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SAMPLING EFFICIENCY OF THE PONAR GRAB IN TWO DIFFERENT BENTHIC ENVIRONMENTS

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ABSTRACT. Numbers of benthic organisms collected with the Ponar grab were compared to numbers in diver-collected cores in a nearshore, sandy habitat in Lake Michigan, and to numbers in box cores taken with a manned submersible in a deep, silty habitat in Lake Superior. The Ponar underestimated benthic abundances at both sampling sites. Ordered from most to least efficiently sampled were sphaeriids, Pontoporeia, *oligochaetes, and chironomids; overall mean abundances in core samples were 1.5, 1.7, 3.4, and 11.3 times greater than abundances in Ponar samples for the four groups. The extent by which abundances were underestimated was remarkably similar at the two sampling locations. This would indicate that underestimates are consistent, thus allowing appropriate correction factors to be applied if absolute abundances are required for a particular study. Total biomass in the box core samples was 1.7 times greater than in the Ponar samples.*
ADDITIONAL INDEX WORDS: Sediment sampler, cores, benthos, bottom sampling.

INTRODUCTION

The Ponar grab was developed in the mid-1960s (Powers and Robertson 1967) and has since become the most widely used benthic sampler in the Great Lakes. The popularity of the Ponar can be attributed to several advantages over other benthic sampling devices: it can collect samples in hard as well as soft sediments, is dependable even under rough conditions, functions consistently in deep water, and is safe and simple to use. In comparative trials with coring devices and other grabs, the Ponar has proven to be the most effective sampler over the widest range of substrate types and conditions (Powers and Robertson 1967, Sly 1969, Flannagan 1970, Hudson 1970, Elliott and Drake 1981). Yet, although considered the best all-around device for benthic sampling in the Great Lakes, it is doubtful whether the Ponar provides a true estimate of benthic populations. For instance, the Ponar collected significantly fewer oligochaetes and chironomids when compared to diver-collected cores in Lake Winnipeg (Flannagan 1970) or when compared to the Ekman grab in the soft sediments of Green Bay (Howmiller 1971). The inefficiency of the Ponar in these comparative trials can likely be attributed to the creation of a shock wave as it is lowered. The Ponar has a fine screen (0.5-mm mesh) on top of its jaws which likely impedes water flow; divers have confirmed that the Ponar blows away surface sediment just before it hits the bottom (Flannagan 1970). Yet, although not ideal, the screen on top of the Ponar's jaws represents a vast improvement over the solid jaw construction of the previously used Petersen and orange-peel grabs.

Considering the advantages of the Ponar, it may not be important if abundances are underestimated as long as underestimates are consistent and only relative abundances are desired. However, when absolute abundance or biomass estimates are required, the Ponar would be inappropriate unless the extent of underestimates are known, allowing appropriate correction factors to be applied. As noted, a number of studies have evaluated the efficiency of the Ponar grab relative to other sampling devices, but only Flannagan (1970) has evaluated the Ponar's ability to provide an unbiased estimate of benthic populations.

In this study, we evaluated the absolute sampling efficiency of the Ponar in two entirely different benthic environments in the Great Lakes. We were particularly interested in evaluating the Ponar's efficiency in capturing *Pontoporeia hoyi*, the dominant benthic invertebrate in the upper Great Lakes and an important organism in energy flow and nutrient transformations through the benthic system (Gardner *et al.* 1985). The first sampling site, consisting of nine stations, was in a shallow (11–23 m) nearshore area of Lake Michigan where sediments consisted of fine to medium sands. Ponar samples here were compared to core samples taken by divers using SCUBA. The second site was a relatively deep (125 m) offshore station in Lake Superior where the predominant substrate was silt. Ponar samples here were compared to box core samples taken with a manned submersible.

METHODS

The study area in Lake Michigan was near the mouth of the Grand River in the southeastern end of the lake. Five stations were located at 11 m (Stations 1, 4, 5, 6, 7), two at 17 m (Stations 8, 10), and two at 23 m (Stations 11, 13). Exact station locations and further descriptions of the benthic environment are given in Nalepa and Quigley (1983). Benthic samples were taken monthly from May to November 1976. Three Ponar samples and four SCUBA cores were normally taken at each station on each sampling data. The core tubes were 23 cm long and 5 cm in diameter, and were forced 7–12 cm into the sediment. All samples were washed through a U.S. Standard #30 screeen (595-μm openings) and then preserved in 10% buffered formalin containing rose bengal stain.

The sampling site in Lake Superior was located in the Ile Parisienne basin of Whitefish Bay (N 46 42.8′ W 87 47.2′). Ten Ponar samples and five box core samples were taken in July 1986. The Ponar samples in Lake Superior, as those in Lake Michigan, were taken off the *R/V Shenehon*. The grab was lowered at a constant rate of 0.5 m/s at both sites. Box core samples in Lake Superior were taken 1 week later from the same site using the manned submersible *Johnson-Sea-Link II*. The box corer sampled an area 13.8 cm × 13.8 cm. The corer was slowly placed into the sediments by the submersible's mechanical arm. Three of the samples were collected on a morning dive and two on an afternoon dive. All samples were immediately washed through a U.S. Standard #35 screen (500-μm openings) and preserved as above.

Residue from the samples was placed in a white enamel pan and the organisms were picked and sorted into four major groups (*Pontoporeia*, oligochaetes, sphaeriids, and chironomids) under a 2x lamp-magnifier. When the number of organisms was extremely large, the sample was split using a Folsom plankton splitter. Organisms were identified to the lowest practical taxonomic level.

Biomass estimates (ash free dry weight) were obtained for the Lake Superior samples only. Lengths of *Pontoporeia*, oligochaetes, and chironomids were measured and converted to weights using determined length-weight relationships (Nalepa and Quigley 1980, 1981). Weights of sphaeriids in a particular sample were determined directly by drying at 60°C for 48 h and then ashing for 1 h at 500°C.

In nearshore Lake Michigan, differences between the Ponar and diver-collected cores were tested using the t-test for paired comparisons (Sokal and Rohlf 1969). The abundance of each major group was averaged over all sampling dates and then paired over the nine stations to test for differences. Since only one site was sampled in Lake Superior, differences between sampling techniques were tested using the standard t-test after the data were transformed (log x + 1). The Lake Michigan data were not transformed since the t-test for paired comparisons does not have the normality and equality of variance assumptions of the standard two-sample t-test.

RESULTS AND DISCUSSION

The Ponar underestimated abundances of all four major benthic groups. In nearshore Lake Michigan, these underestimates were significant ($P < .05$) for *Pontoporeia*, oligochaetes, and chironomids, while in offshore Lake Superior, underestimates were significant for the former two groups only (Table 1). Ordered from most to least efficiently sampled by the Ponar at both locations were sphaeriids, *Pontoporeia*, oligochaetes, and chironomids. In Lake Michigan, mean abundances in diver's cores were 1.5, 1.6, 2.1, and 13.5 times greater than abundances in the Ponar samples for the four groups; similarly, in Lake Superior, abundances in box core samples were 1.4, 1.8, 4.7, and 9.0 times greater than abundances in the Ponar samples.

As discussed by Howmiller (1971), whether or not a benthic group is efficiently sampled by the Ponar grab depends on both the vertical distribution of the particular group and its relative size (or weight). Small organisms occurring at the sediment surface would be the most influenced by the Ponar's shock wave. Although sphaeriids and *Pon-*

TABLE 1. Mean abundance (number per square meter) of each benthic group collected with Ponar grab, diver's cores, and box corer in Lake Michigan (LM) and Lake Superior (LS). Differences between sampling methods in Lake Michigan were tested using the paired t-test on the core/Ponar ratio for each station, while differences in Lake Superior were tested using the standard t-test on log (X + 1) transformed values.

		Sphaeriidae		Pontoporeia		Oligochaeta		Chironomidae	
Station	Depth (m)	Diver Cores	Ponar	Diver Cores	Ponar*	Diver Cores	Ponar*	Diver Cores	Ponar*
LM-1	11	680	330	1,910	570	8,360	2,030	1,080	30
LM-4	11	1,370	1,160	360	910	12,180	4,120	1,630	200
LM-5	11	1,150	1,090	2,010	1,800	11,480	5,560	360	70
LM-6	11	1,150	980	2,870	1,620	4,720	2,160	520	40
LM-7	11	1,020	910	1,520	1,190	2,880	2,670	580	120
LM-8	17	3,610	1,700	6,370	4,140	8,140	3,660	160	50
LM-10	17	2,040	730	6,060	2,830	4,390	1,960	460	20
LM-11	23	2,100	1,980	7,920	6,170	2,410	3,110	1,030	50
LM-13	23	1,450	1,420	6,080	3,730	3,320	2,920	360	50
Core/Ponar Ratio		1.5 ± 0.2		1.6 ± 0.3		2.1 ± 0.4		13.5 ± 3.7	
		Box Corer	Ponar	Box Corer	Ponar*	Box Corer	Ponar*	Box Corer	Ponar
LS-1	125	320	230	2,240	1,212	1,820	390	180	20
Core/Ponar Ratio		1.4		1.8		4.7		9.0	

* Samplers significantly different at .05 level.

toporeia were found mainly in the upper sediments (Nalepa and Robertson 1981, Nalepa unpublished), mean weights of these two groups were greater on the average than those of oligochaetes and chironomids. These groups, in turn, were less influenced by the Ponar's shock wave. The greater impact of the shock wave on smaller (lighter) individuals was evident when comparing the size-frequency distribution of *Pontoporeia* in the box core and Ponar samples (Table 2). The percentage of small individuals (< 3 mm) was significantly lower in the Ponar samples ($P < .05$; G-test, Sokal and Rohlf 1969). Unfortunately, the fragmentation of oligochaetes during the sieving process and the low numbers of chironomids precluded any size-frequency comparisons for these groups; sphaeriids were not measured.

In the only other study to evaluate the absolute efficiency of the Ponar grab, Flannagan (1970) found that the Ponar did not underestimate sphaeriids, but abundances of oligochaetes and chironomids were only 45–55% of abundances found in diver's cores. In this study, underestimates of oligochaetes were generally similar to the underestimates reported by Flannagan, but underestimates of chironomids were much greater. Flannagan did not examine the vertical distribution of chironomids or measure dry weights, but at both sampling locations in this study, chironomids were found mostly in the upper sediments and average weights were only about one-third those of

TABLE 2. Number of **Pontoporeia** *in each of nine different size classes collected by the two sampling devices in Lake Superior. Percentage of the total given in parentheses. * = percentages significantly different (G-test; P< .05).*

Size Class (mm)	Sampler: Box Corer	Sampler: Ponar
<2.0	0 (0.0)	0 (0.0)
2.0–2.9	19 (8.9)	10 (1.7)*
3.0–3.9	22 (10.3)	44 (7.5)
4.0–4.9	52 (24.4)	151 (25.9)
5.0–5.9	40 (18.8)	109 (18.2)
6.0–6.9	17 (8.0)	61 (10.5)
7.0–7.9	37 (17.4)	104 (17.8)
8.0–8.9	17 (8.0)	73 (12.5)
>9.0	9 (4.2)	31 (5.3)
Total	213	583

TABLE 3. Mean (±SE) standing stocks (g/m²) of the various benthic groups estimated with the box corer and with the Ponar in Lake Superior. Differences between samplers were not significant for any of the groups (t-test; P<.05).

Sampler	Major Group				Total
	Sphaeriidae	Pontoporeia	Oligochaeta	Chironomidae	
Box Corer	0.03±0.01	3.16±0.62	0.69±0.10	0.04±0.01	3.91±0.66
Ponar	0.02± <.01	2.06±0.18	0.18±0.03	<.01± <.01	2.27±0.19
Corer/Ponar Ratio	1.3	1.5	3.7	12.1	1.7

oligochaetes (Nalepa and Robertson 1981, Nalepa unpublished).

Despite great differences in sampling depths and substrate types between nearshore Lake Michigan and offshore Lake Superior, underestimated of abundances by the Ponar were generally quite similiar at the two locations. Differences in the core/Ponar ratio between the two locations were not significant for any of the four groups (P < .05; comparison test of single observation to a sample; Sokal and Rohlf 1969). However, although not significant, somewhat greater underestimates of oligochaetes occurred in Lake Superior (Table 1). This can likely be attributed to the deeper vertical distribution of oligochaetes at this location; while 55% of oligochaetes were found below 5 cm in the silty sediments of offshore Lake Superior, only 10% were found below 5 cm in the sandy sediments of nearshore Lake Michigan (Nalepa and Robertson 1981, Nalepa unpublished). Although the Ponar will sample to a vertical depth of 10 cm, its semicylindrical bite makes it more likely to underestimate organisms found deep in the sediments (Flannagan 1970, Hudson 1970).

Reasons for the Ponar's consistency in underestimating the benthos at the two sampling locations are unclear. Conceivably, the greater impact of the Ponar's shock wave in the silty sediments of Lake Superior was countered by a shallower bite in the sandy sediments of Lake Michigan. Yet, with the exception of oligochaetes in Lake Superior, most organisms were found in the upper sediments in both locations, diminishing the importance of differences in penetration of the grab because of substrate type.

These findings suggest that, although the Ponar does not take a true quantitative sample, it is indeed useful for studies requiring only relative estimates of abundance. Examples of such studies are those which examine benthic changes in space or time, including long-term trends and pollution impacts. However, for studies requiring absolute abundance or biomass estimates, such as those examining benthic energy dynamics or trophic transfers, the Ponar should not be the sampler of choice. As shown in Table 3, total benthic biomass in the box core samples was 1.7 times greater than in the Ponar samples, and the biomass of the dominant invertebrate, *Pontoporeia*, which accounted for over 80% of the standing stock, was 1.5 times greater. Studies assessing the role of *Pontoporeia* in energy tranformations based on Ponar estimates of biomass (i.e., Gardner *et al.* 1985) would therefore underestimate the importance of this organism; likewise, studies of the production and growth of *Pontoporeia* based on Ponar estimates of abundance (Lubner 1979, Winnell and White 1984) would be underestimating the number of younger individuals (< 3 mm) in the population. Such studies should use sampling techniques that minimize shock wave effects, i.e., divers in shallow water and corers in deep water. However, given the convenience and dependability of the Ponar, it may be a practical alternative to these other sampling techniques as long as the underestimates given here are taken into consideration.

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