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EVALUATION OF TECHNIQUES TO DECREASE SEA TURTLE MORTALITIES IN THE SOUTHEASTERN UNITED STATES SHRIMP FISHERY

by

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ABSTRACT

The incidental capture and mortality of sea turtles in shrimp trawling gear has become a serious problem in the southeastern United States. Shrimp fishing regulations to reduce the incidental capture and mortality of sea turtles in shrimp trawls are pending. This report presents data on the development and evaluation of selective shrimp trawling gear designed to reduce the incidental capture of sea turtles. Data are presented on the effectiveness of two trawl designs; the "reverse" excluder barrier and the turtle excluder device. Both techniques are effective in reducing turtle captures but cause some reduction in shrimp catch production. Information is also presented on the effectiveness of reducing the length of trawl tow and sea turtle resuscitation techniques on reducing sea turtle mortality in shrimp trawls.

1. INTRODUCTION

The incidental capture and mortality of marine turtles in shrimp trawling gear has been implicated as a threat to the survival of some endangered and threatened sea turtle stocks (Carr, Carr, and Meylan, 1978). Recent concern over declining sea turtle stocks has intensified research into the magnitude of incidental capture of marine turtles in U.S. waters, particularly in the southeastern United States shrimp fishery (Hillestad et al, 1978; Pritchard, 1976; Anon, 1976; and Ulrich, 1978).

Studies on the incidental catch and mortalities of sea turtles in shrimp trawls and the magnitude of turtle strandings on beaches adjacent to shrimping grounds in the southeastern United States have prompted proposed fishing regulations designed to decrease the incidental mortality of marine turtles. The U.S. National Marine Fisheries Service, Southeast Fisheries Center, is conducting research on techniques to reduce the mortality of sea turtles in shrimp trawls. The major emphasis of this research has been the development of shrimp trawls which will significantly reduce the incidental trawl capture of sea turtles. Other techniques under investigation include reduction of towing time, resuscitation of comatose turtles, and restricted fishing. This contribution presents data on the evaluation of two sea turtle excluder trawl designs and the effect of tow time and resuscitation techniques on turtle mortality.

2. METHODS

The development of shrimp trawling gear to prevent the incidental capture of sea turtles while maintaining shrimp production is a complex task. It is complicated by the numerous types, sizes, and rigging configurations of shrimp trawling gear and the desirability of keeping modifications economical and simple. An analysis of the problem resulted in two approaches: (1) to prevent turtles from entering the trawl and, (2) to separate and exclude turtles after they have entered the trawl. Behavioral observations of sea turtles encountering shrimp trawls by scuba divers (Ogren et al, 1977) indicated that a barrier blocking the entrance of the trawl would be an effective method of reducing turtle captures while separating and excluding turtles within the trawl would be difficult.

Research was initiated in 1978 to develop a barrier which could be installed in a shrimp trawl to block the entry of sea turtles while allowing shrimp to pass unhindered. The progress in this development during 1978 and 1979 was reported by Seidel, (1979) and Seidel and McVea, (1979). Two panel designs constructed from #210/180 nylon twine of 66-cm and 81-cm stretch mesh were tested on six shrimp trawl types commonly used in the southeastern United States shrimp fishery. After two seasons of testing, a barrier design and trawl type was selected for final evaluation during 1980 (Seidel, 1979). The data indicated that the most effective barrier design was the "reverse" type barrier which is attached from the trawl headrope to the leadline completely blocking the mouth of the trawl and constructed of #210/180 60-66-cm stretch mesh nylon twine (Figure 1). The most efficient shrimp trawl design for employment of the turtle excluder barrier was found to be the newly developed "tongue" or "bib" trawl design.

Research on excluder trawl techniques has also resulted in the development of a "sea turtle excluder device" (Figure 2). The excluder device is a 1.2 x 0.9 x 0.9 meter frame constructed on a 9.5-mm galvanized pipe with bars slanting at a 45° angle spaced 15.2-cm apart and a 0.9-m square door in the bottom. The device is placed inside the trawl at the intersection of the trawl body and the codend extension or "throat." As a turtle or other large object enters the extension of the trawl it strikes the slanted bars and is forced by water pressure and gravity toward the

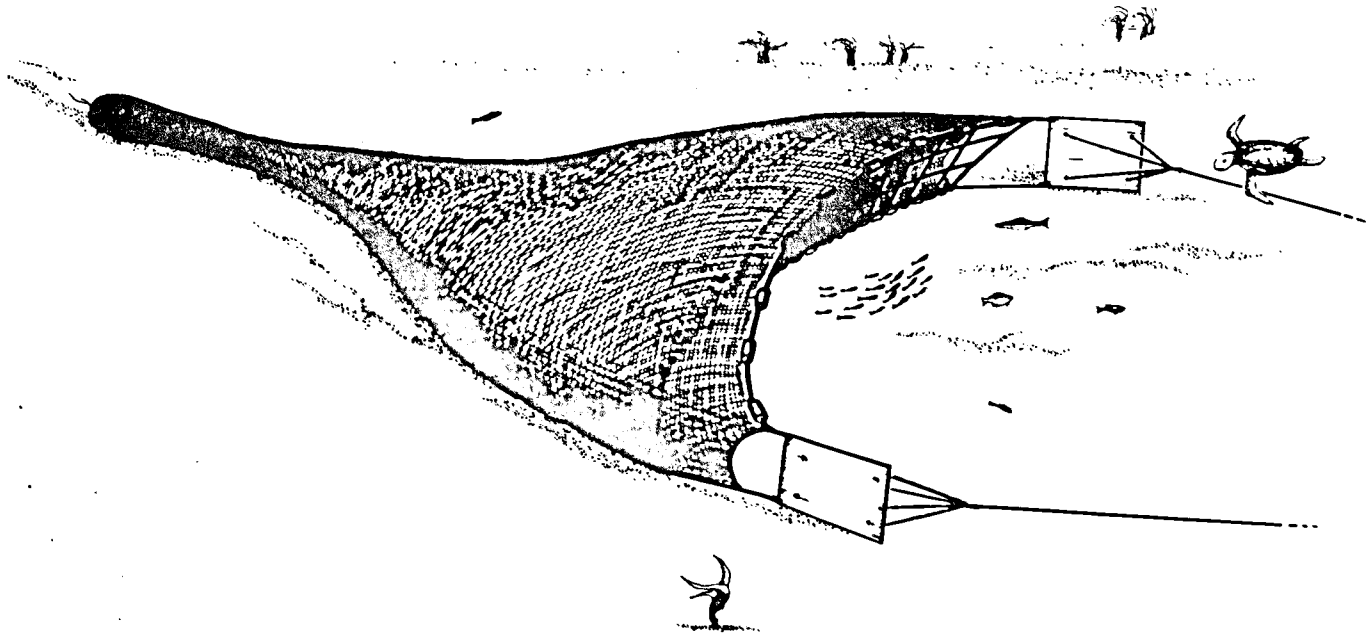

Figure 1. Sea turtle "excluder" shrimp trawl reverse barrier.

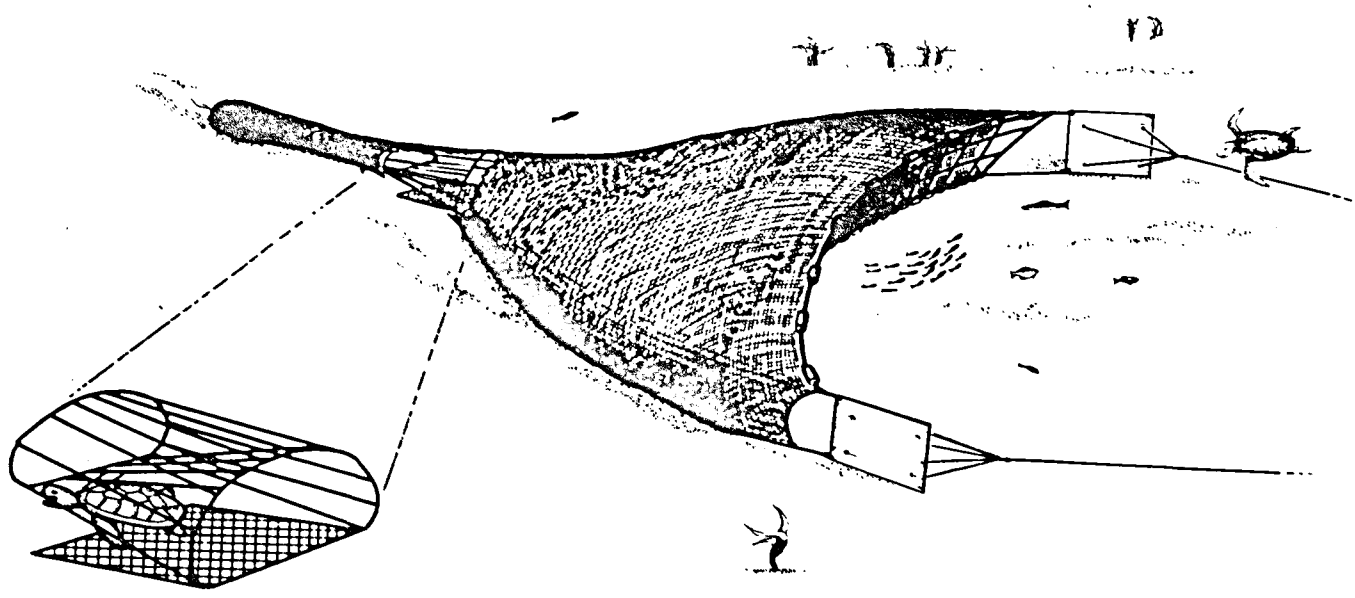

Figure 2. Sea turtle "excluder" device.

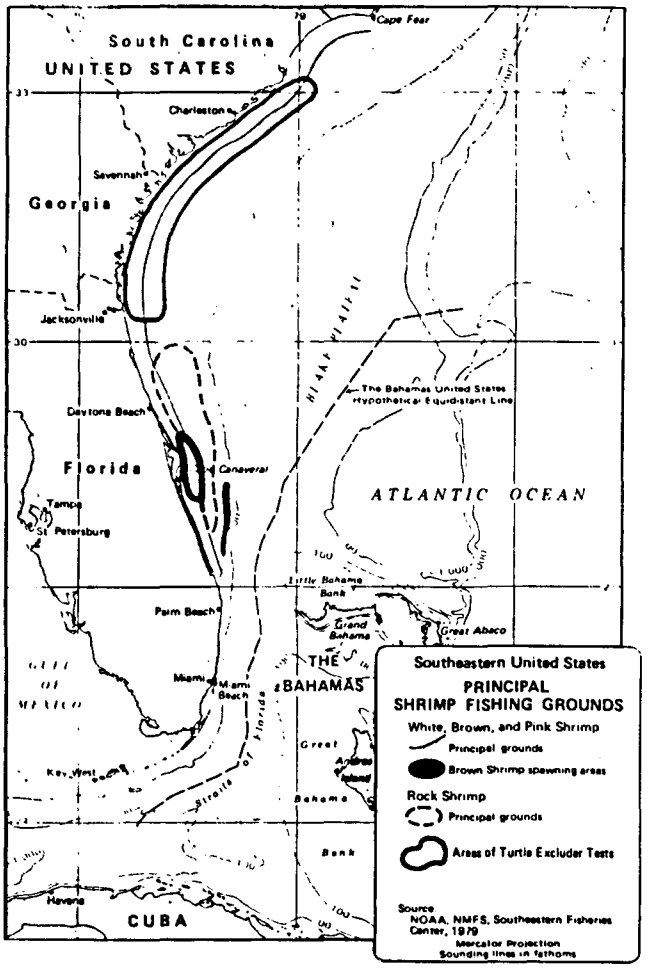

Figure 3. Southeastern United States principal shrimp fishing grounds.

"trap door" which opens on hinges as sufficient pressure is exerted allowing the object to pass out of the trawl and closes as the pressure is released. Smaller objects pass through the bars into the trawl codend. The closing tension on the door is regulated between 8 and 11 kg by rubber cords attached to the device frame.

The turtle excluder barrier and the turtle excluder device are being evaluated on commercial shrimp vessels in the southeastern U.S. shrimp fishery off Georgia, South Carolina, and Florida (Figure 3). Evaluation of the turtle excluder barrier was completed in August, 1980, and evaluation of the turtle excluder device has been initiated. Testing of turtle excluder gear is conducted on two types of shrimp vessels: chartered shrimp vessels where full control of the experimental design is exercised by project personnel and cooperative shrimp vessels which conduct normal commercial fishing operations.

The excluder gear is tested on the shrimp vessels by making paired tows with an experimental excluder trawl on one side of the vessel and an identical (control) trawl without the excluder gear modification on the other side. The gear is tuned by National Marine Fisheries Service (NMFS) scuba divers before being placed aboard test vessels and is maintained and adjusted by NMFS gear specialists during testing. An NMFS Observer accompanies each vessel. The observer monitors trawl performance and collects biological and other scientific data. The trawl catches are kept separate, sorted, weighed, and recorded. Observers record shrimp catch, total catch, turtle captures, condition of turtles, location of tow, length of tow, and other pertinent information. Observers also take subsamples of shrimp by-catch which they sort, identify, and weigh by species or genera. Turtles are measured, sexed, tagged, photographed, and released if active when brought aboard; if they are comatose, resuscitation techniques are employed and the condition of turtles after resuscitation efforts is recorded. Resuscitation techniques employed by observers are: (1) place the comatose turtle in a cool area with its dorsal side down and periodically "pump" the plastron or, (2) place the comatose turtle in a cool area with its ventral side down and its posterior elevated.

2.1 Turtle Capture Rates

2.1.1 Reverse Barrier Trawl

A total of 749 paired tows were made on cooperative and charter vessels testing the excluder barrier trawl. Turtle capture rate statistics for paired comparisons are presented in Table 1. The turtle capture rates are expressed as turtles per hour per 18.3 m headrope length trawl. The mean capture rate for the standard (control) trawls was 0.043 turtles per hour as compared to a mean capture rate of 0.009 turtles per hour for the reverse barrier excluder trawls. The mean difference between standard and reverse barrier trawl was 0.034 turtles per hour with a standard error of 0.0063. The value of the calculated t_s is significant at the 99% level. The percent difference in mean capture rates was 79% with a 90% confidence interval of 23%, showing a significant reduction in turtle capture rate with the turtle excluder barrier.

Table 1. Turtle Catch Rate Statistics* Paired Comparison Between Standard and Turtle Excluder Trawls.

Reverse Barrier Trawl

Charter and Cooperative Vessels	Mean	N
Standard trawl ($\bar{X}$)	0.043	749
Excluder trawl ($\bar{Y}$)	0.009	749
Difference and standard error ($\bar{D} \pm S_{\bar{D}}$)	0.034±0.0063	749
Percent difference and 90% confidence interval	79±23	

$t_s = 5.666$ $P < 0.001$

*Turtle catch rates expressed as turtles per hour per 18.3 m headrope length trawl.

2.1.2 Turtle Excluder Device

Testing of the turtle excluder device was initiated in June, 1980, on a single charter vessel in Cape Canaveral, FL, an area of dense turtle concentration, in order to test the concept. A total of 104 paired tows were made in the initial test period. Testing of the prototype design was started again on four vessels (two charter and two cooperative) in Sept., 1980. Only the data from the initial test period are included in this report. The mean capture rate for the standard trawls was 4.6 turtles per hour (Table 2). The mean capture rate for the excluder device trawl was 0.5 turtles per hour. The mean difference was 4.1 turtles per hour with a standard error of 0.87. The value of the calculated t_s is significant at the 99% level. The percent difference in mean capture rates is 89% with a 90% confidence interval of 31%, showing a significant reduction in turtle capture rate.

Table 2. Turtle Catch Rate Statistics* Paired Comparison Between Standard and Turtle Excluder Trawls.

Turtle Excluder Device

Charter Vessel	Mean	N
Standard trawl ($\overline{X}$)	4.6	104
Excluder trawl ($\overline{Y}$)	0.5	104
Difference and standard error ($\overline{D}\pm S_{\overline{D}}$)	4.1±0.87	104
Percent difference and 90% confidence interval	89±31	

$t_s = 4.692$ $P < 0.001$

*Turtle catch rates expressed as turtles per hour per 18.3 m headrope length trawl.

2.2 Shrimp Catch Rates

2.2.1 Reverse Barrier Trawl

The shrimp catch rates are calculated separately for the charter vessel which operated under a strict experimental design and the cooperative vessels which operated under normal commercial fishing conditions because there was a marked difference in catch results. The shrimp catch rate statistics are presented in Table 3 for the charter vessel and in Table 4 for the cooperative vessels. The standard trawl mean shrimp catch was 7.9 kg per hour for the charter vessel and 8.4 kg per hour for the cooperative vessels. The mean shrimp catch rates for the turtle excluder barrier trawls were 6.7 kg per hour for the charter vessel and 5.9 kg per hour for the cooperative vessels. The mean differences were 1.2 kg per hour for the charter vessels with a standard error of 0.15, and 2.5 kg per hour for the cooperative vessels with a standard error of 0.19. The percent difference in shrimp catch rates is 15%±3% for the charter vessel and 30%±4% for the cooperative vessels (90% confidence interval). The t_s values are significant for both vessel types at the 99% level. A significant shrimp catch rate difference is associated with the reverse barrier design on both vessel types with the difference being larger on the cooperative vessels.

Table 3. Shrimp Catch Rate Statistics* Paired Comparison Between Standard and Turtle Excluder Trawls.

Reverse Barrier Trawl

Charter Vessel	Mean	N
Standard trawl ($\overline{X}$)	7.9	54
Excluder trawl ($\overline{Y}$)	6.7	54
Difference and standard error ($\overline{D}\pm S_{\overline{D}}$)	1.2±0.15	54
Percent difference and 90% confidence interval	15±3	

$t_s = 7.640$ $P < 0.001$

*Shrimp catch rates expressed as kg per hour per 18.3 m headrope length trawl.

Table 4. Shrimp Catch Rate Statistics* Paired Comparison Between Standard and Turtle Excluder Trawls.

Reverse Barrier Trawl

Cooperative Vessels	Mean	N
Standard trawl ($\overline{X}$)	8.4	327
Excluder trawl ($\overline{Y}$)	5.9	327
Difference and standard error ($\overline{D}\pm S_{\overline{D}}$)	2.5±0.19	327
Percent difference and 90% confidence interval	30±4	

$t_s = 13.58$ $P < 0.001$

*Shrimp catch rates expressed as kg per hour per 18.3 m headrope length trawl.

2.2.2 Turtle Excluder Device

Mean shrimp catch rates for the turtle excluder device are presented in Table 5. The mean shrimp catch for the standard trawl is 7.3 kg per hour compared to 6.4 kg per hour for the turtle excluder device. The mean difference was 0.8 kg per hour with a standard error of 0.24. The t_s value is significant at the 99% level. The percent difference in mean catch rates was 11%±5% (90% confidence interval).

Table 5. Shrimp Catch Rate Statistics* Paired Comparison Between Standard and Turtle Excluder Trawls.

Charter Vessel	Turtle Excluder Device Mean	N
Standard trawl ($\overline{X}$)	7.3	28
Excluder trawl ($\overline{Y}$)	6.4	28
Difference and standard error ($\overline{D}\pm S_{\overline{D}}$)	0.8±0.24	28
Percent difference and 90% confidence interval	11±5	

$t_s = 3.402$ $0.01 > P > 0.001$

*Shrimp catch rates expressed as kg per hour per 18.3 m headrope length trawl.

2.3 Turtle Mortality and Length of Tow

Data on the relationship between turtle mortality and length of trawl towing time are presented in Figure 4. A total of 401 turtles were captured in tows varying from 30 to 270 minutes in duration. The number of turtles captured in each time interval is presented in Figure 4. Turtle mortality ranged from 1.3% for tow lengths of 30 minutes to 26.4% for tow lengths of 270 minutes. The linear relationship of tow time from 30 to 270 minutes and turtle mortality is presented in Figure 5. An analysis of variance for the regression showed that a significant portion of the variance in mortality was explained by the regression (Table 6), although the relationship may approach a sigmoid function with more data in the upper and lower tow times as would be expected. The percentage of turtles captured which were comatose and the percentage of

Table 6. Analysis of Variance of the Effect of Tow Time on the Mortality of Sea Turtles in Shrimp Trawls.

Source of Variation	df	Sums of Squares	Mean Square	Fa
Explained	1	817.1530	817.1530	94.6008
Unexplained	7	60.4654	8.6379	
Total	8	877.6184		

[a] $F_{0.001\ (1,7)} = 29.3$

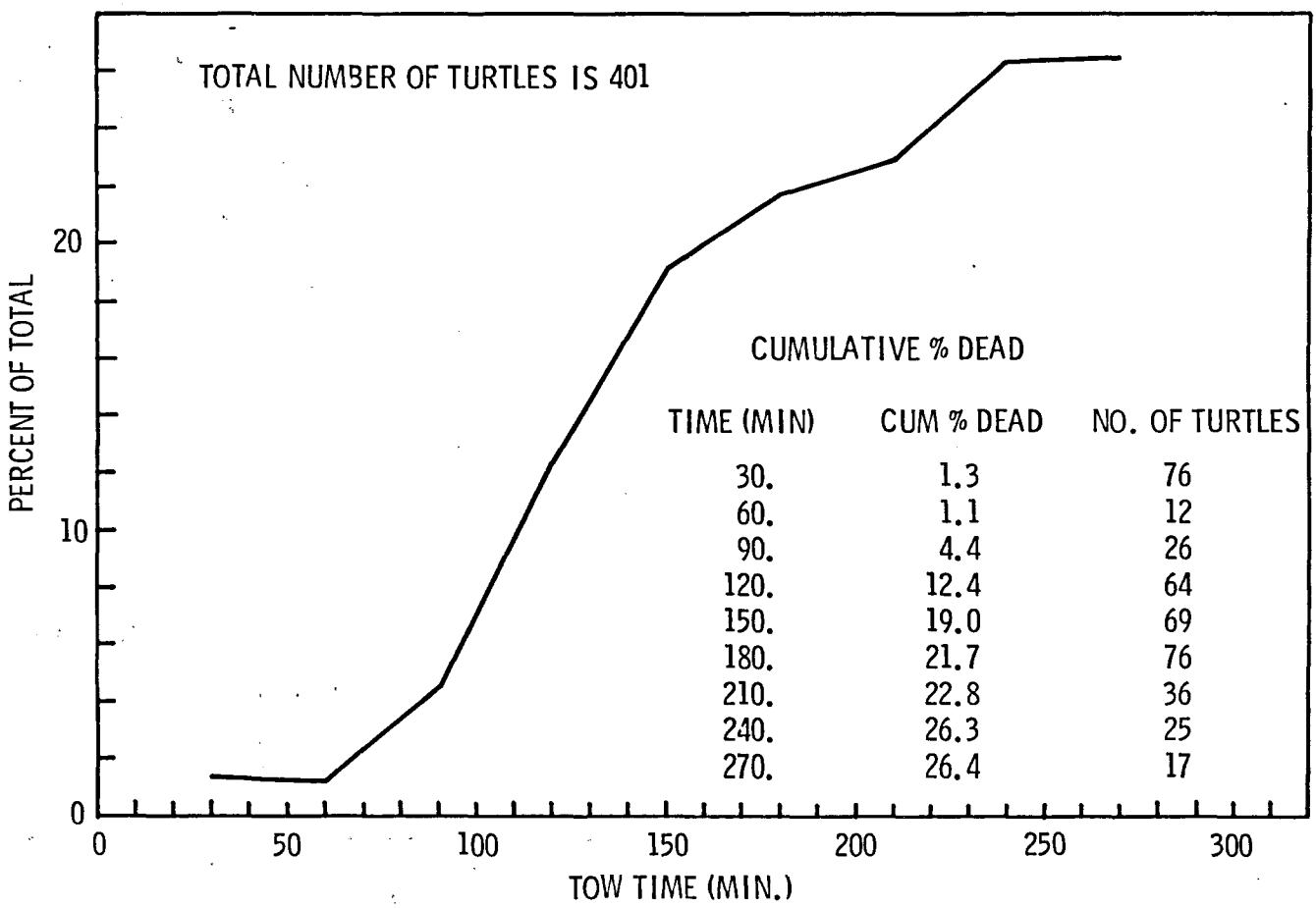

Figure 4. Length of trawl tow and mortality of sea turtles.

those comatose turtles which were revived by resuscitation techniques are presented in Table 7. The percentage of comatose turtles ranged from 2.6% for 30-minute tows to 28.9% for 270-minute tows. The percentage of turtles which could be revived by resuscitation ranged from 50% for 30-minute tows to 9% for 270-minute tows and showed a marked decrease between 120 and 150 minutes.

3. DISCUSSION

Reduction in mortality of turtles caught incidentally in shrimp trawls is a management objective for the preservation of endangered and threatened sea turtle stocks in the southeastern United States. Fishing regulations to achieve this objective may include several options. Among these

Table 7. Percentage of Turtles Captured Which Were Comatose and Percentage of Comatose Turtles Which Were Revived.

Tow Time (Min)	Percent of Turtles Caught Which Were Comatose	Percent of Comatose Turtles Which Were Revived
30	2.6	50
60	6.6	83
90	13.2	67
120	24.2	49
150	25.9	27
180	28.2	23
210	25.3	10
240	26.6	1
270	28.9	9

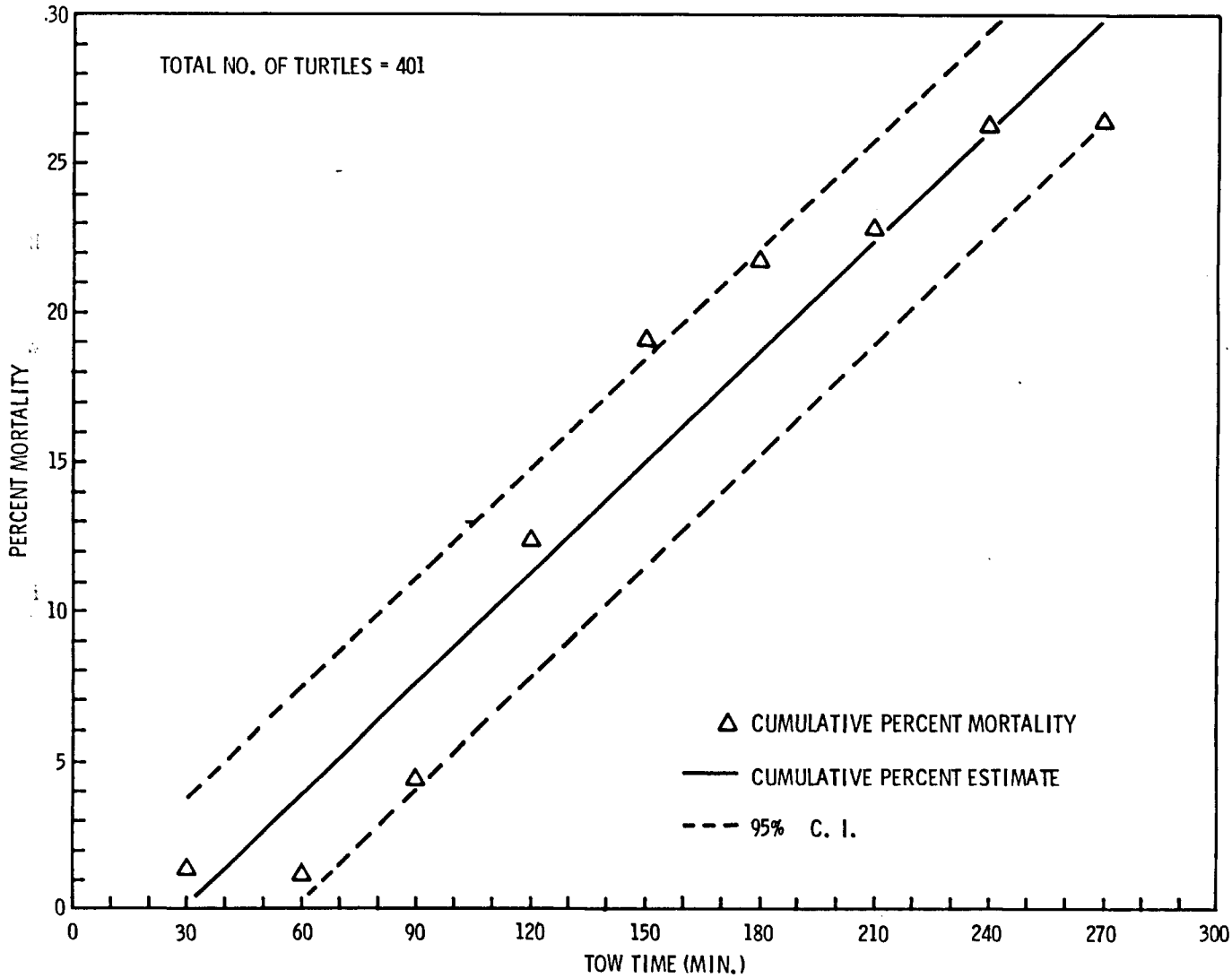

Figure 5. Linear relationship of tow time and sea turtle mortality in shrimp trawls.

options are the use of turtle excluder trawls, reduction in allowable length of tow, mandatory use of resuscitation techniques on comatose turtles, and restricted fishing by geographical area and or time of day and year. The information presented in this report is an evaluation of techniques to decrease sea turtle mortalities by shrimp trawling without restricting fishing grounds.

The research and development of turtle excluder trawls by the Harvesting Technology Branch of the Southeast Fisheries Center has resulted in the development of two potential designs: the reverse barrier trawl, and the turtle excluder device. The reverse barrier trawl has been evaluated in about 2 years of testing and development. The turtle excluder device has been developed, and evaluation initiated in 1980 is scheduled for completion in 1981. The data presented in this report show that both techniques are effective in reducing the incidental capture of turtles in shrimp trawls. The reverse barrier design blocks the mouth of the trawl and effectively prevents the entry of sea turtles into the trawl. The disadvantages of the barrier design are loss in shrimp production, restriction of trawl configuration flexibility, relatively complex design, and additional rigging requirements to maintain bottom contact. The loss in shrimp production varied between fishing vessels and conditions. An overall 15%±3% was obtained on the chartered vessel where the standard trawl and the excluder trawl were identically rigged and optimum rigging maintained. This shrimp production loss rate was the best rate achieved during testing and is considered to be the best rate obtainable with present barrier technology. The shrimp production loss rate on the cooperative shrimp vessels was 30%±4%. The major difference was that the cooperative vessel captains maximized the production rate of the standard trawls by varying the fishing configuration with changing fishing conditions. The excluder barrier attached to the trawl headrope and footrope must be kept tight to prevent turtle entanglement and thus prevents changing of trawl configuration once installed. The barrier stretched between the headrope and footrope creates drag forces on the trawl which limits the maximum headrope height attainable. In certain fishing conditions, shrimp (particularly white shrimp, *Peneaus setiferus*) are found 2-4 meters above the bottom. When this condition occurs fishermen add floats to the trawl headrope obtaining a headrope height of 3-4 meters on larger trawls. The limited height and inflexibility of the barrier trawl in these conditions can result in a 30%-50% loss in shrimp production. Although it would be expected that if regulations requiring the use of barrier trawls were enacted the shrimp industry could improve the barrier technology, it is doubtful if barrier trawls could equal standard trawl production because of innate characteristics of the technique.

The excluder device offers several advantages over the barrier technique, but thorough evaluation under commercial fishing conditions will be required to determine its full potential. The major advantages of the excluder device are simple and inexpensive installation, potential effectiveness in any type shrimp trawl, and potential for minimizing shrimp production loss. The preliminary data presented in this report shows that the excluder device effectively reduces turtle captures and that a lower rate of shrimp loss can be achieved. The shrimp loss in the excluder device occurs only when the "trap" door is open and not continuously as with the barrier design. The excluder device does not restrict changes in trawl fishing configuration and allows flexibility in trawl rigging to optimize shrimp production. Further evaluation and modification of the door design may result in a minimum loss of shrimp production and an effective technique to reduce turtle mortality in shrimp trawls.

Data on the length of trawl tow and sea turtle mortality show that restricting the maximum length of time a trawl is towed can effectively reduce turtle mortality. Mortality of turtles was less than 2% in trawl tows of 60 minutes or less and greater than 20% for tows of 180 minutes or longer. Reducing towing time from 240 minutes to 120 minutes could reduce turtle mortality 53%. A maximum tow time of 90 minutes could result in an 83% reduction in turtle mortality. These figures are based on mortality rates where resuscitation techniques were employed on comatose turtles. For tow times less than 120 minutes more than 50% of comatose turtles were revived. The percentage of turtles which could be revived dropped dramatically for tow times greater than 150 minutes. Maximum reduction in turtle mortality can be achieved by reducing tow time and employing resuscitation techniques on comatose turtles.

The incidental capture, mortality and discarding of non-target species by fishing trawlers employing non-selective gear is becoming an increasingly apparent problem in the management and utilization of our fishery resources. There appears to be an increasing need for selective fishing gear. More research is required to develop fishing technology to efficiently harvest and utilize our fishery resources without catching and destroying other resources through the use of non-selective fishing gear.

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