SCOPE RATIO-DEPTH RELATIONSHIPS FOR BEAM TRAWL, SHRIMP TRAWL, AND OTTER TRAWL

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ABSTRACT

The scope ratio-depth relationships for three types of trawls used during demersal fish and shellfish resource surveys by Bureau of Commercial Fisheries vessels in the eastern North Pacific are summarized. The three types of trawls used were a 20-foot beam trawl, 43-foot Gulf of Mexico shrimp trawl and a 400-mesh fish trawl.

Force factors that influence the choice of optimum scope ratios include towing speed, tension (drag) at the end of the towing cable, sea condition, weight of the gear, and weight of the cable. An increase in magnitude of speed, tension, or sea conditions make necessary a larger scope ratio, whereas an increase in the weight of gear or cable tends to allow a reduction in the ratio.

The scope ratio-depth relationships are different for each of the three types of gear studied. At depths of less than 150 fathoms the shrimp trawl required the highest ratio and the fish trawl the lowest.

INTRODUCTION

Despite the vast amount of trawling that is done around the world, published information on scope ratios[1] employed is scanty. The most detailed account to date is given by Kullenberg (1951), who discusses the computations used to describe the shape relationships of the trawling cable used aboard the Swedish deep-sea research vessel, Albatross. This paper is very theoretical and, thus, would be of limited practical value. Gourock's (1961) practical book on deep-sea trawling recommends warp in the amount of three times the depth of water, plus one extra length[2] for luck. Thus, if fishing at a depth of 50 fathoms, 175 fathoms of warp would be used. Based on actual measurements in 9.3 fathoms of water, de Boer (1957) recommends a scope ratio of about 5.5:1.

Other accounts given by Bullis (1951), Miyamoto (1957), Saito (1957), and Wathne (1959) point out the need for greater scope ratios in shallow water, and Miyamoto (1957) gives the equation $F = \left(3 + \frac{25}{D}\right) D$ for determining the length of warp (F) needed at any depth (D).

Since 1949, the Seattle Exploratory Fishing and Gear Research Base of the U. S. Bureau of Commercial Fisheries has conducted more than 60 cruises along the Pacific coast from northern Mexico to the Arctic Circle. Of these cruises, 28 have been demersal fish and shellfish trawl surveys. Survey results have been published in various journals to provide fishermen with data on the distribution and relative abundance of latent marine resources in this region, but the range of scope ratios used by depth has not been reported. Therefore, this paper is presented to provide a summary of the successful scope ratio[3] used during demersal fish and shellfish surveys conducted from the Seattle Base. This information should be of particular value as vessels are equipped with greater lengths of cable, thereby permitting fishing activities at depths greater than those now being exploited.

VESSELS AND GEAR

VESSELS: Vessels used to conduct the surveys and collect the data for this report were: the M/V John N. Cobb, the Bureau's 93-foot exploratory fishing vessel (Ellson, 1950); the M/V Commando, a 65-foot purse seine-type research vessel chartered by the Bureau from the College of Fisheries, University of Washington; and the chartered 75-foot schooner-type

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1/Scope ratio is the ratio of trawling cable out to water depth.
2/In this situation a length is equal to 25 fathoms.
3/A successful scope ratio pertains to the ratio used for a drag that was considered to have fished properly (i. e. the gear was on bottom and performed in a normal manner).

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vessel, Tordenskjold (Greenwood, 1958). All of these vessels employed $\frac{1}{2}$-inch diameter towing cable.

GEAR: Whereas various types of gear have been used throughout the years in carrying out exploratory operations, scope ratio data pertaining to only three (20-foot beam trawl, 43-foot Gulf of Mexico shrimp trawl, and 400-mesh otter trawl) were summarized for this report.

The 20-foot beam trawl was used in connection with the original shellfish explorations in southeastern Alaskan waters. It is described in detail by Ellson and Livingstone (1952). A single towing cable was used to fish this gear.

The shrimp trawl data were taken from drags made with a 43-foot Gulf of Mexico-type flat shrimp trawl (Schaefers and Johnson, 1957). The doors used with this trawl measured $2\frac{1}{2}$ by 5 feet and weighed approximately 160 pounds each. For drags deeper than 500 fathoms approximately 150 pounds of steel plate was added to the bottom of the doors. Like the beam trawl, the shrimp trawl was towed with a single cable. Doubling the available length of fishable cable by connecting the towing cables end to end permitted operation of the trawl at depths greater than 500 fathoms.

The otter trawl has been used primarily in bottom fish surveys along the Pacific coast. Both the 400-mesh Western-type (Alverson, 1951) and the 400-mesh Eastern-type (Greenwood, 1958) have been used. The doors used with these trawls were larger and heavier than the shrimp trawl doors, measuring 4 by 8 feet and weighing approximately 850 pounds each. The 400-mesh otter trawl was towed with two cables, one to each door, instead of a single cable as with the shrimp and beam trawls.

DATA

Only data for successful drags are included in this report. These data were taken from John N. Cobb cruises 9, 13, 15, 18, 24-26, 29, 37-40, 44, 48, 50, and 52-54; Commando cruises 1-5; and Tordenskjold cruise 32. Scope ratios were calculated from the amount of cable out and the water depth at the time of setting.

Inspection of the data revealed that the scope ratios did not differ greatly among the vessels when similar gear and depth were fished. Therefore, the data from the three vessels were combined. Since the manner of fishing the 400-mesh Eastern and Western-type trawls was similar, the data for these gear were combined.

RESULTS

A summarization of scope ratio data for 133 beam trawl drags, 288 shrimp trawl drags and 429 otter trawl drags is presented in table. Graphical representations of the scope ratio-depth relationships of these data are shown in figure 1.

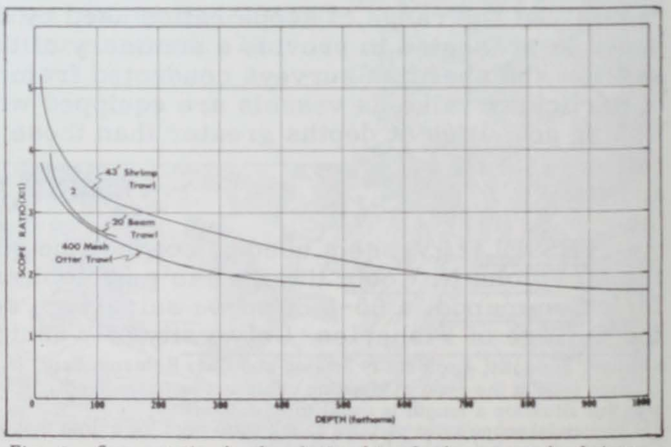

Fig. 1 - Scope ratio-depth relationships for beam trawl, shrimp trawl, and otter trawl. Data used to plot thse curves were taken from the table.

The shrimp trawl was used over the greatest range of depth, 15 to 1,000 fathoms. No drags were made at depths between 275 and 599 fathoms. Average scope ratios ranged from 5.3:1 to 1.7:1. The beam trawl was fished at depths from 21 to 151 fathoms with scope ratios ranging from 5.0:1 to 2.2:1.[4] Depths fished with the otter trawl ranged between 10 and 550 fathoms with scope ratios ranging between 4.7:1 and 1.5:1. Since no accurate measurements were made of towing speeds, it has been assumed that they were generally equivalent.

4/The restriction of this gear to inshore shrimp explorations accounts for the lack of drags at depths greater than 151 fathoms.

Summary of Successful Scope Ratio Observations for 133 Beam Trawl, 288 Shrimp Trawl, and 429 Otter Trawl Drags

	Beam Trawl			Shrimp Trawl			Otter Trawl			
Depth Interval (Fathoms)	No. Drags	Range of Scope Ratios	Average Scope Ratio	No. Drags	Range of Scope Ratios	Average Scope Ratio	Depth Interval (Fathoms)	No. Drags	Range of Scope Ratios	Average Scope Ratio
0 - 19	-	-	-	2	5.0 - 5.3	5.2	0 - 19	11	2.9 - 4.7	3.8
20 - 29	3	3.6 - 4.6	4.1	6	2.9 - 5.0	3.8	20 - 29	16	2.9 - 3.8	3.3
30 - 39	17	2.6 - 4.0	3.1	8	3.0 - 5.4	4.2	30 - 39	13	2.8 - 4.3	3.2
40 - 49	23	2.6 - 5.0	3.4	5	3.4 - 5.7	4.3	40 - 49	12	2.8 - 3.7	3.2
50 - 59	25	2.4 - 3.7	3.0	14	3.1 - 4.3	3.8	50 - 59	19	2.5 - 3.5	3.0
60 - 69	17	2.5 - 3.7	3.1	27	3.0 - 4.0	3.5	60 - 69	15	2.5 - 3.4	3.0
70 - 79	19	2.3 - 3.3	2.8	29	3.1 - 4.3	3.4	70 - 79	11	2.5 - 3.0	2.8
80 - 89	13	2.5 - 3.4	2.8	20	2.9 - 3.8	3.3	80 - 89	16	2.3 - 3.0	2.7
90 - 99	8	2.5 - 3.3	2.7	26	2.6 - 4.0	3.3	90 - 99	12	2.3 - 3.2	2.7
100 - 109	4	2.4 - 3.0	2.6	33	3.0 - 4.1	3.3	100 - 109	46	2.1 - 3.8	2.7
110 - 119				27	2.8 - 3.8	3.2	110 - 119	21	1.9 - 3.0	2.4
120 - 129				12	2.8 - 3.5	3.1	120 - 129	34	2.1 - 3.4	2.7
130 - 139	4	2.2 - 2.7	2.6	10	2.9 - 3.5	3.1	130 - 139	17	2.1 - 3.0	2.7
140 - 149				8	2.9 - 3.8	3.2	140 - 149	12	2.2 - 2.8	2.5
150 - 169				16	2.6 - 3.4	3.0	150 - 169	22	2.0 - 3.0	2.6
170 - 189				4	2.8 - 3.2	3.1	170 - 189	15	1.9 - 2.9	2.4
190 - 219				13	2.9 - 3.2	3.0	190 - 209	25	2.0 - 3.0	2.3
220 - 249				7	2.2 - 3.1	2.8	210 - 229	19	2.0 - 2.7	2.2
250 - 274				1	-	2.8	230 - 249	13	1.9 - 2.5	2.2
275 - 599				-	-	-	250 - 289	22	1.9 - 2.6	2.3
600 - 699				2	2.0	2.0	290 - 329	22	1.8 - 2.5	2.2
700 - 799				1	-	1.9	330 - 369	8	1.9 - 2.3	2.0
800 - 899				3	1.8 - 2.1	1.9	370 - 409	16	1.5 - 2.3	2.0
900 - 999				3	1.8 - 1.9	1.8	410 - 449	3	1.6 - 1.9	1.8
1000				1	-	1.7	450 - 489	6	1.9 - 2.0	2.0
							490 - 529	-	-	-
							530 - 569	3	1.5 - 1.9	1.7

DISCUSSION

FACTORS AFFECTING SCOPE RATIOS: Consideration of the force factors affecting the choice of a scope ratio is important in understanding the observed relationships. Factors that influence this choice include towing speed, tension (drag) at the end of the towing cable, sea conditions, weight of the gear, and weight of the cable. Consideration of several of these factors is given by Pode (1950 and 1951). An increase in magnitude of speed, tension, or sea condition makes necessary a larger scope ratio, whereas an increase in the weight of gear or cable tends to allow a reduction. It is the resultant of all the above forces that determines the optimum scope ratio required.

RELATIONSHIPS: As can be seen in figure 1, the scope ratio-depth relationships for the three types of gear differ. At depths where all three gear have been fished (shallower than 150 fathoms), the shrimp trawl required the highest ratios and the otter trawl the lowest. The low terminal tension of the shrimp trawl (as compared to the tension of the otter trawl) indicated that a lower scope ratio could be used successfully; however, higher ratios were needed to keep the gear on bottom due to the light weight of doors and single warp towing.

The otter trawl, with heavier doors and double warp towing, required a smaller scope ratio to fish successfully, even though the terminal tension was greatest for this gear. The added weight of cable (double cable towing) and the heavier doors more than compensated for the greater terminal tension and allowed smaller scope ratios than were needed with the single cable shrimp and beam trawl operations.

The beam trawl, towed with one cable, had the least terminal tension. Therefore, it did not require scope ratios as high as the shrimp trawl.

As the depth of water increased, the scope ratio needed to keep the gear on bottom decreased (figure 1). This decrease was due primarily to the added weight of cable used in deeper water. Also, the high ratio, used in shallow water to compensate for the action of the swell and to keep the doors adequately spread (Wathne, 1959), was not needed in deeper water.

Since the deep-water scope ratios used for the gear discussed in this report were less than 3:1, the equation of Miyamoto (1957) gives scope ratios which are probably in excess of the optimum needed in deeper water.

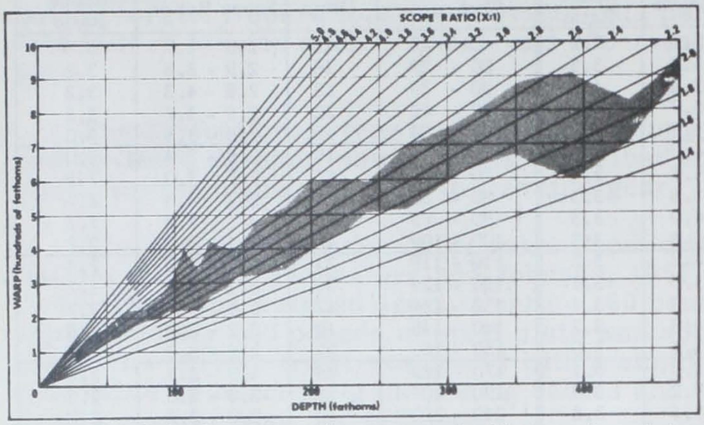

Fig. 2 - Graph for determining the amount of cable (scope) needed at any depth to get a desired scope ratio. Shaded portion indicates the range which has proved successful for the 400-mesh otter trawl during exploratory surveys.

As water currents and sea conditions warranted, ratios were altered from the average. For instance, when dragging against or across strong currents or when sea conditions were "lumpy" on the shallower grounds, high ratios were used.

When towing in deeper water with more cable out, the total drag was greater. Therefore, the engine r.p.m.'s were increased to maintain optimum fishing speed.

A quick means of determining the amount of cable needed to get a desired scope ratio is graphically presented in figure 2. By knowing the scope ratio which is desired at a particular depth, one simply follows this ratio line to determine the amount of cable needed at a particular depth in order to get the desired ratio.

It should be noted that the scope ratio data presented are empirical and that no calculations were used to determine optimum values. Therefore, they do not necessarily represent the maximum or minimum which could be used successfully.

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