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Marine Mammal Research Program of the Northeast Fisheries Science Center during 1990-95

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Note on Species Names

The NMFS Northeast Region's policy on the use of species names in all technical communications is generally to follow the American Fisheries Society's lists of scientific and common names for fishes (*i.e.*, Robins *et al.* 1991[a]), mollusks (*i.e.*, Turgeon *et al.* 1998[b]), a decapod crustaceans (*i.e.*, Williams *et al.* 1989[c]), and to follow the Society for Marine Mammalogy's guidance on scientific and common names for marine mammals (*i.e.*, Rice 1998[d]). Exceptions to this policy occur when there are subsequent compelling revisions in the classifications of species, resulting in changes in the names of species (*e.g.*, Cooper and Chapleau 1998[e]).

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[a]Robins, C.R. (chair); Bailey, R.M.; Bond, C.E.; Brooker, J.R.; Lachner, E.A.; Lea, R.N.; Scott, W.B. 1991. Common and scientific names of fishes from the United States and Canada. 5th ed. *Amer. Fish. Soc. Spec. Publ.*20; 183 p.

[b]Turgeon, D.D. (chair); Quinn, J.F.; Bogan, A.E.; Coan, E.V.; Hochberg, F.G.; Lyons, W.G.; Mikkelsen, P.M.; Neves, R.J.; Roper, C.F.E.; Rosenberg, G.; Roth, B.; Scheltema, A.; Thompson, F.G.; Vecchione, M.; Williams, J.D. 1998. Common and scientific names of aquatic invertebrates from the United States and Canada: mollusks. 2nd ed. *Amer. Fish. Soc. Spec. Publ.* 26; 526 p.

[c]Williams, A.B. (chair); Abele, L.G.; Felder, D.L.; Hobbs, H.H., Jr.; Manning, R.B.; McLaughlin, P.A.; Pérez Farfante, I. 1989. Common and scientific names of aquatic invertebrates from the United States and Canada: decapod crustraceans. *Amer. Fish. Soc. Spec. Publ.* 17; 77 p.

[d]Rice, D.W. 1998. Marine mammals of the world: systematics and distribution. *Soc. Mar. Mammal Spec. Publ.* 4; 231 p.

[e]Cooper, J.A.; Chapleau, F. 1998. Monophyly and interrelationships of the family Pleuronectidae (Pleuronectiformes), with a revised classification. *Fish. Bull. (U.S.)* 96:686-726.

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Acronyms

ESA	=	Endangered Species Act
GIS	=	geographic information system
ICES	=	International Council for the Exploration of the Sea
IWC	=	International Whaling Commission
MMI	=	[NEFSC's] Marine Mammal Investigation [predecessor to the NEFSC's PSB]
MMPA	=	Marine Mammal Protection Act
NEFSC	=	[NMFS's] Northeast Fisheries Science Center
NMFS	=	[NOAA's] National Marine Fisheries Service
PBR	=	potential biological removal
PSB	=	[NEFSC's] Protected Species Branch [successor to the NEFSC's MMI]
SSI	=	[NEFSC's] Sea Sampling Investigation [predecessor to the NEFSC's SSP]
SSP	=	[NEFSC's] Sea Sampling Program [successor to the NEFSC's SSI]
URI	=	University of Rhode Island
USMMC	=	U.S. Marine Mammal Commission
WCR	=	[Gulf Stream] warm-core ring
YONAH	=	Years of the North Atlantic Humpback Project

PREFACE

Marine mammal research conducted and supported by the Northeast Fisheries Science Center through 1989 was summarized in Waring *et al.* (1994). The present paper extends that summary through 1995, as the focus and scope of research expanded substantially. This paper was unfortunately delayed in press for more than 3 yr during administrative reorganization, the manuscript having been completed and accepted for publication in early 1996.

Marine mammal research conducted and supported by the NEFSC since 1995 is reported in the NEFSC Protected Species Branch website – *http://www.wh.whoi.edu/psb*. That website includes: this paper and its predecessor, reports documenting the status of all marine mammal populations off the northeastern United States, reports of marine mammal surveys and research cruises, and a bibliography of publications. The website, however, does not include budgetary details as included here.

ABSTRACT

We summarize marine mammal research supported by the Northeast Fisheries Science Center (NEFSC) from 1990 through 1995, extending the earlier description of NEFSC-supported research conducted during 1980-89 (Waring *et al.* 1994). The studies are classified into four broad research areas: ecological roles and habitat requirements, human interactions, optimum sustainable population size, and research planning and archiving. Each of these four research areas is then further classified into several research topics for a total of 19 topics. In the 1990-95 period, research on marine mammals intensified over that in the 1980s (Waring et al. 1994). In particular, population-level studies moved from population description (*e.g.*, distribution, migration) to population assessment (*e.g.*, abundance, bycatch) as definition and implementation of specific management approaches evolved to meet the changing requirements of the U.S. Marine Mammal Protection Act. Approximately 100 contracts, grants, and in-house projects in the amount of $9.1 KK were supported during 1990-95, and these expenditures are summarized by fiscal year. Research results that have emerged in the form of formal publications, reports, and oral presentations are organized into a series of appendices and are numerically sequenced to relate each one to a specific research topic described in the text. Those projects that appear to fall into more than one research area are classified according to where the most important results were obtained. The implications for future research directions are discussed.

INTRODUCTION

In the northeastern United States, marine mammals are a subject of historical and ecological significance. After decline of the Northeast's American whale fishery in the late 1800s and early 1900s, concern for systematic scientific study of marine mammal species declined. However, in the 1940s, following taxonomic studies undertaken by Remington Kellogg at the Smithsonian Institution and William Schevill at Harvard University, cetacean biology began to be investigated more thoroughly. In the early 1970s, several researchers began studying marine mammals in this region. With passage of the Marine Mammal Protection Act (MMPA) in 1972, this effort expanded. In 1979, the U.S. Marine Mammal Commission (USMMC) sponsored a workshop to address ongoing cetacean studies and to help in defining research needs for U.S. East and Gulf Coast marine mammals (Prescott *et al.* 1980). The National Marine Fisheries Service (NMFS) responded to these needs by funding a variety of projects on marine mammals and their interactions with commercial fisheries. The program expanded further as a result of information needs mandated by the 1988 amendment of the MMPA (Waring *et al.* 1994).

Waring *et al.* (1994) summarized research on marine mammals conducted and sponsored by NMFS in the northeastern United States in the 1980s. They organized this research into four broad areas, and within each area organized contract, grants, and in-house activities into several related topics. For each topic, they described the main results of the several research activities, and related those results to the expenditures and resulting publications.

NMFS marine mammal research activity during the first half of the 1990s was substantially broader and more intensive than that in the 1980s. The focus and conduct of this research effort began to change following the 1988 amendment to the MMPA. Increased funds became available, and NMFS staff became increasingly involved in both contracted and in-house research activities. In 1990, the Marine Mammal Investigation (MMI) was formed within the Northeast Fisheries Science Center (NEFSC) of NMFS. Initially, the MMI included five members, but by 1995 it had expanded to a staff of 10 and was renamed the Protected Species Branch (PSB). In addition, the need for information on bycatch of marine mammals in fishing gear resulted in the expansion of a program placing observers aboard fishing vessels. These at-sea observations were conducted as part of a more general program within the NEFSC by a separate unit, the Sea Sampling Investigation (SSI), beginning in 1989.

Research effort shifted again following the 1994 reauthorization of the MMPA, as increased emphasis began to be placed on information needed to implement the specific management approaches defined therein. In addition, the PSB became increasingly involved in the work of the Scientific Committee of the International Whaling Commission (IWC), especially in areas of expertise initially developed to address domestic research needs.

ORGANIZATION OF RESEARCH PROJECTS

We summarize the research conducted in the six fiscal years of 1990 through 1995, that is, from October 1989 through September 1995. This research effort was focused by the information needs identified under the 1988 amendment to the MMPA, especially those needs relating to fishery bycatch, and by several other more specific information needs. Planning for this research effort was formally organized into the four broad areas, the same identified by Waring *et al.* (1994) from retrospective analysis of the work in the 1980s (Table 1). Theses areas are: 1) ecological roles and habitat requirements, 2) human interactions, 3) optimum sustainable population size, and 4) research planning and archiving. While the four major research areas remained, specific research topics changed somewhat from those in the 1980s. Of the 18 original research topics, five were dropped and six were added for a total of 19 (Table 2).

Table 1. Definition of the four research areas into which marine mammal studies supported by the NEFSC during fiscal years 1990-95 were organized

Research Area	Definition
Ecological roles and habitat requirements	Focus is on seasonal and spatial distribution patterns, on feeding habits, and on basic population biology, including indirect interactions with human activities through the food chain
Human interactions	Focus is on those areas where human activities have a direct impact on marine mammals, including bycatch, entanglement, ship strikes, and whale watching
Optimum sustainable population size	Focus is on abundance of marine mammals, addressing their historic levels especially relative to information needs under the MMPA and Endangered Species Act (ESA)
Research planning and archiving	Focus is on identifying longer-term research planning methods, and on documenting and archiving results of previous research

The research area of ecological roles and habitat requirements continued its focus on distribution and abundance of humpback and fin whales, and also on habitat requirements of the right whale in the North Atlantic. The focus of study on harbor and gray seals shifted entirely from this area into that of optimum sustainable population size. The biological research related to samples and data provided by the NEFSC Sea Sampling Program (SSP), the successor to the SSI, was included within the ecological roles and habitat requirements area under the topic of biological sampling of fishery bycatch. Humpback biopsy sampling was included under the North Atlantic humpback and fin whales topic. The oceanographic correlation to spatial distribution topic contains research information previously listed under the energetic requirements of East Coast cetaceans topic. The satellite tagging and tracking topic was added as development and testing of this technology continued to expand.

The human interactions research area added a more topic on bycatch reduction. Methods are being developed to study the effect of time/area fishing restrictions on harbor porpoise bycatch and fish catch, and also to study the usefulness of deterrent devices attached to fishing gear to prevent marine mammal entanglement.

The optimum sustainable population size research area focuses mainly on the distribution and abundance of harbor and gray seals, harbor porpoise, large marine pelagics, and the right whale, and on the photographic identification of North Atlantic humpback and right whales. Research under the topic of bottlenose dolphin distribution and abundance along the Virginia Capes was taken over by the NMFS's Southeast Fisheries Science Center, and our focus expanded to include a more general topic of large marine pelagic distribution and abundance. The topic of population dynamics and assessment of status was added to address potential management issues implied by increased information resulting from current research, especially on levels of abundance and bycatch. Stock assessments for all marine mammal populations in the region were completed (Blaylock *et al.* 1995) as required under the 1994 reauthorization of the MMPA.

The research planning and archiving research area has one additional topic on the IWC Scientific Committee. This topic was added as U.S. involvement in IWC Scientific Committee issues continued to expand.

SUMMARY OF RESEARCH ACTIVITIES

During 1990-95, approximately 100 contracts, grants, and in-house projects in the amount of $9.1 KK were supported. Expenditures for each research topic within each of the four areas of research are summarized by fiscal year (Table 3). These values reflect all costs to NMFS and the NEFSC (exclusive of SSP contracts), including equipment and supplies, staff, salaries and related costs, contracts, charters, and travel. Salary expenditures for staff members were distributed proportionately among those topics according to the level of work responsibility. Results of this research were communicated in many forms, including formal publications, research reports, contract reports, cruise reports, and oral presentations to scientific bodies. These communication products have been organized in a series of four appendices depending on the degree of formality. Primary peer-reviewed scientific papers are listed alphabetically by author in Appendix A. Contract reports, working papers, and unpublished manuscripts are listed alphabetically by author in Appendix B. Oral presentations at scientific conferences are listed in Appendix C, alphabetically by author within conference. Finally, brief summaries of ship and aerial sighting surveys are listed chronologically in Appendix D.

Table 2. Marine mammal research topics supported by the NEFSC during fiscal years 1990-95 by research area

Topic	Activities and Issues
Ecological Roles and Habitat Requirements	
Oceanographic correlation to spatial distribution	Respiration characteristics; predator-prey relationships; food habits; trophic interactions; marine mammal - fisheries interactions; geographic information system (GIS) program development for habitat and environment analyses
North Atlantic humpback and fin whales	Seasonal distribution and abundance; Years of the North Atlantic Humpback (YONAH) Project; photographic identification; habitat use; demographics
Biological sampling of fishery bycatch	Incidental takes of marine mammals in commercial fishery; laboratory necropsy and subsequent analyses including genetics, contaminants, fatty acids, feeding habits, and health assessment
Northern right whale habitat requirements	Detection of changes in population distribution and size
Satellite tagging and tracking	Development and testing of the application of satellite tags to cetaceans
Human Interactions	
Marine mammal - fishery interactions	Documentation of marine mammals incidentally taken in commercial fisheries; bycatch estimation; sea sampling design for observer program
Whale - vessel interactions	Mitigation of ship strikes; interactions with whale-watch vessels
Bycatch reduction	Research and development of techniques to help prevent bycatch of marine mammals; GIS program development
Optimum Sustainable Population Size	
Harbor and gray seal distribution and abundance	Aerial abundance survey; expansion of population distribution; incidental mortalities
Harbor porpoise distribution and abundance	Shipboard and aerial sighting surveys; seasonal movements; population structure; winter distribution; abundance estimates
Harbor porpoise survey methodology	Vessel avoidance; aerial-vessel survey calibration experiment; development of hand-held, at-sea computer data entry device; adaptive sampling design
Large marine pelagics distribution and abundance	Pelagic delphinid surveys conducted by NEFSC along shelf edge and slope waters from southern edge of Georges Bank to the Scotian Shelf
Humpback photographic identification catalog	Western North Atlantic humpback photographic identification catalog with over 4,500 individual photos (maintained at College of the Atlantic)
Northern right whale photographic identification	Aerial and shipboard photographic identification catalog with approximately 6,800 photo records of 340 right whales (maintained at New England Aquarium); tracking of individuals; documentation of calving intervals; scars and wounds
Northern right whale distribution and abundance	Calving rates; population estimation and seasonal distribution; demographics; behavior; social groups
Population dynamics and assessment of status	Possible unsustainable bycatch levels of harbor porpoise; population dynamics of pilot whales; assessment of all marine mammal populations; performance study of IWC management procedures
Research Planning and Archiving	
IWC Scientific Committee	Overall coordination of U.S. research for submission to IWC Scientific Committee; U.S. annual progress report
Workshop support	Workshops conducted to address harbor porpoise research needs and accomplishments; tag and tracking technology; gear modification for bycatch reduction; NMFS-supported right whale research
Documentation and archiving	Archiving of fisheries observer and port sampling data; right whale database [maintained at the University of Rhode Island (URI)]; survey effort and sighting data; bibliographic system for cetacean literature

Table 3. Expenditures on marine mammal research (thousands of dollars) supported by the NEFSC during fiscal years 1990-95 by research topic. (Research topics have been numerically sequenced only for cross-referencing purposes with Appendix B.)

Topic	Year					
	1990	1991	1992	1993	1994	1995
1. Oceanographic correlation to spatial distribution	153	114	136	40	53	58
2. North Atlantic humpback and fin whales	6	10	202	185	236	61
3. Biological sampling of fishery bycatch	68	70	49	291	144	269
4. Northern right whale habitat requirements	126	126	100	190	40	89
5. Satellite tagging and tracking	-	-	-	117	98	82
6. Marine mammal - fishery interactions	116	105	50	60	44	120
7. Whale - vessel interactions	-	-	48	24	-	20
8. Bycatch reduction	-	-	-	45	69	71
9. Harbor and gray seal distribution and abundance	-	-	109	-	-	23
10. Harbor porpoise distribution and abundance	146	316	237	384	319	453
11. Harbor porpoise survey methodology	94	45	40	50	31	177
12. Large marine pelagics distribution and abundance	45	468	-	129	110	288
13. Humpback whale photographic identification catalog	23	20	30	30	113	50
14. Northern right whale photographic identification catalog	79	79	50	35	-	36
15. Northern right whale distribution and abundance	30	34	37	45	10	86
16. Population dynamics and assessment of status	90	55	12	20	30	82
17. IWC Scientific Committee	45	45	18	25	104	104
18. Workshop support	-	-	140	25	18	17
19. Documentation and archiving	-	-	-	30	50	74
Total	1,021	1,487	1,258	1,725	1,469	2,160

Table 4. Publications, reports, and oral presentations prepared for marine mammal studies supported by the NEFSC during fiscal years 1990-95 by research topic. (Numbers refer to numbered items in the corresponding appendices.)

	Appendix			
Topic	**A**	**B**	**C**	**D**
Oceanographic correlation to spatial distribution	28,48,49,51	33	1,7,15,18,23,28	
North Atlantic humpback and fin whales	3,14,16	2,3,4,5,9,32,49	3	18
Biological sampling of fishery bycatch	23,24,40,43	21,37,36	21,26	
Northern right whale habitat requirements				
Satellite tagging and tracking		36	25	
Marine mammal - fishery interactions	4,8,38,39,41,42, 45,47,50,52	7,22,24	11	
Whale - vessel interactions	12,15	19	16	
Bycatch reduction		20	22	
Harbor and gray seal distribution and abundance		18		
Harbor porpoise distribution and abundance	27,34,37	23,25,26,30,31, 38,51	20	2,4,6,8,10,14-17, 20
Harbor porpoise survey methodology	26,31-33	13,28,29,34,35, 44	8,19,27	
Large marine pelagics distribution and abundance		14,16,17,41	4,17,29	1,3,5,7,9,11-13
Humpback whale photographic identification catalog			2	
Northern right whale photographic identification catalog				
Northern right whale distribution and abundance	11,18,19,22		5,6,9,12,30,31,32	19
Population dynamics and status of assessment	1,2,5,6,9,30,44, 46	1,8,10,15	10,13,24	
IWC Scientific Committee	7,10,35,36	6,12,40,42,43, 45-48,50		
Workshop support	13,17,20,21,25,29	27		
Documentation and archiving	53		14	

The individual research results listed in the four appendices relate to one or more of the specific research topics. This relationship is summarized in Table 4, where the sequence numbers from each of the four appendices are tabulated for each research topic. From this table, it is apparent that the research results pertaining to each specific topic appear in several types of publications and reports.

ECOLOGICAL ROLES AND HABITAT REQUIREMENTS

Oceanographic Correlation to Spatial Distribution

Beginning in 1990, research surveys along the Gulf Stream wall and associated warm-core rings and in several major canyon areas were conducted, focusing on the associations of these features with the sperm whale and pelagic delphinid and beaked whale species. GIS techniques were used to analyze spatial and temporal data to determine overlap between the Mid-Atlantic/New England delphinid complex and its potential pelagic prey resources. Such studies were augmented by expansion of the scope of shipboard sighting surveys to include additional measurements of the water column's oceanographic regime and biological community.

Similar analyses were undertaken to determine better the seasonal habitat of harbor porpoise.

Considerable effort was devoted to developing more powerful statistical methods for analyzing spatial distribution patterns. As support for this work, GIS procedures were developed to describe the bathymetry and sea surface temperatures of the region. These procedures will allow researchers to develop habitat models for cetaceans and their prey, based on oceanographic features.

North Atlantic Humpback and Fin Whales

Beginning in 1984, researchers conducted transect surveys to document seasonal distribution and abundance of both fin and humpback whales in Cape Cod Bay and the Provincetown Slope. These surveys later expanded to the Great South Channel and the northern ridge of Georges Bank.

The YONAH Project began in January 1992 with a large-scale study of the humpback whale in its principal West Indies breeding range. The project continued in summer 1992 with sampling in all known North Atlantic feeding grounds from the Gulf of Maine to Norway. Sampling continued in 1993, and upon completion of the project's field work, the project had photographically identified approximately 4,000 humpback whales, and biopsied almost 2,600. While matches between areas (notably breeding and feeding grounds) will inevitably reduce these totals, these sample sizes remain unprecedented for a marine mammal study. The third year of the YONAH Project, 1994, was devoted to analysis of the huge volume of photographs, data, and tissue samples. All photographs were submitted to the College of the Atlantic (Bar Harbor, Maine) where they were compared and matched.

DNA has been extracted from virtually all YONAH tissue samples by the Institute of Population Biology at the University of Copenhagen, and sex determinations (using a molecular technique) were completed. Principal genetic analyses included an assessment of population structure using mitochondrial DNA and microsatellite systems. A variety of analyses of this data set are underway, including estimates of abundance, genetic relationships, and behavior patterns.

Biological Sampling of Fishery Bycatch

Marine mammals taken incidentally in directed fishery operations were collected by observers aboard U.S. East Coast foreign fishing/processing vessels beginning in 1986, and by observers aboard domestic fishing vessels beginning in 1989. These specimens provided new information on food habits, morphometrics, reproductive biology, physiology, and parasitology.

Bycaught animals continued to be collected by observers under the SSP for use in NEFSC necropsy sessions. These sessions, conducted in cooperation with other organizations such as the U.S. National Museum of Natural History and Woods Hole Oceanographic Institution, serve to train new observers and also to provide a wide variety of information for studies of life history of small cetaceans. All biological samples collected by the SSP and stored at NEFSC were processed and cataloged.

Northern Right Whale Habitat Requirements

The NEFSC has administered an integrated research program on the northern right whale since the mid-1980s which has yielded findings on the species' abundance, distribution, stock structure, and behavior. Methods have included vessel and aerial surveys, radio-satellite tagging, photographic identification, and genetic analysis.

As a result of a Congressional initiative supporting northern right whale research, the NEFSC increased ongoing research on habitat requirements in 1987. Five major habitats were identified: 1) coastal waters of the southeastern United States, 2) Great South Channel, 3) Cape Cod Bay, 4) Bay of Fundy, and 5) Scotian Shelf.

Genetic analysis, based on mitochondrial DNA, suggests that the population is based on three "matrilines," or distinct lineages, stemming from reproductive females.

The population is estimated to number between 300 and 350, and is thought to be recovering at a rate of 3-4% annually. The "Final Recovery Plan for the Northern Right Whale" was released in spring 1992. Science and manage-

ment workshops were held in April 1992 and October 1994 to review research and to identify recovery plan implementation priorities. Recent observations of a drop in calf counts, a possible increase in the average calving interval, longer calving intervals on average than for the southern right whale, and a proportion of apparently nonreproducing mature females, give cause for concern.

Satellite Tagging and Tracking

Beginning in 1992, the NEFSC, working jointly with the Office of Naval Research, supported contract studies to develop and test application of satellite tags to large and small cetaceans. Studies included biocompatibility of attachment materials, hydrodynamic aspects of tag design, and the dorsal fin's morphology and role in temperature regulation.

Increased field testing of satellite tags on harbor porpoise occurred during summer 1995 on Grand Manan Island at the mouth of the Bay of Fundy. Six harbor porpoise were tagged with ARGOS transmitters redesigned for a lower profile. Data were collected on movement and diving patterns as these animals undertook their annual migration.

HUMAN INTERACTIONS

Marine Mammal - Fishery Interactions

Marine mammals in New England and Mid-Atlantic waters are taken incidentally in several fisheries. These fisheries are described in the "List of Fisheries" published annually by the NMFS Office of Protected Resources.

Data were collected by the SSP and other programs on bycatches of marine mammals, and were used with fishing effort information to estimate total annual bycatch levels. Scientific workshops reviewed data collection techniques for use by the SSP, and sought to optimize data collection by changing from random sampling to sampling proportional to fishing effort.

Focus of this work involved the harbor porpoise because of its high incidental take relative to its potential biological removal (PBR) in the Gulf of Maine sink gillnet fishery. The initial focus on harbor porpoise was gradually replaced by an emphasis on all species. Trawl fisheries for Atlantic mackerel and squids and drift gillnet fisheries for swordfish and tunas also take marine mammals in the western North Atlantic. Twenty-one species of marine mammals have been reported as bycatch in these fisheries. These bycatch data are included in the "U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments" published annually by NMFS (Blaylock *et al.* 1995). Bycatch and abundance data from these assessments classify stocks as strategic or nonstrategic as defined by the MMPA.

Whale - Vessel Interactions

The northern right whale population is threatened by human impacts, specifically ship strikes and gear entanglement. In 1992 and 1993, the NEFSC participated in a multiagency mitigation effort with the states of Florida and Georgia as major participants. The effort included an assessment of vessel traffic, education of mariners, development of an early warning network to alert vessel operators in and near shipping areas, and research on right whale distribution, behavior, and habitat. A Southeastern U.S. Implementation Team for the Recovery of the Northern Right Whales became active and based much of its effort on work from the 1992 and 1993 wintering seasons.

Funding was also provided for modeling the dynamics of interactions between cetacean size and ship hull design in order to determine the likelihood of ship strikes of marine mammals, especially large whales.

Bycatch Reduction

The high incidental take -- relative to PBR -- of harbor porpoise in the Gulf of Maine caused much concern about the status of this species. As a result, the NEFSC investigated bycatch reduction methods during 1992 and 1993. To investigate the effect of time-area fishing restrictions on harbor porpoise bycatch and fish catch, a computer program was developed that uses GIS and the 1990-92 sea sampling and commercial weighout databases. The program was designed to link at-sea observer and fisheries port sampling data to estimate the proportion of harbor porpoise bycatch that may be associated with different seasons and areas in sink gillnet fishing operations in the Gulf of Maine. In September 1993, the NEFSC hosted a bycatch reduction workshop which considered net modifications that might make the nets more detectable or otherwise less likely to entangle harbor porpoise. The NEFSC also supported or participated in several experiments to test acoustic deterrent devices for use in the sink gillnet fishery. The 1994 definitive experiment by Kraus *et al.* (1995) was supported with SSP observer coverage.

OPTIMUM SUSTAINABLE POPULATION SIZE

Harbor and Gray Seal Distribution and Abundance

Two major species of pinnipeds occur in New England waters. The harbor seal is a year-round inhabitant of coastal waters of Canada and Maine, and occurs seasonally in Southern New England. The population is subject to influenza outbreaks and incidental mortality in several fisheries. Since 1972, harbor seal abundance along the New England

coast appears to have more than tripled, and range has expanded southward. Pupping ledges along the Maine coast have increased in number and expanded further offshore. An aerial survey was conducted during pupping season in 1993 along the coast of Maine. The number of harbor seal counted was more than double that counted in a 1986 aerial survey.

The gray seal has established breeding colonies on islands in Nantucket Sound and off the Maine coast in recent years.

Harbor Porpoise Distribution and Abundance

In the Northwest Atlantic, harbor porpoise are found from North Carolina to Labrador. The simultaneous timing of reproduction in widely separated geographical areas suggests that there are four populations in the Northwest Atlantic: 1) western Greenland, 2) Newfoundland-Labrador, 3) Gulf of St. Lawrence, and 4) Gulf of Maine (Gaskin 1984). Populations, seasonal movements, and the degree of mixing between putative populations are largely unknown.

To document seasonal distribution of harbor porpoise in the Gulf of Maine region, researchers began by using harbor porpoise sightings made aboard whale-watch and research vessels. In 1982, a shipboard survey was conducted along the Maine coast to estimate coastal distribution patterns and to estimate population size using line-transect methods. After survey methodology experiments that began in 1987, NEFSC researchers conducted aerial and shipboard line-transect surveys from the Gulf of Maine to Florida to improve documentation of seasonal distribution, the southern edge of summer range, and the northeastern distribution pattern of the species. Shipboard surveys were conducted during each August of 1990-93, March 1995, and July-August 1995. Aerial surveys were conducted during October 1991, December 1992, February 1993, April 1993, November 1993, and August-September 1995. Large numbers of harbor porpoise were seen in the Gulf of Maine - lower Bay of Fundy region in summer, but nearly none in the same region in winter. Winter distribution is largely unknown, except that some harbor porpoise have been found stranded on beaches from New York to North Carolina in winter and spring. There is little information on distribution of harbor porpoises in nonsummer months in Canadian waters off Nova Scotia and Newfoundland, and within the Gulf of St. Lawrence.

The best available estimates of population size based on summer survey work are 37,500 (95% confidence interval of 26,700-86,400) animals for 1991, 67,500 (32,900-104,600) animals for 1992, and 74,000 (40,900-109,100) animals for 1995.

Harbor Porpoise Survey Methodology

In 1987, the NEFSC conducted an experimental line-transect survey for harbor porpoise in the Gulf of Maine. Results indicated that harbor porpoise elicited a negative response to the vessel, that a large fraction of animals along the survey track were missed, and that observer elevation above sea surface had little effect on sighting rate.

Another experimental sighting survey for harbor porpoise was conducted during August 3-23, 1993, to test for vessel avoidance. The analysis of survey data suggested that, although harbor porpoise do appear to avoid survey ships, this does not occur at distances greater than can be detected by observers searching with the unaided eye.

In March 1995, a hand-held, pen-based computer system for at-sea data entry of line-transect data was developed and successfully tested at sea.

During August-September 1995 line-transect surveys, a comparison study was conducted of sighting rates, distribution, and estimated abundance of harbor porpoise as detected by an airplane versus a ship sighting platform. Also, methods were used to further study the calculation of g(0), the probability of detecting a group of animals on the track line.

Studies were started on an adaptive sampling design in which a planned transect line is diverted in order to explore an outside area where animals seem plentiful. With development of a proper accountability for bias, this method may be more useful than the systematic sampling method used thus far.

Large Marine Pelagics Distribution and Abundance

Shipboard surveys of pelagic delphinids were conducted along the shelf edge and slope waters from the southern edge of Georges Bank to the Scotian Shelf. Surveys were conducted in August 1990, June-July 1991, March-April 1992, June-July 1993, August-September 1994, and July-August 1995. These surveys investigated beaked whale and pelagic delphinid fine-scale distribution in shelf edge and Gulf Stream warm-core rings. These distribution studies are essential for accurate determination of population abundance as required by the MMPA. Line-transect survey data were also collected and photographic identification studies were done using a rigid-hulled inflatable boat.

Humpback Photographic Identification Catalog

During the 1980s, mark-recapture methods were used to derive population estimates for the five Northwest Atlantic substocks of the humpback whale. Also, researchers conducted a study on the stability of humpback fluke patterns over time using a time series of archived photographs. The study supported the validity of using fluke patterns for long-term studies of individual animals.

Several organizations were funded in the 1980s to conduct song recordings and photographic identification studies which provided information on breeding behavior, stock intermixing, individual identification, and habitat use.

Since 1976, the College of the Atlantic has curated the "North Atlantic Humpback Whale Catalog," the central collection of photographs of the flukes of humpback whales obtained from the North Atlantic region. The collection contains material on more than 4,500 cataloged humpback whales from 1952 to 1992.

Northern Right Whale Photographic Identification Catalog

Beginning in 1987, as a result of a Congressional initiative supporting northern right whale research, individual identification photographs were taken and integrated into a single database. This effort resulted in an improved count of individually known animals in a published catalog and an ongoing system for archiving new photographs. The New England Aquarium (Boston, Massachusetts) maintains the "North Atlantic Right Whale Photographic Identification Catalog." The catalog contains 6,795 photographed records of 340 right whales taken between 1935 and 1994. One component of this catalog documents scars and wounds resulting from human impacts, principally ship strikes and net entanglement.

Northern Right Whale Distribution and Abundance

During the 1980s, the NEFSC administered funding for several northern right whale studies focusing on photographic identification, calving rates, population estimation, demographics, and habitat use. Studies for documenting historic right whaling activities along the southeastern U.S. coast were also supported. Through the earlier-mentioned Congressional initiative, an integrated study of the North Atlantic right whale was implemented in 1987 through a cooperative agreement with the URI with the overall goal of detecting changes and causes of changes in population distribution and size.

In 1992, an airship donated by Sea World, Inc., surveyed winter nursery grounds off the Florida and Georgia coasts and observed distributional overlap between whales and U.S. Navy submarines. A similar project was conducted in 1993, and included ship traffic characterizations in two shipping channels and an education and awareness program for mariners. In August 1993, airship research flights were conducted using airship-mounted, high-resolution camera equipment for studying whale behavior and sightability relative to abundance estimation correction factors.

Population Dynamics and Assessment of Status

Throughout the 1980s, marine mammal research supported by the NEFSC focused on determining basic biology, distribution, and migration of cetaceans, and on primary human impacts. There was a broader emphasis in the 1990s as information increased, especially relative to levels of abundance and fishery bycatch. Research shifted more towards population dynamics and assessments of stock status and associated management implications.

An initial focus on harbor porpoise resulted in identification of possibly unsustainable levels of bycatch for this species. Subsequently, the status of other species was determined by comparing estimates of bycatch and abundance. PBR levels were computed for all species and compared to annual estimates of incidental take. These comparisons identified several species of concern, including harbor porpoise, long-finned pilot whale, shortbeaked common dolphin, whitesided dolphin, bottlenose dolphin, and five species of beaked whales (*Mesoplodon* spp.).

Studies of the population dynamics of pilot whales, in conjunction with the International Council for the Exploration of the Sea (ICES), were also conducted.

Assessments of the status of all marine mammal populations in the region were conducted as mandated under the 1994 MMPA reauthorization (Blaylock *et al.* 1995).

Studies of the performance of management procedures were also undertaken to meet information needs of the IWC Scientific Committee.

RESEARCH PLANNING AND ARCHIVING

IWC Scientific Committee

U.S. scientists have been involved in the work of the IWC Scientific Committee since its beginning in the 1950s. In recent years, scientists from the Alaska, Southwest, and Northeast Fisheries Science Centers, NMFS headquarters, and from several academic institutions have been involved. NMFS scientists were involved primarily because their research was relevant to issues being addressed by the IWC Scientific Committee.

Beginning in 1992, U.S. scientists began to conduct research which directly addressed some Scientific Committee issues, and NEFSC involvement expanded to include: 1) coordination of U.S. research interaction with the Scientific Committee, 2) preparation with other U.S. scientists of an annual progress report for the Scientific Committee, and 3) specific research on population dynamics, management methods, and methods of estimating abundance.

Workshop Support

A harbor porpoise workshop was hosted by the NEFSC during May 5-8, 1992, to evaluate the status of harbor porpoise populations in eastern North America. Information was reviewed on population structure, reproductive rates, population size, bycatch levels, and ecological relationships. The NEFSC also hosted a follow-up harbor porpoise work-

shop during February 23-25, 1994, where scientists from the United States, Canada, and England assessed the status of harbor porpoise by reviewing information on population structure, as well as estimates of abundance, bycatch, and population growth rates. Also, habitat requirements were hypothesized by investigating physical, biological, and anthropogenic factors correlated with the distribution and abundance of harbor porpoise.

A workshop on tagging and tracking technology, supported by the NEFSC, was held during February 11-13, 1992, in Warrenton, Virginia. The workshop was jointly sponsored by the Office of Naval Research, Minerals Management Service, NMFS, and USMMC. Participants included researchers from the United States, Canada, Great Britain, Norway, and Japan, and representatives of engineering and consulting firms involved in developing radio tags. The meeting provided a forum to review past approaches, to describe state-of-the-art technology, and to identify further research and development requirements.

A workshop was hosted by the NEFSC during September 20-23, 1993, to identify possible modifications to sink gillnet fishing gear to reduce harbor porpoise bycatch rates. Participants included representatives from the gillnet fishing industry and research scientists and statisticians from Japan, New Zealand, Great Britain, Canada, and NMFS. The workshop considered modifications which might make nets more acoustically detectable and less likely to entangle animals.

"Right Whales in the Western North Atlantic: A Science and Management Workshop" was conducted on April 14 and 15, 1992, in Silver Spring, Maryland.

In October 1994, an independent peer review of North Atlantic right whale research supported by the NEFSC was conducted in Woods Hole, Massachusetts. A five-member international panel reviewed and evaluated past right whale research and made recommendations for future research and a long-term monitoring program.

Documentation and Archiving

A database documenting right whales in the Northwest Atlantic is kept by URI. Humpback whale photo and biopsy samples from the YONAH Project are being documented and stored in a comprehensive YONAH archive.

Data transfer from a VAX computer to an ORACLE database management system was begun at the NEFSC in 1995. Included in this exercise was the entering of marine mammal bycatch data from the sink gillnet fishery collected by the SSP.

SUMMARY OF RESEARCH RESULTS

The 16 yr of research on marine mammals documented here and in Waring *et al.* (1994), in conjunction with other research programs sponsored by other agencies (*e.g.*, U.S. Army Corps of Engineers, Minerals Management Service, State of Massachusetts), have established a broad general understanding of the distribution, abundance, and ecological roles of the 34 species using the waters off the Northeastern United States. This research has addressed and gone well beyond recommendations of the initial USMMC research planning workshop in 1979 (Prescott *et al.* 1980; see Table 1 of Waring *et al.* 1994).

The spatial scale of the research has expanded to cover more of the ranges of most of the species which are more than intermittent visitors to the region. Sighting and individual identification surveys have been conducted south to the northern wall of the Gulf Stream, east along the southeastern coast of Nova Scotia, and north well into the Bay of Fundy. Further, for selected species, international efforts have been developed which effectively expand the geographic area of research coverage across the Atlantic. These efforts have been facilitated by increased involvement internationally. For example, the geographic scope of harbor porpoise studies has been expanded to address issues of population discreteness through the IWC Scientific Committee and the "Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas." Studies of pelagic delphinids have also been expanded in scope under auspices of ICES. Less formal international efforts have been conducted bilaterally, with both government and academic Canadian researchers focusing on harbor porpoise, and with researchers in Canada, Greenland, Iceland, Norway, Great Britain, and Puerto Rico working on the YONAH Project.

Research activities have involved the application of existing methods and the development and adaptation of new techniques. The 1885 recommendation of Frederick True (True 1885) of collecting and analyzing stranded animals has been generalized to include samples collected by trained observers from fishery bycatch, and has become a well organized and critically important basis for the study of marine mammals in this region. Through such programs, tissue samples have been made available routinely to researchers around the world for a variety of basic research studies. Increasingly sophisticated methods for field collection and for laboratory analysis of these samples have been applied, providing valuable information on population discreteness and vital rates.

Related information has been obtained from individual animal identification studies of some species. These have become a mainstay of studies of humpback and northern right whales. Long-term investments have been made in the annual sampling required for these methods, and in establishing and supporting photographic catalogs and their associated field sampling databases. This effort has provided an improved understanding of movements and improved estimates of vital rates.

Additional information has been obtained from tissue samples using biochemical and molecular genetic analyses. Collection of a variety of tissue samples for this purpose has become routine, both from stranded and bycaught ani-

mals and from biopsy samples collected with increased frequency during photographic identification studies. Such methods have begun to allow strong inferences about population genetic structure and ecological roles.

Aerial and shipboard sighting survey methods have been applied since 1979, first in a major study to determine overall distribution patterns and subsequently for other purposes. These methods have been markedly improved and have received increasing interest in the United States and elsewhere in managing cetacean populations based on abundance estimates derived from fishery-independent data. At-sea data collection methods have been improved through use of better electronics for data collection and automated recording. In addition, the scope of the data collected during sighting surveys has been expanded in this region to include various forms of oceanographic and fishery-related data. This expansion has allowed more specific study of habitat requirements and correlated factors.

Development of increasingly sophisticated electronic tags, communicating radio frequencies, has been matched with a strong effort at development of methods of attaching these tags to cetaceans. Focus has been on methods of attaching tags to captured living animals such as rehabilitated stranded animals (*e.g.*, pilot whale) and fishery-caught animals (*e.g.*, harbor porpoise), and of directly implanting them in larger cetaceans, especially northern right whales. This research effort has increased information on individual animal movement patterns and ecological behavior.

Over the past 16 yr, a large amount of data on a wide variety of aspects of marine mammal biology have been collected. Although the data were collected to answer specific questions, they have also become very useful for new research applications, including identification of longer-term patterns. Spatial aspects have increasingly been addressed using GIS technology, especially in linking the data with other data collected by other elements of NMFS and by other agencies. The application of this technology has been made more effective by developing improved statistical methods for analyzing spatial data.

Focus of the research conducted within each of the four areas has shifted over time as our understanding has increased and as priorities and questions have shifted. The level of activities related to research planning and data archiving has varied over the 16 yr. Initially, general long-term plans were developed, followed in the 1980s by implementation of those plans. More specific long-term planning was undertaken in the late 1980s, followed in 1993 and 1994 by very specific assessment, methodology, and species-oriented planning. A new role began in coordinating the scientific work done by several elements of NMFS in support of the Scientific Committee of the IWC. Strong emphasis was given towards archiving the developing photographic identification and sighting survey databases.

Research on ecological roles and habitat requirements have focused on cetaceans, and increasingly (in the 1990s) on spatial distribution patterns. The long-term focus on the endangered northern right whale and humpback whale has continued, and there has been increased focus on the laboratory analysis of samples obtained from fishery bycatch. In 1992, a major effort to develop methods for satellite tagging and tracking was begun, culminating with the successful tagging of harbor porpoise in 1994 and 1995.

Research on human interactions with marine mammals has been expanded since the early 1980s in response to the increased focus on fishery bycatch in the 1988 and 1994 amendments of the MMPA. Data collected under the NEFSC observer program were used to estimate levels of bycatch, focusing initially on harbor porpoise, but gradually expanding to include all species of marine mammals. This bycatch estimation effort was associated with an increase in emphasis on bycatch reduction methods in response to the identified high bycatch levels for some species. Human impacts on large whales were also studied and research was supported to mitigate ship strikes on right whales through mathematical modeling of ship hulls, with such modeling serving as a tool for evaluating the potential for collisions with right whales on their calving and wintering grounds in the coastal waters of the southeastern United States. This study addressed an issue first identified in the mid-1980s.

Research on optimum sustainable population size increased markedly for harbor porpoise, and was continued for humpback and northern right whales. Surveys to document the expansion of pinniped abundance were repeated in the 1990s. The ecology of pinnipeds has continued to receive little or no attention. The abundance of other cetacean species, especially in the southern portions of the areas, has received increased attention in recent years. The 1994 reauthorization of the MMPA increased the focus on determining the status of all marine mammal populations. This population status work included both preparation of routine summaries of abundance and bycatch estimates, and more basic research into population dynamics of cetaceans. Work was also done here in conjunction with ICES and the IWC.

The results of this research have been used to provide information within NMFS and to other management and scientific bodies, including the New England and Mid-Atlantic Fishery Management Councils, Atlantic States Marine Fisheries Commission, USMMC, ICES, and IWC.

IMPLICATIONS FOR FUTURE RESEARCH DIRECTIONS

Priorities for research in the 1990s increased the focus on a selected set of issues, especially the impacts of fishery bycatch and the status of endangered large whales. During the process of conducting this research, substantial data sets have been accumulated and many new methods have been developed and applied. This is especially true relative to the areas of human interactions and optimum sustainable population levels. We are in a position to be able to answer many questions that are likely to arise in these areas.

To ensure our ability to respond efficiently to future management needs, it is essential that several sets of data collected over the past 16 yr be made more easily accessible. The progress made in working up the Cetacean and Turtle Assessment Program sighting data, and more recently the bycatch and photographic identification data, needs to be continued in order to access efficiently many other sets of data, many collected with evolving field methods.

Many aspects of the ecology of marine mammals remain to be addressed. The need for understanding the ecological role of marine mammals, especially in relation to the heavily exploited fisheries in this region, can be expected to increase. To address such questions will require integration of what we have learned over the past 16 yr, and the development and application of additional new research methods.

Other areas in need of additional attention are feeding ecology, habitat use, and population migration and genetic patterns. These areas are difficult to study, and will require more intense field studies using increasingly sophisticated research methods. The issue of feeding ecology, especially, must be jointly conducted with studies of the principal prey species involved. This will clearly require increasing interaction with other elements of the NMFS, and with other agencies and institutions. It is less clear, however, how priorities for this additional research should be determined. For example, much needs to be learned about feeding ecology of pinniped populations, but determination of the proper balance between dedicated studies of pinniped distribution and abundance and dedicated studies of pinniped feeding ecology will be difficult. Similarly, both direct observation of movements and genetic analyses will be useful in studying population migration and genetic patterns, but the best balance between these issues will be difficult to determine.

The priorities and direction of marine mammal research in the northeastern United States were initially determined by the 1979 workshop (Prescott *et al*. 1980). Beginning in the late 1980s, the priorities were increasingly determined by questions in support of the management of these populations. The management issues have been determined by the focus of successive amendments to the MMPA and the ESA. Those priorities ensure that the most pressing management questions are addressed, but will not necessarily ensure that the knowledge base required into the next century will be developed. To ensure a proper balance in future research activities, it would be timely to once again develop a broad general research agenda, much like that developed in 1979. Such a broad agenda could be used, in conjunction with the likely changing management priorities, to determine the best mix of research programs over the next decade. The scope of the research required and the problem of balancing competing research priorities make developing such an agenda difficult. Obtaining an agreed agenda can most easily be done in the context of a workshop, with broad representation across disciplinary lines. Without the development of such an agenda, the focus of research in this region will tend to drift with management priorities, and the long-term studies required to understand fully the ecological role and human interactions of marine mammals will be difficult to carry out.

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APPENDICES

APPENDIX A

Published Scientific Papers Based on Marine Mammal Research Projects Supported by the NEFSC during 1990-95

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APPENDIX B

Contract Reports, Manuscripts, and Working Papers Based on Marine Mammal Research Projects Supported by the NEFSC during 1990-95

1. Abend, A.; Smith, T.D. 1995. Using ratio of stable isotopes of carbon and nitrogen to determine dietary changes in long-finned pilot whales. Available *from*: T. Smith, National Marine Fisheries Service, 166 Water Street, Woods Hole MA 02543. [Work primarily related to research topic no. 16; see Table 3.]

2. Allen, J.; Clapham, P.; Hammond, P.; Katona, S.; Larsen, F.; Lien, J.; Mattila, D.; Øien, N.; Palsbøl, P.; Sigurjònsson, J.; Smith, T.[D.] 1993. Years of the North Atlantic humpback (YONAH) progress report. *Int. Whaling Comm. Pap.* SC/44/PS2. [Work primarily related to research topic no. 2; see Table 3.]

3. Allen, J.; Clapham, P.; Hammond, P.; Katona, S.; Larsen, F.; Lien, J.; Mattila, D.; Øien, N.; Palsbøl, P.; Sigurjònsson, J.; Smith, T.D. 1994. Years of the North Atlantic humpback (YONAH) progress report. *Int. Whaling Comm. Pap.* SC/45/NA6. [Work primarily related to research topic no. 2; see Table 3.]

4. Allen, J.; Clapham, P.; Hammond, P.; Katona, S.; Larsen, F.; Lien, J.; Mattila, D.; Øien, N.; Palsbøl, P.; Sigurjònsson, J.; Smith, T.[D.]; Stevick, P. 1995. Years of the North Atlantic humpback (YONAH) progress report. *Int. Whaling Comm. Pap.* SC/46/NA9. [Work primarily related to research topic no. 2; see Table 3.]

5. Beard, J.; Clapham, P.; Hammond, P.; Katona, S.; Larsen, F.; Lien, J.; Mattila, D.; Mayo, C.; Øien, N.; Palsbøl, P.; Polacheck, T.; Sigurjònsson, J.; Smith, T. 1991. YONAH: Years of the North Atlantic humpback whale -- a proposal for discussion. *Int. Whaling Comm. Pap.* SC/42/O25. [Work primarily related to research topic no. 2; see Table 3.]

6. Bravington, M. 1995. An appraisal of Bayesian synthesis, with suggested modifications and diagnostics. *Int. Whaling Comm. Pap.* SC/47/AS18. [Work primarily related to research topic no. 17; see Table 3.]

7. Bravington, M.V.; Bisack, K.D. 1995. Estimates of harbor porpoise bycatch in the Gulf of Maine sink gillnet fishery, 1990-1993. *Int. Whaling Comm. Pap.* SC/47/SM24. [Work primarily related to research topic no. 6; see Table 3.]

8. Caswell, H.; Brault, S.; Read, A.; Smith, T.; Barlow, J. 1995. Uncertainty analysis of harbor porpoise population growth rate and bycatch mortality. *Int. Whaling Comm. Pap.* SC/47/SM28. [Work primarily related to research topic no. 16; see Table 3.]

9. DeKing, D.; Clapham, P.; Mattila, D. 1994. YONAH (years of the North Atlantic humpback): final report on field work and preliminary data analysis. *Int. Whaling Comm. Pap.* SC/46/NA5. [Work primarily related to research topic no. 2; see Table 3.]

10. Desportes, G.; Brault, S. 1993. Analysis of reproductive status of long-finned pilot whales from the North Atlantic. Final report. NOAA Contract No. 40-EANF-2-01695. [Work primarily related to research topic no. 16; see Table 3.]

11. Friday, N. 1995. Heterogeneity and capture-recapture estimates of abundance of the North Atlantic humpback whale. Dissertation proposal. Kingston, RI: Univ. of Rhode Island. [Work primarily related to research topic no. 2; see Table 3.]

12. Garrett-Logan, N.; Smith, T.D. 1995. Pingle: a pen-based computer system for data entry on line-transect surveys. *Int. Whaling Comm. Pap.* SC/47/O9. [Work primarily related to research topic no. 11; see Table 3.]

13. Givens, G.H.; Bravington, M.V. 1995. Borel's paradox and sensitivity analysis. *Int. Whaling Comm. Pap.* SC/47/AS21. [Work primarily related to research topic no. 17; see Table 3.]

14. Griffin, R. 1995. Distributional ecology of large marine predators in the North Atlantic: physical and biological interactions. Dissertation proposal. Kingston, RI: Univ. of Rhode Island. [Work primarily related to research topic no. 12; see Table 3.]

15. Heltshe, J.F.; Wentworth, C.; Peng, L. 1995. Alternative sampling plans to estimate abundance of clumped individuals. *Int. Whaling Comm. Pap.* SC/47/SM31. [Work primarily related to research topic no. 16; see Table 3.]

16. International Council for the Exploration of the Sea. 1992. Report of the Study Group on Pilot Whales, Montreal, 3-4 Dec. 1991. *Int. Counc. Explor. Sea C.M.* 1992/N:3; 24 p. [Work primarily related to research topic no. 12; see Table 3.]

17. International Council for the Exploration of the Sea. 1993. Report of the Study Group on Long-finned Pilot Whales, Copenhagen, 30 August - 3 September 1993. *Int. Counc. Explor. Sea C.M.* 1993/N:5 Ref. A. [Work primarily related to research topic no. 12; see Table 3.]

18. Kenney, M.K.; Gilbert, J.R. 1994. Increase in harbor and gray seal populations in Maine. Final report. NOAA Contract No. 50-EANF-2-00064. [Work primarily related to research topic no. 9; see Table 3.]

19. Knowlton, A.R.; Korsmeyer, F.T.; Kerwin, J.E.; Wu, H.Y.; Hynes, B. 1995. The hydrodynamic effects of large vessels on right whales. Final report. NOAA Contract No. 40-EANF-FF-4-00534. [Work primarily related to research topic no. 7; see Table 3.]

20. Kraus, S.; Read, A.; Anderson, E.; Baldwin, K.; Solow, A.; Spradlin, T.; Williamson, J. 1995. A field test of the use of acoustic alarms to reduce incidental mortality of harbor porpoises in gillnets. *Int. Whaling Comm. Pap.* SC/47/SM17. [Work primarily related to research topic no. 8; see Table 3.]

21. McLellan, W.A.; Pabst, D.A.; Westgate, A.J.; Koopman, H.N.; Read, A.J. 1995. Postmortem cooling rates of harbor porpoises, *Phocoena phocoena*. *Int. Whaling Comm. Pap.* SC/47/SM21. [Work primarily related to research topic no. 3; see Table 3.]

22. Northridge, S. 1995. Estimation of cetacean mortality in the U.S. Atlantic swordfish and tuna driftnet and pair trawl fisheries. Final report. NOAA Contract No. 40-ENNF-5-00045. [Work primarily related to research topic no. 6; see Table 3.]

23. Northridge, S. 1995. Seasonal distribution of harbour porpoises in U.S. Atlantic waters. *Int. Whaling Comm. Pap.* SC/47/SM43. [Work primarily related to research topic no. 10; see Table 3.]

24. Northridge, S.; Smith, T. 1994. The use of a geographical information system in analyzing and representing catch and sightings data. *Int. Counc. Explor. Sea C.M.* 1994/N:6. [Work primarily related to research topic no. 6; see Table 3.]

25. Palka, D. 1992. Abundance estimate of the Gulf of Maine harbor porpoise. *Int. Whaling Comm. Pap.* SC/44/SM24. [Work primarily related to research topic no. 10; see Table 3.]

26. Palka, D. 1993. Aerial survey results. Evidence of harbor porpoise seasonal movements. Available *from*: D. Palka, National Marine Fisheries Service, 166 Water Street, Woods Hole MA 02543. [Work primarily related to research topic no. 10; see Table 3.]

27. Palka, D. 1994. Summary of a scientific workshop to evaluate the status of harbor porpoise (*Phocoena phocoena*) in the western North Atlantic and an international proposal to investigate population structure. *Int. Whaling Comm. Pap.* SC/46/SM18. [Work primarily related to research topic no. 18; see Table 3.]

28. Palka, D. 1995. Effects of Beaufort sea state on the sightability of harbor porpoises in the Gulf of Maine. *Int. Whaling Comm. Pap.* SC/47/SM26. [Work primarily related to research topic no. 11; see Table 3.]

29. Palka, D. 1995. Evidence of ship avoidance from harbor porpoises during line-transect sighting surveys in the Gulf of Maine. *Int. Whaling Comm. Pap.* SC/47/SM27. [Work primarily related to research topic no. 11; see Table 3.]

30. Palka, D.; Hammond, P. 1994. Summary of research on harbour porpoises in the North Atlantic and Baltic Sea. *Int. Whaling Comm. Pap.* SC/46/SM17. [Work primarily related to research topic no. 10; see Table 3.]

31. Palka, D.; Read, A. 1995. Summary of current knowledge of harbor porpoises in US and Canadian waters of the NW Atlantic. *Int. Whaling Comm. Pap.* SC/47/SM23. [Work primarily related to research topic no. 10; see Table 3.]

32. Palsbøll, P. 1995. YONAH: the genetic analysis subproject. *Int. Whaling Comm. Pap.* SC/47/NA10. [Work primarily related to research topic no. 2; see Table 3.]

33. Payne, P.M.; Heinemann, D.W.; Smith, T.D. 1990. Seasonal distribution of minke whales in the shelf and shelf-edge waters of the northeastern US. *Int. Whaling Comm. Pap.* SC\42\NHMi32. [Work primarily related to research topic no. 1; see Table 3.]

34. Polacheck, T.; Smith, T.D. 1990. Simulation results on the effects of dive time and movements on line-transect estimates. *Int. Whaling Comm. Pap.* SC/42/NHMi31. [Work primarily related to research topic no. 11; see Table 3.]

35. Polacheck, T.; Smith, T.D.; Waring, G.T. 1990. Review of methods for assessing the status of the harbor porpoise population in the Gulf of Maine and Bay of Fundy region. Results of an at-sea workshop. Available *from*: T. Smith, National Marine Fisheries Service, 166 Water Street, Woods Hole MA 02543. [Work primarily related to research topic no. 11; see Table 3.]

36. Read, A.J.; Craddock, J.E. 1993. Life history analysis of small cetaceans taken in commercial fishing operations. Final report, phase I. NOAA Contract No. 50-EANE-2-00082. [Work primarily related to research topic no. 3; see Table 3.]

37. Read, A.J.; Craddock, J.E.; Gannon, D. 1994. Life history of harbour porpoises and pilot whales taken in commercial fishing operations off the northeastern United States. Final report, phase II. NOAA Contract No. 50-EANE-2-00082. [Work primarily related to research topic no. 3; see Table 3.]

38. Read, A.J.; Kraus, S.D. 1991. Harbour porpoise distribution and relative density in the waters of coastal Maine. Final report. NOAA Contract No. 40-EANF-1-01538. [Work primarily related to research topic no. 10; see Table 3.]

39. Read, A.J.; Westgate, A.J. 1995. Monitoring the movements of harbour porpoises in the Bay of Fundy with satellite telemetry. *Int. Whaling Comm. Pap.* SC/47/SM19. [Work primarily related to research topic no. 5; see Table 3.]

40. Smith, T.[D.]; Bravington, M.; Givens, G. 1995. The basis for the Scientific Committee's 1994 management advice on aboriginal subsistence whaling on the Bering-Beaufort Seas stock of bowhead whales. *Int. Whaling Comm. Pap.* SC/47/AS19. [Work primarily related to research topic no. 17; see Table 3.]

41. Smith, T.D.; Casey, J. 1992. The distribution and ecological role of large marine predators in the North Temperate Atlantic: a proposal for coordinated study. *Int. Counc. Explor. Sea C.M.* 1992/N:23 Ref. H. [Work primarily related to research topic no. 12; see Table 3.]

42. Smith, T.D.; Friday, N.; Palka, D. 1994. Explorations of the behavior of Cooke's catch limit algorithm. *Int. Whaling Comm. Pap.* SC/46/Mg7. [Work primarily related to research topic no. 17; see Table 3.]

43. Smith, T.[D.]; Givens, G.; Bravington, M. 1995. Developing an aboriginal subsistence whaling management procedure: outline of a process. *Int. Whaling Comm. Pap.* SC/47/AS17. [Work primarily related to research topic no. 17; see Table 3.]

44. Smith, T.D.; Polacheck, T. 1991. The development of line-transect methods for estimating cetacean abundance. *Int. Counc. Explor. Sea C.M.* 1991/N:10. [Work primarily related to research topic no. 11; see Table 3.]

45. Smith, T.D.; Polacheck, T. 1994. Information requirements for multi-population application of the catch limit algorithm. *Int. Whaling Comm. Pap.* SC/46/Mg8. [Work primarily related to research topic no. 17; see Table 3.]

46. Smith, T.[D.]; Polacheck, T.; Swartz, S. 1994. The role of science in resource management: the International Whaling Commission's revised management procedure. *Int. Whaling Comm. Pap.* SC/46/Mg9. [Work primarily related to research topic no. 17; see Table 3.]

47. Smith, T.D.; Reilly, S.B.; Swartz, S.; Jones, L. 1992. Data standards for management of commercial whaling under the IWC's revised management procedure. *Int. Whaling Comm. Pap.* SC/44/O25. [Work primarily related to research topic no. 17; see Table 3.]

48. Smith, T.D.; Stokes, K. 1993. Requirements for the revised management scheme. *Int. Whaling Comm. Pap.* SC/45/Mg11. [Work primarily related to research topic no. 17; see Table 3.]

49. Stevick, P.T.; Øien, N.; Mattila, D.K. 1995. Migration of humpback whales (*Megaptera novaeangliae*) between Norway and the West Indies. *Int. Whaling Comm. Pap.* SC/47/NA12. [Work primarily related to research topic no. 2; see Table 3.]

50. Taylor, B.L.; Smith, T.D.; Palka, D. 1994. Towards understanding the performance of the catch limit algorithm. *Int. Whaling Comm. Pap.* SC/46/Mg6. [Work primarily related to research topic no. 17; see Table 3.]

51. Williams, A.S.; Nicolas, J.N. 1995. The seasonal distribution of harbor porpoises in the Gulf of Maine. *Int. Whaling Comm. Pap.* SC/47/SM25. [Work primarily related to research topic no. 10; see Table 3.]

APPENDIX C

Abstracts of Oral Presentations at Scientific Conferences Based on Marine Mammal Research Projects Supported by the NEFSC during 1990-95

[All listed abstracts available *from*: Protected Species Branch, Northeast Fisheries Science Center, 166 Water Street, Woods Hole MA 02543.]

Ninth Biennial Conference on the Biology of Marine Mammals; Chicago, Illinois; December 5-9, 1991

1. Abend, A.; Smith, T.D.; Fry, B. 1991. Ecology of pilot whales studied with stable isotope tracers in whale tissues and stomach contents.

2. Allen, J.; Rosenbaum, H.; Katona, S.; Clapham, P.; Mattila, D. 1991. Regional and sexual differences in fluke pigmentation of humpback whales (*Megaptera novaeangliae*) from the North Atlantic Ocean.

3. Ellis, S.; Gray, B.; Clapham, P.; Hain, J. 1991. Apparent bottom-feeding by humpback whales in Massachusetts Bay.

4. Fairfield, C.; Waring, G.; Sano, M.; Nicolas, J. 1991. Cetaceans on the edge.

5. Hain, J.H.W.; Ellis, S.L.; Kenney, R.K. 1991. Airships, a new platform for marine mammal research: early results.

6. Kraus, S.; Kenney, R.; Knowlton, A. 1991. North Atlantic right whales in the southeastern United States: 1984-1991.

7. Mayo, C.; Goldman, L. 1991. Right whale foraging decisions at the patch margin.

8. Palka, D.; Smith, T. 1991. Line-transect surveys used to describe ship avoidance of harbor porpoise in the Gulf of Maine.

9. Smith, T.; Mayo, C.; Marx, M. 1991. How crooked is a right whale's path?

Tenth Biennial Conference on the Biology of Marine Mammals; Galveston, Texas; November 11-15, 1993

10. Abend, A.; Finn, J.; Smith, T.D. 1993. Diet prediction of the long-finned pilot whale (*Globicephala melas*) using carbon and nitrogen stable isotope tracers.

11. Bisack, K.; Northridge, S.P. 1993. Factors affecting harbor porpoise catch rates in the Gulf of Maine sink gillnet fishery.

12. Brault, S.; Desportes; G.; Caswell, H. 1993. Estimation of foetus mortality in North Atlantic long-finned pilot whales (*Globicephala melas*).

13. Ellis, S.; Hain, J.; Kenney, R. 1993. Sightability of right whales based on dive and respiration patterns observed from a blimp.

14. Garrett-Logan, N.; Smith, T.D.; Palka, D.; Potter, D. 1993. Prototype pen-based computer system for recording line-transect sighting data.

15. Griffin R.B.; Griffin, N.J. 1993. From plankton to whales: a study in identifying characteristics of cetacean habitat.

16. Hain, J.H.W. 1993. Ship strikes on right whales in the coastal waters of the SE United States: a paradigm for action.

17. Nicolas, J.; Williams, A.; Repucci, G. 1993. Observations of beaked whales (*Mesoplodon* sp.) in the western North Atlantic Ocean.

18. Northridge, S. 1993. The use of a geographical information system (GIS) in exploring cetacean habitat use.

19. Palka, D. 1993. The presence of ship avoidance during a line-transect survey of harbor porpoise in the Gulf of Maine.

20. Potter, D.C.; Palka, D.L.; Read, A.J.; Nicolas, J.R. 1993. A field study of the spring migration and habitat use of harbor porpoise (*Phocoena phocoena*) in the Penobscot Bay area of central Maine.

21. Read, A.J.; Craddock, J.E.; Hohn, A.A.; Nicolas, J.R. 1993. Life history and diet of harbor porpoises in the Gulf of Maine.

22. Smith, T.D.; Bisack, K.; Garrett-Logan, N.; Kander, M.; Mayo, R.; Northridge, S.; Palka, D.; Sheehan, D.; Walden, J. 1993. Estimating the effects of season-area controls on fishing on by-catch and landings.

23. Waring, G.T. 1993. Spatial patterns of six cetaceans along a linear habitat.

Eleventh Biennial Conference on the Biology of Marine Mammals; Orlando, Florida; December 14-18, 1995

24. Caswell, H.; Brault, S.; Read, A.; Smith, T. 1995. Uncertainty analysis of population growth rate and the significance of bycatch mortality in Northwest Atlantic harbor porpoises (*Phocoena phocoena*).

25. Hohn, A.; Scott, M.; Westgate, A.; Nicolas, J.; Whitaker, B. 1995. Radiotracking of a rehabilitated pygmy sperm whale.

26. McLellan, W.A.; Pabst, D.A.; Read, A.J.; Nicolas, J.R.; Potter, C.W. 1995. Mass composition of stranded and incidentally taken harbor porpoises (*Phocoena phocoena*) from the western North Atlantic Ocean.

27. Palka, D.L. 1995. The sightability of Gulf of Maine harbor porpoises.

28. Rubenstein, B.L.; Waring, G.T. 1995. Spatial and temporal patterns in pinniped entanglements in the Gulf of Maine sink gillnet fishery and relation to prey availability and consumption.

29. Sheehan, D.; Waring, G.T.; Williams, A.S. 1995. Sperm whale and beaked whale distribution and habitat use in shelf-edge and oceanic waters off the northeast U.S. coast.

Lighter-Than-Air Technical Workshop; Weeksville, North Carolina; June 9-11, 1992

30. Hain, J.H.W. 1992. Airships as a platform for whale research.

Tenth Lighter-Than-Air Systems Technology Conference; Scottsdale, Arizona; September 14-16, 1993

31. Hain, J.H.W. 1993. Airships for whale research: 1993 update.

Fifth Biennial Conference of the American Cetacean Society; Monterey, California; November 6-8, 1992

32. Hain, J.H.W. 1992. Whale research from airships: a new perspective.

APPENDIX D

Cruise Period, Area, and Objectives of NEFSC Marine Mammal Sighting Surveys during 1990-95

SHIPBOARD SURVEYS

1. NOAA R/V *Chapman* Cruise No. CH 90-05: Marine Mammal Survey

The cruise period was August 5-18, 1990. The area of operation was the shelf edge break to the Gulf Stream wall from Cape Hatteras to Lydonia Canyon on Georges Bank.

Cruise objectives were to: 1) determine summer distribution, and if it is continuous between these two areas; 2) determine how the composition of marine mammal species varies latitudinally and between shelf edge and Gulf Stream wall habitats; and 3) investigate fine-scale distribution and habitat utilization within and between canyons on the shelf edge break. Observations were also made on the association of marine mammals within a warm-core ring (WCR).

2. R/V *Abel-J* Cruise No. AB 90-01: Harbor Porpoise Survey and Line-Transect Methods

The cruise period was August 13-30, 1990. The area of operation included line-transect surveys in the lower Bay of Fundy, on the Scotian Shelf as far east as St. Margarets Bay, and on and around the waters of Lahave, Roseway, Browns, German, and Grand Manan Banks. Extensive experiments testing various aspects of line-transect methods were conducted in Owen Basin (east of Campobello Island), in nearshore waters east of Grand Manan Island, and in the channel between Deer and Campobello Island.

Cruise objectives were to: 1) determine distribution and relative density of harbor porpoise along the southwestern coast of Nova Scotia, 2) test a prototype electronic instrument for measuring radial sighting distances, 3) test for vessel avoidance behavior, 4) test efficiency of different-size observer teams for density estimates for harbor porpoise based on line-transect methods [both in terms of f(0) and g(0)], 5) collect information on summer distribution of other marine mammals in offshore Gulf of Maine and Scotian Shelf waters, and 6) train and test observers in distance estimation.

3. NOAA R/V *Chapman* Cruise No. CH 91-03: Marine Mammal Survey

The cruise period was June 5 - July 16, 1991. The area of operation was principally shelf edge waters between 100- and 1000-fathom isobaths from Cape Hatteras to Georges Bank. Also, some transect lines were run out to the Gulf Stream north wall, across WCRs, and through the Great South Channel.

Cruise objectives were to: 1) investigate fine-scale distribution and habitat utilization within WCRs, canyons, and the shelf edge break; 2) determine if distribution of marine mammals, especially beaked whales, is continuous between several major canyons and the Gulf Streamwall; 3) conduct line-transect population surveys along the shelf edge break and out to the Gulf Stream wall; and 4) determine how composition of species varies latitudinally and between the shelf edge and Gulf Stream wall habitats.

4. R/V *Abel-J* Cruise No. AJ 91-02: Harbor Porpoise Survey

The cruise period was July 22 - August 30, 1991. The area of operation was from Port Clyde, Maine, to St. John, New Brunswick, and then over to the Nova Scotian coast and up to Liverpool, Nova Scotia.

A supplementary survey using the 48-ft M/V *Sneak Attack* was conducted during August 3-22. The study area of the supplementary survey was the inland bays from Penobscot Bay (Maine) to Machias Bay (Maine).

Objectives of the R/V *Abel-J* cruise were to: 1) estimate abundance of harbor porpoise in the Gulf of Maine, Bay of Fundy, and Nova Scotia area; and 2) investigate if there are spatial distribution patterns of harbor porpoise, and if those patterns are correlated with water depth or harbor porpoise group size.

5. NOAA R/V *Delaware II* Cruise No. DE 92-05: Marine Mammal Survey

The cruise period was March 16 - April 2, 1992. The area of operation was offshore Mid-Atlantic and Southern New England waters between 30- and 1000-fathom isobaths.

Cruise objectives were to: 1) investigate small cetacean fine-scale distribution in the vicinity of Atlantic mackerel fishing operations; 2) determine if the distribution of marine mammals, especially delphinid species, is continuous between fishing areas and several major canyons within the study area; 3) determine if marine mammal distribution is associated with prey concentrations away from fishing areas; and 4) conduct line-transect population surveys within the study area.

6. R/V *Abel-J* Cruise No. AJ 92-01: Harbor Porpoise Survey

The cruise period was July 29 - September 6, 1992. The area of operation was from Portland, Maine, to St. John, New Brunswick, and then over to Port Joli, Nova Scotia, on the southeast side of Nova Scotia.

Primary objective was to estimate abundance of harbor porpoise in the Gulf of Maine, Bay of Fundy, and Scotian Shelf area.

7. NOAA R/V *Delaware II* Cruise No. DE 93-06: Marine Mammal Survey

The cruise period was June 1 - July 2, 1993, conducted in two parts: June 1-18 and June 21 - July 2. The area of operation was shelf edge and slope waters of the southern edge of both the Scotian Shelf and Georges Bank.

Survey objectives were to: 1) investigate beaked whale and pelagic delphinid fine-scale distribution in shelf edge and Gulf Stream WCR features, 2) determine if the distribution of beaked whales and delphinid species is continuous along the Georges Bank shelf edge to the Scotian Shelf, 3) determine if beaked whales are associated with a WCR that is usually present in the survey region, and 4) conduct line-transect population surveys within the study area.

8. R/V *Abel-J* Cruise No. AJ 93-01: Harbor Porpoise Survey

The cruise period was August 3-22, 1993. The area of operation was from Boothbay Harbor, Maine, to Grand Manan, New Brunswick, and then south to Yarmouth, Nova Scotia.

Cruise objectives were to: 1) investigate two questions associated with the line-transect sighting survey assumptions (*i.e.*, Do harbor porpoise alter their behavior before observers on the R/V *Abel-J* detect them?, and, How do dive time patterns of individual and groups of harbor porpoise which are around the sighting platform affect estimates; 2) determine the spatial distribution patterns of harbor porpoise within the study area and if patterns are correlated with hydrographic features; 3) compare spatial distribution patterns of harbor porpoise with those of previous years; 4) determine if there is a spatial distribution pattern of mother-calf pairs of harbor porpoise; 5) determine spatial distribution patterns of other cetaceans; 6) investigate utility of a new electronic, hand-held, pen-based, data entry system; and 7) collaborate with scientists from other laboratories who are interested in harbor porpoise and survey methodology.

9. NOAA Ship *Relentless* Cruise No. RS 94-02: Marine Mammal Survey/Warm-Core Ring Study

The cruise period was August 22 - September 2, 1994, and covered 534 km of tracklines. The area of operation was shelf edge and slope waters of Georges Bank, principally across a Gulf Stream WCR, including areas within the Canadian Exclusive Economic Zone.

Cruise objectives were to: 1) investigate fine-scale cetacean distribution in a WCR feature; 2) determine if the distribution of cetaceans, especially beaked whales and delphinid species, is continuous through a WCR; and 3) conduct line-transect population surveys within the study area.

10. NOAA Ship *Relentless* Cruise No. RE 95-01: Spring Harbor Porpoise Distribution Survey

The cruise period was March 8-28, 1995. The cruise started and ended in Norfolk, Virginia, and covered approximately 1,190 nm of tracklines. The study area was from Cape Hatteras to Long Island (New York), and from the coastline out to about 72°W (*i.e.*, about 150 nm).

Cruise objectives were to: 1) determine distribution and habitat preferences of harbor porpoise in the Mid-Atlantic during March, a time when harbor porpoise have stranded on beaches from North Carolina to Massachusetts; 2) determine distribution and habitat preferences of other marine mammals; 3) field test and improve a computerized data entry system; and 4) evaluate the NOAA Ship *Relentless* as a sighting platform for future marine mammal sighting surveys.

11. R/V *Pelican* Cruise No. PE 95-01: Marine Mammal Abundance and Distribution Survey

The survey was performed from July 9 to August 3, 1995, beginning in Norfolk, Virginia, and ending in Woods Hole, Massachusetts. The study covered approximately 1,704 nm of tracklines in the slope waters from Chesapeake Bay to Cape Cod, between 10 nm inshore of the 50-fathom contour and 10 nm offshore of the 1,000-fathom contour.

This survey was part of a large-scale marine mammal sighting survey which consisted of two legs (each approximately 1-mo long) where two ships were used during each leg, with an additional leg in which a plane was used to survey for 6 wk. The entire study area was from Chesapeake Bay to the Gulf of St. Lawrence.

Objectives of this leg of the survey were to: 1) determine spatial distribution and estimate abundance of marine

mammals found in the study area; and 2) determine if spatial distribution patterns are correlated with hydrographic features such as water depth, temperature, or salinity, or with biological features such as zooplankton distribution.

12. R/V *Pelican* Cruise No. PE 95-02: Marine Mammal Abundance and Distribution Survey

The survey was performed during August 6 - September 7, 1995, on Georges Bank and in waters east of Cape Cod.

Principal objectives of the survey, which covered 2,160 km of tracklines, were to conduct line-transect populations surveys within the study area and to investigate cetacean distribution on the southern portion of Georges Bank, especially between the 30-fathom isobath and 10 nm beyond the 1,000-fathom isobath. Biopsy samples, conductivity-temperature-depth data, and photographic data were also collected.

13. R/V *Abel-J* Cruise No. AJ 95-01, Part I: Marine Mammal Abundance and Distribution Survey

The survey was performed during July 9 - August 2, 1995, in the Gulf Stream and slope waters between Chesapeake Bay and Southern New England.

Primary objective of the cruise, which covered 2,607 km of tracklines, was to conduct a line-transect population survey and to investigate if the distribution of cetaceans, especially "strategic species," is continuous in Gulf Stream and slope water habitats. Biopsy samples, conductivity-temperature-depth data, and photographic data were also collected.

14. R/V *Abel-J* Cruise No. AJ 95-01, Part II: Marine Mammal Abundance and Distribution Survey

The survey was performed during August 6 - September 5, 1995, beginning and ending in Woods Hole, Massachusetts. The study covered approximately 1,564 nm of tracklines from Portland, Maine, to St. John, New Brunswick, and from the Maine coast to the southern tip of Nova Scotia.

Survey objectives were to: 1) estimate abundance of harbor porpoise in the Gulf of Maine, Bay of Fundy, and Scotian Shelf area using two different field collection and analysis methods; 2) determine spatial distribution and estimate abundance of other cetaceans found in the area; 3) compare sighting rates and spatial distribution of harbor porpoise as seen by two different sighting platforms -- ship and plane; 4) determine spatial distribution patterns of harbor porpoise, and investigate if the patterns are correlated with hydrographic or biological features; 5) determine if harbor porpoise avoid the ship, and if so, at what distance; and 6) compare abundance estimates and spatial distribution of harbor porpoise as seen in this year with that seen in previous years.

AERIAL SURVEYS

15. NOAA DeHavelin Twin Otter: 1991 Aerial Harbor Porpoise Survey

The aerial survey period was October 11-24, 1991. The survey was completed in 14 days with 8 flight days. The survey was based out of Bangor International Airport in Maine, and covered the Gulf of Maine and Massachusetts Bay area. A total of 42.2 hr were flown, covering over 4,600 mi of trackline.

The survey covered the area of the 1991 harbor porpoise shipboard survey in order to get an indication of the fall distribution of harbor porpoise, and surveyed Massachusetts Bay primarily to determine distribution and density of pilot whales during the time of mass strandings on Cape Cod.

16. Beechcraft AT-11 Aircraft: 1992/93 Aerial Harbor Porpoise Survey

The aerial survey was conducted in two parts: the first part was conducted on December 2, 9, and 10, 1992, and the second part on February 11, 1993. Part 1 covered the area from the southern Bay of Fundy to the center of Georges Bank. Part 2 covered the same area as previously surveyed on December 2 -- from Cape Ann (Massachusetts) to Grand Manan Island (New Brunswick). A total of 2,615 nm were covered in 20 hr of flight time.

Objectives were to determine the seasonal distribution of harbor porpoise in the Gulf of Maine region.

17. NOAA DeHavelin Twin Otter: 1993 Aerial Harbor Porpoise Survey

Aerial surveys were conducted on November 17, 23, 24, 26, and 27, and on December 3, 8, and 14, 1993. Over 4,200 nm were surveyed in waters from North Carolina to Sable Island (Nova Scotia).

The survey objective was to determine seasonal movements of harbor porpoise in the Gulf of Maine region.

18. Gulf Airship: 1994 Marine Mammal Research Flight

Three flights aboard the 197-ft, 7,000-m^3 volume, WDL 1-B helium airship were made from June 5 to 9, 1994. The area of operation was coastal waters north and east of Cape Cod.

Survey objectives were to continue research on the sightability of fin whales. Previous observations revealed that fin whales spend some percentage of their time "gliding" just under the surface, visible to aircraft but not to a surface vessel. As a result, it was hypothesized that currently used correction factors for "dive time" needed improvement.

19. Westinghouse S-1000 Airship: 1994 Marine Mammal Research Flight

A 5-hr flight aboard the 222-ft, 10,000-m^3 volume, Westinghouse S-1000 helium airship was made on September 28, 1994. The area of operation was coastal waters of northeastern North Carolina, from Duck to Oregon Inlet.

Survey objectives were to demonstrate the capability of the airship to conduct long-endurance offshore flights, and to establish a precedent and guidelines for offshore scientific airship operations. Because of its capability for increased range, endurance, and lift, the Westinghouse S-1000 airship has been proposed for use in a validation experiment for the U.S. Navy's Marine Mammal/SOSUS (Sound Surveillance System) Program.

20. NOAA DeHavelin Twin Otter: 1995 Marine Mammal Aerial Survey

The 1995 marine mammal distribution and abundance aerial survey was conducted from August 4 to September 20, 1995. Approximately 17,000 nm of trackline were flown. The area of operations included both inshore and offshore waters extending north from the Mid-Atlantic, through Georges Bank, the Gulf of Maine, and into Canadian waters up to the Gulf of St. Lawrence.

Survey objectives were to determine seasonal movements of harbor porpoise and other marine mammals in and around the Gulf of Maine region, and to compare sighting rates and spatial distribution of harbor porpoise as seen by two different sighting platforms -- ship and plane.