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Marine Mammal Strandings in the United States

Proceedings of the Second Marine Mammal Stranding Workshop
Miami, Florida
December 3–5, 1987

John E. Reynolds III
Daniel K. Odell (editors)

U.S. Department of Commerce

NOAA Technical Report NMFS

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CONTENTS

Introduction

Over a decade ago, in August 1977, the First Marine Mammal Stranding Workshop was convened in Athens, Georgia. That workshop, organized by J.R. Geraci and D.J. St. Aubin, not only considered biology and pathology of stranded marine mammals, but it also served as a springboard for the formation of regional marine mammal stranding networks in the United States. The ramifications have been extremely important to the field of marine mammalogy since, for some species, examination or rehabilitation of stranded specimens serves as virtually the only source of information on distribution, anatomy, physiology, reproduction, and pathology. The First Marine Mammal Stranding Workshop led to increased awareness of the marine mammals themselves, as well as the logistic and legal factors associated with effective handling of the animals.

A number of individuals indicated that they felt that a Second Marine Mammal Stranding Workshop held prior to the Seventh Biennial Conference on the Biology of Marine Mammals (Miami, Florida; December 1987) would be both timely and productive. Accordingly, we organized the workshop and scheduled it to occur on 3-5 December. Our goals for the workshop were several, including 1) providing descriptions of some research, especially new techniques, regarding stranded marine mammals[1]; 2) providing a forum where scientists could interact and possibly initiate cooperative research activities; 3) presenting information regarding procedures used effectively to handle stranded animals; 4) assessing ways to standardize data and specimen collection, archiving, and retrieval; and 5) providing a forum for assessing accomplishments and status of regional stranding networks to date, as well as for making recommendations regarding future activities of the networks. Nearly 100 individuals representing Federal and State governments, academic institutions, the oceanarium industry, consulting groups, conservation organizations, and the private sector attended the workshop (*see* Workshop Participants, this volume).

The majority of the papers presented at the workshop are presented in this volume, and they address the goals stated above. The second and third papers provide a historical view of the regional networks, as well as a discussion of legal implications of handling stranded marine mammals. The following six papers summarize the organization, accomplishments, frustrations, and goals of the six regional marine mammal stranding networks in the United States. The next nine papers cover a variety of specific topics including a description of specimen collection and archiving, specific case histories involving marine mammals, and assessments of the use of certain approaches (i.e., cytogenetic and pollutant studies) to permit a better understanding of marine mammal natural history. The final paper in this volume includes a relevant paper that was not given at the workshop.

The Second Marine Mammal Stranding Workshop could not have been planned or held without the help of many individuals and organizations. The participants themselves were an active, vocal group whose presentations and discussions were thorough and productive; group discussion leaders Murray Johnson, Charles Woodhouse, Steven Zimmerman, and Aleta Hohn deserve special mention for their skill in conducting fruitful sessions. Thomas McIntyre, Robert Hofman, and James Mead were particularly helpful in organizing the workshop. We thank the Rosensteil School of Marine and Atmospheric Science at the University of Miami for serving as host for the event. We also thank Andrew Dizon and Linda Jones (National Marine Fisheries Service) for their help in publishing the workshop proceedings and Dean Wilkinson (National Marine Fisheries Service) for his many helpful suggestions and for his support. Several graduate students at University of Miami (Nelio Barros, Vicki Credle, Michael Carvan, and Miriam Marmontel) contributed considerable time and energy to help the workshop run smoothly. Finally, we are grateful to the organizations that provided monetary support that permitted the workshop to be held, receptions to occur, and publication and dissemination of this proceedings volume. Those organizations are Cetacean Society International, Eckerd College, Florida Department of Natural Resources, Florida Power & Light Company, National Marine Fisheries Service, Sea World of Florida, and Sea World Research Institute.

The First Marine Mammal Stranding Network catalyzed considerable research regarding marine mammals and considerable rethinking of the logistics of dealing with strandings. We hope that the information contained in this volume will also be useful to scientists, managers, enforcement personnel, and others whose work involves stranded marine mammals.

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[1] In this volume, different authors have used terms such as "stranded", "beached", and "beach cast" to describe marine mammals on beaches. Although Hofman differentiates between "beached" and "stranded" in his paper (paper 2), we have allowed authors to use the term they prefer to describe dead or live marine mammals that accidently swim ashore, wash ashore, or are trapped by receding tides.

An Assessment of the Accomplishments of the Regional Marine Mammal Stranding Networks and Some Recommendations for Enhancing Their Productivity in the Future

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The Second Marine Mammal Stranding Workshop involved presentation and discussion of 22 papers (17 of which appear in this volume) that considered a variety of topics (*see* Introduction). The Workshop also included two panel discussions, one dealing with mass strandings, the second with the extremely high mortality of bottlenose dolphins (*Tursiops truncatus*) that began along the mid-Atlantic coast in late June 1987. As a culminating event, workshop participants were randomly divided into four working groups (with each group numbering about 20 people) to discuss a variety of questions, including the following:

- What have the regional stranding networks done well that should be continued?
- What could the networks do better, given adequate funding?
- What types of research should be emphasized in the future?
- What basic funding requirements are needed for maintenance and for enhancement of network activities?
- What could be done to standardize data collection and enhance quality control?

Four workshop participants graciously agreed to moderate and report on the working group discussions within particular groups and to report on their group's ideas to all workshop participants. Those individuals (Murray Johnson, Charles Woodhouse, Aleta Hohn, and Steven Zimmerman) did skillful jobs in promoting and moderating discussions and in structuring their reports, and we are grateful for their contributions.

This paper summarizes the responses of the four working groups to the questions posed above. No effort was made to determine quantitatively how many participants agreed with various points; however, the following discussion is based on general group consensus as determined by each group's moderator. A draft of this paper was sent to all workshop participants for their comments, and was revised accordingly.

It should be noted that activities of the regional networks described in papers 4–9 of this volume were not formally compared or contrasted in terms of their effectiveness. Wilkinson (in prep.) considers network effectiveness and makes appropriate recommendations.

Network Accomplishments

Workshop participants felt that the networks have done several things well. First, there was general agreement that most regional networks had established an effective organizational framework consisting of a regional coordinator(s) who maintained a data base and who organized volunteers to respond to stranding events. There was agreement that the network personnel respond well to unusual events, such as mass strandings, and that public knowledge and interest regarding marine mammals has increased.

One important benefit of the well-structured networks has been publication and dissemination of good-quality scientific information. For example, anatomical specimens, especially hard parts, have been and are being collected and used for distributional and systematic studies, and the results of these studies are routinely published in peer review journals. Another benefit has been that people have learned how to evaluate, transport, and rehabilitate abandoned, injured, and sick pinnipeds, manatees, and sea otters; efforts with cetaceans have been less successful.

One of the working groups maintained that three important benefits derive from the efficient operation of the stranding networks. First, as we gain experience dealing with live-strandings, and as better communications lead to shorter response times, the pain and suffering of live-stranded animals can be reduced. Second, the networks provide a means for planning and organizing responses to human health and disposal problems. Third, the networks have helped increase scientific knowledge and public awareness of marine mammals and problems affecting their health and welfare.

Future Goals

Workshop participants made a number of recommendations regarding areas where the networks could improve if there were increased funding available for travel, specimen preparation, salaries, and equipment. The extent to which stranding networks have relied on volunteers and "good will" has limited, in some cases, what can be done. Participants recommended (in no particular order) that individuals involved in regional stranding networks should do the following:

- Learn to recognize and notify relevant authorities before initiating investigations of strandings that might be caused by human activities (e.g., illegal dumping, harassment, commercial fishing) so as to permit the establishment of a chain of custody of evidence. Such notification would help ensure that possible human-related mortalities are properly and effectively investigated. Subsequently, efforts could be made to work with the appropriate agencies to prevent or reduce such mortality.
- Determine cause of death in all possible instances. Some workshop participants noted that cause of death was not determined as frequently as is desirable. Lack of effort, lack of resources, and lack of appropriate training were cited as some of the reasons why cause of death is not being determined in all cases.
- Educate the public and volunteers of the possible consequences of returning live animals to the sea, the value of studying both live and dead stranded animals, the methods and purposes of various study techniques, and the possible dangers associated with contact with both live and dead stranded marine mammals. The view was expressed that people generally respond positively when they are well-informed. Public relations, a problem during some past stranding events, could be improved: a) by using well-informed people trained in public relations to deal with the press and with questions by other interested individuals at the stranding events; b) by distributing prepared information packages or brochures that describe types and causes of strandings, purposes and methods of investigating strandings, how to report strandings, and possible dangers associated with attempts to rescue or handle stranded animals; and c) by providing thanks or acknowledgment for help provided by the public. Some participants suggested that educating school children would be an effective way to communicate the importance of studying stranded marine mammals. The press kits developed by The Cousteau Society and the Smithsonian Institution would be very useful.
- Accurately and promptly record, verify, and archive Level A data (*see* Hofman 1991). This recommendation relates to quality control and data standardization, which we will address later in this paper. Participants believed very strongly that people responding to and investigating marine mammal strandings must conscientiously attempt to collect a full and accurate set of baseline (Level A) data. The view was expressed that collection of inaccurate data could be more harmful than collection of no data at all.
- Accurately and effectively tag, label, or otherwise mark all specimens at the time of collection (*see* Heyning 1991). Participants involved in developing and using museum and other collections noted that specimens that are not accurately and permanently tagged or marked often will become useless over time.
- Tag or otherwise mark all live-stranded animals as soon as possible to a) make it easier to maintain records, and establish priorities for carrying out various tasks; b) avoid taking duplicate samples or administering duplicate treatments to individual animals; and c) ensure that animals that escape or are deliberately returned to the sea can be recognized as they beach again or are seen at sea. The latter procedure is important because scant information is available concerning post-release survivorship and behavior.
- Maintain records of calls not responded to, changes in operational procedures, and other factors that may change over time. The stranding networks are still in their infancy, and failure to keep good records of reporting and other procedures may make it difficult or impossible to detect or assess the significance of changes in the nature, frequencies, or locations of strandings.
- Develop and maintain inventories or directories indicating what and where data and specimens are archived. Such directories would assist scientists and other users to locate data and specimen materials, and thereby promote research and ensure maximum benefit from the regional stranding programs.
- Increase communication within and among regional networks. The need for better feedback to participants and to individuals assisting in stranding events was noted. Annual meetings of members and others interested in the regional networks were suggested as a means by which participants, regional coordinators, and Federal

and State government representatives could review and agree on ways to improve logistic procedures and scientific protocols for investigating and reporting the results of marine mammal strandings. For some regions, it was suggested that data summaries should be distributed to participants more promptly, and that specimen requests should be advertised. It was pointed out that computerization of all data at the regional level would enhance dissemination of information.

- Respond to frequent strandings of pinnipeds, and develop and maintain a centralized data file for pinniped strandings, as is being done for rarer strandings of cetaceans and sirenians. In some regions pinniped strandings occur so frequently that there is little interest and not enough participants to respond consistently. Some workshop participants felt that more volunteers, and funds to provide necessary resources to these volunteers, should be sought and acquired in these regions.
- Train and periodically evaluate the performance of volunteers, professional staff, and participating institutions. This recommendation, similar to the above recommendation for quality control and data standardization, relates to quality control; thus, it will be discussed in greater detail later in this paper. Some workshop participants felt that some volunteers were poorly trained and had insufficient resources to respond effectively to stranding events. Others felt that some volunteers simply do incomplete or inaccurate jobs and that it would be better to have fewer volunteers involved in investigating stranding events.
- Increase coverage of certain remote and inaccessible coastlines to determine frequency and types of marine mammals strandings there. Periodic aerial surveys may be the only way to accomplish this. Prohibitive costs of such surveys could be circumvented if the surveys were "piggy-backed" on an existing routine patrol.
- Encourage increased participation by agencies such as the Coast Guard and National Guard who have manpower and resources that could facilitate handling of stranded animals. Mass strandings, especially those involving large whales, would be cases where such help could be particularly useful.
- Exercise responsibility, ethics, and courtesy in terms of release and use of data from stranded animals. There was uncertainty in some participants' minds regarding to whom stranding data "belong." Data collected during investigations of both live and dead stranded marine mammals may be of value to scientists, to State or Federal agencies responsible for protecting and conserving marine mammals and the ecosystems of which they are a part, and to organizations maintaining marine mammals in captivity for purposes of scientific research or public display. As a general rule, data belong to the individual(s) who collect them or to the agency that funds or coordinates the investigation. Thus, as a matter of practice, data should not be made available to or used by individuals or organizations not involved in particular investigations without the approval of the appropriate individual or organization. Conversely, these individuals and organizations are responsible for analyzing and publishing the results of stranding investigations in a timely manner and for making the data available to anyone with a legitimate interest in them.

Future Research

The research recommendations proposed by the workshop participants involved both live and dead stranded marine mammals. Certain recommendations also involved research involving methods of program or procedural assessment. Workshop participants noted that both live and dead stranded marine mammals provide unique opportunities for acquiring biological and medical information; scientists should be well-trained and well-prepared to make the best use of these opportunities.

With regard to live strandings, participants recommended that networks continue and expand efforts to develop criteria and procedures for quickly evaluating the medical status of live-stranded animals to focus efforts on determining why they strand, what happens to them physiologically when they strand, and how they can best be treated. Field protocols (including transport, tagging, and release methods) should be developed and published. With regard to treatment, it was pointed out that little is known about survival and behavior of stranded animals that are returned to the sea, and that tagging and, where possible, radio and satellite tracking should be done to provide a basis for deciding when and what animals should be returned to the sea. Indeed, tagging of rehabilitated pinnipeds prior to return to the wild is required in the Southwestern Region by the National Marine Fisheries Service. Similarly, it was noted that criteria should be developed to assist in determining when euthanasia would be more humane. A suggestion was made that a paper be developed and published describing potential benefits and consequences of returning stranded and rehabilitated marine mammals to the sea.

With regard to dead animals, a strong recommendation was made to establish a tissue data bank and to determine current levels of potentially harmful contaminants in tissues from recently stranded animals (by species, age, sex, and geographic location). Participants noted that new biochemical and cytogenetic techniques could be used on banked tissues to assess the extent to which marine mammals from different groups and geographic areas are genetically related. Functional anatomical and systematic research will continue to require access to well-preserved specimens.

As indicated in the previous section of this paper, every effort should be made to investigate and determine cause of death. In those instances where human activities cause mortality or illness, identification of cause-effect relationships can help determine steps required to reduce or prevent the deleterious impacts.

Another category of research relates to standardizing, periodically evaluating, and improving methods for reporting, responding to, and archiving data from strandings. This is particularly important if one of the goals of the stranding network is to develop long time series of data that will be useful for detecting changes in the number, species, ages, and other characteristics of marine mammals that strand in different areas, as indices of the status of wild populations and of marine ecosystems. Participants noted that changes in procedures and effort devoted to obtaining reports of, and responding to, strandings could make it difficult to detect changes and trends in stranding patterns. To provide the basis for identifying and evaluating possible sources of bias, they recommended that a) complete records of reporting and response procedures and changes be carefully maintained; and b) directed studies be done in representative "index" areas to provide baselines for assessing the effects of changes in reporting and response procedures on such things as the numbers and proportions of strandings that are observed, reported, and investigated. Participants also suggested that as many data as possible be recorded in a digital, electronic format, possibly using a standard "prompted" entry form.

Funding Requirements

Discussions of funding requirements covered a variety of items ranging from administrative support provided by coordinators, to sponsorship of workshops, to purchase of equipment and supplies, to support of travel and research activities. Appropriate funding sources were not determined, although one of the working groups suggested that the National Marine Fisheries Service and other agencies should encourage corporate and local government support. Two working groups suggested that money derived from fines generated by violations of the Marine Mammal Protection Act be used to support the stranding networks. A final suggestion was that support be sought locally; for example, a local hospital might be willing to do occasional clinical analyses.

The most critical funding needs are for equipment, supplies, and travel. Noncapital equipment such as knives, collecting vials, specimen containers, data forms, scales, and other tools would greatly enhance the quantity and quality of the data collected at stranding events. Additional funds are needed to purchase equipment and supplies for biological and pathological studies. Another critical need is travel money, since responses could be considerably improved and made more consistent if funds were available to reimburse investigators and volunteers for fuel, food, lodging, and telephone costs associated with strandings. Several workshop participants thought that a contingency fund should be established to help ensure a thorough response to unusual situations (e.g., the die-off of about 740 *Tursiops truncatus* in the mid-Atlantic in 1987–1988).

Capital equipment needs include cameras (essential to document and verify species identifications); radio and satellite tags for attachment to representative live-stranded animals that are released; and personal, IBM-compatible computers, with appropriate software and hardware for storing, transmitting, and accessing data files. A suggestion was made that a corporation such as IBM might be willing to provide computers at no cost or reduced cost and that regional coordinators should determine computer needs and make inquiries to determine if they might be met by voluntary contributors.

Workshop participants felt that stable, long-term funding should be obtained to support the activities of regional coordinators and of a national stranding coordinator, the latter being a position that some workshop participants felt was needed. These funds could provide secretarial support for data entry into computers, as well as telephone and general office expenses. Some funds should be acquired to provide "800" telephone numbers that people can use to report strandings. A role that might be assumed by a national stranding coordinator would involve acquiring funds to enhance regional network activities.

The other general category of funding needs involved provision of travel money for network participants to attend international, national, and regional meetings related to stranded marine mammals. The workshop participants felt that regional workshops and training sessions for volunteers should be supported because such gatherings would have important consequences in terms of the quality and quantity of information collected.

Data Collection and Quality Control Needs

Standardization and quality control were identified as important needs by all workshop participants. One of the working groups, in fact, devoted its entire session to these topics. A number of specific and general recommendations were made.

Standardization, it was felt, should be approached to ensure that members have common objectives, standardized data forms, and training in collecting, recording, and reporting various types of data. Communication among and within regions, via newsletters or periodic meetings, is necessary to keep people working together toward common goals, as well as to provide both positive and negative feedback.

Some participants felt that the National Marine Fisheries Service should take a leading role in efforts to standardize procedures used throughout the regions, although it was noted that presently the level of participation and involvement by Service personnel varies considerably from region to region. Several specific recommendations were made by the workshop participants regarding ways to enhance standardization. They are as follows:

- Develop and publicize agreed network objectives. Clear and uniform goals would allow individuals within a region to work better as a team.
- Have one person responsible for verifying, recording, and archiving data within a region. Presumably this individual would be the regional coordinator or someone working closely with the coordinator.
- Hold periodic training sessions to teach volunteers and technicians how to collect, record, and report data. Small, illustrated brochures or handbooks could be developed to accompany training sessions. Training sessions should concentrate not only on logistics of handling the animals, but also on specimen collection and preservation, methods for taking accurate measurements, and how to report latitude and longitude accurately.
- Have regular meetings of network coordinators and network members to review the objectives and operations of the network. Periodic (quarterly) newsletters should be developed to convey information regarding operational changes, specimen requests, and recent stranding events within regions. Such newsletters could also be a vehicle for providing feedback (positive and negative) to network members.
- Use standardized data forms that are consistent among all regional stranding networks. Perhaps the form used by the Smithsonian Institution could be adopted by all regions. A system should be developed to evaluate standard forms periodically to assess their adequacy.
- Computerize and standardize data archival and retrieval systems among the regions to make data more accessible and more comparable.

Quality control was a serious concern among the workshop participants. A general feeling was expressed that network coordinators should discuss and establish performance standards and a system for periodically evaluating performance of network members. One of the working groups made some specific recommendations regarding evaluations and standards.

This group began its discussion by examining how individuals become authorized to handle stranded marine mammals. For cetaceans and pinnipeds, a Letter of Authorization (LOA) is provided by the National Marine Fisheries Service to certain people or organizations. Criteria used to determine the suitability of a particular individual to hold a LOA were unclear. The working group thought that one way to address quality control would be to encourage the National Marine Fisheries Service to develop clear criteria that are consistent among regions for use in evaluating whether a person or institution holding or requesting a LOA should keep or receive it. Further, each LOA should clearly specify the authority and responsibilities of the holder. For example, a particular LOA holder might be restricted to handling only dead animals, and not be permitted to transport or to hold live ones. LOA holders should be required to report their activities periodically to their regional coordinator. Minimum reporting requirements should be specified in LOA's. Finally, LOA holders' activities should be reviewed annually to determine whether they are complying with the terms and provisions of the LOA (e.g., to assess completeness and accuracy of the data they collect, frequency with which they provide voucher materials and photographs of stranded animals, timeliness of their response to strandings, and their effectiveness as part of a regional "team"). The review process, it was noted, should be: a) regional in scope; b) consistent among regions; c) informal, at least initially; and d) constructive and having a goal of improving compliance with standards of quality. LOA holders who regularly provide deficient data or who do not respond adequately to stranding events would not be granted an annual renewal of their LOA.

The working group that provided the specific recommendations did not address who should conduct annual reviews of LOA holders. In many regions, there are very few LOA holders, so a review process would be easy. In other regions (e.g., the Southeastern Region) the large number of LOA holders would make the review process a major task. Nonetheless, the group felt that a review process, combined with consistent criteria for issuing a LOA in the first place, is necessary to ensure consistent high quality among and within regional stranding networks.

Conclusion

Considerable thought went into the recommendations emanating from the working groups. Not all participants agreed with all of the recommendations described above. Some recommendations seemed to recur from group to group. We believe that the following ideas (*most of which require some funding*) were widely and strongly supported by the workshop participants:

- Communication among and within regions should be enhanced by newsletters, meetings, workshops, and informal conversations;
- Data should be collected, recorded, and reported as accurately and completely as possible, using standardized data forms. Computers should be used to help ensure that data are archived and retrieved in a consistent,

efficient fashion among the networks. Data should be recorded in standardized, digital (coded) formats;

- Additional effort should be directed at educating the public regarding marine mammals and marine mammal strandings. Public relations could be improved by using information brochures, by placing designated public relations experts at strandings, and by requiring feedback to and recognition of individuals, particularly volunteers, who report or otherwise assist with strandings;
- Criteria and mechanisms to assess performance and to ensure quality control need to be developed;
- A tissue bank for marine mammal specimens should be established, archived, and advertised among scientists who might use such specimens for research; and
- Individuals should be responsible, ethical, and courteous in their use of stranding data. Acknowledgment of people who assist in data collection or analysis is important.

The stranding networks have provided an important and effective framework for humane handling of stranded marine mammals, for generating scientific information, and for informing the public. Nonetheless, growth and improvement of the networks is necessary. We hope that the recommendations provided in this paper will serve as a useful guideline and form the basis for discussions that will permit even more effective and humane responses to stranded marine mammals.

Acknowledgments

We are extremely grateful to the working group chairs, Murray Johnson, Charles Woodhouse, Aleta Hohn, and Steven Zimmerman, for their effective leadership of discussions. We are also grateful to Robert Hofman, who made his notes regarding workshop group discussions available to us as a resource as we compiled this paper, and who commented on an early draft of this paper. Thomas McIntyre also provided useful comments on a draft of the paper. We thank Deborah Duffield, who provided a thorough and articulate closing statement following the workshop group activities. Finally, we appreciate the willingness of all workshop participants to express their viewpoints and to work diligently to make recommendations designed to improve the manner in which stranded animals are handled.

Citations

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History, Goals, and Achievements of the Regional Marine Mammal Stranding Networks in the United States

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ABSTRACT

This paper provides a brief description of the background, purposes, and results of the August 1977 Workshop on Marine Mammal Strandings which led to the establishment of the current system of regional marine mammal stranding networks in the United States. It notes that the networks do not have clearly articulated goals and that it, therefore, is difficult to judge their performance. It proposes adoption of four general goals: 1) to minimize the threats of beached and stranded marine mammals to human health and safety; 2) to minimize pain and suffering of live-stranded animals; 3) to derive maximum possible scientific and educational benefits from strandings; and 4) to establish long-time series of data necessary to determine natural variation and detect changes in mortality patterns and other variables that may be indicators of population and habitat status. It identifies actions that could be taken by the networks and network coordinators to help meet the suggested goals.

Introduction

The value of beached and stranded marine mammals* no doubt has been recognized for thousands, if not tens or hundreds of thousands of years. In many coastal areas, early humans searched for and used beached and stranded marine mammals for food and for sources of bone and other materials to construct tools, weapons, etc. It is not unreasonable to presume that some beaches were searched systematically, at least at certain times of the year, and that procedures were established to notify other clan or tribe members when animals were found and to govern the dismemberment and the distribution of parts from these animals. Thus, in a historic sense, the first marine mammal stranding networks were organized and operated by stone age societies.

Recognition of the scientific value of beached and stranded marine mammals also is not new. The original descriptions of many marine mammal species were based upon examination of carcasses found washed-up on beaches. Recognizing the relative rarity and value of such specimens, some of the earliest physicians and natural historians in several parts of the world may have made known their interest and established procedures for reporting and recovering beached and stranded marine mammals. Thus, recognition of the scientific value of beached and stranded marine mammals may date back to the earliest civilizations.

A cursory review of recent literature on marine mammal strandings indicates that salvage/necropsy and rescue/rehabilitation programs have been developed and implemented in a number of countries to facilitate reporting of and appropriate responses to beached and stranded marine mammals (*see*, for example, the papers in this volume including Odell 1991; Seagars and Jozwiak 1991; Scordino 1991; Zimmerman 1991; and Nitta 1991; *also see* Anderson 1982; Easton et al. 1982; Hansen 1983; Seagars et al. 1986; Sheldrick 1976; and Smeenk 1986). Responses vary, depending upon variables such as the nature and location of the stranding, the species and number of animals involved, the interest and capabilities of the scientists and institutions present in the vicinity of the stranding location, and the availability of funding, equipment, and logistic support.

In 1977, following a mass stranding of pilot whales (*Globicephala macrorhynchus*) near Mayport, Florida, the Marine Mammal Commission received several phone calls and letters expressing concern that qualified scientists had

* In this paper, the term "beached" refers to dead marine mammals that wash up on beaches and the term "stranded" refers to live marine mammals that swim onto beaches or are stranded by receding tides.

been denied access to the carcasses and that a valuable opportunity to collect certain types of useful data consequently had been lost. Several persons involved in this and previous stranding investigations noted that a workshop was needed to identify and determine how to avoid such problems in the future. The Commission subsequently provided funds to organize and convene the workshop, which was held at the University of Georgia, Athens, Georgia, in August 1977.

The workshop objectives were to 1) provide a general review and analysis of available data concerning the nature and occurrence of marine mammal strandings, and of stranding theories; 2) identify the kinds of data that could be obtained from studies of stranded animals and how those data might contribute to the conservation and protection of marine mammals; 3) identify Federal and state agencies whose missions were such that they would have a use for data derived from stranding studies; 4) provide recommendations regarding the handling, care, and disposition of live-stranded animals; and 5) provide a rationale and plan for a coordinated, nationwide salvage-necropsy program. The principal workshop findings and conclusions (Geraci and St. Aubin 1979) can be summarized as follows:

- the causes of many strandings, particularly mass strandings of live cetaceans, are not clear and merit further investigation;
- strandings sometimes provide valuable and unique sources of information concerning the distribution, relative abundance, morphology, diseases, and natural history of marine mammals, and, in some cases, may be indicators of the status of marine mammal populations and the ecosystems of which they are a part;
- stranded animals provide a relatively inexpensive and unexploited source of specimens and biological material for teaching purposes;
- rehabilitated strandlings provide a valuable source of live animals for public display and scientific research and sometimes can be used in place of taking wild specimens;
- the first consideration at any stranding event should be the care and well-being of live animals;
- means for accomplishing the care and well-being of live animals may vary with circumstances and include returning animals to the sea, transferring animals to holding facilities for care and rehabilitation, and euthanizing animals that likely would die or suffer if returned to the sea and that could not be removed to a suitable holding facility for care and rehabilitation;
- if live-stranded animals are rescued and rehabilitated, decisions whether these animals should be released or maintained in captivity must take into account the possibility that the animals may have lost their natural capacity to locate and capture appropriate prey species, avoid predators, and interact normally with other members of the species;
- certain types of data—termed "Level A Data"—should be collected from *all* stranding events. Additional supplementary information, specimen material, and tissue samples—termed "Level B and Level C Data"—should be collected, if and when possible, from all stranding events (Level A, B, and C Data are described in Appendices 1-3);
- regional stranding networks should be organized and operated to facilitate acquisition of data from strandings; provide an efficient means for disseminating data; ease the efforts of law enforcement agencies; encourage close cooperation among enforcement agencies, investigators and institutions; and eliminate conflicts and duplication of effort among those investigating strandings. The regional networks should be organized along the lines of the existing regional organization of the National Marine Fisheries Service—i.e., northeast, southeast, southwest, northwest, and Alaska—with separate networks in Hawaii and possibly in Puerto Rico and the U.S. Virgin Islands; and
- a small, national office should be established to provide a mechanism for archiving and verifying Level A Data, and to facilitate communications among the regional networks.

In response to the workshop recommendations, six regional stranding networks subsequently were organized. The regions covered by the networks are the northeast (New England, New York, New Jersey, Maryland, and Virginia); the southeast (North Carolina, South Carolina, Georgia, Florida, Alabama, Texas, Puerto Rico, and the U.S. Virgin Islands); the southwest (California); the northwest (Oregon and Washington); Alaska; and Hawaii. In addition, Dr. Mead, at the Smithsonian Institution, has continued archiving stranding records, begun in 1973, although funding constraints have permitted recording only cetacean stranding data since 1983.

Each of the regional networks has a designated individual or organization that functions as the network coordinator. Some coordinators receive and archive data, and coordinate responses to reported strandings, while others do little more than advise members when strandings occur. Most of the network coordinators have developed directories listing the names and telephone numbers of relevant Federal and state law enforcement officers, public display and academic institutions, and individuals who have indicated an interest and willingness to assist in rescuing and investigating beached and stranded animals. Members of the networks are authorized to collect specimens and parts thereof either by scientific research permits or by letters of authorization issued by the National Marine Fisheries Service (for cetaceans and most pinnipeds), or by the U.S. Fish and Wildlife Service (for manatees, sea otters, walrus, and polar bears).

Stranding Network Goals

Although the report from the 1977 workshop (Geraci and St. Aubin 1979) indicates what the responsibilities of the regional stranding networks should be, it does not indicate or suggest their goals or objectives. Likewise, while some of the network directories provide general statements of purpose, none provide clear descriptions of goals or objectives. Therefore, there are no established criteria for judging network performance.

One of the things that this second workshop could do is establish goals or objectives and then use these, in conjunction with the information provided in the presented workshop papers, to judge the effectiveness of the existing networks and what might usefully be done to improve them. For purposes of discussion, the stranding networks should have four general, long-term goals, namely,

- to minimize the possible threats of beached and stranded marine mammals to human health and safety;
- to minimize the pain and suffering of live-stranded animals;
- to derive maximum possible scientific and educational benefits from both live- and dead-stranded marine mammals; and
- to establish long-time series of data which may help to determine natural variation and detect changes in mortality levels and patterns, contaminant loads, and other variables that may be indicators of the status of coastal marine mammal populations and the ecosystems of which they are a part.

Threats to Human Health and Safety

Beach-cast marine mammal carcasses may contain and/or provide media for the growth of pathogens that can infect and kill humans. Similarly, live-stranded marine mammals may thrash about, or be moved by wave action, and consequently kill or injure humans who come near them. Therefore, one of the goals of the stranding networks should be to minimize such threats. To accomplish this goal, the networks, in cooperation with appropriate Federal, state and local law enforcement agencies, should establish protocols and/or guidelines for recovering, handling, and disposing of both live and dead animals, and for restricting public access to stranded animals and stranding sites as and when necessary.

Pain and Suffering of Live-stranded Animals

Live-stranded animals may be subject to much pain and suffering due to disease, sunburn, dehydration, overheating, suffocation, and/or injury from thrashing and wave action. Such pain and suffering sometimes can be avoided or alleviated by shading and keeping the animals wet, by pushing or towing the animals back into the sea, by transporting animals to holding facilities for treatment, or by euthanizing animals which cannot or should not be returned to the sea or be transported to suitable holding facilities for treatment. To help meet the goal of minimizing pain and suffering, stranding networks should 1) develop and publish protocols or contingency plans for dealing with live strandings; 2) stockpile essential rescue/rehabilitation/euthanasia equipment and supplies in strategic locations, and/or publish a directory indicating where and how such equipment and supplies can be obtained in time of need; 3) establish guidelines and procedures for deciding when and what animals should be returned to the sea, moved to holding facilities, euthanized, etc.; and 4) maintain an up-to-date list of facilities suitable and willing to hold and care for live stranded animals. Also, network members should include one or more veterinarians experienced in marine mammal medicine and husbandry.

Possible Scientific and Educational Benefits

Several things must be done routinely if this objective is to be met. As examples, there must be an effective system for obtaining reports of beached and stranded animals and for notifying appropriate network participants of the nature and location of strandings; the Basic Minimum (Level A) Data and, when appropriate, Level B and C Data must be collected from all strandings; data must be recorded and reported accurately, verified, and archived (preferably in a digital, electronic form); an up-to-date inventory (indicating what, where, and in what format data are archived) must be maintained; and both the inventory and the data must be readily accessible, while at the same time the proprietary rights of the persons who collected the data are recognized and protected. Interest, capabilities, and problems will vary from region to region and the regional coordinators should convene meetings of key network participants from time to time to review and agree upon protocols and priorities for collecting and distributing various types of data and specimen material, and other actions that may help to improve the effectiveness of the network and the utility of the data and specimen material.

Possible Causes of Population and Habitat Changes

Long-time series of Levels A, B, and C Data can be useful for detecting and, in some cases, determining the probable cause or causes of changes in age-specific mortality patterns and the general status of some marine mammal populations and the ecosystems of which they are a part. For example, long-time series of Level A Data could provide the basis for detecting both gradual and rapid (acute) changes in general or age-specific mortality patterns (as illustrated by the early detection of the 1987–1988 bottlenose dolphin (*Tursiops truncatus*) die-off along the mid-

Atlantic coast), while Levels B and C Data may indicate corresponding changes in, and suggest possible cause-effect relationships with, variables such as stomach contents, parasite loads, and contaminant loads.

The utility of long-time series data will depend upon a number of variables, including their reliability and comparability over time. For example, changes in reporting or notification procedures, response team interest and capability, methods of recording and reporting data, etc. could cause or contribute to misinterpretation of the data. Thus, quality control and maintenance of an accurate record of changes in reporting and response practices are essential if stranding data are to be of any value for detecting and monitoring population or habitat changes. If systems for reporting and responding to strandings, and the quality of data collection/recording/archiving are variable over time, the resulting data may have little or no value for detecting and monitoring population and habitat change and the time, money, and effort used to collect such data could therefore be wasted.

If stranding data are to be of any value for population or ecosystem monitoring, two of the principal tasks of the network coordinators must be to 1) insure standard and accurate collection of Level A and, as possible, Levels B and C Data; and 2) maintain an accurate record of any changes in systems or procedures for reporting strandings, and the means and frequency of responding to such reports.

Summary and Conclusions

The stranding workshop held in Athens, Georgia, in 1977 called attention, among other things, to the value of data that can be derived from investigation of both dead and live-stranded marine mammals and led to the establishment of four regional stranding networks in the continental United States, as well as subsidiary networks in Alaska, Hawaii, Puerto Rico, and the U.S. Virgin Islands. As illustrated by the papers presented during this second workshop, the networks have demonstrated their value, and have contributed substantially to meeting the four long-term program goals suggested earlier. It also is clear that some networks are operating more effectively than others and that a number of things could be done to improve the effectiveness of each. In particular, if it has not already been done, each network or network coordinator should

- develop, distribute, and periodically up-date a directory listing network participants, their affiliations, addresses, phone numbers, responsibilities, and research interests;
- periodically evaluate the effectiveness of systems for obtaining (reporting) information on the nature and location of strandings, for notifying appropriate network members when strandings occur, and for determining when and how to respond to stranding reports;
- establish protocols or guidelines for a) determining whether and how live-stranded animals should be marked and returned to the sea, transported to a holding facility, rehabilitated, and subsequently released or maintained in captivity, or euthanized to avoid further pain and suffering; b) receiving and responding to requests for data and specimen material; and c) disposing of dead animals;
- clearly describe and develop standard formats and protocols or guidelines for recording, reporting, verifying, and archiving Level A, B, and C Data;
- develop, distribute and maintain up-to-date inventories listing what and where various types of data are archived and how they can be accessed;
- develop and maintain an up-to-date list of institutions authorized and willing to care for live-stranded animals;
- maintain an accurate up-to-date record of any changes in systems or procedures for reporting and responding to reports of strandings;
- periodically evaluate at least Level A Data to detect natural variation and possible changes in stranding patterns and other variables; and
- establish mechanisms for keeping network participants interested and informed, and for periodically assessing and determining how to improve network operations.

Finally, it is important to recognize that the data collected by the networks are of no value unless they are regularly assessed and published. That is, analysis and publication of data collected by the networks is the ultimate standard against which the value of the networks will be judged.

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Appendix 1

Level A Data: Basic minimum data from all stranding events (to be submitted to the National Office)

1. Investigator
   - name
   - address (institution)
2. Reporting source
3. Species
   - preliminary identification (by qualified personnel)
   - voucher (supporting material)
     a) photograph—full lateral view (cetaceans); dorsal view (pinnipeds); dorsal, lateral, ventral views of whole carcass, with close-up of head (when possible). Include a card with field number in each photo.
     b) specimens—canine tooth or entire mandible (pinnipeds); 2 pieces of midrow baleen, or bulla if baleen missing (mysticetes), tooth counts and samples, or entire skull for difficult species (odontocetes).
4. Field number
5. Number of Animals
   - total
   - sub-groups (fragmented mass stranding)
6. Location
   - preliminary description (local designation)
   - latitude and longitude (to 0.1 minute, if possible) with closest named cartographical feature (USGS 1: 250,000 series) as determined subsequently in the lab.
7. Date, time
   - first discovery
   - of data and specimen recovery
8. Length (Girth and Weight, when possible)
   a) cetaceans and sirenians—tip of rostrum to fluke notch
   b) pinnipeds—tip of rostrum to tip of tail, lying on back.
9. Condition—recorded for both discovery and recovery times. Categories as follows:
   1) alive
   2) freshly dead (i.e. edible)
   3) decomposed, but organs basically intact
   4) advanced decomposition (i.e. organs not recognizable, carcass intact)
   5) mummified or skeletal remains only
10. Sex
    a) cetaceans—probe genital slit (anteriorly directed are female, posteriorly directed are male)
    b) pinnipeds—position of apertures
    c) sirenians

Appendix 2

(p. 27 in Geraci and St. Aubin 1978)

Level B Data: Supplementary onsite information (Augments data on life history and the stranding event)

1. Weather and tide conditions
2. Orientation of carcasses
3. Offshore human/predator activity
4. Presence of prey species
5. Behavior
   — pre-stranding
   — stranding (on beach)
   — after return to sea
6. Samples collected for subsequent analysis
   A. Age Determination
      a) odontocetes—4-5 adjacent teeth from the middle of the left lower tooth row.
      b) mysticetes—minimum of one ear/plug, preferably in situ in a sample of externalauditory meatus, or in a glove finger.
      c) pinnipeds—minimum of 1 canine tooth - claw
      d) sirenians—tusk, where present
   B. Reproductive Tracts
      a) females—both ovaries, uterus, fetus (if any) and measurements and samples of mammary glands.
      b) males—one testicle with epididymis, or samples with weights and measurements, baculum (when present), vas deferens.
   C. Stomach Contents
      — weigh contents, if possible
      — preserve in alcohol (never in formalin)
      — freeze whole, if possible
7. Disposition of carcass

Appendix 3

(pp. 28–31 in Geraci and St. Aubin 1978)

Level C Data: Necropsy Examination and Parasite Collection

1. **Necropsy**

Precise recording of findings and appropriate preservation of tissue are of great importance to an understanding of disease conditions. The most important characteristics of an abnormality are its SIZE and LOCATION. Also important are features such as COLOR, TEXTURE, and SHAPE, as well as the nature of the transition from normal to abnormal tissue, that is, whether the boundaries are sharp or vague. All findings are described in STANDARD ENGLISH using NON-TECHNICAL TERMS. Lesions are described using terms such as raised, flat, depressed, rough, smooth, velvety, warty, yellowish, round, irregular, etc. Photographs should be made whenever possible, and should include a ruler or some other non-ambiguous reference object.

External Examination—

Describe all unusual features such as marks, abrasions, parasites; examine mouth and teeth, etc.

Internal Examination—

Samples are to be taken routinely from all organs including brain, muscle, endocrine glands and viscera. When an organ is normal, a random section should be preserved in formalin. Any abnormality should be sampled with an adjacent piece of normal tissue. If an organ is studded with many discrete lesions, all apparently identical, sample only two or three. Describe organs as normal appearing, if that is the case. Vessels and ducts are normally opened throughout their length. While this is in theory desirable for the intestine, sampling of two or three tubular sections may be adequate. All major organs are weighed after cleaning of excess fat and extraneous tissue. Large organs are weighed in pieces, and the partial weights added. Hearts are normally weighed with a short cuff of aorta.

Preservation of Tissue

Formalin (10% neutral buffered) is the standard fixative. Tissue taken for histology should be fixed in formalin of a volume 20 times the volume of tissue. Tissues should be sliced thin—about 3 mm. Other dimensions are not critical; 3 × 3 cm is a convenient size. Larger pieces of tissue do not fix well.

Whole lesions, e.g., stomach ulcer, may be taken and fixed with good results as the wall of the organ is thin. When possible cysts and cavities in tissue, pus-filled lesions and fluid found in body cavity should be cultured for bacteria. Commercial holding media are excellent for the purpose, and their use is recommended. Special requests for research material such as whole organ preparations should only be honored if accompanied by detailed protocols.

Collection of Toxicology Specimens

Tissue samples collected for pesticide and heavy metal analyses may be wrapped in aluminum foil or placed in plastic bags. For prolonged storage, glass containers with teflon-lined lids are recommended. The samples should be frozen as soon as possible, but may be transported on ice without significant loss of residues.

Samples of blubber, brain, liver, kidney and muscle should be collected routinely. Single assays may be performed with as little as 10–20 g of tissue, but samples weighing 200 g or more are necessary for a complete spectrum of analyses.

2. **Parasite Collection**

Parasites may be found anywhere within the body, but problem areas are identified as follows:

Head
- — sinuses
- — ears
- — brain

Skin, Blubber

Muscle, Fascia

G. I. Tract
- — including fecal sample
- — liver, gallbladder, duct
- — pancreas, duct

Respiratory
- — major airways (opened)
- — lungs

Uro-genital
- — kidneys
- — genital organs
- — ureters, bladder

Blood
- — sample or smear

Fixatives

A) Alcohol-Formalin Acetic Acid (AFA)—40 mL of 70% alcohol, 10 mL of 5% formalin, 2 mL of acetic acid, 48 mL of distilled water

B) Glycerin-Alcohol—5 mL of glycerin in 95 mL of 70% alcohol

C) Potassium Dichromate—2% aqueous

D) Formalin—5% solution

E) Ethanol—70% solution

Sampling Procedures

- — subsample when large numbers are present
- — do not distort
- — ensure collection of head and tail
- — sample portion of infected tissue when a parasite reaction is observed. Fix in A if possible
- — measure and photograph, when possible

1) Nematodes
   - — fix in hot (16°C, 60°F) fixative B or
   - — place in tap water in cooler for 12 hours, then fix in solution A

2) Trematodes, Cestodes, Acanthacephalans
   - — place in tap water in cooler for 12 hours, then fix in solution A

3) Lice, Mites, Copepods, Barnacles
   - — fix in either D or E

4) Stool Sample
   - — preserve in fixative C

Legal Framework for Collection of Specimens and Data from Beached and Stranded Marine Mammals*

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ABSTRACT

The Marine Mammal Protection Act generally prohibits the collection of specimens and data from marine mammals unless a scientific research permit is obtained. Data and specimens can be collected from beached and stranded marine mammals without a permit, however, under policies and procedures of the Marine Mammal Stranding Network established by the National Marine Fisheries Service over ten years ago. But, collection of data and specimens is authorized only if it does not interfere with the protection of the marine mammal or public welfare. This paper provides a brief overview of the nature and scope of this collection authority and identifies certain areas of concern that are being examined by the National Marine Fisheries Service.

Introduction

Beached and stranded marine mammals have proven to be an invaluable source of specimens and data for marine mammalogists and other scientists. But access to these marine mammals is not an unconditional right granted to all. Rather it is a restricted privilege exercisable only to the extent permitted under the Marine Mammal Protection Act (MMPA). It is, therefore, essential for scientists dependent upon this source of specimens and data to understand the legal framework from which their source springs.

Discussion

The MMPA establishes a general moratorium on the take of all marine mammals and marine mammal products in U.S. waters and lands adjoining those waters. "Take" is statutorily defined as "harass, hunt, capture or kill, or attempt to harass, hunt, capture or kill" (16 U.S.C. §1362 [12]). This definition of take has been interpreted in regulations to include the collection of any marine mammal or marine mammal part, alive or dead, as well as the restraining of a marine mammal, no matter how temporary (50 C.F.R. §216.3). In addition, the MMPA prohibits any person from transporting, purchasing, or selling any marine mammal or marine mammal product unless expressly provided for in the MMPA (16 U.S.C. §1372). On its face, then, the MMPA precludes, without other authority, the collection of any beached/stranded marine mammal, marine mammal part or specimen.

There are two important exceptions to the MMPA moratorium relevant to the interest of marine mammalogists and other scientists. One exception authorizes the take of marine mammals for purposes of scientific research if the appropriate permit is applied for and granted (16 U.S.C. §1371[a][1]). Theoretically, such a permit would authorize a scientist to take and collect any marine mammal or parts thereof including beached/stranded mammals. But the permit process is time consuming, requiring at the very least 3–4 months to complete. In light of the unpredictable and ephemeral nature of a beaching or stranding, the scientist would usually not have time to obtain the proper permit in order to collect a particular beached/stranded marine mammal or its parts. Therefore, the scientific research permit is generally not appropriate for collecting beached/stranded marine mammal specimens or data.

A second exception has been construed to create the right of access to a beached/stranded marine mammal without

* The views and opinions expressed in this paper are the author's own at the time the final draft of the paper was submitted (February 1990) and do not necessarily represent the views, opinions, or policies of the National Oceanic and Atmospheric Administration or the United States Government.

first obtaining a permit. Section 109(h) of the MMPA provides in pertinent part as follows:

> Nothing in this title shall prevent a Federal, State, or local government official or employee or person designated under Section 112(c) from taking, in the course of his duties as an official, employee, or designee, a marine mammal in a humane manner (including euthanasia) if such taking is for
>
> (1) the protection or welfare of the mammal,
> (2) the protection of the public health and welfare . . . (16 U.S.C. §1379[h]).

This provision serves as the authority for the national Marine Mammal Stranding Network which was established over 10 years ago and is the primary organization involved in responding to the beaching and stranding of marine mammals. The stranding network consists of volunteers throughout the United States who have been designated to "take" beached/stranded marine mammals when the occasion requires. Such a designation has come from the National Marine Fisheries Service (NMFS), the Federal agency charged with administering and enforcing the MMPA for cetaceans and most pinnipeds, pursuant to Section 112(c) (16 U.S.C. §1382[c]) of the MMPA, which grants authority to NMFS to enter into agreements necessary to carry out the purposes of the MMPA.

In practice, NMFS, through its regional offices, has designated persons and organizations to participate in the stranding network through letters of agreement, or other forms of authorization, which specify the nature and scope of authority such designees have as stranding network volunteers. The stranding network is then coordinated by designated coordinators and/or NMFS regional offices.

Although there is no specific statutory or regulatory authority under 109(h) to allow the collection of specimens or data from a beached/stranded animal without a permit, NMFS allows collection of specimens and data from beached/stranded marine mammals if the collection does not interfere with the protection of the marine mammal or the public. The NMFS considers such collection activities as necessary to the overall understanding of beached/stranded marine mammals and helpful for both enhancing their rehabilitation and survival and for promoting important policy objectives of the MMPA. Moreover, NMFS recognizes that collection of data and specimens from beached/stranded animals reduces the need to collect other animals in the wild and thus serves an important conservation function.

The collection activities are subject to the terms and conditions of stranding network agreements and NMFS policy. For a live beached/stranded, animal the first priority is to return it to the wild if it is deemed able to survive. If the animal needs to be rehabilitated first and is unable to be returned to wild, it can be transferred to a facility that has been duly authorized by NMFS. For a dead beached/stranded marine mammal, the first priority is to protect the public health and welfare through appropriate disposition. If these priorities can be achieved, specimens from marine mammals can be taken without a permit under the direction of the stranding network designee or appropriate government employee, who according to 109(h) may be a Federal, state, or local official.

The stranding network as a primary source of beached/stranded specimens and data has worked relatively well for the last 10 years. There are policies and procedures, however, that need to be reviewed and questioned. Some issues and concerns that NMFS is currently reviewing include the need for regulations; standardization of letters of authorization; criteria to qualify as a volunteer; regional vs. national coordination of the stranding network; emergency response systems; mass stranding policies; funding and expenses; clarification of state and local participation; liability policies of/to volunteers and government; and policies regarding the extent of collateral scientific research to be allowed. Based on this review, NMFS hopes to improve the efficacy of dealing with beached and stranded marine mammals as well as the disposition of specimens and data from such animals.

Conclusion

This brief overview of the legal framework for the collection of specimens and data from beached and stranded marine mammals is designed to instill a better understanding of conditions and limitations regarding such collection practices. Such an understanding will hopefully lead to more orderly and efficient collection of specimens and data from beached and stranded marine mammals.

A Review of the Southeastern United States Marine Mammal Stranding Network: 1978–1987

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ABSTRACT

The Southeastern United States Marine Mammal Stranding Network was formally organized late in 1977. In the decade from 1978 to 1987, network volunteers reported 2381 cetaceans, including 74 sightings of live whales, and 3 stranded hooded seals (*Cystophora cristata*). Cetaceans included 5 species of mysticetes and 23 species of odontocetes. Florida and Texas had the most reports with 1081 and 567, respectively. The bottlenose dolphin (*Tursiops truncatus*), and the pygmy sperm whale (*Kogia breviceps*), were the most common singly stranded animals with 1472 and 224 reports, respectively. Twenty-one mass strandings of 9 species of odontocetes were reported. Seventeen of the mass strandings were in Florida, 2 in Louisiana and 1 each in Texas and North Carolina. Although the number of network volunteers has increased over the decade and record keeping has changed from manual to electronic, more attention must be given to the quality and quantity of data gathered, including species verification. Uniform improvement will require resources that go beyond the limits of volunteerism. Stranding networks are an almost untapped resource for gathering basic data on marine mammals.

Introduction

The collection of biological data from stranded marine mammals has long been an important source of natural history information around the world. Biologists have gathered and published information on a wide variety of species of marine mammals. These data are often the only data available on some rare species. In most cases, the gathering of this information has not been done in a coordinated fashion, but has relied on the interest and persistence of a few individuals. For example, Caldwell and Golley (1965), Moore (1953), Layne (1965), Caldwell and Caldwell (1973, 1974), Lowery (1974), Schmidly and Melcher (1974) and Schmidly (1981) have gathered and tabulated much of the historical stranding data in the southeastern United States. In 1974 the U.S. Fish & Wildlife Service and the University of Miami cofounded a separate stranding network to gather data on the endangered West Indian manatee (*Trichechus manatus*) in Florida and the southeast (*see* O'Shea et al. 1985). The manatee carcass salvage network was relatively easy to organize and coordinate because of the limited number of people involved and the limited distribution of the manatee.

The U.S. Marine Mammal Commission, created by the Marine Mammal Protection Act of 1972, recognized the importance of stranded marine mammals and organized the first marine mammal stranding workshop which was held in Athens, Georgia, in 1977 (Geraci and St. Aubin 1979). This workshop resulted in the creation of regional stranding networks organized within the boundaries of the National Marine Fisheries Service (NMFS) regions (i.e., NE, SE, NW, SW). The southeastern network extends from North Carolina to Texas and includes Puerto Rico and the U.S. Virgin Islands.

Methods

The Southeastern U.S. Stranding Network (SEUS) was formed around a core of individuals and organizations that had been active in marine mammal (primarily cetacean) stranding work. Each qualified individual/organization received a Letter of Authorization from the National Marine Fisheries Service Southeast Regional Office in St. Petersburg, FL. The letter bypassed the time consuming permit requirements of the Marine Mammal Protection Act for stranding work. The NMFS maintains and distributes a directory of authorized SEUS participants.

Stranding operations and responses are divided into two categories: dead stranded animals and live strandings. Live

Table 1

Summary of cetacean strandings and sightings reported to the Southeastern U.S. Marine Mammal Stranding Network from 1978 through 1987 by species and by year. Each animal in a mass stranding or herd sighting is totaled separately.

Species	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	Total
Balaenoptera acutorostrata	0	1	0	1	0	0	0	0	0	1	3
Balaenoptera edeni	2	0	0	0	0	1	0	1	1	1	6
Balaenoptera physalus	0	1	0	0	2	0	1	0	0	1	5
Balaenoptera sp.	1	0	0	0	0	0	0	0	0	1	2
Megaptera novaeangliae (sightings)	0	0	0	1	1	3	0	2	3	0	10
Unknown balaenopterid	0	0	0	0	0	0	0	0	1	0	1
Eubalaena glacialis (sightings)	0	1	0	3	7	6	11	3	3	6	40
Feresa attenuata	1	0	1	3	4	7	0	0	0	0	16
Grampus griseus	0	0	3	3	6	3	7	4	2	2	30
Globicephala macrorhynchus	3	7	4	2	1	2	0	11	32	30	92
Globicephala melaena	0	0	0	0	1	0	0	0	0	0	1
Kogia breviceps	18	20	10	25	23	38	24	27	23	16	224
Kogia simus	4	2	5	4	4	3	11	10	4	3	50
Kogia?	0	0	0	0	0	2	0	0	1	1	4
Physeter catodon	2	0	12	0	4	5	1	7	4	4	39
Physeter?	0	0	0	0	1	0	0	0	0	0	1
Lagenodelphis hosei	0	0	0	17	0	0	0	0	0	0	17
Mesoplodon bidens	0	0	0	0	0	0	1	0	0	0	1
Mesoplodon densirostris	0	0	0	1	0	0	2	1	1	0	5
Mesoplodon europaeus	4	1	2	4	3	2	2	2	2	2	24
Mesoplodon mirus	0	0	0	0	0	0	1	0	0	0	1
Mesoplodon sp.	1	0	0	0	0	0	0	1	1	0	3
Ziphius cavirostris	2	1	2	3	2	1	2	1	5	2	21
Unknown ziphiid	0	0	0	0	2	0	0	0	0	0	2
Orcinus orca (sightings)	0	1	0	0	4	0	0	16	0	3	24
Phocoena phocoena	0	0	0	0	1	0	2	1	1	7	12
Pseudorca crassidens	0	0	0	0	1	1	0	0	28	8	38
Stenella attenuata	0	0	0	0	0	5	0	2	0	2	9
Stenella clymene	0	0	0	0	0	10	3	50	3	3	69
Stenella coeruleoalba	2	1	1	2	1	1	0	7	1	1	17
Stenella frontalis	5	1	2	5	2	10	1	1	4	4	35
Stenella longirostris	1	0	0	0	0	1	1	2	1	1	7
Stenella?	0	0	0	0	2	6	3	2	2	4	19
Steno bredanensis	0	1	6	0	0	0	0	1	1	3	12
Steno?	0	0	0	0	0	0	0	0	1	0	1
Tursiops truncatus	51	32	56	79	117	120	171	144	247	455	1472
Tursiops?	0	0	0	0	3	0	6	1	9	16	35
Unknown delphinid	0	0	0	0	2	1	4	6	1	8	22
Unknown odontocete	0	0	0	0	0	0	0	0	0	2	2
Unknown cetacean	0	0	0	2	0	0	5	1	1	0	9
Totals	97	70	104	155	194	228	259	304	383	587	2381

strandings are handled by the several marine zoological parks in the southeast because of the specialized equipment, training, and facilities required.

Network participants are provided with standard cetacean stranding report forms (Level A data; *see* Hofman 1991) and necropsy sheets (a subset of Level B and C data as reported by Hofman 1991). The Letter of Authorization requires that the Level A data sheet be completed for each stranded animal examined and returned to the SEUS scientific coordinator (DKO). Records are tabulated electronically and forwarded to the Smithsonian Institution's Marine Mammal Events Program for entry into the nationwide stranding database. Participation in the network is voluntary and the nature and extent of the examination of stranded animals depends to a large extent on the resources available to the individual participants. Subregional stranding networks (e.g., Texas) have been established in states that have a large number of strandings. Each participant is encouraged to work with local law enforcement agencies to respond quickly to strandings in order to maximize the amount of data gathered. While some participants have, from time to time, obtained short-term funding for stranding operations, SEUS operations as a whole have not received any long-term funding.

Table 2
Summary of cetacean strandings and sightings reported to the Southeastern U.S. Marine Mammal Stranding Network from 1978 through 1987, including Puerto Rico (PR) and the U.S. Virgin Islands (VI).

	State										
	AL	FL	GA	LA	MS	NC	PR	SC	TX	VI	Totals
1987	7	210	21	23	18	100	2	47	157	2	587
1986	0	162	11	11	24	39	3	3	130	0	383
1985	2	109	6	49	17	42	1	3	76	0	305
1984	5	78	19	7	6	44	0	3	95	0	257
1983	0	109	19	0	14	27	0	7	51	0	227
1982	1	120	16	0	1	15	0	6	36	0	195
1981	1	88	20	0	6	13	1	6	19	1	155
1980	0	86	7	0	2	2	0	1	6	0	104
1979	0	52	7	0	6	0	0	6	0	0	71
1978	0	67	17	2	9	0	0	2	0	0	97
Totals	16	1081	143	92	103	282	7	84	570	3	2381

It is important to remember that the data presented herein are based on reports submitted to the network scientific coordinator and that species identifications were not always verified from photos, morphometrics, or meristics. The vast majority of the identifications are probably correct but the data should be viewed with some caution.

Results and Discussion

During ten years of operation the SEUS Stranding Network logged 2381 records, including sightings of 40 right whales (*Balaena mysticetus*), 10 humpback whales (*Megaptera novaeangliae*) and 24 killer whales (*Orcinus orca*). There were 21 mass strandings, and each individual animal was counted separately in reaching the above total. These 2381 events included 5 species of baleen whales and at least 23 species of odontocetes (Table 1). Three stranded hooded seals (*Cystophora cristata*) were also reported. The most common singly-stranded species was the bottlenose dolphin (*Tursiops truncatus*) with 1472 records, followed by the pygmy sperm whale (*Kogia breviceps*) with 224 records (Table 1). The high number of *Tursiops* strandings in 1987 (455, Table 1) reflects the dieoff that started in New Jersey in June 1987 (*see* U.S. Marine Mammal Commission 1988) and reached Florida in late November.

Mass strandings included short-finned pilot whale (*Globicephala macrorhynchus*) (4 stranding events); short-snouted spinner dolphin (*Stenella clymene*) (3); Risso's dolphin (*Grampus griseus*) (3); pygmy killer whale (*Feresa attenuata*) (3); false killer whale (*Pseudorca crassidens*) (2); rough-toothed dolphin (*Steno bredanensis*) (2); spotted dolphin (*Stenella attenuata*) (1); striped dolphin (*Stenella coeruleoalba*) (1); sperm whale (*Physeter catodon*) (1); and Fraser's dolphin (*Lagenodelphis hosei*) (3) (Hersh and Odell 1986). Of these 21 mass strandings, 17 occurred in Florida, 2 in Louisiana, 1 in Texas, and 1 in North Carolina.

Florida had 1081 events followed by Texas with 570 (Table 2). The number of events recorded in a particular state is related both to the amount of coastline and the level of effort which, unfortunately, cannot be measured. Over the decade covered in this review, the Florida component of the stranding network has probably been the most active, based on the number of strandings reported (Tables 2 and 3). Florida records are detailed in Table 3 to give some idea of the wealth of biological information that can be gathered. With few exceptions (e.g., Hersh and Odell 1986; Hersh 1987; Hersh et al. 1990; Barros 1987; Barros and Odell 1990; King 1987; Carvan 1987, 1988; Credle 1987, 1988; Bossart et al. 1985; Carballeira et al. 1987, a and b), the bulk of the information gathered in Florida from 1978–1987 is not available in any published format and the few publications are very recent. While a number of papers are "in prep.," it will be some time before all of the data have been properly analyzed.

We do not have an assessment of the actual cost of operating the stranding network. However, during a census of captive marine mammals in North America (Asper et al. 1988), those aquaria and marine zoological parks active in marine mammal stranding programs estimated that they responded to about 850 live strandings/year at an estimated cost of one million dollars per year (D. Duffield, Portland State Univ., Portland, OR 97207, pers. commun. 1988). Most of these strandings were pinnipeds (about 700/yr). Many of these institutions also respond to and examine dead beached animals. It is clear that the oceanarium community is a significant component in the nationwide stranding program.

Table 3
Summary of cetacean strandings and sightings reported in Florida from 1978 through 1987 by species by year.

Species	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	Total
Balaenoptera acutorostrata	0	1	0	1	0	0	0	0	0	0	2
Balaenoptera edeni	1	0	0	0	0	0	0	0	0	1	2
Balaenoptera physalus	0	1	0	0	0	0	0	0	0	0	1
Balaenoptera sp.	0	0	0	0	0	0	0	0	0	1	1
Megaptera novaeangliae (sightings)	0	0	0	0	0	2	0	1	0	0	3
Unknown balaenopterid	0	0	0	0	0	0	0	0	1	0	1
Eubalaena glacialis (sightings)	0	1	0	0	3	4	3	3	3	6	23
Feresa attenuata	1	0	1	3	2	3	0	0	0	0	10
Grampus griseus	0	0	3	1	6	1	4	3	1	2	21
Globicephala macrorhynchus	0	7	4	2	1	0	0	7	32	30	83
Kogia breviceps	13	14	8	13	16	24	13	19	18	13	151
Kogia simus	2	2	5	3	2	3	10	5	3	3	38
Physeter catodon	2	0	12	0	2	2	0	4	2	0	24
Lagenodelphis hosei	0	0	0	17	0	0	0	0	0	0	17
Mesoplodon bidens	0	0	0	0	0	0	1	0	0	0	1
Mesoplodon densirostris	0	0	0	0	0	0	1	0	0	0	1
Mesoplodon europaeus	4	1	1	2	0	2	0	2	1	1	14
Mesoplodon sp.	0	0	0	0	0	0	0	0	1	0	1
Ziphius cavirostis	2	1	2	1	2	1	0	1	3	2	15
Orcinus orca (sightings)	0	1	0	0	4	0	0	0	0	0	5
Phocoena phocoena	0	0	0	0	0	0	1	1	0	0	2
Pseudorca crassidens	0	0	0	0	1	1	0	0	28	0	30
Stenella attenuata	0	0	0	0	0	5	0	2	0	2	9
Stenella clymene	0	0	0	0	0	10	0	0	0	2	12
Stenella coeruleoalba	2	1	1	2	0	0	0	7	0	1	14
Stenella frontalis	4	1	2	0	2	6	0	0	1	4	20
Stenella longirostris	1	0	0	0	0	1	0	2	0	0	4
Steno bredanensis	0	1	6	0	0	0	0	0	0	3	10
Tursiops truncatus	35	20	41	43	73	44	40	45	63	127	531
Tursiops?	0	0	0	0	6	0	4	2	5	5	22
Unknown delphinid	0	0	0	0	0	0	0	4	0	5	9
Unknown odontocete	0	0	0	0	0	0	0	0	0	2	2
Unknown cetacean	0	0	0	0	0	0	1	1	0	0	2
Totals	67	52	86	88	120	109	78	109	162	210	1081

The potential of stranding networks for gathering vast amounts of data on cetaceans is clear. There is, however, considerable room for improvement. Record keeping has progressed from file cards to computer databases but these records are only as good as the data reported to the network. Some areas of the southeast are incompletely covered (Louisiana, Mississippi, Florida panhandle, the Carolinas), reflecting the lack of volunteers in these areas and, more often, the limitations of volunteerism. While improvements can and will be made with electronic data transfer, the key to improving data collection begins on the beach. More emphasis must be placed on confirmation of species identification through photographs, tooth counts, etc., and the collection of minimal data and samples from each specimen (e.g. teeth, stomach contents, gonads, length, sex). This can often be accomplished with minimal training but, in the end, requires dedication on the part of the volunteer.

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The California Marine Mammal Stranding Network, 1972–1987: Implementation, Status, Recent Events, and Goals

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ABSTRACT

Animals found stranded on California beaches have been of interest to scientists and the general public for many years. In 1980, the National Marine Fisheries Service (NMFS) took a lead role to organize a state-wide network designed to coordinate the response to cetacean, pinniped, and sea turtle stranding events. Response typically flows through 3 tiers: 1) the public report strandings to 2) cooperators (state or local officials) who contact 3) participants (museum affiliates or rehabilitation centers) who examine or otherwise handle the stranded animal. Reports of strandings are submitted to the NMFS on a monthly basis. From 1982 to 1987, 483 cetacean strandings were reported (annual $\bar{x}$ = 80); species reported most frequently include harbor porpoise *Phocoena phocoena*); common dolphin (*Delphinus delphis*); gray whale (*Eschrichtius robustus*); Pacific white-sided dolphin (*Lagenorhynchus obliquidens*); and bottlenose dolphin (*Tursiops truncatus*). Between 346 and 2286 pinnipeds were reported annually from 1983 to 1987 (annual $\bar{x}$ = 883). While there are limitations on their uses, these data are useful to managers as an early warning system for anomalous events in the wild (e.g., fishery related mortality and epizootics). Pinniped rehabilitation centers authorized by the NMFS provide care to hundreds of sick or injured animals each year. A preliminary analysis of the fate of released pinnipeds indicates they are being assimilated into wild populations and are not contributing to marine mammal–human interactions.

Introduction

Stranded marine mammals have been of public and scientific interest for many years in California (Cope 1869; Dall 1873). Many universities, museums, and other institutions have collected and studied stranded animals largely on a local basis since the late 1940's and early 1950's (Hubbs 1946; Orr 1953). Of the U.S. institutions that house large marine mammal collections (>150 specimens), 8 of 20 are located in California (Hansen et al. 1979) and much of their material was obtained from strandings. Despite this interest, it was not until early 1973, following passage of the Marine Mammal Protection Act of 1972 (MMPA), that a statewide approach was implemented to coordinate responses to, and the collection of data from, marine mammal stranding events on the California coast. This paper reviews the evolution, organization, and information flow of the California Marine Mammal Stranding Network (CMMSN). This review summarizes information reported by the CMMSN, discusses the value of such a program, and identifies mechanisms which may facilitate achieving CMMSN goals. While this paper focuses on marine mammal stranding events, it also applies to the relatively rare occurrence of sea turtle strandings. Because there are no sea turtle breeding beaches located in California, sea turtle strandings are viewed as events of interest and have been incorporated within network consideration.

Evolution of the CMMSN

Prior to 1973, regionally focused scientific institutions, educational units, and public aquaria investigated and responded to marine mammal stranding events in Califor-

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**Present address: Kenai National Wildlife Refuge, 2139 Ski Hill Road, Soldotna, AK 99669.

nia. Some organizations had acquired written authorization from, or cooperated with, the California Department of Fish and Game (CDFG). The degree to which an organization coordinated response activities with other institutions varied with curatorial interest and availability; it generally was provincial in nature. Record keeping and quality varied over time within many institutions. Data collected were neither standardized among organizations nor collected on a statewide basis.

The National Marine Fisheries Service (NMFS) became involved with management of California marine mammal stranding events shortly after the passage of the MMPA in late 1972. In March, 1973, the NMFS contracted with the CDFG to assist in the enforcement of MMPA regulations. This included investigation of marine mammal stranding events and the collection of data through the existing framework of CDFG marine wardens.

At the first marine mammal stranding workshop held in Athens, Georgia, in 1977, Nitta (1979) proposed that a more formalized California network be established to coordinate stranding responses better and to facilitate data collection and analysis. Owing to an increasing frequency of stranding related inquiries, the NMFS, Southwest Regional office (SWR) conducted an informal review of the stranding program in 1981. This review found that many stranded animals were not examined, reports were not being filed with the CDFG or the NMFS, some institutions were operating without written authority, and that many organizations were not coordinating or cooperating with similar groups within close geographic areas. In order to rectify these problems and to ensure valuable data were not lost, the SWR began a program to reorganize the network. Letters of Authorization were issued, the Marine Mammal and Marine Turtle Data Record was revised, and the existence of federally authorized institutions that were available to respond to stranding events was publicized. We began by developing the following network goals:

- to establish a mechanism ensuring that a legal, coordinated, and appropriate response is made to stranding events;
- to coordinate mechanisms for the treatment of live stranded animals and to monitor their ultimate disposition;
- to collect basic scientific information from stranded animals;
- to analyze these data and to use them to monitor the frequency of stranding events; and
- to disseminate this information for scientific and public purposes so that marine mammal populations may be better understood and managed.

For the purposes of this regional network the following definition was developed to identify a "stranding event":

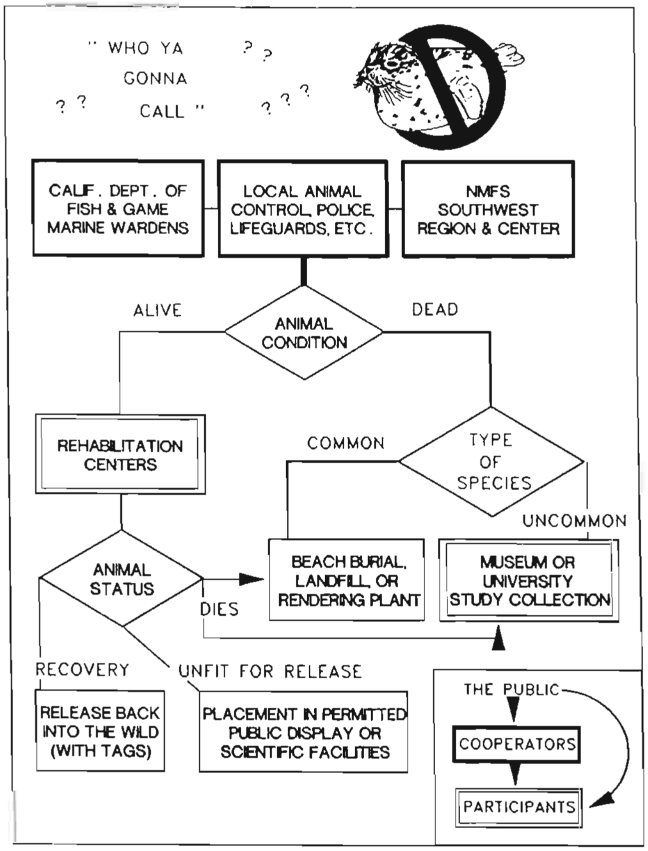

Figure 1
Schematic of the CMMSN response process for a stranded marine animal. Inset shows organizational designations used in text.

> Any *dead* marine mammal on a beach or floating nearshore is considered to be "stranded." A live marine mammal out of its element is considered to be "stranded." Therefore, any *live cetacean* on the beach is considered to be "stranded." Aside from regular haulout or breeding sites, *live pinnipeds* that haulout on mainland California beaches subject to frequent or habitual human use are considered to be "stranded." Pinnipeds hauled out in more remote areas require a 24-48 hour observation period before they are considered to be "stranded." This allows an animal time to rest and to return to the sea on its own. Pinnipeds on offshore islands are considered to be in their element and despite any obvious physical disability and are *not* considered to be "stranded."

Current Network Organization

The CMMSN is organized along a three-tiered system consisting of the public, cooperators, and participants (Fig. 1, inset). A member of the public encountering a stranded animal on the beach would likely contact a "cooperator" in the CMMSN. This category encompasses over 150 local,

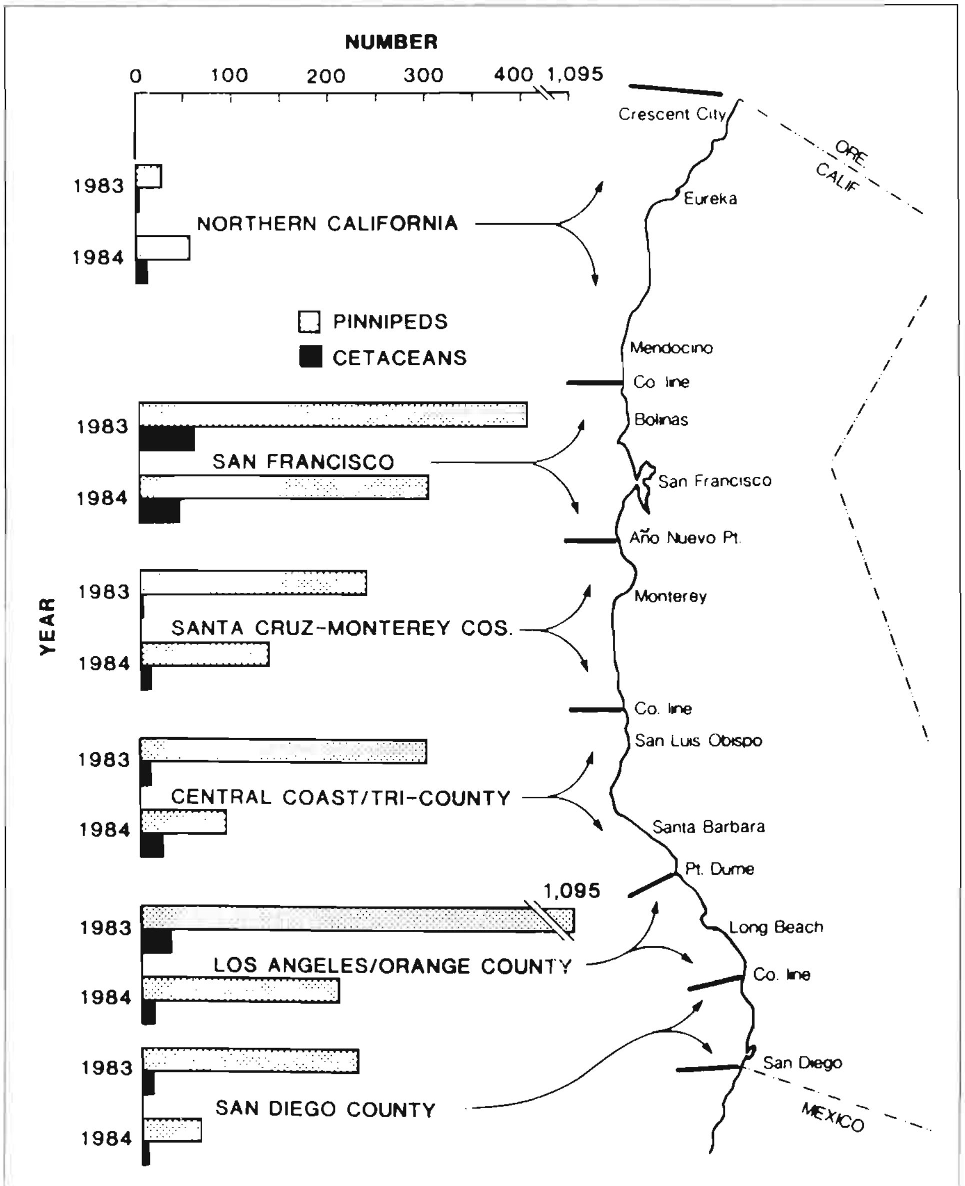

Figure 2
Geographic subdivisions of the CMMSN and the distribution of strandings during 1983 and 1984.

state, and Federal units responsible for beach front management, including: life guards, city animal control, county beach maintenance, police, state marine wardens, park rangers, and harbor patrol units. Authorization for cooperators to do something with the animal (e.g., burial of dead pinnipeds, or transport of live animals requiring treatment) is granted by 50 CFR 216.22, a regulation that has been interpreted to allow state and local officials to take a "stranded" marine mammal humanely in the course of their normal duties for the welfare of either the marine mammal or the public. In cases where some additional response is indicated, or long-term animal care is desirable, the cooperator contacts a "participant." Participants include both scientific and educational institutions responding to dead animals and rehabilitation centers responding to live animals. Participants are delegated under NMFS authority to "take" a stranded animal via a Letter of Authorization (LOA) issued by the Regional Director, SWR. These LOA's have terms and conditions that are consistent with Federal regulations. Currently there are seven rehabilitation centers (with one more anticipated) and 15 scientific institutions covered by LOA's.

The response to an event can be complicated, especially when it involves transfers between various types of organizations. The path leading to a response often is viewed as particularly confusing by observers responding to a stranding event for the first time (Fig. 1). In order to clarify network organization and to facilitate responses, the CMMSN is divided into six geographic sections (Fig. 2). Meetings were held initially from 1981 to 1982 in each section by the NMFS Coordinator to discuss network organization and the responsibilities and roles of members. Additional workshops were held in some sections in 1986 and 1987. A Network Directory was prepared in 1982 and was updated in 1987. It outlines appropriate responses by listing instructions, responsibilities, and the names and addresses of network members by each section and by species of interest.

Responsibilities of CMMSN members include an agreement to operate within stated geographic areas, to cooperate with agencies having ownership or jurisdiction for beach-front property, to submit reports concerning stranding events to the NMFS Regional Coordinator on a monthly basis, and for rehabilitation centers to tag rehabilitated animals prior to their release back into the wild.

Stranding Reports

Historically, records of strandings have been maintained by a number of active scientists. A number of papers discussing California stranding events or considering important biological aspects of a stranded animal have been published in scientific journals. Despite the high level and value of marine mammal research on stranded animals in California (relative to many other coastal regions in the United States), the scope of many publications has been narrow and has not described trends in strandings for any sizable stretch of the coast. Nonetheless, the stranding reports submitted by scientists provide an excellent marine mammal data base for many species found in California waters.

Beginning in 1973, James Mead of the Smithsonian Institution began to collect and organize stranding data for the east coast of the United States. Dr. Mead melded this work into the Smithsonian Institution's Scientific Event Alert Network (SEAN) in 1975. This program strived to collect reports of stranded cetaceans throughout the world using a standardized monthly report system. A few California institutions sent reports of cetacean strandings to SEAN during these early years.

The submission of stranding reports to the NMFS evolved out of our first attempt to use stranding data for agency management purposes. A Marine Mammal Data Record was developed in 1973 by the CDFG with input from SWR management. Data were collected on the CDFG form through the end of 1981. This information remains archived in SWR files but has not been entered into a computer managed database (automated) or analyzed. The NMFS issued a new report form in 1981 to reflect the change in network organization, the need for additional information, and the goal to move toward a nationally consistent database by incorporating many of the attributes of the SEAN program and the recommendations of the first Stranding Workshop. This form was simplified in 1987 to facilitate use by a diverse group of reporters having a wide degree of biological training and entry into a automated database for analysis. Some basic information is required (''Level A'' data; *see* Geraci and St. Aubin 1979; Hofman 1991); space also is provided for ''requested'' (''Level B'') data and investigators are encouraged to attach additional data sheets (for ''Level C'' data) if they so desire. Levels B and C data are considered proprietary; they are not distributed or used in publications without consent of the reporting source.

Reports are required whenever a cooperator or participant does anything with a stranded animal (e.g. buries, relocates, disposes, or collects) and are submitted to the Coordinator by the tenth of the month following the event.*** Amendments to reports, such as releases of rehabilitated animals or changes in the ultimate disposition of specimens, are reported in subsequent months. The database comprised of these reports includes cetaceans, pinnipeds, and sea turtles; sea otter reports go directly to the CDFG. Cetacean records are forwarded to the Marine Mammal Events Program at the Smithsonian Institution (this program superseded the SEAN program in 1982) for dissemination to the interested scientific community. Information on sea turtle strandings is collected also, but since sea turtles are infrequent visitors to the California coast (about 6 strand/yr), these data are not routinely automated or analyzed.

California Stranding Events

Overview of Results and Analyses

A diversity of marine animals strand on California's coast and there is wide variation in annual frequency by species. For example, between 346 and 2286 pinnipeds (annual $\bar{x}$ = 883, S.D. = 721), 54 and 117 cetaceans (annual $\bar{x}$ = 80, S.D. = 26), and 3 and 8 sea turtles were reported by the CMMSN in any one year. Since 1982, at least 23 species of cetaceans have been reported to strand (Table 1). The most frequently reported stranded cetaceans include harbor porpoise (*Phocoena phocoena*); common dolphin (*Delphinus delphis*); gray whale (*Eschrichtius robustus*); Pacific white-sided dolphin (*Lagenorhynchus obliquidens*); and bottlenose dolphin (*Tursiops truncatus*). All six species of pinnipeds occurring off the California coast have been reported to strand (Table 2). California sea lions (*Zalophus californianus*); harbor seals (*Phoca vitulina*); and northern elephant seals (*Mirounga angustirostris*) are reported most frequently; also of note are two strandings of the Guadalupe fur seal (*Arctocephalus townsendi*) constituting the northernmost

***This requirement has been difficult to enforce in a few areas. For example, some life guards and beach maintenance crews within areas of Los Angeles and San Diego counties that experience frequent pinniped strandings routinely bury carcasses without submitting stranding reports. Thus we discuss *reported* numbers and *indices* of events and *not* absolute stranding rates or cycles.

Table 1

Cetaceans stranded in California as reported to the NMFS by the CMMSN, 1982-1987, in order of overall frequency of occurrence.

Common names	Scientific names	1982[a]	1983[b]	1984[b]	1985[a]	1986[a]	1987[a]
Harbor porpoise	*Phocoena phocoena*	27	50	42	27	18	14
Common dolphin	*Delphinus delphis*	6	13	23	20	15	15
Gray whale	*Eschrichtius robustus*	8	8	13	13	6	23
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	5	8	8	5	1	5
Bottlenose dolphin	*Tursiops truncatus*	1	9	4	6	5	5
Dall's porpoise	*Phocoenoides dalli*	—	1	3	—	1	3
Cuvier's beaked whale	*Ziphius cavirostris*	—	2	2	1	—	—
Pygmy sperm whale	*Kogia breviceps*	—	1	3	1	—	—
Sperm whale	*Physeter catodon*	—	2	2	—	1	—
Striped dolphin	*Stenella coeruleoalba*	1	3	—	—	2	—
Blue whale	*Balaenoptera musculus*	—	—	1	—	2	1
Hubbs beaked whale	*Mesoplodon carlhubbsi*	1	—	1	—	1	—
Minke whale	*Balaenoptera acutorostrata*	1	1	1	—	—	—
Rough toothed dolphin	*Steno bredanensis*	1	2	—	—	—	—
Blainville's beaked whale	*Mesoplodon densirostris*	—	—	1	1	—	—
Fin whale	*Balaenoptera physalus*	—	1	—	—	1	—
Short-finned pilot whale	*Globicephala macrorhynchus*	—	1	—	—	—	1
Humpback whale	*Megaptera novaeangliae*	—	2	—	—	—	—
Bryde's whale	*Balaenoptera edeni*	1	—	—	—	—	—
Dwarf sperm whale	*Kogia simus*	—	—	—	—	—	1
Killer whale	*Orcinus orca*	—	—	—	1	—	—
Risso's dolphin	*Grampus griseus*	—	—	—	1	—	—
Spinner dolphin	*Stenella longirostris*	—	1	—	—	—	—
Unidentified balaenopterid		—	—	—	—	2	—
Unidentified dolphin		1	—	—	—	—	1
Unidentified small whale		1	—	—	—	—	—
Unidentified beaked whale		—	—	1	1	—	—
Unidentified cetaceans		—	12	3	—	3	—
Year total		54	117	108	77	58	69

[a]Reports in NMFS, Southwest Region files.
[b]Seagars et al. 1986.

Table 2

Pinnipeds stranded in California and reported to the NMFS by the CMMSN (Sources: 1983-84 data—Seagars et al. 1986; 1985-87 data—NMFS, Southwest Region, Terminal Island, CA files).

	Year				
Species	1983	1984	1985	1986	1987
Z. californianus	1750	624	260	191	211
M. angustirostris	241	99	94	201	79
P. vitulina	232	103	64	90	47
C. ursinus	19	2	6	1	3
E. jubatus	10	8	8	3	5
A. townsendi	0	1	0	0	0
Unidentified	34	13	12	7	1
Total	2286	850	444	493	346

records for the species (Webber and Roletto 1987). From 1983 to 1987, sea turtle strandings included twelve leatherback (*Dermochelys coracea*), eight green (*Chelonia mydas*), three Pacific ridley (*Lepidochelys olivacea*), one loggerhead (*Caretta caretta*), and 3 unidentified sea turtles. Records of unidentified animals from all three groups are not uncommon because of carcass condition or observer unfamiliarity.

In 1985, CMMSN data were examined in an assessment of their utility for NMFS management purposes. This assessment considered all stranding records for the 1983-84 two year period (Seagars et al. 1986) and concluded that CMMSN data can be used as an index of anomalous events (such as fishery related mortality) useful to management as an early warning system. For example, commercial fishermen may be authorized to "take" marine mammals under certain conditions and this take may lead to some of the observed strandings. In 1983 and 1984, significantly higher numbers of harbor porpoises were reported to strand than in previous years (Table 1). These strandings occurred in months and locations where a considerable expansion in the gill net fishery was in progress (Table 3). Although

Table 3

Strandings of *Phocoena phocoena* reported by the CMMSN during 1983 and 1984 (Source: Seagars et al. 1986).

A. Division by county

County of Stranding	1983	1984	Total
Del Norte	0	2	2
Humboldt	2	4	6
Mendocino	0	0	0
Sonoma	0	1	1
Marin	13	12	25
Solano	0	0	0
San Francisco	2	10	12
Contra Costa	0	0	0
San Joaquin	0	0	0
Alameda	0	0	0
Santa Clara	0	0	0
San Mateo	30	8	38
Santa Cruz	1	4	4
Monterey	0	0	0
San Luis Obispo	1	1	2
Santa Barbara	1	0	1
Ventura	0	0	0
Los Angeles	0	0	0
Orange	0	0	0
San Diego	0	0	0
Total	50	42	92

B. Division by month

Month of Stranding	1983	1984	Total
January	0	0	0
February	0	1	1
March	1	1	2
April	1	1	2
May	0	1	1
June	0	1	1
July	8	8	16
August	11	24	35
September	21	1	22
October	6	3	9
November	1	1	2
December	1	0	1
Total	50	42	92

C. Type of stranding occurrence

	1983		1984	
Category	*N*	%	*N*	%
Stranding cause unknown	34	68.0	19	45.2
Human related	0	0.0	1	2.4
Human related—shot	2	4.0	0	0.0
Human related—shot?	0	0.0	1	2.4
Incidental catch—gillnet	4	8.0	19	45.2
Incidental catch—gillnet?	10	20.0	2	4.8
Total	50	100.0	42	100.0

the specific cause of a stranding frequently was not, or could not, be determined, both direct evidence (net material present, well defined net marks, etc.) or indirect evidence (cleanly severed flukes, presumed "drowning" or, more accurately, suffocation of an otherwise healthy individual) pointed to a strong correlation between the reported increase of harbor porpoise strandings and incidental mortality in this fishery. The agencies responsible for marine mammal (NMFS) and fisheries (CDFG) management responded to the stranding data by initiating surveys of the harbor porpoise population (Dohl 1984; Barlow 1987, a and b; Oliver and Jackson 1987), more closely monitoring levels of incidental take (Diamond and Hanan 1986; Hanan et al. 1986, 1987), and implementing changes in fishery management designed to reduce the mortality through seasonal and area closures.

There are limitations to the use of CMMSN stranding data for management purposes. It is not possible to use these data to estimate total mortality of marine mammals in a coastal fishery, or to assess the effect of such mortality on a population, because reporting of events is incomplete and the proportion of the deceased animals that strand is affected by a variety of environmental and anthropogenic factors that may never be known with certainty. Furthermore, data from the stranding records of the CMMSN are insufficient to characterize the structure of fishery related mortality because 1) the sample size is typically small; 2) age and sex descriptions are often listed as "unknown"; and 3) reported ages are assigned to a rather arbitrary set of classes which are based on a subjective determination made by observers having diverse backgrounds in marine mammal biology.

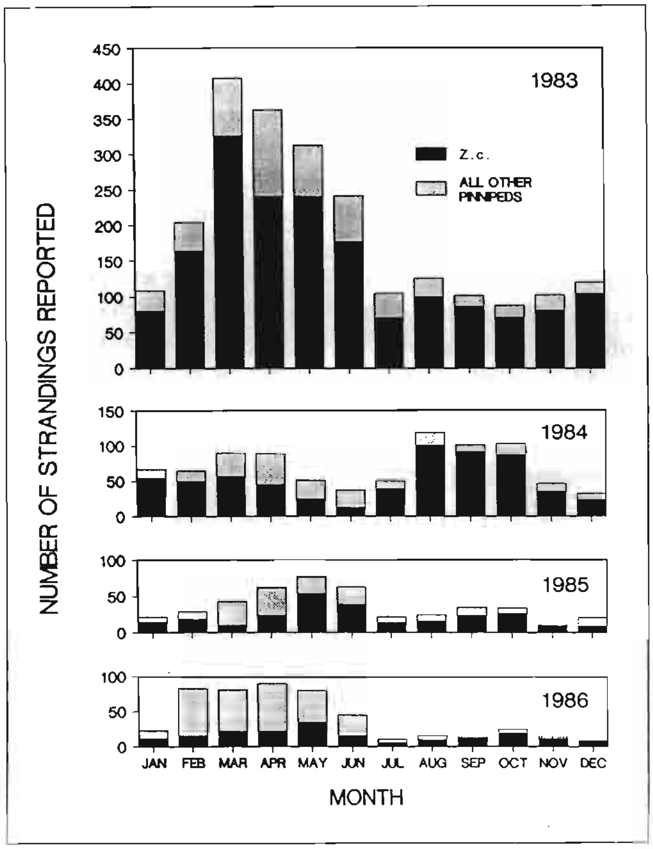

Figure 3
Frequency of pinniped strandings reported by the CMMSN for the years 1983–1986 (Data for 1983–84 from Seagars et al. 1986; for 1985–86 from NMFS, SWR, Terminal Island, CA files).

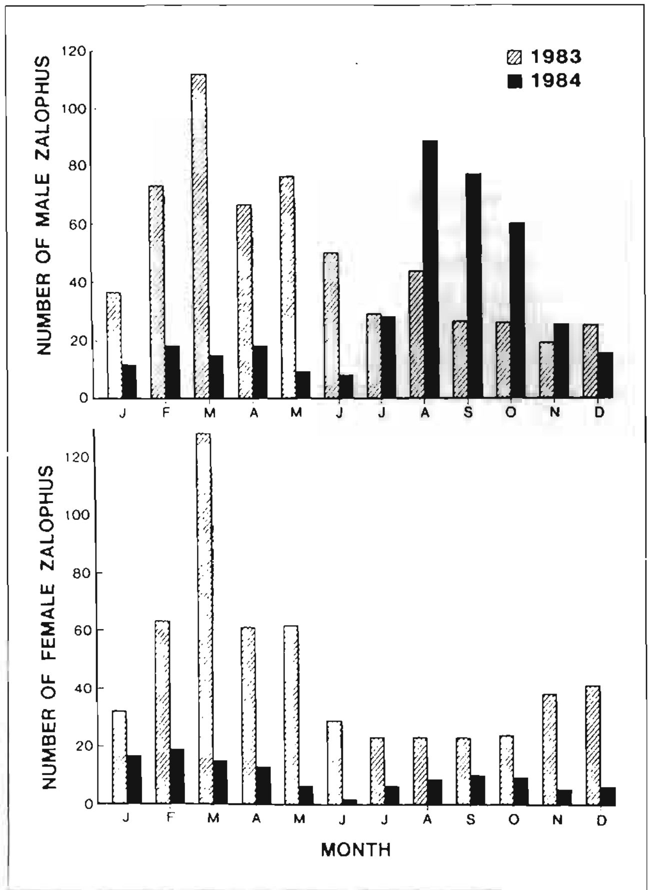

Figure 4
Frequency of male and female *Z. californianus* strandings for the years 1983 and 1984 (Source: Seagars et al. 1986).

Seagars et al. (1986) also found that CMMSN data reflect trends in stranding events that can be related to environmental conditions and are sufficiently detailed to relate to regional occurrences of disease. For example, seasonal peaks in pinniped strandings coincide with periods of winter storms and spring winds when large numbers of young pinnipeds are overwintering pelagically (seasonal peaks, Fig. 3). Annual variations in the magnitude of strandings can be related to annual climatological differences; stranding rates during the severe "El Niño" winter of 1982–83 were an order of magnitude higher than in the successively milder winters of following years (compare magnitude between years, Fig. 3). By examining the records closely for detailed information, such as veterinary findings, the late 1984 peak in *Z. californianus* strandings (Fig. 3B) can be related to an increase in male sea lions stranding in northern California with leptospirosis (Fig. 4, Dierauf et al. 1985).

Each spring numerous harbor seal pups are picked up by well-meaning, but uninformed, citizens from semi-isolated beaches used as rookeries; these animals often are taken to animal shelters for treatment. While perinatal complications are one of the more common natural causes of neonate harbor seal strandings during this period (Dierauf and Dougherty 1983), many of these "stranding" events are of healthy newborn animals. The SWR now issues an annual press release prior to harbor seal pupping season to alert the public and animal control agencies of the need to stay away from newborn pups. Many network members distribute this release within their sections. This is a prime example of how the Network can play an educational role to increase public awareness and protect marine mammals.

Live Stranded Pinnipeds and Rehabilitation Programs

The rehabilitation of live stranded animals occurs through volunteer efforts of private rehabilitation centers authorized by the NMFS. Under veterinary guidance, these centers treat stranded animals and arrange for their release back to the sea when determined appropriate. All rehabilitated animals are required to be tagged prior to release with tags provided by the NMFS. Individuals that have been stabilized but are determined by a veterinarian to be unreleasable because of continuing medical or behavioral problems, become candidates for permanent placement at public display or research facilities. All such requests under the MMPA for California pinniped species have been fulfilled with rehabilitation center animals since 1980. The Network Coordinator may help to locate placement for these dependent animals, initiate correspondence necessary to authorize transfer for research or display, or otherwise facilitate the placement or use of these individuals.

The fate of rehabilitated and released pinnipeds recently has been assessed by examining resight records of the tagged and released animals (Seagars 1988). This analysis was considered to be preliminary because the rate of tag loss was unknown, resight effort was uneven throughout the study area, and most released animals were from younger age classes which reduce the resight probability because higher mortality rates occur in these classes and because most field work emphasizes counts during breeding seasons on rookeries where younger animals may not be present. Given these limitations, the analysis concluded that 1) most released rehabilitated pinnipeds are not restranding (dead or alive) and appear to be returning to wild populations; 2) pinniped rehabilitation programs are not contributing to detectable increases in marine mammal-fishery interactions; 3) animals from rehabilitation center programs are not contributing significantly to population growth since they comprise <0.1% of any species' population. The tagging program is likely to continue for the foreseeable future to address these identified limitations and to continue monitoring the fate of released animals.

Summary and Future Goals

By establishing this network and coordinating the activities of many largely volunteer individuals and organizations, additional understanding of the biology of these animals has been possible, both at the individual and population level. This expansion has benefited scientific knowledge and management programs. Our review of the CMMSN data found that these records can be viewed as an *index* of events in the wild and that management can use them as an early warning system for developing timely responses where appropriate. While most of the issues of concern to the NMFS revolve around the population levels of pinnipeds and cetaceans, aspects of the biology of these species are so poorly known that any single stranding may be an event of significant zoological interest. Many of the details of anatomy, physiology, and life history of marine mammals have been determined by careful, detailed study of a very few stranded animals.

Because of these benefits, the NMFS expects to continue coordination of the CMMSN and the collection, analysis, and dissemination of stranding data. It may be possible to improve the quantity and quality of the data submitted by increasing contact with CMMSN cooperators and participants. We propose this be accomplished by increasing "feedback" through circulation of informational materials, more frequent and wider dissemination of data analyses and reports, and publication of the existence and purposes of the CMMSN through the media and other channels as appropriate. Requests for CMMSN data summaries should be made in writing to Stranding Coordinator, Southwest Region, National Marine Fisheries Service, 300 S. Ferry St., Terminal Island, CA, 97031. The CMMSN Directory will be periodically revised and redistributed. Development of educational materials may assist species identification. Future analyses will be facilitated by automating both archived and incoming data. Many of these proposals are in the preliminary stages of implementation.

Acknowledgments

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Overview of the Northwest Region Marine Mammal Stranding Network, 1977–1987

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ABSTRACT

The Northwest Marine Mammal Stranding Network was developed to investigate and respond to reports of beached and stranded marine mammals on the coastal and inland waters of Washington and Oregon. The Northwest Network is composed of scientific investigators and resource management agencies that cooperate with the National Marine Fisheries Service, Northwest Regional Office. Over 3000 stranded marine mammals representing 25 species have been reported in Washington and Oregon from 1977–1987. Noteworthy events handled by Network personnel include the mass stranding of 41 sperm whales (*Physeter catodon*) near Florence, Oregon in 1979; a stranding episode involving over 40 northern fur seals (*Callorhinus ursinus*) along the Northwest coast over a three-week period in the spring of 1980; an outbreak of leptospirosis in California sea lions (*Zalophus californianus*) in 1984; and the rare appearance of a pod of false killer whales (*Pseudorca crassidens*) in Puget Sound in 1987. The establishment of the Northwest Marine Mammal Stranding Network has enhanced coordinated, systematic responses on marine mammal strandings and provides an early alert system on problems that may be affecting marine mammals and other species whether they be naturally occurring or manmade.

Introduction

The Northwest Marine Mammal Stranding Network was developed to investigate reports of beached and stranded marine mammals on the coastal and inland waters of Washington and Oregon. The Stranding Network is composed of cooperating scientific investigators and academic institutions, volunteer individuals and organizations, veterinarians, resource and land management agencies, and enforcement agencies. Network participants, who are experienced and knowledgeable in the methods of handling beached and stranded marine mammals, volunteer either to respond directly or to provide expert advice on handling a stranding incident. Network participants are authorized by the National Marine Fisheries Service (NMFS) to investigate strandings of live or dead marine mammals, collect biological information and research material from these animals, assist in the disposal of carcasses or deposition of skeletons and other specimen material into bona-fide scientific collections, and aid in the humane care and treatment of live or sick animals. Investigations on stranded marine mammals provide information on food habits, incidence of disease, and reproductive biology in many coastal species. Data collected contribute to baseline ecological information that can be used to monitor changes in coastal marine ecosystems.

Background

Marine mammal strandings have been investigated in the Northwest on an opportunistic basis for many years. Prior to the first marine mammal stranding workshop in 1977 in Athens, Georgia (Geraci and St. Aubin 1979), institutions such as Oregon State University Marine Science Center in Newport, Oregon, the University of Puget Sound in Tacoma, Washington, and the NMFS Science Center in Seattle, Washington, were involved with recovering marine mammal specimens for biological investigations and museum accessions. Tag Gornall of the Marine Animal Resource Center (a nonprofit volunteer organization), the Seattle Aquarium, and other coastal aquariums and veterinarians recovered and attempted to rehabilitate distressed marine mammals, especially harbor seal pups. As a result of the 1977 workshop, an informal "Marine Mammal Alert Network" was formed, Bruce Mate of

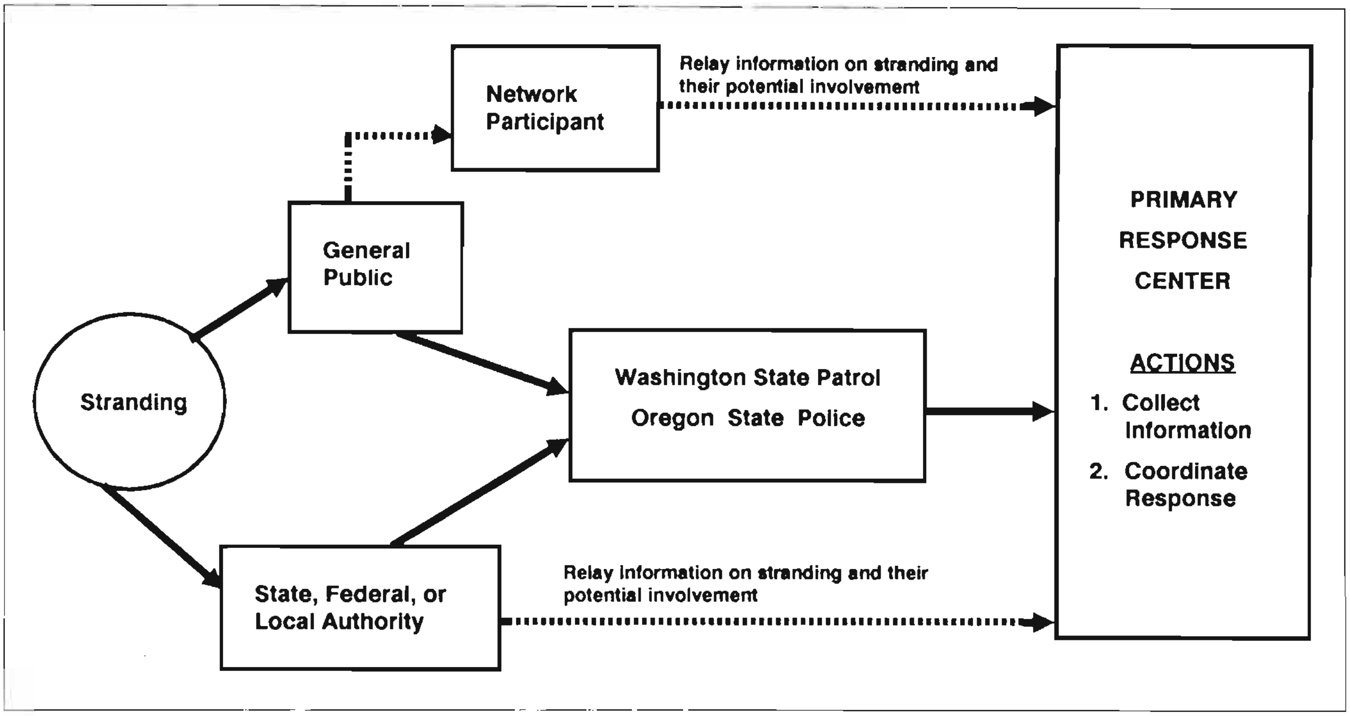

Figure 1
Northwest Marine Mammal Stranding Network Notification Procedure.

Oregon State University taking the lead in Oregon and Tag Gornall taking the lead in Washington. This informal network operated on an ad-hoc basis in consultation with law enforcement agents from the Oregon Department of Fish and Wildlife (ODFW), the Washington Department of Game (renamed Department of Wildlife in 1987) and the NMFS. This "informal" arrangement continued until 1982 when the NMFS-Northwest Regional Office established the current Northwest Marine Mammal Stranding Network.

The NMFS effort to formalize the "Alert Network" was initiated in 1981 to ensure that marine mammal stranding responses were coordinated coastwide and that a coastwide standardized protocol was established for investigations and disposition of animals and specimen material. Although the informal organization of interested network volunteers in Washington and Oregon was functioning relatively well, there was a need to establish a regional focal point for network communications and to develop a regional data file on both the stranded animals and the specimen material collected from those animals. In addition, 1981 marked the end of NMFS marine mammal enforcement contracts with the States of Washington and Oregon which included responsibility for stranded animals, thereby leaving a void in direct state involvement in strandings.

The NMFS-Northwest Regional Office established the Northwest Marine Mammal Stranding Network in early 1982 after convening a meeting of Northwest entities that had previously been involved with stranded marine mammals. State wildlife and land management agencies, law enforcement entities, major academic institutions, and other volunteer researchers and veterinarians were represented at the meeting. The Oregon State Parks, which is responsible for most of the beaches of Oregon, was in the process of developing a statewide disposal policy for dead marine mammals and the network meeting ensured acknowledgment of the scientific interest in strandings and the need for a policy to provide for scientific investigations prior to disposal of carcasses. The meeting resulted in development of a coastwide notification procedure whereby all strandings would be reported to the respective state enforcement agency (Washington State Patrol or Oregon State Police), who would then relay the stranding information to the appropriate network response center (Fig. 1). All entities agreed that NMFS should take the lead in overall network coordination and that the Northwest region should be divided into major geographic areas, each having a primary response center. Each primary response center would receive all reports on strandings in a designated geographic area and would be responsible for determining the appropriate stranding response in coordination with other network participants.

The Northwest Marine Mammal Stranding Network operates under the authority of Section 109 of the Marine Mammal Protection Act of 1972 (MMPA) which provides for 1) the protection and welfare of marine mammals;

2) the protection of public health and welfare (in regard to marine mammals); and 3) the return of the marine mammal to its natural environment. The Northwest Marine Mammal Stranding Network does not just operate under this legal authority but actually enhances administration of the MMPA and thus benefits the marine mammals under each of the three aspects of this legal authority as follows:

1. Provides for the protection and welfare of marine mammals by
   a. assisting Federal agencies in enforcement of laws which contribute to the protection and perpetuation of marine mammals;
   b. collecting biological information to better understand and thereby protect and manage marine mammals more effectively;
   c. informing and educating the public on marine mammals to promote a better understanding that will minimize potentially detrimental human interactions; and
   d. removing disabled marine mammals from areas where people may harm or harass the animals.

2. Provides for the protection of the public health and welfare by
   a. removing dead or diseased animals from public areas;
   b. preventing the transmission of disease from sick or dead marine mammals to people or domestic animals;
   c. removing live marine mammals from public areas where the animals could injure people who approach them; and
   d. investigating the stranding of marine mammals as they may be an indicator of circumstances (such as pollution, ocean dumping, or natural phenomena [e.g., dinoflagellate blooms]) that also may be detrimental to humans or their food resources, including fish.

3. Provides for the return of the marine mammal to its natural habitat when feasible by
   a. ensuring that the animals are handled only by experienced people;
   b. ensuring that the animal is given appropriate care and, if moved to a holding facility, that such facility is operated solely for the animal's well-being and ultimate return to the wild;
   c. collecting biological information on the animals to develop better methods and procedures for providing adequate care and rehabilitation; and
   d. educating the public on marine mammals so that human activities will not preclude live animals from being returned to their natural habitat.

Current Network Protocol

The National Marine Fisheries Service, Northwest Regional Office is the overall network coordinator. The NMFS Regional Marine Mammal Coordinator maintains the Network Directory and Handbook (National Marine Fisheries Service/Northwest Region 1984), maintains lists of authorized network participants, registers specimen materials, receives stranding reports, maintains the regional data file, submits summarized stranding information to the Smithsonian Institution and other requesting entities, convenes periodic meetings of network participants, and acts as a clearinghouse for network communications, specimen requests, etc.

The Network is currently divided into five geographic areas, each having a primary response center and backup response groups that are authorized to take the lead in coordinating an appropriate response to each stranded animal report in their area. Table 1 shows the primary response centers and the area coordinators for each of the five areas as of 1 December 1987. The area coordinators are responsible for ensuring that the procedures set forth in the Network Handbook and Directory (National Marine Fisheries Service/Northwest Region 1984) are followed by network participants. Network participants are required to submit a written report to NMFS-Northwest Regional Office within 30 days of each stranding investigation.

Each primary response center, upon receiving a report of a stranded animal from the state patrol/police, contacts the initial reporting party and obtains all information on the stranding. This information is maintained in a permanent record and copies of this information are periodically submitted to the NMFS regional data file. The area coordinator for the response center determines the appropriate course of action for each reported stranding. Response choices consist of 1) a direct response, 2) an indirect response, or 3) no response.

A direct response occurs when the area coordinator determines that a scientific investigation of the reported stranding is warranted. The area coordinator takes the lead in arranging an on-site investigation. This includes notifying appropriate authorities, such as law enforcement entities and other network personnel who may want to participate in the investigation or who are interested in collecting specimen material.

An indirect response occurs when the primary response center relays the stranding information and responsibility for response coordination to another stranding network entity. One very common situation occurs when the area coordinator relays information on the stranding to other network participants who may be in closer proximity to the stranding location or who have expressed a specific interest in conducting an on-site investigation or recovery of the involved species. If a live, but distressed animal is involved, the area coordinator may notify network

Table 1
Primary response centers for each of the five geographic areas in the Northwest Region.

Geographic area	Primary response center	Area coordinator
Washington		
Inland waters; Puget Sound and Straints of Juan de Fuca	Marine Animal Resource Center (MARC), Seattle, WA	Tag Gornall, MARC
Coastal waters north of Willipa Bay	Washington State Department of Wildlife (WDW), Tacoma, WA	Steve Jeffries, WDW
Washington/Oregon		
Willipa Bay, WA to Tillamook Bay, OR	Portland State University (PSU) Portland, OR	Debbie Duffield, PSU
Oregon		
Central Coast	Oregon State Department of Fish and Wildlife (ODFW) Newport, OR	Robin Brown, ODFW
Southern Coast	University of Oregon, Institute of Marine Biology (OIMB) Charleston, OR	Jan Hodder, OIMB

entities that can assist in retrieving the animal and request they transport it to a scientific investigator or to a veterinarian or rehabilitation center. If the stranding is in a remote area, the coordinator may request assistance from the reporting party or others in obtaining basic morphological information on the stranding (in these cases the carcass is left on the beach). If the stranding reported is a live animal of questionable status, the response center may advise that the animal be left on the beach and observed for at least 24–48 hours. Subsequent notification would be requested from the reporting party if the animal shows obvious signs of distress or if it remains on the beach after 24–48 hours.

In some situations, the area coordinator may be unable to dispatch a response team or may determine that a response is not necessary. In these "no response" situations, the coordinator advises the initial reporting party of the decision not to respond and advises on disposal of the stranding (if dead) or advises people to stay away from the animal (if alive). The decision not to respond is usually due to the remote or inaccessible location of the stranding, a badly decomposed carcass in a distant location, or the determination that a live-stranded animal that is perceived to be sick or injured, is actually likely to be healthy. If there are potential enforcement problems such as harassment of live animals or unauthorized removal of parts from a carcass, the area coordinator also will notify appropriate enforcement entities.

Network participants routinely collect specimen material from stranded marine mammals. This specimen material is subsequently registered to the network participant by NMFS. Most material is tissue samples collected for research purposes, although a number of entire skeletons (especially cetaceans) are collected and catalogued into museum collections each year. MMPA research permits are not required for network participants to collect specimen material from stranded marine mammals. However, in order to authorize the possession of such material under the MMPA and enhance the exchange and transfer of such material for research, the NMFS-Northwest Region has registered all specimen material collected by network participants.

Network Accomplishments

Over 3000 stranded marine mammals representing 25 species have been reported in Washington and Oregon from 1977 through 1987 (Table 2). These reports represent almost all of the marine mammal species recorded for Northwest waters. The only species previously recorded in Northwest waters that were not reported as strandings during this period are the right whale (*Balaena glacialis*) (Scammon 1874); the sei whale (*Balaenoptera borealis*) (Scheffer and Slipp 1948); the Baird's beaked whale (*Berardius bairdii*) (Everitt et al. 1980); the beluga whale (*Delphinapterus leucas*) (Scheffer and Slipp 1948); the rough-toothed dolphin (*Steno bredanensis*) (a 1972 stranding in Washington examined by Ken Balcomb); and the bottlenose dolphin (*Tursiops truncatus*) (Ferrero and Tsunoda 1989).

Pinnipeds have accounted for almost ninety percent of the reported strandings in each of the past years. This occurrence is not surprising because pinnipeds are commonly encountered in the Northwest and frequently interact with human activities, such as fishing. The principal marine mammal species found stranded on the beaches of the Northwest is the harbor seal (*Phoca vitulina*). This is to be expected since *P. vitulina* is the most frequently encountered marine mammal in the Northwest. Also, because harbor

Table 2
Marine mammal strandings reported in the Northwest Region, 1977–1987.

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	Total
Harbor seal, *Phoca vitulina*	92	99	48	88	95	68	114	310	230	207	147	1498
California sea lion, *Zalophus californianus*	19	10	6	27	34	7	33	170	48	28	45	427
Northern sea lion, *Eumetopias jubatus*	10	7	5	15	16	5	16	16	11	5	8	114
Northern elephant seal, *Mirounga angustirostris*	2	4	4	7	1	5	11	8	12	12	9	75
Northern fur seal, *Callorhinus ursinus*	4	6	0	53	4	2	7	4	4	1	2	87
Harbor porpoise, *Phocoena phocoena*	3	1	7	9	13	14	8	16	22	15	33	141
Dall's porpoise, *Phocoenoides dalli*	0	2	2	3	5	4	4	4	2	5	1	32
Pacific whitesided dolphin, *Lagenorhynchus obliquidens*	1	2	0	2	1	5	5	4	0	2	0	22
Common dolphin, *Delphinus delphis*	0	0	0	0	0	0	1	0	1	0	0	2
Striped dolphin, *Stenella coeruleoalba*	0	0	0	1	0	1	0	0	0	0	1	3
Northern right whale dolphin, *Lissodelphis borealis*	0	0	0	2	1	0	0	0	0	0	0	3
Pygmy sperm whale, *Kogia breviceps*	1	0	0	1	0	0	0	1	1	0	0	4
Risso's dolphin, *Grampus griseus*	0	0	0	0	0	0	0	0	1	0	1	2
Pilot whale, *Globicephala macrorhynchus*	1	0	0	1	0	0	0	0	0	0	0	2
False killer whale, *Pseudorca crassidens*	0	0	0	0	0	0	0	1	0	0	1	2
Killer whale, *Orcinus orca*	1	0	0	0	0	0	1	0	0	0	1	3
Cuvier's beaked whale, *Ziphius cavirostris*	0	0	2	1	0	1	2	1	0	2	2	11
Bering Sea beaked whale, *Mesoplodon stejnegeri*	0	0	1	1	1	0	0	1	0	3	0	7
Arch-beaked whale, *Mesoplodon carlhubbsi*	0	0	0	0	1	0	0	0	0	0	0	1
Gray whale, *Eschrichtius robustus*	6	3	3	8	11	2	14	16	2	4	12	81
Humpback whale, *Megaptera novaeangliae*	0	1	0	1	0	0	0	0	0	0	0	2
Sperm whale, *Physeter catodon*	1	0	43	0	0	2	0	0	1	1	0	48
Minke whale, *Balaenoptera acutorostrata*	0	0	0	5	1	1	0	1	2	2	1	13
Fin whale, *Balaenoptera physalus*	0	0	0	0	0	0	0	0	0	1	0	1
Blue whale, *Balaenoptera musculus*	0	0	0	1	0	0	0	0	0	0	0	1
Unidentified sea lion	57	42	17	4	0	6	11	311	67	38	74	627
Unidentified pinniped	22	0	0	3	7	4	0	29	75	48	63	251
Unidentified small cetacean	4	2	2	0	1	0	0	0	2	1	3	15
Unidentified large cetacean	2	0	0	0	0	1	0	0	0	2	1	6
Total	226	179	140	233	192	128	227	893	481	377	405	3481

Note: Data for 1983–1987 was obtained from the NMFS Regional Stranding Network files. The pre-1983 data were obtained from the Smithsonian Institution's Scientific Event Alert Network data file, published reports (Beach et al. 1985; Calambokidis et al. 1984; Everitt et al. 1980; Calambokidis et al. 1978), museum marine mammal catalogs from Oregon Institute of Marine Biology and University of Puget Sound, and data files from Steve Jeffries, WDW; Tag Gornall, MARC; Robin Brown, ODFW; Larry Tsunoda, NMML; and John Rozdilsky, University of Washington-Burke Museum.

seals breed in both inland and coastal areas of the Northwest, some of the natural juvenile mortality of this species is included in the reported strandings. The next most frequently reported stranded animals are sea lions. Although there are two species of sea lions that occur in the Northwest, many of the strandings reported by the public or local enforcement entities do not specify which species. However, the California sea lion (*Zalophus californianus*) is reported more frequently than the northern sea lion (*Eumetopias jubatus*), and it is likely that *Z. californianus* may account for the majority of the "unidentified sea lions" shown in Table 2. The third most frequently occurring stranded species is the harbor porpoise (*Phocoena phocoena*). As this species is neither frequently sighted at sea nor commonly involved in human/fisheries interactions, the high incidence of strandings cannot be explained. As little is known about this species in the Northwest, the long-term data base from stranding incidences is beneficial in better understanding the life history of this species.

The incidence of strandings of other species has varied considerably among years. Natural phenomena such as the 1983/84 El Niño phenomena may have influenced the distribution of stranded animals as well as the "deposit" of carcasses on the beaches owing to changes in currents. The increased number of stranded gray whales in the Northwest in 1983 and 1984 (Table 2) may have been related to the El Niño phenomena rather than to biological or environmental conditions such as increased pollutants.

Vessel collisions with marine mammals also have contributed to the stranded animal data base. The single strandings recorded since 1977 of a blue whale (*Balaenoptera musculus*) in October 1980 and a fin whale (*Balaenoptera physalus*) in April 1986 were a result of large vessels "delivering" the carcasses to docks in Seattle and Tacoma respectively. Otherwise, there are no recent records of these species stranded on the beaches of the Northwest. Some of the more noteworthy marine mammal stranding episodes that have occurred since 1977 in the Northwest are summarized below.

Mass Stranding of Sperm Whales (1979)—The only mass stranding of cetaceans in recent years in the Northwest was the stranding of forty-one live sperm whales (*Physeter catodon*) near Florence, Oregon on 16 June 1979. The stranding attracted so much public attention that the Oregon State Police were forced to close access roads, yet hundreds of people still hiked to the site. Efforts by some to push or tow the whales back to sea proved futile. By 17 June, all of the whales had died. The stranded school consisted of 28 females, ranging in size from 9.3 to 11.4 m, and 13 males, ranging in size from 9.3 to 11.5 m (Rice et al. 1986). Bruce Mate of Oregon State University coordinated and organized the "Alert Network" response by various research teams. Numerous state, federal, and local governmental agencies were instrumental in providing security, crowd control, and disposal of the carcasses.

Northern Fur Seal Stranding Episode (1980)—Over 40 northern fur seals (*Callorhinus ursinus*) were stranded on the northern Oregon and southern/central Washington coast over a three-week period in spring 1980. Most of the seals were females that came ashore exhibiting symptoms of respiratory and central nervous system disorders. In addition, there were two male *C. ursinus* and one male California sea lion (*Zalophus californianus*) that stranded under similar circumstances during this period. A total of 35 live pinnipeds exhibiting these symptoms were recovered and treated primarily by Tag Gornall and volunteers in the Marine Animal Resource Center. Eight female *C. ursinus* survived and six of them were tagged and released back to sea. One of the females, released on 18 May on the Washington coast, was sighted in a breeding colony on the Pribilof Islands on 5 August 1980 (Keyes and Scordino 1981). An exact cause for this stranding episode was not conclusively determined.

California Sea Lion - Leptospirosis (1984)—A dramatic increase in strandings of California sea lions (*Zalophus californianus*), noted by Northwest network participants commencing in August 1984, was attributed to an outbreak of leptospirosis. Network participants received a number of reports of sick, lethargic sea lions on the outer coast from August through December 1984. Researchers examined over 100 California sea lions during this period; however many others were not examined and were recorded as unidentified sea lions (Table 2). Leptospirosis was diagnosed in a number of freshly dead animals both in the Northwest and in California. A joint meeting of the Northwest and California stranding network participants was convened in October 1984 to discuss the outbreak of leptospirosis and to coordinate further research efforts coastwide. Owing to public safety concerns for people approaching these sick animals and possibly contracting the disease, state and local agencies were alerted to the problem by network participants and NMFS distributed press releases coastwide.

Pseudorca In Puget Sound (1987)—A reported live stranding of a pilot whale in southern Puget Sound on 5 May 1987 turned out to be a false killer whale (*Pseudorca crassidens*), an extremely rare visitor to Washington inland waters. The only other known occurrence of this species in Puget Sound was on 15 May 1937 (Scheffer and Slipp 1948). The single stranding was from a pod of 18 to 20 false killer whales that was first sighted in April but not identified as *P. crassidens* until 4 May. Because this species has been reported in mass live stranding episodes in other areas, there was concern for a mass stranding especially since the animals were in the confined inland waters. Contingency plans for a mass stranding were developed and a communication network on the location of the pod was established using participants in the Northwest stranding network. The pod was last sighted in Puget Sound in early July 1987. No further strandings of this species occurred in Puget Sound; however, a live *P. crassidens* was reported beached and released at Ucluelet on Vancouver Island, B.C. on 28 July 1987 (Baird et al. 1988).

Pollutant Research (1984)—The Cascadia Research Collective (CRC), Olympia, WA, actively collected tissue samples from dead marine mammals in Puget Sound from October 1983 to January 1985 during a study to determine if detrimental effects of pollutants could be detected in marine mammals. The target species was harbor seals (*Phoca vitulina*). CRC researchers regularly searched harbor seal haul-out areas for carcasses, as well as responded to stranded animals reported to the Northwest Stranding Network. During the study period, the CRC researchers recovered 150 marine mammals, of which 139 were harbor seals (Calambokidis et al. 1985). The majority of the specimens were recovered during haul-out searches, and consisted primarily of dead seal pups. One interesting aspect of the results is that the researchers did not find a high incidence of biological disorders at those sites with suspected high contaminant levels, but surprisingly, found a higher incidence of disorders at sites with lower contaminant levels (Calambokidis et al. 1985).

Incidental Takes in Fisheries (1980–1982)—The Washington Department of Game (currently Department of Wildlife) undertook an intensive stranded marine mammal recovery program in the Columbia River and adjacent areas as part of a marine mammal/fisheries interaction study. The purpose of the study was to assess the nature and extent of seal/sea lion conflicts with the salmon gillnet fisheries in the Columbia River, Willipa Bay, and Grays Harbor. The stranded animal investigations provided food habit information, baseline data on natural mortality, and information on the marine mammals taken incidentally in the fisheries. The researchers performed gross necropsies on 101 of the 238 specimens recovered from March 1980 to August 1982. Over 85 of the recovered animals were pinnipeds, mostly harbor seals, whose primary cause of mortality was attributed to interactions with the salmon gillnet fishery (Beach et al. 1985). The numbers of stranded marine mammals reported in this area declined dramatically when the active recovery efforts terminated at the end of the study.

Live Cetaceans Taken Into Captivity (1977–1987)—Only a few stranded cetaceans have been recovered and taken live to captivity for rehabilitation. Very few of these survived more than a few days in captivity. One such example is a baby sperm whale (*Physeter catodon*) that was recovered in northern Oregon in September 1979 and was transferred to the Seattle Aquarium under the care of Tag Gornall. This animal died a few days later from congenital defects.

Two porpoises that did survive for extended periods of time are worth mentioning. One was a Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) that was rescued from southern Puget Sound in 1983 and taken to Point Defiance Zoo and Aquarium. This dolphin lived in captivity for almost three years before it died. The other was a newborn harbor porpoise (*Phocoena phocoena*) from Seaside, Oregon, that was taken to Point Defiance Zoo and Aquarium in 1987 where it survived for over three months.

Seal Pups (1977–1987)—Harbor seal pups are the source of an unending problem in the Northwest because people perceive that solitary seal pups must be "abandoned" and must be rescued. Network participants are very active every year from March through September responding to telephone calls and advising people not to touch or disturb these pups that may appear to be abandoned. In many cases, if left alone, the pup may reunite with its mother. However, pups appearing in high public use areas may need to be picked up by Network personnel to prevent them from being handled and harassed by the public. The Northwest Stranding Network policy is to leave seal pups undisturbed for a minimum of 24–48 hours before any action is taken unless there are extenuating circumstances such as repeated handling.

Twenty-five to forty seal pups were delivered to network veterinarians and rehabilitation centers each year from 1983 to 1986. Rehabilitation efforts have ranged from a high of 52% released alive in 1983 to a low of 29% in 1986. Resights of rehabilitated seals are uncommon although a few are reported (Harvey et al. 1983). Network participants are continuously involved in an effort to educate the public on the seal pup issue. The NMFS distributes press releases on this issue every year. The NMFS also has attempted to bring this problem to the public's attention in other publications such as the annual reports to Congress on the Marine Mammal Protection Act (U.S. Dep. Commerce 1984).

Discussion

Investigations of reported marine mammal strandings have increased since the late 1970's primarily because of the existence of the Regional Stranding Network. The Network not only has provided a mechanism for reporting strandings but also has increased public awareness on the need to report such incidences. Such increased reporting has enhanced development of an all-inclusive regional data base on strandings. It should be noted that the numbers of marine mammal strandings reported in the years prior to 1983 may be underrepresented in Table 2 because data records on uninvestigated strandings were not routinely kept. In 1983, NMFS began maintaining a regional data record and requested that network participants submit records of all reported marine mammal strandings, including those not investigated. However there have been instances where such records were not kept routinely in recent years, so there are additional uninvestigated strandings (especially pinnipeds) that are not reflected in Table 2.

Although the existence of the stranding network has enhanced reporting of beached and stranded marine mammals, there is still a need to enhance onsite scientific investigations. Many of the reported strandings are not investigated because of lack of resources for network participants. Most cetacean strandings are investigated whereas the majority of the pinniped strandings are not investigated unless a specific research program is underway that emphasizes recovery of stranded animals. Examples of such programs include the fishery interaction studies in 1980–1982 and the pollutant studies in 1984. Uninvestigated strandings usually involve reports of harbor seals or "seals" (recorded as unidentified pinnipeds in Table 2) that are not examined because of the lack of network resources in personnel, logistical support, and funds necessary for travel expenses. Unfortunately, this creates gaps in the data base as well as compromises the rapport that network participants have developed with locals and entities who routinely report strandings fully expecting network participants to conduct an onsite investigation.

Baseline data collected by network participants are maintained at the NMFS Regional Office in Seattle and copies are routinely provided to other entities requesting such information. For example, cetacean records are provided quarterly to the Smithsonian Institution and annually to the International Whaling Commission. The inclusion of regional cetacean stranding data in the Smithsonian's data base allows for coastwide analysis of stranding incidences and provides indicators to potential trends or developing problems. One of the principal benefits of maintaining long-term data files on strandings is the ability to determine changing trends or "abnormal" situations that may indicate the potential occurrence of problems for certain species. For example, the increase in California sea lion strandings due to leptospirosis in 1984 would not have been easily detected had there not been a long term data file on strandings.

Conclusion

The establishment of the Northwest Marine Mammal Stranding Network has enhanced coordinated, systematic responses to marine mammal strandings coastwide. The Stranding Network has benefitted researchers by enhancing exchange of specimen material, expertise, supplies, and information. It has benefitted the animals by promoting public awareness and providing a mechanism for obtaining life-history information to understand and protect the species better. The network also provides an early alert system on problems that may be affecting a species, including both naturally occurring (such as the leptospirosis outbreak) and human related (such as fisheries or pollutant mortality) factors.

Acknowledgments

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A History of Marine Mammal Stranding Networks in Alaska, with Notes on the Distribution of the Most Commonly Stranded Cetacean Species, 1975–1987

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ABSTRACT

Since the mid-1950s there have been several attempts to establish marine mammal stranding networks in Alaska, or to systematically survey large areas of the coastline for stranded animals. It was not until 1985, however, that a centralized Federal stranding network, similar to those established throughout the rest of the United States, was created in Alaska. In the three years of its existence, this network has more than doubled the number of cetacean strandings reported to the Smithsonian Institution. Additional effort is planned to make Alaska residents more familiar with the network.

Since the Smithsonian Institution began compiling reports on stranded cetaceans in 1975, eleven species of cetaceans have been found in Alaska seven or more times. Stranded gray whales (*Eschrichtius robustus*) have been reported most commonly (127 reports). Other frequently reported species include beluga whales (*Delphinapterus leucas*) (56 reports); Stejneger's beaked whales (*Mesoplodon stejnegeri*) (29 reports); killer whales (*Orcinus orca*) (20 reports); Cuvier's beaked whales (*Ziphius cavirostris*) (19 reports); minke whales (*Balaenoptera acutorostrata*) (19 reports); bowhead whales (*Balaena mysticetus*) (11 reports); humpback whales (*Megaptera novaeangliae*) (9 reports); sperm whales (*Physeter macrocephalus*) (9 reports); Baird's beaked whales (*Berardius bairdii*) (8 reports); and fin whales (*Balaenoptera physalus*) (7 reports).

Introduction

There have been several attempts to establish stranding networks or to systematically survey large coastal areas of Alaska for stranded marine mammals. During the 1950's, the Marine Mammal Committee of the American Society of Mammalogists established a national stranding program directed principally at cetaceans. That program was initiated in Alaska by Francis H. Fay, and his work represents the earliest attempt to coordinate a stranding network for that state. On an opportunistic basis, and without funding, Fay investigated stranded marine mammals from the mid 1950's through the early 1960's, at which time other responsibilities made it impossible for him to continue. In 1975, funding from the Outer Continental Shelf Environmental Assessment Program (OCSEAP) provided Fay an opportunity to reinitiate his work at sites adjacent to areas proposed for offshore oil exploration. From 1975 to 1978, he and his associates surveyed large areas of the Gulf of Alaska and Bering Sea coastlines to locate strandings and determine causes of death (Fay 1976; Fay et al. 1976, 1977, 1978, 1979b). During the late 1970's, National Marine Fisheries Service (NMFS) special agents in Alaska began investigating marine mammal strandings, especially those encountered while monitoring the Eskimo bowhead whale harvest. In Homer, the Homer Natural History Society (now the Pratt Museum) began to collect information on strandings in lower Cook Inlet. Throughout these years the Alaska Department of Fish and Game (ADF&G) continued, as they had for several years, to collect stranding information through an informal network of coastal inhabitants of the eastern Bering and Chukchi seas (Lowry et al. 1986). Handbooks (Schad 1978; Fay et al. 1979c) were printed and widely distributed in an attempt to raise public awareness of the need to identify and report stranded marine mammals.

In 1977 a workshop was held at the University of Georgia to consider how best to coordinate collection of information on strandings of marine mammals (Geraci and St. Aubin 1979). As a result of that workshop, it was anticipated that the NMFS would be "instrumental in coordinating regional efforts" to gather information on stranded marine mammals (Geraci and St. Aubin 1979). Indeed, soon after the workshop was completed, stranding networks were established in four of the five NMFS regions. A plan to establish a stranding network that would encompass the fifth region (Alaska) had been proposed at the workshop (Fay et al. 1979a). However, a lack of funding to implement that plan, and an expectation that the State of Alaska would soon request return of management authority for marine mammals, delayed progress toward establishment of a centralized State-wide network in Alaska for several years.

Funding for stranding studies was no longer available by the early 1980's.* Thus, there was little subsequent effort devoted to investigating stranded marine mammals until the NMFS established an Office of Marine Mammals and Endangered Species within its Alaska Region in 1984. This provided a new opportunity to create a centralized Federal stranding network for Alaska. Such a network was initiated early in 1985.

Methods

Successful operation of a stranding network in Alaska required solutions to several major problems. Foremost among these problems were the length of the Alaska coastline (54 560 km) and its remoteness from most human settlements or road systems. Fay, Dieterich, and Shults (1979) had recommended using resident State biologists who were already located in 18 coastal game management units. These biologists would become the primary source of stranding reports, gained both from their own observations and from those of other local residents. Compilation of information would be done at the University of Alaska branches in Fairbanks, Anchorage, and Juneau. By 1984 however, Fay, Dieterich, and Shults' plan had become untenable for political and financial reasons: The State had withdrawn from taking an active role in managing marine mammals, and the interested University of Alaska personnel had no internal support for a stranding program. Hence, NMFS managers were reluctant to ask State and University biologists to undertake major voluntary responsibilities for a system that probably would remain under Federal jurisdiction. Consequently, an alternative plan was developed for creating an Alaskan Marine Mammal Stranding Network that would be similar to those in the other two NMFS west coast regions.

The NMFS Southwest Region (California—*see* Seagars and Jozwiak 1991) and the NMFS Northwest Region (Oregon and Washington—*see* Scordino 1991) each have a designated Regional Network Coordinator who is responsible for overall administration of that region's network. Each region has been divided into several sections, and in some cases, a Primary Response Center (PRC) has been designated within each section. These PRC's are responsible for coordinating all network activity within their geographic area and for sending stranding data to the Regional Network Coordinator. Data on stranded marine mammals are compiled by the Regional Network Coordinator, computerized, and sent to the Marine Mammal Events Program at the Smithsonian Institution.

In Alaska the Chief of the Office of Marine Mammals and Endangered Species was designated to be the Regional Network Coordinator. The State was then divided into ten coastal areas with a PRC in each area. Responsibility for the 10 centers was divided among six agencies (NMFS; ADF&G; U.S. Fish and Wildlife Service (FWS); University of Alaska-Juneau; Alaska Department of Public Safety; and the North Slope Borough; Fig. 1). The Regional Coordinator supplied each center with an explanation of procedures to follow when investigating a stranding, and a set of reporting forms which had been printed by the Smithsonian Institution's Marine Mammal Events Program. The Regional Coordinator encouraged the PRC Coordinators to branch out into other villages and involve additional agencies and qualified individuals within their areas. In order to publicize the network, a press release describing the development and purpose of the network was sent to most of the larger newspapers, and to radio and television stations in the State. Eighty letters were sent to mayors, city managers, harbor masters, and flying services throughout coastal Alaska. The press releases and letters were individualized to identify which PRC should be contacted in each area.

The Smithsonian Institution's Marine Mammal Events Program focuses its interest on cetaceans rather than pinnipeds. Therefore, the Alaska network was publicized as a cetacean stranding network only. As in other NMFS regions however, participants in the Alaska stranding network were encouraged to investigate unusual strandings of pinnipeds.

Results

Stranded Cetaceans

Since 1975 the Smithsonian Institution has kept a computerized data base of cetacean strandings which have occurred in the United States. Of the 145 Alaskan cetacean

* In 1980 the United States Fish and Wildlife Service (FWS) surveyed the Alaskan coastline from Izembek Lagoon to Barrow looking for walrus carcasses. Only five stranded cetaceans were seen during this survey and none were identified to species. During the late 1970's the FWS carried out yearly surveys for stranded marine birds along the Gulf of Alaska and Bering Sea coastlines. Stranded marine mammals found during these surveys were reported to Francis Fay.

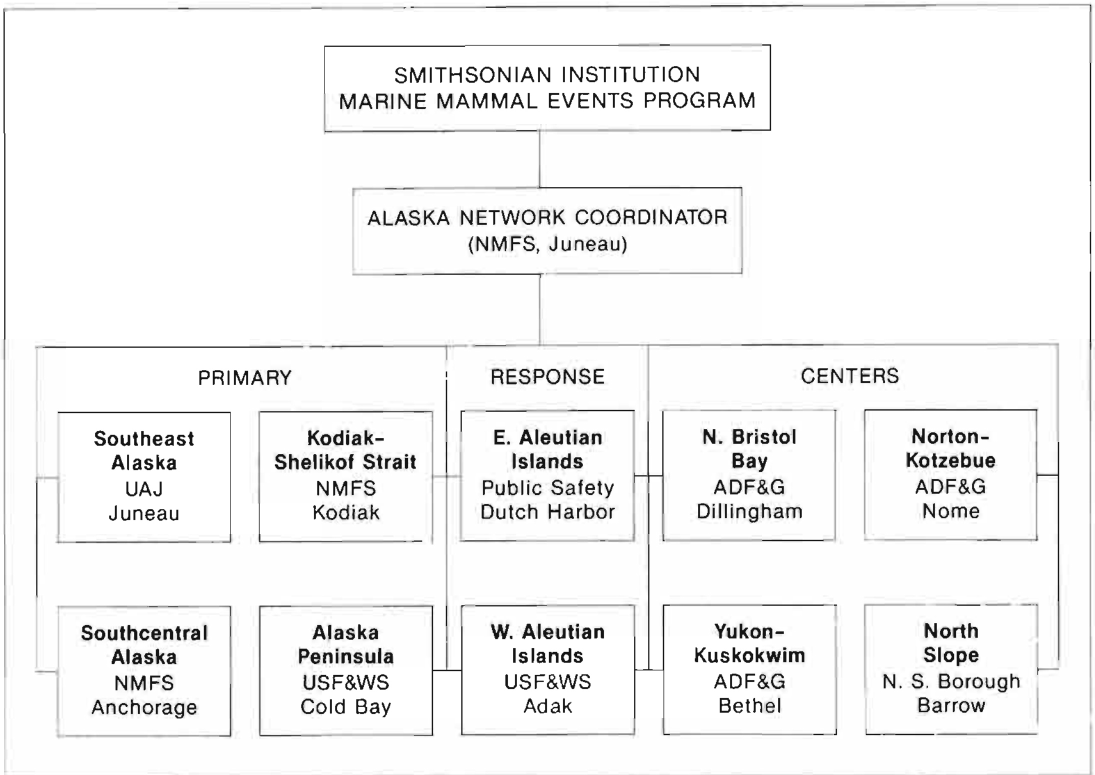

Figure 1
Flow chart for Marine Mammal Stranding data in Alaska.

sightings or strandings reported to the Smithsonian Institution from 1975 through 1987, 58 (40%) were submitted since the establishment of the NMFS Alaska network in 1985. This doubles the annual average number of cetaceans reported over the previous 10-year period when no network was in existence. Numbers and distributions of the most commonly reported stranded cetaceans found in Alaska since 1975 are discussed in the Appendix.

Entangled Cetaceans

Although cetaceans, most notably humpback whales (*Megaptera novaeangliae*), frequently entangle themselves in fishing gear in the western North Atlantic (Lien et al. 1987), such occurrences have been infrequently recorded in Alaska. Until the NMFS stranding network was established in 1985, no live entangled cetaceans had been reported to the Smithsonian Institution from Alaska, although conversations with fishermen indicated that cetacean entanglements do occasionally occur. Since establishment of the network, 15 entangled cetaceans in Alaska have been reported to the Smithsonian Institution. Of these, six (two humpback whales, two sperm whales (*Physeter catodon*), a harbor porpoise (*Phocoena phocoena*) and an unidentified porpoise) were found dead. The dead entangled sperm whales were found near Sitka in southeast Alaska and on Shemya Island in the western Aleutians. One of the dead entangled humpback whales was found near Perryville on the southern coast of the Alaska Peninsula; the other was killed in the salmon gillnet fishery near Haines in southeast Alaska. The dead entangled harbor porpoise was found in Cook Inlet and the unidentified entangled porpoise was found near the mouth of the Copper River. The other nine entangled animals (eight humpback whales and a gray whale [*Eschrichtius robustus*]) were alive when last observed. Seven of the live humpback whales and the gray whale were released from nets or other entangling debris by a variety of rescue efforts. The remaining humpback whale appeared to have freed itself. All of the live humpback entanglements occurred in southeastern Alaska. The entangled gray whale was found and freed by a fisherman in Chignik Lagoon on the western Alaska Peninsula.

Rehabilitation of Marine Mammals

Permits to rehabilitate seals have been given to the Alaska Zoo and to a private facility in Halibut Cove near Homer. From 1985 through 1987, 14 seals were sent to the Alaska Zoo, and 6 were sent to the Halibut Cove facility for rehabilitation. The animals required treatment for a variety of problems including disease, gunshot wounds, and loss of parental care. After stabilizing or rehabilitating the seals, the Alaska Zoo retained several for public display, sent some to aquaria elsewhere in the United States, and returned the rest to the wild. All animals treated at the facility in Halibut Cove were returned to the wild.

Permits

Establishment of the stranding network in Alaska also provided an opportunity to standardize the system under which permits or loan agreements are given to individuals or agencies who wish to keep marine mammal parts. Permits to keep the hard parts from dead, non-endangered species of marine mammals that are found within one-quarter mile of the ocean are issued under authority described in the Code of Federal Regulations (50 CFR 216.26). From 1985 through 1987, 57 such permits were issued by the Alaska stranding network.

Except for research activities, there is no authority under the law which allows individuals or institutions to collect any parts from an endangered species or any but the hard parts from a non-endangered species of marine mammal. Therefore, parts from endangered animals, or "soft" parts from non-endangered animals, can only be loaned to institutions or individuals, and title to the animals remains with the NMFS. From 1985 through 1987, eight loan agreements were written to allow collection of the skeletons of stranded whales or porpoises to preserve them for research or public display.

Discussion

Although the average number of stranded animals reported to the Smithsonian Institution each year has doubled since the establishment of the stranding network in Alaska in 1985, it is apparent that the network is not yet a familiar entity to most people in the State. Persons finding stranded animals still tend to call local biologists or public safety officials rather than the PRC Coordinators. Such reports may take months to reach the NMFS, if they are ever received. This lack of an organized response may be due to the fact that the PRC's have generally not involved other agencies and biologists within their geographic regions, and it is possible that this concept will not work in Alaska. During 1988, NMFS Alaska Regional Office staff planned to contact all coastal offices of the ADF&G, F&WS, National Park Service, University of Alaska, and State Department of Public Safety within Alaska and request their help in responding to marine mammal strandings. Participating agencies or individuals were asked to investigate marine mammal strandings and send reports to Juneau for cataloging. The data were then sent to the Smithsonian Institution.

Because of the large number (7) of humpback whales that became entangled in nets in southeast Alaska in 1987, the NMFS has begun developing plans to initiate a "whale hotline" similar to the one established in Newfoundland (Lien et al. 1987). The purpose of the hotline will be to provide a quick rescue response to reports of entangled whales in southeast Alaska.

To date, the Federal stranding network established in Alaska in 1985 has had limited success. By involving a greater number of agencies and individuals in the investigation of strandings, and by initiation of the whale rescue hotline, along with frequent feedback to the people and agencies involved, it is hoped that the Alaska stranding network will become a more active and better known entity within the State.

Acknowledgments

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Appendix

Notes on the Most Commonly Reported Species of Cetaceans Found Stranded in Alaska 1975-1987

In addition to the Smithsonian Institution's Alaskan stranding reports, and those found in published sources (Fay 1976; Fay et al. 1977, 1978, 1979 [a, b, and c]; Frost et al. 1984, 1986; Lowry et al. 1986), several unpublished reports of Alaskan strandings are also available. These include the 1984 annual report of strandings in the lower Cook Inlet region by the Pratt Museum (strandings investigated by the Pratt Museum since 1984 have been included in the Smithsonian Institution's data base), a file of strandings that were compiled by NMFS special agents in Alaska during the years 1979-1983, and a 1987 stranding survey (Nome to Shishmaref) by the ADF&G.

Three hundred and twenty-five stranded cetaceans are identified to species in these reports. Distributions of the most commonly found animals are shown in Figures 2-12. In some cases (e.g. the Smithsonian data base) geographic coordinates for each stranding were recorded. In other cases (e.g. Fay 1976; Fay et al. 1977, 1978, 1979 [a, b, and c]; Frost et al. 1984) strandings were recorded as the number of animals seen over an entire survey and are so indicated on Figures 2-12.

The gray whale has been the most frequently found stranded cetacean in Alaska since 1975 (Table 1). Approximately 18000 gray whales reside in the Bering and Chukchi seas during the summer and pass through the Gulf of Alaska during fall and spring migrations to and from wintering grounds in Mexico. Gray whales have been found stranded throughout much of this area, from Yakutat on the eastern Gulf of Alaska to Barrow on the Chukchi Sea (Fig. 2). Of 127 reported strandings, 96 were from the Bering Sea, 24 were from the Chukchi Sea and 7 were from

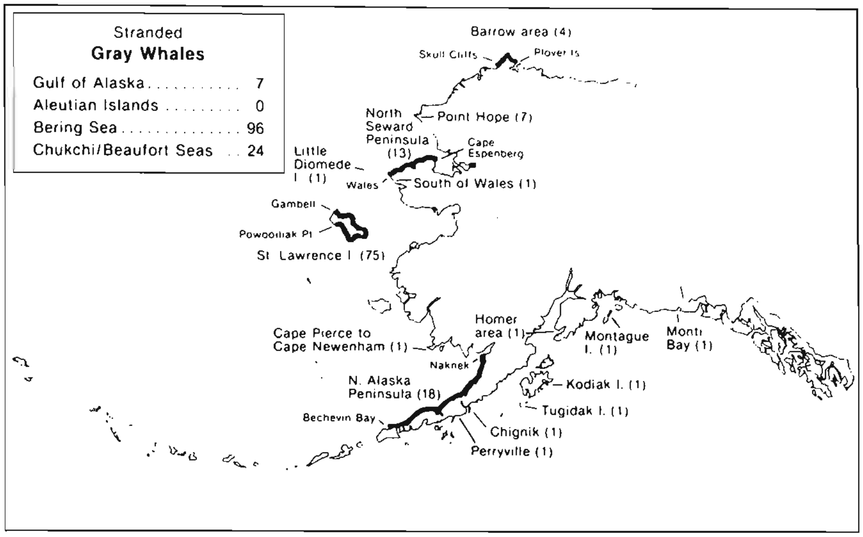

Figure 2
Distribution of stranded gray whales in Alaska, 1975–1987.

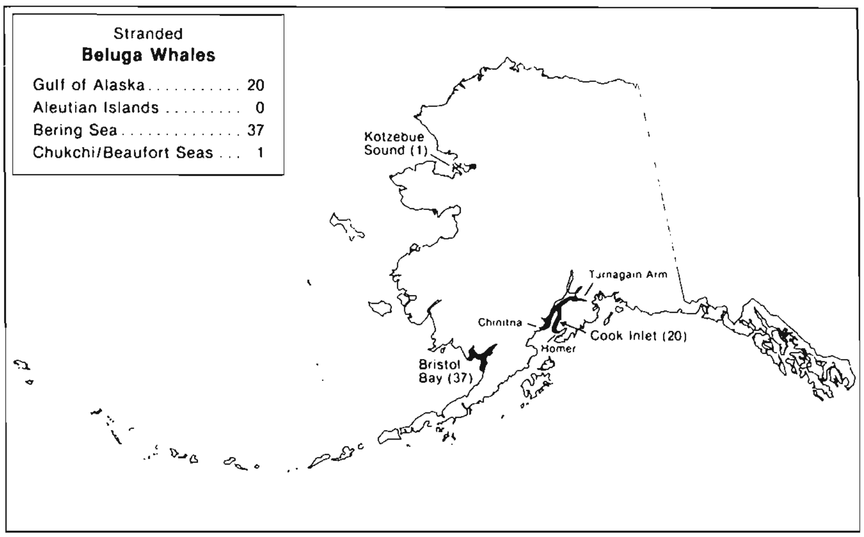

Figure 3
Distribution of stranded beluga whales in Alaska, 1975–1987.

the Gulf of Alaska. Fay (1976) found 24 stranded gray whales in a survey which covered less than 20% of the Bering and Chukchi coastlines, and estimated that at least 100 stranded gray whales, or approximately 1% of the estimated population at that time (about 11000 animals), might be found if all beaches were surveyed. Several of the whales investigated by Fay appeared to have been attacked by killer whales (*Orcinus orca*). Reports compiled by NMFS Special Agents indicated that at least two of the whales investigated in the Shishmaref area had been killed by Soviet whalers.

The beluga whale (*Delphinapterus leucas*) has been the most commonly stranded toothed whale found in Alaska since 1975. Geographically separated populations of beluga whales are found in Cook Inlet and in the Bering Sea (Leatherwood et al. 1983), and Alaskan strandings of this species tend to reflect that distribution (Fig. 3). Nearly one-third of the strandings (20 of 58) were from the Cook Inlet. The other 38 strandings were reported from Bristol Bay to Kotzebue Sound. Most of these animals (37 of 38) were found in Bristol Bay.

Stejneger's beaked whale (*Mesoplodon stejnegeri*) inhabits the cold temperate and subarctic waters of the North Pacific, and strandings of this species have been reported to be fairly common in the Aleutian Islands (Loughlin et al. 1982; Loughlin and Perez 1985). Of the 29 Stejneger's beaked whales reported to the Smithsonian Institution, 21 were found in the Aleutian Islands, 5 were found near the north or south side of the western Alaska Peninsula in the vicinity of Cold Bay, and 3 have been found on the southern Kenai Peninsula.

Killer whales are found in all oceans of the world and the distribution of Alaskan strandings reflects this wide distribution (Heyning and Dahlheim 1988). Of the total 20 strandings reported from Alaska since 1975, 1 was reported from the Chukchi Sea, 13 from the Bering Sea,

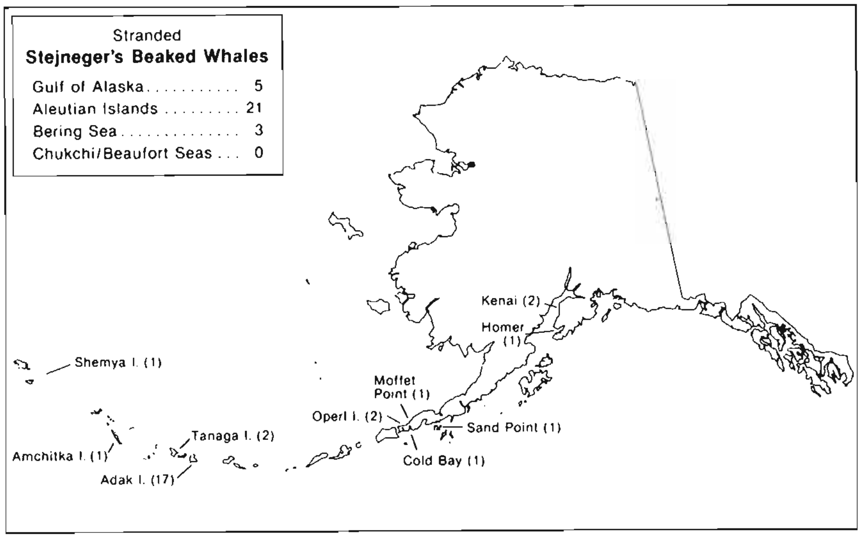

Figure 4
Distribution of stranded Stejneger's beaked whales in Alaska, 1975–1987.

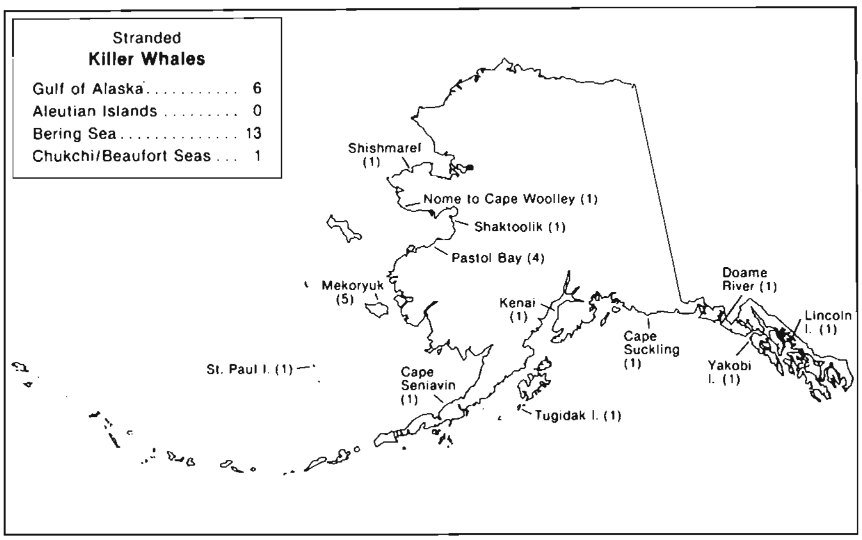

Figure 5
Distribution of stranded killer whales in Alaska, 1975–1987.

and 6 from the Gulf of Alaska (Fig. 5). Five of the Bering Sea animals stranded together near the north end of Nunivak Island in May 1984 (Lowry et al. 1986)—this event represents the only recorded "mass stranding" of cetaceans in Alaskan waters. Reports of stranded killer whales extend from Lincoln Island near Juneau in southeastern Alaska, to Kividlo (near Shishmaref) on the Chukchi Sea.

Cuvier's beaked whale (*Ziphius cavirostris*) is widely distributed in all oceans between the Arctic and Antarctic, and it is believed to be the most abundant beaked whale along the west coast of North America from the Bering Sea to the Equator (Leatherwood et al. 1983). Strandings of this species are commonly reported (Leatherwood et al. 1982). In Alaska, Cuvier's beaked whales have been found stranded from Sitka, on the eastern Gulf of Alaska, to Agattu Island in the western Aleutians. They have been found most commonly in the Aleutian Islands (12 of 19 reports). Single stranded animals were found near Black Hills Beach and Bechevin Bay on the north side of the Alaska Peninsula. The remaining 5 strandings were found across the central and eastern coastal regions of the Gulf of Alaska (Fig. 6).

Minke whales (*Balaenoptera acutorostrata*) are found throughout the world's oceans and they are abundant in the Bering Sea and Gulf of Alaska (Stewart and Leatherwood 1985). In Alaska stranded minke whales have been found from Betton Island near Ketchikan in southeastern Alaska, to Eschscholtz Bay in Kotzebue Sound (Fig. 7). Another animal, believed to have been a minke whale was tentatively identified, but not confirmed, from near Point Hope by NMFS Special Agents. Several of the strandings were from the Cook Inlet area (5 of 19 reports) or from St. Lawrence Island (4 of 19 reports).

Bowhead whales (*Balaena mysticetus*) occur only in Arctic and subarctic waters. The Bering Sea stock of this species

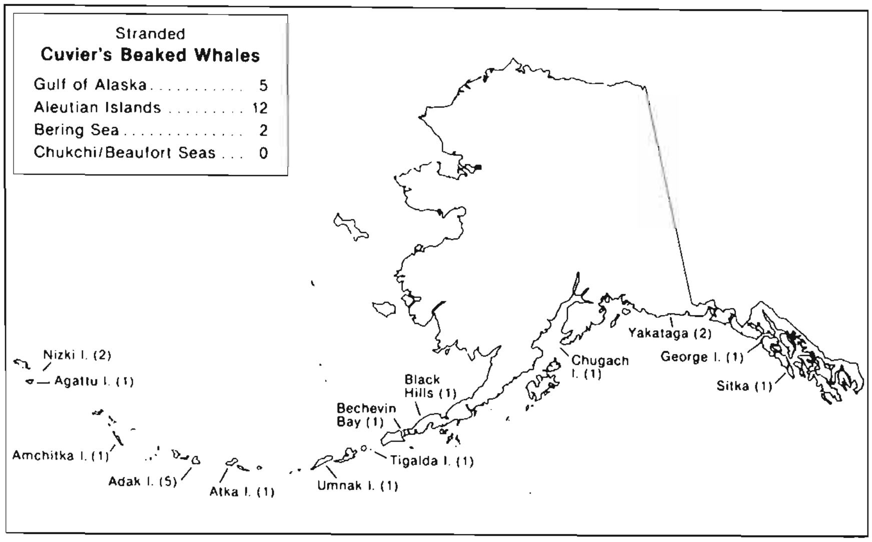

Figure 6
Distribution of stranded Cuvier's whales in Alaska, 1975–1987.

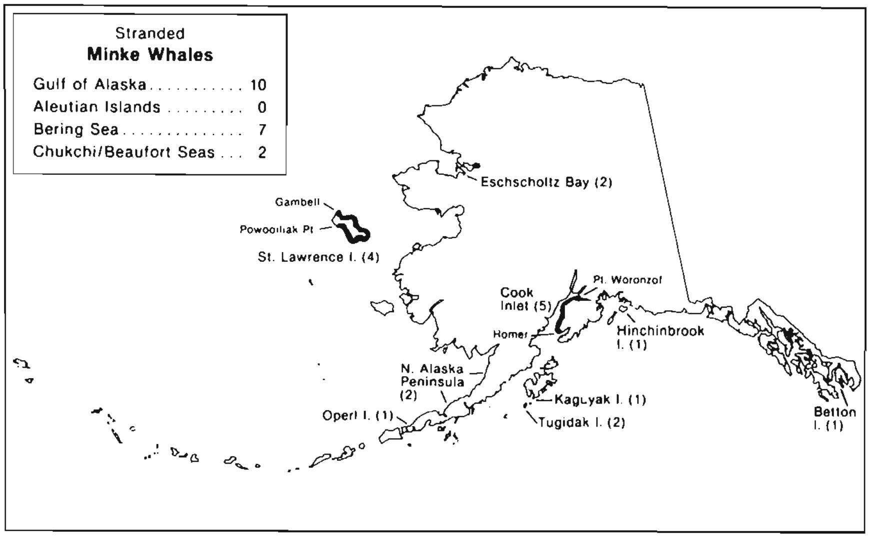

Figure 7
Distribution of stranded minke whales in Alaska, 1975–1987.

makes annual migrations between the central Bering Sea, where they winter, and the eastern Beaufort Sea where they feed during the summer. They are hunted by Eskimos from St. Lawrence Island in the northern Bering Sea to Kaktovik (Barter Island) in the central Beaufort Sea. Although several animals are struck with explosive harpoons and lost each year, there is only one confirmed bowhead stranding in the Smithsonian data base (Table 1). Fay (1976) reported an additional four animals, Fay et al. (1978) reported two, the ADF&G survey in 1987 reported two, and NMFS special agents reported two more. All of the reports are from St. Lawrence Island or northwestern Alaska (Fig. 8.)

Humpback whales are found in all seas lying between the Arctic and Antarctic Oceans (Johnson and Wolman 1984). Although large numbers of humpback whales were taken by Soviet and Japanese whalers in the eastern Aleutian Islands through 1965, the westernmost stranding of this species since 1975 was reported from Kodiak Island (Fig. 9). Since 1975, most of the strandings (8 of 9) have been reported from southeastern Alaska.

Sperm whales are found in all the world's oceans. Although they are widely distributed in the North Pacific (Gosho et al. 1984) the majority of Alaskan strandings (5) have been reported from the western Aleutian Islands (Fig. 10). One each was found on Kodiak Island, in Prince William Sound, on Cape St. Elias, and near Sitka.

Baird's beaked whale (*Berardius bairdii*) is native to the North Pacific and has been found stranded as far north as St. Lawrence Island (Leatherwood et al. 1982). Since 1975 seven strandings of this whale in Alaska have been reported to the Smithsonian Institution, and Fay (1976) described an additional stranding. The northernmost stranding since 1975 has been from the area between Cape Pierce and Cape Newenham (Fay 1976) (Fig. 11). One animal was reported from Bogoslof Island in the southern Bering Sea, and one from Sitkalidak Island near Kodiak.

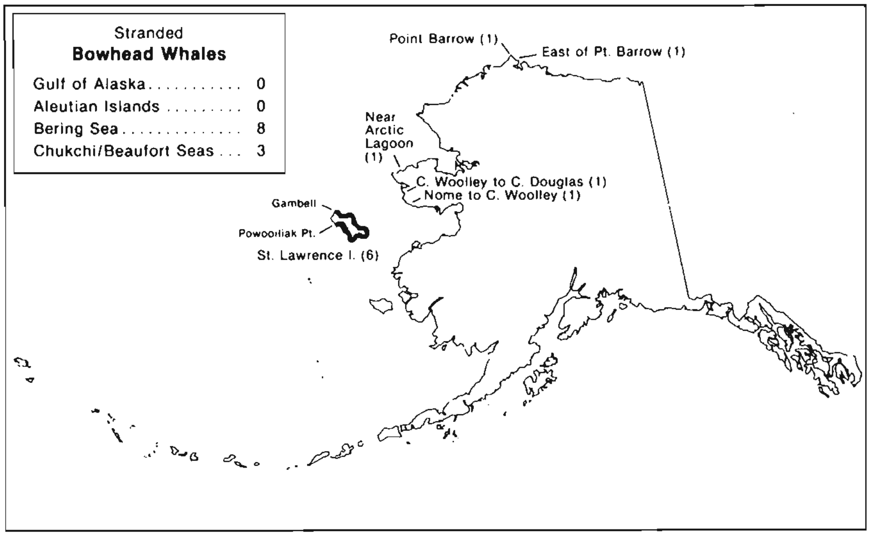

Figure 8
Distribution of stranded bowhead whales in Alaska, 1975–1987.

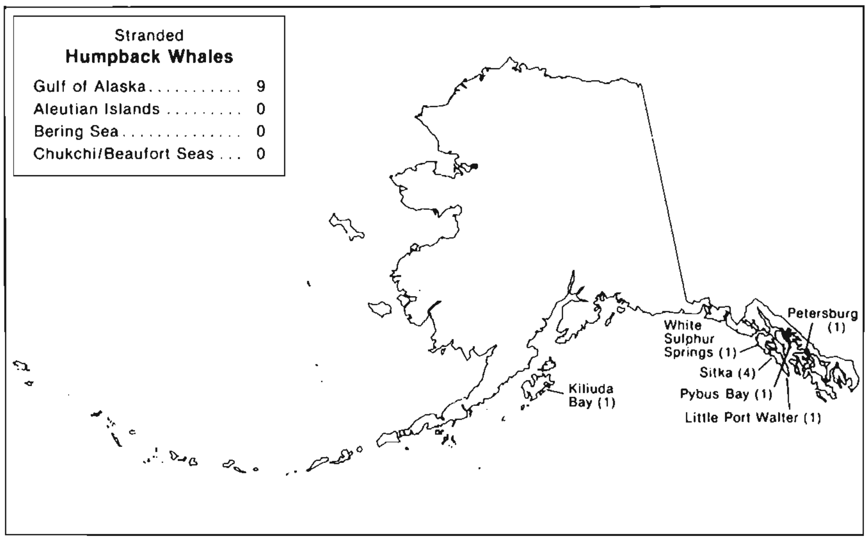

Figure 9
Distribution of stranded humpback whales in Alaska, 1975–1987.

The remaining five strandings occurred in the Aleutian Islands.

The fin whale (*Balaenoptera physalus*) is found in all the major oceans of the world, with Alaskan concentrations occurring in the Gulf of Alaska and the Aleutian Islands (Leatherwood et al. 1983). Five fin whale strandings have been reported to the Smithsonian Institution. Fay (1976) and Fay et al. (1979) each contain an additional report. Stranded fin whales have been found from St. Lawrence Island in the Bering Sea to Tatitlek in eastern Prince William Sound (Fig. 12). Two of the strandings of this species occurred on St. Paul Island in 1981.

In addition to these animals, the following cetacean species have also been reported stranded since 1975: four harbor porpoises; two Dall's porpoises (*Phocoenoides dalli*); one spotted dolphin (*Stenella attenuata*); one Pacific white-sided dolphin (*Lagenorhynchus obliquidens*); and one Risso's dolphin (*Grampus griseus*).

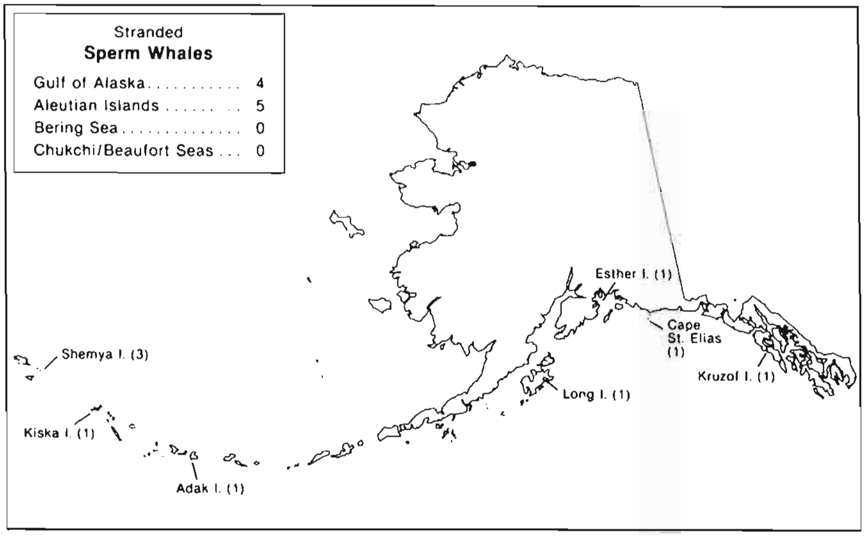

Figure 10
Distribution of stranded sperm beaked whales in Alaska, 1975-1987.

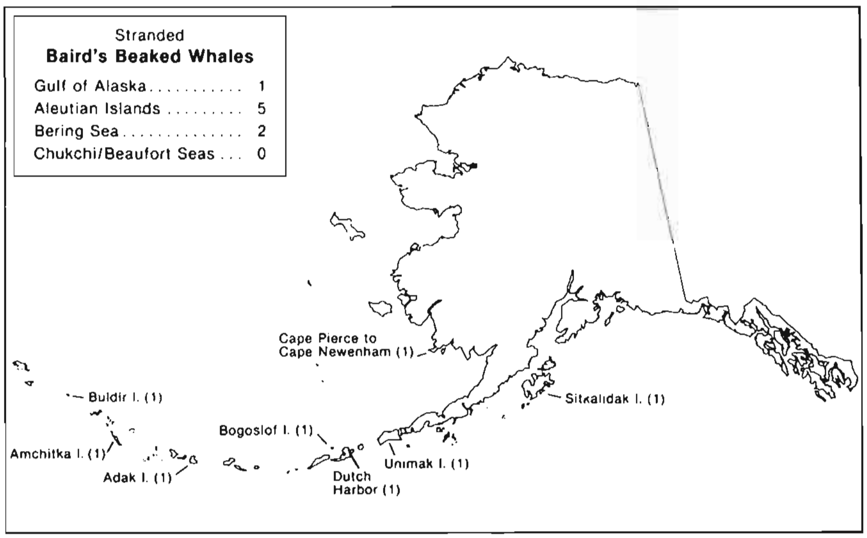

Figure 11
Distribution of stranded Baird's beaked whales in Alaska, 1975-1987.

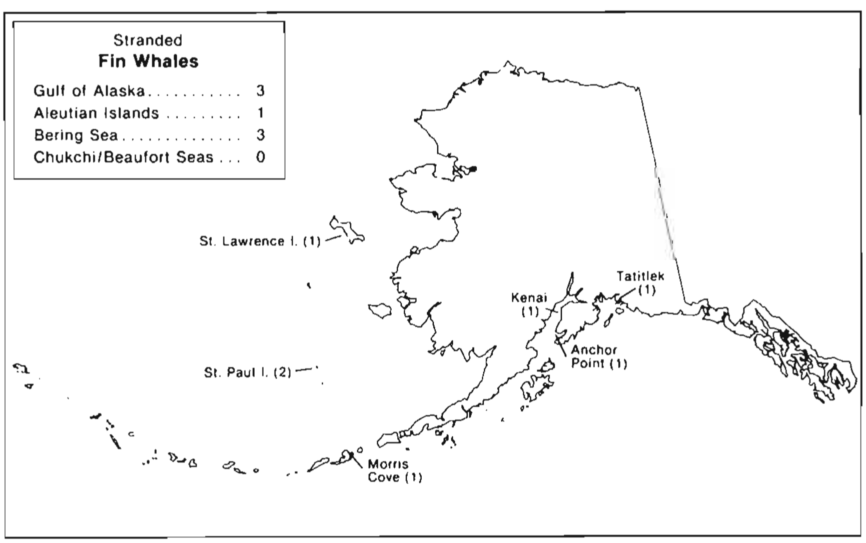

Figure 12
Distribution of stranded fin whales in Alaska, 1975-1987.

Table 1

Numbers of the most commonly stranded cetacean species found on Alaskan beaches during the years 1975–1987.

	Source of stranding reports						
Species	Smithsonian Institution	Fay 1976 Fay et al. 1977 Fay et al. 1978 Fay et al. 1979	NMFS special agent files	Pratt Museum	Frost et al. 1984 Frost et al. 1986 Lowry et al. 1986	ADF&G 1987 survey	Total
Gray whale (*Eschrichtius robustus*)	10	103	9	1	—	4	127
Beluga whale (*Delphinapterus leucas*)	8	11[a]	1	2	36	—	58
Stejneger's beaked whale (*Mesoplodon stejnegeri*)	29	—[b]	—	—	—	—	29
Killer whale (*Orcinus orca*)	8	—	1	—	10	1	20
Cuvier's beaked whale (*Ziphius cavirostris*)	19	—	—	—	—	—	19
Minke whale (*Balaenoptera acutorostrata*)	7	10	—	—	2	—	19
Bowhead whale (*Bacaena mysticetus*)	1	6	2	—	—	2	11
Humpback whale (*Megaptera novaeangliae*)	9	—	—	—	—	—	9
Sperm whale (*Physeter catadon*)	8	1	—	—	—	—	9
Baird's beaked whale (*Berardius bairdii*)	7	1	—	—	—	—	8
Fin whale (*Balaenoptera physalus*)	5	2	—	—	—	—	7

[a]Fay et al. (1979) described 19 beluga whale strandings from Cook Inlet. Only those which were found since 1975 are reported here.
[b]Fay and his associates found two Stejneger's beaked whales. Both of these were reported to the Smithsonian Institution and are listed here as part of that data set.

The Marine Mammal Stranding Network for Hawaii, An Overview

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ABSTRACT

A marine mammal stranding network for the State of Hawaii was formalized and implemented by the National Marine Fisheries Service (NMFS), Southwest Region, Pacific Area Office (PAO), Protected Species Program in 1984. There are records for approximately 100 cetacean stranding incidents for the main Hawaiian Islands dating from 1936. Forty-eight of the stranding records are on file at the PAO. The most frequently reported species were striped dolphins (*Stenella coeruleoalba*); short-finned pilot whales (*Globicephala macrorhynchus*); melon-headed whales (*Peponocephala electra*); humpback whales (*Megaptera novaeangliae*); and pygmy sperm whales (*Kogia breviceps*).

Introduction

The Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973 placed federal legal constraints on the treatment and removal of stranded marine mammals. In the absence of specific regulations dealing with strandings beyond authorizing state and local agencies to ''take'' marine mammals, it became necessary to develop policies, procedures, and programs to deal with strandings. In response to these legal requirements and increasing public interest, regional stranding networks have been developed by the National Marine Fisheries Service (NMFS).

Background

The early Hawaiians referred to dolphins as ''nai'a'' and large whales as ''kohola'' (Pukui and Elbert 1965; Titcomb 1972). Doubtless numerous stranded dolphins and porpoises, as well as large whales, were either consumed, disposed of, or otherwise dealt with by the Hawaiians prior to the arrival of western cultures and their written records in Hawaii. Whale parts, particularly sperm whale (*Physeter macrocephalus*) teeth were used for ornaments (Titcomb 1972), tools, and weapons. The paucity of reference to cetaceans in Hawaiian language, ceremonies, myths, rituals, petroglyphs, and 19th century writings suggests that cetaceans were perhaps not used as extensively as in other western and South Pacific island cultures such as Fiji, Tonga, Samoa, New Zealand, and the Marquesas (Shallenberger 1981).

Although stranded whales were considered a good omen and property of the ''ali'i'' (royalty), it is not known if cetaceans were eaten on a regular basis. Conflicting accounts indicate that whales were not eaten but dolphins were (Titcomb 1972), or that whales were eaten only by men (Malo 1951). Shallenberger (1981; p. 22) citing Peale (1848) noted that 60 melon-headed whales (*Peponocephala electra*) ''were driven ashore by the natives of Hilo Bay and were considered a dainty food and yielded valuable oil.'' Even after the arrival of the ''haoles'' (foreigners), such incidents apparently did not merit much scientific interest or attention in the press because the written record as such is sparse, at least until the 1950s. The earliest available record of a cetacean stranding in Hawaii consists of a newspaper report (Anonymous 1936a) and a photograph (Tinker 1988) of a stranded humpback whale (*Megaptera novaeangliae*) in Waikiki on 14 March 1936.

During the 1960s and 1970s, Norris and Shallenberger reported or responded to over 80% of the recorded strandings in Hawaii (Shallenberger 1981). Beginning in the late 1960s, stranding incident reports were forwarded to the local National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS) office, and as circumstances allowed, there were also direct responses to stranding incidents. In addition to Norris and Shallenberger, other reporting sources included the Waikiki Aquarium, Honolulu Zoo, State Fish and Game wardens, and Coast Guard and Navy personnel with an interest in or responsibility for wildlife management. County police also reported strandings on occasion. The extent of these early records is unknown; much of the data still remains untranscribed in individual log books or memoranda.

A Marine Mammal Stranding Network in Hawaii

Beginning in 1976, the NMFS and the State of Hawaii attempted several times to develop a state/federal agreement to deal with marine mammal strandings in the State. While there is still no formal agreement, biologists from the State's Division of Aquatic Resources continue to respond to strandings on the islands of Kauai, Molokai, and Maui. Officers from the Division of Conservation and Resources Enforcement report strandings to the network in the normal course of their duties. Integration of stranding data from Hawaii into the Smithsonian Institution Scientific Event Alert Network (SEAN) in 1976 and later the Marine Mammal Events Program (MMEP) helped standardize data formats and the types of information to be collected.

Since the 1977 U.S. Marine Mammal Commission-sponsored national Stranding Workshop at Athens, Georgia (Geraci and St. Aubin 1979), regional networks have been developed for all of the NMFS Regions. Although the networks are similar in many respects, by necessity they vary in design and operation from region to region. Because of the isolated nature of Hawaii and the western Pacific, and the great distances between islands, communications and control are often quite difficult, if not impossible. Compounding these issues are the problems of lack of trained personnel, questions of statutory authority, and at times, reluctance of local government involvement.

The Southwest Region of NMFS is responsible for marine mammal and endangered species management activities in California, Hawaii, Guam, the Commonwealth of the Northern Mariana Islands, American Samoa, and the U.S. flag territories of the Pacific, which, until recently, also included the Trust Territory of the Pacific Islands. Cetacean strandings on Guam, the Commonwealth of the Northern Mariana Islands, American Samoa, and other U.S. Pacific possessions are so infrequent that incidents are treated on a case by case basis, usually by the local fish and game or marine resource authority in consultation with NMFS. A Federally coordinated network for California has been in operation since the mid-1970s. Organizational efforts in Hawaii did not begin until 1979–80 when the Southwest Region established a Protected Species Program for the western Pacific. Workshops were held on the major islands in Hawaii and informal working arrangements were developed with state, local and other federal agencies.

By 1984 it was determined that a more structured organization was required for reporting and responding to strandings in Hawaii. Subsequently, in September and November 1984, NMFS representatives met with federal, state and county officials on the islands of Oahu, Kauai, Maui, Molokai, and Hawaii. Attendees at each meeting included personnel from the Hawaii State Department of Land and Natural Resources (DLNR) [Division of Aquatic Resources (DAR) and Division of Conservation and Resources Enforcement (DOCARE)], Hawaii State Department of Health, County Police, and County Department of Public Works. Additional participants at the Oahu meeting included NMFS Enforcement, the University of Hawaii, Sea Life Park, and the Waikiki Aquarium. Stranding procedures were discussed, roles defined, posters provided, and telephone numbers exchanged. Stranding plans for each of the major islands were developed from input obtained at these meetings and sent to all participants.

The problems of limited available resources and the distances between islands were becoming increasingly exacerbated by intervention of well-intentioned, but inexperienced, volunteers in live strandings. In order to provide a higher level of professional expertise and concurrently provide faster responses to live-strandings on the outer islands, veterinarians with experience in marine mammal medicine or those with a particular interest in marine mammals were sought for inclusion in the network. A statewide workshop for veterinarians agreeing to participate in the network was held on Oahu in May 1988 to familiarize them with ongoing practices and recent advances in marine mammal medicine. Veterinarians are now available to respond to strandings on Oahu, Maui, Kauai, and Hawaii.

The working arrangements with the agencies and individuals in the network consist of an agreed-upon and acknowledged level of participation, the acceptance of the stranding protocols developed by NMFS, and an understanding of specific authorities for participation under federal, state, and local statutes. At present, the network consists of well trained professionals, although one or more volunteer organizations have expressed an interest in participating. However, because of the high turnover rate in personnel in volunteer organizations and the infrequent nature of strandings in Hawaii, their participation has not been actively sought. In Hawaii all strandings are coordinated by NMFS either by direct on-scene intervention or by delegation to appropriate federal, state, local agency officials, or an authorized veterinarian.

The primary reporting sources are the county police departments by virtue of their greater numbers of personnel in the field, high visibility, and excellent communication facilities. Other sources include pilots, lifeguards, fishermen, vessel operators, the public, and ocean users in general. Reports are also forwarded to NMFS through the biologists and enforcement officers of the Hawaii Department of Land and Natural Resources, Sea Life Park, the Waikiki Aquarium, and conservation groups. County or separate sub-networks have been organized to report and deal with strandings on the islands of Kauai, Maui, Molokai, Lanai, and Hawaii. All of these sub-networks, including Oahu, are centrally coordinated by the NMFS Protected Species Program in Honolulu. For illustrative purposes, the network for Oahu is described below.

The Honolulu Police Department (HPD), Sea Life Park, or the Waikiki Aquarium are the most likely organizations to receive initial notification of strandings. The HPD conducts the initial investigation and obtains the following information: 1) number and description of the animals, 2) their exact location, and 3) their condition. The HPD secures the scene if necessary, ensuring that unauthorized persons do not interfere. The HPD then notifies NMFS and awaits the arrival of personnel authorized to take action. This is intended to prevent well-intentioned but untrained persons from injuring themselves or possibly causing harm to live, stranded animals, and to ensure an accounting for all parts from dead animals.

Generally, NMFS is the first agency contacted for live strandings and is responsible for making follow-up calls as well as providing on-scene coordination for live strandings. Sea Life Park has made its facilities and personnel available for rehabilitation of live stranded animals.

The public, including interested bystanders and the media, is given, upon request, a brief statement about the species involved, its present status, the fact that stranded animals most often die, that trained personnel are doing everything possible for the animal(s), and, finally, a brief summary about the stranding network. The on-scene coordinator determines whether to deal with questions directly or to designate one person to respond so that work continues uninterrupted.

Animals that strand alive often expire before any action can be taken. Those that die and the ones that wash up dead and are recoverable are collected and necropsied by the State Department of Agriculture, Division of Animal Industry, or NMFS. Basic morphometric data are taken, and stomach contents, parasites, samples for histopathology, and other appropriate tissue and fluid samples are collected for later analysis or for use by other researchers according to need and requests on file. Skulls and complete skeletons are loaned to appropriate institutions for research or educational purposes under agreements where title to the specimens remains with the NMFS. If the animal is too decomposed or mutilated to provide information, County Public Works or City Maintenance is contacted for disposal at a landfill or burial as appropriate. Evidence of human-related injury is reported to NMFS and/or state enforcement where appropriate.

Data recording forms are those used by the Smithsonian Institution. The field number consists of the collector's initials and four digits (e.g., LDC 87-01) signifying year and number for that year. The MMEP at the Smithsonian Institution is also notified after all the reports are completed.

Strandings

Between 1936 and December 1988, 98 cetacean stranding incidents were reported for the Hawaiian Islands (Table 1). The primary source of these reports is Shallenberger (1981; p. 37a) and the remainder from the 1980s are

Table 1

Cetacean strandings in the Hawaiian Islands. An asterisk (*) indicates that a stranding record is on file with the Pacific Area Office, NOAA Fisheries, Honolulu. All other sources are as cited or are unpublished records.

Date	Species	Location	Investigator/source
14 Mar 1936	*Megaptera novaeangliae*	Waikiki, Oahu	Anon. (1936a, b); Tinker (1988)
3 Apr 1937	75 ft. whale	Kilauea, Kauai	Anon. (1937)
Jan 1950	*Ziphius cavirostris*	South Point, Hawaii	Richards (1952)
Jan 1950	*Orcinus orca*	South Point, Hawaii	Richards (1952)
Sep 1954	*Physeter macrocephalus*	Kahuku, Oahu	Anon. (1954a, b)
(?)	*Balaenoptera physalus*	Kohakuloa, Maui	Breese
18 Jun 1957	*Globicephala macrorhynchus* (2)	Oahu	Scott (1957); Anon. (1957)
18 Jun 1957	*Globicephala macrorhynchus* (1)	Punaluu, Oahu	Williams (1957)
2 Mar 1958	*Stenella coeruleoalba*	Ala Wai, Oahu	Hubbs et al. (1973)
12 May 1958	*Globicephala macrorhynchus* (16)	Waikiki, Oahu	Anon. (1958a, b)
3 Oct 1958	*Globicephala macrorhynchus* (24)	Keomuku Beach, Lanai	Brady (1958)
3 Oct 1958	*Globicephala macrorhynchus* (24)	Poaiwa Bay, Lanai	Anon. (1958c, d)

Table 1 (Continued)

Date	Species	Location	Investigator/source
28 Oct 1958	*Globicephala macrorhynchus* (12)	Kalihi Beach, Kauai	Anon. (1958e, f)
10 May 1959	*Globicephala macrorhynchus* (28)	Anini, Kauai	Anon. (1959a); Tomich (1986)
14 May 1959	*Globicephala macrorhynchus*	Waimanalo, Oahu	Anon. (1959b, c, d)
Apr 1961	*Ziphius cavirostris*	Midway	Galbreath (1963)
Apr 1961	*Mesoplodon densirostris*	Midway	Galbreath (1963)
24 Oct 1963	*Kogia breviceps*	Bellows Beach, Oahu	Norris
27 Jun 1964	*Peponocephala electra*	Kahuku, Oahu	Norris
15 Jun 1965	*Peponocephala electra*	Lahaina, Maui	Norris
1 Mar 1969	*Stenella longirostris*	Sandy Beach, Oahu	Norris
27 Jul 1969	*Steno bredanensis*	Waianae, Oahu	Norris
Jul 1970	*Ziphius cavirostris*	Makaha, Oahu	Norris
17 Jun 1971	*Peponocephala electra*	Kahuku, Oahu	Norris
27 Aug 1971	*Peponocephala electra*	Keehi Lagoon, Oahu	Norris
Jun 1972	*Kogia breviceps*	Laie, Oahu	Shallenberger
26 Jun 1972	*Stenella longirostris*	Makapuu, Oahu	Shallenberger
18 Feb 1973	*Megaptera novaeangliae* (calf)	Kaaawa, Oahu	Shallenberger
30 Jan 1974	*Kogia breviceps*	Kalaupapa, Molokai	Shallenberger and Naughton
30 Jan 1974	*Pseudorca crassidens*	Kailua Beach, Oahu	Shallenberger
Feb 1975	*Feresa attenuata*	On fence post/Hawi, Hawaii	Shallenberger
6 Jun 1975	*Stenella attenuata*	Haleiwa, Oahu	Shallenberger
10 Mar 1976	*Steno bredanensis* (18)	Kaanapali, Maui	Naughton*
27 Jun 1976	*Steno bredanensis*	Kihei, Maui	Shallenberger
3 Jul 1976	*Steno bredanensis*	Kahuku, Oahu	Shallenberger
14 Jul 1976	*Peponocephala electra*	Punaluu, Oahu	Shallenberger
29 Jul 1976	*Kogia breviceps* (1 female, 1 calf)	Kihei, Maui	Shallenberger
16 Feb 1977	*Grampus griseus*	Wailuku, Maui	Shallenberger
14 Jul 1977	*Kogia breviceps* (?)	Waimea, Kauai	Telfer
12 Sep 1977	*Stenella coeruleoalba*	Punaluu, Oahu	Shallenberger
5 Oct 1977	*Stenella longirostris*	Mokuleia, Oahu	Shallenberger
5 Jan 1978	*Stenella coeruleoalba*	Reef Runway, Oahu	Shallenberger
11 Feb 1978	*Megaptera novaeangliae*	Kihei, Maui	Iversen
7 May 1978	*Stenella coeruleoalba*	Haleiwa, Oahu	Shallenberger
17 Sep 1978	*Stenella coeruleoalba*	Kailua Beach, Oahu	Shallenberger
17 Nov 1978	*Grampus griseus*	Kahala, Oahu	Shallenberger
14 Feb 1979	*Physeter macrocephalus*	Barbers Point, Oahu	Shallenberger*
23 Feb 1979	*Stenella coeruleoalba*	Kahuku, Oahu	Shallenberger
13 Apr 1979	*Megaptera novaeangliae* (calf)	Volcano Nat. Park, Hawaii	Naughton
21 Oct 1979	*Pseudorca crassidens*	Mokapu Peninsula, Oahu	Shallenberger
24 Dec 1979	*Kogia breviceps*	Kihei, Maui	Shallenberger
26 Apr 1980	*Stenella coeruleoalba*	Kaaawa, Oahu	Shallenberger
10 May 1980	*Stenella coeruleoalba*	Kihei, Maui	Hudnall*
31 May 1980	*Stenella coeruleoalba*	Kihei, Maui	Shallenberger*
21 Oct 1980	*Pseudorca crassidens*	Mokapu Peninsula, Oahu	Shallenberger
6 Jan 1981	*Ziphius cavirostris*	Hilo, Hawaii	Gilmartin*
22 Feb 1981	*Megaptera novaeangliae* (calf)	Punaluu, Oahu	Naughton*
13 Jun 1981	*Feresa attenuata* (4)	Maalaea, Maui	Pacific Whale Foundation*
29 Jul 1981	*Pseudorca crassidens* (?)	Hana, Maui	Maui Police Dept.*
12 Aug 1982	Unidentified dolphin	Kihei, Maui	Pacific Whale Foundation*
17 Aug 1982	Unidentified small whale	Mauna Kea Beach, Hawaii	Karr*
16 Feb 1983	*Grampus griseus*	Kihei, Maui	Ball*
22 Mar 1983	*Physeter macrocephalus* (?)	Haena, Kauai	Heacock*
Apr 1983	*Mesoplodon densirostris*	Laysan Island	Gilmartin*
27 Apr 1983	*Stenella coeruleoalba*	Punaluu, Oahu	Schroeder*
15 Jun 1983	*Peponocephala electra*	Makaha, Oahu	Henderson*
30 Aug 1983	Unidentified beaked whale	Waiakalua-Pilaa, Kauai	Moriarty*
21 Dec 1983	*Tursiops truncatus*	Kepui Beach, Molokai	Sheraton-Molokai*
17 Jan 1984	*Stenella coeruleoalba*	Pauwalu Harbor, Molokai	Sautter*
25 Apr 1984	*Globicephala macrorhynchus*	Kahana Bay, Oahu	Nitta*
10 Jul 1985	*Physeter macrocephalus*	Kaneohe Bay, Oahu	Consiglieri*
27 Aug 1985	*Peponocephala electra*	Mokuleia, Oahu	Consiglieri*

Table 1 (Continued)

Date	Species	Location	Investigator/source
3 Oct 1985	*Tursiops truncatus*	Mokuleia, Oahu	Consiglieri*
8 Jan 1986	*Kogia breviceps*	Kalaupapa, Molokai	Consiglieri*
13 Jan 1986	*Megaptera novaeangliae*	Kahoolawe	Consiglieri*
13 Mar 1986	*Stenella coeruleoalba*	Kailua, Oahu	Nitta*
24 Mar 1986	*Peponocephala electra*	Kuau Bay, Maui	Consiglieri*
2 Apr 1986	*Tursiops truncatus*	Bellows Beach, Oahu	Consiglieri*
9 May 1986	*Globicephala macrorhynchus*	Kahului Harbor, Maui	Consiglieri*
8 Jun 1986	*Stenella attenuata*	Kaoio Pt, Oahu	Henderson*
13 Jun 1986	Unidentified dolphin	Olowalu, Maui	Naughton*
25 Sep 1986	*Pseudorca crassidens*	Mokapu Peninsula, Oahu	Schroeder*
25 Sep 1986	*Stenella coeruleoalba*	Lanikai, Oahu	Naughton*
23 Oct 1986	*Stenella longirostris* (calf)	Mokapu Peninsula, Oahu	Schroeder*
1 Jan 1987	*Steno bredanensis*	Waipio Bay, Hawaii	Henderson*
12 Jan 1987	*Stenella attenuata* (calf)	Makaha, Oahu	Consiglieri*
4 Feb 1987	*Megaptera novaeangliae* (calf)	Waiakalua, Kauai	Heacock*
20 Mar 1987	*Megaptera novaeangliae* (calf)	Kalaupapa, Molokai	Nitta*
20 Jun 1987	*Kogia simus*	Hauola Gulch, Lanai	Nitta*
21 Sep 1987	*Stenella longirostris*	Haleiwa, Oahu	Nitta*
11 Feb 1988	*Grampus griseus*	Paia, Maui	Nitta*
23 Feb 1988	*Stenella longirostris*	Nukumoi Pt, Kauai	Heacock*
16 Jul 1988	*Feresa attenuata*	Kihei, Maui	Nitta*
17 Jul 1988	*Feresa attenuata*	Kihei, Maui	Henderson*
14 Aug 1988	*Kogia breviceps*	Punaluu, Oahu	Nitta*
13 Sep 1988	*Feresa attenuata*	Kihei, Maui	Nitta*
23 Sep 1988	*Physeter macrocephalus*	Ahukini, Kauai	Heacock*
26 Sep 1988	*Stenella longirostris*	Kaanapali, Maui	Kehler*
16 Oct 1988	*Peponocephala electra*	Mokuleia, Oahu	Nitta*

reported by NMFS. Of these reports, 48 records are available and on file with the Protected Species Program, Pacific Area Office. Each stranding is listed as a single incident whether or not more than one animal was involved. The list is by no means complete and there may be other records available. A listing provided by the Smithsonian Institution, MMEP included many entries not reported by Shallenberger (1981) and vice versa, which is due, in part, to apparent discrepancies between the two lists in collection dates, reporting dates, and collectors and/or citations.

The MMEP records and reports only cetacean strandings and, to be consistent, only cetacean stranding reports are logged into the Hawaii data base. Sea turtle and Hawaiian monk seal (*Monachus schauinslandi*) strandings are also reported but are maintained separately by the Honolulu Laboratory, Southwest Fisheries Science Center.

The most frequent strandings by occurrence of reports (since 1936) are of streaker or striped dolphins (*Stenella coeruleoalba*). The next most common species in order of reporting frequency are short-finned pilot whales (*Globicephala macrorhynchus*), melon-headed whales (*Peponocephala electra*), humpback whales (*Megaptera novaeangliae*), and pygmy sperm whales (*Kogia breviceps*). All other reported species had incidences of five reports or less (Table 2). This list, however, is not an accurate measure of the total number of animals of each species that was stranded and reported, since some reports involved two or more individuals and others are mass strandings spread over the course of a few days and/or two or more islands.

Interestingly, significant numbers of strandings, both live and dead, are reported from specific areas such as Maalaea Bay on the southwest coast of Maui, and the northwest coast of Oahu from Mokuleia to Kahuku (Fig. 1). There is no apparent trend in the frequency of stranding by species from these two areas.

Discussion

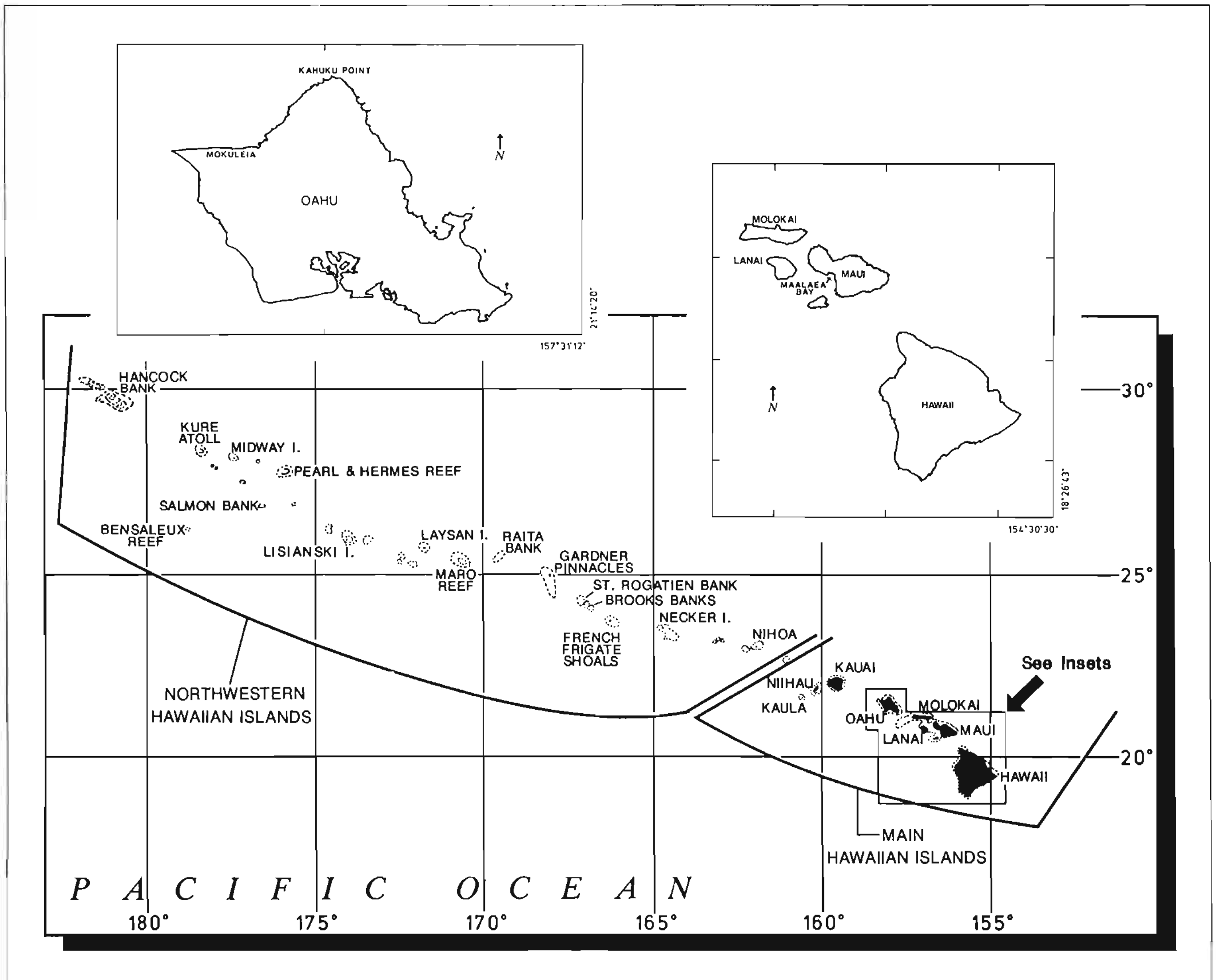
Treatment and on-scene decisions concerning stranded marine mammals are almost always difficult. At the one extreme, there are those that demand (usually the well-meaning public or conservation groups) that heroic measures be undertaken to attempt to save even hopelessly ill marine mammals. At the other end of the spectrum are those individuals and organizations charged with the animal's welfare but having limited resources. As always, marine mammal recovery decisions are judgments based on available veterinary advice and experience, satisfying few of the interested parties. The key agency questions tend to be the following: Should it respond, directly depleting

Table 2
Frequency of stranding reports 1936–1988.

Species	Reports	Species	Reports
Stenella coeruleoalba	13	*Pseudorca crassidens*	4
Globicephala macrorhynchus[a]	11	*Grampus griseus*	4
Peponocephala electra	10	*Stenella attenuata*	3
Kogia breviceps	8	*Tursiops truncatus*	3
Megaptera novaeangliae	8	*Mesoplodon densirostris*	2
Steno bredanensis[b]	5	*Orcinus orca*	1
Ziphius cavirostris	5	*Balaenoptera physalus*	1
Physeter macrocephalus	5	*Kogia simus*	1
Feresa attenuata	5		

[a] At least two mass strandings reported in 1958 were listed as separate incidents because of the different stranding sites and dates. The 1958 strandings involved up to 24 animals each in three separate incidents on Lanai and Kauai over a 25 day period in October.
[b] A single mass stranding of 18 individuals on 10 March 1976 was reported as one incident.

Figure 1
Hawaiian Archipelago and areas of reported high incidences of cetacean strandings.



available funds for the year in order to attempt to save one member of an apparently large and healthy stock of marine mammals? Are some species such as spinner dolphins less "valuable" than bottlenose dolphins or humpback whales? Do all species weigh equally in our decisions to attempt to treat individual animals? Each case is unique and requires the judgment of the responsible person on-scene to evaluate the resources available, prognosis for recovery of the animal (in consultation with a veterinarian); accessibility of animals; and extent of public interest and involvement.

The public in general is still not well informed about the low survivorship of stranded cetaceans. High and undue expectation of survival of animals many times leads to an expenditure of effort, funds, and resources that might be better used for the common good of the species or stock. Loftin (1985; p. 231) argues that "those who take it upon themselves to treat wildlife are well-intentioned and genuinely concerned about their charges." But, he continues, doctoring individual wild animals is of extremely limited value, wastes valuable resources, and diverts attention from higher priority needs. Although it is not wrong to treat or attempt to treat sick or injured individual animals, it should be remembered that value lies in the ecosystem and not so much in the individual (except perhaps in certain endangered species near extinction). Ethical and moral judgments aside, there are tangible benefits to be gained in the treatment of individual animals including increased knowledge of disease identification and treatment, channeling concerned public interest toward species and ecosystem values, and soliciting support for research and management funding from private and public sources, even in areas of apparent low stranding activity such as Hawaii.

Operating within the constraints of limited response resources and the statutory restrictions on the treatment of stranded marine mammals, the Hawaii Stranding Network permits the extraction of the best possible information from stranding incidents while facilitating the expedient and legal removal or treatment of animals if that is warranted. While providing for the short-term treatment and disposition of stranded marine mammals, the Network also contributes to long-term information needs related to understanding population structure, species distribution, and other facets of the natural history of Hawaiian cetaceans.

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The Northeast Regional Marine Mammal Stranding Network

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ABSTRACT

The Northeast Regional Marine Mammal Stranding Network is coordinated and managed by the National Marine Fisheries Service, Northeast Region, and currently includes six Letter of Agreement (LOA) holders between Maine and Virginia. Each LOA holder is responsible for a specified geographic area and has developed response protocols that meet the needs and capabilities of its geographic area. Major species that LOA holders encounter include pilot whales (*Globicephala melaena*) (especially during mass stranding events); harbor porpoises (*Phocoena phocoena*); Atlantic white sided dolphins (*Lagenorhyncus acutus*); common dolphins (*Delphinus delphis*); humpback whales (*Megaptera novaeangliae*); harbor seals (*Phoca vitulina*); and gray seals (*Halichoerus grypus*). Over the past ten years the number of responses to marine mammal strandings has increased greatly and the issues facing the Stranding Network are more complex. Ethical, philosophical, and legal issues regarding treatment, humane care, euthanasia, and the appropriateness of intervention are all being addressed in a regional review by the National Marine Fisheries Service and the LOA holders in an effort to provide the best level of response that is regionally appropriate.

Introduction

The Northeast Regional Marine Mammal Stranding Network is a collaboration of six Letter of Agreement (LOA) holders to the National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Northeast Region (NER), that responds to strandings from the Canadian border through Virginia. Active LOA's are currently (as of 1990) held by the College of the Atlantic (Bar Harbor, Maine); New England Aquarium (Boston, Massachusetts); Mystic Marinelife Aquarium (Mystic, Connecticut); Okeanos Foundation (Long Island, New York); Marine Mammal Stranding Center (Brigantine, New Jersey); and the Virginia Institute for Marine Science (Gloucester Point, Virginia). Current LOA holders include institutions that are private nonprofit corporations established for the purpose of operating a public aquarium; educational institutions; rescue and rehabilitation facilities; and private, nonprofit research and educational institutions.

The earliest LOA's were established following the 1977 stranding conference in Athens, Georgia (Geraci and St. Aubin 1979). In 1982 the NER was "regionalized" by NOAA/NMFS, and LOA holders jointly agreed to divide the network into fixed geographic areas to avoid possible disputes over coverage of an area. As a result, each LOA holder was assigned a defined geographic area. Although each institution works within its specific geographic area, there is a free exchange of help during extraordinary events such as mass strandings and die-offs.

In 1981 several informal stranding meetings served to catalyze establishment of regular regional meetings which, from 1982 through 1988, were held annually in a conference or workshop format. The content of the meetings included business meetings and formal presentations of

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data and related information. These meetings provided a useful forum for the exchange of information and standardization of data collection. Early workshops were well attended by the public, served to increase the visibility of LOA holders, and helped to establish the LOA holders better as focal points for stranding responses.

Data collection was standardized at these meetings in a format appropriate for the Smithsonian Institution's data bases (i.e., the Scientific Event Alert Network now called the Marine Mammal Events Program [MMEP]). The Smithsonian Institution acts as a national repository for specimen material and for all cetacean stranding records. The level of data required by the Smithsonian Institution represents the minimum that is collected and required from all stranding events outlined in the LOA's. The MMEP reports are distributed to other LOA holders through the New England Aquarium. Data collected beyond the minimal data required are controlled by the letter holding institutions. These data augment basic life-history and event reports; document findings from internal and external examinations; and describe the collection and preservation of parasites and tissues for histological and contaminant analyses.

Each LOA holder has developed response protocols that closely match the needs and the capabilities of its geographic area. This provides a specialized and efficient response in each area while maintaining consistency and quality control of collected data within the NER. The following summaries of current LOA holder institutions provide some insight into the diversity of stranding events and the range of responses.

Maine

The College of the Atlantic (Bar Harbor, Maine) responds to 5 to 30 marine mammal strandings annually (Table 1). Most live animals are orphaned and sick young harbor seal (*Phoca vitulina*) pups (live pinnipeds that are initially handled by College of the Atlantic are recorded as accessioned by New England Aquarium, Table 1) that are picked up at the stranding site, stabilized by students and volunteers, and shipped to the New England Aquarium for treatment and care. Other strandings involve large or small cetaceans that commonly occur off the coast of New England, as well as relatively rare or extraliminal species such as pygmy sperm whales (*Kogia breviceps*), and beluga whales (*Delphinapterus leucas*). The College of the Atlantic maintains an active education program called "Whales on Wheels" which has great success with highly innovative uses of specimen materials collected from strandings. Marine mammal parts and skeletons of small cetaceans are kept in a vehicle that can be driven to locations and used as educational tools to teach individuals about the evolution, life history, and ecology of marine mammals.

New Hampshire and Massachusetts

The New England Aquarium responds to the greatest number (i.e., over one hundred annually) of marine mammal strandings in the NER (Table 1). The majority of strandings involve harbor seal pups. Much of the Aquarium's history in marine mammal strandings reflects issues now being faced by other LOA holders as their levels of effort increase. Institutionally the New England Aquarium has maintained a high level of commitment to marine mammal strandings and has continued contact and continuity throughout the Stranding Network. Because of the scope of some stranding events, the New England Aquarium often seeks and receives help from other LOA holders. Jointly, the New England Aquarium, the College of the Atlantic and, until recently, Sealand of Cape Cod, respond to strandings from the Canadian border to Rhode Island.

As of November 1989, Sealand of Cape Cod (Brewster, Massachusetts) is no longer a LOA holder with NOAA/NMFS. The facility is located in an area close to where many pinniped and single and mass cetacean strandings occur. Sealand concentrated its stranding efforts on rescue and rehabilitation of live marine mammals that stranded on Cape Cod. Dead animals were collected and held for the New England Aquarium to examine. Between 1977 and 1986 Sealand of Cape Cod responded to about 700 cetacean and pinniped strandings (*see* Table 1, New England Aquarium). The majority of marine mammal strandings involved mass strandings of pilot whales (*Globicephala melaena*); as well as Atlantic white sided dolphins (*Lagenorhyncus acutus*); harbor porpoises (*Phocoena phocoena*); and common dolphins (*Delphinus delphis*). The harbor seal (*Phoca vitulina*) is the primary pinniped that strands along Cape Cod, but gray seal (*Halichoerus grypus*) strandings have become more common in the past two to three years.

Rhode Island and Connecticut

The Mystic Marinelife Aquarium (Mystic, Connecticut) responds to marine mammal and sea turtle strandings from Rhode Island through Connecticut. The Aquarium also frequently assists other LOA holders in adjoining areas during unusual events such as mass strandings. Approximately 10% of the Aquarium's stranding responses are in Connecticut. Sixty percent of its responses are in Rhode Island and 30% percent are on Cape Cod and Long Island. The Aquarium works primarily to rehabilitate single stranded animals. Since 1974 the Aquarium has responded to 40 pinniped and nearly 60 small cetacean strandings including 35 live strandings (Table 1). The Aquarium has successfully rehabilitated and released an Atlantic white-sided dolphin (*Lagenorhyncus acutus*) and has found permanent homes for 30 beached or stranded pinnipeds. Although there has been only one mass stranding in this area since 1977 (pilot whales [*Globicephala*

Table 1

List of marine mammals accessioned by participants in the Northeast Region LOA holders. Dates in parentheses indicate the earliest year that data were available through 1988. Therefore, the actual numbers of animals accessioned by the College of Atlantic, Okeanos, Marine Mammal Stranding Center, and the Virginia Institute of Marine Science are greater than what are reported here. These data do not include marine mammals that were entangled or incidentally taken in commercial fishing operations. Data for the New England Aquarium and the Mystic Marinelife Aquarium were provided by these institutions. All other data were provided by the Smithsonian Institution. The large number of specimens of harbor seals (*Phoca vitulina*) listed under New England Aquarium reflects epizootics.

	New England Aquarium (1977–1988)	New England Aquarium (1989 only)	College of Atlantic (1983–1988)	Mystic Marinelife Aquarium (1974–1989)	Okeanos Research Foundation (1982–1988)	Marine Mammal Stranding Center (1982–1988)	Virginia Institute of Marine Science (1982–1988)
Eubalaena glacialis	2	1	—	—	—	1	—
Balaenoptera physalus	6	—	1	2	11	7	—
B. acutorostrata	25	—	—	4	4	—	—
Megaptera novaeangliae	20	—	—	1	1	1	1
Physeter macrocephalus	6	—	—	—	—	2	—
Kogia breviceps	8	1	2	—	4	4	6
Kogia simus	—	—	—	—	—	1	3
Mesoplodon mirus	1	—	—	1	—	—	—
M. europaeus	—	—	—	—	—	1	2
M. densirostris	—	—	—	—	1	—	—
Delphinapterus leucas	1	—	1	1	—	—	—
Orcinus orca	—	1	—	—	—	—	—
Globicephala melaena	334	6	4	18	11	10	3
G. macrorhynchus	—	—	—	—	—	—	3
Lagenorhynchus acutus	186	5	3	16	4	2	1
Delphinus delphis	52	—	—	3	9	3	1
Delphinid sp.	—	—	—	—	1	—	11
Tursiops truncatus	4	—	—	1	7	74[a]	274[a]
Grampus griseus	11	—	—	1	—	2	2
Stenella attenuata	—	1	—	—	1	—	—
S. coeruleoalba	17	3	1	1	5	4	5
S. graffmani	—	—	—	2	—	—	—
S. frontalis	1	—	1	—	1	1	1
Phocoena phocoena	212	10	12	5	9	11	15
Ziphius cavirostris	—	—	—	—	1	—	—
Phoca vitulina	1421	145	—	34	2	19	—
Halichoerus grypus	23	19	—	4	5	2	—
Cystophora cristata	11	2	—	1	—	2	—
Pagophilus groenlandica	3	2	—	1	1	1	—
Cetacean sp.	2	—	—	—	1	3	—
Dolphin sp.	—	—	—	—	—	19	40
Total	2346	196	25	96	79	170	368

[a] Dolphin die-off 1987.

melaena], on Block Island in 1983), Mystic Marinelife Aquarium has assisted the New England Aquarium in responding to several mass strandings on Cape Cod, Massachusetts. The Aquarium's records have been standardized recently into a uniform format leading to 32 peer-reviewed papers and articles on marine mammal biology and husbandry; six dealt specifically with stranded marine mammals (e.g., Spotte et al. 1978; Buck et al. 1988).

New York

The stranding activities of the Okeanos Research Foundation (Hampton Bays, New York) have increased greatly in recent years. The Foundation's stranding program is partially funded by the State of New York. Okeanos responds to all live and dead stranded, distressed, or entangled marine mammals and sea turtles in New York and Long Island. The Foundation is also actively engaged in fin whale (*Balaenoptera physalus*) and Kemp's ridley sea turtle

(*Lepidochelys kempii*) research. Okeanos frequently assists other LOA holders in responding to mass strandings. Since 1982 Okeanos has responded to 55 small cetacean strandings and 16 balaenopterid strandings (Table 1). The majority of whale strandings involved dead animals. Okeanos has responded since 1982 to 48 pinniped strandings; about 50% have been live strandings. Prior to 1985 the majority of strandings were cetaceans. Since 1987 the number of pinniped strandings has increased. The majority of strandings involve marine mammals that commonly occur in the western North Atlantic, but occasionally, rare marine mammals have stranded in Okeanos's area.

New Jersey

The Marine Mammal Stranding Center (Brigantine, New Jersey) responds to all live and dead stranded, distressed, or entangled marine mammals and sea turtles along the New Jersey coast, and also north into Delaware. The Center currently responds to an average of 6 pinniped strandings and 12 cetacean strandings a year but unusual events such as the 1987 *tursiops* mortality can lead for a particular year to the Center's handling far more than their yearly average (Table 1). The majority of cetaceans that strand are dead and most of the pinnipeds are alive. The Center is involved extensively in responses to sea turtle strandings and has established an education pavilion on Center property that is open to the public. The Center has also provided support to other LOA holders during mass strandings.

Virginia

The Virginia Institute for Marine Science (Gloucester Point, Virginia) became an official LOA holder in 1988, although it has been responding to marine mammal strandings in Virginia since 1979. The majority of marine mammal strandings involve bottlenose dolphins (*Tursiops truncatus*) (Table 1). The marine mammal stranding activities are expected to increase as funding through state agencies becomes available. The Institute is also actively involved in sea turtle strandings and research.

Conclusion

The NOAA/NMFS is currently conducting a national review of all stranding programs and the NER is currently reviewing the structure of the NER Stranding Network and will be pursuing new LOA's with acceptable institutions in states where a need has been identified (i.e., The National Aquarium, Baltimore, Maryland; State of Delaware; and the Smithsonian Institution, Washington, DC). The past ten years have been marked by both quantitative and qualitative increases in stranding responses. Stranding responses have become more numerous and more complex.

Details of the New England Aquarium's stranding activities over the past 10 years are used here to illustrate trends that are common among LOA holders and may be common in other stranding regions. Since 1977, the New England Aquarium has accessioned over 2500 animals. Over 1600 have been pinnipeds and more than 900 have been cetaceans. The collection of data has been consistent during this time and regularly supplied to the Smithsonian Institution. In-house data are computerized and three years of basic data as well as specimen inventory are currently "on-line." The New England Aquarium attempts to provide a response to all aspects of strandings and has made extensive use of volunteer networks. The Aquarium developed formal agreements called Secondary Letters of Agreement with individuals and organizations subject to approval of NOAA/NMFS, NER in an effort to organize and support local response groups. The Secondary Letters of Agreement outline general and specific activities and guidelines and allow volunteers to act on behalf of the New England Aquarium under its LOA with NOAA/NMFS, NER. In recent years these coordinating efforts have become increasingly complex and additional agreements, specific to mass stranding events on Cape Cod, have been developed. These specific sub-agreements outline the responsibilities of the New England Aquarium, sub-designees, and volunteers. The agreements are reviewed and renewed annually by NOAA/NMFS, NER; the New England Aquarium; and sub-designees. This mechanism enables the New England Aquarium to maintain overall responsibility and a faster and more efficient response over a large geographic range. It also encourages an efficient use of local resources.

Stranding activities in the NER have become more varied and complex involving entanglements, single strandings, mass strandings, and mass mortalities. In the past ten years roughly 16 mass strandings of pilot whales and white sided dolphins (*see* for example, Geraci et al. 1978), and 3 epizootics in the harbor seal population occurred in New England (Geraci et al. 1982; Hinshaw et al. 1984). Mass mortality investigations (i.e., humpback whale [*Megaptera novaeangliae*]; *see* Geraci et al. 1989) and bottlenose dolphin (*Tursiops truncatus* [*see* Geraci 1989] die-offs) add yet another dimension to stranding responses, where a coordinated and directed effort must be made to determine the cause of mortality and monitor short- and long-term effects on the population.

The New England Aquarium is actively involved in the rehabilitation of marine mammals, particularly pinnipeds. Over 60 harbor seals have been rehabilitated and more than half returned to the wild. To better assess and understand the survival prognosis of seals returned to the sea, the Aquarium collaborated with Manomet Bird Observatory (Manomet, Massachusetts) on a project to radio tag and track released harbor seal pups. Released pups were shown to adapt quickly to the wild following release (New England Aquarium, unpubl. data). Currently, released animals are visually tagged (flipper tagged) only. Unreleasable animals are provided to licensed and Department of Agriculture approved zoos or aquaria, thereby reducing the need to remove healthy individuals from the wild for public display.

The New England Aquarium opened its Animal Care Center in 1985. Although not a dedicated stranding facility, the center provides holding areas for harbor seal pups that require a more formal rehabilitation program, and an area suitable for the rehabilitation of small whales and dolphins. The Aquarium's recent success in rehabilitating, releasing, and assisting with the monitoring of three young pilot whales is an extension of this commitment to enhancement of survival of stranded marine mammals (Mate 1989).

Species accessioned by the New England Aquarium's stranding program from 1977 through September of 1989 are shown in Table 1. Over one half of the total (62%) are pinnipeds. With the exception of years of very high mortalities (1980, 1983, and 1985) the number of animals recovered appears uniform (70–80 animals per year). Despite such consistency in the number of animals recovered annually, more effort has been made each year to reduce the number of "unnecessary" harbor seal strandings along the coast of Maine during the pupping season. A major public information and education program, coordinated by NOAA/NMFS law enforcement (Portland, Maine office) since 1984, and currently by NOAA/NMFS Regional Office, has appreciably reduced both human disturbance of rookeries and the premature "rescue" of harbor seal pups temporarily abandoned by foraging mothers. This program involves letters and information packets to local law enforcement and natural resource officers, posters, and televised public service announcements. As a result of this highly visible and successful program, the animals recovered are generally those that would not have survived otherwise. In the past three years there have been more live, sick, and moribund animals recovered, although total numbers recovered have remained nearly the same. It is unclear whether this is because of a greater abundance of harbor seals or quicker reporting on the part of the public and quicker response by the New England Aquarium. There also has been an increase in the number of rare or extraliminal species of pinnipeds (e.g., hooded seals [*Cystophora cristata*]; harp seals [*Phoca groenlandica*]; and gray seals [*Halichoerus grypus*]). Similarly some of these more unusual species are appearing as far south as New Jersey, Virginia, and Florida.

Excluding mass strandings, the New England Aquarium accessions roughly 50 cetaceans per year. This number increases greatly in years of mass strandings. Pilot whale strandings, with their apparent regularity and regional specificity are major events requiring the coordination of many organizations as well as the public and media. Planning for these events takes place year-round among NOAA/NMFS, NER, Aquarium staff; sub-designees under the Aquarium's LOA; local officials; and volunteer groups. The development of procedures, policies, and equipment is ongoing.Clearly stranding responses have changed considerably in the past ten years for all members of the NER Marine Mammal Stranding Network. The basic LOA with NOAA/NMFS, NER allows for the development of a response network that is well suited to the local demands. A general LOA and a limited number of institutions within the Regional Network allow for close coordination and communication among LOA holders and between LOA holders and NOAA/NMFS, NER. A Secondary LOA between the primary LOA holder, NOAA/NMFS, NER, and the secondary LOA holder allows NOAA/NMFS to maintain control of stranding activities and allows the primary LOA holder to designate other institutions or individuals that will adhere to the primary LOA holder's policies and procedures and to respond to strandings on their behalf. The development of "institutional identities" with clear institutional standards, policies, and ethics by LOA holders provides some level of consistency. This level of consistency allows for the development of an informal goal statement by the Network, but differences in policies and institutional structure and purpose have kept the members from adopting a more formal structure.

Not only have sheer numbers of responses increased in all areas throughout the NER but the range of strandings and the complexity of response have also increased. The NER Marine Mammal Stranding Network now faces complex ethical, philosophical, and legal issues of treatment, humane care, euthanasia, and appropriateness of intervention. The New England Aquarium and other public display institutions that are LOA holders in the NER have drawn on many institutional policies to support their program policies. In this way the facilities' response meets certain clear standards for animal care, data collection and dissemination, and public education. A close and clearly defined relationship with NOAA/NMFS, NER and other LOA holders allows LOA holders to provide a response that is regionally appropriate, efficient, and consistent. Close contact with other LOA holders through formal meetings and informal exchanges allows this relationship to develop through the network.

The future will probably bring increasing public interest and exposure to marine mammal stranding activities. This, along with the increasing diversity and complexity of stranding issues, events, and efforts, requires closer coordination among Federal, state, and local agencies, LOA holders, and volunteers; a greater commitment of resources to the Stranding Network; and an increased sophistication of response, particularly concerning emerging issues about ethics, standards for live animals, mass stranding, and mass mortality responses.

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Collecting and Archiving of Cetacean Data and Specimens

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ABSTRACT

Stranded cetaceans are a source of data for a wide range of biological disciplines and virtually the only source of data for some species. The amount of information ultimately available depends on two major factors: 1) the quality and amount of data originally collected from the specimen during a necropsy, and 2) the proper archiving of the data and specimen materials so that they will be available to future researchers. At least a minimal amount of data (*see also* "Level A" data, Hofman 1991) such as sex, total length, locality, and date should be collected from every stranded cetacean, as well as the gonads, stomach contents, and voucher materials (skull or skeleton). Properly accredited museums play a crucial role in stranding programs as they are the ultimate archival institutions for the storage of data and specimens, and thus insure their availability to current and future researchers.

Introduction

For centuries, stranded cetaceans have provided scientists with opportunities to elucidate some of the biology of these mammals. The British have historically had a strong interest in stranded cetaceans which were considered royal fishes and property of the Crown (Fraser 1977). Thus, regions under current or former British influence have tended to document and report strandings better than other regions of the world. Stranded cetaceans received sporadic examination by biologists in the United States until the mid-twentieth century. The collecting of data and specimens from stranding events has increased exponentially in the past thirty years. The type and amount of information gathered from these mammals has also increased.

In the past, many traditionally trained mammalogists who examined stranded cetaceans took only sex, length, and locality data and saved only the skull. The first systematic collection of additional morphometric data and tissues was associated with British whaling efforts in the Antarctic (Mackintosh and Wheeler 1929). In an attempt to standardize additional measures and data collected from all stranded cetaceans, Norris (1961) published a cetacean data sheet. In 1974, the International Whaling Commission held a special meeting on small cetaceans and published a more comprehensive data sheet (Mitchell 1975a: appendix E). This data sheet was modified slightly by James Mead of the Smithsonian Institution and is in wide use today. With the increased awareness of the value and diversity of information that can potentially be gathered from a stranded animal and the increasing number of researchers collecting and using such information, it has become evident that each stranded cetacean should be examined in a standardized manner. Efforts should be made to insure that the maximum amount of information is collected, and that both data and specimens are properly stored and, thus, available to current and future researchers.

For many types of information and samples collected from a stranding, the longer the period between death and examination, the lower the potential value of the specimen. Much of the elapsed time is beyond the control of the collector. Nonetheless, it is important that the investigator be prepared to examine an animal soon after notification of the stranding event. A well conceived necropsy procedure with clear goals and priorities can expedite data collection, and maximize the information obtained.

A stranded cetacean is a potential data source for many biological disciplines including, but not limited to, systematics, paleontology, morphology, histology, genetics, pathology, natural history, parasitology, toxicology, and biochemistry. Examination of cetacean carcasses can also contribute to disciplines in which the use of such data is not obvious. For example, because behavior is essentially the study of patterns of the movement of morphological structures, contributions to this field are also possible by the analysis of morphology, pigmentation, and natural history (e.g., Heyning 1984). Hypotheses regarding cetacean sexual strategies and social organization have been partially constructed from such data (e.g., Best 1979; Brownell and Ralls 1986; Heyning 1988; Sergeant 1982).

Minimum Data

Certain data that are critical (Level A data, as described by Hofman 1991) to most, if not all, of the various disciplines listed previously include the sex, total length, reproductive status, locality, date, and voucher specimens (i.e., skull, skeleton, etc.). The difference in time and date from the first reporting of a stranding to the time when the examination (data collection) actually occurred is useful for interpreting results. This information is quickly noted and thus would not compromise any other type of data collected. The techniques documented by Myrick (1986) for collecting the basic life-history information from dolphins in the tuna purse-seine operation are, with minor modifications, useful for stranded animals.

Priorities for Examination of Stranded Cetaceans

The priorities for data collection from beached animals will obviously vary among researchers. There are, however, some biological and logistical considerations that require a sequence of procedures if complete data (see Levels B and C data in Hofman 1991) are to be taken. The general sequence of data acquisition is listed below.

- **Pigmentation**—Several researchers have noted that the pigmentation pattern of cetaceans darkens quickly *post mortem*, especially if exposed to the sun (Norris and Prescott 1961; Mitchell 1970). Because good documentation of pigmentation patterns are rare for most species of cetaceans, photographs of the dorsal, lateral, and ventral aspects are extremely valuable. I have found that suspending a small cetacean by its flukes permits easy photography of all three views. If the specimen has been frozen, defrosting it underwater will best preserve the true pigmentation pattern.

Pigmentation has been used to differentiate among specimens of closely related species (e.g., Perrin et al. 1981, 1987; Mead et al. 1982), as well as to document ontogenetic (e.g., Perrin 1969) and geographic variations within species (e.g., Perrin 1972, 1975; Evans et. al. 1982). Evolutionary and ecological inferences can be made from the careful analysis of pigmentation patterns (Perrin 1969, 1972; Mitchell 1970, 1975b).

I prefer to use either black and white print film or color slide film to document pigmentation. Black and white has the advantage of being easily used for plates in scientific journals. Disadvantages of black and white film are that it does not document color and that it is more difficult to archive because of the necessity to store and cross reference both prints and negatives. Slide film documents color well and it is easy to label and store, but an inner negative must be made in order to produce a plate. Color films also have the disadvantage that colors change over long time periods. Photographic materials must be stored in archival quality holders (e.g., mylar) because poorer quality plastics (polyvinyls) give off chemicals that will destroy the negatives or slides.

- **External Morphology**—The documentation of the external morphology of cetaceans presents many inherent difficulties. Cetaceans cannot be easily skinned or preserved whole as is typically done for most vertebrates. Thus, a far greater number of measurements is usually taken for cetaceans than for other mammals. These measurements, along with photographs and total weights, are most accurate when done on an intact carcass. Measurements have proven useful in quantifying differences in morphology between closely related species (e.g., Ross 1979), populations within species (e.g., Ichihara 1966; Perrin 1975), and for documenting sexual dimorphism (e.g., Perrin 1975). A researcher working with internal tissues that decompose quickly may forgo these measurements in order to expedite the collection of tissues. However, in every case total length should be taken.
- **Internal Tissues**—There are a wide variety of tissues that must be collected quickly as the natural process of necrosis destroys the desired information. Fresh samples are needed for biochemical, histological, biochemical systematic (including electrophoretic, DNA, karyotyping, etc), and toxicology studies. Most of these studies require only small subsamples that can be quickly taken during the initial examination of the internal organs and for the most part do not compromise other data.
- **Gross Internal Examination**—Most researchers examine the internal organs to: 1) perform pathology studies; 2) examine descriptive and functional morphology; 3) obtain organ weights; and 4) collect samples such as reproductive organs and stomach contents for life-history studies. Tissues saved for histology should be fixed in 10% neutral buffered formalin. As a rule, formalin will penetrate about one centimeter from any direction. Thus samples over two centimeters thick (one centimeter penetration from both sides) should be sliced to expose more surface area to the formalin. It is also important to have a sufficient volume of formalin to tissue (approximately 10 times as much formalin as tissue) in order to get proper fixation.

The proper collection and preservation of reproductive tissues is extremely important. In most incidences, the importance of information from these tissues relating to the reproductive status of that animal outweighs other information that can be gained from these tissues. For instance, the destruction of an ovary to determine the pesticide level within that organ results in less information on that animal than would be obtained by determining the pesticide level from other tissues (e.g., blubber, muscle, liver, etc.) and using the ovaries as indicators of sexual maturity or reproductive status.

The exception to the use of formalin is in the preservation of stomach contents. The otoliths of fish and the statoliths of squid are destroyed by the acidic nature of formalin which breaks down to formic acid. Thus, preserving a stomach in formalin dooms that sample to eventual uselessness. Most researchers store stomach contents either frozen or in alcohol. Alcohol does not fix tissues well, but retards bacterial decomposition and is not inherently acidic. Frozen storage is not a long-term solution, because specimens must be prepared immediately if a mechanical failure occurs. However, frozen stomach contents are needed to test for biotoxins which have been suggested as a potential cause of mortality in cetaceans (Geraci 1989).

Rarely, intact prey items can be found in the stomach, indicating that the prey was consumed shortly before the cetacean's death. A stomach full of fleshy prey items is a strong indication of traumatic death, often associated with fisheries interactions. Prey remains in the digestive tract are usually in the form of fish otoliths or squid beaks, which are retained longer in the digestive system.

Weights

Weights provide a simple, accurate, and readily comparable measure of size. Weights of whole carcasses and various organs are rare for many species. The most important weights to measure are the whole body and the gonads. It is important to note the type of scale and its relative accuracy on the data sheet. For paired organs, it is important to note whether recorded weights refer to the right or left organ (preferably both, but separately). Many published papers dealing with gonad weight have not noted which side was weighed, or even if the weight listed was for one or both gonads combined. This has hindered the use of these data in constructing the reproductive parameters for these species (e.g., *see* Mead 1984:91).

Data Archiving

Primary goals in any stranding program are to record data collected from a carcass and to store this information on paper so it can be used for research and, ultimately, for publication. Thus, the manner of data documentation and archival is just as important as the way in which the data were originally collected. At most major museums, there are three places where data are recorded. The first is the field notebook. Typically, each collector assigns a unique, sequential field number to a specimen and notes the collection date and locality of the collection. Other pertinent data are also noted within each entry. By immediately assigning an animal a unique number, all information subsequently collected can be attributed to that individual in the future. Sometimes field stations or institutions use their own field numbers rather than individual collectors'. If this is the case, extreme care must be taken that two collectors do not assign different animals the same institutional numbers or the same animal different numbers.

The second place where data are recorded is on a specimen data sheet such as that shown in Figure 1. The sheet is usually filled out at the time of the necropsy, which may occur months or years after the stranding, if the specimen was initially frozen. The data sheet should always contain the field number and catalog number (*see* below) so that data can be cross-referenced back to the specimen.

Data are also stored in the museum's specimen catalog. Prior to installing a specimen into a research collection, each animal is given a unique museum number that is entered into an institutional catalog. This catalog number is the ultimate reference number by which specimen material, data sheets, field notes, and photographs can be cross-referenced. Catalogs usually note only basic data, but provide the framework upon which a research collection is organized.

All paper used for storing data must be of high quality. Heavy weight (20 lb or over), 100% rag paper should always be used. Inferior quality paper often yellows, becomes brittle over time, or disintegrates if wet. All the effort of collecting good data is wasted if the paper upon which information is stored disintegrates. For the same reasons, only good quality technical inks should be used for writing data (Williams and Hawks 1986). Ballpoint-pen ink should never be used as it runs when wet or exposed to either alcohol or formalin. Pencil marks made with soft lead will fade and smear with age. I have found data sheets from the 1960s that have become virtually useless due to deterioration because the proper paper and/or inks were not used.

Tagging

All specimens and their parts must be tagged with the field and/or catalog number to be of any use. In the absence of a tag that documents that specimen's identity, there is always a chance for an error. Erroneous data caused by the mismatch of a specimen and data are often worse than no data at all. Tags must always be of high quality and affixed directly to the specimen. Secondary tags on containers are often advantageous for processing and storage but should not be used in lieu of tags attached directly to specimens. Similarly, samples stored in jars should have a tag inside the container and should not just be labelled

CETACEA DATA RECORD

Catalog No ____
Field No ____
Species ____ Sex ____ Length ____ Condition ____
Observer ____ Date of occurrence ____, of data ____
Locality ____
Lat. and Long. ____ Reported by ____
Photographs/Drawings ____
Circumstances, cause of death ____

External description ____

Tooth/baleen count: erupt ____ total ____ up L ____ up R ____ low L ____ low R ____
Diameter largest tooth/length longest baleen plate ____ baleen color ____

MEASUREMENTS (specify units ____)

1 total length.............____
2 snout to anus............____
3 snout to genital slit.....____
4 snout to umbilicus........____
5 snout to throat grooves...____
6 snout to dorsal fin tip...____
7 snout to ant. dorsal fin..____
8 snout to flipper..........____
9 snout to ear..............____
10 snout to eye.............____
11 snout to gape............____
12 snout to blowhole(s)......____
13 snout to melon apex.......____
14 eye to ear*..............____
15 eye to gape*.............____
16 eye to blowhole edge, L*..____
17 eye to blowhole edge, R*..____
18 blowhole length ____ width*____
19 diameter ear opening......____
20 head diameter at eyes*....____
21 length of eye opening.....____
22 rostral width, melon apex*____
23 projection up/lower jaw...____
24 number of throat grooves......____
25 length of throat grooves......____
26 flipper length, anterior*.....____
27 flipper length, posterior*....____
28 flipper width, maximum*.......____
29 length mammary slits R ____ L ____
30 number of mammary slits.......____
31 length genital slit ____ .anal ____
32 perineal length (males).......____
33 fluke width*..................____
34 fluke depth*, lobe* ____ notch* ____
35 fluke notch depth*............____
36 dorsal fin height*............____
37 dorsal fin base length........____
38 girth at eye*.................____
39 girth at axilla*..............____
40 girth, maximum*...............____
41 girth at anus*................____
42 girth midway anus to notch*...____
43 height same place*............____
44 thickness same place*.........____
45 blubber thickness, dorsal.....____
46 blubber thickness, lateral....____
47 blubber thickness, ventral....____

REPRODUCTIVE SYSTEM

Female
ovaries: weight R ____ L ____, dimensions (LxWxD) R ____ L ____
uterus: immature ____ mature ____ uterine horn width R ____ L ____
number corpora albicantia ____, corpora lutea ____ diameter CL ____
mammary gland: color ____, length ____, width ____, depth ____, milk? ____
pregnant? ____, fetus: length ____, sex ____, weight ____
vagina length ____, number of vaginal folds ____

Male
testes: weight with epididymis R ____ L ____, without R ____ L ____
dimensions (LxWxD) R ____ L ____, penis length ____
sperm in epididymis? ____

STOMACH CONTENTS
fore: volume ____ fish ____ bones ____ otoliths ____ squid ____ beaks ____
main: volume ____ fish ____ bones ____ otoliths ____ squid ____ beaks ____
pyloric: volume ____ fish ____ bones ____ otoliths ____ squid ____ beaks ____
general remarks ____

AGE DETERMINATION
growth layer groups: cementum ____, dentine ____, earplug ____
vertebral epiphyses: open ____ mm, closed visible ____, closed invisible ____

WEIGHTS (specify units ____, types of scale(s) ____
intact carcass....____ heart..........____ stomach, empty ......____
viscera...........____ lung, right.....____ intestine............____
muscle: epaxial...____ lung, left......____ pancreas.............____
hypaxial..____ liver..........____ adrenal right........____
misc......____ spleen.........____ adrenal left.........____
total.....____ kidney right....____ brain................____
bone..............____ kidney left.....____ thymus...............____
blubber...........____ stomachs, full..____ intestine length.....____
remarks ____

PARASITE/PATHOLOGY CHECKLIST (X if present, NO if absent, NE if not examined)
eye.........____ forestomach..____ mammary glands ____ muscle........____
mouth.......____ mainstomach..____ liver.........____ Phyllobothrium ____
genital slit ____ pyloric......____ bile duct.....____ Monorhygma....____
anal slit...____ intestine.....____ uterus........____ crassicaudid..____
appendages..____ rectum.......____ lungs.........____ Braunina......____
barnacles...____ kidney.......____ heart.........____ Nasitrema.....____
cyamids.....____ kidney duct..____ brain.........____ other.........____
Penella.....____ pancreas.....____ air sinuses...____ ____

SPECIMEN COLLECTION CHECKLIST
teeth/baleen...____ ear plugs....____ liver sample.____ epiphyses......____
stomach content ____ ectoparasites ____ kidney sample ____ electrophoretic ____
gonads.........____ endoparasites ____ fetus........____ toxicology.....____
mammary gland..____ blubber......____ skull........____ X-Ray..........____
uterine mucosa.____ muscle.......____ skeleton.....____ other ____

MISCELLANEOUS
skull length ____, width ____; length tooth/baleen row up ____ low ____
vertebral count: cervical ____, thoracic ____, lumbar ____, caudal ____
number double headed ribs ____, single headed ____, number chevrons ____

REMARKS ____

Figure 1
Sheet for recording data from cetaceans. All measurements are taken as straight lines, parallel to the body axis except those measurements marked with an asterisk which are measured point to point.

on the exterior. Paper tags should be of the same paper as mentioned above or even heavier. Tyvek tags are readily available and can withstand moisture, grease, and blood. Many institutions use tags with the number embossed on plastic or metal for osteological specimens during preparation. These tags can be read no matter what process is used to clean the skeleton (dermestid beetles, maceration, or burial).

Role of Museums in Stranding Programs

Museums form an integral part of a stranding program by functioning as the institutions that properly store and archive the specimens and data. Most major museums, including those within some universities, have a long-term commitment to house research collections. Thus material collected from the 1800s is still available for researchers to use today, and specimens collected now will be available for future research. For example, when revising the systematics of spotted dolphins (*Stenella* spp.), Perrin et al. (1987) resolved taxonomic questions by examining holotype materials in European museums that were collected in the mid-nineteenth century. For many species, it is only through the accumulation of data and specimens over several decades, or even centuries, that we can begin to understand the basic biology of these species (*see* Mead et al. 1982).

In addition, museum specimens function as voucher specimens to clarify previous research. For example, in their study of pathology of stranded cetaceans in southern California, Cowan et al. (1986) listed field numbers of the specimens examined, and most of this material was deposited at the Natural History Museum of Los Angeles County. In a similar study, Britt and Howard (1983) did not deposit voucher materials in a museum. In the geographical region of both studies, there are at least two distinct populations of the common dolphin (*Delphinus delphis*) (Evans 1982), if not two separate species (Banks and Brownell 1969). Should future evidence prove that there are two species of *Delphinus*, the data presented by Cowan et al. (1986) can be separated into the two species by examination of the skulls housed in museums, whereas the information presented by Britt and Howard (1983) can not be re-evaluated and would have limited value.

Additionally, museum specimens are available for many studies not initially envisioned when collecting the specimens. Isotope concentrations may be used to infer various aspects of feeding habits (e.g., Schoeninger and De Niro 1984) and archaeologists use skeletal specimens in research collections as comparative material to identify animal remains found in middens (e.g., Glassow 1980).

The American Society of Mammalogists (ASM) publishes minimum standards for institutions housing mammal specimens in research collections and accredits such collections (Anon. 1978). The ASM thereby attempts to insure that 1) specimens are curated correctly; 2) materials are available to qualified researchers; and 3) the institution has a longer commitment to the collection than the interests of a particular researcher or collector.

Conclusions

Beached marine mammals can provide a wealth of data useful to numerous disciplines if these data are collected and archived in the proper manner. Minimum data (Level A data) such as species, sex, length, locality, and date should be collected for every stranding as this information is vital, simple to note, and does not compromise other studies. The collection of reproductive organs and stomach contents is also critical to understanding the life history of a species. Individual researchers or local institutions should develop a relatively standardized protocol to insure that basic data, as well as any specialized data, are collected and properly stored. Relatively minor steps can be taken to insure that beached animals are used to the fullest extent and that data will be available for future biologists.

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Medical Findings in a Mass Stranding of Pilot Whales (*Globicephala macrorhynchus*) in Florida

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ABSTRACT

A pod of at least thirty-three short-finned pilot whales (*Globicephala macrorhynchus*) stranded on Marco Island on the southwest coast of Florida on 23 July 1986. Because the animals were already being returned to the Gulf of Mexico by another response group at the time we arrived, our initial examination was limited to bloodwork on eight live individuals and post-mortems on six of eight dead individuals. The remainder of the live individuals, some of which were marked for future identification with plastic tags and by notching dorsal fins, headed north in the Gulf after regrouping at the mouth of the Marco River. On 9 August 1986 the apparent remnants of the pod were found stranded near Key West, Florida. On this date 10 of 17 animals found were dead. Surviving animals were transported to Sea World of Florida from Key West and were sampled for complete blood counts and serum chemistries before therapy began. All of the individuals sampled from the incidents on 24 July and 9 August showed physical, clinical pathological, or histological evidence of illness. None of the individuals survived longer than two weeks. Physical abnormalities noted in the live whales included increased respiratory rate, difficult breathing, and elevated heart rate. Clinical pathologic abnormalities included elevated hemoglobin levels, elevated plasma fibrinogen, leukopoenia, leukocyte left shift, hyperglycemia, elevated serum creatinine, elevated serum bilirubin, decreased alkaline phosphatase, elevated lactic dehydrogenase, elevated liver enzymes, hypocalcemia, and hypophosphatemia.

These findings suggest that the majority of whales sampled in this mass stranding were clinically ill. Stranded individuals should be examined for illness by common diagnostic procedures such as blood counts, serum chemistries, and necropsy to determine the extent of illness in stranded whales.

Introduction

Whales have been found stranded on beaches for thousands of years. During this time humans interested in these events have proposed various theories to explain why whales strand (Cordes 1982; Ridgway 1972; Geraci et al. 1976; Geraci 1978; Robson 1984; Eaton 1979; Best 1982; Morimitsu et al. 1986, 1987; Ellis 1987; Odell 1987; Warneke 1983). Theories advanced include 1) unfamiliarity of deep water species with coastal areas; 2) evolutionary memory of land so that it is sought for unknown reasons; 3) environmental disturbances such as earthquakes; 4) sloping beaches; 5) loss of sonar ability; 6) geomagnetic field abnormalities; and 7) illness (Dudok Van Heel 1962; Sergeant 1982; Klinowska 1985, a, b, and c; Kirschvink et al. 1985). Many of these proposed theories are based on very little factual data, while others are based on "partial" truths which do not fully explain the event. As personnel with medical backgrounds have become involved in mass strandings, more emphasis has been placed on pre- and post-mortem identification of illness factors that may better explain the deaths of many of these individuals. The addition of individual medical evaluations of members of a stranded pod to the data base can help to determine if illness is a factor in the stranding, how many individuals may be involved, and which individuals may have the best chance for survival.

Materials and Methods

A pod of short-finned pilot whales (*Globicephala macrorhynchus*) consisting of at least 33 individuals stranded at Marco Island on the southwest coast of Florida on 23 July 1986. The initial rescue team responded to the stranding by pushing the animals back out to sea on 24 July 1986. At 0800 hr on 24 July 1986 a portion of the pod was still in the Marco River broken into three groups, one consisting of nine individuals on a sand bar, a second on the opposite side of the river (exact number unknown), and a third group of four or five individuals in the channel closer to the river mouth. As many as 20 animals were already in the process of being returned by the initial rescue team toward open water by this time. We detained 10 other individual whales as they were being taken through the channel. These animals were sexed, measured, marked with grease pencils on the dorsal fins with numbers, and tagged with plastic tape with corresponding numbers (Table 1). Two large individuals in the center channel were also marked by notching the dorsal fin.

Table 1
Length and sex of 30 short-finned pilot whales stranded in southwest Florida in 1986. SWF = Sea World of Florida; C = University of Miami.

Field number	Whale ID (in text)	Sex	Length (cm)
SWF-GM-8644-B	1	M	450
SWF-GM-8645-B	2	M	440
SWF-GM-8646-B	3	F	226
SWF-GM-8647-B	4	M	216
SWF-GM-8648-B	5	F	330
SWF-GM-8649-B	6	M	243
SWF-GM-8650-B	7	F	380
SWF-GM-8651-B	8	F	356
SWF-GM-8652-B		F	331
SWF-GM-8653-B	8B	F	308
SWF-GM-8654-B		F	350
SWF-GM-8655-B		F	333
SWF-GM-8656-B		M	367
SWF-GM-8757-B	13	M	292
SWF-GM-8658-B	12	F	331
SWF-GM-8659-B	14	F	360
SWF-GM-8660-B	15	F	328
SWF-GM-8661-B	16	F	330
SWF-GM-8662-B	9	M	123
SWF-GM-8663-B	10	F	144
SWF-GM-8664-B	11	F	323
C-86-19		F	364
C-86-20		M	321
C-86-21		M	453
C-86-22		M	470
C-86-24		M	459
C-86-25		F	362
C-86-26		M	334
C-86-27		F	351
C-86-28		F	354

Heart rates and respiratory rates were taken in five individuals and antibiotics (Dual-Pen [Dual-Pen, Techamerica Group Inc., P.O. Box 338, Elwood, KS 66024]—1 cc/10 kg) administered to each. Blood was drawn from nine individuals for complete blood counts, serum chemistries, hepatitis titers, whole blood element analysis, and serum hormone levels. All blood samples were taken before the administration of any drugs. Complete blood counts were done at Sea World of Florida utilizing a Coulter (Coulter, 540 West 20th St., Hialeah, FL 33010) Model M4-30. Spun packed cell volumes were taken for comparison to Coulter hematocrit values. Total protein values given in Table 2 are derived from a serum refractometer. Fibrinogen levels were determined by indirect method comparing refractometer serum protein levels pre- and post-heated in hematocrit tubes for 3 minutes in a 58°C water bath. Serum chemistries were analyzed on an Abbot Spectrum (Abbot Spectrum, P.O. 152020, Irving, TX 75015). Standards for individual tests were human based and run at 37°C. Electrolytes, blood urea nitrogen and glucose were analyzed on a Beckman Astra (Beckman Astra, 200 South Kraemer Blvd., Brea, CA 92621-6209) unit. Evidence of the presence of hepatitis A and B virus was investigated using human test kits by analyzing serum samples in 11 whales.

It took approximately two hours to herd the survivors down to the river mouth on the Gulf of Mexico. During this time seven more animals, three of which had been bled earlier, died. All dead individuals were towed to a deserted beach where they were necropsied. Morphometric data were collected on all whales at the time of necropsy. Tissues taken from individuals that had not undergone decomposition were placed in 10% neutral buffered formalin for routine histopathologic examination. Bacterial cultures were not taken at this time owing to surf action on the whales during necropsy.

Table 2

Complete blood counts (CBC) from 16 live short-finned pilot whales stranded in Florida in 1986. HGB = hemoglobin; HCT = hematocrit; RBC = Red Blood Cell count × 10; MCV = mean corpuscular volume; MCH = Mean corpuscular hemoglobin (picogram); MCHC = mean corpuscular hemoglobin concentration (grams/deciliter); NR = nucleated red cells per 100 white cells; MORPH = red blood cell morphology (N = normal, B = Burr cell, HJ = Howell Jowell body, C = crenation); TP = total protein (gm/dL); PCV = packed cell volume (%); FIB = fibrinogen (gm/dL); WBC = White blood cell; BA = Bands; SEG = Segmented neutrophils; LY = Lymphocytes; MON = Monocytes; EOS = Eosinophils; BAS = Basophils; PL = Platlets (N = normal).

ID	HGB	HCT	RBC	MCV	MCH	MCHC	NR	MORPH	TP	PCV	FIB	WBC	BA	SEG	LY	MON	EOS	BAS	PL
1	16.7	51	4.18	120.8	40.6	33.1	0	N	8	47	<0.1	5600	0	66	26	2	2	0	N
2	19.1	53	4.13	130.5	46.2	35.4	0	N	7	51	0.4	7800	0	88	10	0	0	0	N
3	20.5	61	4.90	122.0	41.4	33.9	0	B	7	48	0.2	8400	0	90	10	0	0	0	N
4	19.4	63	4.41	143.4	44.0	30.9	0	N	8	53	0.1	2400	0	56	36	4	0	0	N
5	19.3	57	4.48	127.2	43.1	33.9	0	N	8	53	0.1	1300	0	64	28	0	0	0	N
6	17.1	50	3.90	126.5	43.0	34.4	0	N	7	46	0.1	6800	0	76	22	0	0	0	N
7	19.1	58	4.43	130.5	43.0	33.0	1	N	8	53	0.1	4700	0	76	16	0	0	0	N
8	18.3	53	4.28	123.8	42.8	34.8	0	N	8	46	0.1	3700							
8B	18.2	52	4.25	126.6	42.8	33.8	0	N				7300	0	84	6	0	0	0	N
9	17.3	50	4.06	121.9	42.6	34.9	0	N	8	47	1.2	5300	0	79	18	2	1	0	N
10	18.8	53	4.28	123.8	42.8	34.5	0	HJ	8	51	<0.1	7100	0	95	4	0	1	0	N
11	18.2	52	4.21	124.0	43.2	34.9	0	HJ,B,C	8	51	0.1	9100	0	88	11	1	0	0	N
12	18.2	54	4.24	127.8	42.9	33.6	0	B	7	52	<0.1	4500	0	91	8	0	0	0	N
13	19.7	56	4.57	123.0	43.1	35.1	0	B,C	8	56	0.1	4700	0	93	5	1	1	0	N
14																			
15	17.9	53	4.31	123.4	41.0	33.6	0	N	8	48	0.3	7900	0	91	2	2	0	0	N
16	20.2	58	4.47	129.5	45.2	34.9	0	HJ,B,C	7	56	0.3	3700	0	90	5	2	0	0	N

On 8 August 1986 the remnants of the pod which was pushed out at Marco Island restranded in Florida Bay near Key West, Florida. At the time of discovery, 10 individuals were already dead; these were examined by personnel at the University of Miami. Seven live whales were found in various stages of weakness and transported to Sea World of Florida for evaluation and treatment. One individual died during transport. Blood samples were taken from all live individuals before transport and on a regular basis after animals arrived at Sea World. After blood sampling, each whale was given Banamine (Banamine, Flunixin Meglumine, Schering Corporation U.S.A., Kenilworth, NJ 07033) I.M. (1.0 mg/kg of body weight, not to exceed 600 mg), VIT E-Selenium (Vit E - Selenium - Schering Corporation U.S.A., Kenilworth, NJ 07033) I.M. (0.13 mg/kg), Cimetadine (Cimetidine - Tagamet, Skof Laboratory Co., Cidra, PR 00639) 600 mg I.M. and Dual-pen I.M. (1 cc per 15 kg).

Upon arrival at Sea World the survivors were placed in a community pool and given oral fluids twice a day. The fluids consisted of fresh water at a rate of 1 liter/75 kg, which also contained 50 mL of 50% glucose per liter and 3-5 Cimetidine tablets (300 mg). On day two, each individual was given 10 cc of B-complex (B-Complex - Professional Veterinary Lab., Minneapolis, MN 55437) I.M., 5 cc of thiamine (Thiamine - Tech America Inc., Elwood, KS 66024) I.M., and antibiotics were changed to Keflex (Keflex - Cephalexin, Zenith Labs. Inc., Ramsey, NJ 07446) at a dose of 2.5mg/kg I.M. Initial bacterial cultures (aerobic) were taken from inside the blow hole. Identification of bacteria isolated was performed using the API (API, 200 Express Street, Plainview, NY 11803) system and sensitivities to antibiotics were analyzed by Kirby Bauer (Kirby-Bauer Method - BBL, Microbiology Systems, Becton Dickinson and Co., Cockeysville, MD 21030) disc method. Antibiotic for individual 11 was changed from Keflex to tetracycline (Tetracycline, HCL, Purepac Pharmaceutical Co., Elizabeth, NJ 07207) on day 3. Whale number 60 was also given Kanamycin (Kanamycin - Kantrim, Bristol Labs., Syracuse, NY 13201) 2.4 mg/kg I.M. twice a day after 14 August 1986. Two whales were given Ivermectin (Ivermectin - Ivomec, MSD Aguet Merck and Co. Inc., Rahway, NJ 07065) (1 cc/100 kg I.M.). Whales that expired were examined grossly at Sea World of Florida.

Tissue samples were taken from all organs, placed in 10% neutral buffered formalin, and processed routinely. Bacterial cultures (aerobic and anaerobic) were taken from major organs and areas of observed pathology. Gross examination of the animals included inspection of the pterygoid sinus and the eighth cranial nerve area. Urinalysis of samples taken by needle aspirate at necropsy was performed on 4 whales using Multistix (Multistix, Ames Div., Miles Labs. Inc., Elkhart, IN 46515), refractometer (specific gravity) and microscopic exam of sediment.

Table 3

Serum chemistries from 17 live short-finned pilot whales stranded in Florida in 1986. GLU = Glucose (mg/dL); BUN = Blood urea nitrogen (mg/dL); CR = Creatine (mg/dL); BILIT = Total Bilirubin (mg/dL); BLID = Direct bilirubin (gm/dL); CHOL = Cholesterol (mg/dL); TRIG = Triglycerides (mg/dL); TP = Total protein (gm/dL); ALB = Albumin (gm/dL); GLOB = globulin (gm/dL); ALP = Alkaline Phosphatase (U/L); ALT = Serum alanine aminotransferase (U/L); AST = Serum aspartate aminotransferase (U/L); LD = Lactic dehydrogenase (U/L); CA = Calcium (mg/dL) PHOS = Phosphorous (mg/dL); NA = Sodium (Meq/L); CL = Chloride (Meq/L); K = Potassium (Meq/L); FE = Iron (mg/dL); CO_2 = Carbon Dioxide; Serum Uric Acid levels on all animals were not detected (<0.6).

ID	GLU	BUN	CR	BILIT	BILID	CHOL	TRIG	TP	ALB	GLOB	ALP
1	164	29	4.7	0.3		164	126	6.9	3.4	3.6	158
2	117	37	4.5	0.3	0.1	149	113	6.6	3.2	3.4	177
3	119	52	1.9	0.3	0.1	237	264	5.7	3.1	2.7	310
4	251	28	2.1	0.2		265	121	6.6	3.3	3.3	607
5	199	36	3.2	0.1		245	109	6.8	3.1	3.7	237
6	222	29	2.1	0.1		148	86	6.2	3.4	2.8	242
7	144	35	3.7	0.2		269	82	6.8	3.4	3.4	189
8											
8B											
9	120	58	2.0	0.7		213	186	5.1	3.5	1.5	151
10	177	43	2.8	0.3		153	100	7.2	3.4	2.0	71
11	171	43	3.0	0.3		151	102	6.9	3.2	3.7	78
12	154	48	3.1	0.5		221	89	6.2	3.5	2.7	222
13	140	41	2.4	0.4	0.3	197	180	6.1	3.6	2.5	310
14	111	31	4.0	0.5		212	144	7.5	3.5	4.0	90
15	178	34	2.8	0.3	0.1	135	49	6.9	3.8	3.1	178
16	174	43	3.3	0.4	0.2	227	105	6.0	3.5	2.5	81

ID	ALT	AST	LD	CA	PHOS	NA	CL	K	FE	CO_2
1	33	249	730	8.7	2.5	161	117	5.2	—	27
2	26	179	813	8.1	1.9	154	121	5.1	—	24
3	29	348	899	7.6	3.2	146	113	5.5	—	23
4	18	227	1088	10.0	1.8	155	113	4.6	—	24
5	25	238	725	8.3	1.6	150	118	5.3	—	20
6	17	188	984	9.2	2.1	149	121	5.0	—	20
7	40	310	1588	9.1	1.1	156	126	5.3	—	21
8										
8B										
9	27	288	1112	6.9	4.2	153		4.3	326	27
10	20	184	574	8.9	1.0	155	114	5.6	246	15
11	21	193	721	9.1	1.3	157	118	5.6	149	15
12	75	377	534	7.1	2.6	157	123	3.8	220	16
13	51	310	1886	7.3	3.7	150	114	3.6	—	26
14	32	316	984	9.6	2.9	159	109	5.1	326	10
15	73	375	1492	6.8	4.1	153	119	3.6	176	21
16	79	430	2712	7.4	4.9	157	118	4.4	184	24

Results

Male members of the pod sampled at both sites ranged in length from 123 to 470 cm. Female whales ranged in length from 144 to 380 cm. (Table 1.)

Respiratory rates for whales from Marco Island ranged from 6–70 respirations/5 min. Of the portion of the pod which restranded in Key West respiratory rates ranged from 13–25/5 minutes. Heart rates were obtained on only two individuals. Whale 3 had a heart rate of 68 beats per minute (bpm) while number 7 had a heart rate of 37 bpm.

Complete blood count results from the live stranded individuals are given in Table 2. Whales 1 through 8B were animals from the initial stranding while whales 9 through 16 were individuals from the Key West portion. A complete blood count (CBC) was not available from whale 14. Red blood cell morphology abnormalities included Howell-Jolly bodies (3 whales), poikilocytosis (1), Burr cells (2), crenation (3), and acanthocytes (1).

Total protein levels from serum refractometer readings did not appear grossly elevated but were consistently higher than serum protein determination. Spun packed cell vol-

Table 4

Aerobic bacterial isolates from blowhole cultures of 17 live short-finned pilot whales stranded in Florida in 1986.

Bacterium	Whale ID
Streptococcus faecalis	16
Staphylococcus aureus	13
S. duras	9
S. sciuri	9
S. saprophyticus	9
Acinetobacter calco var. *lwoffii*	13,15,16
Enterobacter aerogenes	13
E. cloacae	9
E. gergoviae	12,15,16
Klebsiella pneumoniae	15
Pseudomonas spp., flourescent group	12,13,15,16
Listeria monocytogenes	13

Table 5

Bacteria recovered from tissue cultures from pilot whales stranded in Florida in 1986. Numbers in the table are identification numbers for each whale (*see* Table 1).

	Tissues				
Organism	Kidney	Liver	Lung	Lymph node	Spleen
Streptococcus faecalis	16*	16	11,12,15,16		
Citrobacter fruendi			15,16		
Morganella morganii			9,15,16		
Pseudomonas spp., flourescent group	16	16	12	16	16
Pseudomonas putrefaciens			12		
Escherichia coli			11	16	
Proteus mirabilis			11		
Clostridium sporogenes		11			
Bacteroides asachanolyticus			11		

Table 6

Analysis of urine collected at necropsy of four short-finned pilot whales stranded in Florida in 1986. Analysis by refractometer (S.G.) N-Multistix for urinalysis and microscopic (sediment). S.G. = Specific Gravity; Protein = mg/dL; Glucose = mg/dL; Ketone = mg/dL; Urobilinogen = Ehrlich units/dL; Bilirubin = small, moderate, large; Sediment: WBC = White blood cells per high power field; Epithelial cells = Occasional; — = ?.

Whale ID	Color	Character	S.G.	Protein (mg)	Blood	pH	Glucose (mg)	Nitrite	Ketone (mg)	Uro-bilinogen	Bilirubin	Sediment
10	Yellow	—	1.045	100	—	6	—	—	5	8.0	moderate	—
11	Green	Clear	1.052	300	—	6	500	—	—	8.0	—	WBC(10-15)
13	Brown	Turbid	1.026	300	—	6	250	—	—	8.0	—	WBC(4-6)
15	Yellow	Clear	1.015	300	—	6	500	—	—	8.0	—	WBC(10-15) Epith cells

umes (range = 46-55%) were within the normal range but did not correlate well in some individuals with Coulter hematocrit determinations. Fibrinogen levels were considered elevated when >200 mg/dL, as seen in four whales (Table 2). Normal white blood cell counts (WBC) usually ranged from 5000 to 10000 cells/mm^3 in most cetaceans (Ridgway 1972). Seven individuals had decreased total white cell counts and four individuals showed more severe leukopenia (<4,000 cells/mm^3). A leukocyte left shift, as evidenced by the presence of immature neutrophils, was seen in nine individuals.

Serum chemistry and serum electrolyte results from initial blood samples are given in Table 3. Chemistries were not available from whales 8 or 8B. Glucose levels ranged from 117 to 251 mg/dL. Initial bacterial culture from the external nares (blow hole) of five whales transported for treatment are given in Table 4. Bacterial isolates recovered from various organ tissues at necropsy of five whales are presented in Table 5. Isolates were recovered from the lung, liver, lymph nodes, kidney, spleen, and vagina. It should be noted that these isolates were cultured from individuals that were previously on antibiotics.

Urinalysis

Urine was recovered from four animals at necropsy (Table 6). The urine pH of each whale was 6.0. Specific gravity ranged from 1.026 in whale 15 to 1.052 in whale 10. Protein levels were elevated in each individual even though red blood cells were not present. Urobilinogen levels were elevated compared to urine from other cetaceans. Bilirubin was present in the urine of whale 10. Glucose was detected in whales 11, 13, and 15. White blood cells were seen in the sediment from whales 11, 13, and 15.

Hepatitis Panel

Serum from whales analyzed for hepatitis A and B (Table 7) revealed four whales with positive reactions for Hepatitis A antibody, three individuals with borderline reactions to

Table 7

Serum hepatitis titers from 11 short-finned pilot whales stranded in Florida in 1986. A-AB = Hepatitis A antibody; A-AB-IgM = Hepatitis A antibody IgM; B-Surf-Ag = Hepatitis B surface antigen; B-core-AB = Hepatitis B core antibody; B-surf-AB = Hepatitis B surface antibody; + = Positive; – = Negative; B = Borderline; W+ = weakly positive.

Whale ID	A-AB	A-AB-IgM	B-surf-Ag	B-core-AB	B-surf-AB
2	–	–	–	–	–
4	–	–	–	–	–
5	+	–	–	–	B
8	+	–	–	–	–
8B	+	–	–	–	–
9	–	–	–	–	–
11	–	–	–	–	B
12	–	–	–	–	–
13	–	–	–	–	B
15	+	–	–	–	–
16	–	–	–	–	W+

Hepatitis B surface antibody and one whale with a weakly positive reaction for Hepatitis B surface antibody.

Necropsy

The results of necropsy of animals which expired on Marco Island and at Sea World are given by Bossart et al. (1991). Animal identities are cross-referenced.

Discussion

Numerous theories have been proposed to explain why cetaceans strand in mass. The majority of these theories are based on conjecture rather than facts related tc the stranding. While illness of part or all of the group has been suggested (Geraci 1978), little has been documented regarding the individual clinical health at the time of the stranding other than post-mortem findings. The approach with this stranding was to investigate the possibility that some or all members of the mass stranding were ill at the time they stranded. Cetacean species are likely to suffer from the same disease processes as any other mammals, including trauma, toxins, infectious agents (viruses, bacteria, fungi, yeast, parasites) and nutritional and metabolic illnesses. To eliminate illness as a major factor in a stranding, it is necessary to study in depth three different facets of the event. First, the individual's external health status should be evaluated. Second, an evaluation should be made of the whale's internal health status. Third, a post-mortem examination must be done to include at minimum a gross examination of all individuals, including bacterial cultures of tissues, and histopathologic examination. External health evaluation can be partially accomplished by a superficial physical exam. This should include noting respiratory rates, heart rates, and overall "attitude" (activity, alertness, awareness of surrounding environment, response to stimuli). A single observation of heart and respiratory rates can be confusing if these are used as the only method of evaluation. A "healthy" animal may show elevated rates during phases of excitement and a weak individual who is no longer responsive to external stimuli may show apparent normal values. Initial decisions should be based on serial heart and respiratory rates coupled with other information. It may be necessary to sedate animals lightly which have elevated heart and respiratory rates to rule out the possibility that stress is the cause rather than illness. Because expression of illness is not limited to elements of the cardiovascular or respiratory system, it is also helpful to obtain blood samples for routine diagnostic tests such as complete blood counts (CBC), serum chemistries, and electrolyte values. Values obtained from CBC's and chemistries may differ among laboratories as a result of a lack of familiarity with species differences as well as differences in test methodology.

The CBC can give information relevant to individual health in areas such as hydration, anemia, inflammation, and infection. Using automated counters has some potential problems. The HCT is *calculated* by the instrument after determining the RBC and mean corpuscular volume (MCV). Potential error is greater because of the measurement complexity and the standardization of most machines for human cells. As a result, the packed cell volume (PCV) is used as a more reliable index in the whales. The mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and hemoglobin concentration are also common values supplied by automated equipment. The MCV can be determined directly by some automated counters and may be affected by anemia, an increase in reticulocytes (young red cells) and iron deficiency. The MCH and MCHC are calculated values.

Total serum protein levels (Table 2) were determined with a refractometer. The difference between refractometer levels and levels determined in the serum chemistry section should be noted. The total protein level can be used to determine dehydration in animals where normal values are known; however, total protein level may be affected by starvation, disease states or factors which affect serum clarity such as lipemia. Fibrinogen levels are rough estimates of inflammation. Normal levels are usually less then 300 mg/dL (Duncan and Prasse 1977). Whales 2, 9, 15, and 16 had fibrinogen levels indicating active inflammation which may be related to disease or to damage received during stranding.

White blood cell counts are generally used to help determine the presence of infection or inflammation. Infection may result in a different white count at different stages.

Increases in total white cell numbers (>15000) were not seen in these animals. The presence of young white cells (neutrophils-bands) usually associated with an infection was noted however. Leukopenia (total decreased low white cell count <5000 mm^3) was seen in seven whales. This may be associated with viral infections, or, as in some species such as cattle, there may be a period where the peripheral white cell population migrates to the site of an infection resulting in a temporary circulating total white cell decrease. If the animal is capable of responding to an infection, the total white cell count should increase past the normal level giving the more classic leukocytosis. This did occur in the whales which were treated and given time to respond. Differences in the differential of the white cell count (breakdown of white cell count components) may change because of infection type, response capability and stress. The "stress response" leukocyte picture usually involves an increase in overall numbers (leukocytosis), predominantly a result of an increase in neutrophils, and a decrease in eosinophils and lymphocytes. The absence of a left shift helps to differentiate this from inflammatory diseases.

Serum chemistries can be very helpful in determining whether various organ systems are affected by illness. This information is also affected by variability among laboratories in test methodology and results. Many automated chemistry units run all tests at a constant temperature (ex: 37°C). Other analyzer systems are not run at constant temperature, resulting in variation in enzyme levels especially ALT, AST, CPK, LDH and HBD. The kidneys may be partially evaluated by the BUN (blood urea nitrogen) and creatinine levels. Creatinine levels greater than 2.5 mg/dL are considered elevated. The level of increase in most of the pilot whales is within the range associated with dehydration. Creatinine levels greater than 4.0 mg/dL should be considered serious elevations which may soon become life threatening. Whales treated at Sea World with oral fluids did respond, as evidenced by serial decreases in creatinine levels. Total bilirubin levels greater than 0.3 mg/dL units are usually considered elevated as seen in 5 individuals. This may be associated with liver disease, anorexia, and dehydration.

The significance of cholesterol and triglyceride levels and their relationship to disease is unknown. The levels are given for future reference. Serum total protein levels from the pilot whales differ from refractometer levels as shown in Table 2. The differences may be partially related to inappropriate test application and human specific kits not detecting total albumin and globulin levels. Alkaline phosphatase levels are normally elevated in cetaceans. Levels detected at 37°C generally range from 250–600 μ/L units. Levels less than 150 μ/L are considered abnormally low. Lower levels are usually associated with illness and possibly a decreased food intake. Liver enzymes such as ALT (alanine aminotransferase) and AST (aspartate aminotransferase) may be elevated during liver disease but are not totally specific for liver destruction. Normal levels for this hospital lab are <40 μ/L for ALT and <300 for AST. The LDH (lactic dehydrogenase) levels may be elevated from liver disease or muscle disease. Normal LDH levels are less that 500U/L. Serum calcium levels less than 8 mg/dL are considered low. Levels less than 7 could predispose the individual to weakness or possible seizure activity. Normal phosphorous levels range between 3.5 and 5 mg/dL. The significance of low serum phosphorous levels in cetaceans is unknown. Animals with less than 3 mg/dL are supplemented with oral phosphorous.

Electrolyte imbalances are also seen in ill cetaceans. Increased sodium levels have been associated with dehydration and ingestion of sea water in other ill cetaceans such as the false killer whale (*Pseudorca crassidens*) from a stranding in June 1986 (unpubl. data). Potassium levels are only slightly elevated above the normal range of 3.5–5.0 units. Serum carbon dioxide levels normally range from 18 to 28 units, with levels less than 16 suggesting acidosis as shown by whale 14 which died just after sampling.

Bacterial cultures taken from the blow hole of five animals taken to Sea World of Florida showed that most individuals carried more than one species of bacterium in the external nares. Whether or not these bacteria were pathologically significant is unknown but this does illustrate that there may be more than one species present which could be involved clinically. Of the animals receiving treatment with various antibiotics at Sea World of Florida, those animals which survived longest received more than one antibiotic type concurrently during therapy.

There are some potential problems related to identification of some marine organisms, because many commercial systems available for identifying bacteria do not include these organisms in their data banks. Bacterial cultures taken at necropsy listed in Table 5 show a variety of organisms present in multiple tissues of the whales involved. The clinical significance of these isolates is difficult to determine but it also suggests the need for proper multiple antibiotic use because all of these individuals were on antibiotic therapy before death. In addition it is a possibility that these animals may be immunosuppressed so that "normal" bacterial flora may become pathogenic.

Urinalysis of samples taken by needle aspirate from the bladder is given in Table 6 and shows various abnormalities. The application of many of these findings is unknown at this point because the samples were taken from dead individuals.

From analyses of serum liver enzyme elevations and pathology reports concerning liver disease, it is suspected that hepatitis viruses might be involved in some cetacean disease states. The application of human tests kits for evidence of hepatitis may be of questionable value but the hepatitis viruses are probably present in most species so that it is worthwhile investigating the possibility at this stage.

Parasitic infection as a cause of strandings is one theory which has some factual basis but such infections are probably over-emphasized since they also occur in healthy wild individuals (Ridgway and Dailey 1972). A percentage of parasitic illnesses can result in death when there is central nervous system migration or massive organ dysfunction (lung worms, heart worms, liver flukes, gastrointestinal worms). Intestinal parasites found in this stranding did not occur in large enough numbers to kill the animals. Parasites found in the pterygoid sinuses, while higher in number than in the intestines, did not appear to be causing any obvious pathology. Morimitsu et al. (1986) examined histologically the eighth cranial nerve of a few whales involved in mass strandings in Japan and felt that migrating parasites damaged the nerves, resulting in loss of equilibrium and eventual stranding. It should be noted that nematodes and trematodes are commonly found in the pterygoid sinus. These investigators looked at only a few animals out of the group and did not investigate other health factors; and some of the whales were examined histologically after the tissue had already been refrigerated or frozen.

The results of necropsies of whales involved in this stranding are given by Bossart et al. (1991). Necropsies are an essential part of any illness investigation and should be performed on any cetacean which expires for unknown reasons. This procedure complements the physical and clinical pathology portions of a stranding investigation, often clarifying or contributing to an explanation of the cause of death.

A major complicating factor in understanding a mass stranding is the strong social system which exists among the members of the pod. Members of the group may blindly follow other individuals, especially those who are apparently leaders of the pod. As a result, if an illness is at first isolated in a pod's leader, this individual may lead the group away from normal migration patterns including food sources. An infectious agent may move rapidly through the pod resulting in many ill individuals at the time of stranding.

The actual etiology of a mass stranding event may be unknown because the original inciting factor, such as a virus, may have occurred days or even weeks before. Without knowledge of the time frame involved or how many animals may have already died at sea, it is unlikely that the true cause of many strandings will be established.

Based on clinical pathology findings coupled with histologic findings (Bossart et al. 1991), it is obvious that there are other factors in mass strandings which should be examined in order to understand better why these animals strand. It should be assumed that some or all members of a stranded pod are ill until proven otherwise. The following outline provides recommendations that may help in gathering information relevant to the health of a stranding pod:

1) Provide initial first aid and identification for each animal.
   A) Keep animals in sternal position to avoid inhalation of sand.
   B) Provide shade and keep skin moist with water.
   C) Tag each individual with a numbered "spaghetti" tag through the caudal edge of the dorsal fin for future identification.
2) Collect clinical data on each individual for evaluation and future use.
   A) Record respirations per 5 minutes and heart rate every 30 minutes.
   B) Obtain blood samples (50–100 cc) for complete blood count, serum chemistries, and electrolytes. If possible have these analyzed while working on stranding.
3) Decide disposition of pod based on above information. If members of the pod are already dead assume others will die shortly.
   A) If facilities are available consider transporting the youngest and strongest for treatment.
   B) If no facilities are available and animals must be returned to sea, consider humane euthanasia for those who are dying and might cause the pod to restrand.
4) Animals removed for treatment and which survive should be held for six months. They should not be released without a complete medical workup for evidence of infectious or contagious diseases. Animals that originate from a pod where most have perished from an unknown illness may inadvertently carry a potentially fatal disease back to unexposed pods. Without intervention these animals would have died on the beach limiting the spread of a possible contagious disease.
5) All individuals that are released should be tagged or freeze-branded to help identify them if restranding occurs.

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Histopathologic Findings of a Mass Stranding of Pilot Whales (*Globicephala macrorhynchus*)

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ABSTRACT

Thirty short-finned pilot whales (*Globicephala macrorhynchus*) stranded on the Gulf coast of Florida in 1986. Gross and microscopic necropsies were performed on 10 whales. This report describes the histopathologic findings on these whales. A wide diversity of lesions was present not only within individual whales, but within the stranding group as a whole. The severity of these lesions also had a wide range. Pathologic changes included multiorgan inflammatory and degenerative lesions as well as adrenocortical and lymphoid changes consistent with prolonged stress and possible secondary immunologic suppression. The histopathologic findings were often indicative of chronic progressive disease processes suggesting the existence of disease some time prior to stranding.

Introduction

Numerous theories have been proposed for mass strandings of living cetaceans. In most strandings, however, pertinent biological data are either unobtainable or incomplete, only fueling further speculation concerning stranding circumstances.

The southwest coast of Florida has a history as a site for mass strandings. Recent strandings include short-finned pilot whales (*Globicephala macrorhynchus*) in 1971 (Fehring and Wells 1976), 1979, 1985, and 1987 (Odell 1991, unpubl. data) and false killer whales (*Pseudorca crassidens*) in 1972, 1976, and 1986 (Odell et al. 1980; Odell 1991, unpubl. data). Typically, the herd initially strands on the upper southwest coast (e.g., Ft. Myers area) where the live animals are returned to sea, only to strand again in a few days further to the south (Fehring and Wells 1976; Odell et al. 1980).

On 23 July 1986, 30 living short-finned pilot whales (*Globicephala macrorhynchus*) stranded near Marco Island on Florida's Gulf coast. Thirteen of these whales subsequently died or were euthanized. Stranding data collected from this incident included geographic parameters, population dynamics, animal morphometrics, and hematologic and blood chemistry parameters. Seventeen of the remaining whales were returned to the sea. They restranded 16 days later near Key West, Florida.

Complete gross and microscopic necropsies were performed on 10 whales from the initial stranding. The purpose of the present report is to characterize the histopathologic findings of these pilot whales to determine potential cause(s) of death and suggest circumstances preceding the stranding.

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Materials and Methods

Thirty living short-finned pilot whales stranded on the beaches of the Gulf coast of Florida in July 1986 (for details, *see* Walsh et al. 1991). Ten of these whales had gross and microscopic necropsies performed (Table 1) after assignment of individual case numbers and recording of morphometric and geographic stranding data.

Gross necropsies were performed by the staff of Sea World of Florida and members of the Southeastern Marine Mammal Stranding Network, generally within four hours after death. Carcasses were kept cool with ice in the interim, when possible. Gross necropsy findings were recorded on individual case reports so these findings could be cross-referenced later with microscopic findings.

Tissues from organs and reported lesions were collected and fixed in 10% neutral-buffered formalin. These specimens were processed routinely for light microscopic evaluation, sectioned at 5 μm, and stained with hematoxylin and eosin. In selected cases other stains were used, including Brown and Brenn, Fite acid fast, Grocott methenamine silver, and periodic acid-Schiff. Only data from freshly salvaged whales, which had minimal microscopic tissue autolysis, were used in this study.

For this report a numerical histologic grading system (grade range of +1 to +5 was utilized to categorize inflammatory and degenerative lesions, as well as pathologic changes of primary lymphoid tissues and the adrenal glands. Pathologic changes graded +1 were mild (diffuse or focal); +3 were moderate (diffuse or focal); and +5 were severe (diffuse or focally extensive) in nature with a grade range of +1 to +5 (Table 1).

Results

Parasites were grossly reported in the middle ears of five whales. These were identified as nematodes (probably *Stenurus* sp.) in all cases, with one whale having a combined trematode (*Nasitrema* sp.) infestation. In the gross necropsy reports the number of parasites in this region ranged from "few" to "many." Gross lesions associated with these parasites were not reported and tissues from this region were not included for histologic evaluation.

The graded histopathologic findings are summarized in Table 1 by organ system in relation to individual whale, length, sex, and general lesion classification. For clarity the detailed histologic findings will be presented by organ system.

Gastrointestinal System

Mild to moderate multifocal chronic-active ulcerative inflammation of the fundic and pyloric stomach compartments was present in seven whales. These gastric lesions were uniformly characterized by focal mucosal ulceration with associated submucosal infiltrates of polymorphonuclear leukocytes, plasma cells, lymphocytes, and histiocytes with hemorrhage. Occasional lesions had fibroplasia peripheral to the inflammation. In all cases inflammation was limited to the mucosa and adjacent submucosa.

In six of these whales the gastric lesions were associated microscopically with parasites including nematodes (three whales), trematodes (two whales), and one parasite unidentifiable because of fragmentation and degeneration. These parasites were generally found within the gastric submucosa and associated with marked peripheral fibroplasia. In addition, the gastric mucosal ulcerations in whales B, D, and F were associated with numerous coccoid bacterial colonies, some of which had been phagocytized by inflammatory cells.

Whale I had severe chronic-active non-ulcerative gastritis of the pyloric stomach compartment. This inflammation was not microscopically associated with parasites or infectious agents. Whales A and G had no gastric lesions.

In whales B, C, and J there was severe diffuse chronic-active pseudomembranous inflammation of the small intestine. These enteric changes were characterized by diffuse villous atrophy with a fibrinous to fibrinopurulent adherent mucosal lining. The lamina propria and submucosa were widely infiltrated by increased numbers of lymphocytes and plasma cells, as well as numerous eosinophils and neutrophils. The cause of these extensive inflammatory changes was not apparent from microscopic examinations. Whale I had moderate diffuse chronic-active inflammation of the small intestine without concurrent pseudomembrane formation. This inflammation was characterized by infiltrates of numerous eosinophils with associated multifocal mucosal and adjacent submucosal fibroplasia, suggesting a parasitic etiology. Despite multiple sectioning, parasites were not identified. The intestines of the remaining six whales were histologically unremarkable.

Respiratory System

Whales A, I, and J had moderate bronchoalveolar pneumonia. The lungs were characterized by diffuse (whales A and J) or multifocal (whale I) bronchoalveolar suppuration with infiltrates of neutrophils, macrophages, and occasional lymphocytes and plasma cells. Moderate multifocal pulmonary edema, hemorrhage, and congestion were also present in these whales. Infectious agents were not present.

Whale B had mild to moderate focal chronic inflammation of the upper respiratory tract. Whale D had mild multifocal granulomatous pulmonary inflammation associated with degenerating parasites resembling nematodes.

Myocardium

Whale C had moderate to severe chronic inflammation of

Table 1
Graded histopathologic findings in a mass stranding of pilot whales (*Globicephala macrorhynchus*).

Animal ID[a] length, sex, field no.	Inflammation				Hepatic degeneration	Depletion		Other
	Gastric	Intestinal	Pulmonary	Cardio-vascular		Lymphoid	Adrenocortical lipid	
A. 123 cm; M SWF-GM-8662-B	N	N	3[b]	N	3	5	3	Kidney: Pyelitis, necrotizing, chronic-active, multifocal, moderate.
B. 144 cm; F SWF-GM-8663-B	2(Pu)	5	2	3	N	5	N	
C. 292 cm; M SWF-GM-8657-B	2	5	N	4	N	5	3	Subcutis: cellulitis, necrotizing, chronic-active, multifocal, severe.
D. 323 cm; F SWF-GM-8664-B	2(Pn)	N	1(Pn)	1	N	5	N	Skeletal muscle: myositis, necrotizing, chronic-active, severe. Skin: dermatitis, ulcerative, chronic-active, multifocal, severe.
E. 328 cm; F SWF-GM-8660-B	1(Pt)	N	N	N	3	5	3	
F. 330 cm; F SWF-GM-8661-B	3(Pn)	N	N	1	3	5	NE	Pancreas: pancreatitis, fibrosing, chronic, multifocal, moderate.
G. 331 cm; F SWF-GM-8658-B	N	N	N	2	N	NE	NE	Pancreas: pancreatitis, necrotizing, chronic-active, multifocal, moderate to severe.
H. 350 cm; F SWF-GM-8654-B	2(Pt)	N	N	2	N	5	2	Uterus: tumor, fibroleiomyoma, multiple.
I. 380 cm; F SWF-GM-8650-B	5	3	3	2	3	4	3	
J. 440 cm; M SWF-GM-8645-B	2(Pn)	5	3	N	3	NE	NE	

[a]Animal ID: Total length; sex (M = male; F = female); field no. (SWF = Sea World of Florida).
[b]Grade ranges (1 = mild; 3 = moderate; 5 = severe).
P = Lesions associated with parasites (n = nematode; t = trematode; u = unknown).
N = No specific lesions present; NE = Not examined.

the heart. The heart was characterized by multifocal interstitial infiltrates, primarily lymphocytes and histiocytes with associated fibrosis and occasional Anitschkow cells. The fibrosis was focally extensive and often involved degenerating Purkinje cells. There was also focal myofiber degeneration characterized by swollen eosinophilic cytoplasm, loss of cross-striations, and fragmentation.

Whale B had similar but less extensive chronic myocardial changes with associated edema. Whales D, F, G, H, and I had mild focal to multifocal chronic inflammatory lesions of the myocardium. The cause of these myocardial changes could not be determined. Infectious agents were not present.

Hepatic System

Various moderate nonspecific hepatocellular degenerative changes were present in five whales. Whales A and J had diffuse combined hepatocellular fatty change and hydropic degeneration. Whales E, F, and I had moderate diffuse hepatocellular atrophy. All five of these whales also had hepatic extramedullary hematopoiesis and varying degrees of multifocal hepatic hemosiderosis.

Lymphoid System

Multiple visceral and peripheral lymph nodes from eight whales had extensive lymphoid depletion. The histologic pattern of the depletion was both follicular and paracortical. The spleens of these eight whales had similar but less extensive lymphoid depletion.

The spleens of whales G and J were histologically normal. Lymph nodes were not included for evaluation from these whales.

Adrenal Glands

The adrenal glands of five whales had moderate lipid depletion. This involved principally the zona glomerulosa and zona fasciculata. The adrenal glands of whales B and D were unremarkable. Adrenal glands were not included for evaluation from whales F, G, and J.

Renal System

Whale A had moderate multifocal papillary necrosis involving many renules. This necrosis was associated with focal infiltrates of neutrophils and macrophages. In addition there was multifocal medullary tubular mineralization. The cause of these changes could not be determined.

Pancreas

Two whales had moderate to severe inflammation of the pancreas. The pancreas of whale F was characterized by multifocal fibrosis with exocrine atrophy and moderate focal infiltrates of chronic inflammatory cells. Similar cells were present in peripancreatic fat foci. Whale G had pancreatic inflammation characterized by multifocal acinar necrosis with associated peripancreatic fat necrosis and saponification. There were infiltrates of neutrophils, plasma cells, and macrophages associated with this necrosis. There was also multifocal hemorrhage. The endocrine pancreas of whales F and G was unremarkable.

Integumentary and Skeletal Muscle Systems

Whale C had severe focal acute inflammatory changes involving subcutaneous tissues associated with a grossly reported skin lesion measuring approximately 25 cm by 100 cm, which was attributed to exposure (e.g., sunburn, surf action, etc.). Histologic sections of this region were characterized by focally extensive subcutaneous coagulative necrosis with infiltrates of many neutrophils, eosinophils, mast cells, and macrophages. There was also extensive multifocal hemorrhage and edema.

Whale D had severe multifocal chronic-active inflammatory changes involving grossly reported skin lesions of the peduncle and flukes, as well as adjacent skeletal muscle. The epidermis was characterized by multifocal ballooning degeneration of the stratum spinosum and stratum intermedium with exocytosis. The adjacent papillary dermis had infiltrates of many neutrophils, eosinophils, lymphocytes, and occasional histiocytes. Skeletal muscle adjacent to this area had extensive coagulative necrosis with infiltrates of an admixture of inflammatory cells and hemorrhage.

Reproductive System

The uterus of whale H had multicentric circumscribed arrangements of interlacing bundles of straplike cells resembling well-differentiated smooth-muscle fibers. These cells often intersected at right angles and were characterized by poorly defined cell boundaries, eosinophilic amorphous cytoplasm, cigar-shaped monomorphic hyperchromatic nuclei, small nucleoli, and sparse mitotic activity. There was also a fibrillar background matrix of collagenous connective tissue. These uterine masses were diagnosed as fibroleiomyomas. These benign smooth muscle tumors commonly arise in the mammalian female reproductive tract and have been reported in pilot whales (Landy 1980).

Discussion

A wide diversity of histopathologic lesions was present in this group of whales. In some individuals these pathologic changes were severe and probably related to other organ system lesions representing disseminated infectious processes. Either singly or in combination, many of these lesions could have compromised organ function resulting in death.

Inflammation and degenerative changes involving the gastrointestinal system were common. A similar histologic pattern of severe inflammation of the small intestine was present in three whales (B, C, and J). The diffuse, pseudomembranous, chronic-active nature of these lesions suggests an infectious etiology. Jones and Hunt (1983) showed that in other species similar enteropathies can be caused by bacterial infections (e.g., *Salmonella* sp., *Fusobacterium necrophorium*) and viral infections (e.g., feline infectious enteritis, malignant catarrhal fever).

Two of the whales (B and C) had concurrent moderate inflammation of the heart while the third whale (J) had moderate inflammation of the lungs. This suggests a disseminated infectious disease process possibly originating from the small intestine.

Two other whales (F and G) had moderate to severe inflammation of the pancreas. The histologic pattern of the pancreatic changes was different. In whale F the pathologic changes were consistent with chronic progressive pancreatic disease, while in whale G they were suggestive of a recent acute episode of pancreatitis. Unlike the inflammatory lesions found in the previous whales, the moderate to severe inflammation in whale G involved only one organ system. Acute pancreatic necrosis and chronic "relapsing" pancreatitis are common diseases in humans and dogs and are frequently fatal (Jubb et al. 1985). In whales G and F the cause of the pancreatic inflammation, as in other species, could not be determined.

Moderate degenerative changes of the liver were present in five whales. These were generally present in whales with moderate to severe lesions in other organ systems, a circumstance that suggests the hepatopathies may have been secondary in nature.

Pulmonary inflammation of a moderate nature was present in three other whales (A, B, and I). These individuals also had concurrent moderate to severe inflammatory lesions of other organ systems, ranging from renal inflammation only (whale A) to inflammatory changes involving the pyloric stomach compartment, small intestine, and heart (whale I). These concurrent changes are also suggestive of disseminated disease with possible multiorgan functional compromise.

Inflammation of integument and adjacent tissues was severe in two whales (C and D). In whale C there was a similar concurrent pattern of inflammation of the heart and small intestine suggesting a septicemia.

Parasites were present microscopically in the stomach compartments of six whales and lungs of one whale. The inflammatory changes associated with these parasites were generally mild and focal in nature, confined to the superficial mucosa (in the stomach) and stimulating peripheral fibrosis.

Primary lymphoid tissue in all whales examined was remarkably abnormal. Lymphoid depletion in the spleen and lymph nodes has been associated with chronic stress, immunosuppression, and cachexia in other animals (Bossart 1984; Leighton 1986; Glick 1983; Selye 1973). The universal histologic pattern of lymphoid depletion in the lymph nodes of these whales was both follicular (the bone-marrow derived lymphoid system zone) and paracortical (the thymic-dependent lymphoid system zone). This is the morphologic expression of a combined humoral and cell-mediated immunodeficiency (Jubb et al. 1985; King 1986). In humans and other mammals, immunodeficient states may be congenital or acquired (Tomar 1979). Acquired (secondary) immunodeficiencies in humans can be associated with malnutrition, chronic infection, cancer, renal disease, and primary viral agents.

Increased susceptibility to multiple opportunistic infections frequently is the ultimate cause of death (King 1986; Robbins et al. 1979).

Considering the diversity and severity of the other concurrent, often chronic, lesions in these whales, the lymphoid changes probably reflect a secondary condition that is the consequence of the other disease processes. Further understanding of the cetacean immunologic system is required for any additional interpretation.

In five of seven whales, where adrenal glands were microscopically evaluated, there was adrenocortical lipid depletion suggestive of a stress-related condition. Lipid depletion occurs in adrenal steroidogenic cells responding to adrenocorticotropic hormone (ACTH) stimulation and should be considered an index of this physiologic state rather than a degenerative change (Leighton 1986; Assenmacher 1973). Adrenal glucocorticoid hormones are considered important mediators of stress related lesions (Selye 1973). Further investigation of lymphoid and adrenocortical lesions in relation to stress and the immunopathogenesis of cetacean disease may provide important future stranding data.

With few exceptions, the types of histopathologic changes present in these whales were indicative of chronic progressive processes, encompassing the inflammatory and degenerative lesions as well as the lymphoid and miscellaneous changes. This implies that many of these whales had functional compromise of some organ systems prior to the mass stranding. These findings raise questions regarding the humanity of returning recently mass-stranded cetaceans to the sea.

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Use of Corneal Cell Culture for R-Band Chromosome Studies on Stranded Cetaceans

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ABSTRACT

This paper presents a cell culture technique using corneas of postmortem animals and explores the application of fluorescent reverse banding (R-banding) chromosome analysis in stranded cetaceans. These techniques were used to look at heteromorphic (variable) regions in the karyotypes of five representative cetacean species which strand on U.S. coastlines: pygmy killer whale (*Feresa attenuata*); false killer whale (*Pseudorca crassidens*); short-finned pilot whale (*Globicephala macrorhynchus*); pygmy sperm whale (*Kogia breviceps*); and humpback whale (*Megaptera novaeangliae*). Numerous heteromorphic regions found in karyotypes of these species were compared with similar regions in karyotypes of bottlenose dolphins (*Tursiops truncatus*), a species for which extensive cytogenetic work has been done. An extra, unique chromosome was found in the karyotype of an individual *M. novaeangliae* which stranded in Hawaii. The results suggest that there are cytogenetic markers in these species that can be used, as they are in other cetaceans, to confirm relationships and examine regional population differences.

Introduction

Cytogenetic studies of stranded cetaceans have made an important contribution to the karyotypic data base for the Cetacea by providing an opportunity for chromosome analysis of species largely unavailable by other sampling methods (Arnason et al. 1977; Duffield 1977; Benirschke and Kumamoto 1978; Arnason 1980, 1981). To establish cell cultures for chromosome analysis, living tissue is essential. While sampling blood is a direct way of obtaining cells for standard leukocyte culture from live whales and dolphins (Duffield 1986; Duffield and Chamberlin-Lea 1990), obtaining viable, uncontaminated tissue samples from cetaceans dead for several days is a major problem. We have developed a technique for establishing cell cultures from the corneas of postmortem cetaceans. Corneal tissue has excellent regenerative properties associated with high mitotic indices (Van Horn et al. 1977; Leeson and Leeson 1981) and postmortem cornea can remain viable up to several weeks (Doughman et al. 1976).

Corneal cell cultures have been used for a variety of in vitro studies, including chromosome analysis (Conrad 1970; Dahl et al. 1974; Manski and Whiteside 1974; Pimenova and Simonenko 1974; Kenney et al. 1986). Cell cultures initiated from the corneas of postmortem cetaceans were used in this study to provide a supply of mitotic cells for chromosome preparations. These preparations were stained using a fluorescent reverse banding (R-banding) technique, which, in cetaceans, is particularly useful for chromosome studies because it bands euchromatic regions of the chromosomes for homologue identification and simultaneously visualizes highly variable heterochromatic regions (chromosome heteromorphisms) present in the chromosomes (Duffield 1986; Lambertsen and Duffield 1987; Duffield and Chamberlin-Lea 1990).

In this paper, we present R-band karyotypes derived from corneal cell cultures for five cetacean species which are periodically handled by stranding networks along the coast of the United States. The heteromorphic regions of the chromosomes from these species were compared with those of *Tursiops truncatus*.

Methods

Animals

The R-band karyotypes were prepared for four species that frequently strand on the east coast of Florida: pygmy killer whale ([*Feresa attenuata*], N = 1; field No. C-83-20, male, 215 cm, 10 July 1983); false killer whale ([*Pseudorca crassidens*], N = 2; field No. SWF-8631B, female, 259 cm, 5 June 1986; Id. No. SWC-PC- 8326, female, 312 cm, 25 February 1986); short-finned pilot whale ([*Globicephala macrorhynchus*], N = 2; field No. SWF-8651B, female, 356 cm, 24 July 1986; Id. No. SWC-GM-8003, female, 272 cm, 5 July 1983); and pygmy sperm whale ([*Kogia breviceps*], N = 1; field No. SWF-KB-8330-B, female, 272 cm, 18 September 1983). The R-band karyotypes were also prepared for a humpback whale ([*Megaptera novaengliae*], N = 1; male calf, SLP-Mn-81, 7 March 1981) stranded in Hawaii. Both blood and corneal cell cultures were available for one of the false killer whales and one of the pilot whales.

Collection of Corneal Samples

The eye was removed from the socket by severing the eye muscles, associated connective tissue, and the optic nerve, care being taken to ensure that the eye remained intact. Sterile precautions were not necessary during collection. The eye was stored and shipped dry in a plastic bag at 4° C until culturing; fluid in the bag encouraged tissue decomposition and increased the possibility of contamination. The inner corneal layers were kept moist by the aqueous humor, so desiccation of the cornea was not a problem.

Corneal Cell Culture

The eye was well rinsed in running tap water and placed cornea down in a 1:750 dilution of 17% aqueous Zephiran chloride (Winthrop Laboratories, New York, NY 10016) for 2 to 3 minutes. This procedure removed gross bacterial contamination from the corneal surface and did not appear to damage the inner cell layers. The cornea was carefully rinsed with distilled water to remove any traces of disinfectant.

A piece of cornea (ca. 3–4 mm diameter) was excised aseptically. To ensure maximum viability, two to three pieces were taken from different portions of the cornea. The inner portion of the cornea (including Descemet's membrane) and the associated endothelial cell layer occasionally separated from the stroma. This membrane and cell layer must be included for cell growth. The corneal sample was soaked for 1 hour in culture medium (Ham's F-10 with L-glutamine [Gibco, Grand Island, NY 14072] supplemented with 10–15% fetal calf serum; penicillin-streptomycin (Gibco), final concentration 100 units/mL; and Fungizone, amphotericin B (Gibco), final concentration 2.5 mcg/ml), which was further supplemented with 10 × concentrations of antibiotic and fungicide. The explants were minced, transferred to culture flasks, fed with culture medium and the cell cultures were placed in a 36° C, 5% CO_2-air incubator.

Cytogenetic Analysis

Metaphase cells were collected by the addition of colcemid (Gibco; final concentration 0.1 μg/mL) overnight. Cells were harvested by standard techniques (Hack and Lawce 1980) using a one part 0.075M KCl and one part 20% fetal calf serum hypotonic solution for 12 minutes at 37° C. Cells were fixed in three parts absolute ethanol and one part glacial acetic acid. Chromosomes were banded with a fluorescent R-banding technique using chromomycin A-3 and distamycin A (Sahar and Latt 1978; Schweizer 1980). Photographs, using Kodak Technical Pan 2415 film, were taken on a Zeiss microscope equipped with an ultraviolet light source and epifluorescence. Two to five karyotypes were prepared for each animal. In these karyotypes, the chromosome pairs were arranged into four groups (A–D) based on centromere position and numbered consecutively. The resultant karyotypes were examined for R-band heteromorphisms, discrete chromosomal regions which showed size and/or intensity differences between homologues. Chromosome composites were constructed based on the similarity in banding pattern of these species to *Tursiops truncatus*; the latter species was chosen as the stan-

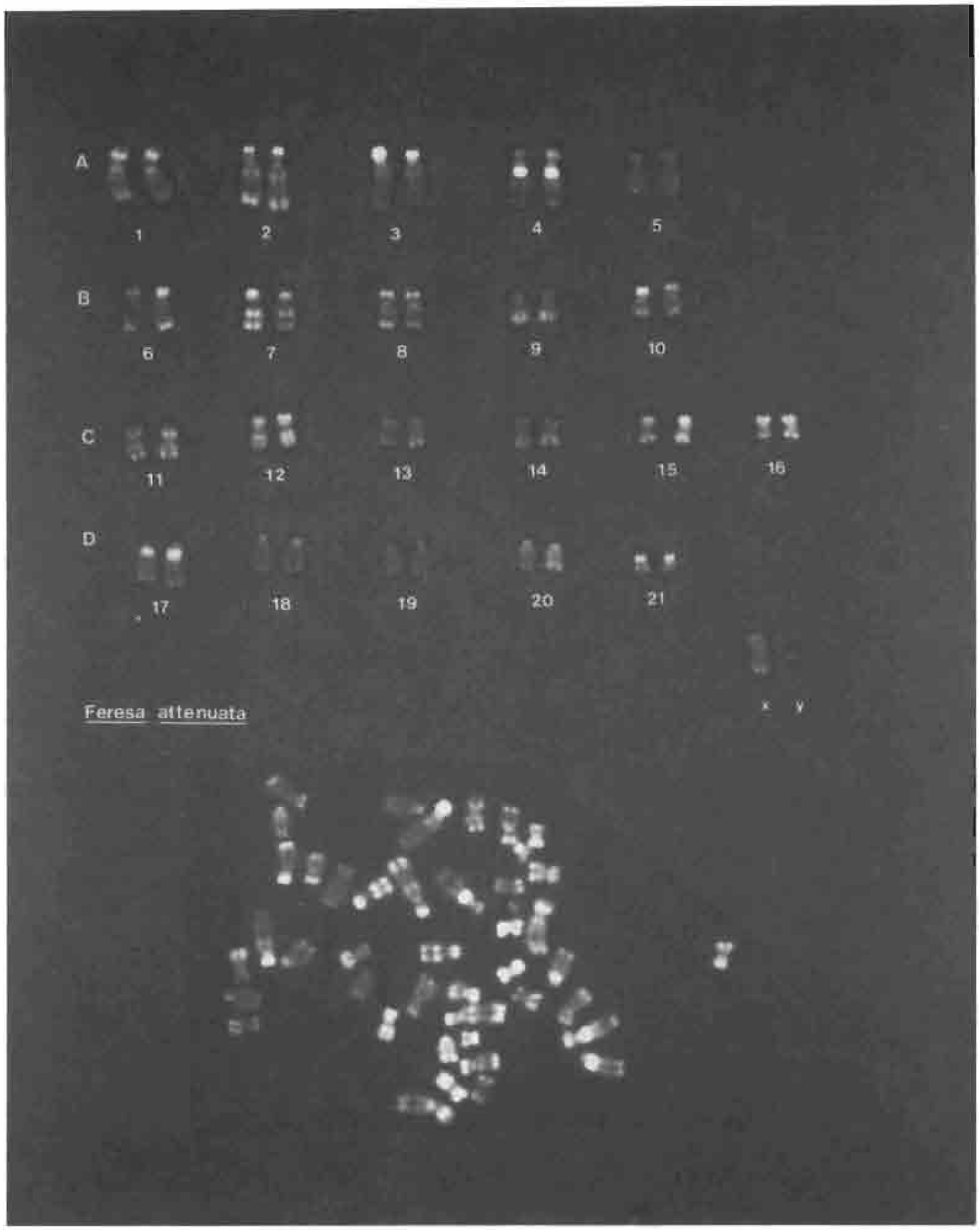

Figure 1
R-banded karyotype of a male *Feresa attenuata* (2N = 44).

dard because of its established R-band karyotype and range of heteromorphisms (Duffield and Chamberlin-Lea 1990). Differences among species in R-band heteromorphisms were noted.

Results

Cell cultures were established from eyes which varied in postmortem age from three days to two weeks. The corneal cells grew vigorously in culture. Outgrowth of cells from the original explant most commonly occurred within one day of the initiation of culture, no matter what the postmortem age of the eye. Significant amounts of cell migration from the explant were observed by the third or fourth days. For one eye, cell outgrowth was delayed for two or three weeks, but once established, this culture grew as well as those which had initially grown out more quickly.

The R-banded karyotypes of *F. attenuata*, *P. crassidens*, *G. macrorhynchus*, *K. breviceps*, and *M. novaeangliae* are shown in Figures 1–5. The *F. attenuata*, *P. crassidens*, and *G. macrorhynchus* karyotypes had a diploid chromosome number of 2N = 44. The *M. novaeangliae* calf had a 2N = 45 (+ mar), exhibiting an extra, small chromosome in its karyotype (Fig. 5). This chromosome stained faintly with R-banding and its origin was unknown, but it was consistently pres-

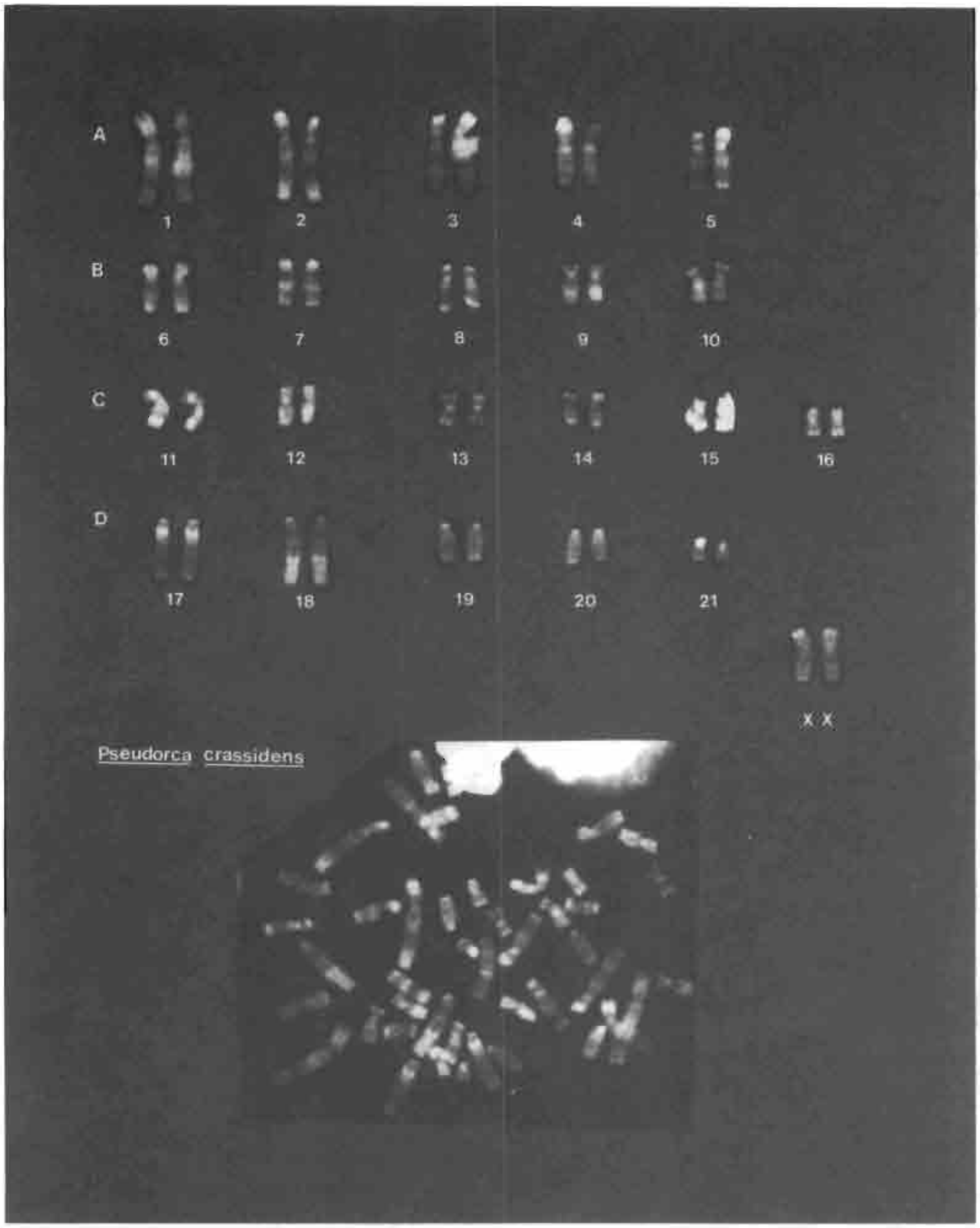

Figure 2
R-banded karyotype of a female *Pseudorca crassidens* (2N = 44).

ent in all cells examined. The karyotype of *Kogia breviceps* had a 2N = 42. For *P. crassidens* and *G. macrorhynchus*, the karyotypes obtained by corneal culture were consistent with those obtained from blood.

To compare the distribution of observed heteromorphic regions, a composite karyotypic comparison was constructed using one chromosome of each chromosome pair from the five species examined (Fig. 6). This composite included *Tursiops truncatus* as a standard because many individuals of this species have been examined by R-banding and both the distribution of heteromorphic regions and the type of variation found is well documented (Duffield and Chamberlin-Lea 1990).

Discussion

From the results reported here, as well as from several years of trials using corneal tissue to establish cell cultures for chromosome analysis in Duffield's laboratory, we have observed that prolonged postmortem viability, freedom from contamination and ease of handling make cornea an extremely useful tissue for establishing cell cultures from stranded cetaceans. We have found that the chances for viability are greatest when eyes are taken either from animals that washed ashore dead or from animals that were returned to the water prior to death. Animals dying out of the water more often exhibited decreased corneal cell

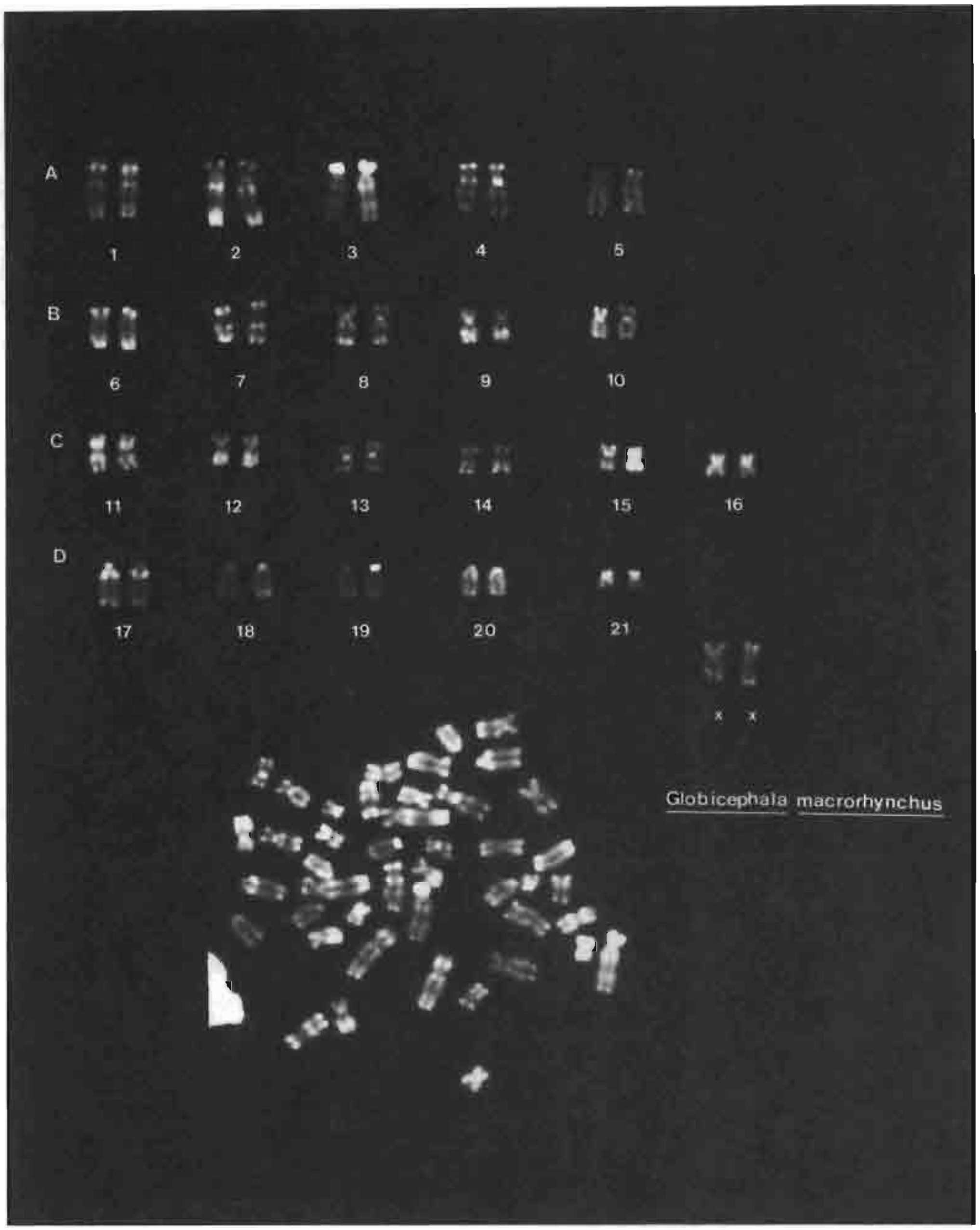

Figure 3
R-banded karyotype of a female *Globicephala macrorhynchus* (2N = 44).

viability, possible owing to extreme overheating (D. Duffield, pers. obs.). In contrast to other postmortem tissues, the inner cell layers of the cornea appear to remain uncontaminated until the eye has become severely decomposed. Because the eye can be removed intact from the animal and does not require sterile handling or preservation in culture media, samples are easy to obtain in the field.

Fluorescent R-band karyotypes have been previously reported for *M. novaeangliae* (Lambertsen and Duffield 1987; Lambertsen et al. 1988), but not for the other stranded species. The diploid number for *M. novaeangliae* is 2N = 44. The stranded calf examined here had a extra, small chromosome (2N = 45, +mar). The origin and significance of the extra chromosome seen in the karyotype of the stranded humpback whale calf is not clear, but a similar extra chromosome has been noted in a live Atlantic humpback whale that was sampled by skin biopsy (Lambertsen and Duffield 1987). An extra chromosome has also been reported for *T. truncatus* (Duffield et al. 1985; Duffield and Wells 1988). In this species, a small, unique marker chromosome was found in certain individuals belonging to a resident female bottlenose dolphin social unit in Sarasota Bay, FL. In contrast to the extra chromosome in the humpback whale, the extra chromosome in the bottlenose dolphin was brightly staining with satellites

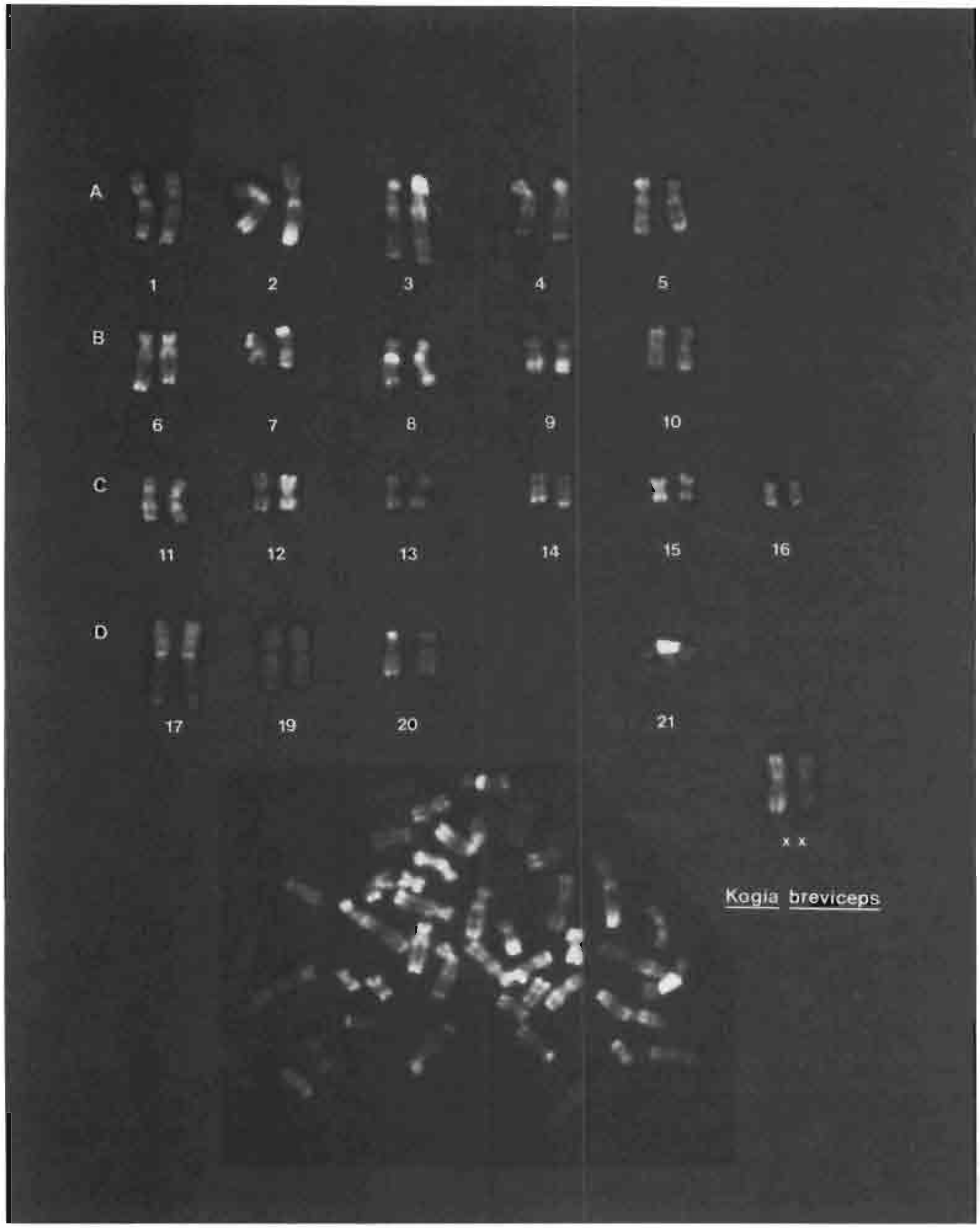

Figure 4
R-banded karyotype of a female *Kogia breviceps* (2N = 42).

and carried nucleolar organizer regions. This marker chromosome had been inherited for three generations and did not appear to have a phenotypic effect in any of the animals. The inheritance pattern of the marker confirmed long-term observational and behavioral data suggesting that resident female bands in the Sarasota study area were composed largely of related individuals (Wells et al. 1980; Irvine et al. 1981; Wells 1986). Because they are relatively rare and found in specific animals, these marker chromosomes are particularly useful for tracing the relationships and reproductive interactions of individuals and groups with neighboring or distant groups of the same species.

Although there were subtle differences in R-banding pattern among the five species examined here, their chromosomes were similar enough that the numbers on the chromosome pairs refer to the same homologous chromosome pair in each species. Pygmy sperm whales, as well as sperm and beaked whales, have a chromosome number of 2N = 42 (Arnason and Benirschke 1973; Arnason et al. 1977; Duffield 1977). A fusion between two of the acrocentric chromosome pairs may account for the 2N = 42 karyotype of *K. breviceps* (observation from the visual comparison of the R-band karyotypes, Fig. 6). However, detailed banding analyses have not been completed to determine the extent of similarities and differences in R-banding

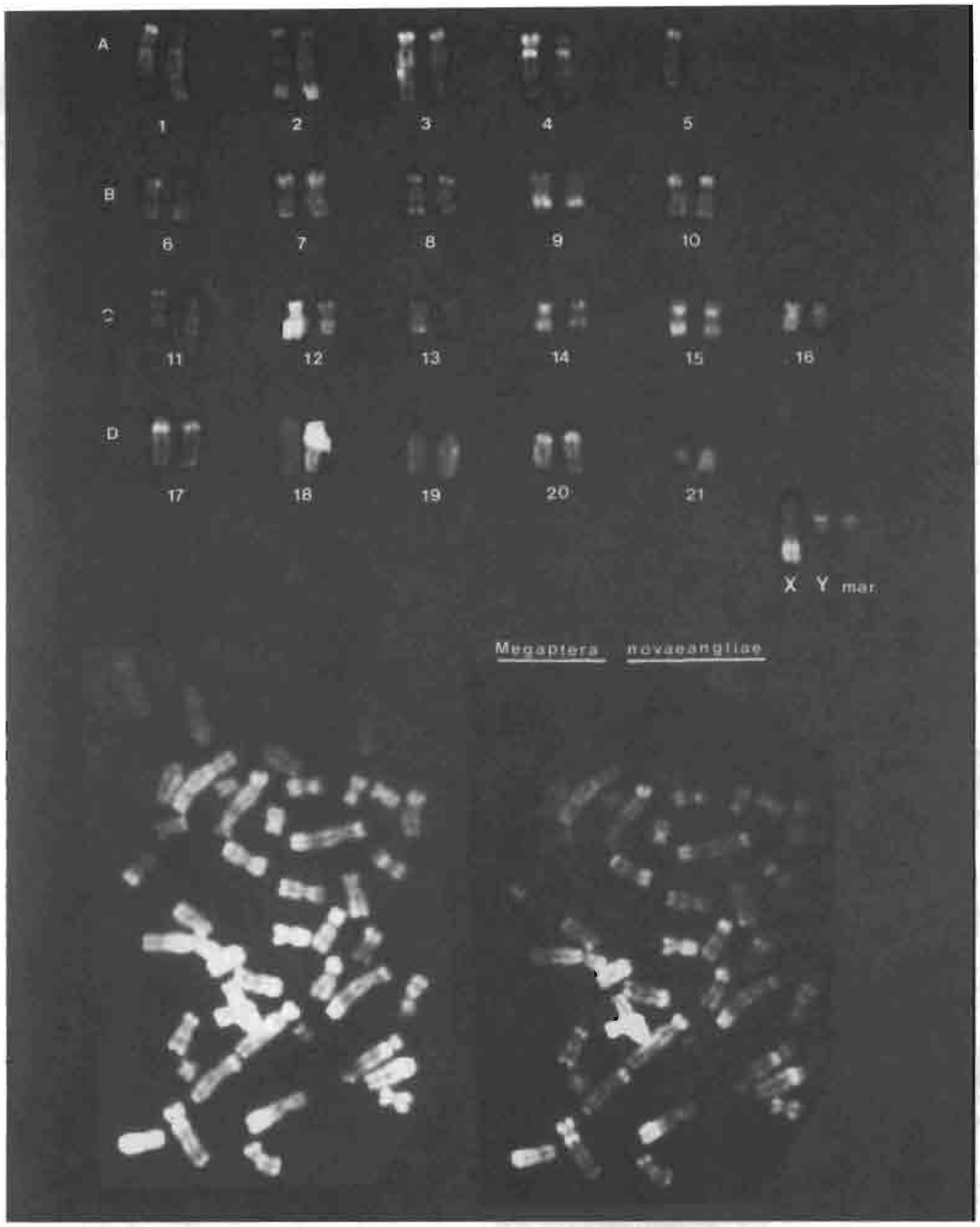

Figure 5
R-banded karyotypes of a male *Megaptera novaeangliae* (2N = 45, + mar). Two intensities of the metaphase spread for *M. novaeangliae* are included to show the faint staining extra chromosome. The presence of this extra chromosome was confirmed with standard Giemsa staining (not shown).

patterns and the basis for the change in number in *K. breviceps*. Instead, this paper concentrates on the presence in these species' karyotypes of chromosomal heteromorphisms which are visualized by R-banding.

Chromosome heteromorphisms have been noted in cetacean karyotypes both by C-banding (Arnason 1974, 1980; Arnason et al. 1977, 1980, 1985; Duffield 1977; Stock 1981; Worthen 1981) and fluorescent R-banding (Duffield 1982, 1986; Lambertsen and Duffield 1987; Duffield and Chamberlin-Lea 1990). C-banding is a chromosome banding technique that leaves tightly coiled C-band positive areas of the chromosome darkly stained (Bradbury et al. 1981) but denatures euchromatic regions. It, therefore, requires the sequential application of an additional banding technique (such as G-banding or R-banding) to identify homologous chromosome pairs. Fluorescent R-banding, in contrast, uses a staining agent which binds to guanine-cytosine (GC) rich DNA areas of the chromosomes. It bands euchromatin areas for homologue identification, while simultaneously binding strongly to GC-rich heteromorphic (variable) regions (Schweizer 1980). A significant number of GC-rich heteromorphic regions have been reported in the chromosomes of cetacean species (Duffield 1986; Lambertsen and Duffield 1987; Duffield and Chamberlin-Lea 1990). In *Tursiops truncatus*, *Orcinus orca*, and *Megaptera novaeangliae* at least half of the chromosome

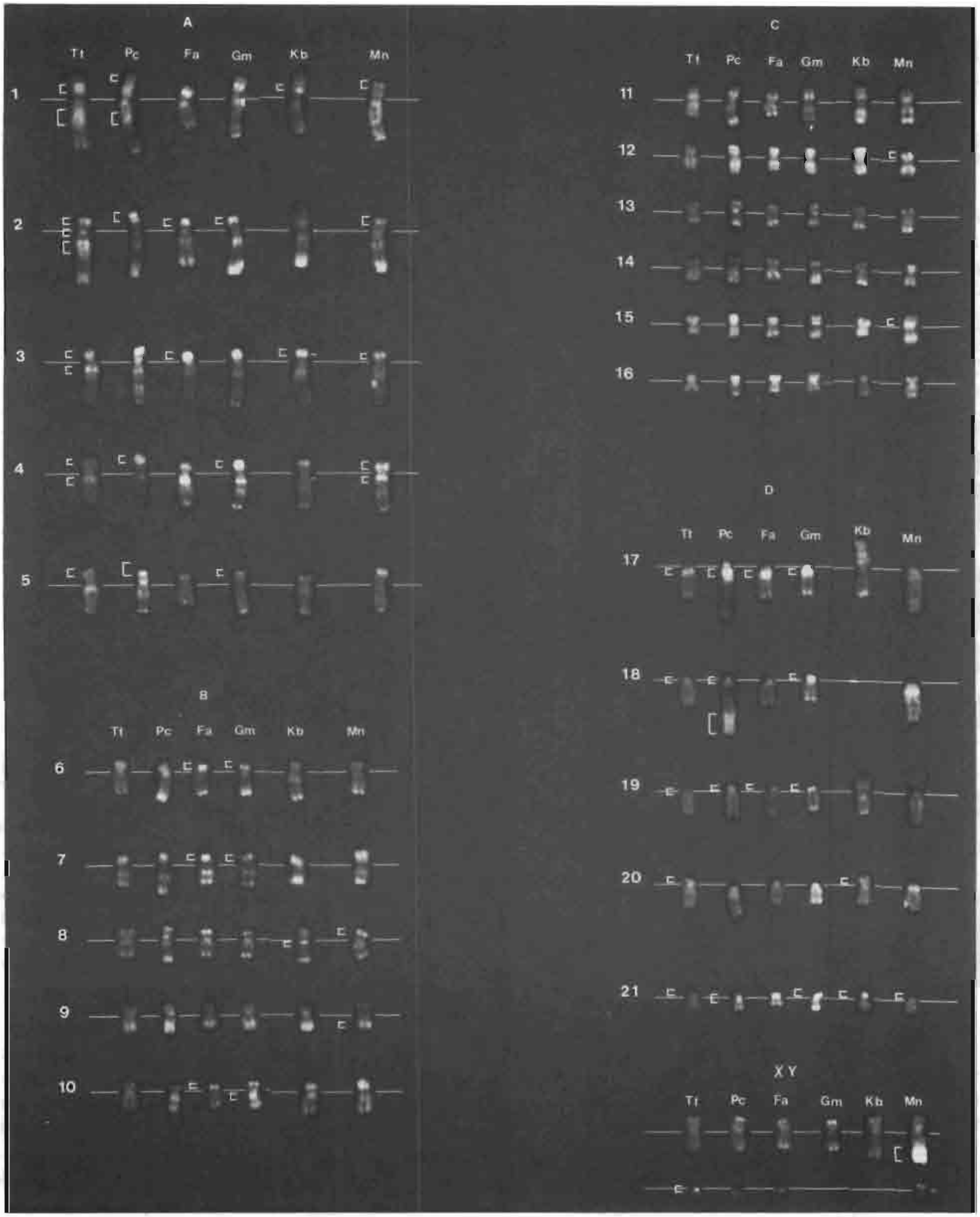

Figure 6

One chromosome of each chromosome pair from the karyotypes of *Tursiops truncatus* (Tt) compared to those of *Pseudorca crassidens* (Pc), *Feresa attenuata* (Fa), *Globicephala macrorhynchus* (Gm), *Kogia breviceps* (Kb), and *Megaptera novaeangliae* (Mn), to demonstrate the positions of known R-band heteromorphic regions in the chromosomes of these species (brackets). Note the unusual blocks of R-band heteromorphic material in *P. crassidens* (D-18) and in *M. novaeangliae* (X chromosome).

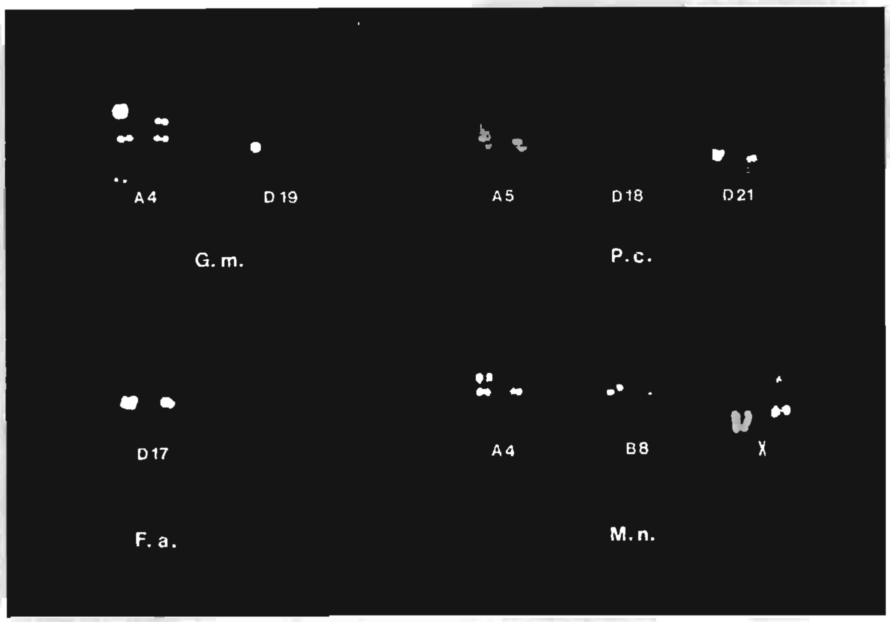

Figure 7
Examples of the types of R-band variants seen in various heteromorphic regions in the karyotypes of *Globicephala macrorhynchus* (Gm), *Pseudorca crassidens* (Pc), *Feresa attenuata* (Fa), and *Megaptera novaeangliae* (Mn).

pairs in their karyotypes exhibit these heteromorphic regions which may vary in size and in intensity of staining.

Chromosome pairs exhibiting R-band heteromorphisms in this study are indicated in each of the karyotypes (Figs. 1-5). A comparison of the distribution of heteromorphic regions in the chromosomes of the five stranded cetacean species and *T. truncatus* (Fig. 6) shows that many of the R-band heteromorphic regions are in the same chromosomal locations in all six species; however, there are also species differences (*see, for example*, the X chromosome in *M. novaeangliae* and D-18 in *P. crassidens*). Examples of the types of heteromorphisms seen in this study are illustrated in Figure 7. In *T. truncatus*, 52 heteromorphisms for 11 chromosome pairs have been found among 104 animals studied (Duffield and Chamberlin-Lea 1990). This number of variants makes R-band heteromorphism analysis extremely useful in population studies, especially when hypotheses of specific relationships need to be tested. As more individuals of each of the stranded species are karyotyped, the number of recognizable heteromorphic regions and the range of heteromorphisms within these regions will be established.

In cetaceans, R-band chromosome heteromorphisms have been used both as genetic markers for determining parentage in captive breeding programs (Duffield et al. 1986; Duffield and Chamberlin-Lea 1990; Hewlett et al. 1989) and for investigating population structure in the field (Lambertsen and Duffield 1987; Duffield and Wells 1988; Duffield et al. 1989). An exciting application of R-band heteromorphisms analysis for stranded cetaceans lies in its potential for confirming suspected relationships among animals stranding together, as in Florida, for example, where *K. breviceps* often strand in adult female-calf pairs or in adult female-calf pairs accompanied by a juvenile or adult male (D. Odell, pers. obs.). Similarly, chromosome heteromorphism analysis could be useful in a mass stranding situation to investigate relationships among specific individuals.

The use of cornea to establish cell cultures from postmortem cetaceans opens up the possibility for cytogenetic studies on stranded cetaceans which have been dead for several days. Fluorescent R-band chromosome heteromorphisms in the karyotypes of these species, as well as the existence of unique marker chromosomes, provide cytogenetic markers for assessing relationships within groups of stranded animals and for looking at regional population differences in these species.

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Chlorinated Hydrocarbon Concentrations and Their Use for Describing Population Discreteness in Harbor Porpoises from Washington, Oregon, and California

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ABSTRACT

Concentrations of PCB (polychlorinated biphenyls, a class of industrial chemicals), DDE (the primary breakdown product of the pesticide DDT), and HCB (hexachlorobenzene, a fungicide) were determined in blubber samples from 45 harbor porpoises collected along the coasts of Washington, Oregon, and California. The primary purpose of this study was to test for regional patterns in the concentration of contaminants and their ratios in order to evaluate the feasibility of using contaminants to gain information about the degree of intermixing of harbor porpoises along the west coast of North America. Concentrations varied widely with averages of 14 ppm (mg/kg by wet weight) PCBs, 31 ppm DDE, and 0.51 ppm HCB. Concentrations of contaminants were strongly associated with latitude (location), length of the animal, and sex. Distinct regional patterns were found in both the concentrations of DDE and the ratios of PCB to DDE and HCB to DDE. Contaminant ratios were far less variable than individual contaminant concentrations and were, therefore, more useful for examining regional patterns. Through discriminant analysis using a combination of pollutant ratios, the state (California, Oregon, or Washington) in which harbor porpoises were collected could be correctly predicted for 86% of the samples. Pollutant ratios did not reveal specific boundaries for stocks but indicated that harbor porpoise movements may be restricted in some areas.

Introduction

Chlorinated hydrocarbon contaminants have been recovered from marine mammals from around the world (Gaskin et al. 1971; Taruski et al. 1975; Clausen et al. 1974; Wagemann and Muir 1984). Risebrough (1978) reviewed the occurrence and impacts of pollutants in marine mammals. Nearshore marine mammals such as pinnipeds and some cetaceans tend to accumulate high concentrations of stable chlorinated hydrocarbons because they 1) are long lived, 2) feed high on the food chain, and 3) have blubber layers that serve as stable repositories for these lipophilic contaminants.

Harbor porpoise (*Phocoena phocoena*) occur primarily in nearshore waters off Europe, Asia, and the east and west coasts of North America (Gaskin et al. 1974). Harbor porpoise populations have declined in many parts of their range (Otterlind 1976; Prescott and Fiorelli 1980; Calambokidis et al. 1984), and there is evidence of high rates of mortality in nets along the California coast (Deiter 1991; Diamond and Hanan 1986; Hanan et al. 1986). Estimates of harbor porpoise population size along the west coast of the United States have recently been completed (Barlow 1988) but there is little information on the presence of different population stocks or interchange among areas.

The potential utility of chlorinated hydrocarbon concentrations or ratios for examining movements and intermixing in marine mammals has been reported previously (*see* review in Aguilar 1987). Winn and Scott (1978) included differences in PCB and DDT concentrations as part of the

Table 1
Sources of harbor porpoise samples analyzed in this study.

Sources	Region	Years collected	No. of samples	Sample prefix
Wa. Dept. Game Olympia, WA	Wash. and N. Ore.	1981–85	4	MMP and WDG
Nat. Mar. Mamm. Lab Seattle, WA	N. Wash.	1984	1	RJF
Cascadia Research Olympia, WA	N. Wash.	1985	4	CRC
Oregon State Univ. Newport, OR	Oregon	1984–86	8	OSU
Ore. Inst. Mar. Biol. Coos Bay, OR	Oregon	1985–86	4	OIMB and UO
Cal. Acad. Sci. San Francisco, CA	Cent. Calif.	1971–86	4	CAS
SW Fisheries Center La Jolla, CA	Cent. Calif.	1983–85	18	LML, REJ, MVZ, and MLML
Nat. Hist. Mus. of LA Co. Los Angeles, CA	S. Calif.	1983	2	JEH

evidence for separate stocks of humpback whales in the western North Atlantic. Gaskin et al. (1982) noted differences in DDT concentrations in harbor porpoises from inside and outside the Bay of Fundy. Calambokidis et al. (1984; 1979a) reported differences in the PCB/DDE ratio in Washington harbor seals and discussed its usefulness in evaluating regional movement and interchange.

The purposes of this study were to 1) determine the concentrations of PCBs (polychlorinated biphenyls, a class of industrial chemicals), DDE (the primary breakdown product of the pesticide DDT), and HCB (hexachlorobenzene, a fungicide) in harbor porpoises from Washington, Oregon, and California; 2) test for regional differences in these contaminants and their ratios; and 3) evaluate the utility of this information in discerning harbor porpoise populations.

Methods

Blubber samples from 45 harbor porpoises were tested for concentrations of PCBs, DDE, and HCB. Also, seven blubber samples were taken from different locations (anterior-dorsal, mid-dorsal, posterior-dorsal, anterior-ventral, mid-ventral, posterior-ventral, and mid-lateral) from each of two harbor porpoises for testing to evaluate toxicant differences based on body location.

Sample Collection

Samples for analysis were received from a wide variety of sources in addition to those collected by the authors (Table 1). All were collected from animals found dead on the shores of Washington, Oregon, and California (Fig. 1). Samples were stored either in glass, aluminum foil, or plastic bags. Samples were stored frozen after collection, except those provided by the California Academy of Science, which had been preserved in formalin. Cooperating organizations also provided information that was tested for association with contaminant concentrations, including collection location, date, sex, length, and blubber thickness.

Sample Analysis

Analyses for concentrations of PCBs, DDE, and HCB were conducted as described in previous reports (Calambokidis et al. 1979b, 1984; Mowrer et al. 1977). The analyses were conducted at the Environmental Analysis Laboratory of The Evergreen State College.

Approximately 5 g of blubber, subsampled from the unexposed interior of samples received, was digested in 50 mL BFM solution (glacial acetic and perchloric acid) over a steam bath for several hours (Stanley and LeFavoure 1965). Samples were extracted four times with 20 mL aliquots of 'pesticide quality' hexane. Lipid weights were determined by evaporating a portion of the hexane-lipid extract to dryness. A 10 mL portion of the hexane-lipid extract was cleaned with 1–2 mL concentrated sulfuric acid (Murphy 1972). After centrifuging, 1–9 μL was injected into a Hewlett-Packard electron capture (63Ni) gas chromatograph equipped with a 1/4" × 6' glass column packed with 10% DC-200 on Gas Chrom Q, 80/100 mesh. The column also had a 1" alkaline (KOH and

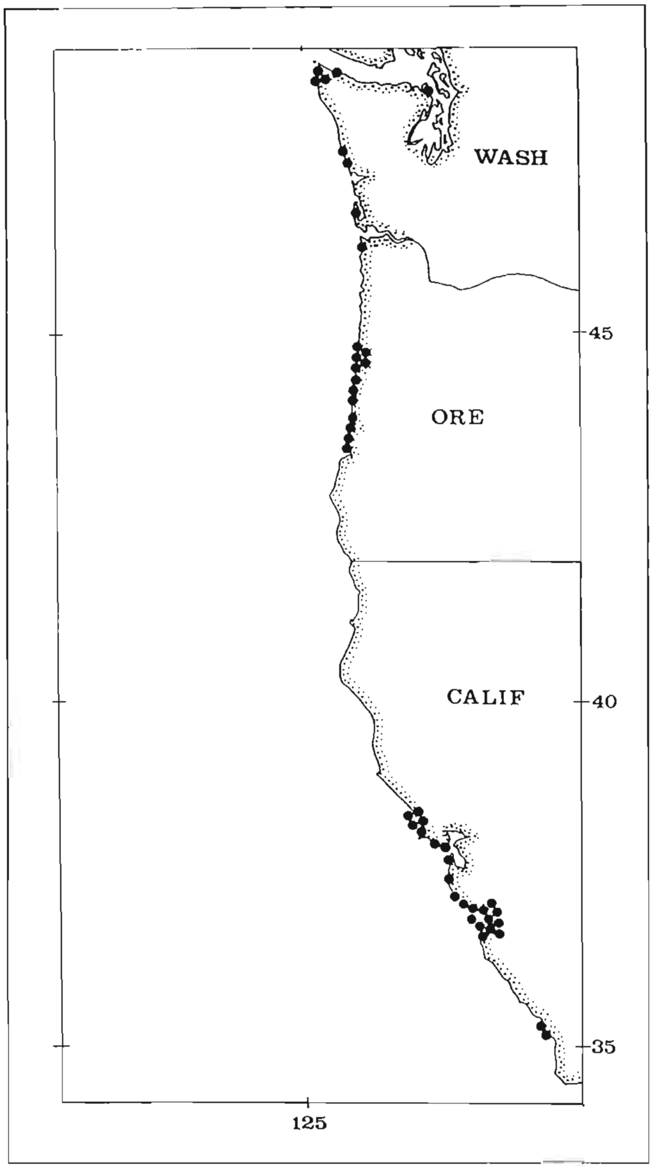

Figure 1
Locations of strandings of harbor porpoises sampled for this study.

NaOH) precolumn to reduce interference from other compounds and to convert any small amounts of p,p'DDT to p,p'DDE (Miller and Wells 1969). The concentration of p,p'DDE plus any p,p'DDT will be referred to as DDE throughout this paper.

Contaminants were identified and quantified based on comparison of elution times and peak areas to PCB, DDE, and HCB standards injected daily. PCBs (a mixture of compounds) were quantified by individual homolog analysis using mean weight percent figures reported by Webb and McCall (1973). Minimum PCB values were calculated using only the more chlorinated PCB homologs corresponding to the PCB components present in the commercial PCB mixture Aroclor 1260. Though additional less chlorinated PCB homologs were present, they were not included in the total because some samples contained interfering compounds and a reproducible minimal value was considered more important than a more variable estimate of total PCBs. The magnitude of this downward bias is approximately 25–40%.

Multiple linear regression and ANOVA were used to evaluate the association between contaminant concentrations and other variables. Concentrations based on lipid weight were used for the linear regressions because lipid weight was found to be significantly correlated to concentrations in models using wet weight. Concentrations were log transformed for these calculations to meet the assumptions of normal distribution of data. In addition to latitude, collection location was categorized by state and five collection locations: the Morro Bay, CA area (n = 2); the Monterey Bay, CA area (n = 13); the San Francisco/Bodega Bay, CA (n = 9); Oregon (n = 13); and Washington (n = 8). (More detail was included in California owing to high fishery mortality there.) Two samples were excluded from multivariate tests: one collected 10 years prior to the other samples and the other collected within the inland waters of Puget Sound, Washington.

Stepwise discriminant analysis and stepwise multiple regression were used to determine whether collection locations could be predicted from linear combinations of pollutant values. Discriminate analysis was formed using collection location as the categorical variable. A jackknifed calculation system was used to determine the predictive power of discriminant functions (Lachenbruch and Mickey 1968). Each sample was classified based on discriminant functions calculated from all data excluding the sample being classified. Multiple regression was performed using latitude of the recovered sample as the dependent variable. Five predictive variables were considered (all expressed as ratios): PCB/DDE, HCB/DDE, PCB-14/PCB, PCB-16/PCB, and PCB-17/PCB. The PCB-14, PCB-16, and PCB-17 components represent homologs of PCB that comprise a portion of the total PCBs quantified. The DDE was chosen as the denominator for the first two variables because it showed lower coefficient of variation than did PCBs or HCB. Because the variables were expressed as ratios, the assumption of homogeneity of variance is violated. For this reason, more emphasis will be placed on the descriptive aspects of multivariate analyses, and little emphasis will be given to significance tests. Multivariate and discriminant statistical tests were performed using SYSTAT (Wilkinson 1986) and BMDP (Dixon 1985) computer programs.

Results

Concentrations of PCBs, DDE, and HCB in the blubber of the 45 harbor porpoises examined varied widely (Tables

Table 2
Description of and results for harbor porpoise blubber samples from California.

Sample #	Latitude (degrees)	Collection date			Sex	Standard length (cm)	Blubber thickness (cm)	% lipid	Concentration (mg/kg, wet wt.)			Ratios		
		(d)	(mo)	(yr)					PCB	DDE	HCB	PCB/ DDE	HCB/ DDE	HCB/ PCB
JEH-338	35.4	27	09	1983	F	138	1.0	76	16.3	85.2	0.77	0.19	0.0091	0.047
JEH-339	35.5	17	08	1983	M	134	1.5	73	22.1	131.8	0.58	0.17	0.0044	0.026
LML-85-4A	36.65	27	02	1985	F	135	2.2	83	7.5	25.1	0.34	0.30	0.0134	0.045
LML-85-4B	36.8	11	04	1985	F	149	2.0	78	21.8	65.4	0.52	0.33	0.0079	0.024
MLML-001	36.8	—	—	1985	M	127	2.2	83	9.9	34.2	0.43	0.29	0.0126	0.044
MLML-005	36.8	—	—	1985	M	131	1.5	87	14.8	60.0	0.69	0.25	0.0115	0.047
LML-86-6	36.8	28	07	1986	M	96	1.5	82	11.3	35.7	0.44	0.32	0.0123	0.039
LML-85-8	36.9	14	09	1983	F	117	1.8	83	5.7	15.2	0.31	0.37	0.0204	0.055
LML-84-5	36.9	03	08	1984	F	150	1.3	73	42.0	101.5	0.64	0.41	0.0063	0.015
LML-85-3	36.95	07	03	1985	F	159	2.0	85	10.0	25.6	0.09	0.39	0.0034	0.009
LML-84-3	36.95	13	05	1984	M	77	1.1	69	2.6	6.3	0.07	0.41	0.0105	0.026
LML-85-5	36.95	27	05	1985	F	103	2.0	74	18.1	66.3	0.89	0.27	0.0134	0.049
LML-85-6	36.95	23	08	1985	F	147	2.0	99	12.7	48.7	0.42	0.26	0.0085	0.033
HJB-008	36.95	09	07	1983	F	131	1.6	68	25.6	77.6	0.58	0.33	0.0075	0.023
LML-86-5	37.1	30	05	1986	F	168	2.5	85	7.2	17.6	0.22	0.41	0.0125	0.031
CAS-A3870	37.35	30	06	1984	F	85	1.7	85	8.2	11.5	0.33	0.72	0.0286	0.040
CAS-A3209	37.8	01	07	1980	M	75	1.0	59	8.8	20.3	0.25	0.43	0.0125	0.029
CAS-22173	37.9	27	05	1980	F	80	1.5	48	9.5	13.0	0.11	0.73	0.0086	0.012
CAS-15892	37.9	23	04	1971	F	69	1.0	51	3.2	14.2	0.07	0.23	0.0048	0.021
MVZ-172409	38.3	15	07	1986	F	108	2.0	92	2.1	8.3	0.15	0.26	0.0181	0.070
REJ-1415	38.4	—	—	1985	F	132	1.7	90	5.6	21.9	0.28	0.25	0.0127	0.050
REJ-1414	38.4	08	05	1985	M	145	1.0	51	6.1	26.9	0.16	0.23	0.0059	0.026
MVZ-172408	38.4	15	07	1986	M	162	0.5	49	63.6	101.0	0.38	0.63	0.0037	0.006
MVZ-173468	38.5	20	08	1986	F	154	2.0	81	5.1	14.1	0.12	0.36	0.0085	0.024

2 and 3). Concentrations of PCBs averaged 14 ppm (mg/kg wet weight, SD = 13) or 21 ppm (lipid weight, SD = 23). The DDE concentrations tended to be higher, averaging 31 ppm (wet weight, SD = 30) or 45 ppm (lipid weight, SD = 46). The HCB concentrations were much lower than PCB or DDE averaging 0.51 ppm (wet weight, SD = O.42) or 0.77 ppm (lipid weight, SD = 0.80). Concentrations of DDE (lipid weight, log transformed) varied significantly among the five regions compared (ANOVA, $P<0.001$). No significant differences were found among regions for PCB or HCB (ANOVA, $P>0.05$).

Stepwise multiple regression analyses were used to determine which factors best explained the variations in concentrations found. A significant regression was found between PCBs and animal length ($r = 0.37$, $P<0.05$). The DDE concentrations were significantly associated with length and latitude ($r = 0.51$, $P<0.01$). The HCB concentrations were weakly associated with latitude ($r = 0.39$, $P<0.05$). Blubber thickness and year of collection significantly influenced contaminant concentrations in some models, with higher concentrations associated with thinner blubber layers and earlier collection years. These effects were generally weak or not significant in all models.

The association between PCB and DDE concentrations and length was not consistent for males and females. For both PCBs and DDE the association between concentrations and animal length was significant in males ($n = 17$, $r = 0.70$, $P<0.01$ and $r = 0.76$, $P<0.01$, respectively) but not in females ($n = 26$, $P>0.05$ for both PCB and DDE). The significant associations with length in the entire sample, therefore, primarily reflect this association in males only.

Ratios of contaminants were less varied than the concentrations. Both the ratios of PCB to DDE and HCB to DDE varied significantly by latitude ($r = 0.70$, $P<0.001$ and $r = 0.83$, $P<0.001$, respectively). Similarly both these ratios varied significantly among regions (ANOVA, $P<0.001$ in both cases). No significant associations were found between ratios and others factors. Figure 2 illustrates differences in the PCB/DDE ratio among regions.

Analyses of blubber samples from seven different locations on two harbor porpoises (14 samples) yielded similar results. In both animals, samples from the dorsal peduncle area had about 20% lower concentrations than other samples. Concentrations from other parts of the body were fairly uniform deviating less than 10% in most cases (never more than 20%) from average values for all samples (excluding the dorsal peduncle). Further details of this comparison are reported in Calambokidis (1986). Concentrations (by lipid weight) and ratios for four samples pre-

Table 3
Description of and results for harbor porpoise blubber samples from Oregon and Washington.

Sample #	Latitude (degrees)	Collection date (d)	(mo)	(yr)	Sex	Standard length (cm)	Blubber thickness (cm)	% lipid	Concentration (mg/kg, wet wt.) PCB	DDE	HCB	Ratios PCB/DDE	HCB/DDE	HCB/PCB
Oregon														
OIMB-C044	43.4	04	07	1986	F	90	1.0	62	2.8	9.5	0.54	0.30	0.0570	0.192
OIMB-C043	43.45	11	07	1986	M	70	0.5	57	1.9	6.9	0.21	0.27	0.0300	0.110
UO-1	43.7	19	03	1985	F	115	—	60	2.2	3.0	0.16	0.73	0.0530	0.073
OIMB-C046	43.9	25	07	1986	F	92	0.5	55	1.4	3.2	0.16	0.45	0.0490	0.111
OSU784-256	44.4	27	07	1984	F	149	1.6	80	11.5	33.2	0.64	0.35	0.0190	0.055
OSU886-764	44.45	21	08	1986	M	149	1.0	57	12.4	28.0	0.47	0.44	0.0167	0.038
OSU786-761	44.6	07	07	1986	F	172	1.5	84	1.5	2.1	0.08	0.70	0.0370	0.054
OSU786-762	44.65	11	07	1986	F	178	1.4	84	2.7	4.7	0.31	0.58	0.0660	0.113
OSU785-658	44.65	15	07	1985	M	159	1.5	85	13.5	32.0	0.51	0.42	0.0160	0.038
OSU784-255	44.65	24	07	1984	M	118	1.5	67	5.7	18.5	0.92	0.31	0.0500	0.162
OSU985-679	44.7	14	08	1985	F	103	—	41	22.9	38.3	1.76	0.60	0.0460	0.077
OSU885-671	44.7	10	08	1985	M	121	2.0	80	13.5	17.7	0.84	0.76	0.0470	0.062
MMP-108	45.9	06	04	1981	M	141	2.0	69	49.6	52.1	1.78	0.95	0.0342	0.036
Washington														
MMP-92	46.7	06	03	1981	M	131	2.0	82	29.9	26.7	0.87	1.12	0.0327	0.029
MMP-SKULL	47.3	04	09	1985	—	120	1.0	19	6.6	10.0	0.43	0.66	0.0436	0.066
MMP-384	47.3	20	09	1985	—	—	—	15	0.2	0.2	0.01	1.02	0.0490	0.048
RCF-112	48.2	26	07	1984	F	176	1.7	85	26.6	15.2	0.56	1.75	0.0370	0.021
CRC-251	48.6	11	08	1985	F	142	1.1	85	22.3	12.5	0.91	1.78	0.0730	0.041
CRC-250	48.6	11	08	1985	M	163	2.0	80	28.1	16.3	0.72	1.72	0.0440	0.026
CRC-248	48.6	11	08	1985	F	171	1.5	79	8.7	7.6	0.42	1.13	0.0550	0.049
CRC-308	48.2[a]	25	04	1986	M	124	0.8	66	15.8	26.7	1.73	0.59	0.0647	0.109

[a] Collected from Puget Sound, Washington.

served in formalin were not significantly different from those that had been frozen (ANCOVA, $P>0.05$, with all other significant factors used as covariates).

Stepwise discriminant analysis was based on five predictive variables and data collected from five locations. The three variables, which included the fractional composition of total PCBs did not, however, add appreciably to the discrimination of collection location and were excluded by the stepwise procedure. Using only two variable (PCB/DDE and HCB/DDE) discriminant analysis, we were able to assign correct collection location to 63% of 43 samples (Table 4). On a coarser geographic scale, 86% of samples were correctly assigned to state (Table 4). Typically with discriminant analysis, the separation of groups is illustrated by plotting the first and second factor scores for each sample. When only two variables are used to compute the factor scores, it is equivalent to plotting the values for each variable (Fig. 3; note that a plot of factor scores would be a simple rotation of this figure). As seen in Figure 3, there are three samples taken in Oregon which appear to be more similar to California samples, and there is one sample from Washington which appears similar to Oregon samples. Within California, the southern samples appear relatively distinct from other areas, but there is considerable overlap between Monterey Bay and areas north of there. Samples from Monterey Bay are characterized by very low variance in both PCB/DDE and HCB/DDE ratios (Fig. 3).

Multiple regression was able to predict accurately the latitude at which samples were collected using 5 variables (multiple $R = 0.89$). Again the fractional components of PCBs did not add appreciably to the regression and were excluded by the stepwise procedure. The regression coefficient (multiple R) was 0.87 using only PCB/DDE and HCB/DDE. The predicted and estimated latitudes for each sample are shown in Figure 4. There appear to be four outliers in Oregon which appear more like those from northern California and one sample from California that appears more like those from southern Oregon.

Discussion

Concentrations of chlorinated hydrocarbons found in this study were generally in the middle of the range reported from harbor porpoises from other areas (Gaskin et al. 1971; 1982; Koeman et al. 1972; Clausen et al. 1974; Otterlind 1976; Calambokidis et al. 1984). Correlations between length and contaminant concentrations found in this study

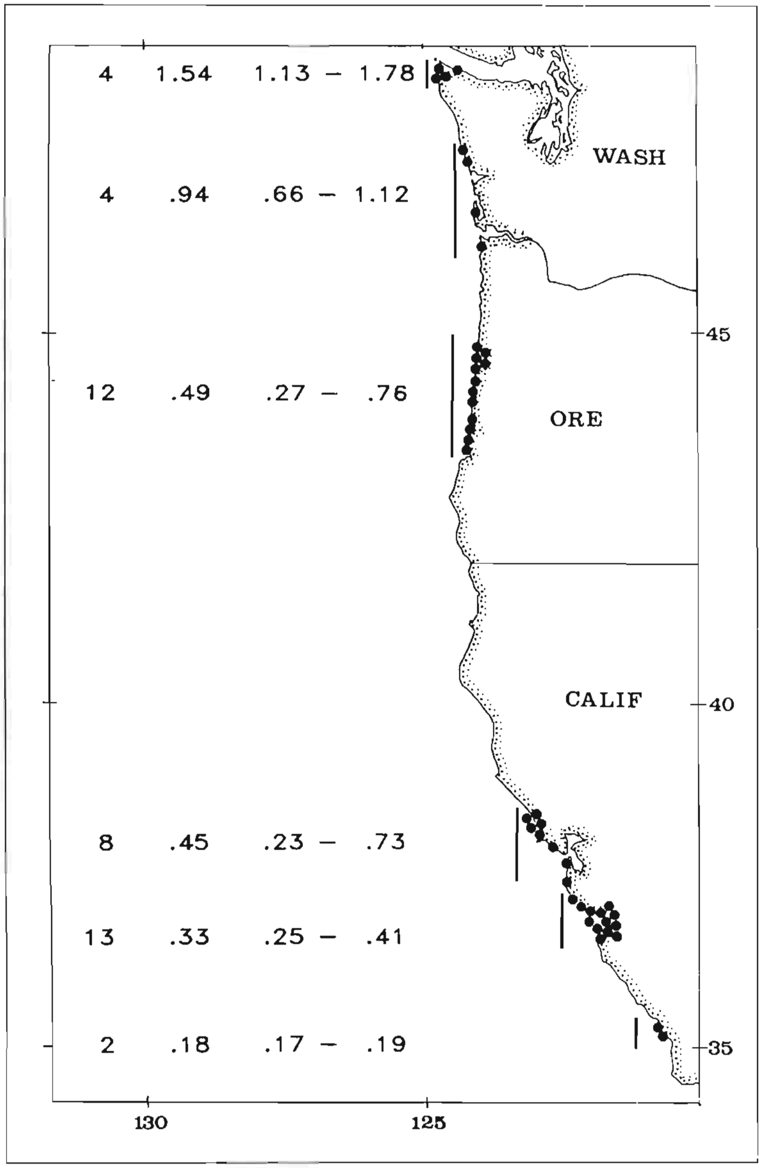

Figure 2
Number of samples, mean, and range of PCB/DDE ratios for harbor porpoises from different areas. Excluded are one sample collected in 1971 and one sample from Puget Sound (inland waters of Washington State).

Table 4
Predicted sample locations from discriminant analysis using PCB/DDE and HCB/DDE as predictive variables. Samples were categorized as being from Morro Bay Area (CA-1), Monterey Bay (CA-2), San Francisco/Bodega Bay area (CA-3), Oregon (OR), and Washington (WA). Excluded are one sample collected in 1971 and one from Puget Sound (inland waters of Washington State). A total of 27 locations were predicted correctly to region and 37 were predicted correctly to state (out of 43 samples).

Actual collection location	Predicted collection location					
	CA-1	CA-2	CA-3	OR	WA	Total
CA-1	2	0	0	0	0	2
CA-2	1	7	5	0	0	13
CA-3	1	3	3	1	0	8
OR	0	1	2	9	1	13
WA	0	0	0	1	6	7
Total	4	11	10	11	7	43

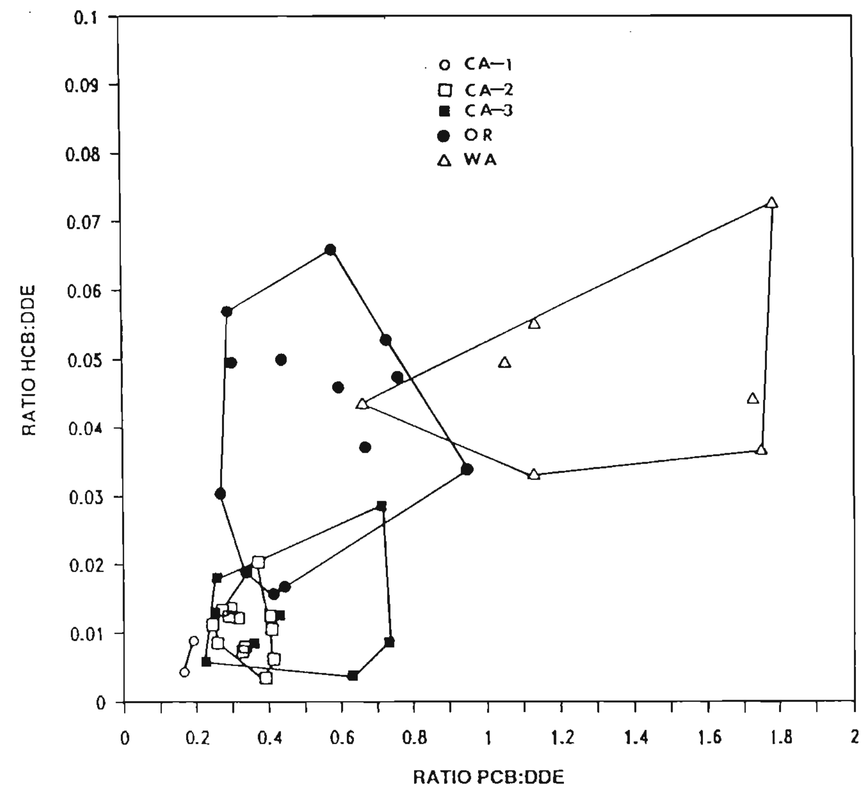

Figure 3
Pollutant residues expressed as the ratios HCB/DDE and PCB/DDE for 43 samples collected in 5 regions. Regions are defined in the text. Polygons enclose all samples collected in each of the 5 regions.

are consistent with other reports of accumulation with age primarily in male harbor porpoises (Gaskin et al. 1982; 1983) and other marine mammals (Addison et al. 1973; Addison and Smith 1974; Donkin et al. 1981; Calambokidis et al. 1984).

Organic pollutant residues give valuable clues regarding the population structure and feeding ecology of west-coast harbor porpoises. If the population were panmictic (randomly mixing), homogeneous pollutant ratios for all samples should exist. Instead, very strong gradients occur with latitude. This is likely to occur only if individual porpoises remain in one area for long periods of time. Similarly, pollutant ratios imply something about the feeding ecology of west-coast harbor porpoises. The observed patterns would not be expected if harbor porpoises were feeding on fish populations which had homogeneous pollutant ratios. It is likely that harbor porpoises feed largely on local fish stocks rather than on highly migratory fish. These patterns appear to differ from those of harbor porpoises along the east coast of the United States which may migrate a considerable distance to feed on a migratory fish, the herring, in the Bay of Fundy (Gaskin et al. 1985).

If an individual changes location, it is not known how much time is required to attain pollutant ratios which are characteristic of the new location. The required time period is related to the residence times of the pollutant and the difference between current pollutant load and that characteristic of the new location. Because chlorinated hydrocarbons accumulate over prolonged periods of time (the entire lifespan in males), we infer that most harbor porpoises remain in a region for extended periods if not most of their lives. Some exceptions may be evident in the data. Both discriminant and multivariate regression analyses identified several individuals from Oregon whose pollutant ratios more closely resembled samples from northern California. Although this could be natural variation about a mean value for Oregon, it could also be due to animals that moved at one point during their lives from California to Oregon or to animals that regularly move between those regions.

Pollutant ratios in Monterey Bay samples are particularly interesting because of their low variance. Monterey Bay samples show little variability in both PCB/DDE and HCB/DDE ratios (Fig. 3). Samples collected north of Monterey Bay (primarily near San Francisco and Bodega Bay) overlap with those values seen in Monterey Bay, but have much higher variance. In the discriminant analysis, 62% of the misclassifications were associated with this San Francisco/Bodega Bay area (Table 4). The low variance may be indicative of a resident population in Monterey

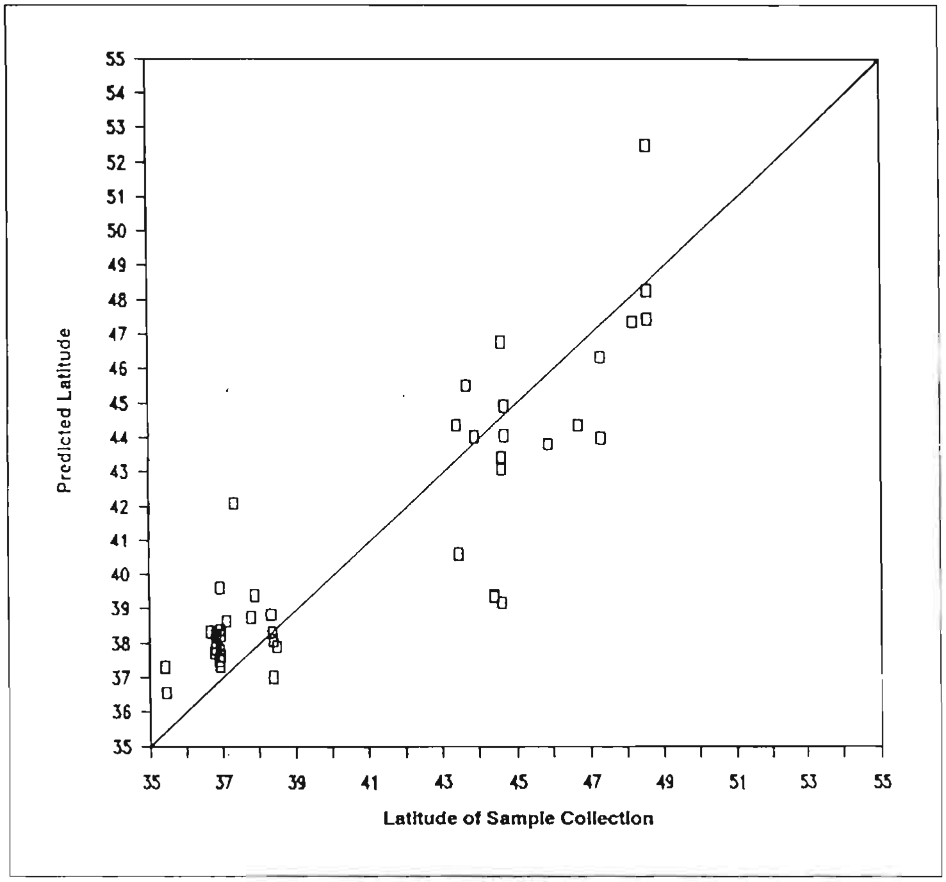

Figure 4
Observed and predicted collection latitudes for 43 samples based on multiple regression. The dependent variables included HCB/DDE and PCB/DDE.

Bay. The higher variance of the more northerly samples may indicate an area of mixing. Although speculative, these interpretations could be tested as additional information becomes available.

Unfortunately, pollutants ratios do not indicate any logical subdivision of the west-coast porpoise population into stock units. A stock is a management term and does not have a widely accepted definition. The Marine Mammal Protection Act of 1972 defines a stock as a group of animals of the same species which inhabit a common spatial arrangement and which interbreed when mature. Perhaps the best definition of a stock is a collection of animals that can be sensibly managed as a single unit (Larkin 1972; MacCall 1984). The problem with harbor porpoise management is that the animals do not appear to fit this concept of a stock. Based on pollutant ratios, harbor porpoises do not move great distances; thus animals from California and Washington are not likely to interbreed and should thus be assigned to different stocks. However, there may be movement from Washington to Oregon and from northern California to Oregon. Harbor porpoise distributions are continuous between California and Washington (Barlow 1988) and there are no apparent barriers to movement or gene exchange. Thus assigning clear boundaries of potentially discrete stocks may not be possible.

It is unrealistic to expect that one technique, analysis of pollutant ratios, will answer all questions about stock structure. We have suggested, however, that harbor porpoise interchange between some areas is relatively restricted. Other techniques, such as conventional tagging or radio tracking may help refine knowledge of their movements and use of cytogenetic and biochemical methods (*see* Duffield et al. 1991) may determine degree of interbreeding. Until such additional information becomes available, we urge a conservative approach to harbor porpoise management, avoiding depletion of populations in local areas.

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Marine Mammal Beachings as Indicators of Population Events

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ABSTRACT

Using two data bases compiled from 1975 to 1987, comparisons of beach cast versus living populations were possible for seven species of marine mammals. The study was conducted in the northern portion of the Southern California Bight and coastal waters of southern central California. Results of the comparisons indicate that beached animals may act as indicators of populations relative to seasonality, residency, natality, and mortality.

Introduction

Single beach cast marine mammals can provide valuable information at the level of the individual organism. This leaves open the question of what that individual may indicate relative to its parent population. An unusual beaching may be interpreted as an anomaly. It may be seen as a sick or injured animal that lagged behind the pod or stock with which it associated, and that either remained longer in an area than normally expected, or accidentally drifted into a region where the species rarely, if ever, occurs. Alternatively, such an individual may indicate the presence of a regional stock of that species. A monospecific series of beach cast specimens may provide indications of population movement patterns, residency, or reproductive status. Correlations drawn between commonly beached species and their parent populations may be applicable to interpreting population information from species that appear beach cast less frequently.

In late 1974 at the Santa Barbara Museum of Natural History (SBMNH), I developed a program devised to incorporate a two-fold compilation of information about marine mammals of the region. To date, one file contains over 1500 records of live sightings primarily of cetaceans, and the other contains over 500 records of beach cast sick, moribund, or dead pinnipeds and cetaceans. After 12 years, a comparison of both data bases provides some insight to the relation of individual beachings and populations offshore.

Materials and Methods

Records of live cetaceans occurring in the northern portion of the Southern California Bight have been maintained since 1975. These are gathered fortuitously from a few sources considered reliable (Woodhouse, in press).

Beach cast cetaceans and pinnipeds have been measured according to the suggested methods of Norris (1961) and Scheffer (1967), respectively. A number of the pinnipeds are small, sick specimens that are nursed back to health by the Santa Barbara Marine Mammal Center, a regional rehabilitation organization. Each specimen that is cared for by that group is given a museum field number, and duplicate records pertaining to each are maintained in the museum's files. All specimens are routinely reported to the Marine Mammal Stranding Network of the National Marine Fisheries Service.

The region covered by this study incorporates the coasts of Ventura, Santa Barbara, and southern San Luis Obispo Counties, California, including the Northern Channel Islands: Anacapa, Santa Cruz, Santa Rosa, and San Miguel. With only a few exceptions, the pinnipeds were recorded from the mainland, and no rigorous attempt was made to monitor mortality among the island rookeries and hauling grounds.

Results

The number of beach cast species recorded since January 1975 reflects the diversity of marine mammals in this portion of the California Current (Table 1). Seven of the 21 species have beached frequently enough to allow some comparison to patterns noted in their living populations offshore. Others are evidently present year round, and yet beach relatively infrequently (Woodhouse, in press; Bonnell et al. 1981; Gentry 1981). Dall's porpoise (*Phocoenoides*

Table 1.
Beach cast pinniped and cetacean records by species for the northern Southern California Bight and southern Central California, 1975–1987.

Species	No. records	Months recorded[a]
Pinnipedia		
Zalophus californianus	252	All
Callorhinus ursinus	5	V, IX, X, XII
Phoca vitulina	65	All
Mirounga angustirostris	35	All but VI, VIII
Cetacea: Mysticeti		
Eschrichtius robustus	33	I, II, III, IV, V, X, XI, XII
Balaenoptera musculus	1	VIII
B. acutorostrata	4	III, IV, VII
Cetacea: Odontoceti		
Delphinus delphis	42	All but I, X
Lagenorhynchus obliquidens	29	All but XI
Lissodelphis borealis	22	III, IV, V, VI, IX
Phocoenoides dalli	8	III, VII, VIII, X, XI
Globicephala macrorhynchus	7	V, IX, XI
Phocoena phocoena	6	III, VII, X
Tursiops truncatus	4	V, VIII, IX, XI
Kogia breviceps	3	VIII, XI
Orcinus orca	2	III, IV
Grampus griseus	1	IV
Mesoplodon densirostris	1	VI
M. carlhubbsi	1	VI
Stenella coeruleoalba	1	XII
Steno bredanensis	1	XI

[a]Months by Roman numeral from I = January to XII = December.

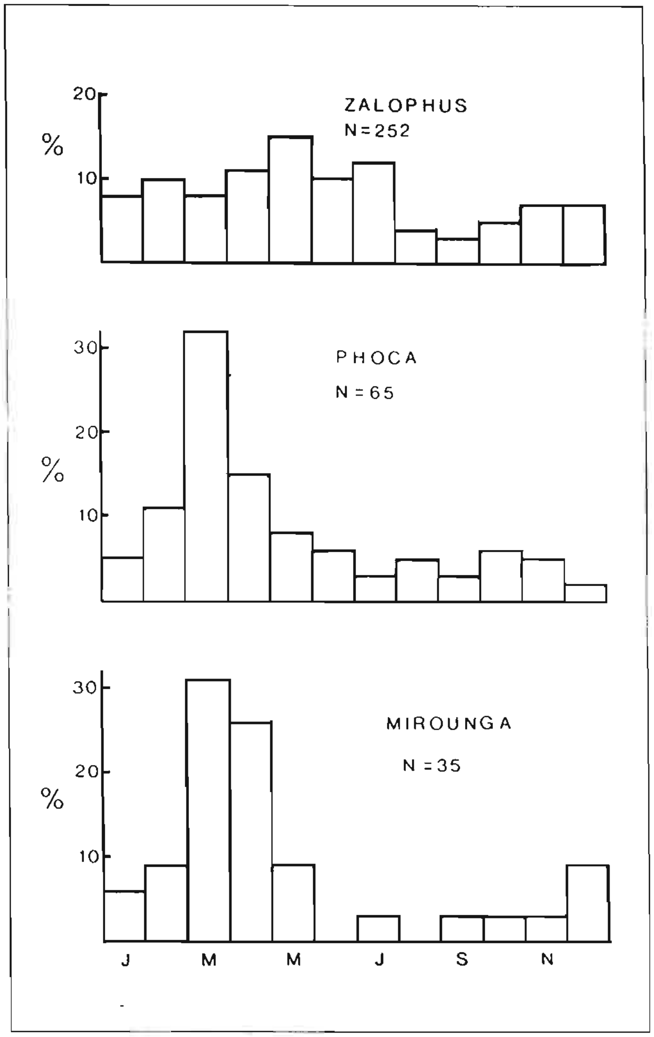

Figure 1
Frequency of beached pinnipeds on the mainland coast of California between latitudes 34° N and 35° N.

dalli), for example, appears to be resident and yet no beach cast specimens have been noted since late 1978. A pod of the coastal form of bottlenose dolphin (*Tursiops truncatus*) was first recorded in the area by the SBMNH program in October 1983. The first dead specimen was noted in May 1984. Since 1983, living bottlenose dolphins have been observed in every month of the year.

Among the three pinniped species most commonly found beach cast, frequencies of sick or dead specimens appear different for each, albeit a spring peak is shared by harbor seals (*Phoca vitulina*) and northern elephant seals (*Mirounga angustirostris*) (Fig. 1). The chi-square statistic was used to determine whether the three species beached with equal frequency over twelve months. California sea lions (*Zalophus californianus*) appear to beach as sick, moribund, or dead animals at an equal rate from November through July, but from August through October this rate is significantly lower (χ^2; $P<0.05$) (Fig. 1). For harbor seals, beached, distressed animals are more frequent in the months February through April (Table 2). Beached, distressed elephant seals reflect a similar pattern (Table 3).

Among cetaceans two species occur seasonally and two appear to be resident. Gray whales (*Eschrichtius robustus*) are markedly seasonal and represent a type of control in correlations between the presence of living populations and beach cast specimens (Fig. 2). Beach cast northern right whale dolphins (*Lissodelphis borealis*) also reflect the seasonality of the living population even with a small sample size (Fig. 3). Comparative frequencies of common dolphins (*Delphinus delphis*) and Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) indicate a year-round presence that is reflected in both live sightings and beach cast records (Figs. 4 and 5). The relative magnitude of histograms reflecting the live sighting data should not be interpreted as a measure of actual fluctuations in the respective species' populations because the information is mainly gathered fortuitously and

Table 2

Chi-square analysis of beach cast harbor seals, *Phoca vitulina*. $\chi^2 = 0.885$, df = 3. Model = 58.5% beached harbor seals during the Feb.-Apr. period and 14% beached harbor seals in each of remaining periods.

Period	No. observations	Expected
Feb.-Apr.	38	37.7
May-Jul.	11	9.1
Aug.-Oct.	9	9.1
Nov.-Jan.	7	9.1

Table 3

Chi-square analysis of beach cast elephant seals, *Mirounga angustirostris*. $\chi^2 = 2.000$, df = 3. Model = 65.7% beached elephant seals during the Feb.-Apr. period and 11.4% beached elephant seals in each of remaining periods.

Period	No. observations	Expected
Feb.-Apr.	23	23.0
May-Jul.	4	4.0
Aug.-Oct.	2	4.0
Nov.-Jan.	6	4.0

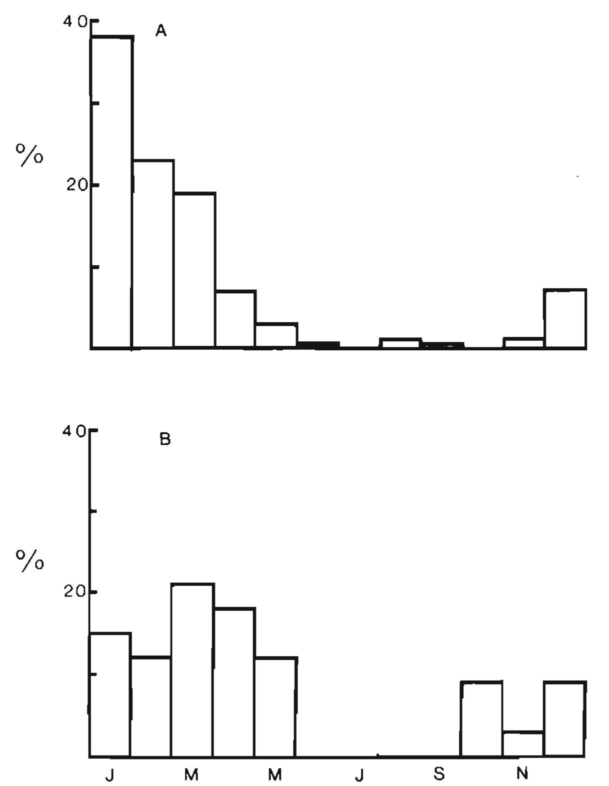

Figure 2

(**A**) Frequency of *Eschrichtius robustus* sightings in the northern portion of the Southern California Bight. (**B**) Frequency of beached specimens for the same region.

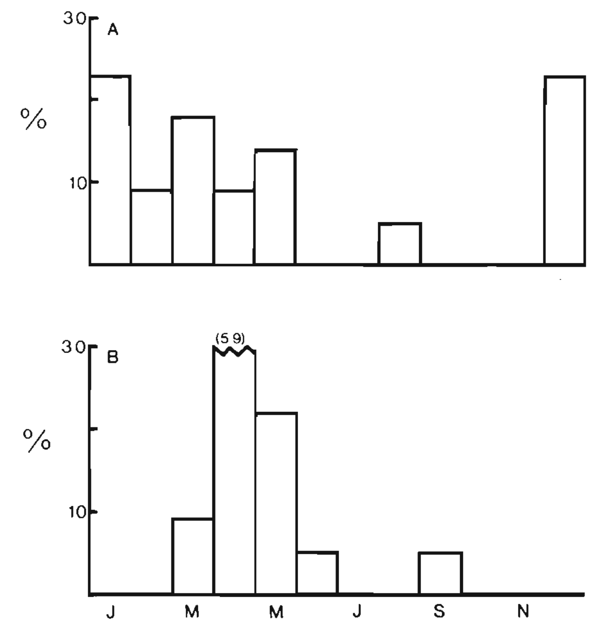

Figure 3

(**A**) Frequency of *Lissodelphis borealis* sightings in the northern portion of the Southern California Bight. (**B**) Frequency of beached specimens for the same region.

lacks the necessary level of effort to determine population size in any given sampling period.

In a small way, reproductive information from individual female dolphins corroborates the residency of each species. Near-term fetuses were noted in specimens of common dolphin and Dall's porpoise.

Discussion

The relative frequency of beach cast pinnipeds may reflect population size and proximity of population centers to the mainland. California sea lions and harbor seals occur regularly along the mainland as well as island coastlines whereas northern fur seals (*Callorhinus ursinus*) and northern elephant seals occur in greater abundance on the offshore islands. Northern fur seals, in particular, concentrate on the western end of San Miguel Island. That, coupled with their pelagic habit, may account for the few records of beached specimens in the data base reported here.

The spring peaks of beach cast harbor and northern elephant seals include a large proportion of small specimens. In the case of elephant seals, the peak in beachings occurs around the time when the animals would be expected to be weaned and starting to leave their island rookeries to fend for themselves. A few of these individuals

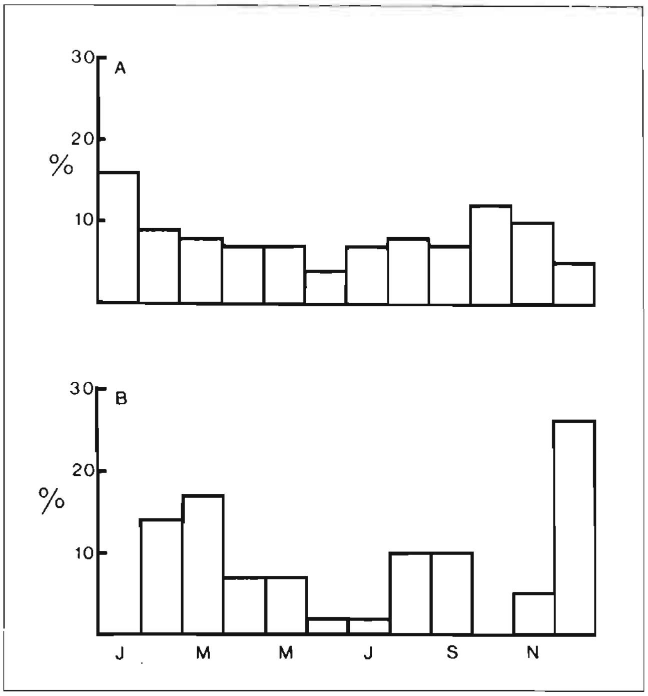

Figure 4
(**A**) Frequency of *Delphinus delphis* sightings in the northern portion of the Southern California Bight. (**B**) Frequency of beached specimens for the same region.

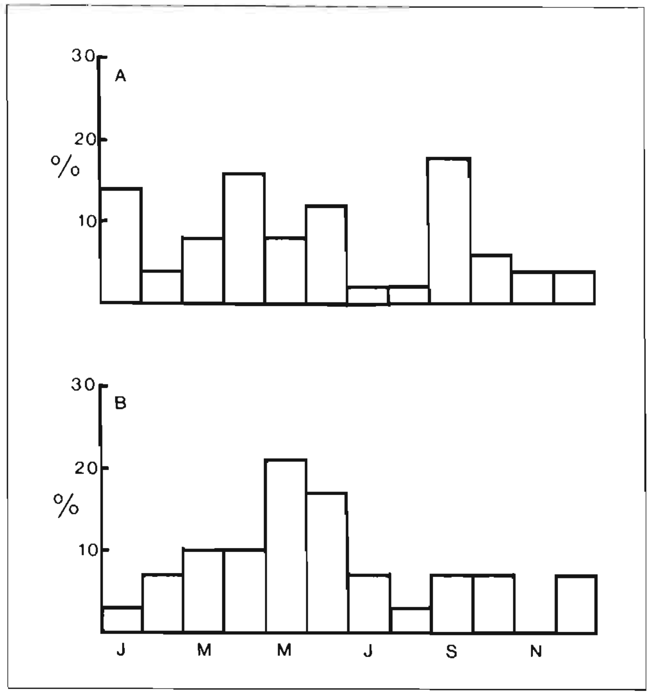

Figure 5
(**A**) Frequency of *Lagenorhynchus obliquidens* sightings in the northern portion of the Southern California Bight. (**B**) Frequency of beached specimens for the same region.

have been found with flipper tags which relate them to rookeries on San Nicolas and San Miguel Islands.

Among the four cetaceans, there appears to be a correlation between the time of beachings and the presence of the parent population offshore (Figs. 2–5). Conversely, presence of a living stock is not necessarily reflected in beachings. The lack of regular beachings noted for other cetacean species that were sighted year round, such as Dall's porpoise, may correspond to relative population size. A review of ten years of Dall's porpoise sightings in the region of this study, forming a sample of 191 records, revealed that 66% were of pods of 1–5 animals, and it was the second most common cetacean recorded (Woodhouse, in press). Alternatively, pods of common and Pacific white-sided dolphins numbering several tens of animals are not atypical. In the case of the former, over 100 animals have been recorded in a single pod. These two species have beached with a higher frequency than the others. Since the arrival of coastal bottlenose dolphins in 1983 during the El Niño Southern Oscillation (ENSO) episode, only four beached specimens have been recovered over a six-year period, and these ranged from neonate size to physically mature adults. Pod counts of up to 50 animals have been recorded, and this may represent the maximum size of the local population.

The northern right whale dolphin has been sighted in groups exceeding 100 animals, and yet they rarely beach. Seventeen of the 22 specimens recorded by this study came ashore in a six-week period in 1981 on island and mainland beaches. Nevertheless, the pattern of beachings reflects their seasonal presence. In terms of the relative frequency of living cetaceans sighted, northern right whale dolphins rank twelfth, whereas gray whales, common and Pacific white-sided dolphins rank first, third, and sixth, respectively. The seasonal presence of the northern right whale dolphin, coupled with a relatively small population size compared to the other seasonal species (e.g., gray whale), may partially explain the relatively low numbers of beachings.

At least in the portion of the California current involved in this study, beached animals appear to act as indicators of population events. Seasonal population changes are expressed, as are indications of residency, among the seven species most commonly found. Knowing the basic habits of each beached species (e.g., gregarious vs. solitary, pelagic vs. neritic, or migratory vs. resident) may help in formulating a judgment as to whether more of its kind are likely to be regionally present.

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Survival and Behavior of Previously Captive Harbor Seals after Release into the Wild

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ABSTRACT

Eight male harbor seals (*Phoca vitulina*) that had been held in captivity for 4–16 years, were weighed, measured, and radio-tagged before being released along the Oregon coast in the spring of 1986 and 1987. These previously captive harbor seals remained in the bays in which they were released for up to eight days. One individual moved 61 km north of the release site, whereas another moved as far south as 210 km. Duration of dive was an average 0.7–1.2 min for four of the harbor seals that were tracked; maximum time underwater was 8.6 min. Four (50.0%) of the eight previously captive harbor seals were found dead and stranded along the Oregon coast; they survived 7, 30, 38, and 223 days after their release. Two probably died from starvation, and another from an infection caused by a fish spine that passed through the upper lip. Cause of death of the fourth animal was not determined. Two had lost 11% and 13% of their body weight after release. Although robust harbor seals probably can survive longer than thinner individuals after release, survival rate in the wild is probably lower for previously captive harbor seals than for wild pups because of the former's dependence on a stable environment. Rehabilitated pinnipeds that were in captivity for less than one year probably adapt more readily to the wild than those held for longer periods.

Introduction

The number of pinnipeds in zoos and aquaria has increased recently because breeding has occurred in captivity, and stranded individuals have been rehabilitated and retained. In the past, excess pinnipeds in one institution often were placed in other aquaria and zoos, or they were used in new public displays and as replacements for animals that had died. The recent surplus of pinnipeds in captivity has made it difficult to find alternate locations for individuals. One possible solution to this problem was to release some individuals into the wild; however, there were few data concerning survival and behavior of previously captive pinnipeds after release.

In this study, I determined survival and behavior of harbor seals (*Phoca vitulina*) released into the wild after being in captivity for many years. Harbor seals were released in Oregon, where there are many isolated haul-out sites and an increasing number of harbor seals, which may indicate sufficient food supplies (Harvey 1987). These conditions could enhance the survivability of previously captive harbor seals in the wild.

Methods

Eight male harbor seals were transported in pairs from Point Defiance Zoo and Aquarium, Tacoma, Washington (n = 6) and Seaside Aquarium, Seaside, Oregon (n = 2) to a 10- by 20- by 2-m cement tank located outdoors at the Hatfield Marine Science Center (HMSC), Newport, Oregon. These harbor seals were kept in captivity for all of their 4–16 years (Table 1). Some became captive within a week of birth and others were born in captivity. Each pair of harbor seals was held at the HMSC for 2.0–3.7 months as subjects of a study regarding digestion of harbor seal prey (Harvey 1987). The tank was completely surrounded by a 2-m high fence, so the harbor seals were isolated from people, other than when the tank was cleaned.

These harbor seals were maintained on a diet of Atlantic herring (*Clupea harengus harengus*) and eulachon (*Thaleichthys*

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Table 1
Length and weight of eight male harbor seals released along the central Oregon coast in 1986 and 1987. The number of days from the release date to the date they were last relocated, and minimum distance traveled in that time, are given for each harbor seal.

				Release	
Seal ID	Length (cm)	Weight (kg)	Captivity (yrs)	Time of release to last sighting (d)	Minimum distance traveled (km)
011	143	~120	16	51 (3)[b]	52.6
082[a]	177	~130	15	223 (17)	270.2
120	156	81	?	28 (6)	98.8
060	149	85	?	29 (7)	7.7
200[a]	128	36	8	7 (1)	0
300[a]	141	46	4	38 (1)	30.9
301	136	86	4	78 (5)	23.2
209[a]	154	65	8	30 (3)	48.0

[a] Found dead.
[b] Numbers in parentheses represent number of times relocated.

pacificus), and periodically fed 13 other taxa of fishes and cephalopods commonly eaten by harbor seals in Oregon (Graybill 1981; Brown and Mate 1983; Roffe and Mate 1984). Fish and cephalopods were thrown over the fence; meals were not presented to harbor seals by hand. Previously frozen prey were fed to harbor seals until the last two weeks of captivity, when live fishes were placed in the tank. Before their release, all harbor seals ate live fish, although the amount was not determined.

Before release, harbor seals were weighed, measured, and marked with external tags. Radio transmitters (5- by 3- by 1.5-cm and 98 g) were glued to the hair on the back of the head using Devcon epoxy adhesive (Fedak et al. 1982; Harvey 1987). Individual radio tags were identified by their unique frequency (148–149 MHz), and signals could be heard from 8 km on land and 16 km in aircraft. Because a radio tag was placed on top of the harbor seal's head, signals would be received when the harbor seal was on land or at the water's surface. Radio tags were designed to operate for 9–12 months and to remain attached until the period of molt (August–September). As an aid for identification an Allflex cattle ear-tag was placed in the webbing of each hind flipper, and a red-dye mark (Woolite1 sheep dye) or a neoprene patch was placed on the back of these harbor seals.

Harbor seals released in Yaquina and Alsea Bays were identified and located by visually recognizing marks on the animals, or by receiving signals from radio tags using a Telonics1 receiver. Generally, during the first two to three days after release, the location and activities of harbor seals were monitored continuously. Thereafter, released harbor seals were located periodically. To locate released harbor seals, nine airplane flights were conducted either south or north of Newport. When released harbor seals were found dead, a necropsy was conducted.

Results and Discussion

Two harbor seals were released in Alsea Bay and six were released in Yaquina Bay between April 1986 and March 1987 (Fig. 1). Harbor seals remained in the bay in which they were liberated for up to eight days after their release (Table 2). One individual (#011) was observed within 16 hours of release with 190 other harbor seals on a haul-out site in Alsea Bay. This individual spent 2.3 hrs on land (13.4% of total time monitored). Two other released harbor seals (#082 and #301) were located on land. Harbor seal #082 was found ashore on three occasions, one of which was a mudflat in Alsea Bay not used commonly by harbor seals. Individual #301 was observed on two occasions on a stretch of beach south of Waldport (Table 2).

Harbor seals probably spent the first days after release becoming familiar with their surroundings before entering the ocean. The duration of dives for four released harbor seals was generally less than for wild seals similarly tagged and tracked (Harvey 1987). Previously captive harbor seals had dives that averaged 0.7–1.2 min in duration (Table 3). The greatest dive duration was 8.6 minutes. Average time spent at the surface between dives was 0.3–0.5 minutes. In Oregon, wild harbor seals spent an average of 1.0–3.1 min underwater during a dive (maximum = 11.4 min), and 0.4–0.6 min at the water's surface between dives (Harvey 1987).

Seven of eight harbor seals moved into the ocean; one individual traveled as far south as Port Orford, Oregon

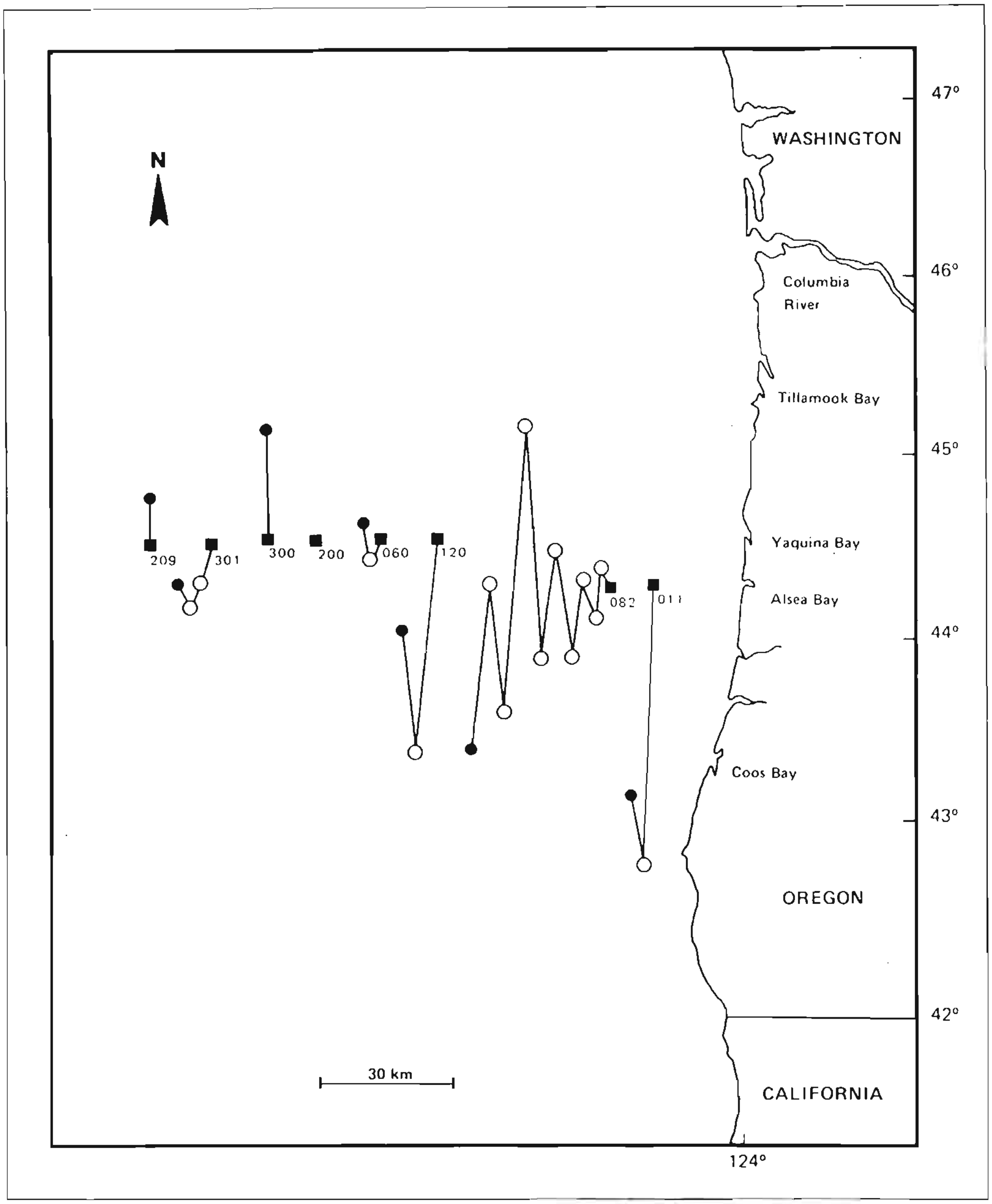

Figure 1
Locations of release (closed squares) for eight male harbor seals along the Oregon coast between 1985 and 1986. Open circles represent locations where these radio-tagged harbor seals were resighted or signals from their tags were heard. Closed circles represent the last known location of these animals. These locations were always on or within 2 km of shore. The numbers identify the individual harbor seals.

(210 km from the release site), another as far north as Cape Kiwanda, Oregon (61 km from the release site; Fig. 1). Movements of captive harbor seals after release in Oregon were similar to radio-tagged harbor seals caught and tagged in Oregon bays (Brown and Mate 1983; Harvey 1987). Wild harbor seals remained within 8 km of their capture site for many months, or moved 280 km north and 250 km south. Movements of some previously captive harbor seals along the Oregon coast, therefore, were not surprising.

Four (50.0%) harbor seals died 7, 30, 38, and 223 days after their release, and their carcasses were recovered (Table 1). Two individuals (#082 and #200) possibly died from starvation, harbor seal #300 probably died as a result of a systemic infection caused by a fish spine through the upper lip, and the #209 died for unknown reasons. Only

Table 2
Locations and movements of eight harbor seals released in Oregon.

Seal ID	Date	Radio or identification	Location and status
011	22 April	Both	Released in Alsea Bay
	23-28 April	Radio	In Alsea Bay
	5 May	Visual	In water near Port Orford docks
	30 May	Radio	On land at Bandon Rocks
	11 June	Radio	In water north of Bandon
082	22 April	Both	Released in Alsea Bay
	23-28 April	Radio	In Alsea Bay
	30 May	Radio	In water near Siuslaw River outlet
	9 June	Radio	In water south of Newport
	11 June	Radio	In water south of Siuslaw jetties
	14 June	Visual	In surf at Cape Kiwanda
	2 July	Radio	In water 8 km S of Umpqua River
	14 July	Radio	On land in Alsea Bay
	1 December	Visual	Found dead near Coos Bay
120	20 August	Both	Released in Yaquina Bay
	21-24 August	Radio	In Yaquina Bay
	6 September	Visual	In Coos Bay
	17 September	Visual	In water at Strawberry Hill
060	20 August	Both	Released in Yaquina Bay
	21-24 August	Radio	In Yaquina Bay
	11 September	Radio	In water south of Newport
	13 September	Visual	In water near Yaquina Head
	18 September	Visual	In water at Yaquina Head
200	25 November	Both	Released in Yaquina Bay
	2 December	Visual	Found dead in Yaquina Bay
300	25 November	Both	Released in Yaquina Bay
	2 January	Visual	Found dead in Sand Lake
209	14 March	Both	Released in Yaquina Bay
	15 March	Radio	In water in Yaquina Bay
	13 April	Visual	Found dead near Lincoln City
301	14 March	Both	Released in Yaquina Bay
	15-16 March	Radio	In Yaquina Bay
	25-27 April	Visual	On beach 12-16 km S Waldport
	1 May	Visual	On beach S Waldport
	29 May	Visual	In water near Alsea Bay

two of these animals (#200 and #300) were weighed after death, and they had lost 11% and 13% of their body weight. Mid-ventral blubber thickness was 4-5 mm, less than the average 20-31 mm found in healthy harbor seals (Pitcher 1986).

For those individuals that died, duration of survival seemed to be related to their mass at time of release. The harbor seal (#082) with the greatest mass survived for over seven months before it was recovered dead near Coos Bay, Oregon. This individual was found with only a few crustacean fragments and feathers in its stomach. It probably had fed on some prey, but had not consumed an adequate amount to remain healthy. The other two harbor seals that died weighed less, when released, than harbor seals of similar length caught in the wild. Harbor seal #200, which weighed the least upon release, died within eight days, and never moved outside the bay in which it was released. Greater fat stores probably allow individuals a greater period of time to adjust to feeding in the wild.

Release of previously captive harbor seals is analogous to the period of weaning for this species. During the 3-6 weeks of suckling, harbor seal pups become obese and are dependent on their mothers for food and protection. Upon weaning, the mother suddenly separates from the pup. Captive harbor seals also are often obese and dependent for their food, and their release to the wild is sudden. Although these captive harbor seals were 4-16 years old, they had to make some of the same adjustments, such as feeding on live prey and gaining self-protection, as do newly weaned pups. Certainly these older captive animals are

Table 3
Mean, standard deviation, and maximum duration of dives and surface intervals between dives (min) for four radio-tagged harbor seals released in Oregon. *n* is number of dives or surfacings recorded.

	Seal identification			
	011	062	082	120
Dive (min)				
n	351	163	653	52
mean	1.2	0.7	1.2	0.7
SD	1.1	0.7	1.0	0.9
maximum duration	8.6	3.9	6.7	4.0
Surface (min)				
n	345	166	645	52
mean	0.5	0.4	0.4	0.3
SD	0.5	0.5	0.4	0.3
maximum duration	4.2	3.9	3.6	1.1

more developed physically and socially than pups. It might be expected that larger individuals, such as these previously captive harbor seals, would have greater survival than pups because they have a greater body mass that provides supplemental energy until they learn to capture prey. In addition, larger individuals may be better able to defend themselves against predators than are pups. The mortality rate of 50% for these captive harbor seals, however, was greater than first-year mortality rate of 20% reported for harbor seals in British Columbia (Bigg 1969). Rehabilitated harbor seals have been located alive and seemingly in good health after their release into the wild. For greater than one year, Picken (1978) found that an 11-month-old harbor seal, released in England, fluctuated in growth and continued to use a boat-slip near the laboratory in which it had been held captive. A pup and 4.5 year-old harbor seal were located 35 days (80 km) and 46 days (92 km), respectively, after their release in Washington and Oregon (Harvey et al. 1983). Webber and Allen (1986) resighted 2 of 27 harbor seal pups that were rehabilitated, tagged, and released off central California. These two pups were resighted 127 days (80 km) and 14 days (42 km) after release. The California Marine Mammal Center has rehabilitated and released 462 pinnipeds, and 109 have been resighted (Gavette and Roletto 1987). Only 17 of these individuals, 7 of which were dead, were found stranded again. The number of individuals that died but were not beached is unknown. Seagers (1987) reported that 16.8% of 398 stranded pinnipeds that were rehabilitated and released in California were subsequently resighted alive, or were found dead (3.5%). Individuals that died were found an average of 120 days after release.

Harbor seals that have remained in captivity for more than one year may not adapt to life in the wild as easily as those individuals that are captive for a shorter period of time. Although captive harbor seals may have large fat reserves and are taught to capture live fish, it may be more difficult for these individuals to initiate feeding on their own in the wild. Individuals that have fed in the wild before captivity may adapt to the wild more readily than individuals that have been in captivity their entire life. The starvation of one released harbor seal (#082) after seven months indicates that observations of released animals after a short period of freedom do not necessarily indicate they have successfully adapted to the wild. It may take extended periods of time for some individuals to adapt. Therefore, we may be overly optimistic regarding their successful transition to the wild if monitoring these individuals is confined to the first 3–4 months of liberty.

Acknowledgments

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Recovery and Necropsy of Marine Mammal Carcasses in and near the Point Reyes National Seashore, May 1982–March 1987

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ABSTRACT

The examination of beach cast marine mammal carcasses provides a unique opportunity to determine the causes and seasonality of mortality. The study was conducted along the coastline from Bodega Bay to Fort Funston, San Francisco, California including the San Francisco Bay. Necropsies were performed to determine cause of death, sex, and reproductive status of the animals recovered. A total of 248 dead marine mammals, involving 14 species, were reported. Cause of death was determined for 80 animals and the majority of these fell into one of three categories: natural disease, 33%; shooting victims, 35%; and set net (gill and trammel net) casualties, 29%. Three species (California sea lion, harbor seal and harbor porpoise) accounted for 85% of all animals reported. Annual, seasonal and size related variation in mortality factors is discussed for these species. Nine percent of the animals reported include: northern elephant seal, northern fur seal, northern sea lion, striped dolphin, Pacific white-sided dolphin, common dolphin, Dall's porpoise, dense beaked whale, Cuvier's beaked whale, gray whale, and dwarf sperm whale. The remaining 6% were pinnipeds or cetaceans reported but not identified because they were not found. A large number of animals must be examined to demonstrate trends in cause of death categories. An ongoing program of examination of dead beach cast animals would provide data useful for management of marine mammals in this area.

Introduction

The occurrence of beach cast marine mammal carcasses provides a unique opportunity to learn about species that can, otherwise, be logistically difficult to study. A regular program of examination of beach cast carcasses makes it possible, for example, to obtain insight into the causes and seasonality of mortality of some species. This type of information can sometimes be used to determine natural variation and the general condition of the individual animals and the populations of which they are a part. Data can also be utilized to detect human related changes in mortality patterns, and to help monitor the health and vitality of the marine ecosystem.

The objectives of this study were to examine all reported dead beach cast marine mammals in and near the Point Reyes National Seashore area. The cause of death, length, sex, and reproductive status of the animals recovered were determined by observation, gross necropsy, and histopathologic examination of collected tissues. Similar work has provided valuable information on many marine mammals in North America (*see*, for example, Stroud and Roffe 1979; O'Shea et al. 1985; and Rice et al. 1986).

Methods

The study was conducted along the coastline from Bodega Bay to Fort Funston, San Francisco including the San Francisco Bay (Figs. 1–3). This report includes data from May 1982 through March 1987. The study is continuing as funds allow. This research is conducted under authority of a Letter of Authorization from the National Marine Fisheries Service issued to the California Academy of Sciences. Research was also conducted under authorization of the Department of the Interior via a permit issued to the Point Reyes National Seashore.

Sightings of beached marine mammal carcasses in the study area were reported by National Park Service personnel and others to the 24-hour answering service at the

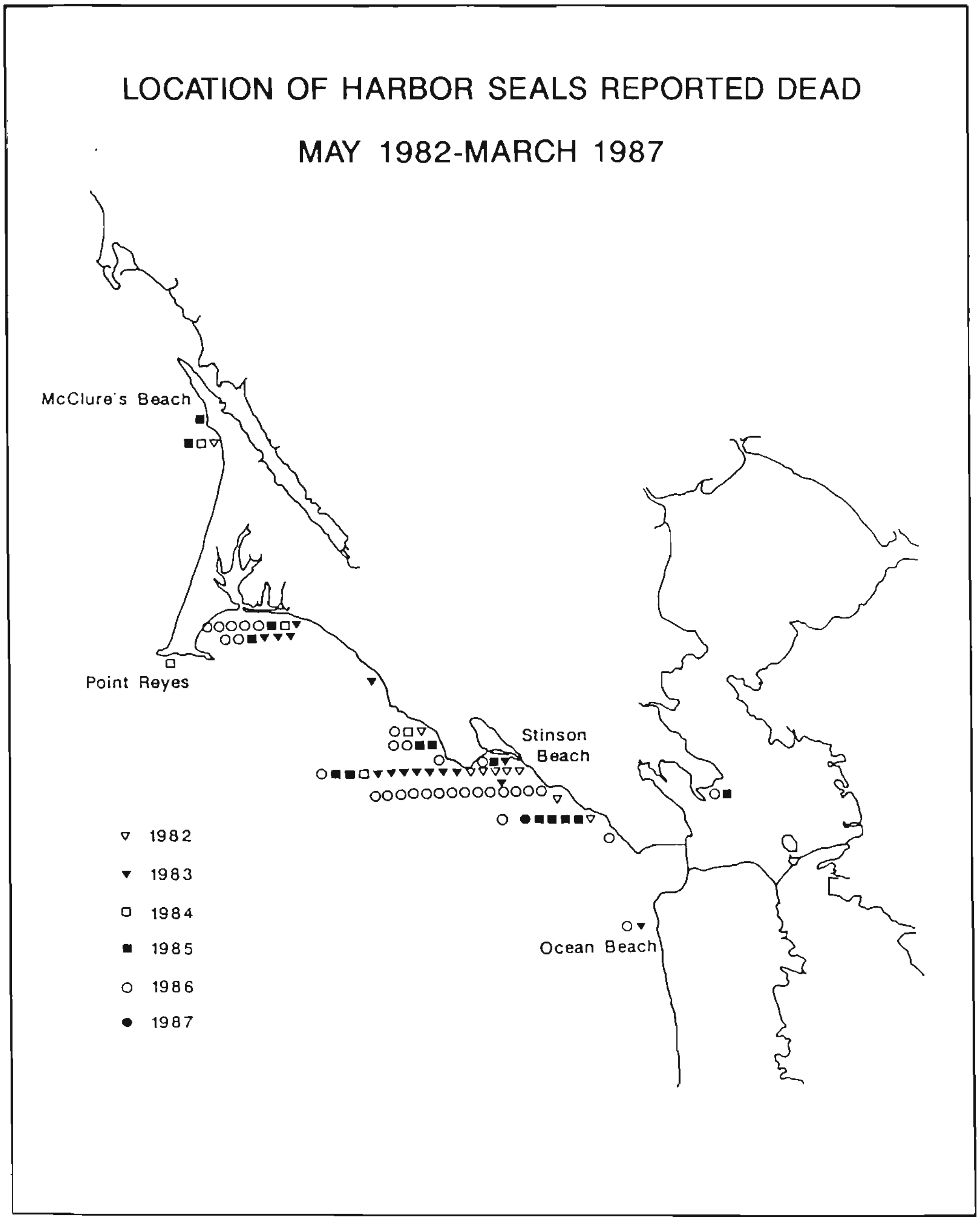

Figure 1
Location of Harbor Seal Reports May 1982-March 1987.

Sausalito and Bolinas animal hospitals. An identification number (RLD #) was assigned to each animal found. Those animals reported by knowledgeable sources (i.e., people competent in identifications of marine mammals) that were not found were not assigned an identification number, but the following data, if available, were recorded and listed in this report: location, species, length, and sex. If possible, all animals were measured. The data were reported tc ıal Marine Fisheries Service using their standara. Marine Mammal and Marine Turtle Data Record form. If the animal was not too autolyzed (decomposed) a complete gross examination and necropsy were done. As funds were limited, histopathology was performed primarily on these animals where tissue conditions were good enough to yield relevant data and where gross observations warranted further investigation. Specimens from animals also were frozen to allow for histopathology at a later date when funds are available. When the animal was suspected of being gunshot, radiographic examinations were done using a mobile x-ray machine or the machines

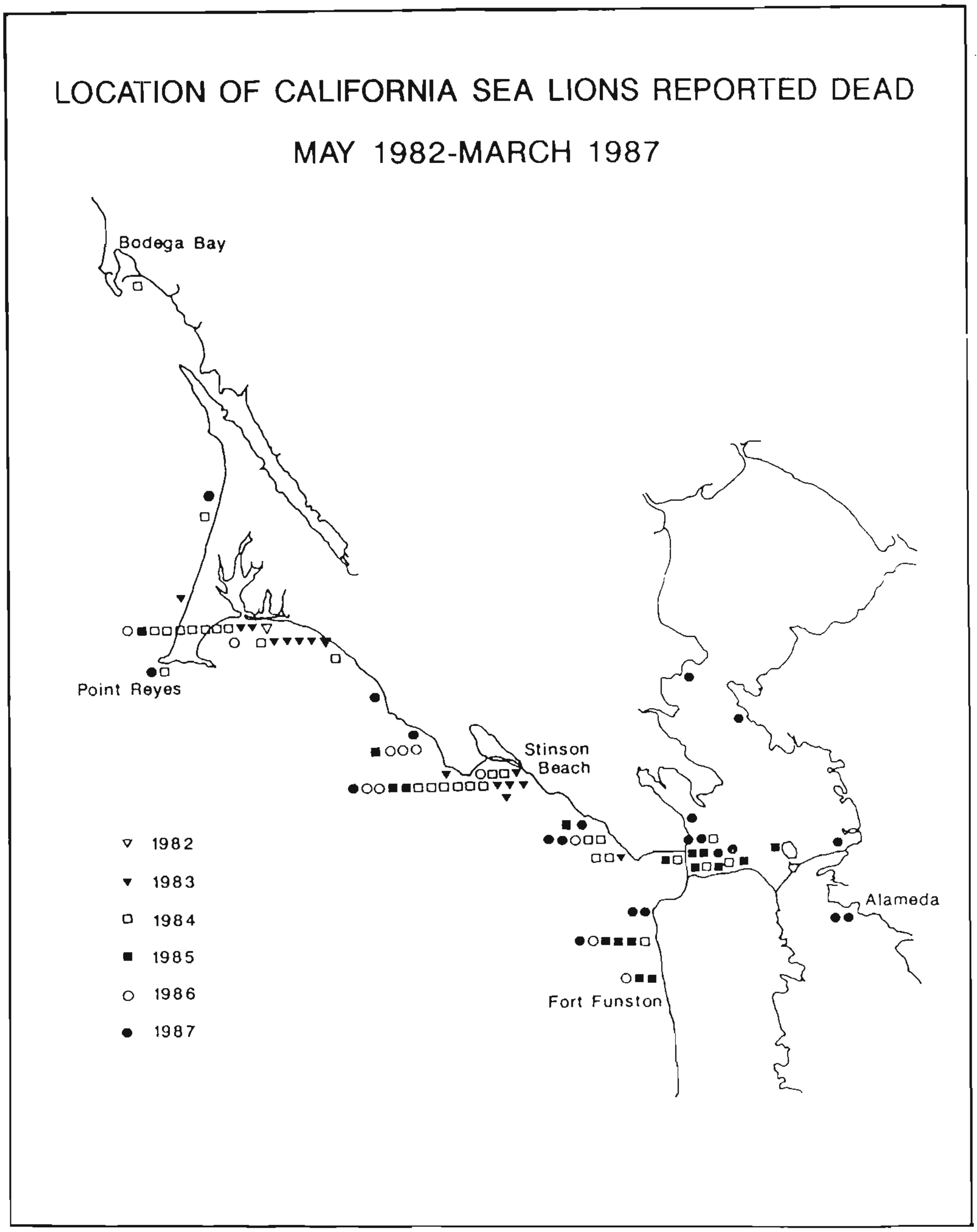

Figure 2
Location of California Sea Lion Recoveries May 1982-March 1987.

at the Sausalito and Bolinas animal hospitals. When possible, animals were photographed with Polaroid and 35 mm cameras. Blubber thickness was measured mid-sternum, to investigate whether chronically ill animals had thin blubber layers, and conversely whether acutely diseased animals had thick blubber layers.

Tissue samples and organs were collected for a variety of studies beyond the scope of this report including life-history evaluation; identification of possible toxic residues; complete determination of stomach contents; phenotyping of stocks; hair coat color analysis; complete identification of parasites, bacteria and viruses; and computerized tomography (CT scan) evaluation of cetacean sonar, vocalization, and echolocation organs. Tissues for toxicological analysis were collected and stored for later analyses. Additional tissues were sent to other researchers who requested them for toxicological analyses. Bacterial typing and parasitological and histopathological studies were conducted by the pathology services group at Army Letterman Institute in San Francisco, by the Veterinary Reference Laboratory

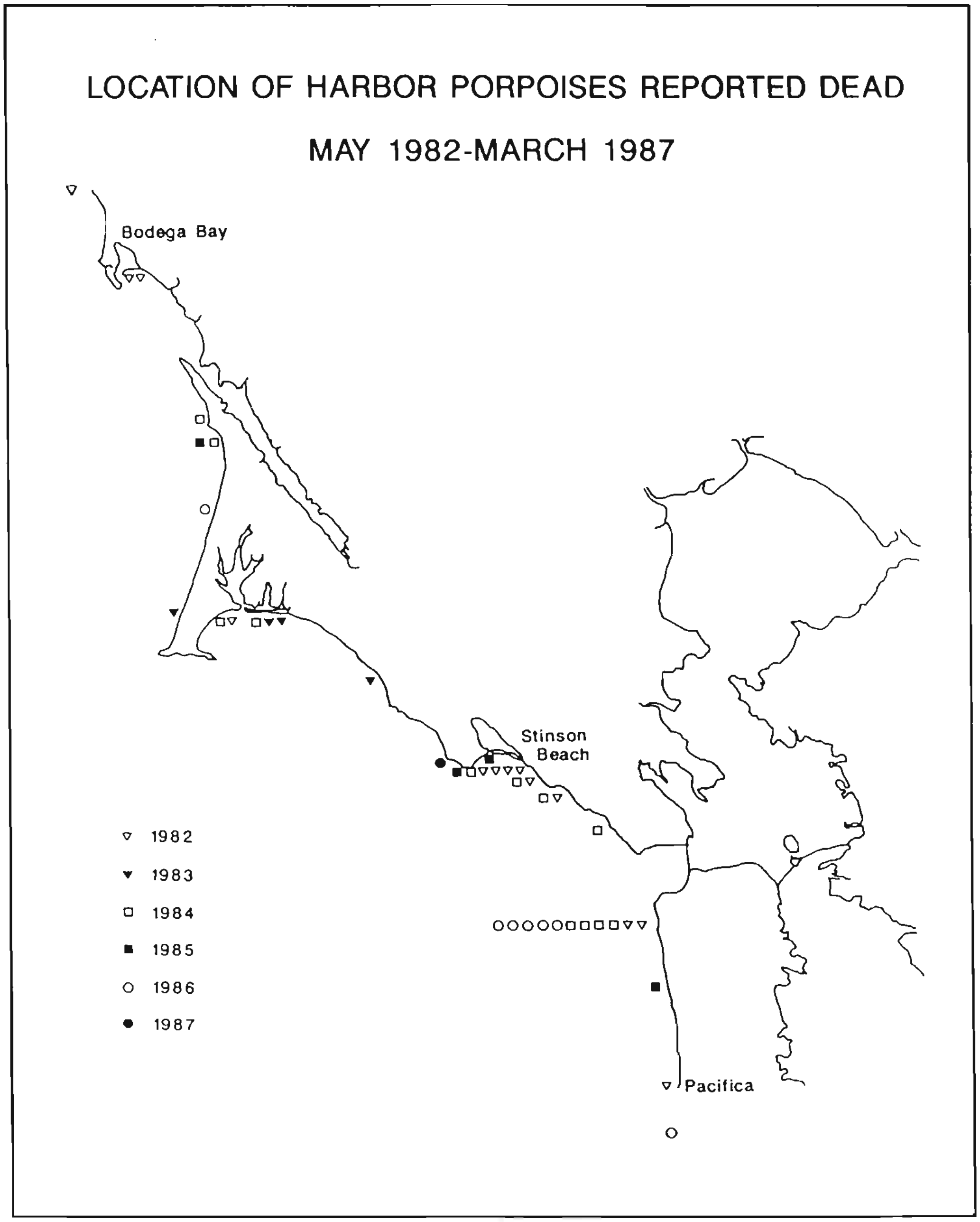

Figure 3
Location of Harbor Porpoise Recoveries May 1982–March 1987.

in San Leandro, and by the California State Veterinary Pathology Laboratory in Petaluma. Viral typing was done at St. Jude Children's Research Hospital in Memphis, Tennessee.

Specimens were assigned one of five categories of approximate maturity: 0-fetus, 1-juvenile, 2-immature, 3-adult, 4-unknown. A fetus was defined as any animal found in the womb. Full-term newborns with or without aerated lungs or milk/colostrum in the stomach were included in the juvenile category. Standard length measurements were used as approximations to differentiate between immature and mature animals for the two most abundant species reported as follows: harbor seals were considered to be mature if they were at least 148 cm long (for females) and 161 cm (for males), as suggested by Bigg (1969); California sea lions were considered mature if they were at least 150 cm long (for females) and 200 cm long (for males), as suggested by Peterson and Bartholomew (1967); harbor porpoise were considered adults if they were at least 129 cm long, as described by Fisher and Harrison (1970).

The latter study, it should be noted, occurred in the North Atlantic rather than the Pacific. Animals for which standard length could not be accurately determined were listed as age unknown.

Carcass condition was categorized as 0-unknown, 1-good, 2-fair, 3-poor. Gross and/or histologic tissue examination was used to determine these classes. Carcasses in good condition had reasonably normal gross and histologic tissue appearance. Fair condition denoted reasonably normal gross tissue appearance but autolyzed histologic appearance. Carcasses were listed in poor condition when gross examination indicated tissue autolysis. When histopathology was performed on tissues from fair or poor carcasses, the tissues indicated autolysis. Environmental conditions such as time in water (which has a refrigeration effect in this study area), time on the beach and amount of sun (both of which have a heating effect), type of beach (rocky or sandy), and surf and weather conditions determined how long the carcass would remain in the above categories. Time of death could not be precisely determined for most carcasses examined. However, based on my veterinary experience with other animals, as well as with marine mammals for which time of death could be determined, I used the following general guidelines: good condition encompassed approximately 0–36 hours post mortem; fair, about 36–72 hours post mortem; and poor over 72 hours post mortem. Rigor mortis, stiffening of the body due to hardening of the muscles by chemical reaction, generally occurs six to twenty-four hours after death (Spitz and Fisher 1980). This time period is shortened to two to four hours if the animal struggled shortly before death. Rigor mortis dissipates usually within 24 to 36 hours, when decomposition begins. This timing is primarily affected by the temperature of the carcass.

Decomposition rate varies by tissue type. The brain, liver, and kidneys autolyze quickly while the skin, connective, and muscle tissues can show gross lesions up to approximately 7–9 days post mortem.

Multiple animal recoveries (animals found at the same time and location) may provide a basis for inference of cause of death when it can be determined for some of the animals in the groups. Such assumptions have not been made in this study.

Natural deaths included any disease process, non-human related trauma, and shark predation. Trauma was diagnosed for many animals but only two animals evidenced severe musculoskeletal and sudden organ injury without any evidence of human impacts. Trauma as a cause of death can be difficult to diagnose owing to livor mortis, the discoloration of soft tissues on dependent parts of a carcass. Liquid blood flows by gravity to the down (dependent) part of the body and gels, usually within 6–18 hours. Once livor mortis occurs, it remains even if the position of the carcass is changed. This "blueness of death" appears similar to blunt trauma but only vessel engorgement of gelled blood and perivascular tissue congestion occurs with livor mortis, while blunt trauma causes hemorrhaging throughout all the affected tissues (B. Stevens, San Francisco Coroner's Office, San Francisco, CA 94103, pers. commun., August 1988).

Where shark bites were diagnosed, an attempt was made to determine premortem or postmortem timing. Generally, when a live animal is bitten, local hemorrhaging is immediate but usually is not recognizable because the open cuts allow sea water to dilute and wash away the hemorrhages. Margination into vascular walls of inflammatory cells, fibrin clots, and collagen swelling occur at a minimum of 30–180 minutes after insult as recognized by light microscopy (Spitz and Fisher 1980). If the animal dies before that time, perimortem histological verification is very difficult, if not impossible. Histochemical changes do occur sooner but these were not analyzed in this study. Unless histopathology verified the attack to be premortem, shark bites were assumed to be postmortem.

Human related causes of death included shooting and entanglement in set nets (gill and trammel nets). Shooting was listed as cause of death only if a projectile or its fragments were found and if it appeared to be more than a superficial or old healed wound. If the projectile could not be found or seen on radiographs, the cause of death was not listed as shooting.

When set-net entanglement was determined as cause of death, type of set-net material, number of filament strands and mesh size (stretched diagonally) were documented. Pieces and sometimes entire nets washed in attached to the animals. Seals and sea lions were listed as having been killed by set nets only if the net or a piece of the net was attached to the carcass and no other significant pathology was recognized. Set nets were listed as cause of death for cetaceans when net marks were found on the body and if there was no other recognizable pathological evidence for cause of death.

Results and Discussion

A total of 248 dead marine mammals involving 14 species was reported from May 1982–March 1987 (Table 1). In 1982 and 1987 the months covered were May–December and January–March, respectively. For the four years with complete information, 1983–1986, the total number of reported animals ranged from 40 in 1985 to 61 in 1986, and included substantial annual variations in numbers of the three species most commonly found: harbor seals (*Phoca vitulina*); California sea lions (*Zalophus californianus*); and harbor porpoise (*Phocoena phocoena*).

It was not possible to determine cause of death for 68% (168) of the animals. Of the 168 animals, autolysis was too advanced in 51% to assess accurately cause of death; 29% of the animals were not found, presumably because of

Table 1
Numbers of reported carcasses by species and year 1982–1987.

Species	1983	1983	1984	1985	1986	1987	Total
Harbor seal, *Phoca vitulina*	9	15	5	14	31	1	75
Northern elephant seal, *Mirounga angustirostris*	—	1	—	1	2	—	4
Northern fur seal, *Callorhinus ursinus*	—	2	—	—	—	—	2
California sea lion, *Zalophus californianus*	1	15	29	17	11	21	94
Northern sea lion, *Eumetopias jubatus*	—	2	—	1	1	—	4
Seal species—not found or identified	—	1	4	2	6	—	13
Striped dolphin, *Stenella coeruleoalba*	—	1	1	—	1	—	3
Pacific white-sided dolphin, *Lagenorhynchus obliquidens*	—	—	1	—	—	—	1
Common dolphin, *Delphinus delphis*	—	1	—	—	1	—	2
Harbor porpoise, *Phocoena phocoena*	13	4	12	4	7	1	41
Dall's porpoise, *Phocoenoides dalli*	—	—	1	—	1	—	2
Small cetaceans not found or identified	—	1	1	—	—	—	2
Dense beaked whale, *Mesoplodon densirostris*	—	—	—	1	—	—	1
Cuvier's whale, *Ziphius cavirostris*	—	1	—	—	—	—	1
Gray whale, *Eschrichtius robustus*	—	1	1	—	—	—	2
Dwarf sperm whale, *Kogia simus*	—	—	—	—	—	1	1
Total	23	45	55	40	61	24	248

recovery by other researchers, tidal action, or miscommunication; 9% exhibited no recognizable lesions; 7% were buried by National Park personnel; and 4% were inaccessible (floating in water).

Of the 80 animals for which cause of death was determined, only 53 were in good enough condition to do histopathology. Diagnosed animals were necessarily broadly grouped by gross necropsy examination into useful categories, the majority dying from three causes: natural disease or infection 33% (26); shooting 35% (28); and entanglement in set nets 29% (23). Two individuals died of non-human related trauma (3%) and one individual (1%) was killed by a shark. For all species and individuals for which the cause of death could be determined, natural causes were responsible for 36% (29) and human related causes were responsible for 64% (51).

Shark attack as a cause of death was frequently mentioned by reporting personnel; however, there was only one premortem, histopathologically verified shark victim during this study. Three animals showed characteristic evidence of great white shark (*Carcharodon carcharias*) bites (silver dollar size teeth marks, tooth fragments, and bite diameters); however, on the basis of histopathology, two of these attacks probably occurred after the animals' deaths. Other animals reported as shark victims had actually gone through normal stages of decomposition and had lost cranial soft tissue and skull parts at about 10–14 days postmortem (specimen identification numbers RLD #52, 77, 117, 119, 148, 171), giving the appearance that the heads were bitten off by sharks. Heads were also removed postmortem by people on occasion.

Preliminary sightings of dead animals often indicated that the animal had been shot. However, in many cases, holes resembling bullet wounds had been produced by birds pecking at carcasses. Birds tended to eat the eyes first, fracturing the thin bone of the skull's frontal lobe, and penetrating the cranial vault. They also pecked holes in the skin, which, during subsequent decomposition and bloating, enlarged. These types of holes in the skin and skull can appear to be large-bore bullet holes. Radiographs revealed shotgun or .22 caliber projectiles in 27 animals, (3 harbor seals and 24 California sea lions). Shooting of marine mammals accounted for 35% (28) of all diagnosed deaths in this study, and varied annually between 6% and 93%.

Twenty-nine percent (23) of the 80 animals for which cause of death was determined had cuts, marks or other indications of having been entangled in set nets. The smooth skin of dolphins and porpoises makes the cause of death by set net entanglement more obvious than in rough hair coated seals and sea lions. Set nets leave characteristic perimortem marks on cetacean skin (RLD #1, 4, 13, 31, 60, 66, 70, 71, 74, 75, 114, 116) and these marks can last for at least nine days postmortem (RLD #7, 59, 63, and 78). The number of filament strands used in set nets and the mesh size can often be deduced by the line cut marks encircling the head or neck of cetaceans. Type of set net material, number of filament strands, and mesh size were identified and recorded from the nets and pieces of nets found attached to some of the animals. In almost every case, these measurements and type of line used corresponded with the type of gill and trammel nets used in fishing for California halibut (*Paralichthys californicus*) (Wild 1987). Seals and sea lions show none of the above characteristic set net marks, probably because of their coarse haircoat. A California sea lion dead 5–6 days (released from the California Marine Mammal Center, CMMC

Table 2
Number of marine mammals dying from various causes, 1982-1987.

	1982	1983	1984	1985	1986	1987	Total
Disease	3	2	8	3	9	1	26
Trauma (non-human related)	—	—	—	1	1	—	2
Shark	—	1	—	—	—	—	1
Shooting	1	1	1	8	3	14	28
Set net (gill and trammel)	7	4	9	2	1	—	23
Undetermined	12	37	37	26	47	9	168
Total	23	45	55	40	61	24	248

#5061) RLD #45, washed ashore on 19 November 1983, entangled in a 200-yard long, 7-inch opening, multistrand green gill net. The net line encircled its neck and left no gross distinguishable marks externally or internally. The only fisherman with a permit to set gill or trammel nets in the Bolinas area said that he had taken ten harbor seals during the 1985 summer halibut fishing season. Two dead harbor seals were recovered in the same vicinity in the summer of 1985; one (RLD #110) was listed as having no lesions recognized, and the other (RLD #111) was autolyzed.

When confronted with a liquid environment, all mammals react with a laryngospasm (involuntary closure of the larynx). It is usually only after death that liquid may leak into the lungs (Spitz and Fisher 1980). Lungs of animals were examined to ascertain presence of seawater. As expected, seawater, (determined by its specific gravity), was nonexistent in freshly dead animals and increased with the amount of time the carcass had spent in the ocean. If sea water enters the lungs while the heart is still active, one would expect increased levels of magnesium in the heart's right chamber owing to high concentration of magnesium in sea water. Magnesium levels were measured in the right and left chambers of five set net victims: 2 harbor porpoise (RLD #4, 31); 1 California sea lion (RLD #17); and 2 harbor seals (RLD #20, 26). Magnesium levels were not elevated in any of the right heart chambers measured (Appendix A); this finding confirms that death from entanglement resulted from suffocation rather than entrance of water into the lungs.

Deaths determined to be from entanglement in set nets averaged 6.7/year in 1982, 1983, and 1984, and 1.5/year in 1985 and 1986. This apparent decrease may be due to a combination of events. First, legislative closure of inshore waters to gill netting may have resulted in fewer harbor porpoises and other marine mammals being caught. Second, animals caught in deeper waters may not be recovered because currents take them away from shore rather than cause them to beach. Third, several fishermen have indicated that, in order to prevent recovery, they section or eviscerate dead marine mammals caught and killed in their nets so that bloating will not occur, allowing the animal to sink and not beach.

Natural causes accounted for 36% (29) of all deaths for which cause could be determined and ranged annually from 27% (3) in 1982 to 71% (10) in 1986, and 7% (1) during the first three months of 1987 (Table 2). California sea lions accounted for 88% (7) of the deaths by natural causes in 1984. Kidney and liver pathology suggested that leptospirosis, which seems to be endemic in the sea lion population, peaked during that year (Vedros et al. 1971; Ettinger 1983; Dierauf et al. 1985). In 1986, 77% (7) of the animals which died because of disease were harbor seals. Six of these seven animals had severe pneumonia.

Three animals, with oil on their body surfaces, were recovered shortly after the sinking of the oil tanker *Puerto Rican* on 3 November 1984. One was a gray whale (RLD #93) found 11 November at Kehoe Beach, which had been dead for a month or more. The second was a harbor porpoise (RLD #94) found at the same location on the same day; it had also been dead several weeks. Both of these animals died before the *Puerto Rican* sank and their bodies probably floated through the oil slick. The third animal, an adult male California sea lion (RLD #95), was found 14 November at Stinson Beach and had been dead approximately 5-6 days. This animal was too autolyzed for accurate determination of cause of death. Petroleum was found externally, but none was seen in the digestive tract or other internal organs.

On 23 occasions more than one carcass was discovered at the same location on the same date. These multiple recovery incidents involved 27% of the animals (68/248) and included single species groups of harbor seals (4 incidents), California sea lions (1) and harbor porpoise (2). The mixed species groups most frequently included harbor seals (11 incidents) followed by California sea lions (8) and harbor porpoises (6). Among these three species, no pattern of association was evident. Three northern elephant seals (*Mirounga angustirostris*) were found on single occasions in association with harbor seals; only four northern elephant seals were reported during the entire study period. No general patterns of recovery with regard to location

Table 3
Harbor seal mortality by month and year, 1982–1987.

	1982	1983	1984	1985	1986	1987	Total
January	—	—	—	—	—	—	—
February	—	—	1	1	1	—	3
March	—	—	—	2	—	1	3
April	—	1	—	—	1	—	2
May	—	1	—	1	2	—	4
June	7	2	1	5	18	—	33
July	1	—	1	—	9	—	11
August	1	5	—	4	—	—	10
September	—	2	—	1	—	—	3
October	—	—	2	—	—	—	2
November	—	—	3	—	—	—	3
December	—	1	—	—	—	—	1
Total	9	15	5	14	31	1	75

Table 4
Harbor seal mortality by age and year, 1982–1987. Definitions of reproductive status as a function of length appear in Bigg (1969).

	1982	1983	1984	1985	1986	1987	Total
Fetus	—	—	—	1	—	—	1
Immature	6	11	2	7	9	1	36
Adult	—	1	1	2	14	—	18
Unknown	3	3	2	4	8	—	20
Total	9	15	5	14	31	1	75

were observed for individual species, except that California sea lions were found more often inside San Francisco Bay than any other species (Fig. 2). It is likely that recoveries are more common on stretches of the coastline that are frequented by humans because animals beached in these areas are more likely to be observed and reported.

Three species were reported more often than any others: harbor seal, California sea lion, and harbor porpoise, which accounted for 30% (75), 38% (94) and 17% (41), respectively, of all animals reported. Because of the small numbers of other species, discussions of variation in size-class, sex, and seasonal and annual composition of recoveries are limited to these three most reported species. A complete list of pathological findings for animals examined in this study appears in Appendix A of this report.

Harbor Seal (*Phoca vitulina*)

Harbor seal recoveries were greatest during the months of June, July, and August when 33, 11, and 10 animals, respectively were recorded during the 5 year study (Table 3). Most of the animals were categorized as adults.

Of the 75 animals reported (Fig. 1), 41% (31) occurred in 1986 (Table 3). Many more mature than immature harbor seals were reported in 1986, in contrasts with other study years when immature seal mortality was higher (Table 4).

Cause of death was determined for 27% (20) of the harbor seals reported. Of these, eight animals (40%) died of pneumonia, and one of the eight also had hepatitis; six of these eight were recovered in 1986. Four animals (20%) had net material encircling their necks suggesting that they were killed in set nets (two in 1982 and two in 1983). Three animals (15%) had been shot (one in 1984 and two in 1985). Single animals were diagnosed as dying from kidney infection, bacterial infection, peritonitis, non-human related trauma and shark predation. As noted earlier, because of the coarse haircoat, pathognomonic signs of entanglement in set nets were not grossly detectable; nor were there pathognomonic indications for drowning. Thus, it is quite possible that deaths due to entanglement in set nets were underestimated for harbor seals.

The large number of harbor seal deaths in June (33) occurred primarily in 1986 when 18 animals were reported. Seventeen of these animals were recovered in 3 groups. Nine animals were discovered at Double Point on 5 June 1986. The heads were gone, the abdomens were open owing to prior examination and collection by Robert Jones of the Museum of Vertebrate Zoology, University of California, Berkeley. The carcasses were too autolyzed at the time of my examination on 8 June 1986 to determine cause of death. One of the two harbor seals found on 8 June 1986 at RCA beach, a beach adjacent to Double Point, died from pneumonia. Of five animals examined 28 June 1986 at Double Point, three died from pneumonia. Some of the lung cultures taken from animals that died of pneumonia revealed the presence of *Staphylococcus aureus* (RLD #152, 153, 154). These bacteria were also isolated by the California State Veterinary Pathology Laboratory in nasal swabs taken for this study from ten of the live harbor seals captured for radio tagging in 1986 at Drake's Estero (Deiter, unpubl.). Bacterial pneumonia was possibly a secondary cause of death, setting in after debilitation by a virus. Severe population declines documented in New England have been attributed to an avian influenza A virus (Geraci et al. 1982). Testing of seventeen animals from the Drake's Estero live harbor seal capture and six animals from the June 1986 Double Point and RCA groups returned negative results for presence of avian influenza A virus. Another viral pneumonia, documented in pinnipeds in the Netherlands, due to a mammalian herpes virus (Osterhaus et al. 1985), was not tested for in this group.

More harbor seals in the Point Reyes area haul out during the spring and summer months, which correspond to the breeding and molt periods (Allen and Huber 1984). This behavior may expose the animals more to both transmittal of disease and harassment by humans. For

Table 5

California sea lion mortality by month and year, 1982–1987.

	1982	1983	1984	1985	1986	1987	Total
January	—	—	—	1	—	2	3
February	—	—	—	4	4	4	12
March	—	—	3	4	1	15	23
April	—	—	1	—	1	—	2
May	—	1	1	2	1	—	5
June	—	1	1	3	1	—	6
July	1	1	1	—	—	—	3
August	—	2	11	—	2	—	15
September	—	4	3	—	—	—	7
October	—	4	1	1	1	—	7
November	—	2	7	—	—	—	9
December	—	—	—	2	—	—	2
Total	1	15	29	17	11	21	94

Table 6

California sea lion mortality by age and year, 1982–1987. Definitions of reproductive status as a function of length appear in Peterson and Bartholomew (1967).

	1982	1983	1984	1985	1986	1987	Total
Immature	1	7	19	3	1	2	33
Mature	—	5	8	11	5	12	41
Unknown	—	3	2	3	5	7	20
Total	1	15	29	17	11	21	94

example, of the two known shooting incidents that involved harbor seals in this study, one occurred in June 1984 and the other involved a pregnant female and her full-term fetus in March 1985.

Although the overall ratio of female to male harbor seals approached unity (28:25, with 22 unknown), the ratio was not consistent among size/maturity classes. Adult females outnumbered adult males by eight to one (17:2), while a 1:1 ratio was approximated for immatures (14 females:20 males). The preponderance of adult females was largely due to the 8 June 1986 examination at Double Point where seven of the eight adult animals were females. This is likely related to the skewed ratio present on the beach at that time due to differences in schedules of molt for males and females (Allen 1986).

Blubber thickness was compared in 33 animals where both age and sex were known. Adults males had a discernible difference in average blubber thickness among these categories:

Adult males:	= 1.6 cm (range 0.7–2.7);	n = 7
Subadult males:	= 2.2 cm (range 0.8–3.2);	n = 9
Adult females:	= 2.2 cm (range 1.0–4.0);	n = 11
Subadult females:	= 2.3 cm (range 0.6–4.0);	n = 6

Sample sizes were too small for comparison of blubber thickness among different cause of death categories. Annual or seasonal variations in blubber thickness were not examined.

California Sea Lion (*Zalophus californianus*)

A total of 94 animals was reported during the study period, 75 of which were recovered for study (Fig. 2). Peak numbers (29) occurred in 1984 (Table 5). Of the animals for which maturity level was assigned, 55% (41) were mature and the remaining 45% (33) were immature. Of animals reported, standard length (and hence maturity) could not be assigned for 21% (20) (Table 6). During the study, approximately equal numbers of mature and immature California sea lions were recovered (41 mature: 33 immature: 1 unknown) despite the virtual absence of immature animals in 1985, 1986, and 1987. Peak numbers for any month occurred during March and were due to a high count of 15 animals in 1987 (Table 5).

Cause of death was determined for 36% (34) of the animals reported. Of these 34, 71% (24) had been shot, 26% (9) died of a variety of diseases/infections and 3% (1) was apparently killed in a set net. All recoveries of animals that had been shot were between December and July. This is in contrast to the overall seasonal variation in mortality. Numbers of animals by season were compared, using only the four years where coverage was complete. More animals were recovered in the fall (38—August to November) than either the winter (19—December to March) or the spring-summer (15—April to July). This trend matches the haul out and in-water occurrence pattern observed on Point Reyes Headlands and SE Farallon Island (Allen and Huber 1984; Huber et al. 1985).

The eleven California sea lion deaths in August 1984 coincides with the peak of the California Marine Mammal Center's admission of California sea lions for that year (J. Roletto, California Marine Mammal Center, Fort Cronkhite, CA 94965, pers. commun., August 1988). Clinical symptoms and histopathology suggest that many of them died from leptospirosis (L. Gage, California Marine Mammal Center, Fort Cronkhite, CA 94965, pers. commun., August 1988).

The seasonal clumping of shooting deaths likely reflects interactions between sea lions and fishermen. Six of the shooting deaths occurred in 1985 and 14 during the first three months of 1987. The majority of animals found in 1987 were on beaches near the entrance to the San Francisco Bay. Twelve of the fourteen had herring (*Clupea harengus*) in their stomachs. The first shooting victim was recovered 27 January 1987 (RLD #169) and the last shooting was estimated to have occurred on 12 March

(RLD #184); herring season closed on 13 March. In 1987, 12 out of 14 animals shot to death were adult males. Thirteen of fourteen sea lions in 1987 were killed by shotgun, and all but two with #6 shot (R. Jones, Museum of Vertebrate Zoology, University of California, Berkeley, CA, pers. commun,, March 1987).

The vast majority of California sea lions which could be sexed were males (94%—68/72) and most of these (41/68) were adults. Of the four females, three were immatures and one was an adult. Sex could not be ascertained for 23% (21/93) of the animals. The strongly skewed sex ratio no doubt is due to the disjunct post breeding ranges of male and female sea lions. Females remain in the southern end of the range, closer to the breeding colonies, while males disperse to the north after the May through July breeding season (Mate 1973, 1975).

Blubber thickness of 18 adult males, 11 subadult males, 1 adult female, and 1 subadult female was measured. The means and ranges of blubber thickness were as follows:

Adult males:	= 2.1 cm (range 0.5-4.0);	n = 18
Subadult males:	= 1.2 cm (range 0.7-2.5);	n = 11
Adult female:	= 2.2 cm; n = 1	
Subadult female:	= 1.3 cm; n = 1	

Sample sizes were too small for comparison of blubber thickness among different cause of death categories. Annual or seasonal variations in blubber thickness were not examined.

Harbor Porpoise (*Phocoena phocoena*)

From 1982 to 1987, 41 harbor porpoises were reported, 32 of which were recovered (Fig. 3). Mortality was strongly seasonal: mortalities for all but two animals reported were in the months of May through September (Table 7). This contrasts with observed seasonal abundance patterns which indicate that harbor porpoises are most abundant in fall, followed by spring, winter and summer. For the animals where cause of death could be determined, 95% (18/19) were due to entanglement in set nets. The other individual apparently died from pneumonia. Cause of death could not be identified for 54% (22/41) of the animals, but 20 out of the 22 animals for which cause of death was undetermined (i.e., 91%) were recovered during the halibut fishing season; an unknown number may have died from entanglement.

Table 7

Harbor porpoise mortality by month and year, 1982–1987.

	1982	1983	1984	1985	1986	1987	Total
January	—	—	—	—	—	—	—
February	—	—	—	—	—	—	—
March	—	—	—	—	—	1	1
April	—	—	—	—	—	—	—
May	2	—	—	—	1	—	3
June	7	—	—	2	1	—	10
July	3	1	2	2	1	—	9
August	—	1	9	—	—	—	10
September	1	2	—	—	4	—	7
October	—	—	—	—	—	—	—
November	—	—	1	—	—	—	1
December	—	—	—	—	—	—	—
Total	13	4	12	4	7	1	41

Between 1972 and 1981, the California Academy of Sciences recovered 45 harbor porpoises for an average of 4.5 animals per year along the coast of the southern tip of Sonoma County, and all of Marin, San Francisco and San Mateo counties. From 1982 to 1985, the California Academy of Sciences recorded approximately 90 harbor porpoises in the same study area, and this study recovered an additional 33 animals between Bodega Bay and Fort Funston, for a yearly average of 31 animals (J. Schonewald, Research Associate, Department of Ornithology and Mammalogy, California Academy of Sciences, San Francisco, CA 94118, pers. commun., November 1985). This change from 4.5 to 31 animals per year coincided with increased effort of the California halibut set net fishery (S. Diamond, California Department of Fish and Game, Long Beach, CA 90813, pers. commun., August 1988).

No apparent skewing of the sex ratio for animals whose sex could be determined (11 females: 17 males) was observed; however, many more mature than immature animals (as defined by standard length measurements) were recovered (23 mature: 8 immature). This is consistent with age ratios observed at sea (Dohl 1984).

Blubber thickness of harbor porpoise averaged as follows:

Adult males:	= 1.7 cm (range 1.3-2.0);	n = 5
Subadult males:	= 1.9 cm (range 1.4-2.3);	n = 3
Adult females:	= 1.6 cm (range 1.3-1.8);	n = 6
Subadult females:	= 2.0 cm; n = 1	

Other Species

Thirteen unidentified seals and two small cetaceans (6% of all animals reported) were reported but not found. The remaining 9% of the dead marine mammals reported in this study include northern elephant seal (*Mirounga angustirostris*); northern fur seal (*Callorhinus ursinus*); northern sea lion (*Eumetopias jubatus*); striped dolphin (*Stenella coeruleoalba*); Pacific white-sided dolphin (*Lagenorhynchus obliquidens*); common dolphin (*Delphinus delphis*); Dall's porpoise (*Phocoenoides dalli*); dense beaked whale (*Mesoplodon densirostris*); Cuvier's beaked whale (*Ziphius cavirostris*); gray whale (*Eschrichtius robustus*); and dwarf sperm whale (*Kogia simus*) (Table 2). Some of the species recovered are somewhat rare in the study area, as shown by the following examples.

An adult female dense beaked whale, pregnant with a female fetus, washed onto China Beach at the entrance to the San Francisco Bay on 17 November 1985. Necropsy indicated cause of death to be pyometra (uterine infection). The only other published record of this species along the North American west coast was a female that washed ashore in San Mateo on 19 November 1978 (Schonewald 1978).

Hubbs et al. (1973) reviewed sightings and specimens of striped dolphin (*Stenella coeruleoalba*) in the Pacific, and indicated that three specimens had been recovered from central-northern California. Three new recoveries occurred during this study, one each in 1983, 1984, and 1986; all were adult animals: one male, one female, and one sex unknown.

Dwarf sperm whale (*Kogia simus*) has been reported once from as far north along the Pacific coast of North America as Vancouver Island, but reports of this species are very rare along western North America (Nagorsen and Stewart 1983). A dwarf sperm whale beached alive at Stinson Beach on 12 January 1987 and died shortly thereafter. The stranding of the immature male in 1987 appeared to be the result of chronic anemia from a massive load of gastrointestinal parasites, *Anisakis* species. The actual death was histopathologically consistent with acute cardiovascular collapse from rolling in the surf. This animal had a row of circular lesions near his eyes and down his body which would suggest an encounter with a squid shortly before his death. His skin also demonstrated disseminated chronic, ulcerative dermatitis with a bacterial and yeast infection. He had three external parasites identified as the copepod *Penella* sp. (Accession #N2657941, Veterinary Reference Laboratory). Other reports of this copepod in *Kogia* could not be found.

Conclusions and Recommendations

The examination of dead beach cast marine mammals during a five-year period provides insights into the causes and seasonality of mortality for fourteen species of marine mammals. Such information helps to understand the life history of these animals and in some cases identifies possible management problems. Because of the duration of the study, natural and human caused changes in mortality patterns have been identified within the study area.

The difficulties involved in accurately assessing cause of death mean that a large number of animals must be examined in order to obtain meaningful results. The large annual variation in cause of death for some species such as the California sea lion also indicates that five years is a minimal baseline period for information. Continuing examination of dead beach cast animals would provide the basis for detecting changes in mortality patterns, determining whether the changes are due to fisheries or other human activities, and assessing the effectiveness of any measures taken to prevent or reduce human related mortality.

Identification and examination of the rarer species provide new distributional records, anatomical data, and other information. This information is important for understanding the diversity of life that is supported in the waters off the coast of central California.

The study area is the coastline of a large metropolitan area with many opportunities for interactions between humans and marine mammals, both on land and at sea. The Gulf of the Farallones supports a large fishing industry as well as many marine mammals. This study indicates that, when the cause of death could be determined, the two major sources of mortality for marine mammals in this area were death due to entrapment in set nets and death by shooting.

Death due to set nets may be abating because of recent legislative action, whereas shooting deaths appear to have increased. These activities affect different species: set nets primarily impact harbor seals and harbor porpoises while California sea lions are more likely to be shot. It is possible that the number of deaths due to set nets is greatly underestimated for some species, such as harbor seals, because the coarse hair coat does not retain net marks and because carcasses may be deliberately sunk.

The harbor porpoise population from Point Sur to Bodega Head is roughly estimated at 1555 animals (Barlow 1988). The California Department of Fish and Game's rough estimate of set net mortality in the Gulf of the Farallones averaged 112–160 harbor porpoises ± 75 annually from 1983 through 1985 (D. Hanan, California Department of Fish and Game, La Jolla, CA 92038, pers. commun., August 1988; S. Diamond, California Department of Fish and Game, Long Beach, CA 90813, pers. commun., August 1988). Because of both the probable vulnerability of harbor porpoise to the set net fishery and the small porpoise population in the Gulf of the Farallones, monitoring of this species should be continued for several more years. Such information would help to determine whether or not this species has truly been protected by gill net legislation or continues to be adversely impacted.

The timing and location of shooting deaths in 1987 suggest herring fishermen could have been responsible. Interviewing herring fishermen during herring fishing seasons might provide information on the nature of the problem and means for preventing, reducing, or mitigating such deaths. Similar interviews have been conducted with fishermen in other areas (Miller et al. 1973). The monitoring program of the central California gill and trammel net operation, conducted by the California Department of Fish and Game, should be broadened to include salvaging and studying animals caught in set nets.

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Appendix Table

List of major findings and pathological lesions of 184 marine mammals (plus a mass mortality of seabirds concurrent with marine mammal beachings) recovered or verified during the study.

ID Identification numbers refer to field numbers. All identification numbers would be prefaced by the letters RLD. Voucher materials have not been accessioned in a common facility, so only the RLD field numbers are given here.

Species (as listed also in Table 2):

1 Harbor seal (*Phoca vitulina*)
2 Northern elephant seal (*Mirounga angustirostris*)
3 Northern fur seal (*Callorhinus ursinus*)
4 California sea lion (*Zalophus californianus*)
5 Northern sea lion (*Eumetopias jubatus*)
6 Unidentified pinniped
7 Striped dolphin (*Stenella coeruleoalba*)
8 Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)
9 Common dolphin (*Delphinus delphis*)
10 Harbor porpoise (*Phoceona phocoena*)
11 Dall's porpoise (*Phocoenoides dalli*)
12 Unidentified odontocete
13 Dense beaked whale (*Mesoplodon densirostris*)
14 Cuvier's beaked whale (*Ziphius cavirostris*)
15 Gray whale (*Eschrichtius robustus*)
16 Dwarf sperm whale (*Kogia simus*)

Cause of death and/or major findings of necropsy

1 Hepatitis
2 Kidney infection
3 Uterine infection
4 Parasitic pneumonia
5 Pneumonia
6 Bacterial infection
7 Hemorrhagic gastroenteritis
8 Gastroenteritis
9 Leptospirosis
10 Stomach ulcers and parasites
11 Peritonitis
12 Trauma, non-human related
13 Shark
14 Emaciated
15 Abdominal cancer
16 Parasitic anemia
17 Pneumonia + hepatitis
18 Shooting
19 Net entanglement
20 Autolyzed
21 No significant lesions recognized
22 Inaccessible

ID	Species	Sex	Exam date	Pathology—noteworthy observations	Probable cause of death
1	10	F	05/07/82	Monofilament circular line cut around head—17 inch; subcutaneous hemorrhaging left side of skull; digested and undigested fish—esophagus and stomach; edematous lungs.	19
2	1	M	06/07/82	Subcutaneous hemorrhaging right side of skull; radiograph-subluxation temporal-mandibular joint; lungs-edematous; digested and undigested shrimp in stomach; microscopically: mild to moderate autolysis with all tissues essentially normal; acute, diffuse moderate congestion of lungs—nonspecific terminal event; 8-inch diagonal green monofilament gill net attached to head.	19
3	1	F	06/09/82	Elliptical corneal ulcerations—both eyes probably from beaching; blood in naso-pharyngeal cavity; lung-acute, diffuse moderate congestion—nonspecific terminal event; all tissues examined microscopically, although mild to moderately autolyzed, were essentially normal; 8-inch diagonal green monofilament gill net attached to neck.	19
4	10	F	06/15/82	Mg levels of right and left ventricles identical: 12,0 mg/dl.	19
5	1	U	06/19/82	Necropsy-like ventral midline incision; abdominal and thoracic contents missing—autolyzed.	20
6	1	M	06/20/82	Autolyzed, cranial soft tissues and lower mandibles gone.	20
7	10	M	06/20/82	Autolyzed, gill net mark around head; lying adjacent to large gill net.	19
8	10	M	06/20/82	Four-inch circular necrotic skin lesion ventral tail stock; autolyzed.	20
9	1	M	06/24/82	Stomach—approximately 1-quart roundworms; lungs congested, edematous; yellow pus engorging bronchial tree and interstitium.	5
10	10	M	07/07/82	Lungs edematous; increased serosanguinous fluid in pleural cavity; lung worms; autolyzed.	20
11	4	M	07/13/82	Subcutaneous hematoma top of head extending down right side of head to upper mandible; stomach engorged with partially digested fish; subcutaneous hematoma—right pectoral fin; radiograph—approximately 72 small lead shot; 11 left side of head, 61 right side of head.	18
12	10	M	07/16/82	Eyed pecked out by birds, many crab marks; digested fish in stomach approximately 1½ pints. Both lungs severely congested with many lung worms throughout parenchyma.	4
13	10	F	07/29/82	Monofilament line marks head and tail flukes; left top of skull crushed; stomach-fresh digested fish and light roundworm infestation.	19

Appendix Table (Continued)

ID	Species	Sex	Exam date	Pathology—noteworthy observations	Probable cause of death
14	1	F	08/06/82	Semi-circular, silver dollar sized, healed teeth mark-about 10"-12" diameter right dorsal cranial pelvic area; culture of large abscess surrounding trachea and esophagus C_3-C_7; pus in all bronchioles of both lungs.	6
15	10	M	09/27/82	14-inch circular line-type cut around head; line cuts on cranial edges of tail; 20-inch diagonal knife cut right side of body; all organs posterior to stomach gone.	19
16	15	U	04/02/83	Baleen collected; autolyzed; no necropsy performed; measurements taken.	20
17	4	M	05/26/83	3 squares green multi-strand gill net attached to neck; no gross lesions seen on neck at attachment of net; white frothy foam in oval cavity; cranial lung lobes edematous, posterior lobes aerated and pink; stomach fluid filled with some squid beaks. Mg levels right and left ventricles: 8.4 and 8.6 mg/dl.	19
18	4	M	06/15/83	Perforating hole in left flipper at metacarpal-phalangeal joint; pus filled; fractures of 3rd, 4th, and 5th metacarpals. Radiograph .22 caliber bullet, retrieved. WBC-44,000, animal seen holding up left flipper on beach for two days.	18
19	1	F	06/15/83	Autolyzed.	20
20	1	F	06/26/83	Partially digested food in stomach; radiographs—fracture of jaw at symphysis and right ramus of mandible; upper and lower molars of side all loose in sockets; lucent monofilament line net around neck—9 inch diagonal; Mg level of right and left ventricles identical: 9.0 mg/dl.	19
21	10	M	07/30/83	Autolyzed.	20
22	1	M	08/10/83	18-inch diameter bite in a silver dollar circular pattern, from pelvis to rib cage removed everything from left abdomen; although moderately autolyzed histopathology shows compatible pre-mortem changes; 1 shark tooth found in subcutaneous tissue of abdominal wall.	13
23	1	M	08/03/83	Autolyzed.	20
24	1	F	08/03/83	White pus in parenchyma of both kidneys; increased amount of pericardial fluid; gastrointestinal tract empty save some roundworms in stomach; yellowish calculi in ureters and urinary bladder; urinary wall thickened.	2
25	5	M	08/03/83	Autolyzed.	20
26	1	M	08/12/83	Blood from nose; chunks of fish in esophagus; heavy hemorrhage lungs; gill net piece attached to neck; Mg levels of right and left ventricles identical: 7.2 mg/dl.	19
27	4	M	08/22/83	Autolyzed.	20
28	14	M	08/25/83	First five thoracic ribs fractured w/o displacement, lungs edematous. 3/8 inch diameter puncture near genital slit extending 4 inches into body; full gastrointestinal tract of digested food; pancreas had multifocal blackened areas.	21
29	1	F	08/25/83	Autolyzed.	20
30	10	M	08/29/83	Chest and abdomen eaten away by birds; autolyzed.	20
31	10	M	09/06/83	Food in caudal GI tract but stomach chambers empty; gouged out area caudal to anus to last vertebrae; subcutaneous hemorrhaging right side of lower jaw; monofilament line marks around head, leading edge of dorsal and tail flukes; Mg levels of left and right ventricles: 10.2, 10.8 mg/dl. Also found within 1 mile of same beach 94 dead murres, 1 harbor porpoise, 2 harbor seals, 2 California sea lions. One of the murres was attached to a piece of gill net; autolyzed.	19
32	10	U	09/06/83	Autolyzed.	20
33	1	F	09/06/83	Autolyzed.	20
34	1	M	09/06/83	Autolyzed.	20
35	4	M	09/06/83	Autolyzed.	20
36	4	M	09/06/83	Autolyzed.	20
37	*Uria aalge*			94 common murres within 1 mile of same beach as RLD 31,32,33,34, 35,36. Most in same state of decay—autolyzed. 1 bird in 8" diagonal green monofilament net piece.	

Appendix Table (Continued)

ID	Species	Sex	Exam date	Pathology—noteworthy observations	Probable cause of death
38	4	M	09/07/83	Autolyzed.	20
39	4	M	09/21/83	Autolyzed.	20
40	4	M	10/08/83	Autolyzed.	20
41	4	M	10/08/83	Autolyzed.	20
42	4	M	10/08/83	Autolyzed.	20
43	4	M	10/12/83	Autolyzed.	20
44	5	F	11/14/83	Small knife-type cut at neck level; head probably decapitated by human; autolyzed.	20
45	4	U	11/19/83	Tag #5061; entangled in an entire multi-strand green gill net with lines and floats; autolyzed, no lesions recognized; net also contained rays, angelfish, sturgeon, hundreds of fish and birds.	20
46	3	F	11/20/83	Tags SMI 2956,2957; bilateral severe opaque cataracts; no food in gastrointestinal system; extremely emaciated animal.	14
47	1	M	11/23/83	Autolyzed.	20
48	2	M	11/24/83	Autolyzed.	20
49	1	M	11/24/83	Autolyzed.	20
50	7	F	12/04/83	Autolyzed.	20
51	1	U	12/28/83	Autolyzed.	20
52	4	M	03/08/84	Reported as shark attack; soft tissues gone from skull, lower jaws disarticulated; on beach 7 days; autolyzed.	20
53	8	F	03/15/84	Right lung field necrotic and pus filled; mediastinal lymph node enlarged and impinging on trachea.	5
54	4	M	03/20/84	Autolyzed.	20
55	4	M	03/31/84	Autolyzed.	20
56	4	M	05/29/84	Slice marks on ventral neck and chest probably post-mortem propeller marks.	20
57	1	M	06/06/84	Macerated right eye; blood from both nostrils; small sized shotgun pellets right side of head entering and penetrating skull.	18
58	4	M	03/31/84	Floating in yacht harbor along rip-rap wall.	22
59	10	M	07/07/84	Circular line cut marks around head; line type marks tail flukes. Watched this animal decomposed; line marks visible for nine days.	19
60	10	F	07/26/84	Milk in mammary glands; line-type marks head and tail flukes.	19
61	4	M	08/02/84	Smooth knife-type cut through neck; head probably cut off by a person; autolyzed.	20
62	11	F	07/31/84	Autolyzed.	20
*63	10	M	08/05/84	Circumferential line type cut circling head and neck; cranial edges of dorsal fin and tail flukes decomposed; digested food in stomach.	19
64	4	M	08/05/84	Small areas of emphysema both lung fields; left eye pecked at and hemorrhaged. Stomach empty save for a few roundworms; small intestine generalized, moderate to severe chronic enteritis with ecchymotic hemorrhages.	7
65	4	F	08/08/84	Approximately one quart of stomach parasites; multiple verminous granulomas in fundic wall, 3 ulcers ranging 1/2 to 1 inch diameter ulcers in fundus, 1 perforating through wall and leaking into abdomen; fibrinous adhesions to omental membranes, 120 cc serosanguinous fluid in abdomen.	10
66	10	M	08/08/84	2-inch hole left commissure of mouth; many crab and bird marks entire body; 3-inch diameter granuloma left lung plus multiple pinpoint lung worm granulomas; 1-inch diameter granuloma of gastric worms. Increased amount of pericardial fluid. Circular line cut around head.	19
67	7	U	08/12/84	Mummified.	20
68	4	M	08/12/84	2-inch hole in abdominal wall left of genital opening with approximately two feet of small intestines eviscerating—probably postmortem; no significant lesions recognized.	21

Appendix Table (Continued)

ID	Species	Sex	Exam date	Pathology—noteworthy observations	Probable cause of death
69	4	M	08/12/84	Emaciated; spleen and liver enlarged and congested; liver mottling at portal triads.	1
70	10	F	08/14/84	Partially digested fish in stomach; circular line-type cut around head; line marks cranial edges dorsal fin and tail flukes.	19
71	10	F	08/20/84	Partially digested fish in stomach; circular line-type cut around head. Line marks cranial edges, dorsal fin and tail flukes; found within 60 yards of 2 dead young California sea lions and 14 dead murres.	19
72	4	M	08/20/84	No significant lesions recognized; eyes pecked out.	21
73	4	M	08/20/84	Autolyzed.	20
74	10	F	08/20/84	Digested fish in stomach with some roundworms; circular line-type cut around head; line marks cranial edges of tail flukes.	19
75	10	M	08/20/84	Circular line-type cut around head; line marks cranial edges of tail flukes.	19
76	4	M	08/22/84	Granulomatous areas involving liver capsule, subcapsular space, and parenchyma.	1
77	4	F	08/24/84	Cranial soft tissues partially missing from head.	20
78	10	F	08/25/84	Enlarged uterus; milk in mammary glands; circular line-type cut around head.	19
79	4	F	08/27/84	No significant lesions recognized.	21
80	4	M	08/29/84	Gastrointestinal hemorrhaging and necrosis; large intestinal wall normal but filled with blood.	8
81	4	M	09/08/84	Autolyzed.	20
82	4	M	09/22/84	Autolyzed.	20
83	4	M	09/23/84	No significant lesions recognized.	21
84	1	F	10/17/84	Autolyzed.	20
85	4	M	10/26/84	Small intestine and stomach necrotic with ecchymotic hemorrhages.	7
86	1	F	10/31/84	Autolyzed.	20
87	4	M	11/04/84	Autolyzed.	20
88	4	M	11/04/84	Autolyzed.	20
89	4	M	11/05/84	Autolyzed.	20
90	4	M	11/07/84	Autolyzed.	20
91	4	M	11/08/84	Autolyzed.	20
92	4	M	11/08/84	Infarcted, hemorrhagic, and mottled kidney, liver and small intestine. Positive silver stain for *Leptospira* sp.	9
93	15	U	11/11/84	Autolyzed.	20
94	10	F	11/11/84	Autolyzed, head missing.	20
95	4	M	11/14/84	Autolyzed.	20
96	4	M	02/16/85	Stomach full of digested fish; pus in mesenteric lymph node; parasitic ulcer in fundus of stomach, petechial hemorrhages in fundus; no significant lesions recognized.	21
97	4	M	02/18/85	Blood from nose, mouth, and left ear; stomach engorged with partially digested and undigested herring; left lung collapsed.	18
98	4	U	02/18/85	In surf at north tower of Golden Gate Bridge; long, longitudinal cuts (14 inches) along back and left flank.	22
99	4	M	03/02/85	Stomach engorged with undigested herring; 2 small holes penetrating from left throat through left thoracic cavity into left abdominal cavity; deformed lead slug found in abdominal cavity.	18
100	1	F	03/03/85	Large healing wound (3 inches × 9 inches) right thorax; reddish color phase anterior half of body; pregnant, near-term; deformed lead slug in left cranium.	18
101	1	M	03/03/85	Female fetus of animal #100. Fetus died when mother died.	18

Appendix Table (Continued)

ID	Species	Sex	Exam date	Pathology—noteworthy observations	Probable cause of death
102	4	M	03/06/85	Large caliber lead slug penetrating upper right mandible down into neck, fracturing mandible and larynx, and severing left carotid artery; massive hemorrhaging in neck.	18
103	4	M	03/07/85	Large caliber slug entering cranium through frontal sinus.	18
104	4	M	03/13/85	Found tied to Pier 41 at San Francisco.	22
105	1	M	05/18/85	Eyes and genital opening pecked by birds; no significant lesions recognized.	21
106	4	M	05/27/85	Autolyzed.	20
107	4	M	05/29/85	Autolyzed.	20
108	4	M	06/01/85	A .22 caliber slug penetrating left lateral abdominal wall, spleen, small intestine, and lodging in liver.	18
109	5	M	06/01/85	Autolyzed.	20
110	1	M	06/02/85	Blood from both nostrils down into trachea; stomach filled with partially digested fish.	21
111	1	M	06/07/85	Autolyzed.	20
112	1	F	06/13/85	Massive subcutaneous hematoma from right pectoral flipper to umbilicus extending from sternum to dorsal midline; 7-inch tract from right pleural cavity leading into subcutaneous fat directed cranially; whole body radiographs normal.	12
113	4	F	06/25/85	Autolyzed.	20
114	10	F	06/25/85	Line-type marks on head, neck and dorsal fin.	19
115	4	U	06/25/85	Autolyzed.	20
116	10	M	07/07/85	Carcass cut in half at level of caudal ribs. Caudal section missing; circular line-type cut around head.	19
117	10	M	07/15/85	Chest and abdominal contents eaten by birds; cranial soft tissues of skull sloughed.	20
118	1	M	08/05/85	Skin of head sloughed; eyes gone; maxillary bones fractured.	20
119	1	M	08/17/85	Autolyzed; soft tissues of skull sloughed.	20
120	1	M	08/21/85	Autolyzed.	20
121	1	F	09/10/85	A 4-inch emphysematous bulla in left lung lobe; parenchyma surrounding bulla heavy, wet and inspissated; emphysematous area on greater curvature of omentum; 1/5 or 20% of each kidney fibrosed.	5
122	13	F	11/18/85	Left chest wall had 5 fractured ribs without displacement; about 5 gallons serosanguinous fluid in uterus with whitish floating plaques that stained gram negative rod bacteria; negative bacterial growth aerobically and anaerobically; well-developed female fetus.	3
123	4	M	12/01/85	Shotgun pellets penetrating left dorsal chest wall and left lung lobe.	18
124	4	M	12/08/85	Abscess (4 cm diameter) serosal surface of lesser curvature of stomach; multilobulated abscess (4 inches × 8 inches) with caseous yellow-green interior attached to omentum; egg sized nodules throughout mesentery were abscessed lymphatic tissue; linear scar tissue tracts in spleen and liver; approximately 2 gallons serosanguinous fluid in abdominal cavity.	11
125	4	M	02/20/86	Small sized shotgun pellets entering calvarium and penetrating first two cervical vertebrae; 3-inch diameter stone in stomach along with digested fish.	18
126	9	M	02/21/86	Partially digested fish in stomach; no significant lesions recognized.	21
127	4	M	02/21/86	Night exam; no significant lesions recognized.	21
128	1	M	02/26/86	Right lung lobe consolidation; many hard, firm 3-mm nodules throughout liver.	17
129	4	M	03/02/86	Skull disarticulated; autolyzed.	20
130	7	M	03/23/86	Bilateral mandibular fractures; autolyzed.	20
131	4	M	04/05/86	Lack of blubber layer and any physiological fat; large fibrous-looking mass in caudal abdomen, posterior to left kidney, measured 9 inches × 6 inches × 4 inches, with a necrotic core; increased vascularity to mass attached to mesentery; numerous similar nodules throughout abdomen up to 1 inch diameter; 1-inch nodules in liver; half inch nodules in diaphragm.	15

Appendix Table (Continued)

ID	Species	Sex	Exam date	Pathology—noteworthy observations	Probable cause of death
132	1	F	04/09/86	All teeth worn down to near gingival margins; autolyzed.	20
133	10	M	05/08/86	Animal partially burned in campfire.	20
134	4	M	05/10/86	Small sized (#6) shotgun pellets entering left side of head and neck, penetrating skull and vertebrae.	18
35	1	M	05/25/86	No significant lesions recognized.	21
136	1	M	05/27/86	No significant lesions recognized.	21
137	1	F	06/08/86	Autolyzed.	20
138	1	F	06/08/86	Autolyzed.	20
139	1	U	06/08/86	Autolyzed.	20
140	1	F	06/08/86	Autolyzed.	20
141	1	M	06/08/86	Autolyzed.	20
142	1	F	06/08/86	Autolyzed.	20
143	1	F	06/08/86	Autolyzed.	20
144	1	F	06/08/86	Autolyzed.	20
145	1	F	06/08/86	Autolyzed.	20
146	1	F	06/08/86	Shrimp in stomach; normal x-ray exam of skull, chest, and abdomen.	21
147	1	F	06/08/86	About 1/3 of left lung lobe consolidated with a circumscribed line on the serosal surface delineating normal and abnormal parenchyma.	5
148	4	M	06/11/86	Cranial soft tissues sloughed; maxilla fractured off; mandibles gone; cranium disarticulated.	20
149	1	M	06/20/86	Autolyzed.	20
150	2	M	06/28/86	Both lung lobes consolidated; normal skull radiographs.	5
151	1	F	06/28/86	Normal skull radiographs; autolyzed.	20
152	1	M	06/28/86	Interlobular emphysema with consolidation of both lung lobes; pure culture of *Staphylococcus aureus* grown from lung cultures; normal skull radiographs.	5
153	1	F	06/28/86	Interlobular emphysema with consolidation of left lung lobe; pure culture of *Staphylococcus aureus* grown from lung cultures; normal skull radiographs.	5
154	1	F	06/28/86	Interlobular emphysema with consolidation of both lung lobes; pure culture of *Staphylococcus aureus* grown from lung cultures; normal skull radiographs.	5
155	1	U	06/28/86	Normal skull radiographs; autolyzed.	20
156	10	U	07/02/86	Autolyzed.	20
157	1	M	07/09/86	Interlobular emphysema and consolidation of both lung lobes; small granulomatous areas in parenchyma of liver, kidney, pancreas, and spleen.	5
158	2	M	07/09/86	Autolyzed.	20
159	1	F	07/09/86	Autolyzed.	20
160	1	F	07/09/86	Autolyzed.	20
161	1	M	07/18/86	Localized granulomas of serosal surface of intestines and greater omentum; cultures of these grew *E. coli*, *Pseudomonas* sp., and *Corynebacterium pyogenes*.	11
162	5	M	07/19/86	Shark bites on left flipper—approximately 12-14 inches diameter; left metacarpalarea pus-filled, with high caliber lead slug; tan plaques on serosa and parenchyma of liver.	11
163	10	F	09/15/86	Circumferential line cut around head at eye level; stomach filled with partially digested fish.	19
164	10	M	09/15/86	Lower jaw disarticulated; no significant lesions recognized.	21
165	10	M	09/15/86	Autolyzed.	20
166	10	F	09/15/86	Autolyzed; 17 dead adult cormorants found on same beach as animals numbered RLD 163-166.	20

Appendix Table (Continued)

ID	Species	Sex	Exam date	Pathology—noteworthy observations	Probable cause of death
167	11	F	11/06/86	Blunt trauma to left side of snout and skull with hemorrhages; radiographs revealed a severely comminuted fracture through left mandible, with dislocation; many copepods in stomach, and a heavy load (1 liter) of nematodes (*Anasakis* sp.)	12
168	16	M	01/12/87	Acute congestion of all tissues consistent with acute cardiovascular collapse, probably from rolling alive in the surf; circular erosive lesions in a curved linear patterns, probably from a squid; focal, chronic, ulcerative dermatitis with bacterial and yeast infection; hemorrhage, gastrointestinal contents; stomach contained squid beaks, otoliths, and a significant load of nematodes (*Anasakis* sp.); packed cell volume less than 5%; two external parasites located near left flipper identified as parasitic copepod, *Penella* sp.	16
169	4	M	01/27/87	Close range, barely expanded #6 shotgun blast penetrating right dorsal chest wall, exiting left ventral abdominal wall.	18
170	4	M	02/05/87	Stomach filled with 43 undigested herring weighing 38 pounds; #6 shotgun pellets throughout head, neck, and chest.	18
171	4	M	02/21/87	#6 shotgun pellets in head and neck penetrating right thoracic cavity into abdomen.	18
172	4	M	02/27/87	Close range #6 shotgun blast, 2.5-inch diameter entry wound in left chest, perforating lung, diaphragm, liver, and intestines; partially digested herring in stomach.	18
173	4	M	03/01/87	#6 shotgun pellets penetrating left shoulder, shattering scapula and 6th cervical vertebra; 14 pounds undigested herring in stomach.	18
174	4	M	03/02/87	Large caliber bullet entering skull.	18
175	4	M	03/06/87	#6 shotgun pellets in skull and cervical vertebrae; large hematoma top of skull.	18
176	4	M	03/06/87	#6 shotgun pellets entering right side of neck and fracturing 3rd cervical vertebra; partially digested herring filling stomach.	18
177	4	M	03/10/87	A 2-inch diameter hole left side of neck, with #4 buckshot fracturing cervical vertebrae and severing spinal cord; partially digested herring filling stomach.	18
178	4	M	03/11/87	Left chest—holes from #6 shotgun pellets penetrating and macerating left lung with pellets lodged in spine.	18
179	1	M	03/13/87	Decapitated by sharp instrument; parasitic granuloma with 2-inch diameter in wall of fundus.	21
180	4	M	03/14/87	Shotgun plastic shot holder and #6 shot penetrating left shoulder and fracturing scapula; digested fish in stomach.	18
181	4	M	03/15/87	Wound penetrating dorsal right neck, exiting ventral right neck; left 7th rib fractured and #6 shotgun pellets in left lung.	18
182	4	M	03/17/87	Wedged between rocks in heavy surf area.	22
183	4	M	03/20/87	#6 shotgun pellets entering left chest wall, fracturing 2nd rib, macerating left and right lung lobes, exiting between 6th and 7th right ribs; partially digested herring filling stomach.	18
184	4	M	03/20/87	#6 shotgun pellets entering right side of head into skull; partially digested herring filling stomach.	18
185	10	M	03/30/87	Head missing, only bones left of rest of body; some soft tissues of tail stock remaining.	20

A Resident Belukha Whale (*Delphinapterus leucas*) in Long Island Sound

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ABSTRACT

Participants in marine mammal stranding networks are often involved in research besides simple recovery and necropsy of beached animals. This report documents the occurrence and activities of a solitary belukha (*Delphinapterus leucas*) that inhabited Long Island Sound from February 1985 until its death in May 1986. The whale's movements are reconstructed from 48 sighting events reported to Mystic Marinelife Aquarium (Mystic, CT). Most sightings are documented from the Connecticut shoreline vicinities of Connecticut River/Saybrook (31.3%); Guilford (22.9%); Patchogue River/Westbrook (16.7%); and New Haven (12.5%); additional sightings are documented from the north shore of Long Island. The whale often approached swimmers and was attracted to slow moving boats and moored buoys. Necropsy results demonstrated extensive skin lesions of probable viral origin and evidence of human related trauma in the form of multiple gunshot wounds in the thorax, a fishing hook embedded in the right commissure of the mouth, and a fishing sinker lodged in the left nasal cavity. The results of tissue examination indicate possible nutritional deficiencies. The behavior of this whale is discussed with reference to other "friendly" cetaceans, and the susceptibility of such animals to vandalism, poaching, and other human activities is reinforced.

Introduction

The belukha or white whale (*Delphinapterus leucas*) is a circumpolar species found in arctic and subarctic waters. Except for an isolated population of approximately 500 animals in the St. Lawrence estuary, most of the estimated 26,500 belukhas in North America are seasonally distributed in coastal waters of Hudson's Bay, Lancaster Sound and vicinity, and the Beaufort Sea (Sergeant and Brodie 1975). Belukhas seldom venture from cold arctic and estuarine subarctic habitats, as evidenced by the paucity of North Atlantic sightings or strandings from the Canadian Maritime Provinces southward (Sergeant and Brodie 1969; Reeves and Katona 1980). The purposes of this report are to 1) document the occurrence and activities of a solitary belukha that strayed into the western reaches

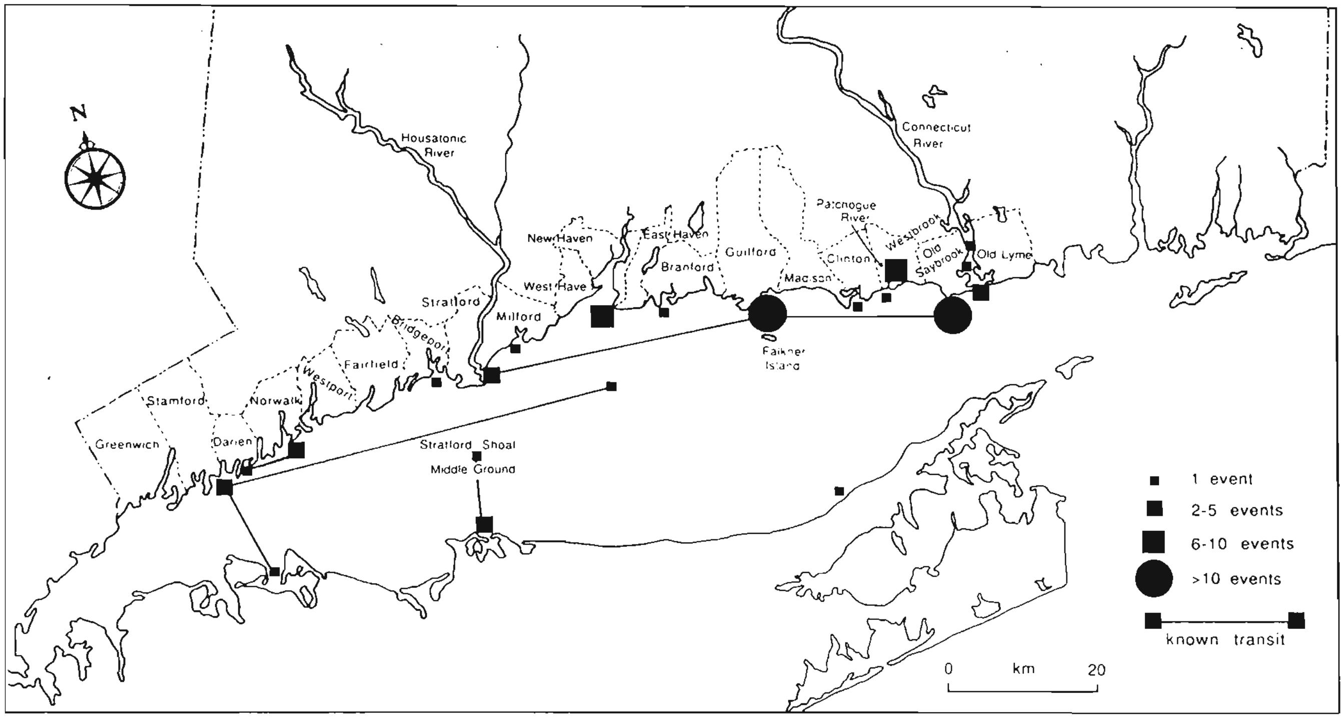

Figure 1
Distribution of belukha sighting events reported to Mystic Marinelife Aquarium.

of Long Island Sound, where the animal resided from February 1985 until its death in May 1986; 2) describe necropsy results that verified trauma of human origin; and 3) demonstrate that "friendly" cetaceans may become easy targets for vandals and poachers.

Materials and Methods

Sighting data were compiled at Mystic Marinelife Aquarium (Mystic, CT) as informal reports by shoreline residents, commercial fishermen, workboat operators, and recreational boaters. Observers were asked to provide date, location, and the behavior and description of the animal. Distinctive dorsal lesions on the whale facilitated positive identification. Many observers also provided written and photographic accounts of their encounters. Numerous attempts by Aquarium personnel to see the animal were unsuccessful. A gross necropsy was performed at Mystic Marinelife Aquarium following the animal's death. Procedures paralleled those outlined by Hare and Mead (1987) and standard measurement methods followed Norris (1961). The head was left intact, then frozen and forwarded to another laboratory (Naval Oceans Systems Center, San Diego, CA) for detailed examination. Excised samples of skin lesions were preserved in 10% buffered formalin and submitted to two pathology laboratories (Pfizer, Inc., Groton, CT; and ZooPath, Sterling, VA) for microscopic examination. To estimate age of the animal, one tooth was sectioned and prepared for densitometric examination of growth layer groups by microradiograph (Goren et al. 1987).

Case History

The movements and activities of the whale were reconstructed from 48 detailed sighting events, many reported independently by several observers. Aquarium personnel first learned of a belukha whale in Long Island Sound in April 1985. A marina owner in New Haven, CT, reported that a few shoreline residents and workboat operators had seen a whale since February. The number of sightings subsequently increased with the onset of recreational boating in May. During the following 12 months, the majority of reports were from the Connecticut shoreline vicinities of Connecticut River/Saybrook (31.3%), Guilford (22.9%), Patchogue River/Westbrook (16.7%), and New Haven (12.5%), as shown in Figure 1. Residents of Long Island's north shore, particularly the Port Jefferson area, also contacted the Aquarium with reports of the whale. Sightings reported to the Okeanos Ocean Research Foundation (Hampton Bays, NY) indicated that a belukha had visited the vicinities of Orient Point and Southold, LI, as well (S. Sadove, Okeanos Ocean Research Foundation, Hampton Bays, NY, pers. commun., 1985). Interestingly, one observer who could identify the whale reported seeing five or six other belukhas near New Haven several times

Table 1
Reported transits of the solitary belukha in Long Island Sound.

Date	Transit	Distance (km)	Comments
24 July 85	Near Faulkner Island (Guilford, CT) to off Old Saybrook, CT	25.9	Light gray color noted.
09 Aug. 85	Near Stratford Shoal Middle Ground to Port Jefferson Harbor, LI	10.0	"Bullseye" scar noted on left side; vessel motoring at ∾12.1 km/h (6.5 kt); "petted" by people aboard.
15 Aug. 85	Off Stamford, CT to off New Haven, CT	51.9	Vessel motoring at ∾10.4 km/h (5.6 kt); light gray color noted.
04 Sept. 85	Near Faulkner Island to Housatonic River, Stratford, CT	35.2	Following pleasure boat.
05 Sept. 85	Off Darien, CT to off Norwalk, CT	9.3	Following oyster boat.
08 Sept. 85	Five Mile River, Rowayton, CT to Huntington Bay, LI	14.8	Following pleasure boat.

during late May and early June 1985. These whales were unapproachable, however, and were not reported from any other localities.

On two occasions the whale was seen in widely separated locations on the same day. On 2 September 1985 the Aquarium received a morning sighting from Port Jefferson, NY, and an afternoon sighting from Clinton, CT (approximately 55.6 km away); on 12 May 1986 the whale was seen both in the Connecticut River and off New Haven (approximately 48.2 km apart). Although this might initially suggest that more than one whale was present, the animal was known to make transits of similar distances while following pleasure boats, the longest well-documented transit being 51.9 km (Table 1). Moreover, commercial fishermen said that the whale routinely followed their boats across the Sound, possibly eating benthic organisms disturbed by fishing gear. Based on these accounts it appeared that the whale was not suffering from impaired mobility. During the 51.9-km transit the whale maintained a 10.4-km/h (5.6 kt) swimming speed for 5 hours, frequently shifting from one side of the vessel to the other. During shorter transits the whale reportedly swam at speeds exceeding 12.1 km/h (6.5 kt).

One consistent feature of the sighting reports was the whale's attraction for navigation buoys and other floating objects. Observers usually found the whale near a buoy, particularly off Lighthouse Point, New Haven, and Cornfield Point, Old Saybrook. The whale frequently rubbed on the bottoms of slow moving boats and on 3 May 1986 spent nearly 1.5 hours pushing around a small inflatable boat with two children aboard.

In addition to this attraction for inanimate objects, the whale solicited contact with people during many sightings. It allowed swimmers and boaters to rub its head and back and it often spit mouthfuls of water in their direction. Once it was even reported that the whale had retrieved blocks of wood. Because of its "friendliness" the belukha became well known to shoreline residents who referred to it as "BW," the acronym for belukha whale. The last time the animal was reported alive was on 12 May 1986 when it was sighted off Lighthouse Point, New Haven.

On 13 May 1986, Coast Guard Group Long Island Sound (New Haven) contacted Aquarium personnel at approximately 1000 h. During routine patrol one of their boat crews sighted what was described as a dead whale or dolphin floating ventral side up in Long Island Sound at 41°10′N latitude and 72°5′W longitude (approximately three miles south of New Haven harbor). The animal was later towed to shore where it was identified as a belukha and retrieved for necropsy.

The whale arrived at the Aquarium at 1800 h where an external examination was performed. It was a female measuring 313 cm total length and 240 cm maximum girth. Weight was 422.7 kg. The skin was light gray in color and had extensive postmortem lesions on the ventral side caused by seabird predation. In addition, large, round ulcerations were present on the ventral thorax (∾20 cm diameter), right lateral thorax (∾6 cm diameter and ∾11 cm diameter), left lateral thorax (∾25 cm diameter), left ventral peduncle (∾7 cm diameter), dorsal ridge (∾8 cm diameter), and dorsal peduncle (∾7 cm diameter). Surrounding several of the ulcerated areas were patches of verrucous, papilliform tissue (Fig. 2). In addition to these pathological abnormalities, there were two small lacerations (∾4 cm and ∾2 cm long) in the integument on the left anterior dorsal region, a flounder hook imbedded in the right commissure of the mouth, and evidence of previous injury to the left commissure in the form of extensive scar tissue. Finally, there were four 0.5-cm diameter, draining punctures in the area dorsal to the left axilla (Fig. 2). Following external gross examination the carcass was covered with ice.

A complete necropsy the next morning revealed extensive autolysis of the internal organs. Of significance, however, was the finding that the punctures were caused

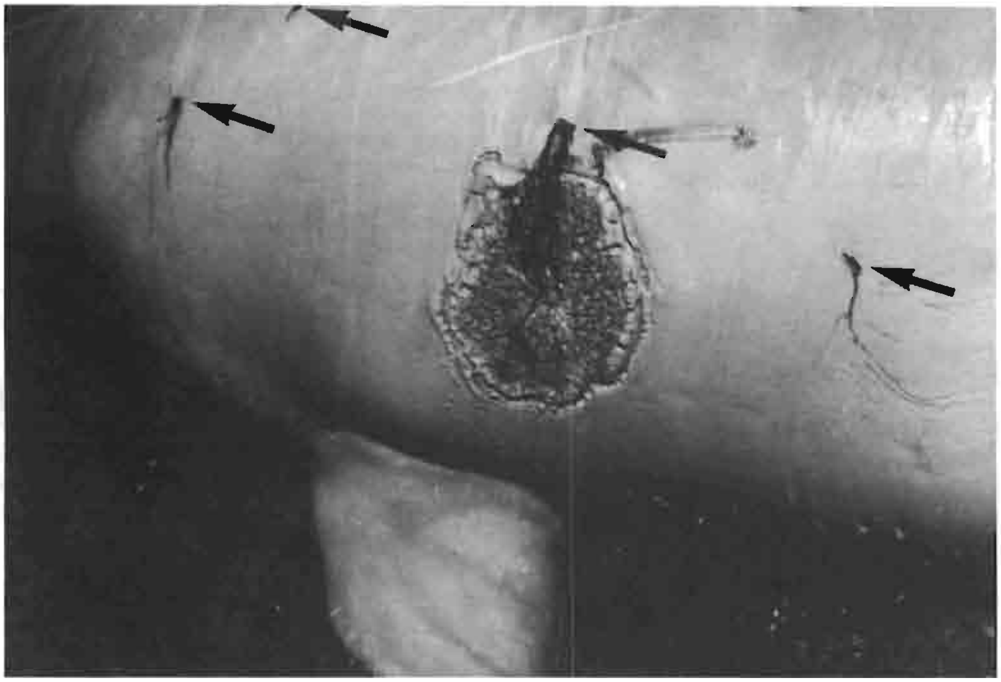

Figure 2
Left lateral view of belukha showing one large skin lesion and four bullet wounds (arrows).

by gunshots. The track of one puncture led to a bullet fragment embedded dorsal to the transverse process of vertebra T6. Another puncture led to a 1-cm opening of the thoracic cavity in the area of vertebrae T8-T9. Careful searching yielded an intact .22 caliber projectile free-floating in the left thorax. Projectiles that might have been associated with the other two punctures were not located.

Transverse sectioning of the head revealed further evidence of human related trauma; a 1.4-cm diameter fishing sinker was found lodged in the left nasal cavity (Fig. 3). Whether the animal accidently aspirated the object, or somehow it was purposely introduced, was unclear; however, it had been reported earlier that the whale was trailing fishing lines at times. The right nasal cavity was unobstructed.

Another notable feature was that the right cerebral hemisphere was shrunken. Most belukhas examined to date have had either slightly larger right hemispheres or both hemispheres have been equal in size (S.H. Ridgway, Naval Ocean Systems Center, San Diego, CA, pers. commun., 1986).

Results of the histological examination of excised skin lesions showed proliferation of surface epithelium into papilliferous projections with well-differentiated squamous epithelium. The condition was compatible with a warty growth that is associated with papovavirus (R.J. Montali, ZooPath, Sterling, VA, pers. commun., 1986), although a lack of appropriate frozen tissue prevented verification of the condition.

Of additional interest was the histological finding that the deep adipose layer of skin tissue showed degeneration of clusters of fat cells and yellowish droplets of what appeared to be ceroid deposits. These deposits were of the type seen in vitamin E deficient states in other species, suggesting the possibility of a nutritional abnormality or deficiency (Robbins 1983). Moreover, during preparation of the tooth it was discovered that the dentine and enamel were hypomineralized, further evidence of a nutritional inadequacy or disorder (Robbins 1983).

No unexpected microorganisms were recovered from either the blowhole, vagina, or anus. No growth occurred in internal organ cultures.

The size of the whale suggested its age to be 5 to 7 years, based on growth data published by Brodie (1971) for belukha populations in Cumberland Sound, Baffin Island. Cumberland Sound belukhas are similar in size to those in the St. Lawrence estuary (Sergeant and Brodie 1969). Subsequent microdensitometric examination of the sectioned tooth revealed 11 growth layer groups (Fig. 4), indicating an age of 5.5 to 6 years based on two growth layer groups per annum (Goren et al. 1987; Brodie 1971).

Discussion

The occurrence of belukhas in waters south and west of Nova Scotia is rare. Extensive aerial and shipboard surveys conducted by the Cetacean and Turtle Assessment Program between October 1978 and January 1982 yielded only one belukha among 5304 identifiable cetacean sightings in this area (Kenney and Winn 1986). Reeves and Katona (1980) compiled a list of extralimital records of belukhas

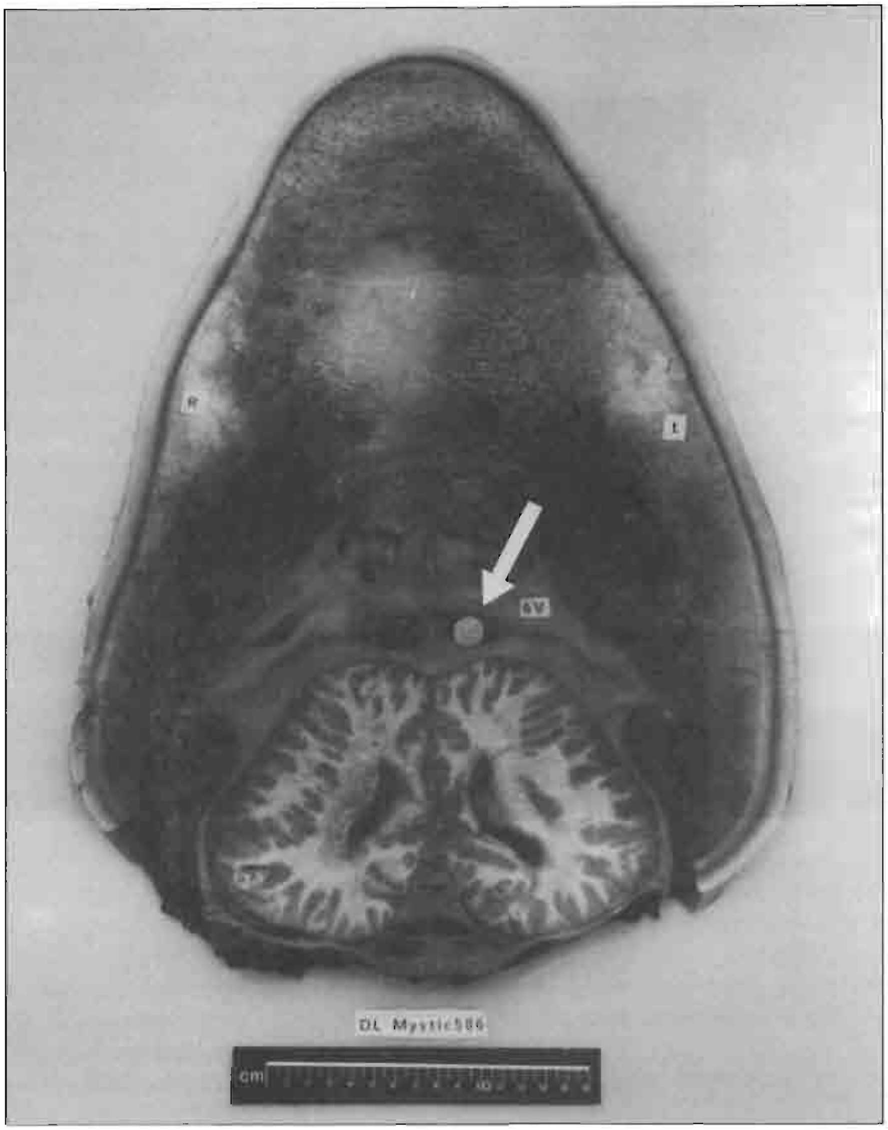

Figure 3
Ventral view of transverse section of belukha's head showing location of fishing sinker lodged in left nasal cavity (arrow). Figure courtesy of S.H. Ridgway.

in continental shelf waters of New England and the Canadian Maritimes. They found 31 published and unpublished accounts dating from 1675, including a description of a juvenile belukha in waters off western Long Island and New Jersey during 1978 (Ulmer 1979). A belukha sighted in Great South Bay, LI, the following year was also thought to be this individual. We know of eight additional sighting events confirmed in the northeast (Table 2). Considering the belukha's affinity for coastal waters it seems likely that most occurrences in the well-populated northeastern United States and Canada would be reported.

The region of origin for belukhas that stray into New England waters is unknown, but probably belukhas sighted from the Canadian Maritimes southward are from the St. Lawrence estuary population (Mercer 1973). Although deep water can effectively inhibit belukha dispersal, individuals in the St. Lawrence population are morphologically similar to those in Cumberland Sound; this finding suggests that some whales may follow the Labrador Current southward along the coast and into the Gulf (Sergeant and Brodie 1975). It is possible that southern strays could swim a similar route and continue around Cape Breton Island and Nova Scotia.

Reeves and Katona (1980) discussed in detail several factors, including temperature, predator avoidance, feeding strategy, and food abundance, that might affect belukha movements and account for their sporadic occurrence off New England and the Canadian Maritimes. They speculated that belukhas may be natural wanderers—as demonstrated in part by the numerous records of solitary belukhas following major rivers hundreds of kilometers inland from the sea—whose distribution is limited mostly by competition with other cetacean species, and possibly even man, for food. Because the belukha we examined appeared well

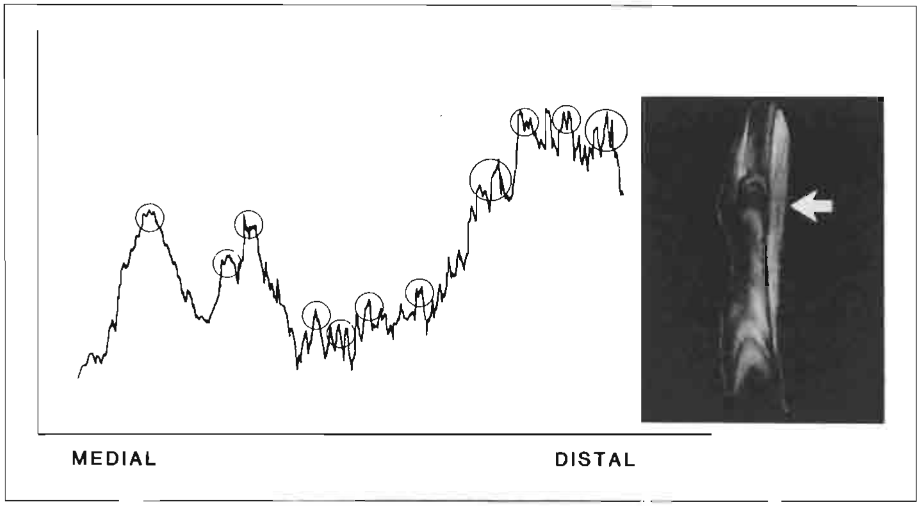

Figure 4
Densitometric trace of belukha tooth across longitudinal section with peaks of growth layer groups circled.

Table 2
Extralimital records of belukhas in northeastern United States waters supplemental to Reeves and Katona (1980).

Date	No. animals	Location and Comments	Source
29 May 72 30 May 72	1	Off Milford, CT; Bartlett's Reef, Waterford, CT; sighting.	The Hartford Courant 31 May 72, 01 June 72
12 Apr. 80	1	Reynolds Channel, Hempsted, LI, NY; sighting.	Smithsonian
22 June 80	1	SW of Moriches Inlet, LI, NY; sighting; possibly same animal as 12 Apr. 80.	Smithsonian
20 May 81	1	Gilgo Beach (Suffolk County), LI, NY; stranding; whale appeared to be wounded.	Smithsonian
18 Aug. 81	1	Fire Island Inlet, LI, NY; stranding; observed in same area over prior 4-week period.	Smithsonian
07 June 83	1	Gay Head, MA, near Philban's Beach; stranding.	Smithsonian
20 July 85	1	Off Marblehead, MA, near Devereux Beach; sighting.	Smithsonian
01 Apr. 87	1	Lubec, ME; stranding.	S. Katona[a]

[a]S. Katona, College of the Atlantic, Bar Harbor, ME, pers. commun., 1987.

fed yet nutritionally deficient, it is interesting to question whether qualitative features of regional food resources might also be a limiting factor. This would be significant, in that the diet of belukhas is normally varied (Vladykov 1946).

Several reports have been published where solitary, habituated cetaceans have demonstrated behavior similar to that of the animal documented here. Reeves and Katona (1980) wrote that the whale in Great South Bay, LI, reportedly "approached vessels and rubbed against working nets," and fed on organisms disturbed by shell fishermen's clam rakes. In addition, most accounts mentioned that the animals developed affinities for particular boats or mooring buoys (Lockyer 1978; Webb 1978; Gilchrist 1967). The suggested reasons for the attractions were varied. In some cases they were associated with play as when one bottlenose dolphin (*Tursiops truncatus*) seemed to enjoy towing certain boats by their anchor chains (Webb 1978), or with food as when fishes were congregating beneath boat hulls (Gilchrist 1967). In another case, a male dolphin rubbed repeatedly on the bottoms of boats for apparent sexual stimulation as captive males often do with inanimate objects (Webb 1978).

In our opinion, two other roles for these attractions should also be considered. First, permanently moored boats or buoys may serve as navigational guideposts for the short-range movements of the animals. Lockyer (1978) noted that one bottlenose dolphin actively defended the areas around such objects as territories. Second, and more important, solitary whales and dolphins may be attracted to underwater objects as surrogates for companionship and security, social needs normally provided by conspecifics. Social deprivation may also be responsible for habituation to humans per se, because large groups of whales and dolphins that frequent populated beach areas are rarely approachable (Connor and Smolker 1985).

Finally, this case exemplifies the problems that government officials and marine mammal stranding organizations may face in dealing with future cases of "friendly" strays. The problem of potential harassment to such animals is not new. In 1906 the New Zealand government by Order in Council enacted, "*The closed season for the fish or mammal of the species known as Risso's dolphin (*Grampus griseus*) in the waters of Cook Strait, or from the bays, sounds, and estuaries adjacent thereto... Any person committing such a breach of this regulation is liable to a fine of not less than £5 nor more than £100,*" thereby attempting to protect one of the most famous of all friendly cetaceans, Pelorus Jack (Cowan 1930). In our view, the prognosis for long-term survival in habituated cetaceans is poor, especially in areas with populated shorelines and heavy boat traffic. Many people may advocate the attempted capture and relocation of small cetaceans, such as belukhas, to populations in their natural range. In most cases this may be neither practical nor prudent, given the possibility for accidental introduction of foreign pathogens to the population. If attempted capture of a stray is deemed necessary, relocation to an aquarium might be considered as a logical means to provide for both the animal's security and its social needs.

Acknowledgments

We thank Laura Kezer, H. Curtis Horton, and David Merritt for assisting in the compilation of sighting event data. Matthew Hare and James G. Mead provided access to information in the Smithsonian Institution's Marine Mammal Events Program computer database. Patricia Bubucis and the Mystic Marinelife Aquarium husbandry staff assisted with the necropsy and John D. Buck processed and analyzed the microbial cultures. Katie Roessner produced Figure 1, Edith Brown photographed the necropsy and produced Figure 2, and Sam H. Ridgway sectioned and examined the skull and produced Figure 3. We also thank everyone who reported their belukha sightings to the Aquarium, including Coast Guard Petty Officer Steve Aykroyd, Laurie Beauchemin, Judith Hughes Burch, Cindy Castiglione, Alan Cungdon, William Horan, Eugene Lattanzi, C.C. Lefferts, Stuart Lumburg, Joseph Muldoon, Linda Jane Parson, Charlot Ras-Allard, J.H. Schuerger Jr., Keven Vanacore, Jane VonBrimer, John Wadsworth, and Robbin A. Zaleski.

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A Note Describing Sounds Recorded from Two Cetacean Species, *Kogia breviceps* and *Mesoplodon europaeus*, Stranded in Northeastern Florida

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ABSTRACT

Live-stranded cetaceans can provide a variety of data that are difficult to obtain from free-ranging animals. Vocalizations, for example, can be recorded and analyzed from strandings for species from which clear sounds are otherwise unavailable. Underwater echolocation-type clicks were recorded at different times from two captive pygmy sperm whales (*Kogia breviceps*). One animal was a 119-cm newborn male, the other a 166-cm juvenile male. Click repetition rate varied at least from one per 0.1 second to 13 per 0.1 second on sound spectrograms. Frequencies ranged at least up to 13 kHz. No narrow-band sounds were recorded. Clicks also were recorded from a 252-cm female Antillean beaked whale (*Mesoplodon europaeus*). Again repetition rates varied widely and frequencies extended at least to 12 kHz. A brief narrow-band sound also was recorded from this animal, suggesting that this species may have a whistle.

Introduction

Cetaceans that strand alive may offer the only opportunity to make recordings of their sounds. Under such circumstances both the vocalizing species and individual are known. In many instances the stranding of a cetacean is the only time that species is recognized at all. Furthermore, recording sounds in the wild requires considerable expertise to guard against contamination. It should be noted, however, that live-stranded cetaceans do not always vocalize.

Previously (Caldwell and Caldwell 1971) we have had such an opportunity to record a right whale (*Eubalaena glacialis*) neonate and a subadult dense-beaked whale (*Mesoplodon densirostris*), both in northeastern Florida. Since then we have been successful in recording two additional species from strandings. The individuals were brought into captivity at Marineland of Florida and placed in isolation for medical observation.

Methods

Recording equipment consisted of a Uher 4400-Report stereo tape recorder (20 kHz upper limit), an Atlantic Research Corporation model LC-57 hydrophone, and a preamplifier especially designed and built for the system by William W. Sutherland, then of the Lockheed-California Company. A running commentary of ongoing events was maintained on a separate track of the same tape. Particular emphasis was placed upon noting the orientation of the animal's head relative to the hydrophone during sound emissions. Although these notes are only approximations, they do lend some insight into the directionality of the sound (*see* Norris 1969, for a review of directionality in cetacean clicks).

Species Accounts

Pygmy Sperm Whale (*Kogia breviceps*)

Almost nothing is known of the vocalizations of this species. Reviews of the sound production of cetaceans (Evans 1967; Poulter 1968; Norris 1969; Wood and Evans 1980; Watkins and Wartzok 1985) indicate that the only sounds of this species described in the literature were made under somewhat less than optimal conditions; i.e., with a contact microphone held against the animal's head in the region of the blowhole (Caldwell et al. 1966). The click-type sounds were of low intensity and with little energy above two kHz.

Underwater recordings of an infant male *K. breviceps* are now available (Figs. 1–4). All sound emissions were clicks.

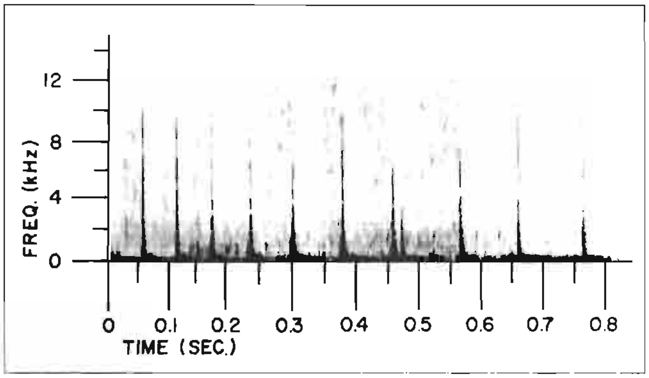

Figure 1

Slow-repetition-rate clicks emitted by a neonate male *Kogia breviceps*. These were classified as sounding "sharp." Note wide frequency spectrum, particularly of last click. Effective filter bandwidth 600 Hz.

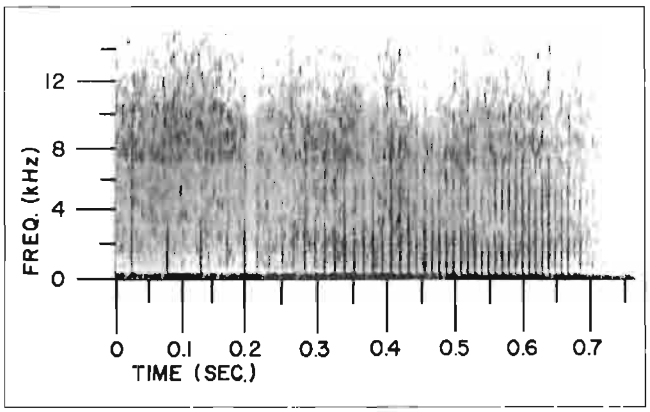

Figure 2

Faster-repetition-rate clicks emitted by the same animal as in Figure 1. Animal appears to vary this parameter even at this young age. Effective filter bandwidth 600 Hz.

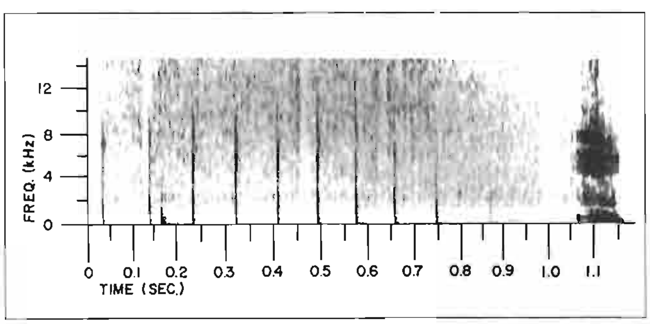

Figure 3

Slow broad-band click train emitted by the same newborn as in Figures 1 and 2. This is followed by "sucking" sound seen from 1.05–1.15 sec. The latter is not an unusual finding in *Tursiops truncatus* recordings. Effective filter bandwidth 600 Hz.

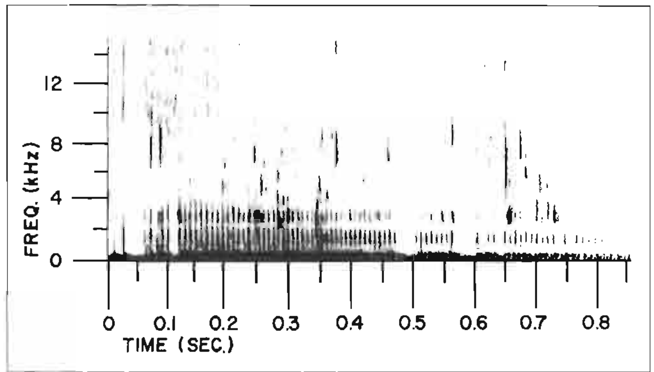

Figure 4

One of several "buzzes" emitted by the same infant as in Figures 1–3. Effective filter bandwidth 600 Hz.

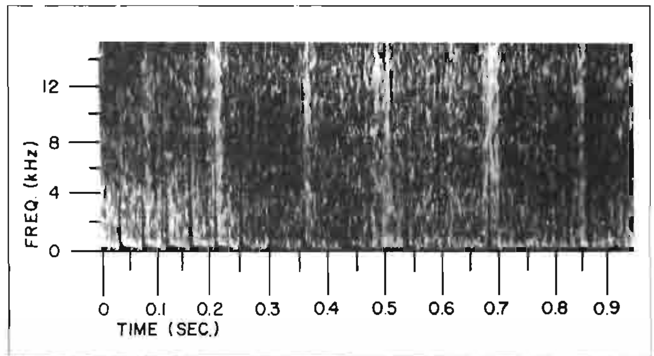

Figure 5

Clicks emitted by a larger (166 cm standard length) male *Kogia breviceps*. Larger individuals of this species have proven far more difficult subjects from which to obtain vocalizations. Effective filter bandwidth 600 Hz.

The animal was recorded in isolation when less than 24 hours old. The circumstances of his captivity are as follows: On the afternoon of 9 August 1973 an adult female of the species gave birth to the infant male in the surf about 1½ miles south of Daytona Beach Shores, Florida. The mother stranded shortly thereafter. The infant (MLF 369) was rescued from the surf by onlookers who had witnessed the birth and was placed in a small plastic pool until it could be picked up by a crew from Marineland of Florida. The animal was apparently in good physical condition when placed in a 6.4-meter wide, acoustically isolated concrete holding tank at Marineland. The animal appeared robust and measured 119 cm from tip of snout to the deepest part of the fluke notch in a straight line. Although pushed back into the surf, the mother stranded again and died. In effect then, the infant probably never heard post-natal sounds made by the mother or other cetaceans.

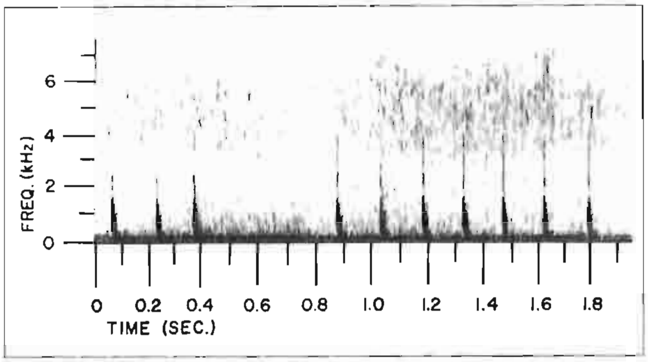

Figure 6
Slow-repetition-rate clicks emitted by a *Mesoplodon europaeus*. To the ear, these sounded like "knocking" clicks. Effective filter bandwidth 300 Hz.

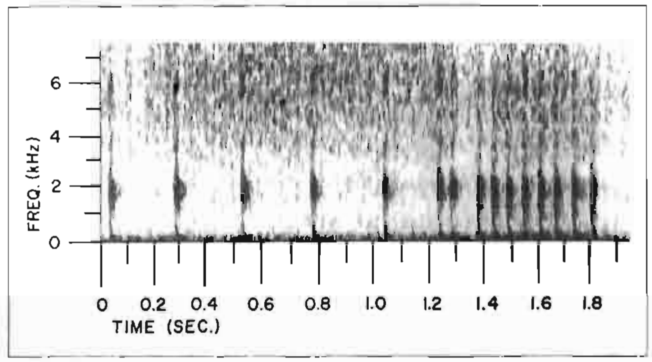

Figure 7
Faster-repetition-rate clicks emitted by the same animal and during the same recording session as in Figure 6. These sounds are described as "sharp" clicks, and the dominant frequency is somewhat higher (ca. 2 kHz vs. 1 kHz). Effective filter bandwidth 300 Hz.

Recordings were begun at 1030 hours on 10 August and were continued for about 3½ hours. The animal died that same evening. During the recording session sufficient data on the underwater sounds of this little-known species were collected to be of some interest. The recordings also shed some light on the sounds of a newborn cetacean uncontaminated by output from the mother. This is significant because under normal circumstances a newborn infant cannot be separated from its mother because of husbandry problems.

Several episodes of click trains were recorded as the infant approached the hydrophone, especially during the early parts of the recording session, just after the instrument was placed in the animal's enclosure. No sounds other than these apparent click trains were heard. Documenting clicks in such a young animal is important.

Click sounds (Fig. 5) also were recorded from a 166-cm male *K. breviceps* (S-85-KB-03) stranded on 2 May 1985 at St. Augustine Beach, Florida. It was placed in isolation in a 6.4-meter concrete tank at Marineland of Florida where it lived for 32 days. He emitted these clicks when food was held underwater, and possibly the whale was echolocating.

Although we have tried to record sounds from a few isolated dwarf sperm whales, *K. simus*, under these same conditions, we have not yet succeeded in obtaining sounds of any kind.

Antillean Beaked Whale (*Mesoplodon europaeus*)

On 11 October 1983, a male (MLF 409) measuring 252 cm in a straight line from the tip of the lower jaw to the center of the trailing edge of the flukes stranded alive about three miles north of the pier at Flagler Beach, Florida. The whale was found at the edge of the surf at low tide and was never fully dry because of rain and a northeastern wind. It was returned to a 6.4-meter isolation tank at

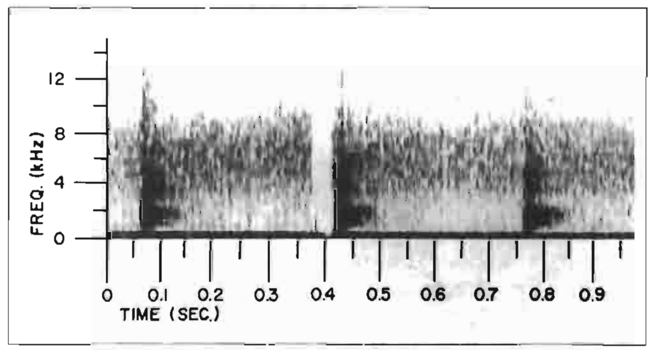

Figure 8
Slow clicks emitted by the same animal as in Figures 6 and 7. These were noted as being emitted while the animal was across the pool from and not oriented toward the hydrophone. Hence, directionality was not a prominent factor in these clicks. Effective filter bandwidth 600 Hz.

Marineland of Florida where it lived until 30 October. Frequent underwater recording sessions were conducted from 12 through 28 October.

The animal vocalized frequently and usually the sounds were at a high amplitude. These included both slow and fast clicks (Figs. 6–8) and a narrow band sound (Fig. 9) suggesting an ability by this species to produce a whistle.

Discussion

The sounds presented here are intended chiefly to report the presence of underwater click emissions in the two species noted. Although it is considered possible that all odontocetes produce clicks and that these clicks are used

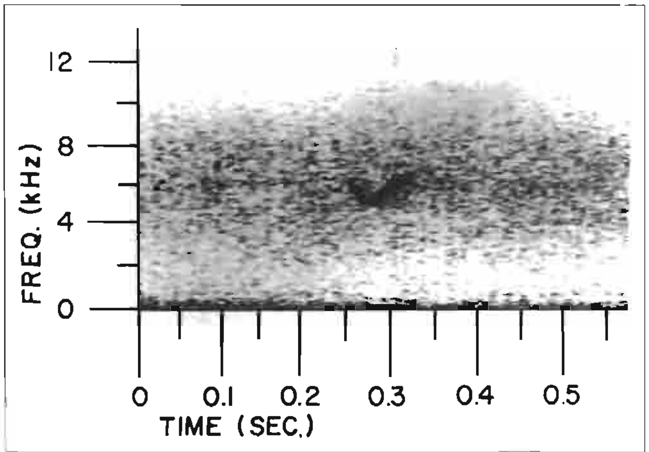

Figure 9
Narrow-band "chirp" at about 6 kHz emitted by *M. europaeus*. This indicates a narrow band whistle capability. Effective filter bandwidth 90 Hz.

by at least some species to echolocate, vocalizations of many species remain undocumented (Watkins and Wartzok 1985). Click emission by a newborn *Kogia breviceps* was considered particularly noteworthy as we know very little about the ontogeny of this class of sounds in any cetacean.

Beyond reporting the sounds and publishing the spectrograms, the constraints of the opportunistic nature of the recordings prohibit much speculation. We note, however, that the *K. breviceps* infant, and to a lesser degree the juvenile, emitted many more audible clicks than we have heard from the older animals. We do not know if *K. breviceps* clicks could be used as identification signals as they reportedly are in sperm whales (Watkins and Schevill 1977; Watkins 1980).

There have been no sounds listed in the published literature for the Antillean beaked whale. The only previously documented sounds for the genus *Mesoplodon* are brief narrow-band chirps or brief whistles recorded in air from a stranded *M. densirostris* (Caldwell and Caldwell 1971). Clicks emitted by both species were of variable repetition rates (Figs. 1–8).

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