Underwater setting methods to minimise the accidental and incidental capture of seabirds by surface longliners

Report on a prototype device developed by Akroyd Walshe Ltd

SCIENCE FOR CONSERVATION: 66

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Published by
Department of Conservation
P.O. Box 10-420
Wellington, New Zealand

Science for Conservation presents the results of investigations by DoC staff, and by contracted science providers outside the Department of Conservation. Publications in this series are internally and externally peer reviewed

ISSN 1173-2946
ISBN 0-478-01958-0

This publication originated from work done by P. Barnes and K.A.R. Walshe, Ackroyd Walshe Ltd., P.O. Box 28814, Auckland 5; funded by the New Zealand commercial fishing industry through the 1995/96 Conservation Sciences Levy as contract 95/3004, part of 1995/96 CSL Project CSL 2A. It was approved for publication by the Director, Science and Research Division, Science Technology & Information Services, Department of Conservation, Wellington.

Cataloguing-in-Publication data
Barnes, P.
Underwater setting methods to minimise the accidental and incidental capture of seabirds by surface longliners : report on a prototype device developed by Akroyd Walshe Ltd / P. Barnes, and K.A.R. Walshe. Wellington, N.Z. : Dept. of Conservation, 1997.
1 v. ; 30 cm. (Science for conservation, 1173-2946 ; 66.)
ISBN 0478019580
1. Longlining (Fisheries)--Environmental aspects--New Zealand. 2. Bycatches (Fisheries) 3. Seabirds--New Zealand--Mortality. I. Walshe, K. A. R. II. Title. III. Series: Science for conservation (Wellington, N.Z.) ; 66.
639.22 20
zbn97-101660

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Abstract

The accidental/incidental capture of seabirds by longline gear may be causing a significant decline in the numbers of some species — most notably albatross (*Diomedea* spp.) — in the Southern Oceans.

In response to the sea bird problem, the New Zealand Department of Conservation commissioned a programme funded by the fishing industry through the Conservation Services Levy in 1996 to develop a device to set baits underwater on commercial surface longliners.

Trials on two U tube devices developed by Akroyd Walshe Ltd are described. A device with the tube opening facing forward was unsuccessful in flushing bait to the setting depth; however, a backward facing U tube succeeded in flushing the bait on all trials to the setting depth of 1.5 m.

A second trial was undertaken with the backward facing U tube. On all trials the U tube successfully flushed the baits to the required 3 m depth.

The U tube is a simple mechanical device requiring only one additional item of equipment — a deckhose. The device requires minimal operator skill, and is easy to build and maintain.

The U tube has the potential to set baits at greater than 3 m. However, this capability has not been tested. Further study is required to test the device under commercial tuna vessel operating conditions and to assess the effectiveness of the device in thwarting seabirds from capturing the baits underwater.

1. Introduction and objectives

When longlines are set sea birds may retrieve the baits on the surface or at shallow depths. Problems occur because bait loss effects fishing efficiency — bait loss rates of 70% have been recorded (Lokkeborg 1996), and because sea birds become snared by hooks and drown. Bird mortality caused by longlining has been suggested as the cause of decline in some albatross populations (Gates 1993).

When no measures are taken to keep seabirds away from the stern of vessels, most bait taking occurs within the first 100 m behind the ship (Brothers 1991). At greater distances the bait is submerged to a depth beyond the reach of an albatross; although petrels, which can dive to a greater depth than albatrosses, can still retrieve baits which are subsequently taken off them at the surface by the larger albatrosses.

A number of measures are already used by surface longtliners to reduce accidental capture of seabirds. These include weighted side lines, bait throwers, thawed bait and night setting.

In December 1995 the New Zealand Department of Conservation requested tenders for a programme to develop underwater setting devices for surface longline vessels. This programme, which was funded by the fishing industry through the Conservation Services Levy, had the following objectives:

1. Design devices for use on surface longliners that enable the bait to be set underwater at a depth of 3 m.
2. Build working prototypes.
3. Fit the devices to surface longline vessels, and undertake sea trials.
4. Refine the devices to overcome any difficulties identified during sea trials.

This report outlines a project funded to achieve these objectives.

Several concepts were considered by the authors resulting in five prototype designs. The concepts considered were:

1. An enclosed tube carrying the backbone, snood and baits down to the release depth

A design prototype was prepared but rejected because of potential entanglement problems between the backbone and snoods in the tube.

2. Venturi assisted water flow

Two variations were considered:
Firstly, the use of a funnel at the base of the longline tube. The funnel would be positioned on the upstream side (just above the lower end) of the longline tube. The water entering the funnel would accelerate into the longline tube and out the longline tube's lower opening. This action would create a venturi action 'sucking' the water and baits down the longline tube.

The second variation considered was to introduce the venturi action at various points along the length of the longline tube. This would be achieved by perforating the longline tube's upstream face at regular intervals throughout the 3 m depth range. These perforations would create 'mini' venturi systems throughout the length of the longline tube accelerating the snood and bait downwards and out the lower opening.

3. U Tube

A third concept was to carry only the snood and bait down to the required depth. The longline backbone would stream out externally from the U tube. The snood and bait would travel the length of the U tube and be released into the surrounding water before the snood came under tension from the backbone line streaming astern of the vessel.

Although five setting devices were considered only two U tube designs were trialled.

Advice on the concepts was sought from Professor Peter Jackson of the Auckland University School of Engineering. Although none of the concepts were rejected as potentially unfeasible, the U tube design was thought the most likely to succeed. It was decided to trial the U tube designs, and only if these were unsuccessful would the venturi concepts be trialed. Subsequent trials demonstrated that one of the U tube designs was highly effective. Consequently no trials were undertaken on the venturi concepts.

2. Methods

Two stages of trials were undertaken. The first stage trials evaluated two types of U tube design at setting depths of 1.5 m. The second stage trial evaluated the most successful first stage trial design to a setting depth of 3 m.

2.1 FIRST STAGE TRIALS

This trial was undertaken on a 10 m commercial snapper longline vessel *Mark IV* in Sand Spit Harbour north of Auckland. The vessel was a single hull fibreglass construction with a deck 1 m above water level.

The trials were undertaken at vessel speeds between 8 and 12 knots. These speeds were determined to be comparable with the speeds used for commercial tuna longline setting.

2.1.1 U tube design

The setting devices comprised U tubes and paravanes but without hinging devices or a bait trough. The tube was attached to a cross bar that secured the upper end to the vessel's stern. A paravane at the lower end of the tube ensured the tube remained stable at the required water depth.

A deck hose was attached to the upper end of the tube to flush the baits down to sea level.

One of the devices had the U tube slot facing upstream while the other U tube has the slot facing downstream. The devices were designed to release the baits at a depth of 1.5 m below sea level.

2.1.2 Fishing gear

A 4 mm longline backbone was used; with 2 mm diameter, 25 m long monofilament tuna snoods fitted with *18/0 Tuna Circle* and *Terashima TH 3.2* hooks holding 30 – 60 count squid and large Sanmar bait.

2.2 SECOND STAGE TRIALS

These trials were undertaken on a 13 m vessel *MV Frae* in the waters around Kawau Island in the Hauraki Gulf. The vessel is a twin hull steel construction with a deck 1.3 metres above water level. Trials were conducted at a range of speeds from 8 to 12 knots in calm seas.

2.2.1 U tube design

The U tube comprises four parts:

1. **Bait trough** The bait trough receives the bait and water from the deck hose. The deck hose water flushes the bait to the bottom of the bait trough and to the opening to the U tube.

2. **U tube** The tube contains the flushing water and baits down to sea level. At sea level the bait is contained and propelled down the tube through increased hydrodynamic pressure of water entering through and upon an open slot running the length of the tube. At the base of the U tube a gusset strengthens the attachment of the U tube to the paravane and acts as a 'kick plate' to ensure the bait ejects at the exit point.
3. **Paravane** At the base of the tube is a double paravane. The paravane acts as a keel to stabilise the tube and hold the tube at a fixed depth determined by the length of the tube. The use of double paravanes increases the stabiliser's effective surface area with a minimal increase in overall size.
4. **Hinging device** Although the U tube creates minimal drag in the water, additional stresses are created if the fishing vessel yaws or pitches in a heavy sea. To minimise the impact of these stresses on the point of contact with the fishing vessel a series of hinge devices were used. A horizontal hinge allowed the tube to remain stable during the pitching action of the vessel. A pin between the hinge plate and the U tube allowed the tube to move from side to side to side as the vessel turned or yawed.

The U tubes were constructed of 3 mm mild steel, the paravanes were made of 3 mm plate. The overall weight of the setting device was approximately 35 kg.

Figures 1 – 7 (see appendix) give further details of the design.

2.2.2 Fishing gear

A 4 mm longline backbone was used with 2 mm diameter, 25 m long monofilament tuna snoods fitted with 18/0 *Tuna Circle* hooks and 30 – 60 count squid baits.

3. Results

3.1 FIRST STAGE TRIAL

The performance of the two U tubes was as follows

Forward facing U tube

The baits were flushed down the tube to sea level, however they remained in the tube at this level and did not submerge. It was observed that at all trial speeds the water level in the tube rose above the ambient sea level. Apparently the force of the water entering the leading edge of the tube created a head of water that rose up the tube. The head of water appeared to create a stagnant body of water that acted as a barrier to baits as they were flushed down to sea level. The forward facing U tube was ineffective and no further trials were undertaken.

Backward facing U tube

The baits were flushed down the tube to sea level and carried underwater down the full length of the tube without obstruction. It was observed that, when the deck hose was not used and the vessel was underway, the water in the pipe at sea level was lower than the ambient water level. It would appear that there was a positive flow of water into and down the tube. Further observations by diving and underwater video record showed the bait and water in the tube was carried down the full length of the tube even at vessel speeds of less than a knot. In 87 trial releases of bait there were no snags as the bait moved down the tube.

3.2 SECOND STAGE TRIALS

Two hundred and three releases of bait were made down the tube, none of the releases snagged in the tube. On 27 releases the baits were timed from entry into the tube and release out of the 6 m long tube. On average the bait took 6.7 seconds to travel down the tube, the maximum time of release was just over 9 seconds.

To test the retention of the bait in the tube, the snood was stopped at various lengths as it travelled down the tube. At each point the bait remained in the tube, and (providing the operator held the snood close to the tube inlet) could be retracted up the tube without escaping. If the operator lifted the snood away from the tube, the line was captured by the water flow outside the tube and the snood and bait released to the surrounding water.

4. Discussion

4.1 ASSESSMENT OF THE U TUBE SETTING DEVICE

Both trial stages demonstrated the effectiveness of the backward facing U tube setting device. The basic principles of the device are as follows:

1. Water flushes the baits to sea level down the U tube.
2. When the setting device is towed the sea water flows freely around the front of the tube. Because of the horizontally elliptical cross section of the angled tube, the water accelerates towards the open slot. If the tube were not slotted considerable drag (suction) would occur directly behind the tube. The slot, however, provides an easier path to the water to escape.
3. The water enters the tube and adds to the velocity of the flushing water already in the tube. All water in the tube is constrained down the complete tube length and exits at a point at the bottom of the tube.
4. Towing the device faster through the water increases the water flow down the tube.

Because the trials were undertaken in relatively calm seas the tension of the setting device on the fishing vessel in rough seas has not as yet been tested. However two simulations gave an indication of the performance of the setting device in a yawing and pitching sea.

While steaming at 12 knots the vessel made a number of turns to simulate a yawing sea. The setting device moved in the opposite direction to the turn but was still effective in releasing the baits from the base of the U tube.

The tension of setting device in a pitching sea was tested by pulling the tube upwards by hand as the vessel steamed at longline setting speed. As one operator could pull the U tube upwards there appeared to be little stress caused by a pitching action.

These simulations however do not reflect rough sea conditions where yawing and pitching actions occur simultaneously and with more rapidity and frequency than our simulations could produce.

As the vessel pitches in a sea, water may be forced up the exit point of the tube. The entry of such water might impede the downward flow of the bait and exit from the tube. The horizontal paravane however acts as a block to stop water being forced up the exit point of the tube.

The advantages of the U tube longline bait setting device can be summarised as follows:

Limited operator skill required The device is a simple mechanical device requiring no special operating skills to manage the U tube. The lack of moving parts or supporting devices (such as hydraulic or electrical motors) makes the device very safe to operate.

Low construction cost and long operating life The U tube is a very simple construction, and uses low cost materials. Many fishers have welding skills and provided with the tubing and the diagrams in this report could manufacture the U tube in a home workshop. Running repairs at sea are likely to be minimal and well within the skill of most mechanically-minded fishers. The mechanical nature of the device and the simple construction and robust materials should ensure a long operating life.

There is little tension on the U tube in the water. Because of the cross section shape of the U tube the device creates little drag. The paravane creates only sufficient force to hold the U tube down and steady — during the trial the U tube can be lifted up by hand while the vessel steamed at 12 knots.

Ease of handling The tube is easy to handle, requiring less than five minutes to install or retrieve. The device is lightweight and can be positioned in the water by one operator. The tube can be hauled aboard by hand at idling vessel speed.

Maintenance Maintenance of the equipment is minimal requiring only the servicing of three points of movement with a grease lubricant. These points all occur at the upper end of the tube — at the two hinges and the base pad. The device could be stored on deck without protection against the elements.Water is needed to flush the bait efficiently to water level. The obvious source is a deck hose. On vessels with decks low to the water line, a forward facing scoop at water level (connected by a water hose to the bait trough) should have sufficient force to drive water up to the entry point of the U tube.

Application to various sizes of vessel The device could be applied to a range of vessel sizes and, as illustrated in Figure 3 (Slot width formula), is applicable to any size of tube and setting depth.
The flushing mechanics should work for a range of setting depths.
The U tube can accommodate a range of bait and hook sizes.

Possible problems Other factors, however, may affect the operation of the device. For example:

1. Depending on the sea state and strength of tube materials, the tension on the tube may limit operational performance.
2. The length of the snood must be sufficient to allow the bait to travel the length of the tube before the snood straightens under tension from the backbone streaming astern.

4.2 MODIFICATION AND IMPROVEMENT TO THE U TUBE DESIGN

The U tube as designed will probably require subtle modification to efficiently operate on individual fishing vessels. Characteristics such as the longline setting configuration, the distance of the deck from sea level and the configuration of the vessel's stern or side longline release point will likely require tailoring the U tube design to each vessel.

The speed of the baits down the tube may increase if the water flow above the water level is more efficient. Orientation of the water discharge into the tube and minimisation of the gap in the U tube above the water surface may provide opportunities for such efficiencies.

The bait is held securely in the tube provided the operator keeps the snood within the tube below the sea level. In the trials this was achieved by the operator holding the snood at the mouth of the U tube as the line ran out between the operator's fingers. The use of a spring flap at the top of the U tube would allow the snood to run down the tube without the need for the operator to remain constantly at the U tube. The spring loaded flap would allow the snood to be released when the bait had left the tube and the backbone pulled the snood away from the vessel.

The device has yet to be tested for its primary purpose — stopping sea birds from diving on the baits as they are released underwater. The Conservation Services Levy programme objective was to design a device to set baits underwater at 3 m. However this depth may be insufficient to stop some sea bird species from diving on the baits. The U tube device appeared to work as effectively at 3 m (the stage two trial) as it did in the 1.5 m depth trial. The device has the potential to work at deeper depths. Further study is required to determine the operating limits of the U tube.

Increasing the length of the U tube and associated paravane may make the device difficult to load and retrieve. The U tube designs in this report are for a fixed U tube that cannot rotate. However, if a split collar surrounding the upper section of the tube were welded to the spigot pin block, the tube could be lowered and raised by sliding up and down inside the collar. A locking pin would secure the tube in the fishing position to keep the U tube secure in heavy seas. The split collar would also allow for the U tube to be rotated through 180° to allow the paravanes to point backward and upward. This position would drive the paravane to the surface to assist retrieval. The use of a small hand powered winch (similar to those used on boat trailers) with a wire attached to an eyelet on the trough could ease the setting and retrieval of large U tubes.

The vessel cannot reverse or back up when the U tube is in position, since the paravane would put tension on the U tube, driving it further underwater. If this is a significant hindrance to the fishing operation, further research into the paravane design (including the operation of U tubes without paravanes) will be required.

5. Conclusions

The backward facing U tube design is effective at setting standard tuna longline baits and hooks at a depth of 3 m.

The device is:

- easy to set and retrieve at sea,
- a 'stand alone' system requiring no additional mechanical or electrical equipment apart from a deckhose,
- operated with minimal training, and
- operated with minimal maintenance,
- able to be build at low cost

Further work is required to test the U tube device in a range of tuna longline operating conditions and to determine whether the device reduces sea bird capture of longline baits.

7. Acknowledgements

This work was commissioned by the Department of Conservation through the Conservation Services Levy funded by the New Zealand fishing industry.

We would like to acknowledge the assistance of Department of Conservation staff (in particular Janice Molloy and Ian West). Valuable assistance was also provided by Professor Peter Jackson (Auckland University School of Engineering), Mark Illingworth (skipper of the *Mark IV*), Harry Verney (skipper of the *MV Frae*) and Geoff Thomas (video assistance).

8. References

Brothers, N. 1990. Albatross mortality and associated bait loss in Japanese longline fishery in the Southern Ocean. *Biological Conservation* 55, 255–268.

Gales, R. 1993. Cooperative Mechanisms for the Conservation of Albatross. Australian Nature Conservation Agency.

Appendix

Figure 1. Underwater setting device for tuna longline.
The figure shows the main design features of the bait setting device.

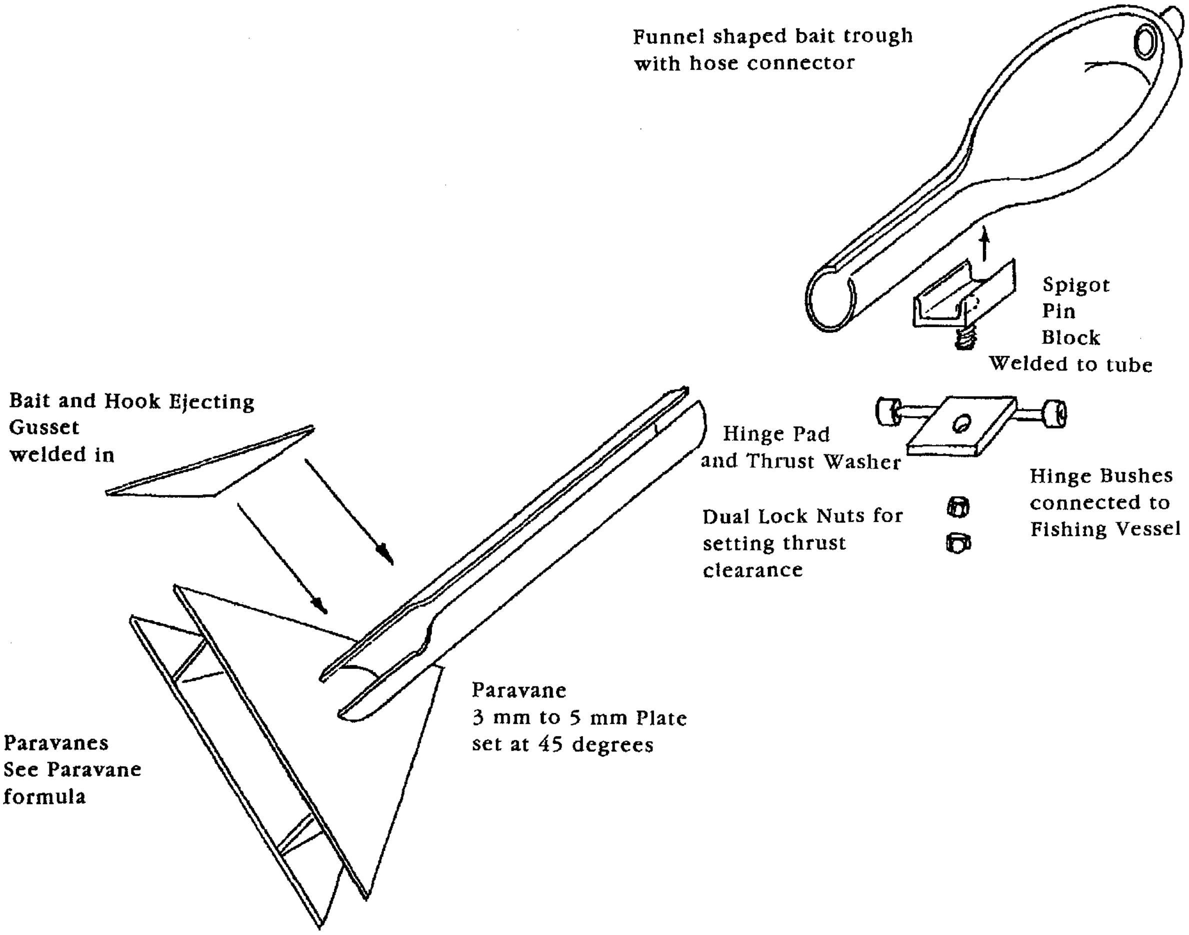


Figure 2. Paravane formula.

Two triangular paravanes are required. The dimensions of the paravane are determined by the surface area of the submerged part of the tube. The total surface area of the rwo paravanes combined has to be equal to the surface area of the submerged part of the tube,

i.e., Setting depth × 1.42 × the O.D. of the tube used.

The square root of the result is the length of each side of the square below.

Once the square is bisected diagonally, two paravanes of the correct size will result,

i.e., 3 m (300 cm) setting depth with a 10 cm O.D. tube $300 \times 1.42 \times 10 = 4260$ cm^2 of which the square root is 65.3 cm.

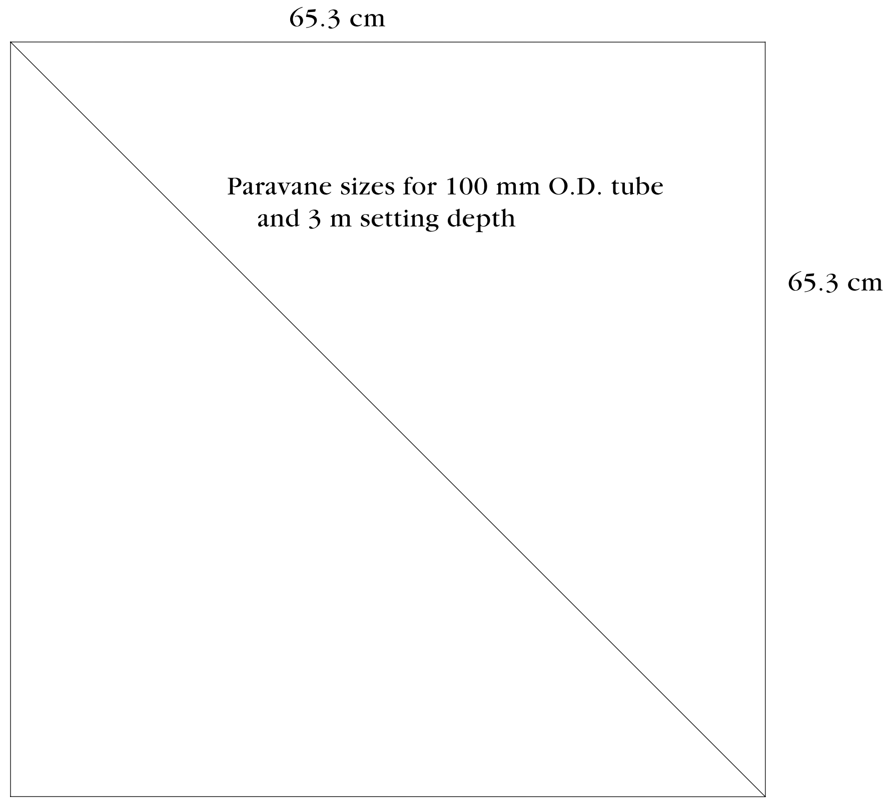
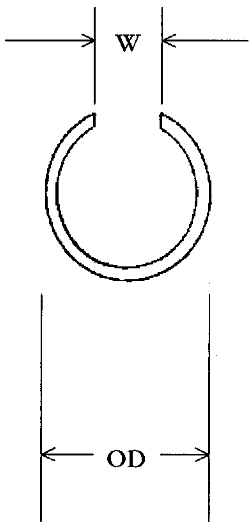


Figure 3. Slot width formula.

The U tube can be made any size appropriate to the size of bait to be used, and the size of the slot is determined by the width of tube. This formula applies only to the section of U tube below the sea level, the slot width diameter above water level can be much narrower, limited only by the diameter of the snood. A narrow slot above sea level would increase the efficiency of the device by better containing the water flowing from the deck hose flushing the bait to sea level.

SLOT WIDTH
FORMULA



W = OD ÷ 2.4

Figure 4. Tube length.

The length of the U tube is determined by the required setting depth of the longline, the height of. the deck above water level and the 45° setting angle of the U tube.

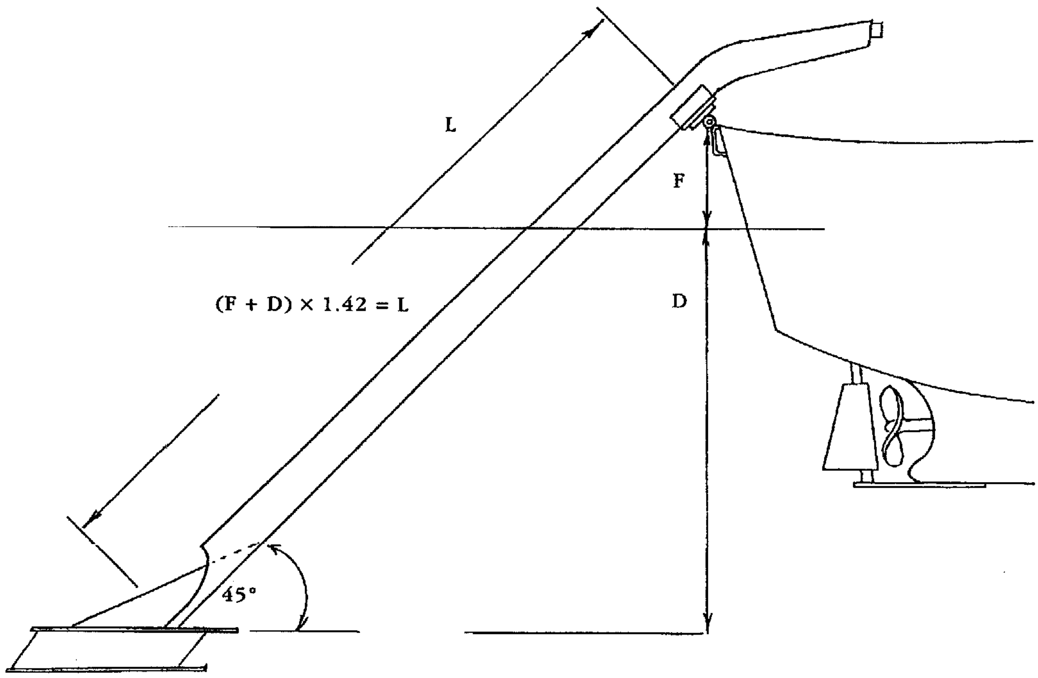


Figure 5. Front view of the U Tube Design (view 1).

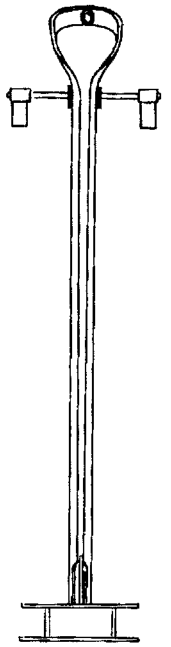


Figure 6. Front view of the U Tube Design (view 2).

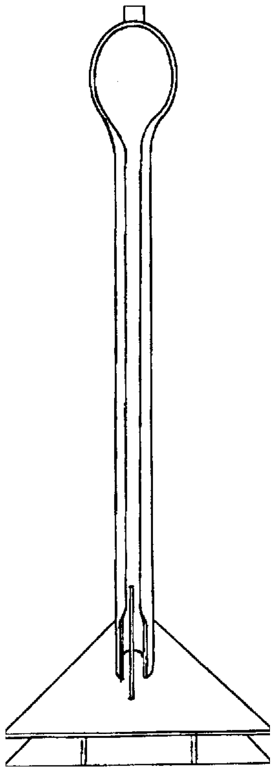


Figure 7. Side view of the U Tube Design.