COOPERATIVE DEDICATED VESSEL RESEARCH PROGRAM

# Research Related to the Tuna-Porpoise Problem: Summary of Research Results from the First Cruise of the Dedicated Vessel, 26 January - 16 March, 1978

by

Mr. John DeBeer, Program Manager
Dr. Frank Awbrey, San Diego State University
Mr. David Holts, National Marine Fisheries Service
Mr. Paul Patterson, Living Marine Resources

Southwest Fisheries Center

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# PREFACE

Thousands of oceanic porpoise die annually incidentally in the course of purse seining for yellowfin tuna in the eastern tropical Pacific. Since the passage of the Marine Mammal Protection Act in 1972, there has been a significant reduction in this incidental mortality. However, the goal of the MMPA is to reduce incidental kill and serious injury to insignificant levels approaching a zero mortality and serious injury rate. Numerous research cruises undertaken since 1972, have contributed to the development of methods for reducing this incidental mortality. However, no single vessel had been designated to study and research this problem exclusively.

During all of the previous research cruises aboard tuna purse seiners the research was secondary to the capture of tuna, because the incentive to allow the researchers to work aboard the tuna seiner was the opportunity to capture tuna within a closed area.

For a number of years, it has been recognized that a vessel should be dedicated to do tuna/porpoise research without the pressure of fish capture to interfere with the research. During 1977 the United States Tuna Foundation offered to charter a tuna purse seiner for 1978 to be used exclusively for tuna/porpoise research.

The Dedicated Vessel Program is a cooperative tuna/porpoise research program under the joint direction of the Marine Mammal Commission (MMC), The National Marine Fisheries Service (NMFS), and the United States Tuna Foundation (USTF). The USTF has chartered a commercial tuna seiner, the M/V Queen Mary, for the calendar year, 1978, to be utilized as a platform for that research. NMFS, USTF, the National Science Foundation (NSF), and the MMC are providing research funds and/or support. Proposals for relevant research are accepted from all interested persons and organizations.

The research plan provides for five cruises of approximately 50 days each. Research goals are as follows:

A. Continue to reduce incidental and/or accidental porpoise mortality by:

1. transfer to the fleet of technological improvements in existing fishing systems, while

2. scaling down research emphasis on the existing system and phasing into major research emphasis on alternative fishing systems not requiring pursuit and/or encirclement of marine mammals.

B. To generate additional data which will lead to refined estimates of status of the porpoise stocks and impacts of the fishery on porpoise.

This report constitutes the final report from the National Marine Fisheries Service and Living Marine Resources on their portion of the research on Cruise I. No formal scientific papers are planned on their portion of the research. The acoustical data collected on this cruise will be included in a general paper on the acoustics of tuna purse seining which is currently in preparation.

## ABSTRACT

The objectives of Cruise I of the Dedicated Vessel were to test methods of pre-backdown release of porpoise from tuna purse seine nets, study and refine current backdown techniques, to define the bioacoustical parameters of the purse seine, to develop and enhance fishing methods which do not require the chase or capture of porpoise, to observe the effects of holding a school of porpoise in the net for an extended length of time, to obtain accurate counts of the porpoise captured in the net by taking movies as they leave the net, to collect porpoise blood for capture myopathy studies, and to collect life history data on all dead porpoise. The significant results were:

- There were 10 sets on porpoise, 17 sets on logs, and 4 sets on schoolfish. One hundred sixteen porpoise (116) were killed, and 159 tons of yellowfin were captured with the porpoise. The log sets produced 63 tons of yellowfin and 303 tons of skipjack tuna, and the schoolfish sets produced 4 tons of skipjack.

- Pre-backdown release of porpoise was tested unsuccessfully, because the porpoise could not be herded effectively and a controllable escape area could not be created.

- Additional information on, and understanding of net dynamics was acquired by SCUBA diving within the net and surface observations from a rubber raft.

- Bioacoustical recordings were made on schools of porpoise and the sounds of the purse seiner and associated work boats do not appear to contribute to in-net mortality of the porpoise.

- A preliminary analysis of sounds recorded in association with logs, where tuna were known to be present, indicated clicking sounds and the number of clicks per unit time appear to be related to the number of fish present.

- A small school of porpoise was confined to the backdown channel for 5 hours and 20 minutes, with no apparent panic, in preparation for porpoise tagging cruises. Four speedboats were able to easily keep the net open for that time.

The cruise was from 26 January to 16 March 1978, and the geographic area was the porpoise grounds in the eastern tropical Pacific.

The Cruise Leader was Mr. David Holts, NMFS. Other scientists were Dr. Frank Awbrey, SDSU, Mr. Donald Ljungblad, NOSC, Mr. Richard Butler, NMFS, Mr. Paul Patterson, LMR, Mr. Dale Powers, NMFS, and Mr. John DeBeer, Program Manager, Dedicated Vessel Research Program.

## I. Introduction

The National Marine Fisheries Service (NMFS), the National Science Foundation (NSF), and the United States Tuna Foundation (USTF), provided research funds for Cruise I of the Dedicated Vessel. Scientific personnel came from the NMFS, the Naval Ocean Systems Center (NOSC), Living Marine Resources (LMR), and San Diego State University (SDSU). They were Mr. David Holts, NMFS, Mr. Richard Butler, NMFS, Mr. Paul Patterson, LMR, Dr. Frank Awbrey, SDSU, Mr. Donald Ljungblad, NOSC, Mr. Dale Powers, NMFS, and Mr. John DeBeer, Dedicated Vessel Program Manager.

The Cruise departed from San Diego on 26 January 1978, and returned to San Diego on 16 March 1978, a 50-day trip. The trip was divided into two legs of 35 days and 14 days, with a 1-day stop in Puntareanas, Costa Rica on 2 March 1978, to exchange part of the scientific crew.

The area of research operations was the yellowfin tuna fishing grounds off Mexico and Central America within the Inter-American Tropical Tuna Commission's Regulatory Area (CYRA). (See Figure 1 for a general cruise track.)

## II. Vessel and Equipment

The M/V Queen Mary was built in 1969, is 151-feet long, has a 34-foot beam and a 17-foot draft. She is propelled by twin Caterpillar diesel engines, 1125 horsepower each, that provide a maximum speed of 12.5 knots. The vessel is equipped with a Caterpillar 333 bowthruster, a Marco #W1062 main winch, and a 42-inch power block. Depending on fish size, it can carry between 520-550 tons of tuna in seven pairs of brine wells and one pair of stern boxes. The net used during the cruise was 560 fathoms long, 11 standard 4 1/4-inch mesh strips* deep with 190 fathoms of double safety panel (1 1/4-inch mesh) and super apron. An experimental pre-backdown release system was installed between the mid-net zipper and the super apron prior to the trip but removed during the trip (see Figures 2-3).

## III. Objectives: Dedicated Vessel Cruise I

| General Goal: Mortality Reduction |
|---|

A. To develop pre-backdown release methods.

1. By developing and testing a controllable pre-backdown release area in the net which could be used to release porpoise during pursing and net roll operation.

*A standard strip is 100 4 1/4-inch meshes deep or about 5.9 fathoms.

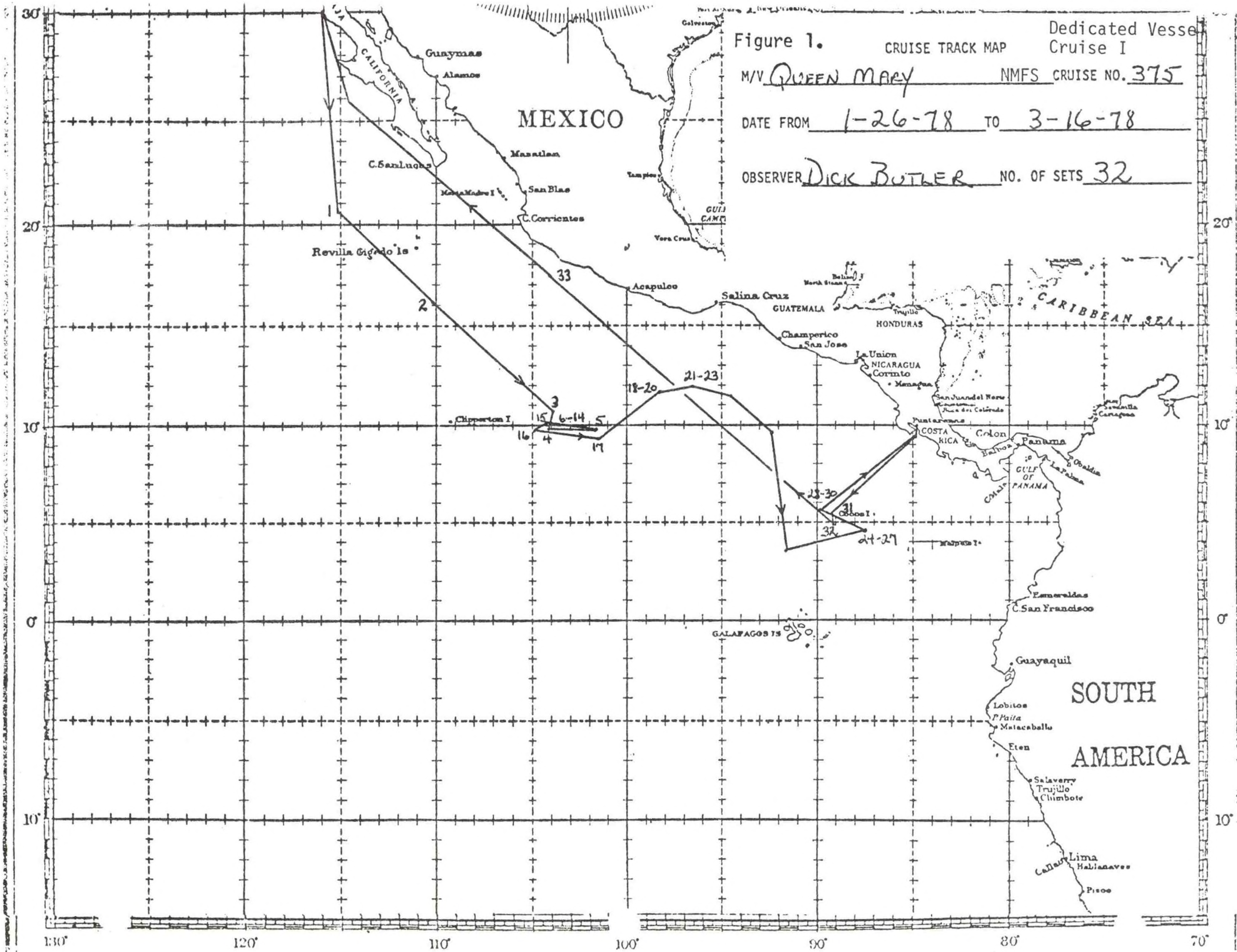



Figure 1. CRUISE TRACK MAP

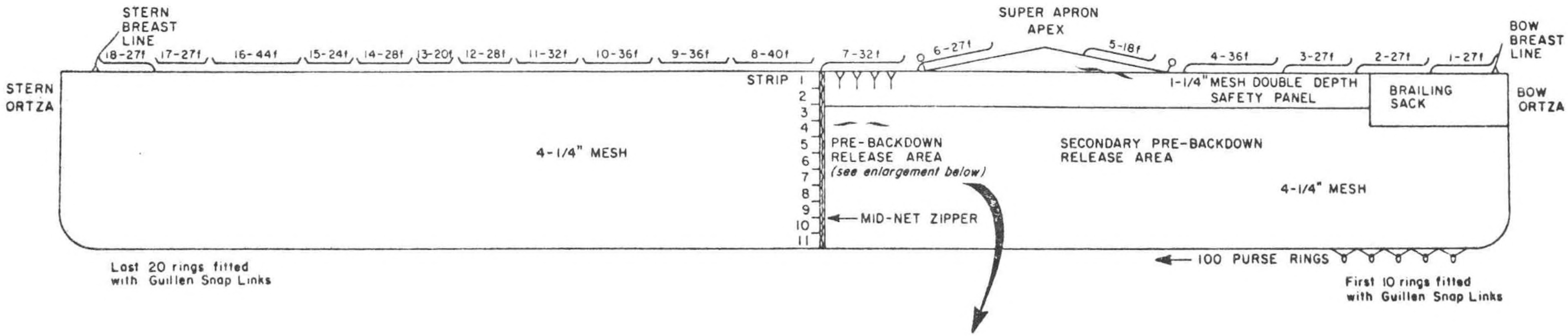
Dedicated Vessel Cruise I

M/V Queen Mary NMFS CRUISE NO. 375

DATE FROM 1-26-78 TO 3-16-78

OBSERVER Dick Butler NO. OF SETS 32

Figure 2. A schematic of the Queen Mary's net. The net is approximately 560 fathoms long.



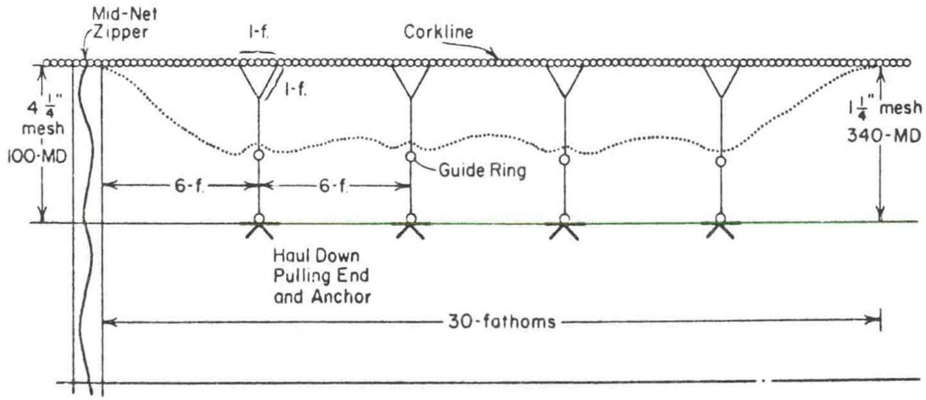




Figure 3. Downhaul System: The four downhauls were installed on the outside of the net and between the mid-net zipper and the stern end of the super apron. The downhaul lines were 6 fathoms apart, forming a 30 fathom release area. The dotted line shows the expected configuration of the corkline with downhauls employed.

2. By recording and playing back porpoise acoustical signals to act as a porpoise attractant for pre-backdown release.

3. By developing and testing techniques and devices to herd the porpoise out of the net using:

   a. speedboats,

   b. pingers,

   c. diver held strobe lights,

   d. inflatable rafts,

   e. bubble screens.

B. To continue to observe and optimize the backdown channel.

   1. By observation of the factors causing canopy formation and "stern sway".

   2. By detailed observation of the formation and decay of the backdown channel.

   3. By observation and location of any mortality occurring during backdown.

   4. By attempting to separate the tuna and porpoise during backdown to allow a more efficient backdown by creating a bubble screen with compressed air.

C. To observe and record in detail all porpoise mortality that occurred anywhere within a set.

D. To develop methods to decrease the impact of roll-ups and/or decrease the frequency of their occurrence.

   1. By continuing observation of the relationship of the purse cable and the net.

   2. By using Guillen snap links.

E. To continue to define the bio-acoustic parameters of the tuna/porpoise fishery.

F. To develop and enchance fishing methods which do not require the chase or capture of marine mammals.

1. By recording the acoustical signals of tuna associated with inanimate objects, i.e., flotsam, logs, etc.

2. By making sets on tuna not associated with porpoise.

3. By recording the acoustical signals of tuna associated with animate objects other than porpoise, i.e., whales, whale sharks.

4. By testing various tuna aggregating devices within sets and at other times.

General Goal: Stock Assessment

A. To observe the effects of long-term holding on schools of porpoise to determine the workability of whole school examination methods planned for future cruises.

B. To obtain accurate counts of porpoise captured in the net by taking movies of the porpoise as they leave the net.

C. To assess the effects of chase and capture on the schools of porpoise through blood serum analyses and studies of the porpoise adrenal glands.

D. To collect standard life history data on all dead porpoise.

## IV. Methodology and Results

General Goal: Mortality Reduction

A. Pre-backdown release of the porpoise

1. Creating a pre-backdown release area - the first priority of Cruise I was to attempt to create a controllable pre-backdown release area, i.e., sunken corks. If an area of the corkline could be controllably submerged prior to backdown, it was planned to test various mechanical and acoustical herding devices to encourage the porpoise to leave the net prior to backdown.

Prior to departure, the M/V *Queen Mary*'s fine mesh safety panel was extended to the mid-net zipper. Four "downhauls" devised by NMFS (Figure 2) were installed on the outside of the net between the stern end of the super apron and the mid-net zipper. It was anticipated that the "downhauls", when utilized, would allow the corkline to be lowered one to two fathoms during pursing, creating a controllable release area.

During Set #4, a schoolfish set, one of the downhauls tangled in the stacked corks as the net was being laid out. This resulted in a 3 1/2-fathom, triangular rip in the fine mesh. Another downhaul became tangled on the following set, Set #5, a log set, and pulled a pile of corks off the net pile but did not rip the net. Because of these problems, the decision was made to remove the downhauls and create a release area by reducing flotation on the corkline. Corks were removed a few at a time during the following sets until the corkline would sink about a fathom during pursing. In addition to this area, a second release area was established without modification to the net. Old and undersized corks in the area of the fourth bunchline (bow side of apron) had a strong tendency to sink during pursing. This sinking was maximized when the shape of the net was elongated after setting so that the fourth bunchline corks were further from the vessel than the mid-net corks. The corks in the mid-net release area sank more easily when the net configuration was circular. This condition existed because the downward forces on the corkline during pursing are strongest in the area furthest from the boat. Prior to setting it was not possible to determine which of the two areas would sink sufficiently to afford a pre-backdown release area. Some of the factors that influence the shape in which the net is set are: school size, whether the school is bunched or scattered, direction of setting with respect to the wind, wind speed, and water currents. For these reasons, <u>a fully controlled pre-backdown release area was not achieved</u>. However, on most of the sets some portion of the corkline sank deep enough (1/2 fathom) and was down long enough (7-9 minutes) so that if porpoise had desired to leave they could apparently have done so easily.

Sets on schoolfish and around logs were generally circular and resulted in sunken corks in the mid-net area, while porpoise sets were usually elongate and produced good sinking ($\geq$9 minutes) in the bow release area.

2. <u>Acoustic early release experiments</u> - Because sound is so prominent a feature of porpoise behavior, it might be useful for manipulating their behavior within the nets. Nets return echolocation signals very well but may prevent the animals from obtaining any acoustic information about the water on the other side. In this case, the net may be the acoustic equivalent of a visual cliff, which the animal will cross only with great caution. If provided with the proper signal from outside the net, the porpoise might be induced to cross the net. A test of this hypothesis was carried out by playing back recordings of spinner and spotted porpoise sounds from positions outside the release apron. Average playback level was approximately 145 dB re 1uPz. The first sounds tried had been recorded during backdown release on the <u>Elizabeth C.J.</u> in October 1976. Tapes of sounds made while animals were escaping and running away from the net seemed most likely to contain information which could inform the other porpoises that some were escaping.

During Set #2, the Elizabeth C.J. (ECJ) tape was played back to the porpoises, which did not respond. The control sound, a sweep from 4 kHz to 20 kHz and back to 4 kHz once per second, was also presented with no response. However, SCUBA divers were in the net raising the possibility that the porpoises were avoiding them and staying away from the release area. The ECJ tape was presented again to a herd of 200-300 animals, during Set #17, again with no apparent response. Because of the possibility that each area might have its own "language", the herd was also presented with a segment of its own recorded vocalizations. They did not respond, but again free divers were in the net. During Set #18, on the same morning, another tape was made and played back directly but a circling speedboat made the lack of response impossible to evaluate. The approximately 2,000 porpoise in Set #20 were presented with the sounds from Set #19 and without divers or speedboats in the way. There was no observable response. The porpoises in Sets #21, 22 and 24 were presented with the tape from Set #20 and again, none showed any discernable response.

3. Mechanical/other acoustical herding devices (speedboats/pingers) - Speedboats were used during two sets (Sets #24 and 25) to herd porpoise into the bow release area where the corkline was sunken 1-2 yards. In both trials the porpoise refused to pass over, or even approach the sunken corkline.

During Set #24 the two speedboats moved to within 30 feet of the porpoise before they began to move. As the porpoise approached to within 40-50 feet of the sunken corkline, they submerged and swam under the speedboats and surfaced at mid-net. The speedboats circled around and headed them back towards the bow area, however, by that time the pursing operation was complete and the corks had surfaced.

During Set #25 the speedboats had only herded the porpoise about 90 feet when the porpoise submerged and swam back under the speedboats to the stern area of the net. The speedboats circled behind the porpoise again and three 54 kHz pingers were deployed about 60 feet behind the porpoise. One observer thought there was some avoidance on the part of the porpoise, the others did not agree. As the speedboats began to circle again the porpoise moved about half the distance to the release area (approximately 50 yards) when they sank and again surfaced behind the speedboats. On the third attempt of this set they were moved to within 40 yards of the sunken corkline but refused to move further. The three 54 kHz pingers were deployed again but no response was detected.

A diver-held strobe light was used during Set #2 in an attempt to herd a small school of offshore spotters. As two divers approached at a depth of 4 fathoms the porpoise slowly moved away. The avoidance may have been caused by divers and/or the strobe light. No further tests involving the strobe lights were conducted.

Rafts were not used as herding devices prior to backdown because the surface area of the net is so large prior to "rings up" that the porpoise could easily out-maneuver a man in a raft.

Bubble screens were not tested as herding devices prior to backdown because the large distances involved made the idea impractical. (Prior to backdown the distance from the vessel to the furthest point on the corkline is over 100 yards.)

B. Studies designed to optimize the backdown channel

1. Canopy formation - Potentially hazardous canopies formed along the sides of the backdown channel in all 10 porpoise sets. These canopies became fully developed in the area approximately one-half to three-fourths the distance from the vessel to the apex of the backdown channel. They start to form as backdown begins and become progressively worse towards the end of backdown. During backdown most porpoise are released before the canopy areas become fully developed. When porpoise did remain in the net with fully developed canopies, they were usually few in number and in the apex area well away from the canopies. Canopies did not occur in the apex area of the channel.

2. Formation and decay of backdown channel

Direct underwater observations by SCUBA divers showed that just prior to backdown, on the sides of the backdown channel, the web hangs nearly straight to a depth that varied between 60 and 90 feet. As backdown begins, the net is pulled thru the water forming the backdown channel. The floor of the channel starts to rise and the walls of webbing on both sides become slack. The floor continues to rise during backdown to about 25 to 30 feet near the end of backdown. The canopies are formed along both sides as a result of water passing thru the slack webbing (Figure 4). Slack webbing along the bow side is pushed out and away from the channel while the stern side webbing is pushed into and across the channel.

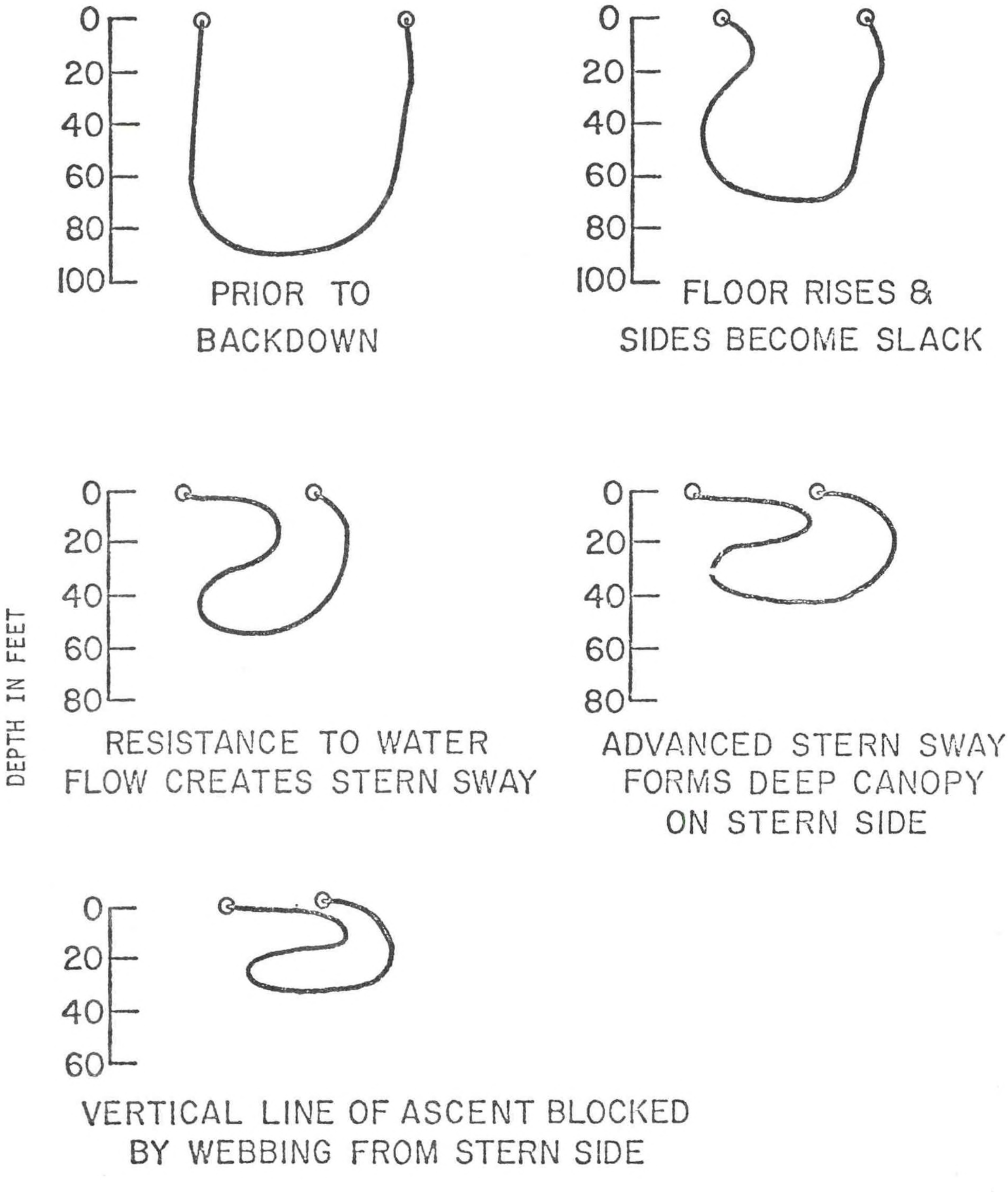



Figure 4. Development of stern sway and canopies during backdown.

The loose webbing being pushed into the channel from the stern side is commonly called the stern sway. The 1 1/4-inch mesh near the surface provided greater resistance to water flow and was affected more severely than the 4 1/4-inch mesh deeper in the channel. As this fine mesh is pushed across the channel, the vertical line of ascent becomes more and more restricted. The resulting canopy provided the greatest potential for entrapping porpoise. During this cruise, the stern sway always developed into a deep canopy. It is in this canopy that it is thought that 98 porpoise were killed during Set #20. (See the general discussion on mortality for backdown-related mortality.)

3. Bubble screens - The limited number of porpoise sets prevented tests involving the bubble screen system during backdown. Prior to departure of the cruise, NMFS personnel constructed an air hose intended to create the bubble screen. This hose was tested once alongside the ship. The air source was a SCUBA tank (72 cubic feet); the hose which was 33 yards long, was tested at a depth of 1 1/2 fathoms; the air was exhausted in 2 minutes.

4. Acoustical herding devices tested during backdown - Pingers (54 kHz at 9 watts peak power output with 3 milli-second pulse width and a 1 or 1/2 second pulse rate) were used during two additional sets in an attempt to alleviate specific problem areas during backdown. During Set #20, six offshore spotters swam toward the boat and were in danger of becoming trapped in the loose folds of webbing. One pinger was deployed between them and the loose webbing but they eventually swam past the pinger and became entrapped. All six were hand released over the corkline by two crewmen.

   During Set #27, one pinger from each of two rafts was deployed in the backdown channel. No obvious reaction was observed. One pinger was then lowered close to a group of nine offshore spotters displaying passive behavior. These animals slowly started to surface, but it was unclear whether the pinger was a factor in causing that behavior. At no time did either the yellowfin or skipjack tuna show any response to the pingers.

C. Discussion of Type and Location of Mortality

A total of 63 offshore spotters (Stenella attenuata) and 53 eastern spinners (S. longirostris) were killed incidentally to scientific research and/or the fishing operation (see Table 1). One hundred thirteen porpoise died as a result of backdown canopies, two animals from entanglement in the 1 1/4-inch mesh of the super apron and one from entrapment in a fold of webbing at the backdown apex. Mortality did not occur in five (50%) of the 10 sets made on porpoise.

Table 1. Summary of Porpoise Sets and Associated Mortality M/V Queen Mary, Dedicated Vessel, Cruise I, January 26 Through March 16, 1978

| Set # | Estimated Number Porpoise Captured | Percent Spotted | Percent Spinners | Number of Known Porpoise Killed: Spotted | Number of Known Porpoise Killed: Spinners | Tons Tuna Caught | Comments |
|---|---|---|---|---|---|---|---|
| 2 | 30 | 100 | 0 | 1 | 0 | 3 | Mortality due to entrapment in fold during backdown. |
| 17 | 500 | 100 | 0 | 0 | 0 | 1/4 | None |
| 18 | 275 | 10 | 90 | 0 | 2 | 15 | Entanglement in 1-1/4-inch mesh at backdown apex, three-four feet below surface. Raftman reported snouts caught in small mesh, not noticed if mesh was broken where snouts penetrated mesh. |
| 19 | 300 | 65 | 35 | 0 | 0 | 3 | None |
| 20 | 2,000 | 65 | 35 | 47 | 51 | 75 | Raftman/diver report seeing only four dead porpoise in the net after backdown. However, many dead porpoise came up at brailing. Speculate mortality due to entrapment in two canopies during backdown caused from crowding of porpoise and tuna. Approximately 30 to 70 tons of tuna were lost over corks. |
| 21 | 325 | 100 | 0 | 14 | 0 | 15 | Entrapment in canopy on bow side of super apron during start of backdown. Caused due to critical time delay at backdown (rescued sinking speedboat). |
| 22 | 225 | 90 | 10 | 0 | 0 | 3 | None |

| Set # | Estimated Number Porpoise Captured | Percent Spotted | Percent Spinners | Number of Known Porpoise Killed Spotted | Number of Known Porpoise Killed Spinners | Tons Tuna Caught | Comments |
|---|---|---|---|---|---|---|---|
| 24 | 250 | 100 | 0 | 0 | 0 | 23 | None |
| 25 | 100 | 100 | 0 | 0 | 0 | 10 | None |
| 27 | 300 | 100 | 0 | 1 | 0 | 12 | Entanglement in 1-1/4-inch mesh at apex during backdown. Raftman/diver reported seeing porpoise come up from bottom of the net, turn and charge the net. Lower jaw broken and stuck in mesh. |
| 10 | 4,305 | | | 63 | 53 | 159 | |

Mortality rates: 0.73 killed per ton of tuna caught and 11.6 per set.

Set #2: Approximately 30 offshore spotters and three tons of yellowfin tuna (Thunnus albacares) were captured. One adult female became entrapped in a deep fold of the fine mesh safety panel at the backdown apex. One crewman saw it struggling but could not reach it at the estimated depth of 3 fathoms. This fold was later eliminated by adjustment of the tie down points.

Set #18: A mixed school of about 275 offshore spotters and eastern spinners (10% and 90%, respectively) was captured with 15 tons of yellowfin tuna. Two sub-adult eastern spinners became entangled in the 1 1/4-inch mesh by their lower jaws and teeth. They were located about 4 feet below the corkline in the backdown apex. Both were struggling when recovered. However, when released over the corkline they slowly sank out of sight.

Set #20: At least 2,000 mixed offshore spotters (~65% of the total school) and eastern spinners (~35%) were captured with 100 to 150 tons of large yellowfin tuna. As backdown configuration approached, the porpoise and tuna moved into the backdown area. The weight and turbulence of the large body of tuna and porpoise apparently sank the bow side of the super apron prior to commencing backdown. At this time porpoise and some tuna started spilling out of the net. Backdown then commenced, and simultaneously, a large stern-side canopy and a smaller bow-side canopy formed. These canopies may have been caused by subsurface turbulences created by the moving tuna school. As the backdown continued, the tuna school moved to the apex of the backdown channel, holding the corks down. One scientist in a speedboat reported a body of tuna 4 feet deep going over the corks for 30-45 seconds. It was estimated that 30 to 70 tons of tuna were lost. At the end of backdown, one scientist in a raft with a face mask reported seeing only four dead porpoise in the net. However, by the completion of brailing, 98 dead porpoise (47 spotters and 51 eastern spinners) were counted. Most of the dead animals had net marks around their snouts, indicating entrapment in 4 1/4-inch mesh. This was a late afternoon set but backdown started an hour before sunset. Divers were not in the water and the low light level prevented direct observation of a deep canopy by surface observers. While this mortality was clearly a result of a deep canopy, it is not fully understood why these animals became trapped. One possibility is that the acoustical playback that occurred during pursing and net roll was the cause. This is unlikely because playback had terminated prior to backdown and there were no playback related problems in the six other sets in which playback occurred. Another more likely cause, is that the estimated 100-150 tons of fish had in some way forced the porpoise under the canopy. Most observers agreed, however, that this mortality was simply a case of too many fish and porpoise in a small area. Biological life history data were collected from 77 of these animals.

Set #21: Approximately 325 offshore spotters and 15 tons of yellowfin tuna were captured and held for 5 hours, 20 minutes. Fourteen offshore spotters died in a bowside surface canopy resulting from a procedural problem at the start of backdown. The four speedboats used to hold the backdown channel open were still attached to the corkline as backdown began. One of these was pulled backward and swamped with water. A 15 minute delay ensued while the sinking speedboat and driver were towed to the vessel and recovered. The backdown channel collapsed during this delay and a bowside surface canopy developed. The last bunchline was released to free the trapped porpoise and then pulled back in before the second backdown started. The 14 dead porpoise were just below where the canopy had occurred.

Note: During hand rescue operations on this set, one of the scientists (Mr. Donald Ljungblad) rescued a small porpoise from a small canopy on the portside of the backdown channel. The animal was released over the corkline and began to sink. Don grabbed it again, pulled it into the rubber raft and squeezed its side several times and observed signs of life. He then slapped it twice on the side of the head with the flat of his hand, it took a breath, was released, and swam away.

Set #27: An estimated 300 offshore spotters were captured with 12 tons of yellowfin tuna. One adult, female spotter became entangled in the fine mesh at the backdown apex. It appeared to have bitten loose webbing about 4 feet below the corkline. This webbing apparently was then pulled tight during backdown, which forced the teeth of its rostrum and lower jaw into the fine mesh. This also forced the animal's mouth open to the extent that the lower jaw was broken. It was dead when first observed by rescuers.

D. Roll-ups - No roll-ups occurred during this trip, nor was there an occasion that the net came up in the rings. The Guillen snap links were never used to alleviate roll-ups because no roll-ups occurred. Also, they were not used to roll the net prior to backdown to shorten the set because on schoolfish and log sets, the Captain wanted the stern bend to form and on porpoise sets, other higher priority experiments were taking place.

E. Bioacoustical parameters of a purse seine set - On Thursday, January 26, 1978, the sounds produced by the *Queen Mary* and attendant small craft were recorded in local deep water off San Diego during a practice set. Thirty-five minutes of tape were recorded during all stages of the set which normally would affect porpoise, from the initial high speed chase through backdown. The same procedures were followed as in previous sets.

by the Elizabeth C.J. and the Michaelangelo with comparable results. Underwater sounds were detected with a calibrated Naval Ordinance Test Set (NOTS) underwater sound level meter/ hydrophone assembly and recorded on a Nagra SJS[c] scientific tape recorder at 37 cm sec $^{-1}$. System response was ± 2 dB from 20 Hz to 35 kHz. Tapes were analyzed with a Rockland 512-S-17[c] FFT spectrum analyzer. Although the seiner in a high speed chase generated some sound at frequencies as high as 25-30 kHz, almost all its sound energy is below 5 kHz. Sound pressure level during the chase was 120 dB (re 1μPa) at 400 m.

As with the other purse seiners examined, the loudest sounds within the hearing range of propoises were generated by the clashing together of steel pursing rings during pursing. These highly transient sounds contained a great deal of energy in the same frequency range as most of the whistles produced in the net by porpoises. Impulse noise levels of 143 dB were recorded from places where the porpoise would be located within the net. Noise levels after pursing and before backdown are primarily low frequency and of reduced level. They are produced mainly by auxiliary generators, hydraulic pumps and winches.

No actual porpoise sets were made with calibrated sound level measuring equipment, but observations were consistent with those made from the Elizabeth C.J. in October 1976. Porpoises did not appear to be strongly affected by sounds from fishing equipment. Whistling and clicking continued unabated during the entire time the animals were inside the net enclosure and did not change markedly with changes in ship noise. The animals did show some change in activity when the ship's bowthruster was employed. The change was an increase in swimming activity and was not interpreted as any kind of "panic".

These observations reinforced the conclusions drawn from data and observations obtained during fishing with the Elizabeth C.J., i.e., with spotted and spinner porpoise stocks in the Commission Yellowfin Regulatory Area, sound produced by the seiner and its associated boats does not appear to contribute to in-net porpoise mortality.

F. Alternative fishing techniques

If tuna fishermen were provided with more efficient methods of catching tuna not associated with porpoise the number of porpoise sets and associated mortality might drop. Any seiner which finds a "log" (all floating objects are called logs by fishermen) with fish will stay with it as long as it keeps producing fish. A more efficient way of ascertaining whether or not a log is "carrying fish" is needed. To this end, sonobuoys were used to listen to the sounds associated with logs.

1. Acoustical signals of tuna with flotsam - A sonabuoy was deployed on Set #5, a log set, but the ship's noise overshadowed any sounds made by the fish. The next morning the ship moved away from the log and a recording was made. After Set #7 was made, the vessel moved about a mile away from the log to diminish the ship's noise and recorded a breezer (a school of yellowfin and skipjack tuna) on the log. The vessel then left to search for porpoise and excellent recordings were made of "breezers" from up to 4 miles away. Later in the afternoon as the vessel returned to the log, excellent recordings of the breezer were made again. During Sets #8 and 10, sound calibration levels were recorded. After Set #10 sounds associated with the log were again recorded as the vessel moved away from it.

   Set #26 was on a large, irregular metal tank. Acoustic recordings were made prior to the set as well as after the set.

   Sets #28, 29, and 30 were on three 55-gallon drums welded together. Some excellent recordings were made before and after Sets #28 and 29. Although Table 2 indicates only 8 tons of tuna were caught in the above three sets, there was a very large body of fish associated with the drums. Thus, the amount of tuna associated with the drums is not reflected in the capture because the tuna could evade or escape the net.

   In those cases where tuna were known to be present on logs, short duration clicking sounds were detected. Spectrum analysis shows them to have peak energy at approximately 5 kHz (Dr. Frank Awbrey, unpublished data). The number of clicks per unit time appears to be related to the number of fish present. Peaks at the same frequency also are found on some tapes made during porpoise sets. Techniques are available for detecting and characterizing these sounds aboard purse seiners. This preliminary finding is very promising but further evaluation is needed.

   If these results are confirmed, acoustic listening devices could or would allow fishermen to deploy floating fish aggregators (artificial logs) and then monitor several of them at a distance for the presence of commercial quantities of fish.

Table 2. Summary of non-porpoise sets, M/V Queen Mary, Dedicated Vessel Cruise I, January 26 thru March 16, 1978.

| Set Number | Set Type | Tons of Yellowfin (Thunnus albacares) | Tons of Skipjack (Katsuwonus pelamis) | |
|---|---|---|---|---|
| 3 | Schoolfish | 0 | 0 | |
| 4 | Schoolfish | 0 | 4 | |
| 5 | Log (a) | 2 | 38 | |
| 6 | Log (a) | 0 | 3 | |
| 7 | Log (a) | 3 | 12 | |
| 8 | Log (a) | 0 | 0 | |
| 9 | Log (a) | 4 | 23 | |
| 10 | Log (a) | 12 | 17 | |
| 11 | Schoolfish | 0 | 0 | |
| 12 | Log (a) | 17 | 18 | |
| 13 | Log (a) | 5 | 7 | |
| 14 | Log (a) | 0 | 0 | |
| 15 | Log (a) | 10 | 18 | |
| 16 | Log (a) | 2 | 13 | |
| 23 | Schoolfish | 0 | 0 | |
| 26 | Log (b) | 0 | 0 | |
| 28 | Log (c) | 0 | 0 | |
| 29 | Log (c) | 4 | 4 | |
| 30 | Log (c) | 0 | 0 | 4 days to to and from Puntarenas, Costa Rica (sets 30–31) |
| 31 | Log (c) | 2 | 100 | |
| 32 | Log (c) | 2 | 50 | |
| TOTAL | | 63 | 307 | |

(a) a well-seasoned, natural log, 3 ft. diameter, 8 feet long
(b) an irregular shaped tank
(c) three 55 gallon drums welded together

2. Sets on tuna not associated with porpoise - There were 17 sets made on logs on the first trip. A well-seasoned log, 8 feet long by 3 feet in diameter, with lots of barnacles, small red crabs, and other marine life attached to it was located at about 1500 on 2 February 1978, at 9°43'N, 101°49'W. Sets #5-10, and 12-16 were made on this log over a period of 9 days. During this period a radio beacon was left on the log so that when the vessel left to search for porpoise or other schoolfish, it could return. The log essentially was home base for the 9 day period. A total of 204 tons of tuna were caught in association with it. During that period, the log traveled almost 200 miles due west (Figure 5). This may be because of the currents, but more likely because the wind blew the vessel and log as they were tied together (mostly at night).

   Another "log" (three 55 gallon oil drums welded together) was located on 28 February 1978, at 5°38'N and 84°58'W. Three sets were made on this log before the Queen Mary left to go to Puntareanas, Costa Rica to drop off a portion of the scientific crew. A radio beacon was left on the log and the vessel returned to it 4 days later and made two more sets (see track of log on Figure 6). A total of 162 tons of tuna were captured on these drums.

3. Acoustical signals of tuna associated with live animals other than porpoise - No schools of fish associated with whales or whale sharks were encountered.

4. Artificial aggregating devices - Three artificial aggregating devices were constructed and deployed. They were constructed of black plastic, PVC pipe and net floats. The first was deployed on 2 February 1978. It collected a number of small red crabs, (*Pleuroncodes* sp.) overnight but no bait fish. On 9 February, another aggregating device was constructed of PVC pipe, net floats and old netting. It was deployed unattached to the vessel, and set free overnight. By the next morning it had collected three small fish (sp. unknown).

   On 10 February, another aggregating device was constructed and set for 2 days. It accumulated a couple of scoops* of bait (sp. ?) a number of dolphin fish (*Coryphaena* sp.) and some sharks, but no tuna. (See Figure 7 for a drawing of the aggregating device.)

*A scoop of bait is about 8 pounds.

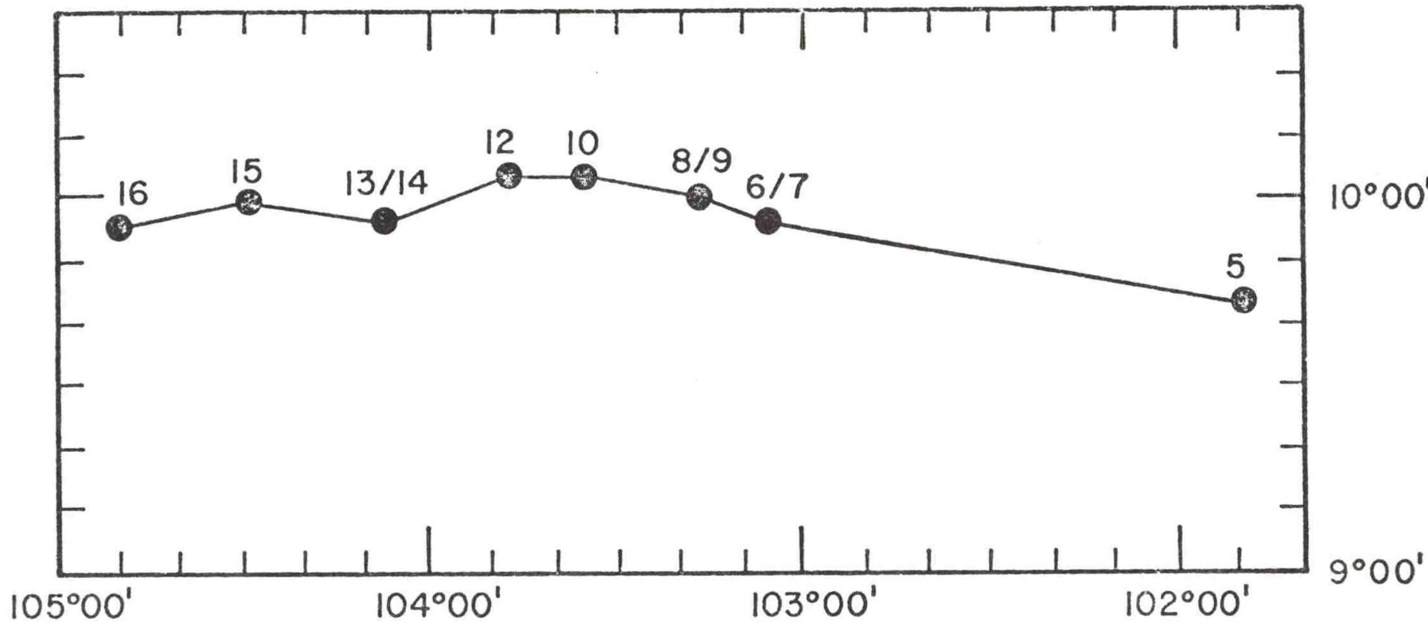



Figure 5. Sets #5-10 and 12-16 were made on the same log over a period of 10 days, February 4-February 13, 1978. This is the track of the set location.

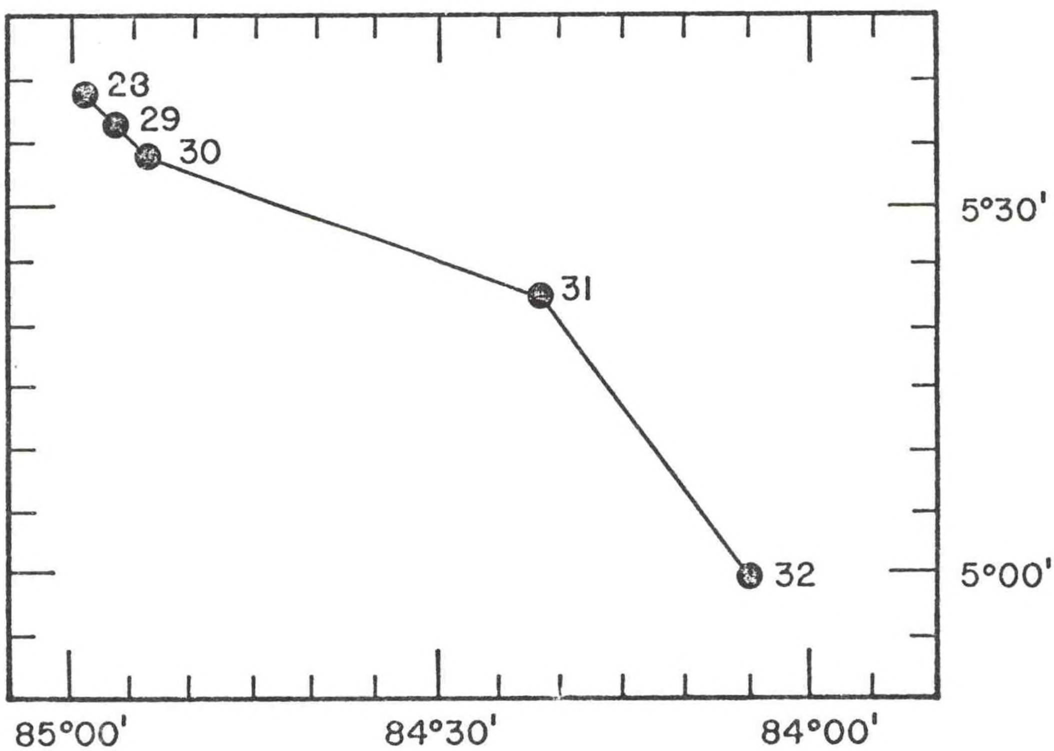



Figure 6. Sets #28-32 were made on the same log over a period of 8 days, February 27-March 6, 1978. This is the track of the set location.

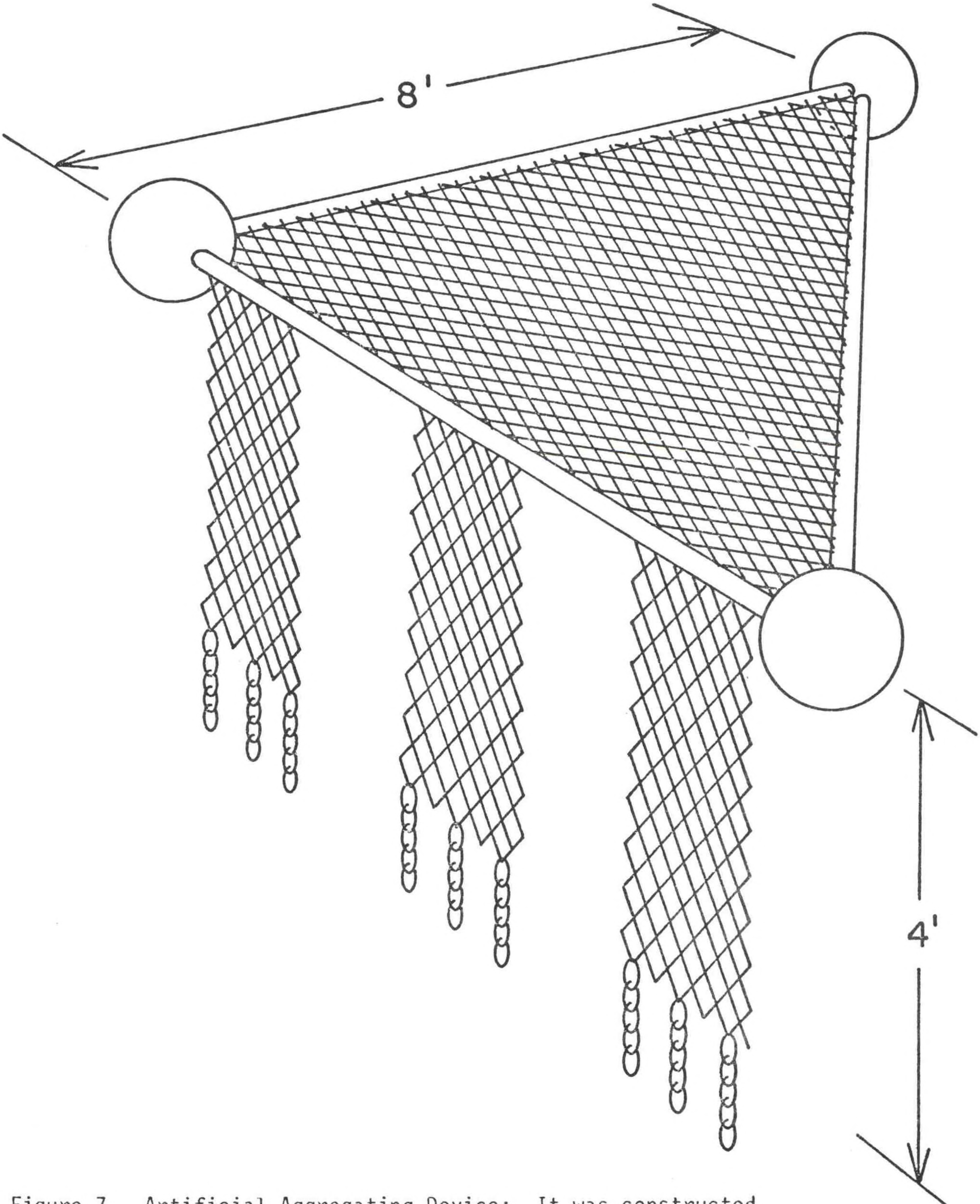



Figure 7. Artificial Aggregating Device: It was constructed of Schedule 40 PVC pipe, standard net floats, 2 inch knotless netting (salvaged from old brailer netting), and various pieces of old chain and rings for weight.

The last two aggregating devices released were left floating, with a sealed bottle attached. A note giving the date and location of release was in the bottle and the note asked that if any tuna were captured on the log, Dr. Frank Awbrey be notified.

No aggregating devices were tested within the net. It was common for the skipper to set the net near the log with the log outside the net and to have a speedboat to hold the log near the net, in hopes that the tuna would stay near the log and not try to escape under the cable or the corks.

## General Goal - Stock Assessment

### A. Long-Term Holding

The second priority of Cruise I was to hold a school of porpoise for an extended length of time. The research plan called for holding 5 or 6 schools but the required conditions of locating a small school, early enough in the day during good weather, occurred only once during the trip.

During Set #21, approximately 325 offshore spotter porpoise, 15 tons of yellowfin tuna and one adult oceanic white-tip shark (Carcharhinus longimanus) were held for 5 hours and 20 minutes. The set proceeded normally through the tie-down for the backdown operation. The vessel was then slowly backed down to effect a broad backdown channel. At this point about 20 to 25 offshore spotters began to entangle in the apex area of the apron. No mortality occurred however, and 16 escaped over the corklines as the channel formed. The vessel's main engines were shut off and the seine skiff maintained a light strain on the vessel throughout the holding experiment. Four speedboats were used to hold the sides of the channel open (Figure 8). The channel's shape remained nearly constant throughout the experiment. Surface area available for porpoise was 2000±350 square yards.

During the long-term holding set, observers were watching the porpoise from rubber rafts, so that they could alert the Captain to start backing down in case the porpoise began to panic and charge the net. The porpoise remained calm throughout the entire holding period and filled only about 1/3 of the surface area at any one time. Porpoise at the surface went through cycles of increased and decreased activity, however, underwater porpoise always stayed calm and appeared to maintain subgroupings. The tuna swam slowly back and forth through the channel passing below or beside the porpoise. The shark swam slowly around the holding area and caused no problems.

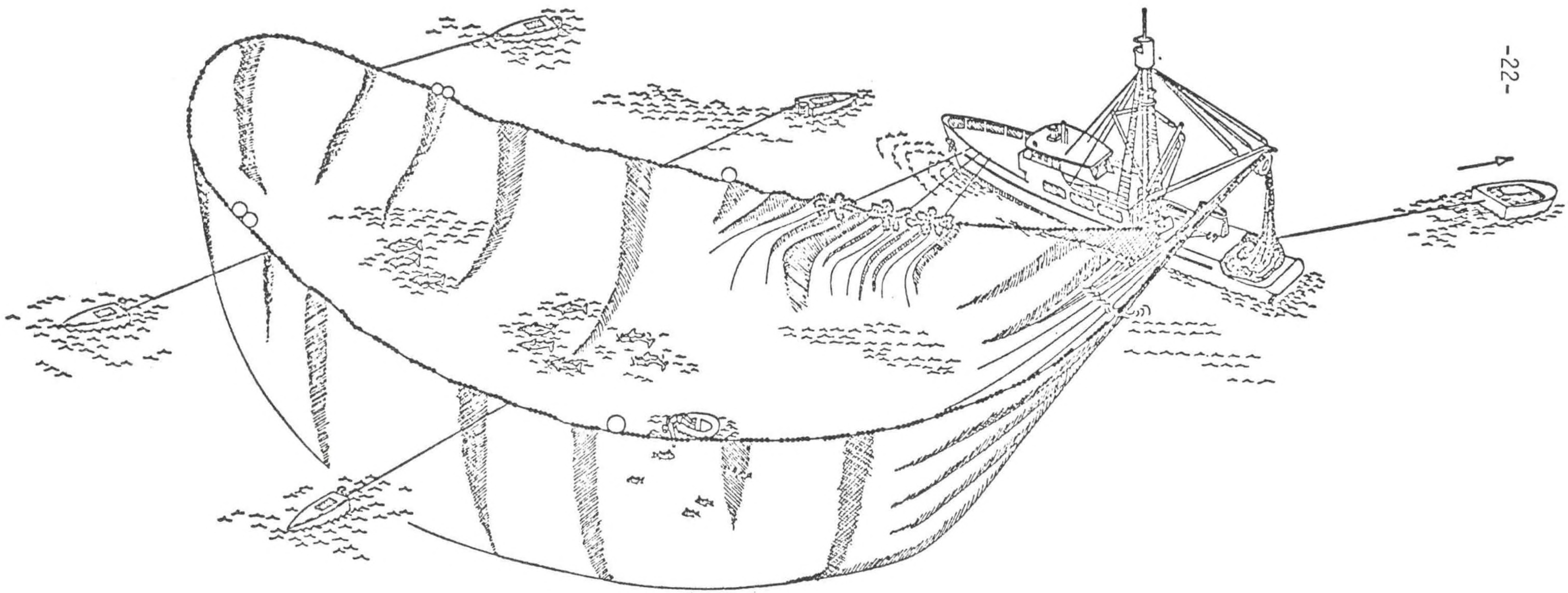


Figure 8. Configuration of net and speedboats during LONG-TERM HOLDING experiment. Surface area available for porpoise was approximately 2000 square yards.

An interesting behavior pattern noted of the porpoise and tuna, was that at times individual porpoise would leave their subgroupings and swim around or to the surface for a breath, but the yellowfin tuna always remained together in a fairly tight school.

The experiment was terminated because there were reports of high winds and heavy swells about 60 miles away and the Captain wanted the net and skiff aboard before bad weather hit.

Both the scientific crew and the ship's crew agree that the porpoise could have been held much longer with no problems, and that after an initial adjustment period of 15-30 minutes, the porpoise settled down and remained calm. Several times during the holding period single juvenile spotters would give a bit of an aerial display but that was not considered unusual because juvenile spotters were giving aerial displays and landing on their sides before the rings were up.

At the end of the holding period, backdown started with all four speedboats still attached to prevent possible net collapse. One of the speedboats was pulled backwards shipping in a great deal of water and started to sink. This caused a 15 to 20 minute delay while the speedboat and driver were towed to the vessel. The backdown channel collapsed during this period and a canopy developed on the bowside of the channel. Fourteen porpoise died as a result of entrapment in the canopy. This mortality was unrelated to the objectives of the holding experiment, however, it is strongly recommended that all speedboats disconnect prior to starting the backdown procedure.

B. Obtaining Accurate Counts of Porpoise As They Leave the Net

A single attempt was made to photograph the porpoise from a speedboat as they left the net. The plan was found not to be feasible because the camera did not have a wide enough lens to record all of the porpoise leaving the backdown apex. Due to the numbers and behavior of the porpoise it is impossible to keep track of every animal so as not to double count them.

C. Collection of Samples for Blood Serum Analysis

1. Blood samples - Post mortem blood samples were collected from 10 offshore spotters for physiological stress analysis.

2. Adrenal glands - A pair of adrenal glands were collected from one offshore spotter.

D. Life History Data and Other Biological Specimens from Dead Porpoise

1. Life history data - Standard NMFS life history samples and data were collected from 47 offshore spotters and 41 eastern spinners.

2. Other biological specimens - Heads and liver samples were collected from 10 offshore spotters and 10 eastern spinners for parasite studies by the Naval Ocean Systems Center.

## V. Conclusions, Recommendations, and Implications for Further Research

Thirty-three sets were made on the first cruise of the Dedicated Vessel (see Table 1 and 2 for summary statistics). Two of the sets were water hauls; the first set was made to adjust the super apron and the last set was made to wash the net. There were 10 sets made on porpoise, 17 sets on logs and four sets on schoolfish. One-hundred-sixteen porpoise were killed and 159 tons of yellowfin tuna were captured with porpoise. Log sets produced 63 tons of yellowfin and 303 tons of skipjack tuna, while the schoolfish sets produced four tons of skipjack.

| | Number of Sets | Yellowfin | Skipjack | # Killed |
|---|---|---|---|---|
| Porpoise | 10 | 159 | 0 | 116 |
| Logs | 17 | 63 | 303 | - |
| Schoolfish | 4 | 0 | 4 | - |
| Total | 31 | 222 | 307 | 116 |

A. Pre-Backdown Release

The pre-backdown release experiments were unsuccessful because the porpoise could not be herded effectively, and a controllable escape area could not be created. The downhaul system was removed after the fifth set because it became entangled with and ripped the net. The corkline could not be sunk controllably, even with reduced flotation.

After several acoustical playback tests elicited no observable response from the porpoise, playback tests were terminated. The method appeared to be of no value in the circumstances under which it was tried. To be of value during regular fishing operations, the system would have to use relatively simple equipment which does not interfere markedly with normal procedures; it also would have to contribute to the regular release of porpoises. The system used met the first criterion but not the second and so does not appear to be a viable technique for early release of porpoises.

Two speedboats were used to herd the porpoise within the seine but the direction the porpoise would take to avoid the speedboats was unpredictable. On three occasions the porpoise dove beneath the speedboats and resurfaced in the original starting position near the stern. Additionally, pingers (54 kHz) appear to be of no value in herding the porpoise; the porpoise showed no response to the pingers on four trys to affect their behavior.

NOTE: Backing down is essentially a mechanical process of removing porpoise from a purse seine net. The vessel moves backwards and pulls the net from beneath the porpoise. For a porpoise to remain in the net on purpose during backdown, it must swim towards the boat, for if it is near the surface and remains motionless it will be flushed from the net.

Pre-backdown release, on the contrary, requires that an opening be created (i.e. a sunken corkline), and then the porpoise must move across the corkline under its own locomotion. The vessel and net are not as easy to control prior to backdown as they are during backdown. Although there have been many reports in the past of porpoise exiting the seine, over a sunken corkline, only a portion of the school would be involved in this pre-backdown escape. The rest of the school would have to be backed out of the net, and subjected to any hazards associated with backdown such as stern sway and canopies. Thus, for pre-backdown release to be more effective than backdown it would have to eliminate the backdown.

Strobe lights to herd porpoise were tested only once by SCUBA divers. The strobes appear to be of little or no value in herding porpoise. The divers felt the porpoise avoided their presence as much as they did the strobe lights. Yellowfin tuna also showed no response to the strobe lights.

Rafts and bubble screens were not tested as herding devices for pre-backdown release because the large distances involved made both ideas impractical.

B. Observations of the Backdown Channel

It is hypothesized that nearly all of the mortality on Cruise I occurred because of backdown canopies. The stern sway canopy formed on each porpoise set, and it is thought that this is where 98 porpoise were killed in Set #20. Detailed underwater observations by SCUBA divers of the backdown channel would be very beneficial for the understanding of the formation of stern sway and backdown canopies. Items that need special scrutiny are: 1) the timing and dynamics of the rise of the floor of the backdown channel, 2) the amount of slack webbing on the sides of the backdown channel that is available to form canopies, 3) and the formation and decay of these canopies and stern sway, and 4) the observation of mortality related to these events that have been heretofore unobserved. Currently it is hypothesized that stern sway and backdown canopies are an inevitable part of backing down. If this is so, then perhaps new techniques will have to be developed to circumvent those problems. If stern sway and backdown canopies can be avoided by merely modifying the backdown procedure, i.e. backing down with less of an arc, backing down faster or slower, then these procedures need to be ascertained.

C. Bioacoustical Parameters of a Purse Seine Set

The sounds produced by the purse seiner and its associated work boats does not appear to contribute to in-net porpoise mortality of spotter and spinner porpoise stocks within the CYRA. The porpoise appear not to be affected by the sounds of the fishing equipment. Whistling and clicking continued unabated during the entire time the animals were inside the net enclosure and did not change markedly with changes in ship's noise.

D. Alternative Fishing Techniques

Preliminary analysis of the sound recordings made on logs, where fish were known to be present, indicated the presence of short durations clicking sounds with a peak at every 5 kHz. The number of clicks per unit time appears to be related to the number of fish present (Dr. Frank Awbrey, personal communication). These preliminary findings are very promising but further recordings and evaluation of logs are needed. If these clicking sounds can be correlated to the number of fish present near a log, acoustical listening devices could be used by fishermen to monitor several logs for quantities of fish. Much of the research during Cruise III of the Queen Mary in June-July will be directed towards further evaluation of acoustics to detect and possibly to attract yellowfin and skipjack tuna.

The artificial aggregators deployed were very primitive. Although they were deployed in an area of tuna, they had not attracted any tuna to them at the times they were checked. Many natural logs were checked for signs of tuna in the course of the first trip and only a few of them had any appreciable quantities of tuna. Thus, the types of artificial aggregating devices which will attract tuna, are as yet unknown.

E. Long-Term Holding

The long-term holding set was an unqualified success. The porpoise were confined to the backdown channel for 5 hours and 20 minutes with no apparent panic. This set was made in preparation for Cruise II of the Dedicated Vessel, during which it is anticipated that some porpoise will have to remain in the backdown channel until it is their turn to be processed through the Porpoise School Impoundment System (PSIS). Both the scientific staff and the ship's crew are in agreement that long-term holding of spotter porpoise will present no problems, if the net can be kept open.

F. Using a Hand Held Movie Camera to Count Porpoise as They Leave the Net

This effort was not productive for two reasons. The camera lens was not wide angle and could not capture all of the porpoise leaving the net; and the time porpoise spent beneath the water as they left the vicinity of the purse seiner could not be estimated reliably.

## VI. Environmental Data

Weather and sea state data were collected during each net set. A total of 50 XBT traces were collected.

## VII. Acknowledgements

The scientific personnel would like to extend their thanks to Captain Ralph F. Silva, Jr. and the crew of the Queen Mary for their assistance and cooperation during Cruise I.

## VIII. Scientific Personnel

Mr. David B. Holts, NMFS, Cruise Leader, Dive Master
Mr. Richard W. Butler, NMFS
Mr. Paul Patterson, LMR
Dr. Frank Awbrey, SDSU (1st leg)
Mr. Donald Ljungblad, NOSC (1st leg)
Mr. John DeBeer, Program Manager (1st leg)
Mr. Dale Powers, NMFS (2nd leg)

Submitted by: John DeBeer
John DeBeer
Program Manager

Approved by: Frank Alverson
Mr. Frank Alverson, LMR

William F. Perrin
Dr. William Perrin, NMFS

R Hofman
Dr. Robert Hofman, MMC