FRAME TRAWL FOR SAMPLING PELAGIC JUVENILE FISH

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ABSTRACT

The frame trawl is a micronekton net designed to sample pelagic larval and juvenile fish that avoid plankton nets and pass through the mesh of large midwater trawls. The mouth of the frame trawl is a rigid, square frame with an area of 5 m². The bridle attaches at two points and leaves the mouth relatively unobstructed and vertical at all tow speeds. A modified Isaacs-Kidd depressor can be attached behind the frame for midwater sampling, or floats can be attached for surface sampling. The frame trawl compares favorably with other similar-size samplers. In sea trials, juvenile anchovy and other species up to 200 mm long, and thousands of 15-20-mm anchovy larvae have been collected.

RESUMEN

La red de marco es una red para micronecton diseñada para muestrear larvas y juveniles de peces pelágicos que evitan redes de plancton y pasan a través de la malla en redes de media agua de gran tamaño. La boca de la red de marco es un marco rígido, cuadrado, con un área de 5 m². La brida se afirma en dos lugares, manteniendo la boca relativamente libre de obstrucción y en posición vertical a cualquier velocidad de arrastre. Un depresor Isaacs-Kidd modificado puede ser adicionado detrás del marco en caso de muestreo a media agua o, pueden ser agregados flotadores para muestreo superficial. La red de marco presenta ciertas ventajas con respecto a otros muestradores de tamaño similar. En muestreos experimentales, se colectaron juveniles de anchoveta y otras especies de hasta 200 mm de largo, y miles de larvas de anchoveta de 15-20 mm.

INTRODUCTION

Studies of recruitment variation in marine fishes have focused on the early larval stages. Certainly these animals have a high mortality rate, and variations in prey abundance, predators, and ocean currents probably cause substantial variation in this mortality. The capability to detect larvae in poor physiological condition is now well developed (Theilacker 1986), but this is only one step in the study of recruitment variation. Several important questions have not been addressed:

How rapidly does the high larval mortality decline? Where are large, old larvae found if adverse drift is a significant factor? Most important, what is the earliest life stage at which an index of recruitment can reliably be made?

There are two aspects to this last question. The first concerns variation in mortality with respect to life stage; larval fish studies cannot provide the final answer to recruitment variation if juvenile mortality varies substantially. The second aspect concerns our ability to sample each life stage. Late larvae and juveniles effectively avoid standard plankton samplers (Murphy and Clutter 1972), leaving a gap in our knowledge until the larger juveniles become available to commercial fishing gear and large midwater trawls (Mais 1974).

The goal is development of a quantitative sampler for late larval and juvenile pelagic fish. This sampler will elucidate larval drift and migration, and extend the survivorship curve throughout the larval life stage. Surveys of late larvae will make it possible to partition recruitment variation into two components: one explainable by variation in larval mortality and the other probably caused by variation in juvenile mortality.

Ideally, a new sampler should: (1) filter a large volume in order to detect rare organisms; (2) be unobtrusive to reduce avoidance by larger organisms; (3) retain little plankton to reduce sorting costs; and (4) be easy to handle. Because the late larval and juvenile stages of some species are surface-associated, it should be possible to tow the sampler near the surface, yet away from disturbance caused by the towing vessel. Because other species inhabit deep waters, it is important to be able to open and close the net's mouth. All of these design characteristics are affected by mouth area, tow speed, mesh size, and bridle design.

The primary target for this sampler is 15-60-mm northern anchovy (Engraulis mordax). This size range overlaps the larvae captured by the 70-cm bongo plankton nets and the juveniles captured by 10-15-m midwater trawls. The plankton net has 0.505-mm mesh, and filters about 150 m³ when sampling along an oblique trajectory from 70 m to the surface (Smith and Richardson 1977). The midwater trawl has variable mesh with a cod-end liner of about 6 mm and a mouth area of over 100 m²; it filters over 100,000 m³ in a horizontal tow (Mais 1974). The new sampler should have
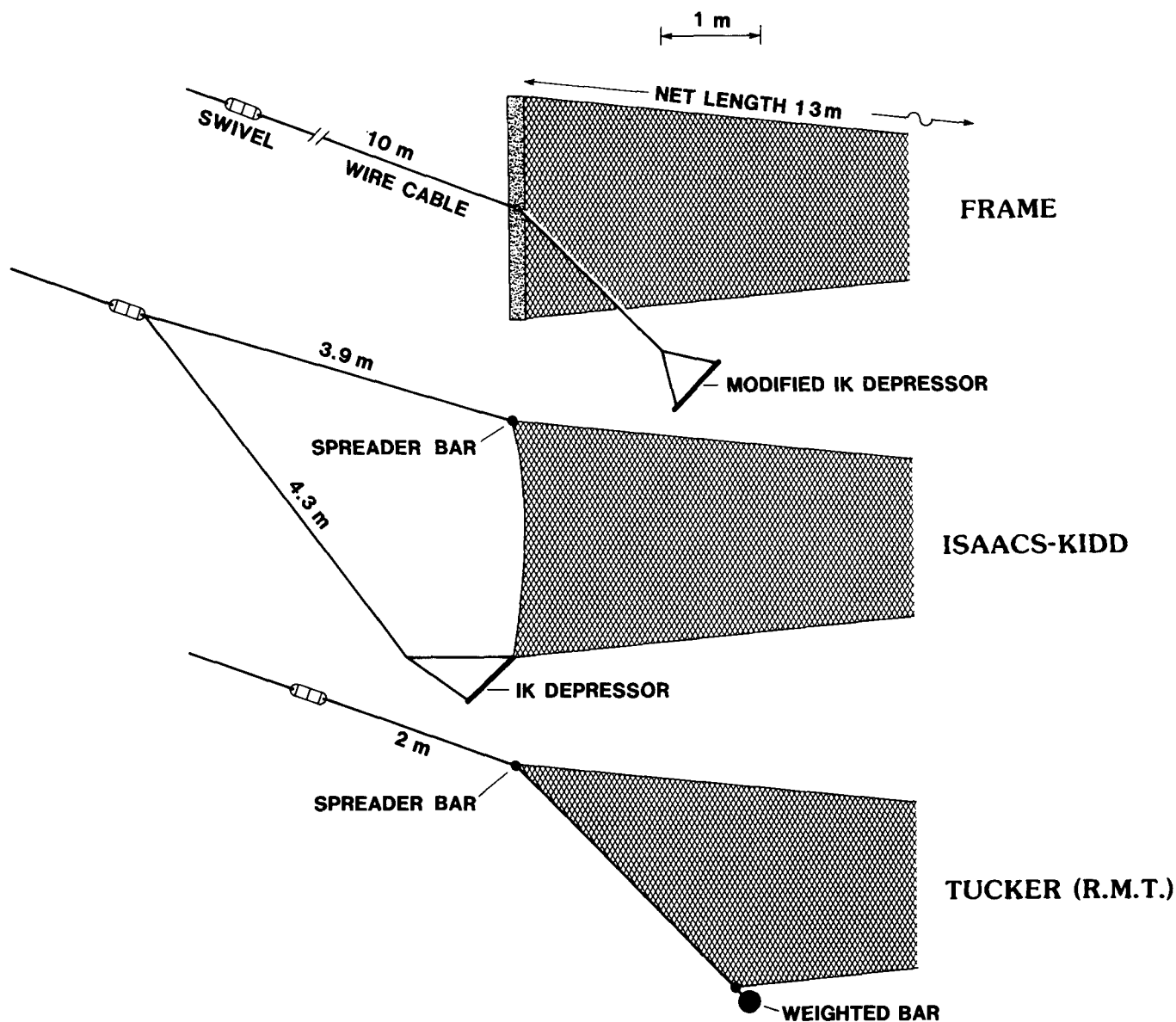
Figure 1. Profiles of Isaacs-Kidd midwater trawl, Tucker trawl (rectangular midwater trawl), and frame trawl. All are drawn with a mouth area of 5m².

2-mm mesh to retain most 15-mm larvae and extrude most plankton, and it should be able to easily filter 10,000 m³ to detect less-abundant late larvae and juveniles.

This target volume can be obtained by a large, slow net or a smaller, faster net. Whether juvenile fish can avoid a large, slow net more easily than they can avoid a small, fast net is uncertain. The disturbance created by the fast net may negate any advantage of its speed. The target volume is difficult to achieve with a small, fast net because the range of reasonable speeds (0.5-3.0 m/sec) is less than the range of reasonable mouth areas (1.0-100.0 m²). A compromise of size and speed seems reasonable, with attention to making the net as quiet and unobtrusive as possible.

Two widely used candidates for this sampler (Figure 1) are the Tucker trawl (Tucker 1951), also called rectangular midwater trawl (Baker et al. 1973), and the Isaacs-Kidd midwater trawl (Isaacs and Kidd 1953). The rectangular midwater trawl (RMT) has been built in sizes ranging from 1 m² to more than 25 m² and is usually equipped with an opening-closing mechanism for the net's mouth. A common design has a 8-m² mouth area, 4.5-mm mesh, and a 291-kg weight in the lower bar (Baker et al. 1973). The disadvantage of this design is that the mouth angle (and area) vary with tow speed because the bridle attaches only to the top of the net frame. This restricts the RMT's tow speed to less than about 1.0 m/sec.

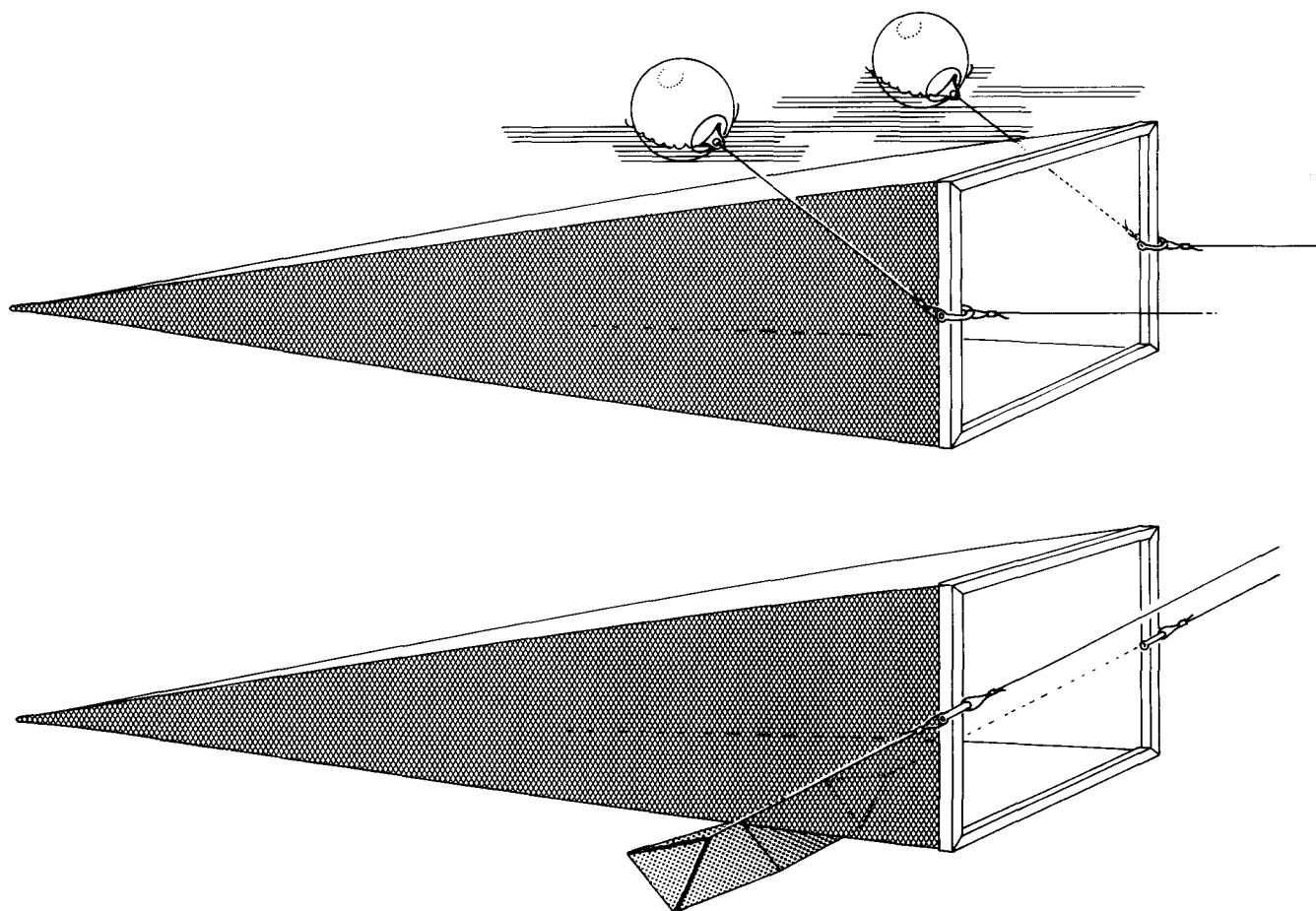The Isaacs-Kidd midwater trawl (IKMT) was de-

Figure 2. The frame trawl in its surface configuration with floats (above), and in its subsurface configuration with the Isaacs-Kidd depressor (below).

signed to be a fast (2.-3. m/sec), deep-diving net for sampling mesopelagic organisms. A common size has a depressor width of 3 m and a mouth area of about 7-8 m^2. The disadvantage of the IKMT is that the depressor is located at the leading edge of the lower portion of the net, where it and its bridle must create substantial disturbance and increase avoidance by larger fish. In addition, neither the RMT nor the IKMT are effective near-surface samplers: they must either be towed very near the vessel or use unreasonably large floats.

A fixed-frame trawl with integral depressor was developed by Matuda et al. (1978) for sampling Antarctic krill. Their goal was the same as mine: to improve on the tow speed and mouth angle limitations of the RMT, and on the lower-bridle disturbance of the IKMT. The 2.5 × 2.5-m sampler they designed has only an upper bridle and maintains a nearly vertical mouth opening and constant ratio of depth to wire over a wide range of tow speeds. This design succeeds in moving the bridle away from the net's opening, but the upper and lower depressor built into the frame must substantially disturb the flow of water near the net's mouth. Matuda et al. (1978) note inflated flowmeter

readings that probably resulted from the lower bridle's deflecting water toward the net's mouth.

DESCRIPTION OF FRAME TRAWL

The frame trawl described here (Figures 1 and 2) is a medium-size net (Pearcy 1983) that shares some characteristics of the bongo, the RMT, and the IKMT. The mouth of the net is surrounded by a rigid square frame, and the long bridle attaches only to the midpoints of two opposite sides. These features give the frame trawl a vertical mouth at all tow speeds, and its mouth is nearly free of obstruction by the bridle (Figure 3). Bridle extensions can be attached to a modified Isaacs-Kidd depressor or to floats, so the frame trawl can quickly be converted from a midwater trawl to a surface trawl. The frame trawl described here has 2-mm mesh, a mouth area of 5 m^2, and a routine tow speed of 2.0 m/sec. It is designed primarily for quantitative oblique tows in the upper 100 m of the water column and cannot be opened or closed during a tow.

The frame is constructed of heavy (schedule 80) steel pipe with an inside diameter of 3.2 cm (1.25-inch) welded to a 10-cm (4-inch)-wide strip of 0.64-cm

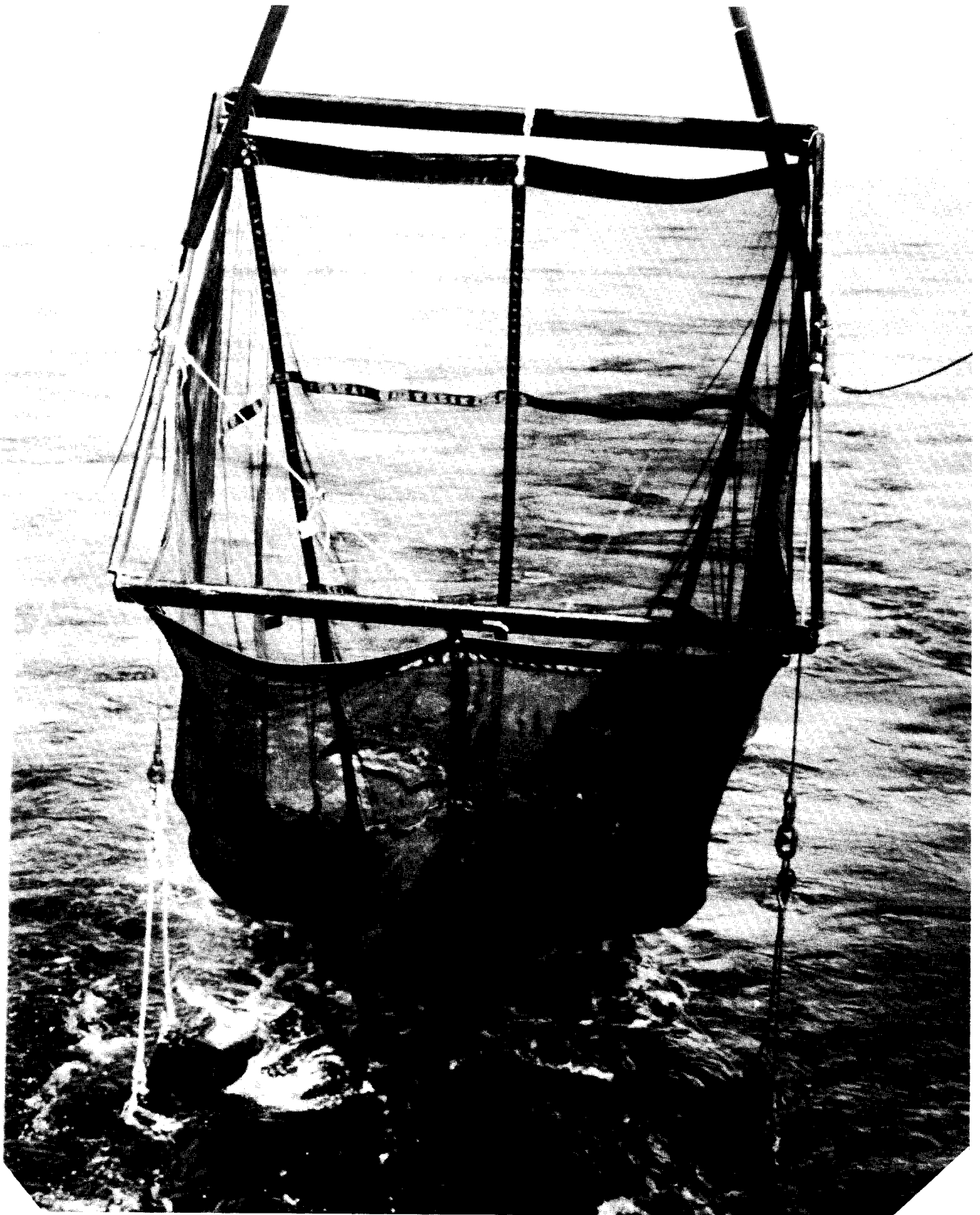Figure 3. Photograph of the frame trawl being deployed. The depressor hangs below the net frame at this time, then trails farther aft during the tow. The two sides of the bridle are held together by the block (pulley) and separate farther when more tow cable is let out. Rigid clip-on cable fairings are on the lower portion of the bridle to reduce cable vibration. A flowmeter is in the lower left corner of the frame.
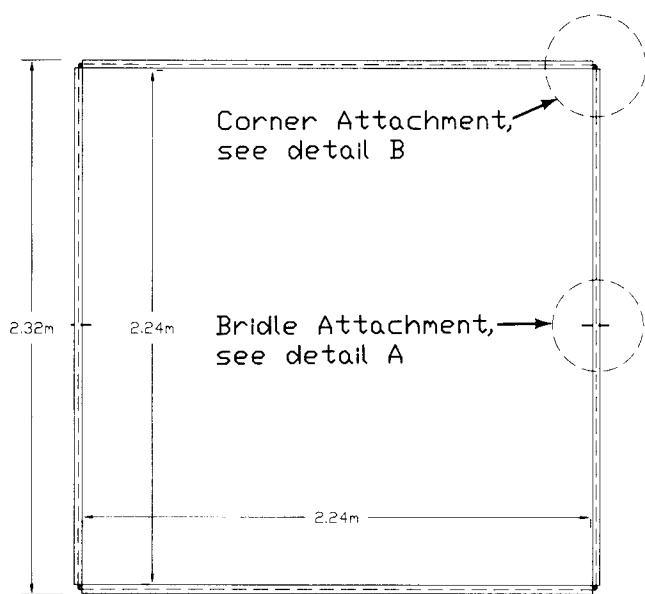
Figure 4. Dimensions of the frame trawl with 5 m² mouth area. See Figure 5 for construction details.

(0.25-inch) plate steel (Figure 4). U-shaped bridle attachments made of 1.3-cm (0.5-inch) steel rod are welded to a reinforced section of the midpoint of each side (Figure 5). A corner bracket of 0.95-cm (0.375-inch) steel is welded to each end of the top and bottom and bolted to the two sides. The total mass of the frame in air is 106 kg; this could probably be safely reduced by narrowing the plate steel to about 7.5 cm.

The depressor is a dihedral, as designed by Isaacs and Kidd (Figure 6). Its dimensions are 2.44 m × 0.61 m (8 ft × 2 ft). The depressor used in the frame trawl differs from the original Isaacs-Kidd depressor in the bridle attachment. The original design had an asymmetric triangle attached by hinges to each end of the depressor. The bridle was attached to the forward-directed apex of the triangles, and the net was attached to the trailing edge of the depressor. The triangular arms were shaped so that the depressor would maintain an angle of attack (45°) that maximized the downward force.

The frame trawl has nothing attached to the trailing edge of the IK depressor; therefore the shape of the triangular arms must be modified to maintain the 45° angle of attack. Trials with a small model in a laboratory flume indicated that an isoceles triangle is a suitable shape, but the angle of attack of this modified IK depressor varies with tow speed. At zero speed, or when the depressor is very heavy, it will hang straight down with no angle of attack and generate no downward force other than its weight. At very high speed or when it has negligible weight, the depressor swings farther back and up until it is vertical (90° angle of attack) and generates maximum drag but no

downward component to this drag. The mass of the depressor (65 kg in air) gives it an intermediate angle of attack. At a speed of 2.0 m/sec the 5-m² frame trawl dives deeper if a 35-kg (75-lb) weight is added to the depressor; the scope (ratio of wire out to net depth) was about 3.0 with the weight attached and 4.0 without the weight. The added weight brings the depressor's angle closer to the 45° optimum. A steep wire angle (low scope) is desirable because it moves the bridle farther out of the mouth opening (Figure 2).

The two floats are heavy-duty vinyl fishing floats. Each has a volume of 200 liters.

The bridle is constructed of 11-mm (7/16-inch) cable. The main bridle consists of two 10-m sections (Figure 7). At one end they come together at a swivel, which is connected to the towing cable. The opposite ends of the main bridle sections terminate at swivels attached to the U-shaped brackets inside the frame. These swivels at the brackets may be unnecessary if torque-balanced cable is used for the bridle. Attached to the U-shaped brackets on the trailing edge of the frame are 1.5-m sections of cable that terminate with quick-release connectors. These connectors can be attached either to the modified IK depressor or to the floats. The total mass of the bridles is 32 kg.

The net is constructed of knotless black nylon 1/8-inch stretch mesh (2 mm × 3 mm oval pores) and black nylon webbing (5-cm width, seat belt strap material). There are eight longitudinal straps and nine circumferential straps (ribs). The mesh material is sandwiched between two layers of strap material, and the entire sandwich is sewn through with zigzag stitching. The net is attached to the frame by extending the eight longitudinal straps about 50 cm beyond the mouth of the net (Figure 8). Heavy, 10-mm (3/8-inch) grommets are set in these strap extensions and in the mouth rib. The straps are looped around the frame, and the grommets in the strap are bolted to the grommets in the mouth rib. The mesh has low porosity, about 23%, and the length of the net is 10 m, so the ratio of pore area to mouth area is low (1.6) when allowance is made for the substantial area occluded by straps. Increasing the net length to 13 m and reducing the number of ribs to two (plus the rib around net mouth) would increase the ratio of pore area to mouth area to about 2.6.

The terminal end of the net is attached to a section of 20-cm-diameter plastic pipe. A cod end constructed of 0.505-mm mesh is attached to the terminal end of the pipe with a band clamp.

The net of 2-mm mesh sandwiched between 5-cm-wide nylon straps has proved difficult to repair. Rips in the net often require replacing sections of the straps, and it is difficult to achieve sufficient strength in longitudinal strap junctions that are resewn.

END VIEW OF DETAIL A

OUTSIDE VIEW OF DETAIL A

DETAIL A

Cross section of
frame through midpoint

3.2cm

4.1cm

1-1/4" Schedule 80 iron pipe

Reinforcement plate 0.64cm x 10.0cm x 30cm

1.3cm

4.0cm

4.2cm

Inside

Outside

10.0cm

0.64cm

1.3cm

DETAIL B
Corner Attachment

FRONT VIEW

D

Schedule 80 Iron Pipe

4.1cm

Plate Steel

0.64cm
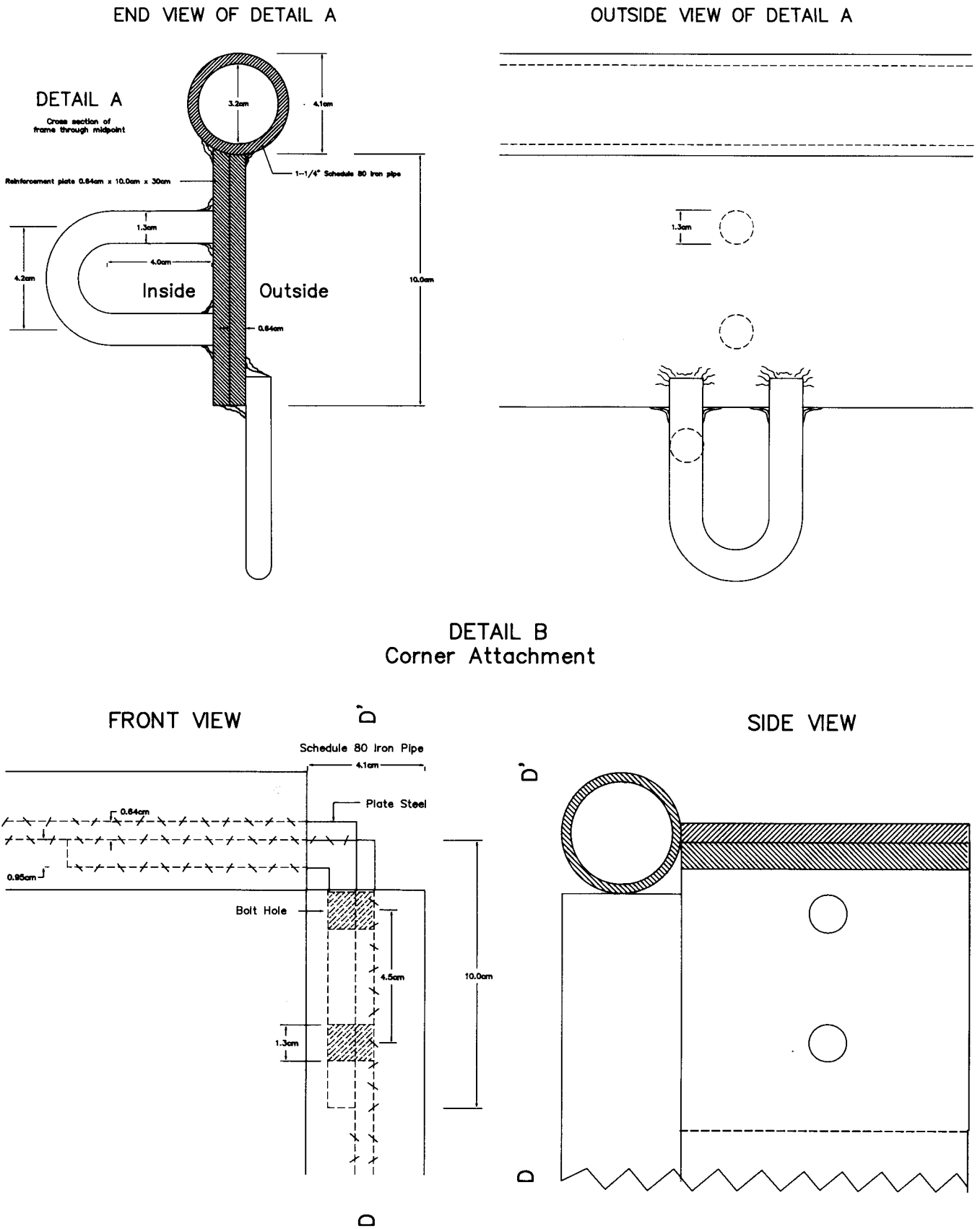
0.95cm

Bolt Hole

4.5cm

10.0cm

1.3cm

SIDE VIEW

D

D

Figure 5. Construction details of the frame trawl: *detail A*, bridle attachment; *detail B*, corner attachment.

Front view of Net Depressor

A

A′

Vane Surface— 1.31m × 0.61m × 3.2mm

1.31m

3.2cm OD pipe

B

1.49m

39cm

6mm (× 25mm)

B′

A ⌐ 7.0cm

9mm diameter

3.2cm ⌐

Side view of A

B ⌐ 61cm ⌐

39cm

1.3cm holes

3.8cm

B′

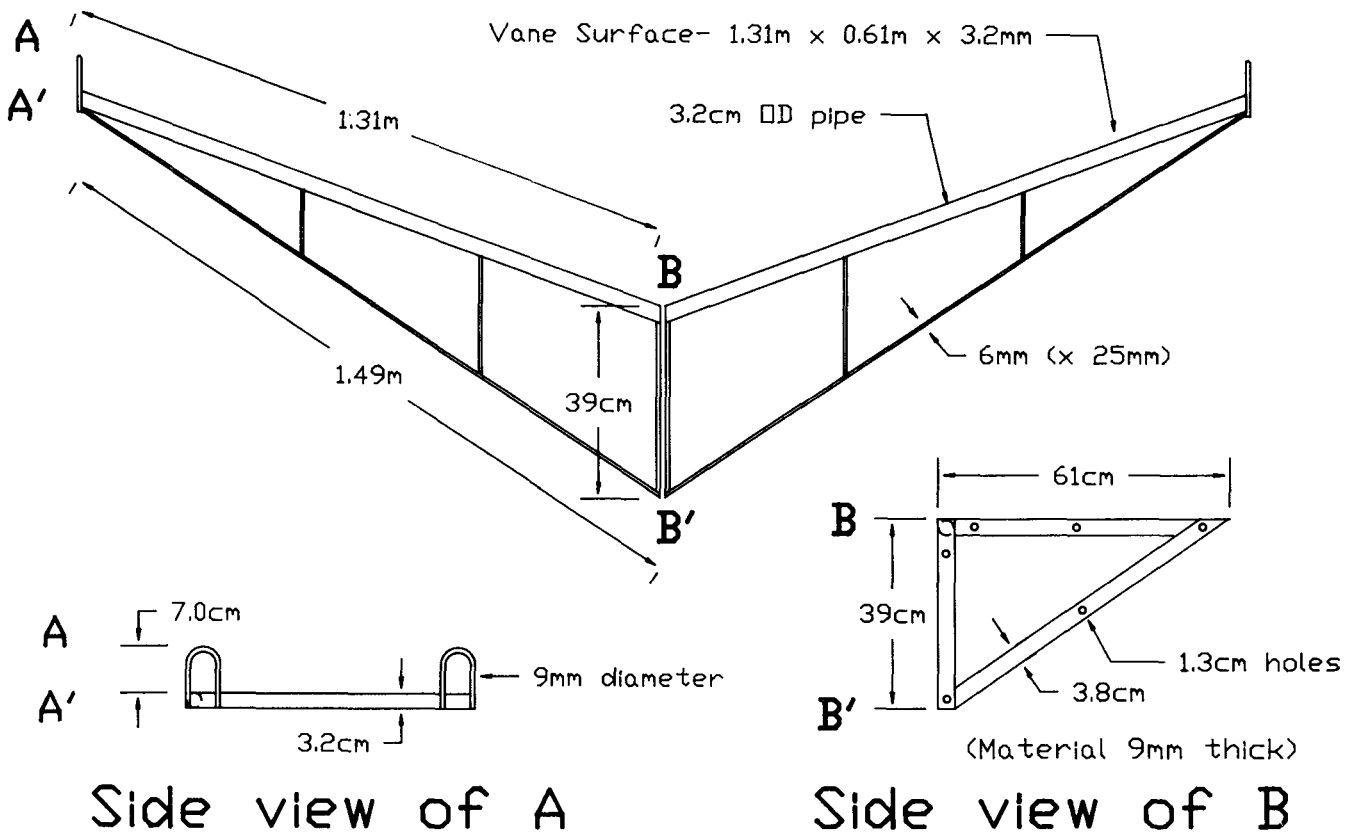(Material 9mm thick)

Side view of B

Figure 6. Modified Isaacs-Kidd depressor used with the frame trawl. The hinged asymmetric triangle on the Isaacs-Kidd depressor has been replaced with two U-shaped brackets. The two halves of the frame bolt together with bolt holes shown in side view of B.

As an alternative, we constructed a second, 13-m-long trawl net with 6.4-cm (2.5-inch) stretch mesh and four longitudinal strain members of 16-mm (5/8-inch) rope. An eye was spliced into the forward end of the strain members for attachment to the frame. A liner of 2-mm mesh was installed inside the trawl. IKMT nets built in this manner have proved durable. This alternative net performed well in a brief sea trial, but was significantly heavier than the original design.

SEA TRIALS

The frame trawl has been to sea three times: January, March, and July 1985. For the first two trials we used a prototype version with a rectangular mouth opening (1.73 m × 1.45 m = 2.5 m²). This frame size was selected to roughly fit the net from a 6-ft IKMT. For the July trial we used the 5-m² working version of the frame trawl.

The January trial was designed to test the basic net principle. We made 16 tows to determine the relation between ship's engine RPM, net speed, and net depth. The frame trawl proved to be easy to handle and to have stable tow trajectories. The deployment procedure is as follows:

1. The tow cable is passed through a block at the top of a stern A-frame.
2. The A-frame is tilted forward to lift the block to its highest position.
3. The swivel and forward portion of the bridle are pulled through the block until the frame and depressor are lifted from the deck.
4. The net is tossed into the water.
5. The tow cable is slowly paid out while the A-frame is tilted aft.
6. After the frame is in water and the swivel clears the block, the tow cable can be rapidly paid out.

The March 29-31 trial was the first test of the frame trawl as a sampler. Eighteen tows were made between San Diego, California, and Santa Catalina Island and along the NE shore of the island. All tows were made at night at a speed of 2 m/sec. Four of the tows were made with floats rather than the depressor. Oblique tows to sample the upper 50 m of the water column were made with 200 m of wire out and retrieved at a rate of 10 m/

INSIDE VIEW OF NET FRAME

TOP

(DRAWING NOT TO SCALE)

10.0m

Swivel

FRONT

1.12m

1.5m

quick-
release

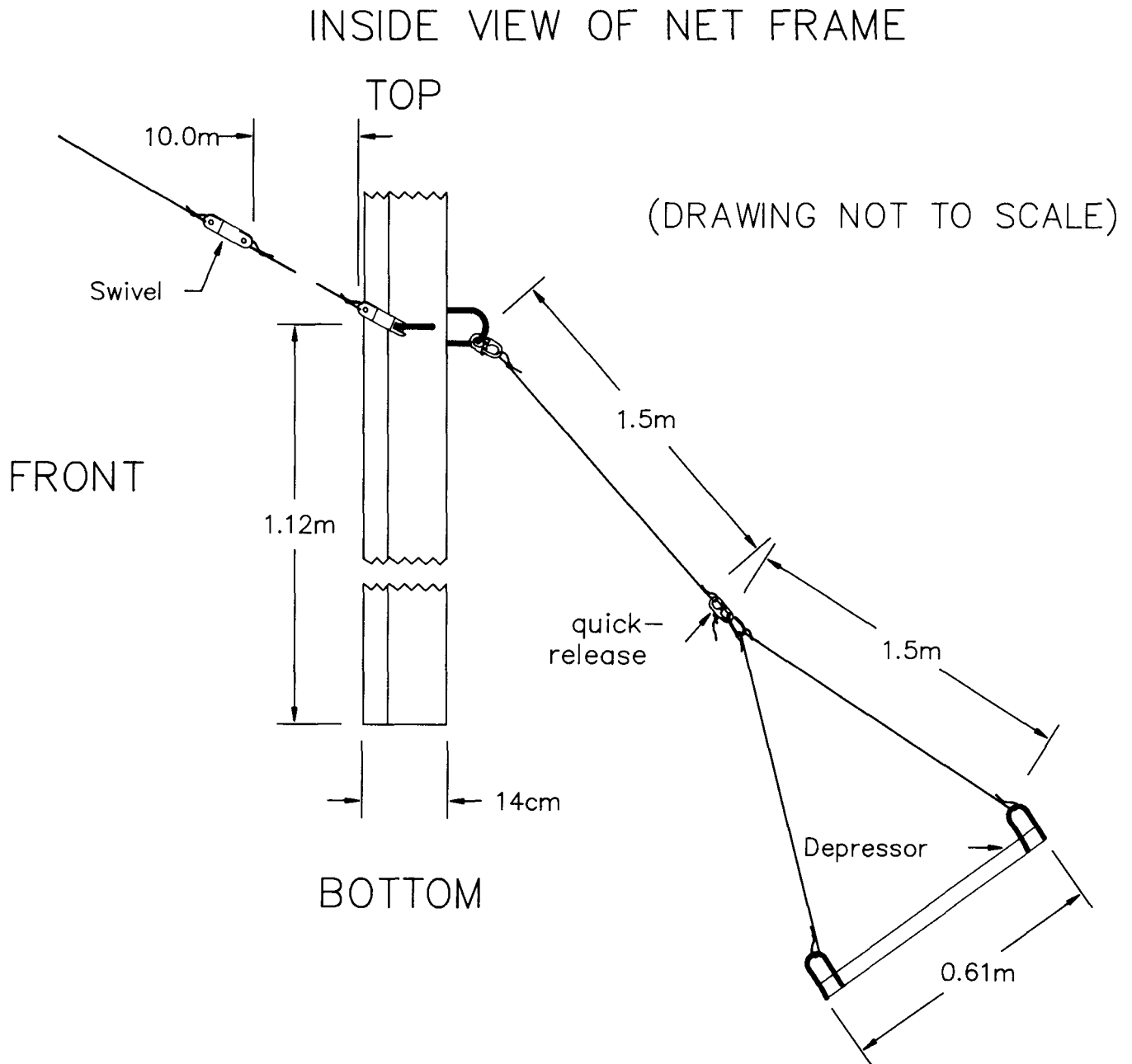1.5m

14cm

Depressor

BOTTOM

0.61m

Figure 7. Bridle lengths for the frame trawl. The swivel and anterior portion of the main bridle are designed to be drawn through the block to lift the frame off the deck. The quick-release connectors can be attached either to the depressor or to the floats.

min. Surface tows were made with 100 m of wire out and a duration of 20 min. During surface tows the ship made a slow turn to keep the net to the side of the wake. A flowmeter installed in the mouth of the net indicated that tow speed ranged from 1.88 to 2.36 m/sec (mean = 2.00) and that the volume filtered during the oblique tows ranged from 5,600 to 7,900 m³ (mean = 7,150).

Large anchovy larvae were consistently collected (Table 1). Most larvae shorter than 10 mm probably were extruded through the 2-mm mesh. The extrusion of small larvae may be reduced if the net is lengthened.

This will increase the ratio of pore area to mouth area and decrease the velocity of water through the pores. The high catches of larvae larger than 15 mm are very encouraging; this size range is poorly sampled by plankton nets because of avoidance and low volume filtered.

Catch rates of all size categories were greater in oblique tows than in surface tows among tows 3-9 (Table 1). In the 15-20-mm size range the mean catch was 0.6 larvae per 1,000 m³ in surface tows and 11.3 per 1,000 m³ in oblique tows. No larvae larger than 20 mm were
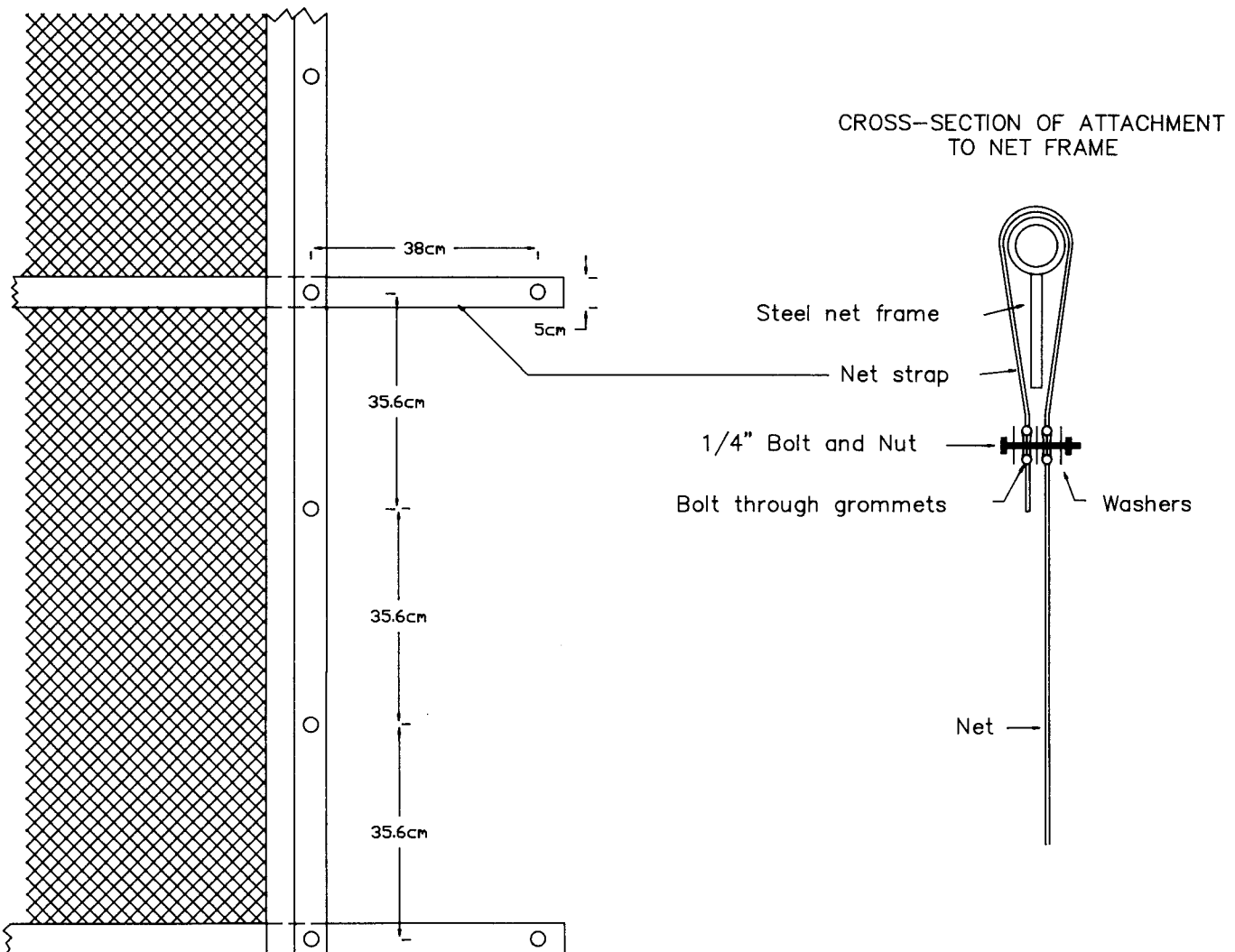
Figure 8. Profile of the anterior portion of the net showing straps used for attachment to the frame.

collected in surface tows. The difference between surface and oblique tows is greater in terms of abundance per unit sea-surface area rather than density. Multiplying the oblique results by 50 m (the maximum depth sampled) and the surface results by 1.45 m (the height of the frame, which is the maximum depth sampled) indicates that abundance of 15-20 mm larvae is 565 per 1,000 m² in the upper 50 m, and only 0.87 per 1,000 m² in the upper 1.45 m.

Juveniles and adults of other species were commonly collected in excellent physical condition (Table 2). The capture of two *Merluccius* was especially encouraging. The frame trawl was designed to be an effective sampler of age-0 fish, but the *Merluccius* were age 1 +.

The 5-m² frame trawl was tested on the night of July 29-30, 1985. Ten tows were conducted along the coast north of San Diego. Tows 5 and 6 were over bottom depths of 100 m, and tows 7-15 were over bottom

depths of 55-66 m. Surface tows were alternated with oblique tows, and tow procedures duplicated those in the March test of the prototype. Large anchovy larvae were commonly collected (Table 3), and sardine larvae often constituted about 10% of the clupeiform larvae (Table 4). Catch rates of anchovy in surface tows were similar to catch rates in oblique tows (Table 3). Larvae shorter than 10 mm had greater density in surface tows, and larvae longer than 10 mm had greater density in the oblique tows. Only two anchovy larvae longer than 20 mm were collected in surface tows.

DISCUSSION

The average abundance of anchovy larvae collected by the frame trawl is similar to historical catches by the bongo plankton net. Hewitt and Brewer (1983) analyzed bongo collections from the nearshore (<43-m bottom depth) between San Diego and Point Conception. From January to June 1980, the catch of 10-15-

TABLE 1
Catches of Anchovy Larvae in Prototype Frame Trawl, March 1985

Tow number and type		Number of larvae	Abundance per 1,000 m³					Longest larva (mm)	Location
			<10 mm	10-15 mm	15-20 mm	>20 mm	Total		
1	O	117	4.7	9.3	1.2	0.1	15.3	23.0	San Diego to Santa Catalina
3	O	523	9.3	41.7	15.9	0.0	66.1	19.0	San Diego to Santa Catalina
4	S	63	0.9	7.2	0.0	0.0	8.1	14.0	San Diego to Santa Catalina
5	O	751	33.1	58.1	8.0	2.0	100.2	21.0	San Diego to Santa Catalina
6	S	54	2.0	4.1	0.4	0.0	6.5	18.0	San Diego to Santa Catalina
7	O	432	6.8	49.9	10.9	1.4	68.4	27.0	San Diego to Santa Catalina
8	S	65	2.0	4.5	1.4	0.0	8.0	16.5	San Diego to Santa Catalina
9	O	278	7.5	18.3	10.4	5.4	41.6	23.5	San Diego to Santa Catalina
10	H	87	4.6	4.0	0.8	0.6	10.0	25.0	San Diego to Santa Catalina
11	O	498	12.4	64.7	11.5	0.0	88.6	19.0	3 km offshore N
12	O	1,242	39.1	117.2	6.5	0.0	162.7	17.5	3 km offshore S
13	O	827	31.9	60.3	9.1	1.1	113.8	21.0	2 km offshore N
14	O	1,622	78.0	117.0	8.2	2.1	205.2	22.5	2 km offshore S
15	O	370	17.3	27.6	1.9	0.0	46.8	16.0	1 km offshore N
16	O	353	22.2	22.2	1.9	0.0	46.3	17.0	1 km offshore S
17	O	557	17.9	40.2	27.7	3.6	89.4	24.0	toward San Diego
18	O	744	43.0	48.1	8.2	3.1	102.4	22.0	toward San Diego
Mean for tows 3-9:									
	S		1.6	5.3	0.6	0.0			
	O		14.2	42.0	11.3	2.2			

O = oblique, S = surface, H = horizontal. Tow 2 was discarded because of the large volume of gelatinous zooplankton. Tows 11-16 were made parallel to the island's shoreline.

mm anchovy larvae averaged 13.8 larvae per tow, and average abundance was 6.7 larvae per m² of sea surface. Hewitt and Methot (1982) estimated that the average abundance of 10-15-mm larvae throughout the larval habitat in March 1978 was 8.9 larvae per m². In

March 1985 the prototype frame trawl collected an average of about 400 10-15-mm larvae per tow, or 2.6 per m², and these numbers must be inflated to account for the unmeasured extrusion through the 2-mm mesh. In July 1985 the four nighttime, oblique frame trawl tows

TABLE 2
Fish Other Than Anchovy Collected by Prototype Frame Trawl, March 1985

Tow number and type		Number of larvae	Larger specimens
1	O	57	(2) bathylagidae 87, 90 mm; several myctophidae
3	O	271	(2) bathylagidae 75, 77 mm; many myctophidae
4	S	7	—
5	O	212	(5) bathylagidae 90-105 mm
6	S	15	—
7	O	47	(1) *Porichthys* 120 mm
8	S	13	—
9	O	6	—
10	H	9	—
11	O	105	—
12	O	121	(1) *Merluccius* 160 mm
13	O	174	—
14	O	178	(1) *Merluccius* 170 mm
15	O	52	(1) *Porichthys* 120 mm
16	O	23	(1) *Porichthys* 120 mm; (1) pleuronectidae 31 mm
17	O	123	(6) bathylagidae 37-82 mm; several myctophidae
18	O	111	(4) bathylagidae 87-101 mm; several myctophidae

O = oblique, S = surface, H = horizontal.

TABLE 3
Catches of Anchovy Larvae in the Frame Trawl, July 1985

Tow number and type		Number of larvae	Abundance per 1,000 m³					Longest larva (mm)
			<10 mm	10-15 mm	15-20 mm	>20 mm	Total	
5	O	9,142	68.2	443.5	170.6	0.0	682.2	17.5
6	S	3,336	42.4	163.9	76.3	0.0	282.7	18.0
7	O	510	6.0	30.7	17.5	0.5	54.8	24.0
9	S	1,956*	67.2	74.7	7.5	0.0	149.3	19.0
10	O	1,462*	18.1	67.3	42.7	1.3	129.4	20.0
11	S	2,311*	81.9	75.4	6.6	0.0	163.9	17.5
12	O	1,699*	7.0	29.5	75.8	28.1	140.4	25.0
13	S	801*	26.4	18.6	3.9	0.0	48.8	18.0
14	O	159	4.0	8.4	3.5	0.2	16.1	21.0
15	S	99	0.7	3.8	2.9	0.2	7.4	20.5
Mean for tows 5-13:								
	S		54.5	83.2	23.6	0.0		
	O		24.8	142.8	76.7	7.5		

*Includes some sardine larvae. O = oblique, S = surface.
Tow 5 began at 32°59.2'N, 117°19.6'W, 100-m bottom depth. Subsequent tows proceeded northward along the coast; tows 7-15 were over bottom depths of 55-66 m. Tow 15 began at 33°14.0'N, 117°29.2'W. Tows 14 and 15 were taken during daylight (0550 and 0719 PDT).

collected an average of 1,600 10-15-mm larvae per tow; average abundance was 7.1 larvae per m² (uncorrected for extrusion through the 2-mm mesh). Although the bongo net and frame trawl indicate similar abundances of 10-15-mm anchovy larvae, the frame trawl estimates will be greater when corrected for extrusion, and the frame trawl will be able to detect and quantify much lower larval abundances because it filters over 100 times as much water per tow.

Variance of catch per tow seems lower with the frame trawl than with smaller plankton samplers. Hewitt and Methot (1982) estimate that the coefficient of variation (standard deviation / mean) is about 1.6 for 10-mm larvae collected with the bongo plankton net and 3.5 for 14-mm larvae. The CV for catch of 10-mm larvae by the prototype frame trawl was only 0.6, and the CV was 0.75 for 15-mm larvae. The similarity of catch between replicate frame trawl tows was especial-

ly high (Table 1; tow numbers 11-12, 13-14, and 15-16). This low variance must be due to the large volume filtered (about 7,000 m³) and long distance towed (about 3 km), which integrates much small-scale patchiness.

The frame trawl seems to be a successful and adaptable design. It can be deployed alone, with depressor, or with floats. The model used here had a mouth area of 5 m², and frames ranging from 1 to 10 m² seem feasible. The frame trawl is superior to the bongo plankton net for sampling large anchovy larvae. Further sea trials will be necessary to determine the overlap in sampling effectiveness between the frame trawl and large midwater trawls.

ACKNOWLEDGMENTS

TABLE 4
Fish Other Than Anchovy Collected by Frame Trawl, July 1985

Tow number and type		Number of sardines	Number of others	Larger specimens
5	O	0	139	(1) Merluccius 49 mm
6	S	121	16	(2) pipefish 94, 173 mm
7	O	17	20	(3) goby 28-37 mm; (2) Sebastes 22-27 mm; sardine 15-17 mm
9	S	220	63	(1) scienidae 140 mm
10	O	present	46	(29) goby 26-43 mm; (1) Porichthys 31 mm; (3) pleuronectidae 22-30 mm
11	S	70	61	—
12	O	?	49	(3) goby 22-39 mm; (1) Sebastes 22 mm; (7) Porichthys 2-27 mm; (3) Porichthys 155-185 mm; (8) pleuronectidae 23-28 mm
13	S	?	28	—
14	O	1	4	sardine 17.5 mm
15	S	3	4	sardine 15.0-21.0 mm

O = oblique, S = surface, ( ) number of specimens.

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