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Porpoise Rescue Methods in the Yellowfin Purse Seine Fishery and the Importance of Medina Panel Mesh Size

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ABSTRACT—Introduction of the porpoise releasing method known as "backdown" by Anton Meizetich and Manuel Neves and the development of small-mesh porpoise safety panels by Harold Medina raises the question of the optimum mesh size for the panels. Medina panels of relatively standard dimensions hung from 2-inch mesh webbing had been installed in about half the nets of the U.S. tuna purse seine fleet before passage of the Marine Mammal Protection Act. The fishermen believed, and several statistical studies indicated, that use of the panel resulted in lower porpoise mortality. Despite the improved performance, however, porpoises were still being entangled in nets during the backdown process and a recent study indicates that up to 30 percent of porpoise mortality is due to this factor. Using mainly porpoise specimens taken in the fishery, measurements of penetration of porpoise snouts and flippers through mesh openings of 2, 1 7/8, 1 1/2, and 1 inches were made to elucidate the potential reduction in porpoise entanglement that could be expected through use of Medina panel mesh sizes of less than 2 inches. With their jaws closed, the snouts of even the smallest specimen could not penetrate 1-inch mesh, and the average penetration with the jaws open was grossly reduced as were penetrations of pectoral fins. Because of added weight and drag, additions of large sections of small-mesh netting can drastically affect the buoyancy and hydrodynamic performance of purse seines. Recent tests of porpoise "aprons" and "chutes" (trapezoidal-shaped sections of webbing appended to Medina panels) promise a means of making small-mesh netting compatible with tuna purse seine performance.


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INTRODUCTION

Historically, fishermen have attempted to select netting of a mesh size that retains their target species while permitting unwanted species or sizes to escape. The situation in the eastern tropical Pacific U.S. tuna purse seine fishery, however, is complex. In this fishery the majority of the most important species, the yellowfin tuna, *Thunnus albacares*, is taken by scouting, herding, and setting purse seine nets on schools of porpoise with which the larger yellowfin associate (Perrin, 1968; Green et al., 1971). Three species of pelagic dolphins, or porpoise as they are more commonly referred to in the fishery, are primarily exploited by the fishermen. In order of decreasing importance, these species are: the spotted dolphin, *Stenella attenuata;* the spinner dolphin, *S. longirostris;* and the common dolphin, *Delphinus delphis*. In the fishery, these cetaceans are referred to respectively as spotters, spinners, and whitebellies. The races and distributions of the stocks are described by Perrin (1975) and Evans (1975).

When "porpoise fishing," as the method is called, the objective of the fishermen has been to retain the tuna and free the porpoise, but because the two forms are approximately the same size it is not possible to separate them by mesh-size choice. While capable of easily leaping over the corkline, porpoises show little tendency to escape in this manner. Thus, in the early years of the fishery, and despite the efforts of the fishermen, large numbers of porpoise were killed when they became entangled in the nylon webbing of nets or were sacked up with the tuna.

Because of the fishermen's subsequent development of a porpoise rescue procedure known as "backdown" and introduction of the related "Medina panel," mesh-size selection became an important consideration, and as a result of passage of the Marine Mammal Protection Act (Public Law 92-522, 92nd Congress, H. R. 10420, 21 October 1972), a consideration that has legal as well as practical implications. This law also mandated the National Marine Fisheries Service (NMFS) to work with the fishermen to develop porpoise saving gear and methods. In the spring of 1973, research directed towards this objective began at the Southwest Fisheries Center in La Jolla, Calif., under the direction of Richard McNeely, who had studied tuna purse seining following the conversion from pole-and-line fishing (McNeely, 1961).

Several innovations such as hydraulic gates, skimmer nets, and various kinds of acoustic signals had previously been tried by Southwest Fisheries Center personnel. None had shown real promise. Therefore, in its early stages, the philosophy of the program was to work with the existing purse seining system and to help perfect those rescue procedures that the fishermen had developed, that they believed in, and that many of them were already using, to rapidly effect as great a reduction in porpoise mortality as possible. Progress in this work has previously been reported (Department of Commerce, 1974; Staff, Porpoise/Tuna Interaction Program, Oceanic Fisheries Resources Division, 1975 and 1976).

The objectives of this paper are to: 1) review the history of porpoise rescue procedures developed by the fishermen; 2) present measurements of the degree of penetration of porpoise appendages through various mesh sizes; and 3) to point out the importance of mesh-size selection.

MEDINA PANEL HISTORY

Prior to passage of the Marine Mammal Protection Act, fishermen experimented with methods and gear modifications that would reduce the incidental kill of porpoise. These efforts resulted in two related developments, "backdown" and the "Medina panel"

Backdown

Running a vessel in reverse to pull the corkline underwater to dump unwanted catches may have occasionally been used in the California sardine or mackerel purse seine fishery, but Anton Meizetich, captain of a small, San Pedro seiner, the original MV *Anthony M.*, is generally credited with developing this method of porpoise removal in 1959-60. Hearing of its success, Manuel Neves, captain of the MV *Constitution*, in 1961 demonstrated to his crew the effectiveness of the method in saving porpoise and time, and the use of backdown, as it came to be called, spread rapidly through the San Diego-based fleet which included the majority of the seiners that regularly fish on porpoise.

Various fishermen developed their own modifications of the method, but essentially, the process is executed by recovering about two-thirds of the net aboard the seiner, securing the hauling end and then, aided by the seine skiff functioning as a tug, moving the vessel in reverse in a wide arc. Coe and Sousa (1972) gave a detailed description of the methods used on one seiner in 1972. Pressure caused by pulling the netting through the water forms the net into a long channel approximately 90–110 m long and about 15–20 m wide (Fig. 1). As the backdown channel develops, porpoise tend to congregate at the extreme end or apex, while the tuna generally range back and forth in the channel between the porpoise and the seiner. At times when the tuna are near the seiner the vessel is backed rapidly, causing the corkline to submerge at the end of the channel where the porpoise are concentrated. The motion of the vessel continues to pull the corkline down and out from under the porpoise (Fig. 1). Usually, three or four such rapid backdown surges are necessary to spill the porpoise out of the net.

During the maneuver, the vessel's speed is crucial, for if backdown is too slow the porpoise may tend to swim with the net rather than passing over the submerged corkline. (This seems to be particularly true of spinner porpoise although behavior of the porpoises varies in different geographical locations.) Those porpoise that could not be backed out and that could be reached were hand-hauled over the corks by crewmen entering the water or working from a small skiff (cork tender). Porpoise were also removed from the net when concentrated with the fish in the bunt or bow end of the net at the time the captured tuna were landed.

Before and following passage of the Marine Mammal Protection Act, "skipper-gear workshops" were sponsored by the American Tunaboat Association in 1972, 1973, and 1974. At these meetings techniques were exchanged between fishing captains for refinement of the backdown process. During this period the stationing of the cork tender manned by one or two crewmen at the backdown area to pull up on the corkline whenever the loss of fish was threatened to aid porpoise over the corks, and to free porpoise entangled in the net became more widespread throughout the fleet (Fig. 1).

The Medina Panel

The second development, the Medina or safety panel, is closely related to backdown. In normal, trouble-free sets porpoise encircled by a purse seine usually loll at the surface, swim and dive in the open area of the net, and tend to avoid the corkline and the walls of webbing, but when porpoises are concentrated in the end of the backdown area and come in contact with the net, the potential for entanglement is greatly increased. Thus, despite the importance of backdown as a rescue technique, some animals are "gilled" in the net during the process and, unable to reach the surface to breath, they usually suffocate.

In the fall of 1970, tuna fishermen and scientists from the Southwest Fisheries Center met at the offices of the American Tunaboat Association to discuss porpoise rescue methods. Harold Medina, captain and owner of the MV *Kerri M.*, argued that strategically positioned smaller mesh would reduce the chances of porpoise entanglement. In December of that year while fitting out for the first trip of the 1971 season in Panama, Medina replaced the 4¼-inch (10.80-cm) stretch-mesh webbing in the top strip of his net in the backdown area with a section of 2-inch (5.08-cm) stretch-mesh webbing 720 feet long by 33 feet deep (about 219.5 by 10 m).

A brief parenthetic discussion of netting may be helpful at this point. Net webbing is measured from the center of one knot to the center of an adjacent knot while the webbing is stretched. Originally, tuna purse seines were hung with 4⅛-inch (10.5-cm) stretch mesh, but in recent years 4¼-inch (10.8-cm) mesh has become standard. The webbing is made from different types and sizes of twine spun from various synthetic fibers. Therefore, mesh dimensions are not critically standardized. Further, once in use, the

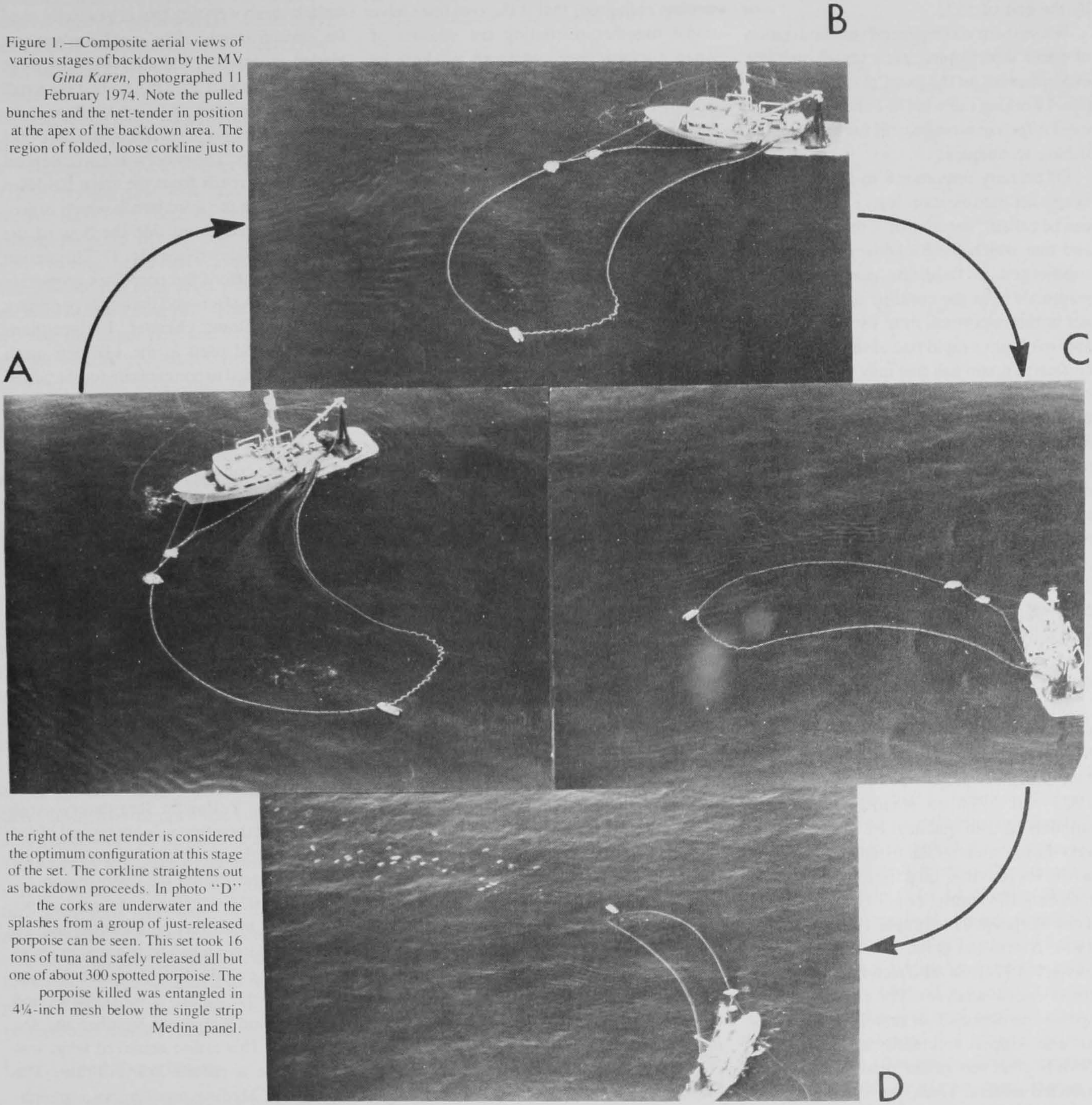


Figure 1.—Composite aerial views of various stages of backdown by the MV *Gina Karen*, photographed 11 February 1974. Note the pulled bunches and the net-tender in position at the apex of the backdown area. The region of folded, loose corkline just to the right of the net tender is considered the optimum configuration at this stage of the set. The corkline straightens out as backdown proceeds. In photo "D" the corks are underwater and the splashes from a group of just-released porpoise can be seen. This set took 16 tons of tuna and safely released all but one of about 300 spotted porpoise. The porpoise killed was entangled in 4¼-inch mesh below the single strip Medina panel.

mesh openings do not retain their original size but become smaller as the twine shrinks. As a general rule, webbing shrinks about 5 percent a year for the first 2 years it is used and then tends to stabilize. Purse seines are constructed by lacing together long strips of webbing that are about 120 fm (about 219.5 m) in length and usually 100 meshes deep (about 5.5 fm, or about 10 m). Thus, one strip of 4¼-inch mesh that has undergone shrinkage can conveniently be replaced by two strips of 2-inch mesh, each 112.5 meshes deep.

Later in the 1971 season a section of webbing similar to that used by Harold Medina was employed by his cousin, Joseph Medina, Jr., on cruises of the MV *Queen Mary*. These highly experienced and skilled skippers concluded that the smaller mesh in the backdown area was effective in reducing porpoise entanglements and did not degrade the performance of their nets. Harold Medina made available diagrams and instructions of panel installation and strongly recommended its use to other fishermen. By the end of the 1972 fishing season similar panels had been installed in the nets of approximately 40 to 50 percent of U.S. tuna seiners. Further voluntary adoptions raised the percentage of the fleet's nets equipped with such a panel to about 60 to 70 percent by the end of 1973.

While there was a general standardization of panel dimensions, each vessel operator experimented on the exact placement of the panel working out what he believed to be the most effective arrangement for his boat and fishing techniques.

Of primary importance to the fishermen in any net modification is its effect on what can be called "net control", that is, the ease and rate which the backdown area can be submerged to facilitate passage of the mammals over the corkline and out of the net at the opportune time while still being able to obtain a rapid rise of the corks to the surface to retain fish that may swim into the backdown area seeking escape. Aside from the buoyancy of the net and the skill and judgment of the captain and crew, such factors as the displacement, weight, and movement of the vessel, its power capabilities, responsiveness to the throttle, turning radius, availability of a bow thruster, and the towing, rigging, and operational characteristics of the seine skiff affect net handling. The tendency of webbing to foul with jellyfishes and other organisms and the vagaries of wind and sea can be added to these factors.

Most fishermen and industry spokesmen were convinced of the effectiveness of the Medina Panel. With some qualifications, four statistical studies completed between 1972 and 1974 on steadily increasing amounts of data obtained by NMFS observers during commercial fishing cruises (and with increasing sophistication) have reached the same conclusion (NOAA Tuna-Porpoise Committee, 1972; Stauffer, 1974; Norris and Dohl, 1974; Fabrick and Faverty, 1974). Several factors complicated the statistical analyses. The early data were sparse and obtained on vessels whose owners and skippers voluntarily accommodated NMFS observers rather than on randomly selected seiners. Thus, the results may not have been representative of fleet performance (placement of observers on randomly selected vessels was initiated in 1974). More importantly, the majority of the porpoise kill on any given trip occurs in a small percentage of the sets, usually where a problem has developed to hinder or slow the procedures. These problems frequently develop when a set has been made on either or both a large number of porpoise and a large tonnage of yellowfin tuna. In some cases the net has collapsed, that is the corklines have come together restricting the amount of open surface area, or large pockets or canopies have developed entrapping the porpoise in webbing before the operation has progressed to the backdown phase of the set. In such cases, obviously, it is difficult to fairly evaluate the reduced entangling factor of small mesh in the backdown area.

NMFS GEAR PROGRAM

Despite the improved performance of Medina panel-equipped nets over those which lacked the smaller mesh sections, underwater observations by NMFS gear specialists during charter cruises in 1972 and the records of porpoise observers from commercial fishing trips indicated that some porpoises were still entangling in nets during backdown. The animals were ensnarling in both the 2-inch web of the Medina panel and below or to the sides of the panel in the 4¼-inch mesh. Clearly, tests of more extensive panels hung with webbing of smaller than 2-inch mesh were strongly indicated.

Experimental Net

Following modeling studies, in the spring of 1973 an experimental purse seine was designed and built. The objectives of the design were to provide a large volume of water to safely contain large numbers of porpoise within a fully pursed net and at the same time create a deep, rapid-sinking net that would be advantageous on school fish sets that do not involve porpoise. Construction of the net also provided an opportunity to experiment with the Medina panel.

Although a few fishermen had used 1⅞-inch (4.45-cm) mesh knotless webbing, the standard Medina panels installed in the fleet's nets had mainly been hung with the equivalent of one strip of 2-inch stretch-mesh knotted webbing. There are several cogent reasons for using this dimension mesh: it is regularly hung in the large dip nets or brailers used to scoop tuna out of the sacked-up bunt end of the purse seine, and is therefore usually available; the 4¼-inch webbing shrinks to approximately 4 inches after moderate usage and the 2-inch mesh can be easily laced in, two meshes to one; and even though the small mesh will suffer shrinkage after use, the lines of strain work well in the net with the larger mesh.

The Medina panel of the experimental net was constructed from 1½-inch (5.08-mm) stretch-mesh webbing that is generally used for shrimp trawls. This webbing was extended in depth to the equivalent of three strips deep (about 30.2 m), so that the small mesh extended down to reach the floor of the channel where porpoise frequently dive during backdown. The panel was also extended in length to reach from the stern tie-down point through the third bunch which is generally gathered along side the bow of the vessel at backdown (see Fig. 1). This design would then afford the porpoises protection from large mesh around the entire periphery of the backdown channel. Lighter-than-normal thread used in the 1½-inch mesh webbing tended to compensate for the added drag caused by the increased amount of small netting.

Early tests of the net during the fall of 1973 on the cruise of the MV *John F. Kennedy* indicated some defects, but a highly encouraging low kill rate was achieved. Both the NMFS gear specialist aboard, Jerry Jurkovich, and the captain, Lionel Souza, credited the more extensive, small-mesh Medina panel with much of the success. Only one porpoise was noted entangled in the small mesh, and that was where the 1½-inch mesh had been torn. Distracting to some extent from the success of this trip was the fact that it was a research charter that granted fishing rights for yellowfin tuna inside the Inter-American Tropical Tuna Commission Yellowfin Regulatory Area (CYRA) and therefore was not typical of the more competitive fishing that prevails earlier in the year during the open season.

In June 1974, a captain of a new seiner volunteered to further test the net and to carry Jerry Jurkovich. The trip was made to the area west of the CYRA where the vast majority of the fishing is on porpoise and conducted under rigorous weather and sea conditions. This cruise achieved what was at that time a record low kill-rate. The small-mesh Medina panel again was considered by Jurkovich of major importance in this performance.

Small Mesh Considerations

Based on these successful, although limited tests of the more extensive smaller mesh Medina panel and the common sense principle that tapered objects, such as porpoise snouts and fins, will not penetrate as deeply into small openings as they will into larger openings, it would seem that the more extensive smaller mesh panels would have been rapidly introduced into the fleet. However, in the real world of tuna fishing other considerations are operative as well.

Purse seines in the modern tuna fleet tend to be tailored to the size of the vessel that will deploy them and to a lesser extent to the type of fishing that will mainly be conducted. Basically, there are three types of fishing: porpoise fishing, log fishing, and school fishing. In the latter cases, schools of tuna that are not associated with porpoises are located and entrapped. The larger vessels use the larger nets and school fishing nets are generally about 100 fm longer than porpoise fishing nets. Most of the newer vessels fishing on porpoise now use nets 600–700 fm (1,097–1,280 m) in length and 10–14 strips deep (about 101–141 m). Because of its added weight, drag, and tendency to clog, addition of large amounts of small-mesh webbing to a net of this size must be approached with caution, for the buoyancy of the net can be lessened to the point that once the corks go under and are squeezed by increasing water pressure they will not rise to the surface. In such a situation, the net can sink to the point where it and even the vessel are in jeopardy.

Again, what appears to be a simple matter of mesh-size opening is complicated by numerous factors. For example, the stretch of the webbing at any given moment can close the area of the openings both before or after penetration of the animal appendage. The angle of incidence of the animal appendage in relation to the plane of the webbing, the dimensions and shape of the teeth or roughness of the skin that would tend to catch and hang in the thread, and the behavior of the animal which in turn may be affected by many variables, are other imponderables that are difficult to predict.

Live Animal Experiments

In view of the above discussed considerations, the most valid tests of mesh-size entanglement factors should be made on live animals under experimental conditions. Such experiments were planned for the summer of 1973 as part of the behavioral studies undertaken for NMFS by the University of California, Santa Cruz, Calif. (Norris and Dohl, 1974). The problems of obtaining and maintaining live specimens of those stocks utilized in the fishery were insurmountable. Thus the Hawaiian spotted dolphin or "kiko", a race of *Stenella attenuata,* was chosen for the experiments. Unfortunately, the animals did not do well in the only cages available for use at the U.S. Navy Undersea Laboratory Marine Mammal Facility at Kaneohe Bay, Oahu, Hawaii. Of the eight animals captured and placed under husbandry, seven died. Because of the inherent dangers of the experiment, the remaining animal was only used in a series of trials of passage through net openings of various sizes similar to the experiments of Perrin and Hunter (1972). As an aside, it should be noted that this animal survived the tests and was released in the general area of his capture.

A casual observation made by Dohl (pers. commun.), but not included in the above cited report, is also of interest here. In all observed cases, when a porpoise had pushed its rostrum and lower jaw through a hole in their wire mesh enclosures, the animals kept swimming and forcing themselves further into the opening until they became exhausted and died. The animals never attempted to withdraw from the ensnaring hole. This behavior also seems to be typical of porpoises entangled in tuna nets. As the fishermen say, "porpoise have no reverse gear."

PORPOISE APPENDAGE PENETRATION TESTS

Unable to acquire data obtained with live animals, we then carried out the tests described below on dead specimens to quantify the relative potential entanglement factor of various mesh sizes. The tests were done in April 1974 at the Southwest Fisheries Center.

Table 1.—Relative life stages and measurements (in centimeters) of porpoise specimens used in the appendage penetration tests.

Specimens		Total length	Rostral length	Jaw ×-section closed		Jaw ×-section open				Pectoral fin length
						Upper		Lower		
Numbers	Description			Width	Depth	Width	Depth	Width	Depth	
1 (WFP 281)	Spinner, large adult female	185.0	13.7	3.3	3.5	3.4	1.8	3.2	2.0	23.5
2 (GMA 115)	Spinner, large juvenile female	127.5	11.3	3.1	3.4	3.1	1.5	3.2	2.1	20.1
3 (WFP 285)	Spinner, medium juvenile male	115.0	8.5	—	—	—	—	—	—	—
4 (WFP 290)	Spotter, medium adult female	182.0	11.0	3.3	3.6	3.3	2.1	2.6	2.0	—
5 (WFP 467)	Spotter, large juvenile female	144.0	9.4	3.2	3.6	3.2	1.5	2.5	2.1	—
6 (WFP 468)	Spotter, small juvenile male	87.0	5.5	2.6	3.0	2.6	1.6	2.5	1.4	14.5
7 (NUC 385)	Whitebelly, large juvenile female	146.0	11.6	4.2	4.0	4.0	2.3	3.9	2.6	24.2

Specimens

Seven animals representing the three porpoise species of major importance were used in the tests: three spinner dolphins, *Stenella longirostris;* three spotted dolphins, *S. attenuata;* and one common or whitebelly dolphin, *Delphinus delphis*. The specimens of the first two species were collected in the eastern tropical Pacific by NMFS observers on commercial fishing vessels and are representative of porpoises utilized in the fishery. The *Delphinus* was taken dead from a Baja California, Mexico, beach by Navy Undersea Center personnel and was probably from a stock that is not involved in the fishery (Evans, 1976). All specimens had been frozen and were thoroughly thawed before the tests were performed. To the extent possible, representative size classes were selected for measurement. Their sex and relative life stage is indicated in Table 1. In the cases of three specimens, number 3 spinner and numbers 4 and 5 spotters, only the heads had been collected and pectoral fin measurements and tests could not be made. The number 3 spinner specimen was damaged to the degree that critical cross sectional measurements were impossible. The nature of the longitudinal measurements made on specimens is indicated in Figure 2, and the pertinent dimensions are listed in Table 1.

Netting

Four different stretch-mesh sizes of coal-tar treated nylon netting were used: 1-inch, No. 18 thread; 1½-inch, No. 18 thread; 1⅞-inch, No. 54 thread (commercially known as 2-inch knotless); and 2-inch, No. 36 thread. (The metric equivalents for mesh sizes are shown in Figure 3.) The thread sizes indicate the number of yarns used for a strand and are not standardized diameters. The 1½-inch mesh webbing was a remnant of the panel built into the experimental net; the 1⅞-inch monofilament mesh was obtained from a commercial source and was not on hand at the time that specimen number 1 was run. The 1- and 2-inch mesh webbing was unavailable commercially at the time of the study and was hand-made by

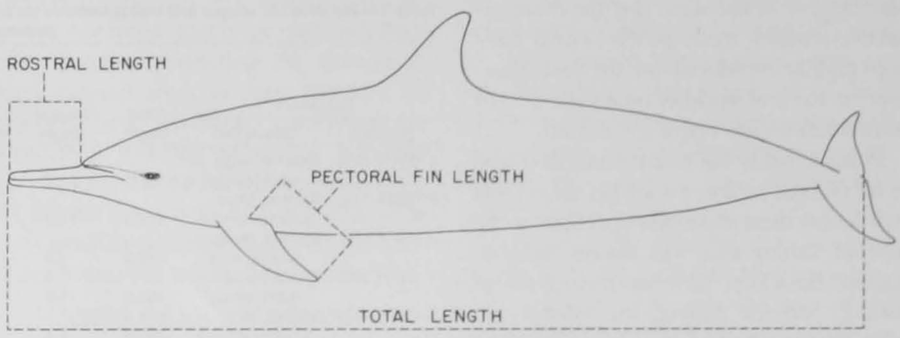
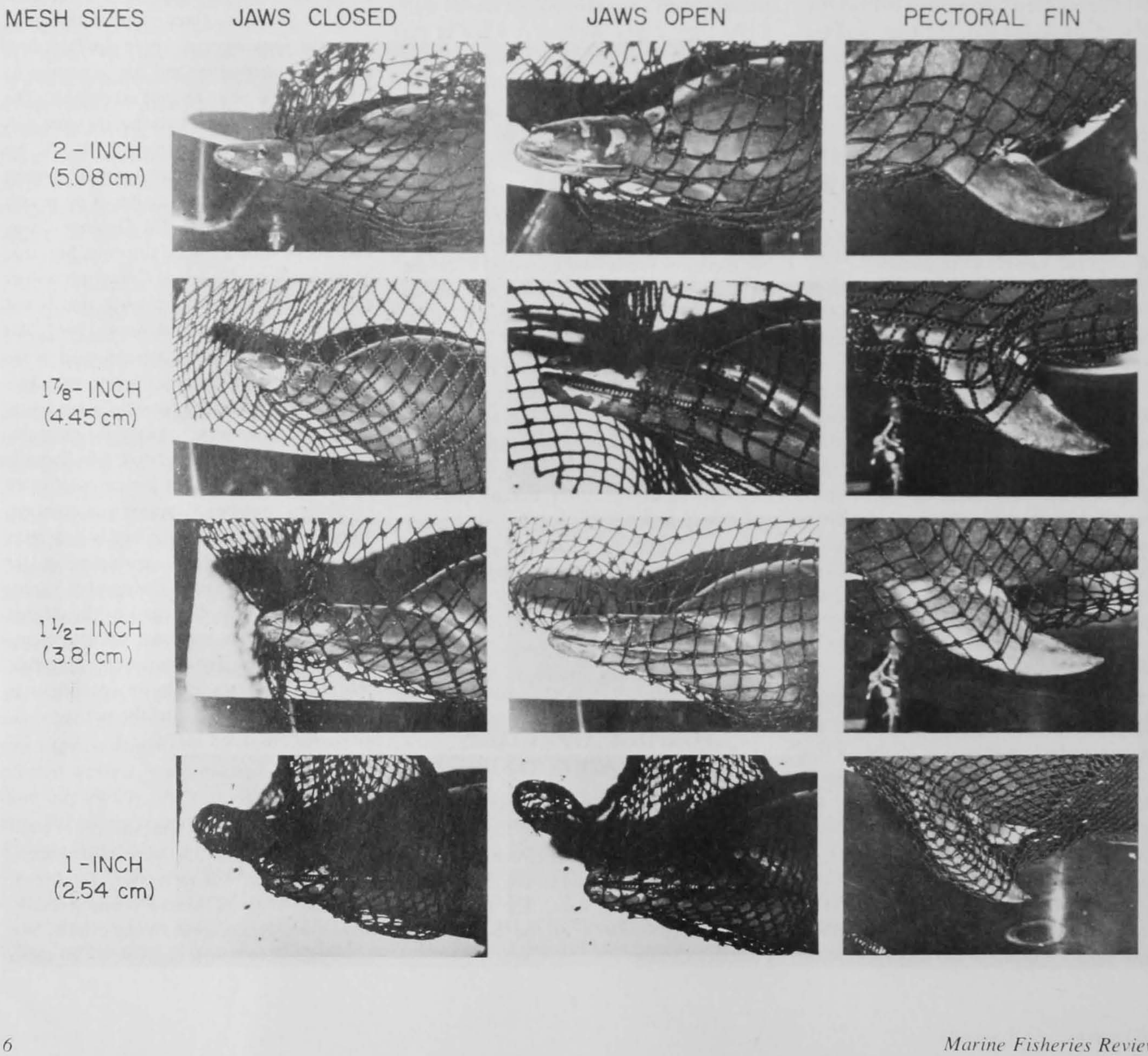


Figure 2.—Longitudinal meaurements made on porpoise specimens used in appendage penetration tests.

Figure 3.—Photographs of penetration tests performed on specimen number 2, a relatively large juvenile female spinner porpoise. (Total length, 127.5 cm; rostral length, 11.3 cm; pectoral fin length, 20.1 cm.)



a professional net builder. All the netting was new and had not been subjected to wear, stretch, or shrinkage.

Method

The netting was snugly pulled down over the rostrum or snout, first with the jaws tightly closed and then repeated with the jaws slightly agape. In the latter case, a net bar was inserted in the mouth and the mandible would penetrate one mesh opening and the lower jaw an adjacent mesh opening. Measurements of penetrations were made with a caliper from the tip of the upper jaw to the net twine. These measurements were then compared to the full-length of the rostrum (measured from the tip of the upper jaw to the apex of the melon) to derive the percent penetration of that specimen. Penetration of the pectoral fin, or "flipper," was similarly measured for the four entire specimens that were available. Measurements were rounded to a millimeter.

Results

Representative photographs of the tests are shown in Figure 4. The appendage penetration measurements through the four mesh-size openings for the three classes of tests, "jaws closed," "jaws open," and "pectoral fin," are listed in Table 2. The percent penetrations (depth of penetration/length of appendage × 100) are also listed and averaged in Table 2, and these average ratios are graphed in Figure 4.

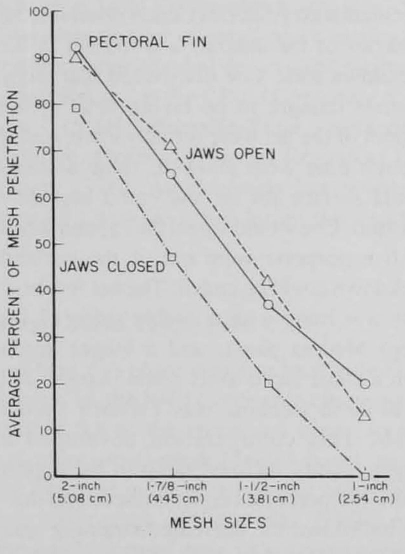


Figure 4.—Average ratios of percent penetration of porpoise appendages through the indicated mesh sizes.

The measurements demonstrate a direct relationship between the depth of penetration and mesh size, and the decreases are approximately linear and about the same rate for all three classes of tests (Fig. 3). Comparing the results for 2-inch and 1½-inch meshes, a marked decrease in penetration was measured for the smaller mesh. With the jaws closed the decrease was 75 percent; with the jaws open when two openings are involved, 53 percent; and the flipper penetration was reduced 60 percent. Surprisingly, the 1⅞-inch mesh (2-inch knotless), a coarse filament nylon net, also proved considerably lower than the 2-inch mesh. This was apparently due to the larger and coarser twine used in the netting. This twine was also more abrasive to the animal's skin than that of the other netting. Finally, the 1-inch mesh by far allowed the least penetration. With the jaws closed there was no penetration for any specimen tested (a reduction of 100 percent from the 2-inch average). With the jaws open, the average penetration was limited to only 13 percent, 86 percent less than the 2-inch measurement and also a marked reduction over the 1½-inch mesh.

Pectoral fin penetration of the four available specimens was restricted to only 20 percent, a decrease of 78 percent over that for the largest mesh.

Table 2.—Porpoise appendage penetration measurements (in centimeters), and the percent of penetration relative to the length of the appendage for four sizes of net mesh openings.

	2-inch mesh		⅞-inch mesh		1½-inch mesh		1-inch mesh	
Test specimens	cm	%	cm	%	cm	%	cm	%
Jaws closed								
1 Spinner, large adult female	9.0	66	—	—	1.5	11	0.0	0
2 Spinner, large juvenile female	9.4	83	4.9	43	2.3	20	0.0	0
3 Spinner, medium juvenile male	8.5	100	3.4	40	1.8	21	0.0	0
4 Spotter, medium adult female	8.3	75	3.7	34	1.3	12	0.0	0
5 Spotter, large juvenile female	7.3	78	4.2	45	1.9	20	0.0	0
6 Spotter, small juvenile male	5.5	100	5.5	100	2.6	47	0.0	0
7 Whitebelly, large juvenile male	5.8	50	2.5	22	1.1	9	0.0	0
Average % penetration		79		47		20		0
Reduction from 2-inch				41		75		100
Jaws open								
1 Spinner, large adult female	10.5	77	—	—	2.6	19	1.1	8
2 Spinner, large juvenile female	10.8	96	6.6	58	4.2	37	1.1	10
3 Spinner, medium juvenile male	8.5	100	8.5	100	4.3	51	1.6	19
4 Spotter, medium adult female	11.0	100	6.9	63	3.6	33	1.1	10
5 Spotter, large juvenile female	9.3	100	5.8	62	4.3	46	1.8	19
6 Spotter, small juvenile male	5.5	100	5.5	100	4.4	80	1.5	27
7 Whitebelly, large juvenile male	6.8	59	5.1	44	3.0	26	0.0	0
Average % penetration		90		71		42		13
Reduction from 2-inch				21		53		86
Pectoral fin								
1 Spinner, large adult female	16.4	70	—	—	10.9	46	6.1	26
2 Spinner, large juvenile female	20.1	100	10.7	53	7.5	37	3.7	18
3 Spinner, medium juvenile male	—	—	—	—	—	—	—	—
4 Spotter, medium adult female	—	—	—	—	—	—	—	—
5 Spotter, large juvenile female	—	—	—	—	—	—	—	—
6 Spotter, small juvenile male	14.5	100	14.5	100	5.8	40	3.1	21
7 Whitebelly, large juvenile male	24.2	100	10.3	43	5.7	24	3.4	14
Average % penetration		92		65		37		20
Reduction from 2-inch				29		60		78

Discussion

The most recent analysis of data taken by NMFS observers on causes of porpoise mortality during commercial fishing trips indicate that over a 2-year period the kill caused by entanglement varies from about 28 to 55 percent depending on the species (Staff, Porpoise/Tuna Interaction Program, Oceanic Fisheries Resources Division, 1976). The rostrum is the most common appendage involved in entanglement, and the numerous, small, conical teeth frequently catch in the twine and play an important part in entanglement. Occasionally, having first become entangled by the rostrum or the jaws the porpoise roll and thrash becoming further entangled by other appendages.

Regarding the penetration test results, while reduction of penetration of porpoise rostra with smaller mesh sizes would logically be expected, the drastic limitation of penetration resulting from a 1-inch decrease in mesh size was striking. It should be noted, however, that even the 1-inch mesh would not totally exclude the tip of the jaws when they were agape. Clearly, however, the test results strongly indicate the potential reduction in entanglement that can be gained through the application of small-mesh netting.

RECENT DEVELOPMENTS

MV *South Pacific* Charter, 1974

As previously indicated, in the past the hesitancy of some fishermen to adopt smaller-mesh Medina panels has been based on their well-founded apprehension about the weight and drag effects of decreased mesh size that can grossly affect the hydrodynamic performance of the net. However, a relatively recent development, the "porpoise apron" may offer one solution to this problem. Designed by Richard McNeely and first tested on the NMFS charter cruise of the MV *South Pacific* in the fall of 1974, the apron is a tapered, trapezoidal section of small-mesh webbing. The apron is centered at the middle of the backdown area and the webbing section is laced in between the corkline and the Medina panel.

Because of the apron's tapered sides, the amount of webbing between the cork and chain lines at the apex of the backdown area is now longer than at the sides. This transfers the strain on the webbing from the center of the backdown area to its margins when the net is in backdown configuration. Several desirable effects result. The deep, porpoise entrapping pocket that commonly forms under the corks at the end of the backdown area tends to be eliminated. Instead, the panel and apron form a ramp that eases the porpoise over the corkline during backdown. It is therefore unnecessary to sink the corks to considerable depths with strong backdown surges, but rather a slow continuous backdown can be performed.

The *South Pacific* charter staged in Panama City, Panama, and the prototype apron was hung with locally available 2-inch mesh webbing when the intended 1¼-inch webbing was lost in air transit. The *South Pacific* charter results were highly encouraging, and the apron was left in that vessel's net for the 1975 season.

During the *South Pacific* charter, McNeely also briefly experimented with an extension to the apron called a "chute". This severely tapered, trapezoidal-shaped section of netting was hung from untarred, 1¼-inch mesh borrowed at sea from another purse seiner under charter to NMFS. From the deck of the *South Pacific* during backdown, the dark bodies of porpoise could easily be seen in contact with this light-colored webbing. The porpoise would come free without entangling. The ship's fishing captain, Joseph Scafidi, was highly impressed with the performance of the small-mesh webbing. For the 1975 season, Scafidi transferred to another seiner and he requested and received from NMFS 1¼-inch mesh webbing for testing from which he hung an apron in the net of his new vessel.

Concurrent with the *South Pacific* charter, another charter vessel, the *J. M. Martinac*, was fishing with a net that had a 120 fm Medina panel of 1¼-inch webbing. The NMFS gear technician, Daniel Twohig, also observed a striking lack of entanglement during contact with this small-mesh Medina panel.

Voluntary April Tests, 1975

In mid-spring of 1975, a group of fishermen who had returned to San Diego following their first trips of the season met with owners and managers to discuss porpoise rescue procedures. Joseph Scafidi attended and he strongly recommended small-mesh panels and aprons. August Felando, General Manager of the American Tunaboat Association, asked for volunteers, and eight captains or managers agreed to install and test aprons during the remainder of that season.

Unfortunately, this period coincided with a world shortage of synthetic-fiber twine due to the petroleum shortage and the destruction by fire of a major twine producer's factory. Orders could only be filled after at least a 6-month delay. The vessels of the "apron volunteers" were in port for only brief periods between fishing trips, and, as a result, most of these aprons were hung with the only small-mesh netting locally available, 2-inch stretch mesh, woven from coarse nylon.

One of us (E. G. Barham) interviewed the "apron skippers" on their return from their first fishing trip with the aprons. In general, their opinions were affirmative, although some troubles were reported due mainly to aprons that were not precisely centered in the backdown area.

MV *Bold Contender* Charter, 1975

Small-mesh modifications designed by McNeely were further tested in the fall of 1975 on the charter cruise of the MV *Bold Contender* under command of John Gonsalves. Operating from a small rubber-raft using face mask and snorkle, James Coe of the Southwest Fisheries Center observed the behavior of the animals and the net in the backdown area. Coe discovered that many animals thought to be laying dead at the bottom of the net were actually alive, and if enough time were allowed, these animals would surface for air and could be safely released. Coe would signal the captain when all live porpoise were out of the net and backdown could be ended. The net for these tests was hung with a double strip (11 fm deep) Medina panel, and a longer apron with a chute laced to its distal margin. All small-mesh webbing was 1¼-inch stretch mesh. This configuration developed a longer, gently inclined ramp in the region where the porpoises concentrated, and during backdown the decreased straining area of the small mesh created an increased flow of water that helped to "wash" the porpoises over the corkline. At the same time, a

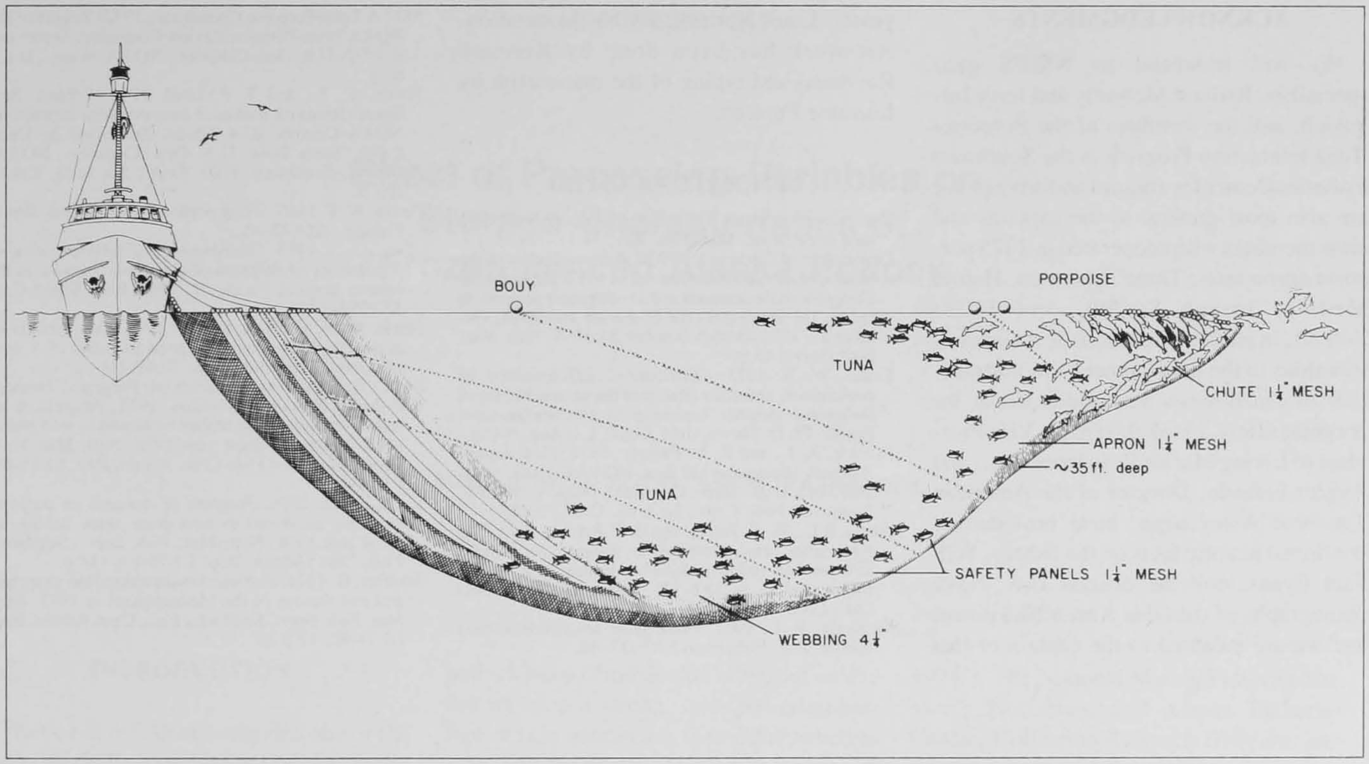


Figure 5.—Schematic cross-section of the apron-chute, double Medina panel, configuration in a tuna purse seine during backdown. Mesh sizes of the various components are indicated.

deep pocket was formed in an area in front of the Medina panel that tended to hold the tuna away from the backdown area (Fig. 5). This arrangement of small-mesh netting in conjunction with other devices and methods is now known as the "Bold Contender System" (Staff, Porpoise/Tuna Interaction Program, Oceanic Fisheries Resources Division, 1976). An extremely low porpoise mortality was recorded during this charter cruise.

Major Field Tests, 1976

There was some doubt as to whether the success of the *Bold Contender* charter was mainly due to the apron and chute, to the extensive small-mesh Medina panel, or to the observer in the small rubber raft. However, as a result of these tests, NMFS and the newly formed tuna industry sponsored Porpoise Rescue Foundation inaugurated a major testing and evaluation program in 1976. As planned, 10 vessels would fish with a double-strip Medina panel and an apron and chute all hung from 1¼-inch stretch-mesh webbing, and another 10 seiners would fish with only a double strip, 1¼-inch Medina panel. Both sets of vessels were to use a face-mask equipped observer working from a small rubber raft. The vessels would also use the other aspects of the Bold Contender System and NMFS field technicians would accompany all vessels and record performance.

As the 1976 season progressed, some of the test trips were aborted due to Judge Charles Richey's court ruling on the validity of the permit to take porpoises issued by NMFS to the American Tunaboat Association, but at this writing most of these trips have been resumed and data are rapidly accumulating from approximately the full vessel complement.

Regardless of the final outcome relative to the apron and chute vs. the extended 1¼-inch Medina panels, it appears that the introduction of small-mesh netting will make a major contribution to further reductions of incidental porpoise mortality in tuna purse seines[1].

[1]While this manuscript was in review, preliminary results of the MV *Elizabeth C. J.* 1976 charter cruise became available. To obtain the cooperation of this modern seiner it was necessary to combine yellowfin tuna allotments for both gear work and behavioral research. The gear work was essentially a continuation of the "Bold Contender System" approach, and the net was equipped with an extensive Medina panel and modified apron hung from 1¼-inch mesh webbing. The results were extremely successful. During the cruise the *Elizabeth C. J.* made 45 sets on porpoise which took 917 tons of yellowfin tuna with only 15 porpoise being killed. Further, the majority of these animals were killed as a result of the behavioral research objectives rather than normal fishing operations. This record low kill rate was attributed to four factors: 1) a successful culmination of NMFS gear research under the direction of Richard McNeely; 2) the underwater observations of James Coe, who again worked from a rubber raft in the backdown area; 3) good environmental conditions; and 4) the skill and dedication of the vessel captain, Manuel Jorge, and his crew members. A full report on this cruise will be published in the next issue (39:6) of *Marine Fisheries Review*. The results of the behavioral research under the direction of Kenneth Norris will be reported elsewhere.

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