Cetacean strandings in Puerto Rico and the Virgin Islands

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ABSTRACT

An assessment of cetacean strandings was conducted in waters off Puerto Rico and the United States and British Virgin Islands to identify, document and analyse factors associated with reported mortality events. Nineteen species of cetaceans were reported stranded. The total number of events recorded between 1867 and 1995 was 129, comprising over 159 individuals. The bottlenose dolphin (*Tursiops truncatus*) was the species most commonly found stranded, followed by Cuvier's beaked whale (*Ziphius cavirostris*), sperm whale (*Physeter macrocephalus*), Atlantic spotted dolphin (*Stenella frontalis*) and short-finned pilot whale (*Globicephala macrorhynchus*). An increase in the number of strandings is evident over the past 20 years, averaging 63.1% per year. Between 1990 and 1995, the average number of cases per year increased from 2.1 to 8.2. The seasonal pattern of strandings was not found to be uniform, with a high number of strandings occurring in the winter and spring. The monthly temporal distribution showed an overall bimodal pattern, with the highest number of cases reported for February, May and September. The spatial distribution was not even, and differed between countries, within countries, and between taxonomic groups and species. Aside from undetermined causes of mortality, the ratio of natural causes in relation to human-related causes was of 1.2:1. Between 1990 and 1995, a reduction of the percentage of undetermined cause of deaths resulted from the establishment of a cooperative effort in studying mortality in an organised and systematic manner. The most common natural cause of death category was dependent calf. The most common human-related cause categories observed were entanglement and accidental captures, followed by animals being shot or speared. Evaluation and recommendations to improve the research conducted are formulated, including guidelines for the development of a strategic plan to obtain baseline data on the biology and life history of cetaceans to be applied to their conservation and management.

KEYWORDS: STRANDINGS; INCIDENTAL CATCHES; DISEASE; EPIZOOTIC; SHORT-FINNED PILOT WHALE; CUVIER'S BEAKED WHALE; BOTTLENOSE DOLPHIN; SPERM WHALE; SPOTTED DOLPHIN; SMALL CETACEANS-GENERAL.

INTRODUCTION

Seventeen species of whales and dolphins have been reported to inhabit the waters of Puerto Rico and the United States (US) and the British Virgin Islands (Mignucci-Giannoni, 1998). Four of these species are classified as vulnerable or endangered by international agreement or local legislation, and are therefore protected by law.

Although the presence of these cetaceans has been documented, and certain species, such as the humpback whale (*Megaptera novaeangliae*), have been studied, there is still a lack of information on factors which affect the survival of cetaceans in the northeastern Caribbean. There is a marked absence of data on the basic biology, life history, stranding and mortality of these species. The data collected by many of the previous studies can be characterised, at best, as fractional (scattered over different sources). In addition, much of these data have not been published previously, and until recently, was not easily accessible. In particular, the cause of mortality and strandings of these cetaceans has not been directly addressed, although during the past four decades, over 100 cetaceans have been found killed or stranded on shore.

Logistical problems associated with cetacean research in the northeastern Caribbean

Mignucci Giannoni (1989) estimated that 70% of the reported mortalities of marine mammals in Puerto Rico and the Virgin Islands were of unknown causes, while most of the remaining 30% were probably caused by human intervention. The author attributed some of the cetacean deaths in the area to increased heavy industrialisation and the resulting discharge of contaminants into coastal areas. However, until recently lack of general knowledge coupled with public, scientific and government indifference resulted in little or no data being collected from strandings, with a large number of the animals being either towed back to sea or buried without proper analysis. This explains the high incidence of undetermined causes of death. When the causes were known, these were frequently the result of human activity.

Live strandings of injured or sick animals also presented a problem since no appropriate facilities existed in Puerto Rico and the Virgin Islands to provide immediate care and rehabilitation to cetaceans. Preliminary analysis of the available data on strandings reported in this paper revealed that most of the animals stranded alive, but died soon after, probably due to hyperthermia resulting from exposure to the extreme heat of the tropics. It is possible some of these animals could have been treated if a response team had been promptly notified and arrived at the location. Valuable data on husbandry protocols and life history of these animals may have been obtained while such animals were in rehabilitation. However, until recently, no trained personnel capable of rescuing, treating or rehabilitating cetaceans were available in the area.

Although federal acts, local laws and regulations, protect to a certain extent, and authorise research and management of whales and dolphins in the area, the relevant agencies have limited finances and personnel. Interagency

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cooperation is required to obtain base-line information to enable practical and informed research and management policies for cetaceans in this area. Research on strandings and causes of mortality can play an important role in this.

Potentially, the most serious problem associated with the effective management of cetaceans in the northeastern Caribbean is their unnecessary mortality due to human activities. Incidental or direct capture of cetaceans and the contamination of shore habitats by industrial discharge are illegal under federal and local laws, and constitute a serious problem that needs to be promptly addressed. Wider environmental problems associated with large-scale global changes have the potential to harm populations of cetaceans (Geraci, 1989; IWC, 1997). In order to document and monitor the situation in the northeastern Caribbean, base line studies are essential. This must include accurate mortality documentation and analysis in order to identify conservation measures that may be required.

Creation of national and Caribbean regional stranding monitoring programs

Answering to a lack of organisation at the national level in the monitoring of marine mammal deaths and strandings in the USA, a Marine Mammal Stranding Workshop held in 1977 (Geraci and St. Aubin, 1979) recommended the creation of a nationally coordinated programme to study these events, with the aims of: maximising data from strandings; providing an efficient format for the dissemination of such data; easing the efforts of natural resources management agencies; encouraging the cooperation of government agencies with investigators and institutions; and eliminating conflicts and duplication of effort. The Workshop's recommendations lead to the creation of six regional networks and a national office to coordinate the assessment of marine mammal mortality and strandings (Dierauf, 1990c). Local participants in each of the networks report cases to a regional scientific coordinator, who in turn reports the cases to the national office, where they are filed.

The participation of Puerto Rico and the Virgin Islands was discussed during the 1977 Stranding Workshop. Two network proposals were discussed, one for the southeastern US, including Puerto Rico and the Virgin Islands (Odell, 1979), and another for the West Indies, including islands from Puerto Rico to Barbados (Winn and Towle, 1979). It was recommended that Puerto Rico and the Virgin Islands be under the jurisdiction of the southeastern network, but with some degree of autonomy in order to function effectively as part of a 'greater Caribbean network' (Geraci and St. Aubin, 1979). However, the southeastern network never developed an autonomous sub-region nor examined any cases in this area due to the great distance between the islands and the US mainland.

It was not until October 1989 that the Caribbean Stranding Network (CSN, *Red Caribeña de Varamientos* in Spanish) was created as the Caribbean Islands Sub-region of the already established Southeastern US Marine Mammal Stranding Network (Mignucci-Giannoni, 1990; Mignucci-Giannoni *et al.*, 1991). The CSN is composed of volunteers from private, university, Commonwealth and Federal agencies whose personnel have agreed to attend the scene of a beached marine mammal and transport it either for treatment or proper salvage and disposal. The CSN, homebased in San Juan at the Universidad Metropolitana's Caribbean Marine Mammal Laboratory, consists of over 100 participants, consultants and volunteers from over 30 cooperating organisations and government agencies.

METHODS

The study area included the continental shelf waters of the Commonwealth of Puerto Rico, the Virgin Islands of the United States and the British Virgin Islands (Fig. 1). For the purpose of the analysis, the area was divided into eleven geographical zones, including the northern and southern Virgin Islands, Puerto Rico's Offshore Islands, and Puerto Rico's north, northeast, east, southeast, south, southwest, west, and northwest coasts.

This study considers all reports that were either historical or opportunistic in nature. These included strandings data collected by scientists who had previously conducted studies in the area, and solicited or voluntary reports of strandings from lay persons, fishermen, scientists, or government officials. However, such occurrences were only accepted as part of the study if they were proved to be reliable in terms of species identification, date and event location. Documentation or salvage of dead and stranded cetaceans in Puerto Rico and the Virgin Islands has been more thorough since 1989, and coordinated by the CSN. The earliest historical occurrence on file dates from 1867. The last stranding included in this report occurred on 30 December 1995.

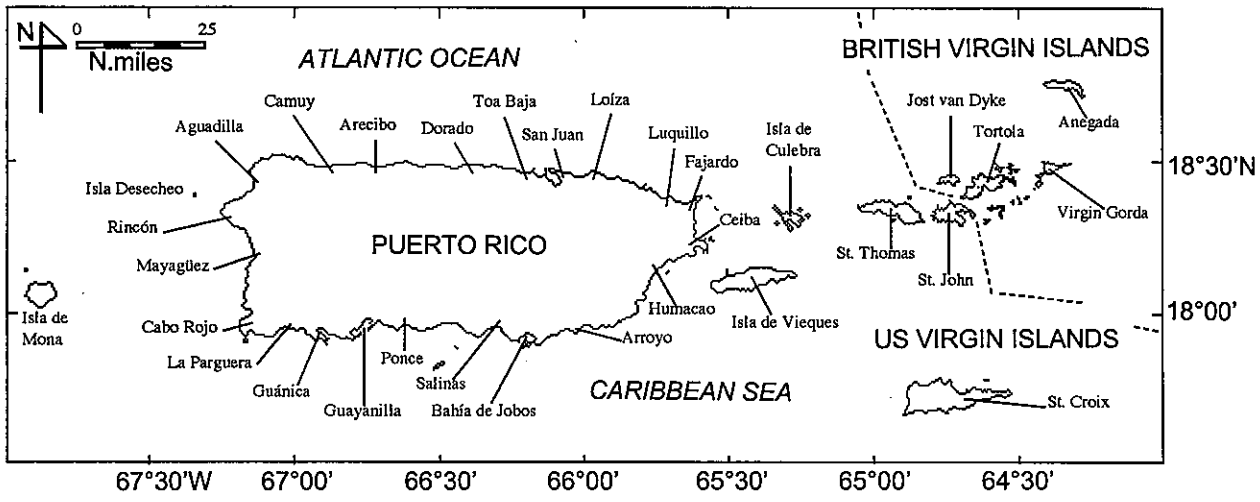

Fig. 1. Caribbean sub-region of the Southeastern US Marine Mammal Stranding Network.

In order to evaluate the strandings and mortality cases reported, a database management system was custom-formatted to file information on the occurrences of the species in the study area. This was based on databases created by the Smithsonian Institution's Marine Mammal Event Program, the southeastern US Marine Mammal Stranding Network (Odell, 1987) and the Australian Cetacean Stranding Database (Nicol and Anderson, 1990). The basic information collected from each stranding or mortality case was detailed in a *Data Summary* sheet formatted in the database. Each case was assigned a catalogue number and a hard copy of the *Data Summary* sheet as well as any other reports received or analyses conducted were filed under this catalogue number.

Salvage and detailed examinations of stranded specimens were carried out, when possible, to assess general parameters related to the event and to attempt to document cause of death. Information gathered from each event contained at the least the Level A data needed to document the event, as detailed in Geraci and St. Aubin (1979). When possible, Level B (basic life history and specific event data) and Level C data (results of careful internal and external examinations), as detailed by Geraci and St. Aubin (1979) were collected.

Protocols for attending strandings and assessing cause of death as described by Dierauf (1990a; b), Dierauf and Gage (1990), Geraci and Lounsbury (1993), Hare and Mead (1987), and Lowenstine and Osborn (1990) were followed. The necropsy protocol by Anderson *et al.* (1990) and Winchell (1982) were followed. Morphometric examinations followed an adaptation from Norris (1961) and the protocol set by the southeastern US Marine Mammal Stranding Network.

RESULTS AND DISCUSSION

Sources of data

A total of 129 strandings and mortality of cetaceans, involving more than 159 individuals, have been recorded for Puerto Rico and the Virgin Islands region. Opportunistic data, whether published or unpublished, comprised solicited or voluntary reports of strandings from lay persons, fishermen, scientists or government officials. More recently, data were collected in a cooperative effort by the CSN. The nature of these data clearly result in a number of difficulties when attempting to reach any biological/ecological conclusions. As is the case for many strandings data, they are non-random and biased in a variety of different ways, mainly due to the varying effort of the researchers and the origin of stranding data: i.e. 'being at the right place at the right time'. It is clear, that the results of the analyses which follow must be treated with caution. However, in the absence of rigorous data, this information represents what is available and serves to provide a preliminary overview of expected patterns involved in mortality and stranding cases in Puerto Rico and the Virgin Islands.

Forty percent of all records were collected after 1989 through the cooperative efforts of the CSN. This validates the need for and effectiveness of such programmes in the collection of valuable and important data.

Taxonomic groupings

Nineteen species of cetaceans were reported stranded in the study area, including 11 delphinids, three physeterids, three ziphiids and two balaenopterids. The number of stranding events and the number of individuals stranded for each species are detailed in Table 1[1].

Listing the species in order of stranding events and total number of animals stranded provides a relative ranking of the commonness of strandings for each species. Combined with the average interval between stranding events each species can be characterised as either commonly, occasionally or rarely stranded. Five species commonly stranded in the study area, including (in rank order): bottlenose dolphin (*Tursiops truncatus*), Cuvier's beaked whale (*Ziphius cavirostris*), sperm whale (*Physeter macrocephalus*), Atlantic spotted dolphin (*Stenella frontalis*) and short-finned pilot whale (*Globicephala macrorhynchus*). Three species occasionally stranded (in rank order): humpback whale, pygmy sperm whale (*Kogia breviceps*) and rough-toothed dolphin (*Steno bredanensis*). The remaining 11 species stranded infrequently.

Table 1

Taxonomic grouping and occurrence for cetaceans stranded in Puerto Rico and the Virgin Islands from 1867 to 1995.

Taxonomic grouping	Stranding events	Animals stranded
Odontoceti	**107**	**137+**
Delphinidae	**63**	**81+**
Steno bredanensis	6	6
Tursiops truncatus	19	20+
Stenella frontalis	10	19
Stenella longirostris	3	3
Stenella coeruleoalba	1	1
Lagenodelphis hosei	1	1
Grampus griseus	1	1
Peponocephala electra	1	1
Feresa attenuata	1	5
Pseudorca crassidens	1	1
Globicephala macrorhynchus	11	13+
Unidentified dolphin	8	10
Physeteridae	**23**	**23**
Kogia breviceps	8	8
Kogia simus	2	2
Physeter macrocephalus	13	13
Ziphiidae	**21**	**33**
Ziphius cavirostris	18	30
Mesoplodon europaeus	2	2
Mesoplodon densirostris	1	1
Mysticeti	**22**	**22**
Balaenopteridae	**22**	**22**
Balaenoptera edeni	1	1
Megaptera novaeangliae	9	9
Unidentified large whale	**12**	**12**
Total	**129**	**159+**

Biodiversity

The first two published accounts of cetacean biodiversity in Puerto Rico and Virgin Islands (Erdman, 1970 and Erdman *et al.*, 1973) documented the presence of 11 species of whales and dolphins. Mignucci-Giannoni (1998) added six species to the known cetacean fauna from the study area. The present work adds nine additional species to the list of reported cetaceans. Most of the strandings records reported herein constitute the first locality records for the species in the northeastern Caribbean, including the rough-toothed dolphin, bottlenose dolphin, Atlantic spotted dolphin, striped dolphin (*Stenella coeruleoalba*), Fraser's dolphin (*Lagenodelphis hosei*), melon-headed whale (*Peponocephala electra*), pygmy killer whale (*Feresa attenuata*), pygmy sperm whale, dwarf sperm whale (*Kogia*

[1] A full listing of stranding and mortality records for Puerto Rico and the Virgin Islands is available from the author.

simus), Gervais' beaked whale (*Mesoplodon europaeus*), Blainville's beaked whale (*Mesoplodon densirostris*) and the Bryde's whale (*Balaenoptera edeni*). Some of the animals reported are scarcely known from the Caribbean, and some even from the Atlantic Ocean (Fraser's dolphin, Risso's dolphin (*Grampus griseus*), melon-headed whale, pygmy killer whale, dwarf sperm whale, and Blainville's beaked whale) and their strandings records constitute important information to enable better understanding of their Caribbean zoogeography.

Gender and age/size classes

Overall, gender was not determined for half (50.9%) of the specimens. In cases where sex was determined, more males (57.7%) were recorded than females (42.3%). This variance from parity may be due to the fact that males are easier to identify than females, especially in moderately decomposed males in which the penis is distended and exposed. Experience in sexing animals may also have had an effect. Undetermined gender reports declined from 62.3% (1867-1989) to 34.7% in the last six years when a coordinated effort by trained researchers was established.

Placement of a given carcass in an age/size class was based on evidence from the literature for the given species or specific examination of the carcass (gonads, pregnancy, lactation, etc.). Overall, age/size class was not determined for 32.7% of the cases. Of those to which a class was assigned, 66.4% were adults, 21.5% were subadults and 12.1% were calves. When analysing gender and age/size classes, calves reported dead had a 50:50 ratio of males and females. In both subadults and adults, males (68.8% subadults, 55.2% adults) were more abundant than females (31.3% subadults, 44.8% adults).

Temporal distribution

Analysis of strandings events showed a general increase in the number of cases reported each year. A steep increase in the number of strandings is evident during the past 20 years. An analysis of frequency of strandings recorded per decade during the past 60 years showed an average increase of 63.1% per year, with over 70% of all records occurring in the past two decades (1980s and 1990s). Analysis of events recorded during these two decades in five-year blocks showed no change in the percentage increase (average of 63.4% per year). The analysis also revealed that for strandings reported between 1975 and 1995, 11.0% of the cases occurred between 1975 and 1979, 21.0% occurred between 1980 and 1984, 19.0% occurred between 1985 and 1989, and 49.0% occurred between 1990 and 1995. Considering the entire dataset, the average number of stranding cases per year was 2.1 (1.7 for odontocetes, 0.4 for mysticetes). Between 1990 and 1995, the average number of cases per year increased to 8.2 (7.2 for odontocetes, 1.0 for mysticetes).

This overall long-term trend of increased reporting of strandings events in the study area probably does not relate to an increase in animal deaths, but rather is a consequence of changes in the interest and dedication of the public and of government agencies in reporting and recording strandings in the study area. The increase in the past five years corresponds to the increased interest and commitment of scientific institutions and universities in the study of these events in conjunction with co-operation with government agencies and a proactive education campaign to inform the public of the status, conservation efforts and need to report sightings and strandings of these protected species.

Cetaceans most commonly stranded in winter (28.4%) and spring (29.4%), with a marked lower number of stranding cases being reported in summer (21.1%) and autumn (21.1%). The highest number of cases was reported for February (11.5%), May (12.5%) and September (11.5%). Strandings were reported for all other months, although at a lower percentage rate, between 5.7% to 9.6%, of all records. An overall bimodal pattern was observed in the monthly seasonality of strandings, with the first peak occurring from February to May and the second during September.

Spatial distribution

The spatial distribution of strandings events differed amongst countries and within countries in the study area. The majority of the strandings events were reported for Puerto Rico (74.0%). Only 22.8% of all records were reported for the US Virgin Islands and 3.2% for the British Virgin Islands.

Spatial distribution was also found to differ between taxonomic group and species of the same order and family. The latter is due to the different natural patterns of distribution of species, some being oceanic, others coastal and others migrating from offshore to coastal waters.

Five areas showed a higher percentage of stranding events: (1) Puerto Rico's west coast (15.7%); (2) Puerto Rico's north coast (13.4%); (3) southern Virgin Islands (13.4%); (4) Puerto Rico's southwest coast (11.8%); and (5) northern Virgin Islands (11.8%) (Fig. 2). In addition, four clusters of high incidence of cetacean strandings were evident when locations were plotted on a map, including: (1) St. Croix; (2) La Parguera; (3) Mayagüez; and (4) Fajardo (Fig. 2).

A number of different factors may affect the spatial distribution of strandings and mortalities. Some of these are physical environmental factors, such as tides, currents and geomagnetic irregularities. Species behaviour, migration patterns and feeding activities may also affect the localities of strandings events. Some animals may have died a number of kilometres from the location where they washed-up, having been carried by nearshore currents. In addition, observer effort may play an important role in the spatial distribution seen in the stranding record, with specific areas having a higher probability than others that stranding events will be reported.

Events and causes

In order to characterise a stranding event, three major pieces of information were noted: type of event; condition of the carcass; and predominant cause of death or stranding.

Event category

Cetacean strandings were divided into seven categories:

(a) single strandings (lone animal);
(b) mass strandings (three individuals or more);
(c) mother/calf strandings (usually a mother with her calf, but at times it may include a third animal, either a calf from the previous year or an adult or subadult companion);
(d) natural predation (either by sharks or killer whales);
(e) capture (intentional 'take' or removal of an individual);
(f) accidental capture (non-intentional); and
(g) undetermined event.

Most animals stranded singly (78.2%). The next category with the highest frequency was accidental captures (7.8%), followed by mass strandings (7.0%). The latter occurred

only in odontocetes and on average once every 5.6 years. Reports of direct captures, mother/calf strandings and natural predation were rare. Direct captures of cetaceans in Puerto Rico and the Virgin Islands were uncommon, being only reported in the 1950s and 1960s.

Condition of carcass

The condition of the animal upon stranding served to describe whether the animal stranded alive or the state of decomposition of the carcass. These were divided into six categories:

(a) Code 1 (live animal);
(b) Code 2 (freshly dead, flesh eatable);
(c) Code 3 (moderately decomposed, organs still distinguishable);
(d) Code 4 (advanced decomposition, organs indistinguishable);
(e) Code 5 (mummified carcass or skeletal remains); and
(f) Code U (unidentified condition).

The condition of the animal was usually recorded when the animal stranded or when it was first found, but at times it was determined upon examination. Most animals stranded alive (30.5%), and the majority died soon after either from complications from the initial cause of the stranding or probably from hyperthermia. Dead animals were most often found in a moderate (16.6%) or advanced state of decomposition (14.6%). Fewer numbers were found in a freshly dead condition (13.2%) or as mummified carcass/skeletal remains (4.0%).

Cause of death or stranding

Predominant causes of death or stranding fall into three main categories:

(a) natural;
(b) human-related; and
(c) undetermined.

The first two were further subdivided into several sub-categories. Natural causes identified in the study area included illness, social/mass strandings, dependent calf, parturition difficulties and predation. Human-related causes identified in the study area included direct captures, entanglement, shot/speared, accidental captures, ingestion of debris and watercraft collision.

Overall, causes were not determined in 62.8% of the cases. Natural causes constituted 20.9% of the cases, while human-related causes totalled 16.3%. Aside from undetermined causes, the ratio of natural causes to human-related causes was of 1.2:1. The proportions of predominant cause of death/strandings have changed over time. Cases between 1990 and 1995 were categorised as natural causes (34.5%), human-related causes (32.2%) and undetermined causes (33.3%). This reduction in the undetermined cause percentage during the past six years was a result of the cooperative effort in studying mortality events in an organised and systematic manner. No change over time was observed in the proportion of human-related deaths, but a better characterisation of natural deaths during the past six years was observed. The most common natural cause category observed was dependent calves (37.0%) followed by social/mass strandings (33.3%) and illness (22.2%). Predation and parturition difficulties were rarely encountered. The most common human-related cause categories observed were entanglement (28.6%), accidental capture (28.6%) and animals being shot or speared (9.5%). Deaths or strandings due to ingestion of debris or watercraft collisions were rare.

CONCLUSIONS AND RECOMMENDATIONS

Although this section of the paper deals with the local features of our region, it is also presented as a guide for other areas where cetacean research is in its infancy. It moves beyond the logistical and scientific aspects of establishing a strandings/mortality programme to using the data obtained to develop a conservation framework for cetaceans in the region.

The following recommendations are based on an evaluation of the experience gained thus far and are grouped into four categories:

(1) identification of organisational and logistical problems;
(2) short-term actions in the context of the strandings/mortality programme;
(3) long-term actions in the broader context;
(4) development of a conservation and management plan.

Organisational and logistical problems

A number of logistical problems have been encountered whilst establishing the programme and attempting to carry out associated research on strandings and mortality of

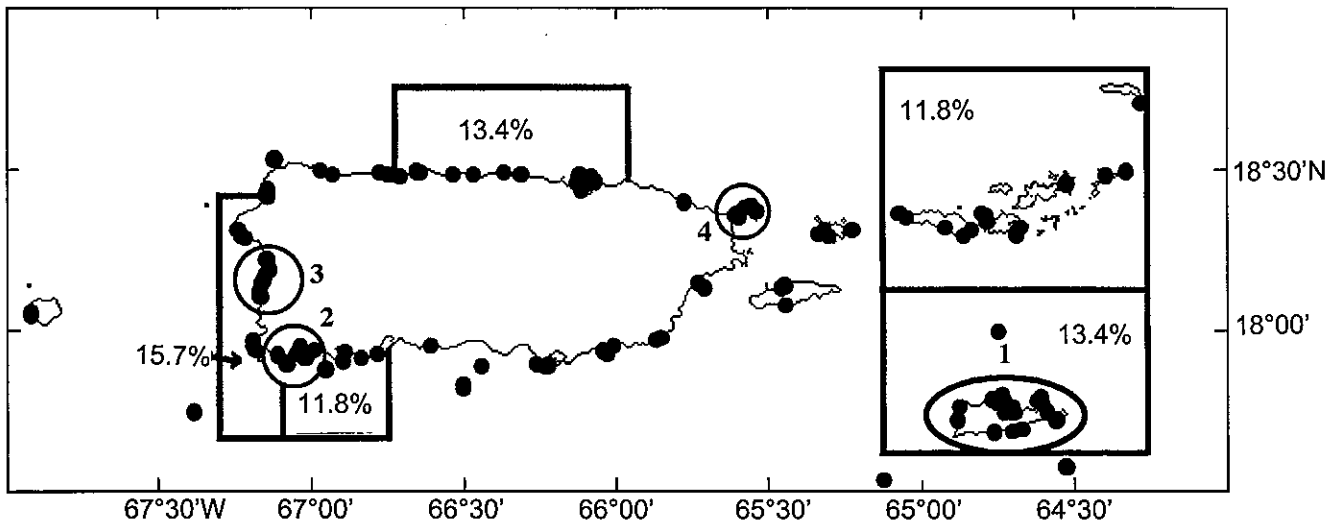

Fig. 2. Distribution of stranded cetaceans in Puerto Rico and the Virgin Islands.

cetaceans in Puerto Rico and the Virgin Islands. These can be summarised as follows.

(1) It takes too long to process and close a case i.e. from receipt of a call to a strandings event to being satisfied that all the data and analyses have been collected and completed and entered into the database. Associated with this is the lack of a feedback process to inform participants of the results of strandings studies in their area.
(2) The large number of participants and institutions has resulted in a lack of consistency when attending an event; both in speed of response and collection of data. For example, data can be lost for a number of associated reasons:
    (i) by the time the case is attended, the animal is in an advanced state of decomposition;
    (ii) the case is not of interest to the particular participant or government official;
    (iii) a lack of equipment or poor working conditions preclude the possibility of a thorough post-mortem analysis;
    (iv) inconsistent levels of training;
    (v) the absence of a set, easy-to-follow protocol which details the important information required.
(3) Lack of funds to finance post-mortem examinations, laboratory analyses, curation of collections of parasites, histopathological and osteological samples.
(4) Variable geographical coverage and effort, leading to problems in interpreting the data collected at the regional scale.

There are a number of short- and long-term actions that can help in rectifying these problems.

Short-term actions

(1) Develop a standardised protocol for attending stranding events, that takes into account the status of the carcass, the availability of expertise, and establishes priorities for data collection and recording. It should include information on how to examine the carcass, what data to record, what samples to collect, how to collect them, and issues related to short- and long-term storage. This should be done in conjunction with well-established programmes from around the world so that established protocols can be adapted to local conditions. The aims of priority studies should be clearly stated.
(2) Train participants regularly, through seminars and written material, especially those whose responsibilities will be to attend strandings events (e.g. rangers and wildlife refuge managers).
(3) Increase effort in areas of poor coverage (i.e. southeastern and northeastern Puerto Rico, St. John, Anegada, etc.).
(4) Provide feedback from the programme's centre to the participants, e.g. with regular summary reports.
(5) Improve the computerised database to enable cases to be processed more quickly and summary reports (including the location of samples and the status of analyses) to be easily compiled.

Long-term actions

(1) Further develop the mortality and stranding monitoring programme, particularly focussing on obtaining information needed by natural resources managers to develop conservation and monitoring programmes in their areas of jurisdiction.
(2) Continue and develop associated educational and public awareness campaigns in order to promote understanding and cooperation from various interests including fishermen and tourist operators.
(3) Find financial support to cover basic costs of equipment, supplies, salaries, maintenance of facilities, laboratory analysis, etc.
(4) Develop parallel scientific studies that utilise as fully as possible the available carcasses; assist in determining the representativeness of sampled animals and improve knowledge of basic biology and life-history parameters.
(5) Meet at least once a year with programme participants and government officers to review and evaluate achievements and difficulties.

Conservation and management plan

The development of a strandings/mortality programme stems from the need to develop an overall conservation and management plan for cetaceans in the region. Any such plan will require scientific input and will have a number of elements including:

(1) a statement of short- and long-term goals and objectives;
(2) a scientific research and monitoring programme (including mortality estimates);
(3) a legal framework (including an effective enforcement strategy);
(4) a public education and awareness strategy;
(5) establishing an ongoing stable financial and organisational basis.

There is clearly interaction amongst these elements.

Objectives

It is important that any management plan tries to establish objectives, and ideally quantifiable objectives. This provides a framework to develop priorities and actions for elements (2) - (4) listed above. For example, if an overall objective is to try to maintain or restore populations of cetaceans to a particular level (e.g. near unexploited levels), then one would need to determine potential threats to cetaceans in the region and develop strategies to minimise such threats. Examples of such threats may include: incidental captures in fishing gear; direct killing (e.g. ship strikes, shooting); disturbance (e.g. unregulated whalewatching; ship traffic in sensitive areas; harassment by jet skis); habitat degradation (e.g. pollution); unexpected large-scale natural mortality (e.g. epizootics).

Different species may well be more vulnerable to some threats than others, and priorities will need to be set on the basis of available scientific information or research programmes developed to obtain that information.

Research and monitoring programme

The current strandings/mortality programme (including the short- and long-term improvements listed above) will clearly have an important role to play and will provide information on several of the research topics given below. Research activities should include:

(1) development of an accurate species inventory;
(2) characterisation of the abundance, distribution and stock identity of cetaceans in the region;
(3) characterisation of areas of critical habitat for different species (e.g. breeding areas), and their overall use of the region (e.g. residency times, migration paths);

(4) establishment of baseline life history and physiological parameters (incl. pollutant burdens)
(5) assessment of human-induced mortality, particularly incidental captures and direct mortality, and develop (in conjunction with user groups) strategies to minimise such mortality.

It is clearly a major and highly expensive undertaking to obtain all this information for all species and priorities must be set. One approach to this is to assign priorities based on an initial assessment of each species and the identified threats, given available knowledge. Linked with this scientific research programme is the need to develop an appropriate response to live strandings (including veterinary assistance and rehabilitation programmes) and a strategy to deal with epizootics.

A legal framework

There are a number of existing laws in the region but there remain a number of important matters that must be addressed, not the least that of enforcement. This paper is not an appropriate forum for such a discussion other than to state that legislation take into account scientific information and that consistency among various administrative units is important.

In this context, it is also important to try and establish cooperation between various interest groups (e.g. fishermen) when developing legislation and guidelines. Laws developed in a cooperative way are much more likely to be obeyed than those imposed from above or developed through confrontation.

Public awareness

Achievement of conservation goals for cetaceans is heavily dependent on the cooperation and involvement of the public. This is best achieved by establishing a system to provide educational materials both directly and via the media. This should address specific directly involved groups (e.g. fishermen and boaters) as well as government officials, school children and the general public.

Finance and administration

Cetacean research can be expensive, particularly with on-going monitoring programmes. It is important to try and establish a firm long-term funding basis. This can be facilitated by establishing a small dedicated inter-government office of marine mammal management for the area whose job would be to establish cooperation amongst the various interested parties including government agencies, universities and relevant non-governmental organisations, seek funding and coordinate research and management efforts.

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