

# Harvesting Technology in the Pacific Whiting, *Merluccius productus*, Fishery

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## Introduction

For any fishery to develop, several interdependent factors must come together. In the simplest terms, these elements include: A resource capable of sustaining some reasonable level of exploitation; adequate demand for the products of the fishery; and appropriate harvesting technology. When dealing with high-volume, low-value fisheries such as the Pacific whiting, *Merluccius productus*, fishery, it is particularly important to have efficient, economical harvesting techniques whereby large quantities of fish may be located and captured at minimal expense. In part, the success of the current fishery can be attributed to the development of such techniques. This paper will review the evolution of harvesting technology and discuss state-of-the-art gear presently in use.

## Evolution of Gear Types

Nelson (1970) and Johnson and High (1970) give good detailed descriptions of early domestic efforts to evaluate and exploit the whiting resource off the coasts of California, Oregon, and Washington, and their discussions of gear will be summarized here. During the 1950's and early 1960's, large incidental catches of Pacific whiting in bottom trawl fisheries targeting on flatfish and Pacific cod, *Gadus macrocephalus*, indicated that there was a substantial

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resource. Due to the poor keeping qualities of the fish, whiting by-catches were discarded at sea or sold as raw material for mink and pet foods, and no interest in establishing a directed fishery developed until 1964. At that time the Bureau of Commercial Fisheries (BCF) started a demonstration fishery for whiting off the coast of Washington (Nelson, 1970). The fish was delivered to a processing plant in Aberdeen, Wash., where it was used to manufacture fish meal and fish protein concentrate.

While whiting are occasionally found in bottom waters and are thus available to bottom trawls, they occur more commonly in large dense schools in midwater. To capture them effectively, it was necessary to develop midwater trawling techniques, a technology that was still relatively primitive as late as the mid-1960's.

The BCF Exploratory Fishing and Gear Research Base in Seattle, Wash. (later the National Marine Fisheries Service (NMFS), Northwest and Alaska Fisheries Center) undertook in 1960 to develop a midwater trawling system that was to evolve into the Cobb pelagic trawl and its derivatives. Unlike modern midwater trawls, the Cobb pelagic trawl (Fig. 1) featured small mesh, 76 mm (3 inches) stretched measure or less, throughout all sections of the trawl and tapered relatively quickly from the large mouth opening to the narrow codend. Aluminum hydrofoil doors were designed for use with this trawl. A pressure-sensing trawl depth telemetry system utilizing electro-mechanical towing warps for depth data transmission was developed. With this system,

the trawl's depth could be adjusted to keep it "on the fish," as detected by the ship's echosounder.

The Cobb pelagic trawl and its derivative, the BCF Universal trawl, were used to capture large quantities of whiting during the subsidized demonstration fishery mentioned above. Despite the effectiveness of the Cobb and Universal trawls, there were problems inherent in their designs that have been ameliorated during subsequent developments in pelagic trawl design. The small mesh sizes in the forward parts of these large trawls contributed a great deal of towing resistance, adversely affecting towing speed and vessel maneuverability. The abrupt (relative to later pelagic trawl designs) body tapers excited escape reactions among the fish within the trawl, resulting in excessive "gilling" in the after parts of the body of the trawl. The special towing warps required for the depth telemetry system were expensive, and the electrical conductors within the warps were prone to failure.

Nevertheless, the contributions of the BCF work should not be overlooked. Midwater trawling was shown to be an effective harvesting method for whiting, and West Coast skippers became familiar with the techniques involved. The importance of reducing drag through trawl design was shown, as was the desirability of taking advantage of the behavioral characteristics of the fish. These experiences also demonstrated that some form of trawl telemetry was essential to successful midwater trawling.

Further evolution in whiting gear designs came with the entrance of foreign fishing fleets into the fishery.



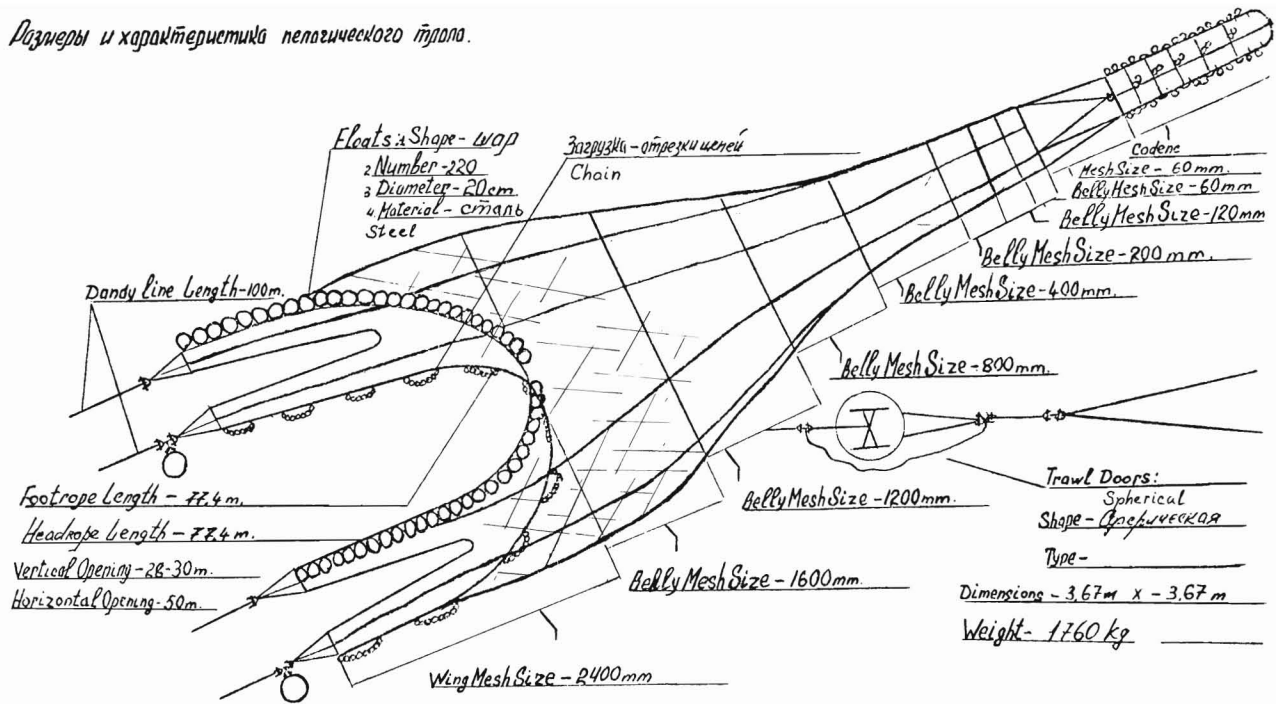


Figure 2. — Illustration of a U.S.S.R. midwater trawl prepared by a Soviet fishing master for a U.S. foreign fishery observer. The Russian legend reads: "Pelagic trawl dimensions and characteristics."

codend. As the fish moved deeper into the trawl, entering more and more confined spaces, the mesh sizes were reduced to enhance the herding effect, a necessary step to prevent panic escape reactions in the fish as they found themselves increasingly confined and crowded within the trawl. By using mesh sizes just small enough to elicit the herding response, and gradually reducing the mesh sizes only when necessary to sustain that response, it was possible to build trawls with the very large mouth openings necessary for capturing large quantities of fish while holding towing resistance down to an acceptable level. This strategy of taking advantage of fish behavior in the design of large, low-drag trawls is still being refined today.

Other design features were similar to some contemporary midwater trawls. The trawl was roughly rectangular in cross section, with abbreviated wings. The headrope and footrope were of equal length, 77.4 m, while the breastlines were 40 m

long. Three hundred kilograms of chain were seized to the footrope to open it downwards, along with an 800 kg weight at each lower wingtip. Doors were round and concave for enhanced hydrodynamic efficiency. Acoustic-link netsondes, or depth sensors, were used to record trawl depth at the headrope and gauge the vertical opening of the trawl from the headrope to the footrope. Unlike more modern designs, floats were used to lift the headrope, and upper and lower bridle lengths were equal, 100 m from each wingtip to the door.

The next step in the development of whiting gear was introduced by the Polish fleet. Gear designers of the German Democratic Republic (East Germany) had developed large midwater trawls that employed longitudinal ropes in the wings and forward body sections instead of meshes (Rehme, 1973). These ropes led into meshes further back in the body of the trawl, which then graduated down as described above. The ropes served the same herding

function as the large meshes in the earlier Soviet designs, while offering still less drag-inducing surface area. Thus, it was possible for the same vessels to fish still larger trawls, with improved fishing power. The Poles were the first to bring rope trawls into the whiting fishery, but the idea was quickly picked up by the Soviets and other Eastern Bloc fishing fleets, and rope trawls dominated the fishery by 1979.

#### Current Gear Types and Fishing Practices

Currently, the dominant Pacific whiting fishery in U.S. waters is the so-called "joint venture" fishery, wherein domestic catcher boats capture the fish and deliver them at sea to foreign-owned vessels for processing. The details of payment procedures, fleet organization, and disposition of the processed fish vary from operation to operation, but the mechanics of locating and harvesting and transferring the catch are similar.

Prior to 1978, the first year of

operation of the joint venture fishery, there was very little domestic fishing effort targeting on whiting other than the short-lived demonstration fishery described earlier. A few boats up and down the coast, of varying sizes and using a variety of trawl types, continued to catch relatively small quantities of whiting for delivery to shore-based processing plants where it was usually made into animal food. While the resource available to the domestic coastal draggers was ubiquitous and abundant, the volumes the processors would buy and the prices they would pay were low, so there was little impetus to develop efficient gear types or fishing procedures. Nonetheless, innovative fishermen experimented over the years with large midwater trawls of European design, pair trawling, and other measures. The coastal draggers, operating in this and other fisheries, gained experience with midwater trawling and refined their boats and gear.

With the advent of the joint-venture whiting fishery came an opportunity that the coastal draggers were ready to exploit, and they moved quickly. Even in the first year, the experienced Soviet whiting fishermen were impressed by the efficiency of the small U.S. catcher boats, and catches routinely exceeded the capacities of the factory ships' processing lines.

From the inception of the joint-venture fisheries, the catcher boats have exclusively used one variation or another of the basic rope trawl design. Known as Polish rope trawls due to their introduction by the Polish fleet, the original design has been refined by domestic gear manufacturers to suit the needs of the joint-venture fisheries and is now a very efficient piece of gear. When they are "on the fish," joint-venture catcher boat skippers expect to catch between 1 and 3 tons of whiting per minute, depending on the size of the trawl used. Refinements have been made on a number of construction details, but perhaps the most important have been in the following areas: Length and mode of attachment of the ropes,

proportions of the top and bottom sections versus the sides, and tapers employed in the body panels. The goals of these refinements are to maintain or increase the mouth openings of the trawls and the herding and containment efficiency by taking advantage of the behavior of the fish, while keeping drag to a minimum. Other vital considerations are durability of the trawl and ease of operation.

Figure 3 depicts a rope trawl design used in the 1981 joint-venture whiting fishery. More recent designs differ somewhat from this to incorporate refinements, and designers are understandably reluctant to divulge the details of their latest advances, but this diagram illustrates the general characteristics of modern rope-trawl design. Gear builders typically offer a series of similar trawls, scaled up or down to match the towing capabilities of the vessel for which a particular trawl is intended.

One noteworthy feature of contemporary rope-trawl design is the virtual absence of floats. Rather than relying on floats to pull the headrope up away from the footrope, in these trawls the footrope is weighted with chain and detachable weights secured ahead of the ends of the footrope, which pull the footrope and lower panels downwards. To facilitate spreading, the upper and lower sweep lines are attached to the upper and lower corners of the doors, respectively, and the lower sweep lines are lengthened to allow the footrope to open down and still stay directly beneath the headrope. The only floats used on the trawl, excluding some floats sewed to the detachable codend, are found along the two top center ropes just behind the headrope where the netsonde is attached. These floats help to orient the trawl and netsonde during setting and haulback, minimizing tangles.

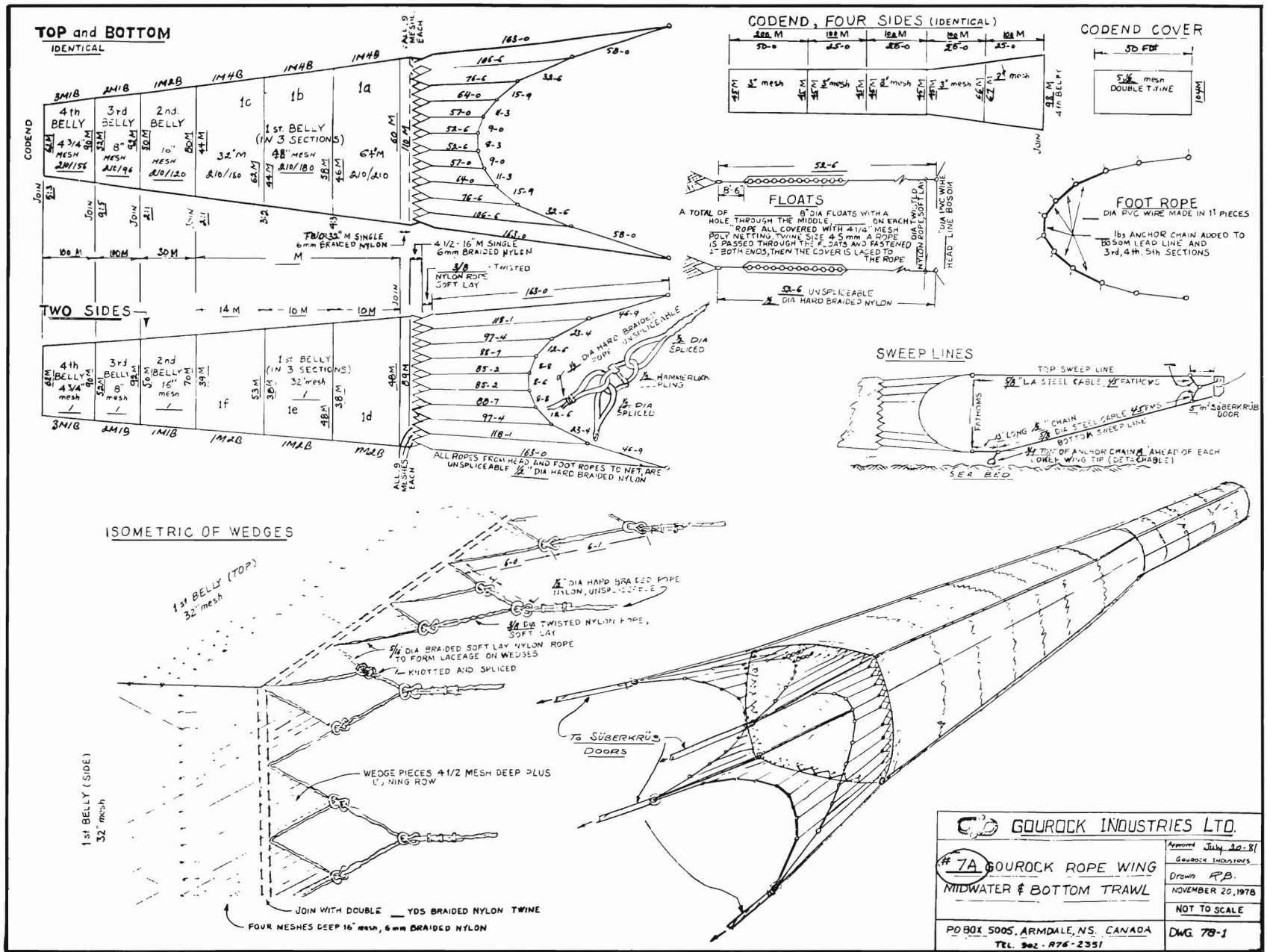
Rectangular, cambered, high aspect ratio midwater doors, also known as "Suberkrub" (FAO, 1974) doors, are the most common type by far in the joint-venture fleet. While most Suberkrub doors are made of steel,

some are of aluminum. The size and weight of the doors must be tailored to the towing capabilities of the vessel, as well as matched to the gear to be towed. Suberkrub doors possess a number of performance characteristics that have made them the standard for the fleet. Of the commonly used designs, they are the most efficient available in terms of spreading power versus drag. They can be quickly and easily "tuned" for different fishing conditions by changing such things as the towing point or the points of attachment for the lower sweep lines. For example, it might be useful when fishing around pinnacles to adjust the doors so that they will rise quickly, pulling up the net, when towing speed is increased. Other adjustments would make the doors become less sensitive to towing speed, or sink faster, or spread less if increased vertical openings were called for.

Perhaps the paramount feature uniquely characterizing the gear used in the joint-venture fisheries is the detachable codend (Fig. 4). Instead of having the codend sewed permanently to the body of the trawl, as is usually done, a "zipper knot" similar to the knot used to close feed bags is used which allows full codends to be quickly detached from the rest of the trawl. At the end of the tow, the trawl is hauled back aboard until the front end of the codend has just been brought aboard, leaving the part containing the fish in the water aft of the boat. The codend is then detached. The open end of the codend is choked off with a nylon line and held on the catcher boat until, using a buoyed messenger line, a tow line from the processor boat has been brought over (Fig. 5) and the codend has been made fast to it. This done, the codend is released from the catcher boat (Fig. 6) and winched aboard the processor (Fig. 7), where the catch is spilled and processed. Meanwhile, empty codends may be transferred from the processor to the catcher boat, which then resumes fishing.

There is no such thing as a "standard" joint-venture catcher boat, as most of the participating vessels were

47(2), 1985



51

Figure 3. — Plan of a typical rope wing trawl used in the 1981 joint venture whiting fishery by vessels of 700-1,000 horsepower.

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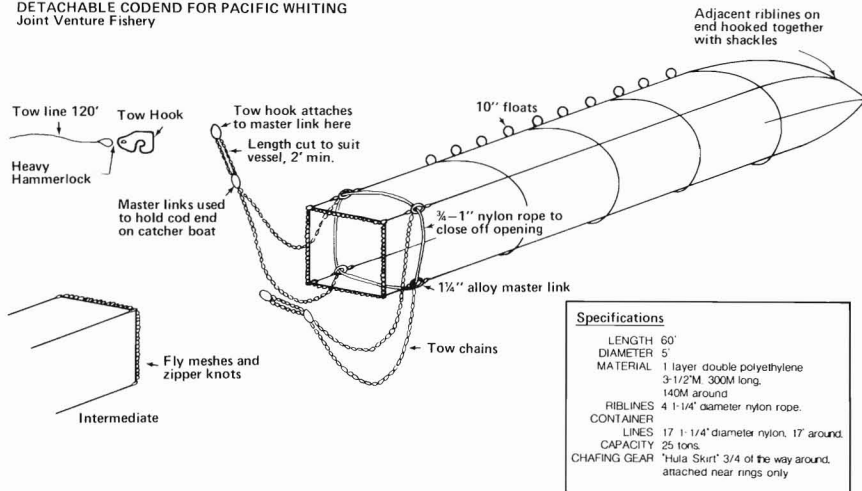


Figure 4. — Detachable codend details.



Figure 5. — Buoyed tow line being streamed back from a joint-venture processing ship to a catcher boat.



Figure 6. — Codend full of fish being towed from a catcher boat to a processing ship.

originally built with other fisheries in mind. Consequently, deck gear and layout vary considerably from boat to boat within the constraints laid down by the requirements of midwater trawling. Having said this, an attempt

will be made to describe the most common features of a joint-venture boat. Many of the catcher boats were built for the coastal bottom-trawl fisheries, and are about 80 feet (24 m) long with a 24-foot (7 m) beam. A

typical boat fishes its primary trawl from a net reel mounted just aft of the house. Spare trawls and/or empty codends may be stored on the after net reel(s), mounted above the deck on a stern gantry. Some kind of

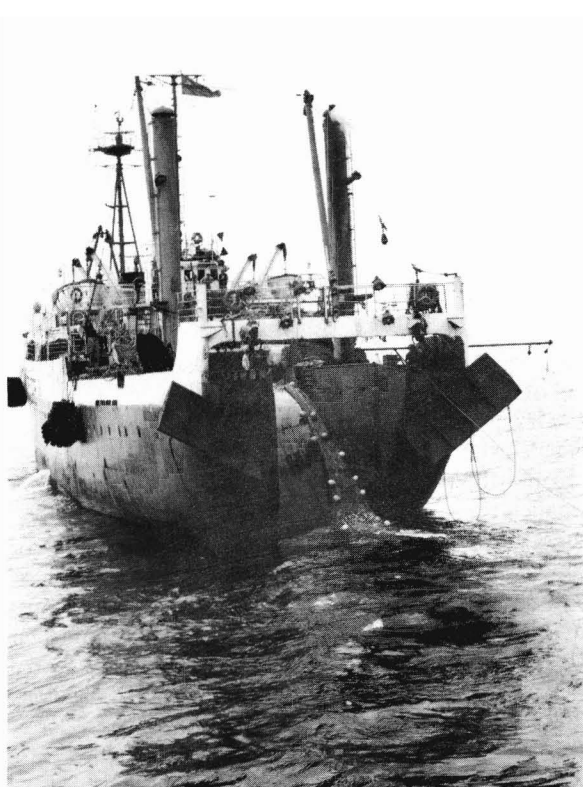


Figure 7.—Full codend being winched up the ramp of the processing ship, a Soviet BMRT factory trawler. Note the “Suberkrub” trawl doors hanging at the stern, and the spherical trawl doors stacked on deck forward of the ramp area.



Figure 8.—The bridge of the *Colentino Rose II*, a typical modern joint-venture catcher boat. Note the numerous electronic aids visible here.

A-frame or boom arrangement facilitates handling the gear on deck, and accessory gilson winches, splitting winches, outhauls, deck cranes, catheads, etc., will be found in various combinations. Conventional trawl winches are most common, carrying warps of  $\frac{5}{8}$ - $\frac{7}{8}$  inches (16-22 mm) in diameter, although some boats are installing the more advanced “constant-tension” winches of European design. Main engines of 750-1,000 horsepower are most common in the 75-90 foot (23-27 m) vessels, with more powerful engines found in some of the larger Alaska king crab vessels that have been converted to trawling. Kort nozzles, aftercoolers, and other means of boosting towing performance are being installed throughout the fleet, the goal being to pull the largest possible trawl that can be towed at 3 knots or more.

The joint-venture catcher boats rely heavily on electronic aids to maximize their catching efficiency (Fig. 8). Sonar systems of varying degrees of sophistication are used to locate schools of fish. Driving the boat over a selected school, the skipper uses the echosounder to get information on school depth, density, and composition. There is a trend toward increased use of color sounders because of the added ease of interpretation of the echo information. For even finer resolution of within-school density distributions an acoustic device known as a “memo-scope” may be employed. With the memo-scope, selected portions of individual echo pulses may be expanded and examined in detail, yielding information about target density within a fairly small area. Loran-C navigation systems provide precise positioning information, especially when coupled to an automatic plotter unit, either paper or video. Using a plotter it is easy to record the exact locations of promising fish traces while scouting for fish.

Once a specific school has been targeted and the gear has been set, electronic aids continue to guide the

fishing process. The echosounder indicates the approximate depth to which the trawl should be set in order to intercept the fish. The netsonde on the trawl provides immediate information on the trawl's performance and its position within the water column. Echoes from fish above or below the netsonde's headrope transducer allow the skipper to adjust the depth of the trawl for maximum catch, especially useful when the fish have moved between the time they were detected on the vessel's echosounder and the time the trawl arrives. Additionally, variations in the intensity of the fish traces passing below the headrope indicate the quantity of fish entering the trawl, an index of catch rate.

Wireless netsondes, which rely on an acoustic link to transmit information via a hydrophone mounted either on the ship's hull or a towed fin, are the most common type found in the joint venture fleet. The more expensive "third-wire" netsondes, using a wire from the netsonde to the ship for data transmission, are favored by some skippers because neither vessel maneuvers nor water conditions can disrupt the data link, and current third-wire systems can provide desirable additional information unavailable with current wireless systems. In particular, the catch-load indicators available as accessories with some third-wire systems have proven their value. With knowledge of the quantity of fish in the codend, the skipper can shorten or extend the tow to get a catch of the preferred size, usually 25-30 tons. Additionally, by comparing the rate at which the codend is filling up with the rate at which fish pass below the netsonde's headrope unit, the skipper can detect escape reactions among the fish within the trawl and alter his operations accordingly.

In addition to the equipment described above, joint venture boats carry the usual assortment of other navigation, communications, and safety gear, such as SSB, CB, and VHF radios, satellite navigation

systems, weather facsimile receivers, and radars.

While the joint venture fishery is the dominant fishery for Pacific whiting, other fisheries do exist. Small-scale shore-based fisheries continue to operate up and down the coast, usually involving smaller, older vessels employing an assortment of trawl types. The whiting vessels delivering to processors in Oregon and California use rope trawls for the most part, with the exception of a few vessels using bottom trawls. Draggers involved in the Puget Sound, Wash., whiting fishery depart from this norm. One vessel uses a smaller version of the "2/3 Cobb pelagic trawl" described by Johnson and High (1970), with an 18.3 m (60-foot) headrope, 18.3 m breastlines, and an 18.3 m footrope. Two other fishermen use two-seam bottom trawls of their own design, incorporating 108 mm (4¼-inch) mesh in the forward panels and with a 21.3 m (70-foot) headrope and a 27.4 m (90-foot) footrope.

Recently joint-venture fisheries for whiting have gotten underway in Canadian waters. No preferred trawl type has yet emerged within this fleet, as a number of different modern mid-water trawl designs are being employed. Otherwise, the vessels and fishing practices are similar in most respects to the U.S. joint-venture operations already described.

### Summary

The harvesting technology in the Pacific whiting fishery is in a state of rapid evolution, particularly in the joint venture fisheries. As fast as improved trawls and electronic instruments become available and prove their worth, they are quickly adopted throughout the fleet. At present, most boats use recent versions of Polish rope trawls spread with Suberkrub pelagic doors. Catch rates between 1 and 3 tons per minute are relatively easy to attain with well-tuned gear.

Extensive use is made of sophisticated electronic aids. Sonars are used to locate schools of fish, and

echosounders are used to gain additional information about school depth and density. Additional information on within-school density patterns can be obtained with memo-scopes and/or color sounders. Automatic plotters coupled to the ship's Loranc systems are valuable for recording the locations of schools when scouting for fish. While fishing, netsondes of various kinds provide essential information on trawl position and catch rates.

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