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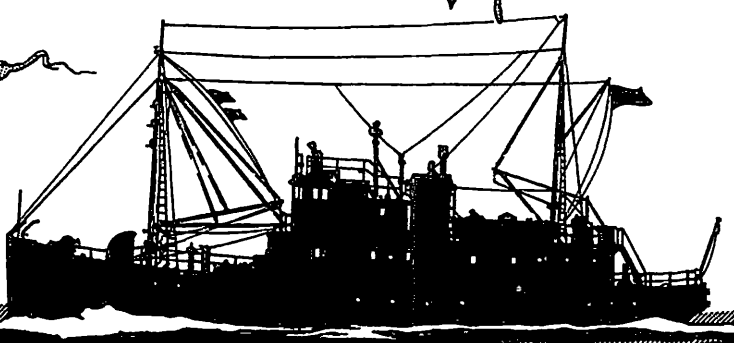

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DIGGING CHARACTERISTICS AND SAMPLING EFFICIENCY OF THE 0.1 m^2 VAN VEEN GRAB, by Ulf Lie and Mario M. Pamatmat. Limnology and Oceanography, 10(3):379-384. 1965.

Technical Report No. 166

GRAVITATIONAL CIRCULATION IN STRAITS AND ESTUARIES, by Donald V. Hansen and Maurice Rattray, Jr. Journal of Marine Research, 23(2):104-122. 1965.

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Made in United States of America
Reprinted from LIMNOLOGY AND OCEANOGRAPHY
Vol. 10, No. 3, July 1965
pp. 379–384

DIGGING CHARACTERISTICS AND SAMPLING EFFICIENCY OF THE 0.1 m^2 VAN VEEN GRAB

BY ULF LIE AND MARIO M. PAMATMAT

DIGGING CHARACTERISTICS AND SAMPLING EFFICIENCY OF THE 0.1 m² VAN VEEN GRAB[1]

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ABSTRACT

Replicate samples were collected with a 0.1 m² van Veen grab during high tide and by hand-digging during low tide on an intertidal sandflat. The volume of sediment in the grab samples was measured; the coefficient of variation from replicate series varied from 7.4 to 20.3%, with a mean for all stations of 13.4%. Digging characteristics of the grab were studied by SCUBA-divers under water, and by an experiment on a sandy beach. It was concluded that the jaws approached each other horizontally when closing rather than digging a semicircular cut. The shock-wave of the grab appeared to be negligible for the infauna included in this study.

Sample counts for the most abundant species obtained by digging and with the grab were compared. In only 8 out of 37 cases was there a significant difference between the two sets of samples. The vertical distribution of the fauna in the substrate in terms of numbers and biomass was studied.

INTRODUCTION

In using grab samplers for assessing benthic populations it is often assumed that the grabs catch all the animals under the surface area covered by its jaws. Experience with the 0.1 m² van Veen grab led to tests of its effectiveness.

Earlier criticism of the use of grabs for evaluating benthos was made by Lindroth (1935). From theoretical considerations rather than actual observations, he stated that severe sampling errors were introduced by the shock-wave of the grab which might push away a part of the fauna; further, he suggested that the semicircular cut into the bottom prevents digging to the same depth below the entire area enclosed by the jaws, and finally, that animals could be lost by leaking out between the jaws of the grab when closing.

Studies of the van Veen grab relative to other gears have been made (Thamdrup 1938; Ursin 1954; McIntyre 1954, 1956), but only Birkett (1958) studied in detail the sampling deficiencies of the van Veen grab itself. He also assumed that the grab made a semicircular cut into the bottom and that the deepest penetration of the grab was the greatest depth of sediments inside the grab when brought onboard ship. The efficiency of the grab was defined as the ratio between the volume of sediment sampled by the grab and the theoretical volume calculated by multiplying the unit area of the grab by the deepest penetration. Birkett found the efficiency to be low and concluded that the sampling would be different for animals inhabiting different depths in the substrate. Reports of numbers or weights per unit area would therefore be valid only for the animals inhabiting the uppermost layer of the sediments. Birkett suggested unit volume to be more meaningful than unit area. Without rejecting the conclusions concerning the digging characteristics of the grab, Longhurst (1959, p. 12) argued that the use of unit volume instead of unit area "appears to pose at least as many problems as it solves."

The previous works on gear comparisons and Birkett's on the digging characteristics of the van Veen grab do not answer the more important question of how effectively the grab captures all the animals actually present under the surface area covered by the jaws. We tried to solve this problem by comparing samples taken with

[1] Contribution No. 345 of the Department of Oceanography, University of Washington. This investigation was supported in part by U.S. Public Health Service Grant GM 10817 from the Division of General Medical Sciences to K. Banse and U. Lie, and by a U.S. Public Health Service Predoctoral Fellowship to M. M. Pamatmat. Ship time was obtained from the Office of Naval Research Contract Nonr-477(10), Project NR 083 012.

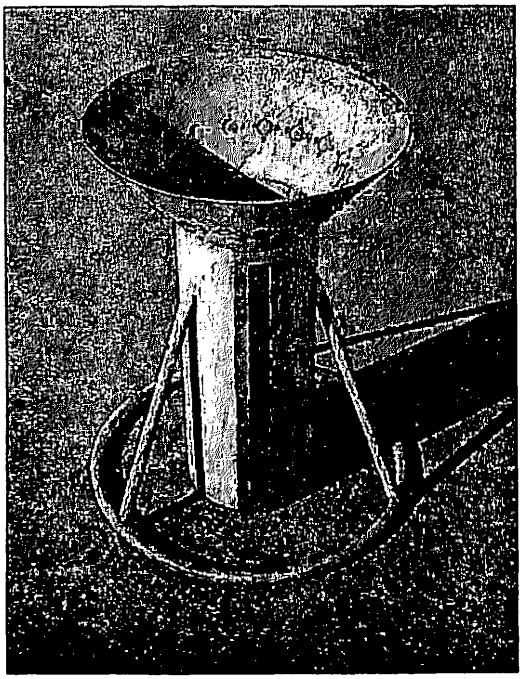

FIG. 1. Sediment measuring device. Metal cylinder graduated in liters with a Plexiglas window.

a 0.1 m^2 van Veen grab at an intertidal sandflat during high tide with samples of the same unit area obtained by hand-digging during low tide.

The authors express their thanks to Mr. Joseph R. Kelsey for help on the cruises and for weighing the material, to Mr. Charles L. Angell, Mr. Richard Petersen and Mr. John Jackson for sorting of samples, and to Dr. Karl Banse and Mr. Robert T. Cooney for the identification of the polychaetes.

MATERIALS AND METHODS

These results are based on 73 samples collected on 18–20 July 1963 at three stations (No. 1–3) and 84 samples on 13–15 May 1964 at three other stations (No. 4–6) in False Bay, San Juan Island, Washington.

The stations were selected on the basis of datum level and compactness of the sediments and to study the efficiency of the van Veen grab at stations with different environmental conditions and presumably different faunas. Stations 1, 4, and 6 were located at a sandbar at the mouth of the bay, Station 5 in a channel near the mouth of the bay, Station 2 at a sandbar in the middle of the bay, and Station 3 at the head of the bay. The stations were marked with stakes visible above the water during high tide when sampling with a 40-kg 0.1 m^2 van Veen grab was done. The ship was anchored during the grab sampling and six samples were collected at each station. The contents of the grab were washed into a measuring device (Fig. 1) where the sediment was allowed to settle for about 5 min before the volume was measured. Water depths during sampling varied from 1–2 m.

During low tide, another six samples were hand dug. A quadrat marker (0.1 m^2 steel frame, 35 cm deep) was pushed into the sand to prevent the sand from caving into the holes; the enclosed sediment was removed by layers. At Stations 1, 2, and 3, the layers sampled were from 0–2 cm and 2–4 cm, and from 4 cm to the deepest penetration of the quadrat marker. At Stations 4 and 6, samples were taken from 0–2 cm, 2–4 cm, from 4 cm to the average depth of penetration of the grab at the station, and from the latter depth to 25 cm. At Station 5, located in a channel, only the layers 0–2, 2–4, and 4–6 cm were sampled.

At Stations 2 and 3, the grab samples were inadvertently taken in or near the channels surrounding the sandbar where the hand-digging was done. The two sets of samples could not therefore be expected to represent the same populations; the samples revealed large differences in total number and species composition between the sets. The material from Stations 2 and 3 was not used for the study of the sampling efficiency of the van Veen grab, but only for the digging characteristics of the grab.

At Station 1, the samples dug by hand were located close to the depressions made by the grab. At Stations 4, 5, and 6, a numbered brick was dropped on the bottom beside the grab before it was hauled onboard, making it possible to take the hand dug sample close to the depression

TABLE 1. *Volumes of sediment in liters of replicate samples with the 0.1 m² van Veen grab at six stations in False Bay*

Samples	Stations					
	1	2	3	4	5	6
a	6.5	3.3	7.0	11.0	6.0	5.5
b	6.5	5.0	5.3	11.0	6.5	5.0
c	7.0	4.5	4.7	11.0	6.0	7.5
d	6.5	3.0	7.0	10.5	6.7	7.5
e	6.5	3.0	6.4	9.0	6.5	7.8
f	5.0	4.0	6.5	10.5	8.0	6.8
g	—	3.5	—	—	—	—
$\bar{X}$ (1)	6.33	3.76	6.15	10.50	6.61	6.70
SD (1)	0.6826	0.7615	0.9434	0.7747	0.7362	1.1690
$V = \frac{100\ \text{SD}}{\bar{X}}$	10.8%	20.3%	15.5%	7.4%	11.2%	15.1%

made by its correspondingly numbered grab sample to give pairs of samples.

The samples were sieved through a 1 mm screen, preserved in 5% neutralized formalin and sorted in the laboratory.

Species of Polychaeta, Crustacea, Lamellibranchiata, and Echinodermata were identified as thoroughly as possible and counted. Specimens of the polychaete families Spionidae and Capitellidae were not counted in the samples from Stations 1–3.

The significance of the difference between the numbers of the numerically dominant species obtained by the two methods of sampling was tested by a Student's "t" test on log-transformed data. The test for independent data was made for the material from Station 1, while the different sampling method for Stations 4–6 required the "t" test for nonindependent data (Croxton 1959).

REPEATABILITY AND DIGGING CHARACTERISTICS OF THE VAN VEEN GRAB

One of the criticisms of the evaluation of benthos from replicate grab samples is the large sampling variation between replicates; that is, the grab has a low repeatability, as found by recording faunal indices in replicate samples. However, besides the deficiency of the grab itself, any patchiness of the fauna will affect the repeatability of the results. To exclude the effect of patchiness, we have evaluated the grab's repeatability by using the sediment volume in replicate samples. Thirty-seven samples from the six stations have been used (Table 1).

The differences in mean volume between the stations reflect differences in sediment composition and compaction. Because of the horizontal cut of the grab (*see* below), 1 liter of sediment is equivalent to 1 cm penetration of the grab.

The coefficient of variation between replicate samples varied from 7.4 to 20.3%, with a mean for all stations of 13.4%. This variation in volume probably reflects the variation in penetration of the grab, corresponding to a range from 0.7 to 1.2 cm from the mean depth of penetration. Therefore, an average variation of 13.4% in faunal indices was expected solely from the error introduced by the variability of the grab. However, as the sampling variation caused by the depth of penetration occurs at the deepest layers sampled and where the faunal density is considerably lower than in the upper layers, the sampling variations for faunal indices were probably considerably lower than 13.4%.

The alleged semicircular cut of the grab has been believed to introduce bias, because it would result in a depth-differential effect (Longhurst 1959) in sampling animals inhabiting different layers of the substrate. However, the depressions left by the grab in the sand on the intertidal sandflat in False Bay had vertical sides and the bottom of the depressions was flat or

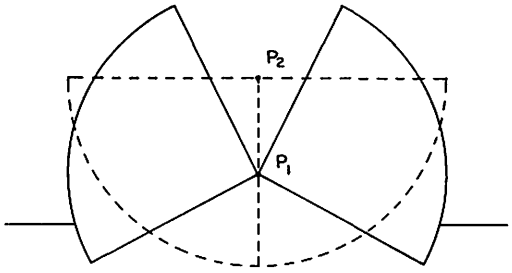

FIG. 2. van Veen grab on the bottom before and after closing. The distance P_1–P_2 indicates the raising of the pivot point.

curved upwards rather than downwards. Skin divers observed the grab as it closed and noted that the grab penetrated the bottom to a certain depth on impact and then the jaws closed horizontally. They found that the pivot-point of the jaws (Fig. 2) was raised during closing, which would not happen if the grab made a semicircular cut. To study the raising of the pivot-point more closely, six samples were taken with the 0.1 m^2 van Veen grab on a sandy beach. The grab was dropped from about 75 cm onto the sand and the depth of penetration and the distance of the pivot-point from the sand was measured. The grab was then closed by pulling the warps, and the pivot-point's new distance from the sand was measured. If the jaws had approached each other horizontally, the pivot-point would have been raised exactly 13 cm. In all our samples the point was raised from 13 to 14 cm. From these observations, together with the visual observations of the depressions, we concluded that the van Veen grab, under ideal sampling conditions, makes a horizontal rather than a semicircular cut on a sandy substrate. Therefore, it is most useful to express faunal indices of benthos per unit area rather than unit volume.

When the grab is used on muddy bottom, the depth of penetration is considerably deeper than on sand, and sufficiently deep to catch the majority of the fauna, and it is therefore immaterial whether the cut is horizontal or semicircular. It is important that the grab be lifted carefully because it tends to leave a part of the sediment if it is jerked from the bottom.

The effect of the shock-wave as a source of error in grab sampling was not studied, but some indications of this effect may be arrived at indirectly. The number of specimens of the various species was rarely lower and usually higher in the grab samples than in the hand dug samples (Table 2). Especially in the case of *Transennella tantilla* this may be indicative of the small effect, if any, of the shock-wave. *T. tantilla* is a small lamellibranch always present in greatest abundance in the uppermost 1-cm layer of the substrate. A strong shock-wave would give considerably lower figures for the grab samples than for the hand dug samples. This was not the case, suggesting that the effect of the shock-wave is negligible for real infauna but may be substantial for the sampling of hyperbenthos or animals inhabiting the interface between the sediment and the water.

SAMPLING EFFICIENCY OF THE 0.1 M^2 VAN VEEN GRAB

The comparison of the catching power of the two methods of sampling is based on the assumption that both gears are sampling the same populations. However, the composition of the fauna is different and considerably poorer at the sandbars than at the nearby channels. The validity of our comparison will then depend on how closely together the two series of samples from each station were taken. The method of sampling at Stations 4, 5, and 6, and possibly at Station 1, ensured that the two series of samples were taken closely together and, accordingly, that the same population was sampled with both methods.

There are 37 pairs of means of abundant species from these stations, eight pairs of which are significantly different at the 95% level (Table 2).

Sample counts from Stations 4, 5, and 6 indicate that some of the species, especially Crustacea, either actively migrate with a tidal rhythm or are passively transported by the tidal currents. This would be an-

other source of error in our comparison, and the results for species that are not transported by tidal currents and do not migrate should be emphasized. Such species are the deep-digging polychaete *Lumbrinereis zonata* and the amphipod *Paraphoxus tridentatus*, the two small clams, *Transennella tantilla* and *Mysella tumida*, and the holothurian *Leptosynapta clarki* that is sufficiently deep-burrowing not to be washed away by the current and incapable of making large migrations. In considering the above species, three of the 19 means are significantly different (Table 2). At Station 1, *Lumbrinereis zonata* was present in significantly higher numbers in the hand dug samples. However, if the specimens found deeper than the depth of penetration of the grab were excluded, the difference was no longer significant. *Leptosynapta clarki* at Station 1 and *Paraphoxus tridentatus* at Station 5 were present in significantly higher numbers in the grab samples, a fact that can only be explained by assuming extreme patchiness of the species.

So far, the grab samples reaching to about 4–10 cm have been compared with hand dug samples of 25–35 cm. The results imply that the majority of the fauna must be in the upper layers of the sediments. The fraction of the number of specimens found in the upper 4 cm compared with the total number of specimens found down to 25–35 cm at each of the stations was: Station 1: 88%; Station 2: 56%: Station 3: 67%; Station 4: 87%; Station 6: 58%.

A relatively high fraction of the fauna at Stations 2, 3, and 6 was found below 4 cm. These stations were located at sandbars that were exposed during low tide considerably longer than Stations 1 and 4 (at a sandbar at the mouth of the bay). As a result, the numbers of fauna at the former stations were considerably smaller than those at Stations 1, 4, and 5, while the relative proportion of the deep-digging species was accordingly higher. At Station 5, as stated above, hand-digging could not be made deeper than 6 cm, but the relative density of the fauna in the 0–2-cm layer, compared with that of the 4–6-cm layer, is even more pronounced than at Stations 1 and 4. Stations 1, 4, and 5 are more comparable to a subtidal environment than are Stations 2, 3, and 6. We suggest that more than 90% of the fauna live in the bottom layer, which is representatively sampled by the grab in subtidal waters. The fraction of the biomass is considerably lower, because the deep-dwelling animals tend

TABLE 2. *Mean number of important species at four stations in False Bay taken in six replicate samples at each station by both hand-digging and with a 0.1 m² van Veen grab*

Station	Species	Hand-digging	van Veen grab	Significance of difference
1	*Lumbrinereis zonata*	38.2	10.5	+
	Leptochelia dubia	135.3	186.7	–
	Paraphoxus spinosus	129.8	108.7	+
	Paraphoxus tridentatus	13.7	12.0	–
	Calliopius sp.	9.3	10.8	–
	Synchelidium shoemakeri	5.7	3.2	–
	Protomedeia articulata	7.8	5.0	+
	Transennella tantilla	20.3	30.5	–
	Mysella tumida	23.3	24.0	–
	Leptosynapta clarki	83.0	119.5	+
4	*Lumbrinereis zonata*	6.8	9.5	–
	Spionidae indet.	50.3	38.0	–
	Paraphoxus spinosus	96.5	236.3	+
	Paraphoxus tridentatus	5.8	7.7	–
	Anisogammarus confervicolus	86.2	107.3	–
	Transennella tantilla	3.2	1.9	–
	Mysella tumida	5.2	7.2	–
	Leptosynapta clarki	5.8	10.3	–
5	*Lumbrinereis zonata*	16.0	27.3	–
	Axiothella rubrocincta	13.2	14.3	–
	Spionidae indet.	615.7	357.8	+
	Paraphoxus spinosus	144.3	162.0	–
	Paraphoxus tridentatus	15.5	31.2	+
	Anisogammarus confervicolus	61.5	122.2	–
	Pontogeneia rostrata	70.5	89.8	–
	Epinebalia pugettensis	22.0	31.7	–
	Leptochelia dubia	38.0	45.6	–
	Transennella tantilla	10.0	11.3	–
	Mysella tumida	17.0	18.2	–
	Leptosynapta clarki	76.8	106.7	–
6	*Lumbrinereis zonata*	25.3	24.3	–
	Spionidae indet.	5.3	4.5	–
	Paraphoxus spinosus	9.8	30.7	+
	Anisogammarus confervicolus	4.7	9.2	–
	Transennella tantilla	4.0	4.5	–
	Mysella tumida	2.3	2.8	–
	Leptosynapta clarki	8.3	10.2	–

to be larger than those near the surface. At Station 4, only 33% of the biomass was found in the upper 4 cm, but 80% was above the depth of penetration of the grab—10 cm. Considering also the vertical distribution of biomass in the 0–2, 2–4, and 4–6-cm layers at Station 5, we would suggest that at least 50% of the biomass of the fauna is found in the upper 4 cm of the substrate in subtidal water. The dominance of the fauna of the upper strata of the bottom in the subtidal water is well known (Johansen 1927; Molander 1928; Sanders 1960; Jones 1961), but the dominance has always been found in terms of numbers.

The data from False Bay indicate that the 0.1 m^2 van Veen grab is efficient in sampling the benthos and will give good replication if it is skillfully handled, if the ship is anchored, and if the weather is not too bad.

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