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The Right Whale in the Western North Atlantic: A Science and Management Workshop

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Edited by
James Hain

Marine Mammal Investigation
Conservation and Utilization Division
Northeast Fisheries Science Center
Woods Hole, MA 02543-1097

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PREFACE

James Hain, Chairman
National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, Massachusetts

A meeting on the science and management of the right whale, *Eubalaena glacialis*, was held in Silver Spring, Maryland, on 14-15 April 1992. This was a meeting of researchers, agency representatives, and managers invited to:

1) present recent results and status of present research,
2) discuss scientific research needs relative to the implementation of the National Marine Fisheries Service's Final Recovery Plan for the Northern Right Whale, released in March 1992, and
3) broaden the base of involvement, expertise (science and management), resources, and funding in right whale research and management.

The meeting was attended by approximately 40 participants (see Appendix).

Objectives of the meeting were tied to three events:

1) The integrated research program (cooperative agreement between NOAA/NMFS and the University of Rhode Island) on the right whale in the western North Atlantic had been in place for about five years. This was judged to be an appropriate time to review the status and accomplishments of that program.
2) The recently released recovery program would, in many ways, play a large role in future program and funding decisions.
3) Details of the NMFS FY 93 budget and the framework of the FY 94 budget were being developed, and input to these processes was envisioned.

The two-day meeting was structured to include three components: (1) presentations by researchers on past and present work, (2) "agency profiles" by agency spokespersons describing the activities, responsibilities, and plans of their agency, and (3) Working Groups to define plans, priorities, and tasks for the future. After some discussion, the participants agreed to focus on two Working Group topics: (1) human impacts, and (2) habitat identification and protection.

In the space of a day and a half, a concise and informative summary and update on right whale research off the eastern United States was provided. Distribution, abundance, and behavior in five major study areas (Figure 1) was well described. Data available from stranded animals have been less than desirable -- largely because many strandings are not reported in time, and information is lost. Satellite tracking of a handful of tagged animals is causing us to rethink commonly-held notions about movements and residence times.

Calving success and calving rates are under close study, and provide information central to understanding population status and recovery potential. In addition, new information on social and genetic structure is being provided by tissue sampling and the corresponding analyses. When right whales are on their feeding grounds, feeding success appears to depend, in great measure, on locating and exploiting high-density prey patches. This depends on feeding strategies that involve extraordinarily fine-scale horizontal and vertical movements.

In addition to the aforementioned satellite tracking and genetic analyses, the application of new technologies includes the use of airships as research platforms, and increasing use of high-resolution video for data acquisition.

Of the various factors that determine the status and recovery of the population, the one most accessible to management actions is the broad area of human impacts. More than half the population has experienced either ship strike and/or net entanglement, and perhaps a third of right whale deaths are caused by human activities. Some mitigation efforts have been initiated, but there was wide agreement that more effort is called for.

Discussion, questioning, and suggestions during and following many of the presentations

provided valuable interchange and input. Topics for general consideration included the following:

- The priority rankings on several of the implementation schedule items (p. 71-77 in the Recovery Plan) were considered by some participants to be different from those agreed on by the Recovery Team.
- Priority 1 items on the schedule appeared to some participants as predominantly management-related, while the supporting science received Priority 2 or lower rankings.
- Opinions were expressed that the distance restrictions for the approach of whalewatching vessels to right whales inappropriately restricted associated research opportunities and data collection from these vessels.
- Some concern was expressed that given (1) the Recovery Plan has been released, (2) a meeting has been held, and (3) a proceedings document will be generated. What happens next? If, when, and how will the plans, tasks, and actions be carried out?

The following text, and in particular, the Working Group conclusions, provide guidance on directions and priorities. The meeting consensus was that with this guidance, the agencies involved should move forward to address important issues and continue to initiate the appropriate programs.

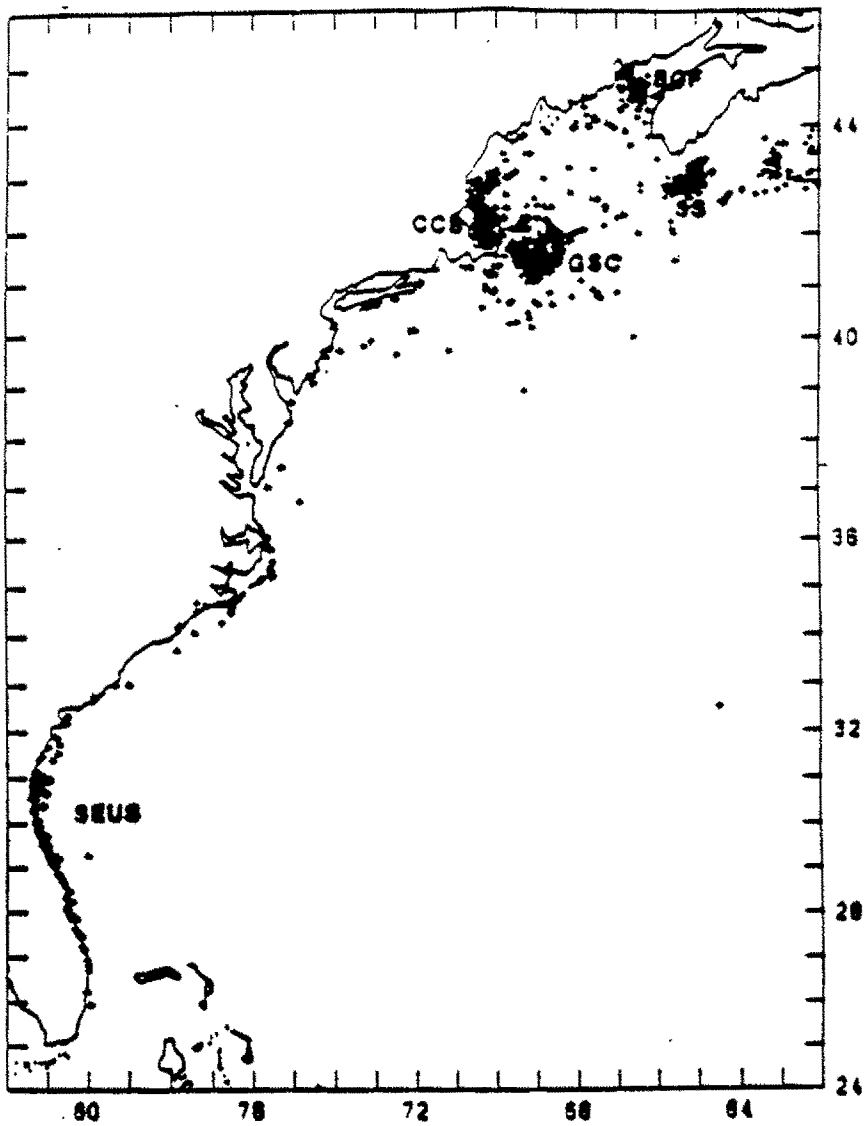

Figure 1. Sightings of right whales in the western North Atlantic, identifying the five known primary habitats: SEUS = Southeastern United States; GSC = Great South Channel; CCB = Cape Cod Bay; BOF = Bay of Fundy; and SS = Scotian Shelf. Number of sightings=4,119; period of record is June 1960 through June 1988.

ABSTRACT

A meeting on the science and management of the right whale, *Eubalaena glacialis*, was held in Silver Spring, Maryland, 14-15 April 1992. Researchers and agency representatives met to review present research, discuss scientific research needs relative to the implementation of the Final Recovery Plan for the Northern Right Whale, and to broaden the base of involvement in right whale research and management.

The meeting included presentations by researchers on past and present work, "agency profiles" by agency spokespersons describing the activities of their agency, and working groups on human impacts, and habitat identification and protection that set out plans, priorities, and tasks for the future.

The summary and update on right whale research off the eastern United States included distribution, abundance, and behavior in five major study areas; the strandings program; satellite tracking; calving success and calving rates; new information on social and genetic structure; feeding strategies; the use of airships as research platforms; and increasing use of high-resolution video for data acquisition.

Recommended management actions assigned high priority to the broad area of human impacts. More than half the population has experienced either ship strike and/or net entanglement, and perhaps a third of right whale deaths are caused by human activities. Some mitigation efforts have been initiated, but there was wide agreement that a greater effort is called for.

The list of meeting participants is appended.

Background Information

RIGHT WHALE RESEARCH IN THE WESTERN NORTH ATLANTIC: HISTORY, STATUS, AND FUTURE

Howard E. Winn
Graduate School of Oceanography
University of Rhode Island
Kingston, Rhode Island

The history is easy, as is the status. The future is clouded.

HISTORY

The past history of the right whale is inextricably intertwined with man as he moved to the sea. The Basques in the 11th to the 17th centuries undoubtedly were the first to significantly reduce the population of right whales in the western North Atlantic. Hunting continued through the first half of the 20th century by many nations.

The North Atlantic right whale is the most endangered large whale in the world. Only the western North Atlantic has a significant number of individuals (300 to 350), with the eastern North Atlantic population virtually extinct, and so few sightings in the Pacific that no significant concentrations are known.

From about 1950 through the early 1970s, only Schevill and Watkins (1976, 1982) supplied any information on western North Atlantic right whales, and at first concentrated on sounds. Since that time, others have contributed significantly to our understanding of the right whale, and most are giving presentations at this meeting. Our newest knowledge on the right whale, based on NMFS support, is being summarized over the next year. An overdue report is in its final stages on SCOPEX (South Channel Ocean Productivity Experiment), supported by NSF and MMS. This study concerned the right whale and oceanographic processes in the Great South Channel. A significant amount of new information has been obtained.

A series of workshops during 1979-1982 demonstrated how little was known about the right whale in the northern hemisphere. These culminated in an IWC workshop at the New England Aquarium (sponsored by many agencies). The report was published in 1986 (Right Whales: Past and Present Status, IWC, Special Issue No. 10). At about that same time, 1982, an important study supported by MMS (BLM) was being completed on the cetaceans and turtles of the Atlantic Coast (CETAP). This study also emphasized our lack of knowledge about the right whale.

During the final IWC workshop, many persons were agitated because, while there were needs for right whale research, absolutely no funding was forthcoming. A representative of Greenpeace said that it was possible, by political action, to obtain such funds. Indeed, with the help of Greenpeace and many representatives and senators along the Atlantic Coast and elsewhere, funding was found. During the following six years, at NMFS/NOAA, Department of Commerce, and higher in the administration, considerable efforts were made to remove the funds for right whale research.

Early in about 1981 or 1982, researchers from the New England Aquarium, Center for Coastal Studies, Woods Hole Oceanographic Institution, and the University of Rhode Island, all who had been contributing to information concerning the right whale, formed a consortium to work together on the problem. Other investigators have been added as appropriate.

THE RECOVERY PLAN AND THE FUTURE

Since there seems to have been no significant change in the status of the northern right whale in recent years, much needs to be done in the future. However, one sees problems that will be created by man. One also sees the problem of a government agency trying to take over all the research that has been accomplished in an exemplary fashion by private individuals and academic institutions. I am not convinced that the job will be well done by the government. Future

work and success will depend on younger individuals, and I assume you will hear much of hopes for the future of the right whale and right whale research.

The Final Recovery Plan for the Northern Right Whale has been published and I cannot add much to that. It must include a significant management program as well as studies including monitoring, tagging, new oceanographic studies, and others. A good interim management strategy is to provide protection until the scientific information required for sound management and decisions is collected. It is only through our understanding of the ecology of the right whale that we will be able to predict the effects of perturbations, and thus contribute usefully to their conservation. As of now, a lack of funding to the private sector is severely inhibiting this effort.

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Watkins, W.A. and W.E. Schevill. 1976. Right whale feeding and baleen rattle. *J. Mamm.* 57(1):58-66.

Watkins, W.A., and W.E. Schevill. 1982. Observations of right whales, *Eubalaena glacialis*, in Cape Cod waters. *Fish. Bull., U.S.* 80(4):875-880.

PRE-EXPLOITATION ABUNDANCE OF RIGHT WHALES OFF THE EASTERN UNITED STATES

Randall R. Reeves
Department of Geography
McGill University
Montreal, Quebec

Jeffrey M. Breiwick
Alaska Fisheries Science Center
National Marine Mammal Laboratory
Seattle, Washington

Edward Mitchell
Natural History Museum of Los Angeles County
Los Angeles, California

In the literature it is often implied, if not stated explicitly, that right whales were present in large numbers in the western North Atlantic at the time of European discovery and colonization. Schevill, Watkins, and Moore (1986) offered a contrary view for one region, noting that their own "encounter rate" (our term) with right whales off Cape Cod was not much different from that reported by Allen (1916) for the Colonial period. Although they acknowledged that many whales might have been missed by both sets of observers (Woods Hole researchers and early European settlers), and that the number of whales present in recent years "would perhaps not have consistently supported the whaling that was carried on," Schevill *et al.* challenged the conventional wisdom by suggesting that "the population of right whales passing near Cape Cod is at worst only slightly smaller now than it was in the 17th century."

Reeves and Mitchell (1987, 1988) compiled information on right whale kills by shore whalers between Maine and Florida from *ca* 1630 to 1930. Although this work revealed that Allen's (1916) compilation had been far from complete, the fragmentary nature of the (mainly) published records still made it impossible to conclude that there were more than a few hundred right whales in the population migrating along the U.S. East Coast in the early to mid-17th century.

Subsequent examination of unpublished records in British archives has made it possible to address somewhat more rigorously the problem of initial right whale abundance in this region.

MATERIAL AND METHODS

Data on whale oil and baleen imports from the colonies were extracted from documents in the Public Record Office in London. These spanned the years 1696 to 1734 and included goods exported from New York, Pennsylvania, Virginia, Maryland, Carolina, Bermuda, and occasionally, "Greenland," and the West Indies. Average yields were used to convert the production figures to estimates of right whales taken each year.

Several population trajectories were plotted (Figure 2) based on arriving at a current population size of 350, with a simple population model (no age or sex structure) and the usual "baleen" type recruitment function:

$$P_{t+1} = (P_t - C_t)S + P_{t-m}(1-S)[1 + A(1 - (P/P)^z)],$$

where the resilience parameter, A, is a function of the density-dependent exponent (z), the survival rate (S), and the maximum sustainable yield rate (MSY rate), defined as the MSY divided by the population size at MSY (MSYL). The MSY rate is a measure of population productivity, with minke whales, for example, having a higher rate than blue whales. We assume an MSYL of 60 percent (the ratio of population size at MSY to the unexploited ["initial"] population size), an age at exploitability (*i.e.*, recruitment into the fishery) of five, instantaneous mortality rates of 0.05 and 0.08, and MSY rates of 0.01, 0.03, and 0.05.

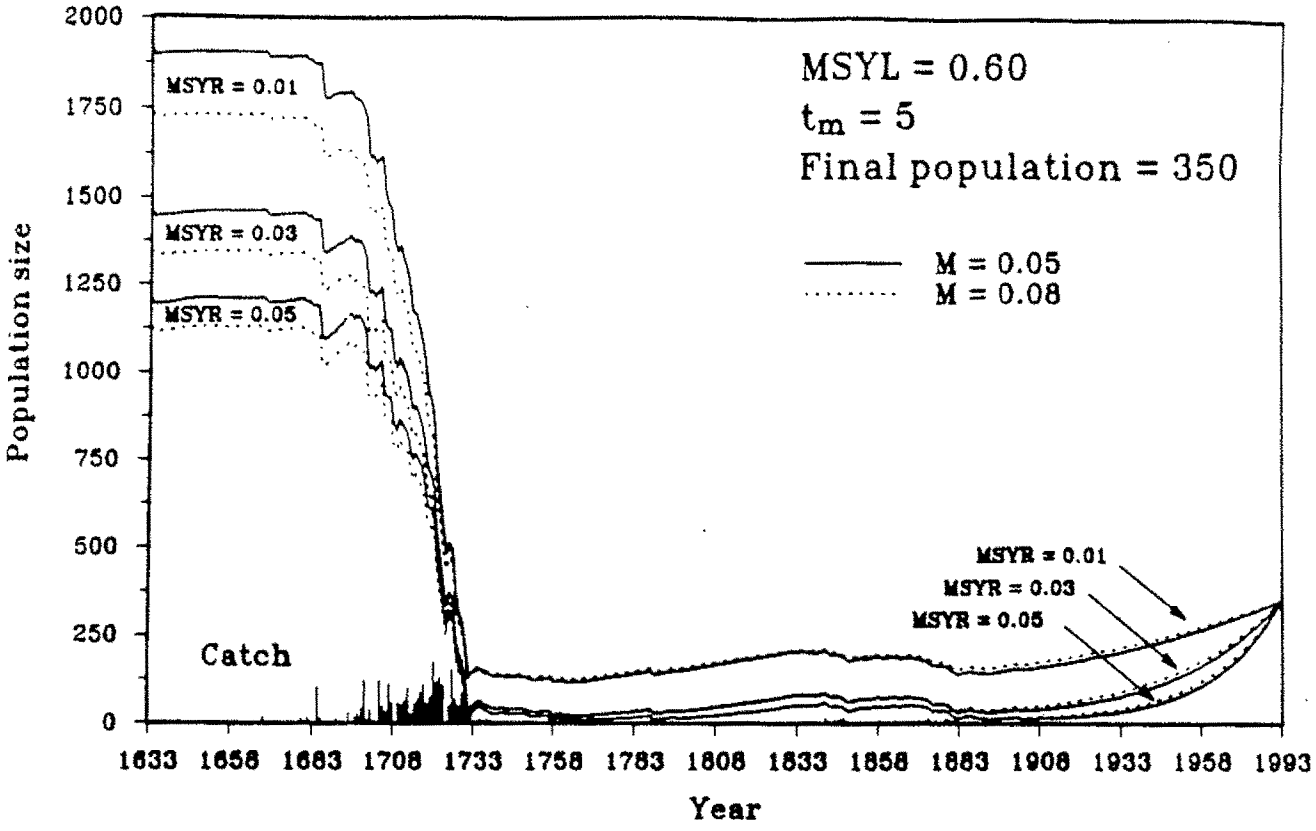

Figure 2. Preliminary results of model runs showing population trajectories for right whales off the eastern United States.

RESULTS

The population trajectories resulting from these parameters and the preliminary catch history indicate that there were more than 1,000 right whales in this population during the early to mid-1600s (Figure 2). Given the presumed slow recovery rate of the right whale in the North Atlantic, the higher MSY rate of 0.05 is probably near the upper end of any plausible range. Estimates of initial population are relatively insensitive to the two mortality rates considered here. We expect that our detailed analysis of the export records and catch data will confirm that the removals used in this preliminary set of iterations were estimated conservatively.

CONCLUSIONS

Before any firm conclusions can be drawn, it is important to consider the limitations and biases of the data used to estimate removals. We have not, as yet, attempted to make interpolations and extrapolations to account for catches in years without production or catch data. Nor have we settled on procedures for estimating species composition, yields of oil and baleen, and loss rates. Some proportion of the oil and baleen in the statistics must have come from drift whales that died of natural causes. These and other factors could affect the results in important ways.

PLANS FOR FURTHER WORK

We intend to complete this project in two stages. First, we need to compile and analyze the aggregate data on removals so that there is a comprehensive table of kills, by year, similar to that used for Alaskan bowhead whales in the IWC. Second, we need to apply these removal estimates in an iterative model to examine possible population trajectories. It would be most useful if at least two alternative sets of conclusions were offered: one using rock-bottom estimates of take based on conservative interpretations of the data along with "worst-case" population parameters, and another using "best estimates" of take based on realistic assumptions, interpolations, and extrapolations along with the most plausible population parameters in light of what is known about right whales and closely related species.

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THE RIGHT WHALE CATALOG

**Scott D. Kraus, Amy R. Knowlton,
Jackie N. Ciano, and Philip K. Hamilton
New England Aquarium
Boston, Massachusetts**

Right whales are individually identifiable on the basis of patterns of cornified skin (called callosities) that are found on their heads. In the North Atlantic, photographs of the callosity patterns have been used since the late 1970s to identify individual whales. Researchers also use supplementary features such as scars, lip ridges, white belly patches, and occasional deformities to assist in the identification of individuals. From photographs of the callosity patterns and other features, a unified catalog of individual right whales has been compiled by the North Atlantic Right Whale Consortium (Center for Coastal Studies, New England Aquarium, University of Rhode Island, and Woods Hole Oceanographic Institution), and is curated at the New England Aquarium in Boston.

RE-SIGHTS OR "MATCHES"

To ensure accuracy and reliability in identifying right whales, Consortium protocols require that three independent researchers must agree on a "match" between any newly photographed whale and the existing catalog. In addition, we require that at least three distinctive features match between the cataloged individual and the putative "match," unless the whale has a uniquely distinctive feature such as a major scar or birthmark.

SUMMARY OF RESULTS

In this population, individual identifications are the basis for most of what we know about the population biology of this species. Catalog data has been used to correct population counts (by eliminating the possibility of counting the same whale twice), to estimate population size (using tag-recapture methods), to determine the age of sexual maturity and reproductive rates (by tracking known females through their lives), and to describe mortality rates and causes, movements, age and sexual segregation by area and season, and age and sex-specific behaviors.

The catalog currently holds 5,535 records of the 316 right whales. It includes sightings of individual right whales by date and location, and incorporates information on age, sex, matriline, and behavior at each sighting. Annually, the Consortium processes approximately 500 sightings of about 160 known individuals. For the last three years, only three to five new whales (not including calves) have been added to the catalog, suggesting that nearly all North Atlantic right whales are known. Matches of known right whales have recently been made from Florida to Iceland (Figure 3), suggesting a single western North Atlantic stock with an extensive range. Additional matches have yielded data on longevity, and shown movements of individuals between all five known right whale habitats. Catalog sightings data have been instrumental in correlating genetic data with movements and migration patterns, and will continue to play a major role in research and monitoring efforts for this species.

REFERENCE

Crone, M.J. and S.D. Kraus. 1990. Right whales *(Eubalaena glacialis)* in the western North Atlantic: A catalog of identified individuals. Published for the North Atlantic Right Whale Consortium. Boston, Massachusetts: New England Aquarium. 223 p.

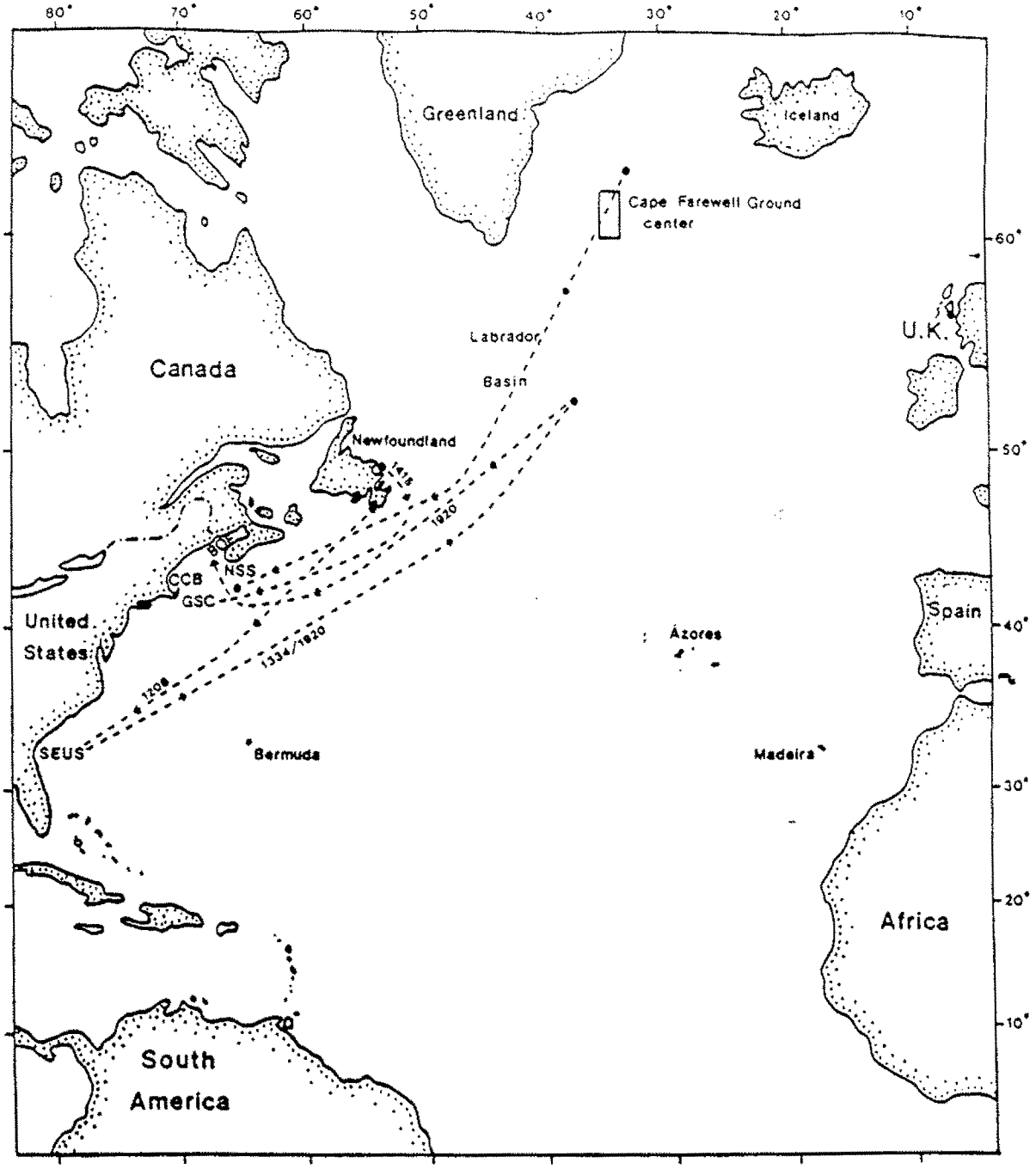

Figure 3. Long-distance matches, or re-sightings, of photo-identified right whales, suggesting an extensive range for at least some individuals within this population.

Right Whales through Their Range: A Geographic Treatment

RIGHT WHALES OFF THE SOUTHEASTERN UNITED STATES

Scott D. Kraus, Amy R. Knowlton, and Chris K. Slay
New England Aquarium
Boston, Massachusetts

Aerial surveys of right whales have been conducted since 1984 during the winter months between Savannah, Georgia, and Cape Canaveral, Florida. Starting in 1988, the Army Corps of Engineers has supported daily aerial surveys locally around the dredging activities at the St.

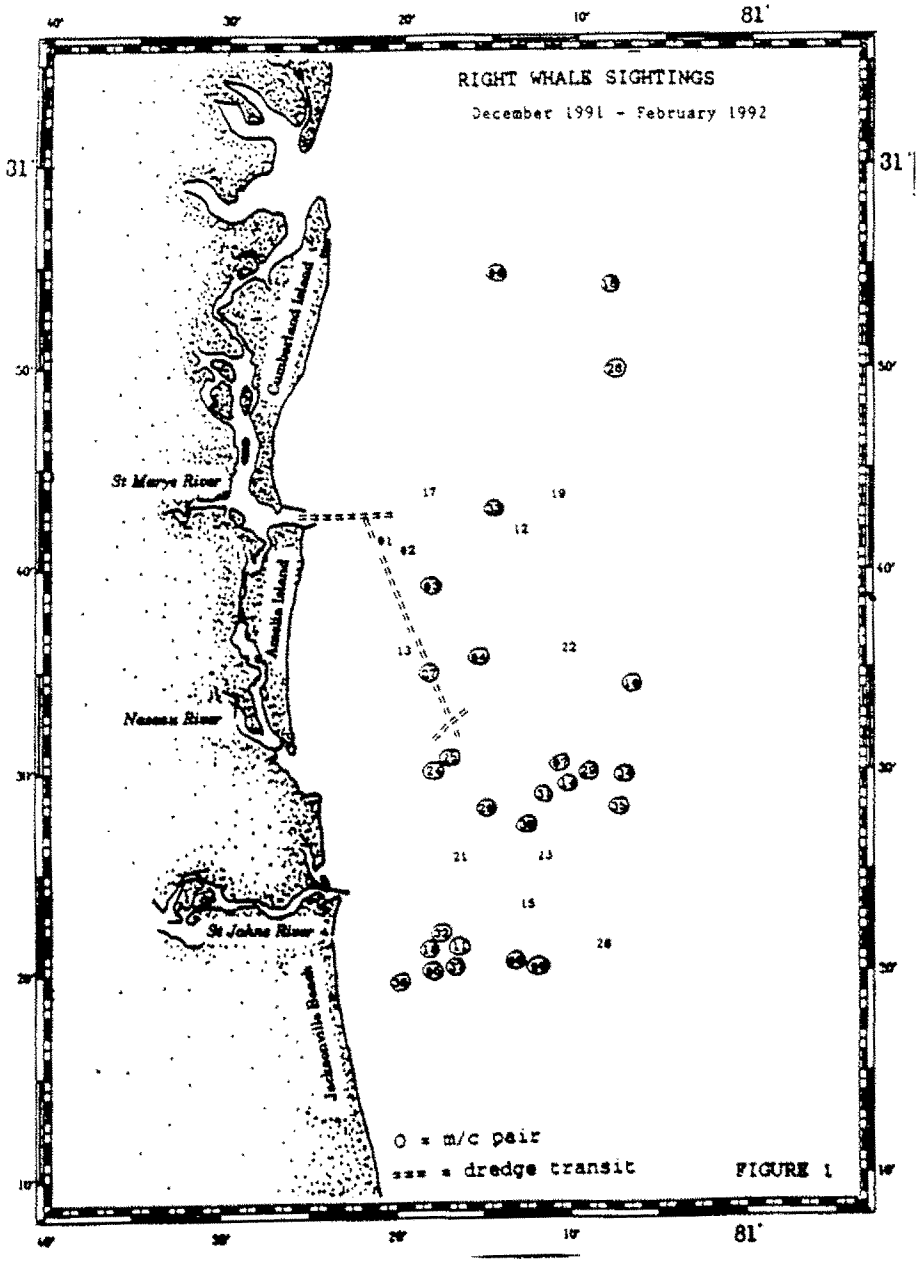

Figure 4. Right whale sightings, December 1991 through February 1992, in the area from Jacksonville Beach, Florida, to Cumberland Island, Georgia. This is apparently the highest density right whale area off the southeastern United States.

Mary's Channel, the highest density right whale zone in the Southeast (Figure 4). The Minerals Management Service (MMS) has supported most of the Right Whale Consortium research in the Southeast since 1989, with aerial surveys to assess the temporal distribution in the region. MMS also supported an expansion of these surveys to Cape Hatteras in 1991 and 1992.

SUMMARY OF RESULTS

A total of 133 right whale sightings were made in the region between 1980 and 1991, 80 of which were adult females (Figure 5). Photographic identifications of six cows have been obtained in the region both before and after calving. More than one-half of all of the calves recorded in this population since 1980 were observed in this calving ground as neonates. Since our aerial surveys covered only about 50 percent of the area, we suspect that most right whales calve in the region. Two cows photographed during the summer months in Newfoundland waters and off Iceland respectively were both observed in the winter months in the southeastern U.S. calving ground. These data suggest that the coastal waters of the southeastern U.S. are the primary calving ground for western North Atlantic right whales.

The distribution of right whales in the region appears to be concentrated in the area between Jacksonville, Florida, and Brunswick, Georgia, although the region around Cape Canaveral may also prove important in the late winter just prior to northern migration. A sightings-per-unit-effort analysis (SPUE = # right whales per survey trackline mile) shows the high density areas in Figure 6. Opportunistic sightings data indicate that right whales are occasionally present in the area from September through April, but a SPUE analysis shows that December through February is the right whale "season" (Table 1).

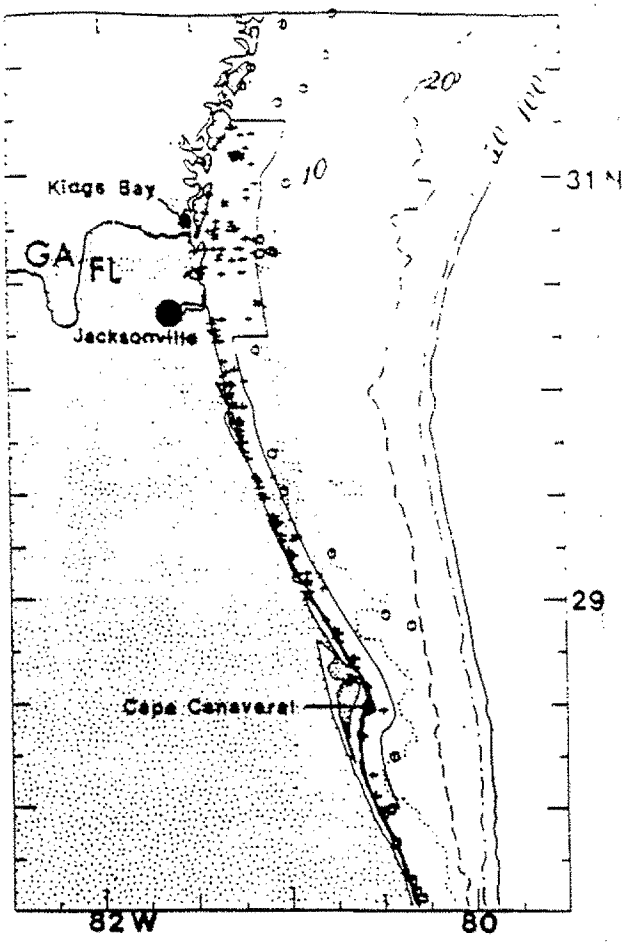

Figure 5. Right whale sightings along the southeastern United States between 1950 and 1989. The black line enclosing all sightings denoted with + is the boundary of the critical habitat proposed by the U.S. National Recovery Team. N = 303 sightings.

Annual variation in the numbers of right whale sightings made in the region each year is high, ranging from 4 to 53, but some of this is due to variable survey effort within each winter season. Right whales observed more than once in

Table 1. Sighting-per-unit-effort indices by month for right whales in the coastal waters of the southeastern United States

Month	# Whales	Survey Mileage	SPUE Abundance Index
November	7	9224	0.00075
December	27	5014	0.00538
January	65	5776	0.01125
February	57	12208	0.00466
March	9	6443	0.00139
April	0	680	0.00000

the region within a given year have been residents from 13 to 76 days.

SHIP STRIKES

Right whales are apparently at risk in the region from vessel collisions. At least one juvenile was killed in 1991, and at least two calves have survived encounters with ship propellers. U.S. Army Corps of Engineers contracts for the St. Mary's Channel have mandated onboard observers and aerial surveys, and require that dredges slow to less than five knots if right whales are present. These measures have probably eliminated any danger to right whales from dredging operations in that locality. Extensive military and commercial shipping traffic exists around Jacksonville and Mayport, Florida, the St. Mary's Channel at the Florida/Georgia border, and from Brunswick and Savannah, Georgia. Seasonal measures to reduce the possibility of whale/ship collisions in the region may be necessary. Aerial surveys could continue to provide "early warning" data for dredging operations, and may be appropriate for heavily used commercial shipping ports or naval bases.

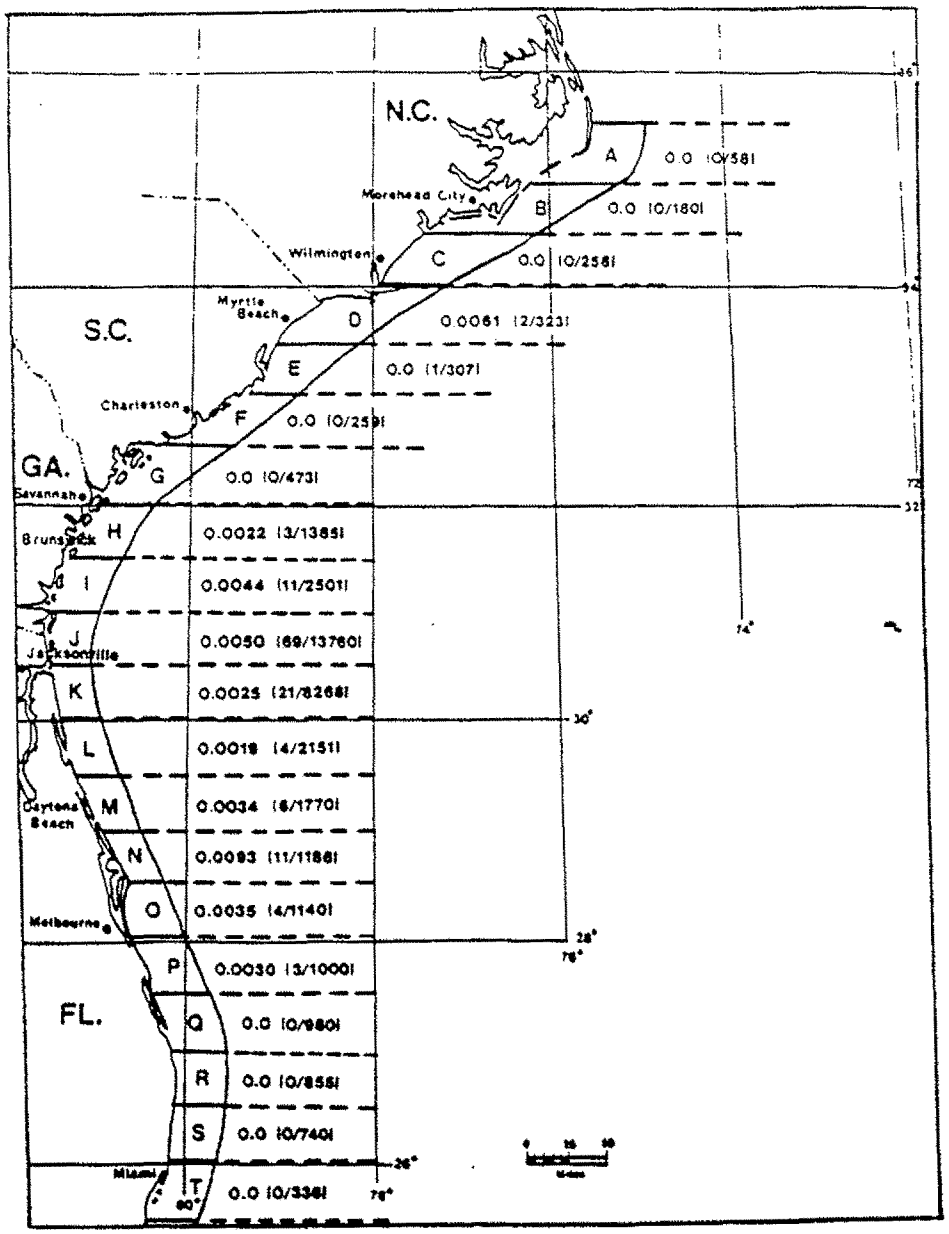

Figure 6. Densities of right whales per survey mile off the southeastern U.S. This sightings-per-unit effort analysis is partitioned by 30-minutes-of-latitude sections.

RIGHT WHALES IN THE GREAT SOUTH CHANNEL, 1975-1991

Robert D. Kenney
University of Rhode Island
Narragansett, Rhode Island

The Great South Channel (GSC) region is one of the most intensively utilized cetacean habitats off the northeastern United States, and comprises the primary spring feeding ground for western North Atlantic right whales (Figure 7). A continuous time-series of sighting data from

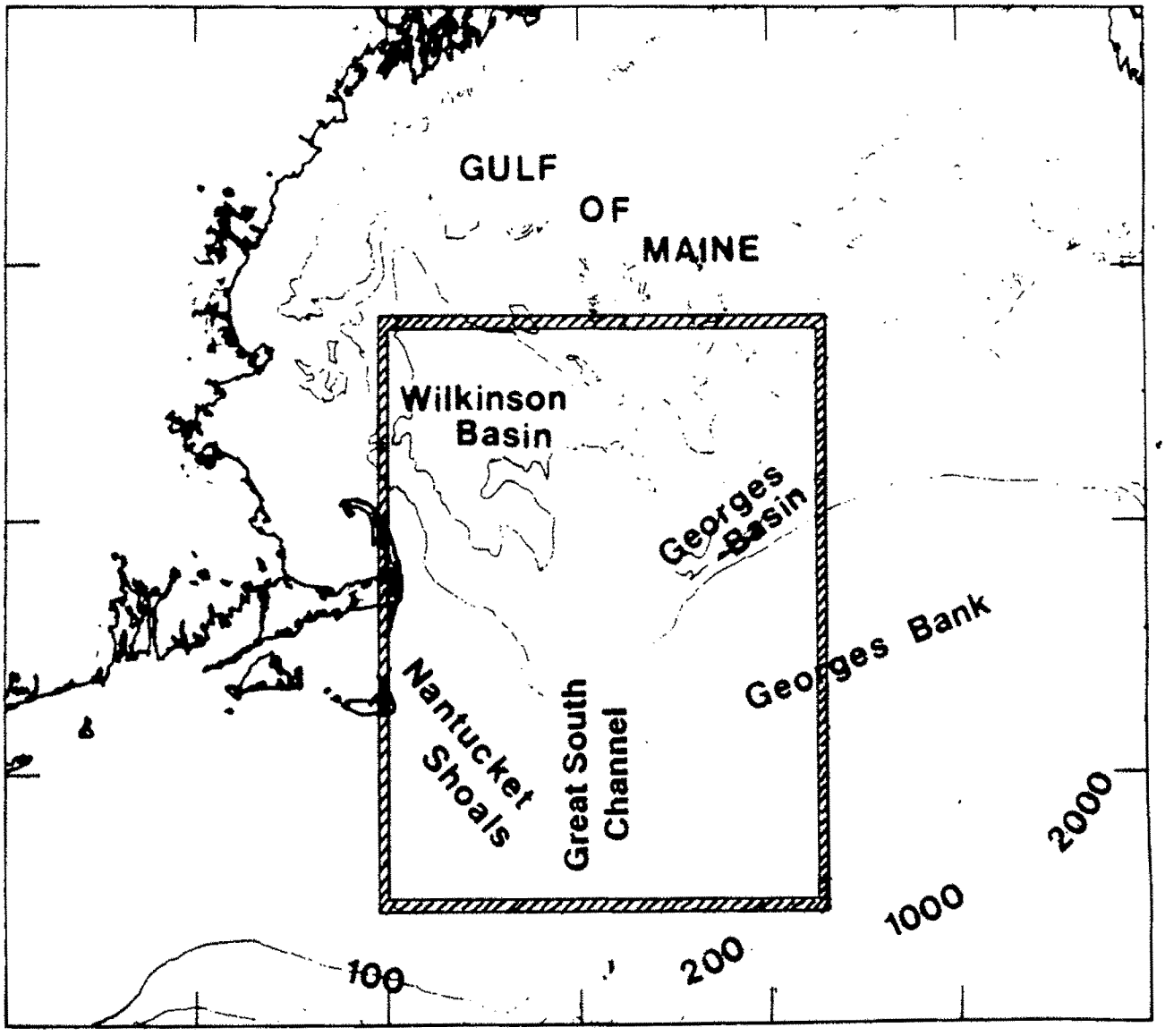

Figure 7. The Great South Channel study area, an intensively utilized cetacean habitat located southeast of Cape Cod and east of Nantucket Island. It is the primary spring feeding ground for right whales. Surveys have resulted in a nearly continuous time-series of sighting data for the spring season, 1979-1992. Depth contours in meters.

spring aerial and shipboard surveys from 1979 through 1989, with additional data from 1975-1978 and 1991, provides a picture of consistent patterns of occurrence with several interesting inter- and intra-annual variations.

RESULTS

Between 1975 and 1991, there were 969 sightings of right whales in the GSC area, totaling 2,157 individuals. The sightings were concentrated in April, May, and June in the central, deeper portion of the area, with the pattern persisting after adjusting for survey effort. Sightings were significantly concentrated in a relatively narrow depth range, with 36 percent in 140 to 160 m of water, and 79 percent in 100 to 180 m.

GSC right whale distribution is highly aggregated (Figure 8). In most years the center of aggregation occurred on the western side of the

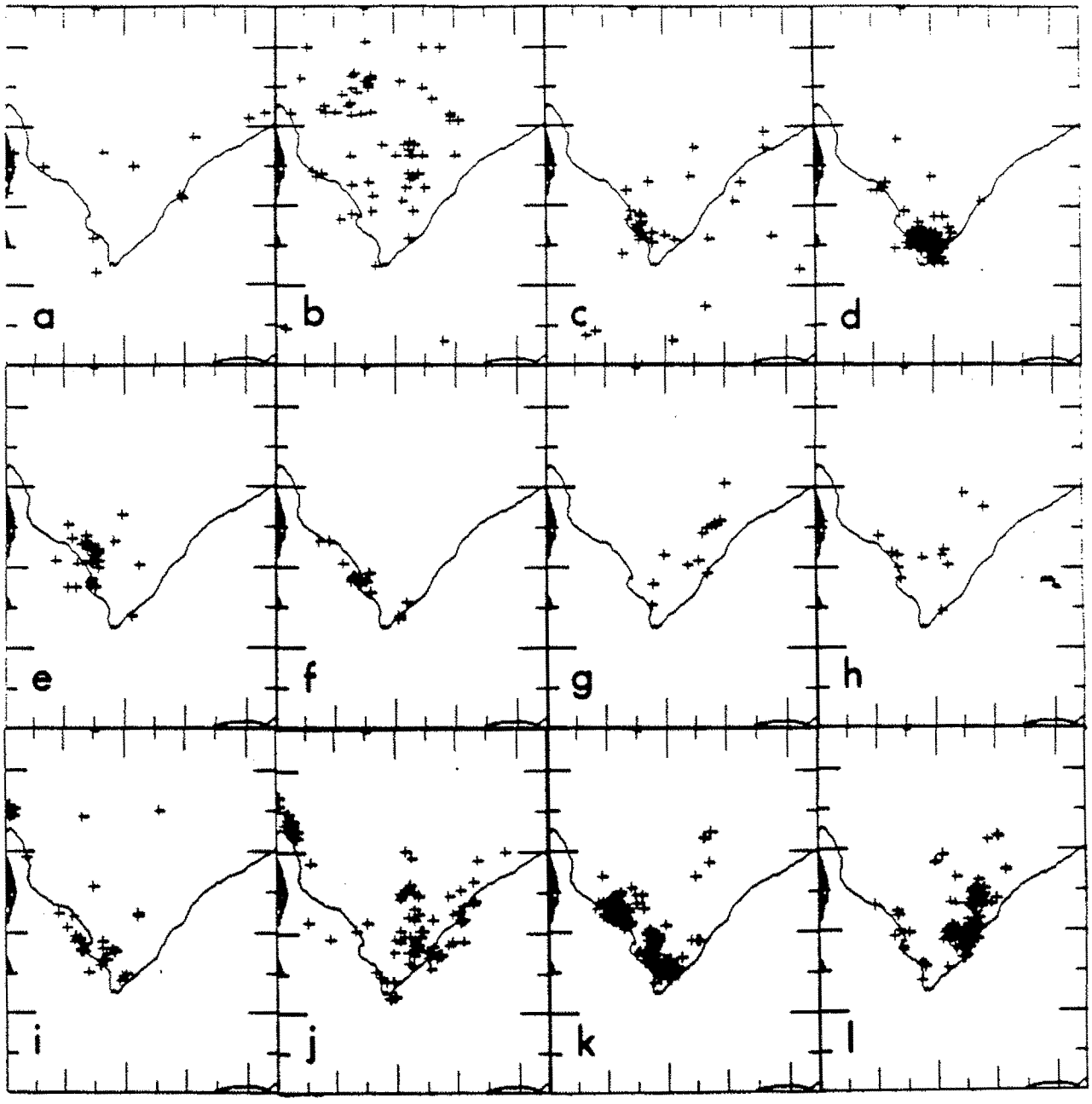

Figure 8. Distribution of right whale sightings in the Great South Channel by year, including only sightings from March through July, except for 1975-1978: (a) 1975-1978; (b) 1979; (c) 1980; (d) 1981; (e) 1982; (f) 1983; (g) 1984; (h) 1985; (i) 1986; (j) 1987; (k) 1988; (l) 1989.

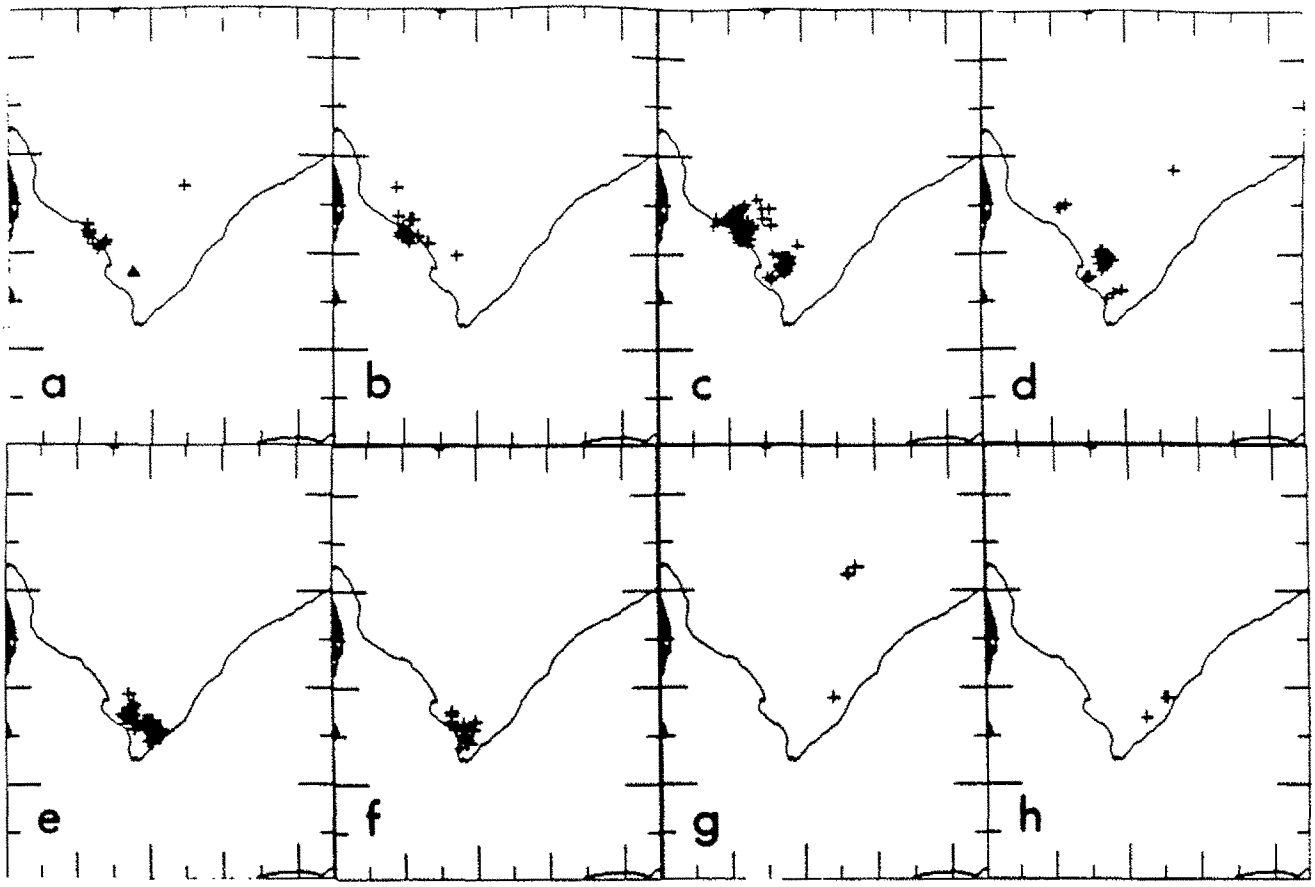

Figure 9. Weekly shifts in the distribution of right whale sightings in the Great South Channel region, 1988: (a) 17 March (D) and 24-30 April; (b) 1-7 May; (c) 8-14 May; (d) 15-21 May; (e) 21-28 May; (f) 29 May-4 June; (g) 5-11 June; (h) 12-18 June.

central basin. In 1984, we first saw a pattern with the main aggregation on the eastern side of the area. This pattern recurred in 1987, 1989, and 1991. A smaller aggregation of sightings occurred in 1986 and 1987 in the northwestern portion of the study area, relatively close to Cape Cod.

There are apparent differences in arrival or departure dates in the region, but these are confounded by effort. Numbers of right whales have been sighted as early as mid- to late March, but in some years few whales have arrived by late April. Date of departure varies by a month or more between "early" and "late" years. Early July surveys in 1981 and 1987 found right whales, but in 1985 and 1991, for example, the whales had departed by late May/early June.

In years with sufficient effort, a general trend over the season could be discerned: dispersed sightings early; followed by aggregation in a smaller area, which often shifts toward the south and more central, deeper portion of the study area; and finally, dispersal and disappearance from the area. The 1988 data, extending from 17 March through 13 June, are the most extensive and show this pattern most clearly (Figure 9).

DISCUSSION AND CONCLUSIONS

The main area of GSC right whale distribution, in central waters deeper than 100 meters, lies north of a thermal front that roughly parallels the V-shaped 100-m isobath. The front divides stratified waters with warmer surface temperatures to the north from tidally mixed water with cooler surface temperatures to the south of the front (Wishner *et al.* 1988). The primary right whale aggregation occurs in the stratified water, usually in the central-western portion of the basin, and gradually shifts southward over the season. The principal aggregation area shifts greater distances between years than it does within a year. There are also major differences in the timing of right whale occurrence between years.

There is an apparent relationship between surface temperature and whether the main ag-

gregation occurs on the east or west side of the GSC region. Through 1989, in years when the average sea surface temperature north of the thermal front during the first week of May was less than 8°C, the whales were on the east side of the region. The 1991 data were used to test this prediction. Temperatures north of the front in early May 1991 were examined on satellite images, and were less than 8°C. All 25 right whales seen on 26 April, and 22 of 24 seen on 9 May, were on the eastern side of the area, in accord with the prediction. However, since the whales have typically made their choice earlier, in mid- to late April, the situation is obviously more complex.

Whale distributions are largely in response to the distributions of their prey (Katona and Whitehead 1988). Western North Atlantic right whale distributions are correlated with the occurrence of dense patches of *Calanus finmarchicus* (Mayo and Marx 1990; Murison and Gaskin 1989; Wishner *et al.* 1988). In the GSC, feeding is presumed to occur most often near the bottom, but surface and near-surface feeding was observed regularly in four years: 1980, 1986, 1987, and 1989. Deep feeding is correlated with diel vertical migration by *Calanus*, while near-surface feeding is correlated with *Calanus* in surface patches without vertical migration (Wishner *et al.* 1988).

Despite a seemingly clear relationship of right whale distribution to the occurrence of dense *Calanus* patches, many questions remain as to the specific underlying factors. All relate to the causes of and influences on zooplankton distribution patterns, and they include:

- What causes the optimal feeding areas to occur within the central basin of the GSC so predictably each spring?
- Why does the feeding area shift to the eastern side of the region in some years?
- What influences the horizontal and vertical patchiness and vertical migration of *Calanus*?
- What is the influence of bottom topography and the thermal structure of the water column on zooplankton distributions?

The SCOPEX investigations, (a multidisciplinary study of the region) included intensive study of the hydrography of the area and of zooplankton distribution and biology. We hope the integrated results of the project will begin to shed some light on these and other questions.

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OCCURRENCE AND DISTRIBUTION OF RIGHT WHALES IN CAPE COD AND MASSACHUSETTS BAYS

Marilyn K. Marx and Charles A. Mayo
Center for Coastal Studies
Provincetown, Massachusetts

Since 1984, the Center for Coastal Studies in Provincetown, Massachusetts has been studying the distribution, occurrence, and population characteristics of right whales in the Cape Cod and Massachusetts Bays (Hamilton and Mayo 1988). This ongoing work has been the Center's contribution to the North Atlantic Right Whale Consortium, which was formed in 1986 and with whom we have worked ever since.

METHODS

Observations were made from two types of vessels: 30 m commercial whalewatching boats that operate between mid-April and October each year, and a 12 m diesel-powered research vessel. The tracks of the whalewatching vessels were determined by the captains and were not random. Our winter survey work from our research vessel generally followed fixed LORAN tracks in Cape Cod Bay. Because of frequent unfavorable weather conditions, the tracks were not surveyed equally; effort has been concentrated in the eastern portion of Cape Cod Bay.

Individual whales were identified using variations in callosity pattern, lip ridges, and prominent scars (Payne *et al.* 1983; Kraus *et al.* 1986). From black-and-white photographs, we attempted to match each whale to a previously cataloged animal. Copies of the photographs were sent to the North Atlantic Right Whale Consortium Catalog at the New England Aquarium in Boston, where each whale match was confirmed or assigned a new catalog number, and then archived.

RESULTS

Right whales are usually seen in Cape Cod Bay beginning in February. In late March and early April, mothers and their calves begin to arrive. By mid-May, most right whales appear to have left the study area.

The yearly observed distribution of right whales in Cape Cod Bay has remained relatively stable. Usually the major concentrations have been seen in the eastern part of the bay (Fig. 10). However, we do record many sightings of right whales outside Cape Cod Bay every year, and occasionally significant concentrations are found both north and east of Cape Cod.

From 1987 through 1991, 75 individual right whales were identified from photographs taken in Massachusetts and Cape Cod Bays. Sixty-six were observed in more than one year. Of the 54 whales for whom gender was determined, 19 are males and 35 are females. Twelve mothers brought seventeen calves here. We have seen an average of 40 right whales each year. The whales were resident for an average of 7 days, but the longest residency was one of 67 days.

Using Consortium data from all years to date, 165 individual right whales have been identified in this study area. This is more than half of the individually identified right whales in the North Atlantic. Of the 165 whales, 84 were observed in more than one year. The sex of 108 individuals has been determined; of these, 38 are males and 71 are females. The number of females represents more than 50 percent of all the known females in the population. Through 1991, we have identified 28 mothers who brought 54 calves to Cape Cod and Massachusetts Bays.

DISCUSSION AND RECOMMENDATIONS

Clearly, Cape Cod and Massachusetts Bays are important habitats for the North Atlantic right whale. We believe it is critical that research continue in this region and offer the following recommendations:

1) Shipboard surveys during the late fall and early winter months of November through January, so that we may gain a better under-

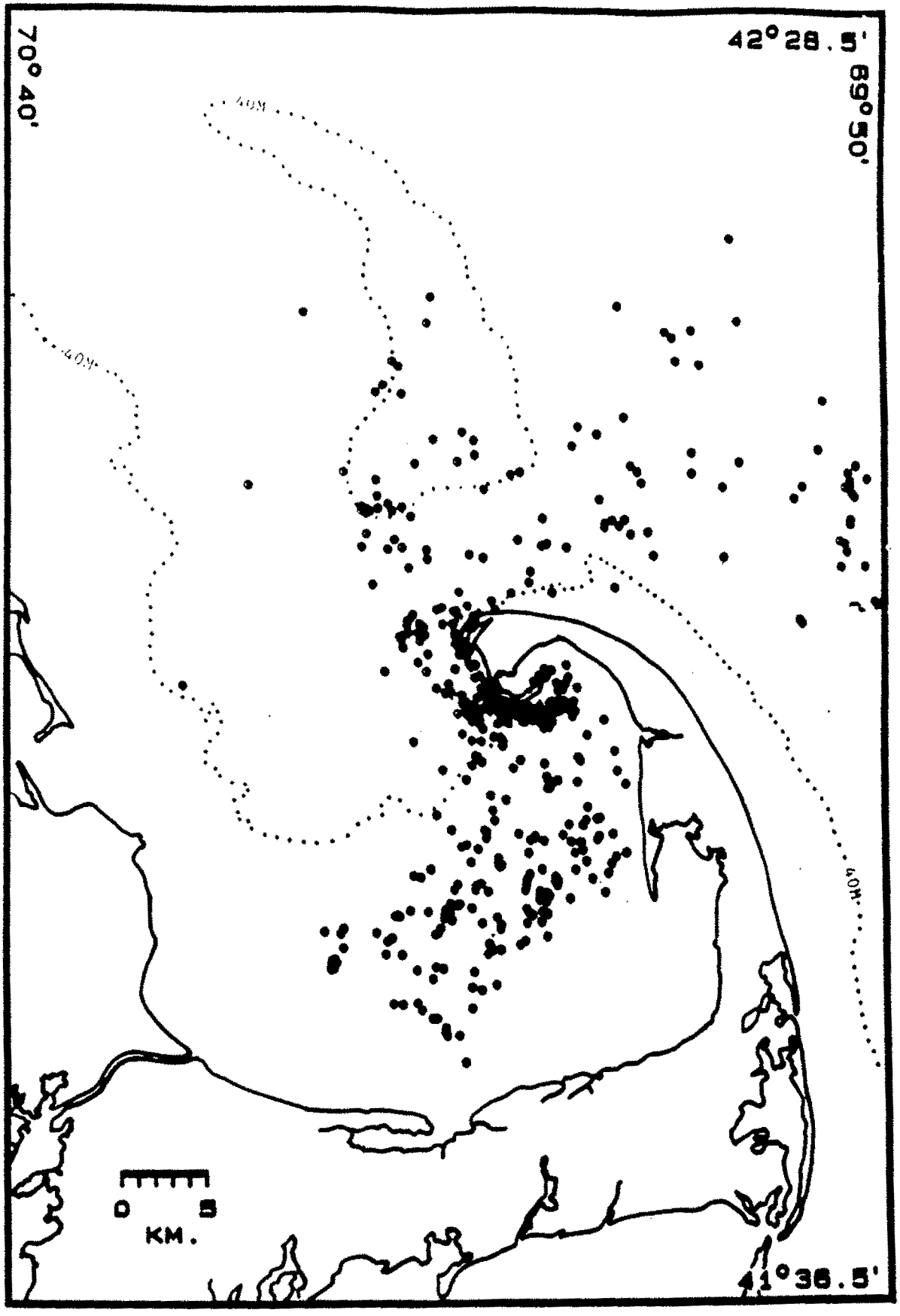

Figure 10. Right whale distribution in and near Cape Cod Bay, 1987-1991.

standing of right whale occurrence, distribution, and habitat use in the Massachusetts and Cape Cod Bays.

2) Weekly or biweekly aircraft surveys during the winter and spring, to get an accurate population estimate for the entire bay region, as well as to assess the wider distribution of right whales.
3) Expand shipboard effort to assess right whale distribution in central and southern Massachusetts Bay where the proposed Boston sewage outfall will likely have the greatest impact on the habitat.
4) Institute genetics studies on the right whales in Cape Cod Bay to better define the genetic stocks of the North Atlantic.

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RIGHT WHALES IN THE BAY OF FUNDY

Scott D. Kraus and Amy R. Knowlton
New England Aquarium
Boston, Massachusetts

Right whales are present in the Bay of Fundy annually from the end of July to the middle of October. Their distribution is usually centered around the northern margins of the Grand Manan Basin, as shown in Figure 11, although the location and degree to which they aggregate varies with tide phase and magnitude.

SUMMARY OF RESULTS

The number of right whales observed annually since 1980 has ranged from 24 to 73, with a mean of 44 individuals. The seasonal population of right whales found in the Fundy region is primarily comprised of cows with five- to ten-month-old calves, and juveniles of both sexes. Over half of all cow/calf pairs observed in the North Atlantic since 1980 have used the Bay of Fundy as the summer and fall nursery. It is the only summer and fall nursery for North Atlantic right whales identified at this time.

The region is used by cows to nurse their young, and by all right whales for feeding. Feces collected from right whales in the region contained almost exclusively remnants of the copepod *Calanus finmarchicus*. Surface-active groups of apparently courting right whales are rare in the area, and were observed in only 6.7 percent of all sightings.

HUMAN IMPACTS

There is a small whalewatching industry in the region, based on Grand Manan Island. On average, one or two boats can be found seeking right whales from August 1 through September 10. Fishing activities are uncommon within the right whale distribution zone, although some fishing draggers operate on the eastern side during the later summer. One right whale was killed in the area in November of 1988 by an offshore lobster trapline, a fishery that is unusual for the area. The shipping lane from St. John, New Brunswick, transits through the eastern portion of the right whale area.

RECOMMENDATIONS

Continued surveys of the right whales in this region are important to monitor the calf production and reproductive health of this population. They may also be useful in monitoring potential threats to the population from fishing and shipping.

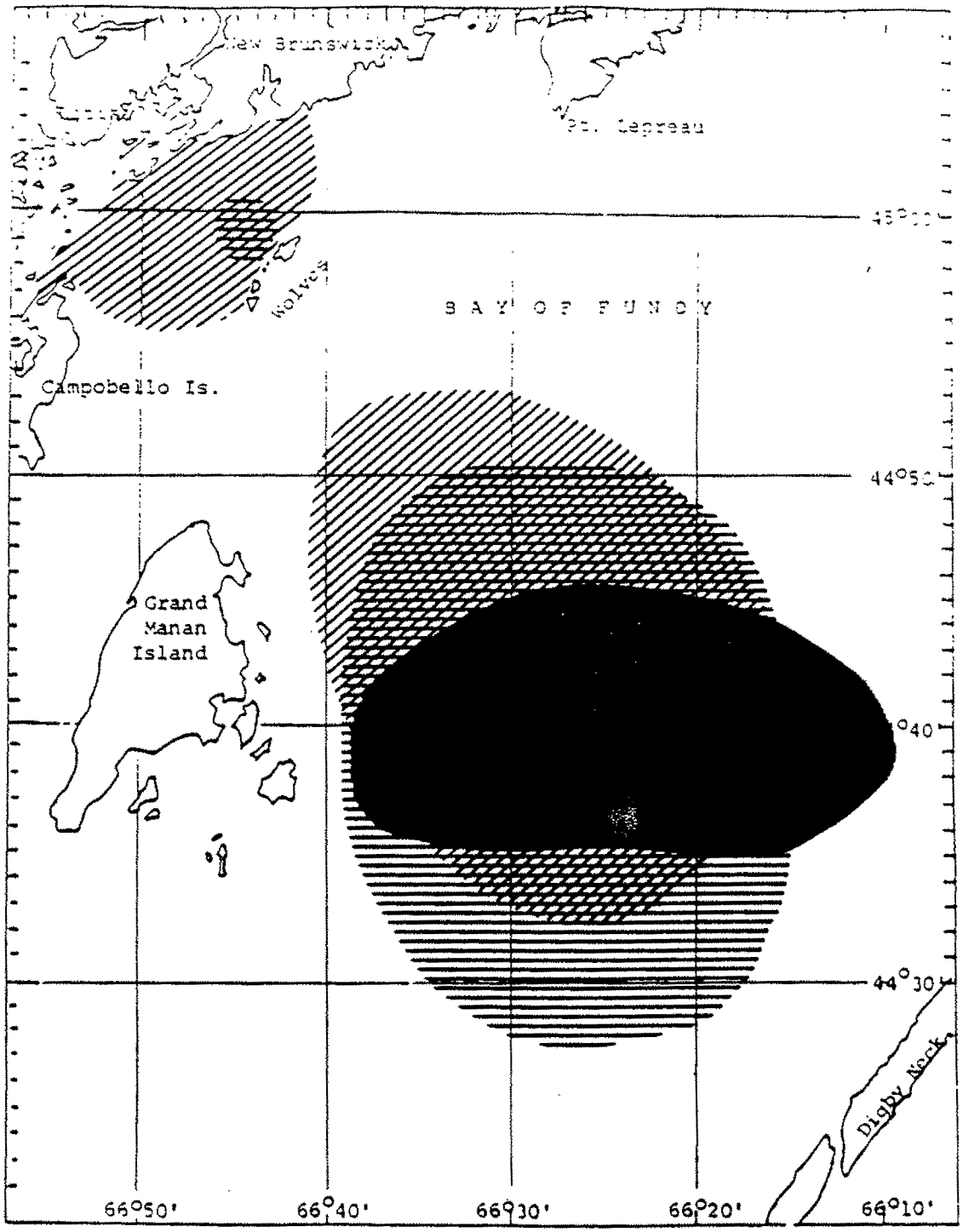

Figure 11. Right whales are present in the Bay of Fundy from late July to the middle of October. Their distribution, particularly in recent years, has been centered around the northern margin of the Grand Manan Basin (the darker of the areas shown).

RIGHT WHALES ON THE SOUTHERN NOVA SCOTIAN SHELF

Scott D. Kraus and Moira W. Brown
New England Aquarium
Boston, Massachusetts

Right whales occur on the southeastern Nova Scotian Shelf from May through November (Figure 12). In May and June, right whales are distributed from Browns Bank along the shelf to the east up nearly to Sable Island. However, by August, the highest densities of this species have been recorded between Browns and Baccaro Banks.

SURVEY EFFORT AND ABUNDANCE

Since 1982, annual shipboard surveys have been conducted in this area from late July through the middle of October, with most of the effort concentrated in September. The number of right whales identified in the Browns/Baccaro Banks region annually since 1982 has ranged from 10 to

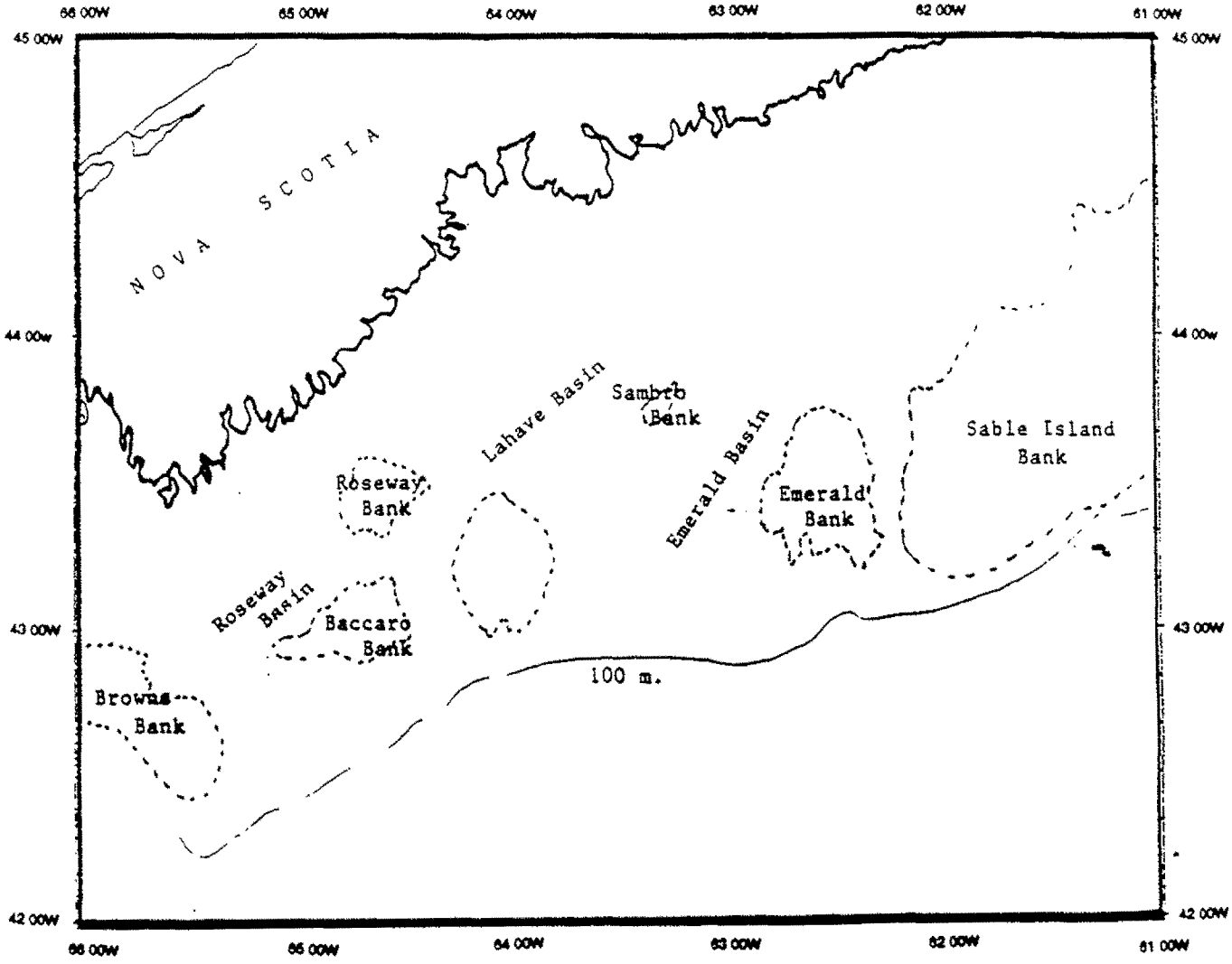

Figure 12. Right whales occur on the southwestern Nova Scotian Shelf from May through November. The highest densities in August appear to be between Browns and Baccaro Banks.

101, with this variation primarily due to variations in survey effort. Since the Consortium formation in 1986, a mean of 72 right whale identifications have been made there annually. Survey effort in this region has been limited by the open ocean location and poor weather.

HABITAT USE

Right whales feed in this area, as defecations have been frequently observed. However, the most striking aspect of right whale behavior in the area is surface activity by large groups of whales apparently engaged in courtship. These groups average about six whales in size, but can be as large as thirty individuals, and are usually comprised of a single focal female surrounded by males. These groups average more than an hour in time duration, and are at the surface nearly all of the time while underway. These courtship groups occur on the Scotian Shelf in more than 52 percent of all sightings, an occurrence rate more than three times that observed in any other known right whale habitat. Since the gestation period for this species is unknown, the high rate of courtship activity in the fall in this area suggests it may be a significant breeding ground.

HUMAN ACTIVITIES

Very little fishing activity occurs in the right whale zone between Browns and Baccaro Banks, with the exception of a few longliners, gillnetters, and draggers. One or two cruise ships stop here to observe whales once or twice in the summer and fall, but there is no other whalewatching activity. Large commercial shipping vessels traveling between the maritimes to ports in the northeastern U.S. transit across Baccaro Bank and may present a threat to right whales. Because right whales within a courtship group appear to be oblivious to the approach of any vessels, there is the potential for a ship/whale collision with significant consequences for the population.

RECOMMENDATIONS

The temporal distribution and dispersion of right whales along the Nova Scotian Shelf is only known from observations taken by whaling vessels in the 1960s. Dedicated surveys for right whales in the region are essential to determine the habitat use patterns there, to better define the critical areas, and to monitor potential threats to the species.

Biology and Life History

VALUE OF STRANDED ANIMALS

James G. Mead
Marine Mammal Program
Smithsonian Institution
Washington, D.C.

The Smithsonian Institution's Marine Mammal Events Program, begun in 1975, is a computerized database of marine mammal strandings (live or dead) and unusual sightings (rare animals or animals outside of their normal range).

The records of strandings and incidental catches for the northern right whale worldwide number 53, the North Atlantic records (including Europe) number 46, and the U.S. records number 42. This database and the associated specimen material, where available, is a source for taxonomic and morphological information.

SYSTEMATICS

There may be morphologic differences in different populations of right whale, but, because of the lack of sufficient specimens, these have yet to be statistically demonstrated. Most workers have accepted the existence of two species of right whale, *Eubalaena glacialis*, the northern right whale, and *Eubalaena australis*, the southern hemisphere right whale. Yet there is reason to believe that those differences would not stand up if the studies were based on a larger sample. Because these differences appear to be minor, one would want good biological data on the specimens to allow for possible sexual and age related differences.

If you accept the North Atlantic right whale as one species and the southern right whale as another species, what are we going to call the North Pacific right whale? It has been geographically isolated for at least as long as the other two species, is it not likely to constitute a third?

ANATOMY

In a group such as this, weighted heavily with management-oriented workers, I feel obliged to give a plug for anatomy, both descriptive and functional. We know a little bit about the anatomy of balaenopterid whales through the efforts of such workers as Schulte, Ommaney, and Slijper who took advantage of the whaling industry to provide specimens for their dissection. We have this brief look at these whales from an industry that took hundreds of thousands in recent years. But what have we got for right whales, who have not been taken in any numbers for better than 100 years? I was fortunate to be allowed to participate in a dissection of a newborn stranded right whale at the New England Aquarium. That work turned up far more questions than it did answers. We are hoping to confirm at least some of our findings with other stranded specimens.

LIFE HISTORY

In order to maximize the value of the data recovered from a stranded carcass, certain elements that relate to the life history of the individual need to taken. First are its sex and total length. If it is a female, the ovaries and a mammary sample need to be taken, because the interpretation of fat soluble toxins in females is highly variable according to how many calves she has successfully born. Tissues to estimate the age of the individual should be taken. At present, the only reliable age estimates on balaenids involve sectioning the auditory bullae (the bullae are located on the ventral surface of the skull just medial to the jaw articulation).

IDENTIFICATION

Since we know a substantial portion of the North Atlantic right whale population by individual, it is important to get photographs of the head, both lateral and dorsal, to attempt to document the animal's identity. If it turns out to be a known animal, the year of birth may be known. This will give us not only an absolute age for interpretation of toxin levels, but will also give us a known-age animal to test the age estimates based on sectioning the bullae.

TOXICOLOGY

Monitoring the potential effects of deleterious anthropogenic compounds is important. All major organ systems should be sampled, and tissues analyzed and archived. Comprehensive analysis of toxins needs to be done. Even though we do not know of any problem with right whales ingesting toxins because of their low level on the food chain, we must still monitor the species.

CAUSE OF DEATH

Cause of death, especially if human related, should be determined. Out of 25 dead stranded right whales that have been investigated during the period 1970-1991, 5 (20 percent) have been struck by vessels; of the 196 appropriately photographed North Atlantic right whales, 22 (11 percent) bear scars that could have been caused by ship collision (Final Recovery Plan for the Northern Right Whale). This indicates that vessel collision is an important mortality factor. Care must be taken in the interpretation of this, because it is possible that the right whales that suffered ship collisions may have been sick or injured beforehand, or the vessel collision may have occurred after the animal was dead.

The Smithsonian's file on right whales that stranded between 1950 and 1991 reveals that 11 out of 40 (28 percent) were entangled in fishing gear ranging from crab pot lines to gill nets. It is important to document such occurrences with specimens of the fishing gear.

RIGHT WHALE STRANDINGS

Amy R. Knowlton
New England Aquarium
Boston, Massachusetts

Strandings of North Atlantic right whales are an infrequent event, in part because of the endangered status of this species. It is becoming clear, however, that the cause of many of these mortalities is human-induced. Kraus (1990) concluded that one-third of all right whale mortalities were caused by either ship strikes or fishing gear entanglements. This estimate may be lower than the actual number of human-caused mortalities, as necropsies are not always performed on stranded right whales. There may also be a small number of mortalities that go undocumented if, for example, they never reach the beach.

Seven right whale mortalities have been documented since 1988. Detailed necropsies were performed on two of these whales. Each necropsy furthered our knowledge on right whale physiology, anatomy, and the cause of death.

TWO WHALES WITH NECROPSIES

On January 3, 1989, a newborn right whale beached alive and later died on Cumberland Island, Georgia. With the assistance of the National Park Service and the Navy, we were able to transport the calf intact to a freezer on the mainland. Five days later the whale was trucked to Boston where a detailed necropsy was performed at the New England Aquarium. Because the animal was so fresh and had been transported to a laboratory, a team of specialists representing many different organizations was invited to participate in the necropsy. Preliminary results indicate the animal may have died of a heart defect, possibly a result of inbreeding.

On March 11, 1991, a two-year-old female right whale stranded on Amelia Island in Florida. This animal had been seen alive three weeks earlier, but looked noticeably ill and had a gillnet tightly wrapped around her tail. Our records show she had acquired that gillnet the preceding summer. This animal was transported by a log lifter to a remote area on the island where a three-day necropsy was performed by the U.S. Fish and Wildlife Service with support from other agencies. While it was initially thought that this whale had died as a direct result of the entanglement, it was only after flensing the animal to retrieve the skeleton that it was determined the whale had died from a shattered skull. This was thought to be a direct result from impact with a large vessel.

Also as a result of this extensive necropsy, Bob Bonde of the U.S. Fish and Wildlife Service discovered the presence of a postanal sac, an organ not previously described in right whales. It is thought these sacs may be scent glands used in "track laying" during migration, or for maintaining group integrity.

Numerous samples, in addition to the routinely collected tissue samples, were collected for analysis and ongoing studies being performed by various researchers.

FIVE WHALES WITHOUT NECROPSIES

Necropsies were not performed on the remaining five whales. A newborn calf was found dead on January 17, 1988, on Ormond Beach, Florida. The whale was in an advanced state of decomposition, but the skeleton was collected by Sea World of Florida. An additional newborn calf was found dead on January 26, 1989, at Melbourne Beach, Florida, however, samples were not collected and the animal was photographed and subsequently buried. A reproductively active female stranded on St. Augustine Beach in Florida in September 1989. Although stranding personnel were in the process of making plans to do a necropsy, the town of St. Augustine independently decided to bury the whale in a landfill and disallowed access to the carcass. Three days later, what was thought to be a manatee washed up a couple of miles down the beach. It was buried and later unearthed only to find it was a right whale fetus. The cause of death for both mother and fetus was therefore not determined.

A whale stranded on a remote Maine island (Head Harbor Island, south of Machias) in November 1991. Marine mammal personnel were not notified of the stranding until weeks later,

making a necropsy or determination of cause of death impossible. However, measurements were obtained and it may represent the longest male right whale ever documented.

SUMMARY

Right whale mortalities and our quick access to them can provide important data for our understanding the causes of death, as well as learning more about right whale physiology and anatomy. Since this requires data beyond what would be routinely collected, I am presently in the process of creating a necropsy protocol specifically for right whales. This protocol will outline special requests for samples: collection techniques materials needed, and the research that the samples will be used for. It will also provide phone numbers for New England Aquarium right whale personnel, as well as researchers interested in participating in a necropsy. This protocol will be provided to all stranding network personnel . full cooperation with NMFS.

It is our hope that with this protocol in hand, future right whale strandings will not go unstudied and will add to a growing and valuable body of knowledge about this endangered species. Funding to support transportation of trained personnel to and from a right whale stranding as well as for acquisition of needed materials will be essential to ensure the protocol could be carried out.

SMALL-SCALE MOVEMENTS AND DIVE PROFILES

Howard E. Winn
University of Rhode Island
Kingston, Rhode Island

The distribution of the right whale and other organisms is not random, but at least during the feeding season, is determined by adequate concentrations of their prey. The evidence supports the idea that across the northern hemisphere, the annual cycle of long- and short-time horizontal and vertical movements of right whales in the North Atlantic is determined by the life cycle of calanoid copepods, in particular, *Calanus finmarchicus*.

COUPLING OF RIGHT WHALES AND *C. FINMARCHICUS*

Upon examination of the annual, temporal distributional patterns of feeding right whales, there appears to be a tight coupling of these to the cyclic population development of their preferred prey consisting of calanoid copepods (*C. finmarchicus*) in the western North Atlantic. The right whale's annual distributional cycle in the western North Atlantic includes a springtime feeding period in the Great South Channel and Cape Cod Bay, followed by a summer-early fall feeding period in the Bay of Fundy and off the southern coast of Nova Scotia. During the winter, a small percentage of the population goes to nearshore areas off the Georgia-Florida Coast to calve, while the remainder of the population resides in largely unknown areas to the north. The springtime feeding period coincides with the development of large concentrations of *Calanus finmarchicus*, which last sometimes into June. These prey concentrations occur later in the northern Gulf of Maine, probably due to a colder temperature cycle coinciding with the summer-early fall feeding period. There are probably times and places where other zooplankters form part of the diet but do not seem to be driving forces in the whales' major movement patterns. If they feed in the winter, then other zooplankters are probably important. However, we know little about the winter distribution of the right whale in the western North Atlantic.

SEARCH STRATEGIES

Since there are a variety of interannual and intra-annual variations in dense-patch distributions of the right whales' preferred food, particularly during the spring to summer period, there should be mechanisms to ensure that the whales can find food supplies sufficient for their energetic needs. Search strategies can vary, but the evidence to date suggests that during any one annual feeding period, such as the April to June spring feeding period, some individuals take time out to explore adjacent areas. For instance, some individuals visit Stellwagen Bank, Cape Cod Bay, and areas south to the Great South Channel. Resightings of known individuals between those areas within one season confirms this hypothesis (Mayo, Dorf, Winn, Kenney, Kraus; unpublished data). It is possible that information on adequate food supplies is stored by the whale so that if in a following year food was inadequate where they fed previously, they could go to the new area. It was suggested by Klein *et al.* (manuscript) that humpbacks, by extensive exploratory movements, could store information on food supplies for future use. Thus, the strategy of temporary movements of whales out of immediate feeding areas are important survival mechanisms to ensure adequate food supplies in response to changing temporal and geographical concentrations of their principle prey.

Right whales have to adapt to both horizontal and vertical changes in the distribution of adequately dense patches and/or layers of copepods (*Calanus finmarchicus*) both intra- and interannually as well as within one area such as the Great South Channel. The copepods vertically migrate to the bottom (more than 100 m) during the day in some years such as 1988, but not in others such as 1989, and this may vary from place to place in one year (Wishner and Macaulay, manuscripts). The locations in the Great South Channel where the zooplankton concentrations within patches are adequate vary from year to year, and within years, as evidenced by the shifts

of the major aggregations of right whales from one side of the channel to the other (Kenney, Winn, and Macaulay, manuscript). As evidenced from fecal eliminations and foul-smelling breaths, the whales were feeding during the observations we made of dives in 1988 and 1989 in the SCOPEX program. Whether or not they fed during all dives could not be determined.

Although the whale prey search and detection methods are unknown, several observations allow some general speculations. In some instances, large groups were observed to disperse out many meters, and minutes to hours later would return directly to a focal animal. Perhaps certain sounds tell individuals where another individual has found food. In all cases where the central aggregation is on a scale of several kilometers, there are a few individual outliers many kilometers away, perhaps representing pioneers searching for food concentrations. There are occasional dives that go out of the main prey patches, perhaps preparing the whales for any changes in depth distribution of prey patches. Clearly the dive patterns of 1988-1989 exhibited adaptations to prey distribution. The shorter dive durations and preponderance of dive depths of 20 m or less during 1989 was an adaptation to the prey concentrations being in the upper water column throughout 24-hr periods (no vertical migration). Concentrations of *Calanus* are also the primary stimulus of how long whales will linger on a specific feeding area.

CONCLUSION

Any management proposals must take into account this close coupling of the right whale and its prey.

SATELLITE-MONITORED MOVEMENTS OF RIGHT WHALES

Bruce R. Mate and Sharon L. Nieukirk
Hatfield Marine Science Center
Oregon State University
Newport, Oregon

Despite more than 50 years of protection from commercial whaling, the North Atlantic right whale (*Eubalaena glacialis*) continues to be the most endangered of the large cetaceans. Of the estimated 350 right whales remaining, 70 percent are scarred from fishing gear entanglement and ship collisions (Kraus 1990) and little is known of their winter distribution. We used Argos satellite-monitored radio tags to study the movements and dive habits of right whales inhabiting the Bay of Fundy (BOF) in the early fall of 1989 and 1990.

RESULTS

Our satellite tracking of free-ranging animals reshaped much of what we know about right whales. They were previously thought of as a slow-moving and nearshore species. From this study, we know that right whales can travel long distances, sometimes at high speed, and can travel reasonably far from shore (500 km) into deep (4,000+ m) water. There was no coherent migration observed. Individual right whale movements were quite variable. This study provided more specific detail on the movements and around-the-clock dive patterns of right whales than any previously reported.

Regions and Distances

Seven North Atlantic right whales were tagged and tracked during 1989 and 1990 in the BOF with satellite-monitored (Argos) radio transmitters. These whales traveled at least 9,590 km between 366 locations. In 43 days, one female and her seven-month-old calf traveled 3,800 km along a nearshore route, while an adult male traveled 3,000 km ranging far from shore. All three whales returned to the BOF, changing our previous notion that multiple seasonal sightings are a minimum estimate of residency time in the BOF. Some movements were associated with oceanographic features including convergence zones, upwellings, eddies, and warm core rings (WCR). These features may have stimulated local primary productivity or resulted in concentrating the density of prey. Surface active breeding groups (SAGs) were common south of Nova Scotia, and many animals moved the 160 km between the BOF and this area within two days. A preference for traveling along the 200 m contour of the continental slope may have increased the whales' risk of collisions with ships especially since some animals appear to rest at the surface for extended periods.

Individual whales averaged 30 to 113 km/day (1.3-4.7 km/hr) with an overall average of 3.7 km/hr for all whales combined. Speeds as high as 16 km/hr were recorded; some (>10 km/hr) were associated with currents in the same direction. The fastest whale was a pregnant female who spent more time at the surface (33 percent) than any other whale.

Diving Records

Data were collected from 92,963 dives. Dives averaged 86 $\pm$48 seconds. Whales were submerged most of the time (x = 78 $\pm$ 13 percent) although some individuals spent long periods at the surface. The shortest dives occurred from dusk to midnight and the longest dives occurred from midnight to dawn. There were substantial differences in dive patterns among individual whales. In 43 days of monitored dives, one adult male dove twice as frequently (with dives that were half as long in duration) as the comparable female with a calf.

One tagged male was equipped with a pressure sensor for 22 days. He dove routinely to the bottom in waters up to 200 m deep, and had a maximum dive depth of at least 272 m. We observed whales surfacing with mud on their dorsum in water 200 m deep confirming dives to the bottom. As copepods may be distributed anywhere from the surface to the bottom, this deep diving may involve both searching and feeding activity.

Effects of Tagging

There was little reaction to tagging. Mild swelling at the tag attachment site was seen up to three days after tagging. A tagged female with a calf was tracked for 43 days and observed 16 days after tag loss, still with her calf. We saw no evidence of unusual scars or swelling after tag loss. We believe that tagging does not cause serious stress or pose a serious health risk to right whales.

RECOMMENDATIONS

We recommend the following additional tagging research:

1) *Wintering Grounds:* It is not known where most right whales winter. Many of our previously tagged whales went to an area off the southern tip of Nova Scotia after leaving the Bay of Fundy. This area may be important for fall feeding, as copepods there move off the banks (or are advected) and concentrate in the basins. Tagging animals here is highly recommended to discover right whale wintering grounds. Additional tagging in the Bay of Fundy would also be advisable. Tagging individuals we have already tagged could resolve whether they have stereotypic movement and dive patterns. Tagging related individuals (grandparents, parents, and previous calves) could determine whether these patterns are "taught."

2) *Winter Calving Grounds:* Tags could be applied to pregnant females and females with calves off Georgia and Florida to determine their movements during the winter as well as spring migration routes northward. The information from the calving area could be helpful in making survey and traffic control decisions where barge, ship, and dredge traffic is deemed potentially dangerous.

3) *Greenland Feeding Stock:* There appear to be three matrilineal stocks of right whales, one of which does not visit the Bay of Fundy but has been seen in Cape Cod Bay during the spring and off Greenland in the summer. We recommend tagging up to 12 individuals in Cape Cod Bay or the Great South Channel during the spring to determine the migration route of this third matrilineal line. Tagging animals which are not known to the BOF would increase the probability of tagging animals going elsewhere.

4) *Spring Dispersion:* Animals could be tagged in the Great South Channel to look at spring dispersion.

In all cases, additional tags will resolve some of the questions regarding individual variability versus correlated differences between age, sex, and reproductive classes.

It may also be desirable to conduct aerial or shipboard surveys off the Scotian Shelf in the late summer or early fall to determine how many whales use this area. Additionally, it might be worth examining photographs and records from natural history cruise ships which transit this area in the late summer and early fall.

We are convinced that satellite-monitored tracking of free-ranging animals is an important technology that can continue to add vital information regarding the distribution, natural history, and critical habitat requirements of right whales. It is our belief that enough information exists currently to move forward and recommend that the U.S. and Canadian Coast Guards work to establish shipping channels beyond the 200 m contour to avoid additional ship strike injuries and mortalities. In addition to designating the calving areas in Georgia and northern Florida as critical habitat, we believe that seasonal periods within Cape Cod Bay, the Great South Channel, Bay of Fundy, and the southern Scotian Shelf also deserve attention from both Canadian and U.S. Governments to further protect this endangered species.

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RIGHT WHALE REPRODUCTION

Amy R. Knowlton and Scott D. Kraus
New England Aquarium
Boston, Massachusetts

A low reproductive rate has been suggested as a possible reason for the slow recovery of the North Atlantic right whale. The New England Aquarium, in conjunction with the Right Whale Consortium, has been curating the right whale photocatalog for the past 12 years. From the sightings database, we have detailed, longitudinal data on the number of calves born per year, calving intervals, and Gross Annual Reproductive Rate (GARR).

SUMMARY OF RESULTS

Sixty-two females have given birth to 134 calves over the study period (1980-1991). The mean number born per year is 11.08. However, there is no significant increase or decrease in the number of calves since 1984 when effort was consistent in all known habitats.

Seventy-six calving intervals ranging between two and seven years have been observed since 1980 with sixty-one percent at three years. The mean observed calving interval equals 3.68 years. Six females first observed with calves have now been sighted with calves of their own. The mean age at first parturition is 7.33 years.

Gross Annual Reproduction Rate (GARR) is the ratio of calves born in a given year versus the total population size and is used as a measure of population increase. Using a minimum population size count of 308 animals in 1991, and subtracting calves born each year, and adding known non-calf mortalities, the resulting annual GARR's range between 2.7 percent to 5.7 percent with a mean of 4.6 percent.

This rate of population increase is significantly lower than South Atlantic right whale populations studied off South America and South Africa, which are growing at 7.6 percent and 6.8 percent respectively. However, these population increases were calculated using different methods and direct comparisons may not be appropriate.

POSSIBLE CAUSES OF LOW REPRODUCTIVE RATE

If this population is in fact reproducing at a significantly lower rate than their southern counterparts, this might be accounted for by inbreeding, higher rates of mortality, or a high percentage of senescent females. Inbreeding has been cited as a potential cause of reduced fecundity and increased mortality of inbred young. Studies to investigate the level of inbreeding using genetic fingerprinting are now underway. Mortality, especially human caused, could be significantly reducing the number of viable females within the population. Three of the four recent non-calf mortalities have been juvenile or adult females. At least two of these were human-caused mortalities. Senescence may also play a part in lowered reproduction, however, we now have documentation of several females calving over a 20- year period. We would not expect this to be a significant factor unless an unusually high number of known cows are of advanced age.

Habitat degradation and reduced food availability, while its effects on reproduction are more difficult to assess, cannot be ignored when evaluating the health of the population. It, remains, therefore, critically important to continue the long-term monitoring of this population.

SEGREGATION BY AGE AND SEX IN NORTH ATLANTIC RIGHT WHALES

Scott D. Kraus and Jackie N. Ciano
New England Aquarium
Boston, Massachusetts

Of the 312 living right whales, 167 (54 percent) are known to be more than ten years old and have been classified as adults. Although the age of sexual maturity is thought to be around ten (hence the classification), several females have been observed that are older than this and have not yet had calves. Including data collected prior to 1980, there are 62 females who have been seen with calves at least once. Since 1976, these females have produced a total of 134 calves of which 113 were photographically identified. Calves are not identifiable before they are four to five months old, so that the total number of calves identified was less than the total number born.

Animals from one to nine years of age are classified as juveniles (there are 90 (29 percent)), and animals less than one year old are classified as calves (11 to date in 1992 (3.5 percent)). There are 47 whales that were beyond the calf stage when first identified, but have sighting histories of less than ten years, and are therefore classified as of unknown age (15 percent of the cataloged whales).

Right whales can be sexed by observations of the genital area, by molecular identification of DNA from the Y chromosome, or in the case of females, repeated association with a calf. Although callosity patterns do statistically show sex differences, these differences are not useful in sexing individuals. A total of 197 (62 percent) North Atlantic right whales have been sexed, 38 genetically and the remainder by visual confirmation (when inverted). There are 89 known males and 108 known females. This does not indicate a biased sex ratio, since there are more methods of sexing females.

Demographic analyses by region are still underway, so only preliminary information is given here. Calves have been excluded from the data in this discussion. Significant segregation exists in the southeastern calving ground. For the period 1980 to 1990, 74 females and 13 males were observed in the region, and none of the males were adults. Significantly more females than males are also observed in Cape Cod Bay. In the Great South Channel and the Bay of Fundy, more females than males are observed, but it does not appear to be significantly different than existing population frequencies.

The Nova Scotian Shelf right whale distribution appears to have more males than females. As the genetics data is incorporated into the catalog, these preliminary findings will be updated and published.

THE USE OF VISUAL AND MOLECULAR SEX IDENTIFICATION TO ASSESS THE SEXUAL COMPOSITION OF THE CATALOGED WESTERN NORTH ATLANTIC RIGHT WHALE POPULATION: SIGNIFICANCE TO POPULATION RECOVERY

Moira Brown
Dept. of Zoology
University of Guelph
Guelph, Ontario

Scott D. Kraus
New England Aquarium
Boston, Massachusetts

David E. Gaskin
Dept. of Zoology
University of Guelph
Guelph, Ontario

Bradley N. White
McMaster University
Hamilton, Ontario

Previous efforts to examine the sexual composition of the cataloged western North Atlantic right whale population have been hampered by our inability to consistently sex animals at sea. The sex of an individual whale can only be confirmed by visual examination of ventral morphology. This requires that an animal roll over and remain inverted at the surface. Visual observation of the genital region has resulted in the sexing of 39 percent of cataloged animals, 58 males and 49 females (n = 308, based on 11 years of sighting data collected between 1980 and 1990). An additional 43 females have been identified based on their repeated association with the same calf, however this requires that a female be sexually mature and be seen in the year in which she bears a calf. The excess of identified females can be attributed to having two methods to sex females and only one to sex males.

DNA ANALYSIS

To identify the sex of more animals, biopsy skin samples from 95 individual right whales were examined using molecular techniques. When *EcoRI* digested DNA was hybridized with a human Y-chromosome probe PDP1007, a clear, sex discriminating banding pattern was apparent. The probe detected male-(presumably Y-) specific bands as well as bands common to both sexes. A male is distinguished from a female by the presence of a 3.4 kilobase band.

This method verified the sexes of 54 animals previously sexed in the field and added the sex of an additional 41 individuals. By combining all three methods, the sex of 191 of 308 (62 percent) photographically identified animals has been determined.

The data indicate that the sex ratio of this population does not differ significantly from unity. However, it has identified ten adult females that have not had calves during the past ten years and this may, in part, explain why no measurable population increase has been detected.

RIGHT WHALE POPULATION STRUCTURE

Catherine M. Schaeff[1]
Queen's University
Kingston, Ontario

Scott D.Kraus
New England Aquarium
Boston, Massachusetts

Moira Brown
University of Guelph
Guelph, Ontario

Bradley N. White
McMaster University
Hamilton, Ontario

Although information about migration patterns at the population level is informative, a great deal of additional information about habitat use, population structure, and breeding biology can also be gained from investigating migration patterns for individual animals. Since right whales can be identified individually using callosity patterns and scars or markings, migration patterns and habitat use can now be investigated for individual right whales. Mitochondrial DNA (mtDNA) is inherited maternally with no paternal leakage, and, as a result, mtDNA matrilines as well as sighting data can be used to interpret the migration patterns of females and their offspring. Thus, mtDNA analysis provides a unique tool for confirming migrational information based on sighting data. It also enables the testing of predictions about geographical locations that are thought to exist, but which have not been identified.

Figure 13. Breakdown of the western North Atlantic right whale population according to their use of the Bay of Fundy: N = 102, 88, and 126, for females, males, and unsexed animals, respectively.

RESULTS AND CONCLUSIONS

Photo-identification and 11 years of sighting data reveal that only two-thirds of the western North Atlantic right whale reproductive females take their calves to the Bay of Fundy, the only known summer nursery (Figure 13). Study of cow-calf pairs further indicate that female, and to a lesser extent male, calves are philopatric with respect to nursery. These findings suggest that the right whales use at least two summer nursery areas and that the use of a given nursery by females is culturally transmitted.

To further examine population structure, mtDNA composite restriction morphs were determined for 150 animals (47 percent of the population). Using eleven restriction enzymes, three composite mtDNA morphs were identified. One morph was not found among reproductive females that brought all of their calves to the Bay of Fundy (Figure 14a). In contrast, all three morphs were present, in the same relative frequency, among males that were seen in the Bay of Fundy and those that were not (Figure 14b). These findings support the hypothesis that this population may be divided into two subgroups, which are defined by their use of the Fundy nursery, and that males are generally less philopatric than females.

Animals from both subgroups were seen on the southern Scotian Shelf, which is where most right whale courtship behavior occurs. Furthermore, the relative frequency of the mtDNA morphs among these animals was the same as among those from the two nursery areas combined. Hence, although segregated by nursery areas, the western North Atlantic right whales probably represent a single breeding population.

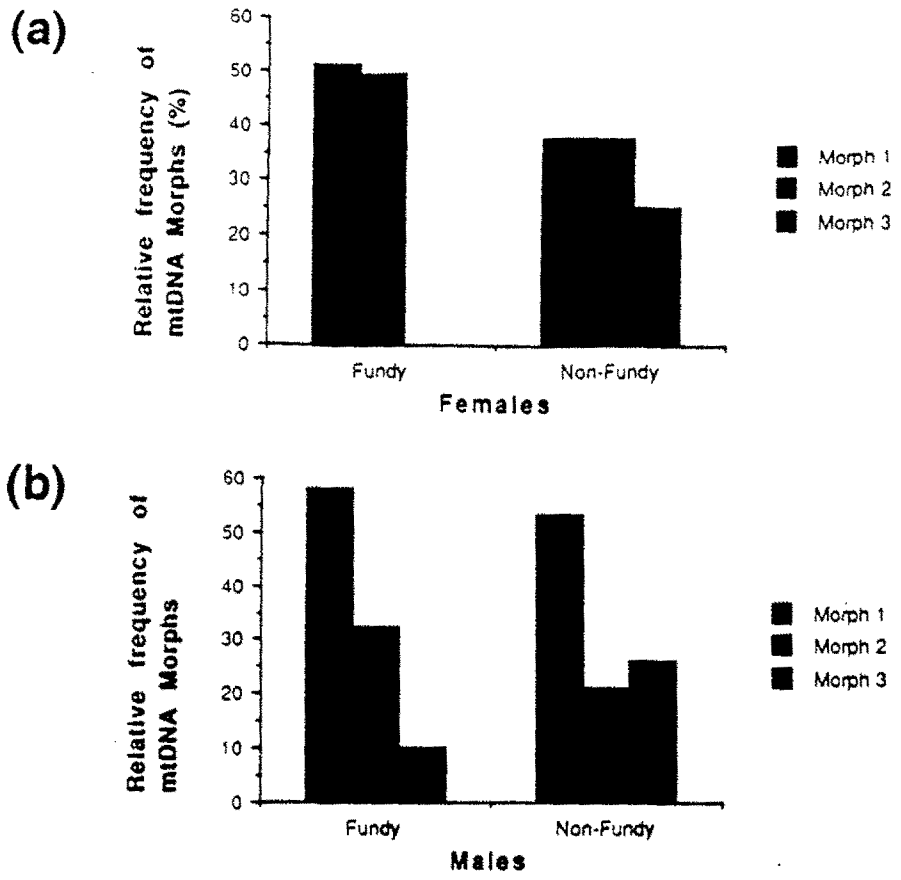

Figure 14. Distribution of the mtDNA morphs among animals that use the Bay of Fundy nursery area and those that do not. (a) Females (N = 67 and 8, for Fundy and non-Fundy females, respectively), and (b) Males (N = 50 and 12, for Fundy and non-Fundy males, respectively).

RECOMMENDATIONS

The discovery that only two-thirds of the western North Atlantic right whale reproductive females use the Bay of Fundy nursery has significant implications for assessment of right whale population recovery. Specifically, additional information is required to confirm that the two subgroups are a single breeding population and to reassess our estimates of population growth.

One factor that may be influencing this population's recovery is inbreeding depression. Since inbreeding is a consequence of small population size, predictions for recovery will be very different if the 350 individuals from the North Atlantic population represent two rather than one gene pool. An inbreeding assessment is currently underway (see Schaeff *et al.*, this report). However, in order to interpret the data from this study, we need to know whether the animals included represent one or two populations. To accomplish this, females, who are highly philopatric, should be surveyed for subgroup-specific population nuclear DNA markers.

Numerous Fundy females have already been biopsy sampled, but very few non-Fundy females. Hence, before this work can be completed, non-Fundy females will need to biopsy sampled, in conjunction with photo-identification, either in the Cape Cod and Massachusetts Bays in the spring, or on the southern Scotian Shelf in the summer.

The discovery that not all reproductive females bring their calves to the Bay of Fundy has led to the realization that approximately 35 percent of the non-Fundy calves are not seen in their first year. As well, because these calves are missed, a number of females that are reproductively active are not designated as such. Since both of these factors affect our perception of population growth, accurate information about this second subgroup is required. Because the location of the second nursery area is unknown, this will require increased photo-identification efforts in the southeastern U.S. in the winter, and in the Great South Channel and Cape Cod and Massachusetts Bays in the spring.

ARE NORTH ATLANTIC RIGHT WHALES SUFFERING FROM INBREEDING DEPRESSION?

Catherine M. Schaeff[1]
Queen's University
Kingston, Ontario

Scott D. Kraus
New England Aquarium
Boston, Massachusetts

Bradley N. White
McMaster University
Hamilton, Ontario

The North Atlantic right whale (*Eubalaena glacialis*) is the most endangered large whale species in the world. Severely depleted by centuries of commercial whaling, these whales have shown no significant signs of recovery, despite more than 50 years of international protection. Because inbreeding depression frequently retards recovery of populations that have been reduced below some critical number, this study examines the potential for inbreeding depression among the North Atlantic right whales.

GENETIC ANALYSIS

To assess this potential, the level of genetic similarity among unrelated North Atlantic right whales is being compared to that of unrelated South Atlantic right whales (*E. australis*) and unrelated bowheads (*Balaena mysticetus*), two closely related species that appear to be recovering successfully. Using DNA fingerprinting, the average bandsharing coefficient (BSC) of unrelated North Atlantic right whales is expected to be significantly higher than that of the other two species.

In order to quantify the amount of genetic variation that is remaining, BSCs are also being determined for known first and second degree relatives. If inbreeding depression is affecting the North Atlantic right whales' recovery, then, based on results from studies with other species that are similarly affected (*e.g.*, Brock and White in press), the average BSC among unrelated animals is likely to have increased such that it is now similar to that for second degree relatives. If this is the case, then it would suggest that some of the matings that occur may be unsuccessful because the individuals involved are too closely related.

RESULTS AND RECOMMENDATIONS

The data for the inbreeding assessment have been collected and will be analyzed within the next few months. This information will provide an indication of the inbreeding potential for the whales. However, to determine the severity of the situation and the chances of recovery, we also require information about this species' mating strategy. The number of animals that contribute to the gene pool (*i.e.*, the effective population size), significantly influences the rate at which genetic variation within a population increases. Hence, our predictions for right whale recovery will be very different if one or two males account for all of the offspring produced, rather than a number of males each fathering one or two offspring.

The most effective way to determine the paternity of right whale calves will be genetically, using minisatellites (*i.e.*, DNA fingerprints) or microsatellites. As a number of right whales have already been biopsy sampled, some of the DNA required for this analysis is available. Additional biopsy samples of potential fathers will probably also be needed.

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[1] Ms. Schaeff was unable to attend the workshop. Her

RIGHT WHALE FORAGING AND THE PLANKTON RESOURCES IN CAPE COD AND MASSACHUSETTS BAYS

Charles Mayo and Laurie Goldman
Center for Coastal Studies
Provincetown, Massachusetts

Studies of the foraging behavior of the right whales and of the zooplankton resources of the Cape Cod and Massachusetts Bays ecosystem began at the Center for Coastal Studies in 1984. The focus of early efforts was the small-scale foraging movements of the right whales, and a comparison of the concentration and composition of surface zooplankton found in the path of the feeding whales with samples collected at regular (or control) stations. A comparison of the angularity of the path of whales when their mouths were open with the path shape when the whales were "searching" demonstrates that right whales employ area-restricted searching movements typical of many taxa of animals. Further, our data support the view that skim feeding is dependent on the density of zooplankton encountered by the whale, with a feeding threshold of 4,000 zooplankters/m^3 of water filtered ultimately governing the behavior. The dominant species of zooplankter collected in the feeding path was the calanoid copepod, *Pseudocalanus minutus*, with other copepods, *Calanus finmarchicus*, *Centropages* sp., and *Temora longicornis*, and cyprid larvae of barnacles occasionally dominating the feeding patches.

FEEDING RATES

Using the mouth dimensions, rack size, and estimated body mass of a 10-m long whale killed off Provincetown in 1986, and applying foraging velocity estimates from the path studies and baleen filtration efficiency calculations, we estimate that this particular surface-feeding whale would take in over 29,000 kcal/hr in an average acceptable patch. This value exceeds a theoretical break-even value, calculated from Lockyer's 1981 estimate, of 26,000 kcal/hr. When the in-path samples from the study were compared with the proposed feeding and energy thresholds, whales in 39 percent of the feeding observations were consuming a surplus of food, and 63 percent were feeding, but at a predicted energy deficit. By treating the bay-wide surface station samples in the same fashion, an index of the suitability of the bays for successful feeding was obtained. Approximately 80 percent of the surface of the bays during the peak of the feeding season were below the feeding threshold (feeding behavior would likely not be released), 16 percent of the area would release feeding behavior, but the whale would be working at deficit, while in only 4 percent of the bays during the season would feeding result in an energy gain.

FEEDING DECISIONS AND PATCH CHARACTERISTICS

Recent investigations of the decision-making behavior of whales at the vertical and horizontal margins of patches has been driven by the need to better understand the characteristics of the patch that define its acceptability to the whales. Shallow vertical pump arrays were pushed in front of the research vessel to collect plankton from the feeding path immediately after the passage of the whale. Results of these studies do not clearly demonstrate the gradients in the horizontal plane on which the whale ought to be cuing. Nevertheless, these high-resolution samples clearly demonstrate the extremely variable character of the patch, with densities along the path varying by several orders of magnitude over distances of 10 to 15 m. In the vertical plane, the consequences of decision-making processes are clear. By feeding with the axis of the mouth, or "the center of the feeding cylinder", at a depth of 50 cm below the surface, the whale at the edge of the patch takes in approximately 25,500 kcal/hr, while if it were to feed 40 cm deeper it would, on average, capture 17,000 kcal/hr, less than the estimated energy threshold. Our results to date seem to suggest that very fine adjustments by a feeding right whale produce significant changes in feeding success.

Ultra-dense surface micropatches that may comprise a critical but as yet undescribed source of food for right whales are presently being studied. In the bays system it appears that conditions may occasionally conspire to cause the aggregation of zooplankters, particularly *Centropages* and *Temora*, in concentrations sometimes exceeding $3 \times 10^6/m^3$. Although the extent of these micropatches and the conditions that form them have not been studied, we suggest that these thin and exceedingly dense aggregations may be critical to the feeding success of the whales.

CONCLUSION

In view of the many human activities in the bays, it is clearly important that the zooplankton resources of the Cape Cod and Massachusetts Bays habitat be described, and that right whale foraging behavior in the context of the food resources be accurately modeled to permit reasonable management of the habitat.

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POPULATION MODELING OF THE NORTHERN RIGHT WHALE

John T. Finn
Dept. of Forestry & Wildlife Management
University of Massachusetts
Amherst, Massachusetts

A population model of the Northern Right whale (*Eubalaena glacialis*) was constructed using a combination of age and stage classes. The model consists of five juvenile age classes (0 to 4), sub-adults, adult males, senescent males, available, pregnant and nursing adult females, and senescent females. Time moves in discrete jumps of one year in the model. Parameters include *mean age-at-first-reproduction*, *reproductive cycle time* (the average time between births), *number of years mature*, *successful pregnancy rate*, and *natural mortality rates* and mortality due to *ship strikes* and gear entanglements. Mortalities are highest for age zero (13 percent), are lower for age one (9 percent), two (7 percent), and three (1 percent), and then remain constant through the subadult stage. Ship strikes and gear entanglements affect age zero-, one- and two-year classes only (6 percent). After age four, individuals enter the multi-age sub-adult class and remain there until they mature. The rate of maturation depends on *mean age at first reproduction* (nominal = 10). At maturity, males enter a single stage class, and stay there until they die or have been in the adult male stage longer than the *number of years mature* (nominal = 40 years). At maturity, females enter the available female stage. Depending upon the parameter *reproductive cycle time* (four years), a portion of the available females become pregnant and enter the pregnant female stage. After one year, a proportion of the pregnant females are successful in giving birth. All pregnant females move on to the nursing stage, whether successful or not. After one year, all nursing females return to the available stage. When females have been in the adult stages longer than the *number of years mature*, they go through menopause and become old females. Adult mortality rate is 0.05 percent. Senescent adults die at a much higher rate (90 percent). With the nominal (best guess) parameters, the population grows at a rate of about 0.5 percent per year.

RESULTS

A sensitivity analysis of this model showed that population growth rate is not very sensitive, *i.e.*, small changes in the parameters produce even smaller changes in the population growth rate. The most sensitive parameter is the *number of years mature*, but it also had the greatest range (30 to 50 years). Population growth rate was not sensitive to a change in *reproductive cycle time* from three to five years. The sensitivity of population growth rate to the remaining parameters in the model was tested over a range of ±10 percent, and found to be moderate to low. Over the range of parameters tested, the population went from slowly increasing to slowly declining.

The model was fitted to the southern right whale population (*Eubalaena australis*) using the data in Payne *et al.* (1990). Payne *et al.* estimated values for *age at first reproduction*, and *reproductive cycle time*, and gave ranges for mortalities. He also estimated the population size from 1972 to 1984, and calf production from 1974 to 1986. By adjusting mortalities and the successful pregnancy rate, the model fit Payne *et al. (1990) estimates of population within the error* bounds. The number of calves predicted by the model fell between Payne's observed and estimated number of births. The northern right whale has a much lower number of births per year (10) and successful pregnancy rate (0.45) than the southern right whale (40 per year and 0.77).

Of all the parameters in the model, only the mortality caused by ship strikes and gear entanglements is amenable to direct manipulation by management. Figure 15 shows the effect of reducing ship strikes from 6 percent to zero on population growth over a century. Regardless of the actual parameter values for the population, a reduction in ship strikes and gear entanglements can significantly improve the growth of the population.

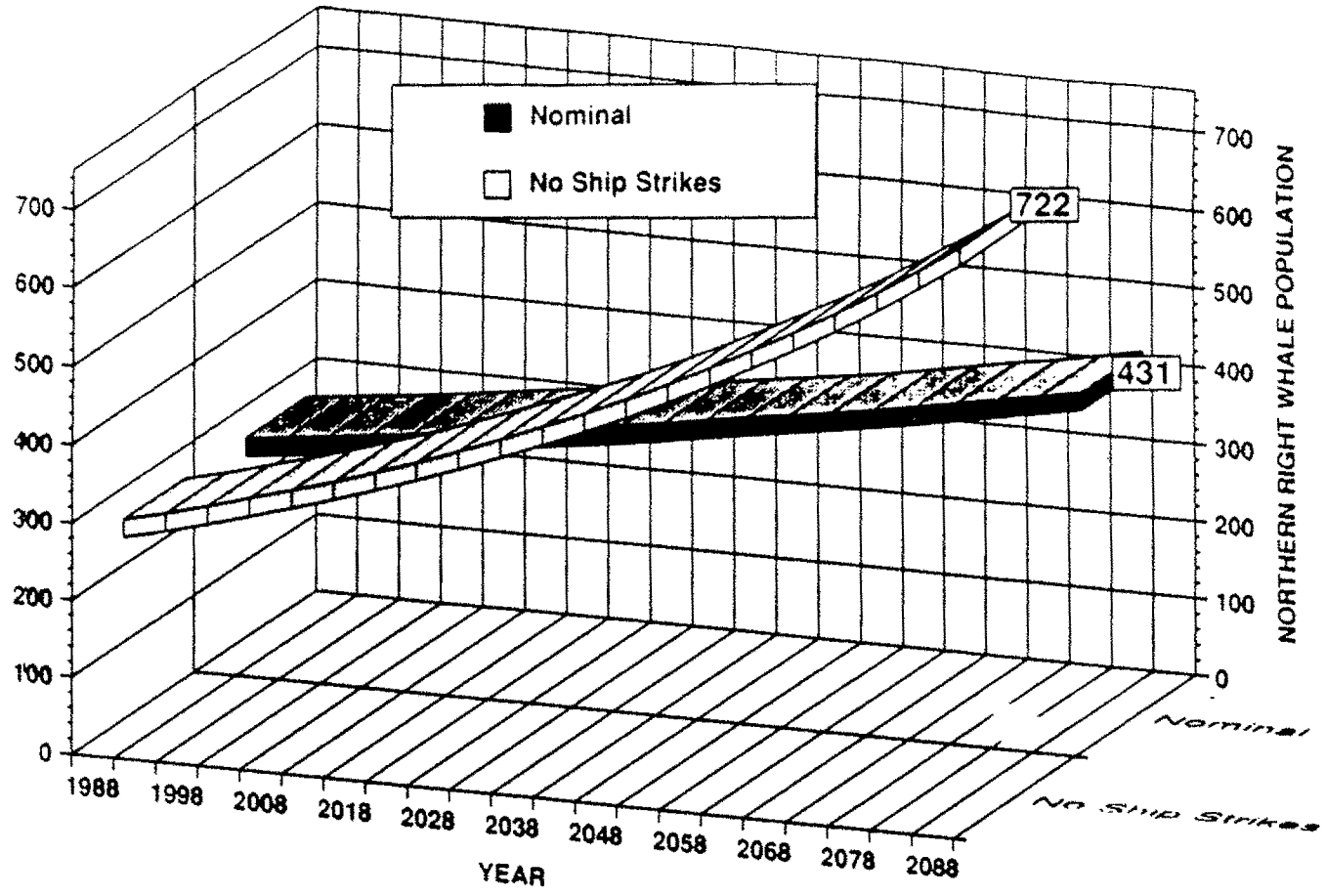

Figure 15. Predicted effect of ship strikes on the population growth of northern right whales. The 'Nominal' run is with the best guess parameters, and the 'No Ship Strikes' run is with the parameter for ship strikes and gear entanglement changed from 6 percent to 0 percent.

DISCUSSION

The ranges of the parameters are still too broad to provide good predictions of population trends. Individual-based modeling, that can incorporate the genetic, and spatial location data, may be able to make better predictions with the currently available data, but better data are still required.

ACKNOWLEDGEMENTS

Many thanks to Scott Kraus who helped estimate the nominal values of the parameters, and commented on the structure of the model. Thanks also to Laurie Thorpe who ran the sensitivity analysis as part of a class project.

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WESTERN NORTH ATLANTIC RIGHT WHALES: ABUNDANCE AND TRENDS FROM GREAT SOUTH CHANNEL AERIAL SURVEYS

Robert D. Kenney
University of Rhode Island
Narragansett, Rhode Island

As the most endangered large whale in the world, the abundance of right whales is a critically important issue for management decisions relative to the animals and their habitats. The issue actually includes two inter-related questions:

- How many right whales are there in the population?
- Is the number increasing, stable, or decreasing?

We have used data from aerial surveys in the Great South Channel (GSC) region east of Cape Cod, Massachusetts, to address both questions for western North Atlantic right whales. At the same time, the data address the often-asked question of why northern right whale stocks have not recovered following protection from commercial whaling, although this assumption of non-recovery is based on nearly no data.

METHODS

Estimates of the density and abundance of right whales in the GSC area were computed using line-transect methods from dedicated aerial survey data flown with a Cessna 337 Skymaster. All of the GSC aerial survey data from 1979 through 1989 for April, May, and June, including three different aircraft, were used for the trend analysis. Surveys conducted largely outside the defined study area, or concentrated on only a small area around known right whale aggregations, were rejected as biased.

Sighting rate (SR) was defined as the number of right whales sighted per 1,000 km of trackline flown within acceptable survey conditions (visibility $\geq$ 2 nmi Beaufort sea state $\leq$ 3, and altitude < 1,000 ft). The analysis for trends was done by linear regression of log (SR + 1) on the year.

RESULTS

Between 1979 and 1989, there were 54 GSC aerial surveys useable for trend analysis, and 29 Skymaster surveys resulting in non-zero line-transect density estimates. Single-day abundance estimates range as high as 179 animals (Table 2).

For the 54 surveys in the trend analysis, the mean sighting rate was 12.2 right whales/1,000 km, with a range of 0 to 36.7. Annual mean effort was lowest in 1986 and highest in 1988, and annual mean sighting rate was lowest in 1980 and highest in 1984 (Table 3).

The sighting rate regression analysis resulted in the relationship:

$$\log_e (SR + 1) = -6.696 + 0.104 (YEAR)$$

There was a large amount of noise in the data ($r^2 = 0.104$), but the slope is positive and significantly different from zero($p = 0.018$). The magnitude of the slope parameter indicates that sighting rate in the GSC, over the ten-year period between 1979 and 1989, was increasing exponentially at an annual rate of 10.4 percent.

DISCUSSION AND RECOMMENDATIONS

The abundance estimates (Table 2) do not account for animals missed while diving. Applying previously computed correction factors suggests that the entire population may occupy the region at given times. Of the five known western North Atlantic habitats, only the GSC appears to be occupied over the course of a season by a significant proportion, or even all, of the population. The region also seems to form a geographic bottleneck for right whales moving into northern feeding grounds from southern or offshore win-

Table 2. Estimated density (whales / km², x 10^{-3}), variance of the density (x 10^{-3}), and abundance (with 95 percent confidence interval) for right whales in the Great South Channel from 29 Skymaster line-transect aerial surveys

Date	Density	Variance	Abundance	95% C.I.
03/28/80	1.969	1.698	45	+ 54
04/02/80	1.899	1.326	43	+ 43
04/19/80	3.225	3.856	74	+ 48
04/20/80	1.282	0.527	12	+ 12
05/06/80	3.610	4.150	29	+ 126
05/16/80	2.213	1.719	16	+ 49
05/09/81	2.968	3.091	37	+ 87
05/10/81	2.999	3.205	38	+ 89
05/14/81	89.350	2096.000	55	+ 75
05/19/81	1.578	0.872	20	+ 46
07/09/81	12.170	51.570	154	+ 712
05/25/84	12.415	33.790	179	+ 278
06/22/84	5.008	17.346	72	+ 199
05/09/85	2.448	1.673	35	+ 73
05/30/85	1.769	1.360	25	+ 44
05/07/87	5.075	8.545	73	+ 140
05/26/87	9.274	22.108	133	+ 179
06/01/87	11.449	18.945	165	+ 208
06/07/87	7.769	7.951	112	+ 135
06/11/87	1.897	1.769	27	+ 96
07/07/87	0.888	0.704	13	+ 32
04/26/88	2.083	1.662	30	+ 54
05/05/88	2.624	1.943	38	+ 53
05/15/88	7.711	13.881	111	+ 142
06/11/88	0.782	0.545	11	+ 28
04/26/89	2.293	1.484	33	+ 46
05/09/89	1.469	0.938	21	+ 37
06/19/89	0.851	0.646	12	+ 31
06/30/89	1.421	0.877	20	+ 36

Table 3. Mean (and SE) sighting effort (km), number of right whales sighted, and right whale sighting rate (SR, whales/ 1,000 km) for aerial surveys in the Great South Channel region, April-June 1979-1989

Year	n	Effort	Whales	SR
1979	11	564.3 (103.9)	5.8 (1.8)	11.1 (3.7)
1980	11	697.9 (65.1)	1.4 (0.3)	2.1 (0.5)
1981	9	784.4 (45.9)	8.2 (3.3)	10.3 (4.2)
1984	2	700.5 (6.6)	21.0 (4.0)	30.4 (6.0)
1985	4	1118.2 (63.0)	10.0 (4.5)	9.5 (4.4)
1986	2	541.0 (287.5)	8.0 (8.0)	9.7 (9.7)
1987	5	891.1 (119.6)	16.8 (5.8)	17.7 (4.5)
1988	4	1226.2 (173.6)	25.0 (5.3)	22.6 (6.5)
1989	6	1207.3 (89.3)	10.5 (3.8)	9.3 (3.5)
Total	54	894.6 (51.3)	11.2 (1.8)	12.2 (1.9)

tering areas. As such, the GSC seems to be the best choice of the known habitats as a location for effective long-term monitoring of population trends.

The 10.4 percent annual rate of increase resulting from the sighting rate trend analysis does not seem biologically realistic. The potential bias due to increasing effectiveness of surveys was estimated by changes in the effective half-swath, which was 1.0732 km for 1979-1981 and 1.8235 for 1987-1989, a 6.6 percent annual increase. Subtracting this from the 10.4 percent rate resulting from the regression analysis leaves an annual increase in right whale sighting rate in the GSC of 3.8 percent. This is much closer to the rates of 3 to 3.5 percent estimated from calving and mortality rates in the western North Atlantic (Kraus pers. comm.) or 6.8 percent for Argentine (Whitehead et al. 1986), and South African (Best 1990) right whales.

It is often assumed that northern right whale stocks have exhibited little or no recovery in response to protection from whaling. Assuming a 1990 population of 350, what might the 1935 population have been? Using an annual rate of increase ranging from 1 percent to 9 percent, the population in 1935 would have been between 2 and 202 animals (Table 4). Genetic data also suggest that the population was reduced to very low numbers at some point (Brown 1991). It is not unrealistic to suggest that the western North Atlantic right whale population might have been reduced to a handful of animals by 1935, and that current numbers represent a significant recovery from this extreme depletion.

Any effective monitoring of right whale population trends and the effectiveness of recovery measures will require a long time-series of data. The regression technique enables the demonstration of statistically valid trends in these highly variable data. Using sighting rates also eliminates the effects of variable effort, while maximizing the number of sightings that can be used in analysis. The GSC monitoring surveys should be continued. At a minimum, the time-series should be long enough so that inclusion of data from one additional season does not drastically change the computed trend. Simultaneous monitoring via photo-identification will allow cross-comparison of results between the two methods.

Table 4. Back-calculated estimates of the 1935 abundance of western North Atlantic right whales, assuming a 1990 population of 350 and different annual rates of increase.

Annual Increase Rate	1935 Population
0.01	202
0.02	117
0.03	67
0.04	39
0.05	22
0.06	13
0.07	7
0.08	4
0.09	2

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Human Impacts and Mitigation

MORTALITY RATES AND CAUSES IN NORTH ATLANTIC RIGHT WHALES

Scott D. Kraus
New England Aquarium
Boston, Massachusetts

Because the North Atlantic right whale population did not appear to be growing at the rate of those in the southern hemisphere, an analysis of mortality rates and causes was conducted. Natural mortality rates were estimated from known strandings and sighting histories of identified individual right whales. When known whales not observed for a period of five years since 1980 are assumed to have died, mortality rates are 17 percent for year one, and average slightly over 3 percent for the next three years. Adult mortality rates are very low, less than 1 percent.

An analysis of data collected on 28 right whales that have stranded since 1970 shows that 11 of these deaths were neonates or very young calves. This probably represents normal natural mortality, but one carefully examined carcass showed signs of an enlarged heart, a birth defect that may be an indication of inbreeding. Of the 17 non-calf right whales stranded since 1970, only two were larger than 13 m (42 ft) in length. The remaining animals appear to have been juveniles or young adults.

Nine (32 percent) of all known strandings were caused by human activities. Six right whales were killed by ships and three were killed due to fishing activities. Since strandings only provide information on whales that died and washed ashore, it is possible that comparable rates and causes of death occur in offshore areas where a whale's death will not be recorded. As confirmation of this suspicion, an analysis of scarring patterns in living North Atlantic right whales showed that 57 percent of the cataloged animals have scars indicative of entanglements with fishing gear at some time in their lives. An additional 7 percent have scars that indicate the whales survived a collision with a propeller of a large vessel.

These data demonstrate that right whale/human interactions are not uncommon, and show that such sources of mortality rates may be more common than indicated in the stranding records. Regardless, the cumulative effects of human causes of mortality appear to be responsible for increasing death rates of right whales, and could be a significant contributing factor in depressing population growth.

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MITIGATING THE EFFECTS OF SHIP STRIKES ON RIGHT WHALES

James Hain
National Marine Fisheries Service
Woods Hole, Massachusetts

This project, in its second year, is aimed at reducing human impacts, specifically ship strikes, on right whales off northeast Florida. This necessarily involves describing the whales and their habitat to provide the scientific basis for management actions. The work has been carried out in collaboration with 10 agencies and organizations: Associated Scientists at Woods Hole, Florida Department of Natural Resources, Georgia Department of Natural Resources, Marine Mammal Commission, Minerals Management Service, National Marine Fisheries Service, U. S. Navy, New England Aquarium, Sea World, and the University of Rhode Island.

The project involves three major components:

technology, and technology transfer
- the airship as a research platform
- video data acquisition

basic science
- biology and behavior of right whales
- habitat characterization

management
- awareness and education
- mitigation recommendations

TECHNOLOGY AND TECHNOLOGY TRANSFER

The station-keeping and positioning capabilities of the airship are complementary to data acquisition with new high-resolution video.

The Airship as a Research Platform

We are in our third year of flying airships as research platforms for marine mammal studies (Figure 16). In this, our second year of working off Florida, we made six flights totaling 40 hours and 600 nautical miles of overwater surveys in sea states of Beaufort three or less. The flights took place 9 to 17 January 1992, and included 12 hours of station time, where position was maintained near whales for observations, photos, and video. Our work with multi-platform efforts continued, and we coordinated with New England Aquarium and Florida DNR aircraft on several occasions. At this time, the airship can be considered fully operational for research applications.

Video Data Acquisition

With the recent developments in high-resolution video at relatively modest cost, video data acquisition will play an increasingly valuable role in research. In this study, we were able to identify and sex right whales; document marks, scars, and wounds; and record behaviors for later analyses. The video complemented other methods, or often acquired information not otherwise possible.

BASIC SCIENCE

A solid understanding of the biology and behavior of the right whales will necessarily underlie any management actions. Our studies add to the data collated at the New England Aquarium, the University of Rhode Island, and elsewhere.

In January 1992, we sighted 16 different right whales: five mother/calf pairs, a surface-active group of four individuals, and two single juveniles. Data were obtained on identifications, distribution, behavior, and in at least one case, human impacts. A summary with examples follows.

Identifications

Identification photos/video were obtained for all sightings except one. The positioning capability of the airship provides for high-quality photos. One noteworthy video analysis shows how key

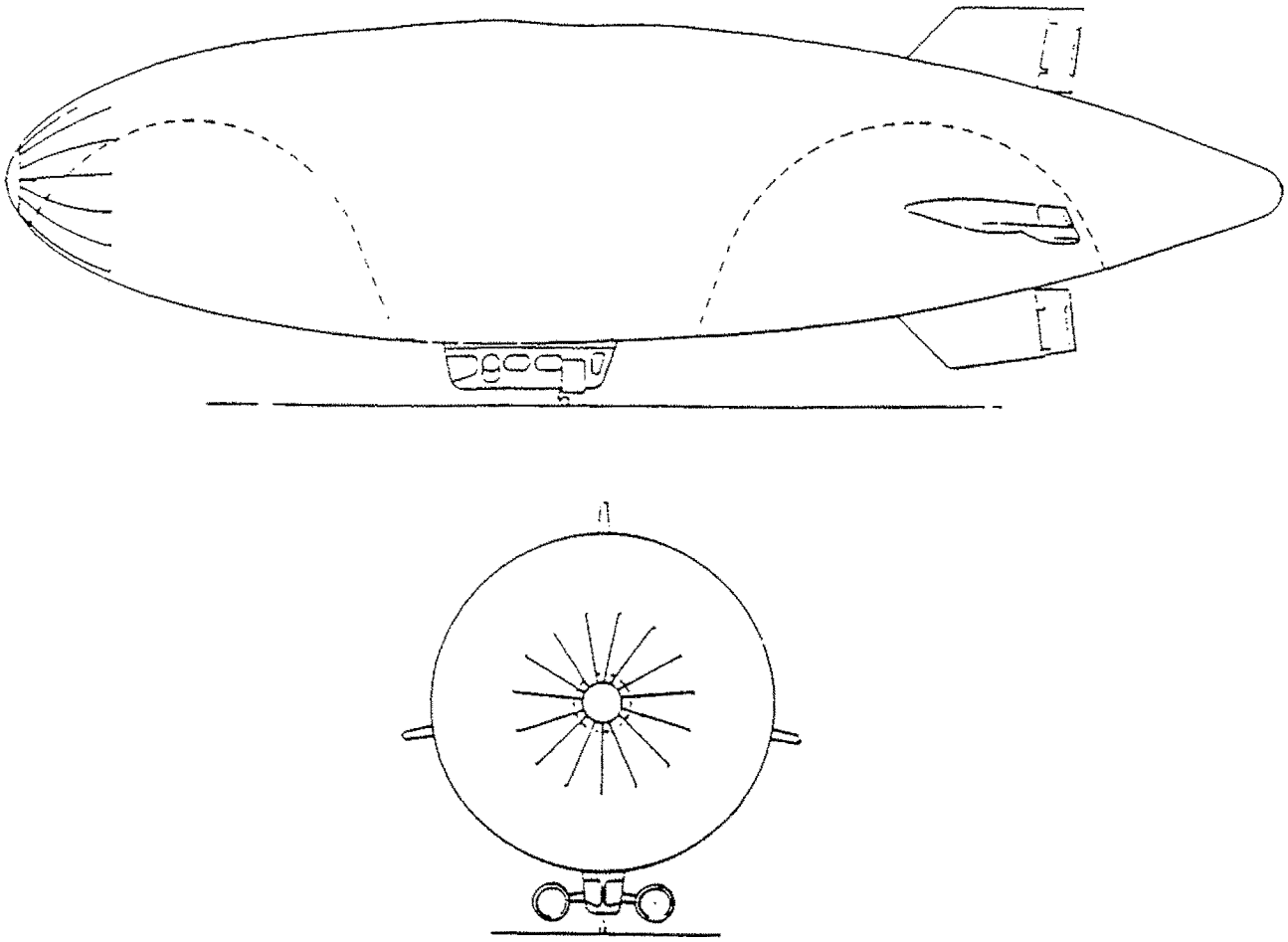

Figure 16. The Westinghouse Airships 500 HL airship, operated by Sea World of Orlando, Florida. In right whale studies conducted during January 1992, this ship typically carried three scientists and equipment on overwater operations for 8-hr flight days.

callosity characteristics change with sighting angle and animal orientation. We also noted apparent pre-callosity markings on calves, as well as orange cyamids typically along the lips and trailing edges of the flukes. The video was also useful in capturing split-second "looks" that could be used later to sex the animal in several cases. This was also true for data on ventral coloration--"white bellied" vs. "black bellied" animals.

Distribution

Habitat use and movements relative to potential human impacts will be essential. As an example, one mother/calf pair (#1001, *Fermata*) was sighted eight times over the course of about seven weeks (our data combined with that of the NEA). Sightings ranged from off South Carolina (no calf) on 12 December 1991 to off Daytona Beach on 17 January 1992. These kinds of resight records are invaluable for describing distribution, movements, and habitat use.

Some areas contained several right whales. On the other hand, repeated flights in other areas turned up no right whales--at least on those dates. Consistent with previous findings by NEA and others, some areas appear to contain most of the occurrences, while others have few or none. Additional within-year and between-year data will prove interesting.

Behavior

Largely through tape-recorded observations and video records, good data in various situations was gathered. Several patterns appeared to be present in mother/calf behavior. These included a general maintenance of close proximity by mother and calf, "nose lifts" or "pushes" by the

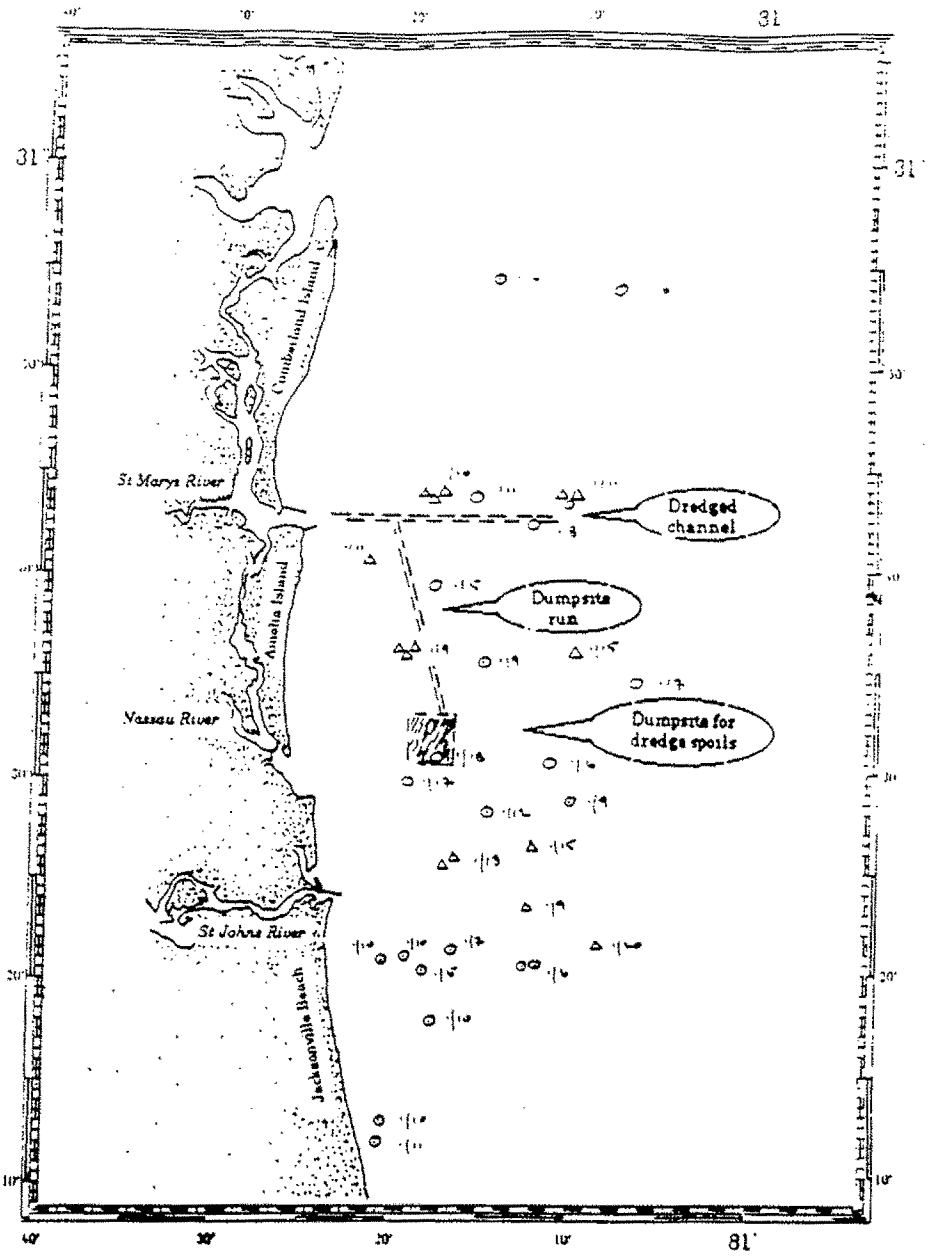

Figure 17. Right whale sightings off northeast Florida during January 1992 (key: ○ = mother/calf, △ = single). The area from Jacksonville Beach, Florida, to Cumberland Island, Georgia, appears to be the highest density right whale area in the southeastern U.S. It is also here that human impacts may occur, as there are shipping, fishing, dredging, and recreational boating activities.

mother, and characteristic surface/dive/respiration patterns.

In at least one instance, on 10 January, there may have been a behavioral response of a mother/calf pair to a passing fishing boat--a previously somewhat distant calf drew up close to the mother rather quickly.

Five instances of possible whale/vessel interaction were recorded. In two instances, there appeared to be no reaction by the whales. In two, the mother/calf distance decreased, and in one involving a Navy submarine, the whales appeared to move to a safe avoidance situation as the vessel passed. In no instance did there appear to be a threat of danger.

Human impacts

On 11 January, we sighted an animal we guessed was a yearling associated with a surface-active group northeast of Amelia Island. This individual appeared unwell, and the body color included large areas of light grey. The dorsal surface of the flukes was mostly white, and there

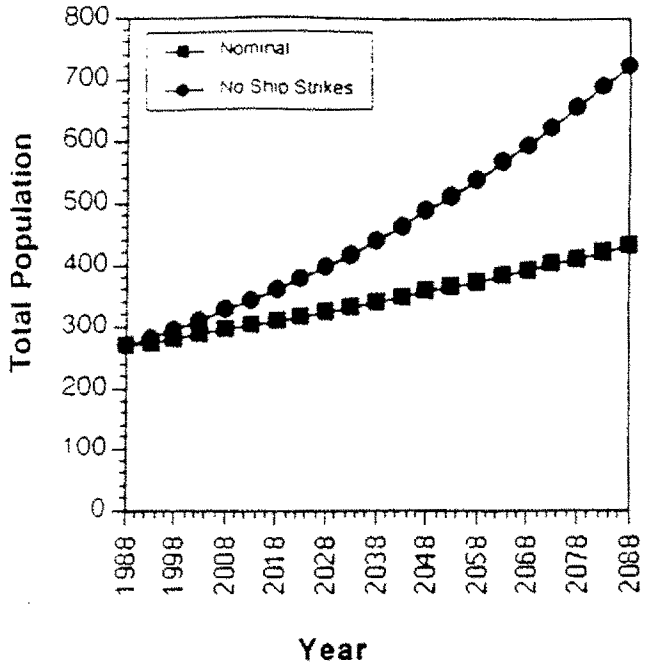

Figure 18. Ship strikes appear to be responsible for an average of one right whale mortality a year, mostly in young animals. By reducing or eliminating this factor, population growth will be increased. (Source: J. Finn, University of Massachusetts).

was a large cyamid-occupied wound on the peduncle and anterior dorsal fluke. There were other marks and nicks on the lateral edges. The wound appeared to be consistent with a propeller strike. In the previous year, 1991, a two-year-old female came ashore on Amelia Island, dead from a ship strike. This, and the 1992 observation, are consistent with the report of Kraus (1990), and suggest that one or more ship strikes may occur in this area in many or most years.

MANAGEMENT

There remains little doubt that ship strikes are a problem. In collaboration with the groups previously listed, we are working on two fronts: (1) awareness and education, and (2) recommendations for changes in vessel operations, traffic lanes, and/or speed. These areas, of course, overlap. At present, most efforts are in the first category, providing vessel operators with information about when and where whales occur and describing what we know about the ship strike problem. Voluntary participation in sighting and avoiding right whales is encouraged. As more and better data become available, we may be able to make suggestions and recommendations for (required) changes in vessel operations. At present, it is our view that with awareness, education, and cooperation, voluntary and reasonable changes and adjustments within standard maritime practices and existing regulations will make additional regulations and more restrictive adjustments largely or totally unnecessary.

In 1992, we focused our efforts on the Cumberland Island to Jacksonville Beach area. This is the area with the highest density of mother/calf right whales, and also an area of more concentrated vessel traffic (Figure 17). In this year, we likewise focused our efforts on the military: the U.S. Coast Guard and the U.S. Navy. This decision was based primarily on the very positive past efforts of these groups, and the existence of a structure and receptivity to the issues we sought to address. On all counts, the outcome was positive. In the future, we hope to broaden our efforts to include the local pilot associations and other commercial operators. Clear progress is being made on the mitigation of ship strikes in the southeastern United States, and additional work will follow.

Dr. Jack Finn at the University of Massachusetts (see also report, this volume) has suggested that if the average ship strike mortality of 1.2 whales per year is reduced or eliminated, a substantial improvement in the population growth of right whales over time will result (Figure 18). Inspection of this figure will reveal that our efforts must be sustained in the face of a rather low incidence of this event, and over a long period of time. Ship strike mortality, however, is one population parameter where a positive change can be effected. Planning and organization are now underway for the 1992-1993 season.

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OBSERVATIONS OF THE SOUTHERN RIGHT WHALE (*Eubalaena australis*) RELEVANT TO THE MANAGEMENT OF RIGHT WHALE POPULATIONS

Roger Payne and Victoria Rowntree
Whale Conservation Institute
Lincoln, Massachusetts

The 20th year of our study of a population of southern right whales (*Eubalaena australis*) was in 1990. This population occurs along the shores of Peninsula Valdes, Argentina. The whales begin to appear in June, reach peak numbers in September and October, and have left the area by December. Every year since 1971 we have made at least one aerial survey of the 500 km perimeter of the Peninsula. We fly at an altitude of 500 ft in a single-engine CESSNA 182. When we encounter whales, we circle over them at 200 to 300 ft and take photographs of each individual's callosity pattern. We note the whales' location, their behavior, and the presence of any calves.

SUMMARY OF RESULTS

The whales concentrate in three distinct regions, which are always near shore, along the 5-m depth contour. The three aggregation areas appear to have different functions as indicated by their different proportions of females with calves, females without calves, and males and subadults (Payne 1986). Not all the whales return to the Peninsula each year. We see about 130 adults and 35 calves in a typical year, though a total of 1,099 individuals have been identified during the 20 years of the study. Mature females tend to return to the Peninsula only in the years when they calve. The mean calving interval is estimated to be 3.6 years. The minimum age of first calving is seven years; the model age is nine years. The population was estimated to contain 1,200 whales in 1986, and to be increasing at 7.6 percent per year (Payne, Rowntree, Perkins, Cooke, and Lankester 1990).

OBSERVATIONS RELEVANT TO MANAGEMENT

In addition to the biology and habitat use described above, we report here four observations of the right whale population at Peninsula Valdes that may be useful in the management of right whale populations.

Table 5. Mean of greatest number of adult right whales sighted on September or October survey flights, by region

	1971-1980	1981-1990
Golfo San Jose (northern bay)	46 ± 15.1	42 ± 24.5
Eastern outer coast	49 ± 18.5	24 ± 16.6
Golfo Nuevo (southern bay)	19 ± 8.6	56 ± 19.4

1. Over the course of the study, we have seen a net movement of whales away from the eastern outer coast of the Peninsula and into the southern bay. To quantify this shift we compared the mean number of whales in each area in the 1970s to that in the 1980s. For each year, we calculated the largest number of adults sighted in each area in either September or October (the months of peak abundance); these maximum abundances were then averaged for the decades 1971-1980 and 1981-1990 (Table 5). While the number of adults in the northern bay remained roughly constant, the number along the eastern outer coast decreased, and the number in the southern bay increased. The northern bay has been set aside as a sanctuary for right whales. The southern bay contains the largest port on the Peninsula, and is the site of an aluminum plant that discharges toxic effluent into the bay. Straggling whales are frequently seen in this port swimming under the pier, around moored fishing boats, and among wind surfers. However, it is more usual to find whales in the southern bay concentrating near a town that has a growing

Table 6. Mean swimming speeds (km/hr), divided into readings taken at intervals of less than and greater than 5 min

Bay	Group type					
	Readings < 5 min			Readings > 5 min		
	M&C	non-M&C	All	M&C	non-M&C	All
Golfo San Jose (protected bay)	1.62	1.21	1.30	0.52	0.62	0.59
Golfo Nuevo (near whalewatch)	1.78	2.03	1.83	1.14	1.56	1.24

whalewatch industry. Here, mothers and calves are frequently visited by whalewatch boats. We are unable to explain the increased popularity of the disturbed southern bay, and decreased popularity of the relatively pristine eastern outer coast. However, our observations clearly indicate that patterns of habitat use may change over time scales on the order of decades.

2. In collaboration with José Truda Palazzo and Maria do Carmo Both (Florianopolis, Brazil), we have documented two instances in which females were seen with calves at Peninsula Valdés and at Laguna, Brazil (some 2,100 km to the north) in different years. A third female was seen at Peninsula Valdés without a calf and in a latter year with a calf off Laguna. The females were not seen with calves at both locations in the same year. These observations indicate that females may use more than one calving ground.
3. In the 1980s, large oval marks began to appear on the backs of some whales at the Peninsula. The marks seem to occur on individuals of both sexes and all ages, and the number of whales with marks has increased with time. We do not know what causes the marks. Two obvious possibilities are disease and injury; to distinguish between them we are currently trying to obtain skin samples for analysis. We hope that other right whale researchers will report any similar marks found on the whales they are studying.
4. Finally, we describe some direct interactions between right whales and people. We worked with three Argentine students who compared the swimming speeds of whales in the northern bay, which is a whale sanctuary with restricted boat traffic, to swimming speeds of whales in the southern bay in an area within sight of whalewatch activity (Colombo, Arias, and Garciarena 1990). The swimming speeds of mother/calf pairs in the two bays were the same, but other whales swam significantly faster in the southern (more disturbed) bay (Table 6). The results could indicate either that mother/calf pairs are unaffected by boat activity or that the calves restrict the pairs' movements to slower speeds. Swimming speeds recorded at longer intervals (>5 min) were significantly slower in the northern (undisturbed) bay indicating that the whales there were spending more time stopping and turning (*i.e.*, milling). The differences in swimming speeds in the two bays could be caused by boat activity, but it is also possible that they are caused by different levels of social activity by whales in these areas.

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Agency Profiles:
Activities, Responsibilities, and Plans

IMPLEMENTATION OF THE NORTHERN RIGHT WHALE RECOVERY PLAN

P. Michael Payne and Robert C. Ziobro
Office of Protected Resources
National Marine Fisheries Service
Silver Spring, Maryland

The Endangered Species Act (ESA), Section 4(f), requires the National Marine Fisheries Service (NMFS) to develop and implement a Recovery Plan (plan) for any species listed as either threatened or endangered under the ESA. Accordingly, NMFS appointed a ten-member Recovery Team (Team) to develop a plan for the northern right whale. The plan was completed and approved in December 1991. In addition to the biology and life history of the northern right whale, the plan identifies known and potential factors affecting the northern right whale. It also recommends management, research, and conservation activities to reduce or eliminate adverse effects to the species, and considered necessary by the team to promote the recovery of the species.

While it is difficult to consider how any management activity would increase the biological productivity of the northern right whale, it is possible to consider those activities that could reduce or eliminate human-induced mortality, thereby having a potential affect on the rate of recovery of this species. The plan outlined the following objectives towards that goal:

- Identify and/or eliminate sources of human-caused injury or mortality.
- Maximize efforts to free entangled or stranded northern right whales and acquire scientific information from all specimens, dead or alive.
- Identify and protect habitats essential to the survival and recovery of the northern right whale.
- Monitor the population size and trends in abundance of the northern right whale.
- Determine and minimize any detrimental effects of directed aircraft, or vessel interactions.
- Coordinate federal, state, international, and private efforts to implement this Recovery Plan.

The Recovery Plan recommended and prioritized management/ recovery actions considered necessary to reach each of the stated objectives. These recovery actions were assigned a priority from 1 to 3 on the following criteria:

- Priority 1 - an action that must be taken to prevent extinction or to identify those actions necessary to prevent extinction.
- Priority 2 - an action that must be taken to prevent a significant decline in population numbers, habitat quality, or other significant negative impacts short of extinction.
- Priority 3 - all other actions necessary to provide for full recovery of the species.

With the completion of the plan, the intent of NMFS is to focus implementation efforts on those management and recovery issues/actions outlined in the plan, and which were considered as having the greatest priority. The following actions were recognized in the Plan as having a Priority 1 ranking:

- Reduce mortality from ship collisions and entanglement with fishing gear. Identify those agencies and groups responsible for assisting in the implementation of mitigating measures.
- Implement seasonal or spatial regulations for use of certain fishing gear in high-use habitats.
- Minimize adverse effects of whalewatching by adopting regulations aimed to protect northern right whales.
- Identify genetic variability in the northern right whale population.
- Protect known high-use habitats, reduce/eliminate pollution, restrict oil/gas exploration, restrict dredging/spoil disposal.
- Locate/protect unknown wintering area(s).
- Promote similar recovery actions in Canada.

- Coordinate multi-agency efforts to implement the Recovery Plan.
  Cooperation and support by many federal, state, local, and private organizations will be needed to implement the objectives of the Recovery Plan. To help initiate the implementation of this plan, the Implementation Committee is suggested.
- Develop an education program to increase awareness of northern right whale habitats, seasonal high-use areas, and behavior.

Certain measures to assist the protection/recovery of the northern right whale are already in place, and a number of the recovery actions identified in the plan are either ongoing, or have been implemented. NMFS has funded population assessment surveys, and the maintenance of individual photo-identification systems, a tool that has provided information on the genealogy and life history (*i.e.*, calving intervals, age at first reproduction, stock isolation, and movements) of this species. Research has also been conducted on the population dynamics, and migration patterns of northern right whales. Important calving grounds have been identified in the southeastern U.S. for right whales, and migratory pathways between calving areas and foraging areas in the North Atlantic have been identified. Research has also been conducted on habitat requirements and use of northern right whales. Genetic/stock relationships in the North Atlantic right whale population are considered a high priority and are currently being studied.

Recovery actions have also been implemented through the ESA, Section 7 consultation process. Dredge projects along the southeast coast are required to have observers on board to watch for right whales when the dredges are transiting to and from spoil dumpsites. The designation of EPA dumpsites are also subject to consultation regarding this, and other, endangered and threatened species of whale, as are outer continental shelf oil and gas activities.

The plan is subject to modification as determined by completion of actions described in the plan. The intent of NMFS is to provide a long-term commitment to the implementation of the actions outlined in the plan to affect the recovery of the northern right whale. Achievement of this goal will require the continuous cooperation of federal, state, and local agencies within the United States, the governments of the United States and other nations, and private organizations, throughout the recovery period.

THE NORTH ATLANTIC RIGHT WHALE: AN OVERVIEW OF DIRECTED MANAGEMENT AND RESEARCH ACTIVITIES CONDUCTED BY THE FLORIDA DEPARTMENT OF NATURAL RESOURCES

James A. Valade
Florida Department of Natural Resources
Florida Marine Research Institute
Jacksonville, Florida

William B. Brooks
Florida Department of Natural Resources
Office of Protected Species Management
Tallahassee, Florida

The North Atlantic right whale, the most critically endangered of all the great whales, can be found in the coastal waters of Florida during the cool winter months. While in Florida waters, the State of Florida protects this whale *via* the Florida Endangered and Threatened Species Act of 1977. (The right whale is officially recognized as endangered under the Wildlife Code of the State of Florida.) These measures additionally provide for the "conservation and wise management" of the species, conferring these duties on the Florida Department of Natural Resources (FDNR).

To date, the FDNR's Office of Protected Species Management and FDNR's Florida Marine Research Institute's Resource Recovery and Assessment Section have been involved in right whale management and research activities. Resource managers have directed their initial efforts at minimizing the effects of maritime activities on these whales. Research efforts have focused on developing a better understanding of right whale abundance, distribution, behavior, and mortality within the coastal waters of Florida. Coordination of these efforts should result in the establishment of statewide management guidelines to protect the right whale.

RESULTS

Management

Initial management efforts have targeted submerged-land lease applicants who propose to construct shipping facilities that would increase large vessel traffic in sensitive right whale areas. Lease applicants must sign leases that have been conditioned to ensure that vessel owners and operators using the leasee's facilities will, during the seasonal presence of right whales, take steps to avoid collisions with right whales. These steps have included controlling vessel speeds during periods of low visibility, requiring changes in course to avoid collisions, and requiring the presence of observers to assist in locating whales. To date, three applicants have received leases that include these provisos.

In addition, the Mayport Naval Station has applied for a permit to dump spoil material dredged from their basin into an offshore dump site. The FDNR Office of Protected Species Management has requested that the facility initiate a program in which observers watch for whales in the path of vessels going to and from the spoil site.

Research

The FDNR Florida Marine Research Institute has been conducting aerial surveys within the coastal waters of northeast Florida to describe right whale distribution, abundance, and behavior. These flights supplement survey efforts initiated by the New England Aquarium. The results are summarized in Table 7.

Survey data are being supplemented by coordination of a sightings network. In 1991-1992, the network documented 19 incidental sighting reports; these described the presence of 42 whales. FDNR has also assisted in coordinating right

Table 7. Summary of aerial survey sightings by Florida Marine Research Institute, 1987-1992

Season	No. of adults/calves	
Winter 1987-1988	0 adults	0 calves
Winter 1990-1991	1 adult	1 calf
Winter 1991-1992	12 adults	4 calves

whale carcass recoveries in an effort to further understand causes of mortality within Florida waters.

CONCLUSIONS

The State of Florida supplements the protection of the North Atlantic right whale during its seasonal presence in coastal Florida waters. Management efforts have been directed at minimizing the impact of human activities on right whales, specifically targeting the threat of vessel collisions to whales. Management decisions have been based on historical data and on information collected by FDNR and other research programs. Ongoing FDNR research efforts have documented right whale distribution, abundance, behavior, and mortality.

Coordinated right whale management and research activities within coastal Florida waters will complement overall recovery efforts and will provide a sound basis for the protection of right whales within Florida waters.

RIGHT WHALE MANAGEMENT IN GEORGIA: THE ROLE OF THE GEORGIA DEPARTMENT OF NATURAL RESOURCES

Michael J. Harris
Georgia Department of Natural Resources
Brunswick, Georgia

Within the State of Georgia, management responsibility for marine mammals is vested in the Coastal Resources Division of the Georgia Department of Natural Resources. Coastal Resources Division's involvement with right whales began in 1979 when a cow and calf were photographed and filmed off St. Simons Island. This film was included in our state's endangered species film "A Time for Choice". During the early 1980s, incidental sightings of right whales were collected and forwarded to the Sighting Network coordinated by Dr. Howard Winn. In 1984, CRD provided logistical support to the New England Aquarium for aerial surveys that were flown by volunteers from Delta Airlines and confirmed that right whales were calving in southeastern waters. In 1985, the right whale was designated Georgia's official marine mammal. The Coastal Resources Division and the Georgia Conservancy cosponsored a symposium on right whales at Jekyll Island in 1986 to increase awareness of right whales and to identify research and management needs. Throughout this period CRD biologists continued photographing right whales sighted incidentally to other work. Photographs were provided to the New England Aquarium for inclusion in the right whale identification catalog.

CURRENT ACTIVITIES

Current activities by Coastal Resources Division to promote conservation of right whales include: coordination of the Marine Mammal Stranding Network in Georgia, maintenance of an incidental sighting program, environmental review of development projects to ensure that consideration is given to minimize potential impacts to right whales, and provision of educational materials to harbor pilots to increase awareness of right whales and to decrease risks of vessel collisions.

Stranding Network

Three neonatal right whales have stranded in Georgia since 1981. The most recent occurrence was a live stranding on Cumberland Island on 4 January 1989. This animal died and the entire carcass was recovered, frozen, and shipped to the New England Aquarium for detailed examination.

Incidental Sightings

Since 1988, CRD has maintained a toll-free number for the public to report whale sightings. The number has been publicized through posters distributed to marinas, boat landings, and commercial fishing docks throughout the coast. Information is recorded on a standard form and provided to the New England Aquarium. Efforts have been made to obtain copies of any photographs taken by the person making the sighting.

Environmental Review

All harbor development and other projects that may impact right whales are reviewed and recommendations are made to mitigate potential impacts to right whales. Recently, Georgia has utilized the 401 Water Quality Certification provision of the Clean Water Act to ensure that dredges utilized in deepening the Savannah Harbor would limit speeds to reduce the risk of collisions with right whales. These recommendations will be included in all Corps of Engineers' channel dredging projects in Georgia in the future.

Education

In 1988, copies of the right whale video "The Fate of the Right Whale: It's Up to You" were purchased and provided to Brunswick and Sa-

vannah Harbor Pilot Associations to increase the knowledge of pilots and reduce collision risk. Follow-up correspondence has been used to maintain interest and awareness. Stories and articles on the right whale have been included in Georgia's nongame wildlife newsletter to educate the general public.

FUTURE PLANS

Coastal Resources Division intends to continue all of the activities that are currently underway. In addition, consideration is being given to establishing systematic aerial surveys to complement surveys conducted by the New England Aquarium and Florida Department of Natural Resources. The goal of these surveys would be to more accurately define the seasonal and spatial distribution of right whales off Georgia to better define areas and times of greatest activity.

Finally, CRD would like to cosponsor with New England Aquarium a training session for commercial and military Harbor Pilots and the U.S. Coast Guard to further increase awareness of right whales and to ensure that pilots know what to look for and how to avoid right whales.

MINERALS MANAGEMENT SERVICE RIGHT WHALE RESEARCH, 1978-1992

Carol P. Fairfield
Minerals Management Service
Herndon, Virginia

The Minerals Management Service (MMS) has funded $6.2 million of research since 1978 focused either directly on right whales, or on right whales and other cetaceans utilizing habitats along the eastern U.S. coast (Table 8). MMS-funded surveys in the Pacific Ocean have also looked opportunistically for right whales. Although only two right whales have been reported during these surveys, this contribution is substantial as it constitutes one-third of the recent Pacific right whale sightings.

MMS-supported efforts have focused on obtaining baseline distributional information along the outer continental shelf from Nova Scotia to Cape Hatteras during all seasons, and in the nearshore waters from Cape Hatteras to northern Florida during the winter. Detailed studies of the distribution, relative abundance, movements, individual identification, feeding ecology, and habitat use have been supported in the Great South Channel area off Cape Cod, Massachusetts. Studies on mother/calf behavior and distribution have been supported in the southern U.S. range of this species. Satellite tag development and deployment research has been supported by MMS, with successful deployment occurring in the Bay of Fundy area. Results of tagging have revealed new information on habitat use, site fidelity, and short-term movements that require review of previously postulated theories. MMS efforts have also supported preparation of publications for submission to peer-reviewed journals, a literature synthesis, and assessment of airships as a platform for studying right whale behavior.

During fiscal year 1992, five of the MMS supported studies will be completed, including: (1) SCOPEX, which is in the final stages of manuscript preparation, (2) two tag development efforts, both of which are in the final manuscript preparation stages with regard to right whale tagging results, and (3) two aerial studies of right whale distribution and behavior off the southern U.S., which will finish analyses and reporting during this year. At present, MMS has no plans to fund additional studies focusing on right whales in Atlantic waters during fiscal year 1993.

Table 8. Minerals Management Service right whale research 1978-1992

Project	Dates	Funding
Cetacean and Turtle Assessment Program (CETAP)	9/78-3/83	$3,704,863
Analysis of High Use Cetacean Habitats, NE. U. S.	8/83-9/85	$19,361
Distributional Biology of Right Whales, NE U.S.	8/83-3/86	$19,303
Visual Matrix Charts Categorizing Literature	9/84-8/90	$74,689
Publication of IWC Right Whale Workshop Proceedings	3/85-9/87	$2,000
Study of Right Whales in South Atlantic, Spring 1986	1/86-2/87	$5,000
Right Whale Survey-North Atlantic	5/86-9/86	$4,950
South Channel Ocean Productivity Experiment	6/87-Present	$559,938
Surveys of Right Whales in GSC, Spring, 1987	6/87-9/87	$9,600
Right Whale Recovery Project Video	3/88-4/88	$1,000
Right Whales in South Atlantic, Spring 1988	3/88-9/88	$3,500
Development of Satellite Tags	9/88-Present	$1,040,130
Endangered Right Whales in the South Atlantic	9/89-Present	$675,267
Design of Satellite Tags for Large Cetaceans	7/90-Present	$32,283
Southeast Atlantic Right Whale Airship Study	9/90-Present	$35,559
Northeast Shelf Symposium	8/91-1/92	$2,000
TOTAL		**$6,170,144**

OVERVIEW OF RESPONSIBILITIES OF THE OFFICE OF THE ASSISTANT SECRETARY OF THE NAVY FOR INSTALLATIONS AND ENVIRONMENT IN RELATION TO MARINE MAMMAL ISSUES (RIGHT WHALES)

Pamela B. Baker
Office of Assistant Secretary of the Navy
(Installations and Environment)
Washington, DC

The position and office of the Assistant Secretary of the Navy for Installations and Environment (OASN (I&E)) was established in 1990 to effectively plan, develop, and manage shore establishment and base structure for the Department of the Navy (DoN) with up-to-date, forward-looking environmental, safety, and occupational health programs. OASN (I&E) responsibilities include formulation of policies and procedures for, and oversight of, all DoN functions and programs related to "environmental protection, planning, restoration, and natural resources conservation". The Special Assistant for Ocean Resources on the OASN (I&E) staff exercises oversight for marine mammal issues as well as other ocean and coastal resource issues such as National Marine Sanctuaries, National Estuary Programs, and environmental quality research and development among others as they relate to the DoN.

The OASN (I&E) coordinates implementation of environmental policy with which the Navy and Marine Corps must comply. Marine mammal issues associated with the Endangered Species and the Marine Mammal Protection Acts and marine mammals as natural resource issues are administered for the Navy through the Environmental Planning Office under the Deputy Chief of Naval Operations (Logistics), and for the Marine Corps under the Deputy Chief of Staff (Installations and Logistics). Various marine mammal research efforts are conducted by the Naval Command, Control, and Ocean Surveillance Center in coordination with the OASN for Research, Development, and Acquisition.

The DoN is aware of the potential for ship strikes to right whales, especially off the southeast coast of the United States. Vessels in the Mayport, Florida, area may encounter concentrations of right whales that use the nearshore area as a calving ground. Because of these concerns and a desire to learn more about how ships can avoid strikes, the DoN provided partial funding to the Marine Mammal Commission for 1992 Right Whale Studies, St. Mary's Channel to Cape Canaveral, 9-17 January 1991. Data from these on-going studies will provide a basis for recommendations to mitigate the effects of ship strikes and other human activities on right whales.

As Department of Defense leaders in marine environmental issues and to satisfy established environmental protection responsibilities associated with marine mammals, OASN (I&E) has developed an environmental protection strategic plan. The plan has several goals, one of which is:

> "...to enrich the biological health of the marine environment in which the Navy operates and increase the productivity of natural resources found on DoN installations."

Specific strategies have been established to meet this goal. Strategies which may be of interest to right whale meeting participants include:

Improve existing agriculture outleasing and forestry programs in support of natural resource management.

This is extremely important because revenue generated in excess of operation and maintenance of these programs are used to fund installation level natural resource projects.

Determine the opportunity for designating marine-based Watchable Wildlife areas.

Several opportunities have been identified and are at various stages of investigation. Naval Out-Lying Field, San Nicholas Island, California, has populations of elephant seals and California Sea Lions; Naval Undersea Warfare Center, Indian Island in Port Hadlock, Washington, has property serving as a seal haulout; manatees are

present in the vicinity of Naval Air Station, Jacksonville; and whales are often present in the vicinity of Marine Corps Air Station, Kaneohe, Hawaii, and Pacific Missile Range Facility, Barking Sands, Kauai, Hawaii.

Identify opportunities for the wider use of Navy expertise in marine mammal health and physiology.

To facilitate transfer of natural history, medical, and nutritional information to universities, aquaria, and zoos, review of data is on-going for possible declass-ification; and an annotated bibliography of publications from the DoN's Marine Mammal Program has been published.

There are several complementary programs within the DoN which relate to natural resources and potentially relate to marine mammals:

Legacy Resource Management Program

This fund was established by Congress in 1991 to be used to elevate natural resource and cultural resource protection on Department of Defense (DoD) installations to a new level of priority. Ninety-one projects were funded in 1991. Under this program, the DoN designed, tested, and evaluated a propeller shroud for protecting manatees from ship thrusters. The shrouds proved successful and have been installed on C-tractor tugs at the Naval Submarine Base, Kings Bay.

Department of Defense and Environment Initiative

This initiative supports efforts to increase environmental awareness and compliance within DoD and to work with the communities and organizations in the private sector to communicate DoD awareness and improve DoD performance. The DoN is supporting several projects including the Puget Sound Initiative and Coastal America Initiative.

Other

Miscellaneous projects consistent with OASN (I&E) goals are supported. For example, as mentioned previously, DoN participated in the 1992 right whale studies off the coast of Florida. DoN also funds grey whale migration studies and "landing craft air cushion" interactions studies off the West Coast.

The DoN is committed to excellent stewardship of natural resources. When the DoN discovered that its actions were impacting manatees in the southeast U.S., propellor shrouds were designed and fitted to C-tractor tugs, alleviating the problem. Official Navy INSTRUCTIONS were also written to guide the DoN operations in areas where manatees occur. Impacts on sea turtles due to dredging operations in the Southeast have been mitigated through placement of observers aboard vessels and restricting dredging to specified windows of time. DoN concern with marine mammal issues, and specifically right whales, is genuine and, through interagency coordination, we hope to continue to contribute to the welfare of this and all endangered species.

U.S. ARMY CORPS OF ENGINEERS' MANAGEMENT ACTIVITIES AND RESPONSIBILITIES FOR NORTH ATLANTIC RIGHT WHALES (*Eubalaena glacialis*) DURING HOPPER DREDGING IN THE SOUTHEASTERN U.S.

Dena Dickerson
USAE Waterways Experiment Station
Vicksburg, Mississippi

John Bushman
U.S. Army Corps of Engineers
Washington, DC

Current population estimates indicate that no more than 350 North Atlantic right whales survive today (Kraus and Brown 1991). The death of even a few animals is likely to have a significant detrimental effect on such very small populations. Data suggest that a minimum of one-third of the current right whale mortalities may be due to human activities such as collisions with ships and propellers and entanglements in fishing gear (Kraus and Brown 1991). Ship and boat traffic may also be excluding them from some former calving areas (Kraus 1990).

North Atlantic right whales move to northern feeding grounds in spring and return to the southern temperate waters in autumn and winter. The only known calving ground of these animals lies off the coast of northeastern Florida and southern Georgia (Kraus et al. 1986). Because right whales depend on inshore areas for reproductive activities and the females have a very strong protective maternal instinct, they may be more vulnerable to the effects of human activity than are many other cetaceans.

Off eastern North America, collisions with ships or ship propellers have resulted in documented right whale deaths; however, the effects of dredging activities on North Atlantic right whales remain largely unknown. No known incidents with right whales have been documented during eastern North American dredging operations; however, one right whale calf was known to be killed by a dredging propeller at East London Harbour, South Africa (Best 1984).

Hopper dredge operations in the shipping channels along the Florida to Georgia coastline constitute a potential threat to North Atlantic right whales during the fall/winter season at this calving ground location. All existing dredging projects require Endangered Species Act Section 7 consultation and coordination with National Marine Fisheries Service (NMFS). The two major groups of animals considered in every dredging related consultation are sea turtles and right whales. As a result of the Section 7 consultation, each project has a biological opinion with specific requirements relating to sea turtles and right whales.

Since documented incidents of hopper dredging related sea turtle mortalities have occurred along the southeastern U.S. coastline, hopper dredging activities in this area are restricted by NMFS to occur only from December through March. This is the window of time in which sea turtles are thought to be least abundant in the shipping channels; however, this is the time when right whales are inhabiting the calving grounds from Florida to Georgia. As a result, during this time the U.S. Army Corps of Engineers maintains NMFS-trained observers onboard the dredges to watch for right whales and sea turtles. Additionally, in the more crucial calving grounds, aerial surveys are conducted three hours per day in the channels and adjacent offshore areas throughout the duration of the dredging operations.

These surveys are designed to detect the presence of right whales within 10 nmi of the dredging location, the offshore disposal site and the transit zone between the two. The exact location of whales sighted during the surveys is relayed to the dredge personnel in order to minimize the potential for dredging collisions with the whales. When right whales are sighted within the 10 nautical miles of survey area, the dredge reduces its nighttime transit to and from the disposal site from normal speeds of 8 to 12 knots to 3 knots. If flights are not made, the dredge must reduce speed to 5 knots at night.

The Corps of Engineers recognizes the severity and gravity of the status of the endangered North Atlantic right whale and the importance of maintaining the security of the only known calving grounds off the Florida/Georgia coasts. Much research is needed to answer questions for better management strategies. More basic biological information is needed on these animals and the effects of disturbances which can only be accomplished through continued communication and cooperative efforts between all responsible parties involved.

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RIGHT WHALE ACTIVITIES OF THE MARINE MAMMAL COMMISSION

David W. Laist
Marine Mammal Commission
Washington, D.C.

The Marine Mammal Commission was established under Title II of the Marine Mammal Protection Act. It is charged with developing, reviewing, and making recommendations on actions and policies of all Federal agencies with respect to marine mammal protection and conservation. To help meet this responsibility, it also is charged with carrying out a research program.

The commission has supported work related to northern right whales since the late 1970s. In 1979, it convened a workshop to identify research priorities for East Coast cetaceans, including right whales. The results helped identify work later supported by the Bureau of Land Management (and subsequently the Minerals Management Service), the National Marine Fisheries Service, the Commission, and private groups. In 1983, the commission provided partial funding for an International Whaling Commission Workshop to review the status of right whale stocks world-wide. The report of that workshop (Brownell *et al.* 1986) is still one of the most complete sources of information on right whales available. In 1984, the commission also provided funds for aerial surveys of right whales in the Great South Channel (Winn *et al.* 1984) and in the Bay of Fundy.

In the mid-1980s, the commission provided the initial recommendation to the National Marine Fisheries Service for developing a right whale recovery plan. It has since provided advice on priority research and management needs throughout the preparation process. For example, in cooperation with the service, the commission funded two workshops convened at the New England Aquarium in 1985 to identify steps to protect and encourage recovery of right whales in the Northwest Atlantic Ocean. The report of the workshop (Kraus 1985) was intended to be a prototype for the Right Whale Recovery Plan. Other right whale studies that the Commission has supported include development of a right whale sighting network in the southeastern United States (Winn 1984), a workshop to examine management needs for right whales off Florida and Georgia (The Georgia Conservancy 1986) and a review of information bearing on the designation of three areas off the U.S. East Coast as critical habitat for right whales (Kraus and Kenney 1991).

The commission recognizes that no one agency has the resources or authority needed to gather all the basic information and assure protection of right whales. This must be done as a cooperative undertaking and the Right Whale Recovery Plan is the appropriate vehicle for coordinating involvement by government agencies and private organizations. For its part, the commission is prepared to continue to provide assistance and advice as it has in the past.

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FOCUS OF RECOVERY EFFORTS FOR ENDANGERED AND THREATENED SPECIES WITHIN THE NMFS OFFICE OF PROTECTED RESOURCES

Aleta Hohn
Office of Protected Resources
National Marine Fisheries Service
Silver Spring, Maryland

One critical factor for ensuring that recovery efforts for endangered and threatened species are adequate is an adequate level of funding. During fiscal year 1992, $1.234 million was appropriated specifically for endangered species recovery efforts, with additional appropriations for northern sea lions ($1.5 million), Hawaiian monk seal ($550,000), and northern right whales ($230,000). In fiscal year 1993, the recommended appropriation for right whales is higher.

Right whales are one of the many endangered or threatened species of critical concern to the National Marine Fisheries Service. Other species that need immediate attention include Snake River sockeye salmon and four runs of chinook salmon; sea turtles; monk seals; and northern sea lions. Each of these species or species groups is currently at relatively low levels, and still declining, or only recently have ceased declining. In addition, due to entanglement and habitat issues, humpback whales in the northwest Atlantic continue to need attention. Even if funds targeted for recovery efforts are divided only amongst the species of greatest immediate concern, they rapidly become limiting.

Because available funds cannot cover all of the needed or desirable recovery efforts and research on all of the critical species, funds that are available must be directed at management questions as identified in the recovery plans. Those actions/ needs classified as Priority 1 are the most critical to prevent the extinction of a species. They will given highest priority for the limited funding that is available.

Working Group Reports

SESSION FOUR: WORKING GROUPS

After hearing from scientists and managers on progress to date, it was agreed that it would be useful to draw on the collective expertise of the attendees to provide guidance for the future. On the afternoon of the second day, two concurrent Working Group sessions were held. The structure and definitions were set forward at the outset. The reports follow.

Working Group Structure

Goal: Determine specific activities necessary to begin implementation of the Right Whale Recovery Plan

Method: Divide Priority 1 tasks identified in the Recovery Plan into two groups: Human Interactions and Habitat Protection. Establish working groups to identify necessary activities (*i.e.*, tasks and people).

Working Group Terms of Reference

1. Activities necessary to implement and evaluate management
2. Research tasks necessary to support management activities
   Choose among tasks in step-down outline by the numbers
   Include justification of the necessity
3. Agency actions to promote inter-agency communication and cooperation
   (Priority 1 tasks 61, 62, 63, 11, 12, 13, 32)
   Program requirements, funding requirements, Canadian involvement

Working Group Definitions

(Reflects a subjective grouping of indicated Priority 1 tasks designed to minimize overlap and facilitate discussion)

WG 1: Human Interaction and Disturbance
(Priority 1 tasks 11, 12 (except 1212), 13 (except 1313-1315), 15, 51, 521, 522)

WG 2: Habitat Identification and Protection
(Priority 1 Tasks 14, 31, 32, 361, 41)

WORKING GROUP ONE: HUMAN INTERACTIONS AND DISTURBANCE

Robert Brownell, Chair
Department of State
Washington, D.C.

Working Group 1 met from 2:00 pm to 4:00 pm on Wednesday, April 15. The charge was to identify specific activities that would begin implementation of the Recovery Plan relative to human interactions and disturbance. The Working Group members were:

Pamela Baker	James Mead
Jeff Brown	Roger Payne
Kim DePaul	Chris Slay
Dena Dickerson	Karen Steuer
Sara Ellis	Jim Valade
Sherrard Foster	Lisa Volgenau
Nina Garfield	Howard Winn
Jim Hain	Robert Ziobro
Mike Harris	
Scott Kraus	others ...
David Laist	
David Littlejohn	

Three subtopics were identified, and with sometimes vigorous discussion, a listing of activities emerged:

A. Reduce Collisions

1. Establish task force to reduce/mitigate collisions with right whales.
2. "Data call"--compilation of all regulations, guidelines, etc. from all agencies and sources now on the books that pertain to avoiding collisions of ships and right whales.
   a. ColRegs.
   b. Look into ability to regulate 3-200 miles from shore.
   c. Use as example industry/bowhead regs/agreements.
3. Identify major users of areas, which types of vessels most often involved in collisions, and locations of strikes.
4. Solicit USCG assistance in notification of location of whales.
   a. Broadcasts, published Notice to Mariners.
   b. Put right whale essential/critical habitat on navigational charts.
5. Place some burden on industry.
6. Place observers on a sample of commercial vessels to determine effectiveness of some of the mitigating actions.
   a. Talk to harbor pilots.
   b. Develop training program for observers (*i.e.*, folks who would be on vessels anyway).
7. Education/awareness
   a. Task force to identify best means of educating
   b. Attend industry/association expos--gather info, educate.
   c. Assign person(s) to visit various facilities to educate.
      1. Possibly work with or through conservation organizations.
      2. Examples: port authorities and shipping companies in ports of concern.
8. Reduce vessel speeds.
9. Restrict time-of-day movements of large commercial vessels.
10. Ensure that stranded right whales are fully worked-up, in a timely fashion, to determine, at least, if death was caused by collision.
    a. Establish contingency plan for coordinating response to stranded right whales.
11. Continue monitoring of scars.
12. Longer term:
    a. Evaluate usefulness of designating critical habitat.
    b. Suggest/evaluate specific regulations relating to boat speed and traffic lanes.

B. Reduce Entanglements

1. Identify gear most involved in (or likely to be involved in) entanglements.
2. Require fishermen to tag/identify their gear so gear entangling whales can be identified as to location and season of entanglement.
3. Monitor number of whales entangled or with signs of entanglement.

4. Evaluate possibility of a program to disentangle whales (including contingency funds).
   a. Communication system/mechanism will be required.
5. Evaluate possibility of gear modification and/or seasonal areal closures.

C. Whalewatching

1. Status--proposed regs at OMB.
2. Distribute proposed regs to scientific community for review and input.
3. Reiterate need to do what's listed under 521 and 522
   a. Evaluate the significance of short-term disturbance.
   b. Evaluate the long-term effects of disturbance.

WORKING GROUP TWO: HABITAT IDENTIFICATION AND PROTECTION

Tim Smith, Chair
National Marine Fisheries Service
Woods Hole, Massachusetts

The members of Working Group 2 were:

Doug Beach	Stormy Mayo
Ben Blaylock	Elizabeth Moses
Carol Fairfield	Charles Potter
Jack Finn	Randy Reeves
Bob Kenney	Victoria Rowntree
Amy Knowlton	
Marilyn Marx	others ...
Bruce Mate	

The Working Group identified several specific activities that it believed should be addressed initially to both implement and evaluate management actions to meet those tasks involving habitat identification and protection designated as Priority 1 in the Recovery Plan. In this discussion, some participants who had been members of the Recovery Team that prepared a draft of the plan noted that the priorities assigned in the final version of the Recovery Plan are not those developed by the team. Further, they disagreed strongly with some of the priorities assigned. Specific concern was raised about the low priority given to several tasks, which the Working Group saw as essential for planning for, and evaluation of, the success of tasks that had been assigned top priority in the plan.

Leaving the concerns about the priorities, the WG identified activities that it felt would be undertaken immediately. These have been summarized into a lesser number of activities (Table 9).

The specific activities are associated there with specific objectives from the Implementation Schedule contained within the Final Recovery Plan. Shown separately are the numbers for those objectives assigned Priority 1 in the plan, and the numbers for the objectives which were given lower priority which the WG judged are necessary to begin implementing the plan. The large number of necessary but Priority 2 objectives shown illustrates in part the conflicts noted above about the assignment of priorities within the Plan. The WG felt that pursuing genetic studies, habitat identification and characterization, and necropsy support were necessary to meet the Priority 1 objectives of the plan. The WG also noted that a strong monitoring program was also essential, but it was agreed that the most useful approach for such monitoring was not clear. Therefore, it recommended a workshop to evaluate the several monitoring programs that have been pursued in recent years and, based on that experience, to design a long-term monitoring program that would meet the needs for implementing the plan.

The WG also identified other agency actions related to promoting inter-agency communication, coordination, and collaboration that it felt should be undertaken to begin implementing the plan. These are shown in Table 10, along with the related Priority 1 and Priority 2 objectives from the Implementation Schedule. The WG felt that increased interaction with Canada was essential. Further, the WG recommended that formalizing the administrative structure for implementation was essential.

Table 9. Specific activities identified by Working Group II members necessary to begin implementation of the Right Whale Recovery Plan, with related Priority 1 and necessary Priority 2 objectives from the Implementation Schedule[1]

Activity	Related Objectives	
	Priority 1	Priority 2
1. Design and implement studies of genetic variability	41	
2. Determine location of winter grounds	361	362, 363, 364
3. Determine location of nursing ground implied by recently collected matriline data	41	362, 363, 364
4. Identify all sources of calf mortality, and control activities to prevent mortality		21, 221, 222
5. Reduce nutrient and contaminant levels, especially from new sources	14	141, 142, 143
6. Evaluate effect of human activities in light of habitat requirements, and protect important habitats from significant negative impacts		341, 342
7. Complete necropsy protocol, and integrate it into the National Stranding Program.		24
8. Conduct a workshop to establish priorities for monitoring programs designed to measure success of Recovery Plan		33, 42, 43, 44, 45,47

[1] **Key to numerical objective codes appended to this WG report.**

Table 10. Specific activities identified by Working Group II members necessary to promote inter-agency cooperation, coordination, and collaboration for implementation of the Right Whale Recovery Plan, with related Priority 1 and necessary Priority 2 objectives from the Implementation Schedule[1]

Activity	Related Objectives	
	Priority 1	**Priority 2**
1. Conduct workshop with representatives of Canadian government	1111, 1112, 1116, 1311, 1312, 32	
2. Increase interaction with Canada at State Department levels and possibly higher levels relative to right whale recovery	32	
3. Assign national coordinator who can direct a substantial amount of time toward implementation of the plan		61
4. Establish two regional Working Groups to address specific regional needs, one in the SE U.S. and one in the NE U.S.		62
5. Ensure interaction among those implementing other ESA Recovery Plans, especially humpback whales		62
6. Conduct technical workshop to define specific methods of analysis, to facilitate comparison of results from different habitat areas		351,352
7. Construct overlay maps showing human activities such as fishing and vessel traffic in comparison to right whale seasonal distribution and movements		63
8. Evaluate use of funds available for handling mass strandings for facilitating collection and analysis of samples from stranded right whales		24

[1] **Key to objective numerical codes appended to this WG report.**

ATTACHMENT TO WORKING GROUP 2 REPORT

Key to Numerical Codes for Objectives in Preceding Tables

1111 Identify those responsible for ship collisions - Brown/Baccaro Banks
1112 Identify those responsible for ship collisions - Bay of Fundy
1116 Identify those responsible for ship collisions -migratory routes
1311 Implement regulations on fishing gear - Bay of Fundy
1312 Implement regulations on fishing gear - southern Scotian Shelf

14 Reduce/eliminate environmental pollution in right whale habitat

141 Assemble data on contaminant effects on habitat
142 Studies on effect of contaminants
143 Monitor contaminants in right whale environment

21 Improve/maintain system for reporting strandings/distressed animals

221 Develop centralized stranding system
222 Identify facilities/system to handle rehab of right whale calves

24 Establish or identify funding for rescue and rehab efforts

32 Promote Canadian action to protect Canadian critical habitats
33 Review effectiveness of protective measures

341 Conduct studies of habitat use and modify protection strategy as appropriate
342 Understand feeding ecology

351 Compile data for known high-use habitats
352 Design/conduct studies to characterize habitats

361 Locate/protect unknown wintering area(s)
362 Review data to ID other possible areas
363 Examine oceanographic data for likely areas
364 Design/conduct surveys of likely wintering habitats and other areas

41 Design/implement studies to establish genetic variation
42 Maintain catalog
43 Maintain sighting database
45 Design/implement other programs--population monitoring
47 Encourage development of new technology for population monitoring

61 Designate implementation coordinator
62 Establish implementation team
63 Identify representatives to periodically review and update Plan

APPENDIX -- MEETING PARTICIPANTS

Baker, Pamela
Special Assistant, Coastal Resources
Office of the Assistant Secretary of the Navy
Room 236, Crystal Plaza #5
Washington, D.C. 20360-5000
(703) 602-2990

Beach, Douglas
Protected Species Office
Northeast Region
NMFS
1 Blackburn Drive
Gloucester, MA 01930
(508) 281-9254

Blaylock, Ben
Southeast Fisheries Science Center
75 Virginia Beach Drive
Miami, FL 33149
(305) 361-4264

Brown, Jeff
Protected Species Management
NMFS
9450 Koger Blvd.
St. Petersburg, FL 33702
(813) 893-3366

Brown, Moira
Department of Zoology
Axelrod Bldg.
University of Guelph
Guelph, Ontario N1G 2W1
(519) 824-4120 x8386

Brownell, Robert
OES/OA
Room 5801
U.S. Department of State
Washington, D.C. 20520
(202) 647-3262

Capuzzi, William
Center for Marine Conservation
1725 DeSales Road
Washington, D.C. 20064
(202) 429-5609

Chu, Kevin
OES/OA
Room 5801
U.S. Department of State
Washington, D.C. 20520
(202) 647-3262

Coogan, Coleen
Protected Species Office
NMFS
1 Blackburn Drive
Gloucester, MA 01930
(508) 281-9291

Credle, Vicki
Office of Protected Resources
NMFS
1335 East-West Hwy
Silver Spring, MD 20904
(301) 713-2325

DePaul, Kimberly
(CNO OP.44E)
Room 10N67
U.S. Navy
Hoffman Bldg. No. 2
200 Stovall Street
Alexandria, VA 22332
(703) 325-7344

Dickerson, Dena
Coastal Ecology Group
Waterways Experiment Station
Army Corps of Engineers
3909 Halls Ferry Road
Vicksburg, MS 39180
(601) 634-3772

Ellis, Sara L.
Associated Scientists at Woods Hole
Box 721
Woods Hole, MA 02543
(508) 564-4449

Fairfield, Carol
Protected Species Office
MS-4310
Minerals Management Service
381 Elden Street
Herndon, VA 22070
(703) 787-1709

Finn, John
Department of Forestry & Wildlife Management
Holdsworth Hall
University of Massachusetts
Amherst, MA 01003
(413) 545-1819

Foster, Sherrard
Sanctuary Program
NOAA/NOS/OCRM/SRD
Suite 714
1825 Connecticut Avenue, NW
Washington, D.C. 20235
(202) 606-4126

Garfield, Nina
Sanctuary Program
NOAA/NOS/OCRM/SRD
Suite 714
1825 Connecticut Avenue, NW
Washington, D.C. 20235
(202) 606-4126

Hain, James
Northeast Fisheries Science Center
NMFS
166 Water Street
Woods Hole, MA 02543-1097
(508) 548-5123 x210

Hamilton, Susan
Office of Federal Activities
A-104
Environmental Protection Agency
401 M Street, SW
Washington, D.C. 20460
(202) 260-5906

Harris, Michael
Coastal Resources Division
Georgia Department of Natural Resources
1 Conservation Way
Brunswick, GA 31523
(912) 264-7218

Hohn, Aleta
Office of Protected Resources
NMFS
1335 East-West Hwy
Silver Spring, MD 20910
(301) 713-2289

Holliday, Barry
Dredging and Navigation Branch
US Army Corps of Engineers
(CECW-OD)
20 Massachusetts Avenue, NW
Washington, D.C. 20314
(202) 272-8832

Horstman, Kathy
Office of Protected Resources
NMFS
1335 East-West Hwy
Silver Spring, MD 20910
(301) 713-2289

Kenney, Robert
Box 41
Graduate School of Oceanography
University of Rhode Island, Bay Campus
South Ferry Road
Narragansett, RI 02882
(401) 792-6664

Knowlton, Amy
New England Aquarium
Central Wharf
Boston, MA 02110
(617) 973-5253

Kraus, Scott
New England Aquarium
Central Wharf
Boston, MA 02110
(617) 973-5253

Laist, David
Marine Mammal Commission
Suite 512
1825 Connecticut Ave., NW
Washington, D.C. 20009
(202) 606-5504

Lang, William
Env. Sci. Inform. Mngmnt.
MS-4310
Minerals Management Service
381 Elden Street
Herndon, VA 22070
(703) 787-1724

Littlejohn, David
Commandant (G-06-2)
U.S. Coast Guard
USCG Headquarters
Washington, D.C. 20593
(202) 267-1770

Marx, Marilyn
Center for Coastal Studies
Box 1036
Provincetown, MA 02657
(508) 487-3622

Mate, Bruce
Hatfield Marine Science Center
Oregon State University
Newport, OR 97365
(503) 867-0236

Mayo, Charles
Center for Coastal Studies
Box 1036
Provincetown, MA 02657
(508) 487-3622

Mead, James
Division of Mammals
National Museum of Natural History
NHB Stop 108
Smithsonian Institution
Washington, D.C. 20560
(202) 357-1923

Moses, Elizabeth
University of Massachusetts
P.O. Box 2922
Amherst, MA 01004

Payne, Michael
Office of Protected Resources
NMFS
1335 East-West Highway
Silver Spring, MD 20910
(301) 713-2322

Payne, Roger
Whale Conservation Institute
191 Weston Road
Lincoln, MA 01773
(617) 259-0423

Potter, Charles
Marine Mammal Program
Smithsonian Institution
Washington, D.C. 20560
(202) 786-2497

Reeves, Randy
27 Chandler Lane
Hudson, Quebec JOP 1HO
(514) 458-7383

Rowntree, Victoria
Whale Conservation Institute
191 Weston Road
Lincoln, MA 01773
(617) 259-0423

Schaeff, Catherine
Biology Department
Earl Hall
Queens University
Kingston, Ontario K7L 3N6
(613) 547-4447 (h)

Slay, Chris
173 Virginia Avenue
Athens, GA 30601
(404) 543-6859

Smith, Tim
Northeast Fisheries Science Center
NMFS
166 Water Street
Woods Hole, MA 02543-1097
(508) 548-5123 x251

Valade, Jim
Florida Department of Natural Resources
Suite 115
3100 University Blvd. South
Jacksonville, FL 32216
(904) 723-5845

Volgenau, Lisa
Code N/ORCA1
Room 220
NOAA/NOS
6001 Executive Blvd.
Rockville, MD 20852
(301) 443-8921

Winn, Howard E.
Box 31
Graduate School of Oceanography
University of Rhode Island, Bay Campus
South Ferry Road
Narragansett, RI 02882
(401) 792-6251

Ziobro, Robert
Office of Protected Species
NMFS
1335 East-West Highway
Silver Spring, MD 20910
(301) 713-2322