NOAA Technical Memorandum NMFS

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RESULTS OF THE CHARTERED CRUISE OF THE M/V MARIA C. J. SEPTEMBER 17 TO NOVEMBER 22, 1979

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CO-SPONSORED BY THE NATIONAL MARINE FISHERIES SERVICE
AND THE PORPOISE RESCUE FOUNDATION

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U.S. DEPARTMENT OF COMMERCE
National Oceanic Atmospheric Administration
National Marine Fisheries Service

NOAA Technical Memorandum NMFS

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NASO Contract 79-ABC-00233

NMFS Cruise 565

National Marine Fisheries Service

Southwest Fisheries Center

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U.S. DEPARTMENT OF COMMERCE

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INTRODUCTION

The M/V Maria C. J. was chartered by the National Marine Fisheries Service to conduct fishing gear dynamics research aimed at reducing incidental mortality rates of porpoise during commercial purse seining for yellowfin tuna. The vessel is 68 m in overall length with a beam of 11.9 m and a draft of 5.5 m, and is equipped with all standard equipment necessary to purse seine tuna in association with porpoise. The net is 14 standard strips of 108 mm mesh deep, 1316 m in length and incorporates a double depth safety panel and super apron of 31.8 mm mesh in the backdown area. For the period of this charter, Joe Brenha was the vessel Master and Joe Jorge was the Fishing Captain.

The charter was conducted in two segments, a local segment in the coastal waters off San Diego, California, and an eastern tropical Pacific Ocean (ETP) segment off Mexico and Central America. The local segment of this charter covered the period from September 17, 1979 to October 1, 1979. The ETP segment of this charter commenced on October 8, 1979 and was completed in San Diego on November 22, 1979.

OBJECTIVES

The purpose of this charter was to establish and verify measurement techniques leading to quantification of various aspects of purse seine behavior which may be relevant to incidental porpoise mortality. The specific objectives were:

A. Repeat and verify a method presently in use to measure net surface area and establish the relationship between net depth in strips and surface area encompassed over time.

B. Make as many simultaneous measurements of backdown speed and channel depth as possible to verify and/or modify a mathematical simulation of the backdown process.

C. To measure the mid-net zipper line ridge and eliminate it without loss of the zipper function.

D. To perform repeated backdowns with the third bow bunch pulled to the starboard bow in order to assess the likelyhood of decreasing the probability of net collapse in late backdown.

E. To measure strains and tensions at points of interaction between the vessel and its net as input to the simulation model of the purse seining process.

F. To mark the net and dive during backdowns to observe the location on the net of lines of force and their movement as backdown progresses.

G. During the ETP segment of the charter the technician aboard was instructed to measure pursing speeds for input into the simulation model of the purse seining process.

RESULTS

During the local segment of this charter cruise 13 net sets were made during which combinations of the above listed objectives were pursued. Table 1 displays the chronology of events and the distribution of studies by set. No porpoise or tuna were captured during the local segment of this charter, all sets were water hauls by design. Eight NMFS scientists and one Porpoise Rescue Foundation representative participated in the cruise and enabled a number of experiments to be carried on simultaneously, particularly during backdown. The first day of the charter was used to make a set to establish correct net tie-down points for backdown through alignment of the super apron. This set was also used as a shakedown for all the other experimental procedures (flowmeters, photographic methods, dynamometer set-up, diving coordination, etc.). The second day was spent at dockside measuring and placing markers on the rings, across the net and along the corkline. Also, the third bow bunchline was modified to permit its lengthening and shortening to accomodate consecutive backdowns in single sets with the third bow bunch in different locations. Beginning on the third day (September 19, 1979) at least one set was made each day except Sundays and Saturday the 29th. By the afternoon of October 1, the local segment of this charter was completed.

SCUBA diving teams entered the water either inside or outside of the net for backdown in sets 2-13. Divers placed BKG's, checked for the zipper line ridge, and observed the development of the backdown channel from several vantage points. All dives were carried out in accordance with diving procedures outlined in the Cruise Announcement. No accidents or mishaps of any kind occurred during diving activities.

A. NET SURFACE AREA MEASUREMENT

The area of the water surface encompassed by the net was estimated for sets 3 through 13 at the time of encirclement, at approximately one-half pursed and at rings up (Table 2). Seven large numbered floats were attached at regular intervals along the corkline so that at selected times in the set, distances and angles to each balloon could be estimated (Figure 1). Distances were estimated using a prismatic range finder while angles were measured with a polaris relative to the longitudinal axis of the vessel.

For each set, at each time period (encircled, 1/2 pursed, and rings up), a series of triangles may be constructed which approximate the surface area within the corkline perimeter. The areas of the triangles are then calculated using the formula $A = 1/2[d_1 \cdot d_2 \cdot \sin \Theta]$, where A = area of triangle, Θ = the angle between the adjacent balloons in degrees and d_1 and d_2 are the distances to the adjacent balloons in meters. The areas of the triangles are then summed to approximate the net enclosed area. For the net of the M/V *Maria C. J.* which was measured on day 2 to be 1316 m (720 fathoms) long and 14 standard mesh strips deep, the average area at encirclement was 89,497 m^2, at approximately 1/2 pursed, 51,175 m^2, and at rings up 17,429 m^2 which was 19% of the initially encircled area.

Due to a delay in the delivery of four newly purchased bathykymographs (BKG) no depth/time records were made during the charter except below the apex of the backdown channel. The two BKG's available had a maximum depth range of 50 m and could not be used to record depth/time traces below about the seventh strip of webbing. The results of the BKG traces are reported in section B below. This lack of BKG's prevented a complete duplication of the depth/area measurements used in previous cruises so that net volume was not approximated. Neither surface area nor volume parameters were measured during the ETP segment of the charter.

B. BACKDOWN SPEED AND CHANNEL DEPTH MEASUREMENTS

Average vessel speed during backdown was measured in at least one backdown for each of the 13 sets made in local waters (Table 3). Average net speed at the channel apex during backdown was measured in 12 of the 13 sets and found to be 38% (0.43 m/s; SD = 0.07) of the average vessel speed (1.13 m/s; SD = 0.24). When the channel apex speed is adjusted for hysteresis while the net is being stretched out (i.e., the vessel is moving but the channel apex is not) it rises to only 55% (0.62 m/s; SD = 0.07) of the measured average vessel speed. Vessel speed was measured from the bow during 30 porpoise sets in the ETP and averaged 1.06 m/s (SD = 0.24).

The method for measuring average speed during backdown in local waters involved the synchronized submersion of calibrated flowmeters. A technician in a raft at the backdown apex and another at the bow of the vessel recorded start and end counts on the flowmeters, elapsed time in seconds and lag time for the flowmeter to begin turning at the apex station. Backdowns were ended and flowmeters recovered simultaneously by signaling with the ship's horn. This method yields only the total distance traveled by the flowmeter and the elapsed time, which when divided yields the average speed of backdown. This method provides no information on the speed of the net or vessel as backdown progresses or as power (shaft RPM) is increased or decreased. The shaft RPM of the vessel during backdown was not controlled during the first 6 net sets to allow divers to compare net shape and dynamics under pseudo-normal conditions and to establish background data on net drag at various positions on the chain (Section E, below). The shaft RPM was controlled in three seperate backdowns executed in Set 7 for the specific purpose of obtaining data on the relationship of RPM, vessel speed, net speed and net floor rise rates, and tensions on specific rings on the ring stripper. These results are shown in Table 3 and Figures 2 and 3. Shaft RPM was controlled and recorded in sets 9-13 during backdown but were not held constant in order to facilitate other experiments. The speeds recorded in set 7 are the only ones which can be related to net floor rise rates as estimated from bathykymograph traces (Figure 2).

During set 3 divers placed 0-50 m range bathykymographs at the bottoms of the third and sixth net strip (not counting the super apron) directly down the meshes from the apex of the backdown channel and placed permanent marks at each place to enable shipboard attachment in subsequent sets. The BKG traces were plotted and the change in depth during backdown and the elapsed time were interpolated to yield the average rise rate in m/min of the corresponding area of net floor (Table 3). For all local segment measurements the net floor directly below the backdown apex 3 strips down rose from an average depth of 16.45 m to 5.00 m in an average of 11.09 min yielding an average rise rate of 1.03 m/min. The same averages for 6 strips down were 20.63 m to 4.68 m in 10.54 min for an average rise rate of 1.51 m/min.

These measurements were repeated on five sets during the ETP segment. On the fishing grounds, the third strip under the apex rose from an average maximum depth of 25.20 m to an average minimum of 4.00 m at an average rate of 2.41 m/min. The sixth strip averages show the channel floor rising from 32.70 m to 3,70 m at a rate of 2.74 m/min. The third and sixth strip rising rates show 134% and 81% increases, respectively, on the ETP segment. During the sets involved (3, 5, 6, 7, 8, 9, 10, and 11), an average of 10.6 tons of tuna were landed and 341 porpoise were encircled. Shaft RPM was not recorded during the ETP segment.

C. MID-NET ZIPPER LINE OBSERVATION

NMFS divers have observed that the mid-net zipper line in several nets causes a 4 to 10 meter high ridge across the floor of the net when the rings are up. This ridge stands high in the net and reaches well into the zone occupied by captured porpoise. The ridge persists until it is rolled onboard and may or may not be the cause of some heretofore unobserved pre-backdown mortality. Observations by SCUBA divers during the local segment of this charter indicated that the purse seine of M/V Maria C. J. is completely free of a "zipper-line ridge." That, in fact, none of the components of the zipper-line system caused distortion in the floor or walls of the pursed seine.

During an examination of the zipper-line installation, on day two at dockside, the following points were noted:

1. Strips of 108 mm (4 1/4 inch) mesh of number 42 nylon twine were separated at mid-net by a ten mesh wide 127 mm (5 inch) stretched mesh selvage, of number 120 nylon twine.
2. The heavier webbing was laced mesh-for-mesh with the adjacent 108 mm (4 1/4 inch) strips.
3. Three-inch diameter steel rings were spaced 18-20 meshes apart along the selvage and each lashed to a single knot. There were 70 rings in all, with 19 mm braided nylon rope threaded through each from corkline to leadline.

D. BACKDOWN CHANNEL WIDENING EXPERIMENT

In an attempt to create a wider backdown channel with improved width-holding characteristics, backdowns were conducted with the third bunchline pulled around the starboard bow. The third bunch itself was pulled up tight against the bow. Backdowns with this configuration were made on sets four, five, and six. Serial photographs were made of this modified backdown channel throughout the backdowns for comparison with normal backdowns. In addition, observations were made from the deck, and during one set, divers observed the bow side of the channel from outside of the net.

The photographs of the backdown channel during backdown were taken at 60 second intervals from the crow's nest. The procedure used was to set the net, pull the bunches and haul in the net to the normal backdown configuration, then backdown. After this first backdown was completed the third bunchline was shortened and brought around the starboard bow, the bunch was next pulled so that the bunched corks were held tightly against the prow at the water line. With these modifications complete and sufficient time elapsed for webbing to re-sink (as verified from BKG traces) the second backdown was conducted.

To analyze the backdown photographs, each frame was projected onto a sheet of paper and the outline of the corkline traced onto the paper. Buoys attached to the corkline at each end of the apron and each end of the apron extension piece were also traced onto the paper (Figure 4). The distance across the backdown channel was measured from the slide projections on three lines. Designated as "A", is the straight line distance between buoys marking the bow and stern ends of the super apron. "B" is the straight line distance between the two points on the bow and stern of the super apron that are one-half the corkline distance between the apron ends and the apron extension piece ends. "C" is the distance on the line between the buoys marking the bow and stern ends of the super apron extension piece (Figure 5). Analysis of these data indicate that pulling the third bunchline from the starboard bow does create a wider backdown channel throughout backdown. However, this configuration caused a greater area of webbing to lie perpendicular to the relative water flow allowing the channel to shallow up more rapidly, and create large canopies of webbing on the bow side of the channel. For these reasons the concept was not pursued further.

E. BACKDOWN NET TENSION MEASUREMENTS

During backdown dynamometers were used to measure the tension on specific rings, on the stern corkline, and on the third bow bunchline. Dynamometers were attached with skackles and slings to selected ring bridles in order to measure tension directly. The stern corkline was attached to a dynamometer at the tie-down point to measure corkline tension, and a similar arrangement was employed to measure the strain on the third bow bunchline during backdown. The tension data from sets 3-6 and sets 8-13 are averaged and presented with ranges in Figure 6. These data indicate that the majority of the backdown pulling force is exerted on the corkline and through bridles directly down the meshes from the super apron apex.

Since uncontrolled backdowns were noted to require approximately 100 RPM, RPM's of 75, 100, and 125 were selected for strain measurements for three backdowns during set 7. As expected, the tensions increased with increasing RPM (Figure 3).

On the fishing grounds, the tension on the stern corkline at the tie-down point was measured during backdown in six sets (19, 20, 41, 45, 53, and 56). In these sets, an average of 600 porpoise were encircled and 9.67 tons of tuna landed. Again, as with the backdown channel floor rising rates, there is disparity between the two sets of data. The average stern corkline tension during backdown for the local segment was 3237 lbs, while in the ETP segment the tensions averaged 4190 lbs., a 29% increase.

F. UNDERWATER BACKDOWN CHANNEL OBSERVATIONS

During the second day of the local segment, a day at the dock, the net was marked with colored polypropylene line. A white marker from the corkline at the super apron apex was laced in the webbing going straight down the meshes (knots) to the leadline. Two yellow lines began at the corkline nine meters to either side of the super apron apex and were laced into the bars running sternward to the leadline. A fourth line, white, began at the corkline at the stern tie-down point and was laced in straight down the meshes to the leadline (Figure 1). These markers were used by divers throughout the backdown maneuvers as reference points from which relative net configuration could be deduced.

During sets 2-13, divers observed the location and orientation of these lines. The two parallel lines running down the bars and the line running down the meshes from the apex were repeatedly observed to come to lie in close parallel proximity of each other during backdown. These three lines and the webbing between them would become wrapped up in a long cylinder of webbing. This sausage-like roll of mesh extended from the vessel to the last one-quarter of the backdown channel length and was 30-60 cm in diameter. Most of the webbing under the stern side corkline during backdown was involved in this "sausage."

Divers observed that the "sausage" of webbing probably plays an important roll in the development of the inward billowing of webbing on stern side of the backdown channel, commonly termed stern sway. As this "sausage" rises during backdown its contact with the stern wall of the backdown channel appears to limit the amount of webbing involved in stern sway. During backdown in set 13, divers placed colored surveyor's flagging on the outermost layer of webbing on the stern edge of the "sausage." When the net was rolled aboard, and hanging from the power block, the flagging was observed to form a straight line very nearly parallel to the stern-going bar markers.

Diver observations were used to construct Figure 7 which is a cross section of the backdown channel looking towards the apex and illustrates the development of stern sway as viewed from underwater about half way down the channel. Figure 8, also from diver observation, shows the location and magnitude of webbing area involved in different parts of the backdown channel.

G. PURSING RATE MEASUREMENTS

To provide input for a simulation model of the purse seining process the speed at which the purse cable was retrieved was measured on an opportunistic basis. The pursing speeds of the bow and stern portions of the purse cable were considered separately, and measured periodically during the pursing operation (Table 4). A stopwatch was used to time a mark on the cable traveling the known distance from the purse block to the cable guide on the winch. The instantaneous speeds for all ten sets were fixed relative to the time pursed, i.e., time pursed equals zero, and grouped into four minute intervals. All speeds falling within the same interval were averaged and plotted in Figure 9. Figure 9 illustrates that as pursing nears completion, pursing speed is reduced. This is probably due to increased load on the pursing winch. Variations in pursing speed can be attributed to the conditions of the set, and the winch operator. The objective here was to measure the magnitude of pursing speed and its change during the operation.

DISCUSSION AND CONCLUSIONS

The ultimate goal of this charter was to discover methods of investigation that would lead to gear and techniques to reduce incidental porpoise mortality in purse seining. The results presented here, when considered in that context, have varying impacts upon future research. For example, the problem of the mid-net zipper line ridge has been considered and a means to alleviate the problem can now be reported to vessel operators, thus potentially reducing porpoise mortality. In the long range, the data gathered on pursing rates, backdown speed and net surface area will be used to verify and set standards for both scale model and computer simulations of numerous net designs. Development of these models as tools for gear research will greatly enhance the range of feasible investigations. The development of adequate field methods for pursuing potentially important lines of investigation was of primary concern during this charter.

The surface area measurement methods were developed and used for a previously completed experiment. The results reported above are comparable with calculations made for a 1116 meter by 14 strip net using the same methods (Cabrillo II - NMFS Cruise No. 552), and verify the methods and calculations used to approximate surface area.

The average areas for the 14 strip nets of the M/V Maria C. J. and the M/V Cabrillo were (1) at encirclement; 89,497 m^2 and 80,494 m^2, (2) at approximately half pursed; 51,175 m^2 and 45,396 m^2 and (3) at rings up; 17,429 m^2 and 19,541 m^2, respectively. These measurements are consistent in that the Maria C. J.'s net had a slightly greater surface area at encirclement at half pursed because it was longer and a smaller surface area at rings up because bow bunches were pulled. In the Cabrillo experiment no bow bunches were pulled at rings up, thus allowing for more corkline in the net perimeter. All these averages are within two standard deviations of one another. This method will be used as a standard to assess area effects of future experimental net modifications.

There is concern as to whether experimental results from net sets conducted locally, without fish or porpoise (i.e., local water hauls) are comparable with similar experimental results from sets made on the fishing grounds. Backdown channel floor rise during this experiment for example, shows increased rates in sets in the ETP when compared with sets conducted locally. Similarly, higher values were recorded on the fishing grounds for the tension on the stern corkline during backdown. This could be due to the presence of fish and porpoise, or to a more deliberate execution of the backdown maneuver in the real situation. In either case, the differences recorded do not invalidate experiments conducted in the waters off San Diego since they are consistent with expected increased strain on the net due to concentration of the weight of tuna and porpoise against the backdown apex.

Some of the work presented here was a first time effort and analysis of the data indicates a need for more accurate and continuous measurements. Measurements of vessel and net speed proved feasible enough in the field, but yielded only an average speed for an entire backdown that includes some error due to wind causing the flowmeter propeller to revolve during deployment and retrieval. While the effort yielded satisfactory data on vessel and net speed, the primary value was in identifying the need for refining procedures and equipment for more accurately repeating these measurements in the future. The method for recording the rise rate of the backdown channel floor was straightforward, i.e., by BKG's. However, the relationship between channel floor rise and backdown speed or distance traveled is not clear from these data. It is interesting to note that in Set 7 in local waters when shaft RPM during backdown was held constant at three different RPM levels, there appears to be a constant relationship between average vessel speed and backdown channel floor rise rates. Division of the rise rate in m/sec by the average vessel speed in m/sec yields the following dimensionless results which indicate a possible constant relationship:

75 RPM:	0.02065
100 RPM:	0.02076
125 RPM:	0.02020

If verifiable, this relationship may be a function of individual nets that can be used in future experiments as one measure of the effect of net modifications on backdown performance. The evaluation of this relationship will require more controlled experiments with continuous vessel speed data over a broad range of propellor shaft speeds.

The value of observations by divers of underwater net configuration cannot be overstated. Surface measurements and observations, no matter how refined, are limited in describing the total picture. These observations continually help to refine and focus our understanding of the mechanics of the purse seining process. The relationship between net behavior and applied forces cannot be fully understood without subjective underwater assessments. No remote sensing system is yet sophisticated enough to integrate the overall picture.

Direct benefits of diving observations during this charter were to identify how, and to what degree various areas of webbing contribute to the make-up of the backdown channel during backdown. The most important discovery was the elucidation of the roll played by the "sausage" of webbing, described in Section VI, F above, in the development of stern sway. The knowledge that the "sausage" exists, and understanding how it interacts with the rest of the webbing during backdown, opens up new areas of investigation aimed at improving backdown efficiency by eliminating or reducing stern sway.

The zipper-line ridge was identified by divers as an area for potential porpoise mortality and it was intended that the ridge be examined during this charter. The purse seine of the Maria C. J. is completely free of this problem, however. The Fishing Captain was aware of the zipper-line ridge phenomenon in other seine nets, and was of the opinion that his particular zipper installation was responsible for the absence of a ridge. The conclusion drawn is that the zipper-line ridge is due to decreasing the working depth of the webbing along the zipper by uneven lacing of the selvage strip to the adjacent webbing and/or by lashing the rings to two adjacent knots instead of one. By lacing the selvage in mesh-to-mesh, lines of tension along the webbing bars are transmitted through the selvage piece without distortion and no depth is lost. By fastening the rings to two adjacent knots instead of only one, one mesh is eliminated from net depth at each ring, which in a 14 strip net with 70 rings for the zipper, causes 70 meshes or 0.7 strips of net depth to be lost. This loss of depth is actually a shortening of the distance from the chain to the corkline and is translated into a ridge across the net. Future research on a seine that has a zipper-line ridge is planned in order to verify these conclusions.

Often ideas are brought forward that lend themselves well to relatively easy and straightforward testing. Pulling the third bow bunchline from the starboard bow to affect a wider backdown channel was such an idea. As mentioned above, this procedure was rejected because it created new areas with the potential to trap and drown porpoise, and also caused the backdown channel to shallow up more rapidly than normal. Had the procedure shown more promise, it could have been refined and possibly perfected in a very short time with a minimum of effort. The experience gained in relating surface measurements and observations with simultaneous underwater observations of net behavior will greatly increase our ability to predict the range of results expected from future proposed net and procedure modifications.

An ancillary result of this charter was a gain in acuity of understanding of the relationship between net depth and backdown parameters. When lacing in marker lines (6.4 mm colored polypropylene rope), during the dockside day, an important observation was made. It was noted that lines marking webbing bars running sternward from the super apron apex, ended at the leadline in close proximity to the marker running down the meshes under the established tie-down point (Figure 1). In fact, the distance between the apex bar at the leadline, and the marker at the leadline under the tie-down point, measured 23.8 meters. This may prove to be a useful observation if the relationship between net depth and corkline distance from the backdown apex to the stern tie-down point can be formulated through future measurements. The length of corkline in the water during backdown is critical to backdown performance; too much and the apex collapses and the corkline will not sink, too little and a large canopy forms at the apex. NMFS requires vessels with new super apron installations to make a trial set to establish the optimum tie-down points for backdown. Trial sets are not practical for vessels operating from Panama however, and therefore many U.S. vessels have not had this benefit. An empirical formula for establishing the stern tie-down point based on net depth would eliminate mortality associated with gross experimentation with tie-down locations during porpoise sets. After a stern tie-down point is established, the third bow bunchline would be pulled until the apron is aligned. It is hypothesized that such a formula can be derived and verified since there appears to be a systematic relationship between the stern tie-down to apex corkline distance, and stretched net depth (i.e., length of bars).

PERSONNEL

A. Local Segment

James M. Coe, NMFS, Chief Scientist/Diver
David B. Holts, NMFS, Dive Master
Richard W. Butler, NMFS, Technical Coordinator/Diver
Dale Fellbaum, NMFS, Technician
Darrell E. Lee, NMFS, Technician
Charles Oliver, NMFS, Photographer
Thomas B. Shay, NMFS, Technician/Diver
William H. Brinkerhoff, NMFS, Technician
Charles Peters, NMFS, PRF

B. ETP Segment

Darrell E. Lee, NMFS, Technician
Gary Worthen, Utah State University, Contractor

Table 1

SUMMARY OF EXPERIMENTS

Date	Set	Running Time (Hours)	Number of Backdowns	SCUBA	BKG	Flow-meter	Dynomo-meter	Backdown Photos	Range finder/ Polaris	Starboard Third Bunch
9/17	1	2	1	-	-	-	-	-	-	-
9/18				Dockside - Net Marking						
9/19	2	4	1	✓	✓	✓	✓	✓	✓	-
9/20	3	2	1	✓	✓	✓	✓	✓	✓	-
9/21	4	6	2	✓	✓	✓	✓	✓	✓	✓
9/22	5	Drift	2	✓	✓	✓	✓	✓	✓	✓
9/23				Day Off - Sunday						
9/24	6	3	2	✓	✓	✓	✓	✓	✓	✓
9/25	7	2	3	✓	✓	✓	✓	✓	✓	-
9/26	8	2	1	✓	✓	✓	✓	-	✓	-
9/26	9	-	1	✓	✓	✓	✓	-	✓	-
9/27	10	3	1	✓	✓	✓	✓	-	✓	-
9/27	11	-	1	✓	✓	✓	✓	-	✓	-
9/28	12	3	1	✓	✓	✓	✓	-	✓	-
9/29				Day Off - Repair Main Winch						
9/30				Day Off - Sunday						
10/1	13	4	1	✓	✓	✓	✓	-	✓	-

- Denotes no experiment

✓ Denotes experiment occurred

Table 2. Surface area encompassed (m^2) by the corkline of the net of the M/V <u>Maria</u> <u>C.</u> <u>J.</u> (14 strips deep by 1316 m long)

Set No.	Area 1 Encircled	Area 2 ∿1/2 pursed	% of Area 1	Area 3 Rings-up (No. bow bunches)	% of Area 1
03	* 75,074	60,787	(81%)	19,319 (3)	26%
04	* 80,642	53,610	(66%)	15,113 (3)	19%
05	* 114,590	48,839	(43%)	17,643 (3)	15%
06	* 88,804	77,565	(87%)	15,236 (3)	17%
07	* 95,212	60,956	(64%)	18,984 (3)	20%
08	* 110,033	81,482	(74%)	21,426 (3)	19%
09	114,690	30,550	(27%)	21,988 (3)	19%
10	81,704	45,276	(55%)	18,563 (3)	23%
11	72,587	21,832	(30%)	16,223 (3)	22%
12	62,341	33,017	(53%)	10,853 (3)	17%
13	88,794	49,011	(55%)	16,370 (3)	18%
N =	11	11		11	
$\bar{X}$ =	89,497	51,175	(57%)	17,429	19%
S.d. =	17,579	18,627		3,163	

* These measurements are for corkline plus towline. All other measurements are for corkline alone after towline is in.

Table 3. Estimated average vessel and net speed, and estimated rates of net floor rise at points directly beneath the apex, three and six strips deep (A-3 and A-6).

	Depth(m)** Start	End	Approx. Time(min.)	Rise Rate(m/min)	Shaft RPM	Backdown Speed m/s (knots) Bow	Net Apex	Adjusted Apex	Stern
SET 1L					-	1.22(2.38)	0.46(0.89)	-	-
SET 2L	(TRACES UNINTERPRETABLE)				-	1.28(2.48)	0.45(0.87	-	-
SET 3L					-	1.19(2.31)	0.42(0.81)	0.65(1.25)	-
SET 4L									
A-3,BD#1	23	5	9	2.00	-	1.03(1.99)	0.35(0.67)	0.65(1.26)	
*A-3,BD#2	16	4	13	0.92	-				
A-6,BD#1	33	5.5	9	3.16	-	1.03(1.99)	0.35(0.67)	-	-
*A-6,BD#2	28	5	13	1.76	-				
SET 5L									
A-3,BD#1	22	5	9	1.88	-	1.40(2.72)	0.47(0.91)	-	-
*A-3,BD#2	17	5	9	1.33	-				
A-6,BD#1	23	4	10	1.90	-	1.40(2.72)	0.47(0.91)	-	-
*A-6,BD#2	17	3	12	1.25	-				
SET 6L									
A-3,BD#1	11	7	10	0.25	75	0.78(1.51)	-	-	-
*A-3,BD#2	6	3	12	0.25	75				
SET 7L									
A-6,BD#1	17	7	12	0.83	75	0.67(1.29)	-	-	
A-6,BD#2	15	5	7	1.42	100	1.14(2.21)	0.36(0.71)	0.51(0.99)	-
A-6,BD#3	16	2	7	2.00	125	1.65(3.20)	0.61(1.18)	0.81(1.58)	
SET 8L	(INSTRUMENTS FAILED)				-	1.00(1.94)	0.39(0.76)	0.66(1.28)	-
SET 9L									
A-3	14	1	8	1.62	75-125	1.07(2.07)	0.40(0.77)	0.61(1.18)	-
A-6	23	4	12	1.58	-				
SET 10L									
A-3	17	5	10	1.20	75-127	1.23(2.38)	0.50(0.97)	0.64(1.25)	
A-6	22	3	13	1.46	75-127				
SET 11L									
A-3	15	8	15	0.46	78-103	0.90(1.75)	0.33(0.64)	0.45(0.88)	-
A-6	15	7	10	0.80					
SET 12L									
A-3	17	6	9	1.11	75-100	-	0.45(0.88)	0.62(1.20)	1.03(2.01)
A-6	18	6	11	1.09	75-100	-			
SET 13L									
A-3	23	6	18	0.94	78-131	1.06(2.06)	-	-	0.97(1.87)
A-3 Average:	16.45	5.00	11.09	1.04	Average Speed:	1.12(2.17)	0.43(0.83)	0.62(1.20)	1.00(1.94)
A-6 Average:	20.63	4.68	10.54	1.51					

* Backdowns with third bunch to starboard-speed not recorded

** Bathykymographs accurate to ± 1m

Table 4. Pursing speeds

Set #	Minutes to Pursed	Time	Activity	Bow Pursing Speed (m/s)	Stern Pursing Speed (m/s)	Comments
21	27	0650	Towline			
	24	0653			.46	slight rollup
	14	0703			.46	set
	10	0707		.45	.46	
	1	0716		.27		
	0	0717	Rings up			
38	40	0650	Net let go			
	11	0707		.54	.58	
	8	0718		.36	.46	
	4	0726		.36	.46	
	0	0730	Rings up			
42	36	0633	Net let go			
	19	0650		.41	.46	
	7	0702		.36	.46	
	1	0708		.32	.35	
	0	0709	Rings up			
44	40	0603	Net let go			
	28	0615		.49		
	23	0620		.54	.58	
	19	0624		.41	.46	
	5	0638		.30	.35	
	1	0642		.19	.27	
	0	0643	Rings up			
47	42	0540	Net let go			
	12	0610		.38	.42	
	7	0615		.36	.42	
	0	0622	Rings up			
49	26	0717	Towline not in		.68	
	18	0725		.55	.68	
	13	0730		.53	.57	
	8	0735		.36	.47	
	2	0741				
	0	0743	Rings up			

Table 4. Pursing speeds (cont'd)

Set #	Minutes to Pursed	Time	Activity	Bow Pursing Speed (m/s)	Stern Pursing Speed (m/s)	Comments
50	22	1625	Towline in			
	20	1627		.54	.76	
	17	1630		.54	.38	
	12	1635		.41	.57	
	7	1640		.41	.51	
	0	1647	Rings up			
51	30	0600	Towline in			
	25	0605		.36	.46	
	19	0611		.36	.46	
	15	0615		.36	.46	
	8	0620		.30	.38	
	3	0625				
	0	0628				
52	20	1110	Towline in			
	18	1112		.49	.58	
	10	1120		.45	.46	
	5	1125		.38	.46	
	0	1130	Rings up			
55	33	0537	Net let go			
	18	0551		.54	.67	
	14	0556		.53	.65	
	9	0601		.39	.47	
	3	0607		.36	.42	
	0	0610	Rings up		.21	

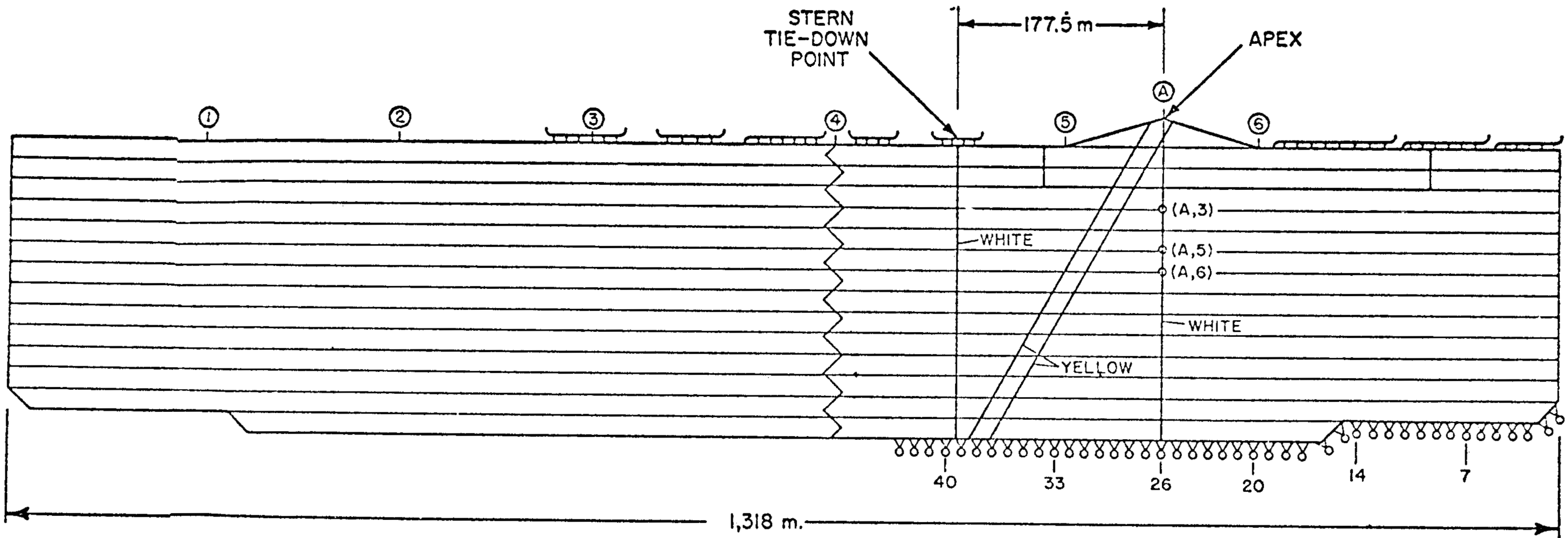

Figure 1. Purse seine of Maria C. J. with numbered balloons and marker lines.

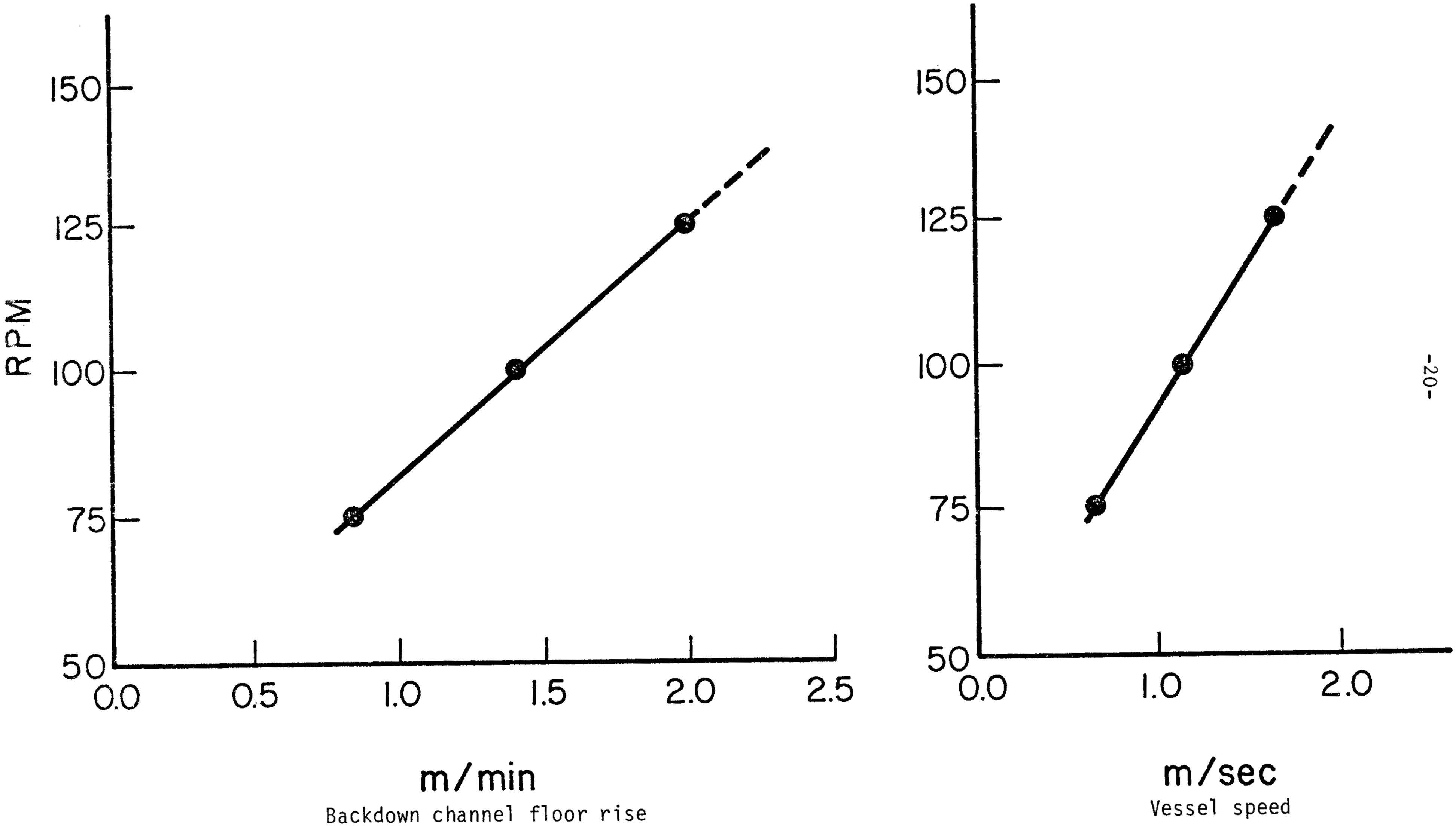

Figure 2. Vessel speed and backdown channel floor rise plotted against shaft RPM.

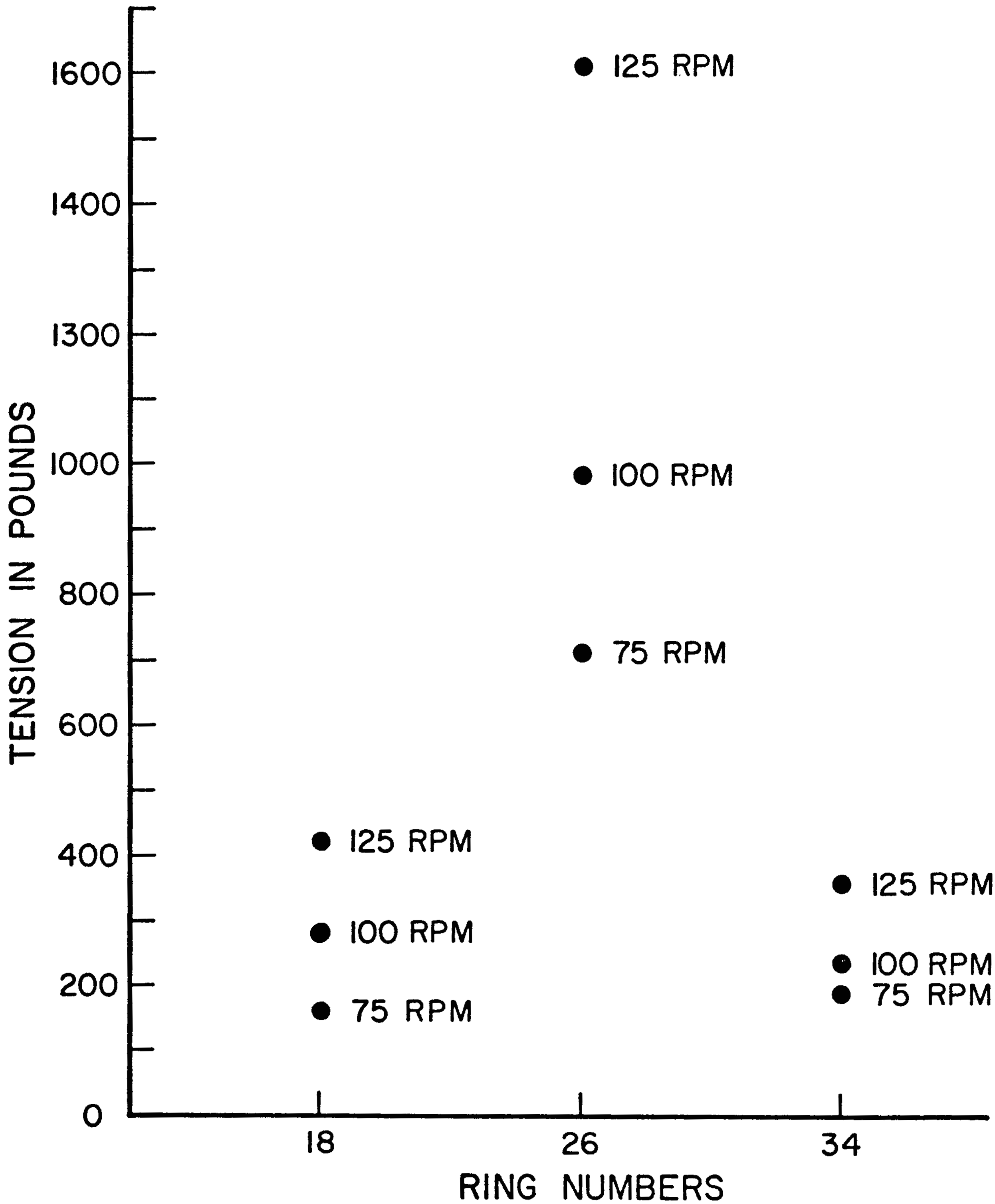

Figure 3. Tension on ring bridles for three backdown speeds.

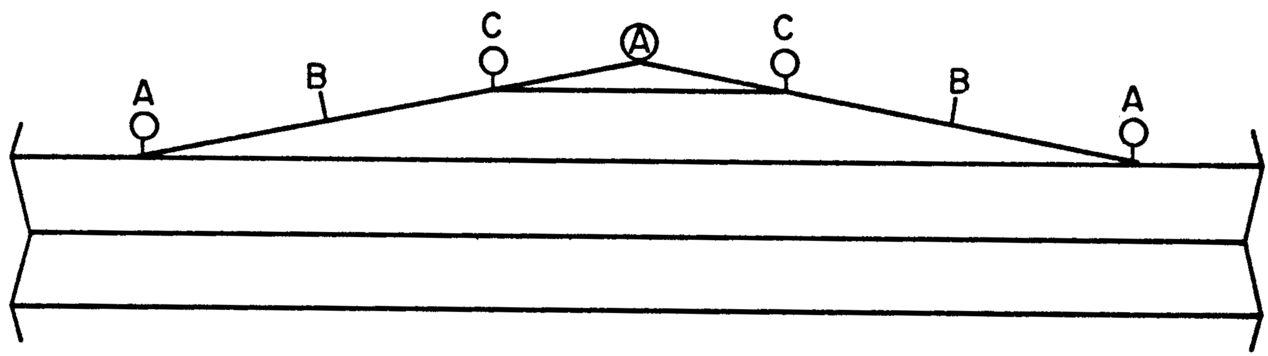

Figure 4. Balloons marking Super Apron.

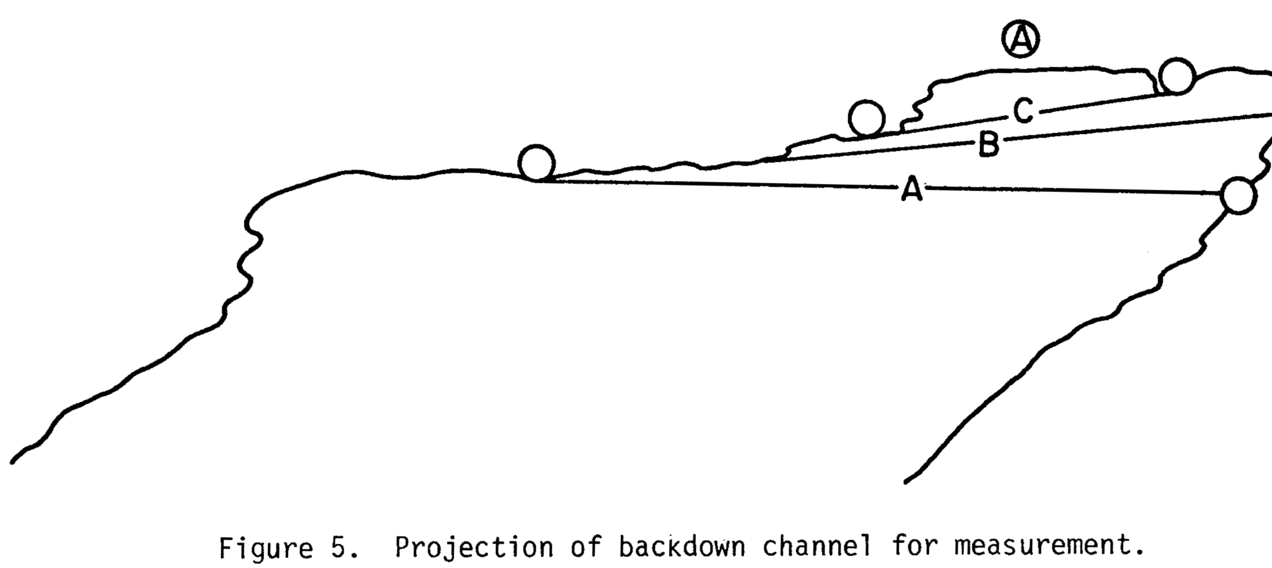

Figure 5. Projection of backdown channel for measurement.

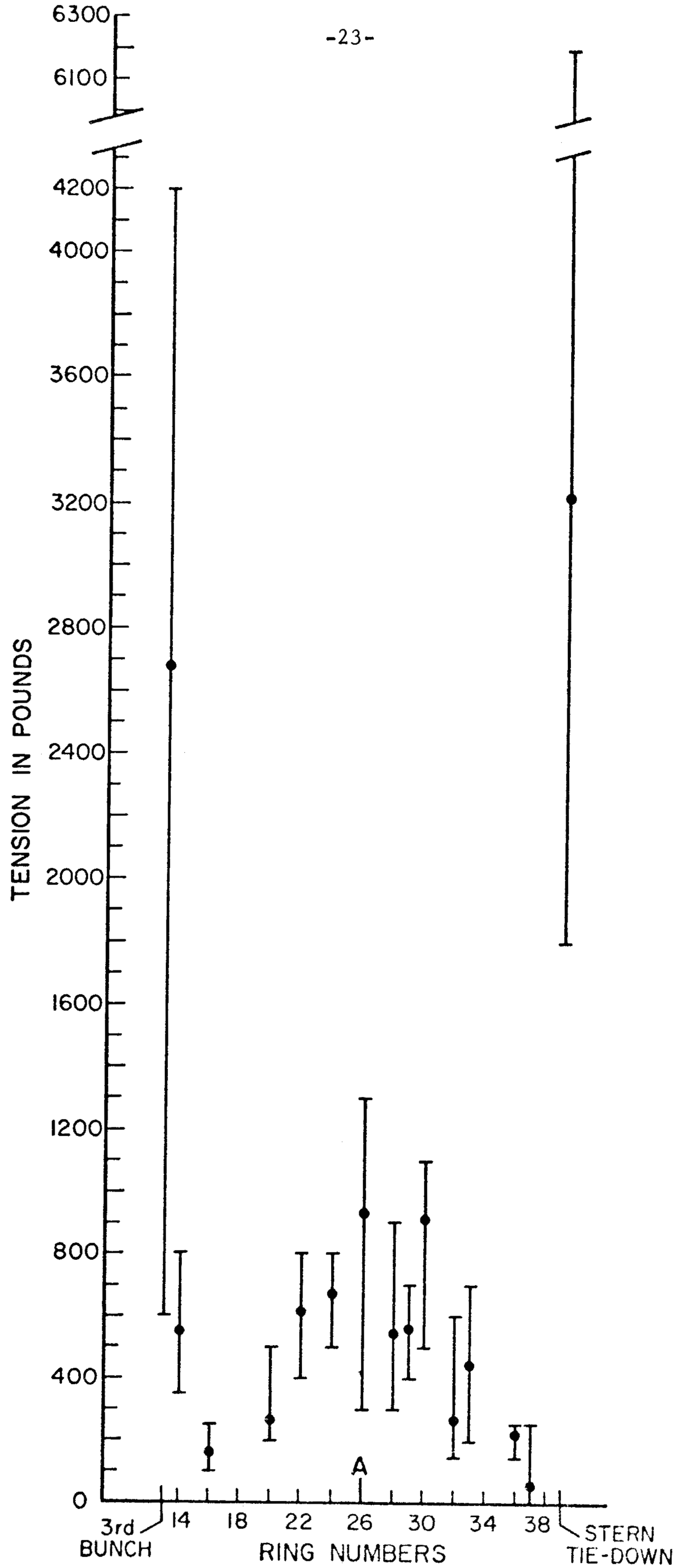

Figure 6. Distribution of tensions during backdown.

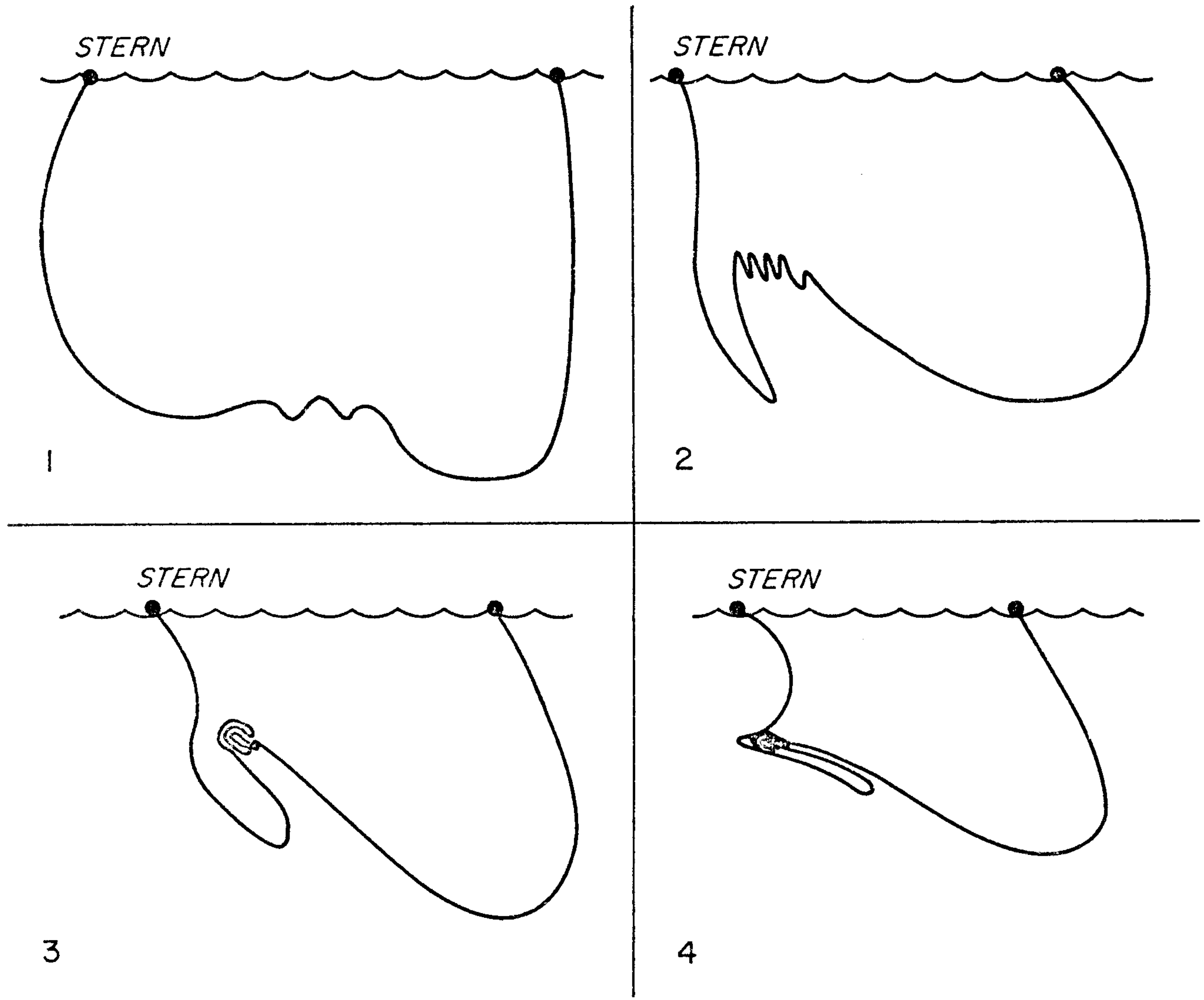

Figure 7. Backdown channel cross section during backdown showing development of stern sway.

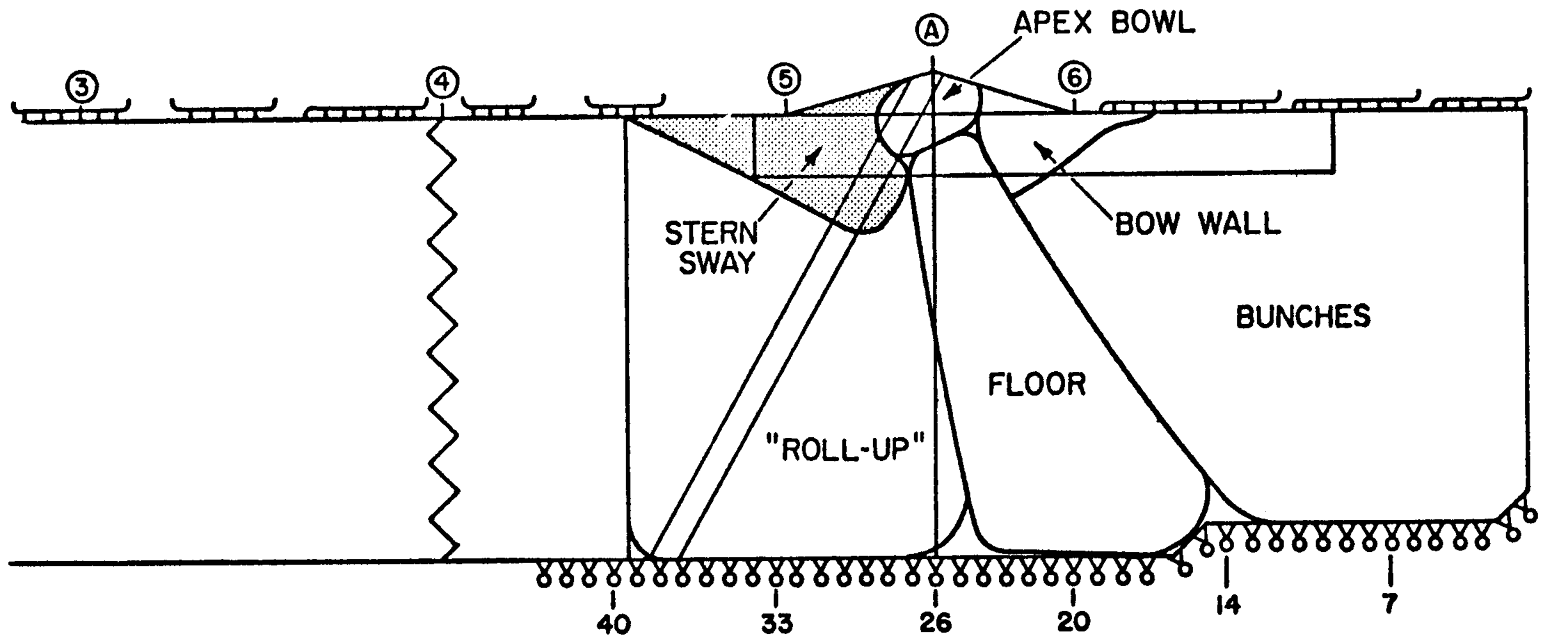

Figure 8. Distribution of webbing during backdown.

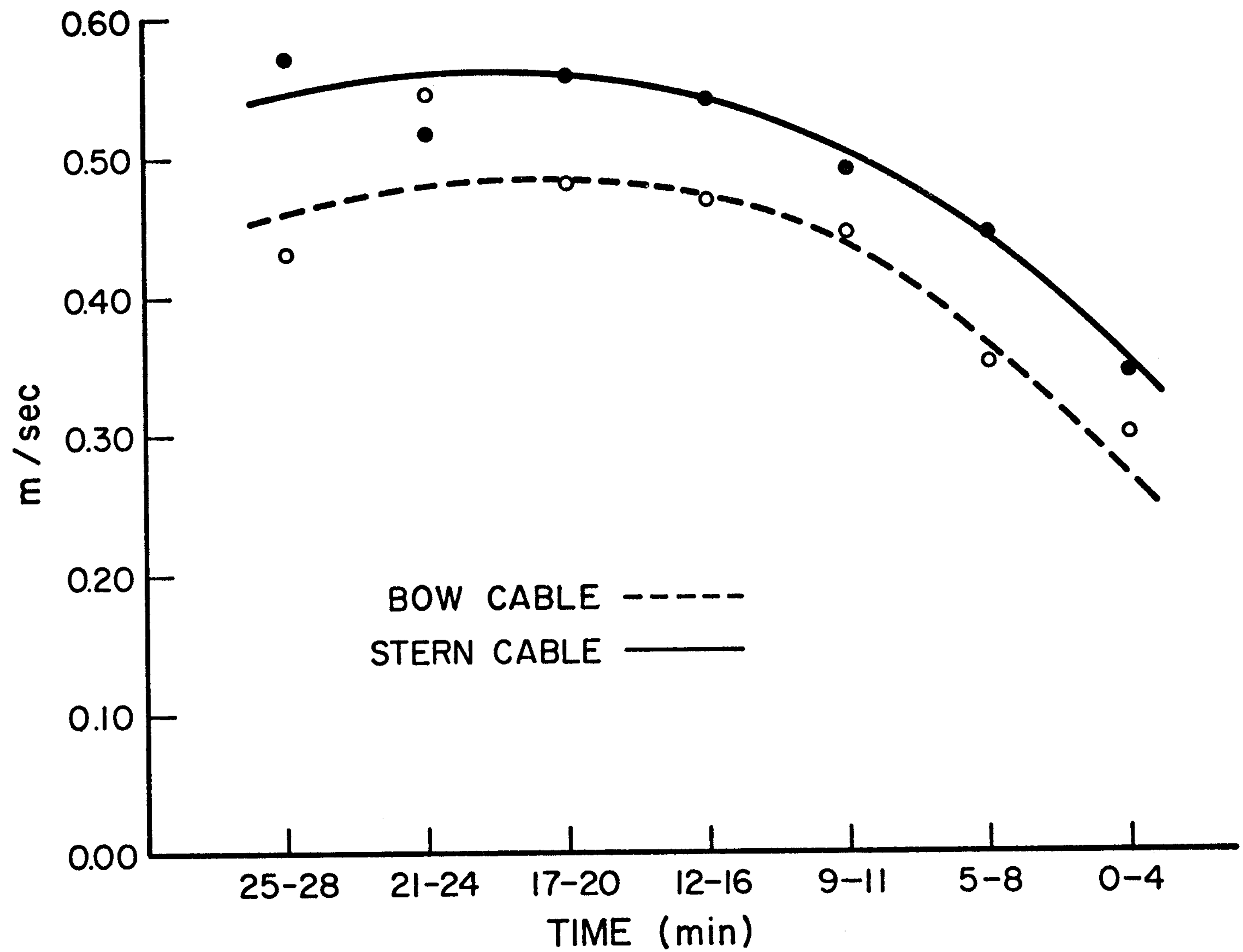

Figure 9. Pursing speed.