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BIOLOGICAL COMPARISON OF GRAB SAMPLING DEVICES

Benthic sampling has been the most useful and direct method for evaluating the response of ocean bottom animals to long-term natural or man-induced stress. The populations of invertebrates inhabiting this environment are sensitive to changes in bottom sediment quality and respond through changes in their species composition and relative abundance. An accurate picture of the response of these populations to important environmental gradients requires precisely collected, undisturbed samples.

In December 1974 and March 1975, we conducted a series of tests at sea to compare seven benthic sampling devices used by California investigators. Our objectives were two-fold—to identify the devices that sampled with the least amount of mechanical variability, and to determine which of the samplers collected the most biologically representative sample at each of the stations. Data on the mechanical and operational sampling characteristics of the benthic samplers (presented in last year's annual report) suggested that a 0.1-sq-m chain-rigged Van Veen grab was the most reliable device. This year, we completed analysis of the data; the results, summarized here, indicate that the chain-rigged Van Veen also takes biologically representative samples.

BIOLOGICAL PARAMETERS

Biological descriptions of an area of the bottom are directly dependent upon the numbers and kinds of organisms present in benthic samples. Since the organisms distribute themselves vertically within the sediment as well as horizontally, a knowledge of these natural patterns of distribution is necessary before attempting to evaluate the effectiveness of the various samplers. Ten replicate 0.1-sq-m samples were taken at a shallow sandy station in order to determine the optimum number of replicates or sample size required to adequately describe this station. Vertical distributional patterns were determined through the analysis of benthic core samples taken at three stations, each representing a different sediment type. These core samples (six from each station) were sectioned at depth intervals of 2, 5, 10, 20, and 30 cm, and the organisms present in each of the sub-samples were identified and enumerated. The results of the analyses of these data were combined to determine the numbers of replicates or size of a sample and the depth of penetration required to obtain the species accounting for over 90 percent of the individuals at each station. Additional analyses were made to predict semiquantitatively the combined effects of pressure waves, leakage, and surface disturbance on the organisms sampled. On the basis of these results, certain criteria were formulated and used in selecting our "ideal" biological sampling device.

SIZE OF BOTTOM AREA SAMPLED AND REPLICATION

We found that horizontal patterns of distribution influenced the numbers and kinds of organisms to a greater extent than vertical distributional patterns, whereas vertical distributional patterns (Figure 1) were more influential than the combined effects of the range of pressure waves, leakage, and sediment disturbance experienced in the tests. Our analysis of the data on replication led to several conclusions. One common method of determining the number of replicates needed to adequately describe a benthic station is to continue sampling until the asymptotic point for the addition of new species has been reached. Upon using this means of analysis, we found that, even after ten replicate 0.1-sq-m samples had been collected, the asymptotic point had not been reached (Figure 2). However, adequate descriptions of benthic stations contain estimates of population size for the various species as well as a species list. In light of this, we performed additional analyses of the relative abundance of the species added by each replicate; this work showed that an average of 90 specimens were collected in each replicate, and an additional replicate added an average of 20 individuals representing new species, or about 10 percent of the total number of specimens collected by both replicates (Figure 2).

Sophisticated analytical techniques (e.g.. Smith and Greene, in press), in which species or stations are clustered together based upon their relative similarities, are only sensitive to those species that account for 90 to 95 percent of the total number of individuals sampled. Since the second replicate only yields species accounting for 10 percent of the fauna, it would appear that, for most purposes, a single sample or at most two will account for the majority of the fauna occurring at this type of station. It can be seen from these two types of analysis that vastly differing conclusions pertaining to the number of replicates required to describe a benthic station can be reached, but it was our opinion that useful descriptive information can be obtained with single 0.1-sq-m benthic samples.

DEPTH OF PENETRATION

Three stations were sampled to determine the vertical stratification of organisms within the sediment. These stations varied in sediment types, from

17 percent silt and clay to 41 percent, and in sampling depths from 12.5 to 260 meters, respectively. In general, we found that, although organisms burrowed more deeply within the finer sediments, about 90 percent of the species and individuals were present in the upper 10 cm of sediment at all stations sampled (Figure 1).

We also found that two groups of organisms, microcrustacea and molluscs, were predominantly present in the upper 2 cm of sediment. These organisms were positioned near the surface of the sediment and would thus be more likely to be lost in sampling when the sediments were disturbed by the pressure waves created by the sampler in descent. The relative density or mass of these two groups of organisms poses some interesting analytical possibilities. The microcrustacea are, as a group, less dense than mollusks and as such are more susceptible to loss resulting from pressure waves or leakage from the sampler, especially after the disturbance created by certain sampling procedures. We determined the relative number of microcrustacea and molluscs collected by different sampling devices at the same station, and compared the results with qualitative estimates of leakage, pressure effect, and sediment disturbance based on our observations. A comparison of this type is unique and as such may be subject to future modifications; however, the results supported the expected trends reflected in the qualitative physical sampling estimates, as shown in Table 1. This table shows that those samplers (Shipek, Van Veen No. 1, and Orange peel) that we estimated to have the greatest combined amounts of surface disturbance, leakage, and pressure waves also yielded samples with the lowest microcrustacea-to-mollusc ratio. In contrast, samples taken with the Ponar, box corer. Van Veen No. 2, and Smith-Mclntyre, which had higher microcrustacea-to-mollusc ratios than those taken with the other devices, also were estimated to have undergone relatively little change as a result of the physical functioning of the sampler.

BIOLOGICAL CRITERIA FOR SAMPLER

The ideal benthic sampler should meet the following criteria:

- The sampler should repeatedly sample the same amount of surface area.
- The sampler should penetrate to a depth within the sediment beyond that in which a minority of species or specimens occur. (In our study, we found that penetration of 10 cm would account for a minimum of 95 percent of the species and 90 percent of the individuals in Santa Monica Bay.)
- The sampler should minimize the effect of pressure waves.
- The sampler should close tightly.

Table 2 lists these criteria as well as several mechanical considerations and shows our rating of the seven devices tested. On the basis of these data, we have concluded that the chain-rigged Van Veen grab, modified to minimize pressure waves, is the most reliable and effective of the devices.

It also appears that, at shallow sandy stations such as the station used for our test in Santa Monica Bay, it is possible to collect those species accounting for 90 percent of the individuals with a single sample—or at most, two—from a 0.1-sq-m sampler. Replication studies in other sediment types are needed.

REFERENCES

Barnard, J.L., 0. Hartman, and G.J. Jones. 1959. Benthic biology of the mainland shelf of southern California. In Oceanographic survey of the continental shelf area of southern California, pp. 265-429. California State Water Poll. Control Bd. Publ. 20.

Smith, R.W., and C.S. Greene. Patterns in biological communities in an area of wastewater discharge. J. Water Pollut. Control Fed., in press.

Table 1. Comparison of grab samplers based on ratios of microcrustacea catch to mollusk catch and estimates of the amount of disturbance of the samples caused by the mechanical functioning of the device. The ratios have been ranked, with 1 representing the lowest and 5 the highest. The estimates have also been ranked, with 1 representing the greatest leakage, pressure wave, and disturbance of surface sediments and 5 representing little or no effects from these factors. The number preceding the slash is the ratio rank, the number following the slash is the mechanical functioning rank.

	December 74			March 75	
Device	Silty Sand	Sandy Silt	Clayey Silt	Silty Sand	Clayey Silt
Ponar	5/4	5/4	5/5	NT*	NT
Box corer	4/5	4/5	4/4	NT	NT
Shipek	3/3	2/2	2/2	3/4	3/4
Van Veen 1	2/2	3/3	3/3	NT	NT
Orange peel	1/1	1/1	1/1	NT	NT
Smith-McIntyre	NT	NT	NT	4/5	4/5
Van Veen 2	NT	NT	NT	5/5	5/5

*NT = Not tested during this cruise.

Table 2. Criteria for a grab sampler and ratings of seven samplers commonly used off southern California.

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Criteria	Van Veen 2	Smith-McIntyre	Ponar	Van Veen 1	Shipek	Orange Peel	Box Corer
Little or no variation in amount of surface area sampled	Good	Good	Good	Good	Poor	Poor*	Good
Penetration to 10 cm	Good	Good	Poor	Good	Poor	Good	Good
Minimal amount of leakage	Good	Good	Good	Poor	Poor	Poor	Good
Little or no pressure wave created in descent	Good	Good	Good	Poor	Poor	?	Good
Low percentage of error resulting from variations in surface area covered or depth of penetration	Good ≥5%	Good, ≥6%	Poor, 5-55%	Fair, 0-23%	Poor, 7-44%	Poor, ≥62%	Good, 0
Few operators required	Fair, 2	Fair, 2-3	Good, 1	Fair, 2	Good, 1	Good, 1	Poor, 3
High percentage of success in capturing samples	Good, 100%	Fair, 63-80%	Fair, 77-100%	Good, 100%	Poor, 20-100%	Poor, 48-100%	Good, 100%

*Barnard et al. (1959) state that area sampled with this device may vary as much as 50%.

Figure 1. Percent of total benthic infauna species and individuals captured with increasing depth of penetration into sediments. Data from box corer samples.

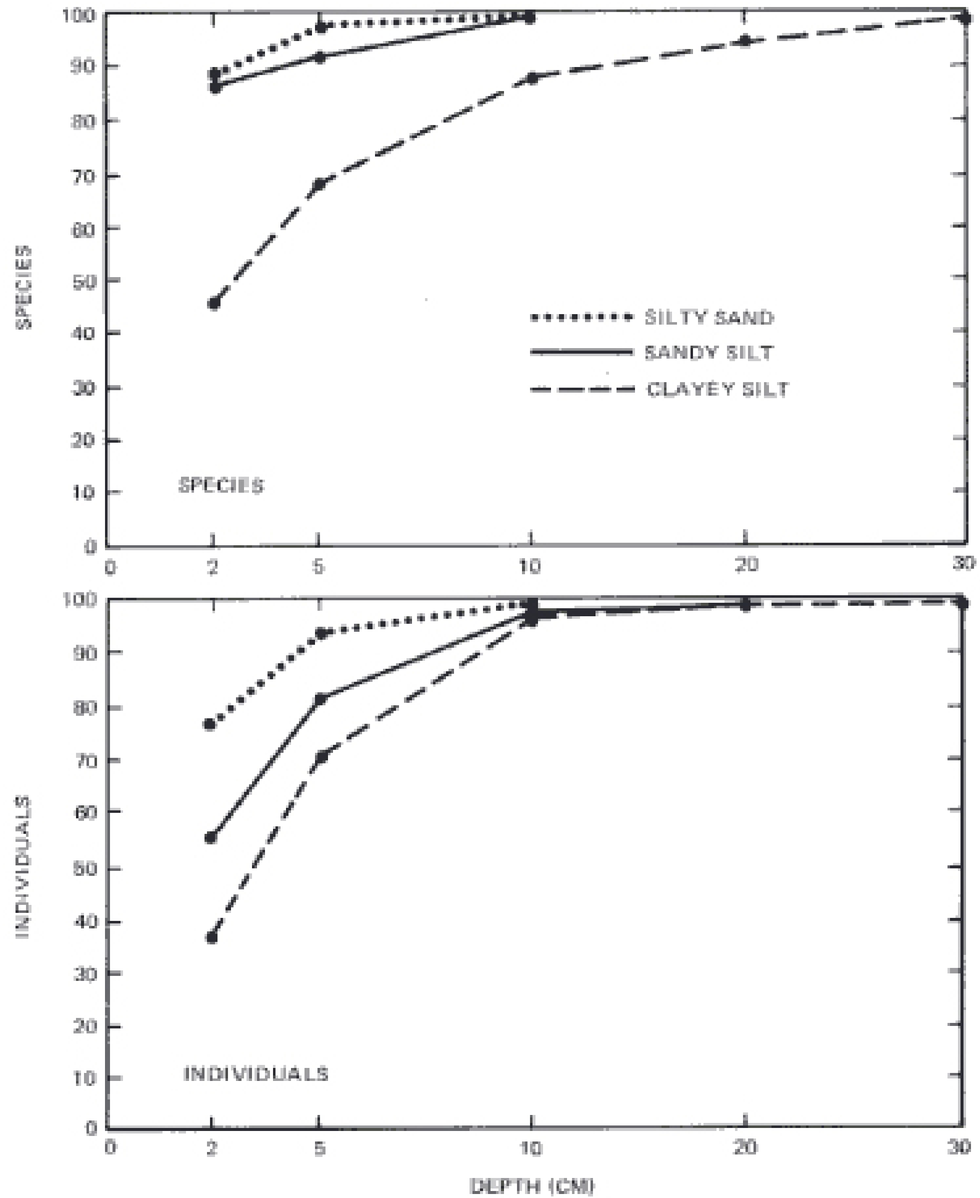

Figure 2. Cumulative species curve and percentage of individuals accounted for by the newly acquired species collected by each of ten 0.1-sq-m replicates.