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A Plankton Net Designed to Exclude Air-sea Interface Phenomena

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ABSTRACT

For use in trace pollutant studies a description is presented of a protected closed plankton net whose purpose is to minimize the exposure of collected samples to surface films and debris. Tests described in this paper appeared to show that the protected closed net was not necessary for the environmental conditions encountered during our field studies. However, additional calculations based on the data of other investigators strongly imply that employment of such a net in heavily polluted surface waters may be highly advantageous.

INTRODUCTION

Assessing the overall impact of both organic and inorganic trace pollutants in marine ecosystems requires a determination of their concentrations in lower pelagic trophic levels. For example, concentrations in plankton need to be accurately known due to not only the potential for biomagnification up food webs (WOODWELL et al. 1967; PORTMAN 1975) but also possible induction of deleterious changes in the species composition of plankton communities (MOSSER et al. 1972).

An obvious difficulty in determining the in situ levels of trace pollutants in plankton involves the potential for contamination of samples during field collection. Investigations have shown that a variety of trace compounds such as chlorinated hydrocarbons (SEBA and CORCORAN 1969; DUCE et al. 1972; BIDLEMAN and OLNEY 1974), petroleum hydrocarbons (WADE and QUINN 1975), petroleum tar lumps (HORN et al. 1970; MORRIS 1971; WONG et al. 1976), plastic particles (CARPENTER and SMITH 1972), and heavy metals (DUCE et al. 1972) are concentrated in the immediate vicinity of the air-sea interface. Passage of an open, unprotected plankton net through such surface waters could lead to contamination of not only the immediate sample being collected but also the plankton net itself (HARVEY and TEAL 1973).

Since part of our field program has included measurement of chlorinated hydrocarbon (CH) residues in zooplankton (CLAYTON et al. 1977), we have modified a standard plankton net to minimize such surface interference. A description of the net and results obtained from a series of field contamination tests are presented below.

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SAMPLER DESIGN

The sampling device (Figure 1) is a modified version of a Juday net (JUDAY 1916). The filtering mesh is "Nitex" nylon monofilament screen cloth. A low porosity, six-ounce nylon utility cloth is used for the collar, skirt, and external protective cover (Figure 2). The skirt, which is cylindrical and open aft, is of such a length that it completely covers the filtering mesh of the net upon retrieval through the surface water. Because of the low porosity of the nylon utility cloth, the "bagged" net has a pronounced tendency to float at the air-sea interface when initiating a tow. To overcome this buoyancy problem a 45 kg weight is attached to either the tripping mechanism or the aft support ring to rapidly pull the enclosed net beneath the water surface. After immersion the release line is retrieved from the net. A 10 kg weight attached to the base of the protective cover proved to be helpful in insuring the separation of the protective cover from the net. When concluding a tow, the tripping mechanism is activated and the mouth of the net closed before final passage through the air-sea interface.

RESULTS

Net efficiency. The filtration efficiency for the net may be defined as

$$F = V_n/V_m$$

where V_n is the volume of water filtered by the net and V_m is the volume swept by a bare ring of the same mouth diameter. Both the net and the bare ring are towed equal distances. V_n and V_m were determined by placing a calibrated TSK flowmeter (NAKAI 1954) midway between the rim and the center of the forward support ring. Replicate measurements gave a filtration efficiency of 0.77 ± 0.09 (mean $\pm$ one standard deviation unit) for the protected closed net.

Contamination tests. To evaluate the capacity of the protected closed net to exclude air-sea interface contaminants, zooplankton samples were collected with both the modified net (Figures 1 and 2) and an open, unprotected net of the same mesh size (333×10^{-6} m) and mouth diameter (0.75 m). A station near the mouth of the Duwamish River in Elliott Bay, Puget Sound was selected because previous analyses of sediments and suspended particulate matter in the water column at this site had indicated a substantial input load of polychlorinated biphenyls (PCB) from the mouth of the river (PAVLOU et al. 1977). Furthermore, surface slicks had previously been noted in the area. The towing procedure, water conditions, and geographical location were virtually the same for all of the tows made in this study. After collection the samples were immediately transferred to screw-cap glass jars (prerinsed with pesticide quality hexane)

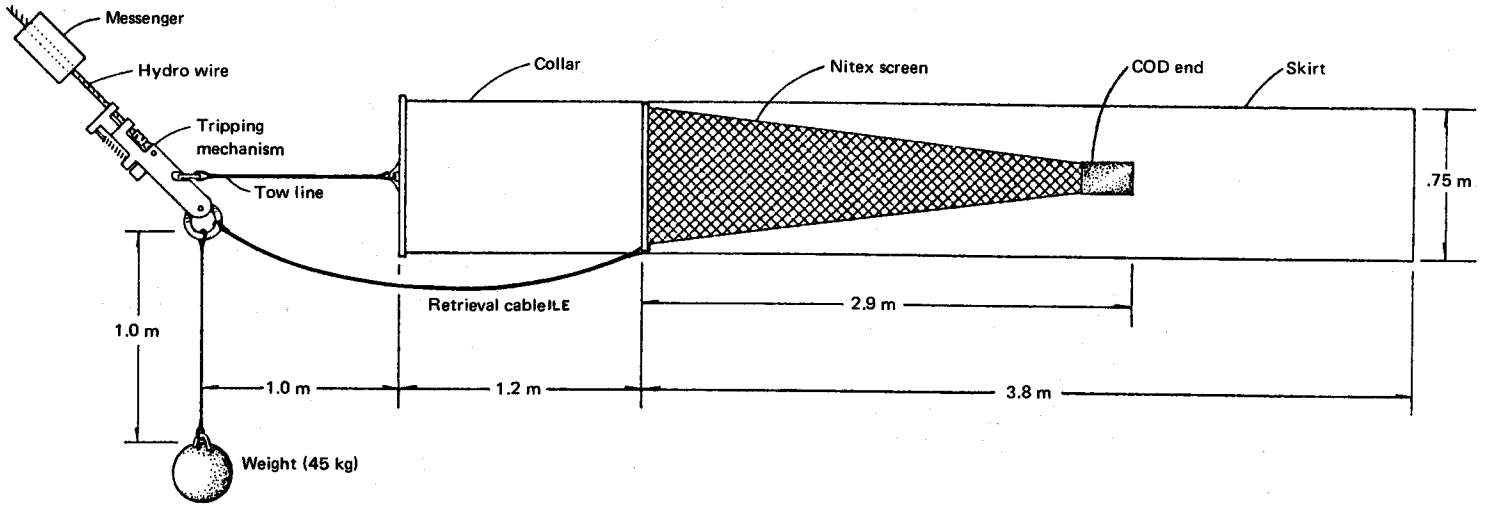

FIGURE 1. A schematic diagram of the protected closed net during a horizontal towing operation.

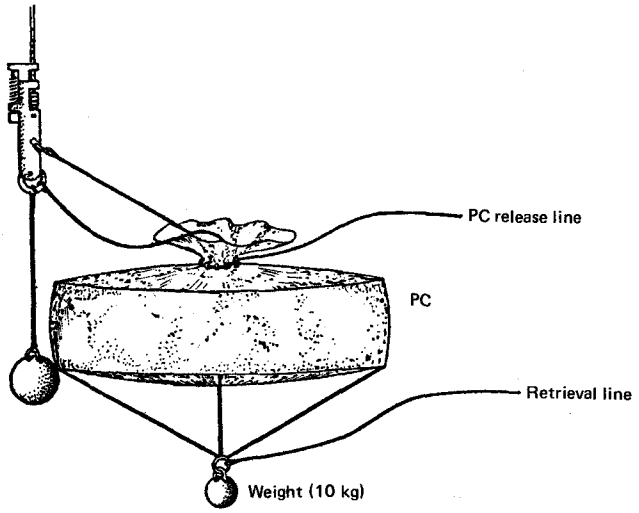

FIGURE 2. A schematic diagram of the protected closed net when initiating a tow. PC refers to the external protective cover.

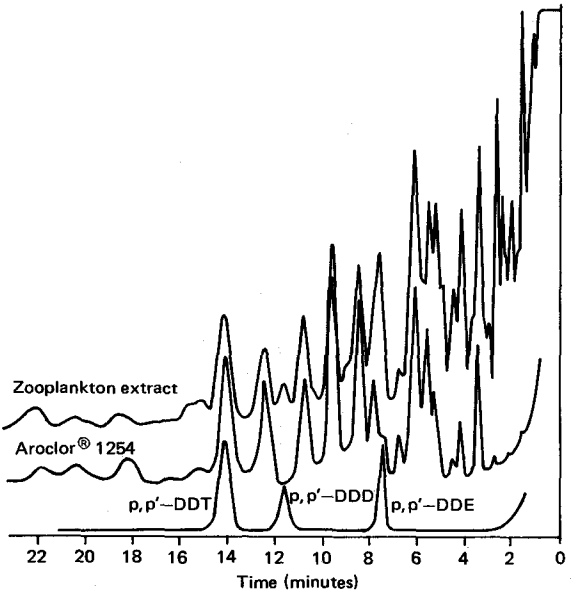

FIGURE 3. Typical chromatograms of chlorinated hydrocarbon samples for zooplankton extract, mixed chlorobiphenyl standard (Aroclor® 1254), and t-DDT (p,p'-DDT + p,p'-DDD + p,p'-DDE) standard.

and frozen until the time of analysis.

The extraction and cleanup procedure for samples was similar to that of PORTER et al. (1970). Chlorinated hydrocarbons were quantitated on a Tracor MT-220 gas chromatograph (GC) equipped with a ^{63}Ni electron capture detector. The stationary phase for the GC analyses was 1.5% SP-2240/1.95% SP-2401 on 100/120 Supelcon AW-DMCS (Supelco, Inc.) packed in 2 mm ID, 180 cm salinized glass columns. The presence of PCB and members of the DDT family was confirmed in all samples by observing appropriate chromatogram responses following ethanolic-KOH saponification. The chlorinated hydrocarbon concentrations found in the samples are summarized in Table 1 and typical GC chromatograms are shown in Figure 3. An initial hexane wash of the "Nitex" screen cloth used for the filtering mesh of the net contained no extractable compounds which would interfere with the CH quantitated in the zooplankton samples.

The t-DDT values in Table 1 have a large analytical uncertainty due to their low concentrations relative to PCB. Consequently, only the PCB data were considered in the evaluation of the exclusion capability of the protected closed net. Although the average PCB concentration was higher in the open net samples, the difference between the values for the two nets was not statistically significant (Student "t" test, α = 0.05). This lack of significant difference, however, was assumed to be the result of a number of factors---the absence of obvious slicks at the time of the actual sampling, the limited number of samples taken with each net, and the large quantities of biomass obtained in each tow (greater than 100 g wet weight) which served to greatly dilute any contribution from extraneous air-sea interface contaminants.

DISCUSSION

Surface film and subsurface (0.5 m) water concentrations of PCB were also determined at several locations in Elliott Bay on June 6, 1973. Sea surface conditions on this date appeared to be identical to those encountered during the zooplankton collections referred to in Table 1. The film samples were obtained with a screen sampler described by GARRETT (1965). Quantities of PCB in the surface film and subsurface water samples are summarized in Table 2.

Given a 0.75 m mouth diameter for the plankton net, a towing velocity of 1.5 knots (0.78 m/sec), and a three second time interval for the net to pass through the surface, approximately 0.9 m^2 of air-sea interface were actually traversed by the nets during each tow in our studies. Using this area value, the maximum surface film concentration from Table 2, and assuming the screen sampler collected water to a depth of 150 X 10^{-6} m (GARRETT 1965), we have calculated the maximum quantity of surface film PCB entering the open net to be only 7.0 X 10^{-9} g (Table 3).

Because of the large quantities of biomass obtained in each tow (greater than 100 g wet weight), this estimated amount of surface film PCB would have introduced less than a 1% increase in the measured zooplankton PCB concentrations of Table 1; a value well below the individual sample variation observed between successive tows.

TABLE 1

Chlorinated hydrocarbon concentrations[a] in zooplankton samples[b] collected in Elliott Bay, Puget Sound on July 10, 1973.

Protected Closed Net			Open Net		
Sample No.	PCB[c]	t-DDT[d]	Sample No.	PCB[c]	t-DDT[d]
T-1	14.7	0.6	T-4	15.2	0.6
T-2	9.6	0.5	T-5	12.1	0.5
T-3	7.8	0.4	T-6	14.0	0.6
$\bar{x} \pm s$	10.7 ± 3.6	0.5 ± 0.1	$\bar{x} \pm s$	13.8 ± 1.6	0.6 ± 0.1

[a] Concentrations are expressed in 10^{-9} g/g wet weight; $\bar{x}$ and s denote the mean and standard deviation, respectively.

[b] In all samples hydromedusae and copepods were the predominant faunal forms, although small numbers of amphipods, crab zoea larvae, chaetognaths, and juvenile euphausiids were also present.

[c] PCB was quantitated as Aroclor(R) 1254, a commercial chlorobiphenyl mixture with an average chlorine number of approximately five.

[d] t-DDT = p,p'-DDT + p,p'-DDD + p,p'-DDE.

TABLE 2

PCB concentrations in surface film and subsurface (0.5 m) water samples collected in Elliott Bay, Puget Sound on June 6, 1973. (Concentrations are expressed as 10^{-12} g/ml)

Station No.[a]	PCB[b]	
	Surface Film	Subsurface Water
8	26.7	5.6
10	53.5	8.7
16	40.4	ND[c]

[a] The station locations are described in PAVLOU et al. (1977)
[b] PCB was quantitated as Aroclor(R) 1254
[c] ND = sample not done

From these tests it can be concluded that for chlorinated hydrocarbons under the surface conditions encountered in Elliott Bay, use of the protected closed net was not necessary. However, it is worth noting that wood chips and pieces of macroalgae were present and had to be manually removed from all of the open net samples, but were absent from all of the protected closed net samples. Even if separated after the plankton collections, non-plankton debris of this type could potentially have served as sources of contamination if covered with films or particles containing the trace compounds to be analyzed.

Under more polluted sea surface conditions adoption of the protected closed net might be highly advantageous. For example, by applying the same sampling assumptions used to calculate the surface film PCB value for Elliott Bay in Table 3, we have estimated the quantities of various trace organic compounds which might be expected to enter an open net under conditions described in a number of other studies. The results are summarized in Table 3. Even with the approximately 100 g wet weight of biomass obtained in each of our tows, our zooplankton values would have been 50% higher if the entire amount of surface film PCB calculated from DUCE's data were to be adsorbed onto our zooplankton samples. Such extraneous contamination could prove to be of even greater significance if very small amounts of total biomass were obtained in each tow.

With respect to other pollutants listed in Table 3, contamination of plankton by petroleum hydrocarbons (either from films or tar lumps) could be severe if samples were collected with an open net. Furthermore, such quantities of petroleum

TABLE 3

Estimated quantities of surface trace organics entering the open plankton net.[a]

Trace organic	Quantity (g) entering net	Location	Investigator(s)
PCB	7.0×10^{-9}	Elliott Bay, Puget Sound	These studies
	550×10^{-9}	Narragansett Bay, R.I. (heavy slick)	DUCE et al. 1972
Petroleum tar lumps	0.86×10^{-3}	Northwest Atlantic Ocean	MORRIS 1971
	17.2×10^{-3}	Mediterranean Sea	HORN et al. 1970
	$0.4\text{-}1.8 \times 10^{-3}$	Northwest Pacific Ocean	WONG et al. 1976
Plastic particles	0.25×10^{-3}	Sargasso Sea	CARPENTER and SMITH 1972

[a] These values were computed assuming the upper 150×10^{-6} m of the water column were sampled in surface film studies (GARRETT 1965).

could also serve to concentrate chlorinated hydrocarbons due to the low water solubility and highly lipophilic nature of the latter. Plastic particles could not only serve as adsorption sites for trace organic pollutants, but are also known to contain a variety of plasticizer agents, including PCB (CARPENTER and SMITH 1972; HAMMOND et al. 1972).

In view of the above considerations, the design of plankton collection gear intended to minimize interference from air-sea interface phenomena is of obvious importance for obtaining meaningful and accurate field samples.

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