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CONSTRUCTION DETAILS OF IMPROVED TUNA LONG-LINE GEAR USED BY PACIFIC OCEANIC FISHERY INVESTIGATIONS

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CONTENTS

This report is a description of the latest type of fiber long-line gear now being used by Pacific Oceanic Fishery Investigations (POFI) to capture tunas in the central Pacific. It is a revision of an earlier report (Niska 1953) and contains a complete description of the gear and its use, with particular attention to changes made since the earlier report was issued.

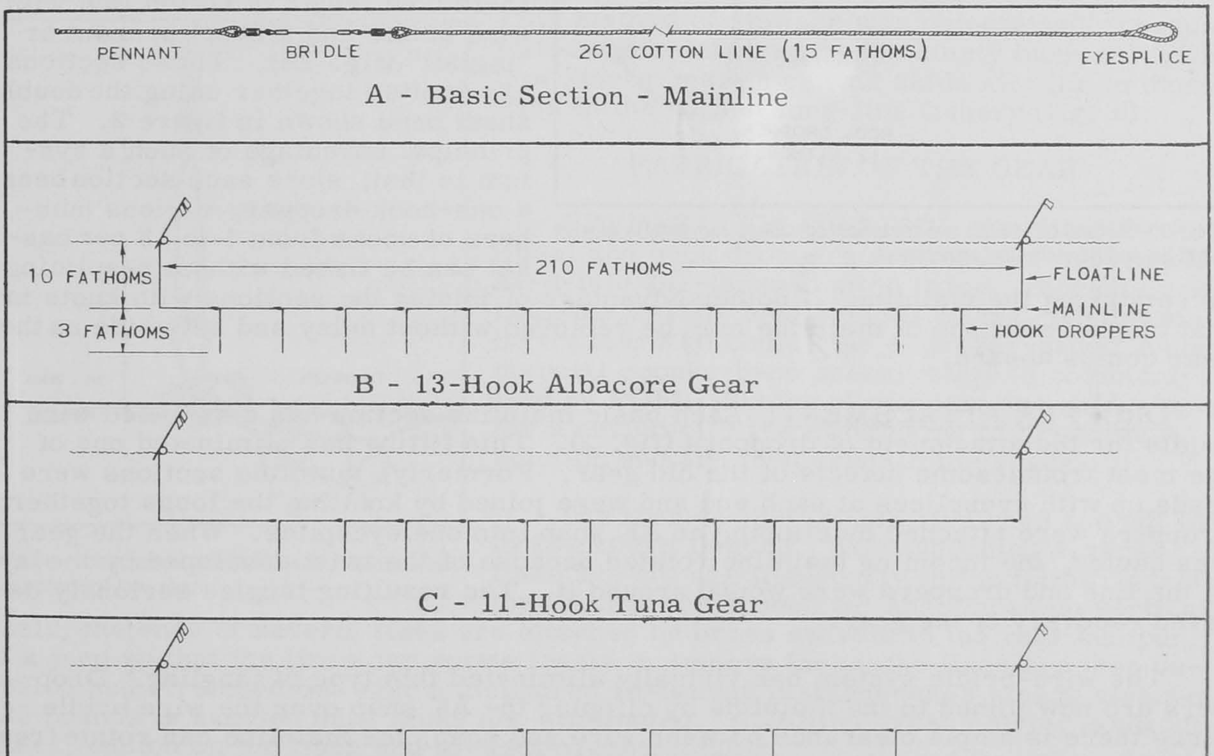

Fig. 1 - Three types of POFI long-line gear, and the basic component of their mainlines. A - 15-fathom section used in making up mainlines. B - 13-hook basket (unit) designed for albacore fishing. C - 11-hook basket used in fishing for larger tunas, such as yellowfin and big-eyed tuna. D - 6-hook "Standard" basket used in most of POFI's experimental fishing.

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The original POFI tuna long-line gear was derived from designs employed by Japanese and Hawaiian fishermen. A general discussion of the history, fabrication, and operation of such gear is included in reports by Shapiro (1950), June (1950), Murphy and Shomura (1953), and Niska (1953). So many changes have been made in the design of the gear since 1953 that a new account is necessary to acquaint the fishing industry with the successful innovations. It should be noted that the dimensions and basic design of the gear have not been changed; however, several modifications have increased the speed of setting and hauling and have resulted in greater flexibility. Each of these changes has been tested in the field under controlled conditions. The results of these field tests are discussed in Murphy and Shomura (1953), and Shomura and Murphy.1/

GENERAL DESCRIPTION

The basic unit of the long line is the "basket" or "skate" (fig. 1), a 210-fathom length of mainline with droppers and buoyline, stored in a canvas skid or a bamboo basket. In the POFI experimental fishing operations about 60 such baskets are joined together to make a day's set. Since they are identical in design, plans of only one basket are shown in the diagram.

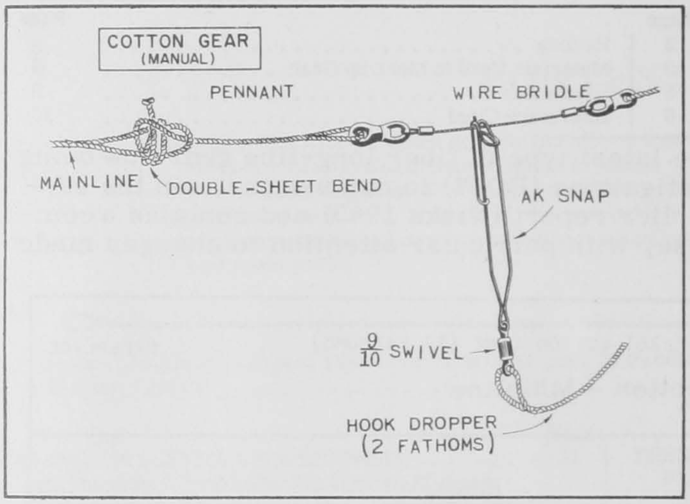

Fig. 2 - Method of joining two mainline sections, and details of wire bridle and branch-line attachment.

MAINLINE: The mainline of each basket is made up of 14 similar sections, each consisting of a 15-fathom length of cotton line with wire bridle and a short pennant or "pigtail" (fig. 1A). These sections are knotted together using the double sheet bend shown in figure 2. The principal advantage of such a system is that, since each section bears a one-hook dropper, various numbers of hooks from 1 to 13 per basket can be fished without resplicing or reworking the mainline. Another advantage of joining the sections with knots is that tangled sections of mainline may be removed without delay and set aside as the gear comes aboard.

DROPPER ATTACHMENT: Each basic mainline section has a swiveled wire bridle for the attachment of droppers (fig. 2). This fitting has eliminated one of the most troublesome defects of the old gear. Formerly, mainline sections were made up with eyesplices at each end and were joined by knotting the loops together; droppers were attached by clipping an AK snap into one eyesplice. When the gear was hauled, the incoming mainline rotated because of the twist developed by the lay of the line and droppers were wound around it. The resulting tangles seriously delayed recovery of the gear.

The wire-bridle system has virtually eliminated this type of tangling. Droppers are now joined to the mainline by clipping the AK snap over the wire bridle. Since there is ample clearance between wire and snap, the mainline can rotate freely without affecting the dropper. The swivels at the ends of the bridle also help to reduce the twisting effect caused by the lay of the line.

HOOK DROPPERS: The 10-fathom and 5-fathom hook droppers, or branch lines (gangions), have been cut to 3 fathoms (over-all length, including leader) and the

1/ Long-line fishing for deep-swimming tunas in the central Pacific, 1953. U. S. Fish and Wildlife Service, Spec. Sci. Rep.: Fish. No. 157.

costly sekiyama[2/] has been eliminated as unnecessary. The 3-fathom length marks the shortest length that can be efficiently fished; 2-fathom droppers have been tried but proved harder to coil and were more hazardous in setting and hauling than the 3-fathom type. Construction of droppers is shown in figures 2 and 3.

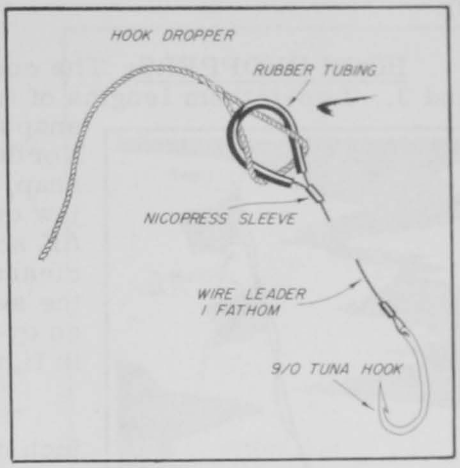

Fig. 3 - Details of branch line, leader, and hook assembly.

FLOATLINES: Floatlines, which join buoys and mainline, are made up of 5-fathom sections. The sections have an eyesplice at one end so that they may be joined by a double sheet bend. The depth of the mainline is varied by adding or removing sections without cutting or splicing line. Floatlines are joined to the mainline by the AK snap and knot shown in figure 4. Attempts have been made to use a wire bridle similar to the one used for the attachment for hook droppers, but the snaps opened up and this arrangement was discarded.

BUOY LIGHTS: Hauling operations may sometimes last until after dark, so battery-powered buoy lights are usually attached to the end poles and to several intermediate poles of the set. A typical light installation is shown in figure 5.

LONG-LINE CONTAINER: POFI long-line gear was originally stored in the standard bamboo basket commonly used in the Hawaiian and Japanese fisheries. This method of stowage was objectionable because of the space taken up by the empty baskets. POFI now stores gear in canvas skids similar to those used in the halibut long-line fishery (fig. 6).

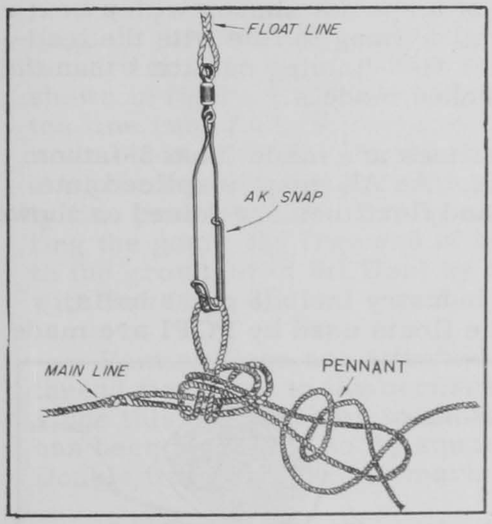

Fig. 4 - Attachment of floatline to mainline at juncture of two skates.

FABRICATION OF THE GEAR

PREPARATION OF LINE: Mainline, floatlines, and hook droppers are made of best grade hard-laid 261-thread cotton twine. Since the gear remains wet for long periods at sea, the line must be treated with some type of preservative. A commercial copper-base preservative is commonly used by POFI. Skeins of new line are cold-dipped for a period of three minutes in a full-strength solution and are then dried in the shade.

The treated line is then stretched and cut into 15-fathom lengths. To save time, several lines are cut simultaneously in the following fashion: skeins are opened out and placed on vertical reels; the ends of several lines are attached by brass swivels to the rear bumper of a jeep so that the lines can rotate freely to remove kinks; the lines are then unreeled and stretched out over a measured 15-fathom distance and a steady strain of 125 pounds is exerted until kinks are eliminated. A Dillion dynamometer is used to check tension on the lines and prevent overstretching.

MAINLINE: Cut lines are coiled down in sets of 14 pieces each, the number required to make up one skate. These basic mainline sections are then completed by splicing in eyes, wire bridles, and pennants as shown in the diagram (fig. 1A). The end pennant of each basket is made from $\frac{1}{4}$-inch cotton rope rather than 261-thread line and the end eyesplice is lengthened.

2/ Sekiyama or shanawa--a stiff pennant consisting of a linen or wire core served with cotton twine, used by Japanese and Hawaiian fishermen to connect the wire leader to the cotton branch line, and formerly employed in POFI long-lines.

Wire bridles 6 inches long are fashioned from $\frac{5}{64}$-inch 1 x 7 stainless wire rope. No. 2 Seadog swivels are fastened to the wire by means of Nicopress fittings (fig. 2).

HOOK DROPPERS: The construction of hook droppers is shown in figures 2 and 3. Two-fathom lengths of treated 261-thread line are made up with a special snap at the upper end. This snap, a model used by the Northwest trolling boats, is a No. 9/0 Kolstrand AK snap, but is constructed of heavy No. 7 wire and has a jaw opening of $\frac{1}{8}$-inch diameter. It is important that the AK snap be designed to fit the wire bridle with a small clearance, since otherwise the snap is apt to jam against the swivel. The lower end of the dropper terminates in an eyesplice to which is joined hook and leader, as shown in figure 3.

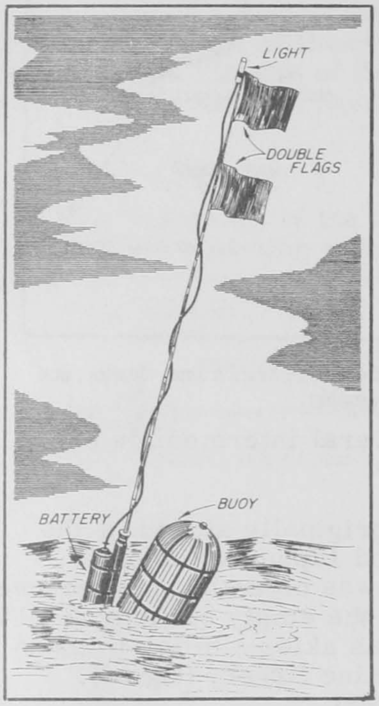

Fig. 5 - Battery-powered light buoy.

The leaders are fashioned of 6-foot lengths of .066-inch diameter right lay 1 x 7 galvanized plow-steel wire. Galvanized wire is used rather than stainless steel since it reduces the electrolytic action between hook and leader. Stainless steel leaders destroy hook plating in a very short time. A 3-inch loop in the end of the leader is fitted with a section of $\frac{3}{8}$-inch O.D. x $\frac{1}{8}$-inch I.D. industrial rubber tubing, which serves to prevent chafe. A 9/0 or 8/0 tuna hook is attached to the leader by a 1-inch loop fastened with a Nicopress sleeve (fig. 3). It should be noted that the hook is of a special shape, with a bent shank which allows the bait to hang in line with the leader. Such a hook has better fish-holding qualities than the conventional straight-shanked models.

FLOATLINES: Floatlines are made from 5-fathom lengths of 261-thread line. An AK snap is spliced into one end and an eye formed in the other. Mainline and floatlines are joined as shown in figure 4.

FLOATS: Floats used in the Hawaiian fishing industry include glass balls, wood billets, and metal tanks of various sizes. The floats used by POFI are made from surplus stainless-steel oxygen tanks of 2,100 cubic inches internal volume (figs. 7 and 8). These are fitted with a $\frac{3}{8}$-inch galvanized eye bolt for attachment of a floatline. Since the tank comes provided with a $\frac{1}{4}$-inch outlet, it is necessary to reduce this opening by fitting a $\frac{1}{8}$-inch to $\frac{1}{4}$-inch hex-head pipe bushing between tank and bolt. An 8-inch grommet of $\frac{3}{8}$-inch diameter manila rope is spliced into the eye for attachment of the bamboo pole. A $\frac{3}{8}$-inch stainless-steel thimble protects the grommet against chafe (fig. 8). Buoys are painted a bright orange for greater visibility.

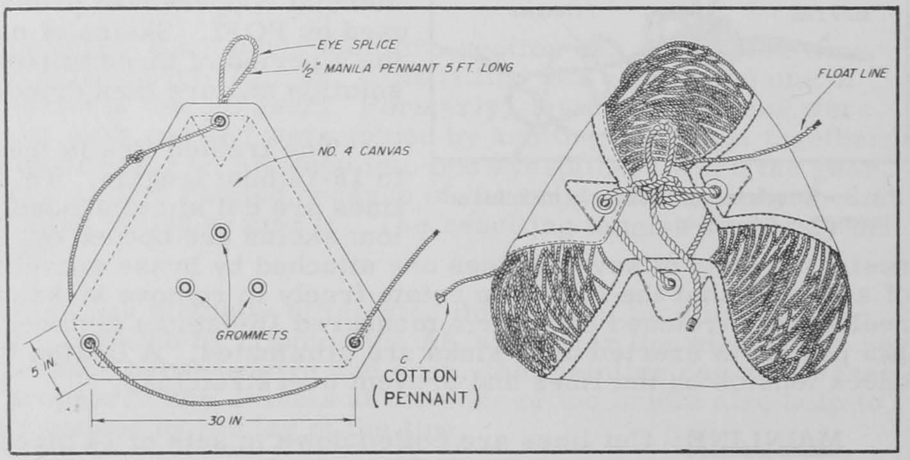

Fig. 6 - Canvas skid for stowing long-line skates.

FLAGPOLES: Alternate buoys have poles with flags to serve as markers in locating gear (fig. 7). Poles are select bamboo 14 to 16 feet in length with a butt diameter of $1\frac{1}{4}$ inches to $1\frac{1}{2}$ inches and a tip diameter of about $\frac{5}{8}$-inch.

The poles are protected from chafing on the floats by a 15-inch section of heavy air hose. Split lengths of hose are clamped on the pole with a lower end 6 feet 6 inches from the butt. Clamps are $\frac{3}{8}$-inch Band-It straps secured with the buckles fixed over the cut. This attachment is made so that the buckles are turned away from the buoy, presenting only the smooth band to minimize chafing.

A 5-inch loop of $\frac{3}{8}$-inch manila line is fastened at the bottom of the pole for attaching the floatline. This loop is held in place as follows: a rosette is made in each end of the line and a Band-It strap is clamped midway on the rosette, which serves as a cushion preventing the loop from slipping under the band. The ridge at the lower joint of the pole tends to prevent the loop and band from slipping off the butt of the flagpole.

The float is tied to the flagpole by a 4-foot lanyard of $\frac{3}{8}$-inch manila line, which is secured to the flagpole just below the chafing gear. The end of the lanyard next to the pole ends in an eyesplice, as shown in figure 8. A safety line of 261-thread cotton line runs from this eye to the bottom of the pole, where it is made fast to the manila loop. If the bamboo pole breaks during fishing operations, the safety line prevents loss of buoy and floatline. On setting the gear, the free end of the lanyard is joined to the grommet of the float by a reverse sheet bend with bow (fig. 8).

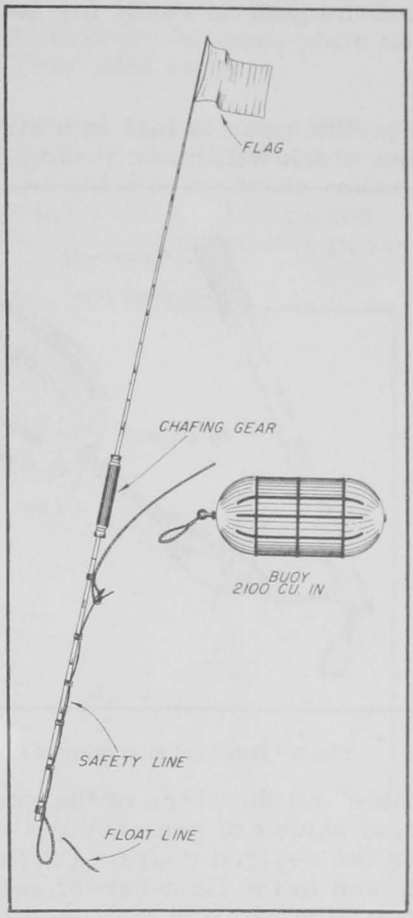

Fig. 7 - Complete flag and float assembly, showing chafing gear.

Bunting flags are attached to the top of the flagpoles by waxed, doubled, cotton-thread ties fixed to the corners of the flags. POFI flags are dyed a bright orange since this color seems to show up well under all sea conditions. The size of flags has been increased to $1\frac{1}{2}$ square feet in an effort to increase the range of visibility. Double flags are used to mark various portions of the set such as the ends and center.

CANVAS SKID: To make the skid (fig. 6), No. 4 canvas duck is cut in the shape of an equilateral triangle 45 inches on a side. Corners are turned in with No. 5 grommets punched in the center. A $\frac{3}{8}$-inch manila becket, 60 inches long, is laced through the grommets. A 3-inch loop is spliced on one end, and the standing end is securely whipped. The loop is secured on one grommet by an overhand knot immediately behind the eyesplice. With the line in place the standing end is laced through the other two grommets and passed through the eye to form a bight. A slip knot finally secures the line. Skids have brass grommets in the bottom to provide proper drainage and ventilation of wet line.

ASSEMBLING LINES FOR SETTING

Prior to setting, mainline and branch lines are assembled and the gear is carefully coiled down on the skid. The bottom end pennant is left exposed for joining to the next basket (fig. 6). Hook-dropper coils are made up smaller than mainline coils and are secured by hooking the tuna hook into the rubber chafing gear on the wire leader. The floatline is coiled down on top of the pile, the skid is then tied up, and the gear is ready for setting.

SETTING

The gear is laid in a straight line and in a direction relative to the wind and sea which will make it easy to haul the line. Hauling is easiest when the wind blows from about 30° off the bow on the side of the line hauler. Therefore, gear is usually laid with the wind about 30° off the stern opposite from the line hauler. When course is reversed to pick up the gear, if no wind shift has occurred, the winch side will be the weather side and wind and sea will be broad on the bow.

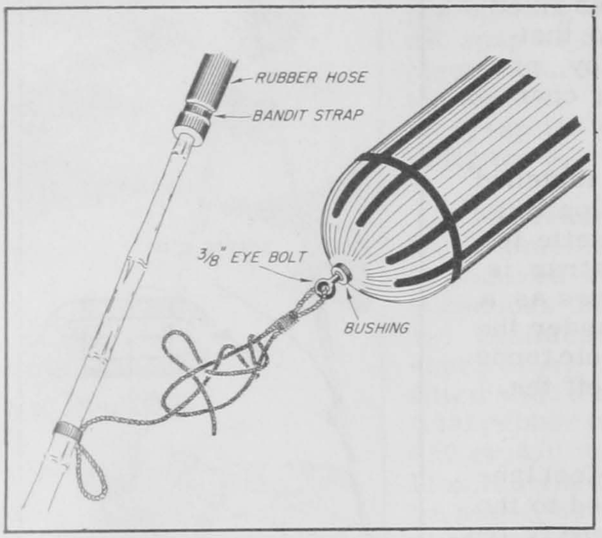

Fig. 8 - Details of attachment of float to flagpole.

When setting close to islands or banks, or in an area where currents are known to be strong, the direction of set must be chosen with care. Setting across a current boundary is avoided as the mainline is apt to part with the strain. Particular care must be taken in setting in shoal water close to land where strong surface currents may sweep the gear into shallow water before it can be recovered.

Setting is usually done from a "setting table" on the stern of the vessel. This is a wooden bench large enough to hold several skates of gear and the bait needed for the set. In setting (1) the vessel is put on the desired course; (2) floatline, buoy, and flagpole (usually with double flag) are joined to the first basket and pitched overboard; (3) one fisherman pays out coils of mainline while others uncoil droppers and bait hooks.

The amount of slack in the mainline, and consequently the fishing depth of the gear, is controlled by the fisherman throwing out the mainline coils. These may be thrown out rapidly to give a "slack set" which fishes at a comparatively great depth, or they may be held until the line is stretched out taut by the vessel, which results in a comparatively shallow fishing depth. A slack set may also be accomplished by steering a zigzag course while paying out the line.

HAULING

LONG-LINE HAULER: The gear is hauled with a Japanese line hauler of the type shown in figure 9. Such a winch is used in preference to an ordinary gurdy because it coils down the mainline automatically with little attention from the winch operator.

The coiling of the line is accomplished by the hauling head shown at the top of the winch. This assembly consists of a split sheave (A) grooved to fit the diameter of the line to be hauled; a wide center wheel with replaceable rubber collar (B); and a movable brass idler (C) controlled by the lever at the left. All three units are connected by a gear train which synchronizes them when they are turned by the drive shaft in the base of the winch.

In hauling, the incoming line is led under the grooved sheave, then over the center wheel and between it and the brass idler. The grooved sheave grips the line and the idler squeezes it against the rubber collar giving friction to pull the line in as the sheaves rotate.

The line is deflected downward by the brass plate (D) to a platform below, where it coils itself. The size of the coil is dependent upon the distance between plate and platform, so it is necessary to adjust the height of the latter with care.

The hauling head is turned by the drive shaft at the bottom of the winch through a multiplate oil-bathed disc clutch located in the base of the winch. The foot-operated clutch control is mounted near the ship's bulwark close to the overside roller so that the winch operator can see the incoming branch lines easily. The clutch control is so arranged that the winch operates continuously unless the clutch pedal is depressed.

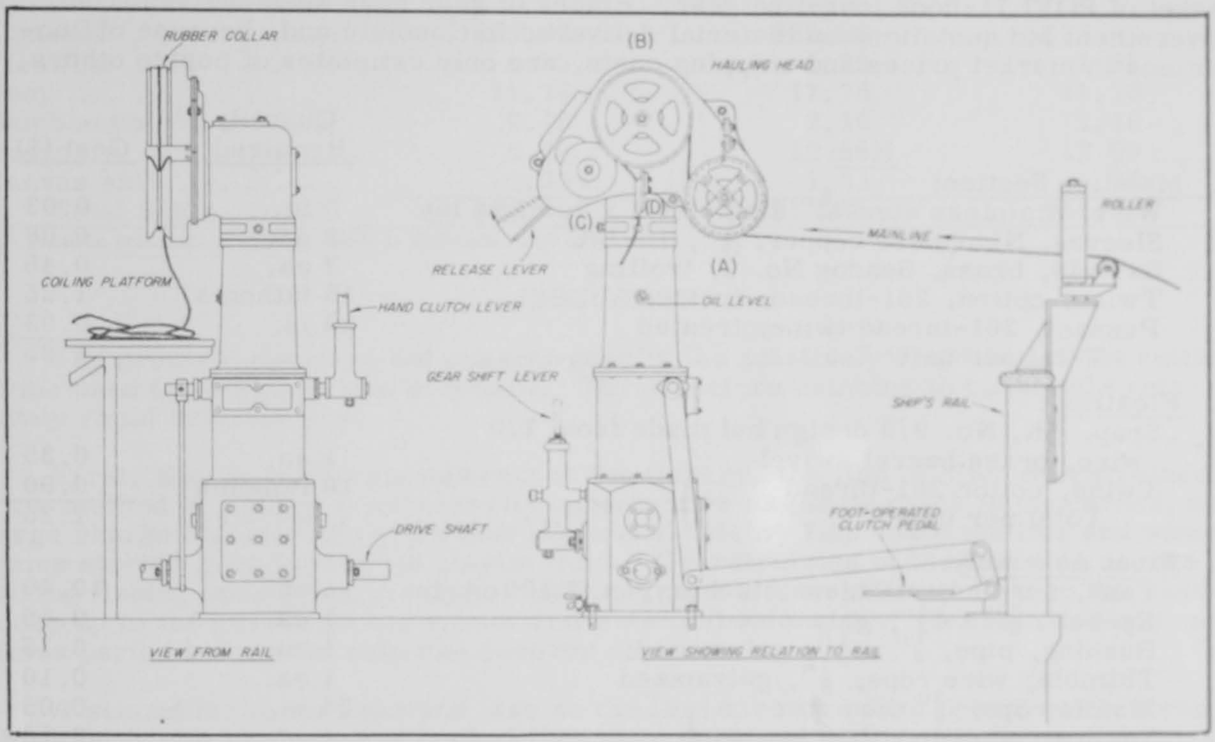

Fig. 9 - Japanese long-line hauler.

The gear-shift lever shown at the lower left controls the hauling speed. With a drive shaft input speed of 300 r.p.m., high gear yields a line speed of about 1,000 ft./min., low gear a speed of 500 ft./min.

Hawaiian and Japanese fishing vessels frequently drive line haulers with a line shaft take-off from the main engine. On POFI vessels an electric drive (3 hp. waterproof motor d.c. 1,725 r.p.m.) and a 5:1 gear reduction, or a hydraulic drive (7.5 hp. 35.8 gal./min. pump at 1,200 r.p.m.) are used to power haulers.

<u>HAULING PROCEDURE</u>: Hauling operations on Japanese vessels have been described by Shapiro (1950) and Shimada (1951). On POFI vessels the mainline is brought aboard, led through the overside rollers, and fed into the line hauler. The winch is controlled by the clutch operator, who stands at the rail and stops the winch by the foot control to detach branch lines. The fisherman tending and coiling line can also stop the hauling by pulling back on the idler lever, thus releasing tension on the line. Floatlines and hook droppers are detached as they reach the overside roller. The buoys and flagpoles are untied and stowed, and the floatlines and droppers are coiled by hand. As the mainline coils under the line hauler, floatlines and

droppers previously coiled by hand are reattached in the proper places so that the "basket" is ready for use the following day.

If the gear is not to be used for some time, as for example, when the vessel changes fishing grounds, droppers are removed from the mainline and are stowed separately. If practicable, hooks and leaders are removed from the droppers, for if assembled gear is stored wet for long periods, metallic components react with the damp line to cause weak spots. Gear is dried whenever possible, but exposure to direct sunlight is avoided.

MATERIALS USED TO MAKE UP GEAR

The following list of materials contains the items necessary to make up one basket of POFI 11-hook long-line gear. Prices of gear have been derived from Government bid quotations on material delivered in Honolulu and, because of fluctuations in market prices and shipping costs, are only estimates of cost to others.

Item	Quantity Required	Cost ($)
1. Mainline Section:		
Wire, stainless steel $\frac{5}{64}$" diameter 1 x 7, right lay	6 in.	0.03
Sleeves, Nicopress copper, $\frac{1}{16}$", 18-1-C	2 ea.	0.08
Swivels, brass, Seadog No. 2, trolling	2 ea.	0.46
Twine, cotton, 261-thread, treated	15 fathoms	1.25
Pennant, 261-thread twine, treated	24 in.	0.03
Total per unit		1.85
2. Floatline:		
Snap, AK, No. 9/0 design but made from 7/0 wire, brass barrel swivel	1 ea.	0.35
Twine, cotton 261-thread	10 fathoms	0.90
Total per unit		1.25
3. Float Assembly:		
Tank, surplus, stainless steel oxygen, 2,100 cu. in.	1 ea.	10.40
Eyebolt, $\frac{3}{8}$" x 4$\frac{1}{2}$", galvanized	1 ea.	0.55
Bushing, pipe, $\frac{1}{4}$" - $\frac{1}{8}$", galvanized	1 ea.	0.16
Thimble, wire rope, $\frac{3}{8}$", galvanized	1 ea.	0.10
Manila rope, $\frac{3}{8}$" diameter	24 in.	0.05
Sealing compound, lashing twine	-	0.10
Paint, Westinghouse, orange enamel	$\frac{1}{2}$ pt.	0.40
Total per unit		11.76
4. Bamboo Pole Assembly:		
Pole, bamboo, 14' long x 1$\frac{1}{2}$" at base	1 ea.	0.70
Flag, bunting, 14" x 18", orange	1 ea.	0.24
Hose, air, surplus, heavy	14 in.	0.80
Strapping, Band-It, $\frac{3}{8}$" width	18 in.	0.09
Buckles, Band-It, $\frac{3}{8}$" width	3 ea.	0.18
Rope, Manila, $\frac{3}{8}$" diameter	6 ft.	0.15
Total per unit		2.16
5. Hook Dropper:		
Snap, AK, 9/0 formed of 7/0 wire with brass barrel swivel	1 ea.	0.35
Twine, cotton, 261-thread	12 ft.	0.18
Tubing, rubber, black industrial, $\frac{3}{8}$" O.D. x $\frac{1}{8}$" I.D.	6 in.	0.08
Sleeves, Nicopress, $\frac{1}{16}$"	2 ea.	0.08
Wire rope, leader, .066" dia. 1 x 7 right lay plow steel, galvanized	6 ft.	0.06
Hook, 9/0 or 8/0 mustad flatted tinned, tuna	1 ea.	0.18
Total per unit		0.93

Item	Quantity Required	Cost ($)
6. Skid:		
Canvas, No. 4, triangle 45" each side	1 ea.	1.03
Manila rope, $\frac{1}{2}$" diameter	60 in.	0.20
Spur grommet, heavy, brass	6 ea.	0.12
Total per unit		1.35

Since POFI gear can be assembled so as to fish different numbers of hook droppers, the cost of individual baskets varies according to the type of gear used. Costs of typical gear assemblies are shown below:

Components	6-Hook "Standard"	11-Hook Tuna	13-Hook Albacore
Maineline--14 sections basket	$25.90	$25.90	$25.90
Floatline	1.25	1.25	1.25
Buoy.	11.76	11.76	11.76
Bamboo pole1/	2.16	2.16	2.16
Droppers	5.58	10.23	12.09
Canvas skid	1.35	1.35	1.35
Total Skate	$48.00	$52.65	$54.51

1/ Bamboo poles are usually attached to alternate buoys only.

DISCUSSION

The greatest defect of the present gear is the relatively short life of the cotton twine used for mainline and droppers. Three factors combine to cause this relatively rapid deterioration.

First, due to conditions inherent in the fishery, the line is often overstrained. This method of fishing is necessarily nonselective as far as catch is concerned, and large sharks and marlins often take the hooks. Heavy fish chafe the line and sometimes stretch gear beyond its elastic limit. Overstraining of the line also occurs during fishing operations in rough weather, for it is then difficult to keep the vessel close up to the gear. As the vessel drifts away from the set, the mainline is sometimes parted before the ship can recover position.

A second factor is wear and tear on the line during hauling operations. Some abrasion is due to chafing of hooked fish when droppers tangle with the mainline, but most of the damage is done by wear on the line as it passes over the rollers and through the line hauler. Wear is especially evident where swivels are inserted in the line.

Finally, the line deteriorates because proper care of the gear is extremely difficult. While on the fishing grounds, gear is set during the day and stored damp at night in the skids; it is frequently stored damp for several days at a time while the vessel changes fishing grounds. Under such conditions cotton line loses strength rapidly. It has been possible to make some progress in methods of preserving gear. For instance, POFI gear treated with copper-naphthenate preservatives now lasts about twice as long as the tan bark-treated line used in the Hawaiian fishery. Tarred line used exclusively by the industry in Japan and to some extent in Hawaii is now being tested but has not yet been evaluated.

It should be pointed out that the gear described in this report has not been designed primarily for commercial use. Rather, an effort has been made to develop a type of gear which would be extremely flexible and which could be changed rapidly for various types of experimental fishing. During the evolution of this gear, several design limits appear to have been reached. Thirteen hooks per basket appear to be the maximum number practicable with this type of gear. As many as 21 hooks per basket have been fished, but the net result was a slowing down and a reduction of efficiency in both setting and recovery of the gear. Hook droppers also have been shortened to their minimum length. Thus, it is anticipated that the general design of the gear may remain unchanged for some time but that futher improvements may well be made in the speed with which the gear is operated and the durability of the materials from which it is constructed.

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HE SHOWED OYSTERS HOW TO PRODUCE PEARLS

Kokichi Mikimoto--the man who developed the art of inducing reluctant oysters to produce pearls, built it into a major industry with world-wide connections, and himself made a fortune from it--died in Japan in September 1954 at the age of 96.

Mikimoto set up in business about 1905, after 15 years of experimentation. So far no one seems to have succeeded in imitating his enterprise on a commercial scale.

His pearls have been wrongly called artificial. All pearls are in unnatural development in an oyster, but, for a chemical aspect, Mikimoto's products are in every sense natural pearls. Even the seed on which the oyster built was a pearl, not a grain of sand as has so often been stated. These seed pearls are usually imported from the United States where they are obtained from small shellfish in the Mississippi and other rivers.

A pearl's value depends largely on its luster, and luster depends on the chemical constituents of the water in which it is produced. Mikimoto's pearls are thus, in this respect, equal to the best Japanese uncultured pearls. However, cultured pearls, produced in the Persian Gulf, an area noted for its beautiful pearls, might be superior in luster to Mikimoto's. The same may be true of pearls cultured at Thursday Island.

The secret, or art, is the highly skilled job of correctly placing the seed pearl in the oyster without killing the oyster.

One of the war reparations Australia gained from Japan was the secret of this artificial pearl culture. It is one thing to explain the process or to put it down on paper and another to develop the skills required--as the Australian CSIRO has discovered at its Thursday Island experimental station in postwar years. The CSIRO's fishery research officer at Sydney said in September 1954 that no great effort had been made at Thursday Island. The experiments were being conducted more or less as a side line . . . .

--Pacific Islands Monthly, November 1954