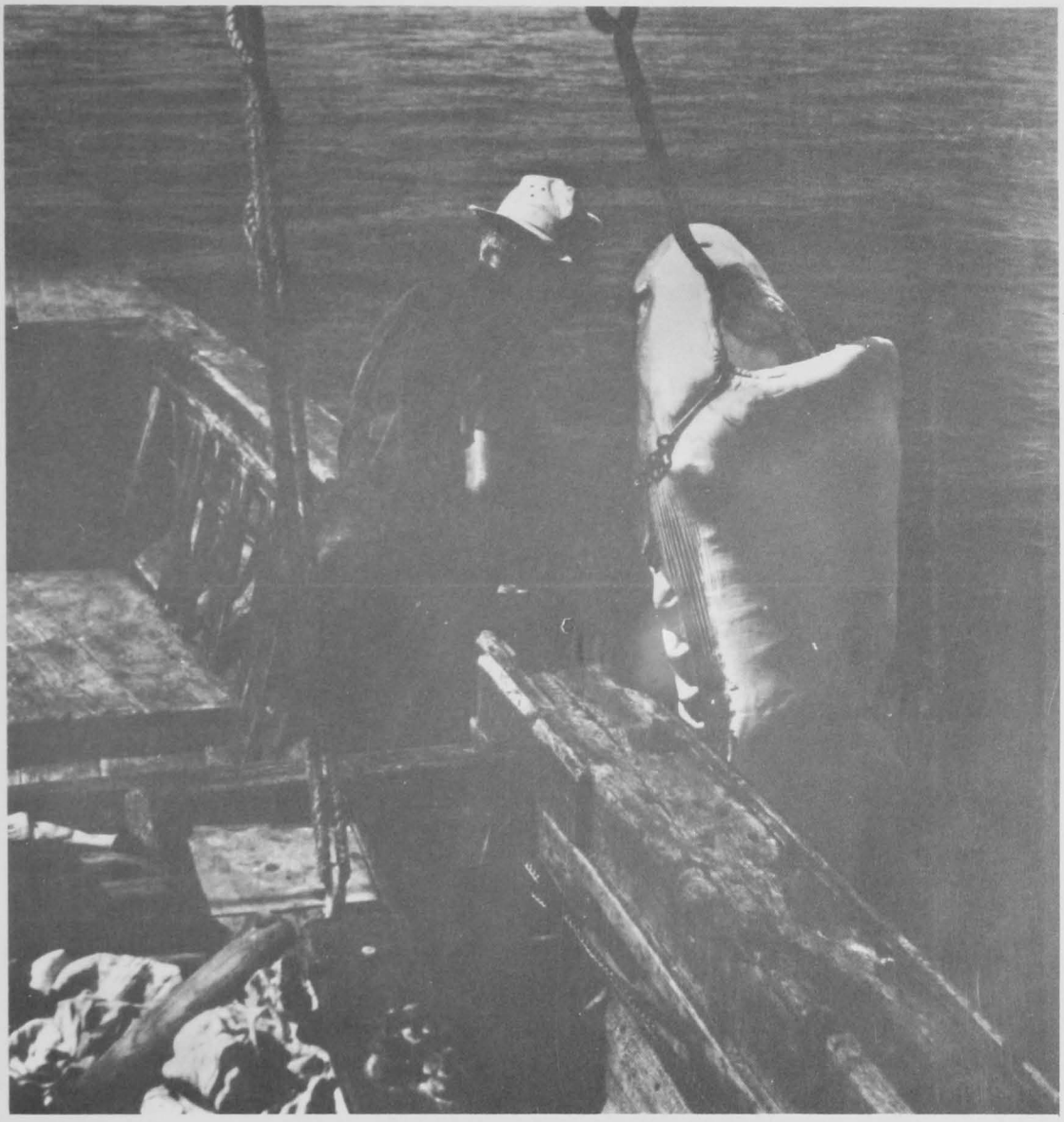
Shark Fishing Gear: A historical review

by Mary Hayes Wagner



UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES

Circular 238

UNITED STATES DEPARTMENT OF THE INTERIOR
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CIRCULAR 238

Washington, D.C.

January 1966

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MARY HAYES WAGNER, Biologist

Bureau of Commercial Fisheries Ichthyological Field Station
Stanford, California

INTRODUCTION

Shark fisheries developed rapidly in the United States between 1935 and 1950, when there was considerable demand for vitamin A from natural sources chiefly for the fortification of poultry feedstuffs. Not only did these fisheries flourish in the Caribbean Sea, off Florida, and in the Gulf of Mexico, but prices for high-potency shark-liver oil made fishing for soupfin shark (Galeorhinus zyopterus) off the Pacific coast so profitable that the species was threatended with extinction. The demand for vitamin A also greatly increased use of livers from the spiny dogfish (Squalus acanthias) of the northeastern Pacific and from many other species from other areas.

Although interest in shark fishing has continued in the United States, the successful production of synthetic vitamin A in 1950 forced the abandonment of most U.S. shark fishing. After the fishery diminished, reports of damage by sharks to fishing gear and to the fish caught in nets increased. Although damage occurs irregularly and varies greatly in intensity, it has recently become a serious problem to the U.S. trawl fishery, the purse seine fishery for tuna, the Florida fishery for Spanish mackerel, and the shrimp fishery. Present evidence indicates that the revival of commercial shark fishing is the most practical way to reduce shark damage. This circular, an account of methods of shark fishing formerly used in the United States and still in use in many parts of the world, has been prepared to encourage the reestablishment of commercial shark fishing in U.S. waters.

Shark fishing is currently carried on in Mexico, Australia, Japan, Denmark, and Norway. The present procedures are not standardized, however, because shark fishing in many areas has not been practiced long enough for the methods to become permanently established. For example, gill nets were originally used in the Mexican fishery at Tres Marias (personal communication, Stewart Springer), but it was found that the nets were effective only at certain times of the year and that larger and more varied areas could be fished productively with the seasonal use of floating longlines. Moreover, the initial phase of exploitation by shark fisheries frequently results in a depletion of shark populations necessitating a change from one gear method to another.

In this account the descriptions of the gear and accessory equipment, and suggestions for fishing methods and bait, are simplified and basic. Advances since 1950 in gear for other fisheries might be incorporated into methods for shark fishing; experimentation can undoubtedly improve gear efficiency. For instance, fishing with baited hooks on anchored bottom lines was more effective and cost little more in 1950 than fishing with the perishable cotton-twine gill nets then available. Now, the introduction of synthetic twine, improvements in gear for handling large nets, and the higher price of bait used with anchored bottom lines, indicate a need to reassess the merits of the two types of fishing gear for large sharks.

Because few U.S. vessels have fished for sharks during the last 15 years, sources of information on shark fishing and gear are limited to a few publications not now readily available. These publications are listed in the last section of this circular and are identified in the text by author and year of publication. In addition, some of the information in this report is based on personal correspondence.

The gear used for the capture of large sharks is the primary concern of this report. Small sharks (such as the spiny dogfish, Squalus acanthias) that travel in schools are easily caught in large numbers by otter trawls. Because fishing for these small species is with standard fishing gear, the reader is referred to Knake (1958) for an account of otter trawl operation and to Alverson and Stansby (1963) for a discussion of fishing for spiny dogfish in the northeastern Pacific.

GENERAL CONSIDERATIONS IN SHARK FISHING

Fishing methods must be adapted to the fishing locality. Weather and sea conditions affect the choice of the vessel and limit the kinds of gear that are practical. Other factors that determine the gear are: the nature of the bottom in the fishing area; the species and abundance of sharks available; local costs of gear and labor; and the value of the products at the point of sale. It is not possible to develop general rules for shark fishing because each situation demands trial and error in the selection of the appropriate gear and method.

Fishing gear is selective for particular species or sizes of sharks. On the southern Florida coast, for example, gill nets are effective seasonally in shallow water for nurse

sharks (Ginglymostoma) and for sand tigers (Carcharias), whereas baited hooks take but few of these sharks in that area. Conversely, tiger sharks (Galeocerdo) in the same area are more readily taken on baited hooks than in nets.

In general, the simple hand line is the only practical gear for one or two men fishing from a small dinghy. Nets are feasible for larger scale fishing only. The anchored bottom line (a line that is distinguished from the floating longline in that it is always anchored) with a minimum of 100 hooks was formerly the most successful method for taking large sharks, and may be used by a sufficiently large boat and a crew of at least three men. Other factors that affect the rate of capture of sharks on lines are the types of hooks used (fig. 1) and their condition (hooks should be clean and highly polished), the kinds of bait, the distance between set lines, and the directions of the sets and tidal currents.

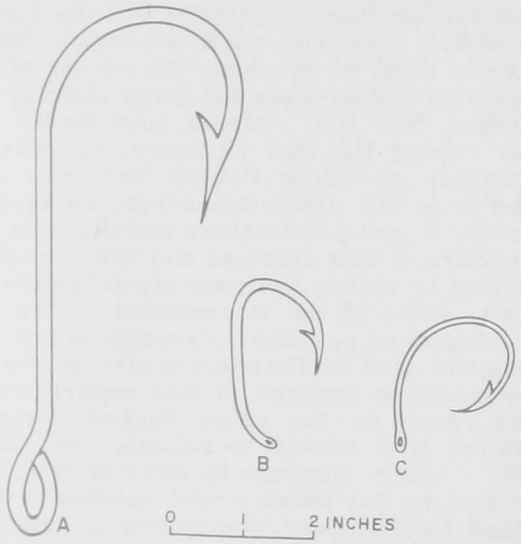

Figure 1.--Shark fishing hooks. A. Type used with heavy gear, such as anchored bottom lines. B. Japanese-style hook for floating longline. C. Japanese circle hook recommended for bottom longlines set in deep water.

The number of sharks available in an area is often overestimated. Most of them are predators and are abundant only in areas where fishes or invertebrates suitable for food are plentiful. Sharks are occasionally conspicuous, and a few can be caught easily, but the total weight of large sharks occupying a segment of the sea is far less than the weight of other fishes or invertebrates on which they feed.

The choice of a fishing area is influenced by seasonal migrations of the sharks and their food. For example, the area off the mouth of the Mississippi River is characterized by a profusion of invertebrates and fishes, but sharks congregate there in large numbers only during the warmer months when the area becomes the center of a region of terminal migration for tropical shark populations. Salerno, on the east coast of Florida (fig. 2), was formerly the site of successful shark fishing that was most productive during the winter and spring when species of large sharks migrating to inshore waters along the Atlantic coast were concentrated on the Continental Shelf. The shelf narrows abruptly near Salerno.

Commercial fishing of any kind is hazardous, but shark fishing has some special dangers. For example, anchored bottom lines of chain, wire rope or even manila rope are much heavier than the standard tuna longline gear and are a serious threat to fishermen, who could be caught accidentally by the hooks and carried overboard. Moreover, large heavy sharks often remain alive for several minutes after being brought aboard; their snapping jaws with razor-sharp teeth must be avoided. Reasonable safety precautions save time and expense. A large shark can be hoisted easily onto the deck of a vessel with various rigs, but because sharks may be active, some routines are much safer than others. Shooting of sharks is especially undesirable in commercial fishing because of the added danger and cost. If it is not practical to drop the sharks into a hold below the deck, a section of the deck separated from the working area by pen boards is excellent (fig. 3).

METHODS OF FISHING FOR SHARKS

Types of shark-fishing gear (aside from trawling rigs) can be grouped into five general categories: gill nets, hook and line, anchored bottom lines (differing from the floating longlines in that they are always anchored), floating longlines, and the benthic line for deep-water fishing. Anchored bottom lines are often called longlines, but a distinction is made here because the two types of gear are used in entirely different ways. It is of historic interest that the floating longline as an important commercial fishing gear was developed by Japanese fishermen as a means for catching tuna. This line is extremely long, extending sometimes for more than 25 miles as a continuous fishing unit. Compared to anchored bottom lines it is extremely light in weight and is very inexpensive. Its use in modified form for shark fishing is a recent development for the capture of some pelagic species. It is not appropriate for the capture of bottom-dwelling species or for use in shallow waters close to land.

Gill Nets

Gill nets (fig. 4) may be fished as drift nets or as fixed bottom nets. Drift nets as used by fishermen in the northeastern Pacific

Figure 2.--Map showing Salerno, Fla., the site of successful shark fishing, where species of large sharks are concentrated on the narrow Continental Shelf.

for soupfin sharks differ from bottom nets in three essentials (Carlson, 1943b): they are 50 to 60 meshes deep, as against 20 to 30 in bottom nets; the web is hung-in nearly 50 percent, as against 25 to 30 percent; and the shackles (sections of net) are shorter (15 fathoms as compared with 25 on most bottom nets). Otherwise, specifications for the two types of nets are much the same: web, 10-inch-stretched mesh, of 18- to 30-thread medium lay seine twine; lead and cork lines, 15- to 18-thread sisal; hanging, cotton, 36- to 54-thread. Leads, lines, floats, hauling cables, and buoys are identical for the two types of nets. Floating shark nets are much more expensive than the bottom nets because of their greater depth.

Gill nets in the soupfin fishery are made up in shackles, linked together to form a string. Flotation is by means of 6-inch glass balls, trapped in twine and secured to the corkline. Weights are individual pieces of lead tight on the leadline, or are in groups of four or five, loose on short beckets spliced into the leadline.

The 6-inch glass balls are spaced 2-1/2 fathoms apart on the corkline of the drift net. Their buoyancy is overcome by the weight of the leadline; in drift net fishing for sharks, the net itself should never float up to the

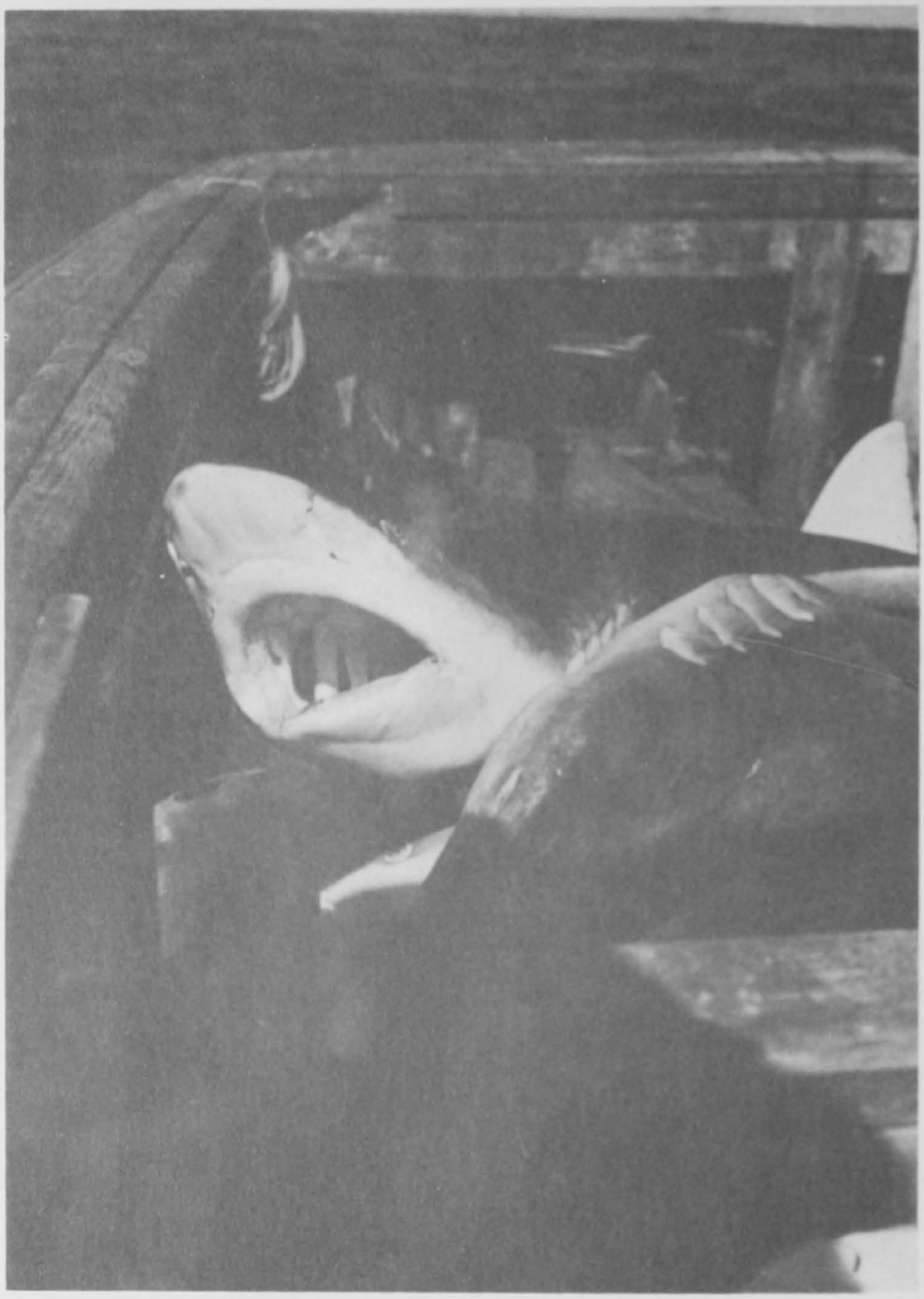

Figure 3.--Part of the catch of a shark fishing vessel. Pen boards shown in the foreground separate the sharks from the working area of the deck.

surface. At 15-fathom intervals along the cork-line, 18-inch inflated rubber buoys are attached to the net in the same manner as the glass floats. Buoy lines of 18-thread sisal, adjustable in length up to 8 fathoms, attach the rubber buoys to the hauling cable. Thus, the hauling cable is supported in the water by the rubber buoys, and the lengths of the lines are regulated to put the net at the best fishing level.

Bottom gill nets were used for shark fishing at Big Pine, Fla. (Higgins, 1945). Details of construction of these nets, which are no longer in common use, were: length, about 100 fathoms; depth, 10 to 20 feet; twine, 72-thread cotton; mesh, 20-inch stretch; depth,

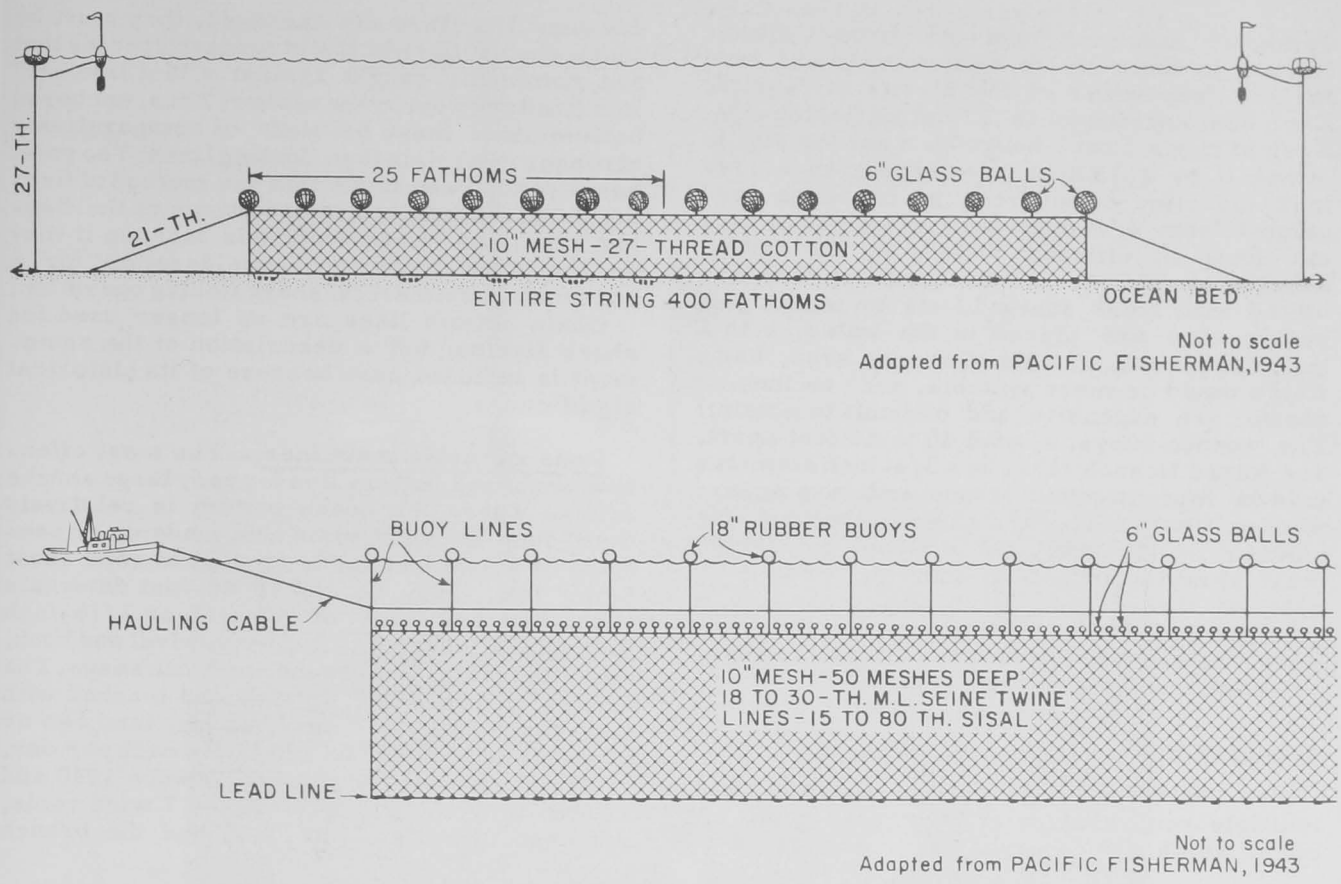

Figure 4.--Two methods of setting gill nets for catching sharks, a bottom net for soupfin sharks (upper diagram) and a subsurface drift net (lower diagram).

10 meshes; hung-in one-third on a hemp or manila corkline of 1/2-inch diameter, strung with 3-inch cork buoys at about 3-foot intervals; and leadline, about 3/8-inch diameter, weighted with 4-ounce leads. Each 100-fathom section was fished separately, anchored at each end, across the tidal currents. The nets were marked with buoys and with flags on 15- to 20-foot bamboo poles, buoyed and weighted to stand upright in the water and thus be visible from a distance.

The cotton nets were handled in groups of three (Springer, 1947); two were fished while one was being repaired or dried. Untreated cotton nets left in the water longer than 5 days at a time deteriorate rapidly. In practice, shark nets were untreated except for washing with lime water before drying. Treated nets were said to fish poorly.

The use of gill nets saves the cost of bait, but they are difficult to handle in rough water and occasionally they catch large numbers of unwanted species. The species of sharks most frequently caught in areas where gill nets can be used are never in one locality for long periods of time, but move seasonally into deeper water where line fishing is more practical.

Hook and Line

Generally each of two men in a skiff operates a line. The line should be at least 72-thread, medium lay cotton. A 6- to 8-foot leader of 1/16- to 1/8-inch diameter stranded wire cable or 3/16-inch chain is connected to the line by a swivel. When 2-1/2- or 3-inch shark hooks (measurement from the point of the hook to the shank) are used, they are spliced directly to the leader (Anglo-American Caribbean Commission, 1945). Now synthetic lines of greater strength and durability than cotton are available in practical diameters allowing ease in operation.

The choice of bait for hand lines varies in different areas. In San Francisco Bay, for example, Edward McCarthy (personal communication) used bait of squid soaked in beef blood to catch large numbers of small sharks (Triakis semifasciata and Rhinotriakis henlei). Bait preference depends on the species of shark sought, the locality of the grounds, and the availability of large freshly cut fish.

At Cojimar, Cuba, natives for generations have successfully employed an unusual method of shark fishing (Gilbert, 1961). Between 9:00 and 11:00 p.m., fishermen (as a rule, two men

comprise the crew) put out from Cojimar Harbor in their 18- to 24-foot boats and head for the deep water of the Straits of Florida. Each boat carries 10 to 15 floating fishing rigs. Each of three 2-inch hooks on a set (or rig) is attached by a 15-foot wire leader to a 1/4-inch diameter cotton rope which hangs suspended from a wooden buoy. The hooks of a set hang at different levels in the water, usually at 20, 50, and 80 fathoms; they are baited with fresh shark fillets or mullet just before they are placed in the water, 1 to 4 miles offshore. (In the Cojimar area, baits which would be more suitable, such as tuna or bonito, are expensive and difficult to obtain.) The wooden buoys, spaced 40 to 50 feet apart, are joined to each other by a 3/4-inch diameter manila rope attached at one end to a square wooden float bearing the name of the boat, the number of the set, and a 4-foot removable mast carrying a lantern and flag. Usually 10 sets of three hooks each are placed in a straight line, 100 to 200 yards apart. After the lines are set and the lanterns lit, the rigs are patrolled until drawn.

Anchored Bottom Lines

The anchored bottom line (fig. 5) is a multiple-hook system of rope, wire cable, or chain which can be arranged in several ways. Because the lines are anchored, they must be tough enough to hold the strongest species that are commonly caught against a taut line held in a fixed position by the anchor. Thus, anchored bottom lines must be made of comparatively stronger materials than floating lines. The point has already been made that the method of fishing must be adapted to conditions in the fishing area, but needs emphasis because it may be the most important consideration for a successful commercial shark fishing operation.

Chain bottom lines are no longer used for shark fishing, but a description of the equipment is included here because of its historical significance.

Rope or cable mainlines.--The most effective anchored bottom line for very large sharks in use where the ocean bottom is relatively even consists of a main line made up of sections of galvanized cable or manila rope about 3,500 feet long; at 25- to 40-foot intervals along the line, 6 feet of 1/8-inch or 3/16-inch galvanized leader chains, with swivel and hook, are attached to the ground line with snaps. The line is anchored at both ends and marked with flag buoys (fig. 6). One boat can tend two or three lines with 200 to 300 hooks each per day. In the Florida shark fishery between 1940 and 1950 preformed galvanized 6 by 7 wire cable, 3/8-inch diameter, was used and the branch

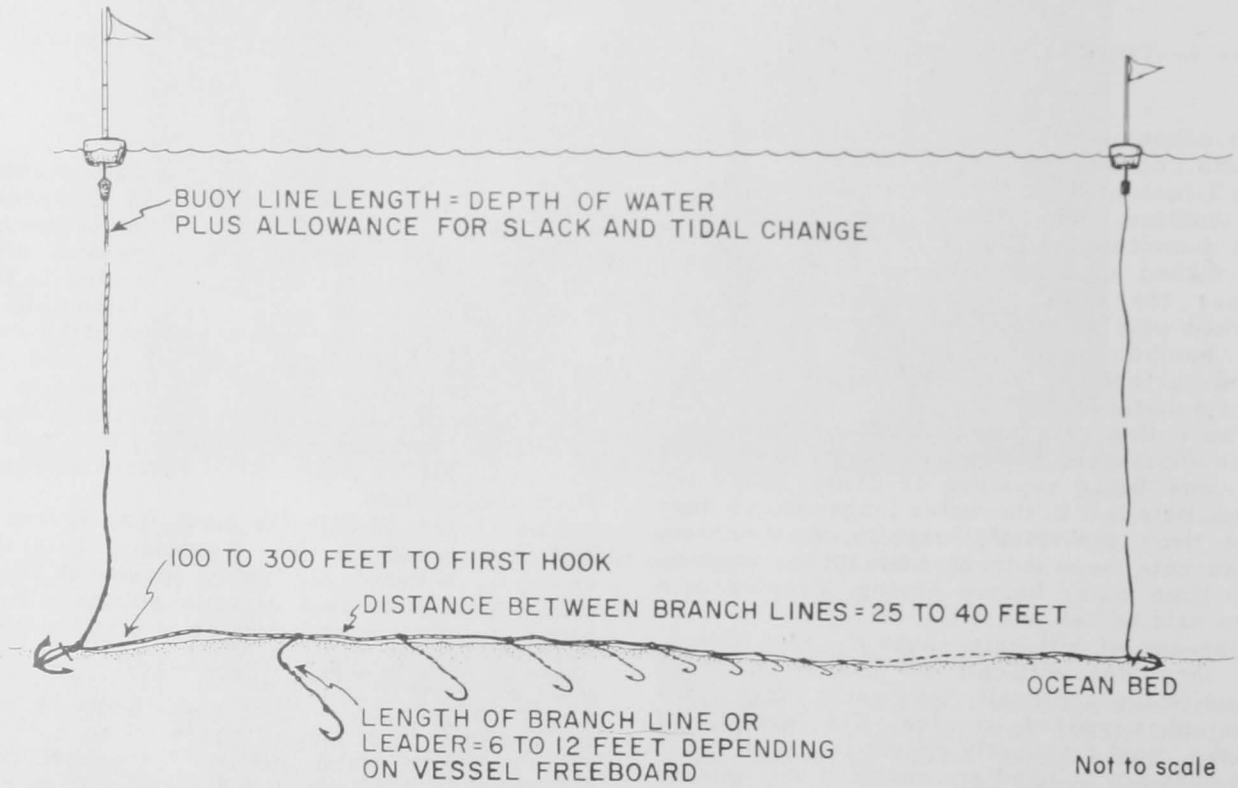

Figure 5.--Anchored bottom line (constructed of wire rope cable, manila rope, or chain) is set parallel to the current so that the chumming effect of the bait is concentrated. Strong currents may sink and crush buoys unless they are inflatable.

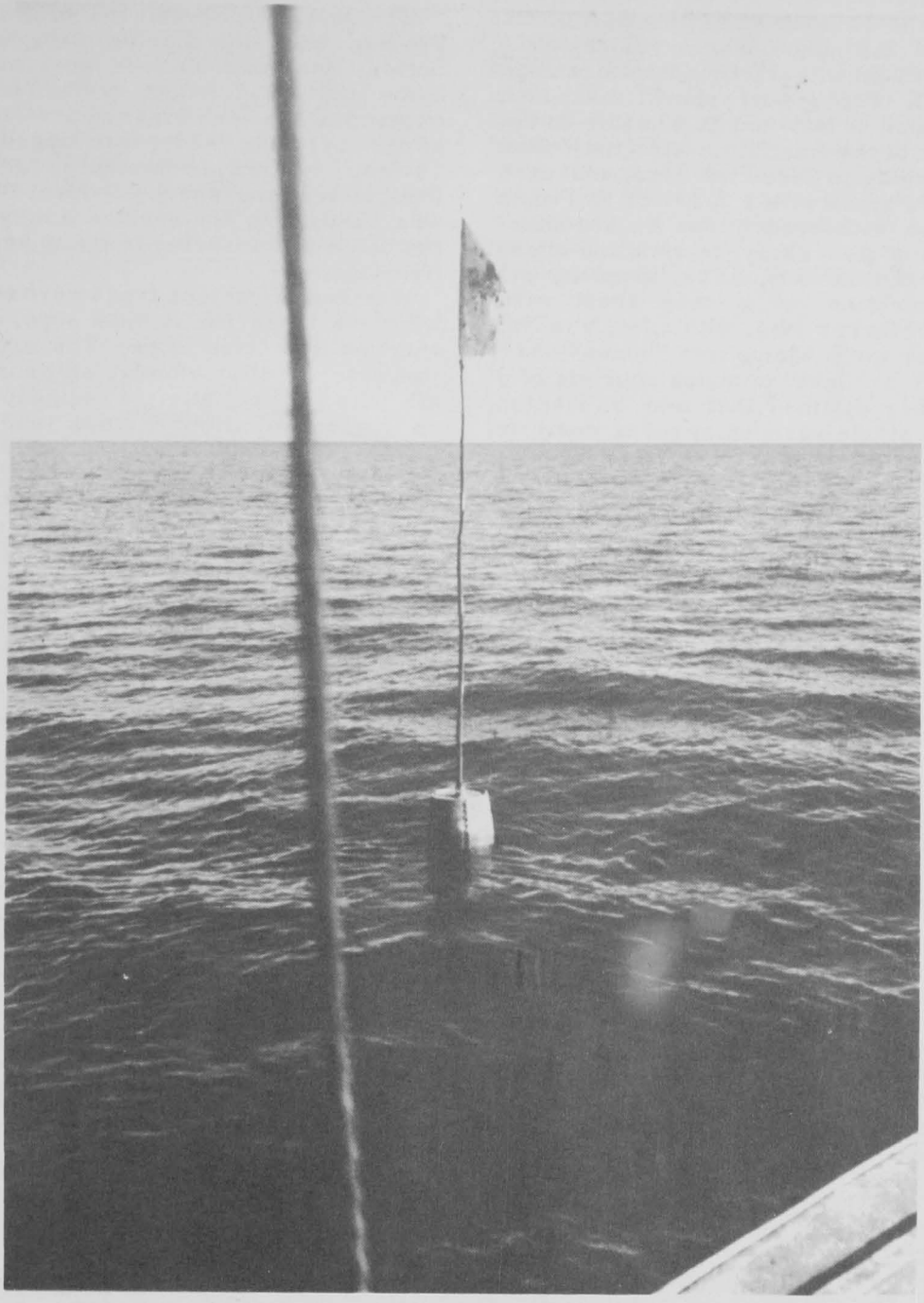

Figure 6.--A flag buoy for marking an anchored bottom line. The important features are good visibility and enough buoyancy to keep the anchor line afloat.

lines were snapped on in the space between a pair of "stoppers," lead balls melted into the wire or U-bolt clamps. Manila rope mainlines, 3/4-inch to 1-1/4-inch diameter, were used on some vessels fishing for large sharks off the Pacific coast of tropical America. The mainline had eyes spliced in at regular intervals to take the snaps holding leaders made variously of chain or wire.

If the ocean bottom is heavily studded with coral, which would hopelessly foul the anchors and hooks of the gear described above, a line and 6 to 10 floats may be operated as a unit (Anglo-American Caribbean Commission, 1945). The distance between the buoys should be approximately 2-1/2 times the length of the hook line.

A part of the Tasmanian and South Australian catch of the school shark (Galeorhinus australis) is made with anchored bottom lines (Olsen, 1954). The school shark reaches a length of about 5 feet and is similar to the soupfin shark of the Pacific coast of the United States. According to Olsen the usual anchored bottom line is made with a 3/4-inch to 1-inch sisal mainline with branchlines or snoods of cotton or hemp tied along the mainline every 3 fathoms or thereabouts. At the terminal end of each branchline is a very short wire leader, 6 to 9 inches long, with a No. 9 to No. 12 hook. Lines are made up into "boxes" of 80 to 100 hooks; a "fleet" of boxes consists of a varying number of lines that may be knotted end to end. A single vessel may set as many as 2,500 hooks on a trip that takes from 12 to 36 hours.

The types of hooks used, their condition, and the manner of bait attachment are all significant factors in productive shark fishing. Shark hooks for large species are 2 to 4 inches across the jaw and have either needle or ringed eyes. Hooks should be sharpened and brushed bright and smooth every day (Springer, 1963). This is especially important when large hooks are used on anchored bottom lines. The points of the hooks should not be hidden in the bait, and the bait itself should be placed in such a way that the hook is not choked. In areas of good fishing in Florida in 1949, about 5 percent of the sharks caught with bright, sharp hooks were hooked through a fin or through some part of the body other than the mouth. In addition, it was suspected by fishermen (because of the frequent capture of sharks in clusters) that the disturbance caused by a fin-hooked shark aroused the interest of other sharks in the vicinity. Big catches were probable when sharks were attached to the gear soon after it was set and when the line became a center of turmoil.

Experience in Florida 20 years ago proved that the best bait for all sharks was freshly cut fish, and that bait frozen when fresh was next best (Springer, 1963). Of the species of fish available in southern Florida, the little tuna, Euthynnus alletteratus, or the Atlantic bonito, Sarda sarda, appeared to be the best bait. No doubt other small tunas would have been equally satisfactory had they been available. Whole fish seemed to be poor bait, so it was necessary to select and cut fish weighing 2 pounds or more. Except for the small tunas, the only available first-quality fish for bait were the crevalle jack, Caranx hippos, and the great barracuda, Sphyraena barracuda. Some species such as the dolphin, Spanish mackerel, and amberjack were used occasionally by fishermen who caught them while trolling to and from shark longlines. Notably unsatisfactory as bait were snappers, groupers, and mullet (Springer, 1963).

The boat, which was used successfully in the Florida area for fishing with the anchored bottom line, was 35 feet long, with a 10-foot beam and a 2-1/2-foot draft. The catch was carried in the open forward and stern sections of the boat. The vessel was rigged with a stout 10-foot mast and a boom with a tackle or winch for hoisting the sharks aboard. When a shark was brought to the surface a large hook from the boom was inserted in the upper jaw or eye (frontispiece).

Winches of various types were used--simple windlass types for manila rope, and spooling winches for wire rope. The spooling winch was placed either athwart-ships in the bow, or aft, with the reel at right angles to the keel and so placed to allow a clear lead forward. A fair-lead, through which the cable was brought aboard, generally was made up of three rollers, one placed on the rail cap and the other two vertically outboard of this roller to form an "H" through which the cable passed.

An advantage in the use of rope gear was the ease with which it could be handled without a special powered spooling device permitting adaptability for use on fishing vessels of various deck plans. The chief disadvantage was in some losses due to cutting of ropes by sharks.

When the lines were set, the leaders with hooks attached were placed in tubs or along the rail toward the stern of the boat where they could be reached easily. The buoy was attached to the end of the line, led aft, and dropped overboard. The buoy line was paid out from the winch drum, and the anchor was attached to the line and dropped overboard. The first leader was snapped to the mainline about 200 to 300 feet from the anchor (the first hook could not be lifted easily if the leader was too close to the anchor); care was taken to clear each hook and the leader from the boat before it was attached to the mainline.

To lift the set, the buoy was picked up, unsnapped, and the line was run through the fair-lead and attached to the winch drum. When the first anchor was reached, the winch was stopped and the anchor unsnapped. The line was spooled on the winch and leaders were unsnapped as they came up to the fair-lead. The leaders generally were dropped in tubs with the hooks hung on the rim of the tub. If a hooked shark was not too active, it was possible to unsnap the leader from the mainline and to lead the shark aft and boat it while the winch continued to reel in more cable.

Chain mainlines.--The following is adapted from a description of gear formerly used for commercial fishing by Shark Industries (Springer, 1947). Chain mainlines are no longer recommended because they are dangerous to use. One hazardous aspect of this gear is the fact that the chain must be put out while

the boat is at full speed to avoid pileups. Because the leaders are not readily detachable from the line, extreme caution must be maintained by the fishermen to avoid entanglement and serious injury from the heavy hooks (fig. 7).

The shark-fishing boat for use with chain mainline was equipped with a stout mast, a boom for hoisting the sharks aboard, and a hand windlass or power winch for rapid handling. The mast and boom were placed in a way to permit loading and distribution of landed sharks from the middle of the boat, and to ensure good trim. One boat fished at least 200 hooks, rigged in two lines.

Fishing lines consisted of a mainline and leaders of welded-link 1/8-inch galvanized chain. The leaders were 25 to 30 feet apart and attached to the mainline with a lap link. Each leader had a swivel half-way between the ends; length of the leaders depended upon the height of the deck from the waterline. Each hook was attached to the end of a leader with a lap link, or, if open-eye hooks were used, by closing the eye. The mainline had an anchor,

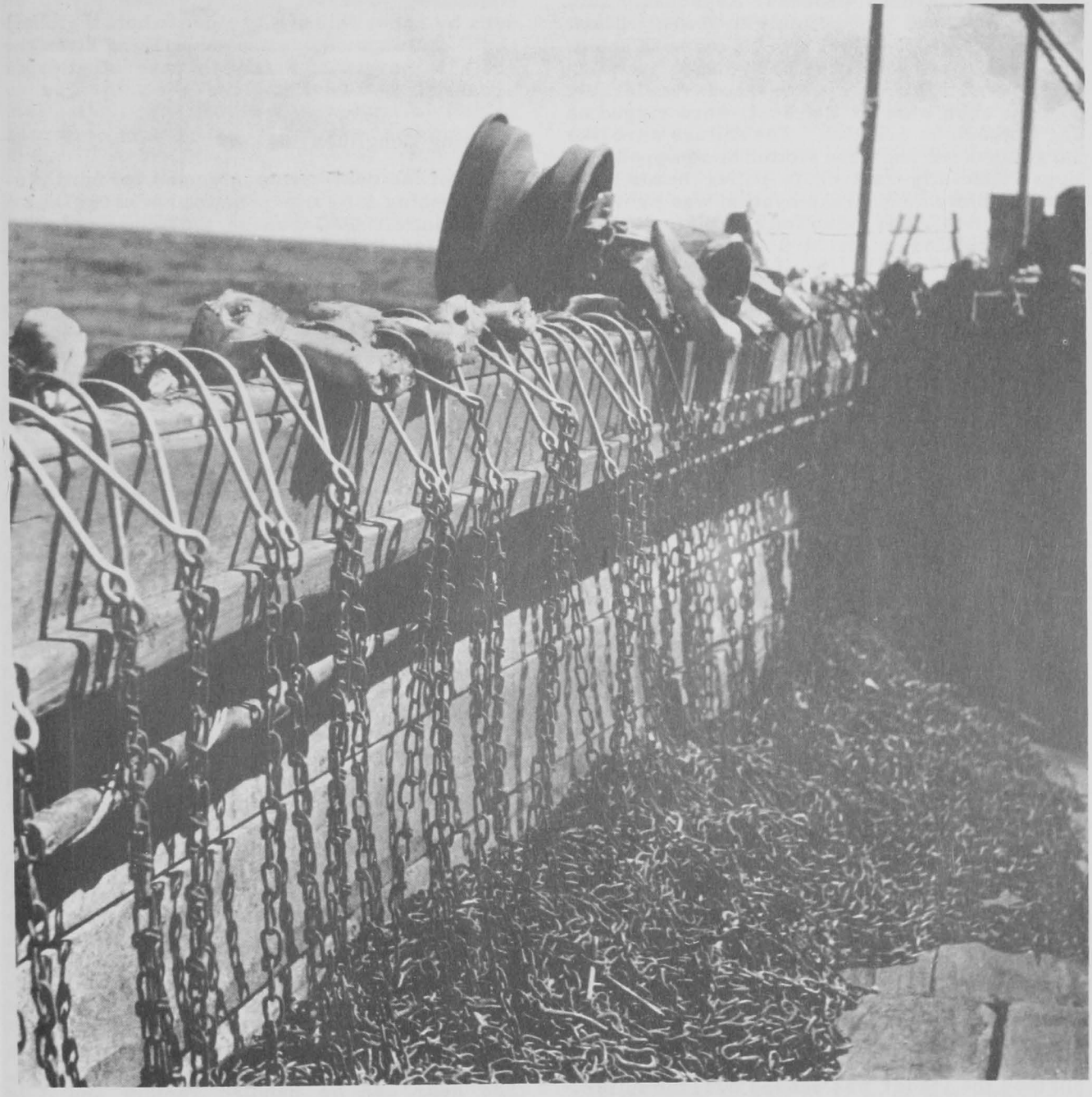

Figure 7.--Baited hooks ready to set as part of an all-chain anchored set line.

buoy line, and buoy at each end. The length of the anchor buoy lines and the manner of rigging depended not only on the depth of the water fished, but on the type of bottom.

The weight of the chain limited the maximum depth in which fishing was feasible to about 25 fathoms; but since shark fishing, even for shallow-water species, is often better in 35 to 50 fathoms, fishermen using chain were tempted to go beyond the 25-fathom limit. Also, it was found that a proper set with chain could be made only at the vessel's full speed of 8 to 10 knots, a hazardous process. Reasonably safe procedures are too difficult to learn without experience on a vessel that fishes with chain, and such operations have been discontinued.

Powered rollers or puller-heads (preferably one on each side of the boat) were rigged as far forward as practical. The rollers were like large sheaves and were slotted or equipped with dogs. Specially cast chain puller-heads were used. A clutch and brake system was provided for each head, and reduction gears were used to turn the puller-heads at a speed of about 40 r.p.m.

To set the chain line, the gear was faked down on deck starting toward the forward end of the boat in the following order: buoy, buoy chain, anchor, mainline, anchor, buoy chain, buoy. The hooks along the mainline were hung on the rail or stuck in slots in the rail (fig. 7). Care was required to keep the hooks in consecutive series and the leads clear. The buoy toward the stern of the boat went overboard first.

The line was set straight and tight. The fine points of getting the line overboard safely, quickly, and in proper position to catch sharks were best learned by experience. To some extent the method used depended on the structure of the boat and the depth of the water. A few general rules, however, were always applicable: the gear was ready and everything cleared before setting; the boat, with the engine running, was kept under control at all times; the entire crew stayed clear of the chain and the hooks as they went overboard; a taut chain or hook was never touched if the line became tangled or fouled; if the line or a hook caught on the boat, all strain on the line was released immediately by maneuvering the boat; and the gear was set with the tide in order to get a tight line.

Baited lines were left out overnight, and the set lifted in the morning. The gear was recovered in the following manner: the downwind buoy was picked up first and the chain was passed over one of the puller-heads; the anchor also was brought in over the puller-head. As the chain came aboard it was faked down in position to reset; as each hook came to the surface the leader was passed over the puller-head by hand or, if a shark was on the hook, the puller was stopped while the shark was just below the surface. The fish was gaffed with a heavy barbless hook attached to the hoisting gear and lifted alongside, clear of the chain, where the leader hook was removed. If the shark was still alive, it was quieted by beating it over the end of the nose with a suitable club. The shark was then hoisted into the section of the boat set aside for cargo, and the puller-head was restarted. The boat's engine was kept running while the line was being lifted, and the boat was maneuvered to keep itself directly over the line. After the line was passed over the puller-head a heavy bight of chain was accumulated overside before it was pulled on deck by hand. This bight helped to hold the chain in the puller and gave the man faking down the chain a margin of safety in case of slips or breaks.

Floating Longlines

All of the gear commonly used for multiple-hook fishing for large pelagic sharks is similar in essentials to Japanese tuna-longline gear. Such gear has some important limitations. Multiple-hook floating lines for large sharks are practical only when used in relatively deep water, usually in true pelagic situations beyond the limits of the Continental Shelves (personal communication, Stewart Springer). Floating lines too close inshore are often subject to changing currents. They may become snagged in shoal water or drift into navigation lanes. Attempts have been made to fish with longlines anchored at both ends but with the entire central portion of the rig afloat. On such a rig a catch of one or more large sharks usually produces such an incredible tangle of gear as to preclude its effective use. Experiments with floating longlines by Florida shark fishermen in 1935 to 1945 were unsuccessful even well offshore where depths exceeded 200 fathoms. The fishermen used relatively heavy gear for these attempts because this was the custom; it did not occur to them that large sharks could be caught with comparatively light gear. The heavy floating gear caught sharks but the catch rate (number of sharks caught per baited hook per day) was far too low for profitable commercial fishing. Furthermore, the high cost of gear limited the sets to a few miles of line.

The tuna longline used by Japanese fishermen for large fishes is especially suited to fishing for pelagic sharks that are sparcely distributed near the surface. Although the gear is light in weight and the mainline typically has a breaking strength of slightly less than 1,000 pounds, it holds very large fish. The line acts merely as a drag against initial rushes of the fish when it is hooked. The spacing of the hooks and the depths at which the hooks hang in the water may be adjusted to fishing conditions. The gear can be handled rapidly and it is not unusual for tuna longline vessels to set and take in as much as fifty miles of line in a day.

Japanese longliners now in operation are comparatively large vessels and the methods used in setting and handling the lines require a large fishing crew. Thus the value of the catch must be high to make the operation profitable. Only a part of the catch of sharks made by Japanese longliners is landed because these vessels, especially when on long trips, must carry as large a quantity of the more valuable tuna as possible. A substantial proportion of sharks taken by the Japanese fishery are landed as byproducts or secondary catches of operations aimed primarily at catching other fishes.

Only a brief and general description of floating longline gear will be attempted here because fishing with floating longlines primarily for pelagic sharks is a new kind of fishing operation and details of the gear and methods are still evolving. Furthermore, the gear described here was developed for tuna fishing and merely catches sharks incidental to tuna fishing. Modifications of the Japanese longline proposed for use by American fishermen or tried experimentally by exploratory fishing vessels of the United States for tuna fishing have been made with the intent of reducing the number of fishermen required in the crew. Japanese floating longline gear is described in detail by Niska (1953), and some special adaptations of the gear used by U.S. fishermen are covered by Captiva (1955) and by Mann (1958).

The following specifications condensed from Captiva's account refer to gear generally available in the United States and to gear shown experimentally to be effective in catching pelagic sharks as well as tunas. Tuna catches were the primary objective of the operation; the potential for catching sharks was not determined although substantial numbers were hooked in spite of efforts to avoid catching them. Daily sets of about 25 miles of this line were made experimentally in the Gulf of Mexico by the M/V Oregon of the Bureau of Commercial Fisheries with a crew of 14 men.

This U.S. longline gear consisted of three basic components: the mainline; the branch lines (gangions) with wire leader and hooks; buoys and buoy lines. The gear was made up in sections usually called "baskets" (traditionally, a section of mainline with a varying number of branch lines is coiled in a basket or other suitable container for convenient handling). Floating longlines are now usually set in a single long line, the mainline of one basket tied to the mainline of the next. Buoy lines with a buoy are used at each end of the string of baskets and at the junction between each two baskets of gear.

In the experimental operation mentioned in the preceding paragraph the basket included 138 fathoms of 132-thread (or 11/64-inch diameter), type-E filament nylon to which 10 branch lines were tied at 12-fathom intervals. Branch lines made of the same size nylon line as the mainline were 3 fathoms long, tied to an 8/0 barrel swivel which was attached to a 1-fathom leader of 3/32-inch, 7 by 7, preformed, stainless-steel wire with a 9/0 Japanese-style tuna hook. Buoys used with the experimental longlines were 16-inch diameter rubber seine floats. Buoy lines were 1/4-inch diameter manila and of lengths varying from 5 to 50 fathoms.

The hooks used for tuna fishing appear to be too small for large sharks, but are strong enough and, in practice, catch sharks on floating longlines better than the heavier shark hooks. Sharks often swallow the small hooks and it is then time-saving to leave the hook and branch-line with the boated shark until the catch is butchered. When this is done, spare branch-lines are used immediately to replace the ones temporarily left with the catch.

In tuna longline fishing, baits are usually herring, saury, or squid weighing less than a half-pound each. These baits do catch sharks, but comparisons of bait preferences of tuna and sharks have not been reported. (See table 1 for a summary of hooks and bait recommended for four types of shark fishing gear.)

Recently, vessels of Norway, Denmark, and the Faroes have fished with floating longlines in the North Atlantic, especially for the porbeagle (Lamna nasus). In 1963, landings of porbeagles by Norwegian vessels amounted to 5,000 tons as compared to 5,700 tons landed by Japanese vessels (Yearbook of Fishery Statistics, 1963, Food and Agriculture Organizations of the United Nations). Landings of Atlantic porbeagle became significantly large following the development of an Italian market for this shark at a comparatively high price. The level at which this fishery will be able to operate in the future is uncertain.

Porbeagles landed as food are frozen within 24 hours after capture with head and viscera removed. Consequently, vessels fishing for them require freezing equipment and are thus comparatively large. The gear reported in use by one of the Atlantic fishing vessels consists of a tarred hemp mainline one-half inch in diameter with branchlines (hooklines) 2 fathoms long with an additional fathom of plastic-covered wire adjacent to the hook (Aasen, 1965). Branchlines attached by snaps to the mainline are spaced about 10 fathoms apart with floats on every fourth hook. The best depth of fishing is determined by test sets, and the float lines are adjusted to hold the line at the indicated depths, usually ranging from 10 to 200 fathoms. The hooks are comparatively small, about the same size as the hooks used by Japanese longliners. North Atlantic vessels are reported to set about 1,200 baited hooks per day with a crew of 12 to 18 men during the season from April to October.

Table 1.--Summary of hooks and bait recommended for four types of shark fishing gear

GEAR	HOOKS	BAIT
Hook and line	2 1/2- or 3-inch shark hooks (measurement from the point of the hook to the shank); smaller hooks may be used if small sharks (less than 5 feet long) are sought	Small chunks of fresh fish or frozen fish. Squid soaked in beef blood
Anchored bottom line	Shark hooks; 2-4 inches across the jaw, with either needle or ringed eyes	One pound of freshly cut fish per hook (tuna, bonito, or crevalle jack preferable)
Floating longline	9/0 Japanese-style tuna hooks	Squid or small oceanic fish such as herring or saury
Bottom longline with magnesium link	2-inch Japanese-style circle hooks	6- to 10-inch jack, scad, or hard-fleshed fish, caudal fin removed and cut in 2 or more pieces

The Benthic Line for Deepwater Fishing

Commercial fishing for sharks in the past has been restricted to pelagic surface waters or to bottom fishing at depths usually less than 200 fathoms. Little is known about sharks in deeper water, but experimental gear with time-release links has been used to catch specimens of bottom-dwelling sharks (in depths of a thousand fathoms) for biological study. In theory, the gear is not restricted in depth of fishing, and if valuable products are ever found to be present in sharks living at great depths, this equipment could be used in commercial fishing.

This deepwater gear (fig. 8) consists of a long mainline with a series of baited hooks on short branch lines, and/or a trap or series of traps. At one end of the line is an expendable anchor, one of a pair of magnesium time-release links (fig. 9), and a spreader vane. At the other end is a heavier expendable anchor, the other magnesium time-release link, and floats with a radar target. The fishing time is determined by the diameter of the magnesium links, the water temperature, and the time required for the gear to move from the bottom to the surface.

The mainline consists of 400-foot lengths of 3/16-inch and 1/4-inch diameter polypropylene rope or 132-thread hard-lay cotton. Branch lines with 4-foot wire leaders (total length about 8 feet) should be placed at 3-fathom intervals. Two-inch Japanese-style circle hooks are recommended.

The bait, fresh-frozen 6- to 10-inch jacks or other firm-fleshed species of fishes with the tail fin removed and cut in two or more pieces, stays on the hooks satisfactorily. Squid and sardines are not suitable.

As mentioned previously, two expendable anchors are required for each set. In one series of experimental sets a concrete block weighing about 30 pounds (in air) was used for the vane end of the line, and a 60-pound block for the float end. Anchor weights should be sufficient to exceed buoyancy by more than a few pounds. Three or four glass balls, made to withstand great pressures and each with about 12 pounds positive buoyancy, were used. The glass floats were enclosed in netting and, at the end of the line where two were used together, held apart by a plastic ring. For fishing at depths too great for glass floats, the substitution of floats consisting of polyethylene bottles filled with gasoline is possible.

Spreader vanes are made of 2- by 3-foot rectangular sheets of light-weight aluminum, crimped at the edges for greater rigidity and fitted with a short bent aluminum pipe.

Radar reflectors made of wire mesh on a collapsible frame that opens to form three intersecting squares 44 inches wide are available, but reflectors may be fabricated from

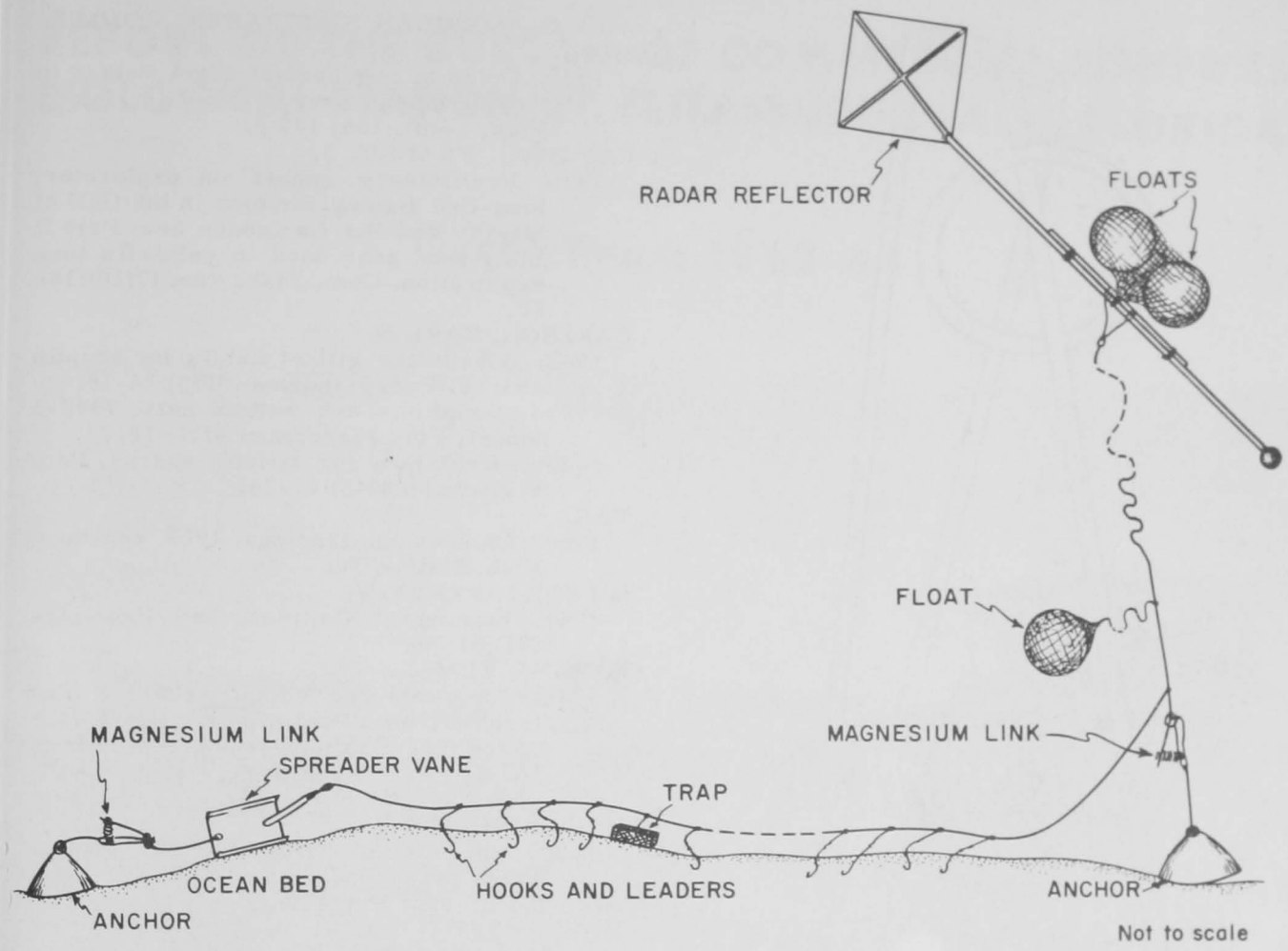

Figure 8.--Diagram of bottom line for use at depths of more than 300 fathoms. This type of rig has never been used for commercial fishing, but possibly would be adaptable for the capture of deepwater sharks.

light-gage aluminum sheet metal (three 20-inch squares) intersecting to make all angles 90 degrees. The reflector may be mounted at the tip of a light-weight aluminum pipe about 14 feet long and 1 inch in diameter; this pipe may be strengthened by taping a piece of light-weight angle aluminum to the midsection. To the lower end of the pipe are attached 8 pounds of lead. Two glass ball floats with about 24 pounds positive buoyancy should be attached 5 feet from the lower end of the pipe and the longline secured to the pipe at this point by a short bridle. Another trapped float is attached by a short lead, approximately 100 feet along the mainline from the radar reflector.

The magnesium-link release mechanism (fig. 9) is a variety of pelican hook that releases the anchor when the magnesium rod that holds the pelican hook in a closed position is weakened by corrosion and breaks. The thickness of this rod determines the time of release of the anchor. If the construction and arrangement of components are standardized, the release time can be estimated. Those used most successfully surface in 8 hours from depths ranging from 400 to 700 fathoms.

To set the gear, the vane end and vane anchor are arranged on one side of the stern of the vessel, and the buoy end, buoy, and buoy anchor are held at the other side of the stern. While the vessel moves forward into the wind at about 2 knots, the mainline with baited hooks is paid out to form a lengthening "U". When all of the hooks are overboard, the vane anchor is released. As the mainline begins to lose its slack, but before it becomes taut, the other anchor with the buoy is released (Springer, 1965).

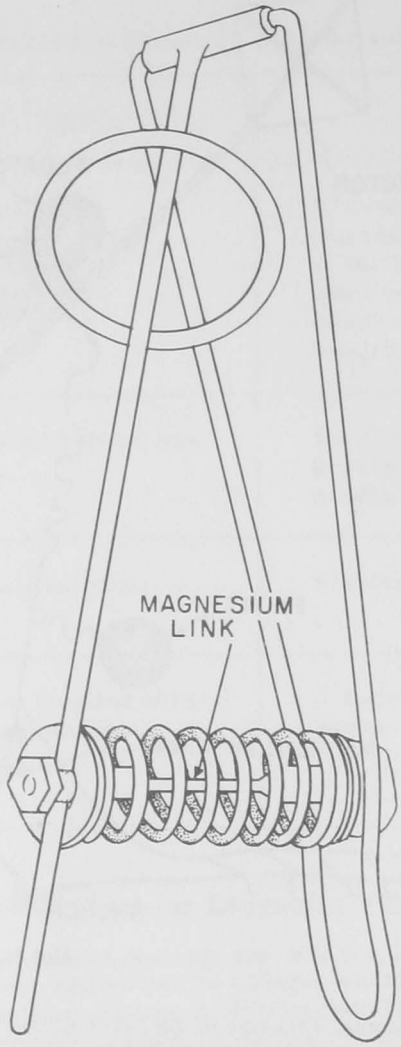

Figure 9.--A magnesium release link for use with bottom lines in deep water. The tie rod is magnesium of proper diameter; other components shown are of uncoated steel and brass. These are incorporated into a pelican hook that takes most of the strain from the magnesium rod while the gear is being set.

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