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Industrial Development Branch
TECHNICAL REPORT

Industrial Development Branch

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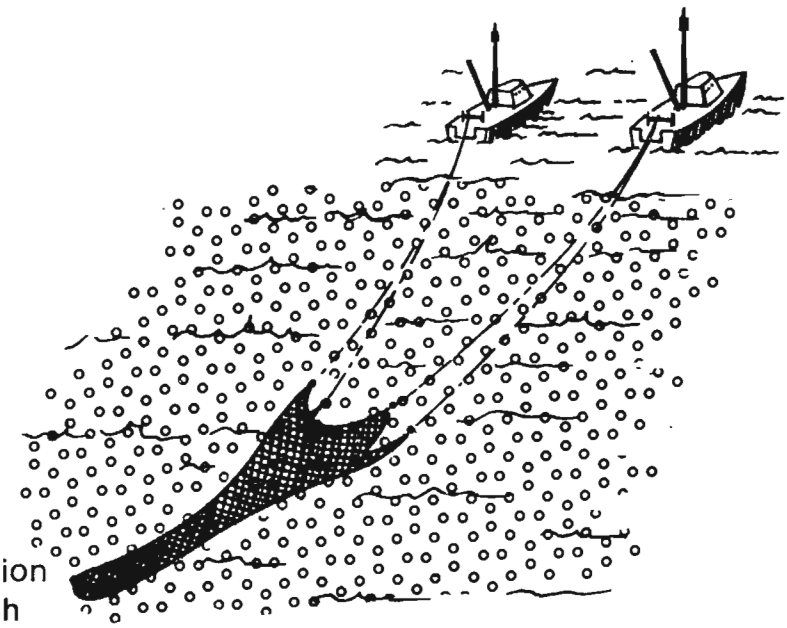
EUROPEAN METHOD OF PAIR MIDWATER TRAWLING

 (ATLANTIC 1973)



The Exploratory Fishing Division
Industrial Development Branch

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EUROPEAN METHOD OF PAIR MIDWATER TRAWLING

(ATLANTIC 1973)

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Industrial Development Branch
Fisheries and Marine Service
Environment Canada

Division Chief
Jack Rycroft

Issued under the
authority of the
Honourable Jack Davis, P.C., M.P.,
Minister,
Environment Canada

ACKNOWLEDGMENTS

We wish to express our sincere appreciation for the facilities provided by Ocean Harvesters Limited, Harbour Grace, Newfoundland and for the help and encouragement of Messrs. Alex and David Moores and their staff.

We further acknowledge the support of the Office of the Regional Director, Fisheries and Marine Service, Newfoundland, and the Newfoundland Department of Fisheries.

Finally, we must mention the substantial contribution of the vessel skippers and crews whose interest and dedication contributed greatly to the success of the project.

A. Flett
F. King

TABLE OF CONTENTS

INTRODUCTION:

The Industrial Development Branch of the Fisheries and Marine Service, Department of Environment carries out an ongoing program to diversify the operations and thus increase the income of both the inshore and offshore sectors of the primary fishing industry. Canadian Pair Seining, for example was a completely new method of fishing introduced in 1969 to allow small boats such as those used in the inshore lobster fishery to participate effectively in the groundfish fishery (Industrial Development Branch project report #30). Pair seining allows two low powered vessels to pool their capabilities in order to operate a fairly large net. Catches using this method, have been as high as 15,000 pounds for a one hour tow.

In view of this success, it was decided to utilize a similar principle in the inshore fishery for midwater trawling. This method is of course not new. It was invented in about 1948 by Robert Larsen in Denmark. British Columbia fishermen used two boat midwater trawls as early as 1950 and the method was tried in Nova Scotia in 1969. The nets used in 1973, however, were of extremely light construction with 24" meshes in the fore-body. This allowed two low powered boats to tow a very large net.

Newfoundland was chosen as the site of the first project which was funded and carried out by the Industrial Development Branch. Although not described here, a similar project was subsequently initiated in Prince Edward Island as a part of an Industrial Development Branch/Provincial shared cost program.

It is felt that pair midwater trawling in the inshore sector should be expanded in the 37-65' vessel range. There are many vessels in the Atlantic provinces which could successfully utilize this method for pelagic species particularly in the food-fish industry.

Captain Flett, a contracted technologist with the Industrial Development Branch, divided his time between the two provinces and we wish to record that his services were invaluable in the implementation of this development program.

Jack Rycroft
Chief,
Exploratory Division.

THE PROJECT:

Forty thousand dollars was allotted to this project in 1973-74. This sum was to cover all expenditures for the rigging and chartering of two vessels.

The project was initiated as a result of a discussion which took place at Ocean Harvesters Limited, Harbour Grace, between Alec Moores, General Manager, Ocean Harvesters Limited, Jack Rycroft, Chief, Exploratory Fishing Division, and the authors. The large number of boats capable of being adapted for this technique was a major factor considered. Implementation was to begin on June 15, 1973, but this was delayed until June 24 by late delivery of the vessels and equipment.

A considerable amount of preliminary work was necessary in planning deck arrangements and the design of the power block gantry and gallows.

Further delays occurred in the release of the vessel "Sylvia and Sisters", because of incompleted miscellaneous jobs and also because of the late delivery of the rams for the power block boom.

The first fishing day was July 14, 1973 and the vessel charters date from that time. A catch table is included (Appendix III).

Initially the catches were mainly capelin and it can be stated that the pair midwater trawl catches this species very easily. On one day a total of eight consecutive hauls were made through one school and this failed to scare the fish. In fact the last set showed the best marks and gave the best results.

Prior to installation of the power block the net had to be fleeted in from the belly section. This was a time consuming exercise and also very hard work since capelin pack so heavily in the bag. It is therefore essential that power hauling be utilized when working with capelin.

The first good signs of herring showed up on July 25 in Spaniard's Bay. These were mainly in surface schools and the method of finding and towing for them was completely visual with many course alterations and the net being towed on the surface.

During the period from late July to mid-August mechanical troubles developed on one of the boats; also, fish seemed to disappear completely. Charters were subsequently suspended until such time as the boats were again mechanically fit. During this period the second boat requested and was given permission to go bottom trawling until the charters resumed.

Upon resumption of pair midwater trawling a lot of time was spent in the searching mode, the fish being rather scarce. Tows ranging from 10-20 minutes on scattered marks yielding 1,000-4,000 pounds of herring. The final tow was made on September 8th. It was of 45 minutes duration, yielding 10,800 pounds of herring.

During the experiment a total of 22.03 towing hours resulted in a catch of 355,900 pounds, an average of 15,453 pounds per hour towed.

PAIR TRAWLING:

This is an effective technique whereby two boats tow a large pelagic, semi-pelagic or bottom trawl between them at a pre-selected depth.

In pair trawling, efficiency is determined by certain factors. These can be summarized as follows:

1. Unlike single boat trawling where vessel noise can have a scattering effect on fish close to the surface, in pair trawling the noise of each vessel creates a herding effect towards the trawl path down to depths of around 30 fathoms.

2. In pair trawling, the net can be towed very close to or even on the surface when necessary. The herding action of the warps in the water leads the fish into the path of the net.

3. With two boats, utilization of power is extremely efficient because doors are not required This allows the size of the net and subsequently the swept volume to be increased by at least 100%. (in one boat midwater trawling up to 40% of the power is consumed by the drag of the doors).

4. The search mode is obviously very effective since two boats can cover a wide area.

Some of the disadvantages in pair trawling are:

1. trawl handling is slightly more complicated

2. the depth of the trawl cannot be controlled significantly by alteration of towing speed

3. turning while towing is not easily accomplished when fishing with long warps in deep water.

N.B. Manoeuvrability of the boats and co-ordination between skippers is essential to the operation.

The depth of the net is controlled by the amount of warp set i.e. the more warp out the deeper the net sinks. The fishing depth is indicated by a headline transducer on the net linked to a recorder on one of the boats or by a warp angle meter (see diagram). If a headline transducer is not used (as is the case in most European boats, where, by experience, the fishing depth is known) the rule of thumb is approximately three fathoms per 25 fathoms of warp set, i.e. 100 fathoms of warp set gives a headline distance from the surface approximately 12 fathoms. However, in certain circumstances where surface schools of fish are encountered, a large number of floats can be attached and the net towed on the surface with warp lengths of 75 or 100 fathoms (flotation overcomes the gravitational force of the weights).

GEAR AND TECHNIQUES: (Detailed diagrams are in Appendix IV)

The trawl used in this project was a four panel pair midwater trawl (all panels equal) in nylon with 24" mesh in the forenet (see diagram IV). The vertical and horizontal mouth openings when towing, were approximately 10 fathoms.

Trawl opening is sustained by:

1. the separation of the vessels (horizontal opening)

The horizontal opening depends entirely on the separation of the vessels since there are no trawl doors. In general, the distance between the vessels should be half the warp length. Maintaining this ratio (separation = 1/2 warp length) ensures the correct horizontal opening of the trawl.

Extreme separation of the vessels should be avoided since this would put the net under severe strain causing it to distort and therefore decrease its efficiency.

2. The addition of weight to the lower warps and toes of the trawl plus the vertical thrust of floats (vertical opening)

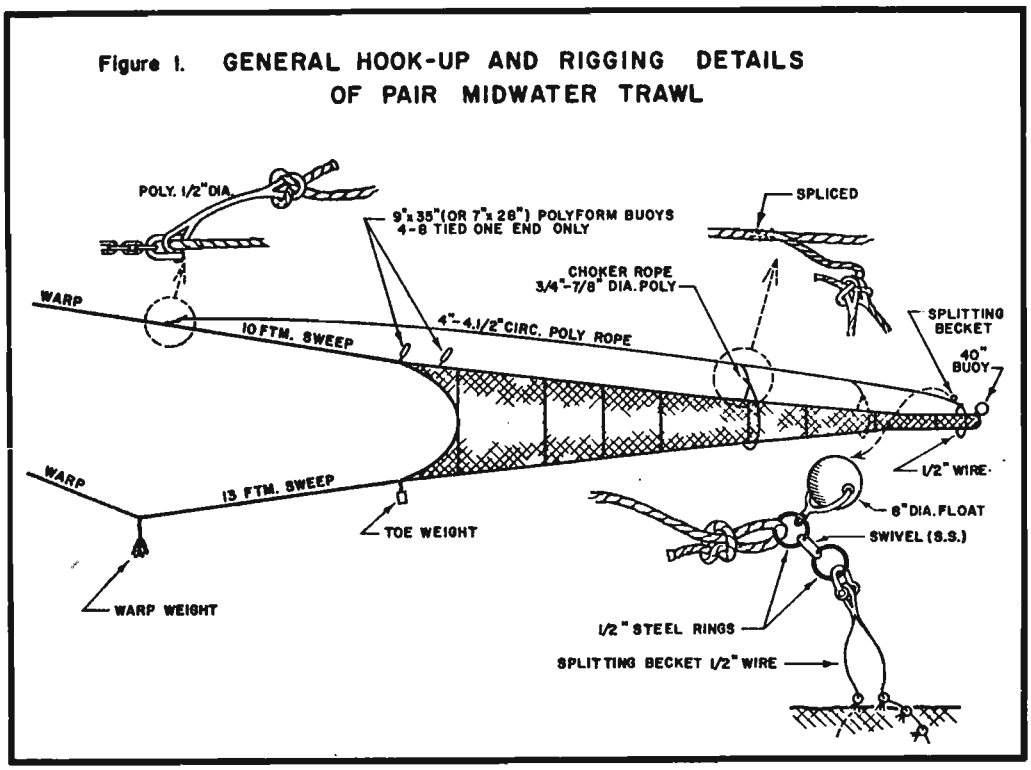
The amount of weight added to the warp ends depends on the horsepower of the boats, the rule of thumb being approximately 110 pounds per hundred h.p. These warp end weights are slung on chain varying in length from 6-8 feet when fishing close to rough bottom, to 2-3 feet for fishing on smooth bottom or in midwater.

The wing-end or toe weights are generally 50-80 pounds each. (These weights can be left off, if need be, to keep the footrope clear when fishing close to bad bottom).

The trawl does not rise or sink significantly with an increase or decrease in towing speed. Coming together of the vessels while towing causes the headline to rise about a fathom, whereas separation of the vessels more than the half warp-length ratio will cause a decrease in the vertical opening.

Sweeps (bridles) are added between the toes of the net and the warps (see Figure 1), the usual length being 10 fathoms for the top pair and 13 fathoms for the lower. This difference in length between the upper and lower sweeps allows the net to attain an optimum vertical opening when towing, with the headrope directly above the footrope. The three fathom differential holds good when using warp lengths up to 150 fathoms. Beyond that, extra 3-4 feet is slacked out on the lower warp. This is achieved by braking both marks even at the towing block, then slacking out the lower warp the required amount.

Figure 1. GENERAL HOOK-UP AND RIGGING DETAILS OF PAIR MIDWATER TRAWL



Pair trawling can be carried out with either two or four warps (see Figure 2&3). Although with the latter system the trawl opening is greater and the herding effect of the warps is increased.

Figure 2. PAIR MIDWATER TRAWLING
2 WARP METHOD

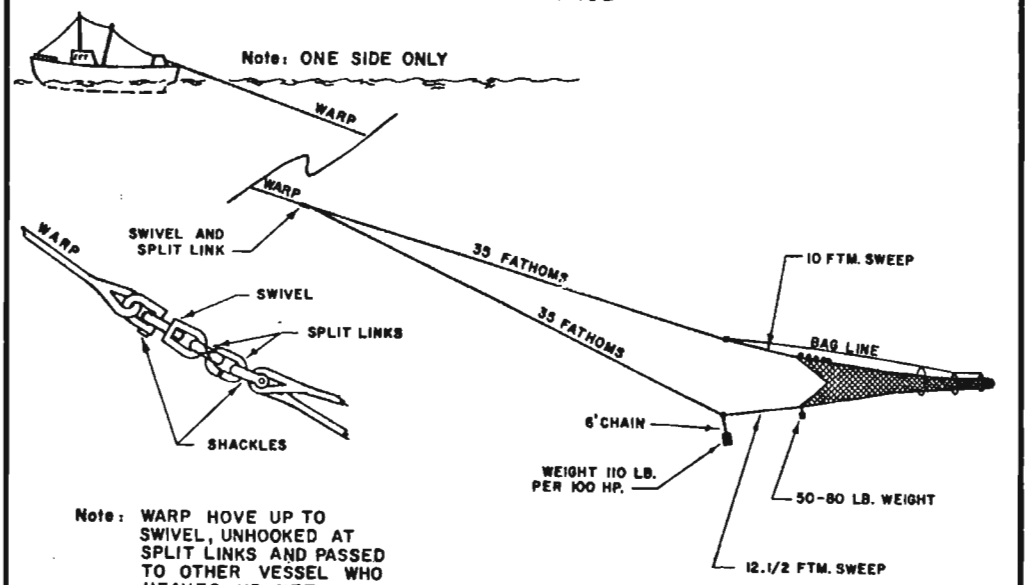
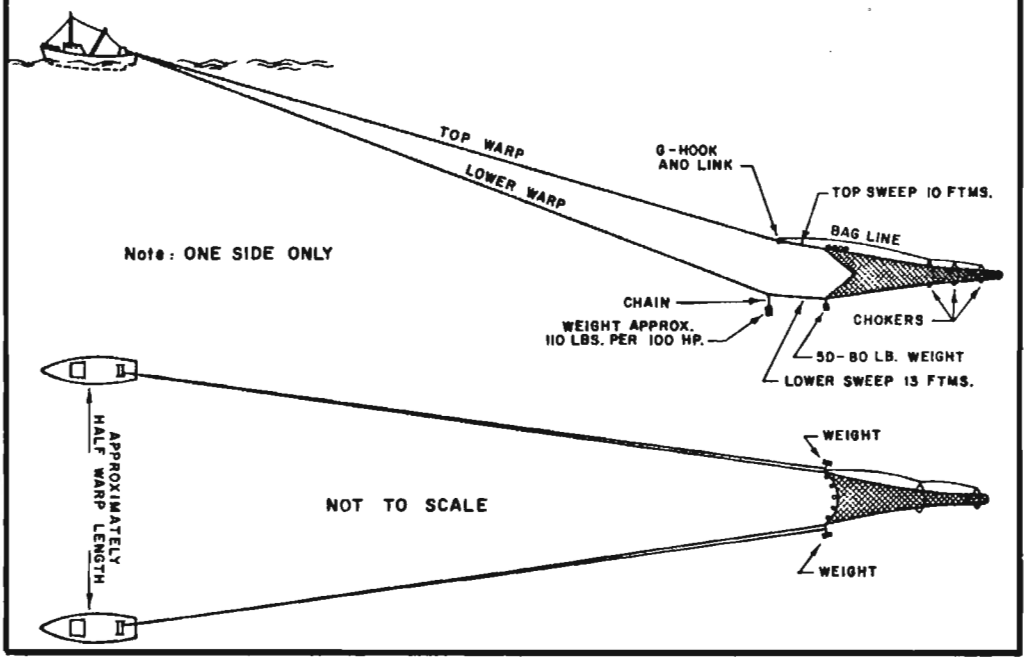


Figure 3. PAIR MIDWATER TRAWL
OPERATIONAL DIAGRAM



With the four warp system (see Figure 4), the pulling forces T and T1, and the resultant vertical forces P and P1 regulate the vertical spreading of the trawl. The rigging of the trawl is less complicated: that is no weights are needed along footrope and very few floats on the headline.

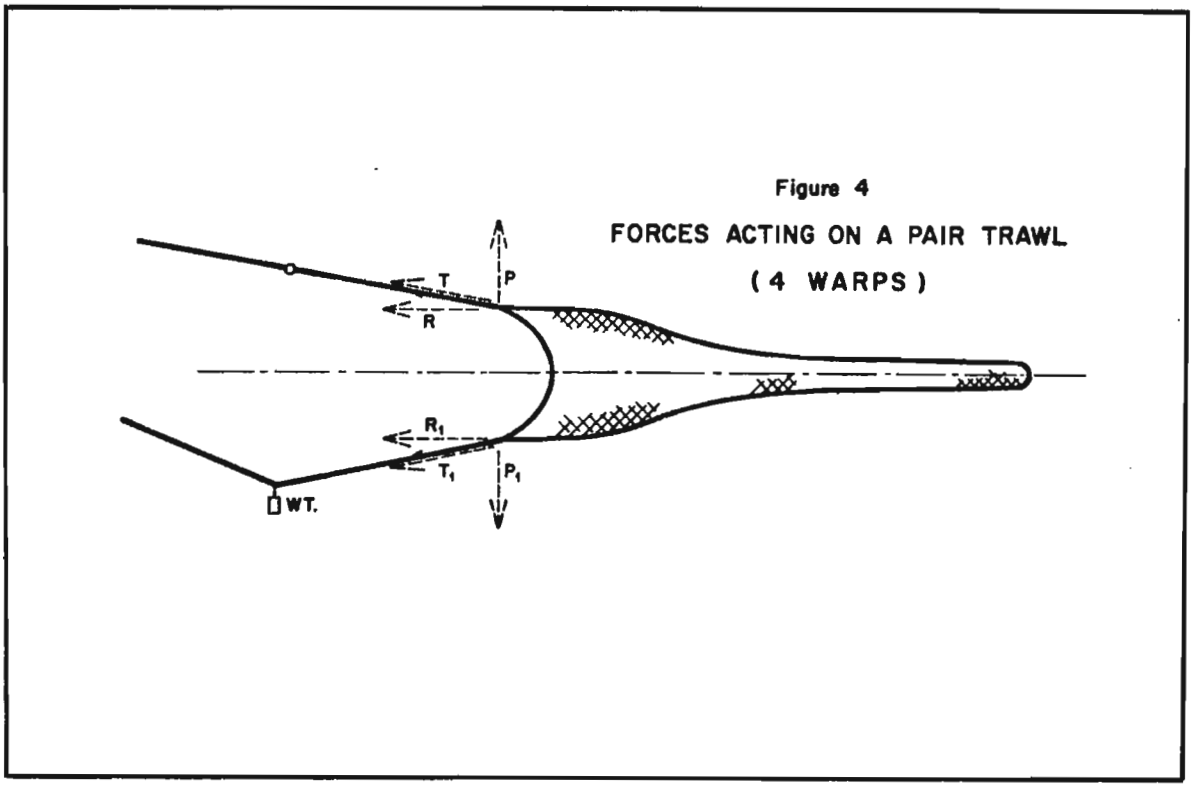


Figure 4

FORCES ACTING ON A PAIR TRAWL

(4 WARPS)

In addition, if a change over is made to bottom trawling it is known that both warps (on each vessel) will have remained the same length whereas with the two warp system, stretching of one warp is encountered. When using the two warp arrangement there can be no adjustments made to the net whilst towing, (with the four warp system when towing, adjusting the warps will reduce the vertical spread of the trawl. This is very useful when working near bad bottom).

Towing speeds vary between approximately 4 and 6 knots. It is necessary to tow fast enough to prevent the escape of the species being fished. The speed required varies the annual cycle. Herring, for instance, prior to and during spawning, become lethargic and are much easier to catch than other times of the year.

The use of boats of the same class and horsepower makes for easier working, but this is not a necessity. With unmatched vessels, the more powerful vessel, when slowed down to the other vessel's towing speed, takes more than half the load and therefore eases the strain on the smaller boat.

The capital cost of the vessels employed may be as low as 12% of the cost of a single vessel employing gear with the same capabilities. The boats can range from 40 feet -50 h.p. units up to 100 feet-800 h.p. although pair midwater trawling has been carried out in boats up to 180 feet with 1,250 h.p. In the larger vessels, however, (over 100 feet) operational costs are so high that two boat trawling could only be profitable under exceptionally good fishing conditions.

SHOOTING:

The net is set over the stern, usually before or against the wind, in the conventional manner, codend first. Care must be taken to ensure that the gear, especially the choker, is clear. Once the gear is in the water, the second boat picks up it's respective sweeps and attaches them to the tow wires by means of G hooks and recessed links. The boat with the net usually leaves its sweeps attached to the warps.

This manoeuvre of picking up the sweeps depends entirely on the weather prevailing. In fine weather the ships can come alongside but in any significant sea the sweeps are passed by the use of a heaving line snaphooked into the sweeps for easy removal. It must be said here that both boats should be heavily fendered for coming alongside.

With the net thus attached and with the winch brakes set, the boats veer away from each other spreading the gear. When it is seen to be clear, the brakes are released, the weights dropped and the warps run out to a predetermined length. At this point the vessels should be half the warp length apart with the warp marks square and the brakes set. The tow is commenced along an agreed course at the desired speed.

When pair trawling for pelagic or demersal species, "aimed trawling" is the main factor which determines the level of success.

TOWING:

During the tow a careful watch must be maintained for fish marks on the fish finding equipment of both vessels. If both boats are marking fish then the towing course is maintained. If one vessel records a mark on his side, the the boats are sharply turned towards it, and an attempt is made to line up the net with the mark, the boats are then turned back onto their original course, maintaining the half warp-length ratio between them. If one vessel continually keeps marking fish on his side, then the vessels again turn to that side until both boats are marking the fish, and a new towing course is set.

If during a tow the vessels run out of marks they can be turned around to tow back through those seen before. In turning, the vessels close up to about 100 feet apart and with the outside vessel on the turn going full speed, the inside vessel slows down and keeps pace until the reciprocal course is attained. (This slowing procedure of the inside boat applies to any course alteration.) If more wire is needed during the tow to allow the trawl go deeper, then the required amount is let out and the brakes set again.

The length of the tow will be dependant on the fish marks seen and may be as short as a few minutes on heavy marks to as long as three or four hours on light scattered marks.

HAULING:

At the end of the tow, the vessels come together until they are about 50 feet apart (alongside in good weather). The winches are engaged and hauling commences with the vessels maintaining headway. When the weights come up to the towing blocks and with the vessels still going ahead, the dickie line is unhooked, put on the warping head and hove in to close off the choker which stops fish escaping into the large mesh sections.

When the strain is on the dickie line, the boats are stopped, the sweeps passed across to the hauling boat and net hauling commences.

Hauling the smaller nets can be accomplished manually but mechanization is needed with the larger nets (from 2 x 200 h.p. size up). In this project a power block on a slewing boom was used, (see diagram and photos). The power block is mainly used in Europe for the hauling of midwater trawls in boats up to 85 feet with approximately 800 h.p. It is especially useful when splitting a bag of fish. The bag is left in the block and when the codend has been emptied and thrown overboard, the slack is taken up through the block, flushing the fish down into the codend ready for another lift. Used in conjunction with a fish pump it is a very fast and easy method since the tedious and slow job of fleeting is obviated.

During the period when the net is being hauled, the other boat should be scouting the area to try to locate marks. If marks are found the net is set again as soon as hauling is completed. In this way no time is lost. It must be stressed here that a lot of time, (even days, when fish are scarce) may have to be spent in a searching mode. It is useless to set the net and tow the gear if no marks are seen.

OBSERVATIONS ON NEWFOUNDLAND PROJECT:

1. It was noted when turning during a tow and also when lifting a bag of fish (2,500 lbs) that the boats developed a pronounced list (approximately 15°)

2. The vessels when built were not fitted with propellers of suitable speed and size for towing. In most boats of this type (longliners) the reduction gear ratio is too low and hence the propeller speed is too high.

3. Lack of adequate landing facilities caused undue delay in turnaround time.

4. The method can be used in conjunction with the ring net i.e. one boat with the pair trawl and one with the ring net either gear can be shot as circumstances permit.

5. Where large amounts of herring are seen on the bottom it would be advisable to have a high reaching bottom or combination trawl onboard in addition to the pelagic trawl.

6. Hanging ratios and net dimensions of midwater trawls are extremely critical and it would therefore be advisable for fishermen to purchase the first net from the manufacturer rather than trying to build one.

APPENDIX 1 - Vessel and Equipment Specifications

APPENDIX 11 - Costs of Gear and Conversion

APPENDIX 111 - Tow Sheet

APPENDIX 1

THE VESSELS:

		Susan & Sisters	Sylvia & Sisters
Owner	:	Martin Smith Harbour Grace Newfoundland	Austin Forward Harbour Grace Newfoundland
Registration Number	:	347236	346771
Reg. Length	:	58'	58'
Reg. Depth	:	5'8"	5'8"
Reg. Breadth	:	16'8"	16'8"
Engine	:	Cummins NT380	Cummins NT380
Reduction	:	2.94:1	2.94:1
Propeller	:	42" x 30" x 3	42" x 30" x 3
Power Take Off	:	Twin Disc	Twin Disc
Shaft H.P. (at 2000 r.p.m.)	:	236	236

ELECTRONICS:

Elac Echosounder	Elac Echosounder
S.S.B. Transceiver	S.S.B. Transceiver
Minidec Navigator	----
Loran Navigator	Loran Navigator
----	Autopilot

DECK EQUIPMENT:

Winch - Norlau #8	Winch - Norlau #8
Cap. - 285 fms of 1/2"	Cap. - 285 fms of 1/2"
Power Block	----
Marco 19" on Hydraulic Boom	
Gallows, Lead Blocks and Fish Gilson	Gallows, Lead Blocks and Fish Gilson

APPENDIX 11

COSTS OF GEAR AND CONVERSION

NETS:

2	Pair trawls of 2 x 250 h.p. size complete	$ 4,140.
1	Complete net in spares	1,855.
1	Capelin brailer (12 fathoms)	627.
	+ air freight for same	556.
	Nets TOTAL	$ 7,178.
	Twine for mending purposes	$ 80.
8	Sweeps for both nets and swivels	139.
	Shackles, swivels, Chain, codend clips, G. hooks, recessed links, etc.	500.
	Polyrope for Dickielines	170.
	Floats - 8 - 8" x 35" plastic polyform fender type	80.
	Weights - 2 x 300 lbs. + 2 x 50 lbs.	60.
	Nets & Associated Gear TOTAL	$ 8,207.

HYDRAULIC POWER BLOCK & SLEWING CRANE:

	Marco open sided 19" power sheave	$ 1,773.
	Seattle - Newfoundland - Air Freight	83.
	Sub TOTAL	$ 1,856.
2	Hydraulic lifting and Slewing Rams Control valve, flow control valve & filter	1,700.
	Ontario - Newfoundland - Air Freight	80.
	Hydraulic hoses and fittings	300.
	Time to install hydraulics	800.
	Block and Hydraulics TOTAL	$ 4,736.
	Steel for Crane	$ 200.
	Time on Welding & Fitting of same	150.
	Crane TOTAL	$ 350.
	BLOCK & SLEWING CRANE TOTAL	$ 5,086.

STEELWORK:

(a)	4 Gallows + Joining Beams - Steel	$ 450.
	Welding time	500.
(b)	2 Gilsons rigged - Steelwork + standing rigging	226.
	Welding time	432.
	Blocks & Gilson ropes	300.
	Gallows & Gilsons TOTAL	$ 1,908.

TOW SHEET

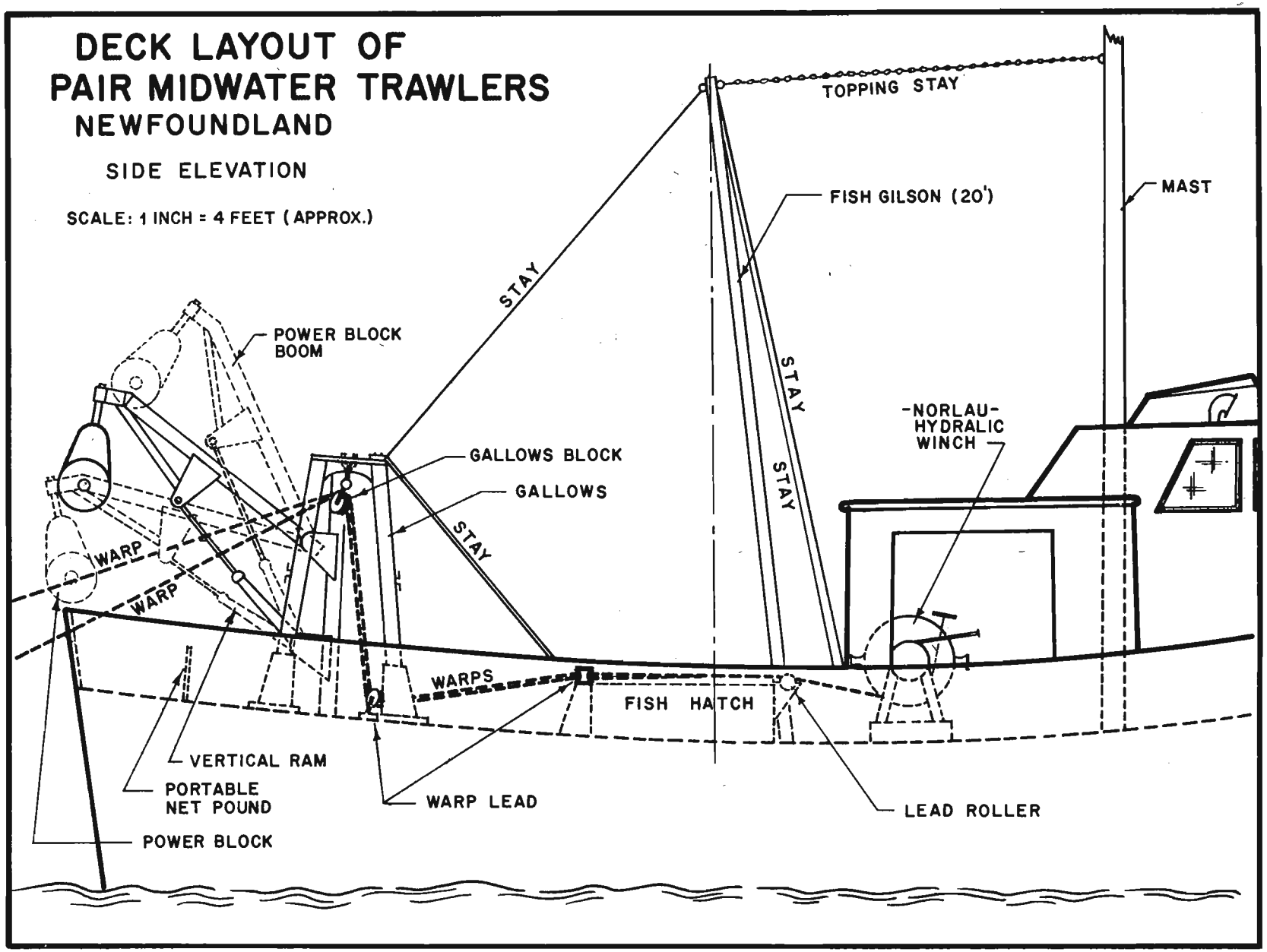
PAIR MIDWATER TRAWL 1973 - NEWFOUNDLAND

Date	Tow No.	Towing Time	Catch	
			Capelin	Herring & Mackerel
July 14	1	55	27,000	3,000
July 17	1	40	25,000	
	2	50	18,000	
	3	30	15,000	
	4	40	15,000	
	5	30	17,000	
July 20	1	25	40,000	
	2	12	45,000	
July 24	1	15	25,000	
	2	15	12,000	1,500
July 25	1	55		11,000
	2	55		12,080
July 26	1	50		7,000
July 30	1	60		5,380
July 31	1	55		800
Aug. 20	1	10		3,700
Aug. 22	1	10		15
	2	20		3,500
	3	15		4,000
	4	20		2,000
	5	20		4,500
Aug. 24	1	30		25
	2	30		500
	3	60		400
Aug. 26	1	30		500
	2	20		500
	3	60		1,500
Aug. 31	1	15		2,200
Sept. 1	1	40		12,000
	2	45		4,000
	3	45		3,500
	4	60		2,000
Sept. 3	1	60		20,000
	2	60		6,000
Sept. 4	1	40		6,500
Sept. 8	1	45		10,800
TOTAL	36	1,322 Min.	239,000	116,900
TOTAL		22.03 Hr.	355,900 lbs.	

APPENDIX lV - Diagrams

APPENDIX V - Photographs

APPENDIX Vl - Echograms

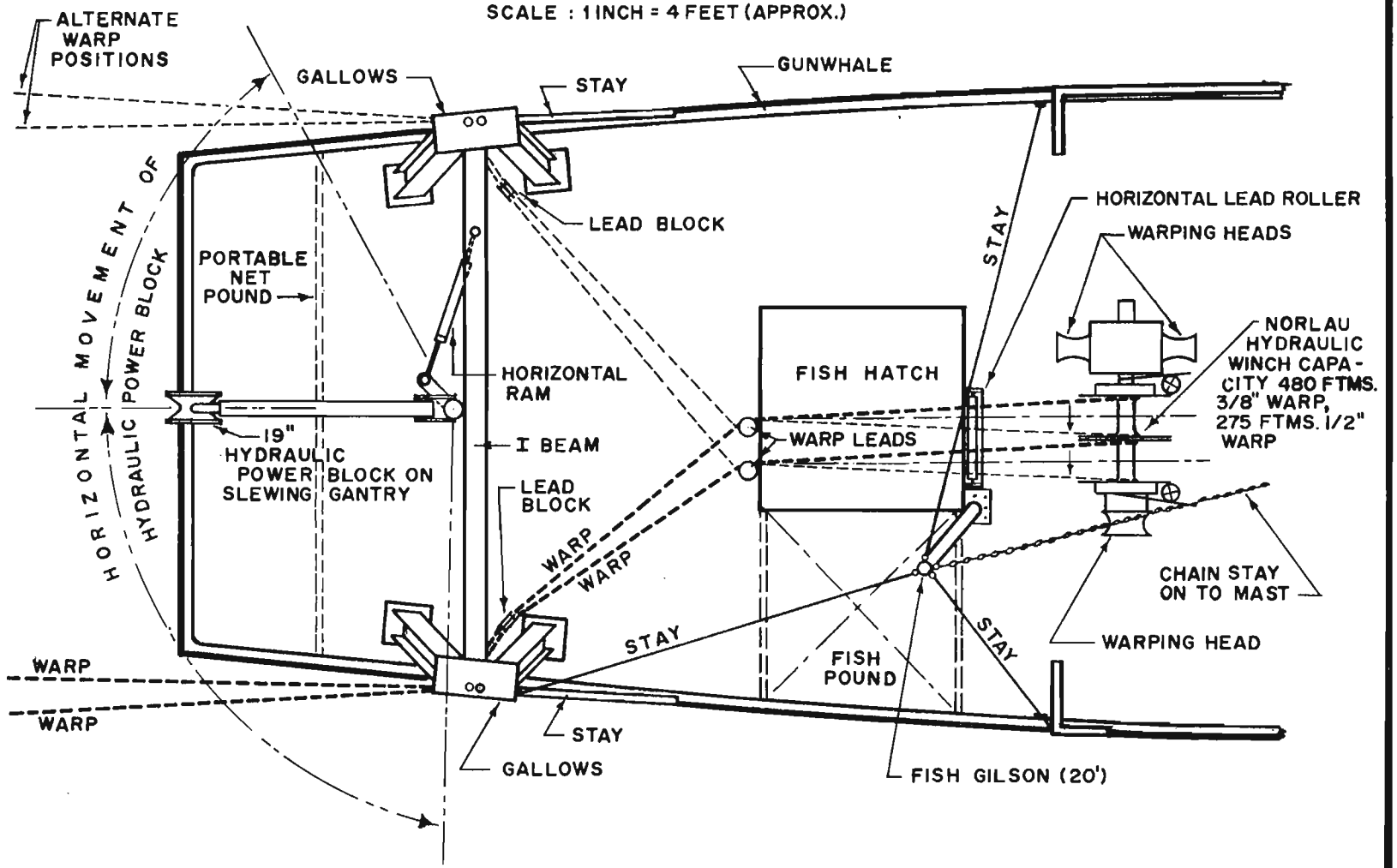

DECK LAYOUT OF
PAIR MIDWATER TRAWLERS
NEWFOUNDLAND
SIDE ELEVATION
SCALE: 1 INCH = 4 FEET (APPROX.)
TOPPING STAY
FISH GILSON (20')
MAST
STAY
STAY
STAY
POWER BLOCK
BOOM
-NORLAU-
HYDRALIC
WINCH
GALLOWS BLOCK
GALLOWS
STAY
WARP
WARP
WARPS
FISH HATCH
VERTICAL RAM
PORTABLE
NET POUND
WARP LEAD
LEAD ROLLER
POWER BLOCK

DECK LAYOUT OF PAIR MIDWATER TRAWLERS

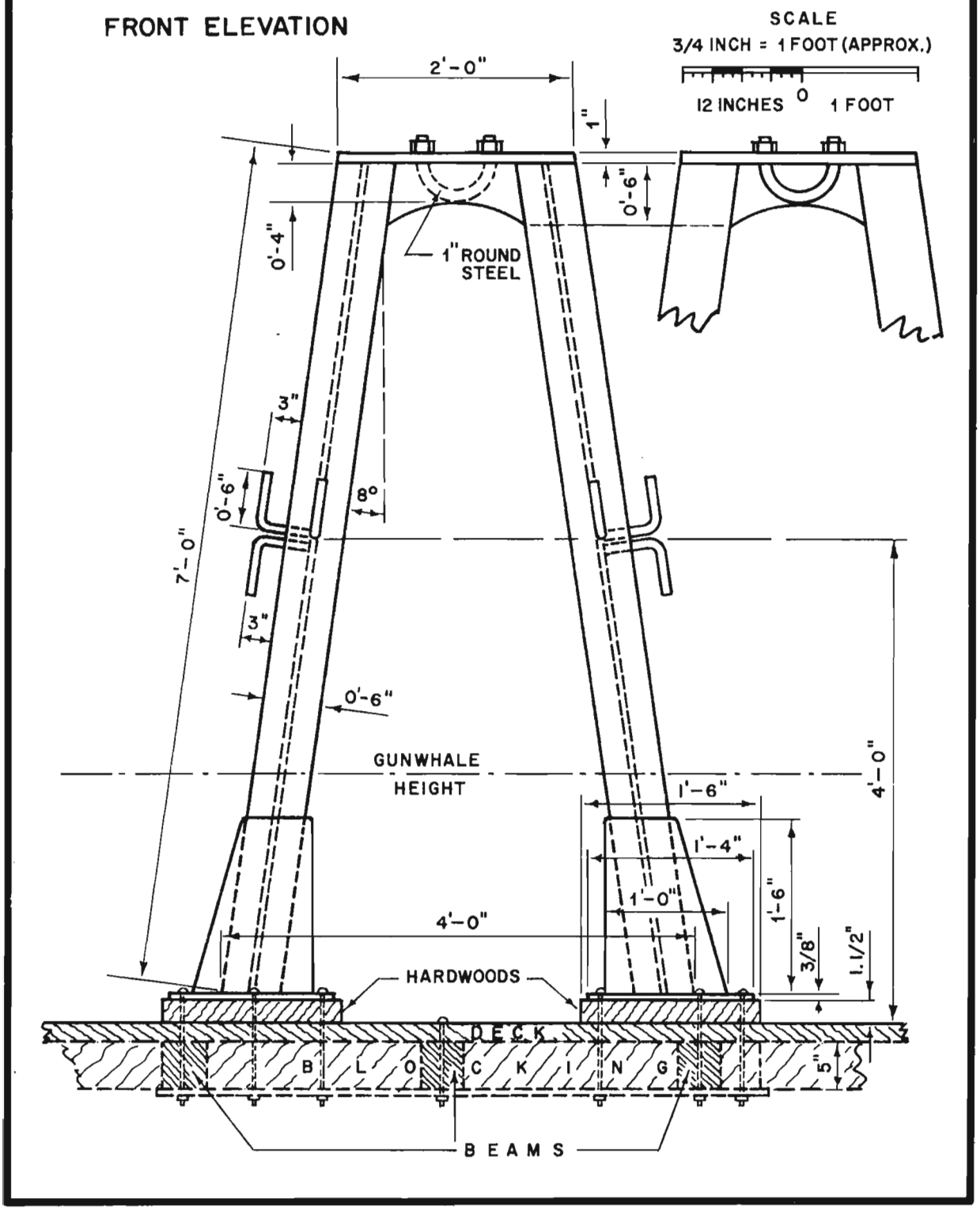
NEWFOUNDLAND

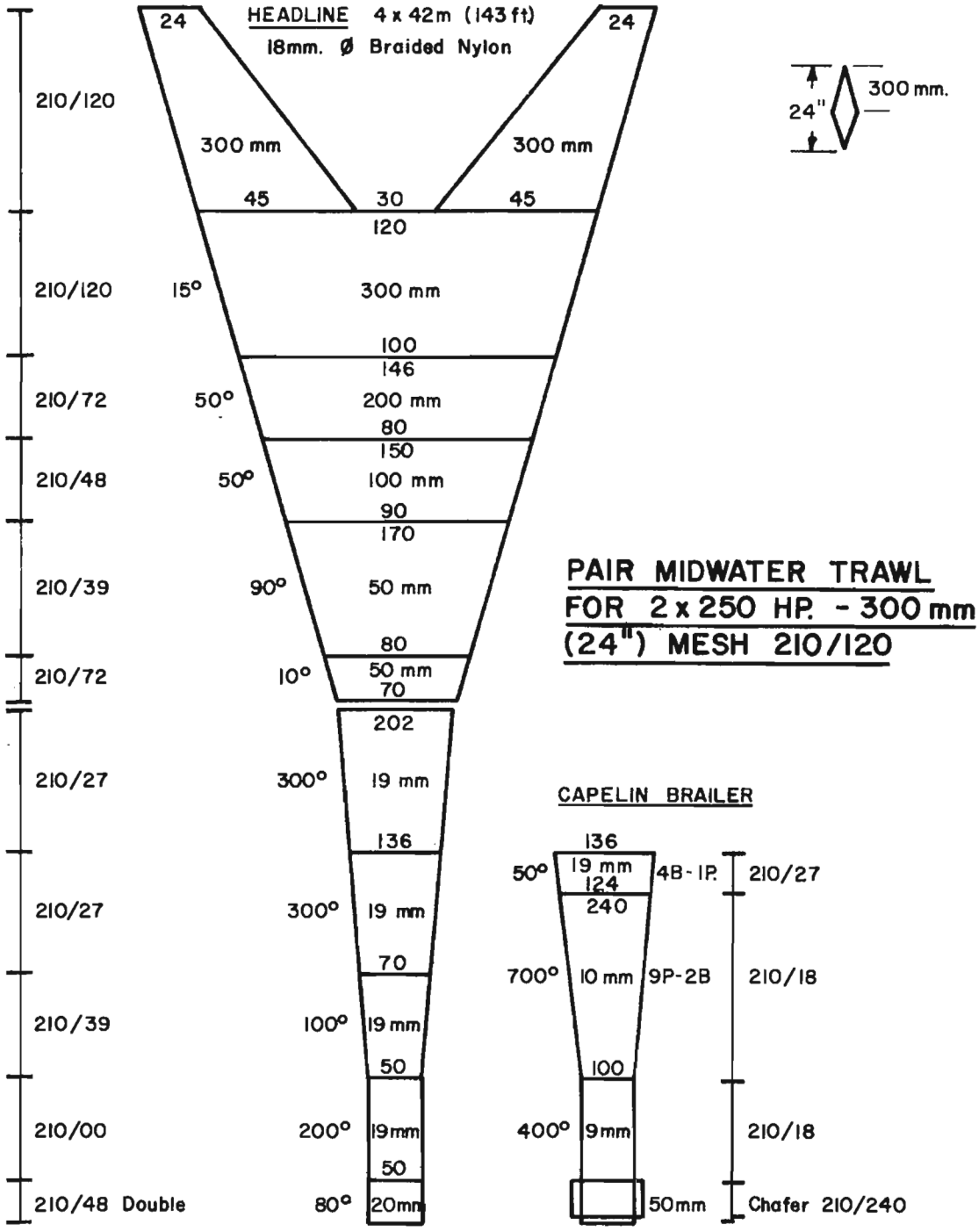
PLAN VIEW

SCALE : 1 INCH = 4 FEET (APPROX.)



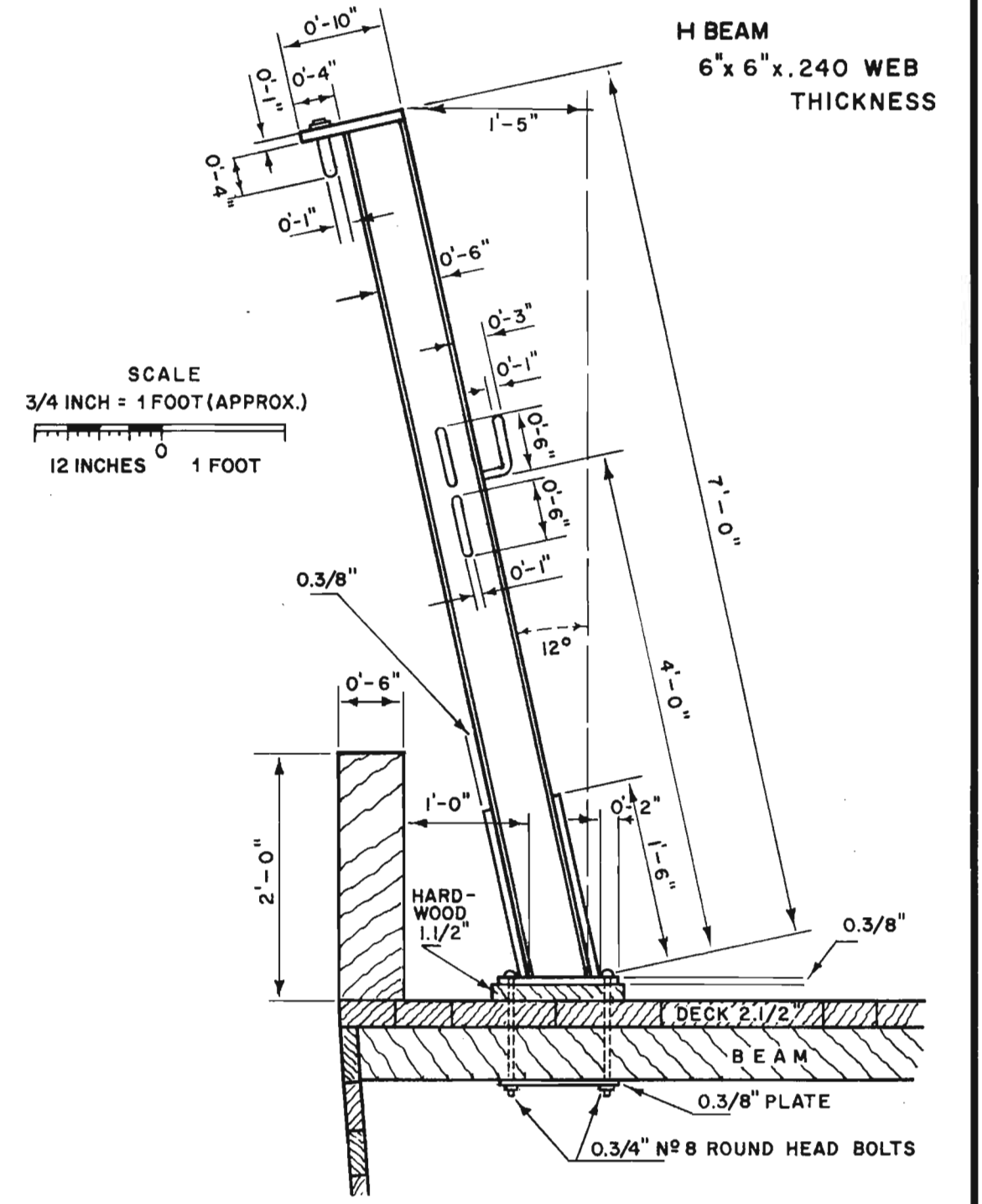
GALLOWS FRAME FOR PAIR TRAWLERS
NEWFOUNDLAND

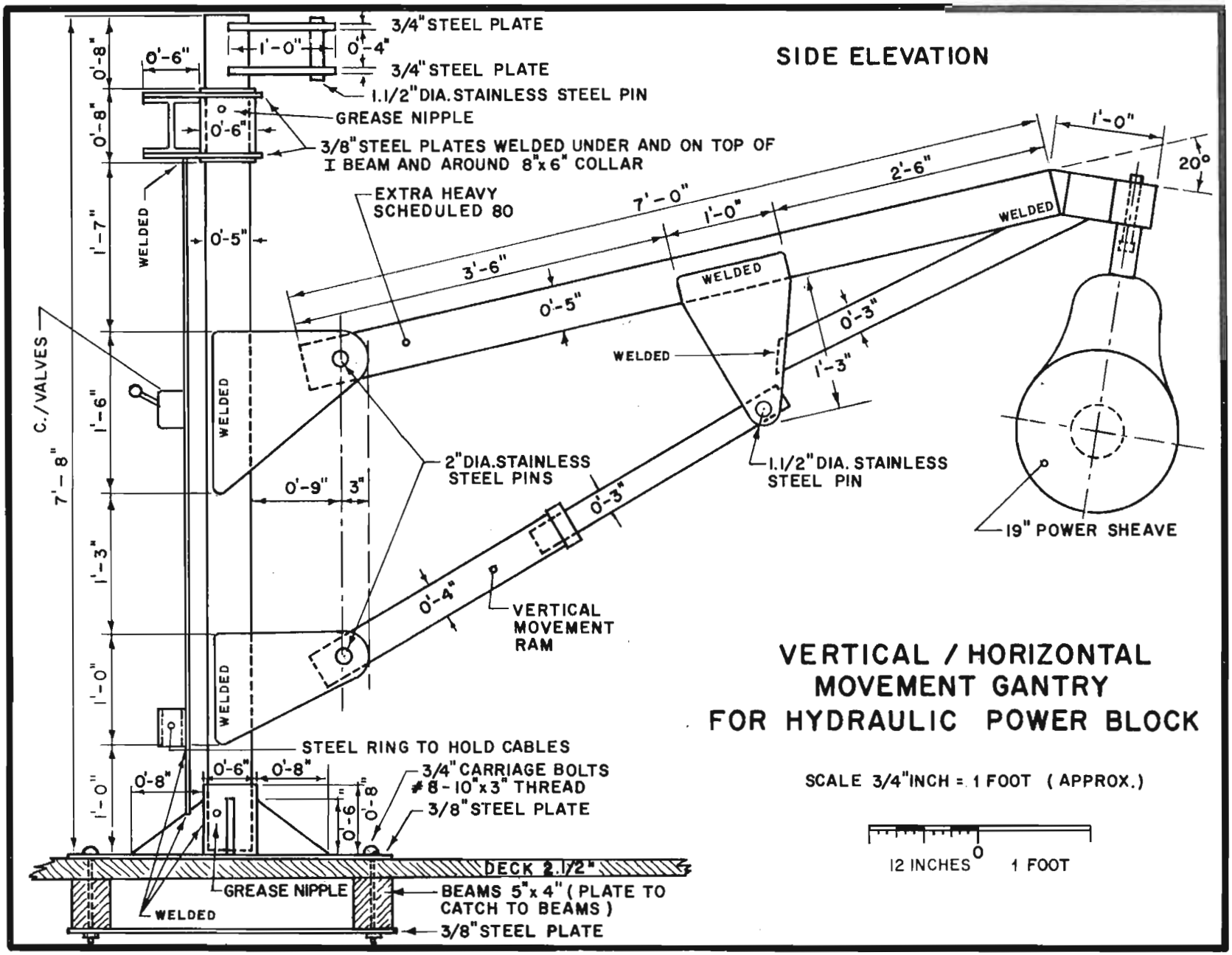


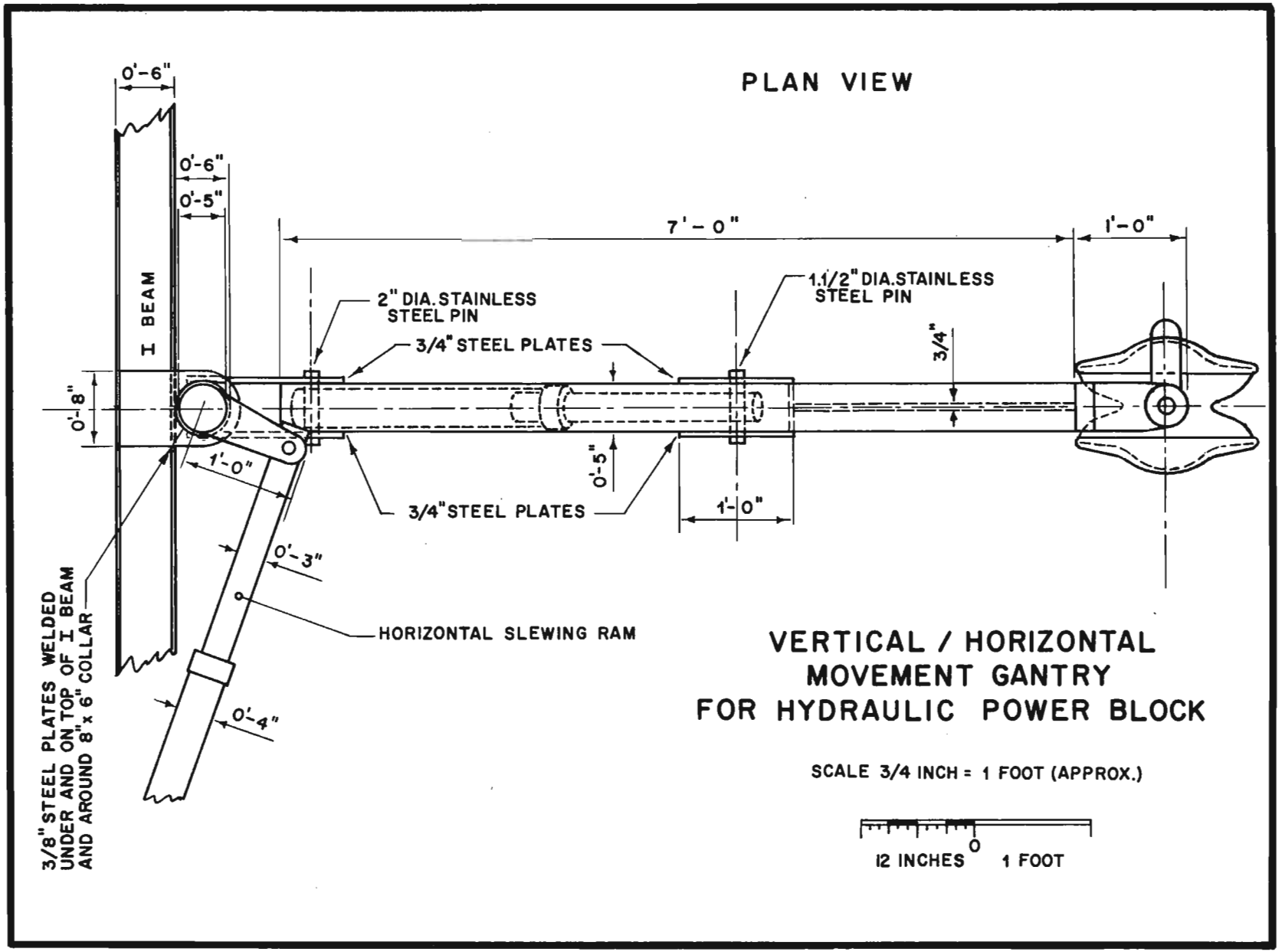

HEADLINE 4 x 42m (143 ft)
18mm. Ø Braided Nylon
24
24
300 mm
300 mm
45
30
45
120
210/120
210/120
15°
300 mm
100
146
210/72
50°
200 mm
80
150
210/48
50°
100 mm
90
170
210/39
90°
50 mm
80
210/72
10°
50 mm
70
202
210/27
300°
19 mm
136
210/27
300°
19 mm
70
210/39
100°
19 mm
50
210/00
200°
19mm
50
210/48 Double
80°
20mm
300 mm.
24"
PAIR MIDWATER TRAWL
FOR 2 x 250 HP. - 300 mm
(24") MESH 210/120
CAPELIN BRAILER
136
50°
19 mm
124
48-IP.
210/27
240
700°
10 mm
9P-2B
210/18
100
400°
9mm
210/18
50mm
Chafer 210/240

GALLOWS FRAME FOR PAIR TRAWLERS
NEWFOUNDLAND

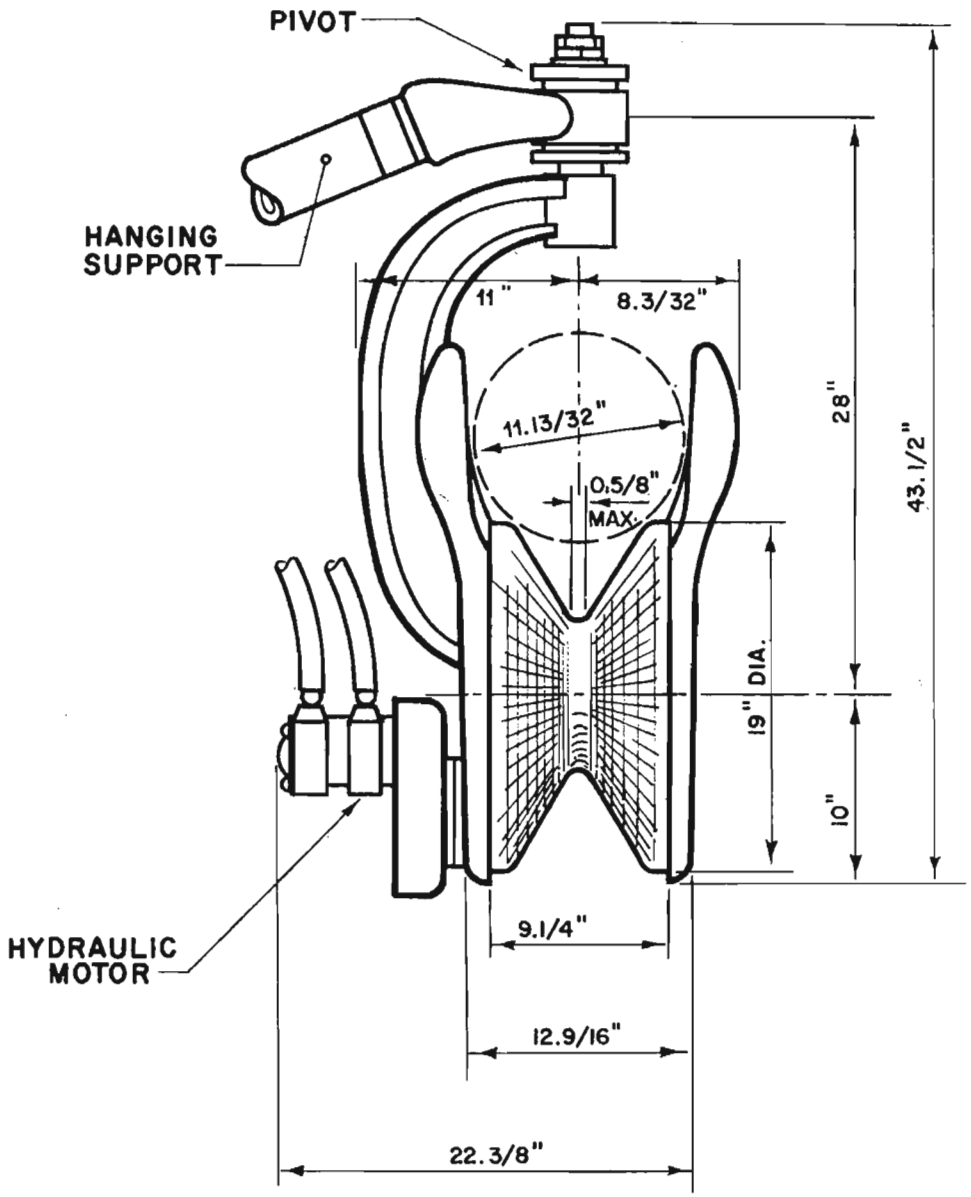
SIDE ELEVATION

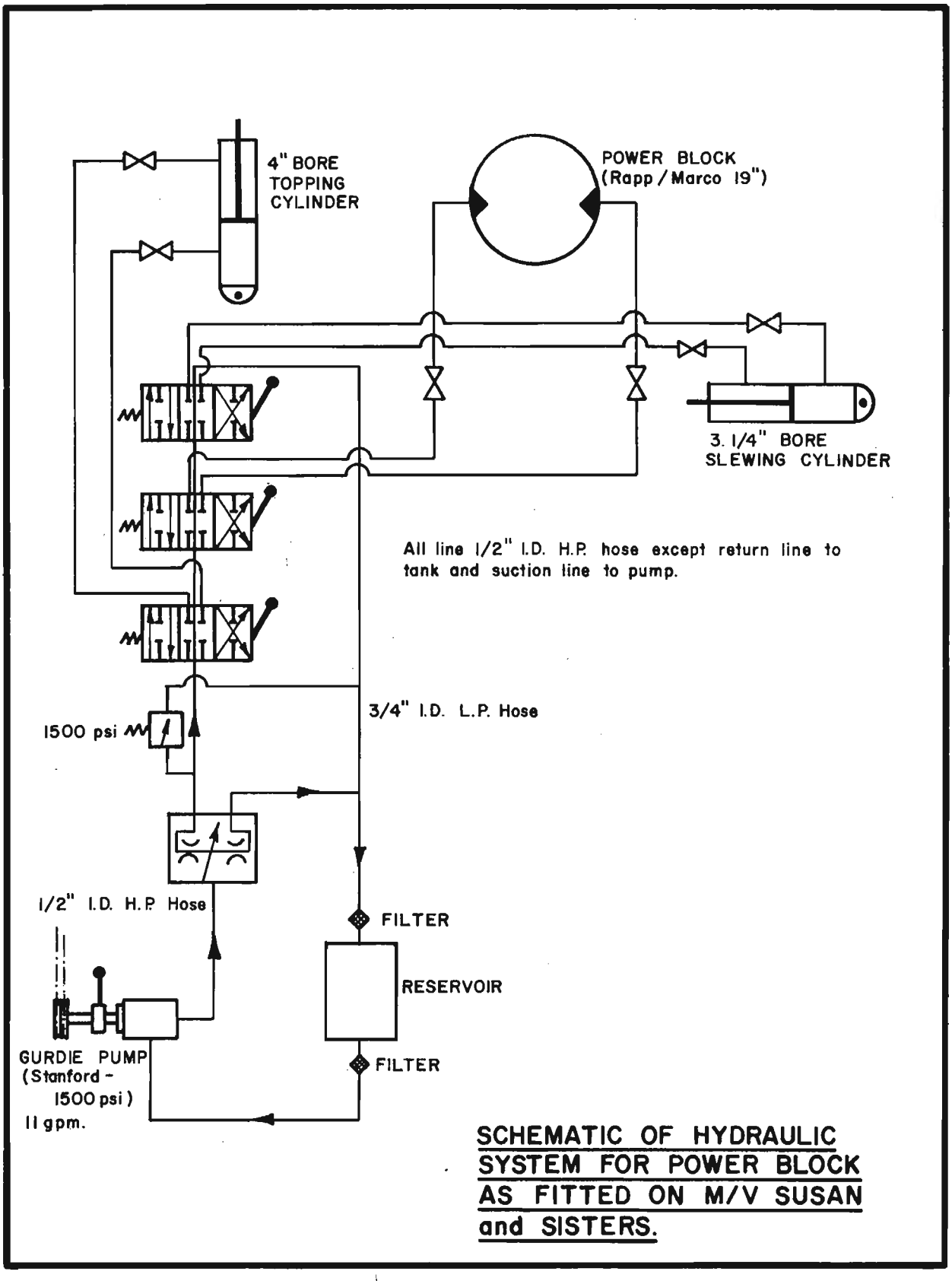



SIDE ELEVATION
3/4" STEEL PLATE
1'-0"
0'-4"
3/4" STEEL PLATE
1.1/2" DIA. STAINLESS STEEL PIN
GREASE NIPPLE
3/8" STEEL PLATES WELDED UNDER AND ON TOP OF I BEAM AND AROUND 8"x6" COLLAR
EXTRA HEAVY SCHEDULED 80
7'-0"
1'-0"
2'-6"
20°
3'-6"
0'-5"
WELDED
0'-3"
1'-3"
2" DIA. STAINLESS STEEL PINS
1.1/2" DIA. STAINLESS STEEL PIN
19" POWER SHEAVE
C./VALVES
7'-8"
0'-8"
1'-7"
1'-6"
1'-3"
1'-0"
0'-6"
0'-5"
0'-9"
3"
0'-4"
VERTICAL MOVEMENT RAM
STEEL RING TO HOLD CABLES
0'-8"
3/4" CARRIAGE BOLTS # 8-10"x3" THREAD
3/8" STEEL PLATE
DECK 2.1/2"
GREASE NIPPLE
BEAMS 5"x4" (PLATE TO CATCH TO BEAMS)
3/8" STEEL PLATE
VERTICAL / HORIZONTAL MOVEMENT GANTRY FOR HYDRAULIC POWER BLOCK
SCALE 3/4" INCH = 1 FOOT (APPROX.)
12 INCHES 0 1 FOOT


PLAN VIEW
0'-6"
0'-6"
0'-5"
I BEAM
7'-0"
1'-0"
2" DIA. STAINLESS STEEL PIN
1.1/2" DIA. STAINLESS STEEL PIN
3/4" STEEL PLATES
3/4"
0'-8"
1'-0"
0'-5"
3/4" STEEL PLATES
1'-0"
0'-3"
HORIZONTAL SLEWING RAM
3/8" STEEL PLATES WELDED UNDER AND ON TOP OF I BEAM AND AROUND 8" x 6" COLLAR
0'-4"
VERTICAL / HORIZONTAL MOVEMENT GANTRY FOR HYDRAULIC POWER BLOCK
SCALE 3/4 INCH = 1 FOOT (APPROX.)
0
12 INCHES
1 FOOT

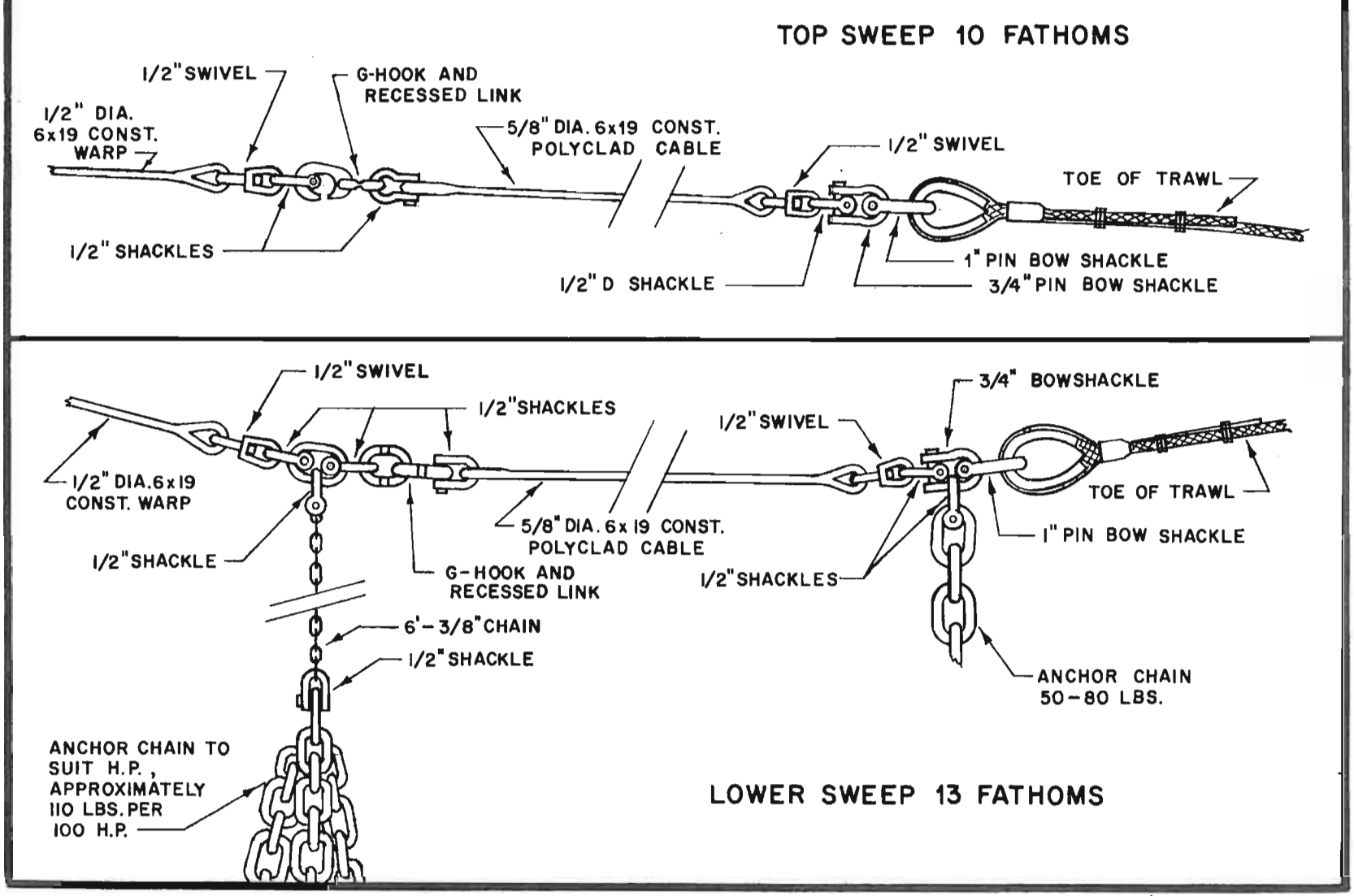
MARCO POWER SHEAVE





SCHEMATIC OF HYDRAULIC SYSTEM FOR POWER BLOCK AS FITTED ON M/V SUSAN and SISTERS.

SWEEPS, WEIGHTS, NET, HOOK-UP FOR PAIR M.W.T.

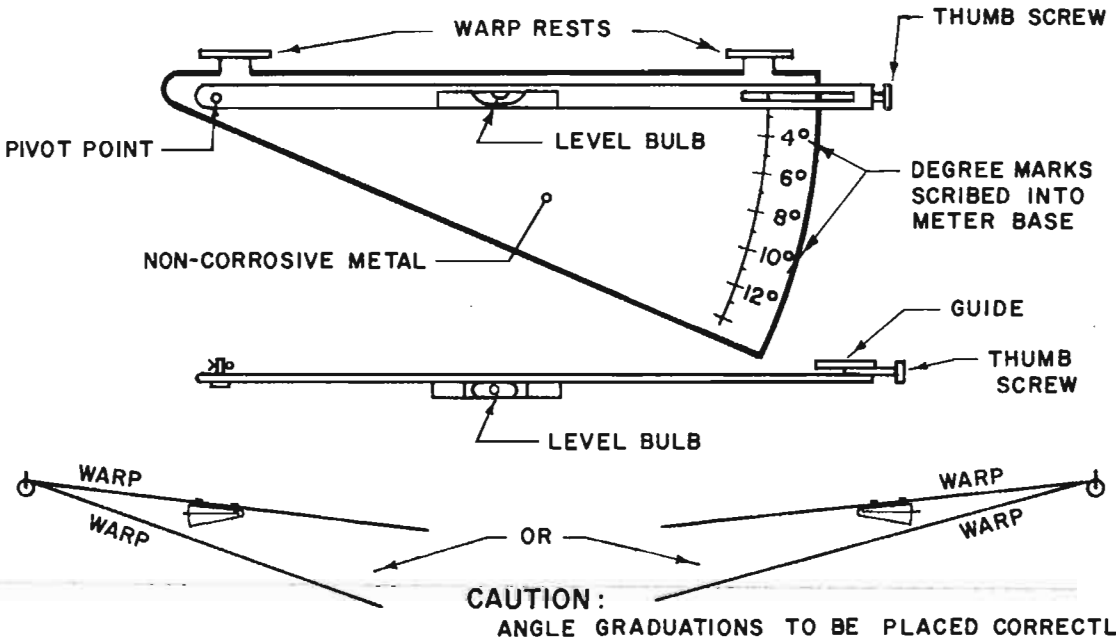


HEADLINE DEPTH FOR VARIOUS WARP ANGLES AND TOW WARP LENGTHS

(ROUNDED OF TO THE NEAREST HALF-FATHOM)

LENGTH OF TOW WARP (FATHOMS)	MEASURED WARP ANGLE							
	5°	6°	7°	8°	9°	10°	11°	12°
25	2	2.1/2	3	3.1/2	4	4.1/2	5	5
50	4.1/2	5	6	7	8	8.1/2	9.1/2	10.1/2
75	6.1/2	8	9	10.1/2	11.1/2	13	14.1/2	15.1/2
100	8.1/2	10.1/2	12	14	15.1/2	17.1/2	19	21
125	11	13	15	17.1/2	19.1/2	21.1/2	24	26
150	13	15.1/2	18.1/2	21	23.1/2	26	28.1/2	31
175	15.1/2	18.1/2	21.1/2	24.1/2	27.1/2	30.1/2	33.1/2	36.1/2

WARP ANGLE METER

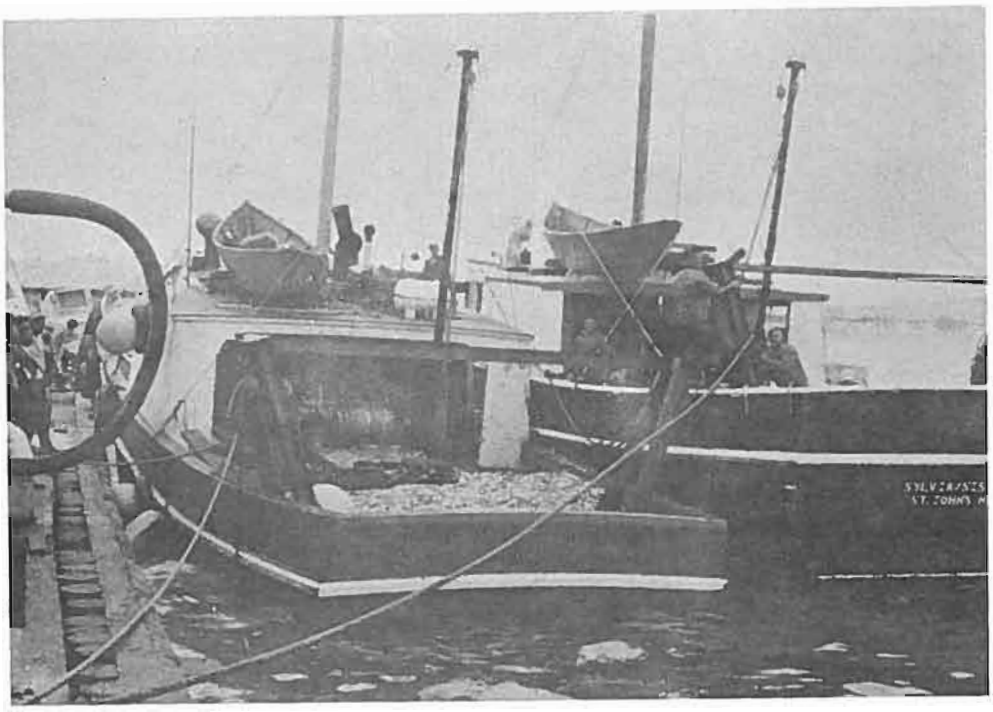


CAUTION:
ANGLE GRADUATIONS TO BE PLACED CORRECTLY.

VESSELS USED FOR PAIR MIDWATER TRAWL EXPERIMENTS

MV Susan and Sisters

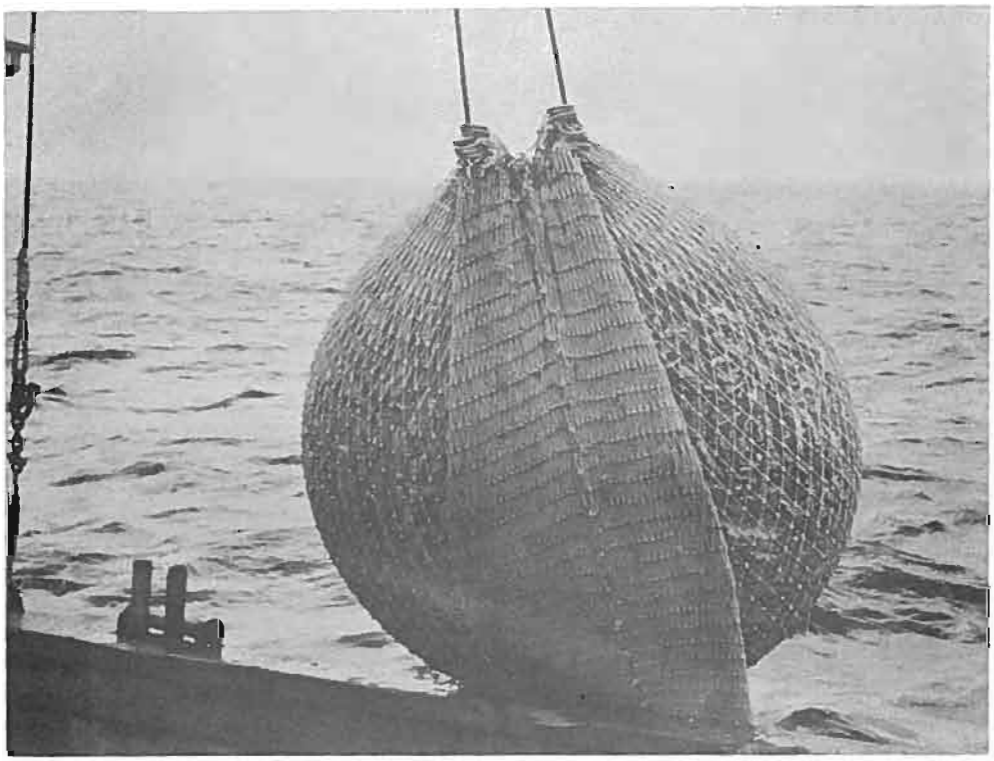
MV Sylvia and Sisters



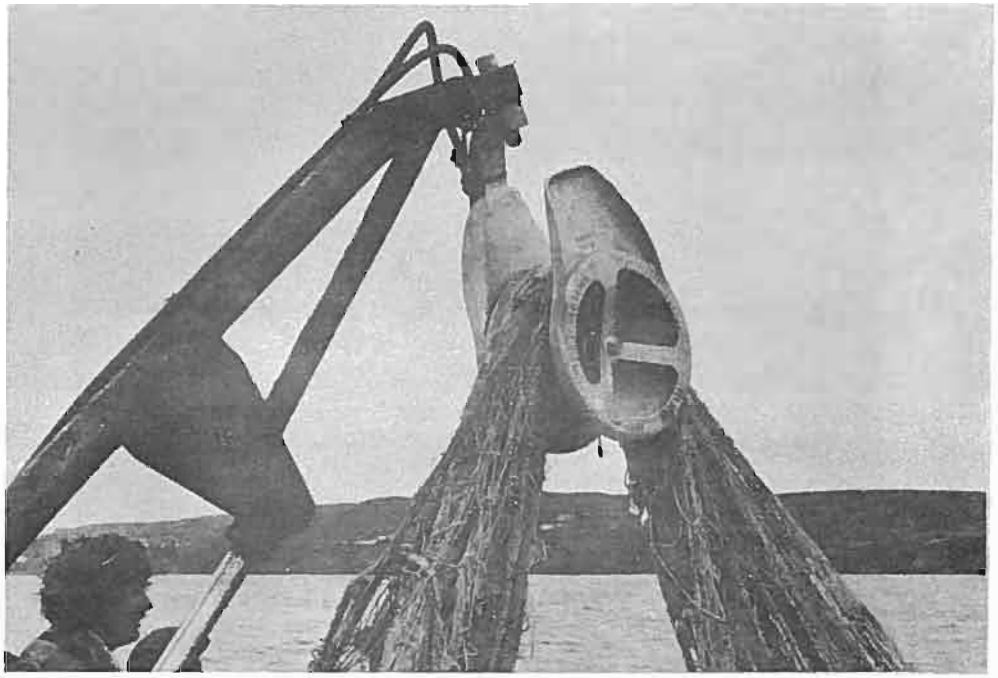
Susan and Sisters — 90,000 lbs. Capelin

Overflowing Through the Scuppers

A Lift of Herring



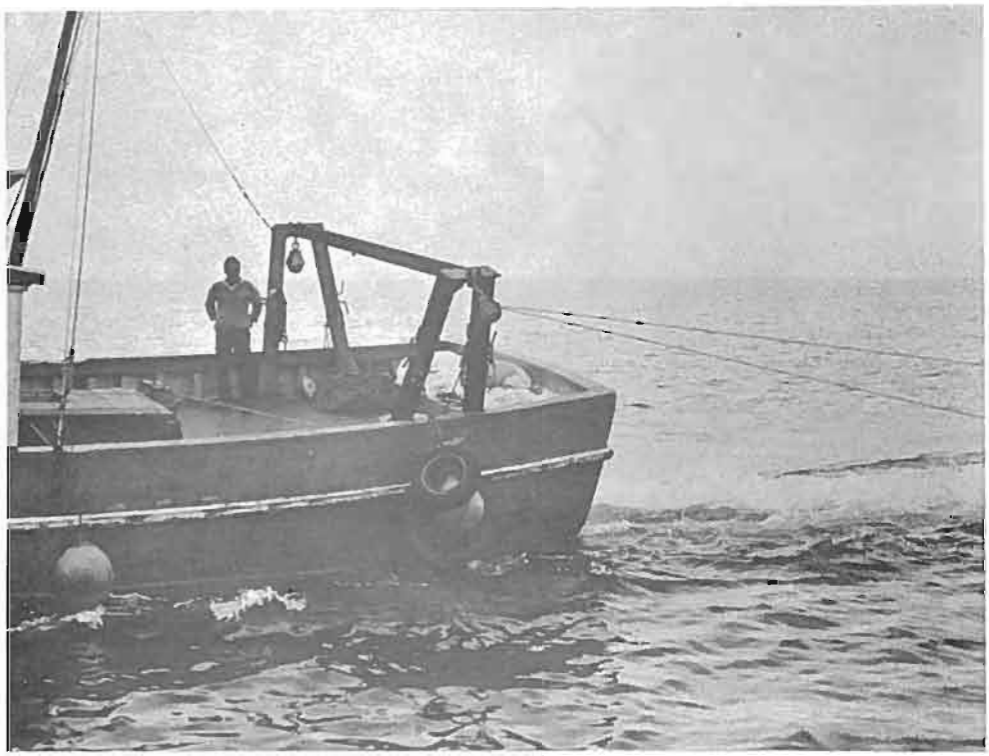
A Lift of Capelin



Hauling with the Power Block

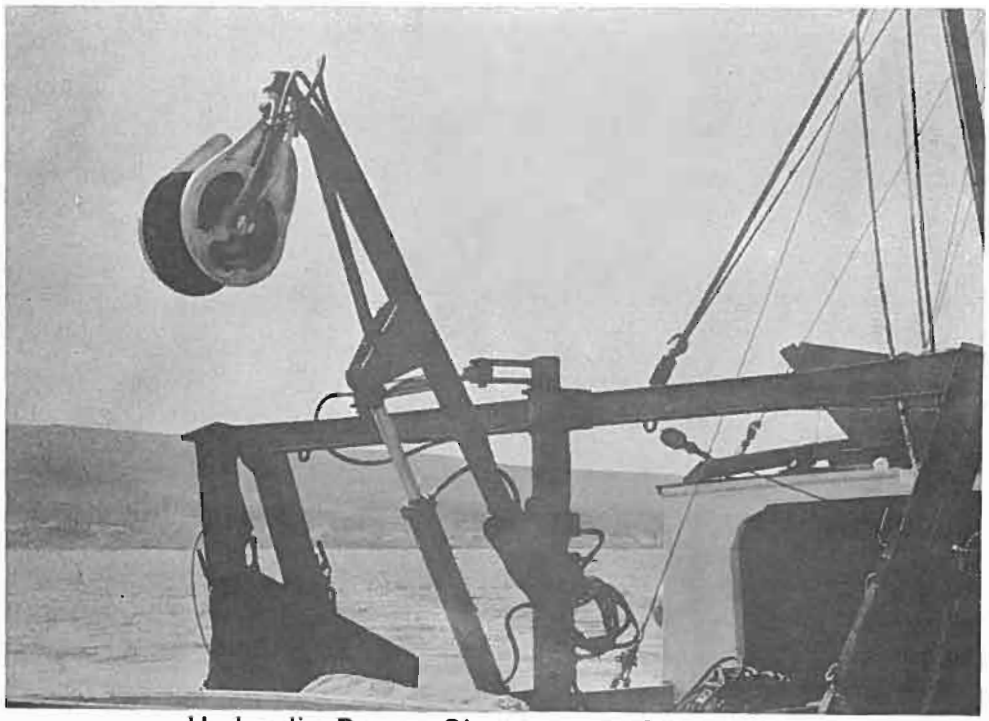
Herring Alongside

300 lb. Weight on Lower Warp

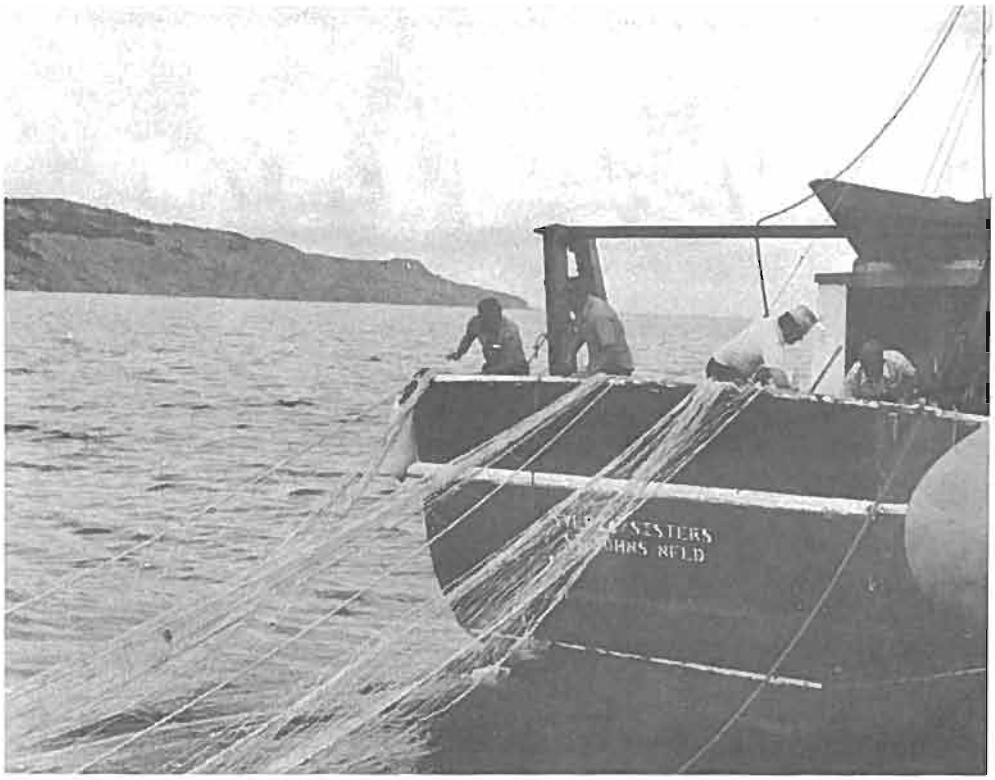


Coming Together at End of Tow

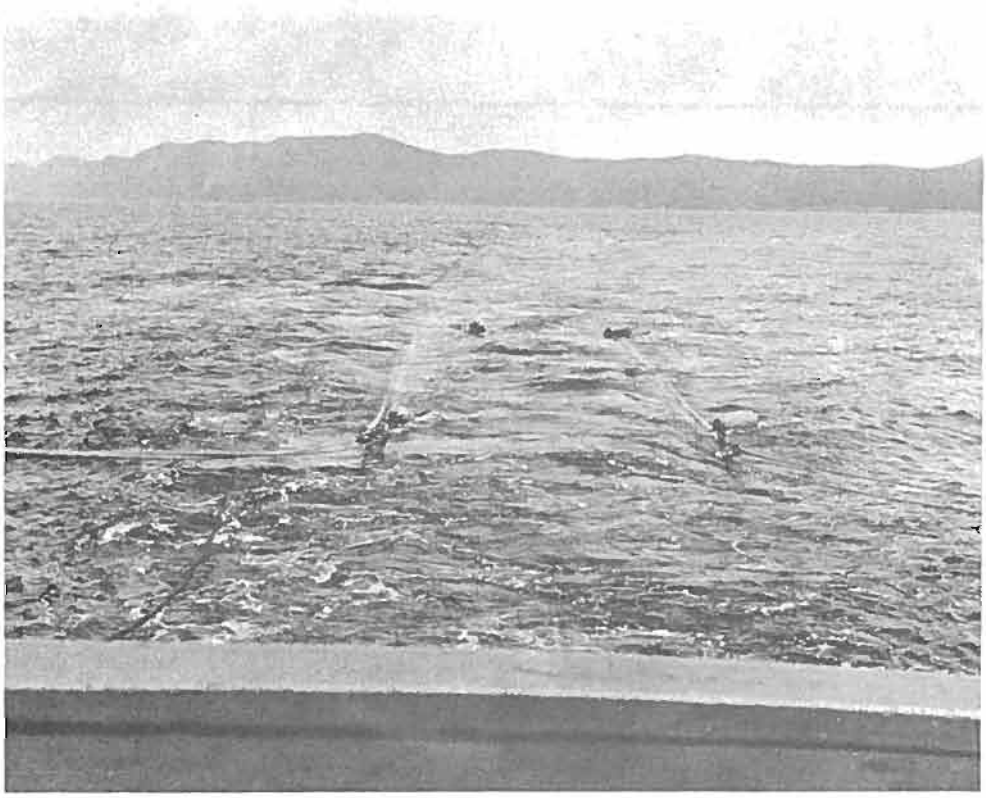
Towing — Note Divergence of Top and Bottom Warp



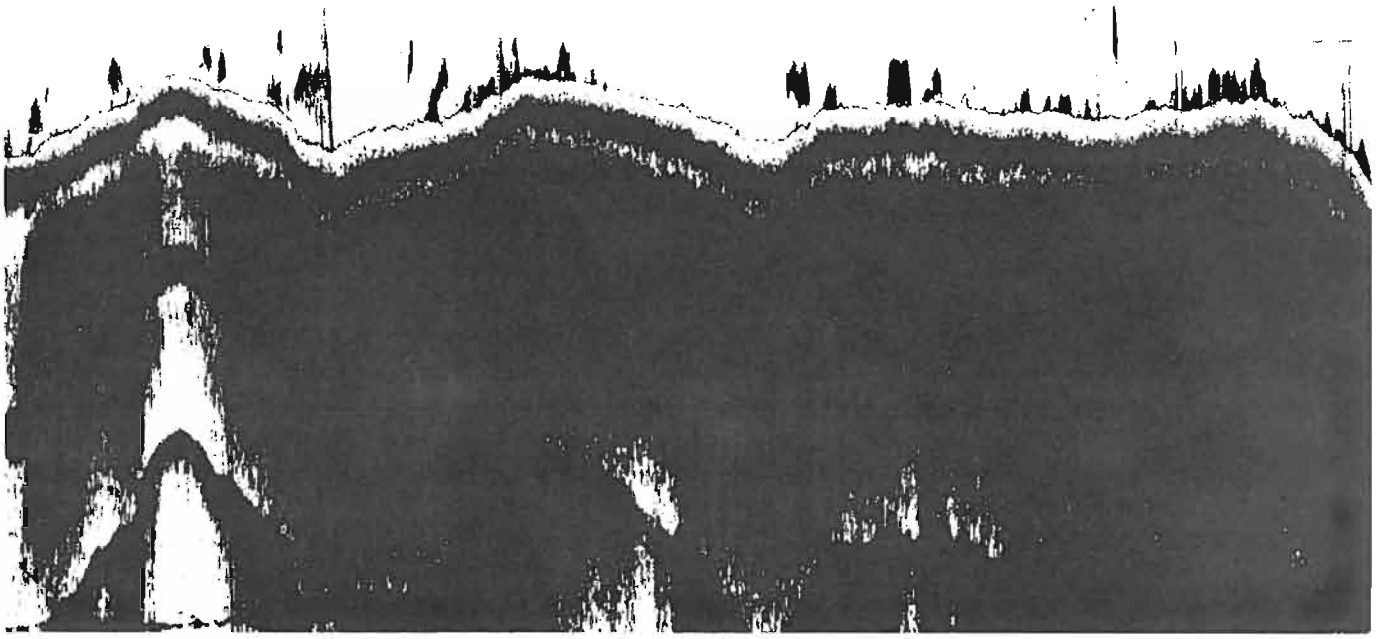
Hydraulic Power Sheave on Lifting and Slewing Gantry



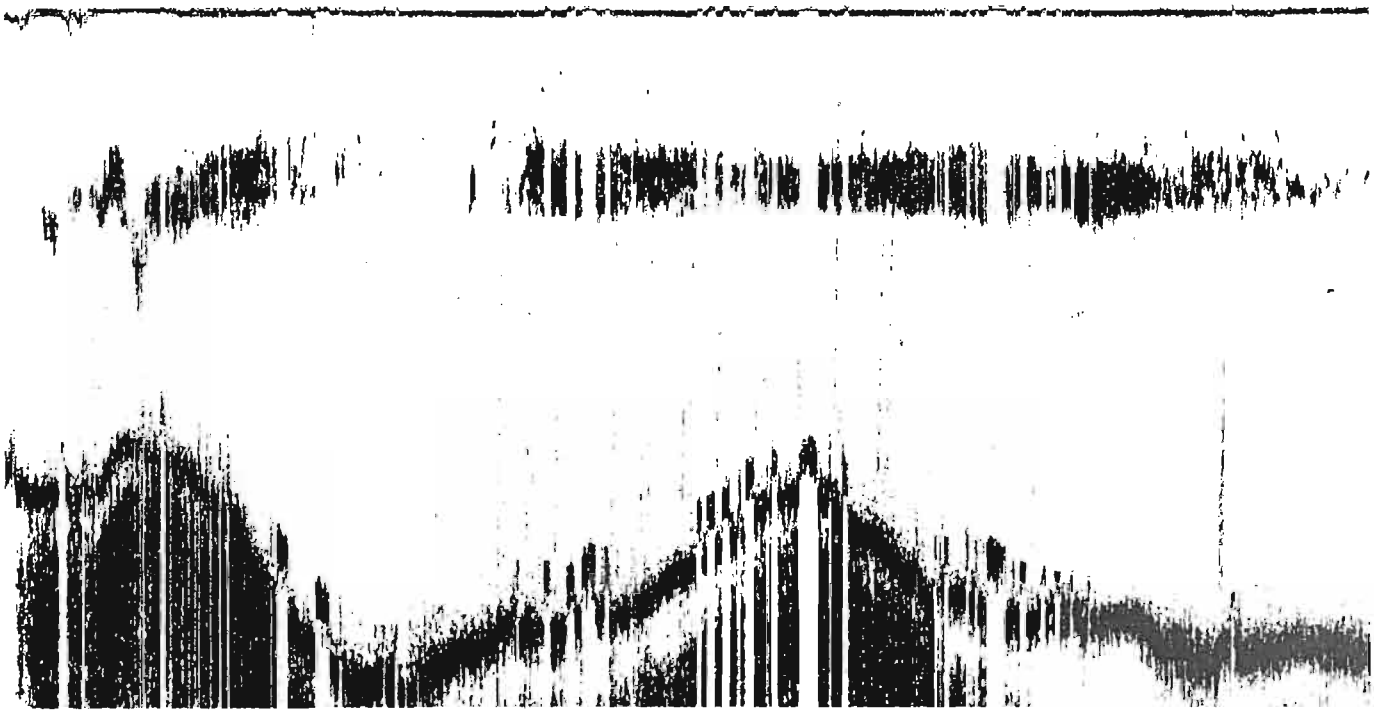
Setting the Trawl



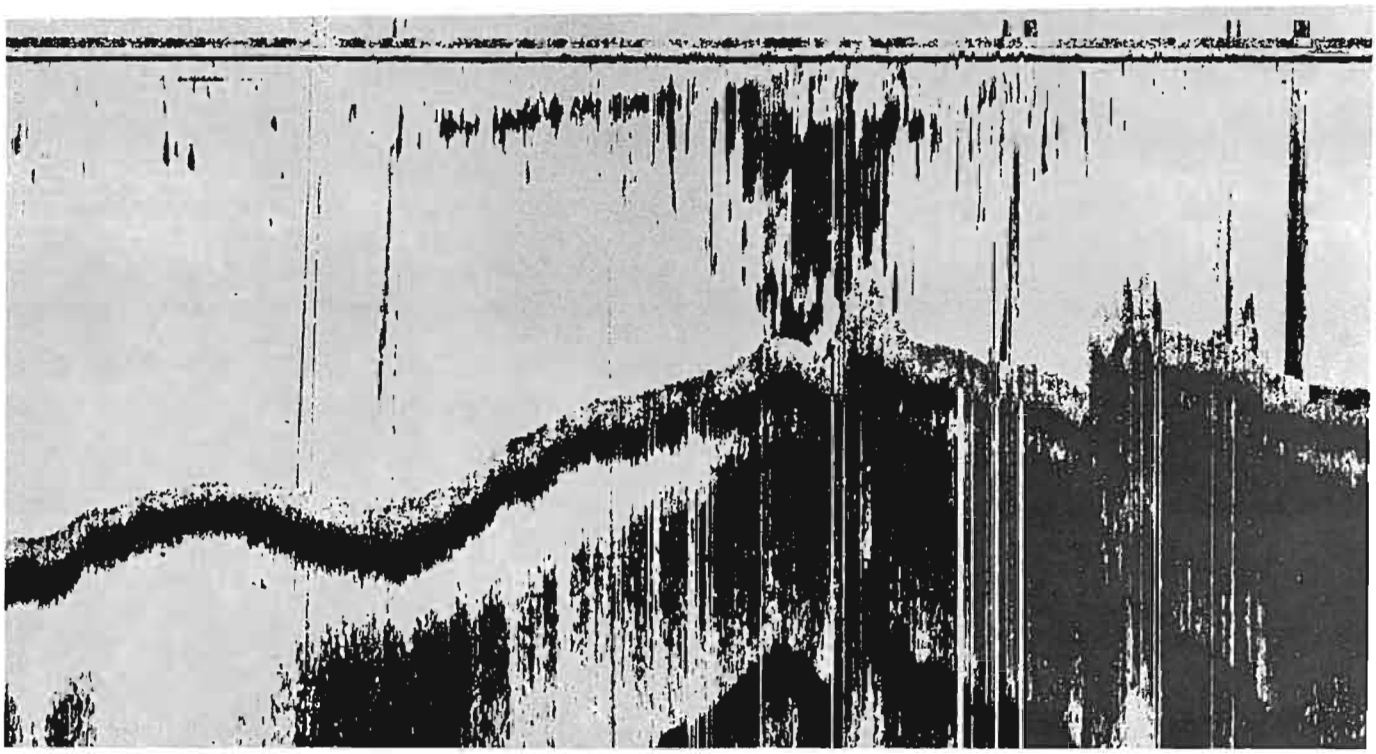
Trawl Set — Note Fender Type Buoys Used as Floats



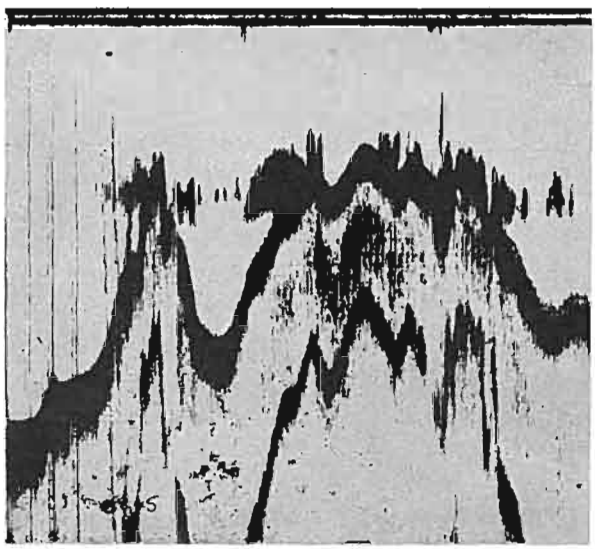
Herring on Bottom in Daylight



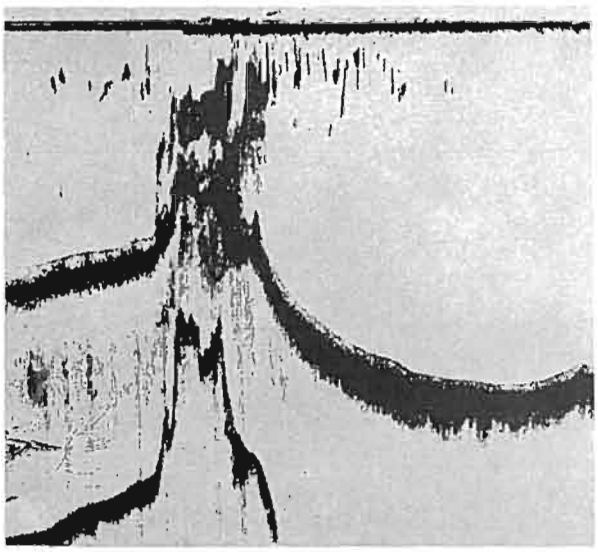
Herring Midwater at Night



Capelin off Bottom in Shallow Water in Afternoon



Capelin on Bottom in Early Morning



Capelin Rising Later in Morning