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NET FILTERING EFFICIENCY OF A 3-METER ISAACS-KIDD MIDWATER TRAWL

The errors associated with quantitative sampling of open ocean populations of zooplankton and epipelagic nekton have received considerable attention. Net selectivity, net sampling efficiency, and patchiness have been examined by Barkley (1964), Murphy and Clutter (1972), and Wiebe and Holland (1968), respectively. Studies of the error caused by avoidance have been summarized by Clutter and Anraku (1968) and further advanced by Barkley (1972). Aron and Collard (1969) have reported on the effects of net speed on catch. Extrusion of organisms through the net, the degree of mesh retention, and the effects of net clogging have been summarized by Vannucci (1968), and a review of filtration problems has been presented by Tranter and Smith (1968).

Somewhat less effort has been directed toward problems encountered in sampling the midwater fish fauna. Harrison (1967) reported on the reliability of trawl data, the bias that may result from using various types of gear, and the problems associated with sampling mesopelagic fishes. These fishes are commonly sampled with an Isaacs-Kidd Midwater Trawl (IKMT) (Isaacs and Kidd, 1953) and results of such sampling, which include considerations of net performance, have been reported by Pearcy and Laurs (1966), Gibbs et al. (1971), Friedl (1971), Backus (1972) Krueger and Bond (1972), and others.

Net performance is critically dependent on the filtering efficiency of the net. Filtering efficiency is a measure of the total volume of water filtered by the net and enables a better quantitative estimate to be made of the actual population density of organisms sampled. Pearcy and Laurs (1966) reported a filtering efficiency of 85% for a 2-m IKMT. To the authors' knowledge, no comparable figure has been published for the 3-m IKMT. This paper investigates the efficiency of this larger net.

Methods

In conjunction with studies of macroplankton and midwater fishes of an area off Bermuda called Ocean Acre (Brooks, 1972), experiments were conducted in January 1973 to determine the net filtering efficiency of a 3-m IKMT.

Although the design and shape of the 2- and 3-m IKMTs in general use are similar, it is obvious from the literature that net construction may vary considerably. The size of the mesh and the thread of the outer net may differ widely, as may the pattern of a graded mesh. Liner mesh size, type, and placement within the outer net, as well as size, shape, and mesh of the cod end of the net, may also differ. As shown in Table 1, the cross-sectional area of the net mouth may also vary.

Since the influence of such factors on the filtering efficiency of a given net can be considerable, the net used in the present experiment is described in detail. Dimensions and material specifications are shown in Table 2. The net was made of No. 21 thread nylon and has outer walls of 6.36-cm stretch mesh. The entire inner surface of the net was lined with No. 42 thread knotless nylon having a 0.95-cm stretch mesh, which was sewn to the outer walls of the net at every foot.

The aft tube of the IKMT was fitted with four rings made of 0.95-cm-diameter stainless steel rod spaced as follows: one 0.81-m-diameter ring at the aft end of the funnel, one 1-m-diameter ring at the aft end of the tube, and two 0.66-m-diameter rings in the aft tube centered between the other rings. The mouth of the net was hung on 1.59-cm-diameter Polydac[1] net rope with four legs extending 0.61 m and the center bosom leg extending 0.41 m. Riblines, composed of 0.95-cm-diameter nylon rope, were rigged down each of the five seams from the mouth opening to the cod end. A standard 1-m conical nylon plankton net (1-m mouth diameter tapering to 19 cm over its length of 3 m) of No. 00 mesh (0.752-mm aperture) was attached to the aft end of the main body of the IKMT. Dimensions of the IKMT mouth are shown in Figure 1; cross-sectional area was 7.08 m^2, and principal dimensions of bridle and paravane were as specified for the 3-m IKMT in Aron (1962).

TABLE 1.—Mouth area of Isaacs-Kidd midwater trawl.

Reference	2-m IKMT (m^2)	3-m IKMT (m^2)
King and Iversen (1962)[1]	3.21	8.19
Aron (1962)	—	7.44
Pearcy and Laurs (1966)	2.89	—
Friedl (1971)	2.94	7.68

[1]Calculated from dimensions given in Figures 7 and 9, respectively.

[1]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

TABLE 2.—Dimensions and material specifications of 10-foot IKMT net used for filtering-efficiency studies.

Item	Dimension
Mesh size	
Forward section	[1]0.95 cm
Intermediate section	[1]0.95 cm
Cod end	0.75 mm
Cross-section area	
Mouth	7.08 m^2
Intermediate section	
Forward end	0.52 m^2
Mid section	0.34 m^2
Aft end	0.79 m^2
Cod end	0.79 m^2
Filtering area	
Forward section	52.39 m^2
Intermediate section	12.12 m^2
Cod end	2.27 m^2

[1]Knotless nylon liner—stretched mesh size

When the net is in regular use, a Mark III (15-cm-diameter) GM discrete-depth plankton sampler (DDPS) (Aron et al., 1964) is attached to the aft end of the 1-m plankton net.

Estimates of the filtering efficiency of the 3-m IKMT described here were obtained by two different methods. In the first method, a calibrated TSK (Tsurumi-Seiki Kosakusho) flowmeter was mounted in the net mouth as shown in Figure 1. The meter (A) was tautly suspended by 0.32-cm steel cable (B) inside a 1-m-diameter ring of 1.9-cm-diameter brass rod (C). The 1-m ring, in turn, was suspended in the net mouth by three legs of 0.95-cm-diameter shock cord (D). Each leg of the shock cord was tensioned so that the ring and suspended flowmeter were positioned in the approximate center of the net mouth and maintained at right angles to the water flow during net towing. During the tows, the shock cord stretched, positioning the ring and flowmeter about 1 m inside the net mouth. It is assumed that the water flow at the center of the net mouth was representative of the average flow through the entrance. A second TSK meter of identical design and calibration characteristics was mounted on the spreader bar outside the net. The difference in the number of revolutions registered by the two meters was used in arriving at the estimate of filtering efficiency. The four-bladed impeller of each meter was restrained from turning until after the net was launched and in its towing position.

In the second method used to determine filtering efficiency, a Clarke-Bumpus (C-B) plankton sampler (Clarke and Bumpus, 1950), with shutter

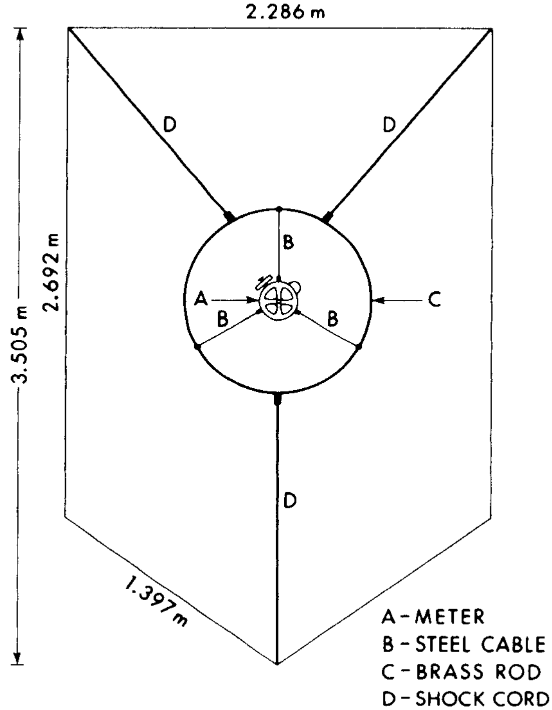

FIGURE 1.—Diagrammatic view of 3-m IKMT mouth with mounted flowmeter.

and net removed, was suspended in the IKMT mouth. This sampler had been calibrated by carefully controlled tows over distances of 2 and 6 nautical miles before being installed in the IKMT. Start and end positions for each tow were determined by radar, LORAN, and shore fixes.

The three legs of shock cord used in the previous trial were attached directly to the frame of the C-B sampler so that the flowmeter could pivot freely within its frame. During launch and again as soon as the flowmeter cleared the water during retrieval, the flowmeter automatically pivoted, causing the axis of the impeller to lie perpendicular to the direction of the tow; i.e., the meter did not register. The impeller blade housing protected the blades from winds, thus preventing rapid spinning of the impeller and erroneous flow readings. As soon as the net was lowered and in towing position, proper aspect of the impeller axis (parallel to the flow) was maintained by water pressure acting on the stabilizing fins attached to the impeller blade housing.

Two net tows were carried out using this apparatus, with the shock cord again stretching to place the C-B sampler just inside the net mouth. Start and end positions were obtained, as during the calibration runs, by radar, LORAN, and shore fixes. Previously determined calibration information allowed calculation of the number of revolutions that would have resulted if the sampler had been towed by itself over the same known distances covered during the two tows.

All net tows were made at ship speeds ranging between 3 and 4.5 knots over distances of 6 and 10.75 nautical miles. The direction of the tows was approximately perpendicular to the prevailing current flow. Very little biological material was captured during these net tests, hence clogging was considered a negligible factor.

Results and Discussion

The two methods used to determine filtering efficiency yielded similar results (Figure 2). For method 1, the total number of revolutions (N′) registered by the meter in the net mouth is plotted against the number of revolutions (N) registered by the meter on the spreader bar for the two net lowerings. These results are shown as squares. For method 2, the number of revolutions (N′) registered by the calibrated C-B meter

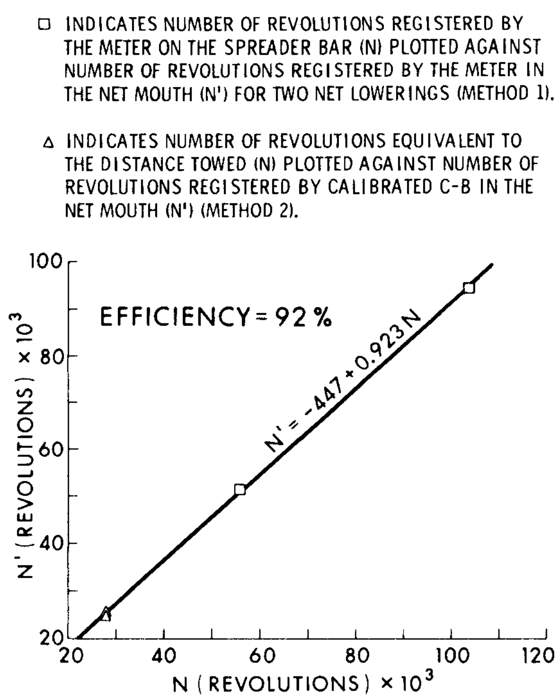

FIGURE 2.—Filtering efficiency of 3-m IKMT.

in the net mouth is plotted against the number of revolutions (N) obtained in the calibration distance tow. These data are shown as triangles.

A linear regression analysis performed on the data points produced the regression line shown in Figure 2. The slope of the line (regression coefficient) was taken as a measure of the filtering efficiency of the 3-m IKMT and had a value of 92%. Although the filtering efficiency determined by this study applies to the specific net described in this note, it can probably serve as a guide to the filtering efficiency of most 3-m IKMTs and enable a better quantitative estimate to be made of the actual population density of organisms sampled.

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