INTER-AMERICAN TROPICAL TUNA COMMISSION
COMISION INTERAMERICANA DEL ATUN TROPICAL

Data Report — Informe de Datos
No. 6

Report on estimating the size of dolphin schools, based on data obtained during a charter cruise of the M/V Gina Anne, October 11 - November 25, 1979

Informe sobre la magnitud de los cardúmenes de delfines basado en los datos obtenidos durante un crucero del barco fletado Gina Anne, 11 de octubre - 25 de noviembre de 1979

by — por

R. L. Allen, D. A. Bratten, J. L. Laake, J. F. Lambert[1], W. L. Perryman[2] and M. D. Scott

La Jolla, California

1980

1. Living Marine Resources, 7169 Construction Court, San Diego, CA 92121.
2. NMFS, SWFC, 8604 La Jolla Shores Drive, La Jolla, CA 92038.

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INTRODUCTION

Estimates of dolphin school sizes made by observers and crew members aboard tuna seiners or by observers on ship or aerial surveys are important components of population estimates of dolphins which are involved in the yellowfin tuna fishery in the eastern Pacific. Differences in past estimates made from tuna seiners and research ships and aircraft have been noted by Brazier (1978). To compare various methods of estimating dolphin school sizes a research cruise was undertaken with the following major objectives:

1) compare estimates made by observers aboard a tuna seiner and in the ship's helicopter, from aerial photographs, and from counts made at the backdown channel,
2) compare estimates of observers who are told the count of the school size after making their estimate to the observer who is not aware of the count to determine if observers can learn to estimate more accurately, and
3) obtain movie and still photographs of dolphin schools of known size at various stages of chase, capture and release to be used for observer training.

The secondary objectives of the cruise were to:

1) obtain life history specimens and data from any dolphins that were killed incidental to purse seining. These specimens and data were to be analyzed by the U.S. National Marine Fisheries Service (NMFS),
2) record evasion tactics of dolphin schools by observing them from the helicopter while the seiner approached the school,
3) examine alternative methods for estimating the distance and bearing of schools where they were first sighted,
4) collect the Commission's standard cetacean sighting, set log and daily activity data and expendable bathythermograph data.

METHODS

Participation

The names of the scientific party and the crew are given in the appendix. Of the scientific party two were experienced tuna seiner observers (DAB - 5 previous trips, JFL - 4 previous trips), one had experience in school size estimation and photography from helicopters, ships and aircraft, (WLP), and the remaining three (RLA, JLL, MDS) had no experience in estimating dolphin school size in the eastern Pacific.

The NMFS funded the participation of LCDR Wayne L. Perryman (NOAA Corps) and provided most of the photographic equipment and supplies. The Porpoise Rescue Foundation (PRF) funded the participation of Mr. James F. Lambert.

Vessel and Equipment

The M/V GINA ANNE, a 65 m long purse seiner, was built in 1974, with a fish carrying capacity of about 1200 tons. She had a cruising speed of about 15.5 knots and was equipped with a bowthruster and a 44-inch (112-cm) power block. The net was 1420 m long and 14 strips deep (each strip is about 10 m) and had a standard super apron. The vessel carried a Bell 47A helicopter with a Soloy gas turbine conversion. A mounting for a 5-inch (12.7-cm) aerial reconnaissance camera was built on the tail assembly of the aircraft.

The photographic equipment used included a KA5IA 5-inch aerial reconnaissance camera, a 2 1/4-inch (5.7-cm) Hasseblad 500 EL camera, two Canon Scoopic 16-mm movie cameras, and two Canon 35-mm cameras.

Procedures

As soon as possible after a school was sighted from either the ship or the helicopter, the scientist in the helicopter made an estimate of the school size, species composition, and amount of tuna with the school. This information was passed on to the ship's captain in general terms to avoid biasing later estimates made by the other observers. If a set appeared likely, an attempt was made to photograph the entire school. The decision to photograph was also affected by the configuration of the school, sea state, and time of day.

Photographs were taken with the hull-mounted 5-inch aerial reconnaissance camera using Kodak 2448 film, and the Hasselblad 2 1/4-inch using Kodak Ektachrome 200 & 400 ASA films. All 5-inch and some 2 1/4-inch photographs were taken during passes directly over the schools at altitudes between 225 and 375 m and at speeds between 60 and 70 knots. Hasselblad photographs were also taken as the helicopter circled over some schools. After the schools were captured, photographs were taken using various filter combinations to evaluate their effects on water penetration.

At times it was possible to make extra passes over the school to make estimates of its size comparable to those made during the NMFS aerial survey of 1979. Frequently, however, the proximity of the boat was such that only a quick estimate could be made before the helicopter returned to the vessel to pick up a crewman who thereafter advised the skipper of the location of the dolphins and tuna during the chase.

The remaining five observers (RLA, DAB, JLL, JFL, MDS) made estimates of the original school size and of any successful evasion from the encirclement of the net by the dolphins. After completion of pursing, and prior to backdown, each of the five observers also made an estimate of the number of dolphins that were captured. The estimates of the school size and the number captured were not discussed by the observers. However, in order to be sure all

observers saw all evading dolphins the attention of all observers was drawn to any evading group. It was impossible for the observers not to be aware of at least some of the crew estimates because crew estimates were recorded at the same times. For some sets aerial photographs and an estimate of numbers captured were made from the helicopter.

At backdown between two and four observers (RLA, DAB, JFL, MDS) equipped with hand counters, were stationed on speedboats near the apex of the backdown channel (Figure 1), and counted all the dolphins which were released during backdown, rescued by hand and those killed incidentally. Three speedboats were considered to be the maximum number that should be attached to the corkline at the end of the backdown channel. One speedboat was placed at the backdown channel apex, one speedboat several fathoms to the bow-side of the apex, and one speedboat several fathoms to the stern of the apex. Two observers were placed in the center speedboat, and one each in the bow and stern-side speedboats. The procedure followed when all three speedboats and four observers were employed was:

1) Observer No.1 in the stern-side speedboat counted all the dolphins released or rescued over the corkline from his speedboat bowline to the vessel.
2) Observer No.2 in the center speedboat counted all the dolphins released or rescued over the corkline from his speedboat bowline to the stern-side speedboat's bowline.
3) Observer No.3 in the center speedboat counted all the dolphins released or rescued over the corkline from his speedboat's bowline to the bow-side speedboat's bowline.
4) Observer No.4 in the bow-side speedboat counted all the dolphins released or rescued over the corkline from his speedboat bowline to the vessel.

A sea trial was held near San Diego on October 5, 1979, aboard the chartered vessel. Two practice sets were made to check the alignment of the super apron and to simulate an actual backdown count with all three speedboats and four observers in position at the backdown area. Three speedboat tie-up points on the corkline were chosen that would allow adequate separation between the speedboats, but not so much as to give an observer too much area to count. These points were marked and steel rings were attached after completion of the sets.

This arrangement of speedboats and observers was generally adhered to during the cruise. The number of speedboats and observers was reduced for some sets if there were a small number of dolphins in the net. For the two-speedboat arrangement, the center and bow side speedboats were used, and for the one-speedboat arrangement the center speedboat was used.

In order to provide support and thus ensure the safety of the scientists standing on the bows of the speedboats during the backdown counts, braces were welded to three of the aluminum speedboats (Figure 2).

The entire counting procedure from the launching of the speedboats prior to backdown to their retrieval after backdown remained fairly constant during the cruise. The typical procedure was as follows:

1) Before backdown started, the required number of speedboats with observers were launched. Usually one or more of the observers had already entered the net in a rubber raft for underwater observations of the captured dolphins.
2) The speedboats were tied to the corkline, and the observers prepared for backdown. Counts were made using two hand counters: one for counting individuals and one for counting estimated groups of ten. Polarized sunglasses were worn to reduce surface glare.
3) The count began as the dolphins passed over the corkline. As the channel narrowed and the speedboats drifted closer together one or both of the outer speedboats untied from the corkline leaving the remaining dolphins in their areas to be counted by the observers in the center speedboat. This prevented too much congestion at the apex in the latter stages of backdown.
4) After all the dolphins in the net had been accounted for the observers returned to the seiner, recorded their counts, and noted any problems which made counting difficult. Each observer recorded the maximum error he thought might have been made in his count. Dolphins killed during the set were included in the total count. Following each set the four observers (RLA, DAB, JFL, MDS) were informed of the total number of dolphins counted to determine whether this would allow them to improve their estimation during the course of the cruise compared to the crew and other observers.
5) Observers who remained on the ship during backdown counted the number of dolphins which they saw being released or escaping at backdown.

During the chase, capture and release phases of sets, one observer (JLL) took 16-mm movie and 35-mm still photographs to be used for training purposes.

Photographic Analysis

Upon returning to San Diego, all of the aerial transparencies were previewed on a light-table to select those photographs or series of photographs that included entire schools and were of good quality. The 2 1/4-inch slides were projected on paper and individual animals were marked and counted. The 5-inch films were magnified and analyzed on Variscan Mark II projectors at the U.S. National Aeronautics and Space Administration facility in Bay St. Louis, Mississippi. A clear sheet of plastic was placed over the viewing screen of the Variscan machines and the animals were marked on the plastic.

A team of five scientists reviewed the photographs (see appendix). Three of the scientists (EGB, TDJ, WLP) had been involved

in processing photographs from previous aerial surveys. The other two (JLL, MDS) had no previous experience at making estimates from aerial photographs and were briefly trained in the procedure before processing their first film of a school. Estimates of the size of each school were made based upon the number of animals marked, the opinion of the reviewing scientists concerning the visibility of all school boundaries, the swimming behavior of the animals, the quality of the photograph, and the notes that were taken at the time the school was photographed. All estimates were made independently and without knowledge of the backdown count for the school.

RESULTS

Figure 3 shows the cruise path for the charter. The vessel was restricted to fishing on tuna associated with dolphins, but in other respects searched for fish as it would on a normal fishing trip. Thus, the pattern of movement was dictated by reports of fish or dolphins, weather conditions, and on two occasions, the need to enter port.

During the cruise there were 194 sightings of cetacean schools recorded. At each sighting the position, distance and bearing of the school, weather conditions, and the means of making the sighting (helicopter, 20x binoculars, or other) were recorded. Table 1 lists the number of observed marine mammal schools by stock composition.

Set summary

Dolphin schools were chased by the speedboats and seiner 33 times during the cruise resulting in 26 sets. Seven chases were begun but terminated prior to a set due to: (1) evasive behavior by the dolphins, (2) poor conditions for aerial photographs of the whole of the school, (3) the school being too small to set upon,or (4) losing sight of the school (Table 2). The median of successful chase times was 25 minutes (range 11-76 minutes) from speedboats launched to net set and was 17 minutes (range 3-66 minutes) from the time the first speedboat began pursuit to net set. Normal chase operations were often delayed from 1 to 10 minutes because of changes in flight personnel required for aerial photography of schools prior to a set. The helicopter participated during the chase of all dolphin sets except sets 6,7,16, and 18. During the chase, the crewman in the helicopter advised the skipper as to: (1) where the school was, (2) the distance between the edge of the school and the speedboats, (3) where the fish were in relation to the dolphins, (4) where the birds were in relation to the dolphins, (5) school composition, and (6) direction of travel.

Eight sets were attempted on pure schools of offshore spotted dolphins,two sets on pure schools of eastern spinner dolphins, and sixteen sets on schools containing a mixture of these two species.

The school size estimates made during the chase ranged from 62 to 929 dolphins and totalled more than 9314 dolphins. The number of dolphins captured per set ranged from 90 to 863 dolphins and totalled 6960 dolphins, or 75 percent of the animals chased. All chase-set sequences began with the intention of capturing the entire school for scientific purposes; no dolphins were to be deliberately cut out. Therefore 25 percent of the dolphins chased avoided capture by some form of evasive action during the chase or shortly after the setting of the net.

Dolphin evasion

Evasion occurred in 21 of the 26 dolphin sets during the cruise. In 2 sets, all dolphins evaded capture, and in the remaining 19 sets, a fraction of the school evaded capture. In seven sets, all evasion occurred during the chase prior to the setting of the net (Table 3). In another seven sets all evasion occurred after the net was set. In the remaining seven sets evasion occurred during both periods.

Four basic patterns of evasive behavior were noted. The behavioral descriptions and terminology first used by Holts *et al.* (1979) have been followed where appropriate.

1. Quiescent behavior (referred to by Holts *et al.* (1979) as hiding behavior)
   The dolphins stayed low in the water with nearly imperceptible movement until the speedboats passed and the seiner approached. Then the animals moved out of the containment circle formed by the wakes of the seiner and speedboats by swimming rapidly past the bow of the seiner (Figure 4). This behavior contains elements of backing up behavior. The dolphins in sets 23, 24 and 25 exhibited this type of behavior.
2. Backing up
   The dolphins turned and escaped the containment circle by either running between the speedboats or underneath them (Figure 5). The dolphins in sets 1, 2, 4, 6, 7, 15, 18, 19, 20, 21, 22, 26, 27, 29 and 30 exhibited this type of behavior.
3. Under Net Behind Seiner
   The dolphins escaped the containment circle by diving out underneath the net behind the seiner or the skiff as the net was being set prior to encirclement. Only eastern spinner dolphins were observed to evade in this manner (Figure 6). The dolphins in sets 13, 19, 21, 26, exhibited this behavior.
4. School Exploding
   Schools that were spread out over 1 to 2 nm as chase began expanded further during the chase until it became impossible to encircle the entire school. Portions of the original school could not be held within the containment circle of the speedboats and seiner (Figure 7). The dolphins in sets 5 and 16 exhibited this behavior.

Backdown counts

Table 4 presents counting procedures and the individual and total backdown counts from the speedboats for each set, including the observers' estimates of the largest possible error in their counts. There were a variety of problems that may have produced errors. Some were minor distractions, while others made accurate counting difficult. Twelve problems associated with counting were reported by the observers during the cruise; the problems and their frequency of occurrence are described as follows:

A. Deep cork sinkage (15 counts). The backdown area corks sank enough (more than 1 m) to allow groups of dolphins, often in layers, to be backed out at once. The deep sinkage of the corkline also allowed dolphins to dart out of the net, well below the surface. These animals were difficult to count because they often were not seen until after they had passed over the corkline.

B. Splashing (12 counts). Turbulence caused by dolphins splashing near the corkline reduced the observer's ability to keep track of dolphins in the immediate release area.

C. Speedboat bow over corks (11 counts). The speedboat bow was pulled on top of the corks, blocking the observer's view of those dolphins directly under the bow. This was caused either by a bowline that was too short or by deep cork sinkage.

D. Dolphins re-entering the net (10 counts). Dolphins that were backed out sometimes swam back into the net over the submerged corkline increasing the chances of counting animals more than once.

E. Large area to count (4 counts). The observer had too much area to cover, and the dolphins left the net far (more than 5 m) from his vantage point.

F. Dolphins on bowline (4 counts). The bowline of each speedboat acted as a boundary of each section. Dolphins lying on the bowline or entangled in it made it difficult for the observers to determine whose section it was in, and also distracted them from the rest of their sections.

G. Late afternoon backdown (4 counts). Reduced lighting near or after sunset made it difficult to see the dark shapes of dolphins leaving the net beneath the surface.

H. Large number of dolphins to count (2 counts). Counting was difficult due to the large number of dolphins captured and backed out. Groups and individuals were released rapidly, often in layers.

I. Obstructed vision (2 counts). In both cases, the stern speedboat swung around over the corkline, blocking the center speedboat observer's view of his section. This was caused by the narrowing of the backdown channel which pulled the stern speedboat over the corkline.

J. Rough sea (1 count). Turbulent sea surface conditions reduced sub-surface visibility.

K. Counting large numbers of hand-rescued dolphins (1 count). One observer had to count all the dolphins hand-released by the other observers (turned rescuers), raftmen, and speedboat drivers

during a late backdown.

L. Glare (1 count). On one occasion an observer did not use polarized sunglasses and had trouble seeing with the glare.

Some of these problems were interrelated. Deep cork sinkage (A) often led to the speedboat bow being pulled on top of the corkline (C). A large number of dolphins in the net made counting difficult (H) and also resulted in dolphins being released at a distance from the speedboats (E).

The most frequently encountered problem was trying to count groups of animals as they were backed out. Minimal cork sinkage reduced the frequency of large groups passing over the corkline but it was difficult for the vessel to regulate cork sinkage to the best depth for counting. Reducing the release rate of the dolphins too much also increased the risk of unnecessary mortality.

An important factor in obtaining good counts within a section of corkline was the observer's ability to watch the activity of the dolphins approaching and being released in his section. Many of the problems had the effect of diverting attention to one particular animal or to a small area of his section which may have caused the observer to miss activity in another part of his section (D,F). Other problems may have prevented an observer from seeing animals leave a part of his section. (B,C).

Counting of a single area by two observers was attempted in order to check the accuracy of the count. During two sets observers No. 1 and No. 2 tried double counting No. 2's section. These attempts at double counting one section proved to be quite difficult due to 1) an unexpected number of dolphins released beyond the anticipated boundaries of the section to be double counted, and 2) a narrowing of the backdown channel requiring the stern speedboat to drop off with an incomplete count. On one set a section was double counted by observer No. 1 and a speedboat driver and each obtained the same result (94).

Backdown counts were also made by observers who remained on the ship. These counts have been compared in Table 5 to the backdown counts made from the speedboats. Due to the distance of the observers from the backdown area, not all of the dolphins could be counted, and these ship-based counts consistently underestimated the school size.

Pre-set estimates of original school size

Pre-set estimates of school size were made for most schools from the helicopter and the vessel by both the scientific party and the crew. These estimates were made at different times; usually the scientist in the helicopter made an estimate before the speedboats were launched, the crewman in the helicoper made an estimate at the beginning of or during the chase, and the crew and scientists aboard the vessel made their estimates during the chase. Table 6 shows these estimates together with an estimate made by adding the backdown count

to the estimated number which escaped. The estimates made from the vessel are medians of up to five estimates by the scientists and three estimates made by crew members.

The column showing percent captured is included in this table to give an indication of the accuracy of the total school estimate. A high degree of confidence is placed in estimates where the numbers captured and counted were 80% or more of the school (and hence the estimated portion formed no more than 20% of the school), and less confidence in the estimate otherwise. The backdown count provided a minimum estimate of school size.

Estimates of captured school size

Table 7 shows the deviations of the estimates made by the crew and scientists from the backdown count. The crew estimate is the median of three estimates and the scientists' estimates have been shown separately to compare experienced observers (DAB, JFL) with unexperienced ones (RLA, JLL, MDS); and to show any effect of knowing the count after an estimate was made (RLA, DAB, JFL, MDS) as opposed to JLL who did not know the backdown counts until after the cruise. Two measurements of performance in estimation are the bias and mean squared error ($X^2 + S^2$); the first measure gives an indication of the average estimation error and the second an indication of the likely error in a particular estimate. The observer who was unable to calibrate his estimates had the largest bias but was more consistent than the others and achieved the lowest mean squared error. There was little difference between the remaining scientists and the crew all of whom showed a surprisingly small bias.

Mortality and injuries

A total of 18 dolphins; 10 eastern spinners and 8 offshore spotteds, were incidentally killed during the fishing operations. Seven died due to entrapment, six due to entanglement, two due to sacking up, and three due to other or unknown causes. The mortality occurred in 8 of the 26 sets . The resulting mortality rates were 0.69 animals per set and 0.09 animals per ton of yellowfin tuna. Life history data were collected for the NMFS on 8 eastern spinner and 8 offshore spotted dolphins.

Four eastern spinner dolphins, three offshore spotted dolphins, and twenty-one unidentified dolphins were injured (indicated by bleeding).

Raft rescue

The No. 1 and/or 3 speedboats were untied from the corkline during late backdown when (1) channel collapse forced the speedboats too close together for an effective count, or (2) it was determined

one or more of the three speedboats were not necessary for the count. At this time, one scientist entered a rubber raft and aided in releasing dolphins by hand.

The two rafts (1) allowed more rescue effort by hand during critical stages of backdown, (2) increased the probability of observing dolphins in need of rescue by hand and (3) increased the effectiveness of herding dolphins with rafts. Because of the experimental procedures, principally the congestion of three speedboats and the presence of the scientific party at the backdown apex, kill rates are not comparable with those observed on normal fishing cruises; nevertheless it was the opinion of the scientific party that the use of an extra raft could occasionally help reduce dolphin mortality.

Photographic analysis

School size estimates were made from photographs of 11 schools (Table 8). All but three of the photographs which were suitable for analysis were taken before 1000 hrs or after 1400 hrs. All were taken when the sea state was Beaufort 3 or less. For schools that were evaluated in both 2 1/4-inch and 5-inch format, the best set of estimates from each format were included for comparison. The last two columns of the table list the best estimates of school size based on counts at backdown plus estimates of the number of dolphins that escaped, and median estimates of the percentage of the school captured.

Since it may be helpful to compare the estimates from this study with those from the photographs of the 1979 aerial survey, two slides that were taken during an NMFS aerial survey were included with the helicopter study slides. With the exception of WLP, none of the scientists making the estimates knew that these slides were from another source. The average estimates and the range of estimates for the two times that these slides were examined are as follows:

School No.	Range of Estimates 1979	Range of Estimates 1980	Average estimate 1979	Average estimate 1980
4	130 - 143	121 - 152	130.0	139.8
34	265 - 304	256 - 352	289.7	298.6

Other objectives

It was not possible to collect data on the reaction of dolphin schools to the seiner before and during the chase. A large number of 35-mm slides and 2600 m of movie film were taken during the cruise. These are being edited and will be used for training observers in school size estimation techniques.

The standard IATTC daily activity records and cetacean sighting

and set records were collected for the duration of the charter. XBT traces were taken immediately after sets and in the late afternoon on days when no sets were made. These data are available at the IATTC laboratory in La Jolla.

ACKNOWLEDGEMENTS

We are grateful to Captain Pete Balestrieri and the crew of the M/V GINA ANNE whose willing cooperation and assistance made it possible to carry out this research.

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TABLE 1. Sightings of marine mammals

Stocks	Number of sightings
Offshore spotted dolphin (*Stenella attenuata*)	40
Coastal spotted dolphin (*Stenella attenuata graffmani*)	2
Eastern spinner dolphin (*Stenella longirostris*)	7
Mixed offshore spotted dolphin and eastern spinner dolphin	39
Mixed unidentified spotted dolphin and eastern spinner dolphin	1
Common dolphin (*Delphinus delphis*)	4
Bottlenose dolphin (*Tursiop truncatus*)	7
Striped dolphin (*Stenella coeruleoalba*)	1
Rough-toothed dolphin (*Steno bredanensis*)	2
Risso's dolphin (*Grampus griseus*)	5
Unidentified dolphin	24
Shortfinned pilot whale (*Globicephala macrorhynchus*)	4
False killer whale (*Pseudorca crassidens*)	1
Unidentified beaked whale	4
Unidentified small whale	8
Sperm whale (*Physeter catadon*)	3
Unidentified large whale	6
Unidentified cetacean (sightings by crew only)	36
TOTAL	194

TABLE 2. Dolphin schools chased but not set on

Date 1979	Sight No.	Time chase began	Duration of chase (min.)	Dolphins chased			Reason Chase Aborted
				Spotteds	Spinners	Total	
10/25	60	1452	34	--	--	850	Poor weather conditions (Beaufort 3), school spread too out, no fish, dolphins evaded during chase
11/4	82	1616	45	--	235	235	poor weather conditions (Beaufort 4), lost sight of school
11/7	87	1118	12	250	--	250	school spread out, no fish, 5 in. camera not working
11/7	89	1308	47	376	24	400	no aerial photos, school too spread out, too much glare, dolphins evaded speedboats
11/13	120	0902	23	87	--	87	school was too small to set on
11/19	136	0724	7	175	--	175	poor conditions for aerial photos, low light, small school, no fish
11/24	193	1514	44	205	382	587	one speedboat broken down during chase, dolphins evaded speedboats during chase
		TOTAL		1093	641	2584	

TABLE 3. Median of dolphin evasion estimates by four scientists aboard the vessel by set and by sighting number during the chase and after net set began.

Set	Sighting	Evaded: During chase, before net set: Spotted	Spinner	Unid.	Evaded: After net set began: Spotted	Spinner	Unid.	Total evasion
1	17	--	--	--	100	--	--	100*
2	19	50	--	--	--	--	--	50
3	36	--	--	--	--	--	--	0
4	37	--	--	--	--	30	--	30
5	41	--	--	700	--	--	--	700
6	42	77	79	--	--	--	--	156
7	44	105	--	--	35	--	--	140
8	56	--	--	--	--	--	--	0
9	59	--	--	--	--	--	--	0
13	72	--	--	--	--	25	--	25
15	79	10	--	--	--	--	--	10
16	84							no estimate
17	86	--	--	--	--	--	--	0
18	91	--	--	--	31	31	--	62*
19	97	35	--	--	--	60	--	95
20	105	17	147	--	--	--	--	164
21	108	--	50	--	--	50	--	100
22	110	60	40	--	--	--	--	100
23	114	6	--	--	--	--	--	6
24	121	71	90	--	30	--	--	191
25	131	10	--	--	5	12	--	37
26	147	--	13	--	--	37	--	50
27	153	--	--	--	47	--	--	47
28	159	--	--	--	--	--	--	0
29	171	--	--	--	87	87	--	174
30	181	--	--	--	71	35	--	106

* All of the dolphins evaded capture

TABLE 4. Count procedure set summary

Set	# Spdbts. used for count	# of Observers	Individual counts with estimated maximum errors by observer position (Figure 1) 1	2	3	4	Mortality	Total	Problems*	Notes
1										No catch
2	3	4	0	89±8	86±10	1±0	0	176±18	A,D	Stern and bow spdbts. must move closer to center spdbt.
3	3	4	0	265±20	82±2	23±1	2	372±23	A,B,C,D	Stern and bow spdbts. moved closer to center before backdown. Must move closer still to increase share of count.
4	3	4	108±3	148±10	195±8	108±5	0	578±26**	A,D	Stern and bow spdbts. moved closer to center, counts more even.
5	3	4	67±10	86±12	67±5	5±0	2	229±27***	A,B,D,J	Stern and bow spdbts, separated by ~4-5 meters of corkline from center spdbt.
6	3	4	136±12	179±20	94±6	14±0	4	427±38	A,G	Bow spdbt. moved ~5-8 meters toward bow and counted toward center spdbt.
7	1	2	-	155±12	164±15	-	1	320±27	None	Dolphins appeared to cross corkline more readily with only one spdbt. present. Adequate cork sinkage for steady release.
8	1	2	-	95± 4	19±0	-	0	114±4	None	Adequate cork sinkage for steady release.
9	3	4	0	34±3	122±6	133±10	1	290±19	C	Adequate cork sinkage for steady release.
13	2	3	-	69±4	49±5	1±0	0	119±9	C,D	Adequate cork sinkage for steady release. Good water clarity.
15	1	2	-	54±3	79±6	-	0	133±9	C	Adequate cork sinkage for steady release
16	1	2	-	70±5	76±7	-	0	146±12	B,D,	Adequate cork sinkage for steady release. Good water clarity.
17	2	3	-	95±7	36±2	61±6	0	192±15	A,B,D,G	
18										No catch
19	3	4	4±0	56±7	93±3	62±0	0	215±10	B,C	Adequate cork sinkage for steady release.
20	3	4	89±4	116±8	100±6	111±10	0	416±28	A,C,F	
21	3	4	87±6	125±12	177±9	258±30	3	650±57	B,D,E,G,H	Dolphins escaped over large area of corkline on bow side.
22	2	3	-	79±6	56±5	104±5	0	239±16	A,B,F	
23	1	2	-	81±7	63±2	-	0	144±9	A,C,E	Dolphins escaped over large area of corkline on bow side early in backdown.
24	3	4	-	43±4	49±1	123±10	0	215±15	A,B,C,I	JFL and DAB tried double count of combined sections but JFL's spdbt. released early with incomplete count.
25	3	4	78±5	301±35	203±20	278±100	3	863±160	A,B,C,E,F H,I,L	Bow spdbt. late tying up. Dolphins escaped over large area on bow. Apron misalignment moved stern spdbt. out of good counting position.
26	2	3	-	53± 5	102±5	38±2	2	195±12	B,D,F	
27	3	4	119±20	136±40	67±20	17±4	0	339±84	A,B,D,G,K	Many dolphins in net after backdown requiring hand release.
28	3	4	-	126±15	17±1	0	0	143±16	A,C,E	JFL and DAB tried double count of combined sections. JFL counted 105, DAB counted 95 when JFL had to release from corkline.
29	1	2	-	69±4	21±1	-	0	90±5	A	
30	3	4	94±4	149±15	74±4	50±5	0	367±28	A,B,C	JFL and spdbt. driver counted stern section. Both counted 94.

*Problems (may apply to one or more counters)

A. Deep cork sinkage
B. Splashing
C. Speedboat bow over corks
D. Dolphins re-entering net
E. Large area to count
F. Dolphins on bowline
G. Dim lighting
H. Large numbers of dolphins to count
I. Obstructed vision
J. Rough seas
K. Counting large number of hand rescued dolphins
L. Glare

** Includes 19 released after backdown near boat
*** Includes 2 released after backdown near boat

TABLE 5. Comparison of backdown counts made from the ship and speedboats

Set	Bakdown count from the speedboats	Backdown counts from the ship
7	320	162,150,125
8	114	47
16	146	45
17	192	117
23	144	86
26	195	172
27	339	210
29	90	59

TABLE 6. Pre-set estimates of original school size compared to backdown counts. The percent of the school captured implies the degree of confidence in the comparison.

Set	Helicopter (Pre-chase) Scientists	Crew	Vessel (Chase estimate) Scientists	Crew	Estimate based on backdown count*	Percent Captured**
2	375	300	250	237	226	78
3	580	450	300	525	372	100
4	875	750	600	712	608	95
5	1200	1000	1175	1250	929	25
6	---	---	475	675	582	73
7	---	---	350	400	460	70
8	175	225	100	150	114	100
9	650	550	550	462	290	100
13	285	350	250	300	144	83
15	135	---	140	162	143	93
16	260	300	400	350	---	--
17	140	250	200	218	192	100
19	180	400	315	294	310	69
20	475	500	510	450	580	72
21	600	600	500	675	750	87
22	240	250	330	512	339	71
23	125	---	125	162	150	96
24	450	600	400	825	406	53
25	900	800	750	875	900	96
26	275	450	300	225	245	80
27	175	250	200	300	386	88
28	115	175	150	162	143	100
29	285	175	230	162	264	34
30	160	275	250	300	473	78
	393	433	369	433	391	

* backdown count plus the medians of evasion estimates (Table 3)

** median of evasion estimates divided by estimate of original school size based on backdown count.

TABLE 7. Deviations of estimates of numbers captured from the backdown count.

Set	Crew	DAB	JFL	RLA	MDS	JLL	Backdown count
2	24	-26	-56	-76	-106	-26	176
3	128	53	-72	-122	-20	-72	372
4	172	-103	-98	72	27	-28	578
5	71	1	231	-29	121	21	229
6	174	-246	-86	-166	-126	-146	426
7	-20	-105	-75	-120	60	-80	320
8	36	-4	-39	16	-14	11	114
9	373	170	245	310	10	10	290
13	81	1	-49	81	131	31	119
15	36	-3	-13	57	-13	7	133
16	4	14	-36	104	64	-11	146
17	108	-12	-12	48	-52	8	192
19	35	-70	-35	-15	-35	-65	215
20	-116	109	-76	-16	-76	-141	416
21	-250	-350	-220	-130	-230	-250	650
22	11	11	26	1	141	-79	239
23	56	-29	6	-34	56	-44	144
24	35	-15	-55	105	-55	-40	215
25	-363	37	-148	337	-113	-213	863
26	5	5	-5	45	55	-45	195
27	-89	-99	-49	21	-59	-64	339
28	7	-3	67	137	77	-18	143
29	-15	-45	-20	-50	-18	-25	90
30	-67	133	108	-42	-127	-142	367
$\bar{X}$	18	-24	-19	22	-13	-58	290
S	141	109	102	122	92	73	
$\sqrt{\bar{X}^2+S^2}$	142	112	104	124	93	93	
% Bias	6	-8	-7	8	-4	-20	

TABLE 8. Estimates of school size from photographs and backdown counts

Sighting	Format	EGB	TDJ	JLL	WLP	MDS	Average estimate	Best est. from photo.	Best est. from backdown count	Estimated percentage of school counted
6	2¼"	411	351	392	395	400	390	390		
31	2¼"	47	49	59	59	63	55	55		
40	2¼"	76	90	76	79	80	80	80		
72	2¼"	190	192	190	186	184	188			
72	5"		191	216	204	193	201	201	144	83
91	2¼"	64	62	60	62	60	62	62		
100	2¼"	161	146	141	148	168	153	153		
110	2¼"	304	315	258	301	298	295			
110	5"		407	391	398	389	396	396	339	71
127	2¼"	133	134	142	130	136	135	135		
127	5"		126	125	126	127	126			
147	2¼"	203	202	202	214	236	211			
147	5"		225	208	221	211	216	216	243	80
159	2¼"	134	135	137	146	154	141			
159	5"		146	168	160	170	161	161	143	100
171	2¼"	189	160	170	170	196	177			
171	5"		242	229	246	233	238	238	264	34

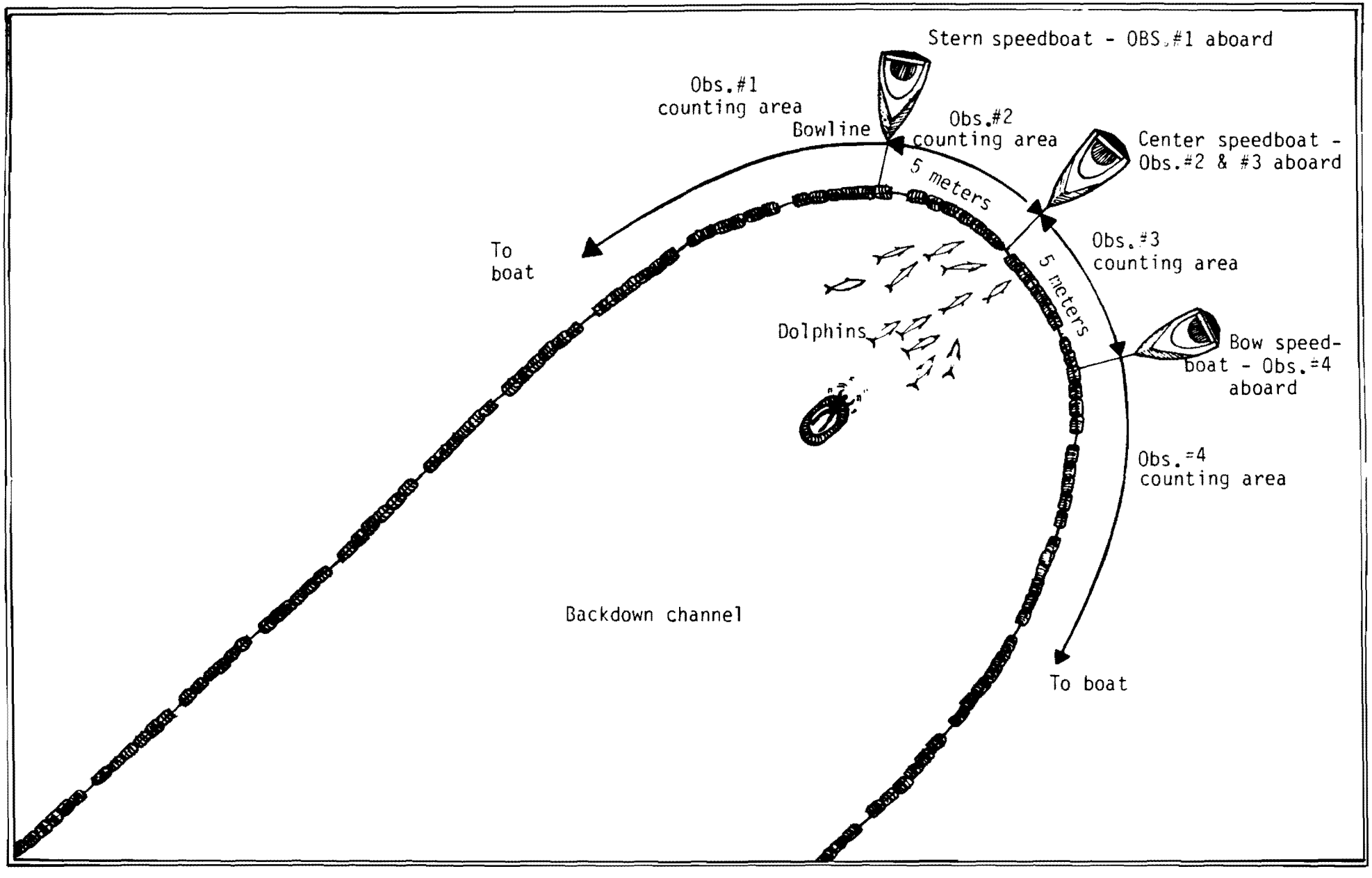

FIGURE 1. Positions of speedboats during backdown

Note: 2 speedboat/3 observer arrangement utilized center and bow speedboats.
1 speedboat/2 observer arrangement utilized center speedboat.

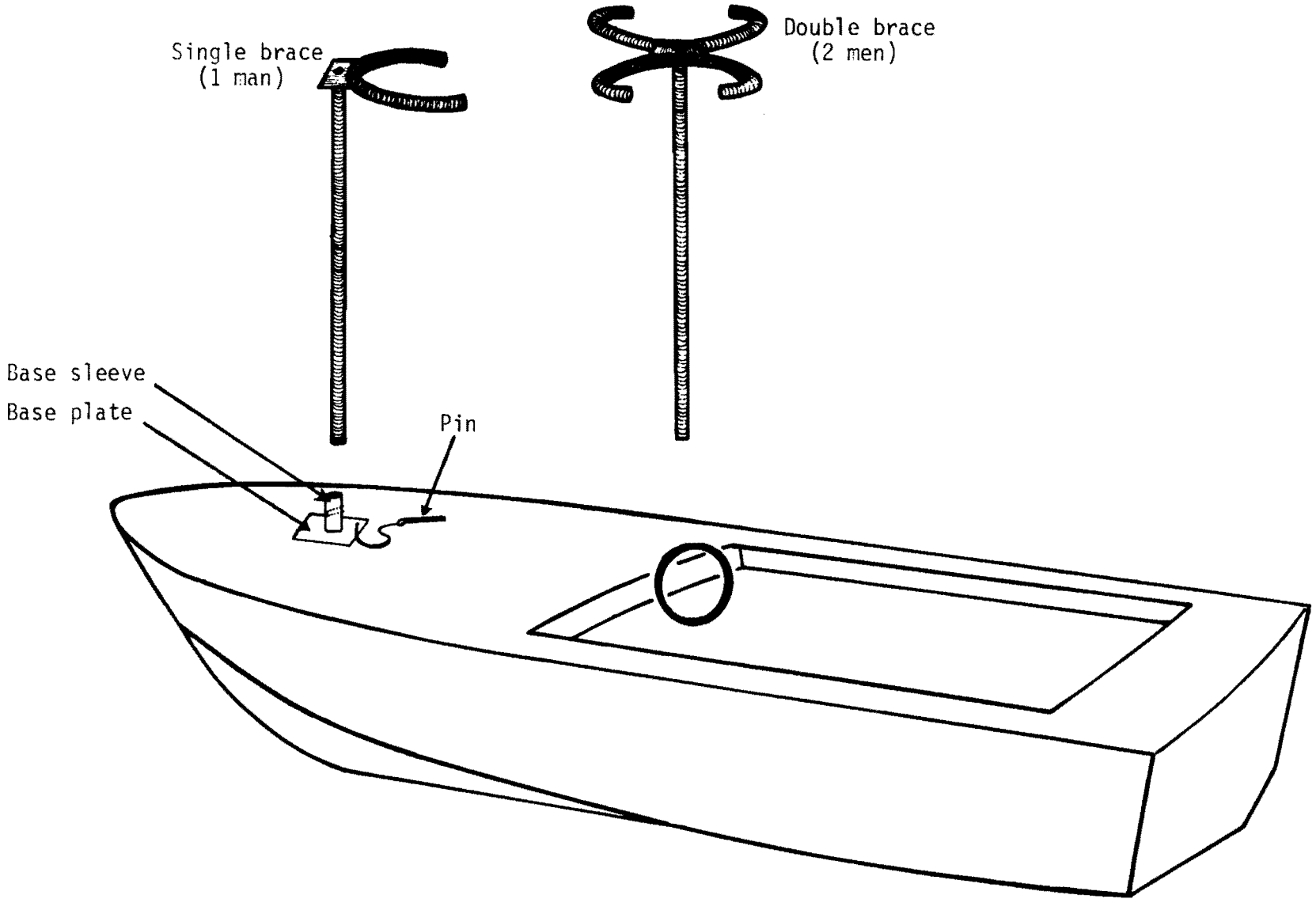

FIGURE 2. Aluminum speedboat and stands.

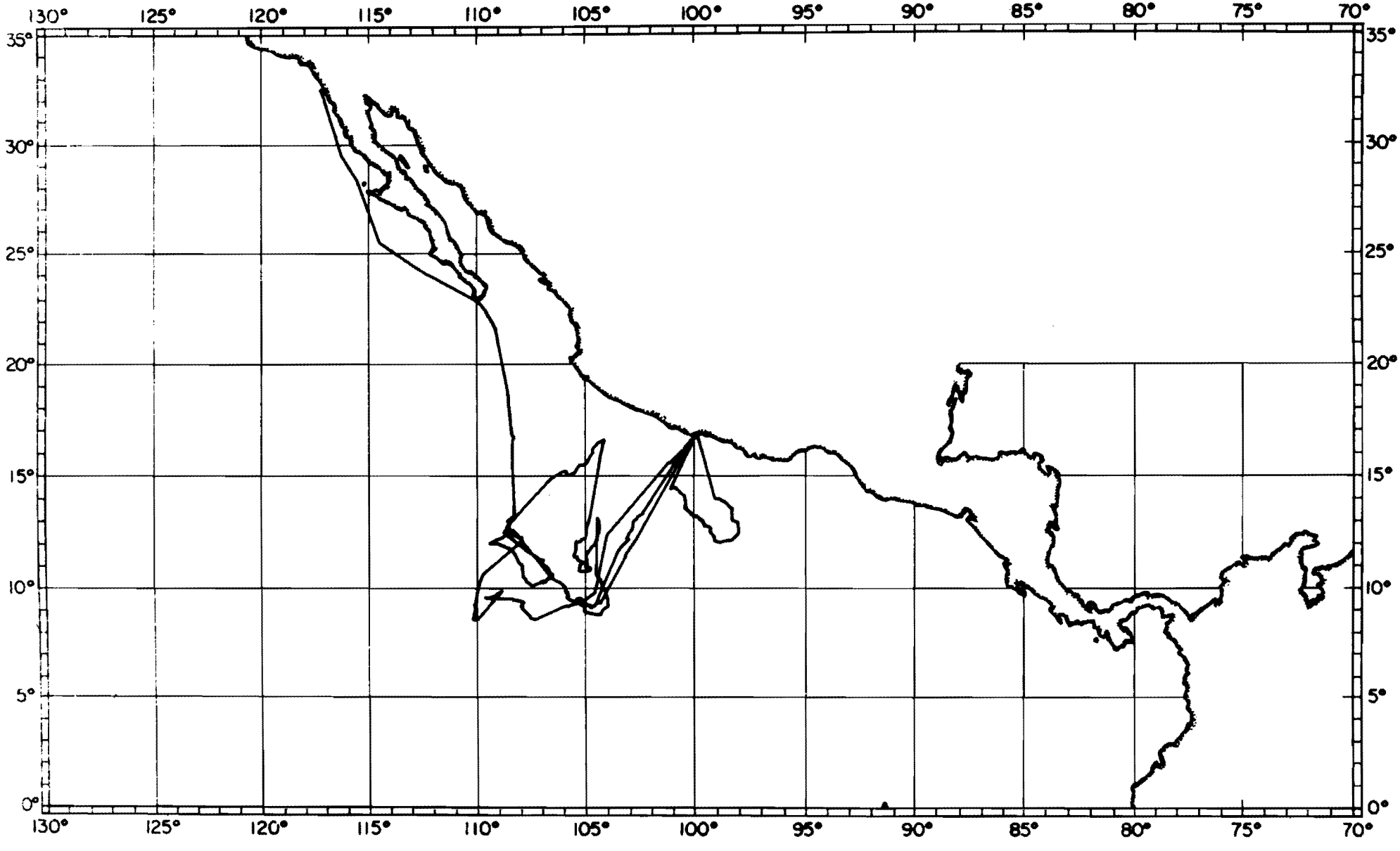

FIGURE 3. Cruise track of the M/V GINA ANNE, October 11 - November 25, 1980.

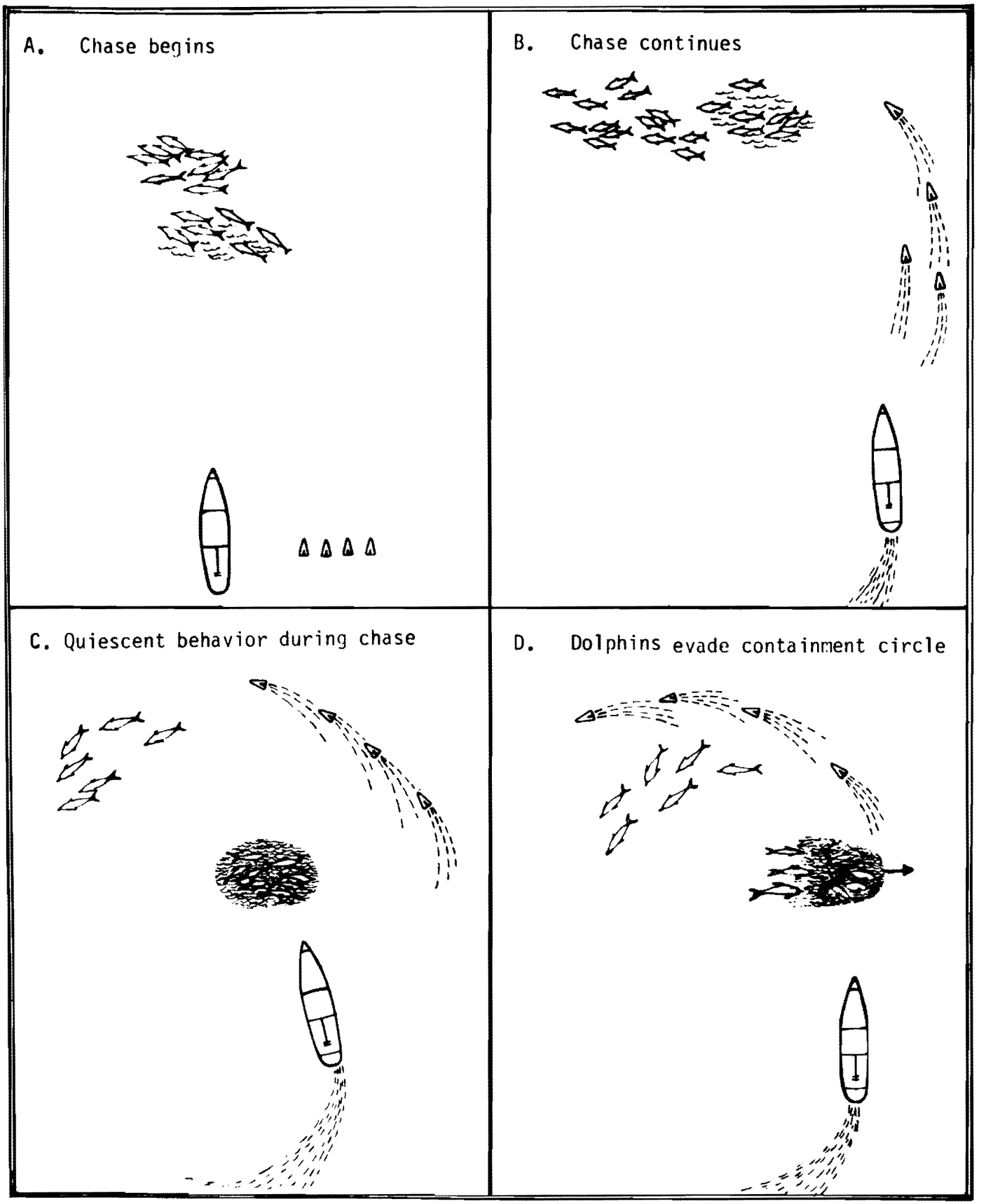

FIGURE 4. Dolphin chase sequence depicting quiescent behavior as evasive technique (After Holts, et. al., 1979)

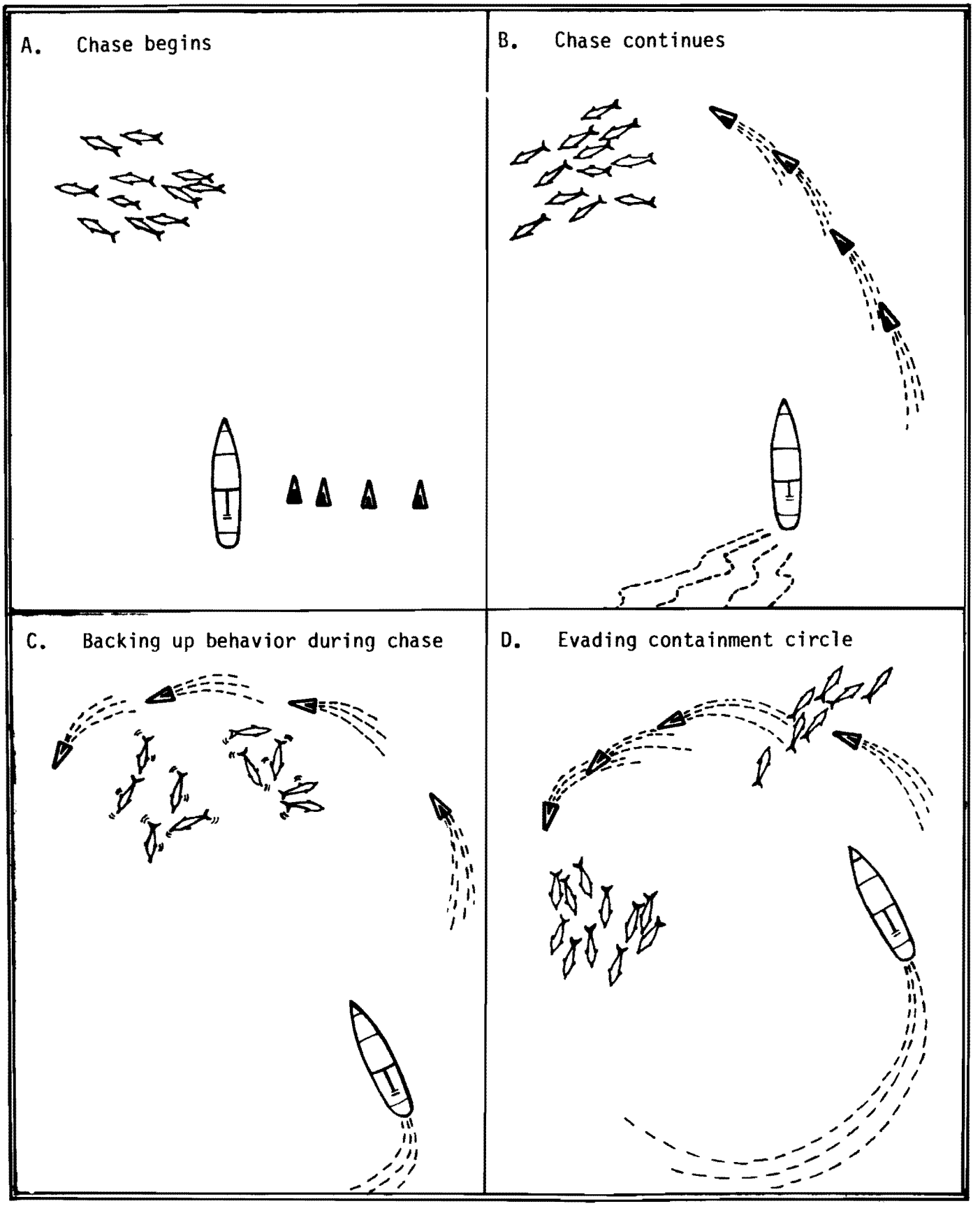

FIGURE 5. Dolphin chase sequence depicting "backing up" as an evasive technique (After Holts et al., 1979).

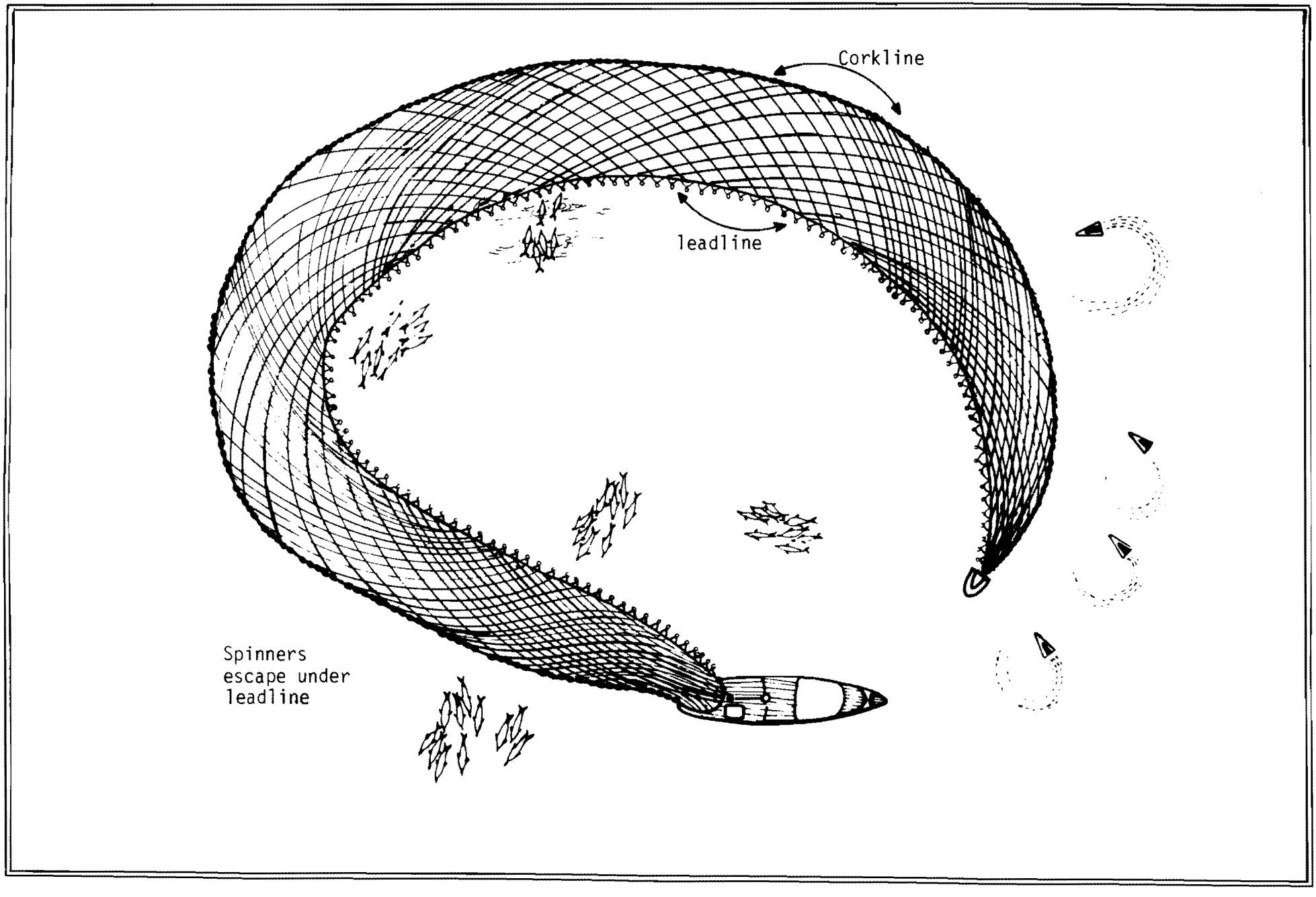

FIGURE 6. Dolphin evade containment circle by diving under the net behind seiner prior to encirclement.

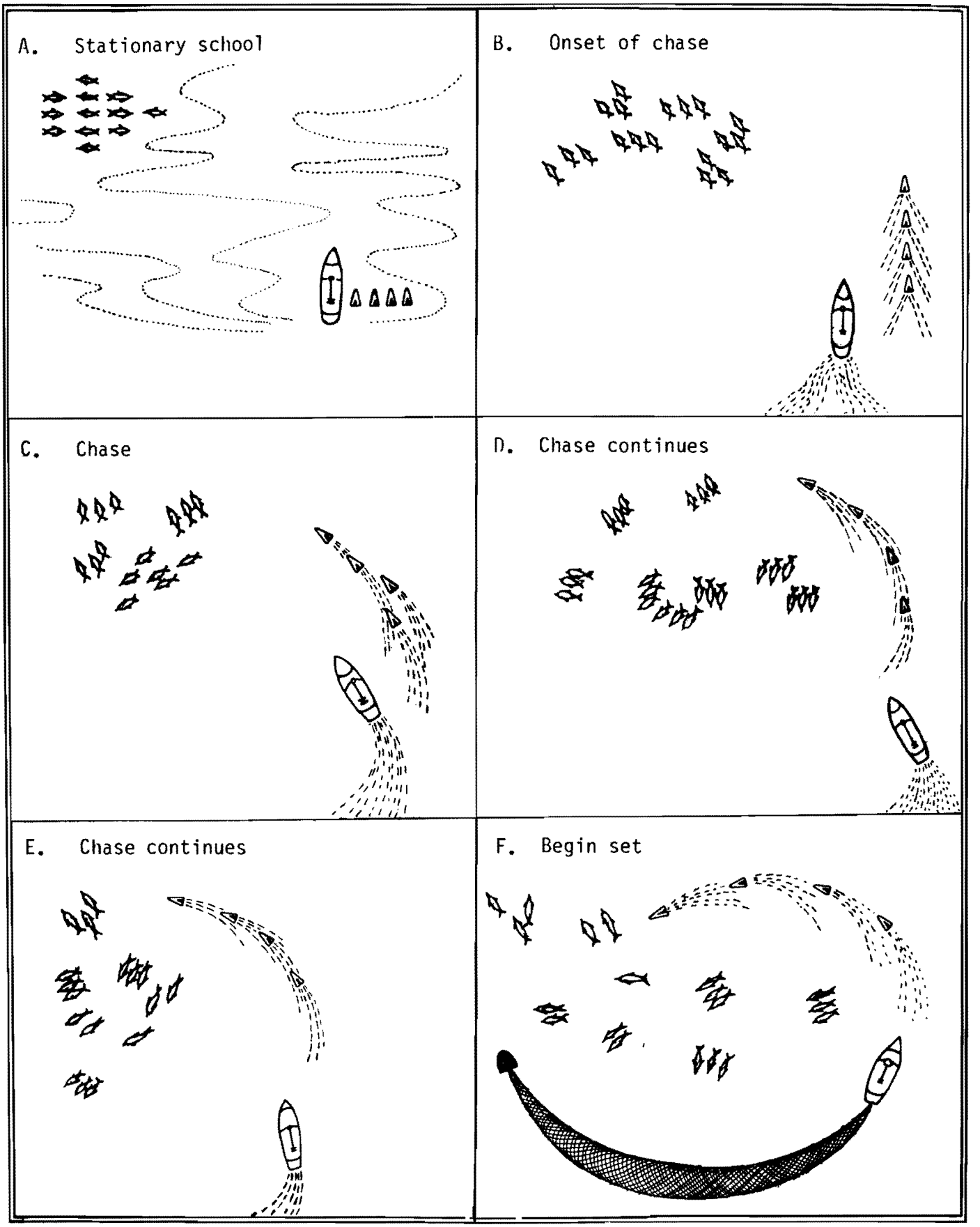

FIGURE 7. Dolphin school "exploding" during chase leaving part of the school out of the containment circle.

APPENDIX

Crew Members	
Capt. Pete Balestrieri	Captain
Mr. Wilbur J. Souza	Navigator
Mr. Heinz A. John	Chief engineer
Mr. Joseph Moniz	Deck boss
Mr. Steven Alexander	Helicopter pilot
Mr. Joe C. Jardin	
Mr. John R. Lewis	
Mr. Joel P. Rebelo	
Mr. Randall K. Takasugi	
Mr. Marcus J. Phares	
Mr. Nick Leano	
Mr. Gilberto Silva	
Mr. Jose Da Silva	
Mr. Lawrence Texeira	
Mr. Joseph Coito	
Mr. Jose M. Falante	
Mr. Jorge Espinoza	
Mr. Sabino G. Gil	

Scientific party		
Dr. Robin L. Allen	IATTC	Cruise leader
Mr. David A. Bratten	IATTC	
Mr. Jeffrey L. Laake	IATTC	
Mr. James F. Lambert	LMR	
LCDR Wayne L. Perryman	NMFS	
Mr. Michael D. Scott	IATTC	

Photographic party	
Dr. Eric G. Barham	NMFS
Lt. Terry D. Jackson	NMFS
Mr. Jeffrey L. Laake	IATTC
LCDR Wayne L. Perryman	NMFS
Mr. Michael D. Scott	IATTC