The Fish Funnel: A Trawl Modification to Reduce Fish Escapement

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ABSTRACT—In the Gulf of Mexico there is a need to assess the potential of underutilized fish resource stocks before a commercial fishery develops. Standard sampling trawls used in the Gulf are ineffective for sampling the resource, so larger, high opening, bottom trawls have been introduced. The larger trawls are more effective, but most of the faster swimming fish species are able to escape these nets, especially during haul back.

To reduce fish escapement, webbing panels, attached inside the trawls ahead of the cod ends, were tested. Initial tests were conducted with two single panel designs—a fish flap and a "floppa." Neither design reduced fish escapement. The floppa distorted the trawl webbing and actually increased fish escapement.

A multi-panel conical funnel design (the fish funnel) was tested and found to increase fish retention by trapping the fish after they passed through it. When used in combination with a technique known as pulsing the trawl, the fish funnel substantially increased trawl catch rates with no indication of fish escapement.

Introduction

Latent or underutilized fish resources in the Gulf of Mexico represent a large biomass of potential commercial importance (Houde, 1976, 1977a, b, c; Reintjes, 1980). The consequence of large-scale fishery development, however, could have a major ecological impact not only on latent resource stocks but also on other species in the food chain. Generally these stocks have received little study. Collection of biological and ecological data is needed before an effective management plan can be developed to protect the resource.

For reliable results, efficient sampling gear has to be used to assess Gulf latent fish resources. Standard sampling trawls used in the Gulf were considered to be too small and inefficient for reliable sampling. Because of their success in similar fisheries in other areas, large-mesh, high opening, bottom trawls were selected to serve as sampling trawls and evaluations were conducted to determine their efficiency.

Early in the evaluation process, a problem was identified when sampling herring and herring-like species collectively known as coastal herrings (Table 1). These fishes are strong swimmers capable of outswimming a trawl at normal speeds of 3.0-3.5 knots. Signs of the problem were evident during net retrieval, when fish were observed gilled in trawl meshes and lying in the belly webbing well ahead of the cod end. Scuba divers noted that coastal herrings encountered during trawl evaluations had no problem keeping up with the trawls, and that, during haul back, they would exit at the slightest hesitation of the net or when the trawl webbing started to go slack.

In an effort to prevent fish escapement, webbing panels were incorporated into the sampling trawls and tested. The first webbing panel tested was a fish flap similar in design to those used by Danish and Norwegian side trawlers. The fish flap was attached inside the trawl ahead of the cod end. The intent was for the webbing panel to flap down at the end of a tow and hold the catch in the cod end. During evaluations, however, divers observed that the fish flap remained flush with the trawl webbing during haul back and did not prevent fish from escaping.

Next, a webbing panel known as a "floppa" (Hodson, 1953) was tested. The floppa is a single-panel, wedge-shaped funnel design that is attached ahead of the trawl cod end with its back opening to the bottom of the trawl. Evaluations showed that the floppa was not only unsuccessful at preventing fish from leaving the cod end; it also distorted trawl meshes at the point of attachment, increasing the possibility of fish escapement.

Last to be tested was a multi-panel conical funnel similar in design to the funnels used in combination with trawl separator devices developed in the United States (Watson, 1982; Taylor, et al., 1985; Watson et al., 1986) and Norway (West et al., 1984). Unlike the separator-device funnels which help to exclude parts of the catch, the

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Table 1.—Gulf of Mexico coastal herrings

Common name	Scientific name
Atlantic thread herring	*Optisthonema oglinum*
Spanish sardine	*Sardinella aurita*
Round herring	*Etrumeus teres*
Scaled sardine	*Harengula jaguana*
Rough scad	*Trachurus lathami*
Round scad	*Decapterus punctatus*
Bigeye scad	*Selar crumenophthalmus*
Atlantic bumper	*Chloroscombrus chrysurus*
Chub mackerel	*Scomber japonicus*

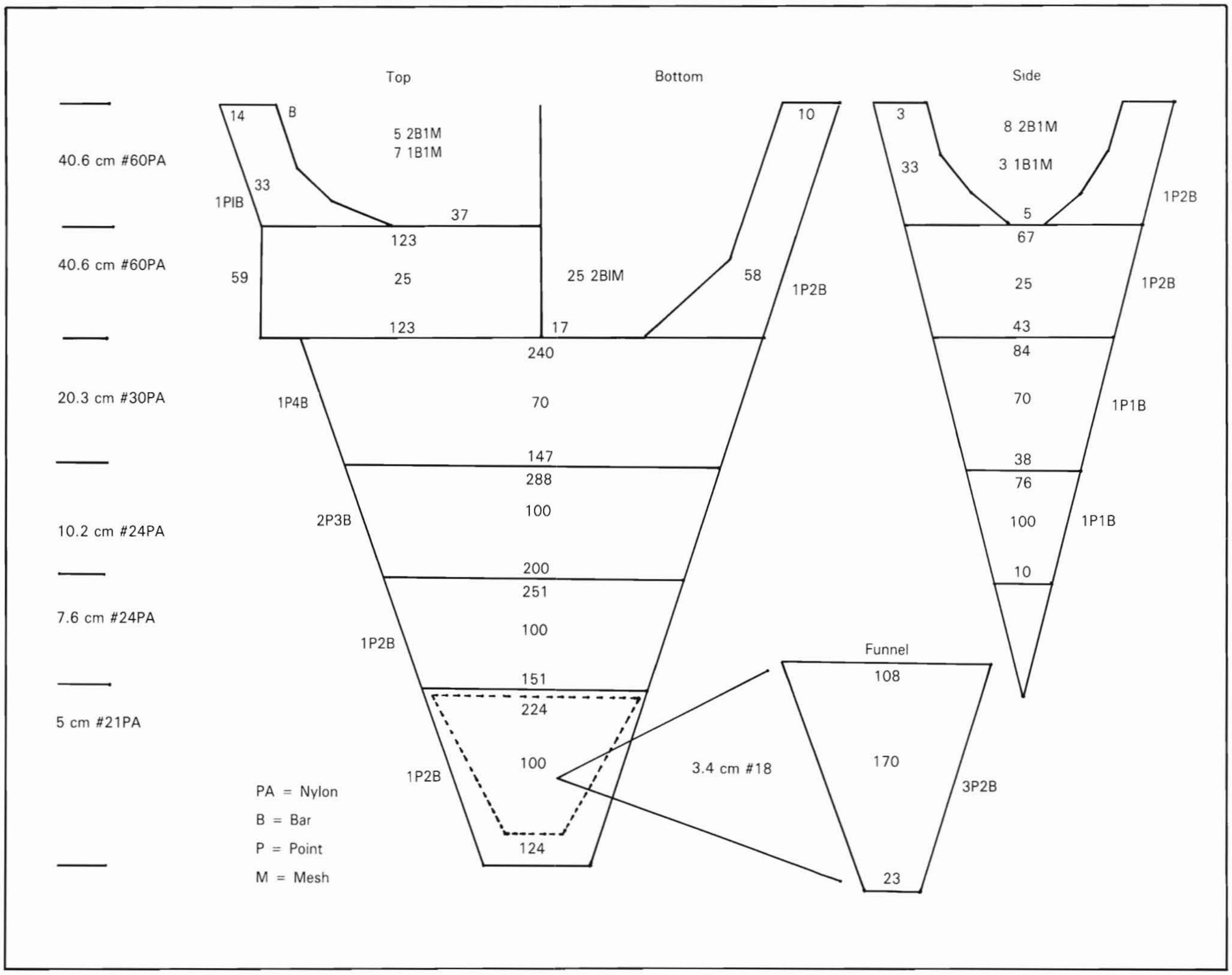

Figure 1.—NMFS trawl with two-panel fish funnel.

conical funnel, herein called the fish funnel, was designed to trap fish in the trawl. The potential of the fish funnel was evident from the first tests, and we continued to modify and perfect the design to develop an effective latent fish resource sampling trawl. This paper describes the methods and results of the tests conducted with the fish funnel.

Materials and Methods

A 40.6 cm mesh NMFS trawl and an 80 cm mesh Shuman trawl[1] were used in testing the fish funnel. The NMFS trawl is a basic four-panel trawl design with the taper beginning at the leading edge of the wing tips (Fig. 1). Mesh sizes reduce from 40.6 cm at the front of the NMFS trawl to 5 cm meshes ahead of the codend.

The Shuman trawl, also a four-panel design, has overlapping jibs (Fig. 2). Mesh sizes in the Shuman trawl reduce from 80 cm leading meshes to 5 cm meshes ahead of the codend.

Two fish funnel designs were tested. A two-panel funnel was tested with the NMFS trawl (Fig. 1). Constructed from 5 cm mesh nylon webbing, the two panels were 100 meshes deep and cut with a four bar-one point taper on each side. The two-panel funnel was attached at the leading edge of the 5 cm joining round on the NMFS trawl.

The Shuman trawl was fitted with a four-panel funnel (Fig. 2). Initial construction material was 3.4 cm nylon webbing. This was later changed to 3.4 cm heat-set and depth-stretched polyethylene webbing. Each panel was 192 meshes deep and cut on a two bar-one point taper on each side for 120 meshes. The remaining 72 meshes were cut on a two bar-three point taper. The four-panel funnel was attached at the leading edge of the 8 cm

[1]Reference to trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

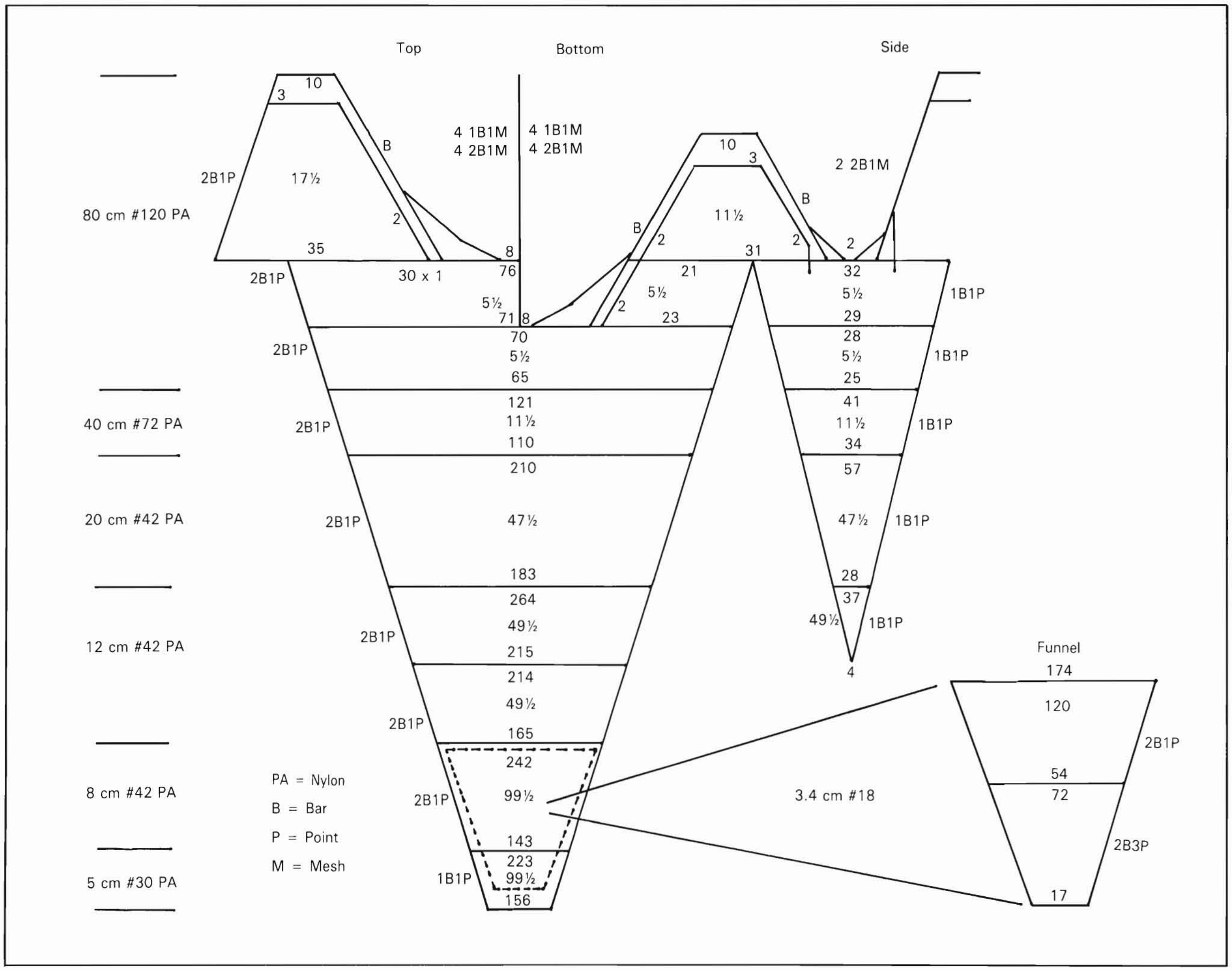

Figure 2.—Shuman trawl with four-panel fish funnel.

joining round on the Shuman trawl.

Evaluations were conducted from the NOAA Ships *Chapman* and *Oregon II* working in the northeastern Gulf of Mexico in depths of 20 to 300 m. Test tows were made at 3-3.5 knots, and on most tows the trawl was pulsed up to 4 or 5 knots for 5 minutes just before hauling back. Methods of evaluations included scuba diver measurements and observations, observations with a remote control underwater video camera system, and fishing tests.

Scuba diver measurements and observations were conducted in 20-30 m of water using standard trawl diving techniques (Wickham and Watson, 1976; Workman et al., 1986; Workman, 1987). Divers first determined the position for the fish funnel by observing the trawls under normal towing conditions. They looked at trawl taper, mesh size and circumference to determine the best point of attachment. Following installation and determination of proper fit and form, divers observed water flow through the fish funnel with the aid of rhodamine B dye injected at the back opening and to the side of the funnel. Water flow speeds in and around the funnel were measured with a General Oceanics current meter rigged for diver operation. Divers used 8mm video cameras, contained in underwater housings, to record fish behavior in relation to the fish funnel. These recordings were studied later in the laboratory.

Manta II, a remote control underwater vehicle equipped with still and video cameras, was used to observe the fish funnel equipped trawls in depths beyond the safe working limits for divers. After the net had been set, Manta II was deployed from the research fishing vessel and "flown" into position by the vehicle pilot using an on board control console. Observations made with Manta II were mainly to determine if any changes occurred in trawl or funnel configuration when moved from shallow to deeper water.

Fishing tests with the funnel-equipped trawls were conducted in areas where fish were detected using depth sounding instrumentation aboard the research vessel. Fishing times normally ranged from 15 to 30 minutes, and, at the end of the tow, the trawl was pulsed before haul back. As the net was hauled on deck, attention was paid to the location of fish in the net and if any gilling had occurred in either the net or funnel.

Results

Initial evaluations were made by scuba divers on the two-panel fish funnel installed in the NMFS trawl. Although the funnel performed reasonably well, it did not have an optimal shape, and, due to its 5 cm webbing construction, fish gilling in the funnel was a problem. The two-panel funnel was replaced with the four-panel design constructed with 3.4 cm webbing.

Dye flow studies conducted with the four-panel fish funnel showed that water flow was greater at the back opening than to the side of the funnel. Water flow speeds measured in the funnel corresponded closely with the towing speed of the vessel (Table 2). Water flow to the side of the funnel, depending on towing speed, ranged from about 40-50 cm per second slower than flow in the funnel.

Divers observed that, given enough time, most of the fish species of concern would drop back through the funnel at a towing speed of 3.5 knots. After passing through, the fish would either continue to fall back into the cod end or would swim to the side of the funnel where water flow was reduced. Pulsing the trawl at the end of the tow helped to ensure that fish ahead of the funnel were forced through it. Once the fish passed through the funnel, escape—even if the trawl came to a stop during haul back—was nearly impossible unless the funnel failed to perform properly.

The first funnels tested were constructed from nylon webbing. When new, the nylon funnels had good shape and performed well. However, as the nylon aged it stretched and lost its shape. Divers observed that fish gilling and debris clogging in the funnel became more of a problem as the nylon funnels aged. The back openings on the older nylon funnels stretched and would not close properly when the trawl was slowed. The nylon webbing was replaced with heat set and depth stretched polyethylene webbing to prevent the funnel from stretching out of shape. The polyethylene funnel held its shape better and had less gilling problems than the nylon funnel.

Table 2.—Measurements of water flow ahead, behind, and to the side of the fish funnel at 3.0 and 3.5 knots towing speeds.

Towing speed (kt – cm/sec)	Ahead of funnel (cm/sec)	At back opening of funnel (cm/sec)	To side of funnel (cm/sec)
3.0 – 154	150	156	105
3.5 – 180	171	173	130

Table 3.—Comparative maximum catch rate (metric tons per hour) for select latent fish resources caught with experimental bottom trawls operated from NOAA research vessels (1985–1987).

Species	1985	1986[1]	1987[1]
Gulf butterfish, *Peprilus burti*	12.8	7.2	45.4
Rough scad, *Trachurus lathami*	1.7	3.1	4.6
Driftfish, *Ariomma bondi*	1.0	0.8	3.9
Round herring, *Etrumeus teres*	0.4	1.2	9.1
Chub mackerel, *Scomber japonicus*	0.7	1.5	0.8

[1]Fish funnel used in the latter part of 1986 and all of 1987.

Manta II evaluations of a funnel equipped trawl were conducted at a depth of 80 m. The funnel maintained its shape with no differences observed in the funnel or trawl from what had been observed by divers in shallow water.

No fish loss was observed during fishing trials when the trawls were equipped with funnels. When the nets were hauled and brought on board, all of the fish were behind the funnel. Fish gilling was only a problem in the nylon funnels that had stretched with use.

Although no statistical analysis can be applied due to possible temporal and spatial variations in fish abundance, the efficiency of the fish funnel is indicated in a comparison of maximum catch rates for selected target species by year on Table 3. The fish funnel was introduced in the latter part of 1986 and used throughout 1987. Sampling effort remained almost constant over all 3 years while maximum catch rates for most species increased substantially when 1987 is compared to 1985.

Discussion and Conclusions

Prior to the development of the fish funnel, we lacked an effective method for sampling fast swimming fish species in the Gulf of Mexico. Standard sampling trawls were relatively small and inefficient for sampling these faster swimmers. The introduction of large-mesh trawls and faster towing speeds improved catch rates but did not prevent fish escapement. Catches were larger because the larger nets caught more fish, but the escapement problem remained unsolved until the development of the fish funnel.

A properly performing fish funnel virtually eliminates fish escapement. Fish funnel performance, as determined by diver observations and fishing tests, depends on: 1) Funnel shape, 2) position in the trawl, 3) mesh size, and 4) construction material.

A slow taper gives the funnel a smooth shape and ensures that no humps or pockets form. Humps and pockets cause catch and debris to collect and increase the probability of fish gilling.

Funnel placement is determined by trawl mesh size and circumference. Fish will escape if the funnel is attached at a point where the surrounding trawl meshes are too large. However, if it is attached where trawl circumference is too small, the taper and opening of the funnel may be too small to allow larger fish and objects in the catch to pass.

Fish gilling is a problem if the funnel is constructed from meshes 5 cm or larger or from the wrong webbing material. To prevent the funnel from stretching or becoming distorted, heat-set and depth-stretched polyethylene webbing is used in construction. To ensure that the funnel closes properly if trawl speed slows, small floats are attached to the underside near the back opening of the funnel.

Pulsing the trawl at the end of the tow further increases the efficiency of the funnel equipped trawl. By speeding up to about 5 knots before hauling the net back, fish ahead of the funnel are forced through.

The NMFS Mississippi Laboratories, using fish funnel equipped trawls in combination with pulsing the trawl, are now able to sample coastal herrings and other fast swimming species effectively. We now have the capability to collect biological and ecological data on latent fish resources in the Gulf of Mexico.

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