COOPERATIVE DEDICATED VESSEL RESEARCH PROGRAM ON THE TUNA-PORPOISE PROBLEM: OVERVIEW AND FINAL REPORT

by

JOHN DEBEER
PROGRAM MANAGER
1630 Burgundy Road
Leucadia, California 92024

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ABSTRACT

Thousands of oceanic porpoise are incidentally killed each year during the course of purse seining for yellowfin tuna in the Eastern Tropical Pacific. The Cooperative Dedicated Vessel Research Program was a year-long government/industry research effort intended to: (1) refine and develop fishing gear and/or practices so as to further reduce the incidental mortality or serious injury of porpoise; and (2) provide demographic and biological data needed to better assess the impacted porpoise stocks. The Program was carried out under the terms of a tripartite agreement among the Marine Mammal Commission (MMC), the National Marine Fisheries Services (NMFS), and the United States Tuna Foundation (USTF). Pursuant to the terms of the agreement, the USTF chartered the M/V Queen Mary and made it available from January through December, 1978.

This report summarizes the research that occurred on the five cruises of the Dedicated Vessel. Detailed reports were published for each cruise. Thirty-two scientists representing 10 organizations participated in the at-sea research. The vessel spent 234 days at sea, 15 days on local sea trials or experimental shore-side testing, and 116 days in port. There were 137 sets: 7 test sets, 78 porpoise sets, 17 log sets, and 35 schoolfish sets. Almost 50,000 porpoise were chased and approximately 25,000 were captured. There were 225 porpoise killed and 1,234 tons of tuna taken incidental to the research. The research investigations covered four general areas: mortality reduction, alternative fishing methods, stock assessment, and porpoise behavior.

Mortality Reduction: Purse seine performance was observed and parameters were measured by SCUBA divers to refine the understanding of the purse seine process. Film footage was shot to produce a training film to demonstrate effective methods for releasing porpoise.

Alternative Fishing Methods: The ideas tested for developing alternative fishing techniques included certain aggregating devices, tuna olfactory attractants, and tuna detection systems. None were successful.

Stock Assessment: A Porpoise School Impoundment System (PSIS) was used to examine 1,320 porpoise for age and sex, disc-tag 656 porpoise and inject 331 porpoise with tetracycline for growth studies. Schools of tagged porpoise were radio-tracked four times and recaptured twice. Twenty-seven disc-tagged porpoise were recaptured. Forty-nine blood samples were collected for capture-myopathy research, and 71 porpoise were necropsied for diseases.

Behavior Studies: The focal-animal sampling system, previously used only for terrestrial animals, was successfully used to study captured porpoise. A total of 135 5-minute case observations of porpoise were made. The sub-groups comprising a porpoise school were described.

The results of the Program provided tools and techniques for significant breakthroughs in stock assessment and behavioral research. The results of the mortality reduction research will be used to further refine methods for reducing porpoise mortality.

Recommendations are made for further research.

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I. INTRODUCTION

The tuna/porpoise issue is an extremely complex, multi-species, multi-national, multi-cultural problem. The heart of the issue is that thousands of oceanic porpoise (*Stenella* spp., *Delphinus delphis*, and others) are incidentally killed or seriously injured each year during the course of purse seining for yellowfin tuna (*Thunnus albacares*) in the Eastern Tropical Pacific (ETP). The problem results from the fact that tuna and porpoise are found in association with each other so that the porpoise are herded and encircled with purse seines in order to catch the tuna associated with them.

Congress addressed the tuna/porpoise problem in the Marine Mammal Protection Act of 1972. It directed the Secretary of Commerce to conduct research to develop fishing gear and practices which would allow porpoise to escape from the nets unharmed, thereby reducing the incidental take to insignificant levels approaching a zero mortality and serious injury rate. The Act also created the Marine Mammal Commission and charged it with reviewing activities affecting the conservation and protection of marine mammals and recommending such actions as it deems necessary to further the policies of the Act to appropriate Federal officials. Under Section 101(a)(2) of the Act, commercial fishermen are required to obtain permits to take porpoise in the course of commercial fishing operations. They are also required to fish in accordance with regulations promulgated by the Assistant Administrator for Fisheries, NOAA, to whom the Secretary of Commerce has delegated responsibility for administering and enforcing relevant provisions of the Act.

Since passage of the Act, a great deal of at-sea research has been conducted to assess the status of the impacted porpoise stocks and to develop methods and gear for reducing the incidental injury and mortality of porpoise. This research has lead, among other things, to the development of improved fishing gear and practices which, coupled with regulations and the continuing efforts of the U.S. tuna fleet, has resulted in the reduction of porpoise mortality from about 390,000 in 1972 to about 15,000 in 1978. During the same time period, the number of porpoise killed per ton of tuna caught has been reduced from about 0.90 to about 0.36.1/

1/ These figures do not include porpoise killed or injured by "foreign flag" fishermen.

Almost all of the research, except for aerial and research ship surveys, has been conducted from tuna seiners. Most of the research carried out aboard tuna seiners has been secondary to the capture of tuna because the incentive for the seiners to carry researchers has been the opportunity to take tuna within an otherwise closed area (i.e., the IATTC's Yellowfin Tuna Regulatory Area). The exceptions to this "fishing" incentive were the twenty-vessel test of the Bold Contender System and the Fine Mesh Medina Panel System in 1976 and the behavior/gear/acoustic research carried out during the October-November 1976 cruise of the Elizabeth C.J. (Coe and DeBeer, 1977; Norris, Stuntz and Rogers, 1978). In the former case, provision of a substantial amount of free webbing was the incentive for the skippers to conduct gear research; in the latter case, the charter agreement included payment of $75,000, as well as the opportunity to fish within the Yellowfin Tuna Regulatory Area during the closed season.

For almost as long as the MMPA has existed, the Marine Mammal Commission (MMC), the National Marine Fisheries Service (NMFS), and the environmental community have requested that the tuna industry provide researchers with a tuna purse seiner staffed with an experienced crew to be "dedicated" exclusively to research efforts related to the tuna/porpoise problem. The MMC, the NMFS and the environmental communities felt that, although certain kinds of research could be conducted under commercial fishing conditions, there were many research projects that could not be accomplished without interfering with the normal fishing practices in a major way. Brief examples of this research are (1) testing porpoise release gear or techniques which may result in the loss of the captured tuna and (2) tagging and examining large numbers of porpoise.

In 1977, in response to a request for a dedicated vessel, the United States Tuna Foundation (USTF) offered to charter a purse seiner for the calendar year 1978, and, on 30 December, 1977, the MMC, the NMFS, and the USTF entered into a cooperative research agreement covering the use of the vessel. The goals of the "Cooperative Dedicated Vessel Research Program" were to (1) further refine procedures and gear to reduce incidental porpoise mortality, (2) assess the practicality of developing fishing methods as an alternative to catching tuna with porpoise, (3) conduct stock assessment research on the porpoise populations impacted by the fishery, and (4) conduct research on the behavior of the tuna and the porpoise in the fishery.

A. Background on Mortality Reduction Research

The primary technique of releasing porpoise is to "back down" (Coe and Souza, 1972). After the net is set and

and pursed, about half of it is rolled aboard the seiner and stacked neatly on the stern, awaiting the next set. The net is then fastened securely to the seiner, and the seiner travels backward through the water. The act of backing down confines the porpoise to a fairly small area, and, as the boat is propelled backward through the water, the net is pulled from beneath the porpoise. Although some of the porpoise seek release actively, by trying to escape over the corks, the majority of them are "washed" out of the net.

During the past 8 or 9 years, modifications of gear and fishing practices have resulted in a ten-fold reduction in the mortality rate of porpoise. The major changes involve measures to protect the porpoise in the backdown area. In addition to backdown, the first change was the introduction of the 2-inch-mesh Medina panel. This was followed by the Bold Contender System and the fine-mesh (1¼ inch) Medina panel. The introduction of the super apron, in use at this writing, is considered to be the most effective porpoise release gear developed (Everett, 1977).

Although there has been a dramatic reduction in the levels of porpoise mortality since the passage of the MMPA, if further reductions in the incidental kill or injury are mandated, research to improve gear and procedures must continue.

However, it should be recognized that the exact cause or causes of the observed drop in deaths and injuries is not fully documented and that further reductions in the mortality rate may prove difficult. The dramatic decline has occurred because the small-mesh webbing reduces the possibility of entanglement and because the new techniques have helped skippers control the net. They have learned (1) to set so that the wind keeps the seiner out of the net during pursing and net retrieval, (2) to use speedboats to adjust the net to prevent or ameliorate collapse, and (3) to tie down the net at the same point so that backdown channel configuration is the same from set to set. Crewmen in rafts or speedboats, manually removing the porpoise from the net, have also helped to reduce mortality. Further reductions probably can be achieved by refinement of existing fishing gear and practice, but obtaining zero mortality and injury may well require development of practical alternatives to "setting-on-porpoise."

B. Background on Development Alternative Fishing Methods

Sixty to seventy percent of the porpoise deaths in the last few years occurred during "disaster sets" (sets killing

16 or more porpoise), but these sets accounted for only 4 or 5 percent of the total sets.[1] In over half (55 to 60 percent) of the sets in which both porpoise and tuna are captured, all the porpoise leave the net safely. Even the best of skippers, fishing with the most modern seiners and the latest release gear, will experience some mortality, and, because of the vagaries of weather, subsurface currents, or equipment breakdowns, the danger of a large kill always exists. Thus, unless setting on porpoise is abandoned altogether, the risk of some porpoise mortality and injury will always be present.

As one alternative to catching tuna associated with porpoise, it has been proposed that the tuna be attracted away from the porpoise to artificial aggregators so they can be seine-caught without catching the porpoise. The research is in its infancy, and a fundamental question that must be answered is: what is the attraction between the tuna and the porpoise? Although numerous theories have been formed to describe the tuna/porpoise bond, none have been proved or have even been tested. These theories range from the supposition that porpoise and tuna have formed a mutual relation based on food to the conjecture that porpoise serve merely as objects in the ocean on which the tuna can orient themselves. It seems clear, however, that the tuna follow the porpoise once the bond is formed.

It follows, therefore, that a better understanding of the tuna/porpoise bond could prove helpful in solving the problem that confronts the tuna purse seining industry, i.e., how to catch the large tuna normally associated with porpoise and at the same time meet the intents and provisions of the MMPA.

C. Background on Stock Assessment Research

The MMPA of 1972 directs the NMFS to assess the status of the porpoise stocks affected by commercial fishing operations.

To achieve a reliable assessment of the status of porpoise stocks in the tuna-fishing areas, it is essential to accurately estimate and monitor species composition, population size, age/sex composition, and birth/death rates. Data acquired by line transect methods during aerial and ship survey are used in estimating the size of porpoise populations. In this procedure, average school size and school density are the bases for the estimates. School size is the critical variable here because there presently is no method for verifying the number of porpoise in a sighted school.

1/ Paul Patterson, Porpoise Rescue Foundation, personal communication, 9 May, 1979.

Another way of making population estimates is through mark/recapture (tagging) studies. In this method of estimating population size, school size may not be a critical variable, although other variables (e.g., rate of capture/escapement) may bias the estimate. Tagging and tag recovery information also help determine the migration patterns of the porpoise and aid in estimating mortality rates, data that are useful in the overall assessment of the status of porpoise stocks.

A knowledge of the age and sex structure of the porpoise populations is important because these parameters, combined with birth and mortality rates, determine whether the population levels are increasing, decreasing, or remaining steady. At present, it is assumed that the incidental mortality is cross-sectional with respect to age and sex structure. If, however, one age group or one sex is not represented proportionally in the kill, then the estimates of the impact on the population may be biased. Hence the need to examine entire schools.

D. Background on Behavioral Studies

The importance of porpoise behavioral studies is four-fold. First, a knowledge of porpoise behavior may contribute to the development of improved gear and procedures to reduce porpoise mortality. Observations made during the October-November, 1976, cruise of the Elizabeth C.J., for example, confirmed anecdotal reports of live porpoise lying in the bottom of the backdown channel (Norris, Stuntz, and Rogers, 1978). The observations were communicated to the fishermen so that the men hand-rescuing the porpoise could look for these passive porpoise and make sure that they were released. Second, it is important to observe porpoise behavior to determine whether the porpoise appear to be stressed heavily while they are in the seines. If the animals are heavily stressed, then perhaps the fishing mortality rate is not limited to those animals killed in the seine but might include animals that die later because of the stress of chase and capture. Third, it is important to observe porpoise behavior to obtain knowledge on how these species are adapted to their environment and may respond to changes in their environment. Fourth, it is important to make and compare observations of the behavior of different species within the purse seine. For example, why do common dolphins, <u>Delphinus delphis</u>, have a higher mortality rate in the seine than spotters or spinners? Is it because of their behavior, and can anything be done about it?

II. <u>DESCRIPTION OF THE COOPERATIVE DEDICATED VESSEL RESEARCH PROGRAM</u>

During 1976 and 1977, numerous meetings to plan the Cooperative Dedicated Vessel Research Program were held by members of MMC, NMFS, and the Porpoise Rescue Foundation (PRF), the tuna/porpoise research organization funded by the tuna industry. At these meetings, the general research goals were outlined, and tentative research assignments by cruise were made. Near the end of November, 1977, the final research plan[1/] was drafted, and, in it, five cruises and the general research for each cruise were outlined.

On December 30, 1977, the tripartite agreement among MMC, NMFS, and USTF on the use of a dedicated vessel was signed[2/]. Among other points, the agreement provided that: (1) the USTF would charter the M/V Queen Mary at the UTSF's expense and make it available for research during 1978, (2) the Queen Mary would spend not fewer than 250 days at sea on research, (3) the parties to the agreement would select a program manager for contracting by MMC to coordinate and manage the research program on a day-to-day basis, (4) a Program Board, composed of representatives of each party to the agreement, would oversee the implementation of the program, (5) the parties sponsoring the research would be solely responsible for all costs and expenses of the research, and (6) tuna incidentally caught in the course of the research would be the property of the USTF.

The M/V Queen Mary was captained by Mr. Ralph F. Silva, Jr., and owned by Joseph Medina, Jr. The Program Board was Mr. Franklin G. Alverson, Living Marine Resources (LMR); Dr. William W. Fox, NMFS; and Dr. Robert J. Hofman, MMC (Dr. William F. Perrin replaced Dr. Fox on September 18, 1978). The Program Manager was Mr. John DeBeer.

Although much of the research to fulfill the program objectives was tentatively outlined before the interagency agreement was signed, proposals for relevant research were solicited from numerous organizations and individuals once the program was under way. The researchers were informed that (1) the research had to deal with the tuna-porpoise problem and (2) each organization must provide its own funding, other than ship support.

Each cruise had a major emphasis, e.g., mortality reduction, stock assessment, or behavioral research, with additional research to take advantage of all opportunities. At least 2 months prior to a cruise, organizations scheduled to participate on the cruise submitted detailed research proposals to the Program Manager. The Program Manager combined the proposals into a draft cruise plan, and submitted the draft to the Program Board and others for comments and suggestions.

1/ Alverson, F.G. Plan for Dedicated Vessel Research, Calendar Year 1978, dated November 28, 1977.

2/ Copies of the tripartite agreement are available from the signatories.

Following receipt of comments, the Program Manager prepared a final cruise plan and submitted it to the Program Board for approval.

A Cruise Leader, appointed to head each cruise, held planning meetings, attended by the investigators, the captain, navigator, vessel owner, Program Manager and Program Board, to introduce the cruise participants and discuss the research plan. A pre-cruise meeting was also held on the seiner, at which time the scientists were introduced to the crew and were given a tour of the vessel and the research goals were explained to the crew.

After each cruise, the Program Board was briefed on the results of the cruise, and the Cruise Leader and other principal investigators submitted trip reports to the Program Manager. The individual trip reports were compiled into one cruise report, and each cruise report was reviewed and approved by the Program Board. Six cruise reports (two for Cruise III) were issued. They are listed in Appendix A.

A complete analysis of all the data and observations collected on the Dedicated Vessel has not been completed at this time; however, numerous reports and publications are expected from the research. A partial list of expected reports is presented in Appendix B. When this report was written, the Program Board had recommended archiving copies of the field notes and set logs, the cruise reports, and all of the slides, movies, and photographs from each cruise in the San Diego History Research Center (SDHRC), located in the Love Library, San Diego State University, San Diego, California 92182.

III. DESCRIPTION OF THE M/V QUEEN MARY

The M/V *Queen Mary* is a modern tuna purse seiner, built in 1969. It is 151 feet long, has a 34-foot beam, and a 17-foot draft. It 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 seine winch, and a 42-inch power block. Depending on fish size, it can carry between 520 and 550 tons of tuna in seven pairs of brine wells and one pair of stern boxes. The net is 560 fathoms long, 11 standard strips deep with 190 fathoms of porpoise safety panel (1¼-inch mesh), two strips deep, and a standard super apron (Figure 1). The *Queen Mary* carries four speedboats to herd the porpoise.

The vessel was built to accommodate 15 fishermen; however, it normally operates with 14 men. During the Dedicated Vessel Research Program, five extra bunks were installed to accommodate the scientists. Other equipment installed during the year included a 3-ton crane, an aluminum arc welder, an air compressor and storage bottles, a -60°C freezer, a centrifuge, and radio-tracking antennas. All the equipment was removed at the end of the year. The specialized research equipment used on each cruise is described in the individual cruise reports.

IV. RESULTS

Five cruises were made during the Cooperative Dedicated Vessel Research Program. The first, third, and fifth cruises were split into two legs. A schedule of the cruises is presented in Table 1. The vessel spent 234 days at sea, 15 days on local sea trials or experimental shore-side testing, and 116 days in port. The 116 days in port were spent unloading tuna, readying the vessel and net for the next trip, and taking shore leave.

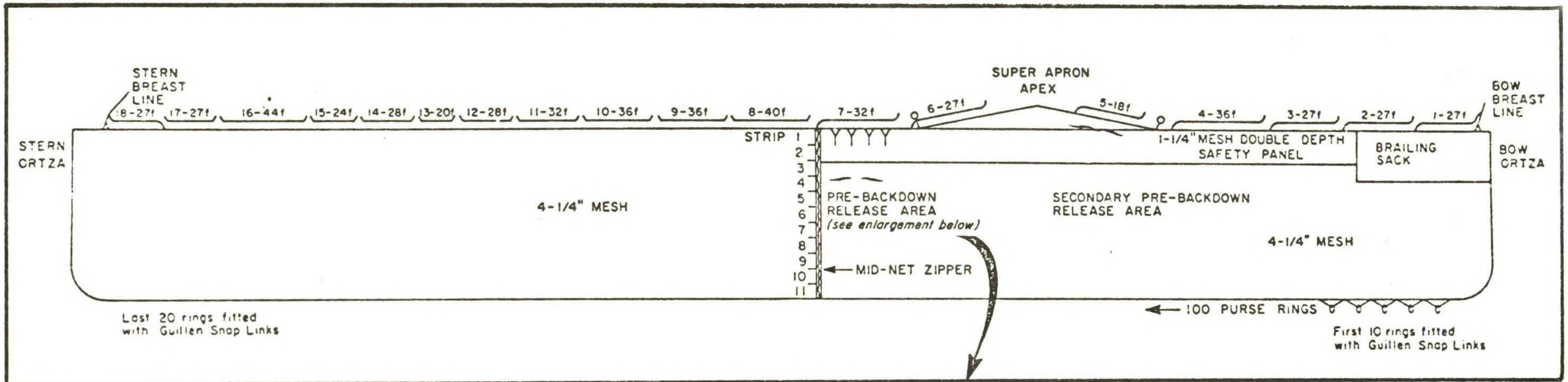
Thirty-two scientists from 10 different organizations participated in the research (Appendix C). Nineteen different crewmen operated the seiner during the 5 trips (Appendix D).

A summary of all the sets is presented in Table 2. There were 137 sets: seven test sets, 78 porpoise sets, 17 logfish sets, and 35 schoolfish sets. Almost 50,000 porpoise were chased, and about 50 percent of those were captured. A total of 225 porpoise was killed, and 1,234 tons of tuna were captured incidental to the research.

A summary of all the photographic material taken aboard the Dedicated Vessel is presented in Table 3. More than 4,500 slides and 10,400 feet of movie film were shot covering research, fishing operations and porpoise. Each slide and all the movie footage has been cataloged, and copies of the catalog have been given to USTF, MMC, NMFS, LMR, and the San Diego History Research Center (SDHRC). All the original photographic material will be available for public perusal at SDHRC.

As noted earlier, the general goals of the research on the Dedicated Vessel were (1) to further refine procedures and gear to reduce incidental porpoise mortality, (2) to assess the practicality of developing alternative fishing methods, (3) to conduct stock assessment research, and (4) to study porpoise behavior. Although research on all of these goals was conducted on an opportunistic basis on all the cruises, a primary research goal was emphasized on each cruise. Research to reduce porpoise mortality was emphasized on Cruises I and V,

Figure 1. A schematic diagram of the Queen Mary's net.



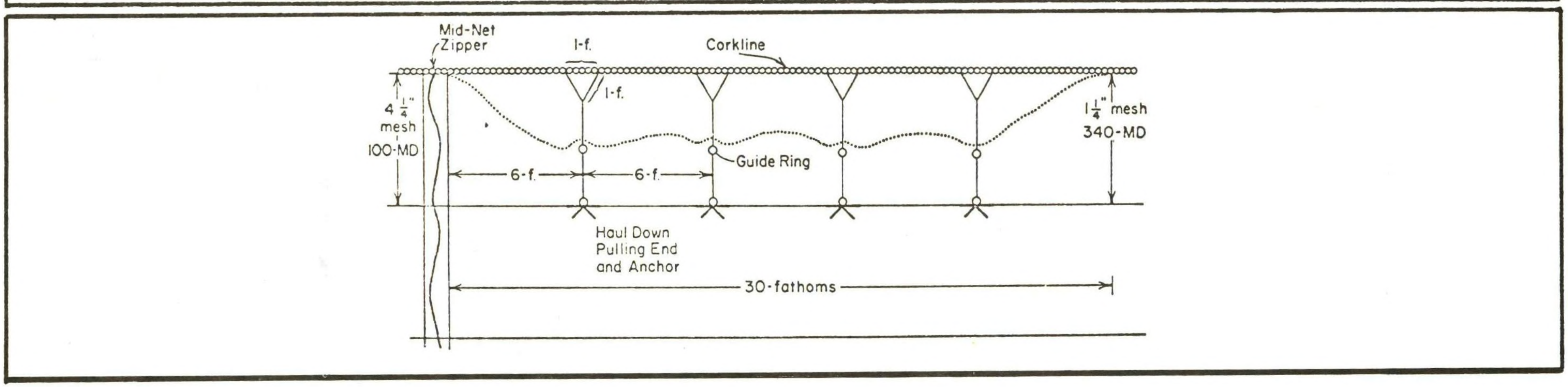


Figure 2. A schematic diagram of the experimental "downhaul system". The four downhauls were installed on the outside of the net and between the mid-net zipper and the stern end of the super apron. The downhaul lines were 6 fathoms apart, forming a 30-fathom release area. The dotted line shows the expected configuration of the corkline with downhauls employed.

Table 1. Schedule of Dedicated Vessel activities - 1978

Dates	Cruise Number	Sea Days: Actual Trip	Sea Days: In-port Sea Days	In-port	Comments
1/1-1/25				25	Vessel preparation
1/26-3/16	I	50 1/			
3/17-4/16			10	21	In-port/sea trials and preparation of PSIS
4/17-6/05	II	50			
6/06-6/21				16	
6/22-7/15	III-1	24			
7/16-7/19			4		Vessel returned to San Diego to pick up scientists for Leg 2
7/20-8/18	III-2	30			
8/19-9/11			1	23	In-port/PSIS sea trials
9/12-10/31	IV	50 2/			
11/1-11/10				10	
11/11-12/10	V	30 3/			
12/11-12/31				21	Vessel preparation for 1979 fishing season
TOTAL		234	15	116	

1/ Includes one day in Puntarenas, Costa Rica, to drop off scientists.

2/ Includes three days in Acapulco, Mexico, to drop off a crew member because of a death in the family.

3/ Includes one day in Acapulco to exchange scientists.

Table 2. Summary of all sets made on Dedicated Vessel

Cruise Number	Total Sets	Test Sets*	Porpoise Sets						Non-porpoise Sets						Total Tons
			Porpoise Sets	Estimated		Porpoise Killed	Tons		Log Sets	Tons		Schoolfish Sets	Tons		
				Porpoise Chased**	Porpoise Captured		YF	SJ		YF	SJ		YF	SJ	All Tuna
I	33	2	10	∿ 7200	∿ 4305	116	159	-	17	63	303	4		4	529
II	22	-	22	∿14700	∿ 5850	49	158	9							167
III-1	32	1										31	240	56	296
III-2	17	-	17	∿ 7140	∿5688	3	44	5							49
IV	18	1	17	∿10938	∿5507	45	92	1							93
V	15	3	12	∿ 8361	∿3484	12	85	15							100
TOTAL	137	7	78	∿48339	∿24834	225	538	30	17	63	303	35	240	60	1234

* I - One set to adjust super apron, and one set to wash the net

III-2 - One set to test the net after some repairs

IV - One set to practice with the PSIS.

V - Three sets for SCUBA-diving research

**Does not include porpoise chased during aborted sets.

research to design and develop alternative fishing methods on Cruises I and III-1, stock assessment research on Cruises II and IV, and porpoise behavioral research on Cruise III-2. The background, objectives, methods, and results of each research topic are detailed in the individual cruise reports.

A. Summary of the Mortality Reduction Research

Numerous procedures, techniques and items of equipment were tested on the Dedicated Vessel in an effort to decrease the mortality of captured porpoise. Pre-backdown release and herding tools were tested so that porpoise would have less time to spend in the seine. The formation and configuration of the backdown channel were observed to help formulate methods for optimizing the backdown channel and reducing stern sway and canopies. Ideas and methods were tested in an effort to separate the tuna and the porpoise during backdown to reduce the fear of loss of fish. The cause and correction of each malfunction was carefully noted because, historically, malfunctions during a set have caused large numbers of porpoise to die. Measurements from the seiner to specific points on the corkline were collected so that the surface area of the net could be calculated. Net parameters were measured and observations of the net performance were collected by SCUBA divers for simulation studies. A depth finder was used to record the profiles of the net at various stages of pursing and net retrieval. Dynamometers were used to measure pursing forces and the force exerted by the skiff in various states of its operation. Movie footage was filmed so that a 30-minute movie could be made for use in skipper-training workshops and observer-training sessions.

1. Pre-Backdown Release and Herding Techniques

For a complete discussion of this topic, see the report from Cruise I. Releasing the porpoise before backdown to minimize the time the porpoise spend in the seine was suggested by Norris et al., 1978. Two major innovations are necessary to develop a pre-backdown release system: (1) development of an area in the corkline that can be sunk with predictable control so that porpoise can leave the net, and (2) development of a procedure for herding the porpoise within the net. Prior to Cruise I, a system of rope downhauls and two strips of fine mesh were installed in the net between the net zipper and the normal fine mesh area to create an escape route from the net (Figure 2). The downhauls were to haul the corks down after the net was set. On

Table 3. Inventory of photographic material from the Dedicated Vessel Program.

D.V. Cruise #	NMFS Cruise #	Photographer	Number of Slides	# of B/W Prints	Reels of Movies	Footage	Movie Description
I	375	F.T. Awbrey (SDSU)	~250				
I	375	D. Holts (NMFS)	~590				
I	375	D. Ljungblad (NOSC)	~950		2 reel/16mm	2000 feet	General fishing operations
II	395	J. Lambert (NMFS)	~100				
II	395	C. Peters (LMR)	~320				
II	395	R. Silva, III(Q.M.)			1 reel/16mm	600 feet	PSIS operations
III-1	411	G. Sanford (NMFS)	~370				
III-1	411	S. Johnson (NOSC)	~ 37		7 reels/8mm		Time-lapse photographs of water column down to 1200 feet
III-1	411	T. Duffy (NMFS)	~106				
III-1	411	W. Evans (HSWRI)	~370				
III-2	411	W. Ikehara (UH)	~ 76				
III-2	411	I. Kang (SLP)	~ 38				
III-2	411	NMFS/Pryor (NYU)	~350	27			
IV	434	NMFS (various)	~270		1 reel/16mm	800 feet	PSIS Operation
V	451	S. Birk/Irwin (NMFS)	~100		9 reels/16mm	7000 feet	General fishing operations - porpoise safety gear, porpoise release techniques
V	451	D. Holts (NMFS)	~590				
TOTAL			~4500	27	12 reels/16mm	10400 feet	

the fourth set, following installation of the downhaul system, the ropes entangled in the net and ripped the net. On the fifth set, the ropes again entangled in the net and the downhaul system was removed.

As a next experiment, corks were removed from the area of the net where the downhauls had been installed to test whether or not the corkline could be sunk predictably through reduced flotation. The test was complicated by the fact that areas other than those altered also sank because the corks in those places were small and old and did not have much flotation. The results were that, although some areas of the net sank during pursing, the area could not be predicted because of the variables of weather and pursing speed. If the net was set in a circle, the areas where the corks were removed sank as intended. However, if the net was set in an oval, the bow and stern bends sank. It was evident from this erratic net behavior that, although submerged segments of the corkline could not be predicted, portions of the corkline would sink deep enough so that porpoise could easily have gotten over the corkline at the submerged section if they could be herded to that point.

Several herding tools and techniques were tested. Because speedboats herd porpoise before making the set, they were tried within the net. It developed that, although porpoise could be moved within the net, their direction could not be controlled. The porpoise would move away from the speed boats, but if driven too close to the net, they would swim under the speedboats and resurface at the opposite end of the net.

Acoustic pingers (54 KHz) were tested twice before backdown and twice during backdown to determine whether they could be used to herd porpoise. No response from the porpoise was noted. Sounds produced by the porpoise were played back to them on several sets through an underwater hydrophone in an attempt to herd them or attract them. Again, no response from the porpoise was observed. The effect of underwater magnesium flares on porpoise behavior was tested with no apparent response from either porpoise or tuna.

In summary, no controllable pre-backdown release area in the net was created, and no effective methods to herd the porpoise within the net were developed.

2. Stern Sway and Canopies

The formation of "stern sway" and "canopies" during backdown is one of the most common causes of incidental porpoise mortality.[1/] As the vessel is backed through the water, it does not back straight, because if it did, the backdown channel would be extremely narrow. Thus, the seiner must back up in a large arc. The stern wall of the net is then forced into the backdown channel, and this in-folding is termed stern sway. The stern sway is hazardous to the porpoise at the bottom of the backdown channel because it blocks their ascent to the surface.

Stern sway and canopies were apparent on most sets in which the formation and configuration of the backdown channel were observed. There were two sets on the five cruises in which 20 or more porpoise were killed. In one set, 98 porpoise died. The cause was unknown, but it was thought that they died in a large canopy, having been forced there by the large number of tuna present in that set. On the other set, 26 porpoise died in canopies that formed when the backdown was terminated because tuna were escaping over the corks. When the corks would not rise, the seiner was kicked ahead, and the strain went off the net; the backdown channel became narrow and deep, and canopies formed. Profiles of the backdown channel and good discussions of stern sway are found in the cruise reports from Cruises I, II, and V.

3. Preventing Tuna Loss During Backdown

Stopping backdown before all of the porpoise are released because tuna are being lost is also a significant cause of mortality.[1/] Because the sole reason for fishing is to capture tuna, the skippers and crew are loathe to allow any tuna to escape, so when tuna do start to escape, backdown is generally slowed down or halted. Canopies then form in which porpoise can get entrapped.

To reduce the tuna loss during backdown, and thus minimize the risk of porpoise entrapment, a study was designed to test whether tuna olfactory attractants could be used to separate the tuna from the porpoise during backdown. A tuna olfactory attractant developed at the University of Hawaii, under NMFS contract, was tested on 10 sets. Some tuna responded to the attractant on two sets; however, they did not stay near the attractant for long. They came near, showed feeding bars or dorsal fin erections, then

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1/ Mr. David Holts, NMFS, Personal Communication returned to the porpoise in the deep end of the net. It appeared that, although the attractant lured some tuna, they would not stay near it without further reinforcement. A complete description of this research can be found in the report from Cruise III-2.

4. Malfunctions

Equipment malfunctions are a significant cause of porpoise mortality (Coe and DeBeer, 1977). When a malfunction occurs, the set routine is broken, an emergency situation arises, and the attention of the skipper and crew are focused on salvaging their gear or preventing any more problems from occurring. At that time, porpoise safety and release may become secondary to gear recovery.

Very few malfunctions occurred in any of the sets on the Dedicated Vessel. There were no "rollups," for example. During a set on Cruise I, in which porpoise were held in the net for over 5 hours to observe their reaction to long-term holding, a speedboat began to sink at the start of backdown. Canopies formed when backdown was halted to recover the speedboat and rescue the driver, and 14 porpoise died. On one set on Cruise IV, the net was entangled in the propeller, but no mortalities occurred.

5. Net Measurements

On three cruises, the distance from the seiner to the corkline was measured during various phases of the set. Researchers used these measurements to calculate the surface area of the net during the set sequence. Plans had been made to deepen the net before Cruise V to compare surface areas before and after the net was deepened; however, the net was not deepened, because of time constraints and because it was thought the net would not fit through the seiner's 42-inch power block. The surface area of the net is estimated at 35,000 square meters after pursing is complete and falls to 2,000 square meters just before backdown. A complete description of net area configurations can be found in the report from Cruise V.

6. Pursing and Towing Forces

To better understand the forces acting on the net, measurements of the forces necessary to purse the net and tow the seiner during pursing were taken during Cruise V.

The skiff's towing force on the net and seiner was measured on one set. The weather and sea conditions were mild, and the seining operation was normal in all respects. Although one set of measurements does not justify conclusions, it is interesting to compare the skiff towing force with the pursing forces collected on the same set. The pursing forces ranged between 5,000 and 7,300 pounds, and, during the same period, the skiff towing forces ranged between 2,200 and 6,500 pounds. Thus, although the data on these forces are inadequate to allow direct comparisons, it appears that the skiff merely holds the seiner from being pursed into the net, i.e., it does not move the entire net and seiner through the water.

7. Mesh Shapes and Tensions

To identify the major stress points on the net during the seining operation, SCUBA divers measured the tensions and photographed the mesh shapes at the top of each strip of webbing during three sets on Cruise V. There were no apparent trends in either depth or location. The measurements will be used in a simulation model of the net currently being developed by Science Applications, Inc., under contract to NMFS.

8. Net Profiles

Profiles of the purse seine during various phases of the set were obtained with a depth recorder during Cruise V. The maximum recorded fishing depth of the Queen Mary's seine was 154 feet, when the net was about half pursed; however, the leadline may have gone somewhat deeper in the first few minutes of setting and retrieving the towline. The winch brake always has a slight tension on it during setting the net to prevent backlash. This strain prevents the leadline from sinking to the fullest possible extent. The profiles indicated that the leadline remained at about 130 to 150 feet at the start of pursing and began to rise during the last half of pursing. The mid-net area of the corkline is the furthest from the seiner and has the greatest amount of tension on the webbing during pursing. The increased tension on this webbing caused the mid-net area to rise more rapidly than the areas on either side. This mid-net bulge rose during pursing and eventually maintained a depth of between 43 to 105 feet. A complete description of the net in action is contained in the Cruise V report.

9. Training Movie

Over 7,000 feet of movie film for a training movie were shot on Cruise V. The movie is being prepared from the footage filmed at sea, with short animated sections prepared to cover subjects which were not filmed.

B. Summary of the Research to Develop Alternative Fishing Methods

Several ideas for development of an alternative fishing technique were investigated on the Dedicated Vessel. The items included deploying aggregating devices, testing tuna attractants, and testing acoustical devices to detect tuna.

1. Aggregating Devices

Prototype aggregating devices were deployed in known areas of log fishing three times during Cruise I. Over the period of the few days they were deployed and checked, they attracted only a couple of scoops of baitfish (spp. unknown). 1/

2. Tuna Olfactory Attractants

The tuna olfactory attractants that were tested were discussed earlier in the summary of mortality reduction research. Researchers also attempted to attract schoolfish tuna to a low-frequency sound source during Cruise III, Leg 1; however, there was no detectable response from the tuna.

3. Tuna Detection Systems

Passive acoustic (listening) devices were tested to ascertain whether tuna were present near a log. During Cruise I, the sounds associated with logs, with and without tuna present, were recorded. The preliminary conclusions from that cruise suggested that tuna could be detected by listening devices. On Cruise III, other attempts to determine the sounds of tuna were unsuccessful, although failure to detect tuna sound may have resulted from equipment malfunction.

1/ One scoop of bait is approximately 8 pounds.

C. Summary of Stock Assessment Research

A Porpoise School Impoundment System (PSIS), designed and developed by the NMFS, allowed the researchers to attempt most of the stock assessment research. The PSIS represents a major development in the field of marine mammal science because it allows scientists to process large numbers of live, wild porpoise and to release them back into the ocean. With it, the researchers on this Dedicated Vessel were able to count, examine, sex, and tag porpoise, to inject them with tetracycline, and to draw blood samples. The PSIS and its use are described in detail in the report for Cruise II; a PSIS operations manual is in preparation. 1/ The concept of the PSIS is relatively simple: porpoise are captured with a purse seine, transferred to a smaller net, and then caught and guided by hand to a chute where they can be examined and/or tagged.

1. Demographics of Porpoise Schools

On Cruises II and IV, in 13 sets, 1234 offshore spotted porpoise and 86 eastern spinners were examined for color phase and sex, using the PSIS (Table 4). The number of porpoise processed through the PSIS, per set, averaged about 100 and ranged between 53 and 204 (Table 5). The majority of the porpoise processed and examined in the PSIS came from the area around Clipperton Island (Figure 3).

During ten of the PSIS sets on Cruises II and IV, the researchers were able to compare the actual number of porpoise processed through the PSIS to the estimates of the number of porpoise captured (Table 6). Although all of the schools captured would be considered "small schools," it is interesting to note that the average of the overall estimates was very close to the average actual count. Twice the estimates were higher than the actual count, once by 3 percent and once by 91 percent. For three schools, the average estimate was within 5 percent of the count. For six schools, the estimates were low by 9 to 29 percent. Except for one scientist and three crewmen, personnel making the estimates were different on Cruises II and IV.

2. Tagging and Radio-Tracking Porpoise

Mark/recapture studies were conducted on Cruise IV. A total of 656 porpoise were tagged with disc tags,

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1/ Personal communication, Mr. James Coe, NMFS

Table 4. Color-phase and sex composition of porpoise examined through the PSIS on 13 sets

	Offshore Spotters		Eastern Spinners	
Color Phase	Male	Female	Male	Female
Neonate	5	8		
Two-tone	53	71		
Speckled	95	104		
Mottled	67	66		
Adult	345	420		
TOTAL	565	669	53	33
%	46.8	54.2	61.6	38.3

Table 5. Number, sex, and species composition of porpoise examined through the PSIS by set

Cruise & Set No.	Offshore Spotters			Eastern Spinners			Total Porpoise Examined	Number of Backdowns Required
	♂	♀	Total	♂	♀	Total		
II, 3	28	38	66	-	-	-	66	1
II, 4	80	124	204	-	-	-	204	2
II,11	31	50	81	31	12	43	124	3
II,21	15	38	53	-	-	-	53	1
IV, 2	58	48	106	3	3	6	112	1
IV, 4	24	38	62	-	-	-	62	1
IV, 7	87	54	141	2	4	6	147	1
IV, 8	62	102	164	-	-	-	164	1
IV,11	52	58	110	2	2	4	114	1
IV,12	11	23	34	6	9	15	49	1
IV,13	41	16	57	4	1	5	62	1
IV,15	43	50	93	5	2	7	100	1
IV,16	33	30	63	-	-	-	63	1
TOTAL	565	669	1234	53	33	86	1320	16

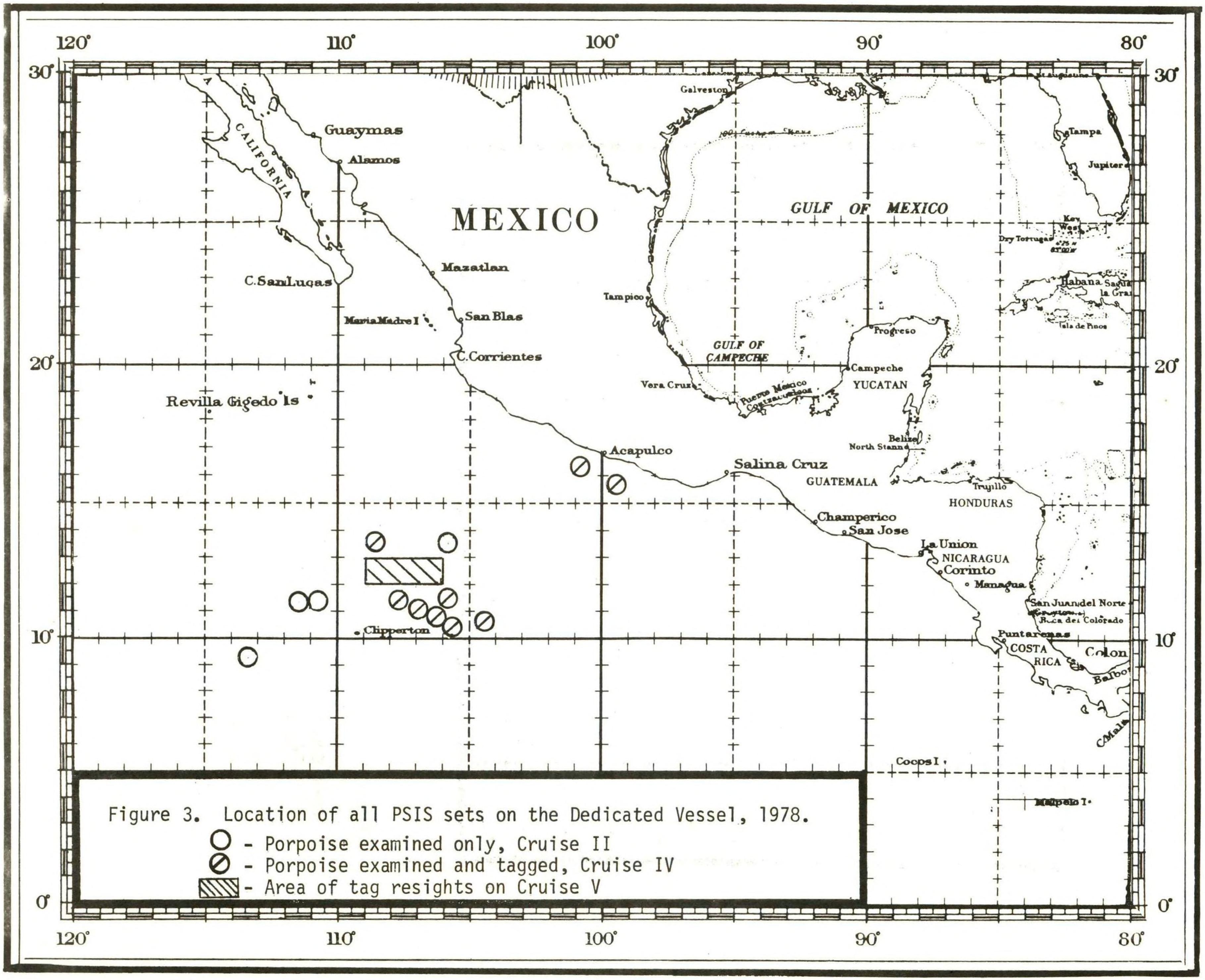

Figure 3. Location of all PSIS sets on the Dedicated Vessel, 1978.

○ - Porpoise examined only, Cruise II

⊘ - Porpoise examined and tagged, Cruise IV

▨ - Area of tag resights on Cruise V

Table 6. A comparison of the estimates of school size captured with the best count of those captured.

Cruise No. and Set No.	Species in School	Average Estimate of Porpoise Captured	Range of Estimates	Best Count of Porpoise Captured	Percent Difference (calculation below)**
II,2	Spotters	98	80-150	138	-29
II,4	Spotters	256	200-350	268	- 4
II,11	Spot/Spin	261*	200-275	136	+91
II,21	Spotters	43	35-55	56	-23
IV,2	Spot/Spin	100	50-200	120	-17
IV,4	Spotters	57	30-175	68	-16
IV,7	Spot/Spin	134	35-165	167	-20
IV,8	Spot/Spin	163	80-200	179	- 9
IV,13	Spot/Spin	77*	55-140	75	+ 3
IV,16	Spotters	79	60-100	79	--
MEAN		126.8		128.6	+ 1

*The entire school was captured

** $\frac{\text{(Best Count - Average Estimate)}}{\text{Best Count}}$

and six were tagged with radio tags in nine PSIS sets. Schools of tagged porpoise were radio-tracked four times; radio-tracked porpoise were recaptured on two sets. The school of porpoise accompanying the radio-tracked porpoise evaded capture on one set, and the radio pack came loose from the porpose on the other tracking attempt.

Twenty-two of the disc-tagged porpoise were recaptured during Cruise IV. Eleven of the recaptures were examined in the PSIS, and all but two of these were released with the tags intact. Two of the porpoise appeared to be affected by the tag, so the tag was removed, and the animals were released. The tags that were removed were found to be defective. Ten tagged porpoise were recaptured in three gear sets. Although it was not possible to get exact information, in one set, it was observed that eight porpoise that had been tagged in at least four different sets were recaptured together. All of the animals recaptured in that set had been tagged within 30 miles of the set.

Six tag resights occurred during three sets and one chase on Cruise V. Some of the tags observed had migrated toward the trailing edge of the dorsal fin, but most of the animals and tags looked good. The number could be read on one tag: the animal had traveled 170 miles northwest in 48 days. All of the resights from Cruise V occurred within the general tagging area (see Figure 3).

3. Aging Porpoise with Tetracycline Techniques

During Cruise IV, 331 porpoise were tagged with orange "T" tags and injected with tetracycline for aging studies. As of June 1, 1979, none of these porpoise had been recovered with the tags intact; however, most of the tag resights subsequent to Cruise IV are reportedly the orange "T" tags.

4. Capture Myopathy Studies

Blood samples were collected from 34 live and 15 dead porpoise during Cruise IV for an analysis to determine whether or not capture myopathy is a problem in the fishery (Table 7). The data have been analyzed and were presented at the Capture Myopathy Workshop held at the Southwest Fisheries Center on May 1-3, 1979. The results were not available at the time this report was written; however, a complete report from the workshop will be published by Dr. Warren Stuntz, NMFS.

Table 7. Blood samples collected on Dedicated Vessel cruises

Cruise Number	Live animals			Dead animals		
	Stenella attenuata	Stenella longirostris	Delphinus delphis	Stenella attenuata	Stenella longirostris	Delphinus delphis
I	-	-	-	10	-	-
III-2	-	-	-	2	-	-
IV	34	-	-	-	-	-
V	-	-	-	2	1	-
TOTAL	34	-	-	14	1	-

5. Porpoise diseases

Seventy-one porpoise were necropsied on Cruises II and IV and examined for diseases and parasites (Table 8). The data and observations were presented at the Capture Myopathy Workshop; however, the results and conclusions were not available at the time this report was written. A contract report to the NMFS from Mr. William Walker and Dr. Dan Cowan is in preparation.

6. Dietary, life history and ancillary research

Porpoise and tuna stomachs were collected for dietary research on three cruises (Table 9). None of the stomach contents have been analyzed as yet. The standard NMFS life history data were collected from all of the porpoise incidentally killed and recovered (Table 10). Samples of selected tissues were collected for various investigators (Table 11).

Table 8. Number of porpoise necropsied on Dedicated Vessel

Cruise Number	Stenella attenuata	Stenella longirostris	Delphinus delphis
II	29	3	-
IV	20	16	3
TOTAL	49	19	3

Table 9. Stomachs collected for dietary studies

Cruise Number	Porpoise stomachs			Thunnus albacares
	Stenella attenuata	Stenella longirostris	Delphinus delphis	
II	20	2	-	69
IV	5	1	-	Ø
V	2	3	-	45
TOTAL	27	6	-	114

Table 10. Standard NMFS Life History Data and biological samples collected on Dedicated Vessel cruises

Cruise Number	Stenella attenuata	Stenella longirostris	Delphinus delphis
I	47	41	-
II	29	3	-
III-2	2	-	-
IV	20	16	3
V	2	7	-
TOTAL	100	67	3

Table 11. Miscellaneous biological specimens collected

Cruise Number	Stenella attenuata	Stenella longirostris	Delphinus delphis	Comments*
I	10	10	-	Livers and heads-Ridgway
	1			Adrenal gland-Stuntz
II	18	2		Eyes-Bada
	2			All major tissues-Walker except brain, blubber, skin sent to Cowan
III-2	2			Tissue samples-Crawford
	2			Eyes-Bada
	2			Melon-Varanasi
	2			Adrenals-Stuntz
	2			Tissue-Stuntz muscle, liver, heart, kidney, spleen, lungs
VI	9	8		Eyes-Bada
	2	2	2	Melon-Varanasi
	3			Tissues-Walker all major organs
V	1	2		Brains-Tarpley
	1			Tissue-Stuntz all major organs

*Work addresses are given in Appendix E.

D. Summary of Porpoise Behavioral Research

Porpoise behavioral observations, summarized in individual cruise reports, were made on every cruise whenever the opportunity was available.

1. Observations of captured porpoise in the seine

Porpoise behavior studies were one of the primary goals on Cruise III, Leg 2. The principal technique used by the behaviorists was the focal-animal sampling method, which was developed to study terrestrial animals. This was the first time this technique had been used to study pelagic marine mammals. The researchers found that the study technique was comparatively easy to apply. They swam with the porpoise within the seine and recorded every action (in a shorthand) of a single animal for 5-minute periods. They were able to follow the focal animals and record their observations with ease, except when the sea state was too rough for snorkeling. The researchers recorded 135 5-minute case observations of porpoise of all ages and sizes, and from their observations, compiled a behavioral dictionary. They were able to identify subgroups of porpoise within the schools. So different were the results of observations made under water from those at the surface that it was evident that observations from the two vantage points would lead to very different conclusions on porpoise behavior. The final results and conclusions of the behavioral studies will not be known until the final contract report is submitted to NMFS by the principal investigator, Ms. Karen Pryor.

2. Observations of porpoise behavior within the PSIS

The question of how the porpoise would react to the close confines of the porpoise school impoundment system (PSIS) and how they would react to being examined and tagged by the researchers, was one of the major uncertainties during the development of the PSIS. If the porpoise reacted badly to being handled or being closely confined, then the PSIS could not have been used.

Observations of the porpoise behavior within the PSIS are detailed in the reports from Cruises II and IV. In summary, researchers felt that the spotted porpoise generally remained calm within the PSIS and that they were not particularly difficult to handle, examine, and tag. On the contrary, the spinner porpoise were very active and continually swam around. Their movements were abrupt and quick, and many times the personnel processing and handling the animals were struck and rammed. The spinners' behavior was such that if the total number of spinners in the school was too high, the school could not be processed through the PSIS. This condition--i.e., too many spinners in the school--occurred two times on Cruise II and four times on Cruise IV, and the chases were aborted.

3. Observations of the evasive behavior of porpoise

Estimates of the number of porpoise chased and captured were collected on every set. Evasive behavior was observed on every set. The percentage of the school captured on each of the 77 porpoise sets was calculated and stratified into 10 equal strata (Table 12). On almost three-quarters of the sets made, less than 90 percent of the porpoise chased were captured. However, these data may be slightly skewed because, at times, the skipper would cut out portions of the schools. If these data are applicable to other vessels in the fleet, it is very apparent that it is more common for some or all of the porpoise to escape than for the seiner to catch the whole school. These estimates are also very valuable for planning stock assessment cruises that will use the PSIS. This type of porpoise behavior inhibits examining whole schools of porpoise or calibrating school size estimates made before the set with the number of porpoise counted in the PSIS.

Table 12. Percentage of porpoise schools captured.

Percent of School Captured	Sets Sampled	Percent of Total Sets
0-10	8	10
11-20	8	10
21-30	6	8
31-40	5	8
41-50	5	8
51-60	4	5
61-70	4	5
71-80	8	10
81-90	6	8
91-100	21	27
TOTAL	77	100

V. CONCLUSIONS

The concept of the Cooperative Dedicated Vessel Research Program was to conduct research more effectively and efficiently than possible if the vessel were simultaneously engaged in competitive fishing to defray research or operation costs. From that point of view, the program was very successful. Although collected data have not been analyzed and reported fully, the available information indicates significant results in many areas.

The value of the program was that researchers were able to test theories, procedures, and equipment that otherwise would not have been testable. Many of the ideas tested had been proposed and discussed in fishing circles for years with no hope of verification because of the gamble involved. Some proved workable; others did not.

A. Mortality Reduction Research

The research conducted during the dedicated vessel program produced no short-term breakthroughs in reducing porpoise mortality. No new tools or procedures were developed that would contribute immediately to a reduction in mortality levels; however, because of the opportunities afforded by the program, researchers made observations and collected measurements both above and below the water surface not otherwise possible. In the long term, the results of these observations very well may prove important.

Although porpoise mortality rates have dropped by about 90 percent in the last 6 or 8 years, the mandated goal is to approach a zero rate. A remaining percentage gain probably will be more difficult to achieve than the first 90 percent. To reduce mortality further, a more sophisticated understanding of net dynamics, porpoise behavior, and tuna behavior likely will be needed. Probably no single technique or piece of equipment will prove a panacea, and the mortality reduction program will involve diverse procedural and equipment changes. For the near term, reduction of incidental kills can be accomplished by: education and training to increase skipper skills in releasing porpoise; minimizing stern sway and canopy formation during backdown; and educating and training fishermen to reduce both the incidence of gear malfunctions and their effects on porpoise mortality.

1. Improving skipper skills

Increasing skipper skill at releasing porpoise will probably be one of the most effective ways of further reducing mortality. With the gear that is currently available (super apron, fine mesh, speedboats, etc.), some skippers in the fleet are able to consistently achieve very low levels of mortality, while others, using the same gear, fishing the same areas, have much higher levels. Clearly, in these cases of high mortality, it is not new gear that is required to reduce kills but improvement in ship and net handling by the seiner captains.

The Porpoise Rescue Foundation (PRF) currently has an extension program in which skippers with high mortality rates are counseled by other, more skilled skippers. This program should continue to be given top-priority funding by the tuna industry. Improving skipper skills at releasing porpoise is the basic step toward lower mortality, for, unless porpoise release gear is used correctly, high levels of mortality will continue. The training film currently being produced by the NMFS from footage shot on the Dedicated Vessel better demonstrates many of the problems encountered and the proper release techniques.

2. Minimizing stern sway and canopies

To assist the skippers in increasing their skill in releasing porpoise, more knowledge must be obtained of net dynamics through research. Stern sway and canopies in the backdown channel are now the cause of most porpoise mortality. The skippers with low levels of mortality apparently do not have problems with stern sway or canopies or have learned to minimize them. Research is necessary to learn exactly why these skippers are able to avoid or minimize problems.

Researchers involved in the porpoise mortality problem hypothesize that by pre-forming the backdown channel before backdown, instead of during backdown, stern sway and canopies can be minimized. Although the theory was tested to some extent during the Dedicated Vessel Program, it has not been proven. Tests must continue on different backdown patterns to minimize the formation of stern sway and canopy formation. Three testing methods are possible:

a. The most immediately available method, and the one that will eventually have to be conducted, is to charter a purse seiner for actual *in situ* tests of various backdown techniques. This is an expensive but essential and inevitable course. It suffers in two respects: all variables cannot be controlled and the entire backdown channel cannot be seen at any one time.

b. A much cheaper method than full, at-sea purse-seine tests, but one that will suffer significantly from scaling, is to study model nets in a pool. This method offers the advantage of rapidly testing many backdown practices and makes the entire backdown channel visible.

c. The third type of study, and one that is already underway, is to develop a simulation model of the net. NMFS now has a contract with Science Applications, Inc., to develop and test a simulation model. The data gathered on the Dedicated Vessel will serve as input to the program and will be used to check the results of the model test. Ideas appearing feasible at the model level will then be tested at full scale, with considerable savings in time and money.

3. Reducing equipment malfunctions

Equipment malfunctions are a significant cause of porpoise mortality. When a malfunction occurs, the set routine is broken, an emergency situation arises, and the attention of the skipper and crew are focused on salvaging their gear or preventing other problems from occurring. At that time, porpoise safety and release may become secondary to gear recovery. The indoctrination of purse-seine skippers by NMFS and Porpoise Rescue Foundation personnel should stress the development and practice of backup procedures, implemented automatically during emergencies to ensure orderly net retrieval with a minimum of porpoise mortalities.

The importance of good communication between the fleet, gear researchers, and extension people cannot be emphasized enough. All of the research done is of no use unless the results can be applied throughout the fleet.

B. Alternative Fishing Methods

If zero mortality and injury is to be acheived, it may be necessary to develop a method for catching the large tuna normally associated with the porpoise, without also capturing the porpoise. The research conducted on the Dedicated Vessel provided some baseline information on tuna. Olfactory and acoustical attractants were tested, and attempts were made to detect tuna by acoustical means. The results were not encouraging. Very few tuna were attracted to the olfactory stimulants and none to the acoustical. Researchers thought they could detect tuna on Cruise I using acoustical devices, but were unable to confirm this on Cruise III.

The key to developing successful alternative fishing methods is an understanding of the reason or reasons for the apparent affinity of tuna to surface aggregators, e.g., logs and porpoise. It is common knowledge that there is a size difference between the schoolfish or logfish and fish caught under porpoise. Most of the fish caught free swimming or associating with a floating object are less than 70 cm, and most of the fish caught under porpoise are greater than 90 cm. There is, of course, a considerable overlap in the size of tuna by set type.

Why tuna are attracted to surface objects, either active or passive, is not known. Certainly, the food beneath a log cannot support any significant tonnage of tuna, so a log may be used as a visual cue. As the tuna get larger, they may learn that porpoise are good locators of food or the tuna and porpoise may just be attracted to the same area at the time that food is present in that localized area. It may be patches of food or some other factors that draw them together, not gregariousness.

If an aggregator could be developed, it would have to be more continuously effective than porpoise. The experience of the baitboats showed that tuna could be attracted away from porpoise for a time, but for only a short time. In baitboat fishing (a form of tuna fishing in which fish are attracted by chummed bait and caught by hook, line, and poles), as soon as the boat approached a school of porpoise and tuna, chumming would start and the tuna would respond. The boat would then drift, and the crew would fish. As the porpoise school moved on, however, the tuna would leave the baitboat (that was feeding them live bait) and would re-join the porpoise. From this experience, it seems apparent that an effective aggregator more attractive than live bait must be developed to separate tuna from porpoise (see also Hofman, 1979).

One must never forget, though, that the only reason for seining is to catch tuna. If the tuna are available as schoolfish or near flotsam (logfish), they will be caught there. If the tuna are available under porpoise, they will be caught there, unless, of course, there are more effective methods or regulations that prohibit chasing or setting on porpoise. One also must remember that this is not just a U.S. problem; thus, if the U.S. fleet is prohibited from fishing porpoise and the foreign fleet continues to seine with porpoise, the problem of porpoise mortality continues. If alternative fishing methods are developed, they must include mechanisms for attracting the large yellowfin tuna away from the porpoise or aggregating the large yellowfin not associated with propoise.

Development of an alternative fishing method may not be practical or possible. A workshop should be convened to assess all of the available information and to determine whether further research in this area is likely to lead to practical, cost-effective alternatives. This research is in its infancy, and this is the time to get the widest range of input into the entire study area.

C. Stock Assessment

1. The Porpoise School Impoundment System (PSIS)

The major contribution of the Dedicated Vessel Program to the assessment of porpoise stocks was the development and use of the Porpoise School Impoundment System (PSIS). Prior to its development, researchers had no effective method of measuring, sexing, or tagging large numbers of live, wild porpoise. This was accomplished for the first time with the PSIS. Although the PSIS has limitations, its utility as a research tool was demonstrated fully. However, further use of the PSIS must be done from a chartered or "dedicated vessel." Operation of the PSIS requires six or seven people and so totally disrupts the set sequence that this kind of research cannot be "piggybacked" on a commercial fishing trip. Because chartering a vessel to use the PSIS will be expensive, the decision of whether or not to use it in the future likely will rest on budgetary rather than technological considerations.

2. SCUBA diver observations

The SCUBA divers on Cruise V reported that, when they were at a depth of 120 to 130 feet, the entire school could be seen and photographed. They suggested that this "below the school photography" might be a method of calibrating school estimates.

3. Myopathy and necropsy research

No comment can be made at this time regarding the capture myopathy research or the necropsy research. The Dedicated Vessel provided researchers the opportunity to collect the samples that otherwise could not have been collected.

4. Ancillary research

The value of much of the ancillary research conducted on the dedicated vessel is not readily quantifiable; however, an analysis of the samples will add to our basic understanding of the porpoise stocks.

D. Behavioral Studies

As stated earlier, behavioral researchers were able to apply focal-animal sampling methods to porpoise studies within the seine. The implications for further research with this technique are broad-ranging. The technique of focal-animal sampling can be applied to studying behavioral differences among species within the seine. For example, is there a quantifiable behavioral difference between Delphinus delphis and Stenella attenuata that causes the Delphinus to have a high mortality rate in the net?

The focal-animal behavioral observations could be accommodated during commercial fishing more easily than such complex, time-consuming activities as tagging. A pair of researchers could accomplish the work while two crewmen stood shark guard. The equipment is minimal, and the observations barely disrupt the normal set sequence. Some very real potential exists here for descerning inter-species behavioral differences.

The behavioral researchers reported one item of particular interest that may apply to school size estimation techniques. They reported that the behavior of the porpoise was relatively constant throughout the set, from the time of encirclement to just prior to release. For example, the percentage of animals rafting at the beginning of the set usually appeared to be similar to the percentage rafting at the end of the set. Far more difference was seen from set to set than within sets. The researchers also reported several different types of school activities within the seine. The activity ranged from two-thirds of the school rafting on the surface to less than one-fifth of the animals on the surface. This implies that if a person estimating the school size simply multiplies the number of porpoise on the surface by a constant factor, the resulting estimates could be quite inaccurate.

VI. RECOMMENDATIONS

These recommendations are not all-inclusive and are those of the author. They do not necessarily reflect the opinion of the Program Board, the Marine Mammal Commission, the National Marine Fisheries Service, or the United States Tuna Foundation.

A. Mortality Reduction

1. Stress the importance of mortality reduction to the fleet.

2. Determine the exact causes of stern sway and canopies during backdown and determine ways to reduce their effects by:

    a. Net modeling,

    b. Studying the backdown channel on gear charters or as an adjunct of a regular fishing trip, or

    c. SCUBA diving in the net.

3. Update the paper describing backdown by Coe and Souza to include everything that has been learned since then relative to backdown and porpoise release.

B. Alternative Fishing Methods

Organize and convene a workshop to discuss all relevant informations and identify promising lines of research.

C. Stock Assessment

Test whether SCUBA divers can photograph an entire school from underneath to obtain accurate counts.

D. Behavior Studies

Conduct behavior studies with the focal-animal sampling system to determine why there is a difference in mortality rates among the different species.

The researchers conducting behavioral studies should establish and maintain contact with skippers and fish captains to ascertain if they, the people on the fishing grounds working with the porpoise, think that the reason for the difference in mortality rates among species is behavioral in nature, and what can be done about it.

GENERAL RECOMMENDATIONS

Much of the additional mortality reduction research and the behavioral research that should be conducted can be done more cheaply by placing researchers aboard regular fishing trips than by chartering a dedicated vessel. Many research tasks can be done with no hindrance to regular fishing operations--for example: observing the net by SCUBA diving, measuring the purse-seining parameters, and observing porpoise behavior with the focal-animal sampling method. Slight inconveniences in providing sleeping accommodations for researchers can be overcome by adding bunk space or facilities in a recreation room, and the cost would be considerably less than chartering a vessel.

It is strongly recommended that behavioral studies and other research leading to reduced mortality which can be accomplished during standard purse seining be encouraged and that, if necessary, research personnel be carried in place of some of the present field observers. The NMFS is now attempting to place 130 field observers with the purse seine fleet each year. These observers are not researchers and conduct no tests, make no scientific observations of the type discussed, and do not necessarily provide data leading to improved fishing practices or gear. The number of observers tends to strain the hospitality of the fleet. To the skippers and crews of vessels, there is little difference between an observer or a researcher. They are both government employees, and it becomes difficult for research personnel to obtain passage when a ship is already required to take aboard an observer or has done so on the previous trip.

VII. ACKNOWLEDGEMENTS

The position of Program Manager and his secretarial support were funded by the Marine Mammal Commission under Contract No. MM8AC006.

The cooperation and dedication of Ralph Silva, Jr., Captain of the Queen Mary, and his crew were invaluable to the success of the Cooperative Dedicated Vessel Research Program. Their professional expertise and good will contributed substantially to the accomplishment of a unique and difficult task.

Each cruise leader and scientist is to be commended for a job well done. They had the difficult task of organizing and conducting several types of research on each set. Some of the research conducted successfully on the Dedicated Vessel had never been conducted before, much less attempted in a purse seine net on the high seas.

A special thanks is extended to the members of the Program Board, Mr. Franklin G. Alverson, LMR; Dr. William F. Fox, NMFS; Dr. Robert J. Hofman, MMC; and Dr. William F. Perrin, NMFS, for their assistance and direction. Each reviewed and commented on individual cruise plans, each cruise report and this report. They provided much needed and valuable advice during all phases of this research program.

I wish, also, to thank Mr. Joe Medina, Jr., managing owner of the M/V Queen Mary, and Mr. Harold F. Cary, Executive Director of the USTF, for their cooperation and advice in handling some of the day-to-day activities associated with managing a tuna seiner as a research vessel.

I would like to thank Mr. Izadore Barrett, the Director of the Southwest Fisheries Center and his staff for providing office space, telephone service and other support for 18 months for me and my secretary. The Southwest Fisheries Center has graciously consented to print all of the cruise reports from the Cooperative Dedicated Vessel Research Program under their Administrative Report Series.

I wish to give a special acknowledgement to Ms. Linda Kadubec and Ms. Penny Soderberg for their secretarial assistance during every phase of the Cooperative Dedicated Vessel Research Program. They were truly part of the heart and soul of the operation.

I wish to thank Dr. Douglas G. Chapman, University of Washington, Dr. L. Lee Eberhardt, Battelle Memorial Institute, and Mr. John Prescott, New England Aquarium, for reviewing this report and Mr. Robert Fay for editing the cruise reports and this report.

Finally, a special thanks to my wife, Mona Baumgartel, for her support and help during all of the hours this project demanded. She provided much needed editorial assistance on all of the cruise reports and on this report.

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APPENDIX A. Cruise reports issued from the Cooperative Dedicated Vessel Research Program

Cruise I. DeBeer, J., Awbrey, F.T., Holts, D., and Patterson, P. RESEARCH RELATED TO THE TUNA-PORPOISE PROBLEM: Summary of Research Results from the First Cruise of the Dedicated Vessel, 26 January - 16 March, 1978. Southwest Fisheries Center Administrative Report #LJ-78-14.

Cruise II. Coe, J.M., Jennings, J.G., Peters, C.B., and DeBeer, J. RESEARCH RELATED TO THE TUNA-PORPOISE PROBLEM: Summary of the Research Results from the Second Cruise of the Dedicated Vessel, 17 April to 5 June, 1978. Southwest Fisheries Center Administrative Report #LJ-79-6.

Cruise III,1. Awbrey, F.T., Duffy, T., Evans, W.E., Johnson, C.S., Parks, W., and DeBeer, J. THE TUNA/PORPOISE PROBLEM: DEDICATED VESSEL RESEARCH PROGRAM, Summary of the Research Results from the First Leg of the Third Cruise of the Dedicated Vessel, 22 June to 15 July, 1978. Southwest Fisheries Center Administrative Report #LJ-79-11.

Cruise III,2. Bratten, D., Ikehara, W., Pryor, K., Vergne, P., and DeBeer, J. THE TUNA/PORPOISE PROBLEM: DEDICATED VESSEL RESEARCH PROGRAM, Summary of the Research Results from the Second Leg of the Third Cruise of the Dedicated Vessel, 20 July to 18 August, 1978. Southwest Fisheries Center Administrative Report #LJ-79-13.

Cruise IV. Powers, J.E., Butler, R.W., Jennings, J.G., McLain, R., Peters, C.B., and DeBeer, J. THE TUNA/PORPOISE PROBLEM: DEDICATED VESSEL RESEARCH PROGRAM, Summary of the Research Results from the Fourth Cruise of the Dedicated Vessel, 12 September to 31 October, 1978. Southwest Fisheries Center Administrative Report #LJ-79-14.

Cruise V. Holts, D.B., McLain, R., Alverson, F.G., and DeBeer, J. THE TUNA/PORPOISE PROBLEM: DEDICATED VESSEL RESEARCH PROGRAM, Summary of the Research Results from the Fifth Cruise of the Dedicated Vessel, 11 November to 9 December, 1978. Southwest Fisheries Center Administrative Report #LJ-79-20.

APPENDIX B. Tentative list of reports issued or planned on research conducted on the dedicated vessel

A. Mortality Reduction

Contract reports on the simulation model of the purse seine net are being developed by Science Applications, Inc.

Movie, "Tuna Seining and Porpoise Safety," produced by the Tuna/Porpoise Management Branch, Southwest Region, NMFS, "B" Street Pier, Room 7, 1140 N. Harbor Drive, San Diego, CA 92101

A contract report on tuna olfactory attractant, in planning for submission to NMFS by the University of Hawaii.

Dr. Frank Awbrey plans to include the data from the bioacoustical research aboard the dedicated vessel in a general paper on the acoustics of purse seining.

B. Alternative Fishing Methods

No papers planned.

C. Stock Assessment

A PSIS operations manual, in preparation, by Mr. James M. Coe, Mr. Richard W. Butler, and Ms. Jacqueline G. Jennings, for publication under the NMFS, Southwest Fisheries Center Administrative Report Series.

A poster paper, describing porpoise radio tracking written by Mr. Richard W. Butler and Ms. Jacqueline G. Jennings, presented at the "International Conference on Telemetry and Radio Tracking in Biology and Medicine," 20-22 March 1978, Oxford, England. The paper will be published in the fall of 1979 in the Proceedings from the International Conference on Telemetry and Radio Tracking in Biology and Medicine," published by the Biological Engineering Society, 1979.

A report on the capture myopathy research, by Dr. Warren Stuntz, NMFS, presented at the "Capture Myopathy Workshop" at the Southwest Fisheries Center, in preparation.

A contract report by Mr. William Walker and Dr. Dan Cowan, on findings from the necropsy studies will be submitted to the NMFS.

D. Behavior

Ms. Karen Pryor will submit a contract report to the NMFS on the results from her behavior research. She also plans to publish at least three other papers on the results of her research. The topics will be (1) a behavioral dictionary of captured cetaceans, (2) the structure and subgroups of schools captured in purse seines, and (3) learned behavior of porpoise in the tuna fishery.

Mr. Philippe Vergne plans to submit his observations of the composite behavior of porpoise schools for publication.

E. Miscellaneous

Dr. Scott C. Johnson, Naval Ocean Systems Center, plans to publish a short note on the reaction of sharks to the "shark shield."

APPENDIX C. List of the scientists who conducted research on the Dedicated Vessel

Dr. Frank T. Awbrey, San Diego State University
Mr. Serge Birk, National Marine Fisheries Service
Mr. David.A. Bratten, National Marine Fisheries Service
Mr. Andrew W. Brittain, University of Hawaii
Mr. Richard W. Butler, National Marine Fisheries Service
Mr. James M. Coe, National Marine Fisheries Service
Mr. John DeBeer, Program Manager
Dr. Thomas N. Delmer, Science Applications, Inc.
Mr. Thomas M. Duffy, National Marine Fisheries Service
Dr. William E. Evans, Hubbs-Sea World Research Institute
Mr. Dale B. Fellbaum, National Marine Fisheries Service
Mr. John R. Henderson, National Marine Fisheries Service
Mr. David B. Holts, National Marine Fisheries Service
Mr. Walter M. Ikehara, University of Hawaii
Mr. William K. Irwin, National Marine Fisheries Service
Ms. Jacqueline G. Jennings, National Marine Fisheries Service
Dr. C. Scott Johnson, Naval Ocean Systems Center
Ms. Ingrid Kang, Sea Life Park (Hawaii)
Mr. James S. Lambert, National Marine Fisheries Service
Mr. Donald K. Ljungblad, Naval Ocean Systems Center
Mr. Rodney W. McLain, Living Marine Resources, Inc.
Dr. Wesley W. Parks, Living Marine Resources, Inc.
Mr. Paul H. Patterson, Living Marine Resources, Inc.
Mr. Charles B. Peters, Living Marine Resources, Inc.
Mr. Dale H. Powers, National Marine Fisheries Service
Dr. Joseph E. Powers, National Marine Fisheries Service
Ms. Karen W. Pryor, New York University
Mr. Gordon A. Sandford, Jr., National Marine Fisheries Service
Mr. Thomas B. Shay, National Marine Fisheries Service
Dr. Warren E. Stuntz, National Marine Fisheries Service
Mr. Philippe J. Vergne, Living Marine Resources, Inc.
Mr. William A. Walker, Contractor to National Marine Fisheries Service

APPENDIX D. List of the crew members of the M/V Queen Mary

Mr. Ralph F. Silva, Jr. - Captain
Mr. Robert J. Blocker - Navigator
Mr. Ralph F. Silva, III - Navigator - Cruise V
Mr. Melvyn P. Medina - Chief Engineer
Mr. Manuel T. Joseph - Assistant Engineer
Mr. Frank J. Mitchell - Deck Boss
Mr. Edward Anfuso
Mr. Raul S. Ferreira
Mr. James Garofalo, Jr.
Mr. Louis G. Gomes, Jr.
Mr. Albert W. Larson, Jr.
Mr. Carlos Luz
Mr. John O. Machado
Mr. Leoberto P. Marques
Mr. Frank E. Medina
Mr. Francis R. Misiewicz
Mr. John Rodrigues
Mr. Adolph Romero, Jr.
Ms. Evelyn M. Silva

APPENDIX E. Addresses of the researchers receiving biological specimens collected on the dedicated vessel

Ridgway, Dr. Sam H.
Code 842
Naval Ocean Systems Center
San Diego, CA 92152

Walker, William A.
21 Barkentine Road
Rahcho Palos Verdes, CA 90274

Crawford, M. A.
Department of Biochemistry
Zoological Society of London
Regents Park, London NW1 4RY
01-722 3333

Cowan, Dr. Ian McT.
University of British Columbia
Vancouver 8, B.C., Canada

Varanasi, Usha
ONR Principal Investigator
Department of Chemistry
Seattle University
Seattle, Washington 98122

Tarpley, Dr. Raymond J.
Department of Veterinary Anatomy
College of Veterinary Medicine
Texas A and M University
College Station, Texas 77843

Bada, Dr. J.
UCSD-A-012
Scripps Institution of Oceanography
La Jolla, California 92039

Stuntz, Dr. Warren
Southwest Fisheries Center
8604 La Jolla Shores Drive
La Jolla, California 92039