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A STUDY OF VESSEL AND GEAR USAGE IN THE SHRIMP FISHERY OF THE SOUTHEASTERN UNITED STATES

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SUMMARY

As a portion of a program designed to study means of improving the efficiency of fishing gear and fishing practice in the shrimp fishery of the Southeastern States, operators of 58 highline shrimp vessels were interviewed concerning vessels, gear, and practices employed. Results were analyzed in an attempt to determine the extent of uniformity of gear design and usage, the existence of general trends within the fishery, and points of confused or questionable practice.

A diversity of types of gear, vessel-gear combinations, and fishing practices was uncovered. This diversity points to the pressing need for study leading to the development of standards by which the efficiency of fishing gear and methods can be evaluated. Such study has been started by the U. S. Bureau of Commercial Fisheries Gear Research Unit at Pascagoula, Miss.

INTRODUCTION

The U. S. Bureau of Commercial Fisheries has been engaged in a formalized program of exploratory fishing and gear research since 1948. One current phase of the gear-research work is the study and improvement of the methods and gear used in the shrimp fishery of the Southeastern States.

Fig. 1 - A typical double-rigged "Florida-type" shrimp trawler. At sea, the "outriggers" or port and starboard booms are lowered and one trawl is dragged from each.

This report provides a general evaluation of the present status of some of the fishing practices used by the industry. Primary objectives are to determine: (1) What uniformity of gear and methods is present; (2) what regional trends, if any, exist; and (3) what aspects of gear design and usage show the greatest need of improvement. Determination of these objectives is a necessary step in initiating the development of recommendations for standards for vessel equipment, fishing gear, and fishing practice; and is a means of uncovering areas of questionable or confused practice that can be analyzed in the underwater photographic studies of shrimp trawls currently being carried out by the Bureau.

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The basic data for the study were obtained through the Bureau's statistics personnel at ports, from North Carolina to the Texas-Mexico border, where the operators of 58 selected highline shrimp vessels were located. Information compiled therefrom is divided into the following main topics: (1) Type, size, and power of the vessels used; (2) size, design, and construction material of gear used; and (3) correlations existing between vessels and gear and among gear components. In addition, a discussion is included of the angle of trawl-door set and its influence.

THE VESSELS

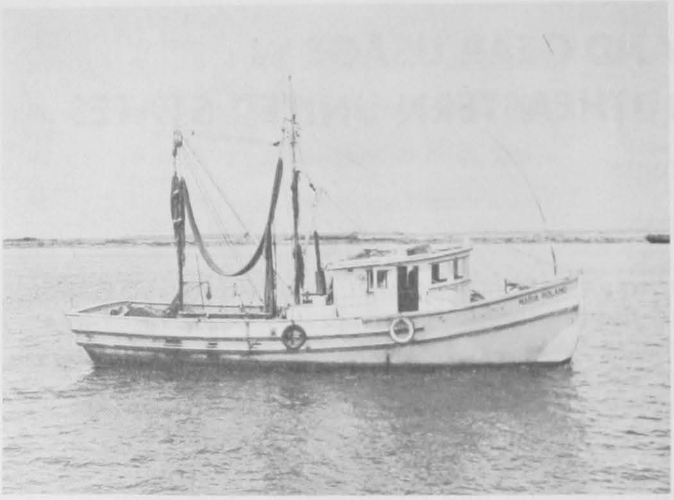

Fig. 2 - A typical single-rigged "Florida-type" shrimp trawler. The single net is dragged from the starboard boom. The smaller port boom or "outrigger" is used to drag a small trynet.

The vessels used in the shrimp fishery of the Gulf of Mexico and southeastern coast of the United States have been described previously (Knake, Murdock, and Cating, 1958; Sundstrom 1958; and USF&WS, 1959). Of the 58 highline vessels included in this study, 43 are double-rigged "Florida-type" trawlers (fig. 1), 12 are single-rigged "Florida-type" trawlers (fig. 2), and 3 are "Biloxi-type" trawlers (fig. 3). This numerical relationship is not intended to approximate the distribution of these types within the total fleet. The vessels were chosen, rather, on the basis of their records as highline units. Table 1 summarizes some of the more important attributes of the vessels studied.

Analysis of figures for individual vessels shows that the gross and net tonnages are related fairly closely to the lengths of the vessels. This relationship may be attributed to the uniform hull design of the "Florida-type" vessels. Horsepower, however, shows no such close relationship with length (fig. 4). The variation between horsepower and length is evident in all three vessel types and in vessels of all sizes, but is most pronounced in the 50- to 70-foot, 100- to 200-hp. class.

Table 1 - Summary of the Characteristics of the Vessels and Gear Used by 58 Highline Shrimp Fishermen

Characteristic and Unit	Range	Mode	Mean 1/
VESSELS:			
Length over-all, feet	38 - 82	54 - 67	60.0
Beam, feet	12 - 24	18	17.5
Gross tonnage, tons	9 - 103	38 - 48	50.5
Net tonnage, tons	5 - 62	27 - 30	30.0
Effective horsepower	80 - 585	165 - 170	184.0
NETS:			
Used by Double-Rigged Vessels:			
Corkline length, feet	30 - 62	40 - 50	46.5
Leadline length, feet	39 - 79	48 - 60	55.0
Leadline weight, pounds	0 - 70	10 - 25	22.0
Mesh size, cotton, inches	2 - 2 1/4	2 - 2 1/4	-
Mesh size, synthetic, inches	1 3/4 - 2 1/4	2	-
Used by Single-Rigged Vessels:			
Corkline, length, feet	40 - 99	40-60 & 83-99	71.0
Leadline, length, feet	50 - 110	70 - 93	79.0
Leadline, weight, pounds	10 - 100	30 - 50	46.0
Mesh size, cotton, inches	2 - 2 1/4	2 - 2 1/4	-
Mesh size, synthetic, inches	1 3/4 - 2 1/4	2	-
DOORS:			
Used by Double-Rigged Vessels:			
Height, feet	2.75 - 3.33	2.66 - 3.0	2.87
Length, feet	6 - 9	7	7.12
Area, feet square	17 - 30	18 - 21	20.60
Feet of net (corkline length squared) per sq. ft. of door	1.55 - 3.05	2.21 - 2.58	2.27
Used by Single-Rigged Vessels:			
Height, feet	2.16 - 3.66	3.33	2.97
Length, feet	5.5 - 11.0	8.0	7.82
Area, feet square	15 - 40	20 - 30	23.50
Feet of net (corkline length squared) per sq. ft. of door	1.77 - 4.75	2.36 - 3.54	3.02
FLOATS, number used	0 - 11	3	3.6

1/Figures in this column cannot be used to illustrate "typical examples owing to the small percentage of the sample lying within the mean.

Seven different makes of engines are represented in the vessels, but over 82 percent were supplied by two major manufacturers. Diesel power is used in 57 of the boats; gasoline power is used in only 1.

Fig. 3 - "Biloxi-type" shrimp trawlers. The single net is dragged astern from warps leading over blocks at the after corners of the house.

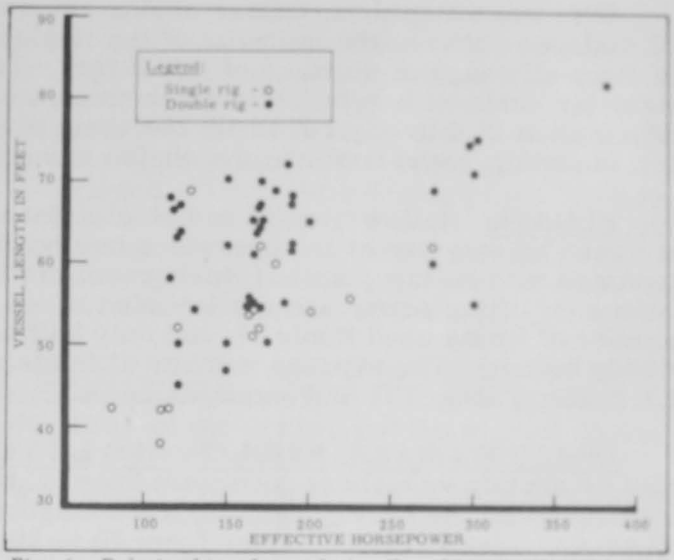

Fig. 4 - Relationship of vessel size (length) and main-engine horse-power. Lack of standardization is clearly indicated.

THE GEAR

Table 1 also summarizes the principal characteristics of the gear used by the vessel operators interviewed. This gear has been described by Bullis (1951) and, more briefly, by Knake, Murdock, and Cating (1958).

NET DIMENSIONS, DESIGNS, AND CONSTRUCTION MATERIALS: Results of the survey demonstrate that, whereas the nets used with single-rigged vessels fall into two distinct size groups, those used with double-rigged vessels are more evenly distributed about a single mode (table 1).

Nets of three designs--flat, balloon, and semiballoon--are used by the highliners. No distinct preference is found among the operators of single-rigged vessels as a group, but a definite preference for flat trawls is found among operators of double-rigged vessels (57 percent use flat trawls, 36 percent use balloon trawls, and 7 percent use semiballoon).

When the nets reported are divided into two groups, cotton and synthetic without regard to size or type, no distinct preference is discernible (table 2). Synthetic webbing, however, is used in the construction of all nets reported with a corkline length of 60 feet or over, with one exception, and randomly in nets of smaller size. The synthetic category includes four synthetic blends: nylon, nycot, marlon, and nylon-rayon combination.

Table 2 - Shrimp-Trawl Construction Materials

Trawl Type	Number of Trawls		
	Cotton	Synthetic	Total
Flat	20	16	36
Balloon	9	15	24
Semiballoon . . .	2	6	8
Total	31	37	68

LEADLINES AND TICKLER CHAINS: The leadlines or footropes used differ from one another principally in the amount of weight attached to them (table 1). In all cases, chain of varying length and generally of $\frac{1}{4}$-inch diameter, is used to hold the leadline near the bottom. The distance between the leadline and the bottom is adjusted further by the use of rollers 1/, by lengthening or shortening the chain loops on the leadline, or by a combination of the two. The survey average (mean, table 1) shows that approximately one-third more weight is used on the leadlines of nets dragged by single-rigged vessels. Individual variation, however, is extreme, and chain weight can vary considerably depending on bottom conditions and the choice of the individual captain.

1/Rollers used by shrimp fishermen are made in two ways: By drilling holes in hollow-plastic floats and attaching these to the footrope; or by constructing spindle-shaped rollers from thin wooden slats.

With two exceptions, tickler chains are used on all nets reported. The average horizontal distance between the midpoint of the tickler chain and the leadline is 2 feet 8 inches with an over-all range of distance of 1 to 6 feet. Tickler chains are constructed from $\frac{3}{16}$- to $\frac{7}{16}$-inch-diameter chain with $\frac{1}{4}$-inch-diameter chain most often reported. Of the 49 users providing information in this regard, 19 tie the chain directly to the doors and 30 to the wings of the net, including 7 who continue the chains along the lower legs.

FLOATS: Hollow-plastic and plastic-foam floats are used most commonly; cork floats are used by only two of the operators interviewed. Since plastic foam may inadvertently be confused with hollow plastic (which would instill considerable error in calculations), calculations on lifting power are not included here. Considerable variation exists, also, in the number of floats used (table 1), and only half as many are used, generally, on sandy as on muddy bottom. The average number of floats reported for the 3 types of nets is: Flat nets, 2.1; balloon nets, 4.1; and semiballoon, 6.1.

DRAGGING WARP, BRIDLES, AND LEG CABLES: The length of the dragging warp carried by shrimp vessels is governed, largely, by the depth of water in which those vessels trawl. Within the survey sample, warp lengths vary from 75 to 750 fathoms. Warp carried by single-rigged vessels varies from 75 to 200 fathoms with a mean of 133 fathoms per drum, and that carried aboard double-rigged vessels varies from 100 to 750 fathoms with a mean of 145 fathoms per drum. The wire used varies from $\frac{1}{4}$- to $\frac{5}{8}$-inch diameter, in multiples of $\frac{1}{16}$ inch.

Bridle lengths vary from 17 to 50 fathoms, but the great majority fall within 20 to 25 fathoms. In all cases where bridles longer than 25 fathoms are reported, the net used with those bridles is over 51 feet in corkline length. Bridles are not used with single rigs.

Leg (door-to-wing connections) lengths vary with the type of trawl (table 3) and also with the type of vessel. Single-rigged vessel operators use longer legs than double-rigged vessel operators, and the longest legs are used in conjunction with semiballoon trawls.

Table 3 - Leg (Door to Wing) Lengths Used by 58 Highline Operators 1/

Vessel Rig	Mean Length of Legs (feet)		
	Flat Trawls	Balloon Trawls	Semiballoon Trawls
Double . . .	5.50	5.50	7.50
Single . . .	7.75	8.75	11.50
Combined .	5.75	6.50	10.50

1/Rounded to nearest 3 inches.

TRAWL DOORS: In all cases, the trawl doors used were reported as flat, of wooden construction, and fitted with chain bridles shackled to rings for attachment of the bridles or dragging cables. Door dimensions are given in table 1. Although the doors used with single-rigged vessels are slightly shorter (on the average) than those used with double-rigged vessels, the average length-height ratio for all doors is 2.4:1.

CORRELATIONS BETWEEN VESSELS AND GEAR AND AMONG GEAR COMPONENTS

The foregoing discussion has served to indicate that there is a wide range of characteristics of both vessels and gear used by the operators included in the sample of 58 highliners. It can be assumed that a survey of a random sample of the whole fleet would show an even greater range. The task remains of determining whether or not patterns exist between vessel characteristics and the gear used, whether or not there are patterns existent among gear components, and whether or not differences in use exist which offset the wide range of characteristics.

HORSEPOWER AND NET SIZE: In this and the following sections, vessel horsepower, rather than vessel speed or vessel size, is used in determination of correlations, or lack of correlations, between vessels and gear because of the questionable reliability of estimated values for vessel speed and the lack of correlation between vessel size and power.

When net size is plotted against vessel horsepower, a vague correlation appears, suggesting a tendency for net size to be proportional to vessel horsepower in both single- and double-rigged categories. Examination of the actual net size-horsepower relationships, however, shows that none of those reported fall within the mean expected. Variation is more evident in single-rig combinations than in double-rig combinations, owing, no doubt to the larger range of values presented by the former group. Three single-rigged vessels, for example, are included in the survey with engines of the same horsepower. One of these drags a 60-foot net, one an 83-foot net, and one a 96-foot net. Extremes for the whole sample (double and single rigs) are represented by a single-rigged, 80-hp. vessel dragging a 72-foot net and a double-rigged 170-hp. vessel with two 62-foot nets. Despite the small sample, especially of single-rigged vessels, lack of conformity to any standard appears evident.

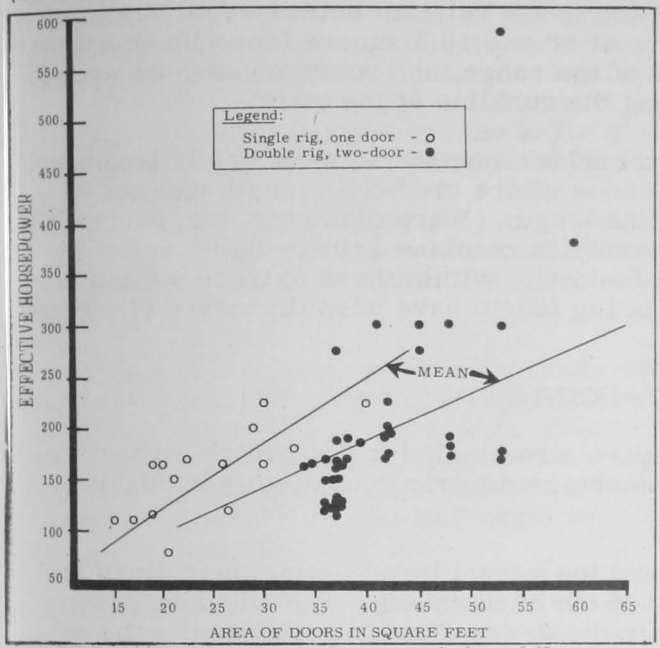

Fig. 5 - Relationship of vessel horsepower and size of doors. Despite a general tendency for door size to increase with horsepower, little standardization is evident.

HORSEPOWER AND DOOR SIZE: In determinations of possible correlation between horsepower of the vessel and the size of doors used (fig. 5), the area of one door is used for single-rigged vessels and the area of two doors is used for double-rigged vessels. A much closer relation is demonstrated between horsepower and the doors used with single-rigged vessels than between these factors with double-rigged vessels. In both cases, however, the deviation from the mean shows a variance sufficiently large that only the vague statement, that with increase in horsepower the size of the doors tends to increase, is permitted.

DOOR SIZE AND NET SIZE: When the size of the doors is plotted against the size of the net (fig. 6), a lack of conformity is evidenced that is even greater than is shown when horsepower is plotted against door size. For these determinations, the combined area of one door and the attached net was used for single-rigged vessels, and the combined area of two doors and the two attached nets was used for double-rigged vessels. Net area is calculated as the square of the length of the corkline. A decided random pattern results from plotting these areas. This may be explained by the tendency, normal among shrimp fishermen, to maintain a relatively constant wing height regardless of the size of the net. Since the doors are normally constructed so that they are a little more than twice as long as high, since the height of the wings is dependent on the height of the doors, and since the height of the net does not increase with the size (corkline length or area) of the net, it follows that door size should not be expected to vary proportionally with net size.

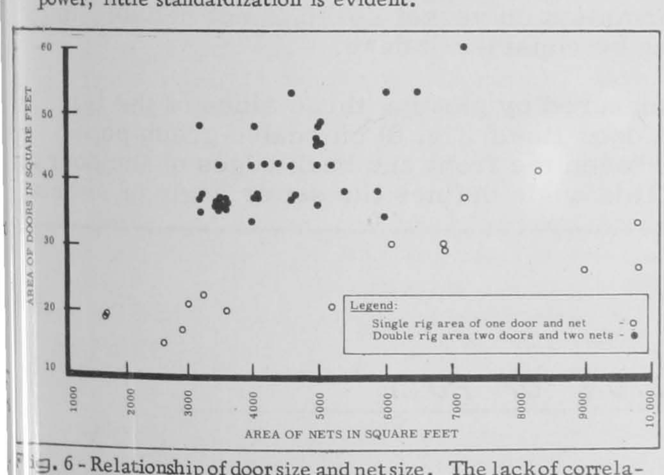

Fig. 6 - Relationship of door size and net size. The lack of correlation between these two factors is thought to be due, in part, to a tendency to retain a constant net height regardless of net size, and to the relatively constant 2.4:1 ratio of door length to door height. A tendency for the doors used by double-rigged vessels to be larger than those used with the same-sized nets by single-rigged vessels is shown.

Figure 6 shows, in a fairly well-defined manner, that double-rigged vessels use larger doors than single-rigged vessels for nets of equivalent size. Table 1 shows that there is a mean difference of three-quarters of a

Fig. 7 - Relationship of door size and corkline length of attached nets. A clearcut tendency for double-rigged vessels to use larger doors on nets of equivalent size is shown. Great variation in the two factors is evident.

foot (26 percent) in corkline length per square foot of door area between combinations used by double-rigged and single-rigged vessels. This relationship is shown more clearly in figure 7. Use of larger doors by operators of double-rigged vessels may relate to an attempt to compensate for the additional drag of pulling two nets and for the subsequent decrease in speed and spreading power.

Figure 7 also shows the great variation existing in the relation between door area and corkline length. Extreme examples combine doors of 18 and 18.5 square feet with nets measuring 30 and 62 feet along the corkline on one end of the range, and doors measuring from 17 to 26 feet in area with nets measuring 55 feet along the corkline at the other.

MISCELLANEOUS CORRELATIONS: Little correlation exists between bridle length and net size, except that, as stated previously, in all cases where the bridle length exceeds 25 fathoms, the attached net exceeds 51 feet in corkline length. Warp diameter, too, bears little relation to the size of the net, although extreme examples combine $\frac{1}{4}$-inch-diameter cable with a 40-foot net and $\frac{5}{8}$-inch-diameter cable with a 91-foot net. Within those extremes there is little uniformity or proportionality. Differences in leg length have been discussed elsewhere and are shown in figure 3.

ANGLE OF TRAWL-DOOR SET

Data received from the 58 vessel operators were also studied to determine whether or not there is a correlation between the high catches obtained fairly consistently by highline vessels and a standard angle of set.

The angle of trawl-door attack is preset aboard the vessel by adjusting the ratio of the length of the front chains of the door to the length of the back chains. The shearing power necessary to offset the drag of the trawl and create the desired wing spread is directly related to the area of the doors and the speed of the vessel. The ideal condition, in the door-net relationship, is to obtain the greatest possible spread of the wings without deforming the net opening or causing excessive drag. Because information on vessel speed is not reliable, only the area of the doors and the angle of door-set can be considered here.

The angles at which the doors are set was measured by plotting three sides of the triangle formed by the front and back chains and the door itself (fig. 8) on scaled graph paper. A line drawn from the centerline, or midpoint between the front and back edges of the door, through the apex of the chains forms angle "a." This angle defines the set or angle of attack

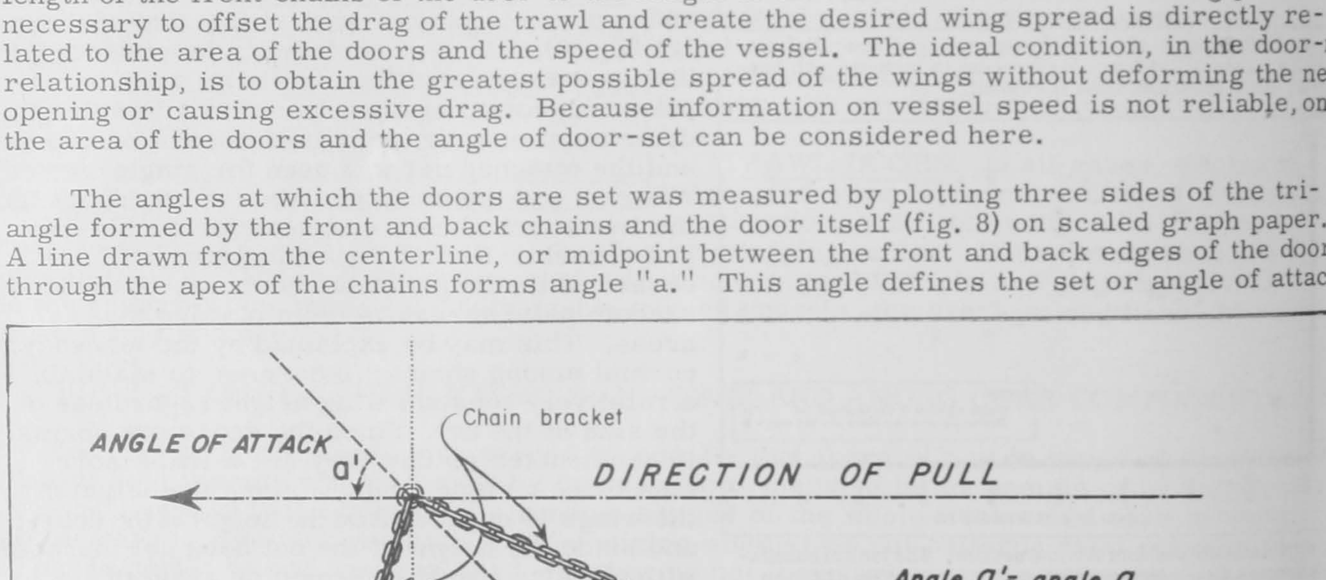

Fig. 8 - Trawl door showing the measurements used in determining the angle of attack.

that the door will assume when pulled through the water. The angles were read directly with a protractor. Where the front and back points of chain attachment were not placed at equal distances from the edges of the door, the centerline was shifted accordingly.

The angle values obtained are not representative of the true angles at which the doors would fish under actual operational conditions because they do not take into consideration the additional deflective force of the plowing effect exerted by the doors as they move over, and partially through, the bottom or the straightening effect exerted by the net on the doors. Nevertheless they are sufficiently accurate to provide concise information on the range of values and possible over- and under-optimum settings.

The values calculated for the angle of door set for all of the vessels in the sample range from 31 to 56 degrees (a variation of 25 degrees), with a modal interval of from 40 to 45 degrees, and a mean figure of 42.5 degrees. Omitting the extreme values on either end of the range as being particularly subject to error, still leaves a range of 35 to 52 degrees, which represents a variation in practice of 17 degrees for 52 vessels. The variation from the mean is uniformly scattered within the range with only a slightly greater grouping indicating the mode.

The angle of trawl door set not only varies to a greater degree among the double-rigged vessels than among the single-rigged vessels, but also tends to be less than the average angle in a great proportion of the cases. Since no correlation can be found between the size of the doors and the angle of set, this smaller angle cannot be ascribed directly to the use of larger doors. The possibility does exist, however, that the larger doors, used by the double-rigged vessels are set with a smaller angle to minimize the additional spreading effect of superfluous surface areas.

In all but one case, the reports showed that the upper front and back chains are set longer than the lower chains. The single exception reported no difference. Of the reports showing a difference, 31 percent showed one chain link more in the upper chains and 69 percent showed 2 chain links more. The shorter chain length on the lower chains tends to tilt the door outward. A compensating inward tilt is achieved by the counterweight of the chains and the bridles or cables. Presumably, when fishing in relatively shallow water, the outward inclination of the doors will be more pronounced than when fishing in deep water because the lighter weight of a decreased amount of warp has less effect on the doors.

CONCLUSIONS

Evaluation of the information extracted from survey data indicates the existence of general trends and similarities within the industry, but the consistent deviation from the mean in most of the categories does not allow extraction of conclusive statements concerning characteristics of "standard" vessels and gear. Moreover, the wide range of fishing practices and gear usage uncovered in this survey indicates an unsystematic method of combining closely interrelated features.

These deviations from a mean characteristic and the wide ranges in use and practice point to the need for a more thorough evaluation of existing fishery practices for the purpose of establishing effective standards for gear design and usage.

<u>GENERAL TRENDS</u>: (a) A tendency for a close correlation between vessel length and tonnage (uniform hull design), not accompanied by any tendency toward application of power.

(b) An almost exclusive use of Diesel engines for main-engine power and a preponderent use of engines manufactured by only 2 manufacturers.

(c) A tendency to favor flat trawls for use with double-rigged vessels, and a lack of any tendency toward choice of nets of one design for use with single-rigged vessels.

(d) A tendency for larger nets (60 feet and larger) to be constructed of synthetic twines.

(e) An almost universal use of tickler chains.

(f) Use of more floats on muddy than on sandy bottoms and progressively more floats on balloon than on semiballoon or flat trawls.

(g) Use by double-rig vessel operators of 20- to 25-fathom bridles on most nets regardless of net size.

(h) Use of longer legs (door-to-wing connections) in single-rig gear.

(i) Use of doors that invariably are constructed slightly more than twice as long as high.

(j) A tendency for net height to remain constant regardless of the size of the net.

(k) A lack of uniformity in angle of trawl-door set.

(l) A tendency for setting lower door chains from 1 to 2 links longer than the upper chains.

AREAS NEEDING IMPROVEMENT: The need for more study leading to greater standardization is evident. The following factors are among those that are currently unknown and that must be determined if choice and use of gear and vessels is to be put on a rational, scientific basis:

(a) Optimum horsepower requirement for specific hull designs.

(b) The relation existing between horsepower and net size so that the most efficient combination can be chosen.

(c) Exact and simple methods of measuring dragging speed and the most effective speed under varying conditions to assure optimum fishing power.

(d) The most effective door- and net-size combinations so that the optimum spread of the net can be achieved with a minimum door size, the least distortion of the net, and the least resistance.

(e) The best angle of attack of the doors under different fishing conditions, bottom type, and topography so that the greatest fishing power can be extracted from the gear.

The last two items (d and e) will be incorporated in the underwater studies of shrimp trawls which are to be carried out by the Bureau in the Gulf and South Atlantic Region in the near future.

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