $15,000

   Scientific Authority: M. Waldichuk, DFO /WVL
   Contractor: E.V.S. Consultants Limited
   DSS File No.: 06SB. FP 941-3-1318

3. Development of fish habitat on dredged material at Campbell River Estuary. $15,000

   Scientific Authority: C.D. Levings, DFO /WVL
   Contractor: Edward Anderson Marine Sciences
   DSS File No.: 06SB. FP 941-3-0179

4. A shipboard method for evaluating the toxicity of dredge-spoils and sediments using micro-organisms. $10,000

   Scientific Authority: N. Antia, DFO /WVL
   Contractor: Atlantic Oceanics Company Limited
   Subcontractor: Seakem Oceanography Limited
   DSS File No.: 03SB.KE603-3-0806

5. Organization of west coast ocean dumping workshop and preparation of workshop proceedings for publication. $ 5,000

   Scientific Authority: A. Cornford, DFO /IOS
   Contractor: Dobrocky SEATECH Limited
   DSS File No.: 06SB. FP 941-3-2244

APPENDIX IV

1984-1985 CONTRACTS
PACIFIC REGION

1. Study of the effects of wood wastes for ocean disposal on the recruitment of marine benthic communities (macrobenthos). $ 7,500

   Scientific Authority: M. Waldichuk, DFO/WVL
   Contractor: Coastline Environmental Services Limited
   DSS File No.: 06SB. FP 941-4-0776

2. An experimental simulation of the release of cadmium and lead from contaminated dredge-spoil in sea water. $22,000

   Scientific Authority: C.S. Wong, DFO/IOS
   Contractor: Seakem Oceanography Limited
   DSS File No.: 06SB. FP 941-4-1832

3. National quality assurance project. $24,000

   Scientific Authority: R.W. Macdonald, DFO/IOS
   Contractors: numerous laboratories
   DSS File No.: numerous

4. Organization of west coast ocean dumping workshop and preparation of workshop proceedings for publication. $5,000

   Scientific Authority: L. Giovando, DFO/IOS
   Contractor: Sea-I Research Canada Limited
   DSS File No.: 06SB. FP 941-4-2409