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MIDWATER TRAWLING FOR FORAGE ORGANISMS IN THE CENTRAL PACIFIC 1951–1956

BY JOSEPH E. KING AND ROBERT T. B. IVERSEN

FISHERY BULLETIN 210

From Fishery Bulletin of the Fish and Wildlife Service

VOLUME 62

PUBLISHED BY UNITED STATES FISH AND WILDLIFE SERVICE • WASHINGTON • 1962
PRINTED BY UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C.

For sale by Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. – Price 40 cents

The series, Fishery Bulletin of the Fish and Wildlife Service, is cataloged as follows:

U.S. *Fish and Wildlife Service.*
Fishery bulletin. v. 1–
Washington, U.S. Govt. Print. Off., 1881–19

v. in illus., maps (part fold.) 23–28 cm.

Some vols. issued in the congressional series as Senate or House documents.
Bulletins composing v. 47– also numbered 1–
Title varies: v. 1–49, Bulletin.
Vols. 1–49 issued by Bureau of Fisheries (called Fish Commission, v. 1–23)

1. Fisheries—U. S. 2. Fish-culture—U. S. I. Title.

SH11.A25 639.206173 9—35239*

Library of Congress [59r55b1]

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ABSTRACT

Collections from 274 midwater trawl hauls made in the central Pacific Ocean by the Bureau of Commercial Fisheries during the years 1951 through 1956 were analyzed quantitatively to obtain estimates of the abundance and distribution of forage organisms. Occurrence of these organisms in the trawl catches was compared with the occurrence of similar organisms in the stomachs of yellowfin, bigeye, skipjack, and albacore tunas taken by longline, surface trolling, and pole-and-line fishing. Four trawls were utilized (6-foot beam trawl, 1-meter ring trawl, and 6-foot and 10-foot Isaacs-Kidd trawls) in double oblique hauls between the surface and 400 meters.

The largest catches by the Isaacs-Kidd trawls were made in the Aleutian Current and in the region of upwelling at the Equator, and the poorest catches south of latitude 5° S. in the North Equatorial Current between latitudes 10° N. and 18° N., and in Hawaiian waters. The greatest variety of organisms occurred in catches made in the South Equatorial Current and in the Countercurrent.

There was poor correspondence between the composition of trawl catches and the contents of tuna stomachs, since most trawl hauls were made at night and the fishing which provided the tuna stomachs occurred in the daytime. There was marked diurnal variation in the trawl catches. Night hauls produced catches larger in volume, number, and size of organisms. Diurnal differences in composition of the trawl catches were striking.

The larger trawls generally produced the largest catches, but in catch per unit of mouth area the trawls were about equally efficient in a geographic area. The largest catches and greatest variety of organisms were obtained by the largest and most frequently used trawls. All four trawls sampled organisms of about the same phyla, classes, and orders; the major difference was in the families and genera of fishes caught. Only six juvenile tunas, from 18 to 60 mm. in length, were caught, although juvenile tunas were thought to be present in the area at the time of the trawling.

Trawl catch volumes were correlated with various environmental factors and found to be more closely related to zooplankton than to inorganic phosphate or to the uptake of C^{14} by phytoplankton.

Checklists of the organisms captured, showing percentage occurrence and average number per haul of a large number of taxonomic categories according to six latitudinal zones, and a table of references useful in identifying organisms captured by midwater trawling are presented.

MIDWATER TRAWLING FOR FORAGE ORGANISMS IN THE CENTRAL PACIFIC, 1951–1956

By Joseph E. King and Robert T. B. Iversen, *Fishery Research Biologists*
Bureau of Commercial Fisheries

Since the inauguration of field work early in 1950, the staff of the Bureau of Commercial Fisheries Biological Laboratory, Honolulu,[1] has conducted studies on the oceanography, productivity, and fishery resources of the central Pacific Ocean. Although not a major activity of the Laboratory's research program, midwater trawling has received considerable attention. Four kinds of trawls were tested and employed to a varying extent on 22 cruises in the central Pacific from 1951 to 1956. Trawling was not conducted, however, with the expectation of discovering new fishery resources of commercial importance, but rather to sample quantitatively the forage organisms which are the basis and support of fishery stocks in general, and particularly those organisms utilized by the tunas.

Midwater trawling has been conducted along the west coasts of Canada and the United States by a number of institutions employing different types of gear. The Fisheries Research Board of Canada, Biological Station, Nanaimo, British Columbia, pioneered in the development of a commercial-type trawl for use in the herring fishery (Barraclough and Johnson, 1956). This trawl, or one of its modifications, has been used by the Bureau of Commercial Fisheries in fishery explorations in the eastern Pacific (U.S. Fish and Wildlife Service, 1956; Schaefers and Powell, 1958). The California Department of Fish and Game has also tested a commercial-type midwater trawl of somewhat different design (Pacific Fisherman, 1953). The Isaacs-Kidd midwater trawl was developed at Scripps Institution of Oceanography to collect bathypelagic fishes and invertebrates (Devereaux and Winsett, 1953). This type of trawl has been employed by Scripps staff members on numerous cruises in the eastern Pacific and has also been used recently in the northeastern Pacific by personnel of the University of Washington Department of Oceanography to relate variations in the abundance of plankton and nekton to other oceanographic features (Aron, 1959). Some of the studies mentioned here have resulted in discoveries and information that have been of great value and interest to the commercial fishing industry, and all have made worthwhile contributions to our scant knowledge of the abundance and distribution of animal life in the mid-depths of the ocean—a life zone that presently contributes little in the way of human food (Whiteleather, 1957; Powell, 1958).

Specific objectives of the trawling program were as follows:

(1) To obtain a measure of the abundance and distribution of potential tuna food; (2) to obtain an estimate of the standing crop of forage organisms; (3) to sample juvenile tunas; (4) to learn something of tuna feeding behavior, e.g., depth of feeding, diurnal variation, and selectivity; and (5) to evaluate the general catching abilities of different midwater trawls in the highly transparent waters of the tropical and subtropical Pacific. This report describes and evaluates the results of our trawling studies with respect to these objectives.

H. J. Mann, of the Honolulu laboratory, prepared the engineer's drawings of the trawls and helped the authors with the detailed descriptions of the trawls. From the engineer's drawings, Tamotsu Nakata prepared the drawings and other figures that appear in this paper. Isaac Ikehara and Allen Shimomura assisted in the sorting, counting, volume measurement, and identification of the organisms in the collections.

[1] Formerly Pacific Oceanic Fishery Investigations.

The senior author is presently Assistant Chief, Branch of Marine Fisheries, Washington 25, D.C.

Approved for publication, November 30, 1961. Fishery Bulletin 210.

TABLE 1.—*Number of hauls, cruises, and general areas where midwater trawling was accomplished, by type of gear, central Pacific, 1951–56*

Gear and cruise	Cruise period	General area	Number of hauls
6-foot beam trawl:			
John R. Manning: Cruise 9	November 1951	Hawaiian waters	10
Hugh M. Smith:			
Cruise 14	February 1952	Equatorial Pacific	2
Cruise 15	June 1952	do	4
Subtotal			16
1-meter ring trawl:			
Charles H. Gilbert:			
Cruise 11	April 1953	Hawaiian waters	10
Cruise 12	May 1953	do	10
Cruise 13	June 1953	do	2
Hugh M. Smith: Cruise 21	August 1953	do	1
Subtotal			23
6-foot Isaacs-Kidd trawl:			
John R. Manning:			
Cruise 15	May 1953	Equatorial Pacific	1
Cruise 16	July 1953	do	3
Cruise 20	April-May, 1954	Equatorial Pacific and Hawaiian waters	22
Cruise 21	July 1954	Hawaiian waters	4
Cruise 22	September-October, 1954	North Pacific and Hawaiian waters	10
Cruise 23	December 1954	North Pacific	2
Cruise 24	March-April 1955	Equatorial Pacific	13
Hugh M. Smith: Cruise 27	January-February, 1955	North Pacific and Hawaiian waters	23
Subtotal			78
10-foot Isaacs-Kidd trawl:			
Hugh M. Smith:			
Cruise 27	January-February, 1955	North Pacific	3
Cruise 30	July-August, 1955	North Pacific and Hawaiian waters	37
Cruise 31	September-December, 1955	Equatorial Pacific	53
Cruise 32	February 1956	Hawaiian waters	8
Cruise 33	March 1956	Equatorial Pacific	5
Cruise 34	May 1956	Hawaiian waters	4
Cruise 35	August-October, 1956	Equatorial Pacific and Hawaiian waters	43
Cruise 37	December 1956	Eniwetok	4
Subtotal			157
Total			274

SOURCE OF DATA

This report is concerned with the results of 274 midwater trawl hauls made on 22 cruises of Bureau of Commercial Fisheries vessels in the central Pacific during the years 1951–56. A summary of the hauls made and the general areas sampled by each vessel on each cruise is given in table 1. Positions of the trawl stations are supplied in appendix tables 1 to 4.

The area investigated extended from latitude 49° N. to 19° S. and from longitude 108° W. to 162° E. The approximate positions of stations where each type of trawl was employed are shown in figures 1 to 4.

DESCRIPTION OF GEAR AND METHODS OF HAULING

This report is concerned with the results obtained with four kinds of trawls: (1) 6-foot beam trawl, (2) 1-meter ring trawl, (3) 6-foot Isaacs-Kidd trawl, and (4) 10-foot Isaacs-Kidd trawl. A description of each trawl follows.

6-FOOT BEAM TRAWL

This trawl consists of a net 30 feet in length with a 6-foot-square mouth opening held open across the top and bottom by 6-foot lengths of galvanized pipe (fig. 5). The body of the net is constructed of 1-inch (stretched measure) cotton netting; the cod end is of ½-inch mesh. The rear half of the net, including the cod end, is lined with 3/16 mesh (square measure) minnow netting. We do not know where the design for this gear originated.

This trawl was operated from the *John R. Manning* and the *Hugh M. Smith* at speeds of 4 to 5 knots, using a towing cable of ¼-inch wire rope. On each haul a 50-pound bronze depressor or a 100-pound streamlined lead weight was suspended from the lower pipe beam. Table 2 gives the minimum and maximum towing tensions obtained when hauling at various speeds and with different amounts of wire out. At the usual hauling speed (4 to 5 knots) the maximum tension did not exceed 2,000 pounds. Most hauls were oblique tows, ranging from the surface to depths as great as 450 meters. The depth of the haul was esti-

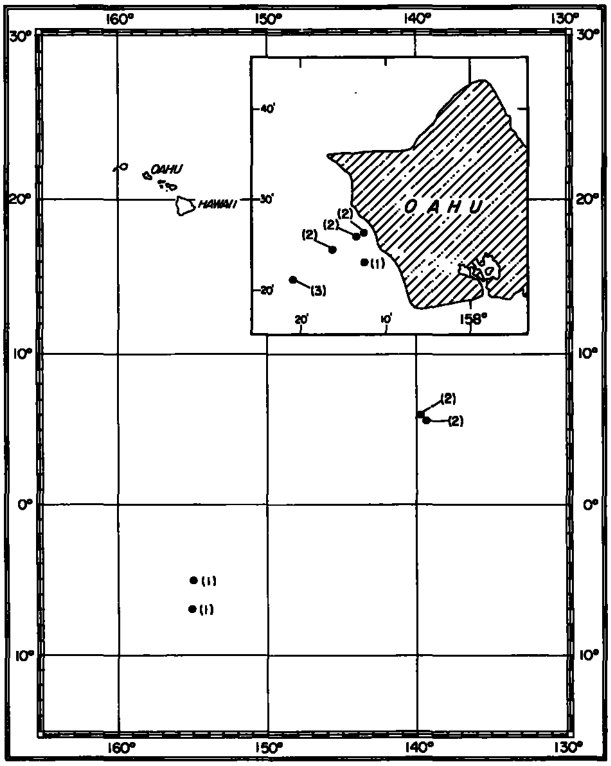

FIGURE 1.—Location of the 16 stations where hauls were made with the 6-foot beam trawl. (Number of stations in parentheses.)

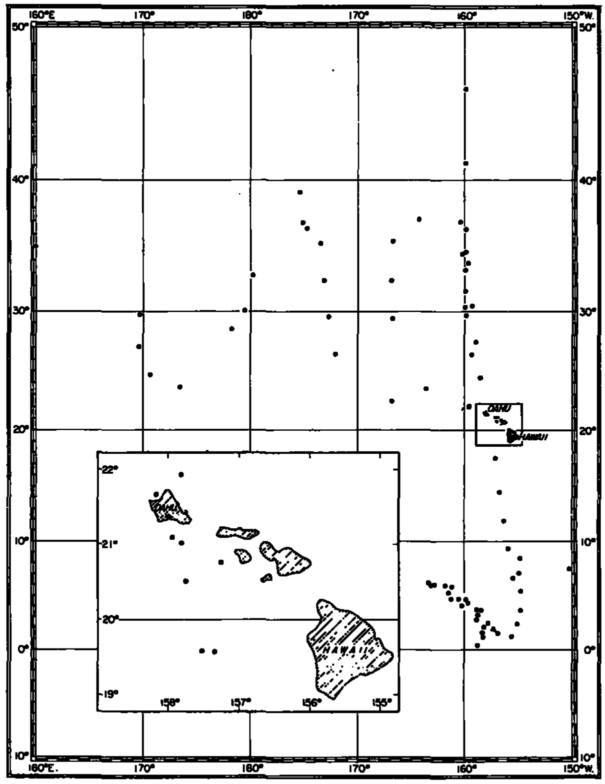

FIGURE 3.—Location of the 78 stations where hauls were made with the 6-foot Isaacs-Kidd trawl.

mated from the angle of the towing wire and the length of wire out, using the secant relationship with the assumption that the towing wire described a straight line in the water.

TABLE 2.—*Towing tensions obtained with the 6-foot beam trawl, measured with a dynamometer, on* John R. Manning *cruise 9*

Wire out	Main engine speed	Estimated vessel speed	Towing tension	
			Minimum	Maximum
	R.p.m.	*Knots*	*Pounds*	*Pounds*
10 meters	110	3.5	430	640
10 meters	150	4.7	850	1,280
200 meters	150	4.7	850	1,280
400 meters	150	4.7	920	1,350
400 meters	200	6.2	1,280	2,200

The collections were stored in glass jars and preserved in formalin neutralized with borax.

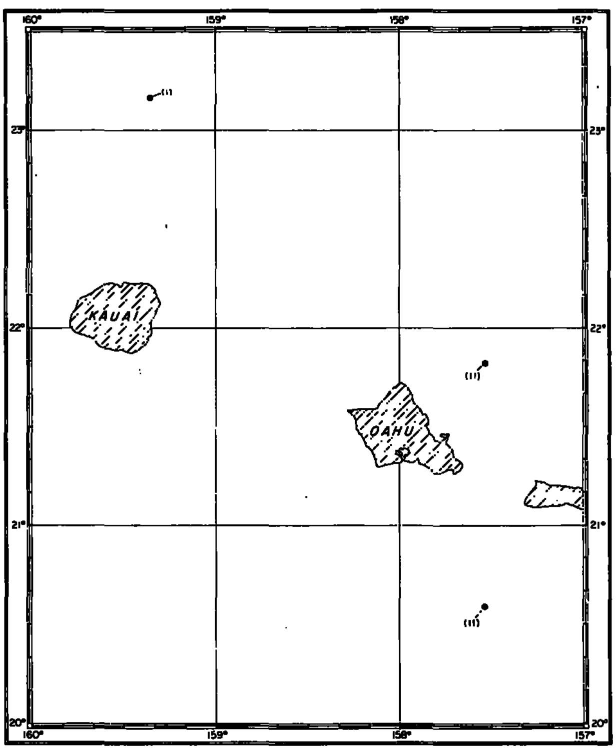

FIGURE 2.—Location of the 23 stations where hauls were made with the 1-meter ring trawl. (Number of stations in parentheses.)

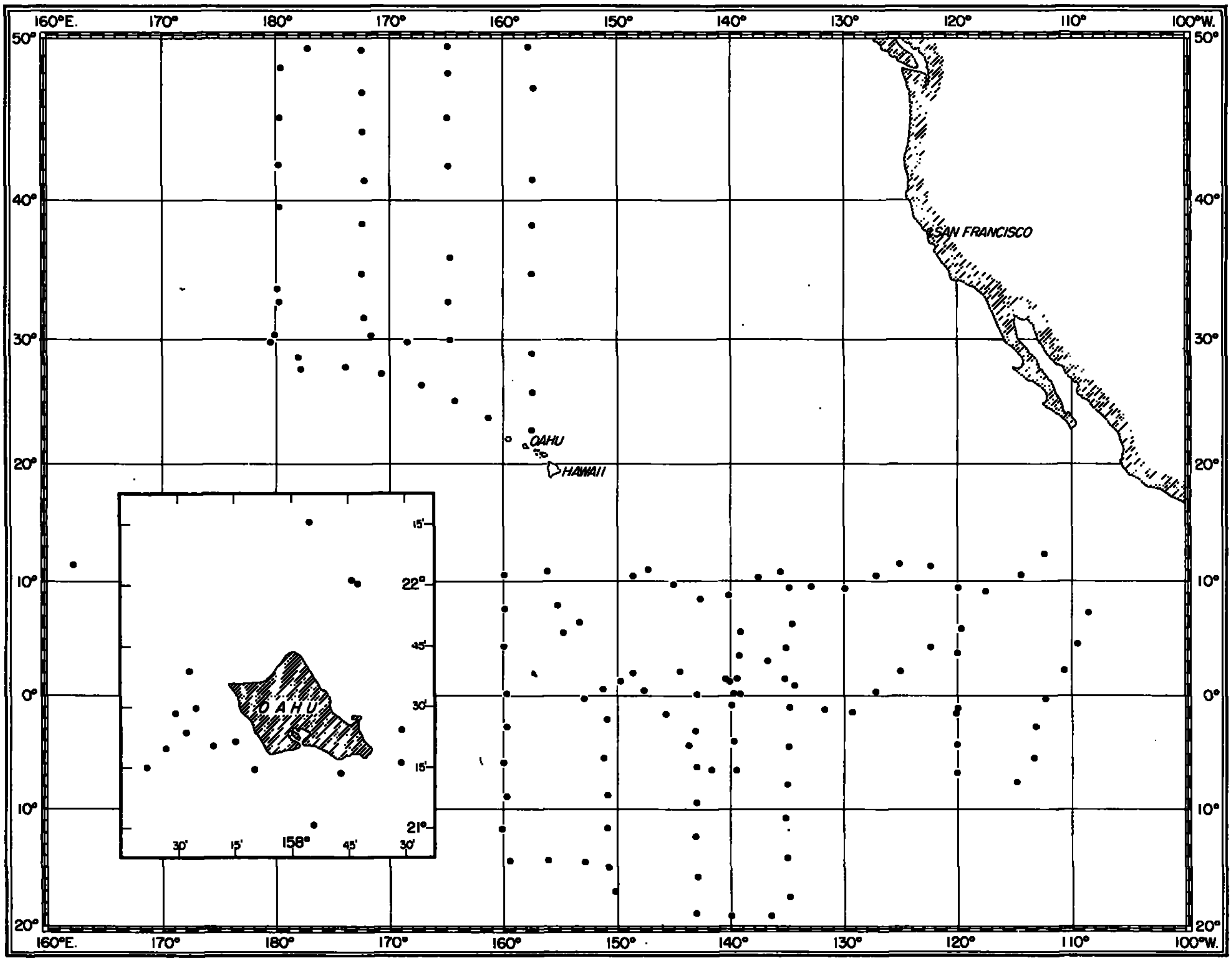

Figure 4.—Location of the 157 stations where hauls were made with the 10-foot Isaacs-Kidd trawl.

1-METER RING TRAWL

This gear, which we termed a "ring trawl," consists of a circular net, 1-meter in mouth diameter and 4½ meters in length, attached to a steel ring 1-meter in diameter (fig. 6). The net is of 2-inch mesh (stretched measure) No. 12 cotton twine and is equipped with a cod-end liner of 3/16-inch mesh (square measure) minnow netting. On most hauls an additional liner, slightly more than 1 meter in length and of ½-inch mesh (stretched measure) cotton netting, was attached in the net just forward of the cod end.

Except for one haul this gear was operated only from the *Charles H. Gilbert*, usually at speeds of 6 to 7 knots, but reaching a maximum of 8½ knots on a few test hauls. The towing cable was ¼-inch diameter wire rope. The 1-meter ring at the mouth of the net was initially constructed of ⅞-inch stock and was without reinforcement. At higher towing speeds the ring did not retain its shape and was replaced with one of 1-inch thickness, reinforced with two transverse bars (fig. 6).

A 50-pound depressor or a 100-pound streamlined weight was suspended below the net. At average towing speeds (6 to 7 knots), the maximum towing tension did not exceed 1,000 pounds (table 3). The trawl was operated, usually on oblique tows, at depths ranging from the surface to 200 meters. As in the case of the 6-foot beam trawl, the depth of haul was calculated trigono-

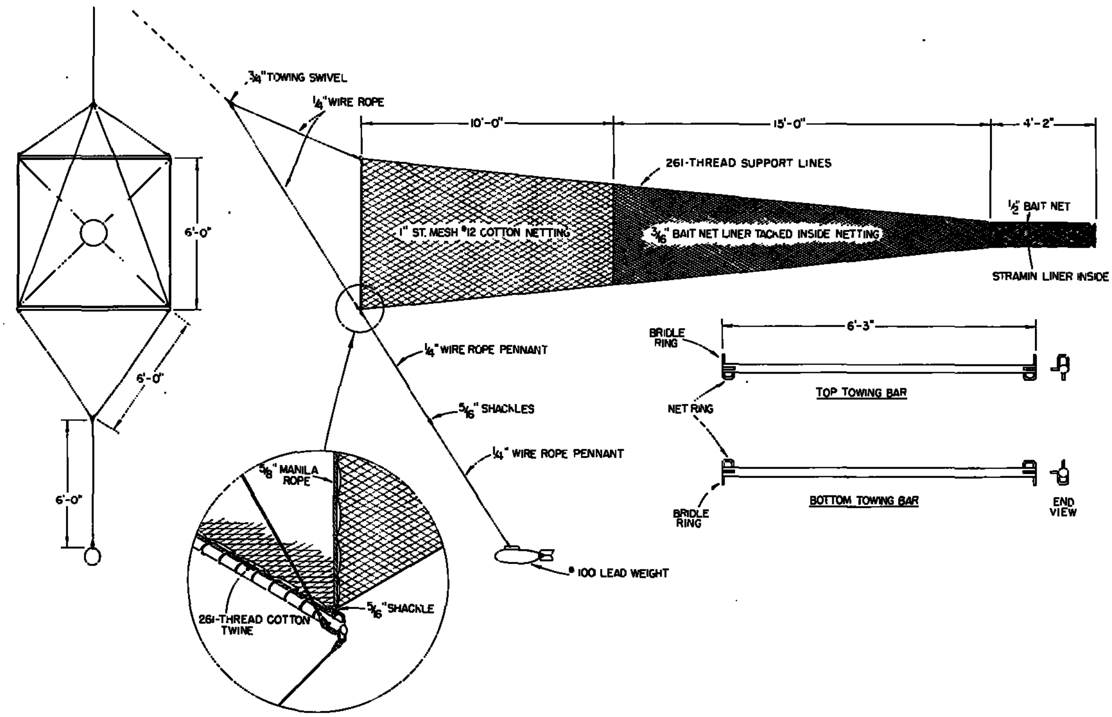

FIGURE 5.—Diagram of the 6-foot beam trawl, showing the arrangement of weight and bridle lines.

metrically with the assumption that the towing wire described a straight line.

6-FOOT ISAACS-KIDD TRAWL

A scaled down, 6-foot model of the Isaacs-Kidd trawl was constructed from plans provided by Scripps Institution of Oceanography for 10- and 15-foot models. The net is 28 feet in length with the forward section of 1½-inch mesh (stretched measure) No. 9 cotton twine; the middle section is of ¾-inch mesh and the rear section of ½-inch mesh (fig. 7). The cod end is lined with stramin or with No. 14XXX silk grit gauze. Since the diving vane of the trawl exerted a strong depressing action, no extra weights were needed.

TABLE 3.—*Towing tensions obtained with the 1-meter ring trawl, measured with a dynamometer, on* Charles H. Gilbert *cruise 13*

Wire out	Main engine speed	Estimated vessel speed	Towing tension	
			Minimum	Maximum
	R.p.m.	*Knots*	*Pounds*	*Pounds*
195 meters	550	5.9	130	260
195 meters	700	6.7	200	390
195 meters	800	7.2	280	620
195 meters	900	7.7	390	720
195 meters	950	7.9	440	750
195 meters	1,000	8.1	440	1,005
575 meters	1,000	8.1	620	880
990 meters	1,000	8.1		1,080
975 meters	1,000	8.1		1,500

This trawl was hauled from the *Manning* and the *Smith* at speeds of 4 to 6 knots, on a towline of ¼-inch wire rope. At these speeds and with 100 to 300 meters of wire out, the towing tension ranged from 600 to 1,200 pounds.

Devereaux and Winsett (1953) provide data on the shape of the towing wire for the 10- and 15-foot models of the Isaacs-Kidd trawl during towing. Because of the depressing action of the diving vane, the straight-line assumption could not be applied when we calculated hauling depths. Since a suitable depth meter was not available, we estimated the curvature of the towing wire and the trawl depth by a method described by Hida and King (1955), which required frequent measurement during the haul of wire angle and amount

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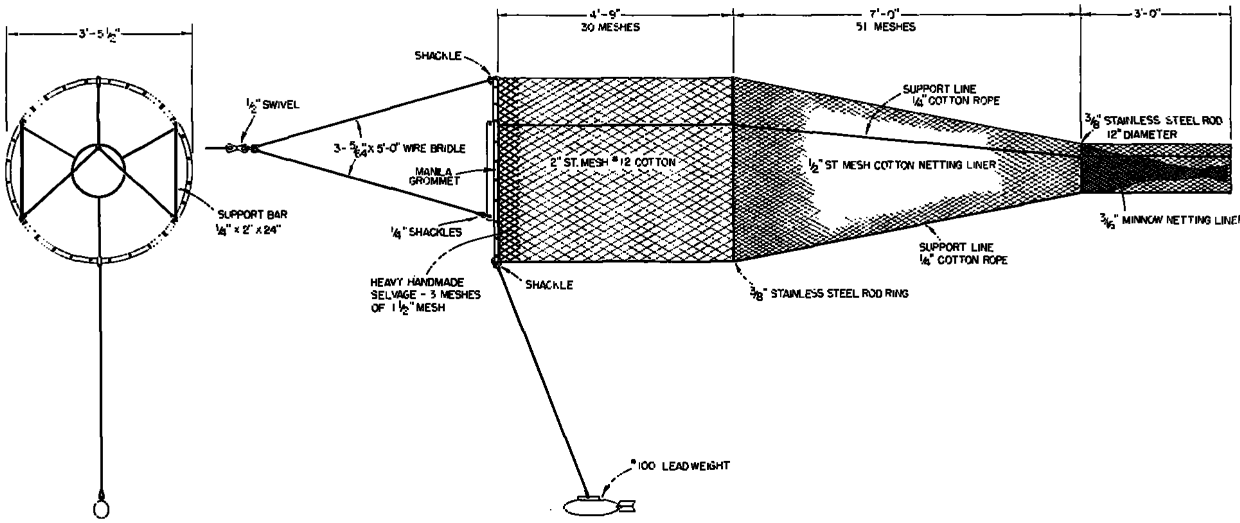

FIGURE 6.—Diagram of the 1-meter ring trawl, showing arrangement of bridle lines and streamlined lead weight.

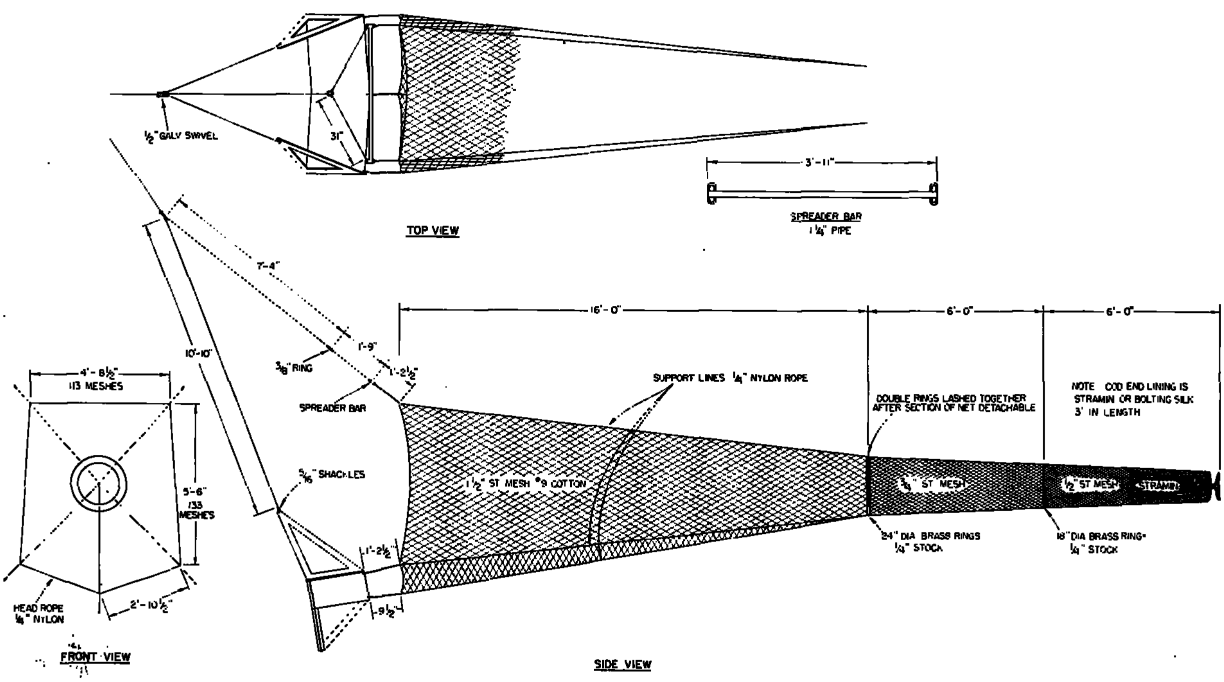

FIGURE 7.—Diagram of the 6-foot Isaacs-Kidd trawl used in central Pacific studies by the Bureau of Commercial Fisheries Biological Laboratory, Honolulu.

of wire out. Depth conversion factors (table 4) were calculated from plots of these data.

TABLE 4.—*Depth conversion factors used to estimate depth of haul for 6-foot Isaacs-Kidd trawl*

[Wire out (in meters) × factor = trawl depth (in meters)]

Wire angle	Depth conversion factor	Cosine [1]
68°	0.44	0.375
69°	.42	.358
70°	.40	.342
71°	.38	.326
72°	.36	.309
73°	.34	.292
74°	.32	.276
75°	.31	.259
76°	.30	.242

[1] Cosine of the wire angle, the appropriate conversion factor if the towing wire described a straight line, is given for comparison.

10-FOOT ISAACS-KIDD TRAWL

Since the 10-foot trawl used in this study by the Laboratory in Honolulu has been considerably modified from the original plans given by Devereaux and Winsett (1953), we shall provide a detailed description of the main features of the gear.

Trawl Net

A schematic view of the net is shown in figure 8 and detailed plans are given in figure 9.

The front section of the net, about 27 feet in length, is made of 1½-inch mesh (stretched measure), double-knotted, No. 207 nylon twine, dyed red. The mesh counts for tapering the top, bottom, and side panels are shown in detail "A" (fig. 9). The headlines and other supporting lines are of ⅜-inch 3-strand nylon. The headline is attached to the diving vane by wire pennants of ¼-inch-diameter 7 x 19 stainless steel wire Nico-

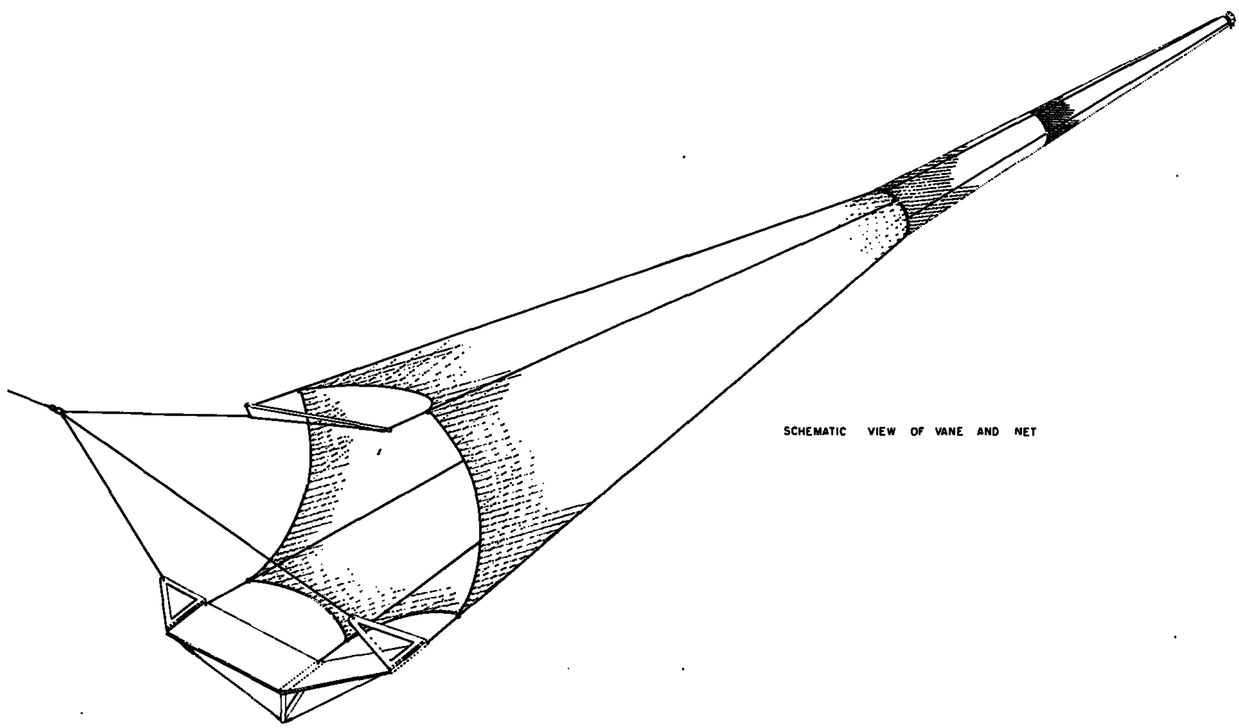

FIGURE 8.—Schematic view of the 10-foot Isaacs-Kidd trawl used by the Bureau of Commercial Fisheries Biological Laboratory, Honolulu.

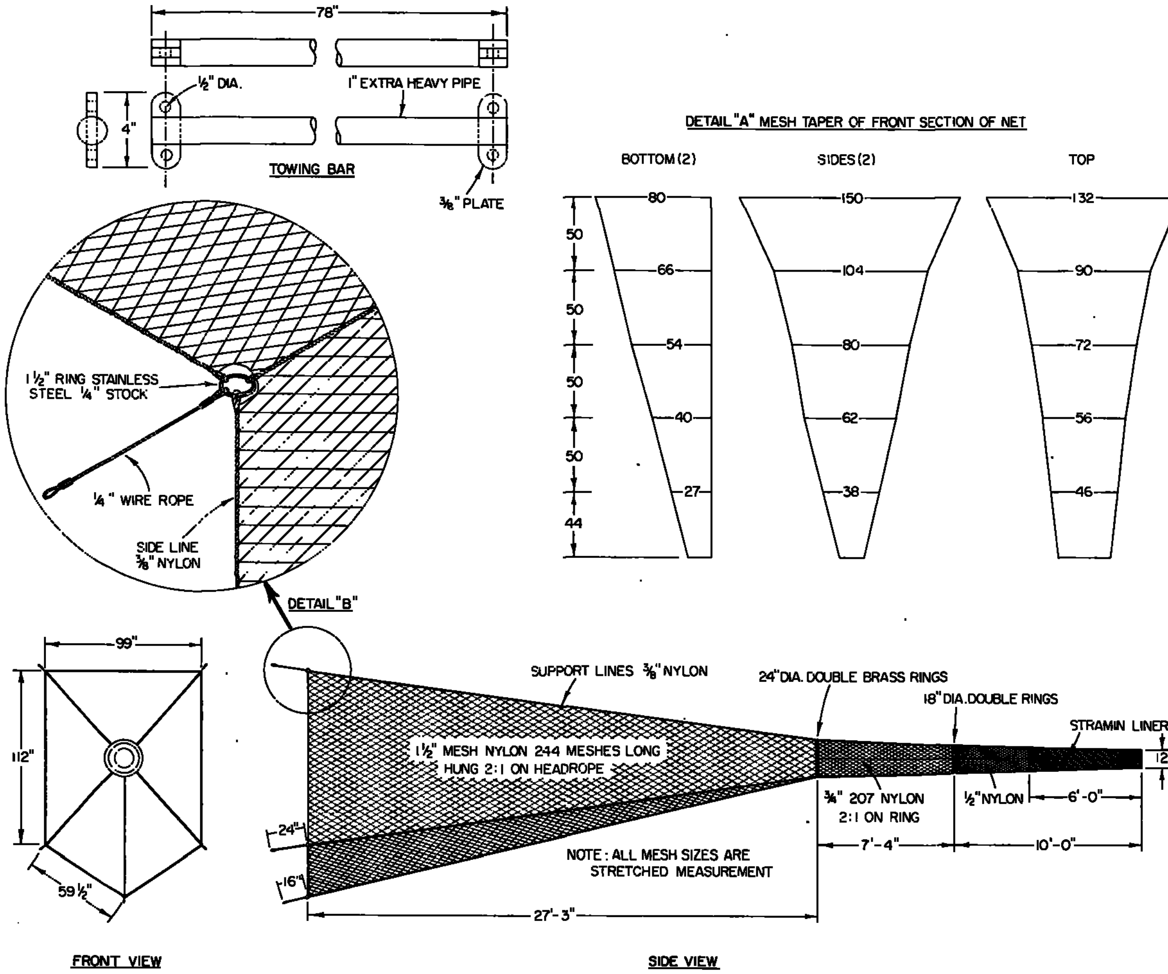

FIGURE 9.—Construction details of the 10-foot Isaacs-Kidd trawl net.

pressed to stainless rings (shown in detail "B," fig. 9).

The midregion of the net, 7 feet 4 inches in length, consists of a circular tapered section of ¾-inch mesh No. 207 nylon, detachable from both front section and cod end by a system of double rings lashed together with No. 207 nylon twine. Rings are of ¼-inch brass rod, 24 inches in diameter at the front of the section, 18 inches in diameter at the after end. Four equally spaced support lines of 3-strand ⁵⁄₁₆-inch nylon are eye-spliced into a ring at each end of the section.

The cod end is a circular tapering section, 10 feet in length, of ½-inch mesh No. 207 nylon. The last 6 feet of this section is lined with stramin, coarse silk grit gauze, or fine-meshed nylon netting, which is attached at its forward margin to the main net.

Diving Vane

Plans of the diving vane are shown in figure 10. The body of the vane is formed of ⅛-inch steel plate, 24 inches in width and 10 feet 10 inches in length, bent at the midpoint to form an angle of 140°. The leading edge (section A–A, fig. 10) is reinforced by a 1 x 2-inch channel iron welded to the underside of the plate. A streamlined entry is formed by pressing a 1½-inch angle iron to shape and welding it to the plate and channel as shown. The leading edge is faired at the afterside by a strip of ⅛-inch plate 2 inches wide welded to both the channel iron and the plate. All of these welds are continuous and the entire leading edge assembly is made watertight to avoid corrosion from the inside. Holes ¾-inch in diameter

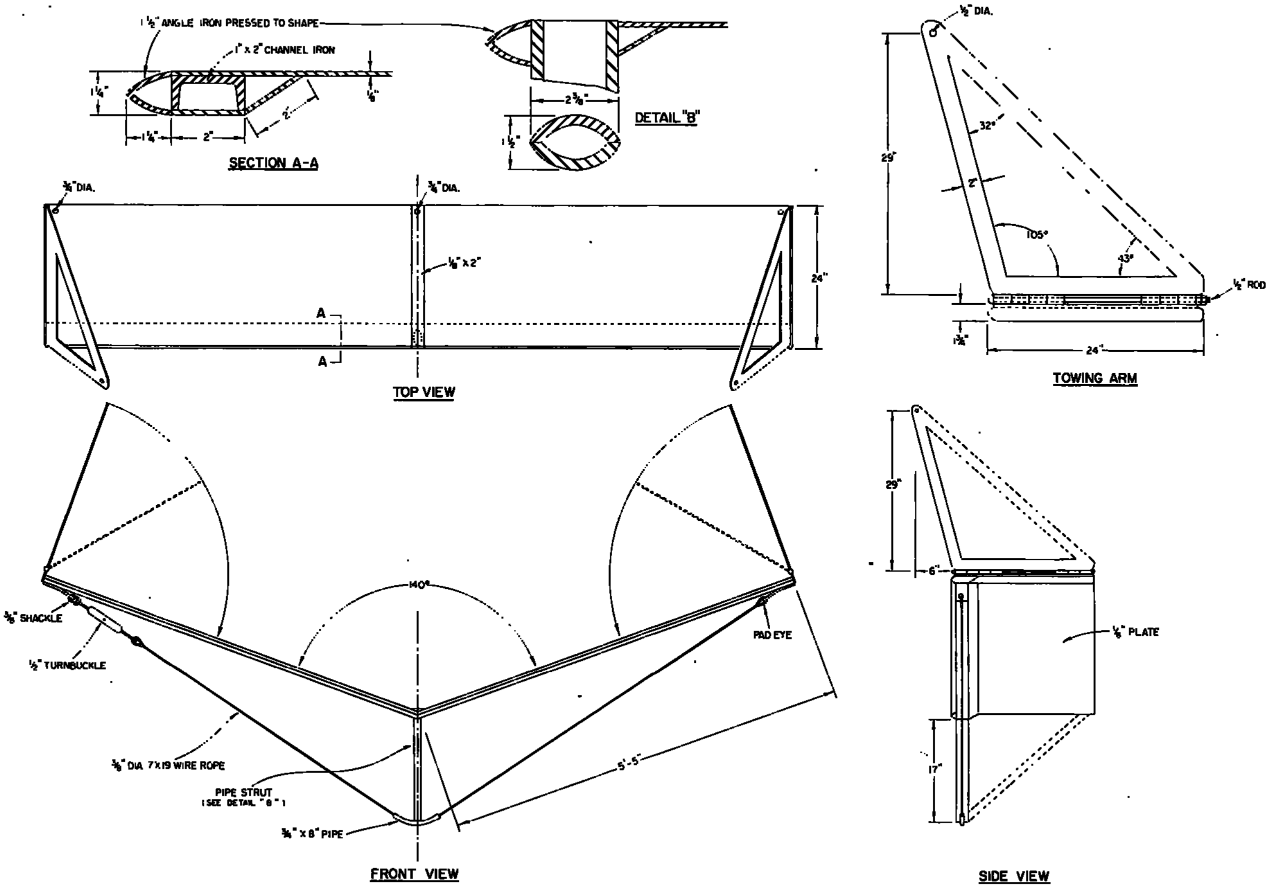

Figure 10.—Construction details of the diving vane of the 10-foot Isaacs-Kidd trawl.

are drilled on the midline and ends of the vane with their centers 1 inch from the after edge of the vane.

A pipe strut 17 inches in length extends downward from the front center of the vane (detail B, fig. 10). Lengths of 6-inch pipe are split lengthwise and welded together to form a faired cross section. This strut extends up through the leading edge of the vane and is welded both above and below. A 2-inch-wide center strip of ⅛-inch plate covers this point and adds stiffening to the vane.

The tension member consists of a wire pennant made from ⅜-inch-diameter 7×19 preformed stainless steel wire rope. Solid rigging thimbles are installed at each end. The tension adjustment is made with a ⅝-inch closed pipe turnbuckle secured by ⅜-inch galvanized chain shackles. Pad eyes of ⅜-inch plate drilled for ⅜-inch shackles are welded to the vane at each end. An 8-inch length of ¾-inch pipe is bent around a suitable radius and welded to the lower end of the pipe strut to serve as a guide for the tension member. Tension on the wire should not be excessive; the wire after prestretching should be just hand-tight since too much tension during towing will cause the vane to buckle.

The towing arms are hinged triangular members formed by welding ¼ x 2-inch plate bars into a triangle with the towing center 6 inches forward of the leading edge and 29½ inches above the hinge center. The arms are hinged by means of a ½-inch diameter galvanized pin held by 2-inch-long

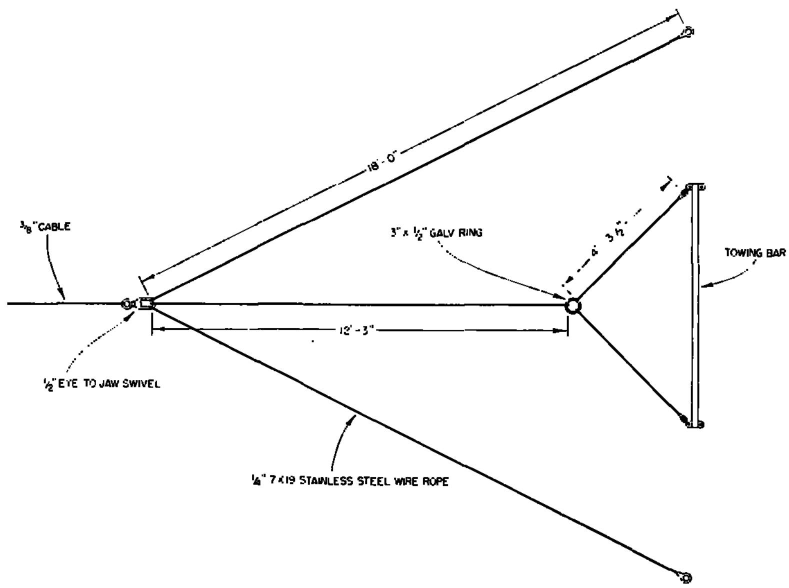

FIGURE 11.—Towing bridle and spreader bar used with the 10-foot Isaacs-Kidd trawl.

sections of 3/4-inch pipe welded alternately to the towing arm and to the end plate of the vane. This plate is fabricated from 1/4-inch plate 1 3/4 inches wide. All leading edges of the towing arms are ground to a thin edge and the hinge pin head is turned to a point to minimize resistance and turbulence during towing.

After final assembly the vane is thoroughly sandblasted and galvanized.

Towing Bridle and Spreader Bar

Details of the rigging of the towing bridle are shown in figure 11. All sections are made of 1/4-inch-diameter 7×19 preformed stainless steel wire rope. The spreader bar is a 78-inch length of heavy pipe with 4-inch bars welded at each end and drilled to take 3/8-inch shackles.

Hauling Methods

The 10-foot Isaacs-Kidd trawl was hauled by the *Smith* at speeds of 4 to 6 knots, on a towing line of 3/8-inch wire rope. At 5 knots, with about 800 meters of wire out and a wire angle of 71°, the towing tension ranged from 1,750 to 2,600 pounds; at 6 knots, with the same amount of wire out and a wire angle of 73°, the towing tension was 2,000 to 3,000 pounds.

As previously mentioned, data on the shape of the towing wire during hauling of 10- and 15-foot Isaacs-Kidd trawls have been given by Devereaux and Winsett (1953). We have independently calculated the trawl depth by the method described by Hida and King (1955), based on measurements of wire angle and wire out. Depth conversion factors derived from these measurements are listed in table 5.

TABLE 5.—*Depth conversion factors used to estimate depth of haul for 10-foot Isaacs-Kidd trawl*

[Wire out (in meters) × factor = trawl depth (in meters)]

Wire angle	Depth conversion factor
66°	0.46
67°	0.45
68°	0.44
69°	0.43
70°	0.42
71°	0.41
72°	0.40
73°	0.39
74°	0.38
75°	0.37
76°	0.36

LABORATORY PROCEDURES

The trawl collection, drained of the preserving liquid, was spread out in a shallow, white-enameled pan and sorted into two size categories: organisms less than 2 cm. and organisms greater than 2 cm., greatest dimension. This separation was made since the first category was not judged to have been sampled in a quantitative manner because of the coarse mesh of the nets used. Each size group was further sorted into kinds of organisms, with identifications being made to the most precise degree that seemed practical.

The number of individuals and displacement volume were determined for each kind or group of organisms identified. The minimum and maximum lengths, in millimeters, were recorded for each category of organisms. In some instances the total number of the more numerous organisms in the less-than-2-cm. category was estimated from the number in a subsample.

In examining the resulting data it was evident that those organisms less than 2 cm. in longest dimension usually constituted a very small fraction of the total volume of the catch. Of greater importance was the infrequent occurrence of organisms of large bulk. It was decided, therefore, to give in the summary tables (appendix tables 1 to 4) the number of organisms and the volume of the total catch, expressed in terms of 1 hour of hauling, with the two size categories combined but with added reference to the occasional occurrence of large numbers of small organisms, such as euphausiids, and the infrequent bulky forms, such as jellyfish or large fish, that greatly influenced the volume of the catch or the total number of individuals in it.

The nature of the trawling gear and the methods used did not permit or justify an exact quantitative evaluation of the catch. The amount of water strained on each haul was not metered. Vessel speed during hauling, however, was fairly uniform for each trawl, since an attempt was made to hold the wire angle within a narrow range of values. Although most hauls were for a period of 1 hour, the time varied somewhat, as indicated in appendix tables 1 to 4, and this variation was taken into account. Other possible sources of variation in the data were those relating to the hour of hauling and to depth of haul. The majority of the hauls, however, were made at night within 1 to 3 hours after sunset and sampled the upper ocean layer between the surface and 400 meters.

Detailed lists showing composition of the catches for each of the four trawls are given in appendix tables 5 to 8. Because of the great variety of invertebrates and fishes in the collections, it was not possible to give equal attention or bring the same skill to the identification of all groups. Major effort was spent on the euphausiids, shrimps, and stomiatoid and myctophid fishes because of their prominence in the collections. References used in the identification of the different groups are listed in the appendix (p. 304). Berg's (1947) system of classification and nomenclature was used in most respects for the family names of the fishes.

Where appropriate, the data were subjected to statistical analysis and the results expressed in terms of the probability that the event occurred by chance alone. We regarded events with $P \leqq 0.05$ as not occurring by chance and therefore of significance.

CATCHING ABILITIES OF THE FOUR TRAWLS

The catching ability, or efficiency, of a midwater trawl is related to many factors, including size of the mouth opening, mesh size of the net, and hauling speed, and also to the amount of disturbance or turbulence directly ahead of the net caused by the towing cable and bridle lines. These general features, except turbulence, are summarized in table 6 for the four trawls. The 1-meter ring trawl, which had the largest mesh and was towed at a slightly higher speed than the other three trawls, produced the poorest catches, both in number and in volume of organisms. As shown in figure 6, this trawl also had the most obstruction immediately ahead of the net; the other three trawls were much better designed in this respect.

TABLE 6.—*Factors affecting catching ability of the four trawls used*

Factor	6-foot beam	1-meter ring	Isaacs-Kidd	
			6-foot	10-foot
Size of mouth opening (sq. ft.)	36.0	8.4	29.8	88.3.
Mesh size:				
Front and midsection (stretched measure)	1-inch	2-inches	1½- and ¾-inch	1½- and ¾-inch.
Cod end liner (straight measure)	3/16-inch	½- and 3/16-inch	⅛-inch (stramin or equivalent)	⅛-inch (stramin or equivalent).
Hauling speed	4–5 knots	6–7 knots	4–6 knots	4–6 knots.

Although the amount of water strained by our midwater trawls was not metered, it can be estimated fairly accurately if we can accept certain assumptions; namely, that (1) the hauls were made at uniform speed; (2) the nets were 100 percent efficient, i.e., all of the water entering the mouth of the net passed on through; and (3) the amount of water strained was, therefore, proportional to the area of the mouth opening. It must be admitted that these assumptions may include some error, but we believe that for our purposes here they can reasonably be applied to the Isaacs-Kidd trawls. The nets had a high ratio of length to mouth opening and were of relatively coarse mesh, except for the cod end. There was never any evidence of clogging. Vessel speed was adjusted during the tows to yield a wire angle of 70°–72°, and the actual hauling speed was generally maintained within a range of 4 to 6 knots. If we accept 5 knots as the average hauling speed, in 1 hour the 6-foot trawl would strain 25,663 cubic meters of water and the 10-foot trawl would strain 76,043 cubic meters.

We have calculated average values in terms of number and volume of organisms in the total catch, for each of the four trawls for each major geographic region investigated (table 7). The results show considerable variation, part of which is influenced by the large numbers of euphausiids and barnacle larvae obtained in the North Pacific with the two Isaacs-Kidd trawls and by a few large catches, also of euphausiids, made in the equatorial Pacific with the 6-foot beam trawl. The volume of catch varies generally with the size of the trawl. When evaluated in terms of volume of catch per unit of mouth area, we find that the two Isaacs-Kidd trawls were on the average about equal in catching efficiency; they showed no marked superiority over the 6-foot beam trawl or the 1-meter ring trawl when used in Hawaiian waters, and were even slightly inferior to the 6-foot beam trawl when operating in the equatorial Pacific.

The average individual size (ml.) of organisms in the catch varied inversely with the relative amount of fine-meshed netting used to line the cod ends of the trawl nets. The net with the largest mouth diameter caught, on the average, the largest organisms. The net with the smallest mouth diameter did not catch the smallest organisms, however, because its cod-end liner was of slightly larger mesh than that used in the other three trawls.

TABLE 7.—*Number of organisms and volume of catches made with the four trawls, in relation to size of mouth opening of the trawl net and to geographic region*

[Number of quantitative hauls in parentheses]

Region	6-foot beam	1-meter ring	Isaacs-Kidd 6-foot	Isaacs-Kidd 10-foot
Average number of organisms per hour of hauling:				
North Pacific			5,615 (26)	1,485 (32)
Hawaiian waters	130 (10)	68 (23)	322 (19)	314 (24)
Equatorial Pacific	3,234 (6)		600 (33)	657 (101)
Average	1,294 (16)	68 (23)	2,204 (78)	773 (157)
Average volume (ml.) of catch per hour of hauling:				
North Pacific			59.3	165.3
Hawaiian waters	22.4	5.4	22.4	88.2
Equatorial Pacific	147.6		103.2	232.9
Average	69.3	5.4	68.9	197.0
Average number of organisms per hour per square foot of mouth opening:				
North Pacific			188.4	16.8
Hawaiian waters	3.6	8.0	10.8	3.6
Equatorial Pacific	89.8		20.1	7.4
Average	35.9	8.0	74.0	8.8
Average volume (ml.) of catch per hour per square foot of mouth opening:				
North Pacific			2.0	1.9
Hawaiian waters	.6	.6	.8	1.0
Equatorial Pacific	4.1		3.5	2.6
Average	1.9	.6	2.3	2.2
Average individual size (ml.) of organisms in the catch:[1]				
All areas	.05	.08	.03	.25

[1] Average volume of catch divided by average number of organisms.

On *Smith* cruise 27 to the central North Pacific, the 6- and 10-foot Isaacs-Kidd trawls were used on consecutive hauls on three successive nights for the purpose of comparing the catches obtained with the two sizes of gear. The results of the test, summarized in table 8, indicate that the catch of the larger trawl was about three times as great, with respect both to volume and to number of organisms, as that of the smaller trawl. When judged in terms of catch per unit of mouth area, the two trawls took essentially the same volume and number of organisms. The kinds and sizes of organisms in the collections were also similar for the two trawls.

A checklist of organisms identified in the catch of the four trawls is given in appendix tables 5 to 8. In general, the greater the number of hauls and the more regions sampled by a trawl, the longer the list. A study of appendix tables 5 to

TABLE 8.—*Volume and number of organisms obtained with the Isaacs-Kidd trawls on* Hugh M. Smith *cruise 27, central North Pacific, 1955*

Item	6-foot	10-foot
Station 23:		
Position:		
Latitude	28°28′ N.	28°32′ N.
Longitude	178°10′ W.	178°10′ W.
Date	Jan. 31	Jan. 31
Time of haul (zone time)	1948–2049	2102–2202
Estimated maximum depth (m.)	122	118
Catch per hour's hauling:		
Volume (ml.)	6.7	57.1
Number of organisms	265	882
Station 25:		
Position:		
Latitude	30°02′ N.	29°56′ N.
Longitude	179°31′ E.	179°28′ E.
Date	Feb. 1	Feb. 1
Time of haul (zone time)	2049–2151	1939–2041
Estimated maximum depth (m.)	122	118
Catch per hour's hauling:		
Volume (ml.)	28.1	62.1
Number of organisms	1,487	3,629
Station 28:		
Position:		
Latitude	32°52′ N.	32°46′ N.
Longitude	179°55′ W.	179°54′ W.
Date	Feb. 2	Feb. 2
Time of haul (zone time)	2049–2149	1943–2042
Estimated maximum depth (m.)	144	118
Catch per hour's hauling:		
Volume (ml.)	56.1	177.7
Number of organisms	542	1,456
Average (all stations):		
Per hour of hauling:		
Volume (ml.)	30.3	99.0
Number of organisms	765	1,989
Per 1,000 m.^{3} of water strained:		
Volume (ml.)	1.2	1.3
Number of organisms	29.8	26.2

8 shows that many groups of vertebrates and invertebrates were common to the catch of all four trawls. In an attempt to determine whether there were wide differences in the catch composition, we counted the major categories appearing in each list and assembled the results in table 9. The same number of phyla and classes was sampled by all four trawls. The major differences were in the families of invertebrates and the families and genera of fishes, with the most-frequently used trawl catching the greatest variety of organisms.

VARIATION OF TRAWL CATCH

DIURNAL VARIATION

Size of Catch

Although our data indicate that catches made at night greatly exceeded day catches both in volume and number of organisms (table 10), the information available is insufficient to describe the diurnal variation in forage abundance. On *Manning* cruise 9 (appendix table 1) two series of four hauls each were made with the 6-foot beam trawl with the stations at various distances from shore, one series in the daytime (1000–1800 hours) and the other at night (2000–0300 hours). The day hauls yielded an average volume of 8.6 ml. per hour of hauling and the night hauls 38.6 ml.; the night/day volume ratio was therefore 4.49. With respect to number, day hauls produced an average of 123 organisms and the night hauls 134, for a night/day ratio of 1.09. The difference between these two ratios indicates a difference in the size of organisms in the night and day catches. When the average volume is divided by the average number in the catch we obtain a value of 0.07 ml. for the average individual size of the organisms in the day catches and 0.29 ml. for the individual size in the night catches.

In April–June 1953, the 1-meter ring trawl was used repeatedly at two "fixed" stations in Hawaiian waters, one located to windward and the other to leeward of the islands. The stations were about 75 miles apart, and both were thought to represent open ocean conditions. On each of the *Gilbert* cruises 11, 12, and 13, the windward station (station A) was visited during the early afternoon hours and the leeward station (station D)

TABLE 9.—*Number of taxonomic groups in the catch of the four trawls and in the stomach contents of tuna*

	Invertebrates				Vertebrates (Pisces)		Number of hauls or stomachs	Authority
	Phyla or subphyla	Classes	Orders	Families	Families	Genera		
Gear:								
6-foot beam trawl	6	8	12	19	17	26	16	
1-meter ring trawl	6	6	12	15	12	11	23	
Isaacs-Kidd trawl:								
6-foot	7	7	15	25	33	42	78	
10-foot	7	7	16	30	53	77	157	
Stomach contents:								
Yellowfin	3	5	11	19	37	19	1,097	Reintjes and King (1953).
Do	3	4	12	31	48	52	439	King and Ikehara (1956).
Bigeye	4	4	9	22	36	38	166	Do.
Skipjack	3	5	11	17	42	30	707	Waldron and King.[1]
Albacore	5	6	12	29	34	24	348	Iversen (in press).

[1] See footnote 4, p. 295.

TABLE 10.—*Quantitative differences in the catch of day and night hauls with three types of trawls*

[Based on 40 hauls]

Trawl and vessel	Cruise	Area	Day hauls			Night hauls			Night/day ratio		Average size of organism [1]	
			Number of hauls	Average volume	Average number of organisms	Number of hauls	Average volume	Average number of organisms	Volume of catch	Number of organisms	Day	Night
				Milliliters			*Milliliters*		*Milliliters*		*Milliliters*	*Milliliters*
6-foot beam trawl:												
John R. Manning	9	Hawaiian waters	4	8.6	123	4	38.6	134	4.49	1.09	0.07	0.29
1-meter ring trawl:												
Charles H. Gilbert	11, 12, 13	Hawaiian waters	11	1.8	47	11	9.0	93	4.90	1.98	.04	.10
6-foot Isaacs-Kidd trawl:												
John R. Manning	20	Hawaiian waters	2	5.8	106	2	22.8	257	3.91	2.42	.06	.09
Do	20	Equatorial Pacific [2]	4	11.4	158	2	106.4	614	9.33	3.89	.07	.17

[1] Displacement volume.
[2] Countercurrent.

shortly after midnight. Although minor differences between these two stations in the physical and chemical features of the environment might have influenced the abundance of forage organisms, we believe that the major differences in the catch were related to the time of hauling. The average volume of 11 hauls at station A was 1.8 ml. and the average number of organisms in the catch was 47, as compared with an average volume of 9.0 ml. and an average number of 93 for 11 hauls at station D. The night/day ratio for volumes was 4.90, and for numbers, 1.98. The average individual size of organisms was 0.04 ml. for the day hauls and 0.10 ml. for the night hauls.

At the start of *Manning* cruise 20, four test hauls were made with the 6-foot Isaacs-Kidd trawl in Hawaiian waters to determine the difference in catch between hauls made in the morning about 2 hours after sunrise and at night about 1 hour after sunset. For this series the average volume of the two night samples was 22.8 ml. and the average number of organisms was 257; for the two day samples, the average volume was 5.8 ml. and the average number of organisms was 106. The night/day ratio was 3.91 for volume and 2.42 for number of organisms. Again the average size of organisms was much larger in night than in day hauls (table 10).

The main objective of *Manning* cruise 20 was to conduct longline fishing in the equatorial Pacific. During the first 4 days of operations in the Countercurrent, a trawl haul was made each morning about 2 hours after sunrise, soon after the longline had been set. Because of the poor catches that were being made, the hauling time was changed on the 5th day to about 1 hour after sunset, just after the longline gear had been retrieved for the day and the ship was underway to the next station. The two hauls made at this new time were also in the Countercurrent, and averaged 106.4 ml. in volume, as compared with an average of 11.4 ml. for the four day hauls taken earlier. The average numbers of organisms, night/day ratios, and average size of the organisms are given in table 10, along with similar data for the other cruises mentioned. No day hauls were made with the 10-foot Isaacs-Kidd trawl.

Composition of the Catch

There were also marked diurnal differences in the composition of the trawl catches. Lists of organisms occurring in the day and night hauls referred to above are given in tables 11 and 12 and appendix table 6 and summarized by general category in table 13. Coelenterates, certain molluscs, and tunicates occurred in about equal frequency in the day and night collections. Among the Crustacea, the amphipods and stomatopods were taken in about equal numbers in day and night hauls, whereas the decapods were taken principally at night. Very few squids and fishes, except larval and juvenile forms, were captured during daylight. The main difference, therefore, between day and night hauls was the capture at night of the stronger swimming animals which were either absent from the upper layer during the day or were able to dodge the net. We suspect that most of these animals were capable of making extensive vertical migrations during the day to depths below those sampled by the trawls and became concen-

TABLE 11.—*Composition of catches obtained in four day hauls and four night hauls with the 6-foot beam trawl in Hawaiian waters,* John R. Manning *cruise 9, November 1951*

Organisms	Day		Night	
	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul
COELENTERATA: Unidentified	50	1	75	[1]
Hydrozoa:				
Siphonophora	50	[1]	25	35
Medusae: Unidentified			50	2
CHAETOGNATHA: Unidentified	100	50	100	14
Sagitta sp.	50	24		
ARTHROPODA:				
Crustacea:				
Copepoda			25	[1]
Mysidacea:				
Lophogastridae			25	10
Amphipoda:				
Oxycephalidae:				
Rhabdosoma sp.			25	1
Stomatopoda (larvae)	75	55	100	27
Euphausiacea	50	15	75	29
Decapoda:				
Penaeidae:				
Gennadas sp.			50	3
Pandalidae:				
Parapandalus zur strasseni	25	3	25	2
Hoplophoridae:				
Hoplophorus gracilirostris			50	2
H. grimaldii	25	1		
Systelaspis debilis			25	2
Sergestidae: Unidentified	25	10	50	6
Sergestes gardineri			50	5
Sergestes sp.			25	22
Scyllaridae: Phyllosoma	25	1		
Unidentified Decapoda	25	[1]	50	[1]
Unidentified Crustacea	75	[1]	25	[1]
MOLLUSCA:				
Gastropoda:				
Pteropoda	25	[1]		
Heteropoda:				
Pterotracheidae	75	3	25	6
Cephalopoda:				
Decapoda (squids)	25	7		
Chiroteuthidae			25	1
Unidentified Mollusca	25	[1]		
UNIDENTIFIABLE INVERTEBRATE MATERIAL	75	[1]	75	[1]
CHORDATA—Tunicata:				
Thaliacea:				
Pyrosomatidae	25	18		
Salpidae	25	35		
Unidentified Tunicata	50	[1]	50	[1]
CHORDATA—Vertebrata:				
Pisces:				
Gonostomidae:				
Vinciguerria lucetia			25	1
Chauliodontidae:				
Chauliodus sp.			25	1
Astronesthidae:				
Astronesthes lucifer			25	1
Idiacanthidae	25	1		
Synodontidae			25	1
Myctophidae: Unidentified	25	13	75	7
Benthosema sp.	25	1	25	4
Diogenichthys atlanticus	25	1		
Centrobranchus nigro-ocellatus			25	1
Myctophum brachygnathos			25	2
M. spinosum			25	1
M. evermanni			25	4
Notolychnus valdiviae			50	4
Diaphus sp.	25	2	75	3
Lampanyctus pyrsobolus			25	1
Lampanyctus sp.	25	1	50	18
Ceratoscopelus townsendi			50	4
Apogonidae			25	1
Acanthuridae			25	1
Larval fish:				
Leptocephali: Unidentified	50	1	50	1
Unidentified larvae	100	10	100	32
Unidentified Pisces			25	1

[1] Actual number not determined.

TABLE 12.—*Composition of catches obtained in six day hauls and four night hauls with 6-foot Isaacs-Kidd trawl in Hawaiian waters and in the Equatorial Countercurrent,* John R. Manning *cruise 20, April–May 1954*

Organisms	Day		Night	
	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul
COELENTERATA:				
Hydrozoa:				
Siphonophora	100	27	100	32
Medusae: Unidentified	17	1	25	1
CTENOPHORA: Unidentified			75	5
CHAETOGNATHA: Unidentified	100	78	100	66
ARTHROPODA:				
Crustacea:				
Mysidacea:				
Lophogastridae			25	1
Amphipoda:				
Phronimidae:				
Phronima sp.	33	1	50	2
Oxycephalidae:				
Oxycephalus sp.			25	2
Rhabdosoma sp.	67	1	50	5
Unidentified Amphipoda	67	71	50	32
Stomatopoda (larvae)	33	2		
Euphausiacea			50	370
Decapoda:				
Penaeidae:				
Gennadas scutatus			25	20
Gennadas sp.			25	8
Funchalia taaningi			25	1
Pandalidae:				
Parapandalus zur strasseni			50	6
Heterocarpus ensifer			25	1
Hoplophoridae:				
Hoplophorus typus			25	1
H. gracilirostris			25	1
Sergestidae:				
Sergestes gardineri			25	1
Sergestes sp.			50	6
Palinuridae: Phyllosoma	17	1		
Unidentified Decapoda	33	22		
Unidentified Crustacea			100	34
MOLLUSCA:				
Gastropoda:				
Heteropoda:				
Pterotracheidae			75	2
Cephalopoda:				
Decapoda (squids):				
Cranchiidae	17	2	25	1
Unidentified Mollusca	17	2	50	10
UNIDENTIFIABLE INVERTEBRATE MATERIAL	33	[1]	25	[1]
CHORDATA—Tunicata:				
Thaliacea:				
Pyrosomatidae	17	1	50	21
Salpidae	83	7	50	12
Unidentified Tunicata	67	11	100	20
CHORDATA—Vertebrata:				
Pisces:				
Gonostomidae: Unidentified			25	1
Vinciguerria lucetia			25	6
Gonostoma elongatum			50	2
Diplophos taenia			25	4
Stomiatidae: Unidentified			25	2
Thysanactis dentex			25	1
Thysanactis sp.			25	2
Eustomias sp.			50	4
Malacosteidae:				
Photostomias sp.			50	2
Aristostomias sp.			25	2
Paralepididae: Unidentified			25	7
Myctophidae:				
Myctophum evermanni			25	2
M. affine			25	1
Diaphus sp.			50	2
Lampanyctus pyrsobolus			25	2
Lampanyctus sp.			50	4
Ceratoscopelus townsendi			25	1
Bregmacerotidae:				
Bregmaceros macclellandi			25	4
Gempylidae: Unidentified	17	1		
Tetragonuridae:				
Tetragonurus sp.			25	1
Larval fish:				
Leptocephali: Unidentified	33	2	50	1
Unidentified larvae	100	5	100	21
Unidentified Pisces			50	2

[1] Actual number not determined.

TABLE 13.—*Number of categories of organisms taken in comparable day and night hauls, by trawl*

[Based on tables 11 and 12 and appendix table 6]

Gear and cruise	Area	Number of hauls		Coelenterata		Decapod Crustacea		Other Crustacea		Mollusca		Tunicata		Pisces	
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
6-foot beam trawl:															
John R. Manning:															
Cruise 9	Hawaiian waters	4	4	2	3	5	8	3	6	4	2	3	------	8	20
1-meter ring trawl:															
Charles H. Gilbert:															
Cruise 11	Hawaiian waters														
Cruise 12	do														
Cruise 13	do	11	12	2	2	3	9	8	8	7	6	3	3	7	17
Hugh M. Smith:															
Cruise 21	do														
6-foot Isaacs-Kidd trawl:															
John R. Manning:															
Cruise 20	Hawaiian waters	2	2	2	2	2	9	4	7	2	3	3	3	3	22
	Equatorial Countercurrent	4	2												

trated in the upper layer of the ocean only at night, so that the augmentation of the fauna in the upper strata at night was most likely the more important cause of the day/night difference in our catch.

Aron (1959) presents interesting data on diurnal variation in midwater trawl catches obtained with a modified Isaacs-Kidd trawl in the northeastern Pacific. He also found wide differences between day and night hauls, but through the use of stratified tows was able to show that day/night differences in the catch diminished with increasing depth between the surface and 250 meters. For night hauls he reports a general decrease in the catch with an increase in depth and just the reverse for day hauls.

VARIATION WITH AREA AND CURRENT SYSTEM

The general pattern of ocean currents in the Pacific has been described by Schott (1935, p. 161–171, plates XXIX and XXX) and by Sverdrup et al. (1942, p. 698–728, chart VII). Figure 12 is a diagrammatic representation of the gross features of the current system of the central Pacific region in relation to the boundaries of seven "faunal zones" selected by us for use in comparing latitudinal differences in the trawl catch. As far as possible the boundaries of the different zones were chosen to coincide with natural subdivisions of the environment. Zone 1 extends from the limits of our sampling in the south (about latitude 19° S.) to latitude 5° S. in the north, within the South Equatorial Current (SEC); zone 2 brackets the region of upwelling and enrichment at the Equator and extends from 5° S. to the northern boundary of the South Equatorial Current (SEC) at about 5° N.; zone 3 is the Equatorial Countercurrent (ECC) between approximately latitude 5° N. and 10° N.; zone 4, the North Equatorial Current (NEC) between the northern boundary of the Equatorial Countercurrent and waters adjacent to the Hawaiian Islands; zone 5, the Hawaiian Islands (H) from about latitude 18° N. to 28° N.; zone 6, the North Pacific Current (NPC) between Hawaiian waters and 35° N., the approximate center of the "transition zone" of McGary et al. (1958), which is the zone of convergence between the Central Water Mass on the south and the Subarctic Water Mass on the north; and zone 7, the Aleutian Current (AC) from 35° N. to about 50° N., the northern limit of our sampling. The representation of the South Equatorial Current (zone 1) does not take into con-

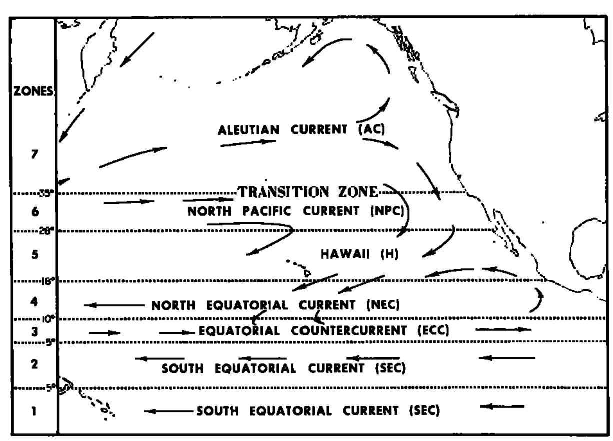

FIGURE 12.—Boundaries of the seven "faunal zones" employed in the comparison of latitudinal variations in the trawl catch, in relation to the major features of the ocean current system in the central Pacific.

sideration Reid's (1959) report of a weak easterly countercurrent near 10° S.

Variation in Size of Catch

Latitudinal variations.—Since the major environmental boundaries or discontinuities in the central Pacific are zonal, i.e., east-west in alinement, we assumed that variations in trawl catch associated with longitude would be of much less significance than the latitudinal variations. Therefore, in order to examine major variations in the data with respect to the current system, the catch data for the 6- and 10-foot Isaacs-Kidd trawls were combined over the longitudes sampled but segregated according to the latitudinal zones we have defined.

The results, shown in figure 13, demonstrate a marked variation with latitude in the abundance of forage organisms sampled with the Isaacs-Kidd trawls. With respect to volume,[2] the curves were similar for both trawls, with peak values recorded for each trawl in the same zones. With respect to number of organisms, the catch was similar for the two trawls except in the most northern zones, where the data were strongly influenced by a few large catches of euphausiids and barnacle larvae. These organisms were particularly abundant in catches of the 6-foot trawl on *Manning* cruise 22 in September 1954 and account for the major difference between the two trawls in the Aleutian Current and in the North Pacific Current. Both trawls, however, captured the largest numbers of organisms in the northern zones, with a secondary peak at the Equator.

The least productive areas, with respect to both volume and number of organisms, were the South Equatorial Current south of latitude 5° S., the North Equatorial Current between about latitudes 10° N. and 18° N., and waters around the Hawaiian Islands.

One interesting feature of the data, illustrated in figure 13, is the increase of variance, particularly in numbers of organisms, in the northern zones. This increase is indicated by the width of the 0.95 fiducial interval shown for each mean. McGary et al. (1958) have pointed out that this northern region is an area of great complexity and

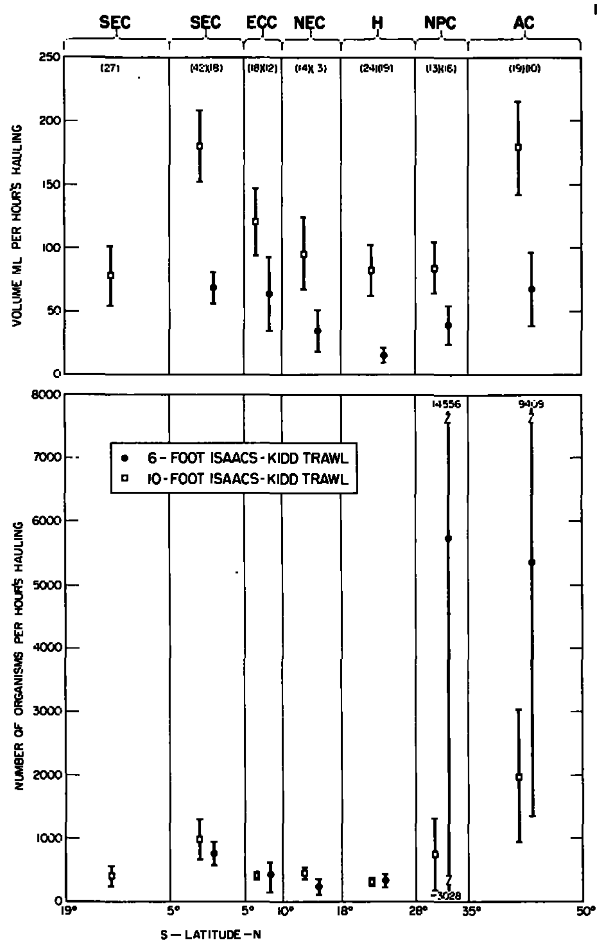

FIGURE 13.—Variation with latitude in average volumes and numbers of organisms captured per hour of hauling with the 6- and 10-foot Isaacs-Kidd trawls. (The limits of the 0.95 fiducial interval are indicated for each mean; the number of samples for each area is shown in parentheses. Zones defined in figure 12.)

of wide fluctuations, both seasonally and otherwise, in such features as temperature, salinity, phosphate concentration, and zooplankton abundance. The high variance in the trawl catches may be related to these fluctuations in the environment in the northern waters, as contrasted with the comparatively stable conditions in tropical and subtropical waters.

Although the data obtained from the 1-meter ring trawl and the 6-foot beam trawl were not of sufficient geographic coverage to treat in a detailed manner, the catches of the beam trawl did show a marked difference between the two major areas sampled. For five night hauls of *Manning*

[2] The volumes used in this comparison were the total catches minus unusually large or bulky organisms constituting approximately 50 percent or more of the catch.

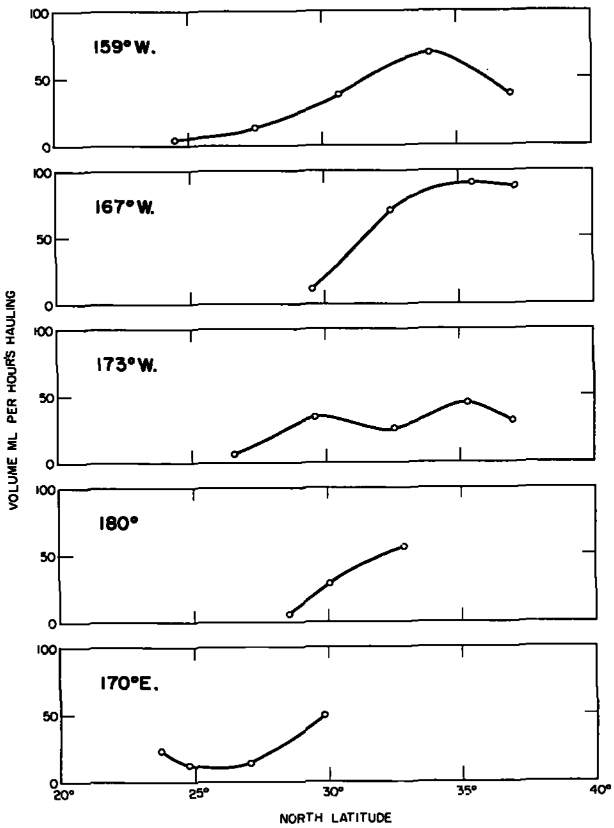

FIGURE 14.—Variation in trawl catch (volume in milliliters per hour of hauling) of 6-foot Isaacs-Kidd trawl on five north-south sections, *Hugh M. Smith* cruise 27, January–February 1955.

cruise 9 in November 1951 in Hawaiian waters, the average volume was 34.6 ml. and the average number of organisms was 138 per hour of hauling. Four night hauls of *Smith* cruise 15 in June 1952 at about latitude 6° N. in the Equatorial Countercurrent yielded an average volume of 217.9 ml. and an average number of 4,803 organisms. The chief difference in the composition of the catch from the two areas was the much greater quantity of euphausiids taken in the Countercurrent. The variety and quantity of fish captured in the two areas were approximately equal. Although the two cruises occurred at different times of the year, we do not believe that the differences observed were seasonal in nature, but rather were associated with geographical differences in the fauna or differences in standing crop of certain faunal groups.

Longitudinal variations.—The 6-foot Isaacs-Kidd trawl was employed on one cruise, *Smith* cruise 27, in such manner as to provide a rough evaluation of differences in the volume of catch among longitudes in the central North Pacific. During January and February 1955, three to five night hauls were made on north-south sections along the longitudes 170° E., 180°, 173° W., 167° W., and 159° W., within the latitudinal range of 23° N. to 37° N. As evidenced in figure 14, and evaluated by an analysis of variance, the differences among longitudes were not significant ($F=1.79$; d.f.$=4$ and 16; $P>0.05$); however, the residual variance in the test was composed of variability due to latitude as well as to chance, which reduced the F value for longitude. Although the data are few they do show a definite trend. For four of the five longitudes, the catches were generally low in volume between 23° N. and 30° N., and moderately higher in volume between 30° N. and 37° N. in the region of the transition zone. Judging by the shape of the curves (fig. 14), we postulate that during this winter season the southern boundary of the transition zone may have occurred as far south as latitudes 30° N. to 32° N.

It would have been desirable to evaluate differences in the catch due to longitudinal variation using a two-way analysis of variance so as to separate variability due to latitude from that due to experimental error. Unfortuately, unequal groupings of observations along the various longitudes made this possible for only *Smith* cruises 30 and 31. Even for these two cruises some data collected at the extremities of several longitudinal sections could not be used owing to lack of corresponding data on adjacent sections. Also, in three instances, one of two values recorded close together along a longitude section was discarded in order that the analysis could be undertaken. The discarded values were determined by flipping a coin.

During *Smith* cruise 30, in July and August 1955, 6 or 8 night hauls were made with the 10-foot Isaacs-Kidd trawl on each of four longitudes, 180°, 172° W., 165° W., and 157° W., within the latitudinal range of 22° N. to 50° N. (fig. 15). As evaluated by a two-way analysis of variance, the differences in catch among longitudes were not significant ($F=3.09$; d.f.$=3$ and 15; $P>0.05$; F at the 0.05 level was 3.29). As for the 6-foot trawl (fig. 14), the catches taken on the northern portion of each section, in this case between 35° N.

and 50° N., averaged higher than those to the south. In this summer season it appears that the northern boundary of the transition zone occurred at about latitude 40° N., longitude 157° W., and then sloped to the south in a westerly direction.

Sampling with the 10-foot Isaacs-Kidd trawl was conducted on two cruises to the equatorial Pacific during which hauls were made along north-south sections. On *Smith* cruise 31, in October and November 1955, six or seven hauls were made at night on each of three longitudes, 140° W., 120° W., and 112° W., within the latitudinal range of 8° S. to 7° N. (fig. 16). In this case, as evaluated by a two-way analysis of variance, the differences among longitudes were significant ($F=6.81$; d.f.$=2$ and 10; $P<0.05$). Catches were generally higher in volume north of the Equator than south.

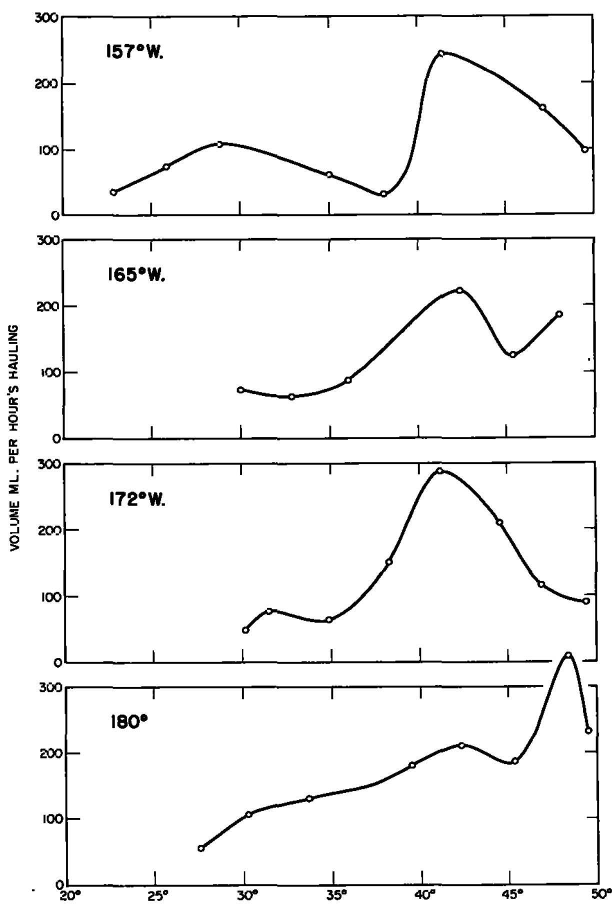

Figure 15.—Variation in trawl catch (volume in milliliters per hour of hauling) of the 10-foot Isaacs-Kidd trawl on four north-south sections, *Hugh M. Smith* cruise 30, July–August 1955.

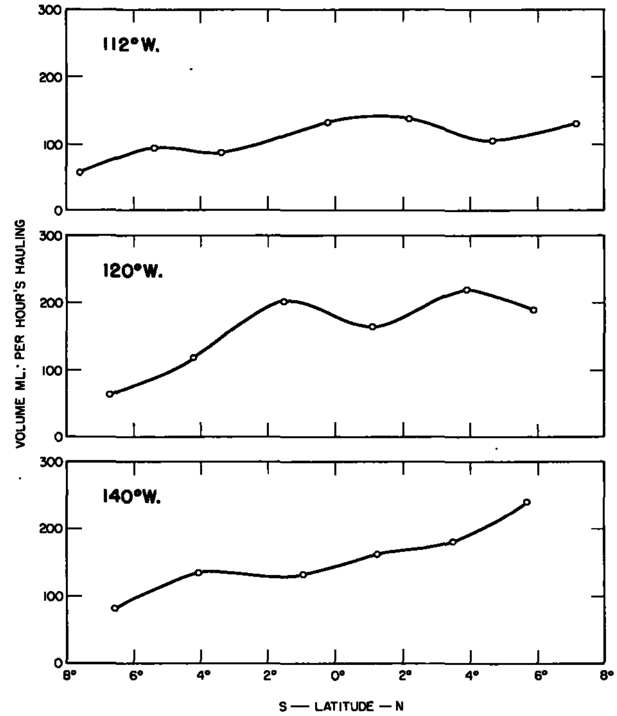

Figure 16.—Variation in trawl catch (volume in milliliters per hour of hauling) of the 10-foot Isaacs-Kidd trawl on three north-south sections, *Hugh M. Smith* cruise 31, October–November 1955.

During one part of cruise 31, hauls were made each night while the *Smith* was running generally to the east on a meandering course along the northern boundary of the Countercurrent. Volumes of the catches obtained on these hauls are plotted in figure 17 in relation to longitude and the position of the current boundary. There appears to be a doming or peaking in the volumes in the neighborhood of longitude 140° W. and again at 115° W. with a single high catch at 125° W. There is no apparent relation between volume of catch and distance north or south of the current boundary.

On *Smith* cruise 35, in August to October, 1956, 8 to 11 hauls were made on each of 4 longitudes, 160° W., 151° W., 143° W., and 135° W., within the latitudinal range of 20° S. to 11° N. (fig. 18). On three of the four sections, the peak volume occurred within 2° of the Equator. Although differences among longitudes were not significant ($F=0.37$; d.f.$=3$ and 32; $P>0.05$), there is indication of a trend in the region of the Equator

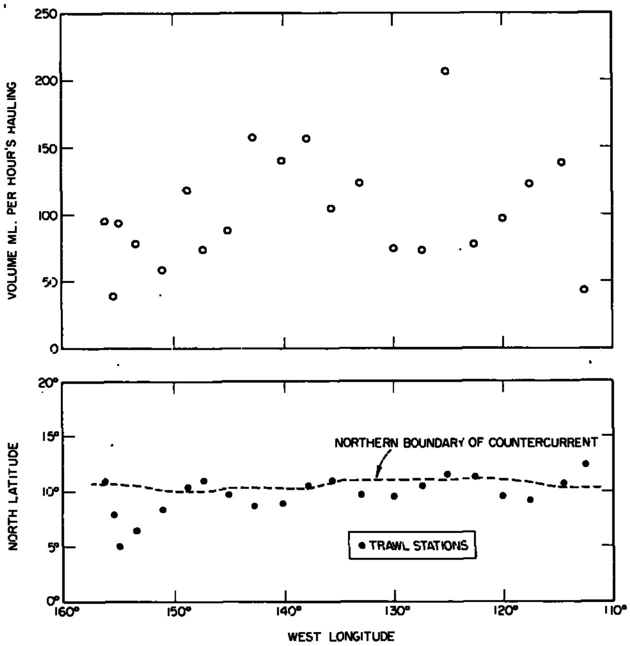

FIGURE 17.—Variation in trawl catch (volume in milliliters per hour of hauling), of the 10-foot Isaacs-Kidd trawl along the northern boundary of the Countercurrent, *Hugh M. Smith* cruise 31, September–October 1955.

with the catch volumes increasing to the westward between longitudes 135° W. and 151° W.

Austin and Rinkel (1958) have shown that there is an east-west variation in upwelling at the Equator with the maximum occurring in the eastern Pacific and the period of most active upwelling being August through October, which is the period of this cruise. King and Hida (1957a) found a gradient of decreasing zooplankton abundance along the Equator between longitudes 140° W. and 180°. Austin (1958) has shown that as the surface currents carry the newly upwelled water to the westward it "ages," i.e., it becomes warmer, its content of inorganic phosphate is reduced, and the thermocline deepens. We realize that the following explanation is an oversimplification of a very complex series of events, but we hypothesize that the reduction in the zooplankton standing crop to the west of 140° W. may be the result of heavy predation by an increasing population of forage organisms.

Differences between cruises.—The midwater trawling study was not conducted in a manner to permit the proper evaluation of differences related to seasons for any of the areas sampled. In three instances, however, an area was visited on two cruises at different times of the year, or in different years, which provided some comparison of differences between cruises that most likely were related to seasonal or annual changes in the environment.

The mean volumes obtained with the 6-foot Isaacs-Kidd trawl on *Manning* cruise 20 (April–May 1954) and *Manning* cruise 24 (March–April 1955) to the equatorial Pacific were not significantly different ($t=0.759$, $P>0.4$).

The catch volumes obtained with the 6-foot Isaacs-Kidd trawl on *Manning* cruise 22 (September–October 1954) and on *Smith* cruise 27 (January–February 1955) to the central North Pacific

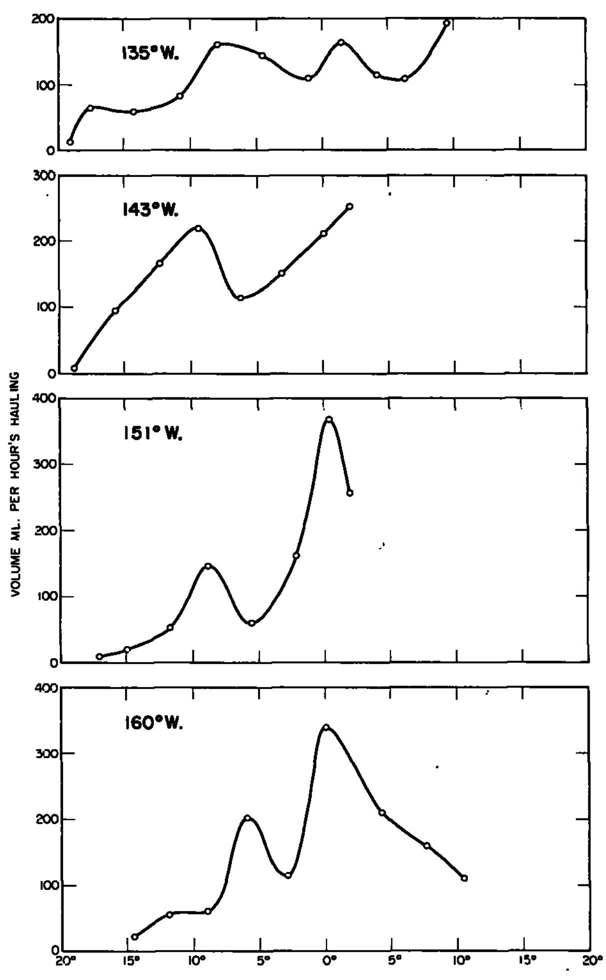

FIGURE 18.—Variation in trawl catch (volume in milliliters per hour of hauling) of the 10-foot Isaacs-Kidd trawl on four north-south sections, *Hugh M. Smith* cruise 35, August–October 1956.

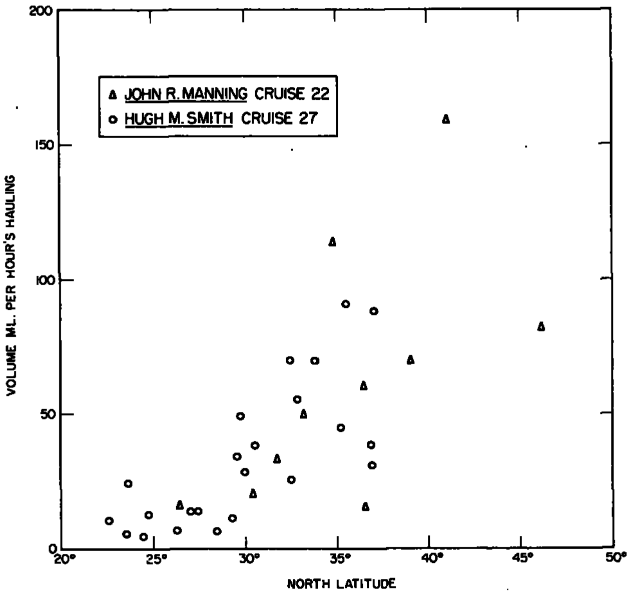

FIGURE 19.—Variation in trawl catch (volume in milliliters per hour of hauling) with latitude of the 6-foot Isaacs-Kidd trawl, *John R. Manning* cruise 22, September-October 1954, and *Hugh M. Smith* cruise 27, January-February 1955.

are plotted in figure 19. If the volumes north of 40° N., exclusively *Manning* cruise 22, and south of 25° N., exclusively *Smith* cruise 27, are omitted from the analysis, we find no significant difference ($t=0.614$, $P>0.5$) between cruises.

Employing the 10-foot trawl on *Smith* cruise 31 (September–December, 1955) and on *Smith* cruise 35 (August–October, 1956) to the equatorial Pacific, we obtained catches with mean volumes not significantly different ($t=0.657$, $P>0.4$). Despite a wide variance in the data, there was a close similarity in the catch means when summarized by latitudinal zone (fig. 20).

On the basis of these simple "t" tests of the difference between means, we found in two instances no significant differences between cruises to the same general area at about the same time of year but in different years, and in a third instance no significant difference between two cruises to the same area but at different seasons (late summer and winter). These findings, together with those of the previous sections of this report, seem to indicate that the tropical marine fauna sampled by our midwater trawls is highly uniform in abundance both in space and time.

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Variations in Composition of the Catch

It is evident from appendix tables 7 and 8 that there are north-south differences in the kinds and numbers of organisms captured by the Isaacs-Kidd trawls. These are summarized in a general manner in tables 14 and 15. We conclude that the largest number of categories of organisms was captured in the South Equatorial Current and in the Countercurrent (table 14); Hawaii and the North Pacific Current were next in rank; the poorest zones with respect to kinds of organisms were

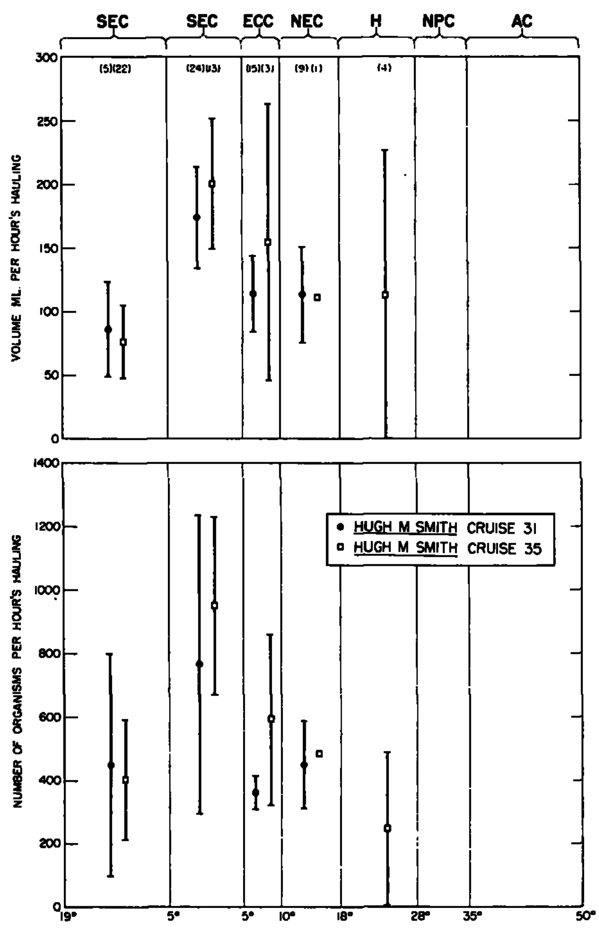

FIGURE 20.—Variation in trawl catch (volume in milliliters and number of organisms per hour of hauling) with latitude of the 10-foot Isaacs-Kidd trawl, *Hugh M. Smith* cruise 31, September–December, 1955, and *Hugh M. Smith* cruise 35, August–October, 1956. (Limits of the 0.95 fiducial interval are indicated for each mean. Number of hauls in each area is shown in parentheses.)

TABLE 14.—*Number of fish families and categories of organisms taken in the central Pacific, by trawl and latitude, 1953–56*

[Basic data in appendix tables 7 and 8; see p. 286 for description of faunal zones]

	SEC 20° S.–5° N.	ECC 5°–10° N.	NEC 10°–18° N.	Hawaii 18°–28° N.	NPC 28°–35° N.	AC 35°–50° N.	All areas
6-foot Isaacs-Kidd trawl:							
Number of samples	18	12	3	19	16	10	78
Number of fish families represented	17	17	7	16	16	8	33
Total number of categories, all forms	89	95	35	77	73	46	174
10-foot Isaacs-Kidd trawl:							
Number of samples	69	18	14	24	13	19	157
Number of fish families represented	36	25	18	30	15	15	53
Total number of categories, all forms	240	138	116	150	99	104	355

the North Equatorial Current and the Aleutian Current. As might be expected, this relation also holds true generally for the number of fish families represented in the catch. Although these data are variable, partly because there were more hauls in some areas than in others, they do show a general reduction in the variety of the fauna in a tropics-to-arctic direction, a well-known phenomenon (Hesse, Allee, and Schmidt, 1947: p. 24).

In table 15 we have attempted to classify the major groups of organisms according to their probable trophic level, based on information derived from a number of sources with MacGinitie and Mac Ginitie (1949) and Marshall (1954) being among the more useful. If we are not too greatly in error in our food-habit evaluations, it would appear that the Isaacs-Kidd trawls sample principally the primary carnivores, some of which are also herbivores and detritus feeders, such as the shrimps, and other animals which are secondary carnivores as well, such as the majority of the fishes. Very few, if any, of the fishes captured can be classed as herbivores.

TRAWL CATCHES AS ECOLOGICAL INDICATORS

The staff of the Bureau of Commercial Fisheries Biological Laboratory, Honolulu, has attempted to maintain an ecological approach in its investigations on the causes of variation in the abundance

TABLE 15.—*Major categories, probable trophic level, and latitudinal variation in abundance of organisms taken in the Isaacs-Kidd trawl catches, central Pacific, 1953–56*

Organisms	Probable trophic level			Occurrence and relative abundance [1]
	Herbivores and detritus feeders	Carnivores		
		Primary	Secondary	
Siphonophora		x		In all zones; abundant.
Medusae, unidentified		x		In all zones; numerous.
Ctenophora		x		In all zones; common.
Chaetognatha		x		In all zones; abundant.
Annelida	x(?)	x		In 4 zones; common.
Cirripedia	x(?)	x		In NPC and AC only; very abundant when present.
Mysidacea	x	x		Hawaii and south; few.
Amphipoda	x	x		In all zones; abundant.
Stomatopoda (larvae)		x		In 4 zones; common; not in NEC and AC.
Euphausiacea	x	x		In all zones; common to abundant; most abundant in NPC and AC.
Decapod Crustacea	x	x		In all zones; common to numerous; less abundant in NPC and AC.
Heteropoda	x			In all areas; common; more numerous in southern zones.
Pteropoda	x			In 5 zones; most numerous from Hawaii north.
Decapod Mollusca		x	x	In all zones; common; greatest variety in SEC.
Octopod Mollusca		x	x	In 4 zones; few.
Pyrosomatidae	x			In all zones; abundant; decreasing to the north.
Salpidae	x	x		In all zones; abundant.
Gonostomidae		x	x	In all zones; numerous; several species represented.
Sternoptychidae		x	x	In all zones; common.
Stomiatidae		x	x	In all zones; numerous; greatest variety of species in SEC.
Idiacanthidae		x	x	In all zones; common.
Paralepididae		x	x	In all zones; common.
Myctophidae		x	x	In all zones; abundant; greatest variety of species in SEC, fewest in NPC and AC.
Nemichthyidae		x	x	In all zones; common; most numerous in SEC and ECC.
Melamphaidae		x	x	In all zones; common.
Bramidae		x	x	In 3 zones; common; Hawaii and south.
Gempylidae		x	x	In 4 zones; common; not in NPC and AC.
Molidae		x		Only in SEC; few.
Leptocephali		x		In all areas; common.
Larval fish		x	x	In all areas; numerous.

[1] Faunal zones referred to are those indicated in appendix tables 7 and 8; see also p. 286.

and distribution of tunas. Studies have been pursued on the ocean currents, chemical nutrients, photosynthetic activity, zooplankton, and forage fish simultaneously with studies on the tunas. The trawling program has been conducted on the premise that highly mobile fishes, such as the tunas, are most likely to occur in areas with the most favorable concentrations of food. Other environmental factors, of course, such as temperature, can also be of a limiting nature and influence fish distribution. In general, however, when broad areas of the sea are being compared, it is our belief that a positive relation must exist among the various levels of the food chain. This does not mean that we expect to find a high positive correlation at all times and places between the volume of food and the abundance of tunas; in fact, it is possible that an inverse relation may exist locally after a period of heavy predation.

STANDING CROP AND PRODUCTIVITY MEASUREMENTS

Correlation analyses, made to investigate the association between trawl-catch volumes and environmental variables that might be expected to have some direct or indirect influence on the trawl catches, are summarized in table 16. For these analyses only data from the major cruises which were sufficient for meaningful statistical tests were employed.

On two of three cruises examined (*Smith* cruises 27 and 35), we found a significant ($P<0.01$) positive correlation of trawl volumes and surface inorganic phosphate concentrations; on the third cruise (*Smith* cruise 31) the relation was again positive but not significant ($P>0.05$).

Only two cruises (*Smith* cruises 31 and 35) provided estimates of photosynthetic activity based on the uptake of C^{14} by phytoplankton. Since the trawl hauls on these cruises were all made at night, at which time the photosynthetic activity was negligible, we also determined the correlation of trawl catch with the C^{14} uptake recorded at a station on the morning of the same day, and also with the C^{14} uptake measured at the station occupied on the morning following the night trawl haul. For both cruises the resulting correlation coefficients have positive values, but only those for *Smith* cruise 35, relating trawl catch to the rate of C^{14} uptake at the morning stations, were significant ($P<0.01$).

TABLE 16.—*Correlations of trawl catch (milliliters per hour of hauling), as the X_1 variate, with X_2 variate the surface inorganic phosphate, C^{14} uptake, or zooplankton volumes at the same station or from adjacent stations of the* Hugh M. Smith

Trawl and cruise	X_2 variate	Degrees of freedom	Correlation coefficient (r)	P
6-foot Isaacs-Kidd:				
Cruise 27	*Surface inorganic phosphate, µg. at./l.	21	0.665	<0.01
Do	†Zooplankton volumes, ml./1,000m.^{3}; oblique 0–100 m. hauls.	21	0.617	<0.01
10-foot Isaacs-Kidd:				
Cruise 30	‡Zooplankton volumes, ml./1,000m.^{3}; oblique 0–140 m. hauls.	35	0.701	<0.01
Cruise 31	§Surface inorganic phosphate, µg. at./l.	49	0.166	>0.05
Do	§Surface C^{14} uptake; mg. C/hr./m.^{3}			
	a. Same station (1900–2000)	16	0.214	>0.05
	b. Adjoining station (0800–0900, same day).	28	0.198	>0.05
	c. Adjoining station (0800–0900, following day).	22	0.221	>0.05
Do	§Zooplankton volumes, ml./1,000m.^{3}; oblique 0–200 m. hauls.	46	0.371	<0.01
Cruise 35	‖Surface inorganic phosphate, µg. at./l.	36	0.450	<0.01
Do	‖Surface C^{14} uptake, mg. C/hr./m.^{3}			
	a. Same station (1900–2000)	36	0.237	>0.05
	b. Adjoining station (0800–9000, same day).	37	0.571	<0.01
	c. Adjoining station (0800–0900, following day).	36	0.581	<0.01
Do	‖Zooplankton volumes, ml./1,000m.^{3}; oblique 0–140 m. hauls.	36	0.473	<0.01

* From McGary and Stroup (1958).
† Unpublished data in the files of the Bureau of Commercial Fisheries Biological Laboratory, Honolulu.
‡ From McGary, Jones, and Austin (1956).
§ From King, Austin, and Doty (1957).
‖ From Austin (1957).

In all four cruises examined (*Smith* cruises 27, 30, 31, and 35), the correlation between trawl-catch volume and zooplankton volume, as sampled on 0–100 m., 0–140 m., and 0–200 m. oblique hauls with 1-meter nets of silk or nylon grit gauze (aperture widths approximately 0.65 mm.), was found to be highly significant ($P<0.01$). It was certainly to be expected that the larger forage organisms sampled by the trawl would be found more closely related to zooplankton—their food for the greater part—than to inorganic phosphate or the metabolic activity of phytoplankton.

The distribution of the number and size of the organisms making up the different trophic levels, whether on land or in the sea, takes the form of a pyramid, with the plants or primary producers forming the broad base and the larger carnivores the peak (Odum, 1953: p. 73). Actually three ecological pyramids result from food and energy relationships: the pyramid of numbers, the pyramid of biomass, and the pyramid of energy or food production rates. (Some ecologists consider the three—numbers, biomass, and energy—as different concepts of the same pyramid.) The concept of the pyramid of numbers was, perhaps, first given definite form by Elton (1927: p. 69). The pyramid of biomass was described for some Wisconsin lakes by Juday (1942) and similar studies have been made in other areas. The pyramid of production rates was introduced by Petersen (1918) in his calculations of the quantitative food relations in coastal waters where eelgrass, *Zostera* sp., is the main source of primary food. He postulated that 10 plant units were needed to produce 1 unit of herbivorous animal weight, and in turn, 10 herbivorous units were required for each unit weight of primary carnivore produced. The pyramid of energy, expressed in terms of efficiency or productivity rates for the various trophic levels, has been determined for lake environments by Lindeman (1942) and Juday (1942), and for a marine area—Georges Bank—by Clarke (1946).

A table of conversion factors, the pounds of feed needed to produce 1 pound of fish, is given in Brown (1957: vol. 1, p. 386); they range from 2.3 to 7.1 for various species. Petersen's 10× factor, however, is the one most frequently quoted.

The Honolulu Laboratory staff has obtained estimates of the biomass, or standing crop, at three trophic levels in the central Pacific: zooplankton, forage organisms, and tunas. Information on rate of production has also been obtained for the primary producers, i.e., the uptake of C^{14} by phytoplankton. Such data are not available for the other trophic levels but may be calculated from the information on hand.

Employing the data used in figure 13, we calculate that the average catch of the 6-foot trawl in 78 hauls was 1.86 ml./1,000 m.^{3} of water strained, and the average catch of the 10-foot trawl in 157 hauls was 1.65 ml./1,000 m.^{3}. For the same general area, zooplankton hauls averaged 29.64 ml./1,000 m.^{3}, or roughly 16 to 18 times the catch of the trawls. Although we are dealing with two standing-crop measurements, the relation is of the same order of magnitude as the 10× factor calculated by Petersen (1918) for the difference in production rate between two adjacent trophic levels.

Over the range of latitude sampled (49° N. to 19° S.), variations in zooplankton abundance were closely paralleled by the trawl-catch volumes (fig. 21), except in the region of the Aleutian Current, where there was a marked increase in zooplankton catch that was proportionally much greater than the increase in trawl catch. Both measures of the fauna show the influence of enrichment in the region of the equatorial upwelling and to the north in the Aleutian Current.

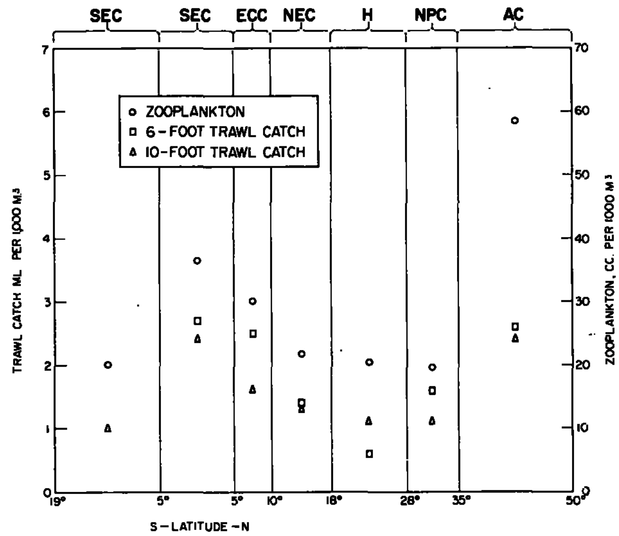

FIGURE 21.—Variation with latitude in the average volume of trawl catch per cubic meter of water strained by the 6- and 10-foot Isaacs-Kidd trawls, as compared with the zooplankton catch. (Zooplankton data for areas south of latitude 30° N. are from King and Hida, 1957a and 1957b; for areas to the north of 30° N. from files of Bureau of Commercial Fisheries Biological Laboratory, Honolulu.)

Although the 6-foot trawl caught at a higher rate per unit of water strained than the 10-foot trawl in five of the six areas, the close correspondence in catch rates between the two trawls is of interest and provides further evidence that the trawls were about equal in efficiency. If the difference between the two trawls is of any significance, however, it may indicate that the larger net was sampling at a slightly different trophic level than the smaller net. This possibility is also indicated by the difference in size of organisms sampled by the two nets (table 7).

TRAWL CATCHES AS A MEASURE OF TUNA FOOD

One of the major aims of the midwater trawling program was to obtain a quantitative measure of the abundance and distribution of potential tuna food. Several reports have been published, others are in press or in manuscript form, describing the food of tunas in the central Pacific (Welsh, 1949; Reintjes and King, 1953; King and Ikehara, 1956; Tester and Nakamura, 1957; Yuen, 1959; Nakamura, MS.;[3] Iversen, in press; and Waldron and King.[4]) These reports all emphasize the great variety of food that tunas consume, but point out certain differences related to the species and size of tuna and the depth, distance from land, season, and area of capture. Although adult tunas eat a number of organisms that might be classed as plankton (e.g., euphausiids, amphipods, and stomatopod and crab larvae), the bulk of their food consists of nekton, such as fishes, squids, and shrimps.

By means of the midwater trawl, we hoped to sample at a trophic level "closer" to the tunas than was possible with the 1-meter zooplankton nets. For this purpose, however, our procedures had a basic weakness: the trawls were operated almost entirely at night, since the catches were very poor during daylight hours, but our tuna fishing was carried out during the day because the few nighttime fishing stations had yielded very poor results. Therefore, the only comparison which our data afford is that between forage organisms captured at night and the stomach contents of tunas captured during the day. It would seem theoretically possible, however, as a result of the diurnal migration of the forage organisms, that the deep-swimming tunas caught in the daytime at depths of 100 to 500 feet may have been feeding on the same organisms that were taken at night in the trawl when it was fishing near the surface. Despite these basic differences in the data, we thought it worthwhile to make some general summaries and comparisons of trawl catch and tuna food, and also to examine station-to-station variations in these factors, as observed on certain cruises where both variables were evaluated.

In table 9 we summarized the number of taxonomic categories of organisms found in the trawl catches and in tuna stomachs. Although such a summary does not show the specific kinds of animals involved it does indicate that about twice as many phyla or subphyla were found in the trawl catches as were represented in the tuna stomachs. It is also evident, however, that a great variety of forms was found both in the trawl catches and in tuna stomachs.

An attempt is made in table 17 to illustrate the major differences and similarities in the composition of the trawl catches and of tuna stomach contents. Every item was listed that occurred in 10 percent or more of either the trawl collections or the stomachs of four species of tuna. Again, the data demonstrate the greater variety of organisms characteristic of the trawl catches, which seems to indicate that the tunas were not feeding at random but were exercising some degree of selection. The greatest similarity between the trawl catches and the tuna stomach contents was the occurrence in both of Amphipoda, *Phronima* sp., Stomatopoda, Euphausiidae, Decapoda (Crustacea and Mollusca), Enoploteuthidae, Salpidae, Tunicata, Stomiatidae, Paralepididae, Myctophidae, Gempylidae, and *Collybus drachme*. Some of the major differences were the high occurrence in the tuna stomachs of crab larvae, squids of the families Ommastrephidae and Loliginidae, and such fishes as *Gempylus serpens* and representatives of the families Bramidae and Acanthuridae, as contrasted with the low occurrence of these organisms in the trawl catches. On the other hand, it is evident from the table that a large number of animals of frequent occurrence in the trawl catches were not found in the tuna stomachs.

If the percentage of occurrence of the different taxonomic groups listed in table 17 for the Isaacs-Kidd trawls is plotted as a function of their occurrence in tuna stomachs, we obtain a series of distributions (fig. 22) which show, in 3 out of 10 instances, some indication of an inverse correlation. Organisms occurring with the highest frequency in the trawl collections were usually rare in the tuna stomachs, whereas those forms occurring most frequently in the tuna stomachs were not generally common in the trawl catches. (In fig. 22 we plotted points only for those organisms which occurred in both the tuna stomachs and the trawl catches.)

On a few cruises, tuna longline fishing and mid-

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[3] Nakamura, E. L., MS. Food and feeding habits of Marquesan skipjack (*Katsuwonus pelamis*). Bureau of Commercial Fisheries Biological Laboratory, Honolulu.

[4] Waldron, Kenneth D., and Joseph E. King. Food of skipjack in the central Pacific. U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries Biological Laboratory, Honolulu. (Experience Paper No. 26, Section No. 5, FAO World Scientific Meeting on the Biology of Tunas and Related Species, La Jolla, Calif.), July 1962.

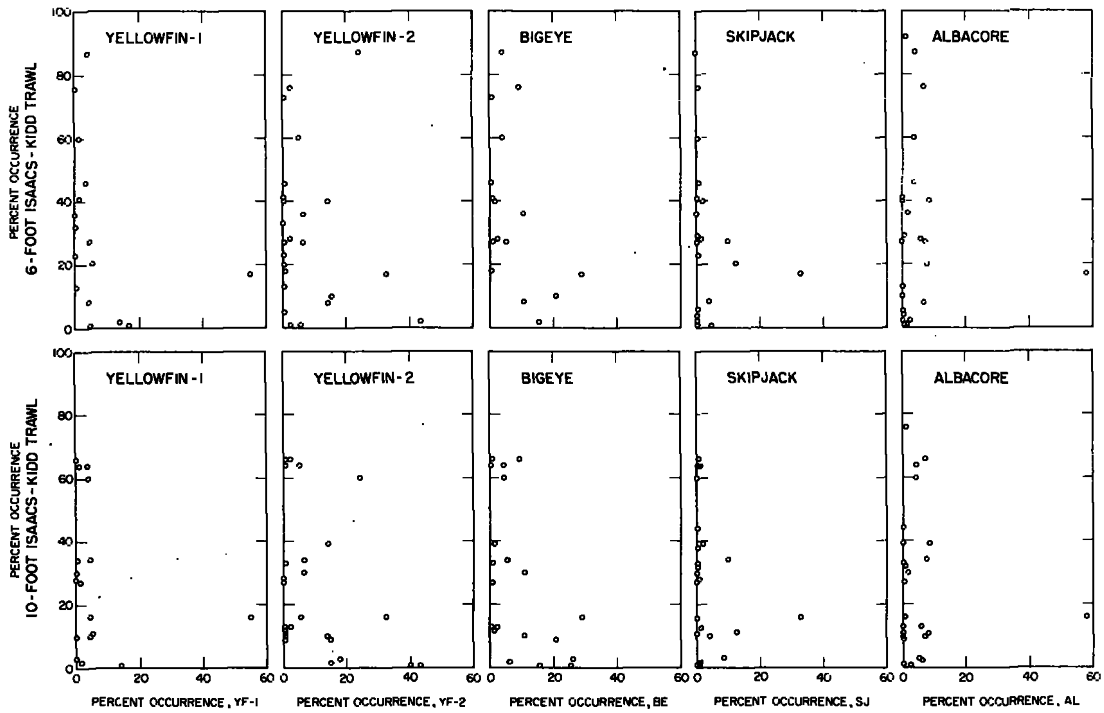

FIGURE 22.—Percentage occurrence of different taxonomic groups, listed in table 15, in the catches of the Isaacs-Kidd trawls and in tuna stomach contents. YF–1, yellowfin tuna, both surface dwelling and deep swimming; captured by live-bait fishing, surface trolling, and longline fishing (data from Reintjes and King, 1953). YF–2, yellowfin tuna, deep swimming; captured by longline fishing (data from King and Ikehara, 1956). BE, bigeye tuna, deep swimming; captured by longline fishing (data from King and Ikehara, 1956). SJ, skipjack tuna, both surface dwelling and deep swimming, captured by live-bait fishing, surface trolling, and longline fishing (unpublished data; see text, footnotes 3 and 4). AL, albacore tuna, both surface dwelling and deep swimming; captured by trolling and gill net and longline fishing (data from Iversen, in press).

TABLE 17.—*Percentage occurrence of all items identified in 10 percent or more of either the trawl collections or of tuna stomach contents*

Organism	In hauls of—				In stomach contents of—				
	6-foot beam trawl	1-meter ring trawl	6-foot Isaacs-Kidd trawl	10-foot Isaacs-Kidd trawl	Yellowfin [1]	Yellowfin [2]	Bigeye [2]	Skipjack [3]	Albacore [4]
Siphonophora	56	87	92	76					1.4
Medusae, unidentified	25	13	26	38					
Coelenterata, unidentified	44		4	20					
Ctenophora			8	13					
Chaetognatha	100	91	87	74					
Crustacea, unidentified	38	9	46	64	3.6	0.7	0.6	0.9	4.0
Copepoda	31	48	4	11				.1	.6
Idotheidae						10.0	7.2		.3
Amphipoda, unidentified	19	30	27	34	4.6	6.6	5.4	10.0	7.5
Phronima sp	25	9	40	39		14.1	1.8	2.1	8.6
Rhabdosoma sp	31	9	47	33					
Oxycephalus sp	25	13	29	32				.4	.9
Stomatopoda, unidentified	56	61	20	11	5.3	.5		12.6	8.0
Odontodactylus hanseni					12.9			.4	.3
Euphausiidae, unidentified	62	83	76	66	0.2	2.3	9.0	1.0	6.9
Thysanopoda monacantha			9	46					
T. tricuspidata	12		6	38				.6	
T. obtusifrons				11					
T. pectinata				15					
Nematobrachion flexipes			5	12					
Stylocheiron abbreviatum	6			15					
Sergestidae, unidentified	44	26	40						.3
Sergestes gardineri	19	4							
Sergestes sp	12		30	94					
Decapoda (Crustacea), unidentified	31	13	28	13		2.3	2.4	1.7	6.0
Gennadas scutatus	12		27	30					
G. propinquus				27					
G. tinayrei				10					

TABLE 17.—*Percentage occurrence of all items identified in 10 percent or more of either the trawl collections or of tuna stomach contents—Continued*

Organism	In hauls of—				In stomach contents of—				
	6-foot beam trawl	1-meter ring trawl	6-foot Isaacs-Kidd trawl	10-foot Isaacs-Kidd trawl	Yellowfin [1]	Yellowfin [2]	Bigeye [2]	Skipjack [3]	Albacore [4]
G. incertus				24					
Gennadas sp	25	9	2	39					0.3
Funchalia taaningi	6		22	18					
Hoplophorus typus	12		20	16					
H. gracilirostris	12		6	11					
H. foliaceus			15	25					
H. grimaldii	6		17	13					
Acanthephyra trispinosa	12	4	5	27					
Parapandalus zur strasseni	38	13	26	28					
Phyllosoma	6	9	13	10	0.5	0.5			.3
Crab larvae		13			48.2	7.1	0.6	13.3	.3
Heteropoda, unidentified			1	16	4.6	5.5		.1	.9
Pterotracheidae, unidentified	38	17	33			.2			
Pteropoda, unidentified	12	9	23	28	.1	.2		.4	
Corolla sp			17						
Cymbuliidae, unidentified	12	4	20	7					
Decapoda (Mollusca), unidentified	19	26	17	16	55.0	32.6	28.9	33.0	58.0
Enoploteuthidae, unidentified	6		10	9		15.3	21.1		.3
Abraliopsis sp			6	13					
Cranchiidae, unidentified	25	9	5	9		.5			.6
Ommastrephidae, unidentified				1		39.9	25.3	.7	.3
Loliginidae, unidentified						13.4	14.5	.9	4.9
Mollusca, unidentified	19		41	11					.3
Pyrosomatidae, unidentified	44	30	73	66		.9	1.2		
Salpidae, unidentified	44	52	87	60	3.9	24.1	4.2	.1	4.3
Iasis zonaria			6	16					
Tunicata, unidentified	44	35	41	27	1.5	.2	1.2	.1	.6
Gonostomidae, unidentified				10					
Gonostoma elongatum			15	19					
Gonostoma sp	6			13					.3
Vinciguerria nimbaria			9	15					
V. lucetia	38	4	40	12		.5	1.8		
Vinciguerria sp			4	34					
Diplophos taenia	31		5	7					
Argyropelecus aculeatus				20					
Thysanactis dentex			13	10					
Eustomias sp	12		12	23					
Stomiatidae, unidentified	6	4	27	33		.9	1.2	.3	.3
Chauliodus sp	6		1	29					
Idiacanthus sp			1	23					
Paralepididae, unidentified		4	36	30	.1	6.4	10.8	.1	2.0
Scopelarchidae, unidentified				10					
Myctophidae, unidentified	56	9	60	64	1.5	4.8	4.2	.7	4.0
Hygophum reinhardti	6		19	1					
Hygophum sp			1	16					
Benthosema sp	12			1					
Myctophum evermanni	25		17	12					
M. brachygnathos	12			1					
M. spinosum	12			1					
M. aurolaternatum	12			1					
Notolynchnus valdiviae	19	9	9	5					
Diaphus sp	50	4	41	44				.1	.3
Lampanyctus pyrsobolus	25		18	20					
L. macropterus				11					
Lampanyctus sp	44	13	40	38					
Ceratoscopelus townsendi	38	4	24	31					
Cololabis sp								.6	10.6
Nemichthys scolopaceus			10	20					
Serrivomer beani	12		1	3					
Bregmaceros macclellandi	2	4	18	13		.7	.6		
Melamphaidae, unidentified			2	23					
Howella sherborni				10					
Bramidae, unidentified				2	1.9	15.0	6.0	1.7	6.3
Collybus drachme		4	2	1	13.8	43.3	15.7	.3	2.6
Acanthuridae, unidentified	6		1		16.8	2.3		4.8	1.4
Gempylidae, unidentified			8	10	4.5	14.1	10.8	4.2	6.9
Gempylus serpens				3	.1	18.1	25.9	8.5	5.2
Leptocephali, unidentified	50	13	32	34	.5				
Heterosomata larvae	25								
Fish larvae	75	87	79						
Unidentified fish	44	22	29	86	48.2	48.5	48.8	30.7	34.2
Number of hauls or stomachs	16	23	78	157	1,097	439	166	707	348

[1] From Reintjes and King (1953).
[2] From King and Ikehara (1956).
[3] From Waldron and King (see footnote 4, p. 295).
[4] From Iversen (in press).

water trawling were conducted as a combined operation, with the longline being set in the early morning and hauled in the afternoon, and with a trawl haul usually being made about 2 hours after sunset on the run to the next fishing station. The data from *Manning* cruise 20 to the equatorial Pacific afford the best opportunity to compare, on a station-to-station basis, the composition of trawl catches obtained with the 6-foot Isaacs-Kidd and stomach contents of yellowfin tuna, *Neothunnus macropterus* (Temminck and Schlegel). The yellowfin captured on this cruise, from which stomachs were examined, ranged in size from 85 to 155 cm. (26 to 160 lb.) and averaged about 120 cm. (74 lb.). The fishing method, localities, and catch data for this cruise have been described by Iversen and Yoshida (1956).

Table 18 lists, for 16 days of cruise 20, the categories of organisms that comprised 1 percent or more, by volume, of the trawl catches and tuna stomach contents. Except for the first three stations (stations 1, 2, and 4), all the trawl hauls were made just after twilight or at night between 1840 and 2030 (zone time). It is obvious that whereas the trawl consistently caught such animals as siphonophores, chaetognaths, crustaceans, and tunicates, these organisms were largely missing from the tuna stomach contents. Decapod molluscs (squids), on the other hand, were prominent in tuna stomachs, but poorly sampled by the trawl. Among the families of fishes, the Thunnidae (*Katsuwonus pelamis*), Tetraodontidae, Molidae, Sternoptychidae, Bramidae, Nomeidae, and Balistidae were commonly found in the yellowfin stomachs but were not captured in any quantity by the trawl. Most of these families may be considered as pelagic fishes characteristic of the surface layer both in periods of light and darkness. For the Sternoptychidae, Marshall (1960) cites records of *Sternoptyx diaphana* being taken at 600–800 m., and *Argyropelecus hemigymnus* at 150–500 m. at night but below 500 m. during the day. The Myctophidae, Nemichthyidae, Gonostomidae, and Stomiatidae, which were the principal fishes captured in the trawl, are bathypelagic in distribution, occurring at the middepths during the day (Marshall, 1960: p. 82–88), but migrating to the surface layer at night. The virtual lack of these fishes in the food of yellowfin may indicate that this species feeds principally in the daytime and in the surface layer.

Some fishes, such as Thunnidae, Balistidae, and Gempylidae, commonly found in tuna stomachs, are strong, fast swimmers, and their absence from the trawl catches may simply indicate the ineffectiveness of the gear, and not that the tunas were particularly selective in their feeding, or that the trawl and the tunas were sampling different environments.

The results of two cruises to the central North Pacific, *Manning* cruises 22 and 23, provide an opportunity to compare the composition of trawl

TABLE 18.—*Percentage composition of the stomach contents of longline-caught yellowfin tuna and of the catches of the 6-foot Isaacs-Kidd trawl on* John R. Manning *cruise 20, equatorial Pacific, 1954*

Organisms [1]	Stomach contents	Trawl catch
May 17:		
Longline and trawl, station 1; 7 stomachs:		
Siphonophora	--------	20
Chaetognatha	--------	18
Amphipoda	--------	41
Rhabdosoma sp	--------	2
Octopoda	2	--------
Sepioteuthis sp	9	--------
Unidentified Decapoda (Mollusca)	15	--------
Tunicata	--------	14
Katsuwonus pelamis	18	--------
Nomeidae	1	--------
Acanthuridae	1	--------
Ostraciidae	2	--------
Lactoria diaphanus	2	--------
Bramidae	3	--------
Ranzania laevis	33	--------
Apogonidae	3	--------
Leptocephali	--------	2
Larval fish	--------	2
Unidentified fish	11	--------
May 18:		
Longline and trawl, station 2; 3 stomachs:		
Siphonophora	--------	1
Medusae	--------	76
Chaetognatha	--------	2
Amphipoda	--------	16
Argonautidae	3	--------
Unidentified Decapoda (Mollusca)	8	--------
Salpidae	--------	1
Katsuwonus pelamis	47	--------
Acanthuridae	6	--------
Collybus drachme	1	--------
Tetraodontidae	29	--------
Leptocephali	--------	1
Larval fish	--------	1
Unidentified fish	4	--------
May 19:		
Longline and trawl, station 4; 1 stomach:		
Siphonophora	--------	46
Chaetognatha	--------	6
Amphipoda	--------	9
Phronima sp	--------	6
Rhabdosoma sp	--------	8
Unidentified Decapoda (Mollusca)	50	--------
Salpidae	--------	21
Lactoria diaphanus	17	--------
Bramidae	17	--------
Larval fish	--------	2
Unidentified fish	16	--------
May 22:		
Longline, station 8; trawl, station 9; 1 stomach:		
Siphonophora	--------	2
Medusae	--------	41
Euphausiacea	--------	6
Octopodidae	58	--------
Argonautidae	25	--------
Pyrosomatidae	--------	28
Salpidae	--------	2
Lampanyctus sp	--------	2
Photostomias sp	--------	2
Eustomias sp	--------	4
Thysanactis sp	--------	9
Unidentified fish	16	--------
May 23:		
Longline, station 10; trawl, station 11; 7 stomachs:		
Siphonophora	--------	5
Euphausiacea	--------	5
Sergestes sp	--------	2
Hoplophorus typus	--------	2
Octopodidae	2	--------
Onycoteuthis banksii	4	--------
Unidentified Decapoda (Mollusca)	39	--------
Unidentified Tunicata	--------	1
Pyrosomatidae	--------	48
Salpidae	--------	1
Isistius brasiliensis	--------	16
Lactoria diaphanus	2	--------
Unidentified Bramidae	5	--------
Collybus drachme	6	--------
Anoplogaster cornutus	2	--------
Chauliodus sp	--------	3
Nemichthys scolopaceus	--------	2
Diaphus sp	--------	4

[1] Includes all organisms or groups of organisms comprising 1 percent or more, by volume, of the stomach contents or of the trawl catches.

TABLE 18.—*Percentage composition of the stomach contents of longline-caught yellowfin tuna and of the catches of the 6-foot Isaacs-Kidd trawl on* John R. Manning *cruise 20, equatorial Pacific, 1954*—Continued

Organisms [1]	Stomach contents	Trawl catch
May 25:		
Longline, station 13; trawl, station 14; 8 stomachs:		
Siphonophora		26
Chaetognatha		2
Euphausiacea		6
Unidentified Decapoda (Crustacea)		3
Portunidae: Megalopa	8	
Funchalia taaningi		1
Sergestes sp.		3
Hoplophorus typus		1
Unidentified Decapoda (Mollusca)	11	
Unidentified Tunicata		2
Pyrosomatidae		9
Salpidae		3
Trachypterus sp.		8
Vinciguerria lucetia		15
Thysanactis dentex		5
Nemichthys scolopaceus		2
Diaphus sp.		10
Cubiceps sp.	9	
Nomeidae	25	
Acanthuridae	1	
Molidae	5	
Gempylus serpens	1	
Balistidae	29	
Unidentified fish	6	
May 26:		
Longline, station 15; trawl, station 16; 5 stomachs:		
Siphonophora		7
Chaetognatha		1
Euphausiacea		7
Unidentified Decapoda (Crustacea)	3	
Gennadas scutatus		1
Sergestes sp.		1
Unidentified Decapoda (Mollusca)	14	
Vinciguerria lucetia		9
Echiostoma tanneri		16
Photostomias sp.		2
Diaphus sp.		7
Nomeidae	2	
Bramidae	18	
Gempylidae	2	
Paralepididae	2	
Balistes sp.	17	
Balistidae	4	
Tetraodontidae	14	
Unidentified fish	23	
May 27:		
Longline, station 17; trawl, station 18; 10 stomachs:		
Siphonophora		5
Euphausiacea		2
Unidentified Amphipoda	6	
Phronima sp.	3	
Gennadas scutatus		1
Sergestes sp.		2
Hoplophorus typus		2
Unidentified Decapoda (Mollusca)	9	
Unidentified Tunicata	5	
Pyrosomatidae		69
Salpidae	1	
Photostomias sp.		7
Thysanactis sp.		3
Eustomias sp.		2
Diaphus sp.		2
Nomeidae	2	
Sternoptychidae	59	
Unidentified fish	13	
May 30:		
Longline, station 21; trawl, station 22; 12 stomachs:		
Siphonophora		13
Chaetognatha		2
Euphausiacea		6
Unidentified Decapoda (Crustacea)	2	
Hoplophorus foliaceus	6	
Funchalia taaningi		2
Sergestes sp.		1
Portunidae: Megalopa	5	1
Unidentified Decapoda (Mollusca)	4	
Pyrosomatidae		18
Vinciguerria lucetia		36
Thysanactis dentex		2
Photostomias sp.		1
Diaphus sp.		12
Chaetodontidae	1	
Ranzania laevis	52	
Balistidae	2	
Tetraodontidae	6	
Sternoptychidae	14	
Paralepididae	5	
Unidentified fish	2	

TABLE 18.—*Percentage composition of the stomach contents of longline-caught yellowfin tuna and of the catches of the 6-foot Isaacs-Kidd trawl on* John R. Manning *cruise 20, equatorial Pacific, 1954*—Continued

Organisms [1]	Stomach contents	Trawl catch
May 31:		
Longline, station 23; trawl, station 24; 1 stomach:		
Siphonophora		22
Euphausiacea		13
Sergestidae		3
Funchalia taaningi		2
Unidentified Decapoda (Mollusca)	80	
Pyrosomatidae		21
Salpidae		7
Vinciguerria lucetia		1
Howella sp.		6
Diaphus sp.		10
Lampanyctus sp.		3
Collybus drachme	17	
Larval fish		4
Unidentified fish	3	
June 1:		
Longline, station 25; trawl, station 26; 6 stomachs:		
Sergestes sp.		2
Unidentified Decapoda (Mollusca)	12	
Pyrosomatidae		84
Salpidae		4
Aristostomias sp.		2
Diaphus sp.		1
Nomeidae	2	
Lactoria diaphanus	1	
Collybus drachme	2	
Ranzania laevis	58	
Gempylus serpens	6	
Tetraodontidae	1	
Remora remora	3	
Unidentified fish	10	
June 2:		
Longline, station 27; trawl, station 28; 5 stomachs:		
Siphonophora		15
Euphausiacea		16
Gennadas sp.		3
Hoplophorus typus		3
Unidentified Decapoda (Mollusca)	48	
Pyrosomatidae		30
Salpidae		2
Nemichthys scolopaceus		3
Isistius brasiliensis		23
Vinciguerria lucetia		1
Collybus drachme	3	
Gempylidae	2	
Exocoetidae	16	
Paralepididae	3	
Tetraodontidae	11	
Sternoptychidae	2	
Unidentified fish	11	
June 3:		
Longline, station 29; trawl, station 30; 5 stomachs:		
Siphonophora		4
Euphausiacea		12
Gennadas scutatus		1
Sergestes orientalis		1
Hoplophorus typus		3
Octopoda	4	
Unidentified Decapoda (Mollusca)	76	
Unidentified Tunicata	2	
Pyrosomatidae		20
Echiostoma tanneri		32
Bathophilus sp.		1
Photostomias sp.		1
Thysanactis sp.		2
Bregmaceros macclellandi		2
Stomiatidae		9
Diaphus sp.		4
Notolychnus valdiviae		1
Nomeidae	1	
Echeneidae	5	
Unidentified fish	9	
June 7:		
Longline, station 33; trawl, station 34; 5 stomachs:		
Siphonophora		14
Chaetognatha		2
Euphausiacea		26
Unidentified Decapoda (Crustacea)		1
Unidentified Crustacea	1	
Funchalia taaningi		5
Sergestes sp.		2
Hoplophorus foliaceus		3
H. typus		2
Enoplometopus sp.	2	
Portunidae: Megalopa	1	
Unidentified Decapoda (Mollusca)	2	
Enoploteuthidae		4
Pyrosomatidae		16
Diaphus sp.		13

TABLE 18.—*Percentage composition of the stomach contents of longline-caught yellowfin tuna and of the catches of the 6-foot Isaacs-Kidd trawl on* John R. Manning *cruise 20, equatorial Pacific, 1954*—Continued

Organisms [1]	Stomach contents	Trawl catch
June 7—Con.:		
Myctophum evermanni		2
Acanthuridae	5	
Collybus drachme	3	
Bramidae	2	
Tetraodontidae	58	
Balistidae	1	
Echeneidae	6	
Exocoetidae	7	
Larval fish		2
Unidentified fish	9	
June 9:		
Longline, station 36; trawl, station 37: 3 stomachs:		
Siphonophora		8
Odontodactylus sp.	1	
Euphausiacea		19
Funchalia taaningi		2
Sergestes sp.		9
Hoplophorus typus		4
H. foliaceus		2
Unidentified Decapoda (Mollusca)	6	
Liocranchia reinhardti		8
Unidentified Tunicata		2
Pyrosomatidae		9
Salpidae		1
Astronesthes sp.		2
Echiostoma tanneri		10
Photostomias sp.		2
Diaphus sp.		10
Hygophum reinhardti		2
Lampanyctus pyrsobolus		2
Myctophidae		2
Nomeidae	3	
Acanthuridae	5	
Ranzania laevis	76	
Balistidae	2	
Larval fish		3
Unidentified fish	4	
June 10:		
Longline, station 38; trawl station 39; 2 stomachs:		
Siphonophora		13
Euphausiacea		16
Sergestes orientalis		1
Argonautidae	1	
Unidentified Decapoda (Mollusca)	12	
Unidentified Tunicata	1	
Pyrosomatidae		31
Salpidae		2
Vinciguerria lucetia		7
Ceratoscopelus townsendi		4
Lampanyctus sp.		1
Unidentified Myctophidae		1
Diaphus sp.		16
Katsuwonus pelamis	84	
Larval fish		2
Unidentified fish	1	

[1] Includes all organisms or groups of organisms comprising 1 percent or more, by volume, of the stomach contents or of the trawl catches.

catches obtained with the 6-foot Isaacs-Kidd trawl with the stomach contents of albacore tuna, *Thunnus germo* (Lacépède), captured by longline. The fishing method, localities, and catch data for these cruises are described by Shomura and Otsu (1956). The 10 albacore stomachs preserved on *Manning* cruise 22 were from fish averaging 73.3 cm. in fork length, whereas the 14 stomachs preserved on *Manning* cruise 23 were from fish averaging 101.2 cm. All trawl hauls were made at night between 1900 and 2030 hours.

Although the data are sparse and do not permit a station-to-station comparison, when summarized over the entire cruise as in tables 19 and 20, they show certain major features in common with the yellowfin stomach contents-trawl catch comparison (table 18). Coelenterates and crustaceans made up important percentages of the volume of the trawl catches but, except for Amphipoda (cruise 23), were relatively insignificant in the stomach contents. Of the Mollusca, Pteropoda were of some importance in the trawl collections whereas Cephalopoda were largely missing; this situation was just reversed in the albacore food, where Pteropoda were absent and Cephalopoda were very important. Among the Tunicata, the Pyrosomatidae were an important part of the

TABLE 19.—*Percentage composition of stomach contents of 10 albacore taken by longline and of catches of the 6-foot Isaacs-Kidd trawl,* Manning *cruise 22, central Pacific, September–October 1954*

Organisms [1]	Stomach contents	Trawl catch
Siphonophora		4
Unidentified Medusae		5
Lepas fascicularis (larvae)		10
Lepas sp.		5
Phronimidae	1	
Unidentified Euphausiidae	1	20
Thysanopoda sp.		2
Funchalia taaningi		1
Hoplophorus grimaldii		4
Unidentified Sergestidae		5
Unidentified Crustacea		4
Unidentified Pteropoda		1
Corolla sp.		3
Unidentified Decapoda	7	
Abraliopsis sp.		1
Pyrosomatidae		15
Salpidae	2	2
Unidentified Myctophidae		8
Tarletonbeania sp.	40	
Scomberesocidae:		
Cololabis sp.	46	
Total	97	90

[1] Includes all organisms or groups of organisms comprising 1 percent or more, by volume, of the stomach contents or of the trawl catches.

TABLE 20.—*Percentage composition of stomach contents of 14 albacore caught by longline and of the catches of 3 trawl hauls made with the 6-foot Isaacs-Kidd trawl,* John R. Manning *cruise 23, central North Pacific, December 1954*

Organisms [1]	Stomach contents	Trawl catch
Siphonophora		4
Unidentified Medusae		1
Chaetognatha		2
Annelida		1
Unidentified Amphipoda	4	
Unidentified Crustacea		12
Unidentified Decapoda	25	1
Onycoteuthidae	14	
Argonautidae	3	
Unidentified Cephalopoda	1	
Pyrosomatidae		32
Salpidae	3	40
Sternoptychidae	3	
Alepisaurus sp.	2	
Unidentified Myctophidae		1
Lampadena sp.		3
Cololabis sp.	35	
Unidentified Pisces	8	
Total	98	97

[1] Includes all organisms or groups of organisms comprising 1 percent or more, by volume, of the stomach contents or of the trawl catches.

TABLE 21.—*Collection data for six juvenile tuna captured by midwater trawl in the central Pacific, 1952–56*

Number of juveniles	Species	Total length	Gear of capture	Depth of haul	Vessel and cruise	Date taken	Time taken	Station No.	Position	
									Latitude	Longitude
		Millimeters		*Meters*			*Zone time*			
1	*Katsuwonus pelamis*	18	6-ft. beam	0–103	*Hugh M. Smith*—15	June 21–22, 1952	2235–0015	62-1	5°56′ N.	139°26′ W.
1	do	18	1-m. ring	0–187	*Charles H. Gilbert*—11	Apr. 9, 1953	0212–0314	12-D	20°35′ N.	157°32′ W.
1	Unidentified	<20	6-ft. Isaacs-Kidd	0–95	*John R. Manning*—20	June 3, 1954	1842–1957	30	1°44′N.	158°15′ W.
2	do	20 60	10-ft. Isaacs-Kidd	0–118	*Hugh M. Smith*—27	Feb. 1, 1955	1939–2041	25-1	29°56′ N.	179°28′ E.
1	*Katsuwonus pelamis*	22	do	0–176	*Hugh M. Smith*—35	Sept. 26, 1956	1905–2005	165	0°02′ N.	159°50′ W.

trawl catches and the Salpidae were present in lesser volume; in the tuna food the Pyrosomatidae were lacking, but the Salpidae were present in about the same volume as in the trawl samples. Sauries (*Cololabis* sp.), the largest single item in the albacore stomachs examined, were not taken in the 6-foot Isaacs-Kidd trawl. On cruise 22, a lanternfish (*Tarletonbeania* sp.) ranked large in volume in the albacore food, but was not taken in the trawl. Other kinds of lanternfish were captured in the trawl on cruise 23, however, that did not occur in the tuna stomachs.

On the basis of these data we conclude that the 6-foot Isaacs-Kidd trawl did not sample the immediate food of yellowfin and albacore tuna in the equatorial Pacific and central North Pacific. With respect to the food of other tuna species, such as bigeye (*Parathunnus sibi*) and skipjack (*Katsuwonus pelamis*), we do not have sufficient information collected concurrently with midwater trawl catches to provide within-cruise or station-to-station comparisons. For these species our best data are those given in table 17 and figure 22.

MIDWATER TRAWLS AS SAMPLING DEVICES FOR JUVENILE TUNAS

Larval tunas of several species have been captured in the central Pacific in 1-meter zooplankton nets with mesh apertures about 0.65 mm. in width (Matsumoto, 1958; Strasburg, 1960). The young tunas captured in this manner have ranged from 3 to about 12 mm. in length, but specimens larger than 6 mm. were uncommon in the catch. The number captured per 30-minute haul has varied from none to several hundred. Both of these authors concluded that diurnal differences in the catch of tuna larvae resulted primarily from vertical migrations and only secondarily from the increased ability of the larvae to dodge the net during the daytime.

The almost complete absence from the plankton catches of young tuna more than 12 mm. in length (Strasburg, 1960) could possibly be attributed to their living in a different habitat or level of the sea than that sampled by the plankton nets or to their ability to dodge the net. Since the plankton net sampled the mixed layer and usually beyond, to depths as great as 200 meters and sometimes greater, and the hauls were spaced over a wide range of latitude and longitude at all seasons of the year, it would seem reasonable to believe that the environment occupied by the young tunas was being sampled, but at sizes above 12 mm. they easily escaped the 1-meter net.

It was our hope that by means of midwater trawls we would capture juvenile tunas of lengths above 12 mm. which were able to elude the plankton nets. In 274 hauls made with the four midwater trawls described in this report we captured only six juvenile tunas, which ranged from 18 to 60 mm. in length. Three of the six were caught in the 10-foot Isaacs-Kidd trawl; the remainder were taken in the other three trawls. The collection data for these six specimens are given in table 21.

On cruise 15 of the *Smith*, 7 yellowfin, 36 skipjack, and 13 unidentified tuna larvae were captured in hauls of 1-meter zooplankton nets between latitude 6° N. and the Equator along longitude 140° W. (Matsumoto, 1958). Four hauls with the 6-foot beam trawl made in this area on cruise 15 yielded only 1 juvenile tuna, a skipjack (*Katsuwonus pelamis*) 18 mm. in length (table 21). There was evidence, therefore, that considerable numbers of larval tunas, and most likely juvenile tunas, were in the area but were not captured by the beam trawl. We expected the larvae to escape through the relatively coarse meshes of the trawl net, but we did hope to retain the juveniles 20 mm. and larger.

The plankton collections obtained on the other four cruises cited in table 21, on which one or two juvenile tunas were taken in midwater trawls, have not yet been sorted for larval tunas. From our knowledge of the widespread occurrence of the larvae (Matsumoto, 1958), however, and of the distribution of the adults, we believe that juvenile tunas were present in the areas sampled. Our failure to catch them in larger quantities indicates the ineffectiveness of our gear for sampling this portion of the fauna.

SUMMARY

This study is based on the quantitative analysis of the catches from 274 midwater-trawl hauls made on 22 cruises of Bureau of Commercial Fisheries vessels in the central Pacific Ocean between latitudes 49° N. and 19° S., and longitudes 108° W. and 162° E., during the years 1951 to 1956.

Chief purpose of the trawling program was to obtain quantitative estimates of the abundance and distribution of forage organisms, particularly those utilized by tunas.

Four types of trawls were employed: 6-foot beam trawl, 1-meter ring trawl, and 6-foot and 10-foot Isaacs-Kidd trawls. Descriptions and specifications of the four trawls are provided. Hauls were usually of the double oblique type with the net fishing between the surface and depths as great as 400 meters.

In the laboratory, the catch was sorted and the different kinds of organisms identified to the most precise degree considered practical. The number and displacement volume were determined for each kind or group of organisms identified.

Volume of the catch varied generally with size of the trawl. In terms of volume of catch per unit of mouth area, the trawls were about equal in catching efficiency within a geographical area. Essentially, all four trawls sampled organisms from the same phyla, classes, and orders, but differed in the families and genera of fishes they sampled—the largest and most frequently used trawls caught the greatest variety of organisms.

Night catches greatly exceeded day catches both in volume and number of organisms, and also yielded organisms of larger size. Marked diurnal differences were noted in the composition of the trawl catches. Coelenterates, amphipods, stomatopod larvae, certain molluscs, and tunicates occurred in about equal frequency in day and night collections, whereas the faster-swimming forms, such as the decapod Crustacea, squids, and most of the fishes, were taken principally at night. We believe that the day/night difference in catch was due largely to a diurnal migration and the movement of the organisms into the surface layer at night, rather than to an ability to dodge the net during the day.

With respect to geographic variation, catches of the Isaacs-Kidd trawls showed two peaks in abundance: in the Aleutian Current and in the region of upwelling and enrichment at the Equator. The poorest catches were made in the South Equatorial Current south of 5° S. latitude, in the North Equatorial Current between 10° N. and 18° N. latitude, and in Hawaiian waters. Evaluation by a two-way analysis of variance indicated differences ($P<0.05$) among longitudes in the volume of trawl catches made with the 10-foot Isaacs-Kidd trawl during one cruise to the equatorial Pacific.

On the basis of "t" tests of the difference between mean catch volumes, we found no significant differences between cruises to the same general area (equatorial Pacific) at about the same time of year, or to the same area (central North Pacific) at different seasons (late summer and winter).

In correlation analyses of the relation of trawl catch volumes and various environmental factors, we found a significant ($P<0.01$) positive correlation of trawl volumes and surface inorganic phosphate for two cruises and a positive but not significant ($P>0.05$) relation for a third cruise. On one cruise the relation of trawl volumes to C^{14} uptake by phytoplankton was positive but nonsignificant ($P>0.05$), whereas on a second cruise the correlation coefficient was significant ($P<0.01$). On all four cruises studied, the correlation between zooplankton volumes and trawl catches was found to be significant ($P<0.01$). These results were in line with our expectations: that the forage organisms would be more closely related to zooplankton—their food for the greater part—than to inorganic phosphate or the metabolic activity of phytoplankton.

Expressing the catch in terms of volume per unit volume of water strained, we obtained an average catch for the 6-foot Isaacs-Kidd trawl of 1.86 ml./1,000 m.^{3}, and an average of 1.65 ml./ 1,000 m.^{3} for the 10-foot Isaacs-Kidd trawl. These volumes are approximately one-sixteenth to one-eighteenth of the average zooplankton volume obtained for the same general area.

A much greater variety of organisms was found in the trawl catches than in the tuna stomachs, which might indicate some degree of selection by the tunas. Most fishes in tuna stomachs were pelagic—characteristic of the surface layer during both day and night. The most abundant fishes in the trawl catches were bathypelagic, occurring in the middepths during the day and migrating to the surface layer at night. A virtual lack of these fishes in the tuna stomachs examined may indicate that tunas feed principally in the daytime and in the surface layer. Since the trawls were operated almost entirely at night because the catches were very poor during daylight and tuna fishing was carried out during the day, it was not too surprising to find a very poor correspondence between the composition of the trawl catches and the contents of tuna stomachs, with the similarities greatly outweighed by the differences.

In 274 hauls made with the 4 types of trawls we caught only 6 juvenile tunas, ranging in length from 18 to 60 mm. On the basis of catches of larval tunas made in zooplankton nets and our knowledge of the distribution of the adults, we believe juvenile tunas were present in these areas at the time of the trawling.

The greatest variety of organisms was captured in the South Equatorial Current and in the Countercurrent, the poorest variety in the North Equatorial Current and Aleutian Current. Midwater trawls sampled principally primary and secondary carnivores, some of which may also be classed as herbivores and detritus eaters. Strictly herbivorous animals were very scarce in the catches.

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APPENDIX TABLE 1.—*Summary of collection of organisms with 6-foot beam trawl, by cruise, central Pacific, 1951 and 1952*

Station	Position		Date	Start of haul	Length of haul	Estimated maximum depth	Catch/hour haul			Unusually numerous or bulky organisms	
	Latitude	Longitude					Number	Volume	Adjusted volume [1]	Number	Volume
John R. Manning:				*Zone time*	*Hours*	*Meters*		*Milliliters*	*Milliliters*		*Milliliters*
Cruise 9:			*1951*								
17	21°26.4′ N	158°12.5′ W	Nov. 26	1200	1.07	44	7	1.3	----------	----------	----------
18	21°26′ N	158°13.5′ W	Nov. 26	1410	.88	156	131	8.0	----------	----------	----------
19	21°24.5′ N	158°16.3′ W	Nov. 26	1525	.97	182	126	5.3	----------	----------	----------
20	21°21.8′ N	158°21.1′ W	Nov. 26	1704	1.02	175	228	19.8	----------	----------	----------
21	21°26.4′ N	158°12.5′ W	Nov. 26	1947	.93	25	112	5.9	----------	----------	----------
22	21°26′ N	158°13.5′ W	Nov. 26	2101	1.07	169	80	20.6	----------	----------	----------
23	21°24.5′ N	158°16.3′ W	Nov. 26	2233	1.05	169	159	77.1	----------	----------	----------
24A	21 21.8′ N	158°21.1′ W	Nov. 27	0021	1.00	200	184	51.0	----------	----------	----------
24B	21°21.8′ N	158°21.1′ W	Nov. 27	0204	2.27	450	154	31.4	18.6	1 Scyphozoa	29.0
27	21°23.1′ N	158°12.5′ W	Nov. 27	1040	.58	200	117	4.0	----------	----------	----------
Hugh M. Smith:											
Cruise 14:			*1952*								
14	04°58′ S	155°00′ W	Feb. 1	1923	.33	5	106	13.0	----------	----------	----------
16	06°50′ S	155°05′ W	Feb. 2	1412	.33	5	82	1.2	----------	----------	----------
Cruise 15:											
61-1	06°00′ N	139°57′ W	June 20	2301	1.48	300	1,695	83.4	----------	1,000 euphausiids	18.0
61-2	06°00′ N	139°54′ W	June 21	0040	1.83	103	14,310	434.0	----------	25,000 euphausiids	613.4
62-1	05°56′ N	139°26′ W	June 21	2235	1.67	103	2,062	217.2	----------	1,000 euphausiids	48.4
62-2	05°56′ N	139°23′ W	June 22	0035	2.40	219	1,146	136.9	----------	720 euphausiids	37.8

[1] Total catch per hour less unusually large organisms or "jellies" constituting 50 percent or more of the catch.

APPENDIX TABLE 2.—*Summary of collection of organisms with 1-meter ring trawl, by cruise, central Pacific, 1953*

Station	Position		Date	Start of haul	Length of haul	Estimated maximum depth	Catch/hour haul	
	Latitude	Longitude					Number	Volume
Charles H. Gilbert:								
Cruise 11:				*Zone time*	*Hours*	*Meters*		*Milliliters*
5A	21°49.3′ N	157°32.2′ W	April 1	1405	1.65	200	14	1.3
8D	20°35.1′ N	157°32′ W	2	0224	1.03	200	134	6.3
9A	21°49.3′ N	157°32.4′ W	8	1330	1.00	134	54	2.3
12D	20°34.9′ N	157°32.3′ W	9	0212	1.03	187	83	11.6
13A	21°49.9′ N	157°32.1′ W	14	1307	1.18	198	31	5.3
16D	20°35.2′ N	157°32′W	15	0234	1.02	198	136	6.9
17A	21°48.8′ N	157°32′ W	22	1310	1.12	144	50	2.5
20D	20°35.2′ N	157°32′ W	23	0202	.98	165	167	14.2
21A	21°50.7′ N	157°31′ W	29	1248	.98	227	58	1.9
24D	20°35′ N	157°32′ W	30	0410	1.08	196	94	3.8
Cruise 12:								
1A	21°50′ N	157°32′ W	May 8	1505	1.25	200	81	0.9
4D	20°35.2′ N	157°32′ W	9	0250	.92	199	25	9.6
13A-1	21°50′ N	157°32′ W	14	1320	1.08	134	16	0.6
13A-2	21°50′ N	157°32′ W	14	1430	1.00	171	154	2.8
16D-1	20°35′ N	157°32′ W	15	0225	1.10	118	141	9.7
16D-2	20°35′ N	157°32′ W	15	0335	1.00	171	54	27.6
16D-3	20°35′ N	157°32′ W	15	0440	1.08	169	157	6.9
17A-1	21°49.8′ N	157°32′ W	28	1440	1.25	193	25	0.4
17A-2	21°49.8′ N	157°32′ W	28	1602	.83	206	26	1.1
20D	20°35.2′ N	157°32.2′ W	29	0510	1.18	168	32	0.7
Cruise 13:								
1A	21°50′ N	157°32′ W	June 4	1550	1.25	155	7	1.1
4D	20°35.3′ N	157°32.3′ W	5	0340	1.17	169	4	1.8
Hugh M. Smith:								
Cruise 21:								
23	23°10′ N	159°21.2′ W	Aug. 10	2140	1.25	90	14	5.7

APPENDIX TABLE 3.—*Summary of collection of organisms with 6-foot Isaacs-Kidd trawl, by cruise, central Pacific, 1953–55*

Station	Position		Date	Start of haul	Length of haul	Estimated maximum depth	Catch/hour haul			Unusually numerous or bulky organisms	
	Latitude	Longitude					Number	Volume	Adjusted volume [1]	Number	Volume
John R. Manning:				*Zone time*	*Hours*	*Meters*		*Milliliters*	*Milliliters*		*Milliliters*
Cruise 15:			*1953*								
4	08°23′ N	150°12′ W	May 4	1930	1.00	200	129	93.1			
Cruise 16:											
Test	21°05′ N	157°58′ W	July 21	0853	1.32	169	39	8.0			
5	08°27′ N	154°48.6′ W	July 30	1930	1.27	200	346	136.8			
7	07°04.2′ N	154°55.1′ W	July 31	1935	1.35	200	381	110.1			
Cruise 20:			*1954*								
Test 1	21°40′ N	158°09′ W	Apr. 28	1900	.33	15	264	10.0			
Test 2	21°39.5′ N	158°10.3′ W	Apr. 28	1931	.60	230	250	35.7			
Test 3	21°00.5′ N	157°49′ W	Apr 29	0713	1.25	135	122	7.5			
Test 4	21°56′ N	157°49′ W	Apr. 29	0838	.93	232	90	4.2			
1	05°58′ N	162°52.5′ W	May 17	0755	1.38	110	170	3.2			
2	05°59′ N	162°28′ W	May 18	0712	1.33	110	260	16.1			
4	06°05′ N	162°18′ W	May 19	0650	1.27	100	161	5.3			
5	05°58′ N	161°53′ W	May 20	0710	1.22	100	41	20.9			
7	05°49′ N	161°03.9′ W	May 21	1848	1.17	90	631	67.4			
9	05°18.5′ N	161°29′ W	May 22	1855	1.30	100	597	145.3	49.2	23 medusae 22 tunicates	78.0 47.0
11	04°46.5′ N	161°03.5 W	May 23	1847	1.38	100	1,086	114.6	59.5	33 tunicates	76.0
14	04°41′ N	159°53′ W	May 25	1850	1.30	90	867	111.8			
16	04°36.5′ N	159°41′ W	May 26	1843	1.28	85	962	126.2	77.7	44 tunicates	62.0
18	04°07.5′ N	160°12.4′ W	May 27	1846	1.28	100	523	163.3	50.0	38 tunicates	145.0
22	03°53.2′ N	158°47.8′ W	May 30	1842	1.25	100	2,042	79.0			
24	03°53.2′ N	158°23′ W	May 31	1842	1.28	95	756	67.3			507.0
26	02°47.1′ N	158°55.4′ W	June 1	1845	1.45	90	323	415.6	65.9	36 tunicates	507.0
28	02°09′ N	158°16.5′ W	June 2	1842	1.27	95	475	104.7			
30	01°43.9′ N	158°14.9′ W	June 3	1842	1.25	95	574	99.8		1 fish	40.0
34	01°48.5′ N	156°54.9′ W	June 7	1840	1.27	90	806	66.8			
37	01°26′ N	158°18.8′ W	June 9	1840	1.28	85	594	42.4			
39	00°38.4′ N	158°48′ W	June 10	1844	1.30	90	736	47.4			
Cruise 21:											
2	20°42′ N	157°14.5′ W	July 23	2016	1.35	187	181	30.4			
4	19°36.5′ N	157°32.5′ W	July 25	1913	1.23	144	141	55.2			
6	19°35.4′ N	157°21′ W	July 26	2008	1.23	136	85	10.2			
9	20°45′ N	157°15′ W	July 28	2011	1.40	209	174	17.1			
Cruise 22:											
2	26°24.5′ N	159°14.2′ W	Sept. 15	1924	1.05	105	341	37.8	16.1	6 tunicates	22.8
4	30°25.1′ N	159°57.5′ W	Sept. 17	1910	1.05	95	2,328	36.5	20.3	5 tunicates	17.0
6	31°45.5′ N	159°57.2′ W	Sept. 18	1905	1.03	100	412	33.1			
8	33°16′ N	159°54′ W	Sept. 19	1910	1.08	95	528	80.2	49.8	9 tunicates	32.8
10	34°51.5′ N	159°51.4′ W	Sept. 20	1905	1.05	100	67,476	113.4		68,600 barnacle larvae	75.2
12	36°30.5′ N	159°51.3′ W	Sept. 21	1904	1.02	90	17,307	59.9		16,500 barnacle larvae	24.8
16	41°06.4′ N	159°58′ W	Sept. 24	1919	1.10	100	12,137	158.5		9,300 barnacle larvae 3,600 euphausiids	94.4 11.1
20	46°13′ N	159°57.5′ W	Oct. 4	1906	1.03	95	8,578	82.1		5,300 barnacle larvae	1.7
25	36°33.2′ N	174°47.5′ W	Oct. 21	1910	1.00	100	170	65.4	15.1	8 tunicates	50.3
27	39°05′ N	175°22′ W	Oct. 24	1908	1.05	100	1,390	69.5			
Cruise 23:											
2	29°54.6′ N	159°48′ W	Dec. 6	1912	1.13	105	137	4.2			
6	34°39.5′ N	160°01′ W	Dec. 9	1913	1.20	100	1,533	55.6	16.0	44 tunicates	47.5
Cruise 24:			*1955*								
1	20°30.1′ N	157°45.6′ W	Mar. 24	1910	.93	100	238	24.3		5 tunicates	9.2
2	17°29.5′ N	157°05′ W	Mar. 25	2012	.97	90	202	88.6	30.0	1 fish	57.0
3	14°38′ N	156°44′ W	Mar. 26	2022	1.05	100	199	33.1			
4	11°58.9′ N	156°13′ W	Mar. 27	2017	1.00	90	283	42.5			
5	09°24′ N	155°55.5′ W	Mar. 28	2012	.97	90	877	114.2			
6	06°45′ N	155°27′ W	Mar. 29	2016	.97	95	853	92.3			
8	05°29′ N	154°46.3′ W	Mar. 30	2010	1.03	90	772	157.1	60.4	58 tunicates	99.6
10	03°48.6′ N	154°49.8′ W	Mar. 31	2005	1.00	95	605	311.3	28.3	38 tunicates	283.0
12	02°23.2′ N	155°05.5′ W	Apr. 1	2010	.97	100	560	64.0		18 tunicates	24.1
14	01°18.8′ N	155°27.5′ W	Apr. 2	2012	1.00	95	1,040	78.4			
18	02°37.2′ N	157°43.8′ W	Apr. 5	1920	.93	95	838	50.9			
20	03°11.9′ N	158°39.3′ W	Apr. 6	1916	1.00	90	557	156.4	33.6	20 tunicates	122.8
23	04°48.3′ N	160°37.5′ W	Apr. 8	1915	1.02	105	563	178.4	105.3	21 tunicates	74.6
Hugh M. Smith:											
Cruise 27:											
3	23°34.3′ N	163°37.4′ W	Jan. 7	1946	1.23	104	383	5.9			
5	22°39.2′ N	166°56′ W	Jan. 8	1946	1.12	112	678	10.8			
13	23°43.1′ N	173°34.5′ E	Jan. 14	2028	1.12	110	486	23.7			
15	24°45.1′ N	170°41.1′ E	Jan. 15	1940	1.02	110	482	12.6			
18	27°02′ N	169°44.3′ E	Jan. 16	1908	1.00	105	404	13.3			
21	29°46.7′ N	169°48.2′ E	Jan. 17	1917	1.00	105	1,020	48.9			
23-1	28°27.8′ N	178°10.5′ W	Jan. 31	1948	1.02	122	265	6.7			
25-2	30°02.5′ N	179°31′ E	Feb. 1	2049	1.02	122	1,487	28.1			
28-2	32°52′ N	179°55.3′ W	Feb. 2	2049	1.00	144	542	56.1			
32	36°57.5′ N	175°03′ W	Feb. 5	2048	1.03	135	1,157	31.6			
35	35°15.9′ N	173°26.8′ W	Feb. 6	2014	1.00	122	2,268	44.8			
37	32°34′ N	173°01.5′ W	Feb. 7	1911	.98	144	2,759	25.5			
40	29°36.1′ N	172°42.5′ W	Feb. 8	1911	.98	100	3,639	136.8	33.8	4 tunicates	101.0
43	26°34′ N	172°02.5′ W	Feb. 9	2055	1.00	122	302	101.9	6.9	1 tunicate	95.0
47	29°32′ N	166°41.5′ W	Feb. 12	1957	1.00	135	1,128	11.4			
49	32°28.1′ N	166°44.3′ W	Feb. 13	1901	1.00	100	2,350	69.8			
53	35°31.5′ N	166°44′ W	Feb. 14	1947	1.03	100	5,869	90.8			
55	37°07′ N	164°17′ W	Feb. 15	1932	1.00	104	2,698	88.0			
58	36°58.5′ N	160°12.5′ W	Feb. 16	1904	1.00	100	2,187	37.9			
62	33°56.2′ N	159°42.8′ W	Feb. 17	1912	1.02	100	4,732	68.9			
65	30°36′ N	159°19.5′ W	Feb. 18	1930	.98	100	1,890	37.8			
68	27°26.2′ N	158°55.5′ W	Feb. 19	1931	.98	100	731	13.5			
71	24°29.5′ N	158°35.2′ W	Feb. 20	1930	1.00	117	738	4.1			

[1] Total catch per hour less unusually large organisms or "jellies" constituting 50 percent or more of the catch.

APPENDIX TABLE 4.—*Summary of collection of organisms with 10-foot Isaacs-Kidd trawl,* Hugh M. Smith *cruises, central Pacific, 1955 and 1956*

Station	Position		Date	Start of haul	Length of haul	Estimated maximum depth	Catch/hour haul			Unusually numerous or bulky organisms	
	Latitude	Longitude					Number	Volume	Adjusted volume [1]	Number	Volume
			1955	*Zone time*	*Hours*	*Meters*		*Milliliters*	*Milliliters*		*Milliliters*
Cruise 27:											
23-2	28°32.1′ N	178°10′ W	Jan. 31	2102	1.00	118	882	57.1			
25-1	29°56.3′ N	179°28.5′ E	Feb. 1	1939	1.03	118	3,629	62.1			
28-1	32°46.5′ N	179°54.5′ W	Feb. 2	1943	.98	118	1,456	177.7			
Cruise 30:											
3	23°39′ N	161°20′ W	July 16	2005	2.17	192	560	97.0			
6	25°02′ N	164°23′ W	July 17	2038	.97	215	203	96.8	37.0	5 tunicates	58.0
9	26°11′ N	167°17′ W	July 18	2135	1.28	205	485	86.2			
12	27°11′ N	170°54′ W	July 19	1936	1.15	250	540	53.1			
15	27°47′ N	174°00′ W	July 20	2041	1.40	228	464	97.2			
18	27°37′ N	177°58′ W	July 23	2125	1.25	238	262	56.2			
21	30°17′ N	179°53′ E	July 24	2135	1.08	223	288	107.7			
23	33°41′ N	180°00′	July 25	2130	1.20	275	237	131.2			
27	39°31′ N	179°54′ W	July 27	2123	1.15	224	1,116	180.3			
30	42°21′ N	179°52′ W	July 28	2139	1.55	253	1,215	211.0			
33	45°22′ N	179°50′ W	July 29	2134	1.00	204	1,539	188.0			
36	48°20′ N	179°47′ W	July 30	2149	1.23	200	6,865	347.6		9,450 euphausiids	207.0
38	49°30′ N	177°19′ W	July 31	2134	1.05	213	2,695	232.4		3 squids	79.0
40	49°25′ N	172°35′ W	Aug. 1	2131	.83	185	380	91.2			
42	46°57′ N	172°31′ W	Aug. 2	2132	.97	236	1,222	116.4			
45	44°37′ N	172°27′ W	Aug. 3	2236	.73	217	7,984	210.5			
48	41°08′ N	172°22′ W	Aug. 4	2200	.75	231	1,728	584.1	288.1	6 heteropods 59 pteropods	222.0 86.0
51	38°17′ N	172°30′ W	Aug. 5	2100	.98	231	1,047	150.0			
54	34°53′ N	172°36′ W	Aug. 6	2105	.57	206	793	64.6			
57	31°31′ N	172°25′ W	Aug. 7	2209	.68	206	676	77.2			
60	30°08′ N	171°48′ W	Aug. 8	2204	1.10	215	293	48.2			
63	29°54′ N	168°32′ W	Aug. 9	2101	1.00	210	259	133.1	77.1	5 tunicates	56.0
65	29°59′ N	164°49′ W	Aug. 10	2048	1.00	206	245	71.6			
67	32°49′ N	164°59′ W	Aug. 11	2049	.93	206	662	116.1	62.4	8 tunicates	50.0
69	36°00′ N	164°53′ W	Aug. 12	2104	.98	217	760	88.3			
75	42°22′ N	164°55′ W	Aug. 14	2101	1.10	218	1,335	431.3	223.1	103 heteropods	229.0
78	45°23′ N	164°59′ W	Aug. 15	2105	1.00	210	2,782	126.1			
80	48°01′ N	164°55′ W	Aug. 16	2104	1.20	206	934	186.3			
82	49°37′ N	162°58′ W	Aug. 17	2105	1.10	212	4,342	228.6			
85	49°34′ N	157°55′ W	Aug. 18	2100	1.07	211	252	99.0			
88	47°09′ N	157°14′ W	Aug. 19	2202	1.07	209	1,136	163.8			
95	41°23′ N	157°24′ W	Aug. 21	2134	1.03	214	212	245.3			
98	38°07′ N	157°30′ W	Aug. 22	2037	1.02	211	206	145.0	33.2	2 tunicates	114.0
101	34°54′ N	157°30′ W	Aug. 23	2030	1.25	206	252	62.2			
107	28°53′ N	157°30′ W	Aug. 25	2031	1.15	219	83	107.1			
110	25°53′ N	157°30′ W	Aug. 26	2005	1.02	211	213	75.0			
113	22°48′ N	157°32′ W	Aug. 27	2006	1.15	224	178	36.6			
Cruise 31:											
2	10°50′ N	156°07′ W	Sept. 26	2038	1.07	337	430	95.2			
5	07°55′ N	155°18′ W	Sept. 27	2045	1.75	339	285	39.0			
8	05°30′ N	154°52′ W	Sept. 28	2023	1.28	462	324	93.3			
11	06°25′ N	153°24′ W	Sept. 29	2030	1.22	382	461	166.7	78.0	Tunicates	108.2
14	08°21′ N	150°59′ W	Sept. 30	2024	1.05	337	378	159.4	58.5	7 tunicates	106.0
17	10°21′ N	148°47′ W	Oct. 1	2025	1.32	395	200	167.7	117.7	5 tunicates	66.0
20	11°00′ N	147°15′ W	Oct. 2	2027	1.08	433	326	74.1			
23	09°45′ N	145°01′ W	Oct. 3	2020	1.05	357	213	149.9	88.3	4 tunicates	64.7
26	08°37′ N	142°41′ W	Oct. 4	2023	1.17	298	261	156.8			
29	08°50′ N	140°08′ W	Oct. 5	2020	1.00	265	233	140.4			
32	10°25′ N	137°48′ W	Oct. 6	2022	1.08	337	365	157.2			
35	10°50′ N	135°39′ W	Oct. 7	2017	1.02	629	495	105.0			
38	09°40′ N	132°58′ W	Oct. 8	2015	.95	357	368	123.5			
41	09°30′ N	130°01′ W	Oct. 9	2026	1.03	337	296	777.0	75.0	Tunicates	723.0
44	10°30′ N	127°20′ W	Oct. 10	2023	1.03	379	437	1,510.5	73.7	1 fish; tunicates	800.0 680.0
47	11°33′ N	125°06′ W	Oct. 11	2012	1.00	298	596	2,206.8	206.8	1 fish	2,000.0
50	11°23′ N	122°32′ W	Oct. 12	2008	1.00	337	802	258.0	77.5	66 tunicates	180.5
53	09°30′ N	120°03′ W	Oct. 13	2010	.98	318	410	289.5	97.6	64 tunicates	188.1
56	09°10′ N	117°35′ W	Oct. 14	2012	1.00	337	313	209.8	122.8	30 tunicates	87.0
59	10°38′ N	114°39′ W	Oct. 15	2016	1.02	298	515	138.9			
62	12°20′ N	112°30′ W	Oct. 16	2011	1.02	322	317	208.3	43.6	31 tunicates	168.0
64	07°06′ N	108°36′ W	Oct. 27	2025	1.05	337	491	130.7			
67	04°39′ N	109°24′ W	Oct. 28	2002	1.00	318	631	106.7			
70	02°10′ N	110°53′ W	Oct. 29	1938	1.02	337	355	139.5			
73	00°12′ S	112°25′ W	Oct. 30	2003	1.02	375	334	132.5			
76	02°54′ S	113°08′ W	Oct. 31	2006	1.02	318	521	343.0	88.2	1 fish	260
79	05°24′ S	113°18′ W	Nov. 1	2019	1.02	413	931	93.6			
82	07°37′ S	114°48′ W	Nov. 2	2003	1.03	357	348	195.4	59.5	1 fish	140
86	06°43′ S	120°06′ W	Nov. 4	2015	1.03	329	436	63.2			
89	04°13′ S	120°06′ W	Nov. 5	2003	1.00	337	643	118.3			
92	01°32′ S	120°05′ W	Nov. 6	2017	1.02	318	1,289	203.6			
95	01°06′ N	120°00′ W	Nov. 7	2016	1.03	318	296	167.6			
105	03°54′ N	120°01′ W	Nov. 9	0005	1.02	375	304	946.9	220.7	Tunicates	740.7
109	05°52′ N	119°53′ W	Nov. 9	1955	1.03	357	483	191.3			
112	04°10′ N	122°33′ W	Nov. 10	2002	1.00	298	390	381.3	156.3	8 tunicates	225.0
115	02°03′ N	125°05′ W	Nov. 11	2011	1.05	318	1,178	297.6	195.6	129 tunicates	107.1
118	00°23′ N	127°14′ W	Nov. 12	2012	1.00	395	722	344.5	144.5	1 fish	200.0
121	01°28′ S	129°24′ W	Nov. 13	2008	1.00	357	5,818	474.7		5,124 euphausiids	355.0
124	01°09′ S	131°48′ W	Nov. 14	2005	1.02	375	497	144.0			
127	00°51′ N	134°26′ W	Nov. 15	2005	1.02	337	758	115.3			
130	03°00′ N	136°56′ W	Nov. 16	2010	.95	279	412	110.3			
133	05°40′ N	139°15′ W	Nov. 17	2107	1.00	375	482	241.0			

See footnote at end of table.

APPENDIX TABLE 4.—*Summary of collection of organisms with 10-foot Isaacs-Kidd trawl,* Hugh M. Smith *cruises, central Pacific, 1955 and 1956*—Continued

Station	Position		Date	Start of haul	Length of haul	Estimated maximum depth	Catch/hour haul			Unusually numerous or bulky organisms	
	Latitude	Longitude					Number	Volume	Adjusted volume[1]	Number	Volume
				Zone time	*Hours*	*Meters*		*Milliliters*	*Milliliters*		*Milliliters*
Cruise 31—Con.			*1955*								
136	03°31′ N	139°15′ W	Nov. 18	2005	1.02	357	378	181.5	--------	--------	--------
141	01°18′ N	139°31′ W	Nov. 19	2012	.95	379	480	164.4	--------	--------	--------
146	00°57′ S	140°00′ W	Nov. 20	2010	.95	318	158	348.2	132.8	Tunicates	204.6
151	04°03′ S	139°49′ W	Nov. 21	1955	1.02	318	314	136.1	--------	--------	--------
154	06°33′ S	139°30′ W	Nov. 22	2005	1.00	337	215	82.2	--------	--------	--------
164	06°37′ S	141°53′ W	Dec. 1	2010	1.02	337	319	134.0	--------	--------	--------
167	04°20′ S	143°55′ W	Dec. 2	2010	.90	279	988	122.1	--------	--------	--------
170	01°41′ S	145°53′ W	Dec. 3	2013	1.02	337	545	855.0	76.9	Tunicates 1 heteropod	493.7 300.0
173	00°28′ N	147°46′ W	Dec. 4	2011	.93	239	566	753.8	311.1	Tunicates	411.7
176	01°07′ N	149°56′ W	Dec. 5	2010	.95	318	452	638.9	398.1	32 tunicates	228.8
179	00°09′ S	153°00′ W	Dec. 6	2013	92	394	329	249.4	127.7	51 tunicates	1,120.0
Cruise 32:			*1956*								
3	21°01′ N	157°54′ W	Feb. 2	2105	.95	230	284	90.4	--------	--------	--------
11	21°20′ N	158°21′ W	Feb. 3	2025	1.00	189	432	35.7	--------	--------	--------
19	21°29′ N	158°26′ W	Feb. 4	1912	1.02	189	422	75.4	--------	--------	--------
31	22°02′ N	157°44′ W	Feb. 5	2025	1.00	192	628	66.7	--------	--------	--------
42	21°24′ N	157°31′ W	Feb. 6	2225	1.00	171	450	118.9	--------	--------	--------
47	21°15′ N	158°38′W	Feb. 8	1935	1.03	191	214	209.4	58.0	1 fish	156.0
49	21°19′ N	158°33′ W	Feb. 9	1920	1.02	221	152	34.3	--------	--------	--------
51	21°23′ N	158°28′ W	Feb. 10	1915	1.05	248	188	61.3	--------	--------	--------
Cruise 33:											
18	00°12′ N	139°53′ W	Mar. 18	2119	1.07	171	2,520	287.6	--------	--------	--------
20	00°01′ N	139°27′ W	Mar. 19	2104	.98	180	2,171	190.1	--------	--------	--------
21	01°07′ N	140°07′ W	Mar. 20	2105	1.02	171	3,476	173.0	--------	--------	--------
24	01°06′ N	140°10′ W	Mar. 22	2106	1.10	180	1,431	61.3	--------	--------	--------
28	01°14′ N	140°35′ W	Mar. 24	2114	.98	176	1,561	96.9	--------	--------	--------
Cruise 34:											
T1	21°38.5′ N	158°25.7′ W	May 7	1915	1.00	183	68	92.0	--------	--------	--------
T2	22°00.3′ N	157°42′ W	May 8	2000	1.00	176	318	49.0	--------	--------	--------
T3	21°16.7′ N	157°31.5′ W	May 9	1920	1.00	171	78	47.1	--------	--------	--------
T4	21°14.3′ N	158°11′ W	May 10	2120	1.00	166	413	114.6	--------	--------	--------
Cruise 35:											
1	21°21.5′ N	158°15′ W	Aug. 1	1930	1.10	176	192	158.7	--------	--------	--------
10	21°28.7′ N	158°31.5′ W	Aug. 2	2007	1.13	162	449	181.2	--------	--------	--------
20	22°15.7′ N	157°56.4′ W	Aug. 3	2020	1.17	180	262	92.0	--------	--------	--------
30	21°13.3′ N	157°47.4′ W	Aug. 4	1939	1.10	176	86	93.0	22.4	18 tunicates	77.7
54	09°33.2′ N	134°52.4′ W	Aug. 15	2014	1.00	180	482	195.0	--------	--------	--------
56	06°17′ N	134°39.8′ W	Aug. 16	2100	.95	191	699	210.0	107.9	32 tunicates	97.0
59	04°06.1′ N	135°07.5′ W	Aug. 17	2012	1.03	173	513	224.8	115.6	6 tunicates	112.5
61	01°30.5′ N	135°13.6′ W	Aug. 18	2005	1.03	176	887	164.4	--------	--------	--------
63	01°03.8′ S	134°56′ W	Aug. 19	2007	1.00	173	453	219.7	109.7	1 fish	110.0
66	04°33.6′ S	134°58.5′ W	Aug. 20	2007	1.08	176	313	145.5	--------	--------	--------
70	07°52′ S	135°03.6 ′W	Aug. 21	2006	1.02	176	156	161.5	--------	--------	--------
74	10°44.9′ S	135°08′ W	Aug. 22	2000	1.00	181	518	83.0	--------	--------	--------
78	14°14′ S	135°01.9′ W	Aug. 23	2000	1.00	180	389	59.3	--------	--------	--------
82	17°35′ S	134°57.5′ W	Aug. 24	2100	.98	181	186	64.3	--------	--------	--------
84	19°03.2′ S	136°38.1′ W	Aug. 25	2006	.95	171	57	12.4	--------	--------	--------
88	19°01′ S	140°02.1′ W	Aug. 26	2004	1.00	176	173	34.2	--------	--------	--------
91	18°57′ S	143°00.5′ W	Aug. 27	1947	1.00	166	33	7.9	--------	--------	--------
95	15°44′ S	142°59.8′ W	Aug. 28	1902	1.00	171	515	94.2	--------	--------	--------
99	12°21.2′ S	143°03.7′ W	Aug. 29	1900	1.00	166	1,109	167.0	--------	--------	--------
103	09°22.4′ S	143°01.8′ W	Aug. 30	1900	1.00	171	1,100	440.5	219.0	1 fish	221.5
107	06°15.1′ S	143°03.8′ W	Aug. 31	1901	1.00	176	293	114.3	--------	--------	--------
111	03°06′ S	143°05.9′ W	Sept. 1	1913	.98	166	612	310.1	152.4	74 tunicates	154.5
113	00°01.9′ N	143°02.3′ W	Sept. 2	2015	1.00	176	935	212.4	--------	--------	--------
115	02°02.4′ N	144°34.7′ W	Sept. 3	1903	1.00	189	838	253.4	--------	--------	--------
118	01°58.6′ N	148°42′ W	Sept. 4	2007	1.00	180	879	258.0	--------	--------	--------
121	00°27.9′ N	151°13.8′ W	Sept. 5	1958	1.00	176	788	368.9	--------	--------	--------
124	02°03′ S	150°59.5′ W	Sept. 6	2000	1.00	171	1,245	370.9	162.9	580 euphausiids 1 fish	96.0 112.0
126	05°29.7′ S	151°11′ W	Sept. 7	2012	1.00	180	313	59.9	--------	--------	--------
129	08°44.9′ S	150°59′ W	Sept. 8	2000	1.00	171	579	147.1	--------	--------	--------
132	11°37′ S	150°59.5′ W	Sept. 9	2001	1.00	171	1,633	219.1	52.8	1,500 euphausiids	166.3
136	14°59.2′ S	150°49.8′ W	Sept. 10	2008	1.07	170	176	46.0	21.2	12 tunicates	26.5
138	17°02.2′ S	150°18.4′ W	Sept. 18	2007	1.00	176	45	30.1	10.8	11 tunicates	19.3
140	14°37′ S	152°56′ W	Sept. 19	2005	1.00	176	100	34.6	12.8	19 tunicates	21.8
143	14°30′ S	156°05.5′ W	Sept. 20	2005	1.00	166	131	33.3	--------	--------	--------
146	14°30′ S	159°34′ W	Sept. 21	1905	1.00	171	68	20.6	--------	--------	--------
150	11°51.5′ S	160°11.5′ W	Sept. 22	1905	1.00	180	140	55.2	--------	--------	--------
154	08°57.5′ S	159°55.3′ W	Sept. 23	1907	1.00	166	187	159.8	59.8	1 fish	100.0
158	05°57′ S	160°04′ W	Sept. 24	1904	1.00	176	960	202.7	--------	--------	--------
162	02°52.9′ S	159°52.6′ W	Sept. 25	1906	.97	166	1,561	189.8	114.5	1 squid	73.0
165	00°01.7′ N	159°50′ W	Sept. 26	1905	1.00	176	1,885	584.1	339.1	1 fish	245.0
168	04°19′ N	160°08′ W	Sept. 29	1905	1.00	176	1,466	441.9	210.9	7 siphonophores 34 tunicates	73.5 157.5
170	07°38.3′ N	160°00′ W	Sept. 30	1904	.97	166	596	159.3	--------	--------	--------
173	10°27.9′ N	160°02.2′ W	Oct. 1	1905	1.00	180	485	111.7	--------	--------	--------
Cruise 37:											
24	11°19.3′ N	162°07.9′ E	Dec. 2	2031	.95	238	511	61.1	--------	--------	--------
33	11°20.6′ N	162°07.8′ E	Dec. 6	1956	.95	286	241	42.5	--------	--------	--------
42	11°21.7′ N	162°05′ E	Dec. 9	2012	1.05	278	452	23.4	--------	--------	--------
43	11°18.3′ N	162°06.4′ E	Dec. 9	2113	1.00	290	393	86.7	--------	--------	--------

[1] Total catch per hour less unusually large organisms or "jellies" constituting 50 percent or more of the catch.

APPENDIX TABLE 5.—*Checklist of organisms captured in 16 hauls with the 6-foot beam trawl, by areas, 1951–52*

Organisms	Size range (mm.)	Hawaiian waters		Equatorial Pacific		Total	
		Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul
COELENTERATA:							
Hydrozoa:							
Siphonophora	5-41	40	35	84	257	56	193
Scyphozoa:							
Coronatae:							
Periphyllidae:							
Periphylla sp	70	10	1	------	------	6	1
Medusae: Unidentified	10-40	30	1	17	2	25	2
Other Coelenterata	<25	60	1	17	500	44	253
CHAETOGNATHA	9-44	100	29	100	178	100	90
ANNELIDA	157	------	------	17	1	6	1
ARTHROPODA:							
Crustacea:							
Copepoda	2-5	30	100	33	6	31	38
Mysidacea:							
Lophogastridae	20	10	10	------	------	6	10
Amphipoda:							
Hyperiidae	26-68	------	------	17	2	6	2
Phronimidae:							
Phronima sp	20-32	------	------	67	9	25	9
Oxycephalidae:							
Oxycephalus sp	20-33	------	------	67	13	25	13
Rhabdosoma sp	28-75	10	1	67	36	31	29
Unidentified Amphipoda	<20	------	------	50	34	19	34
Stomatopoda (larvae)	7-53	90	36	------	------	56	36
Euphausiacea:							
Euphausiidae:							
Thysanopoda tricuspidata	20-27	------	------	33	28	12	28
Stylocheiron abbreviatum	22	------	------	17	1	6	1
Unidentified Euphausiacea	5-47	50	28	84	5,492	62	3,064
Decapoda:							
Sergestidae: Unidentified	20-70	40	6	50	76	44	36
Sergestes gardineri	20-31	20	5	17	24	19	11
Sergestes sp	20-37	10	22	17	40	12	31
Lucifer sp	<20	------	------	17	2	6	2
Penaeidae:							
Gennadas scutatus	22-40	------	------	33	2	12	2
Gennadas sp	20-53	30	5	17	5	25	5
Funchalia taaningi	21-60	------	------	17	4	6	4
Hoplophoridae:							
Hoplophorus typus	40-50	10	1	17	1	12	1
H. gracilirostris	48-65	20	2	------	------	12	2
H. grimaldii	27	10	1	------	------	6	1
Acanthephyra trispinosa	60-83	10	1	17	10	12	6
A. curtirostris	75	10	1	------	------	6	1
Acanthephyra sp	62-78	------	------	17	6	6	6
Notostomus sp	23	10	1	------	------	6	1
Systellaspis debilis	50-70	10	2	------	------	6	2
Pandalidae:							
Parapandalus zur strasseni	30-55	20	2	67	12	38	9
Parapandalus sp	37-46	------	------	17	2	6	2
Scyllaridae: Phyllosoma	26	10	1	------	------	6	1
Unidentified Decapoda	10-40	10	12	67	152	31	124
Unidentified Crustacea	<20	60	(1)	------	------	38	(1)
Insecta:							
Hemiptera:							
Gerridae:							
Halobates sp	<20	------	------	17	1	6	1
MOLLUSCA:							
Gastropoda:							
Pteropoda:							
Cymbuliidae	20-32	------	------	33	22	12	22
Unidentified Pteropoda	<20	10	(1)	17	62	12	(1)
Heteropoda:							
Pterotracheidae	20-40	50	4	17	1	38	3
Cephalopoda:							
Decapoda (squids):							
Enoploteuthidae	32	------	------	17	1	6	1
Chiroteuthidae	245	10	1	------	------	6	1
Cranchiidae	7-35	10	2	50	1	25	1
Unidentified Decapoda	5-40	10	7	33	4	19	5
Unidentified Mollusca	<20	10	(1)	33	25	19	(1)
UNIDENTIFIABLE INVERTEBRATE MATERIAL	<20	80	(1)	67	75	75	(1)
CHORDATA—Tunicata:							
Thaliacea:							
Pyrosomida:							
Pyrosomatidae	3-76	10	18	100	26	44	25
Salpida:							
Salpidae	17-105	10	35	100	62	44	58
Unidentified Tunicata	<20	40	(1)	50	283	44	(1)

[1] Actual number not determined.

Appendix Table 5.—*Checklist of organisms captured in 16 hauls with the 6-foot beam trawl, by areas, 1951–52*—Continued

Organisms	Size range (mm.)	Hawaiian waters		Equatorial Pacific		Total	
		Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul
CHORDATA—Vertebrata:							
Pisces:							
Gonostomidae: Unidentified	----	10	7	----	----	6	7
Gonostoma sp.	60	10	1	----	----	6	1
Vinciguerria lucetia	20–38	10	1	84	246	38	205
Cyclothone canina	20–50	10	56	----	----	6	56
Diplophos taenia	43–51	30	2	33	2	31	2
Sternoptychidae: Unidentified	30–40	10	3	----	----	6	3
Sternoptyx diaphana	11–12	10	2	----	----	6	2
Stomiatidae: Unidentified	20	----	----	17	1	6	1
Thysanactis sp.	87	----	17	17	1	6	1
Eustomias sp.	58–85	10	1	17	1	12	1
Chauliodontidae:							
Chauliodus sp.	43	10	1	----	----	6	1
Astronesthidae:							
Astronesthes lucifer	54	10	1	----	----	6	1
Malacosteidae:							
Photostomias sp.	65	10	1	----	----	6	1
Idiacanthidae: Unidentified	24	10	1	----	----	6	1
Idiacanthus fasciola	63	10	1	----	----	6	1
Synodontidae	40	10	1	----	----	6	1
Evermannellidae:							
Evermannella atrata	33	----	----	17	1	6	1
Myctophidae: Unidentified	15–46	50	7	67	18	56	12
Hygophum reinhardti	20	----	----	17	1	6	1
Benthosema sp.	27–31	20	2	----	----	12	2
Diogenichthys atlanticus	21	10	1	----	----	6	1
Centrobranchus nigro-ocellatus	41	10	1	----	----	6	1
Myctophum brachygnathos	36–45	10	2	17	1	12	2
M. spinosum	84–100	10	1	17	4	12	2
M. evermanni	20–46	10	4	50	4	25	4
M. aurolaternatum	28–31	----	----	33	1	12	1
Notolychnus valdiviae	21–27	30	3	----	----	19	3
Diaphus sp.	20–48	40	3	67	6	50	4
Lampanyctus pyrsobolus	20–61	20	1	33	2	25	2
L. tenuiformis	52	----	----	17	1	6	1
Lampanyctus sp.	20–70	40	10	50	7	44	9
Ceratoscopelus townsendi	20–58	20	4	67	9	38	7
Nemichthyidae:							
Serrivomer beani	133–230	10	1	17	1	12	1
Exocoetidae:							
Exocoetus volitans	142	----	----	17	1	6	1
Bregmacerotidae:							
Bregmaceros macclellandi	16–20	----	----	33	1	2	1
Melamphaidae:							
Melamphaes sp.	60–70	----	----	17	2	6	2
Apogonidae	20	10	1	----	----	6	1
Acanthuridae	21	10	1	----	----	6	1
Thunnidae:							
Katsuwonus pelamis	18	----	----	17	1	6	1
Larval fish:							
Leptocephali: Unidentified	25–280	50	2	50	2	50	2
Heterosomata	17–28	40	2	----	----	25	2
Unidentified larvae	4–19	100	17	33	14	75	17
Unidentified Pisces	20–70	20	1	84	8	44	6

APPENDIX TABLE 6.—*Checklist of organisms captured in 23 hauls with the 1-meter ring trawl, by time of haul, central Pacific, 1953*

Organisms	Size range (mm.)	Percent occurrence	Average number per haul	Day hauls (11)		Night hauls (12)	
				Percent occurrence	Average number per haul	Percent occurrence	Average number per haul
COELENTERATA:							
Hydrozoa							
Siphonophora	5-18	87	19	100	22	75	16
Medusae: Unidentified	20-70	13	1	9	1	17	1
CHAETOGNATHA	15-40	91	7	91	7	83	6
ANNELIDA	6	4	1	----	----	8	1
ARTHROPODA:							
Crustacea:							
Copepoda	3-5	48	27	36	26	58	27
Mysidacea:							
Lophogastridae:							
Gnathophausia ingens	57	4	1	----	----	8	1
Amphipoda:							
Phronimidae:							
Phronima sp	22-25	9	1	18	1	----	----
Oxycephalidae:							
Oxycephalus sp	27-20	13	1	18	1	8	1
Rhabdosoma sp	30-35	9	1	18	1	----	----
Unidentified Amphipoda	5-18	30	4	45	4	17	6
Stomatopoda (larvae)	11-43	43	2	45	2	42	2
Euphausiacea:							
Euphausiidae: Unidentified	5-33	83	33	82	20	92	39
Nematoscelis sp	22	4	1	----	----	8	1
Stylocheiron sp	24	4	1	----	----	8	1
Decapoda:							
Sergestidae: Unidentified	24-39	26	3	----	----	50	3
Sergestes gardineri	33	4	1	----	----	8	1
Penaeidae: Unidentified	22	9	1	9	1	8	1
Gennadas sp	23-32	9	6	----	----	17	6
Hoplophoridae:							
Acanthephyra trispinosa	59	4	1	----	----	8	1
Pandalidae:							
Parapandalus zur strasseni	34-61	17	2	----	----	33	2
Palinuridae: Phyllosoma	16-30	9	1	9	1	8	1
Crab larvae: Unidentified	<20	13	3	----	----	25	3
Unidentified Decapoda	20-30	13	2	27	3	8	1
Unidentified Crustacea	<20	4	(1)	9	(1)	----	----
MOLLUSCA:							
Gastropoda:							
Pteropoda:							
Cavoliniidae:							
Cavolinia sp	<20	4	1	9	1	----	----
Cymbuliidae	20	4	1	9	1	----	----
Unidentified Pteropoda	5-20	9	5	9	8	8	2
Heteropoda:							
Pterotracheidae	25-50	17	2	18	1	17	2
Cephalopoda:							
Decapoda (squids):							
Cranchiidae: Unidentified	11-15	9	1	9	1	8	1
Liocranchia globulus	9	4	1	----	----	8	1
Unidentified Decapoda	10-14	26	1	36	1	17	2
Larval Cephalopoda	13-18	9	(1)	9	(1)	8	1
UNIDENTIFIABLE INVERTEBRATE MATERIAL	<20	52	(1)	55	(1)	58	(1)
CHORDATA—Tunicata:							
Thaliacea:							
Pyrosomida:							
Pyrosomatidae	15-97	30	2	9	1	50	2
Salpida:							
Salpidae	20-82	52	2	27	4	67	2
Unidentified Tunicata	12-61	35	4	36	4	42	5
CHORDATA—Vertebrata:							
Pisces:							
Gonostomidae: Unidentified	35	4	1	----	----	8	1
Vinciguerria lucetia	20-23	4	2	----	----	8	2
Stomiatidae: Unidentified	20	4	1	----	----	8	1
Echiostoma tanneri	50	4	1	----	----	8	1
Idiacanthidae	35	4	1	9	1	----	----
Paralepididae	32	4	1	----	----	8	1
Myctophidae: Unidentified	>20	9	2	----	----	17	2
Notolychnus valdiviae	22-24	9	2	----	----	17	2
Diaphus sp	20	4	1	----	----	8	1
Lampanyctus sp	22-45	13	3	----	----	25	3
Ceratoscopelus townsendi	22-32	4	3	----	----	8	3
Nemichthyidae:							
Nemichthys scolopaceus	595	4	1	----	----	8	1
Exocoetidae	20	4	1	9	1	----	----
Bregmacerotidae:							
Bregmaceros macclellandi	31	4	1	----	----	8	1
Aulostomidae:							
Aulostomus valentini	113	4	1	9	1	----	----
Bramidae:							
Collybus drachme	72	4	1	----	----	8	1
Thunnidae:							
Katsuwonus pelamis (juvenile)	18	4	1	----	----	8	1
Nomeidae	42	4	1	9	1	----	----
Larval fish:							
Leptocephali: Unidentified	20-80	13	1	9	1	17	2
Unidentified larvae	4-19	87	6	91	4	83	7
Unidentified Pisces	20-40	22	2	9	2	33	2

1 Actual number not determined.

APPENDIX TABLE 7.—*Checklist of organisms captured in 78 hauls with the 6-foot Isaacs-Kidd trawl, by zones, 1953–55*

[For explanation of abbreviations of faunal zones, see p. 286]

Organisms	Size range (mm.)	SEC		ECC		NEC		Hawaii		NPC		AC		All zones	
		Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul
COELENTERATA:															
Hydrozoa:															
Siphonophora	5–65	100	77	100	46	100	37	74	35	100	149	80	257	92	102
Scyphozoa:															
Coronatae:															
Periphyllidae:															
Periphylla sp	26			8	1									1	1
Medusae: Unidentified	20–80	11	7	50	2	66	1	5	1	50	2	5	1	26	2
Unidentified Coelenterata	29	6	1	8	2					5	2			4	2
CTENOPHORA	5–39	6	3	17	2			16	5	5	1			8	4
CHAETOGNATHA	6–50	100	94	83	78	100	17	95	38	88	64	50	41	87	62
Sagitta sp				8	[1]									1	[1]
ANNELIDA	20–160							5	1	25	10	30	1	10	6
ARTHROPODA:															
Crustacea:															
Copepoda		6	[1]									20	500	4	[1]
Cirripedia:															
Lepadidae:															
Lepas fasicularis (larvae)	<20									6	68,640			1	68,640
Lepas sp. (larvae)	<20											40	8,025	5	2,006
Mysidacea:															
Lophogastridae: Unidentified	22	6	1					5	1					2	1
Lophogaster intermedius	20	6	1											1	1
Unidentified Mysidacea	<20	6	[1]											1	[1]
Amphipoda:															
Hyperiidae	76			8	1									1	1
Phronimidae:															
Phronima sp	20–35	50	3	75	2			10	1	25	1	70	2	40	2
Oxycephalidae: Unidentified	22–60									19	2			4	2
Oxycephalus sp	21–60	67	3	33	2	33	1			19	2	30	2	29	2
Rhabdosoma sp	25–70	89	5	75	5			37	5	25	4	10	6	47	5
Unidentified Amphipoda	3–21	50	23	66	53	33	12	10	11			10	[1]	27	[1]
Stomatopoda (larvae)	10–48	11	1	17	1			47	8	19	2			20	5
Euphausiacea:															
Euphausiidae: Unidentified	5–35	100	355	83	240	100	74	47	114	69	1,225	80	2,375	76	681
Euphausia gibboides	20–25									19	16	20	5	9	10
Euphausia sp	21–25											10	3	1	3
Thysanopoda monacantha	23–33							16	1	25	4			9	3
T. tricuspidata	20–26			8	82			5	1	12	1			6	17
Thysanopoda sp	<20–30									12	4			2	4
Nematoscelis difficilis	20–23											10	1	1	1
Nematoscelis sp				8	1									1	1
Nematobranchion flexipes	21–26									6	2	30	2	5	2
Stylocheiron maximum	21–28			8	4									1	4
Stylocheiron sp	21–22			17	1									2	1
Decapoda:															
Sergestidae: Unidentified	12–55	28	20	33	53	66	5	26	14	50	5	70	22	40	18
Sergestes orientalis	23–35	11	11											2	11
S. gardineri	21–34	33	3	8	1									9	3
Sergestes sp	20–65	67	20	33	31	33	5	37	33					30	25
Penaeidae: Unidentified	22–27									6	2			1	2
Gennadas scutatus	20–39	50	9	42	17	66	2	16	1	12	1			27	8
Gennadas sp	20–27	6	1	8	8									2	4
Funchalia taaningi	20–75	55	8	17	1			5	1	25	2			22	5
Benthesicymus sp	21							5	1	5	1			1	1
Hoplophoridae															
Hoplophorus typus	20–64	61	6	33	1					6	1			20	4
H. gracilirostris	20–53	11	3					10	1	6	1			6	2
H. grimaldii	22–63							5	1	44	1	50	5	17	2
H. foliaceus	21–45	50	10	8	3			10	1					15	8
Hoplophorus sp	20–31	17	10									20	2	6	7
Acanthephyra trispinosa	48–70			17	6			10	1					5	4
A. quadrispinosa	64											10	1	1	1
Acanthephyra sp	39–55											20	2	2	2
Pandalidae:															
Parapandalus zur strasseni	21–59	78	4	42	5			5	1					26	4
Heterocarpus ensifer	135							5	1					1	1
Scyllaridae: Phyllosoma	21–31									6	1			1	1
Palinuridae: Phyllosoma	20–40			8	1			26	1	19	1			12	1
Portunidae: Megalopa	<20	8	1											1	1
Unidentified Decapoda	7–19	61	23	50	18	33	8	16	17	6	[1]			28	[1]
Unidentified Crustacea	3–20			25	33	66	20	74	155	56	912	80	975	46	475
MOLLUSCA:															
Gastropoda:															
Pteropoda:															
Cymbuliidae: Unidentified	20–32	72	3	8	2			10	5					20	3
Corolla sp	20–80									38	1	70	6	17	4
Unidentified Pteropoda	5–45	11	3	17	2			21	40	25	50	60	125	23	62
Heteropoda:															
Pterotracheidae	20–50	89	4	25	10	33	1	32	3					33	4
Carinariidae:															
Carinaria sp	24–45											10	2	1	2
Unidentified Heteropoda	35									6	1			1	1

[1] Actual number not determined.

APPENDIX TABLE 7.—*Checklist of organisms captured in 78 hauls with the 6-foot Isaacs-Kidd trawl, by zones, 1953–55*—Continued

Organisms	Size range (mm.)	SEC		ECC		NEC		Hawaii		NPC		AC		All zones	
		Per-cent occur-rence	Aver-age num-ber per haul	Per-cent occur-rence	Aver-age num-ber per haul	Per-cent occur-rence	Aver-age num-ber per haul	Per-cent occur-rence	Aver-age num-ber per haul	Per-cent occur-rence	Average number per haul	Per-cent occur-rence	Aver-age num-ber per haul	Per-cent occur-rence	Aver-age num-ber per haul
MOLLUSCA—Continued															
Cephalopoda:															
Decapoda (squids):															
Enoploteuthidae: Unidentified	21–81	22	1							12	1	20	2	10	1
Pterygioteuthis sp.	20–28	17	1					10	1					6	1
Abraliopsis sp.	22–125			8	11			10	1	6	1	10	2	6	3
Abralia sp.	45	6	1											1	1
Onychoteuthidae:															
Onychoteuthis banksii	30			8	1									1	1
Histioteuthidae	25											10	1	1	1
Chiroteuthidae:															
Mastigoteuthis sp.	20–25							5	1	6	1			3	1
Cranchiidae: Unidentified	25–32	11	1	17	2									5	2
Liocranchia globulus	77	6	1											1	1
Liocranchia sp.	<20–55	6	1	8	2									3	2
Helicocranchia sp.	20–41	11	4	8	1					6	1			5	3
Megalocranchia sp.	70							5	1					1	1
Unidentified Decapoda	20–100			17	1	33	1	5	2	44	1	30	3	18	2
Octopoda: Unidentified	<20									6	11			1	11
Bolitaenidae:															
Eledonella sp.	30–60			8	2									1	2
Argonautidae:															
Argonauta bottgeri	33			8	1									1	1
Unidentified Mollusca	3–20	67	15	33	14	66	8	42	10	31	31	10	50	41	17
CHORDATA—Tunicata:															
Thaliacea:															
Pyrosomida:															
Pyrosomatidae	4–370	100	29	75	24	100	13	58	3	75	7	40	3	73	16
Salpida:															
Salpidae: Undentified	20–190	94	10	83	18	100	3	74	22	94	158	90	193	87	70
Iasis zonaria	20–45									12	20	30	6	6	12
Doliolidae	12–50	11	13											2	13
Unidentified Tunicata	3–21	67	29	58	24	66	9	42	14	19	38			41	23
UNIDENTIFIABLE INVERTEBRATE MATERIAL	3–40	55	(1)	42	x	33	15	32	90	25	100	30	250	37	(1)
CHORDATA—Vertebrata:															
Pisces:															
Squalidae:															
Isistius brasiliensis	165–215	11	1			33	1							4	1
Alepocephalidae	21									6	1			1	1
Argentinidae: Unidentified	20									6	1			1	1
Nansenia sp.	24									6	1			1	1
Bathylagidae: Unidentified	60											10	1	1	1
Bathylagus ochotensis	42–95											30	2	4	2
Gonostomidae: Unidentified	22–106	6	1	8	1					12	3	10	1	6	2
Gonostoma elongatum	21–77	22	1	25	2	66	2	16	1					15	1
Vinciguerria lucetia	20–47	94	13	58	8	100	2	10	3	12	3			40	10
V. poweriae	20–33									25	3			5	3
V. nimbaria	20–36							21	2	19	11			9	6
Vinciguerria sp.	21–33							5	1	12	2			4	2
Diplophos taenia	34–48	6	1	17	3			5	1					5	2
Sternoptychidae:															
Argyropelecus sladeni	25–49			17	6									2	6
Stomiatidae: Unidentified	20–131	33	1	25	2	33	1	10	1	38	1	30	2	27	1
Thysanactis dentex	52–112	17	2	17	1	66	1	16	1					13	1
Thysanactis sp.	164–167	11	1	8	2	33	2							5	2
Leptostomias sp.	71	6	1											1	1
Bathophilus sp.	74–79	11	1											2	1
Eustomias sp.	60–157	17	1	25	3	33	1	5	1	6	1			12	2
Melanostomias sp.	95											10	1	1	1
Echiostoma tanneri	106–267	22	1											5	1
Photonectes sp.	75–175			8	1			5	1					2	1
Haplostomias tentaculatus	69							5	1					1	1
Chauliodontidae:															
Chauliodus sloanei	135			8	1									1	1
Chauliodus sp.	25–103	17	2					5	1	19	2			9	2
Astronesthidae: Unidentified	91–105									6	1			1	1
Astronesthes lucifer	31	6	1											1	1
A. richardsoni	75									6	1			1	1
Astronesthes sp.	26–55	22	1											5	1
Malacosteidae:															
Photostomias sp.	33–108	33	2	17	2			5	1					12	2
Aristostomias sp.	80–110	6	1	25	1	33	1							6	1
Idiacanthidae:															
Idiacanthus fasciola	192–333							10	1					9	1
I. panamensis	222–283			8	2	33	1							2	2
Idiacanthus sp.	26–360			17	2			5	1	25	5	10	3	4	4
Scopelarchidae: Unidentified	20–33									19	2	10	1	5	2
Scopelarchus sp.	20–39							5	2					1	2
Evermannellidae:															
Evermannella atrata	22–57			25	1									4	1
Evermannella sp.	67			8	1									1	1
Paralepididae	20–109	72	4	25	5			16	2	38	4	40	1	36	3
Alepisauridae	56							5	1	5	1			1	1

[1] Actual number not determined.

APPENDIX TABLE 7.—*Checklist of organisms captured in 78 hauls with the 6-foot Isaacs-Kidd trawl, by zones, 1953–55*—Continued

Organisms	Size range (mm.)	SEC		ECC		NEC		Hawaii		NPC		AC		All zones	
		Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul
CHORDATA—Vertebrata—Continued															
Pisces—Continued															
Myctophidae: Unidentified	20–105	61	6	25	5			53	4	88	12	90	10	60	8
Hygophum reinhardti	22–45	61	1	17	2	33	1	5	1					19	1
H. macrochir	25–34	6	1			33	1	5	1					4	1
Hygophum sp	46–47			8	3									1	3
Diogenichthys atlanticus	21–23	17	2											4	2
Myctophum asperum	36–68	6	1	8	1									2	1
M. affine	20	6	1	8	1									2	1
M. evermanni	20–56	44	7	33	2			5	1					17	5
M. rufinum	26			8	1									1	1
M. lychnobium	21	6	1											1	1
Myctophum sp	20–33	11	1											2	1
Lampadena nitida	21			8	1									1	1
Lampadena sp	39–45									6	1			1	1
Notolychnus valdiviae	20–24	22	18	8	9			10	1					9	12
Diaphus nipponensis	25									6	1			1	1
D. ostenfeldi	50			8	1									1	1
D. rafinesquei	47			8	1									1	1
Diaphus sp	20–85	100	9	75	5	33	1	21	2					41	7
Lampanyctus pyrsobolus	20–47	61	3	8	2			10	3					18	3
L. omostigma	51–56			17	2									2	2
Lampanyctus sp	20–122	78	4	75	6	100	5	26	3					40	4
Ceratoscopelus townsendi	20–62	44	2	58	2	66	4	10	1					24	2
Nemichthyidae: Unidentified	250–560			8	1							10	1	2	1
Nemichthys scolopaceus	292–680	17	1	8	1			5	1	19	2			10	1
Serrivomer beani	144–281			8	2									1	2
Hemirhamphidae	28			8	1									1	1
Bregmacerotidae: Unidentified	18–51							5	2					1	2
Bregmaceros macclellandi	22–77	50	2	33	2			5	1					18	2
Bregmaceros sp	20									6	1			1	1
Syngnathidae:															
Hippocampus sp	22							5	1					1	1
Trachypteridae:															
Trachypterus sp	25–118	6	1	17	2									4	2
Melamphaidae: Unidentified	9–26			8	1					6	1			2	1
Melamphaes sp	24–77			25	4									4	4
Serranidae	30	6	1											1	1
Priacanthidae:															
Priacanthus hamrur	20–24							5	2					1	2
Apogonidae:															
Howella sp	27–66	6	1	8	1									2	1
Bramidae:															
Collybus drachme	26–62	11	1											2	1
Coryphaenidae	37									6	1			1	1
Chaetodontidae	27							5	1					1	1
Brotulidae	37							5	1					1	1
Acanthuridae:															
Acanthurus sp	28	6	1											1	1
Gempylidae	20–46	11	1	17	2	33	4	5	1					8	2
Scombridae: Unidentified	<20	1	1											1	1
Dicrotus sp	22									6	1			1	1
Tetragonuridae:															
Tetragonurus sp	34			8	1									1	1
Larval fish:															
Leptocephali: Unidentified	40–350	11	1	66	2			42	2	19	3	40	1	32	2
Unidentified larvae	4–61	100	178	75	27	33	2	84	30	88	148	40	88	79	102
Unidentified Pisces	10–86	28	2	50	2	66	45	21	14	38	21	10	3	30	13

APPENDIX TABLE 8.—*Checklist of organisms captured in 157 hauls with the 10-foot Isaacs-Kidd trawl, by zones, 1955–56*

[For explanation of faunal zones, see p. 286]

Organisms	Size range (mm.)	SEC		ECC		NEC		Hawaii		NPC		AC		All zones	
		Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul
COELENTERATA:															
Hydrozoa:															
Siphonophora	5–450	78	71	77	57	78	31	67	41	100	88	63	61	76	62
Scyphozoa:															
Coronatae:															
Periphyllidae:															
Periphylla sp	20–65	6	1	22	2	7	1							6	1
Medusae: Unidentified	3–100	26	2	44	3	57	1	25	7	46	5	74	109	38	27
Unidentified Coelenterata	5–100	25	76	39	38	21	50			8	200	16	98	20	70
CTENOPHORA	<20–70	3	10	11	10	7	2	4	6	23	3	58	7	13	7
CHAETOGNATHA	3–61	68	15	50	22	78	4	75	10	100	7	95	257	74	51
ANNELIDA	4–148	3	1			7	1			15	3	21	10	6	5
ARTHROPODA:															
Crustacea:															
Ostracoda	20									15	21	21	24	4	23
Copepoda	3–12	1	500					1	150	31	52	63	720	11	528
Mysidacea:															
Lophogastridae:															
Lophogaster sp	20							8	2					1	2
Gnathophausia calcarata	30–68	4	1			7	1							2	1
G. longispina	50							4	1					1	1
Unidentified Mysidacea	15–16	1	1					8	10					2	6
Isopoda	<20	1	1											1	1
Amphipoda:															
Gammaridae	26–31	1	3											1	3
Cystisomatidae:															
Cystisoma sp	28–90	9	1	11	2							5	1	6	1
Phronimidae: Unidentified	34									8	1			1	1
Phronima sp	20–39	45	2	39	2	71	2	17	1	23	2	32	1	39	2
Phrosinidae:															
Phrosina sp	20	3	1											1	1
Oxycephalidae: Unidentified	20–40	1	3					8	1					2	2
Oxycephalus sp	20–82	45	4	33	2	21	1	12	1	31	1	16	3	32	3
Rhabdosoma sp	28–95	51	4	39	6	7	1	25	4	15	2	5	1	33	4
Unidentified Amphipoda	3–70	38	24	11	11	21	9	29	13	38	23	58	43	34	25
Stomatopoda (larvae):															
Squillidae: Unidentified	20–50	10	2	6	1			38	2	8	2			11	2
Squilla sp	20–42	1	1					17	2					3	2
Pseudosquilla sp	20–40	1	2					25	1					4	1
Lysiosquilla sp	25–35	4	1					8	1					3	1
Odontodactylus hanseni	29							4	1					1	1
Euphausiacea:															
Euphausiidae: Unidentified	5–33	64	275	39	128	57	163	71	116	77	97	95	522	66	258
Euphausia pacifica	7–23											63	629	8	629
E. eximia	20–23	9	320	6	1	21	1							6	192
E. lamelligera	20									8	1	5	1	2	1
E. gibboides	20–30	12	8							15	4	10	4	8	7
Euphausia sp	20–31	4	1									5	2	2	1
Thysanopoda monacantha	20–40	45	9	89	16	43	15	46	2	62	3	5	1	46	9
T. cristata	23–40	3	1	6	2			12	4	8	2			4	2
T. tricuspidata	20–33	68	91	39	15	14	1	12	1	8	1			38	73
T. aequalis	20–22							25	2					4	2
T. obtusifrons	20–24	1	2			28	2	25	6	46	4	5	8	11	4
T. pectinata	20–38	16	2	44	2	14	5	12	2					15	2
T. orientalis	21–37	6	2	11	2	14	2	8	2					6	2
T. acutifrons	23–40	3	1	6	3			4	1			37	6	7	4
Thysanopoda sp	20–36	7	51			7	31	4	1	15	3	5	7	6	30
Tessarabrachion oculatus	20–32											37	7	4	7
Thysanoessa spinifera	21–26											16	8	2	8
T. longipes	20–26											26	25	3	25
Nematoscelis difficilis	20–23									8	1	10	24	2	16
N. atlantica	20							4	1					1	1
N. tenella	20–21			6	2									1	2
Nematoscelis sp	20–24	6	2					17	1					5	2
Nematobrachion flexipes	20–27	9	1	6	2	36	3	20	1	15	2			12	2
N. sexspinosus	24–29					7	4	4	2					1	3
Nematobrachion sp	20–24									8	3	5	30	1	16
Stylocheiron abbreviatum	20–37	6	1	50	2	7	1	4	2			47	9	15	4
S. maximum	20–25											5	6	1	6
Stylocheiron sp	21–40									8	6	10	8	2	7
Decapoda:															
Sergestidae:															
Sergestes prehensilis	60									8	1			1	1
Sergestes sp	20–100	94	45	94	31	93	20	96	19	92	4	95	42	94	34
Penaeidae: Unidentified	<20–33	3	20	11	70	7	35	8	1					4	31
Penaeus sp	20							4	4					1	4
Gennadas scutatus	20-32	38	4	78	11	50	12							30	7
G. propinquus	20–45	29	3	44	3	28	2	12	4	31	3	16	3	27	3
G. tinayrei	20–30	7	1	28	1	14	2	12	2					10	1
G. incertus	20–45	22	4	33	3	21	2	12	1	46	3	26	3	24	3
G. bouvieri	20–32	7	2			28	3							6	2
G. parvus	20			6	1									1	1
Gennadus sp	<20–45	42	6	56	14	57	9	54	4	8	1	5	1	39	7
Bentheogennema pasithea	32–42	3	1			21	1							3	1
Funchalia balboae	105							4	1					1	1
F. taaningi	20–80	33	3	17	3	7	1	4	1					18	3
Funchalia sp	25-85	12	8	11	2			4	1	15	1			8	5

APPENDIX TABLE 8.—*Checklist of organisms captured in 157 hauls with the 10-foot Isaacs-Kidd trawl, by zones, 1955–56*—Continued

Organisms	Size range (mm.)	SEC		ECC		NEC		Hawaii		NPC		AC		All zones	
		Per-cent occur-rence	Aver-age num-ber per haul	Per-cent occur-rence	Aver-age num-ber per haul	Per-cent occur-rence	Aver-age num-ber per haul	Per-cent occur-rence	Aver-age num-ber per haul	Per-cent occur-rence	Average number per haul	Per-cent occur-rence	Aver-age num-ber per haul	Per-cent occur-rence	Aver-age num-ber per haul
ARTHROPODA—Continued															
Crustacea—Continued															
Decapoda—Continued															
Pasiphaeidae:															
Pasiphaea flagellata	80					7	7							1	7
Pasiphaea sp	20-63	1	1			21	1							2	1
Hoplophoridae: Unidentified	<20-68	7	32					17	1					6	18
Hoplophorus typus	33-76	32	3	17	3									16	3
H. longirostris	50-63	4	1			7	2	4	1					3	1
H. gracilirostris	20-78	9	4			7	2	42	8					11	6
H. grimaldii	22-80	1	2					25	3	85	3	10	10	13	4
H. foliaceus	20-60	45	8	11	2	7	1	21	2	8	3			25	7
Hoplophorus sp	20-70	4	1			14	1	8	2					4	1
Acanthephyra trispinosa	20-103	33	3	72	6	43	3							27	4
A. sanguinea	70-80	1	3											1	3
A. stylorostrata	50	1	1											1	1
A. quadrispinosa	55-90	1	1							15	2	16	3	4	2
A. gracilipes	28							4	1					1	1
Acanthephyra sp	22-62	1	1	6	2	7	4	4	1	8	12	5	(1)	4	(1)
Notostomus sp	54-95											5	3	1	3
Systellaspis debilis	45-82					14	2	38	2					7	2
Systellaspis sp	60-73					7	5							1	5
Hymenodora sp	50											5	1	1	1
Thalassocaridae:															
Thalassocaris sp	20	6	3											2	3
Pandalidae: Unidentified	22-55	7	1	11	2	14	2							6	1
Parapandalus zur strasseni	27-60	40	6	39	8	7	2	25	1	15	2			28	5
P. cottei	47	1	1											1	1
Parapandalus sp	37-55							8	2	15	2	5	2	3	2
Plesionika sp	45-67	1	1	6	6									1	4
Heterocarpus sp	40							4	1					1	1
Portunidae	20							4	1					1	1
Phyllosoma	11-40	16	2	6	1			12	2	8	1			10	2
Unidentified Decapoda	19-72	7	16			7	3	12	4	38	25	32	31	13	20
Unidentified Crustacea	2-90	61	288	89	136	86	208	75	136	54	596	32	118	64	238
MOLLUSCA:															
Gastropoda:															
Pteropoda:															
Cymbuliidae	20-60			6	1			4	1	31	2	21	11	6	5
Unidentified Pteropoda	5-60	32	28	6	2			21	6	54	24	47	33	28	26
Heteropoda:															
Carinariidae:															
Carinaria sp	29-36					7	1			8	1			1	1
Atlantidae	<20	1	1											1	1
Unidentified Heteropoda	20-177	22	2	11	1	14	1	12	3	8	1	16	40	16	6
Cephalopoda:															
Decapoda (squids):															
Enoploteuthidae: Unidentified	20-285	17	1	6	2							5	1	9	1
Enoploteuthis sp	20-260	1	1	6	2			4	1			5	1	2	1
Abralia trigonura	59-100	3	2	6	1									2	2
A. astrosticta	33-50	3	2											1	2
Abralia sp	20-60	10	2											4	2
Abraliopsis morisii	40-70					7	2							1	2
Abraliopsis sp	20-100	12	2	28	7	7	2	4	1	8	1	21	2	13	3
Pterygioteuthis giardi	20-50	12	2			7	1							6	2
P. microlampas	30							4	1					1	1
Pterygioteuthis sp	20-35	4	1	11	2									3	1
Pyroteuthis margaritifera	50-100									15	1	5	2	2	1
Onychoteuthidae: Unidentified	35	1	1											1	1
Onychoteuthis banksii	310	1	1											1	1
Veranyidae:															
Octopodoteuthis sp		1	1											1	1
Histioteuthidae: Unidentified	25-110	7	1	6	1			12	1					6	1
Histioteuthis sp	35-132					7	1					5	1	1	1
Calliteuthis meleagroteuthis	115-150									15	1			1	1
Bathyteuthidae:															
Benthoteuthis sp	30-60	1	2	6	1									1	2
Ctenopteryx sp	20	1	1											1	1
Brachioteuthidae:															
Brachioteuthis sp	35									8	1			1	1
Ommastrephidae: Unidentified	230	1	1											1	1
Symplectoteuthis oualaniensis	47	1	1											1	1
Chiroteuthidae: Unidentified	60-100					7	1	4	1					1	1
Chiroteuthis imperator	20-510											16	2	2	2
Chiroteuthis sp	50	1	1											1	1
Mastigoteuthis sp	30							4	1					1	1
Doratopsis sp	20					7	1							1	1
Cranchiidae: Unidentified	20-180	10	1	6	1			8	1	15	1	10	2	9	1
Cranchia scabra	20-205	7	1	6	1									4	1
Liocranchia globulus	20-135	10	1	6	1									5	1
L. valdiviae	20-25	2	2	6	3									2	2
Liocranchia sp	20-210	7	1	6	2			4	1					4	1
Helicocranchia sp	34-35	1	1							8	1			1	1
Desmoteuthis sp	30-45	3	2											1	2
Corynomma sp	32			6	1									1	1
Euzygaena pacifica	40					7	1							1	1
Euzygaena sp	20-31			6	1	7	1							1	1

[1] Actual number not determined.

APPENDIX TABLE 8.—*Checklist of organisms captured in 157 hauls with the 10-foot Isaacs-Kidd trawl, by zones, 1955–56*—Continued

Organisms	Size range (mm.)	SEC		ECC		NEC		Hawaii		NPC		AC		All zones	
		Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul
MOLLUSCA—Continued															
Cephalopoda—Continued															
Decapoda—Continued															
Unidentified Decapoda	19–205	22	3	28	1	21	1	4	1			10	3	16	2
Octopoda: Unidentified	7–30	3	1	6	1					8	1	10	2	4	1
Unidentified Cephalopoda	3–85	1	2					12	10			26	3	6	5
Unidentified Mollusca	<20	10	28	17	12	7	5	21	19			5	3	11	20
CHORDATA—Tunicata:															
Thaliacea:															
Pyrosomida:															
Pyrosomatidae	20–310	65	26	72	5	71	12	83	6	92	6	21	4	66	15
Salpida:															
Salpidae: Unidentified	5–180	56	34	56	7	71	5	50	16	92	64	58	54	60	35
Salpa sp	20–110	1	6	17	6									2	6
Ritteriella sp	60					7	1							1	1
Metcalfina hexagona	20–150	3	1	22	7	28	4							6	5
Thetys vagina	35–220	1	3	33	5	21	6			8	1			7	5
Iasis zonaria	<20–66	17	9	33	9	36	3	4	1	8	14	5	2	16	7
Unidentified Tunicata	16–55	35	41	44	30	50	18	8	50			5	5	27	34
CHORDATA—Vertebrata:															
Pisces:															
Squalidae: Unidentified	380	1	1											1	1
Isistius brasiliensis	202–360	4	1											2	1
Alepocephalidae	34			6	1									1	1
Dolichopterygidae:															
Bathylychnops exilis	115											5	1	1	1
Argentinidae	23–59			6	1							5	4	1	2
Bathylagidae:															
Bathylagus nigrigenys	20–85	1	2	11	2	36	4							5	3
B. bericoides	107–122	2	1											1	1
B. longirostris	112–146							8	2	8	1			2	2
B. ochotensis	25–107											16	6	2	6
Bathylagus sp	50–153	1	2	6	3	7	1			8	1	16	14	4	7
Gonostomidae: Unidentified	20–130	13	14	11	1			8	2	15	1			10	9
Gonostoma elongatum	35–195	25	4	6	1			33	3	31	2			19	3
G. denudatum	48					7	1							1	1
Gonostoma sp	38–197	12	8	6	2	21	2					47	12	13	8
Cyclothone sp	38	1	1											1	1
Margrethia sp	110–115	1	2											1	2
Vinciguerria lucetia	20–54	3	8	56	5	43	25			8	1			12	11
V. poweriae	21							4	1					1	1
V. nimbaria	21–40	1	1					54	2	54	2	10	4	15	2
Vinciguerria sp	20–62	54	8	28	13	14	2	33	4	15	4			34	8
Diplophos taenia	38–166	9	1	17	1			12	1					8	1
Ichthyococcus ovatus	42–75	1	1									10	1	2	1
Sternoptychidae: Unidentified	41			6	1									1	1
Sternoptyx diaphana	20–53	1	1	6	3					8	1	5	1	2	2
Argyropelecus aculeatus	31–72	12	2	50	5	43	6	8	2	38	2	5	2	20	4
A. sladeni	37–57	1	1	6	2					8	1	47	5	8	4
A. affinis	35–50					14	2							1	2
Argyropelecus sp	20–45	7	2	17	8									5	4
Polyipnus sp	37–55					7	1					5	1	1	1
Stomiatidae: Unidentified	22–195	43	4	33	2	14	1	33	2	46	2			33	3
Stomias nebulosus	63–106	1	8											1	8
Stomias sp	22–195	20	4											9	4
Opostomias micripnus	165–215									8	2			1	2
Opostomias sp	107–185									15	2			1	2
Thysanactis dentex	40–160	17	2	6	1	7	1	4	2					10	2
Thysanactis sp	50–190	1	5											1	5
Leptostomias sp	95–225	6	1											2	1
Bathophilus filifer	75–105	7	2	11	2	28	2							7	2
B. pawneei	63	1	1	6	1									1	1
B. metallicus	115	1	1											1	1
Bathophilus sp	20–90	1	1	6	7	7	1			8	1			2	2
Eustomias brevifilis	65	1	1											1	1
E. enbarbatus	72–76	1	2											1	2
E. patulus	185	1	1											1	1
E. longibarba	75	1	1											1	1
E. schmidti	175			6	1									1	1
Eustomias sp	50–205	38	2	11	1	21	1	21	1					23	2
Melanostomias albibarba	220	1	1											1	1
Melanostomias sp	55–135	4	1											2	1
Echiostoma tanneri	33–280	7	3											3	3
Echiostoma sp	100							4	1					1	1
Photonectes sp	125–175			6	1	7	1	4	1			32	5	6	4
Chauliodontidae:															
Chauliodus barbatus	25–122	1	20											1	20
Chauliodus sp	22–210	40	3	22	2			21	1	23	1	26	2	29	2
Astronesthidae: Unidentified	20–209	9	1	6	1			17	1	15	1	5	1	9	1
Astronesthes richardsoni	76									8	1			1	1
A. cyaneus	90–120	7	1	6	1									4	1
A. indicus	23–165	6	2	6	1									3	2
A. filifer	96	1	1											1	1
A. caulophorus	110			6	1									1	1
Astronesthes sp	25–131	13	1					8	1					7	1
Heterophotus ophistoma	160–190	3	1											1	1

APPENDIX TABLE 8.—*Checklist of organisms captured in 157 hauls with the 10-foot Isaacs-Kidd trawl, by zones, 1955–56*—Continued

Organisms	Size range (mm.)	SEC		ECC		NEC		Hawaii		NPC		AC		All zones	
		Percent occurrence	Average number per haul	Per cent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul
CHORDATA—Vertebrata—Continued															
Pisces—Continued															
Malacosteidae: Unidentified	38-95	6	2	6	2									3	2
Photostomias sp	50-102	13	2					8	1					7	2
Aristostomias scintillans	137	1	1											1	1
Aristostomias sp	50-170	2	1					12	2					3	2
Idiacanthidae:															
Idiacanthus fasciola	75-345	1	3			7	2					16	1	4	2
I. panamensis	220-365					21	2							2	2
Idiacanthus sp	22-330	20	2	17	1	36	2	50	1	8	1	5	1	23	2
Synodontidae	35							4	1					1	1
Aulopidae	72							4	1					1	1
Scopelarchidae: Unidentified	20-95	10	2			21	1	8	1	15	1	5	1	10	1
Scopelarchus analis	24-85	3	2			7	1	8	2			5	5	4	2
Scopelarchoides nicholsi	55			6	1									1	1
Evermannellidae: Unidentified	21-38	13	2	6	1									6	2
Evermannella atrata	36-110	7	1	6	1	14	1							5	1
E. indica	50-63	1	2	11	2									2	2
E. normalops	93	1	1											1	1
E. balbo	26-56	1	3											1	3
Evermannella sp	32	1	1											1	1
Paralepididae: Unidentified	20-147	39	2	28	2	29	1			15	2	32	2	30	2
Lestidium japonicum	230	1	1											1	1
Lestidium sp	260	1	1											1	1
Myctophidae: Unidentified	20-168	81	21	50	16	50	8	67	12	54	14	32	4	64	17
Electrona crockeri	35											5	1	1	1
E. rissoi	20-46											26	2	3	2
Electrona sp	25-44											26	2	3	2
Hygophum reinhardti	35	1	1											1	1
H. hanseni	20-58	3	2							8	1			2	2
H. benoiti	20-40							4	6					1	6
Hygophum sp	21-60	22	3	6	1	14	2	17	1	8	(1)	10	1	16	(1)
Benthosema suborbitale	23-35	1	2					21	5	15	4	5	3	6	4
B. fibulata	20	1	1											1	1
Benthosema sp	22-23	3	2											1	2
Diogenichthys laternatus	22-30	4	2	17	9									4	6
D. atlanticus	21-24	3	1					4	1	23	1			4	1
D. panurgus	21-27					7	3							1	3
Diogenichthys sp	22-29					14	2							1	2
Gonichthys cocco	31	1	1											1	1
G. tenuiculum	43			6	1									1	1
Centrobranchus nigro-ocellatus	33-43	1	1					4	4					1	2
Tarletonbeania sp	38-64											10	4	1	4
Myctophum asperum	36-66	4	1											2	1
M. brachygnathos	29-72							8	2					1	2
M. aurolaternatum	35	1	1											1	1
M. spinosum	92	1	1											1	1
M. affine	21-55	3	1			7	1	4	1	8	1			3	1
M. evermanni	21-70	19	3	11	2			17	2					12	3
M. rufinum	63					7	1							1	1
M. californiense	30											5	1	1	1
Myctophum sp	20-80	7	4	11	1			17	2			5	2	8	3
Ctenoscopelus phengodes	112	1	1											1	1
Lampadena nitida	72							4	1					1	1
Lampadena sp	22-83	7	1					12	1					5	1
Notolychnus valdiviae	20-29	8	14					8	4	15	1			6	9
Diaphus theta	65							4	1					1	1
D. nipponensis	29-55							4	1					1	1
Diaphus sp	20-105	48	12	22	8	36	5	42	6	54	15	58	5	44	10
Lampanyctus pyrsobolus	20-55	33	2	11	2			29	2					20	2
L. macropterus	23-103	22	6	6	5	7	3	4	4					11	6
L. festivus	32-75	1	6							8	2			1	4
L. microchir	24-35	1	5											1	5
L. omostigma	25-105	3	2	6	3									2	2
L. steinbecki	20-60	3	6					4	1	8	1			2	4
L. leucopsarus	20-113											37	12	4	12
L. nannochir	48											5	1	1	1
L. ritteri	45-110					7	6					5	6	1	6
L. regalis	44-80											10	4	1	4
L. tenuiformis	39	1	1											1	1
Lampanyctus sp	20-135	32	5	28	7	64	2	33	6	31	3	63	4	38	4
Ceratoscopelus townsendi	22-100	46	7	11	1			38	3	31	2	10	3	31	5
C. maderensis	20-28					7	4							1	4
Notoscopelus sp	57-67									8	1	5	1	1	1
Cetomimidae	85-100					7	1	4	1					1	1
Giganturidae:															
Gigantura indica	80					7	1							1	1
Nemichthyidae: Unidentified	35			6	1									1	1
Nemichthys scolopaceus	110-1,200	29	2	22	1	28	1	4	1	8	1	5	1	20	2
Avocettina infans	170-390	1	1	17	2	28	6					5	1	6	4
Serrivomer beani	40-320	1	1	39	2	28	1							8	2
Belonidae	35-65	1	2											1	2
Scomberesocidae	86			6	1									1	1
Hemirhamphidae	24-34	3	1											1	1

[1]Actual number not determined.

APPENDIX TABLE 8.—*Checklist of organisms captured in 157 hauls with the 10-foot Isaacs-Kidd trawl, by zones, 1955–56*—Continued

Organisms	Size range (mm.)	SEC		ECC		NEC		Hawaii		NPC		AC		All zones	
		Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul	Percent occurrence	Average number per haul
CHORDATA—Vertebrata—Continued															
Pisces—Continued															
Exocoetidae: Unidentified	20–28	1	1											1	1
Exocoetus sp.	53–65			6	1			4	1					1	1
Bregmacerotidae: Unidentified	20–51	1	1	6	1									1	1
Bregmaceros macclellandi	20–95	23	2	11	2			8	2					13	2
Bregmaceros sp.	38–50	3	1											1	1
Gadidae:															
Melanonus sp.	80–96	3	1											1	1
Fistulariidae	50	1	1											1	1
Trachypteridae: Unidentified	300–920			11	1									1	1
Trachypterus cristatus	413	1	1											1	1
Trachypterus sp.	82–555	6	1											2	1
Caulolepidae:															
Anoplogaster cornutus	76–80	1	2											1	2
Diretmidae:															
Diretmus argenteus	24–72	4	1	6	1									2	1
Holocentridae	21							4	1					1	1
Melamphaidae: Unidentified	20–70	20	1	56	3	43	5	4	1	15	2	16	2	23	2
Melamphaes suborbitalis	31–52			6	1	7	1					5	(1)	2	x
M. frontosus	24–90	1	2			7	1	4	1	8	2			2	2
M. robustus	38									8	1			1	1
M. beanii	20–50							8	2					1	2
M. mizolepis	49–50			6	2									1	2
Melamphaes sp.	22–77	1	2	6	4	14	3	4	1	8	1	10	1	5	2
Zeidae	55–65	1	2											1	2
Serranidae:															
Planctanthias sp.	21–33	1	1					4	7					2	4
Apogonidae:															
Howella sherborni	20–64	16	1	11	1	7	2	4	1					10	1
Howella sp.	40											5	1	1	1
Carangidae: Unidentified	20							4	1					1	1
Decapterus pinnulatus	78–90							4	3					1	3
Bramidae: Unidentified	25–36	3	1	6	1									2	1
Brama raii	42–65	3	2											1	2
Collybus drachme	30							4	1					1	1
Chaetodontidae	21–27							12	1					2	1
Chiasmodontidae: Unidentified	110–133	1	1	6	1	7	1							2	1
Pseudoscopelus cephalus	35	1	1											1	1
Pyramodontidae:															
Snyderidia sp.	210–220							4	3					1	3
Brotulidae: Unidentified	28–51	1	1					4	1					1	1
Brotula multibarbata	44							4	1					1	1
Gempylidae: Unidentified	20–175	16	3	6	1			17	1					10	2
Gempylus serpens	70–170	1	1	6	1	7	1	8	1					3	1
Trichiuridae: Unidentified	82							4	1					1	1
Benthodesmus sp.	80	1	1											1	1
Nomeidae: Unidentified	32	1	1					4	1					1	1
Cubiceps sp.	20							4	1					1	1
Psenes sp.	24	1	1											1	1
Thunnidae: Unidentified	20–60									8	2			1	2
Katsuwonus pelamis	22	1	1											1	1
Bothidae	41									8	1			1	1
Monacanthidae:															
Pervagor melanocephalus	30	1	1											1	1
Ostraciidae:															
Lactoria diaphanus	70					7	1							1	1
Diodontidae	26							4	1					1	1
Molidae: Unidentified	<20	1	8					4	12					1	10
Mola mola	20	1	1											1	1
Ranzania laevis	25–42	2	2											1	2
Masturus sp.	20	1	1											1	1
Himantolophidae:															
Himantolophus groenlandicus	300					7	1							1	1
Ceratiidae:															
Cryptopsaras couseii	25									8	1			1	1
Leptocephali: Unidentified	42–350	52	2	17	8	7	1	25	1	46	2	10	2	34	2
Unidentified Pisces	3–130	88	29	89	19	93	14	88	21	85	49	68	16	86	26
UNIDENTIFIABLE MATERIAL	<20–48	14	45	6	75	14	62	58	46	23	100			19	53

[1] Actual number not determined.

U.S. GOVERNMENT PRINTING OFFICE: 1962 O—637256