

Coastal Stock(s) of Atlantic Bottlenose Dolphin: Status Review and Management

Proceedings and Recommendations from
a Workshop held in Beaufort,
North Carolina, 13-14 September 1993

Compiled by

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National Oceanic and Atmospheric Administration
National Marine Fisheries Service

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This report documents, in a timely manner, the communication of preliminary results that were presented at the workshop. It has not undergone external scientific review. Also, the interpretation of the results of these studies, and the information presented at the workshop, represent the opinions and views of the participants and not the NMFS. This workshop report is intended to act as a first step towards the completion of a Conservation Plan under the MMPA for the coastal stock(s) of Atlantic bottlenose dolphin that, when approved by the Assistant Administrator for Fisheries, will prepresent the official position of the NMFS.

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Background

A. Species Description¹

Bottlenose dolphins belong to the Order Cetacea, Family Delphinidae and Genus *Tursiops*. Currently, all forms of Atlantic bottlenose dolphins are assigned to the species *truncatus*, although this status may change as more knowledge is obtained about the different forms now considered to be separate *Tursiops truncatus* stocks.

Bottlenose dolphins are distributed throughout U.S. Gulf of Mexico and U.S. Atlantic waters. In the U.S. Atlantic, this species is distributed along the coast from Long Island, New York to the Florida Keys. North of Cape Hatteras, North Carolina, this species demonstrates a disjunct distribution, with concentrations of animals near-shore (in embayments and within several kilometers of the coast) and offshore, near the continental shelf margin, from 60 to 200 km from the coast. South of Cape Hatteras, the nearshore/offshore distribution pattern is less distinct and there appear to be latitudinal clusters of animal concentration rather than the longitudinally discrete concentration areas found north of Cape Hatteras (Fig. 1).

Seasonal density distribution patterns have been described for U.S. waters north of Cape Hatteras (CETAP, 1982) and south of Cape Hatteras (Burn et al., 1987). During summer in the U.S. Atlantic, bottlenose dolphins are distributed along the coast, usually as far north as Long Island, New York, and offshore as far north as Nova Scotia, Canada. The main coastal concentrations of migratory bottlenose dolphins during the summer occur from North Carolina, northward to New Jersey (Fig. 2). During autumn, density distribution patterns suggest near-shore animals migrate south along the coast to Florida. During winter, coastal migratory bottlenose dolphins do not occur north of Cape Hatteras, but rather, are distributed from south of Cape Hatteras to the central Florida coast. They are concentrated at the southern end of their range at this time (Fig. 2). Although bottlenose dolphins occur year-round along the southeastern Florida coast, in winter they are only about 1/10th as abundant as along the central and northeastern Florida coast (Burn et al., 1987).

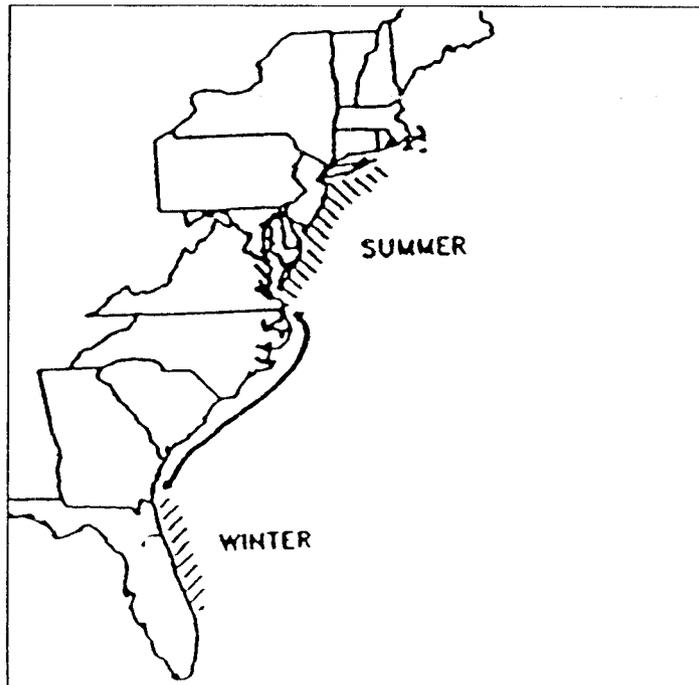
During spring, the dolphin distribution again shifts northward along the coast. It is unclear if the offshore portion of the population follows a similar north-south pattern, or what the actual extent of offshore distribution might be, since sampling has generally been limited to areas within 200 km of the coast.

¹Taken from Scott et al. (1988).

Figure 1. Distributional Range of Bottlenose Dolphins along the U.S. Atlantic Coast

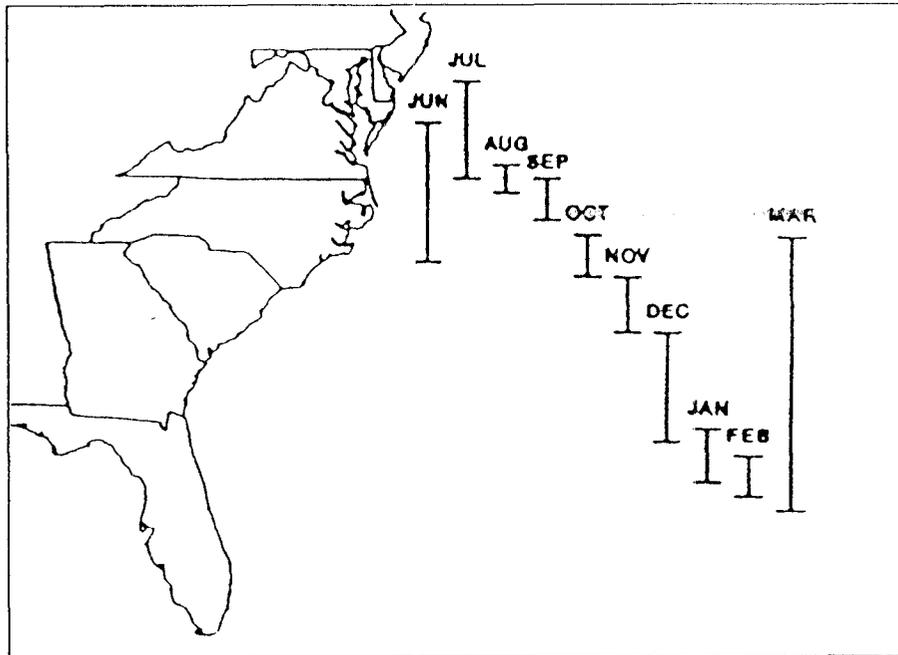


Figure 2. Areas of Major Concentrations of Coastal Migratory Stock(s) of Bottlenose Dolphins



Stock Differentiation: There appear to be both near-shore and offshore forms (stocks) of bottlenose dolphin along the U.S. Atlantic coast and in other ocean areas (Hersh, 1987a; 1987b). Burn (1988) found the pattern of strandings to correlate with the hypothesized coastal migratory pattern, which was based on density distribution patterns along the U.S. east coast (Fig. 3). The stranding data collected during 1987 and 1988, and the observed density distribution patterns along the U.S. Atlantic coast, support the hypothesis of a single coastal migratory stock of animals that ranges seasonally as far north as Long Island, New York and as far south as central Florida. It has been observed that many geographically localized populations of dolphins in the Gulf of Mexico and Atlantic waters show seasonally cyclical patterns in abundance, suggesting emigration from and immigration into embayments (Shane, 1980a; Gruber, 1981; Shane, Wells and Würsig, 1986). It has been well documented that there are both resident and transient animals that utilize localized, near-shore environments over numerous years (Scott, 1990). The working hypothesis for bottlenose dolphin stock structure in southeastern U.S. waters is that the near-shore bottlenose dolphin population is composed of local, resident stock(s) in certain embayments, and also transient stock(s) which migrate into and out of these embayments on a seasonal basis (Hersh, 1987a; Scott, 1990). It is these coastal stock(s), in general, which were the subject of this workshop, and more specifically, the coastal migratory stock(s), inasmuch as it can be distinguished from the resident stock(s).

Figure 3. Interquartile Latitude Range of Bottlenose Dolphin Strandings Along the U.S. Atlantic Coast, June 1987-March 1988



B. The 1987/1988 Die-off - What Happened?²

Introduction: From early June, 1987, until March, 1988, unprecedented numbers of bottlenose dolphins, *Tursiops truncatus*, washed ashore along the Atlantic coast from New Jersey to Florida. Details of the initial response to the event, subsequent organization of a multi-disciplinary team of investigators, and scope of the analyses were provided in an unpublished Interim Report submitted to the U.S. Marine Mammal Commission in May 1988. An account of the extent and impact of the mortality was prepared by Scott et al. (1988).

The event was unparalleled, and therefore demanded a comprehensive investigation of proximate and contributing factors. Routine laboratory protocols were modified to meet rigorous research standards. Contributing laboratories with expertise in pathology, biochemistry, microbiology, virology, contaminants, and biotoxins performed analyses on coded samples from the dolphins. Specimens for contaminant and biotoxin analysis were mixed with controls from unrelated *Tursiops* and four other cetacean species. At the termination of each study, data were transferred to our laboratory at the University of Guelph, and integrated with identifying information.

This report describes how the investigative process evolved, and the evidence implicating a biological toxin as the proximate cause. The dolphins apparently were poisoned by brevetoxin, a neurotoxin produced by the dinoflagellate *Ptychodiscus brevis*, Florida's red tide organism. The dolphins were eventually infected with a host of bacterial and viral pathogens which produced an array of beguiling clinical signs.

Discussion: Between the time the first dolphin stranded in New Jersey in June 1987, and the last on Florida's east coast eleven months later, over 740 animals died. The exact toll is not known, since almost certainly some animals were not recovered. However, Scott et al. (1988) estimated that 50 percent or more of the coastal migratory stock between Florida and New Jersey died during this period. Without a guiding precedent to help uncover the cause, it was necessary for the investigation to sweep a broad range of disciplines before settling on the eventual path to the probable solution. The two most likely potential causes for an outbreak of this kind were considered to be infectious disease and poisoning. After weighing evidence from 18 months of field and laboratory analyses, we concluded that brevetoxin, the neurotoxin produced by the dinoflagellate *Ptychodiscus brevis*, probably was the proximate cause of this devastating event.

Early findings led the investigators away from microbial agents as the principal cause of death. There was no single pattern of illness that could be associated with a known pathogen, though it was clear that infectious agents contributed to and sometimes dominated the clinical picture. The first animals to come ashore on Virginia Beach in late summer clearly had been ill for some time, with a condition that ultimately affected skin, liver, and lung, and led to the accumulation of fluid in the abdominal and thoracic cavities. Meanwhile, in New Jersey, Drs. W. Medway (University of Pennsylvania) and D. Roscoe (New Jersey Division of Fish, Game and Wildlife) indicated in personal communication that carcasses there were in better condition and less affected with secondary bacterial infection. It appeared these differences were regional; dolphins coming ashore on Virginia Beach died in warmer waters heavily contaminated with opportunistic bacteria. Over 50 percent of the 21

²Taken from Geraci et al. (1988).

species of potentially pathogenic bacteria isolated from 48 dolphins were of the genus *Vibrio*. These seemed to have been associated with some of the problems in skin and blood vessels that ultimately killed many of the animals but were not the primary cause of disease. The overwhelming nature of some of the infections, which probably arose in the lung, may have been related to immunoincompetence, the cause of which cannot be established. The depletion of lymphoid follicles in spleen, lymph nodes, and the intestine supports this suggestion.

Some dolphins also had viral infections. Eight had a skin condition characteristic of dolphin pox (Geraci et al., 1979), complete with suspicious inclusion bodies but in which no virus particles could be detected. In view of public sentiment expressed during the outbreak, it was comforting but not surprising to learn that none of the dolphins examined showed evidence of retroviruses, the group of viruses associated with Acquired Immune Deficiency Syndrome (AIDS) and whose counterparts in animals could have been a cause of reduced ability to fight normally harmless diseases. In any event, such viruses have a long latent period, and would not likely culminate in a single outbreak of disease. Dr. K. Somers is continuing to characterize the reovirus-like particles isolated from an ulcer on the palate of a dolphin. It is premature to comment on the serological titers to canine distemper virus, a morbillivirus, in 6 of 13 blood samples. Kennedy et al. (1988) have diagnosed morbillivirus infection and found distemper-like lesions in harbor porpoises, *Phocoena phocoena*, from the Irish sea. We found no evidence of such infection nor was a morbillivirus detected using techniques suitable for its propagation. It is possible that the dolphins had been previously infected with a virus that escaped detection, or was no longer present at the time of the outbreak. A study must be undertaken to determine whether the virus or other antigen responsible for the serological reaction is widespread in dolphins and whether it is a pathogen. This calls for an examination of blood samples from a broad range of cetaceans, and an investigation into the nature of the antigen.

Geographic and temporal patterns of mortality also lacked the hallmark of infectious disease. During August 1987, at least 125 dolphins stranded dead along the Virginia coastline; nearly 50 came ashore in each of the months before and after. Others, according to fish-spotter/pilot Mr. D. Thompson, were reported dead in small clusters at sea 18 miles from Cape May, New Jersey (August 21, 1987). To create such an overall pattern, an infectious agent would have had to be highly virulent -- causing acute disease across all ages and both sexes, spreading rapidly over a broad geographic range, and killing groups of animals without pause. Viruses and some bacteria introduced either by airborne transmission or through direct contact are capable of producing such havoc. Seals exposed on crowded rookeries have fallen victim to epizootics of influenza (Geraci et al., 1982), morbillivirus, (Mahy et al., 1988; Osterhaus and Vedder, 1988) and leptospirosis (Vedros et al., 1971). Yet there is little to suggest that these or other contagious organisms could spread as explosively among cetaceans. Dolphins are more dispersed in an environment which, unlike air, solid substrate or even a closed body of water, would not readily support the transmission of such agents.

The accumulating evidence led us to consider a point source contaminant as the cause of mortality. This was also a subject of public concern, as reflected by a train of media reports that sewage and toxic wastes were being discharged in the New York Bight and Delaware Bay areas. We approached the Environmental Protection Agency to obtain information on permitted and illegal dumping of municipal and industrial wastes off the mid-Atlantic states, and submitted tissues for heavy metal and organochlorine contaminant analysis.

Levels of contaminants in the dolphin's blubber were found to be among the highest recorded for a cetacean (Gaskin et al., 1971; 1983; Aguilar, 1983; Tanabe et al., 1984; Martineau et al., 1987; and Muir et al., 1988). Unfortunately, it is not possible to compare the levels with those in other *T. truncatus*, as the only study on this species employed a different technique (King, 1987). To ensure that the high values were not an artefact of our methodology, we analyzed blubber and liver samples from pilot and humpback whales, and harbor porpoises, for which published data exist. Results of PCB, DDE, and t-nonachlor analyses on the pilot whales agree closely with the recent findings of Muir et al. (1988) for the same species. Residues in the blubber of humpback whales (DDE and PCB) are comparable to those reported by Taruski et al. (1975).

Our DDE and PCB values in the harbor porpoise are similar to or lower than Gaskin et al.'s. (1971; 1983). The values in *Tursiops* stand unreservedly among the highest in cetaceans - a commentary on the state of eastern coastal waters.

High organochlorine levels in *T. truncatus* were not restricted to the stranded group; the captives had concentrations similar to those in all but the stranded mature males. The results for the beach-cast specimens obviously reflect the levels of contaminants in the nearshore environment, where the dolphins accumulate these substances. The residues occur in the blubber of captives perhaps because they are given contaminated food, or more likely because with a steady diet, they have no need to mobilize blubber fat, which would deliver the compounds to liver for excretion. Under these stable conditions, the presence of organochlorines in blubber may not pose a risk. Free-ranging animals facing intermittent food supply, or mobilizing fat during lactation, migration, or times of illness, release compounds from this depot into vital, perhaps more critical organs such as liver.

Considering the evidence that at least some of the dolphins were mobilizing PCBs from blubber to liver, it is conceivable that blood levels rose and were sustained long enough to exert an effect. One class of organochlorines, the polychlorinated biphenyls (PCBs), can be harmful following both acute and chronic exposure (Safe, 1985). Typically affected are liver and skin, and nervous, reproductive, and immune systems (Safe, 1985). Yet we cannot categorically relate any of the conditions observed in the dolphins to the known effects of these compounds because of vast differences in response within and between species. Furthermore, it is unlikely that contaminants were the key to the event. The timing of the outbreak would have required that these compounds be mobilized to functionally toxic levels within a synchronized time-pulse. This is an unlikely scenario for substances which for decades have been a constant ingredient in their environment and body tissues, unless something else triggered their release by first debilitating the dolphins.

Biotoxins were considered to have this capability. The possibility was strengthened when saxitoxin, a neurotoxin produced by marine dinoflagellates, was found to be responsible for the deaths of 14 humpback whales, *Megaptera novaeangliae*, in early December 1987 and January 1988, in Cape Cod Bay (Geraci et al., 1989). Following that study, we analyzed liver samples from 17 dolphins that had died during the early, middle and late phases of the outbreak. There was no evidence of saxitoxin in these tissues

By late summer 1988, some of the dolphin liver samples were reported to contain brevetoxin (PbTx), a lipid-soluble polyether toxin produced by the unarmored marine dinoflagellate *Ptychodiscus brevis*, Florida's red tide organism. The neurotoxin is extraordinarily potent, capable of generating effects in the nanomolar to picomolar concentration range in vivo (Schulman et al., 1990). When the

analyses were completed in January, 1989, PbTx was found to be in the livers of 8 of the 17 beached dolphins collected during the outbreak. No toxin was detected in any of the 17 controls, selected from dolphins that died in captivity, others in regions or at a time not related to the fatalities under investigation, and three that died during capture in October, 1987 (Table 1). A greater number of analyses would have added statistical weight to these findings, yet the tests are time-consuming, and by this writing, 34 dolphin samples in addition to the fish specimens were all that could be processed. The pattern is nevertheless clear: 47 percent of the 17 diseased animals contained the toxin; all the rest did not.

Levels in dolphin liver ranged between 80-16,000 ng/g, and the calculated total amount in that organ was 0.08-14.7 mg. Assuming all the toxin was confined to liver, the total body burden would have been 2-290 μ g/kg, comparable to or orders of magnitude higher than the 2.85 μ g/kg level known to cause illness in man (McFarren et al., 1965). These values are conservative. Standard extraction procedures are only qualitative for one unaltered form of PbTx. Other forms that are covalently bound or otherwise modified were not considered, nor is it reasonable to assume that all the toxin was in the liver.

Signs of PbTx poisoning in fish and mammals are related to its action on the nervous system. Mice lose motor control, become paralyzed and die of respiratory arrest (Baden and Mende, 1982). The site of action is the voltage-sensitive sodium channel in excitable membranes, where the toxin causes increased sodium flux with subsequent depolarization and persistent activation of excitable cells (Poli et al., 1989). Death is rapid, and there are no reports of discernable histopathologic changes in acutely poisoned animals. Might this account for the presence of PbTx in a menhaden recently consumed by dolphin KDL 644 (SWF-TT-B804-B) that showed no evidence of toxin in its liver?

Most of the dolphins did not die this way. They manifested an array of chronic disorders including fibrosis of liver and lung, adhesions of abdominal and thoracic viscera, and secondary microbial infections associated with immune suppression, as evidenced by histological changes in lymph nodes. We suggest that sublethal exposure to PbTx precipitated the train of events leading to some or all of these chronic changes. PbTx promotes peripheral vasodilation (Poli et al., 1989) and is cardiotoxic (Rodgers et al., 1984). As a toxic aerosol, or once absorbed, it disrupts neural control of respiration (Borison et al., 1980) and induces bronchoconstriction (Baden et al., 1982). Symptoms of poisoning in humans reflect the gastrointestinal and neurologic action of the toxin. They include nausea, vomiting, diarrhea, reversal of temperature sensation, ataxia, and numbness and tingling of extremities (Baden, 1983). A dolphin so affected would likely stop eating, eventually exhaust its blubber reserve, and thereby lose its passive buoyancy and thermal shield. The stress associated with these changes alone could set the stage for infection by the ubiquitous opportunistic organisms that were isolated from the affected dolphins. Superimposed on this, any direct neurotoxic effect of PbTx would be particularly threatening to a diving mammal.

How Were Dolphins Exposed to the Toxin?: Red tides in southeastern U.S. waters normally originate 20-75 km west of the central Florida coast in the Gulf of Mexico (Steidinger and Haddad, 1981), and generally dissipate. Occasionally, as in 1972, 1977, and 1980 (Roberts, 1979; Steidinger and Baden, 1984), they can be entrained and transported to the east coast of Florida by the Gulf Loop Current-Florida Current-Gulf Stream system. This happened in the fall of 1987, and resulted in the eventual closure of shellfish beds along the North Carolina coast; there also were reports of respiratory and eye irritation in fishermen and residents (Tester et al., 1989), yet the toxin

was found in the livers of dolphins that beached in Virginia three months before that time. They must have encountered the organisms sometime and somewhere along their northerly migration route.

In February, 1987, a *P. brevis* bloom was 25 km from a point where Gulf waters are transported to the east coast. Drift bottle data (Williams et al., 1977) suggest that a fragment could have reached the east coast by spring of that year. The possibility exists that blooms had been occurring all summer in and adjacent to the Gulf Stream, and went undetected until a filament reached the North Carolina coast in October, 1987. Such blooms would have been difficult to detect at sea, as they are not easily seen from vessels and there would have been little in the way of toxic aerosols, which are generally produced by waves and surf action in shallow waters. Planktivorous fish might have consumed the cells offshore during their migration northward, and dolphins could have obtained this toxin by eating these fish or their predators. These conditions would have exposed dolphins both directly in water, and indirectly in food, to PbTx for an extended period, with effects manifested a short time later as they reached the mid-Atlantic coast.

Brevetoxin was recovered from three yellowfin menhaden, *Brevoortia smithii*, caught off Vero Beach, Florida in late February 1988, and one unidentified menhaden taken from the stomach of a dolphin that stranded near Cape Canaveral on January 12, 1988. The finding of brevetoxin in fish at that time and place suggests that there was a persistent, undetected bloom that kept the food-web contaminated through the winter. Alternatively, the bloom that had delivered the filament to North Carolina in October 1987, had dissipated and left fish contaminated for at least three months. The first scenario challenges our understanding of the process of *P. brevis* blooms, the second of the dynamics of brevetoxin transfer in marine organisms.

In the fall of 1987, on their southerly migration, dolphins encountered the bloom off North Carolina. P. Tester (NOAA-NMFS Beaufort Laboratory, personal communication) observed dolphins surfacing in the blooms at that time. Three months later, and perhaps all along, they were feeding on contaminated fish. We believe that this second encounter with the toxin was responsible for the wave of stranded animals recovered along the Florida coast in the winter of 1987/1988; three of six dolphins examined had PbTx-2 in their livers.

Levels of PbTx in the viscera of the live-caught menhaden translate to 200 μ g of toxin per 500g fish. Using this value, a dolphin feeding on menhaden at a rate of 10 kg each day would consume 4 mg of PbTx. That is below the 6 mg/kg LD50 for mice, but if general toxicological dogma is applied, much lower doses would be required to incapacitate an animal as large as a dolphin. In fact, only 0.2 mg can cause illness in people.

Not all the dolphins were poisoned by eating fish. PbTx was found in the livers of three nursing calves. Dolphin WAM 295 (Table 1), with the highest concentration of PbTx in liver, was estimated to be less than 3 months of age. The toxin had to have been delivered in the milk, suggesting that like other lipid soluble residues, PbTx may be stored in fatty depots and mobilized along with fats as the animal draws on these reserves. There is no precedent for the finding of PbTx in milk, nor has this route of PbTx elimination been considered.

The circumstantial evidence suggests that PbTx is the most probable cause for the mortality. Contributing to the ultimate demise of the animals was a host of microbial and environmental factors. This is unlikely to have been the first time that dolphins have been exposed to the toxin. *P. brevis*

blooms regularly occur on the Gulf coast of Florida. There they are restricted geographically, in contrast to dolphins, which move about freely. The chance of encounters is therefore reduced. They do occur, and at least one other associated mortality of dolphins has been reported (Gunter et al., 1948). Because there has been no search for biotoxins in stranded animals, other poisonings would have gone undiagnosed. One might also speculate that dolphins in the Gulf of Mexico have encountered blooms often enough to associate malaise with the ingestion of toxin-containing organisms or the aerosol, and thereafter avoid contact.

The episode along the east coast obviously required that the circumstances that delivered the organisms there be coupled with the presence of carrier-fishes situated in the path of migrating dolphins. The unparalleled scope of this event would suggest that all of these conditions have been met rarely, if at all, in the past. The summer of 1987 was unusual by any measure. In North Carolina, human poisoning from consumption of fish (Bonaventura and Bonaventura, 1987) and shellfish (P. Tester, personal communication) further attest to the unusual conditions that year.

The toxin in yellowfin menhaden has relevance to human health. Though not a fish that is commercially harvested, its southern range overlaps with related species of surface-feeding planktivores that are. In this case, the toxin was present in viscera and not the flesh, thus presenting no risk to humans consuming traditionally prepared fish, or in the oils, which are extracted under conditions that should destroy the toxin (Poli, 1988). To establish whether a risk in fact exists, studies should be directed toward determining the uptake, distribution, persistence and transfer of PbTx in some representative commercially exploited species.

The discovery of PbTx in the dolphins and its previous circumstantial link to manatee deaths (O'Shea et al., 1991) lead to a new generation of thought on factors contributing to natural mortality of marine mammals. Many questions will remain unanswered until directed studies are pursued. They must include: biological toxins; studies on effects of chronic, sublethal exposure to PbTx; retrospective correlations between blooms and peak episodes of mortality; and determination of the environmental conditions that lead to the unusual event of 1987. Equally important is the need to resolve the growing question of whether contaminants at levels found in the dolphins might have affected their resilience and rendered them more susceptible either to the toxin or to the microorganisms that eventually brought them to their demise.

Editor's Note: Since the time when this workshop report was given, Dr. Thomas Lipscomb, of the Armed Forces Institute of Pathology, presented preliminary results of analyses conducted on tissues from several of the dolphins obtained from the 1987/1988 mortality event. Lipscomb *et al.* (in press) histologically examined lungs and lymph nodes from 79 dolphins that died from August 6, 1987 to April 16, 1988 along the Atlantic coasts of New Jersey, Virginia, and Florida. These tissues were tested for the presence of morbillivirus antigen by an immunoperoxidase technique. Indications of morbilliviral infection were present in 42 (53%) of the 79 dolphins examined. The results of this study will be published in the *Journal of Wildlife Diseases*, most likely in the October 1994 issue.

Table 1. Results of Brevetoxin Analysis in Dolphin Samples from the 1987/1988 Die-off.

Sample	Bioassays			HPLC	Conc ng/g
	1st	2nd	3rd		
<u>Stranded, Virginia, Aug 1987</u>					
WAM 239	+	+	+	+	93
WAM 231	+	+	+	+	83
WAM 226	+	+	+	1	
WAM 214	+	+	+	2	
WAM 219	+	+	+	2	
JGM 448	+	-			
<u>Stranded, Virginia, Sept-Oct 1987</u>					
WAM 295	+	+	+	+	15820
WAM 280	+	+	+	+	14530
WAM 296	+	+	+	+	1851
WAM 282	+	+	+	2	
CWP 273	+	-			
<u>Stranded, Florida Jan-Feb 1988</u>					
S-88-TT-51	+	+	+	+	14700
S-88-TT-57	+	+	+	+	310
S-88-TT-01	+	+	+	+	155
S-88-TT-11	+	+	+	1	
K 644	+	+	+	1	
SS-88-TT-04	+	+	+	2	
<u>Died During Capture, Virginia Beach, Oct 1987</u>					
VB-87-004	+	+	+	1	
VB-87-014	+	+	-		
VB-87-009	+	+	-		
<u>Stranded, Texas 1987-1988</u>					
C 552	+	+	+	1	
C 391	+	-			
C 575	+	-			
<u>Stranded, mid-Atlantic Coast, Aug-Nov 1988</u>					
WAM 331	+	+	-		
WAM 336	+	+	-		
WAM 340	+	+	-		
WAM 332	+	+	-		
WAM 335	+	+	-		
WAM 339	+	-			
<u>Captive Tursiops</u>					
MH82222 L21	+	+	-		
MH7408 L22	+	-			
MH7516	-				
MH79179	-				
<u>Stranded, Cape Cod 1983</u>					
MH83216	-				

¹Peak present, but did not comigrate with standard.

²No peak suggestive of PbTx.

C. The Coastal Migratory Stock - The Depleted Determination³

Introduction: In the United States, marine mammal populations are managed under the legislative authority of the Marine Mammal Protection Act (MMPA) of 1972 (as amended). The management goal defined in the MMPA is optimum sustainable population (OSP) level, which has been defined to be population levels at or greater than those that produce maximum net productivity (MNP) to the ecosystem carrying capacity. Population stocks outside of OSP (below MNP) are defined as depleted. Removal of animals (incidental bycatch, live-capture, etc.) can be legally authorized from non-depleted stocks.

Although there is considerably more information on bottlenose dolphins than most other cetacean species, for the most part, information necessary for determination of stock status relative to OSP levels is inadequate. Generally, long, consistent indices of population production and abundance are necessary to determine OSP. However, there are cases where catastrophic changes in populations can occur, thereby allowing assessment of the degree of change and status relative to OSP. The recent massive die-off of bottlenose dolphins along the east coast may be such a case.

During the summer and fall of 1987 and the winter of 1988, an apparent disease epidemic resulted in the death and stranding of an unusually large number of Atlantic bottlenose dolphins, *Tursiops truncatus*, along the U.S. east coast from New Jersey to central Florida. In response to this anomaly, a multi-agency team was formed to investigate the causes and effects of the mortality event. This paper is directed at the second component of the investigation: assessment of the effects of the mortality event.

Population Levels and Indices of Change: At the present there is no comprehensive estimate of the size of the stocks of bottlenose dolphins in U.S. jurisdictional waters. The abundance of bottlenose dolphins in certain "priority" regions has been estimated. Scott, Hansen and Burn (1988) summarized these estimates and proposed that the number of bottlenose dolphins comprising the numerous stocks throughout both the U.S. Gulf of Mexico and U.S. Atlantic waters prior to 1983 may have ranged to at least 23,000 individuals. Extrapolation of this estimate to existing abundance, however, assumes that the stocks have been stable over a period of 15 or more years and that no net migration occurred during the different sampling periods of the studies summarized. The abundance of the stock(s) affected by the apparent disease epidemic was certainly less than the total number of U.S. Gulf of Mexico and U.S. Atlantic bottlenose dolphins.

Historically, about 15,000 animals are thought to have lived in mid-Atlantic near-shore waters, based on North Carolina shore-based fishery catch records from the turn of the century (Mead, 1975). In 1979-1981, the estimated average mid-Atlantic summer abundance of bottlenose dolphins is believed to have ranged from 4,300 to 12,900 animals (95 percent confidence region), including both the near-shore and offshore groups (CETAP, 1982). The best available information suggests that in recent times, coastal North Carolina and Virginia supported 1,200 or more dolphins during part of the spring and summer (Mead, personal communication). This number may have represented a substantial portion of the mid-Atlantic coastal migratory stock prior to the disease epidemic.

³Taken from Scott et al. (1988).

Population survey data from several independent sources suggest that there was a greater abundance of dolphins near-shore in 1987 and early 1988 than in recent prior years (Keinath and Musick, 1988; Valade, personal communication). Offshore, the abundance of dolphins may have been slightly lower in August, 1987, than in the summers of 1980-1981 (Scott and Burn, 1987). The apparent increase in near-shore abundance might have been caused by immigration from the offshore stock, a real increase in the coastal stock, concentration of animals from wide geographical range, a change in the sightability coefficient for animals surveyed, or some combination of these factors.

Table 2. Summary of Coastal U.S. Atlantic Bottlenose Dolphin Strandings from January 1982 to May, 1987, Classified by Interaction Type. Data Provided by Smithsonian Institution Marine Mammal Events Program.

State	All	Fishing Gear	Parts Missing	Gunshot Wounds	Prop Wounds	Broken Bones	Other	p ¹	f ¹
MA	3	1	0	0	0	0	0	33.0	3.5-6.9
RI	1	0	0	0	0	0	0	0	0
NY	2	0	0	0	0	0	0	0	0
NJ	4	0	0	0	1	0	0	25.0	2.3-4.7
DE	1	0	0	0	0	0	0	0	0
MD	7	0	0	0	0	0	0	0	0
VA	70	8	5	0	0	1	0	20.0	1.8-3.5
NC	122	3	3	0	0	0	1	5.7	0.4-0.8
SC	9	0	0	0	0	0	0	0	0
GA	38	1	4	1	0	0	0	15.8	1.3-2.6
FL ²	129	4	3	0	0	0	0	5.4	0.4-0.8
Total	386	17	15	1	1	1	1	9.3	0.7-1.4

¹p = Percent of total strandings resulting from human actions; f, expressed as percent, represents the estimated annual human-induced mortality rate using p and the range of natural mortality rates 7-14 percent per year.

²Data for Florida represent central Atlantic and northern coastal regions only.

It is not clear if both the coastal and offshore stocks were affected by the mortality event. The size and coloration of some of the stranded animals examined suggested that both of the groups were involved (Mead, personal communication). In addition, reports received from fishermen and recreational boaters of floating carcasses in the offshore mid-Atlantic region, although not verified, further suggested involvement of the offshore group. Duffield (personal communication) analyzed 36 blood samples from different stranded and live-caught bottlenose dolphins sampled from Virginia and Florida during the mortality event. All but one of the samples analyzed exhibited the coastal hemoglobin characteristics (Duffield, Ridgway and Cornell, 1983). The single different sample exhibited hybrid coastal/offshore characteristics. This result does not necessarily imply that the offshore stock was unaffected, since the likelihood of an animal dying offshore and then being cast ashore is expected to be considerably less than that for an animal dying near the coast. There were no known animals from resident, local dolphin stocks, such as the Indian and Banana River, Florida stock, found stranded with symptoms of the disease epidemic. The best information suggests that the

observed mortality may have primarily affected the coastal, migratory stock of animals that ranges between Florida and New Jersey.

The most direct means of assessing the impact of the mortality on the dolphin populations is by comparison of consistent pre- and post-event population indices. Assessment of impact on the basis of the number of dolphins stranded relative to the population at large is dependent on assumptions about the accuracy of abundance estimates and the relationship between the stranded carcass count and the true total mortality (Scott and Burn, 1987). The number of animals observed washing ashore is likely a fraction of the total mortality. There is also some chance that the reporting rate of stranded carcasses differed between the years prior to the stranding anomaly due to increased public awareness in 1987/1988. In addition, the accuracy of absolute abundance estimates may be questionable since the estimates are usually of surface abundance unless there has been an effort to correct for animals submerged at the time of the sample.

For the offshore stock in the mid-Atlantic region, a comparison of pre-event (1980-1981) average population index, and an index based on a sample taken in August 1987, was used to assess the likely range of the impact of the mortality on the stock (Scott and Burn, 1987). The 1987 sample indicated that the impact through August was most likely small (< 10 percent) relative to the 1980-1981 summer abundance level. Because the mortality event was not complete at the time of the August 1987 sample, and due to the uncertainty about the population trajectory since 1981, this result needs further testing.

For the coastal stock of dolphins, there are no consistent pre- and post-event population survey indices yet available with which to assess potential impact. The pre-event patterns observed in areas such as the Chesapeake Bay mouth (Keinath and Musick, 1988) and Nassau County, Florida (Valade, personal communication), may be confounded by the apparent increase in abundance in 1987 and 1988. Thus, the potential impact on the coastal stock was estimated by comparison of the die-off period to prior year average stranding rates. Inherent in this estimation is the assumption that stranding rate is a consistent index of the stock mortality rate.

As of June, 1988, 742 stranded bottlenose dolphins from New Jersey to Florida's east coast were reported to the Smithsonian Institution's marine mammal stranding events program for the 11-month period from June, 1987 through April, 1988 (Mead, personal communication). In the prior 3 years, for the same geographical range and months, an average of 73.33 dolphins were reported to the stranding network. Thus, the 1987/1988 anomaly represents an order of magnitude increase (10.11 times) in reported strandings relative to the most recent 3-year historical level. Natural mortality rates on the order of 7 to 14 percent per year are believed to encompass the most likely range for bottlenose dolphin populations (Hersh, 1987c). Assuming the stock natural mortality rate (m) to be the lower end of the reported range (7 percent per year, 6.42 percent per 11 months), that the observed mortality wholly affected the near-shore stock, and further assuming that the reported stranding rate is proportional to m and consistent between years, then the observed mortality represents an 11-month m of 64.9 percent. An annual m would be slightly larger than this value if only the long-term average risk of death was applied to the final 1-month period.

The annual rate of change in the dolphin stock abundance is the difference between the annual mortality rate, annual birth rate, and annual net immigration rate. For the coastal mid-Atlantic stock of dolphins affected by the disease epidemic, Blaylock (1984) observed up to 11.5 percent of the

population sampled were calves, implying an annual birth rate (b) on that order. Data collected from stranded animals suggest that calving for this stock occurs in the spring and is not generally protracted over the year. Thus, a potential decline for this stock since early 1987 is estimated as >50 percent ($b - m = 53.4$ percent).

Table 3. Parameter Values Used in Simulations of the Dynamics of the Coastal Migratory Stock(s) of Bottlenose Dolphins.

	Symbol	Values	
Natural Mortality Rate	m	0.07, 0.14	
Human-induced Mortality Rate	f	0.0, 0.007 0.0, 0.014	$m=0.07$ $m=0.14$
Maximum Net Productivity Rate	MNP	0.02 0.04, 0.06	
Maximum Net Productivity Level	MNPL	0.6, 0.8	
Median Age at Sexual Maturity	x	8, 11, 14	

Estimates of Human-induced Mortality: The magnitude of annual removals from this stock due to incidental catch and other directed human causes is not well documented. Marine mammal stranding data provide information useful for estimating an index of human-induced mortality of cetaceans in the U.S. Gulf of Mexico and along the Atlantic coast. Many of the cetaceans that strand are examined for causes of mortality. Burn and Scott (1988) examined the stranding data provided by the Smithsonian Institution (Mead, personal communication) for evidence of human-induced mortality in bottlenose dolphins. A total of 386 bottlenose dolphins stranded from central Florida north along the Atlantic coast were reported from January 1982 through May 1987. Of these, 9.3 percent showed some evidence of human-induced mortality (p). Data from June 1987 to the present were not examined in this context because of the (then) ongoing stranding anomaly. For the range of the disease-affected coastal stock of dolphins, Table 2 lists the bottlenose dolphin strandings by state and type of purported human-induced mortality.

Assuming the classification scheme of Burn and Scott (1988) to be accurate and that the stranding data indexes human-induced mortality rate in proportion to the natural mortality rate, then estimates of human-induced mortality rates can be derived from these data. Using the range of natural mortality rates ($m = 7$ to 14 percent), the additional mortality rate due to human-related activities (f) can be estimated by these proportions ($f = m((1-p)^{-1}-1)$). Estimates of f by state and for the coastal migratory stock range are presented in Table 3. These data indicate that added mortality due to human activities may range from 0.7 to 1.4 percent per year for the coastal migratory stock of dolphins.

Optimum Sustainable Population (OSP): The OSP is defined as the range of population size from the level resulting in maximum net productivity to the ecosystem carrying capacity (K). Under the terms of the MMPA, population stocks outside the OSP range are defined as depleted. By analogy with other large animal species, the population level expected to result in MNP for bottlenose dolphins is greater than 50 percent of K (Fowler, 1981a; 1981b).

Management of bottlenose stocks has been based not on explicit determination of stock status relative to OSP, but rather on the estimated MNP for the stocks of interest. The basic assumption upon which this management method was developed was that annual MNP for cetacean stocks generally ranged from 2 to 6 percent of stock abundance. This range has been demonstrated to be biologically achievable, depending on combinations of calf and non-calf mortality rates and upon the age of first calving and calving intervals (Reilly and Barlow, 1986).

Under this management scheme, if 2 percent represents the true MNP, then a long-term average removal rate of 2 percent, in addition to natural mortality and with no net migration effect, is expected to result in an equilibrium stock abundance level at the lower end of the OSP range for stocks with initial abundance outside of OSP, an average long-term removal equal to MNP is expected to result in an equilibrium stock level below OSP. Stocks outside of OSP can be recovered to OSP while sustaining removals as long as the long-term average removal rate is less than MNP.

Estimates of Recovery: The dynamics of the mid-Atlantic coastal migratory stock of bottlenose dolphins were modeled as a difference equation with density dependence as described by the Pella-Tomlinson model routinely applied to whale stocks by the Scientific Committee of the International Whaling Commission (Allen, 1976; de la Mare, 1986). The model takes the form:

$$P_{t+1} = (P_t - H_t)S + R_{t+1}$$

where P represents the population size, H , human-induced removals, R , recruitment, and S , survival over time index t (taken as 1 year). Human-induced removals were taken as:

$$H_t = P_{t-1}e^{-m/2}(1 - e^{-f})$$

where f is the human-induced mortality rate estimate, conditioned on natural mortality rate, m . The annual survival rate, S , is taken as e^{-m} . The number of recruits, R , is defined as:

$$R_{t+1} = (1 - S)P_{t-x}(1 + A(1 - (P_{t-x}/K)^z))$$

where x is the median age at maturity (Table 3), A the resilience term, K the carrying capacity, and z the compensation term. Given a range of the relative lower limit of OSP (i.e. $MNPL$) and independent ranges of MNP and m assumptions (see Table 3 for values used), the corresponding parameter value for A was found as in Holt (1985):

$$A = MNP/m(1 - MNPL^z)$$

with the value of z found by solution of:

$$MNPL = (1/(z + 2))^{1/(z+1)}$$

The time to recovery was taken as the number of years required for the simulated stock size to reach *MNPL* after an overall reduction of 53 percent from the assumed equilibrium population level in existence just prior to the disease epidemic. Holt (1985) argues that $A > 1/(z + 1)$ results in a super compensation effect in the stock-recruitment relationship whereby the absolute number of recruits increases at declining population sizes relative to that number at *K*. However, constraining $A \leq 1/(z + 1)$ implies that the full range of assumed *MNP* cannot be realized given the range of assumed *MNPL*. As literature suggests that the *MNP* and *MNPL* ranges are biologically reasonable (Fowler, 1981a; 1981b; Reilly and Barlow, 1986), the unconstrained *A* values were used.

The distribution of population recovery times over the range of parameter values used is shown in Fig. 4 for the cases of no human-induced mortality versus constant human-induced mortality rates. The recovery time distributions are heavily skewed. In the cases of no human-induced mortality, the median expected recovery time from a reduction of the specified magnitude was 32.5 years, with a range of 14 - 90 years. In the cases where there is an assumed constant rate of human-induced mortality equal to estimates of the pre-epidemic rate, the distribution of expected recovery time is shifted to longer periods, with a median value of 50.5 years and a range of from 18 to > 100 years. For the cases including human-induced mortality, 22 percent of the simulations resulted in no recovery within a 100-year time interval. None of the trajectories simulated resulted in extinction.

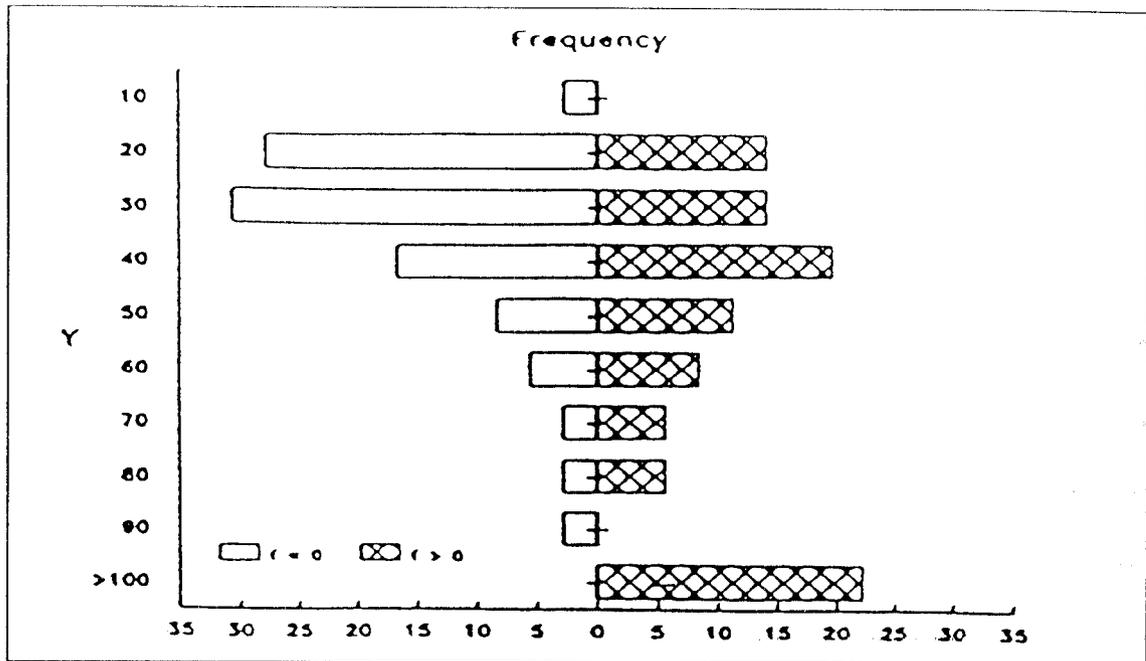
As the recovery standard used in these calculations was the lower limit of OSP, the recovery time estimates can be considered conservative. Uncertainty in the degree of reduction was not explicitly treated in the simulations run. However, parameter ranges used result in a large range of reductions from *K* and thus may reasonably reflect expectations for reductions > 53 percent. In contrast, if the true reduction was less than the specified level, then the recovery time distributions are non-conservative.

Consistent and long-term population monitoring of the affected stock will be necessary to reduce the uncertainty associated with the estimates of recovery. Assumptions about the magnitude of depletion, the degree of human-induced mortality, and the degree of involvement of other bottlenose stocks need testing via direct experimentation and monitoring. As no consistent pre-and post-event indices are yet available, development of such indices through continued and new population sampling surveys and studies of biological samples from stranded animals will be needed to test the assumptions.

D. Determination of Bottlenose Dolphin Stock Discreteness: Application of a Combined Behavioral and Genetic Approach
Randall S. Wells

Effective conservation programs require basic knowledge of the population units to be managed. Are distinct population units, or stocks, identifiable? Are the geographical ranges of these stocks known? How discrete are different stocks? Efforts to identify bottlenose dolphin stocks and to assess their discreteness in the coastal waters of the southeastern United States have been complicated by the nearly continuous distribution of these animals, and by the wide variety of ranging patterns reported for this species.

Figure 4. Frequency Distribution of Simulated Bottlenose Dolphin Population Recovery Times in Years for the Cases of $f = 0$ (No Human Induced Mortality) and $f > 0$ (Constant Human Induced Mortality Rate).



Gross distinctions can often be made between bottlenose dolphin stocks inhabiting significantly different geographical ranges. These distinctions can be based on differences in general morphology, morphometrics, or genetic factors such as hemoglobin values. Evaluation of these parameters requires handling specimens, and is usually based on examination of beachcast carcasses (usually of unknown geographic origin) or specimens caught incidentally in fisheries. Along the U.S. Atlantic seaboard, three stocks have been thus identified: the coastal migratory, the coastal resident, and the offshore (Hersh and Duffield, 1990). The level of discreteness of these stocks remains to be adequately evaluated. Within the depleted migratory stock of the Atlantic coastal bottlenose dolphin, are there finer-scale stock distinctions that might aid in conservation planning? For example, does the migratory stock consist of a single large inter-breeding unit, or are there discrete migratory stocks functioning independently of one another? Are these stocks geographically based? Are there differences in the status or prospects for recovery of each of these small units?

In the development of a conservation plan, real-time answers to the questions posed above are needed. The most effective approach would be one that made use of living members of the stocks in question, in addition to obtaining supplementary information from strandings. We have employed such an approach in defining the population structure of bottlenose dolphins along the central west coast of Florida. Using behavioral and genetic data, we have been able to identify stocks, evaluate stock discreteness, and measure vital rates (Duffield and Wells, 1986b; Wells, 1986; Wells and Scott, 1990).

Approach: Our current approach involves combining data on the ranging and social association patterns of individually-identifiable dolphins with genetic data from blood samples from many of the same dolphins. During 1970-1976, we began our individual identification efforts through a capture, tag, and release program. Thirty dolphins were tagged during 1970-1971, and 47 were tagged with vital tags and/or radiotransmitters during 1975-1976, including 11 from the earlier efforts. A number of other individuals with distinctive natural markings were photographed during this time in adjacent waters. Repeated sightings of identifiable individuals suggested that at least some of the dolphins in the area were year-round residents, and that there was a recognizable structure to their social relationships (Irvine and Wells, 1972; Irvine et al., 1981; Wells, Irvine and Scott, 1980).

Photographic-identification efforts were intensified in 1980, and are ongoing. Efforts have been expanded to include not just the Sarasota area, but also Tampa Bay, Charlotte Harbor, and adjacent Gulf of Mexico waters. Our photographic identification catalog now includes more than 1,680 dolphins. Most of these dolphins have been observed repeatedly over the years (up to 330 times each; Scott, Wells, and Irvine, 1990; Wells, 1991). In many cases, sufficient numbers of repeat sightings have been collected to allow definition of home ranges and social patterns. These data have suggested a population structure with a geographical basis.

In order to facilitate interpretation of the observed ranging and social patterns, a capture, sample, mark, and release program has been conducted since 1984. This program has provided opportunities to determine the gender, age, reproductive condition, health, body condition, morphometry, and environmental contaminant body burden, and to mark for future identification those individuals lacking individually-distinctive natural markings. The capture/release program has provided blood samples for detailed examination of the genetic structure of dolphins in Sarasota and surrounding waters. A total of 140 individuals have been sampled during the 10 years of the program. Additional genetic samples from known individuals have come from the efforts of the Mote Marine Laboratory Stranding Program.

Genetic analyses of our samples are conducted by Dr. Debbie Duffield, Portland State University, Portland, Oregon. Protein electrophoresis, chromosome banding, mitochondrial DNA (mtDNA), and DNA fingerprinting have been applied sequentially to the individual blood samples. Each technique has provided a slightly different perspective on the population structure (Duffield and Wells, 1991). Protein electrophoresis and mtdna analyses have proven useful in examining stock discreteness questions. From electrophoretic analyses, allele frequencies of three of the five polymorphic red blood cell enzymes examined have been considered informative in evaluating differences. Four different mtdna haplotypes have been identified; two of these may be area-specific. Chromosome banding and DNA fingerprinting have been used to define the genetic structure within stocks.

Results and Discussion: Observational studies over the last 23 years indicate a year-round resident population unit of about 100 dolphins in Sarasota Bay, Florida. The distribution of resightings indicates a very long-term, well-defined home range, occupied by the same individuals year after year. The frequency of associations between individuals sharing the waters of the home range suggest a social as well as a geographical basis to the structure of the population unit. A genetic basis to the structure is indicated by the observational tracking of maternal lineages through at

least three generations within the home range. Chromosomal and mtDNA analyses indicate a multi-generational association between members of different maternal lineages.

Observations of distinctive individuals further indicate the existence of similar home range and social patterns in adjacent waters to the north and south. The result is a mosaic of overlapping, long-term home ranges. Distinctions in individual membership in different adjacent population units can be made on the basis of differences in enzyme allele frequencies, mtDNA haplotypes, ranging patterns, and frequencies of social associations.

Behavioral and genetic data both indicate that while most of the activities of the members of each of the different population units take place within their own home range; these units are not socially nor reproductively isolated from one another. Observations of occasional temporary movements of males and, to a lesser extent, females between adjacent population units suggest a mechanism that could explain the preliminary results of paternity tests suggesting some amount of genetic exchange between these units. Thus, these population units should be considered to be communities, rather than totally discrete populations. Each community has its own long-term structure and integrity, but some interbreeding occurs with other communities (Duffield and Wells, 1986; Wells, 1986b; Wells, Scott, and Irvine, 1987).

The dolphin communities appear to be extremely stable over time. Calves observed to be born into the Sarasota community have remained there throughout their lives. Individuals now 30-50+ years old have been observed in the community for the last 18-25 years. Permanent immigration and emigration occurs at very low rates. Anecdotal information on the stability of community structure comes from the reintroduction of two bottlenose dolphins, Misha and Echo, back into their native Tampa Bay waters in 1990 after two years in captivity. Both were released into Misha's original home range. The animals remained tightly bonded to one another through the first few months following release, and interacted with the other residents of the range. Within six months, however, Echo left Misha's range, and returned to his own adjacent, original home range, where he has since remained, associating with the same individuals he was with prior to capture (Bassos, 1993). In another example, dolphins residing in the waters off San Diego shifted their range northward several hundred kilometers in association with an El Niño warm water incursion. Several of the dolphins have been observed together in both regions, suggesting social stability even in the absence of site fidelity (Wells and Scott, 1990). The possibility of transience involving some of the members of our photographic-identification catalog is being examined, but it is clear that community residency is a very strong feature of the population structure of bottlenose dolphins along the central west coast of Florida, and perhaps in other parts of the species' range as well.

The well-defined structure and the long-term stability of communities suggest that, where they exist, communities might serve as biologically meaningful management units.

Recommendations: In order to design effective conservation plans and understand the potential implications of the plans, it is recommended that a program be implemented to define that structure of the population units comprising the "migratory stock of the Atlantic coastal bottlenose dolphin". The components of such a program might include:

- Large-scale photographic-identification efforts, building upon existing efforts, and filling gaps in coverage (spatial and temporal) along the Atlantic seaboard;
- coordinating the photo-ID programs to standardize level of effort, methodology, and to ensure timely and accurate comparisons of dorsal fins across individual efforts;
- establishing a program for processing genetic samples from stranded dolphins. Fresh blood and heart muscle should be collected whenever possible.
- coordinating stranding program and photo-ID project efforts to track the fates of known individuals, and to obtain data on the genetics, gender, age, and reproductive condition from stranded dolphins that can then be disseminated and applied retroactively to observation records to facilitate interpretation of population unit structure. A catalog-quality photograph of the dorsal fin of each stranded dolphin must be a top priority for this to be effective.
- initiating capture, sample, mark, and release programs, where it can be done safely, with follow-up monitoring of marked individuals. The use of telemetry would greatly enhance the quality and quantity of the data collected.

E. Recognizing Two Populations of Bottlenose Dolphin, *Tursiops truncatus*, off the Atlantic Coast of North America: Morphologic and Ecologic Considerations
James G. Mead and Charles W. Potter

This study is part of an on-going project concerned with the life history of the bottlenose dolphin in the northwest Atlantic. Mead and Potter (1990) published the results of 15 years' work in which the authors speculated on the existence of two or more populations. True (1891) spoke of 12-foot specimens that were taken in the fishery for *Tursiops* at Cape Hatteras, North Carolina. Mead and Potter (1990) hypothesized that those animals might represent a population of larger *Tursiops*, since the modal length of coastal *Tursiops* was about 9 feet.

Tursiops has long been recognized as an exceedingly variable taxon. A glance through the Catalog of Living Whales by Hershkovitz (1966) reveals 24 nominal taxa referred to as *Tursiops*. Detailed studies of particular geographic localities have often revealed two forms present, usually differentiated by their distribution (offshore versus coastal).

At first, we [Mead and Potter] were unable to differentiate the two populations in our mixed sample of stranded animals. It was only when we obtained access to specimens that had been taken offshore in fisheries operations that we managed to isolate the morphometric factors that allowed separation of individual specimens.

Based on a sample of 105 animals (33 offshore and 72 coastal), we found that the following relationships (Fig. 5) between the relative diameter of the internal nares, compared to either

condylobasal length (Fig. 6) or zygomatic width, are greater in the offshore specimens of western North Atlantic of *Tursiops*:

Condylobasal length vs internal nares width

$$NW = 0.129 \text{ CBL} + 0.84$$

Zygomatic width vs internal nares width

$$NW = 0.202 \text{ ZW} + 1.85.$$

If the observed value is higher than this, the specimen is an offshore animal. This difference allows separation of all specimens and is more pronounced in young animals. Between the late summer of 1987 and May 1988 at least 742 bottlenose dolphins were found dead along the east coast of the United States from New Jersey to Florida.

Other Differences between coastal and offshore *Tursiops*: The offshore specimens are generally larger, and are infected with the parasites *Phyllobothrium*, *Monorhynchus*, and *Crassicauda* (Table 4). These parasites have life histories that make them useful as biological tags. The coastal specimens are smaller and have none of these three parasite species, but do have chronic pancreatitis.

The offshore specimens also have stomach contents comprised of pelagic squid and fish (also see Barros and Odell, this report). The coastal specimens have mainly three species of fish of the family *Sciaenidae* in their stomachs. Squid are very rarely found in the stomachs of coastal animals and, when they are, they are of the coastal genus *Loligo* (but see Barros, 1993).

Hersh and Duffield (1990) did a study of morphometrics, comparing samples of Indian River, Florida, coastal individuals with specimens determined to be offshore animals by the presence of two hemoglobin types. They determined a number of characters in both the skull and external measurements where the offshore and coastal forms appeared to differ. Their sample of offshore animals was sufficiently small (2-4) to preclude statistical verification. They also made the anecdotal observations that the offshore forms tended to be larger and darker than the coastal forms.

Hersh and Duffield (1990) hypothesized that the offshore forms dove deeper than the coastal forms and that the differing structure of the hemoglobin facilitated that. Our finding of relatively greater narial diameter in offshore specimens would also seem to indicate an increased respiratory function.

The 1987 dolphin mortality began to increase during the late summer along the east coast of the United States. This increased mortality extended from New Jersey to Florida and lasted until May 1988. During that time period at least 742 animals were found dead. Preliminary assessments concluded that this mortality was limited to the coastal population (Scott et al., 1988). Our findings confirm this conclusion (Table 5).

Table 4. Characterization of Inshore vs. Offshore Forms of Bottlenose Dolphin Found along the U.S. Atlantic Coast.

	Distribution	Modal Length	Parasites and Commensals
COASTAL	Within 2 miles of the coast Seasonal distribution to New Jersey	250-260 cm	<i>Braunina</i>
OFFSHORE	Mid-shelf to Shelf-Shelf-edge, and northern edge of Gulf Stream	290 cm	INTEGUMENT- Phyllobothrium (6%) No <i>Penella</i> or cyamids DIGESTIVE SYSTEM- <i>Braunina</i> (83%), c.f. <i>Campula</i> (55%) ABDOMINAL- <i>Monorhagma</i> (8%) CRANIAL AIR SINUSES- <i>Nasitrema</i> (50%), <i>Crassicauda</i> (27%), <i>Stenurus</i> (5%) APPENDAGES- <i>Xenobalanus</i> (65%) <i>Platylepas</i> (2%)

Table 5. Ratio of Coastal to Offshore Forms of Bottlenose Dolphin Prior to, During, and Following the 1987/1988 Die-off (Preliminary Results), Based on Cranial Measurements.

Time-Frame	Sample Size		Ratio
	Offshore	Coastal	
05/31/87 (pre-die-off)	21	99	0.2121
06/01/87 - 04/31/88 (during die-off)	1	146	0.0068
01/05/88 (post-die-off)	6	22	0.2727

pre 1987/post 1988 -- Chi squared = 0.4786, probability = ca. 0.500
 pre 1987/1987-1988 -- Chi squared = 22.63, probability < 0.005

Figure 5. Mathematical Relationship Between Internal Nares Width and Condylbasal Length (cm) for Western North Atlantic Populations of Bottlenose Dolphin, *Tursiops truncatus*.

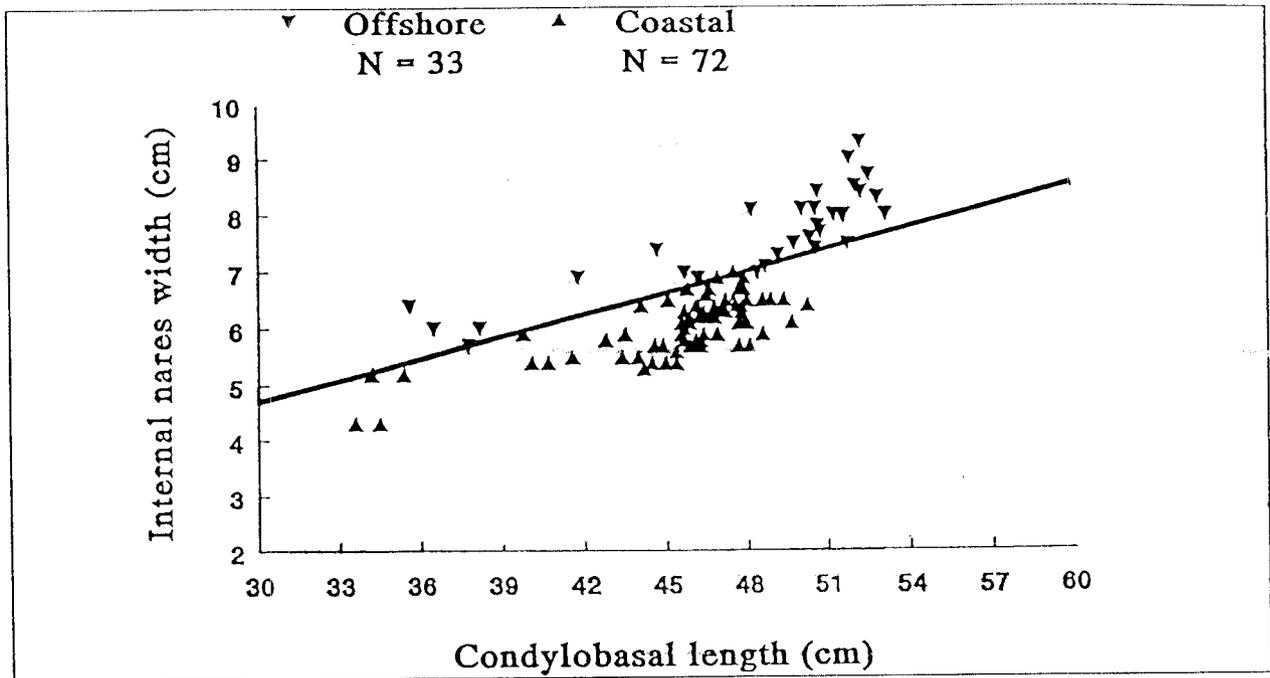
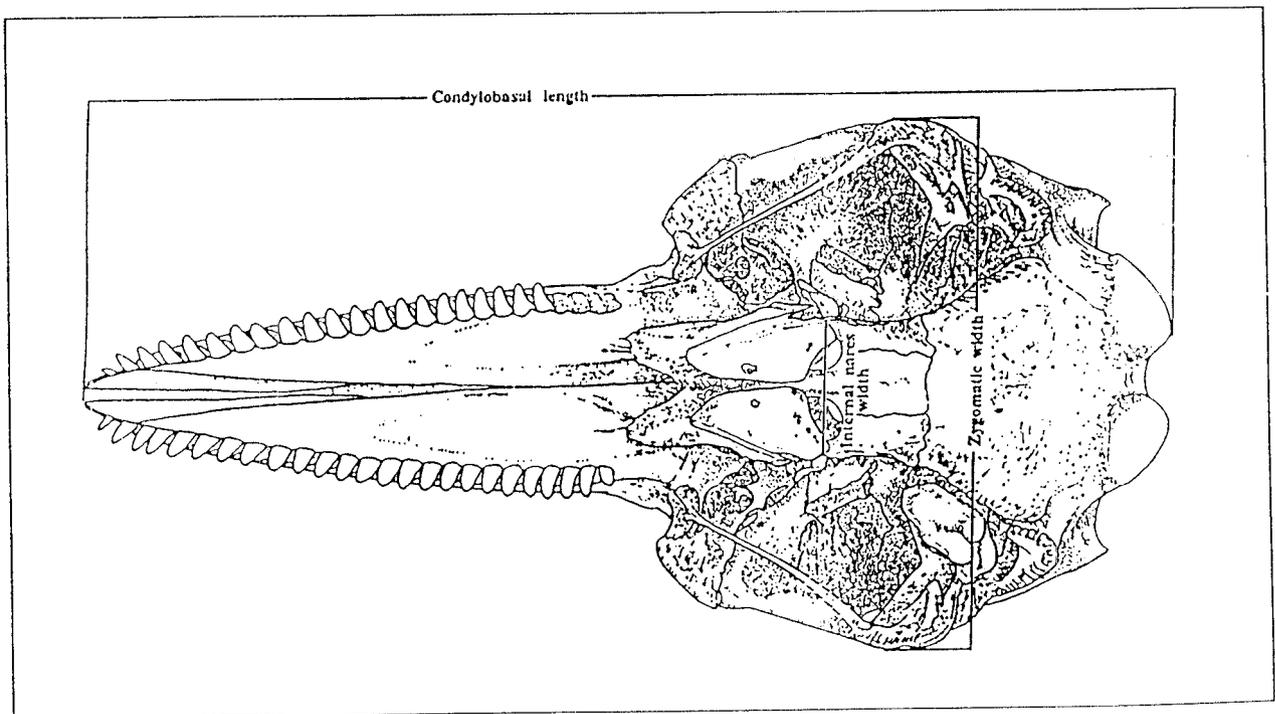


Figure 6. Diagrammatic Representation of a *Tursiops* Skull.



STATUS OF RESEARCH AND/OR MANAGEMENT PROGRAMS THAT MONITOR COASTAL BOTTLENOSE DOLPHINS

A. Surveys of U.S. East Coast Bottlenose Dolphin Abundance Larry Hansen

Surveys of bottlenose dolphin abundance in U.S. east coast waters have been conducted by a number of different groups. Most of these surveys were aircraft-based, and utilized strip- or line-transect methods to estimate densities of bottlenose dolphins. This review covers both large-scale surveys which covered most or perhaps all of the coastal migratory stock's seasonally fluctuating range, and localized surveys which were conducted within a smaller portion of the stock's range.

Large-Scale Surveys: The first large-scale aerial survey of cetaceans on the U.S. east coast, including bottlenose dolphins, was the Cetacean and Turtle Assessment Program (CETAP), which was conducted by the University of Rhode Island under contract to the Department of the Interior (CETAP, 1982). The study area covered waters from Cape Hatteras, North Carolina, north to the Gulf of Maine, and included water from the shoreline out to about the 1000 fathom isobath, but did not include bays or sounds. These surveys were conducted each season during the period 1979-1981. Shipboard observations were also collected during the study, but only the aerial survey data were used to estimate animal abundance.

The CETAP surveys indicated that bottlenose dolphins had a distinct J-shaped distribution within the study area. This distribution consisted of an elongate portion along the 1000 fathom isobath, and a shorter distribution nearshore. Available evidence indicates that these distributions represent two stocks of bottlenose dolphins, with the nearshore group being the coastal migratory stock. Estimates of abundance within the study area varied from a spring high of 8,603 ($\pm 4,307$, 95 percent Confidence Interval, CI) to a winter low of 1,295 ($\pm 1,633$, 95 percent CI). The animals that were found in nearshore waters represented a fraction of the overall sightings, and the abundance estimates for this coastal distribution varied seasonally from 0 during the winter to a high of 378 (± 723 , 95 percent CI) during the summer. Spring and fall estimates of the nearshore distribution (202-520, 315-787, respectively) were not much different from the summer estimate.

The CETAP surveys were replicated during the fall of 1991 by NMFS. Preliminary analysis of the 1991 survey indicates that sightings of bottlenose dolphins were infrequent. Consequently, the resulting density estimates will likely be low for both the nearshore and offshore distributions, with high coefficients of variation (CV).

A second large-scale survey was conducted seasonally for one year during 1982-1983. This survey, termed the Southeast Turtle Survey (SETS), was conducted under contract to NMFS. The survey was flown primarily to provide sighting data for estimation of sea turtle abundance, but survey methodology was consistent with that for the CETAP surveys (including recording of data on cetaceans). The SETS study area covered waters from Key West, Florida, north to Cape Hatteras, North Carolina, and included waters from the shoreline out to approximately the western wall of the Gulf Stream. Bays and sounds were not surveyed during this study.

An analysis of the SETS data indicates that bottlenose dolphins were distributed continuously from shore out to the offshore edge of the study area. Although the dolphins were continuously

distributed (in comparison to the highly disjunct distribution observed north of Cape Hatteras), sighting density was greater nearshore. Figures 7-10 illustrate the sighting density by season, and show that the distribution of bottlenose dolphins was centered around northern Florida during the winter, was intermediate during the spring and summer, and shifted to the Carolinas during the fall.

The winter SETS survey was replicated by NMFS during 1992. A preliminary analysis of this survey and the 1983 winter survey indicates that the overall density estimates are not dissimilar between the surveys. However, the overall estimates likely include bay, nearshore, and offshore stocks. Finer-scale estimates possibly representative of stocks, may be derived by post-stratification. The finer-scale estimates may show change by stock, whereas the overall estimates may not. For instance, a stock may represent only a small portion of the overall population, or a negative change in one stock may be offset by a positive change in another.

Localized Surveys: NMFS sponsored aerial surveys to estimate abundance of bottlenose dolphin in Helena Sound, Port Royal Sound, and the mouth of the Savannah River (Hansen and Scott, 1989). This area was surveyed seasonally for one year during 1982. Most of the survey effort was directed at the inshore waters within the sounds, but a nearshore transect was included, located approximately 1 km off and parallel to the Atlantic coastline.

Density estimates were calculated for the inshore waters but not for the nearshore transects because of potential but unmeasured biases. Density estimates were highest for summer and lowest for winter, with abundance varying from 173 (120-226, 80 percent CI) to 103 (67-139, 80 percent CI). Seasonal density estimates were not significantly different, using non-overlap of 80 percent CI as criteria for significant difference. The mean number of dolphins counted in the nearshore zone per flight by season was lowest in the spring (13.3, range 0-44) and winter (20.7, range 0-44), and highest in the summer (48.0, range 16-95) and fall (47.3, range 20-91).

NMFS sponsored localized seasonal aerial surveys of the Indian/Banana River, Florida area, for one year during 1979-1980. This area was also surveyed by vessel in the mid-1980s, and more recently, with a five-year series of seasonal aerial surveys sponsored by NMFS from 1988-1992 as part of a long-term, bottlenose dolphin monitoring program. The abundance of dolphins in the area has been estimated to be about 200-400 animals. Estimates from the most recent surveys are not yet available.

Other Surveys: Additional aerial and vessel surveys of bottlenose dolphin abundance have been conducted along the U.S. east coast, but in areas that likely are outside of the coastal migratory stock's range. These include one-year, seasonal surveys of an approximately 25,000 km² rectangular block immediately south and offshore of Cape Canaveral, Florida, conducted during 1980-1981 (Fritts et al., 1983), sponsored by the Department of the Interior. The majority of the survey block was in waters greater than 200m deep. Bottlenose dolphins were sighted during all seasons of these surveys, but only in the more shallow side of the relatively small, offshore survey block.

Large vessel surveys of primarily offshore U.S. east coast waters from Miami to Cape Hatteras were conducted by NMFS during the winters of 1985 and 1991. These surveys extended out to the western wall of the Gulf Stream. Bottlenose dolphins were sighted throughout the survey areas. Estimates of density cannot be calculated from the 1985 survey, and are not yet available for the 1991 survey.

Figure 7. Distribution and Relative Abundance of Bottlenose Dolphins, *Tursiops truncatus*, Sighted During the SETS Aerial Surveys in the Southeast U.S., Spring, 1982.

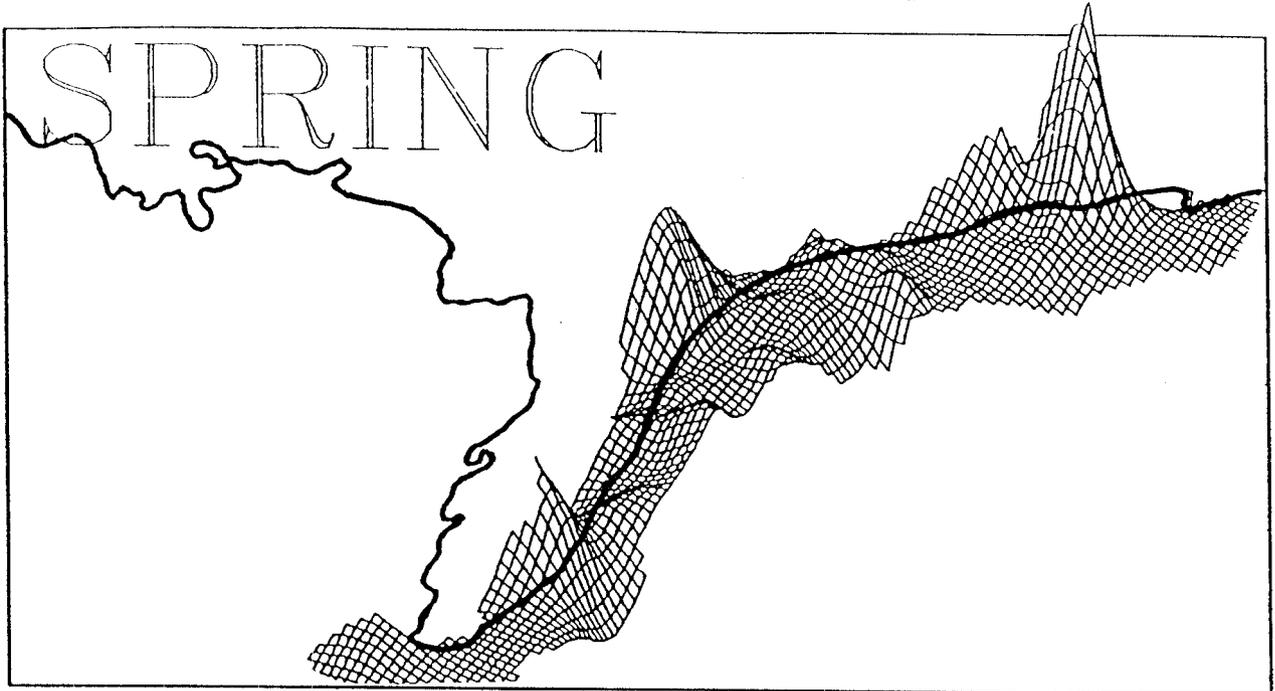


Figure 8. Distribution and Relative Abundance of Bottlenose Dolphins, *Tursiops truncatus*, Sighted During the SETS Aerial Surveys in the Southeast U.S., Summer, 1982.

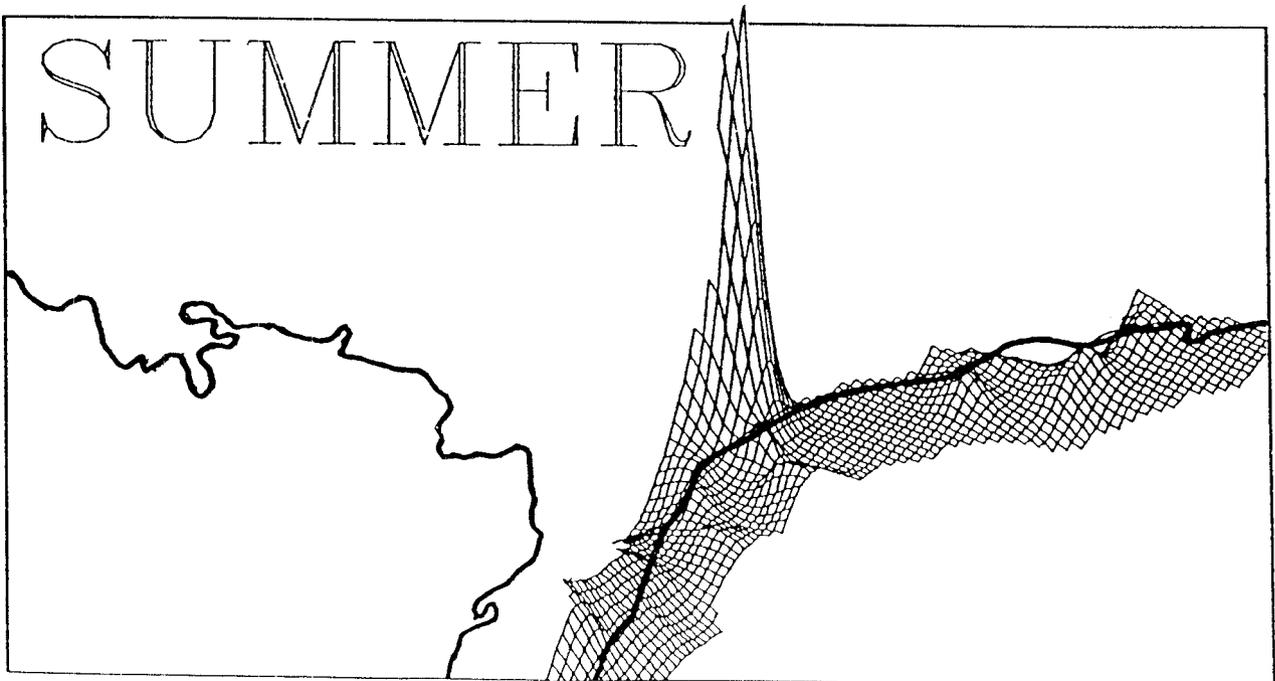


Figure 9. Distribution and Relative Abundance of Bottlenose Dolphins, *Tursiops truncatus*, Sighted During the SETS Aerial Surveys in the Southeast U.S., Fall, 1982.

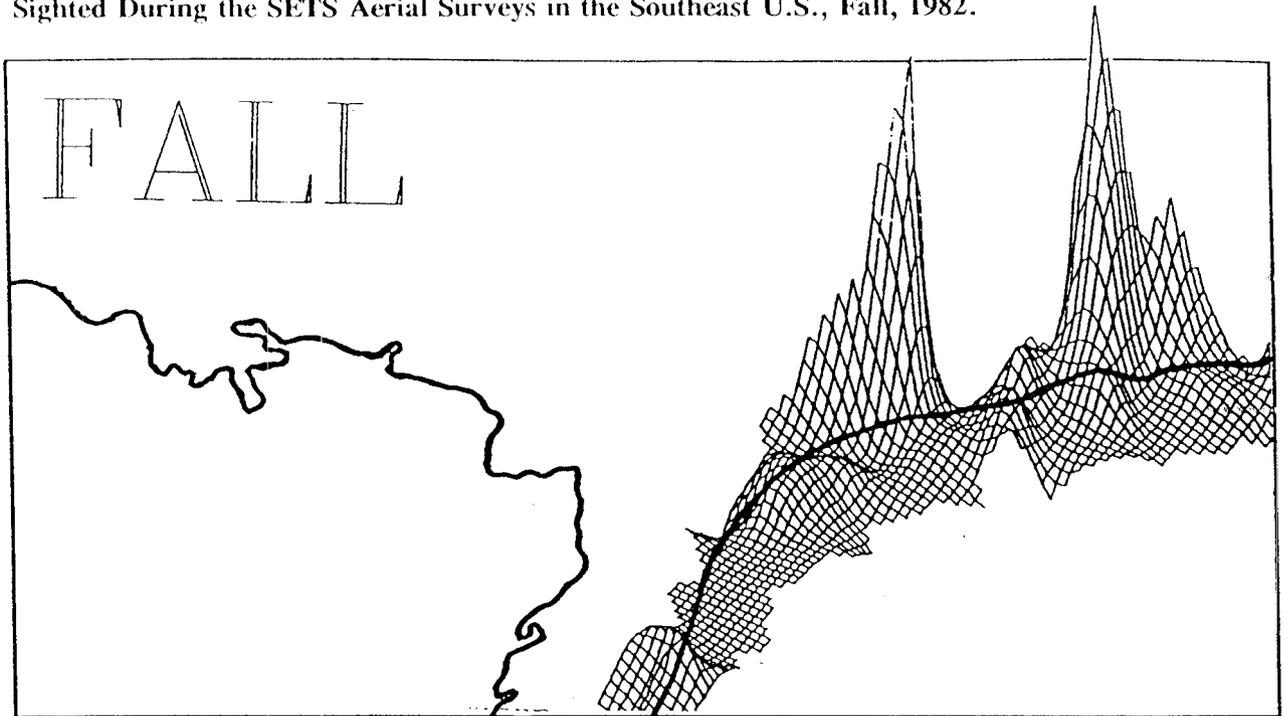
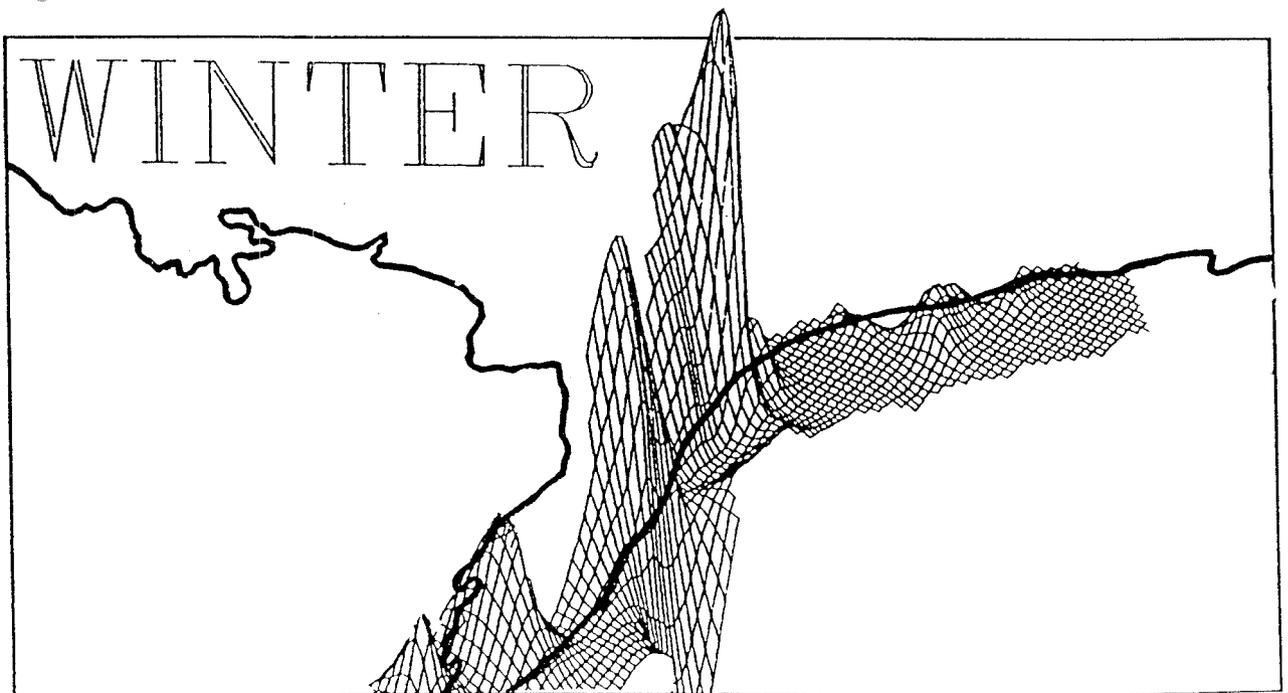


Figure 10. Distribution and Relative Abundance of Bottlenose Dolphins, *Tursiops truncatus*, Sighted During the SETS Aerial Surveys in the Southeast U.S., Winter, 1983.



B. Research/Management Programs and Stranding Networks in Coastal Atlantic Waters (by State)

New Jersey (Dave Jenkins): Bottlenose dolphins are present in New Jersey coastal waters and the mouths of estuaries from late spring to early fall (approximately May through September, when water temperatures exceed 60°F). Based on evidence from strandings, New Jersey waters are apparently used to some degree as calving and nursery areas.

In 1993, the New Jersey Marine Mammal Stranding Center (MMSC) participated in the July 10 multi-state dolphin count, in which volunteer observers were stationed at 1-mile intervals along the coast, at land-based observation posts.

The MMSC responds to strandings and also runs a sighting hot-line. Reports include sightings in general, and in back bays in particular.

Prior to the 1987/1988 die-off, recovered bottlenose dolphin strandings averaged about 2 per year. Since that time, the numbers have increased to 6-12 per year. It is not known whether this increase is due to greater awareness of dolphin strandings (and the need to report them) since the die-off, whether the dolphins have started coming in closer to shore, whether there has been an increase in fisheries interactions, or whether there is some other explanation (or some combination of these factors).

In 1992, there were 6 bottlenose dolphin strandings reported to the MMSC. Five were in Atlantic County (Brigantine or Atlantic City), and 1 was in Delaware. Three appeared to be boat hits, 1 was attributed to complications with calving, and the other 2 died of unknown causes.

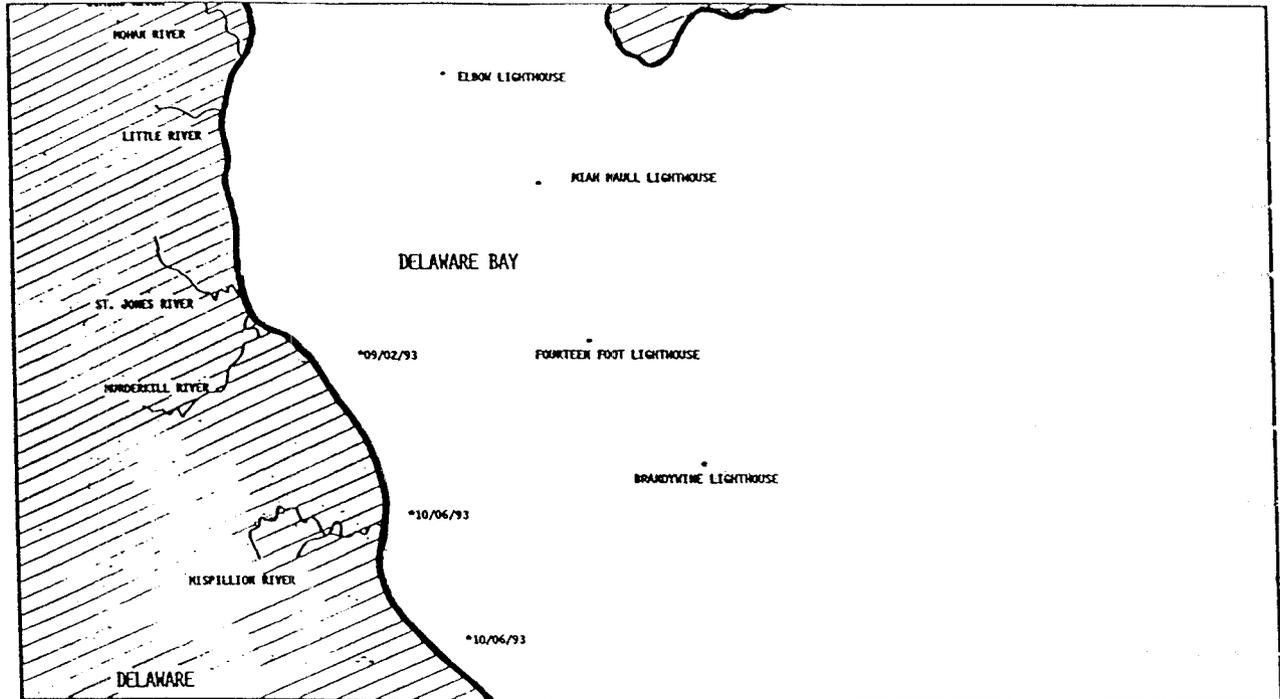
In 1993, there have already been 6 *Tursiops* strandings to date. Four of these were in Cape May County, 1 was in Ocean County, and 1 was in Atlantic County. Five of these died of unknown causes, and 1 was a newborn, or possibly stillborn.

More detailed information on strandings in New York or New Jersey may be obtained by contacting the Marine Mammal Stranding Center, Brigantine, NJ.

Delaware (Leon Spence): Currently, Delaware does not have an Atlantic bottlenose dolphin monitoring program, although we do have an organized stranding network. In the past, marine police were responsible for responding to stranded marine mammals and sea turtles. A call-list was established in 1986, in order to notify state officials and other organizations interested in obtaining data and tissue samples. Dates and locations of bottlenose dolphin strandings along Delaware's Bay and Atlantic coastlines are presented in Figure 11.

Although Delaware does not have a dolphin monitoring program at this time, it is hoped that a program will soon be initiated. The Delaware Division of Fish and Wildlife currently conducts small-boat surveys for crabs and other fisheries. We hope to incorporate marine mammal sightings

Figure 12. Dates and Locations of Bottlenose Dolphin, *Tursiops truncatus*, Sightings in Delaware Bay, 1993.



into this program. A few sightings have already been recorded (Fig. 12). All ideas and expertise in getting such a program underway would be appreciated.

At this time, all strandings are handled through the endangered species program, although sometimes fisheries personnel respond. All data and any tissues collected are managed by the marine mammal and reptile stranding coordinator.

Maryland (Dave Schofield): Three years ago, the National Aquarium in Baltimore (NAIB) implemented a Marine Animal Rescue Program (MARP). Through a Letter of Authorization with NMFS, MARP has responded to live strandings in Maryland, Delaware, and Virginia. Over the past year, this program has slowly become more involved with dead strandings than with live sightings. Working closely with the Maryland Department of Natural Resources (MDDNR), we have received reports of dolphins and humpback whale sightings in the Chesapeake Bay area. The MARP staff has, over the past year, provided the U.S. Coast Guard stationed at Ocean City, Maryland, the Ocean City Beach Patrol, and the Delaware Fish and Wildlife Department with stranding and sighting information. Since this effort was implemented, we have had overwhelming support from the Maryland agencies on sighting and stranding reports. In the future, these institutions will continue to provide valuable information required for a more accurate evaluation of the distribution and abundance of marine mammals in our area.

The MARP is interested in becoming involved in annual coastal migratory dolphin counts in the summer of 1994. At the disposal of NAIB is a strong volunteer program (500+ volunteers), an

active conservation program with a conservation coordinator, and the support of special agencies as well as a volunteer air flight service for surveys.

The MARP suggests that NMFS provide the methodology for the survey. We need input on how data should be recorded and reported to best be interpreted by NMFS. Guidelines for survey dates, locations, and methods will help ensure consistent information. The MARP will work with the Marketing and Development Departments at the NAIB to acquire public and private support to assist in the coordination of this survey program.

Sightings of Bottlenose Dolphin in the Chesapeake Bay: The most notable sighting of a bottlenose dolphin that involved MARP was that of a lone dolphin in the upper Chesapeake Bay. This dolphin was observed on a weekly basis from May to mid-July 1992, and occasionally until September, when the sightings stopped. This dolphin was found in the Miles and Wye rivers of the Eastern Shore of Maryland. In some instances this animal was seen in tributaries and creeks of these rivers that were as shallow as three feet with salinities of 10 to 15 parts per thousand (ppt).

The Maryland DNR often took MARP Staff and volunteers out to observe this animal's behavior. The MARP has video and photo-ID cataloged for future reference. Various behavior reports were submitted from MARP volunteers, Maryland DNR, and locals who observed this dolphin swimming near their private docks. It was particularly interesting that on several occasions, different groups of animals numbering from 4 to 7 would come in close proximity to this lone animal for various lengths of time, but with no apparent association.

Current Level of Stranding Response: To provide care for stranded animals, the MARP has a 98,500 gallon quarantine/hospital pool, and a medical laboratory and treatment room. To date, MARP has released two harbor seal pups and an injured sea turtle back into the wild. Our hospital area has housed a juvenile pilot whale, *Globicephala*, from Virginia, a striped dolphin, *Stenella coeruleoalba*, from New Jersey, a pygmy sperm whale, *Kogia breviceps*, from New York, and harbor seals, *Phoca vitulina* from the New England Aquarium in Boston, Massachusetts. Over this past year, MARP has also acquired an off-sight facility to provide more space for stranded animals. This area will act as a pre-assessment area before animals are brought to the quarantine/isolation pool area. The MARP has averaged 10-15 live marine animal responses per year.

The Maryland Department of Natural Resources Marine Mammal Stranding Program (Joyce Evans and Frances Cresswell): The Marine Mammal Stranding Program was developed under the Tidewater Administration Fish Health/Disease Unit located at the Cooperative Oxford Laboratory in the fall of 1990. The Maryland DNR (MD DNR) Natural Resource Police maintain a 24-hour toll-free line (800/628-9944), and contact us when they receive calls concerning marine animals. Through the end of August 1993, our organization had responded to a total of ninety-one stranded marine animals, including cetaceans, seals and sea turtles. Fifty-three of these strandings were marine mammals, of which fifteen were *Tursiops*.

Figure 13 depicts the Maryland coastline and the location of *Tursiops* strandings. Approximately half of Maryland's Atlantic coastline is part of Assateague Island National Seashore and State Park. Park rangers patrol the area every day and report any strandings to us. The rest of Maryland's coastline contains Ocean City. Procedures for reporting strandings in Ocean City are

more complicated, as here there are city police, the Coast Guard, Natural Resource Police, the beach patrol and the Humane Society - all of whom work with us on the reporting and recovery of strandings.

Strandings: There were two bottlenose dolphin strandings reported in 1990, two in 1991, five in 1992, and six in 1993 (through the end of August). The increasing numbers of strandings may be due to the network becoming more established and publicized. The greatest number of bottlenose dolphin strandings occurs in the spring (mid-May to early June), with another pulse in mid-August through September. There have also been occasional strandings throughout the remainder of the year: one animal in January, one in July, and one in October. A breakdown of bottlenose strandings by year is presented in Table 6. For 8 of the *Tursiops* we necropsied, the cause of death could not be determined. Of the 7 bottlenose dolphins for which the cause of death could be determined, three were fisheries-related and four were disease-related (Table 7).

Only one animal has been known to strand within the Bay (it had gone far up a tributary, Figure 14). This is of interest to a conservation plan, since the lack of strandings in this area may indicate a lower incidence of disease in this particular segment of the population, or it may be attributable to the fact that fishing gear regulations differ between the ocean and bay waters. Alternatively, the lack of reports may simply be because the recreational boaters and vacation homeowners in the Bay area have not been educated about the need to report strandings. In an effort to inform the public of our work, posters are being published for the Maryland, Delaware and Virginia stranding networks.

Stranded marine mammal specimens are photographed as part of data collection and documentation. Morphometric data are collected to the extent that the condition of the animal will allow. Tissues for toxicology, histology, virology and bacteriology are also taken from fresh specimens. Gonads, stomach contents and skulls from each bottlenose dolphin are stored for the Smithsonian. Our tissue request list is referred to, and researchers are contacted to clarify sample handling methods and to arrange for transport. In this way, we try to maximize the information obtained from each stranding event. A database which includes species, sex, geographic location, probable cause of death and samples collected has been created for the stranding network.

Sightings: The Chesapeake Bay comprises a significant portion of Maryland's marine and estuarine habitat. Dolphins, sea turtles and occasionally humpback whales are all sighted in the Bay. In the Chesapeake Bay, sightings of live bottlenose dolphins usually occur in late spring (May) through fall (September). Although most sightings occur below the Bay bridge and in various tributaries, dolphins are sighted as far north as the Magothy River and Prospect Bay.

Along the coast, bottlenose dolphin sightings seem to follow the same temporal patterns as those in the Bay, except that here, *Tursiops* have also been observed over the winter months (December and January).

In general, we are receiving more sighting reports from the Chesapeake Bay each year. Some plausible explanations follow:

- 1) There is now (since 1990) an agency to receive reports of such sightings;
- 2) increasing public awareness along the Bay may increase sighting reports;
- 3) perhaps these animals are barometers of changing or improved conditions in the Bay (i.e. increased food supply and/or better water quality).

Figure 13. Strandings Responded to by the Maryland DNR Stranding Network, September 1990-June 1993.

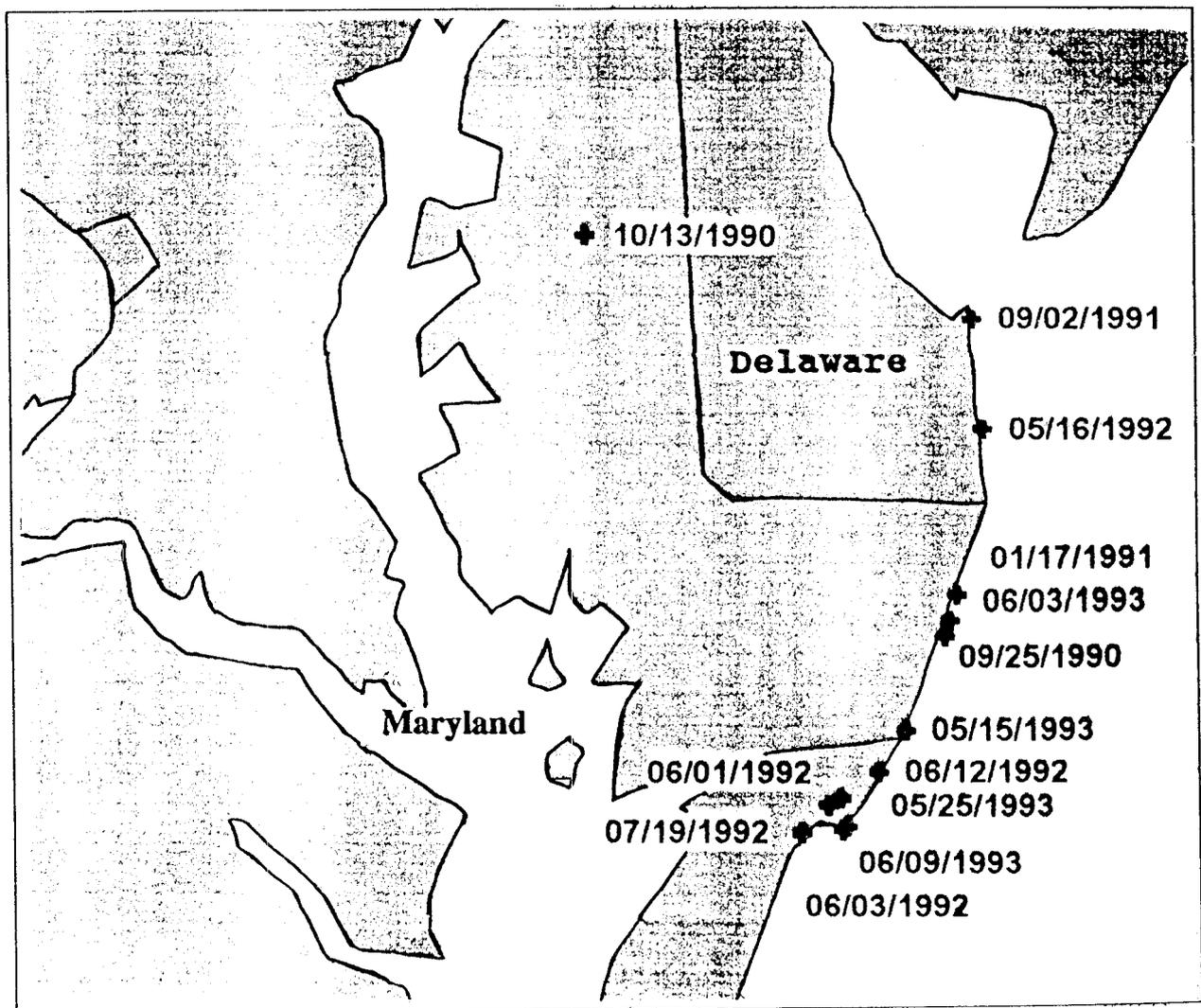


Table 6. Bottlenose Dolphin Strandings Reported in Maryland, 1990-1993

	1990	1991	1992	1993	Total
Winter	0	1	0	0	1
Spring	0	0	4	4	8
Summer	0	1	1	2	4
Fall	2	0	0	0	2
TOTAL	2	2	5	6	15

Table 7. Probable Causes of Dolphin Mortality in Maryland, 1990-1993

	1990	1991	1992	1993	Total
CAUSE					
Unknown	1	1	3	3	8
Disease	1	1	0	2	4
Fishery Interaction	0	0	2	1	3
TOTAL	2	2	5	6	15

Virginia (Mark Swingle): What Do We Know About Coastal Bottlenose Dolphins in Virginia?: Bottlenose dolphins, *Tursiops truncatus*, arrive in Virginia waters generally somewhere between April 15 and May 15, moving from south to north as ambient water temperatures increase. The dolphins depart Virginia waters between October 15 and November 15, moving from north to south as water temperatures decrease.

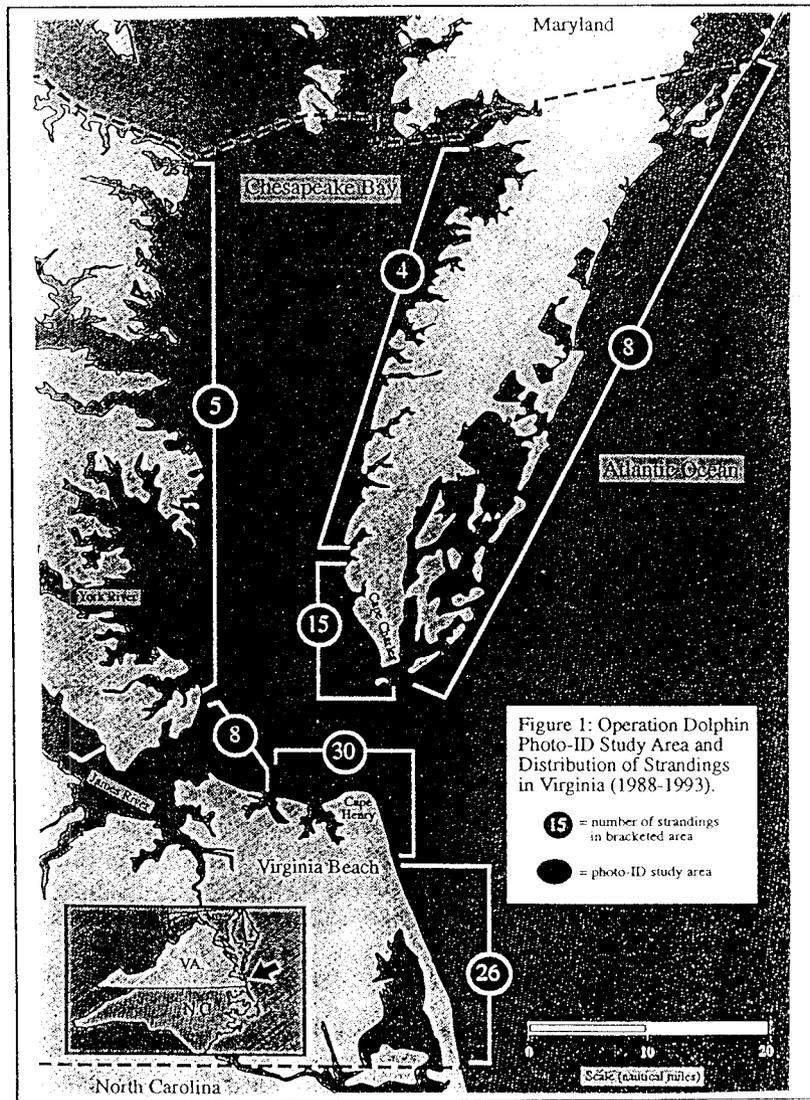
Large, tight groups of 25-100 dolphins have been sighted in Virginia coastal waters within 1.5 km of shore in January and February. It is unknown whether these animals represent an inshore movement of the offshore population, or remnant, isolated cases of the coastal migratory stock.

There are no true year-round resident dolphins in Virginia. A limited photo-ID study conducted in 1980-1981 (Blaylock, 1984) suggested that at least some dolphins returned to Virginia waters in successive years. Much more extensive photo-ID work was carried-out by the Virginia Marine Science Museum (VMSM) in 1989. This study yielded much valuable information about bottlenose dolphins. For example, we now know that a number of coastal dolphins return annually to Virginia waters. Some dolphins have been sighted since 1989 and some individuals are associated

with the same dolphins from year to year. One dolphin sighted in 1993 had a red tag in the dorsal fin which matched the description of dolphins captured and tagged in Virginia Beach during the 1987 die-off (McLellan, pers. comm.).

Early results of analysis of the Virginia dolphin photo-ID catalog indicate that bottlenose dolphins are moving north through Virginia waters in spring, and south in fall. Individuals have been sighted in spring and fall, but not mid-summer, suggesting that they are not spending the summer season in Virginia but rather, probably somewhere further north. Other groups of dolphins appear to spend the summer season in Virginia waters, with concentrations of them occurring around the Chesapeake Bay mouth.

Figure 14. Operation Dolphin Photo-ID Study Area and Distribution of *Tursiops truncatus* Strandings in Virginia, 1988-1993.



Recent evidence from comparisons of the VMSM VA catalog with the Beaufort, North Carolina catalog, suggest that some individuals which are seasonally present in Virginia during summer may be seasonally present in Beaufort, North Carolina during winter. Further study of photo-ID catalogs from areas south and north of Virginia will yield more information on the end-points of seasonal migrations.

Distribution and Abundance: On the ocean coast, bottlenose dolphins can be seen at almost any location. They are almost always within 4 km of shore, and often within 1 km. Within the Chesapeake Bay, sighting records and aerial surveys indicate a wide distribution, though they are less abundant and more dispersed than on the ocean coast. Surveys have identified areas where dolphins are most abundant, or "hot spots". These are located around the Chesapeake Bay mouth, in the Cape Charles/Fisherman Island area to the north, and the Cape Henry area to the south, with the south side being the area of highest density. Routinely, groups of over a hundred dolphins are sighted in the Cape Henry and south Virginia waters. Calves are present throughout the summer season, with clear evidence of Virginia waters representing important calving grounds for the coastal migratory stock.

Operation Dolphin: Operation Dolphin is a research project of the VMSM designed to study the coastal migratory stock of bottlenose dolphins in Virginia's waters. This study was initiated following the mass mortality of coastal dolphins along the U.S. east coast in 1987/88. More than 200 dolphins died in Virginia during that mortality event (Mead et al., 1988). Still, little is known of their population ecology in this region. The study area for Operation Dolphin includes the Chesapeake Bay and Atlantic Ocean coastal waters of Virginia (Fig. 14). Small boat surveys and photo-ID work are concentrated in the nearshore waters of Virginia Beach. Operation Dolphin's long-term goals are: 1) The creation of a photo-ID catalogue for coastal dolphins in Virginia's waters; 2) analysis of the social structure, movements, distribution and abundance of these dolphins; and 3) analysis of strandings in Virginia as they relate to the population biology of the coastal migratory stock.

The study period from 1989 to the present includes five study years. We have defined a study year as the 184-day time period from May 1 to October 31. Coastal bottlenose dolphins are not present during all months of the year; this time period approximates their seasonal range in Virginia.

Photo-Identification: Photo-ID efforts were initiated in 1989, and have continued through 1993 (Table 8). We did not undertake any photo-ID efforts in 1991. In discussing photo-ID, we define a sighting as a photographic record.

Multiple-Year Resights: Sixteen individuals have been sighted in multiple study years and four have been sighted over the entire five-year span of the study. Analysis of the multiple-year resight data indicates several interesting patterns. Dolphins sighted in multiple study years were usually resighted during the same general time periods. Seven dolphins were resighted in subsequent years within 10 days of their initial sighting date. One individual, seen in three study years, was resighted within four days of the initial sighting date. Another pattern occurred with three dolphins which were sighted before May 31 and after August 15, but not between. One example was Acid Wash (Tt92040), which was initially sighted on August 30, 1992, and resighted on May 31, 1993. Individuals like Acid Wash may be migrating north through the study area in May, and south in August. We believe these sighting patterns describe a migratory population whose individuals may follow similar routes both spatially and temporally from year to year.

Table 8. Results of Operation Dolphin Photo-ID Study

Study Year	No. of Trips	New Individuals Resighted	Within Year Resights	Multiple Year Resights	Individuals Sighted Per Year
1989	4	43	3	NA	43
1990	1	11	NA	1	12
1991	0	NA	NA	NA	0
1992	12	93	6	5	98
1993	12	111	11	14	125
Total	29	258	20	20	278

(18 individuals) (16 individuals)

Within-Year Resights: Eighteen individuals have been resighted within a study year (Table 9). Analysis of within-year resights from 1992 and 1993 provides residency information on dolphins within the study area (Table 9). We define a residency resight as a resight occurring within 46 days of a previous sighting. The 46-day period equals 25% of a study year, and incorporates at least three trips. Using our definition of residency, five dolphins in 1992 and nine in 1993 were resident. Most of these resident individuals were sighted only twice within a study year. Based on these criteria, the average residence times describe a dolphin population which is transient through Virginia waters.

Table 9. Residency Patterns of Identified Dolphins in the Operation Dolphin Study Area.

Study Year	No. of Trips	Average Days Between Trips	Individuals Sighted Per Year	Residency ¹ Resight	Number of Residents	Average Days Resident
1992	12	12.1	98	7	5	22.6
1993	12	10.5	125	10	9	21.7

¹A residency resight must occur within 46 days of the previous sighting.

Distribution and Abundance: Throughout our study, dolphins were concentrated along the lower bay and ocean coastlines within 2.0 km of shore. On July 10, 1993, a shore-based survey of dolphins in Virginia was conducted (Table 10). Operation Dolphin Count 1993 encompassed a survey area which included 41 observation posts (OP's) distributed within Virginia's borders from North Carolina to Maryland. A best estimate of 206 dolphins was tallied from a one-hour period. Some

observers recorded dolphin numbers for time periods of up to four hours. Enlarging our analysis to include all survey data, we estimate that more than 300 dolphins were present in the survey area. During the one-hour period, 65% of the dolphins counted were located south of the Chesapeake Bay mouth. North of the bay, dolphins were found in the areas of Cape Charles and again near the Maryland/Virginia border. The Eastern Shore of Maryland had virtually no dolphin activity observed between the Cape Charles/Fisherman Island area and Assateague Island. The virtual absence of dolphins between these two areas was the most surprising result of the survey. Also, no dolphins were sighted in areas of highly concentrated jet-ski activity.

Table 10. Results of Operation Dolphin Count, 1993

No. of Observation Posts (OP's)	Average Distance Between OP's (miles)	No. of Observers	Best Estimate of Dolphins Counted (in 1-hour period)	Estimate of Total Abundance
41	3.2	85	206	325-350

Strandings: VMSM is an authorized Letter of Authorization (LOA) Holder under the Northeast Regional Stranding Network, and has been collecting data from dolphin strandings since 1988. The distribution of strandings shown in Figure 14 corresponds to observed areas of high abundance for live dolphins. Areas such as Cape Henry, where large numbers of dolphins are observed, also have high numbers of strandings. An analysis of monthly stranding frequency since 1988 (Fig. 15) shows that most dolphins strand during the months of May through October. This time period also represents the seasonal range of coastal bottlenose dolphins as defined by our study year. We believe that most of the strandings outside this seasonal range involve the offshore stock of bottlenose dolphins which are present in the stranding record year-round. Stranding data since 1988 (Fig. 16) indicate that the total number of dolphin strandings has increased in 1992 and 1993. Whether this increase in strandings is a reflection of an increasing population, new natural or human induced mortality, or both, is not yet known.

Summary: Operation Dolphin has begun to develop a picture of the migratory population of coastal bottlenose dolphins in Virginia. A catalogue of identifiable dolphins, developed using photo-ID, has yielded valuable information regarding seasonal residency and yearly population movements. We believe this information describes a highly transient dolphin population. Distribution and abundance data for Virginia dolphins is scarce and represents an area requiring further investigation. Results from aerial surveys conducted in the early 1980's produced an estimated abundance of 340 dolphins (Blaylock, 1984). Operation Dolphin Count yielded similar numbers from a shore-based coastal survey in 1993. We believe these numbers represent only a minimum, and that rigorous statewide surveys that include all state waters are needed to measure total abundance. The coastal migratory dolphins along the U.S. east coast have recently been listed as depleted under the Marine Mammal Protection Act. Virginia is the southernmost state on the coast whose nearshore population of dolphins is exclusively coastal migratory stock. The results of this on-going study may prove to be invaluable in the conservation of this depleted population.

Figure 15. Monthly Frequency of *Tursiops truncatus* Strandings in Virginia (Jan 1988-Oct 1993).

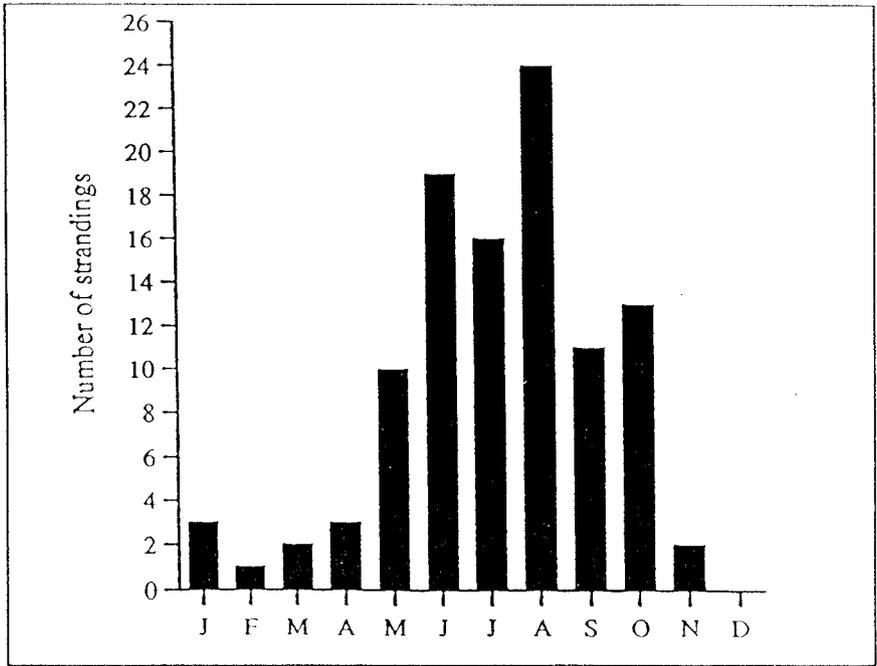
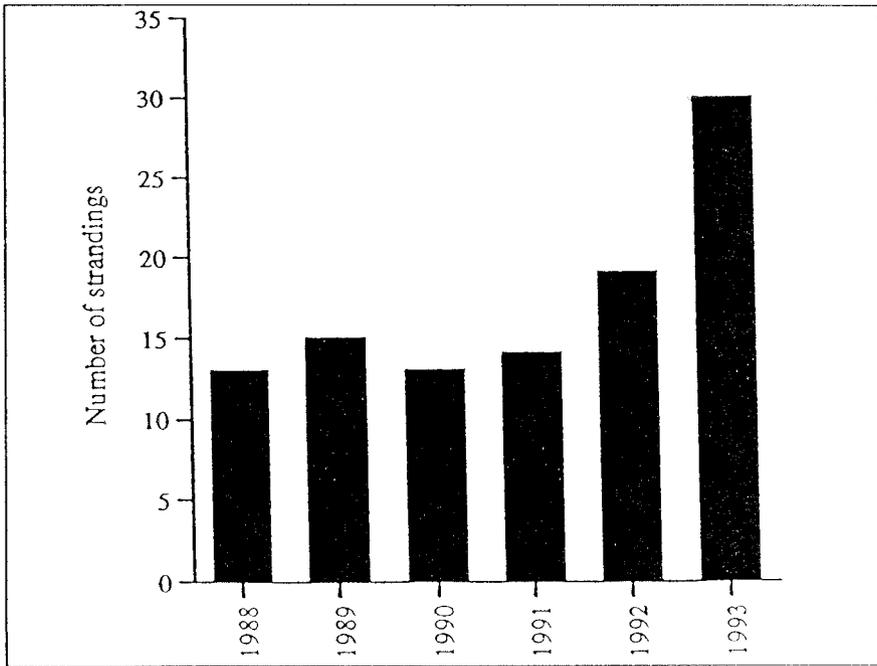


Figure 16. Number of *Tursiops truncatus* Strandings in Virginia (Jan 1988-Oct 1993).



Status of Bottlenose Dolphin Research in Virginia: The following is an outline of researchers involved with bottlenose dolphin research in Virginia, including their affiliations and the status of their studies to date.

Research organizations within the state:

Virginia Marine Science Museum, Virginia Beach: Mark Swingle

- NMFS Northeast Region Marine Mammal Stranding Network LOA holder
- respond to 90 percent of marine mammal strandings in Virginia
- full level A data and necropsy on all animals
- Operation Dolphin - coastal bottlenose dolphin research
- photo-ID study established and ongoing since 1989
- more than 250 individuals in current catalog
- behavioral records established in 1992 in association with photo-ID
- dolphin counts encompassing all ocean coastal waters and other selected areas
- dolphin watch educational/survey cruises in Virginia Beach
- aerial surveys and collections of sighting reports
- active education programs and exhibits devoted to dolphins

James Madison University, Harrisonburg: Dr. Ann Pabst, Bill McLellan, Susan Barco

- active participants in stranding network through expertise with necropsy and response training
- active support of Operation Dolphin research through direct participation and graduate student support
- active in cetacean research, particularly functional morphology of delphinids

Christopher Newport University, Newport News: Sherman Jones

- active photo-ID research in lower Chesapeake Bay and Eastern Shore since 1992
- 65 cruises have yielded a catalog of more than 150 individuals

Virginia Institute of Marine Science, Gloucester Point: Jack Musick

- stranding network LOA holder
- active in network primarily in 1980's
- graduate student thesis on abundance and distribution of bottlenose dolphins in Chesapeake Bay in early 1980's
- aerial surveys in 1980's

Virginia Tech, Blacksburg: Carl Pfeiffer, Larry Freeman

- supported stranding network in 1970's and 1980's
- repository for collected data and specimens/tissues throughout the existence of the stranding network

Virginia (Lee Morgan⁴, John A. Musick⁴ and Charles Potter): Temporal and Geographic Occurrences of *Tursiops truncatus* Strandings in Virginia, 1983-1989⁵: Examination of stranded marine mammals can provide valuable data on relative abundance, spatial and temporal distribution, and life history. Records of Virginia strandings have been scattered in the literature (Bailey, 1946; Handley and Patton, 1947; Wall, 1972; and Potter, 1980). Since Potter (1980), collection and reporting of marine mammal records have become more complete. This paper analyzes *Tursiops truncatus* strandings from Virginia between January 1983 and December 1989.

Methods: Stranding records were collected in Virginia between January 1, 1983 and December 31, 1989. Records typically contained information on species, sex, total length (TL), location of stranding, date of stranding, and notes pertaining to cause of death or to unusual circumstances (net scars, line marks, etc.). Personnel from several state and federal agencies collected data on strandings which were archived at the National Museum of Natural History, Smithsonian Institution, and were designated by catalogue numbers prefixed by letters 'SEAN', 'USNM', or 'MME'. Virginia records that had not yet been archived at the National Museum of Natural History were given an identification code with 'MM' preceding the date of a reported stranding. Total length (TL) measurements were taken from the tip of the snout to the notch of the tail. Each stranded animal was considered an individual event, even when more than one animal stranded at the same time.

Results and Discussion: Bottlenose dolphins, *T. truncatus*, stranded more than any other species during the study period, probably because they occur primarily in shallow coastal waters and are Virginia's most common cetacean (Blaylock, 1985; 1988). This species comprised 301 (72.7 percent) of the total strandings. An additional 38 animals were tentatively identified as *Tursiops*. Most strandings were reported from Virginia Beach (n=184, or 61.1 percent) and from Hampton (n=17, or 5.6 percent) (Table 11).

The greatest number of reported strandings of *Tursiops* in Virginia in any single year over the study period occurred in 1987, with an order of magnitude greater mortality than in any of the prior three years or the subsequent two years. Two hundred and eleven *Tursiops* (70.1 percent of the total number of reported marine mammal strandings) were recorded from 13 counties or cities during this year. The majority of these strandings occurred during the months of August and September, with 99 and 48 reported, respectively. The August total represented 44.5 percent of the 1987 total and 31.2 percent of the seven-year total. An increase in *Tursiops* mortality was also reported in 1987 along the entire eastern seaboard of the United States (Geraci, 1989; Scott et al., 1988; Keinath and Musick, 1987), with over 750 dolphin strandings reported from the summer of 1987 through March 1988 (Geraci, 1989). In Virginia, monthly mortalities returned to normal levels by November 1987, with only one stranding reported from that time until March 25, 1988. One additional animal which stranded in 1989 (MM15 JAN89) showed symptoms similar to dolphin pox observed in dolphins involved in the 1987 die-off event.

Estimates of relative mortality for the 1987 epizootic have been as high as 50 percent (Scott et al., 1988). However, this estimate may be high, because the authors assumed that a large percentage of the dead were unaccounted for. Conversely, most *Tursiops* that died during the epizootic may have been recorded, because the population affected occurs close to shore and because the dominant

⁴Virginia Institute of Marine Science, College of William and Mary

summer weather patterns along the East Coast usually produce brisk onshore sea breezes every afternoon. Thus, dead and bloated carcasses should have been blown onshore. Aerial surveys along the Virginia and North Carolina coasts in 1987 after the peaks of the epizootic found *Tursiops* abundances to be comparable to those found in surveys made in previous years (Keinath and Musick, 1987).

The sex ratios of *Tursiops* strandings in Virginia were not statistically different from a 50:50 distribution (using a Chi-square test with correction for continuity) during the 1987 die-off (97 males, 85 females, and 29 unsexed animals). This suggests that the epizootic did not affect the sexes differentially. For the seven-year period, there were 145 males, 113 females and 43 unsexed animals reported.

Length ranges from 141 males were 107-303 cm (\bar{x} =211.8 cm, SD=46.1 cm). Length ranges from 107 females were 102-289 cm (\bar{x} =196.5 cm, SD=45.9 cm). In the northern hemisphere, lengths for sexually mature males and females range from 245-260 cm and 220-235 cm, respectively (Harrison, 1969; Harrison et al., 1972; Perrin and Reilly, 1984). Using Perrin and Reilly's criteria, 40 (28.4 percent) of the males and 40 (37.4 percent) of the females were sexually mature.

Although *T. truncatus* occurs in Virginia waters primarily in the warmer months, strandings have been reported in all months except February, when sea water temperatures are coldest (Fig. 17). The distribution of *Tursiops truncatus* strandings in Virginia over the years 1983-1989 are presented in Figure 18.

Table 11. *Tursiops truncatus* Strandings in Virginia by Year and by City/County.

Location	Year							Total by City/County		
	1983	1984	1985	1986	1987	1988	1989	Tot.	?Tot.	Net Tot.
VA Beach	0	14	12	10 (1)	128 (13)	8 (1)	12	184	15	199
Hampton	0	2	2	1	17 (6)	3	1	26	6	32
Northampton	5	5	1	(1)	9 (7)	2	1	23	8	31
Norfolk	0	1	1	3	16 (2)	1	1	23	2	25
Mathews	0	0	0	(1)	13 (2)	0	1	14	3	17
Accomak	0	0	1	1	6 (2)	0	0	8	2	10
York	0	0	0	0	7	1	0	8	0	8
Gloucester	0	0	0	0	6 (1)	0	0	6	1	7
Isle of Wight	0	0	0	0	2	0	0	2	0	2
Lancaster	0	0	0	0	2	0	0	2	0	2
Newport News	0	0	0	0	2	0	0	2	0	2
Unknown Locale	0	0	0	0	2	0	0	2	0	2
Middlesex	0	0	0	0	1	0	0	1	0	1
Northumberland	0	0	0	0	(1)	0	0	0	1	1
Total	5	22	17	15	211	15	16	301		
?Total				3	34	1			38	
Grand Total										339

Numbers in parentheses are animals thought to be *Tursiops*, but positive identification was not made. Totals for these animals are designated by a question mark in the "totals" column.

Figure 17. Frequency Distribution of *Tursiops truncatus* Strandings in Virginia, 1983-1989, by Month.

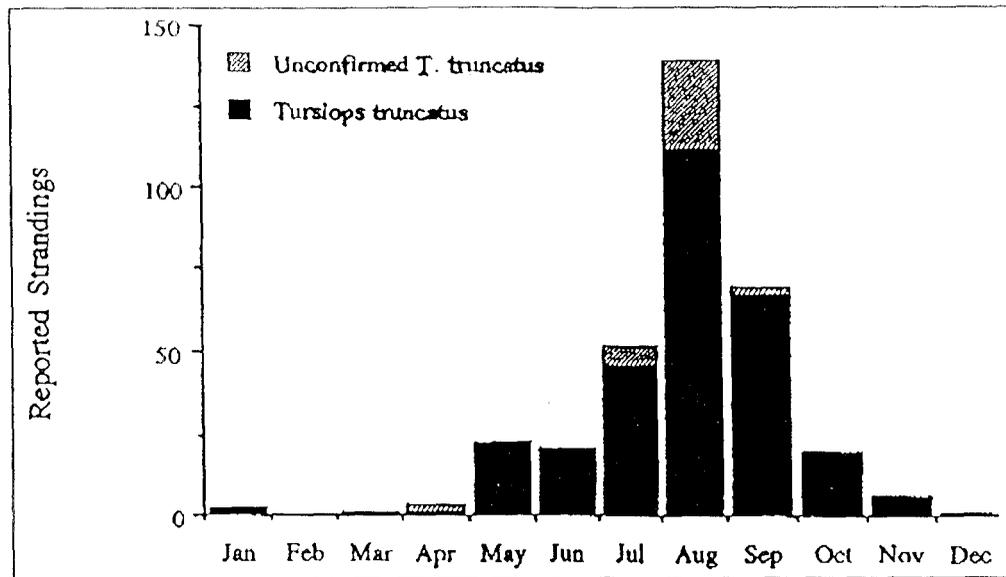
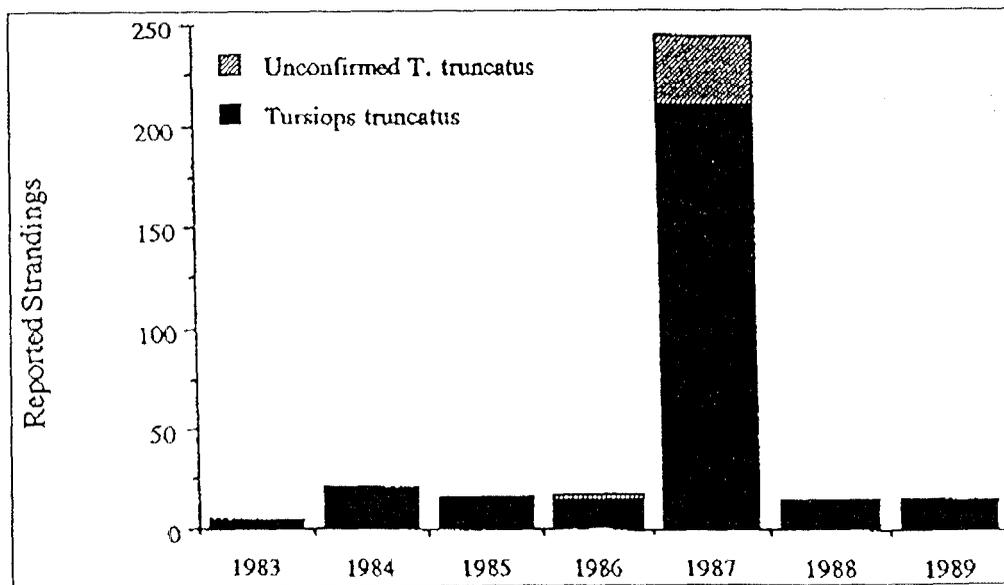


Figure 18. Frequency Distribution of *Tursiops truncatus* Strandings in Virginia, 1983-1989, by Year³.



³ This is Contribution No. 1852 from the School of Marine Science, Virginia Institute of Marine Science, College of William and Mary.

North Carolina (Keith A. Rittmaster and Victoria G. Thayer): Site-Specific Monitoring of Atlantic Coastal Bottlenose Dolphins in the Beaufort, North Carolina Area: Long-term studies of bottlenose dolphins have contributed much to the available information about the animals' home range, community size, and seasonal distribution (Shane, 1980a; Wells, 1986a; Scott et al., 1990). These studies provide a framework from which to design and compare investigations of bottlenose dolphins in other areas. In 1986, we [Rittmaster and V. Thayer] began dorsal fin photo-identification and direct-count boat transects in the waters around Beaufort, North Carolina. We intend to produce seasonal and inter-annual indices of abundance, residency, movement patterns, and to estimate reproductive rates for a portion of the mid-Atlantic coastal bottlenose dolphin stock(s).

The three objectives of this research are to:

- 1) Use direct counts from boat transects to detect seasonal habitat preferences and annual trends in abundance;
- 2) express an annual crude reproductive rate as a percent of neonates (calves of the year) in the total number of dolphins observed during the summer months;
- 3) use dorsal fin photo-ID methodology to track the residency patterns, social affiliations and movements of individual animals.

Methods: Our study area includes the nearshore (up to 2 miles off the ocean beach), coastal and estuarine waters between Cape Lookout and the confluence of the Newport River and Core Creek near Beaufort, Carteret County, North Carolina (Fig. 19). A direct-count transect on two predetermined tracklines is conducted by small boat. One transect is estuarine, running 3.6 nm from the Beaufort drawbridge up the Newport River to Core Creek. The second transect is coastal, and runs 5.5 nm along the shoreline of Shackleford Banks, between Beaufort and Barden Inlets.

The data we collect include number of dolphins observed, pod size and composition (adults, calves, juveniles, and neonates), location, and dorsal fin photographs for individual photo-identification, when possible. Transect counts are tabulated by month and by area (estuarine or coastal) for comparison.

Features used in designating an animal as a neonate (calf of the year) are as follows:

- 1) A small dolphin surfacing consistently next to a larger dolphin at least twice its size (a requisite feature);
- 2) the presence of fetal folds;
- 3) a dorsal fin curved to one side;
- 4) an indentation posterior to the skull;
- 5) dark grey to nearly black coloration; and
- 6) extreme buoyancy

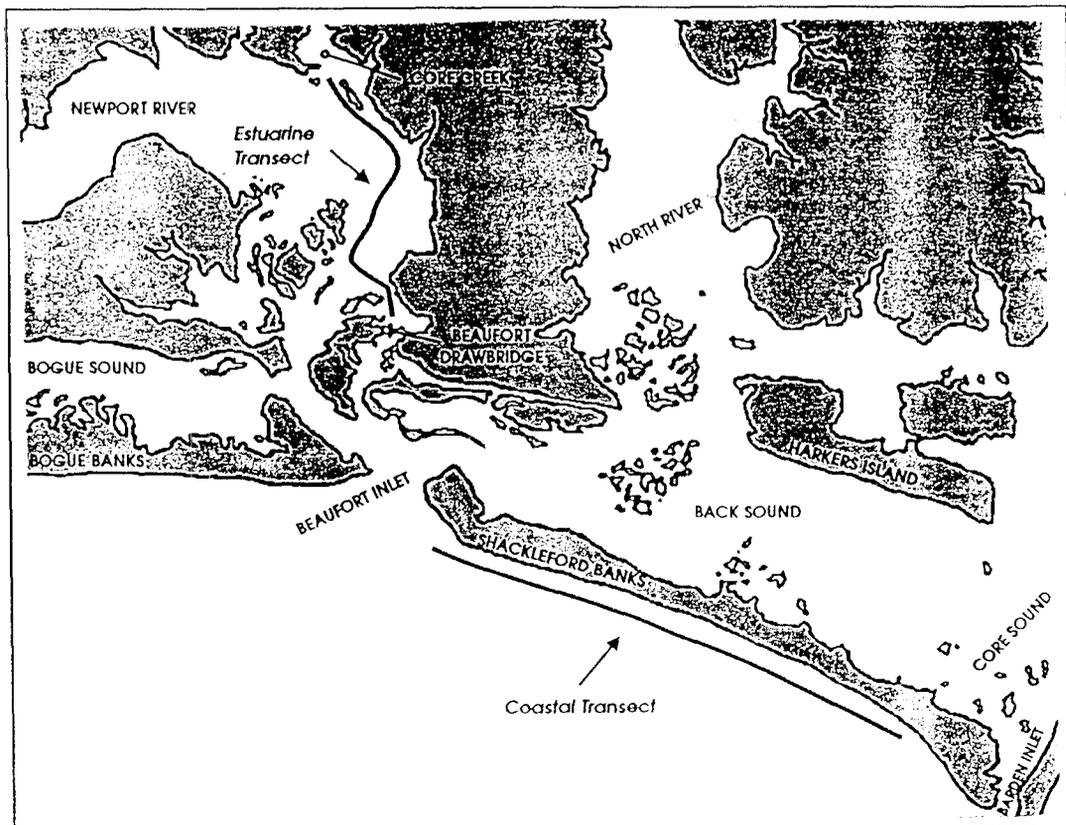
Feature #1, plus any of the other above features observed, constitute a neonate for this study. The percent of neonates of the total number of dolphins observed each summer (June - August) are calculated for comparison.

We conduct dorsal fin photography, environmental conditions and animal behavior permitting, for each sighting. Single lens reflex cameras with winders, and fitted with up to 400 mm zoom

lenses are used. After processing the negatives, we mark all clear shots of distinctive fins for printing. Usable prints are catalogued chronologically according to fin features (e.g. top notch, leading edge notch, 1-2 notches, 3+ notches, scars, bent fins, and epibionts), and assigned an identifying number. "New" fins, those presumably not previously photographed, are assigned the next sequential number. We enter these numbers, and the dates the photos were taken, into a table to analyze resight patterns.

Results: To date, 269 survey transects have been conducted during the past five years - 173 in the ocean and 96 in the estuary. Figure 20 demonstrates the average number of dolphins per nautical mile using combined data from both transects to show monthly trends in abundance in the study area. These data represent approximately 1,300 on-effort miles during the two survey transects over the past five years. Our data demonstrate that there are dolphins in the study area year-round, with higher numbers present during winter months than in summer months. The highest mean counts are 2.9 and 3.2 dolphins per nautical mile in February and November, respectively. The lowest monthly mean is 1.1 dolphin per nautical mile in May and June. Figures 21 and 22 illustrate trends in the mean number of dolphins per nautical mile for each month in the estuarine and coastal transects, respectively. Habitat preference seems to shift from the nearshore ocean during the winter months to the estuarine tidal rivers in the summer.

Figure 19. Map of the Beaufort, North Carolina Study Area, Including Both Coastal Oceanic and Estuarine Transects



The reproductive rates observed to date in this area are shown in Figure 23. After a high value of 16.2 was observed in 1989, the rate moderated over the next 3 years before showing a considerable increase to 10 in 1993.

Since 1986, we have catalogued approximately 1,200 good, usable photos of dolphins with distinctive dorsal fins. Our numerical sequence is currently up to 830, but this may represent as few as 200-400 individuals, as many numbers have now been eliminated and many resights may yet be detected. Patterns that have emerged so far are strong seasonal site fidelity, but no evidence of year-round residency. Some individuals have been photographed over successive summers and others over successive winters, with no intermixing detected.

Discussion: The transect data shown in figures 21-23 highlight the seasonal trends in abundance and shifting habitat preferences of bottlenose dolphins within the Beaufort study area. This, in combination with evidence (obtained from the photo-ID component of the study) for a lack of year-round residency in the study area, suggests that most, if not all of the dolphins that use these waters are of the coastal migratory stock(s).

The high reproductive rate of 16.2 observed in 1989 may reflect a compensatory response to the decreased population size following the 1987/1988 die-off (Scott et al., 1988). However, significant interannual variability in reproductive rates has been observed in other studies of localized dolphin populations (e.g. Scott, Wells and Irvine, 1990). It is possible that by monitoring reproductive rates, both variations in population parameters such as die-offs, and the progress of recovering populations can be detected. Monitoring reproductive rates may also highlight nursery areas and regional variations. We suspect that the confluence of the Newport River and Core Creek may be a "nursery area" similar to the nursery areas described by Scott et al. (1990) in the Sarasota, Florida area.

Identifying individuals enables residency patterns, migration patterns, and social affiliations to be analyzed. Dorsal fin photos of animals from the Beaufort area are compared to photos from other areas in order to understand movements along the coast that may represent migration patterns. To help sex and track individuals, reference frames are photographed after observation of a suspected female with calf. In this way the calving interval and separation age of the calf from the cow (or weaning) may be detected. For example, a cow/neonate pair was first photographed in the summer of 1988. The mother was observed with a progressively larger calf over the following two years. She was then seen without a calf in 1991, and in 1992 she was not observed at all. During 1993, five years later, this animal was photographed with another neonate. Associations of pairs of animals we suspect to be males have been photo-documented to persist for at least three consecutive summers. Increased photographic effort locally, coupled with comparisons of photos obtained from other study areas, will likely answer questions regarding the range and migratory endpoints of individual dolphins, as well as the habitat used by the coastal migratory stock(s).

Conservation Notes: A sign reading "FOR SALE - WATERFRONT PROPERTY..." was recently posted at the confluence of Core Creek and the Newport River. This is most likely a nursery area for bottlenose dolphins. Any summer day, 15-30 dolphins with neonates and other calves can be observed in this area within 100 meters of the riverbank. This appears to be essential habitat that faces irreversible change with the potential sale and development of the adjacent property.

Different inlets used by bottlenose dolphins in the immediate vicinity of our study area, Beaufort, Barden and Drum Inlets, are presently undergoing various levels of development, dredging activity and boat traffic. The relationship between level of dredging and potential habitat modification, and use of these areas by dolphins warrants further study. Also, most individuals that we talked to were unfamiliar with any laws that relate to how boaters should operate around dolphins, nor were they aware of the Marine Mammal Protection Act and its influence upon the regulation of these activities. This highlights the need for an educational campaign as part of any bottlenose dolphin conservation plan. The development of enforceable regulations, in addition to research, should also be priorities.

Conclusion: Our future research plans include continuation of our direct-count transects and analyzing the results for seasonal and inter-annual trends, estimating reproductive rates in other areas and habitats to identify nursery areas and/or regional variances, and intensifying and expanding our photographic effort outside our current study area and comparing our photos with those from other regions.

Figure 20. Mean Number of Dolphins Sighted per Nautical Mile During Direct-Count Transects in the Beaufort, North Carolina Study Area, March 1988-December 1993 (Coastal and Estuarine Transects Combined).

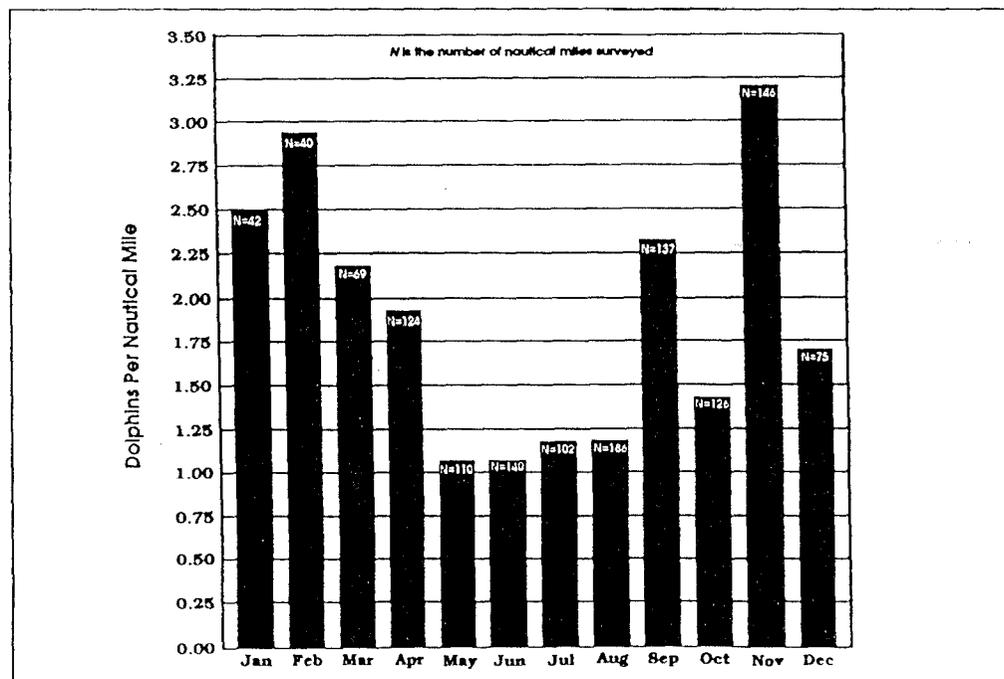


Figure 21. Mean Number of Dolphins Sighted per Nautical Mile During Direct-Count Estuarine Transects in the Beaufort, North Carolina Study Area, March 1988-December 1993.

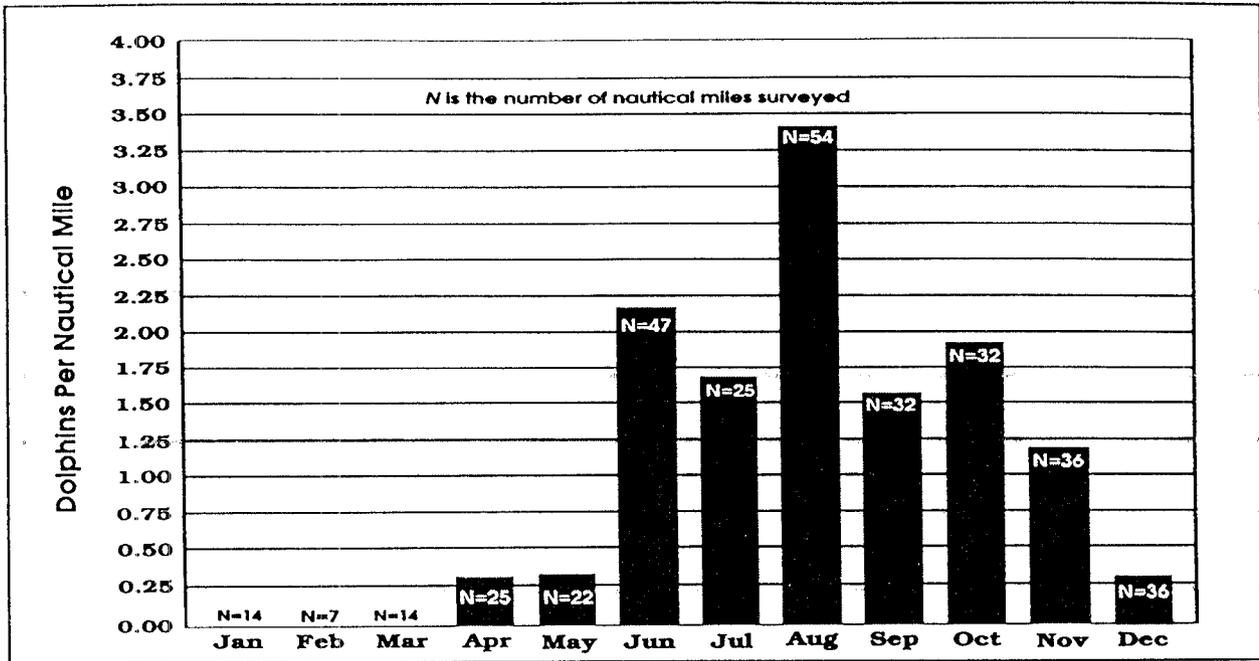


Figure 22. Mean Number of Dolphins Sighted per Nautical Mile During Direct-Count Coastal Transects in the Beaufort, North Carolina Study Area, February 1990-December 1993.

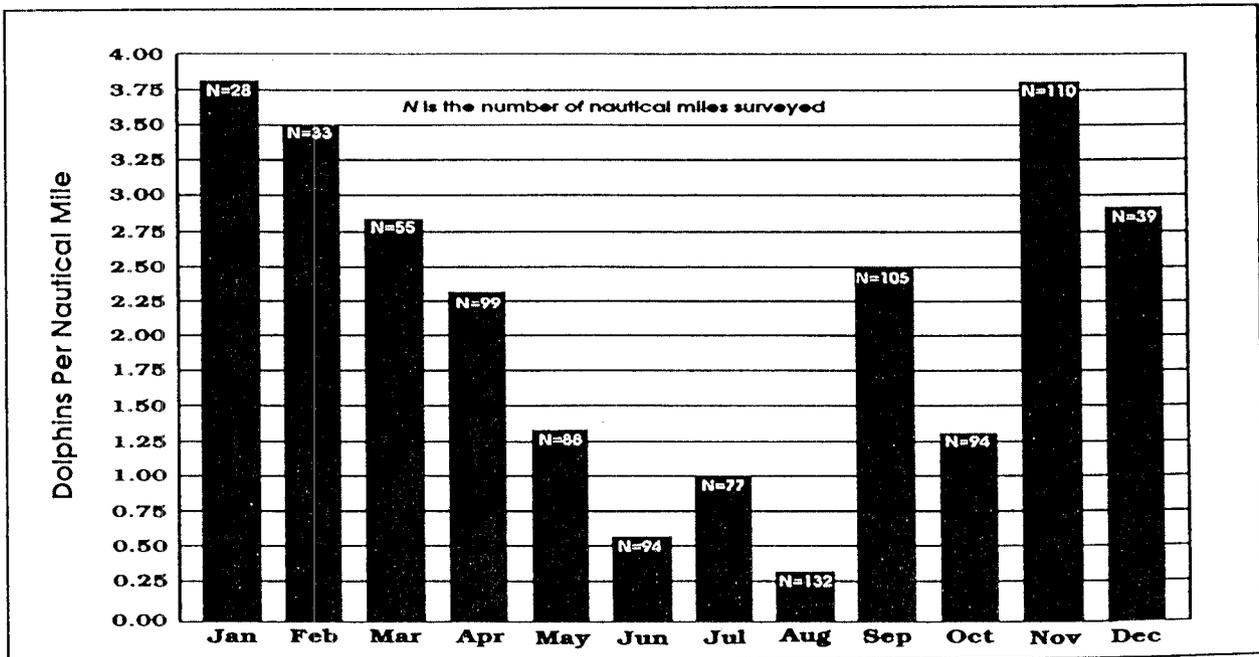
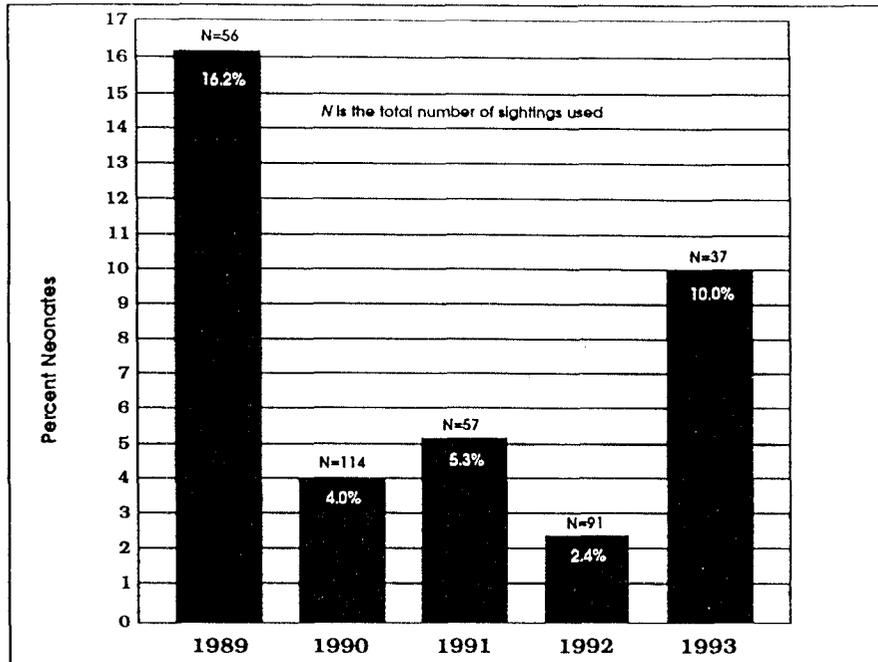


Figure 23. Percent Neonates of the Total Number of Dolphins Sighted During the Summer Months in the Beaufort, North Carolina Study Area, by Year, 1989-1993.



Marine Mammal Strandings in North Carolina (Victoria G. Thayer and Keith A. Rittmaster): Along the Atlantic coast of the United States, North Carolina is second only to Florida in the number of marine mammal strandings each year. This is partially due to the fact that the cold Labrador Current extension and warm Gulf Stream meet here, and because Cape Hatteras, Cape Lookout and Cape Fear jut out into the Atlantic Ocean, forming physical barriers for some species. For both flora and fauna, North Carolina is the southern limit of distribution for some temperate species, and the northern limit of distribution for some subtropical species. This results in a high diversity of marine mammal strandings of both temperate and tropical/subtropical species, including sperm whales, *Physeter macrocephalus*, long- and short-finned pilot whales, *Globicephala spp.*, both dwarf and pygmy sperm whales, *Kogia spp.*, Risso's dolphin, *Grampus griseus*, striped and spotted dolphins, *Stenella spp.*, common dolphins, *Delphinus delphus*, and humpback whales, *Megaptera novaeangliae*, and fin whales, *Balaenoptera physalus*.

The total number of reported strandings in North Carolina was 89 during 1992 (Fig. 24) and 123 during 1993 (Fig. 25). Bottlenose dolphins comprised 59.6 percent (N=53) of the total number of strandings (N=87) in 1992 (Fig. 24), and 60.2 percent (N=74) in 1993 (Fig. 25).

The monthly distribution of bottlenose dolphin strandings is shown in Figure 26. Peaks in strandings occur in spring and fall months, with comparatively few occurring during the summer.

Data on strandings and their potential causes are limited and are only beginning to be developed in North Carolina. Stranding response and data collection could be improved in a number of ways:

- 1) Decrease time to respond to reports of strandings;
- 2) increase number of animals examined by experienced personnel;
- 3) initiate a protocol for consistent data collection and formatting;
- 4) complete human interaction sheet (Haley and Read, 1994) for every stranding;
- 5) encourage voluntary reporting of fishery interactions (by fishermen involved, or by others);
- 6) provide feedback information to volunteers, from recipients of tissues;
- 7) educate stranding network volunteers;
- 8) improve funding (at least to supply and reimburse volunteers).

Among the items that should be collected from each stranding, we recommend:

- Skin in DMSO for mtDNA;
- skull for morphometrics;
- dorsal fin photos;
- tissue samples (stomach, gonads at minimum);
- parasites.

Protocols either exist, or need to be developed for these collections so that each stranding team is prepared to take samples/measurements in a similar manner and format.

Figure 24. Percent Bottlenose Dolphin Strandings of Total Marine Mammal Strandings in North Carolina, 1992

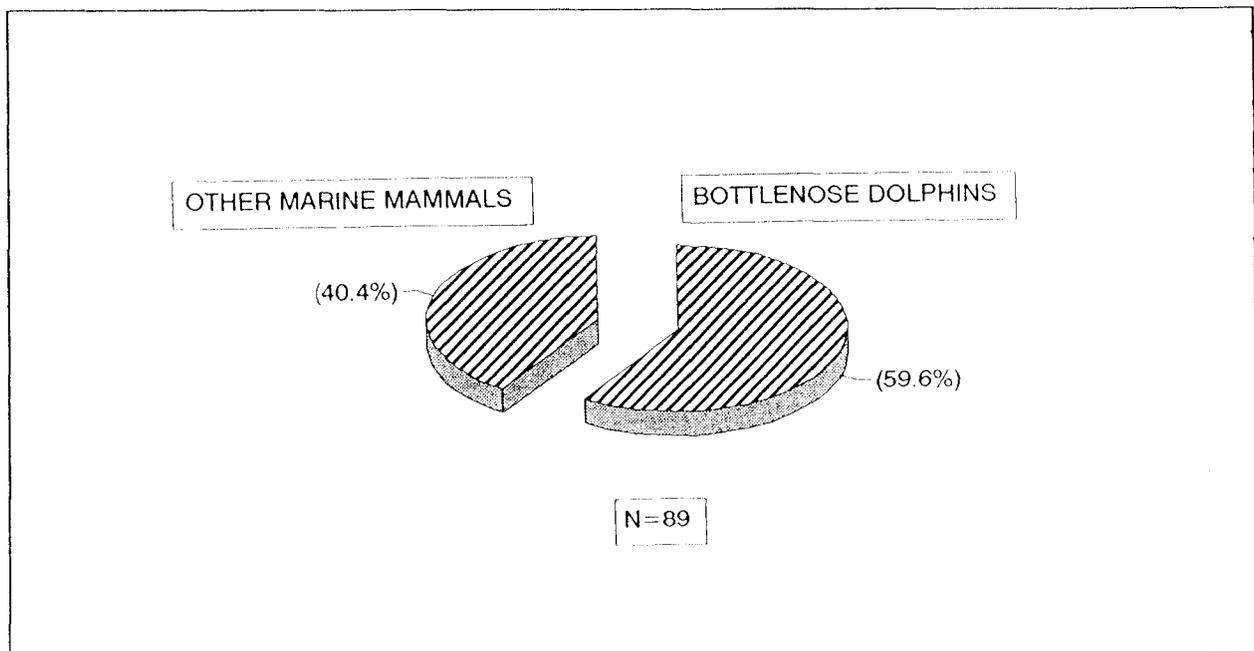


Figure 25. Percent Bottlenose Dolphin Strandings of Total Marine Mammal Strandings in North Carolina, 1993

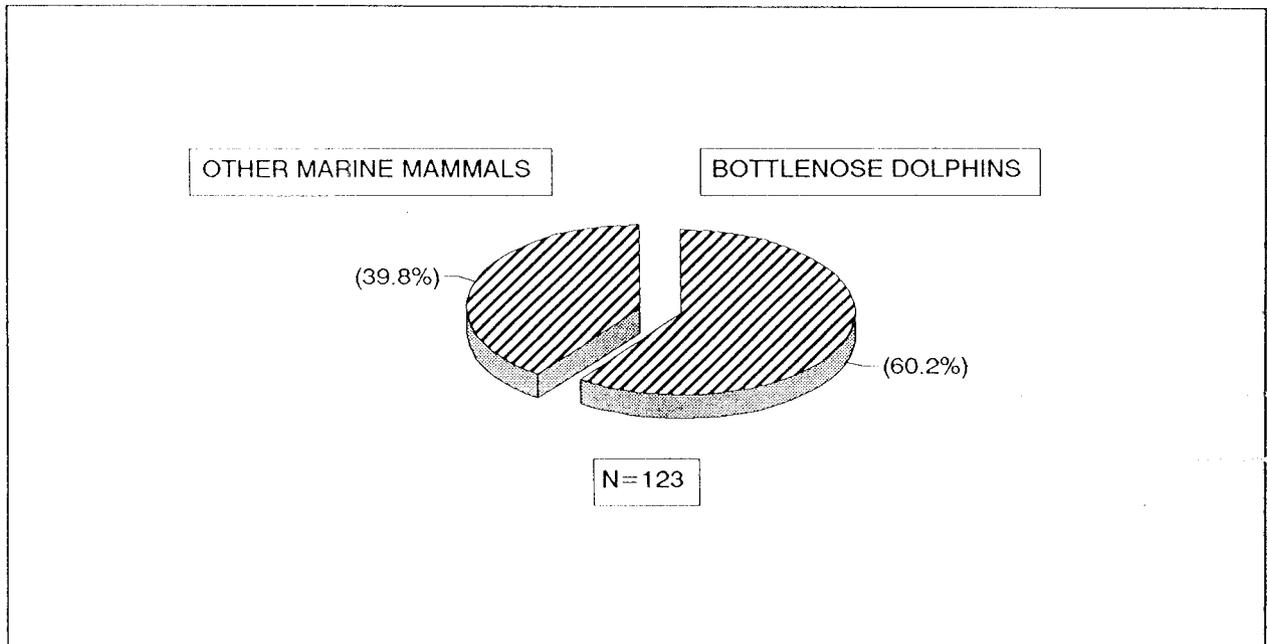
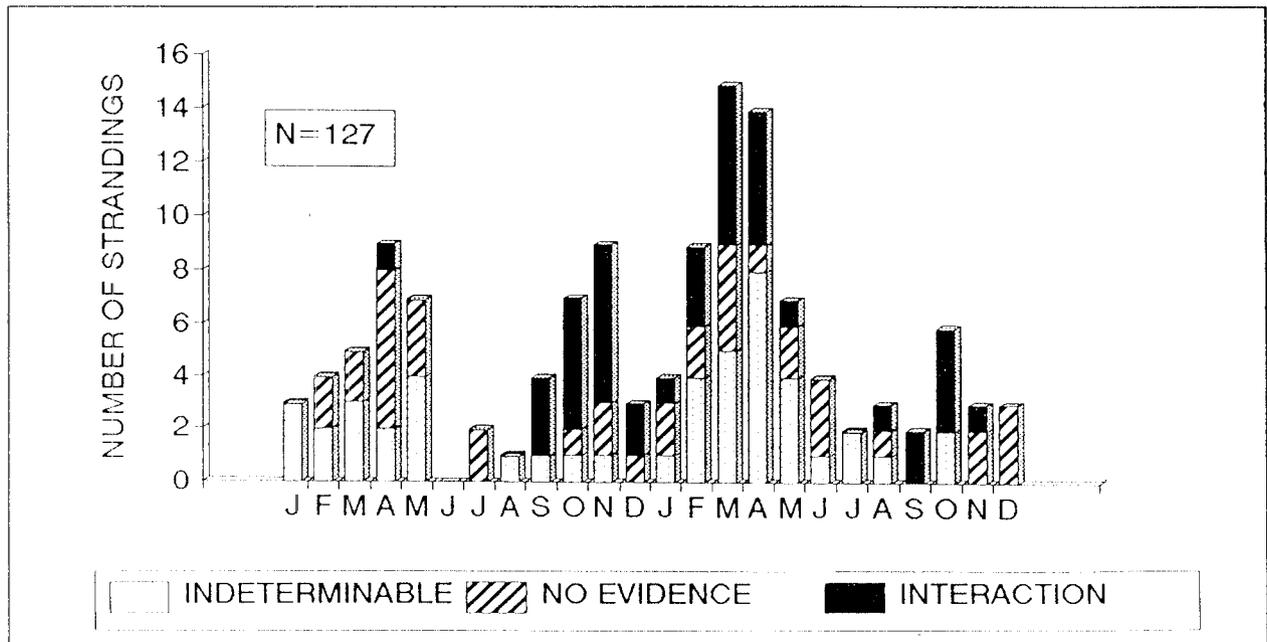


Figure 26. Monthly Distribution of Bottlenose Dolphin Strandings in North Carolina, 1992-1993, and Evidence of Human Interaction



Marine Mammal Research and Stranding Response in South Carolina

(Sally Murphy): There have been no organized statewide surveys specifically for bottlenose dolphins in South Carolina, although NMFS has conducted aerial surveys to estimate herd sizes and density of the populations for the Savannah River, Port Royal and St. Helena Sounds (Carew, 1982).

Beginning in August 1992, aerial surveys were conducted monthly to document stranded sea turtles and marine mammals, mainly over the undeveloped portions of the South Carolina coastline, from the entrance of Port Royal Sound in Beaufort county, to Debidue Beach in Georgetown County. The northward leg of the surveys was flown approximately one mile offshore. We used this part of the survey to document the seasonal occurrence of sea turtles and marine mammals in nearshore waters. The plane was flown at an altitude of 1,000 feet, at a speed of 120 knots. The monthly counts of bottlenose dolphins are presented in Table 12.

Our department was asked by NMFS to conduct aerial pelagic surveys during April and May of 1993, to document the density and distribution of leatherback turtles along the South Carolina coast. Other sea turtles and marine mammals, mostly bottlenose dolphins, were also counted on these flights. The flight path consisted of line transects, perpendicular to shore for eight nautical miles. The start and end points of each transect were six nautical miles apart. The return leg to the airport was flown parallel to shore. The results of these surveys are presented in Table 13.

Table 12. Nearshore Sightings of Bottlenose Dolphins in South Carolina During Aerial Surveys, 1992-1993

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1992	-	-	-	-	-	-	-	16	18	31	1	0
1993	2	6	1	1	5	3	33	20	44	12	61	21

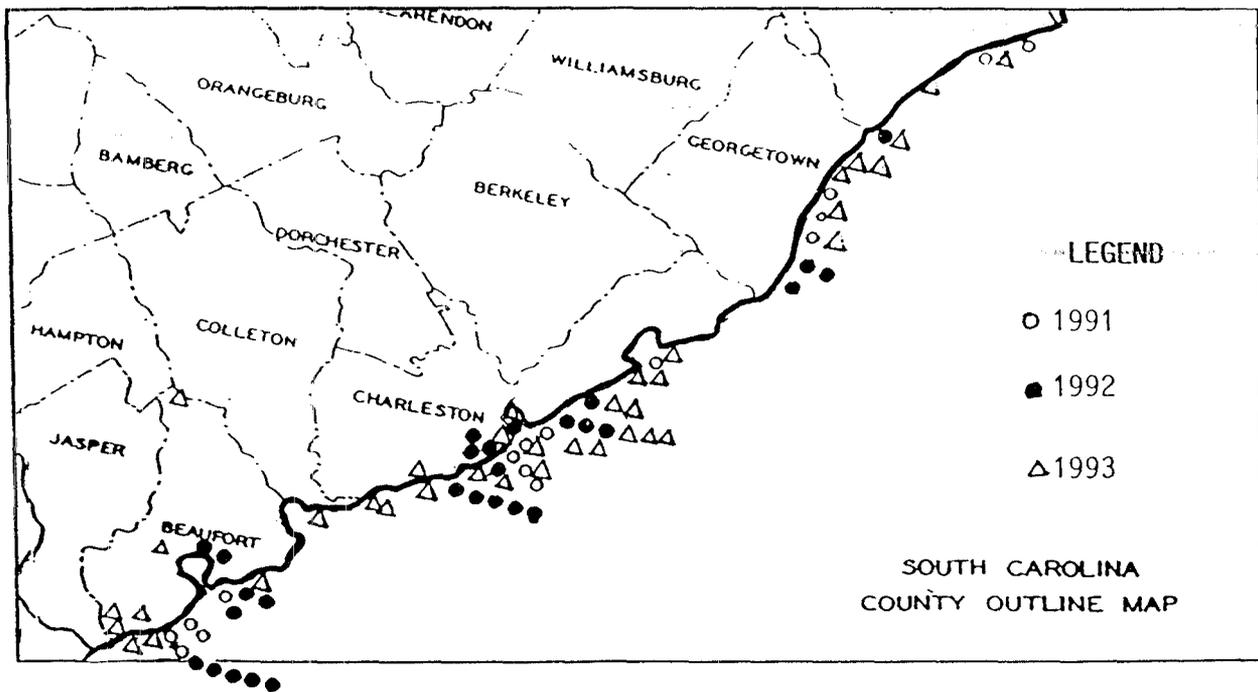
Table 13. Sightings of Bottlenose Dolphins in South Carolina During Dedicated Leatherback Turtle Aerial Surveys, April-May 1993

Survey Date	Number Seen on Transect	Number Seen on Parallel Path
April 22	3	Not Flown
May 1	16	Not Flown
May 5	59	Not Flown
May 12	8	10
May 20	46	0
May 27	Not Flown	0

We hope to find funding to obtain a point-in-time index for the bottlenose dolphin population in Calibogue Sound by means of a combination of aerial, boat and land-based surveys. Within the scope of this project, a determination of actual population numbers will not be attempted. We hope to acquire only documentation of relative numbers, distribution, and the acquisition of a benchmark survey number which can be useful in the long-term monitoring of the population. The use of multiple indices will enable an evaluation of changes in rates of observation for any one method. For example, when dolphin feeding by the public alters the behavior of dolphins around boats, one might expect boat surveys to show higher rates of observation relative to the other methods. With a multiple ratio index, this can be evaluated. All observations will be used to identify areas of concentration or high use.

Stranding Networks: The South Carolina Marine Mammal Stranding Network was established in 1991 under the authority of the Wildlife Department. Prior to this time, there was no organized network, and coverage was spotty. The number of bottlenose dolphin strandings on the coast of South Carolina during 1970-1993 is presented in Table 14. The distribution of dolphin strandings for 1991-1993 is shown in Figure 27.

Figure 27. Distribution of Dolphin Strandings in South Carolina, 1991-1993



Our network has a state coordinator, a NMFS representative, an archivist at the Charleston Museum, and about 30 members. It is divided into two groups: one to respond to dead stranded animals and collect Level A data, and the second, response teams, to respond to live stranded animals. There are 22 individuals in the first group, including 18 volunteers and four wildlife department personnel. Some of the volunteers also collect jawbones for NMFS. Training workshops are held each year for volunteers with Letters of Authorization (LOAs). The state coordinator and

NMFS representative review the items on the data form, sexing techniques, species identification, and the techniques used to collect measurements.

There are three response teams, one each for the northern, central and southern sections of the coast. Each response team consists of a Wildlife Department biologist, one or two veterinarians and a conservation officer. The central response team also has a public relations specialist. Response team members also supply jawbones, tissue samples, and/or entire carcasses to the NMFS Charleston Laboratory. In 1991, Dr. Joseph Geraci, V.M.D., conducted a seminar and demonstration necropsy for the members of the response teams.

Table 14. Bottlenose Dolphin Strandings in South Carolina, 1970-1993

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1993	2	1	1	6	3	1	4	0	3	0	7	6	34
1992	0	2	3	2	5	2	3	1	4	1	5	0	28
1991	1	0	1	2	2	1	2	2	1	1	1	3	17
NO STANDARDIZED NETWORK PRIOR TO 1991													
1990	-	2	-	3	-	4	1	-	-	1	2	3	16
1989	-	1	-	-	1	1	2	1	1	1	1	-	9
1988	4	1	1	1	-	1	2	2	-	-	-	2	14
1987	-	-	2	-	1	-	1	4	-	12	23	17	60
1986	1	-	-	-	-	-	-	-	-	-	1	3	5
1985	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	3	1	-	-	-	-	-	-	-	-	4
1983	1	-	2	1	-	1	-	-	-	1	-	-	6
1982	-	1	2	-	-	-	1	-	-	1	2	-	7
1981	-	2	3	2	1	-	1	-	-	1	1	-	11
1980	-	1	10	2	-	1	-	-	-	-	-	-	14
1979	1	-	-	-	4	-	-	-	-	-	2	-	7
1978	-	2	2	-	-	-	-	-	-	-	1	-	5
1977	-	-	-	-	-	-	-	1	-	3	-	-	4
1976	-	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	1	-	-	1	-	-	-	-	-	-	-	2
1974	1	-	1	1	1	-	1	-	-	-	-	-	5
1973	-	-	-	-	-	1	1	-	-	-	-	-	2
1972	-	-	-	-	-	-	-	-	-	-	-	-	-
1971	-	-	-	-	-	-	-	-	-	-	-	-	-
1970	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	11	14	31	21	19	13	19	11	9	22	46	34	250

The Wildlife Department maintains a 1-800 number 24 hours a day, so that stranding network members or the public can report stranding events and receive an immediate response. We have

upgraded our equipment in order to salvage larger specimens. This includes a four-wheel-drive pickup truck with winch, fully equipped for necropsy, and a two-axle trailer for transporting medium-sized whales.

In addition to the volunteer network, as mentioned previously, monthly aerial surveys are flown to search for carcasses on the more remote sections of the coastline. The aerial beach surveys are flown at 300 feet and 100 knots, just over the surf zone. Both stranded sea turtle and marine mammal carcasses are documented.

Our newsletter, "Marine Mammal Matters in South Carolina", is distributed quarterly to network members and to other interested parties in government and private conservation groups. The newsletter contains the total number of strandings to date, announcements to network members and information from NMFS on any carcasses that have been necropsied.

Population and Behavioral Patterns of Bottlenose Dolphins in Bull Creek, South Carolina (Ric Petricig): The goal of this study was to determine the population size, spatial distribution and behavior of free-ranging Atlantic bottlenose dolphins, *Tursiops truncatus*, in Bull Creek, Beaufort County, South Carolina (Fig. 28). Analysis of dorsal fin photographs has resulted in the identification of 67 individual dolphins within the study area. Of these 67 individuals, 22 have been determined to be permanent year-round residents of the study area. Temporal positions of identifiable individuals coupled with associations with other identifiable dolphins were used to determine the existence of pods or social units within the population and to track patterns of movements within the study areas.

Dolphins within this study area employ an interesting foraging strategy. Groups of two or more dolphins will, in a synchronized effort, force a school of fish onto mud banks, beaching themselves in the process. While on the banks, the dolphins then pick up and eat the stranded prey. For purposes of this study, this behavior is referred to as "strand-feeding". Observations during all seasons since 1988 have revealed that the "strand-feeding" behavior in the study area was limited to those animals that were long-term or permanent residents, and that foraging pods were composed of relatively stable subgroups within this population.

Occurrences of the "strand-feeding" foraging technique generally took place within two hours of low tide, when the banks were exposed. During the study period, the use of the strand-feeding technique was independent of water temperature, which ranged from 9 to 33°C. Turbidity of the water varied, but strand-feeding only occurred when the recorded Secchi depth was less than 50cm. Light-enhancing night-vision equipment revealed that the dolphin's repertoire of behaviors within the study area was independent of the varying light levels that occurred during the day-night cycle. Occurrences of strand-feeding, other foraging and social behaviors and movements within the study area were regulated by the tidal stage.

Detailed sonar profiles of bottom topography at repeatedly used sites have revealed the existence of submerged structures that result in concentrations of prey fish. The selection of strand-feeding sites were therefore determined by prey location, and strand-feeding did not involve herding of the prey.

Figure 28. The Study Area in Bull Creek, Beaufort County, South Carolina



Georgia (Charles Maley): Georgia has a relatively short (150 km) coastline with a series of barrier islands separated by deep sounds and rivers. High tidal amplitude (mean range = 2.2m) and flat bottom topography create a vast estuarine system, encompassing over 122,000 ha of salt marsh and related marine habitat. Bottlenose dolphins can be found along the coast on a year-round basis, both inshore and offshore.

At present, there is no comprehensive population estimate of the resident or migratory stocks of bottlenose dolphins in Georgia. Aerial surveys were conducted by the Georgia Department of Natural Resources (GDNR) to locate right whales in their calving grounds, from January through March in 1993. These surveys were exploited to provide information on bottlenose dolphins. The surveys consisted of 24 km east-west transects flown at 3-minute intervals at an altitude of 0.23 km, and at 160 km/hr. Similar surveys were flown in the spring, in order to estimate leatherback turtle abundance in the coastal waters of the state, this time with 12.8 km transects flown at 0.3 km. In both cases, incidental sightings of *Tursiops* were recorded in terms of numbers and location (Fig. 29). The reports indicate a peak in abundance offshore during the month of April. This was not, however, a directed census of coastal dolphins.

A comprehensive survey [The Dolphin Project] is currently underway to obtain photographic information and relative abundance and distribution data for dolphins in Georgia's rivers, sounds, and creeks. This quarterly boat-based survey is in the fourth year of a ten-year volunteer program. Up to 90 individual dolphins have been catalogued in an opportunistic photo-I.D. effort (Odell, pers. comm.). Additionally, aerial surveys have been flown for the past 2- 1/2 years, with a single line transect flown 1.2 km from shore, starting at Tybee Lighthouse, or approximately 32°N. latitude, switching to multi-line spot surveys at the sounds, and then continuing south to St. Mary's at the Florida Border. The return leg north follows the main channel of the Intracoastal Waterway.

Stranding Records: Dolphin stranding records have been collected in Georgia since the 1930's, but standardized surveys have been instituted only recently (Fig. 30). The Marine Mammal Stranding Network in Georgia is organized through the GDNR, with assistance from private citizens, the National Park Service, U.S. Fish and Wildlife Service, Cumberland Island Museum, the city of Tybee Island, the National Marine Fisheries Service, St. Catherines Island Foundation and Little St. Simons Island, Ltd. Increased boating activity and public awareness on the coast has resulted in a steady increase in the number of reported strandings. Since 1981, GDNR response to reports from the public of stranded dolphins has instilled greater confidence that these reports will be investigated, even in the most remote locations on the coast.

Based upon stranding reports for bottlenose dolphins, mortality seems to be lowest in late spring and autumn, higher in December and January, and peaking in March and April (Fig. 31). This coincides with the highest relative abundance of *Tursiops* observed during the winter and spring aerial surveys of 1993 (Fig. 29).

Figure 29. Sightings of Bottlenose Dolphins During Right Whale and Leatherback Turtle Surveys in 1993

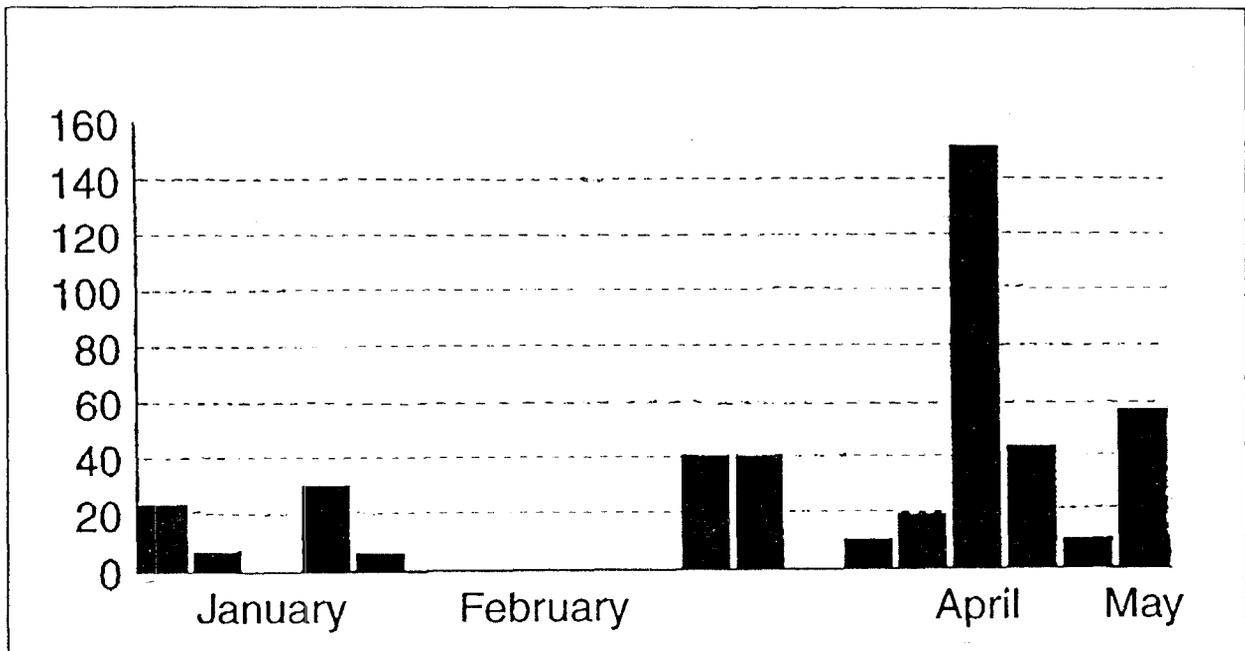


Figure 30. Historical Stranding Records for *Tursiops truncatus* in Georgia, 1972-1993.

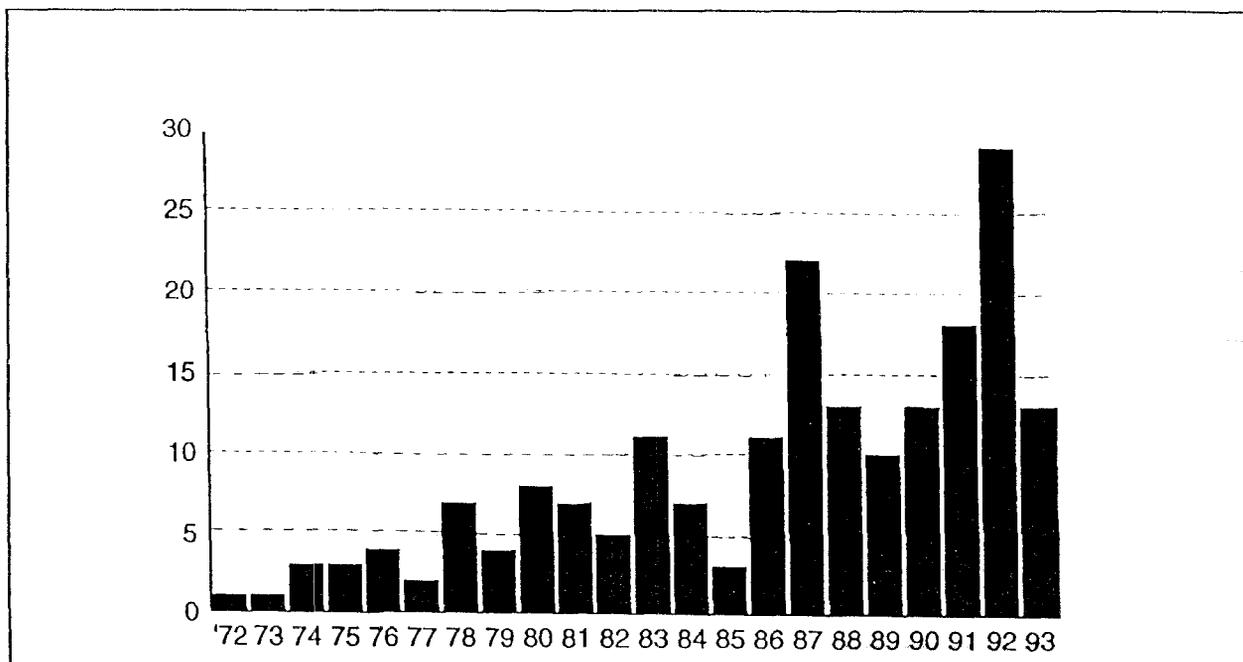
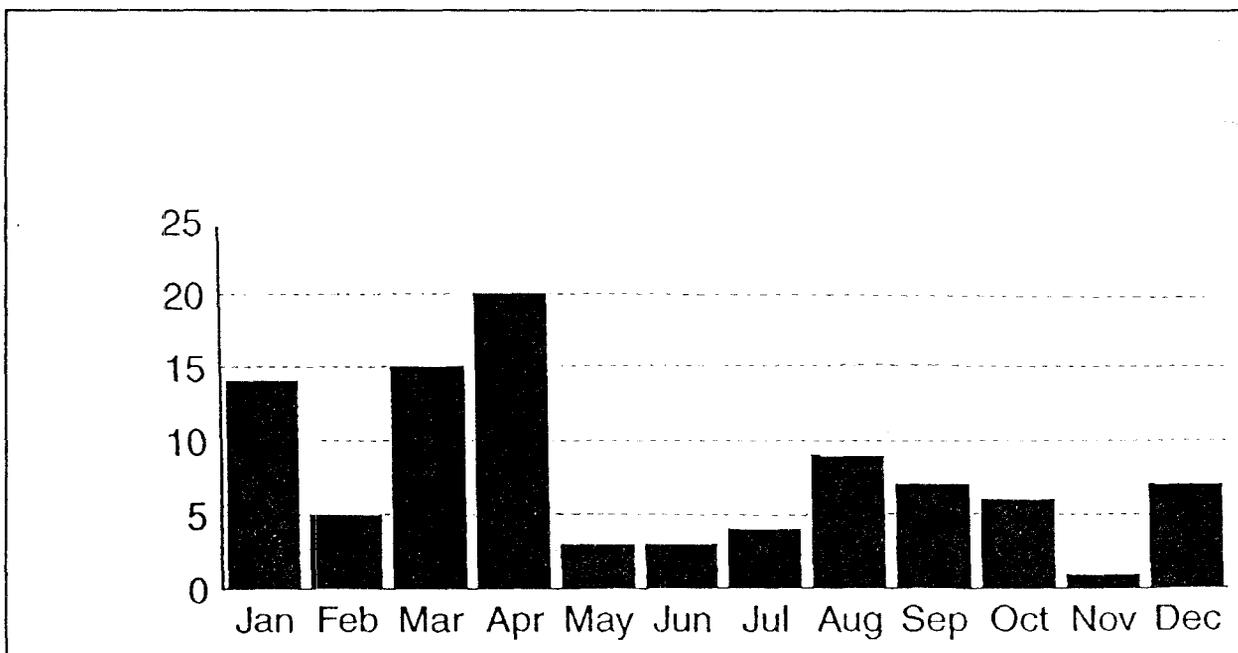


Figure 31. Monthly Stranding Trends for Bottlenose Dolphins in Georgia, 1989-1993



Florida (Bill Brooks): Section 15.038 of the Florida Statutes (FS) designates the bottlenose dolphin as the Florida state "saltwater" mammal, and states that it is unlawful to catch, attempt to catch, molest, injure, kill, annoy, or otherwise interfere with the normal activity and well-being, of mammalian dolphins (§370.12(3) FS). There are exceptions, related to research and collection, that require a permit from the Division of Marine Resources of the Florida Department of Environmental Protection (FDEP). The statutes mandate that the FDEP shall develop and implement programs to manage, protect, restore, and conserve marine mammals (§372.7701 FS).

The FDEP's Marine Mammal Management Program: The FDEP has both a marine mammal management program and a marine mammal research program. The Office of Protected Species Management (OPSM) oversees the management of the endangered West Indian manatee, *Trichechus manatus*, dolphins, and other cetaceans. Current management efforts at OPSM include the implementation of manatee protection speed zones, coordination of county manatee protection plans, protection of marine mammal habitats, and the review of environmental permits in those counties where manatees occur.

Marine Mammal Research in Florida: The Resource Recovery and Assessment Section of the Florida Marine Research Institute (FMRI) conducts research on marine mammals in Florida. Although the major emphasis is on the West Indian manatee, the endangered northern right whale, *Eubalaena glacialis*, as well as other cetaceans such as bottlenose dolphins, are also subjects of research in this program. The Resource Recovery and Assessment Section has four major areas of research:

- 1) Development of a Geographical Information System (GIS) database;
- 2) Telemetric and satellite tracking of manatees on the west coast of Florida;
- 3) manatee and marine mammal rescue, salvage, and necropsy; and
- 4) Assessment of population and distribution of manatees by using data obtained from aerial surveys.

Information specific to bottlenose dolphins is collected as ancillary data during aerial surveys and during the process of recovering, salvaging and necropsying marine mammals. All marine mammal stranding data are provided to the Southeast U.S. Marine Mammal Stranding Network (SEUS). All survey data are incorporated into the FMRI's GIS.

The Aerial Survey Program: The Aerial Survey Program staff collect bottlenose dolphin data during manatee surveys and right whale surveys. We have a minimum of 1-year's data from aerial surveys documenting manatee distribution in Florida's Atlantic coast counties and a majority of the Gulf coast counties (Table 15). Coastal, riverine, estuarine, and ocean-front waters were surveyed twice-monthly. This information has been entered into the FMRI GIS database. Because manatees are the target species of this research, dolphin data have not as yet been evaluated. These data can be used to assess resident populations within the survey areas, and will provide information on coastal migratory dolphins as well. For example, in the manatee distribution surveys of St. Johns, Flagler and Volusia counties, 1,787 bottlenose dolphins were sighted during 44 flights made from March 1991 through November 1993 (Table 16). The average number of bottlenose dolphins sighted was 40.6 per survey, ranging from 3 to 95.

Table 15. Manatee Aerial Surveys Along the Atlantic Coast of Florida

County	Survey Agency	Start Date	End Date	No. of Flights
Nassau	FDEP	Oct 1986	Oct 1988	52
Duval	FDEP	May 1988	Apr 1988	51
St. Johns	FDEP	Mar 1991	Nov 1993	44
Flagler				
Volusia				
Volusia	USFWS	Dec 1985	Jan 1987	30
Brevard	USFWS	Dec 1985	Jan 1987	30
(Indian River)				
Brevard	USFWS	Dec 1985	Jan 1987	29
(Banana River)				
Brevard	NASA	Jan 1977	Ongoing	239
(Banana River)				
Indian River	FDEP	Jun 1985	Dec 1987	63
St. Lucie				
(Inter Inlet)				
St. Lucie	FDEP	Nov 1990	June 1993	46
Martin				
St. Lucie	USFWS	Jan 1986	Jan 1987	27
Palm BEACH				
Palm Beach	Palm Beach County	Aug 1990	June 1993	57
Broward	Broward County	Nov 1991	July 1993	18
Broward	FDEP	Jan 1988	Mar 1990	48
Dade	Dade County	Mar 1990	Ongoing	16

FDEP = Florida Department of Environmental Protection
 USFWS = United States Fish and Wildlife Service
 NASA = National Aeronautics and Space Administration

The FDEP conducted right whale surveys along Florida's east coast during the winters (December - April) of 1987-1988, 1991-1992, and 1992-1993. The survey area extended from the Georgia/Florida border at the St. Marys River Entrance Channel (Nassau County) to Riviera Beach (Palm Beach County) in 1987-1988, and to Sebastian Inlet (Brevard County) in 1991-1992 and 1992-1993. Sightings of all right whales and other species of concern, for example, humpback whales, dolphins (Table 17), other cetaceans, sea turtles, etc., were recorded. Any observed potential threats, all vessels, fishing gear such as gill nets, oil slicks, etc., were also recorded.

Based upon a preliminary review of the right whale surveys, the number of bottlenose dolphins documented increase from February through March, but then decrease by the end of April (Table 18). These data were tabulated by latitude, and showed a pattern of increasing dolphin

sightings in the southern part of the survey area in February and early March. The number of sightings continued to increase and also shifted in location to the north, in March and early April. This pulse of bottlenose dolphins moved north and out of the Florida coastal waters by the end of April. Others have also reported a northward migration of bottlenose dolphins from the wintering area off of Florida's east coast (Scott, Burn and Hansen, 1988).

1993-94 Survey Plans: The FDEP Right Whale Surveys for the winter of 1993-1994 will begin earlier than in past seasons, (November 15), and will continue until April 15. Survey efforts have been increased from twice monthly to once per week. We are also considering surveying once per month from May to October, outside the right whale season. By extending this survey, the fall migration of coastal bottlenose dolphins into northeast Florida waters should be detected.

Manatee surveys have provided data on the coastal resident dolphin population along Florida's Atlantic coast. The FDEP will review these data and extract dolphin information.

Table 16. Number of Bottlenose Dolphins *Tursiops truncatus* Sighted During the Florida Marine Research Institute's Aerial Surveys of Manatees in the Ocean, Estuarine and Riverine Waterways of St. Johns, Flagler, and Volusia Counties

Month	1991	1992	1993
Jan	No Survey	9	77
Feb	No Survey	13	15
		24	77
Mar	30	86	95
		42	
Apr	14	36	48
		13	37
May	39	32	42
		41	46
Jun	40	25	20
			39
Jul	No Survey	44	No Survey
		61	
August	45	No Survey	24
	47		50
Sep	13	No Survey	75
	30		38
Oct	73	No Survey	76
	27		45
Nov	16	No Survey	47
			44
Dec	9	45	No Survey
	38		

The Manatee and Marine Mammal Rescue/Salvage and Necropsy Program: This program is based at the Florida Marine Resource Institute (FMRI) Marine Mammal Pathobiology Laboratory (MMPL), located on the campus of Eckerd College in St. Petersburg. The laboratory has a pathobiologist and 3 biologists on staff. All manatee carcasses are transported to MMPL for necropsy. This facility also has regional field stations in Jacksonville, Melbourne, Tequesta and Port Charlotte. Each field station is staffed by a biologist and weekend support staff. The staff at the MMPL and the field stations coordinate manatee salvages and rescues for the entire state. The MMPL and its field stations are also part of the Southeastern U.S. Marine Mammal Stranding Network (SEUS) in Florida. Staff assist on or coordinate rescues of live, stranded (Code 1) marine mammals. Fresh cetacean carcasses (Code 2) are transported to MMPL or oceanaria for thorough necropsies. Moderately fresh to very decomposed (Code 3 through 5) carcasses are necropsied by field staff or staff of other associated organizations. Data are provided to the SEUS Marine Mammal Stranding Network.

Table 17. Total Number of Bottlenose Dolphins, *Tursiops truncatus*, Sighted During the Florida Marine Research Institute's Aerial Surveys of Right Whales along Florida's East Coast from St. Mary's River Entrance Channel to Riviera Beach in 1987/1988 and to Sebastian Inlet in 1992 and 1993

Month	1987/1988	1991	1993
Dec	179	No Survey	No Survey
Jan	24	3	15
	48	44	48
Feb	200	63	58
			70
Mar	275	573	261
			316
Apr	No Survey	424	308
		111	60

Table 18. Breakdown of Number of Bottlenose Dolphins, *Tursiops truncatus*, Sighted During the Florida Marine Research Institute's Aerial Surveys of Right Whales along Florida's East coast from St. Mary's River Entrance Channel to Riviera Beach in 1987/1988 and to Sebastian Inlet in 1992 and 1993, by Date and Survey Leg

Survey Date	Total	Nearshore Leg	Offshore Leg
21 Dec 1987	179		
12 Jan 1988	24		
28 Jan 1988	48		
22 Feb 1988	200		
16 Mar 1988	275		
01 Jan 1992 ¹	44	21	23
02 Feb 1992 ¹	3	3	0
14 Feb 1992	63	24	39
03 Mar 1992 ²	573	254	319
01 Apr 1992	424	101	323
16 Apr 1992	111	62	49
01 Jan 1993 ³	15	7	8
29 Jan 1993	48	42	6
19 Feb 1993	58	35	23
24 Feb 1993	70	17	62
10 Mar 1993	261	221	40
30 Mar 1993	316	253	63
13 Apr 1993	308	115	193
30 Apr 1993	60	22	38

¹ Southern terminus of survey was Ponce De Leon Inlet.

² Survey had navigational problems because local LORAN station was down for a portion of the survey.

³ Southern terminus of survey was Port Canaveral Entrance Channel.

HOW CAN STRANDED ANIMALS BE MORE FULLY UTILIZED?

A. Bottlenose Dolphin Strandings Along the East Coast of Florida: What Do We Know, What Can We Learn? (Nelio B. Barros and Daniel K. Odell⁵): Strandings often provide the only available source for most types of biological data on cetaceans, not only for poorly known species, but also for the most common of inshore cetaceans, the bottlenose dolphin, *Tursiops truncatus*. Information on several aspects of natural history can be obtained from a stranded dolphin (Heyning, 1987; Odell, 1987; McLellan and Driscoll, this report), particularly if the animal is freshly dead.

The establishment of the regional marine mammal stranding networks in the U.S. dates back to 1977 (Reynolds and Odell, 1991). These networks are composed of volunteer individuals of various backgrounds, and as a result, collection of biological data from strandings varies, both in

⁵Sea World of Florida

quantity and quality. Recommendations for improving the efficiency of the networks have recently been proposed (Reynolds and Odell, 1991; Wilkinson, 1991), but lack of adequate funding will probably play an important role in the implementation of these recommendations. In ten years of existence, the Southeastern United States Marine Mammal Stranding Network (SEUS), operating from Texas to North Carolina and extending to Puerto Rico and the U.S. Virgin Islands, documented 2,381 cases of strandings and sightings (Odell, 1991). During that period, nearly half (45 percent) of all records made were for the coast of Florida (Odell, 1991).

Bottlenose dolphins stranded along the east coast of Florida have provided the basis for studies on pollutant burdens (King, 1987), mortality patterns (Hersh et al., 1990a), food habits (Barros and Odell, 1990), and external morphology and osteology (Hersh et al., 1990b), among others. Though most studies have concentrated on a resident population of dolphins inhabiting the Indian River Lagoon System (IRL) in the central coast of the state (Odell, 1989; Odell and Asper, 1990; Rudin, 1991; Spellman, 1991), at least three other populations (or stocks) occur in this area: dolphins resident in nearshore waters, dolphins seasonally present in the area (members of the migratory stock), and dolphins occurring in offshore waters. The nearshore and the offshore stocks can be distinguished by external morphometrics, hematology, food habits and parasite load (Hersh and Duffield, 1990), but most of these tools are not useful in distinguishing between the nearshore stocks (see Table 19). Genetic variation among localized nearshore populations in the U.S. Atlantic coast

Table 19. Characters Distinguishing the Various Stocks of Bottlenose Dolphins along the East Coast of Florida

	Nearshore		Offshore
	Indian River Lagoon	Coastal Oceanic	
ECTOPARASITES			
Barnacles	XXX ¹	XXX	XXX
Cyamids		XXX	
ENDOPARASITES			
Trematodes	XXX	XXX	XXX
Nematodes	XXX	XXX	
Cestodes			XXX
HEMATOLOGY			XXX
MORPHOMETRY			XXX
SHARK (<i>Isistius</i>) BITES			XXX
FOOD HABITS	Fish	Fish, Neritic Cephalopods	Pelagic Cephalopods

¹A single case in 18 years of stranding coverage

has been recently reported (Dowling and Brown, 1993), thereby suggesting that mitochondrial DNA samples may be useful in determination of stock identity.

In the central east coast of Florida, Barros (1993) found differences in food habits between resident IRL dolphins, dolphins occurring in nearshore ocean waters, and offshore dolphins. Dolphins belonging to these stocks prey primarily on fish, fish and squid, and squid, respectively (Table 19). Data pertaining to dolphins stranding on open-ocean beaches probably refer to both the resident and migratory stocks, and more samples are needed to investigate whether these can be separated on the basis of food habits. On-going analysis of carbon and nitrogen isotopes, a longer-term indicator of dietary preferences (Ostrom et al., 1993), collected from stranded animals in this area may support additional evidence of the usefulness of food habits data in distinguishing among stocks of bottlenose dolphins.

The 1987/1988 mortality event along the Atlantic coast of the United States involved primarily the migratory stock of bottlenose dolphins, and may have caused a depletion of 50 percent or more of the stock (Scott, Burn and Hansen, 1988). Bottlenose dolphin strandings in Florida increased significantly during that event (Table 20). Differences in stranding figures between pre- and post-mortality event (e.g., Nassau and Duval counties) are likely explained by the increase in stranding network participants and a heightened awareness of dolphin strandings. For most counties along the east coast of Florida, the number of strandings has remained relatively constant in years subsequent to the mortality event (Table 20).

Whereas the southern distribution of the mortality event may have reached St. Lucie and Martin counties in 1988 (Table 20), very little is known about inter-annual variability of the southern limit in the latitudinal distribution of the migratory stock. Also unknown is the nearshore distribution of migrating dolphins as it relates to existing resident populations along the coast.

On-going studies along the east coast of Florida to better understand the presence of the migratory stock include: continuation of the food habits study, analysis of carbon and nitrogen isotopic ratios, determination of pollutant loads (pesticides, heavy metals), examination of internal and external parasites, studies of mortality patterns and reproductive biology, and of population dynamics in the area. These are part of a multi-disciplinary effort to study the natural history of bottlenose dolphins occurring in Florida waters.

Table 20. Strandings of Bottlenose Dolphins Along the East Coast of Florida, by County (Listed Geographically from North to South), 1983-1993

	1983	1984	1985	1986	Die-Off Years		1989	1990	1991	1992
					1987	1988				
Nassau	0	0	0	1	8	6	4	1	7	4
St. Johns	3	2	1	4	9	23	10	6	4	8
Flagler	1	3	1	1	8	10	1	6	2	6
Volusia	2	2	3	8	16	32	7	11	6	5
Brevard	13	10	12	17	21	58	24	21	25	26
Indian River	2	2	1	3	3	10	2	2	3	4
St. Lucie	2	1	0	3	4	11	8	2	2	3
Martin	1	0	0	0	1	7	2	3	3	1
Palm Beach	1	0	0	1	0	0	0	1	1	0
Broward	1	2	0	0	0	1	0	1	1	0
Dade	2	2	0	0	2	2	1	2	0	1
Monroe	4	2	3	1	1	1	0	4	0	3
TOTAL	32	26	21	39	82	168	61	64	66	71

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B. Strandings in the context of bottlenose dolphin conservation: What should we collect?

(William A. McLellan and Cindy Driscoll): The epizootic event of 1987/1988 that led to the mortality of approximately 50 percent of the coastal migratory stock of bottlenose dolphins, *Tursiops sp.*, was probably the most intensively investigated stranding event in U.S. history. This was predominantly due to two factors: (1) the qualities that the stranding team brought to the investigation and (2) the mandate requiring the team to determine cause of death for the event. During the 1987/1988 epizootic, all carcasses recovered were necropsied and data were collected on a wide suite of characters ranging from viral inclusion bodies to age and reproductive status. All of these data were required from each carcass to adequately describe how that animal had "made its living", and what eventually had led to its demise. It can be argued today that all of these data are equally

important and needed to adequately describe the health and reproductive potential of the depleted coastal migratory stock of bottlenose dolphin.

Strandings of bottlenose dolphins provide excellent (and one of the few) sources of biological data needed to build a picture of what is happening intrinsically (with) and extrinsically (to) the coastal migratory stock. Data and tissues should be collected from stranded bottlenose dolphins that can be used to address specific needs of the conservation plan, including: **Who's there?, when are they there?, why are they there?, and, what are we doing to them?** During the following discussion of each section, tissue/data collection necessary will be printed in bold-type, and a summary (Table 21) will be provided at the end. It should be noted that this text is not an exhaustive treatment of this subject. Recent publications (Marine Mammals Ashore: A Field Guide for Strandings, by Geraci and Lounsbury, 1993; and Marine Mammal Strandings in the United States, by Reynolds and Odell (eds.), 1991) add greatly to this field.

Who's there? - species/subspecies/population status of bottlenose dolphins in the western North Atlantic: The first and most basic question to answer in a conservation plan is "do we know who we are conserving?". Bottlenose dolphins have remained a taxonomic problem since they were first described (see Mead and Potter, this report). Recently, Mead and Potter (in prep) presented skull characteristics that clearly separate the offshore stock of western north Atlantic bottlenose dolphins from the inshore stock, the latter of which includes both coastal migratory and coastal resident stock(s). Now that we can definitively assign bottlenose dolphin strandings into coastal or offshore categories, it is imperative that data collected from strandings also be assigned to the appropriate category. To do this we must collect **skulls** from all strandings as a voucher to identify the carcass as an offshore or coastal animal. Additionally, because live strandings are invariably offshore animals, while coastal animals rarely live strand, it is important to carefully determine and record the **condition code** of the animal when it first stranded, i.e., 1 = alive, 2 = freshly dead, 3 = moderately decomposed, 4 = severely decomposed (no organs remaining), 5 = skeletal remains only.

All along the east coast there are a number of photo-identification projects currently underway. These studies rely almost exclusively on dorsal fin scarring and shape patterns to identify individuals and determine subsequent resights (Scott et al., 1990). When a carcass hits the beach, it is vital to collect a quality **photo of both sides of the dorsal fin**. As a dorsal fin catalogue begins to build, there is a great potential to match photos taken of strandings with those taken while the animal was alive. Data from these "terminal" mark-recapture events will prove vital in determining mortality and migratory patterns of all bottlenose dolphin stocks. These and other data collected from strandings will also help us identify the coastal migratory stock. **Coloration patterns** have proven valuable in distinguishing coastal and offshore stocks (Mercer, 1973). There is at present a generalized consensus on the color patterns of coastal/offshore dolphins - with coastal animals being light gray above and fading to creamy white below, while offshore animals are dark gray above with a distinct demarcation to bright white below.

Parasite & food habits data: Coastal and offshore specimens can be separated by parasite loads and food habits (Barros and Odell, 1990; Mead and Potter, 1990; Barros, 1993). As a general rule, offshore animals have *Monorygma grimaldii* in the mesenteries of the reproductive track and gut wall, and *Phyllobothrium delphini* in the blubber, while coastal animals do not; coastal dolphins have *Braunina cordiformis* in the main and pyloric stomach chambers, while offshores do not.

Tissue samples: Tissues for genetic analysis, including **blood, skin & heart**, have shown great value in separating species and stocks (Duffield, Ridgway and Cornell, 1983). Monitoring of pollutant loads has also shown potential for separating stocks (Aguilar, 1987; Kuehl, Haebler and Potter, 1991). Ideally, the data described above should all be collected from the same carcass. This would allow a more complete picture of the animal's life to be re-constructed from each stranding. In an effort to more systematically collect these data, a **collection protocol** has been developed (Rommel et al., 1991). This protocol is designed to systematically sample body compartments, describe lesions, collect blubber, muscle and organ weights, and tissues for histology, in a quantitative and repeatable manner. **Samples for histology** on fresh animals must be collected for disease monitoring. For example, the recent finding of morbillivirus in Gulf of Mexico bottlenose dolphins was diagnosed through histological exam. The goals of the collection protocol are to: (1) Determine in what ways stranded animals differ from healthy animals; (2) build a baseline for determining the general health of dolphin populations; (3) collect tissues and data pertinent to distinguishing species and stocks; (4) archive tissues that can be used to monitor environmental contaminants/health status over time; and (5) provide tissue banks for researchers around the world.

When are they there? - temporal and spatial distribution of bottlenose dolphins in the western North Atlantic: Strandings of delphinids take place along the east coast in all months of the year. Strandings of pelagic delphinids, i.e. common or saddle-back dolphins (**Delphinus delphis**) and Atlantic spotted dolphins (**Stenella frontalis**) generally indicate the presence of that species in the local region. Similarly, bottlenose dolphin strandings can tell us a great deal about temporal and spatial segregation of the coastal migratory, offshore, and potentially, coastal resident stocks. Now that we have osteological characters that separate coastal from offshore stocks (Mead and Potter, in prep.), it would be interesting to look at bottlenose dolphin strandings in the Northeast Region from the winter months. If we accept the hypothesis that the coastal migratory stock(s) migrates south out of the northeast waters during the winter, then the remaining bottlenose strandings should only be offshore animals. Alternatively, it would be interesting to look at bottlenose dolphins stranded in the waters from Florida to North Carolina during the summer months. Employing the same hypothesis, i.e. that the coastal migratory stock should be in northern waters in the summer, one could assume that the southern strandings are either coastal residents or offshore specimens. By using this "back door analysis", we might better understand the offshore and coastal resident stocks and potentially weed these stranding events from the pooled bottlenose dolphin stranding data base. With this accomplished, the remaining stranding data will start giving us the life history and human interaction data that is necessary to conserve the coastal migratory stock.

Why are they there? - resource requirements of bottlenose dolphins in the western North Atlantic: For reasons that we yet do not fully understand, the coastal migratory stock(s) of bottlenose dolphins apparently undergoes a migration of several hundred miles from the winter to summer grounds. Conversely, the coastal resident stock is only found in discretely defined regions of the southeast throughout the year (Caldwell and Golley, 1965; R. Petricig, pers. comm.). The question remains, what is driving these stocks to vary their distribution from sympatric in the winter to generally allopatric in the summer? Strandings offer a glimpse into some of the biological pressures that are potentially "driving" these animals.

The most obvious migratory data that can be gathered from strandings is from **stomach contents** (Barros and Odell, 1990; Mead and Potter, 1990; Barros, 1993). Are the animals migrating to higher latitudes in the summer to exploit fish resources that for some reason are not available to

them in the winter months? Again, the question remains, what resources are both stocks of bottlenose dolphins targeting on while they are sympatrically distributed? These questions are extremely hard to answer by simply watching the animals at the surface. The collection of stomach contents from strandings along their entire distribution could answer these questions rather quickly.

One of the most important aspects of bottlenose dolphin conservation is monitoring the calving interval and crude reproductive rate. These values determine the number of offspring entering the population and therefore tell us if the population has the potential for growth. We know that calving is potentially one of the most difficult periods for adult females, and contributes greatly to their mortality. Neonate mortality is quite high as well (Hersh et al., 1990a). With this in mind, we need to pay extra attention to **reproductive tissues** collected from our primary source of these materials - our stranding networks. Postpartum females can tell us a great number of things about a population, including when they would first be expected to calve, how often they will calve, and how many calves they might have in their lifetime (Mead and Potter, 1990). With these data, along with a good estimate of the population, we can determine how many calves will be delivered each year to the next generation.

All of the above data are of greater value if one can correlate them to a specific age for the animal. To determine the age of a bottlenose dolphin, **teeth** must be collected, processed, and examined to determine the number of growth layer groups (GLG) (Hohn, 1980). The current method for collecting teeth from carcasses is to take three from the middle of the tooth row from the left mandible. To date, there exists a reasonable data record of age in western north Atlantic bottlenose dolphins (Sergeant et al., 1973; Hohn, 1980; Hersh et al., 1990a; Mead and Potter, 1990). With the present understanding of stock distinction (offshore, coastal migratory, coastal resident), a re-analysis of these data, including stock distinctions, would prove valuable.

Along with reproductive data from mothers, data gathered on **stranded neonates** tell a number of things about the next generation. One of the first types of data that we can gather from stranded neonates (and possibly the most important aspect of the conservation plan) is where calving grounds exist for bottlenose dolphins. A stranding of a condition 2, 120 cm bottlenose dolphin, with folded dorsal fin and clear fetal folds, would imply that the animal was born within a very short distance of the stranding site. Review of the existing stranding record, specifically for strandings of neonates, could prove extremely valuable in determining localities of calving grounds, and in turn, focusing on these areas as essential habitat in the conservation plan.

What are we doing to them? - potential impacts caused by human activities:

It is safe to say that coastal bottlenose dolphins come in contact with humans with greater frequency than any other cetacean in the northwest Atlantic. With the continuing growth in recreational boating, fishing, and more recently, jet skis, there would appear to be no lessening of human impact on bottlenose dolphins in the near future. Commercial fishing operations, including gill nets, pound nets, and trawls all operate within the known distribution of coastal bottlenose dolphins. All of these fisheries have the potential to impact resident and migratory stocks of bottlenose dolphins. At present, there are no observer programs monitoring these fisheries, and there are little or no data relative to incidental mortality from these stocks.

Most of the data gathered concerning human impacts on Atlantic coastal bottlenose dolphin stocks have come from stranded carcasses. From these carcasses we have inferred mortality from

evidence of human interaction such as **propeller cuts**, massive **blunt trauma**, **cuts on the leading edge of the dorsal fin and flukes** suggesting monofilament fishing gear, and **abrasions** where the impression of braided line remains in the skin and blubber.

Many, if not most, strandings occur for reasons not attributable to human interactions. Occasionally, though, there will be some evidence of human interaction gathered from the carcass. Unfortunately, our understanding of these human interactions will remain tenuous if we do not have a systematic approach for recording and characterizing them. The new **Human Interaction Form** (Haley and Read, 1993) is a data sheet designed to quantify objective observations on the condition of a stranding or fisheries-take animal. This data sheet should become an integral part of each stranding response.

Humans have produced and used an immense quantity of chemicals, including heavy metals, organochlorines, and pesticides, in agriculture and industry. These chemicals regularly end-up in river run-off or are dumped directly into the world's oceans. As bottlenose dolphins feed high in the food chain and are very long-lived, these chemicals end-up constantly accumulating in the tissues of these animals, even if delivered at relatively small doses. This situation is exacerbated in coastal bottlenose dolphins, due to their close proximity to sources of human-made pollutants. Tissue samples collected from coastal bottlenose dolphins during the 1987/1988 epizootic were shown to have extremely high levels of PCB and DDE (Geraci, 1989; Kuehl, Haebler and Potter, 1991). Systematically collecting **tissue samples** from blubber, muscle, liver, and brain are necessary to continue monitoring these compounds in coastal bottlenose dolphins.

Collection Protocol: The collection protocol (Rommel et al., 1991) can also be used to gain insights into which bottlenose dolphins may have been involved with fisheries or other human activities. By systematically weighing the body compartments (i.e. blubber, muscles, organs, skeleton), one can identify variations in the carcass condition. Comparing the conditions of stranded animals with those of known takes from fisheries will help us identify a "healthy" animal. These data will help us discriminate a healthy stranding from one that was chronically ill. This sort of information will help us identify animals that may come to the beach because of illness versus those that have not suffered disease, but have rather been victims of human interaction. Veterinary involvement, if available, can be useful in identifying the health status of stranded animals. This protocol, in combination with that described by Haley and Read (1993), provides an excellent platform from which to perform a comprehensive pathologic exam.

Table 21. List of Tissues, Collecting Media, and Potential Uses for Samples Collected from Stranded Bottlenose Dolphins

Tissue Type	Condition Code	Medium	Value & Usage
Blood:			
Serum	1	Frozen	Serology} Health/Disease Monitoring
Whole	1	Refrigerated	Hematology} " " "
Blood	1,2,3	DMSO	Genetic Analysis
Skin	1,2,3	DMSO	Genetic Analysis
Heart	1,2,3	DMSO	Genetic Analysis
Histology	1,2	10% B. Formalin	Health Indicators, Pathologies
Microbiology	1,2	Swab/Culture	Disease Monitoring
Virology	1,2	Fresh Frozen Tissues (pref @-70°C)	Disease Monitoring
Tissue Samples	1,2	Frozen (Whirlpacks)	Pollutant Loads, Stock Distinction, Health Parameters
Testis Samples	1,2,3	10% B. Formalin	Reproductive Condition
Ovaries	1,2,3	10% B. Formalin	Reproductive Condition (Imperative for Pollutant Load Samples)
Stomach Contents	1,2,3,4,5	Frozen	Food Habits, Distribution, Fisheries Interaction
Skeleton	1,2,3,4,5	Frozen	Voucher Specimens, Systematics, Morphology, Pathology/Health Parameters
Skull	1,2,3,4,5	Frozen	Species ID, Stock ID, Systematics, Voucher Specimens, Tooth Samples, Morphology
Teeth	1,2,3,4,5	Water	Age Determination, (Potential Genetic Analysis)
Dorsal Fin Photo	1,2,3	Color Slide	Human Interaction, Photo-ID
Lateral Photo	1,2,3	Color Slide	Species ID, Stock ID, Human Interaction
Gross Necropsy - Descriptive	1,2,3,4	Data Sheet	Health/Disease Monitoring
Morphometrics	1,2,3,4	Data Sheet	Species ID, Growth Parameters/Curves, Health Parameters
Interaction Data	1,2	Data Sheet	Strandings/Fisheries Take Determination
Protocol Data	1,2	Data Sheet	Stranded/Healthy Determination, Body Compartment Data

FACTORS POTENTIALLY AFFECTING COASTAL BOTTLENOSE DOLPHINS IN COASTAL ATLANTIC WATERS

A. Interactions with Commercial Fisheries

New Jersey (Dave Jenkins): In exploring potential interactions with marine fisheries, we need to examine when, where and what types of fishing gear are used. Of the gear that may potentially threaten bottlenose dolphins, most fish in New Jersey waters are taken by either the otter trawl or the purse seine (Table 22).

Table 22. Relative Importance of New Jersey Commercial Fisheries Gear (Based on 1992 Landings)

Gear	Pounds Landed	Percent of Total
Otter Trawl	58,409,947	28.97
Purse Seine	25,889,828	12.84
Gill Net	4,347,476	2.16
Longline	2,364,601	1.17
Other (low potential for interaction)	110,575,397	54.86

Gill Net: Gill nets are used in near-shore waters and are potentially the most dangerous fishing gear to bottlenose dolphins. The fish species taken include bluefish and weakfish. Also, the season when gill nets are most used in New Jersey waters coincides with the time when dolphins are present. The weakfish fishery occurs in Delaware Bay from April to June, and off Ocean and Monmouth Counties during the spring and fall. The bluefish fishery occurs in New Jersey waters in the spring and fall. However, the mesh size used in targeting for these particular fish species may not pose a high risk to dolphins.

Otter Trawl: Most fish captured in otter trawls are taken well off the New Jersey coast, during the winter months. Regulations do not allow otter trawls to be used closer than 2 miles from the New Jersey shoreline. Thus, there is little potential for interaction with coastal migratory dolphins and this fishery; however, it is possible that interactions with offshore dolphins occur.

Purse Seine: Purse seine nets are used almost exclusively for menhaden. This fishery occurs beyond 1.6 miles offshore and the vast majority of fish caught in this fishery are taken during the season when bottlenose dolphins are present in New Jersey waters. If dolphins are feeding on, or otherwise associated with menhaden, some potential for interaction exists.

Skipjack and yellowfin tuna are also taken with purse seines, as are Atlantic mackerel and bluefish. There may be higher potential for dolphin/fishery interactions here than with the menhaden fisheries; however, these fisheries occur offshore and do not likely interact with the coastal migratory stock.

Longline: The primary species taken in the longline fishery is yellowfin tuna. Longlines are used predominantly during the season when dolphins are present in New Jersey waters, and are used throughout coastal and offshore waters of this state. A summary of this fishery and the other major commercial fisheries in New Jersey waters that have potential for interaction with coastal bottlenose dolphins, as outlined above, is provided in Table 23.

Table 23. Summary of Major Commercial Fisheries in New Jersey Waters that have Potential for Interaction with Coastal Bottlenose Dolphins, *Tursiops truncatus*

Gear Type	Landings (lbs/yr)	% of Total lbs Landed	% of Total lbs Landed May-Sep ¹	% of Total lbs Landed Oct-Apr ²	Target Species
Gill Net	4,347,476	2.16	55.73	44.27	Bluefish, Smooth- Dogfish, Dogfish, American Shad, Menhaden, Weakfish, Spiny Dogfish
Otter Trawl	58,409,047	28.97	36.48	63.52	<u>Illex</u> and <u>Loligo</u> Squid, Mackerel, Herring, Scup
Purse Seine	25,348,814	12.84	90.48	9.52	Menhaden
Longline	2,364,601	1.17	60.96	39.04	Yellowfin Tuna, Swordfish, Sharks, Bigeye Tuna

¹Months when Coastal *Tursiops* are Generally Present in New Jersey Waters

²Months when Coastal *Tursiops* are Generally Present in New Jersey Waters

Delaware (Leon Spence): The fishery of most concern with respect to marine mammal interactions in Delaware waters is probably the fixed gill net fishery. In 1992, there were also reported incidents of harbor porpoise deaths attributable to fixed gill nets. This fishery occurs in the late winter and early spring in coastal waters. The target species within Delaware Bay during the late winter/early spring fixed net season are white perch, shad, striped bass and herring. Then, beginning in late April, through May 10, the fishery targets sea trout or weakfish. The timing of this fishery precludes it from being much of a threat to the coastal migratory bottlenose dolphin stock(s).

In the waters off Delaware, oceanic fisheries probably have the greatest potential for interaction with Atlantic bottlenose dolphins, although presumably not the coastal stock(s). Similar to the coastal fisheries, the primary target species at this time are striped bass and shad. The mesh sizes in this oceanic fishery range from 5 to 6 inches (stretch mesh). From late April until May 10, the target species change to weakfish or sea trout. The mesh size changes also, ranging from 3-1/8 to 5-1/2 inches.

Each year, all fixed net gear must be removed from Delaware waters by May 10. This excludes fixed recreational gill nets (less than 200 feet) which are permitted north of the Broadkill River within one-half mile of shore. In the case of severe weather, a grace-period may be granted. Drift nets probably do not pose as great a threat to coastal dolphins in Delaware as do fixed nets. By law, driftnet fishermen are obligated to stay with their nets the entire time nets remain in the water; this may minimize impacts on marine mammals.

The menhaden purse seine fishery in Delaware Bay has been eliminated. We have no data to substantiate whether or not this fishery was a threat to dolphins in Delaware state waters. There is also an off-shore trawl fishery off Delaware, but currently there is no evidence of impacts to marine mammals from this particular fishery. However, it is known that this fishery does take turtles; therefore, it should be monitored for possible marine mammal interactions as well.

Finally, about 40 miles up the Delaware River, there is a small, local fishery for bluefish, sea trout and occasionally black drum. This is about as far up-river as dolphins have been reported. Dolphins have been observed near nets in this fishery, but so far no interaction problems have been reported.

Maryland (Joyce Evans): To determine the extent of commercial fishery operations in the Chesapeake Bay and Atlantic Ocean, a number of reports were reviewed, including the Maryland DNR's 1992 Laws and Regulations Concerning the Harvest of Finfish, Snapping Turtles, and Terrapin and Crabs in Tidal Waters; the Chesapeake Bay Program Annual Program Reports; and Fishery Management Plans (FMPs) for a number of species. These laws are extremely detailed and complex, and need to be consulted in order to clarify questions concerning fishing areas, gear types and season. Tables 24 and 25 reflect gear types, dates, location, mesh size and target species for commercial fisheries in the Chesapeake Bay and Atlantic Ocean, respectively. In addition to these factors, there are however, other concerns when considering fishing activity. The sheer number of boats engaged in both recreational and commercial fishery activities is extensive and could potentially lead to death or injury to bottlenose dolphins. Fish aggregating devices may also pose a hazard to dolphins, by attracting them to an easy meal in locations where dense concentrations of fishing boats are likely.

Fishery interaction cases have comprised a large portion of strandings in Maryland, not only for *Tursiops*, but for other cetacean species as well. These interactions were determined by the presence of attached gear and/or carcass condition, line marks, missing appendages, etc. For example, 5 pilot whales stranded on Maryland beaches between May and June, 1992. One of these had ropes attached to its caudal peduncle. We have recovered monofilament line attached to marine mammal appendages, and a tangle of 7 cm of monofilament line attached to the caudal peduncle of a skeletonized harbor porpoise, *Phocoena phocoena*). In most instances, we are not fortunate enough

to recover an animal with the gear still attached, so we must rely on such indicators as missing teeth and flukes in order to attribute the cause of such strandings to human actions, if not fisheries interaction.

Table 24. Commercial Fishing in Chesapeake Bay. Prohibited Forms of Fishing Gear: Gig, Gig Iron, Purse Net, Beam Trawl, Otter Trawl, Trammel Net, Troll Net, Drag Net and Monofilament Gill Nets

Gear Type	Dates	Location	Mesh Size	Target Species
Gill Nets (Tended)	Nov-Apr	Tributaries, Excluding Striped Bass	2.5"-3.5"	Bluefish
Drift Gill Net	Oct-Apr	Spawning Tributaries	2"-3.5"	White Perch, Catfish, Herring
Anchor, Stake & Drift Gill Net	Jun-Sep	Northern Bay	4"-6"	Bluefish
Pound Nets	Spring-Fall	Restricted in Head Waters	> 1.5"	Baitfish (Alewife), Bluefish, Summer Flounder, Striped Bass, Weakfish, Spotted Sea Trout
Hook & Line	Nov 16-Dec 7 Oct 1-31, Nov 6-8, 13-15 & 20-22	Chesapeake Bay Chesapeake Bay	Recreational	Striped Bass Striped Bass
Purse Seine Hard Crab Pots Trotline Dip Nets, Traps, (collapsible) Scrapes, Skimming	Prohibited May-Dec	Chesapeake Bay Chesapeake Bay		Blue Crab
Hydraulic Dredge	Spring-Summer	Chesapeake Bay		Softshell Clams
Hydraulic Dredge	Year-Round	Chesapeake Bay		Razor & White Clams
Tongs, Dredge	Fall-Winter	Chesapeake Bay		Oysters
Diving Rakes	Fall-Winter	Chesapeake Bay		Oysters
Spear Gun, Bow & Arrow, Snagging	Jun 15-Dec 31	Chesapeake Bay		Carp, Garfish, Skate, Shark, Toadfish, American Eel, Stingray
Eel Pots	Spring-Fall	Chesapeake Bay		Eel

Table 25. Commercial Ocean Fishing in Maryland

Gear Type	Dates	Location	Mesh Size	Target Species
Bottom Trawls Beam/Otter	Winter-Early May	> 1 Nautical Mile		Summer Flounder, Sea Trout, Weakfish, Other Bottom Fish, American Shad
Gill Nets 567 Registered in MD	Feb 4 - Apr 30	Within 2-5 Miles	2.5"	American Shad
	Fall & Spring		3"-3.25"	Weakfish, Spot, Croakers
	Dec 8-19, Jan 4 - Feb 28			Striped Bass
Anchor & Stake Gill Nets	Spring	Atlantic Coastal Bays, Behind Assateague & Assawoman Islands		Mixed Species
Hook & Line	Year-Round			Pelagics, Bottom Fish
Longline	Year-Round	Exclusive Economic Zone		Shark, Swordfish, Tuna
Hook & Line	Nov 16 - Dec 7			Striped Bass
Purse Seine	Not Operative			
Pots	Year-Round	> 3 miles		Lobster
Hydraulic Dredge				Hardshell Clams, Quahogs

Virginia (D. Ann Pabst): Preliminary data on fisheries in Virginia were obtained from the Virginia Marine Resources Commission (VMRC). These data were gathered by VMRC field personnel from interviews with fish/seafood dealers. On a voluntary basis, dealers reported the amount of a given species received from fishermen, the location where the fish had reportedly been caught, and the gear type used.

Until 1993, dealer reporting was strictly voluntary and no fishermen were directly queried. Beginning in 1993, the VMRC instigated a mandatory declaration of all catch from commercial fishing operations. It is expected that while this will strengthen the Virginia fisheries data base in the long run, there may be initial problems with compliance.

For the purposes of the workshop, I queried the VMRC for records of target and non-target species reported from fisheries that operate within zero to three miles from shore for 1992. The data collected by the VMRC indicate that the commercial gear types used in Virginia waters in 1992 were conch dredges, hook and line, gill nets (both anchored and drift types), fish pots, and scallop dredges (Table 26). Gill nets were the most common type of gear used. While at the workshop, I spoke with Mark Swingle (Virginia Marine Science Museum), who has first-hand knowledge of fisheries in the Virginia Beach area. According to him, crab pots, haul seines, and purse seines are also used in Virginia waters. Mark also mentioned that the pound net fishery in the bays and estuaries was an important fishery to consider for potential human interactions with bottlenose dolphins.

An important fishery that is not included in the state records is the menhaden purse seine fishery. This fishery is apparently monitored by NMFS, and is not categorized as a coastal fishery. A number of people in the VMRC, as well as Mark Swingle, suggested that large menhaden seiners can be seen in Virginia Beach quite close to shore. I can attest to having seen seiners operating less than one-half mile offshore of Virginia Beach.

Table 26. Commercial Gear Types Used in Virginia Waters in 1992

Gear Type	Pounds Landed	Value (\$)	Target Species
Hand Line, Other	14,379	23,706	Bluefish, Black Sea Bass, Tautog
Otter, Bottom, or Fish Trawl	7,132	7,475	Anglerfish, Bluefish, Butterfish, Red Drum, Summer Flounder, Witch, King Whiting, Black Sea Bass, Sheepshead, Spadefish, Conch, <i>Loligo</i> Squid
Gillnet/Sink or Anchor, Other	445,945	223,445	Amberjack, Bluefish, Butterfish, Croakers, Black & Red Drum, Red Hake, Harvestfish, Herring, Mackerel, King Whiting, Pompano, Black Sea Bass, Grey Sea Trout, American Shad, Smooth Dogfish, Sharks, Spanish Mackerel, Spot, Northern Puffer, Tautog
Gillnet/Drift, Other	859,817	280,836	Bluefish, Bonito, Butterfish, Cobia, Croakers, Black Drum, Summer Flounder, Red Hake, King Mackerel, King Whiting, Scup, Black Sea Bass, Grey Sea Trout, American Shad, Sharks, Smooth & Spiny Dogfish, Spanish Mackerel, Spot, Tautog, Albacore, White Perch
Scallop Dredge	46,456	193,220	Anglerfish, Summer Flounder, Black Sea Bass, Sea Scallops
Pots and Traps	21,283	18,015	Summer Flounder, Black Sea Bass, Northern Puffer, Tautog
Conch Dredge	4,500	5,000	Conch
Total	1,399,512	751,697	

Potential Interactions Between Fisheries and Bottlenose Dolphins in North Carolina Waters (Victoria G. Thayer and Keith A. Rittmaster): As previously stated [in the section on marine mammal strandings in North Carolina], North Carolina is second only to Florida in the number of marine mammal strandings each year. What are the causes of mortality? In most cases, the cause of death cannot be determined since not all stranded animals are examined by experienced personnel, and we are unable to examine some animals. Causes could range from biotoxins and pollutants to mortality from fishing and boating interactions.

Many examples of human interaction have been noted for stranded marine mammals in North Carolina (Table 27). Evidence of human interactions include net or monofilament line scars, entanglement, imbedded hooks, cleanly severed appendages, ingested litter, and crushed bone. For example, a 215.9 cm female bottlenose dolphin washed-up with 70 lb test monofilament line wrapped around the head, mandible (more than 20 wraps) and pectoral fins. The line had been there long enough for the tissue to callous and the skin to grow over the line. One female, 234.3 cm long, with flukes cleanly severed, was pregnant with a near-term fetus. Another female, 165.2 cm long, washed up with line around the peduncle, cutting into the vertebral bone. Most strandings attributed to human interactions had evidence of monofilament line that had cut into the skin and blubber around the "neck" region. I also know of three bottlenose dolphins which were caught in a haul seine and escaped, apparently unharmed. In another incident, two dolphins were discovered in a haul seine; one animal escaped alive, while the other died.

Of the 53 bottlenose dolphins that stranded during 1992, 15 (28.3 percent) showed evidence of interaction with humans, 19 animals showed no evidence of interaction and 19 animals were too decomposed to make a determination of interaction or were not examined (Fig. 32). During 1993, 26 animals (35.1 percent) showed evidence of human interaction (Fig. 33), 20 animals showed no evidence of interaction, and 28 animals were either too decomposed to evaluate or were not examined. Thus, there appears to be a trend of increasing interaction with humans from 1992 through 1993. Because of the deterioration of some carcasses, and the lack of examination of others, this trend may be more apparent than real.

The peaks in strandings occur in spring and fall months, with comparatively few occurring during the summer. During the spring, ocean gill nets are in operation, while stop nets are in heavy use during the fall. It is possible that increased strandings observed are related to these commercial fishing activities. A brief description of common types of commercial fishing operations, seasons of greatest use, location of common use, and target species in the ocean are provided in Table 28, and for the bays and sounds, in Table 29.

Figure 32. The Percentage of Strandings of Bottlenose Dolphins in North Carolina that Could be Attributed to Human Interaction, or Could Not Be Determined, 1992

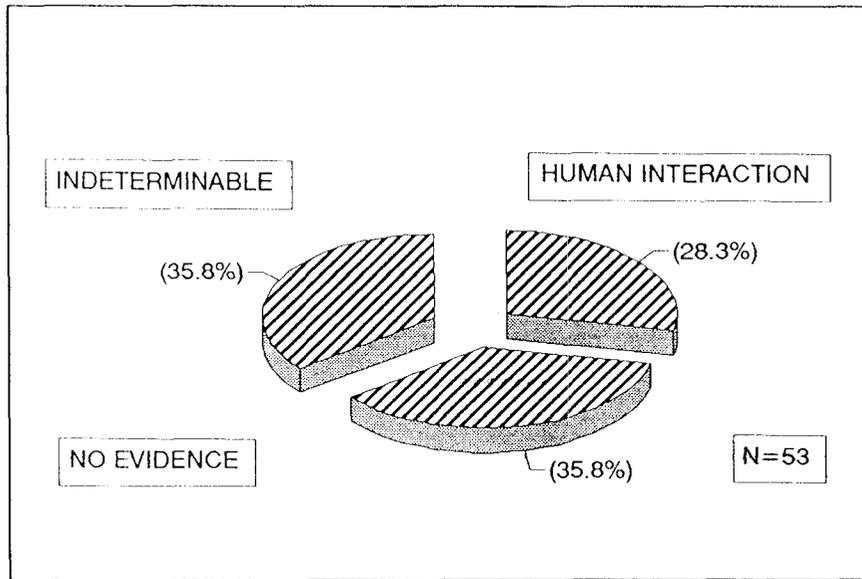


Figure 33. The Percentage of Strandings of Bottlenose Dolphins in North Carolina that Could be Attributed to Human Interaction, or Could Not Be Determined, 1993

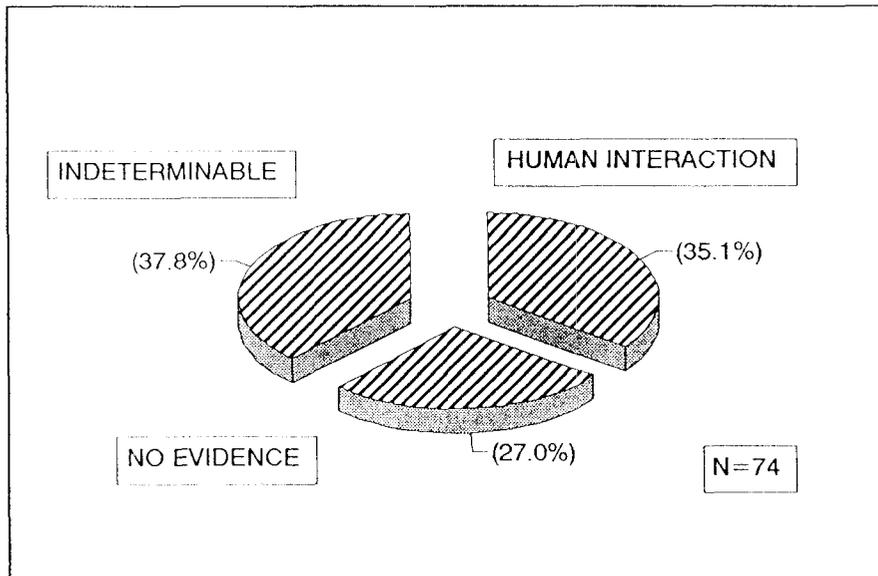


Table 27. Description of *Tursiops truncatus* Interaction Mortality in North Carolina from January 1992 to December 1993. F=female; M=male; Y=yes; NE=no evidence; CBD=could not be determined; * =animal(s) caught in net, released alive

Specimen Number	Date (m-d-y)	Length (cm)	Sex	Evidence of Human Interaction	Type of Evidence				
					Mutilation	Missing Appendages	Voucher Samples	Gear	Scars
2-1-92-HNS-P	1-7-92	147.32	M	CBD	-	Y	-	-	-
5-2-92-BRC-P	2-2-92	187.96	F	NE	-	-	-	-	-
8-2-92-NHC-P	2-16-92	245.00	M	CBD	-	-	-	-	-
12-2-92-HNS-P	2-27-92	205.70	U	CBD	-	-	-	-	-
14-2-92-HNS-P	2-27-92	114.30	U	CBD	-	-	-	-	-
15-2-92-CRC-P VT92003	2-28-92	166.50	M	NE	-	-	Y*	-	-
16-3-92-HNS-P VT92007	3-7-92	296.00	M	NE	-	-	-	-	-
18-3-92-HNS-P	3-8-92	175.00	M	CBD	-	-	-	-	-
23-3-92-HNS-P VT92011	3-24-92	284.00	M	NE	-	-	Y	-	-
24-3-92-HNS-P	3-26-92	224.00	M	CBD	-	-	-	-	-
25-4-92-LNS-P KR003	4-4-92	171.00	U	CBD	-	-	Y	-	-
26-4-92-CCC-P VT92012	4-10-92	249.00	F	NE	-	-	Y*	-	-
27-4-92-PEC-P VT92013	4-11-92	220.00	M	NE	-	-	Y	-	-
29-4-92-CUL-P	4-14-92	231.10	M	NE	-	-	-	-	-
31-4-92-HNS-P VT92014	4-18-92	108.5	M	CBD	-	-	Y	-	-
33-4-92-BEC-P VT92016	4-18-92	253.50	F	NE	-	-	Y	-	-
36-4-92-LNS-P	4-23-92	283.00	M	NE	-	-	-	-	-
37-4-92-NHC-P	4-30-92	205.74	M	NE	-	-	-	-	-
39-5-92-LNS-P KR007	5-3-92	245.00	U	CBD	-	Y	-	-	-
40-4-92-DAL-P	4-24-92	239.00	F	CBD	-	-	-	-	-
42-5-92-PEC-P VT92017	5-13-92	226.80	F	Y	Y	-	Y*	-	Y
44-5-92-CCC-P	5-16-92	233.68	M	CBD	-	-	-	-	-
46-5-92-DAL-P	5-19-92	114.30	M	NE	-	-	-	-	-
47-5-92-DAL-P VT92019	5-20-92	261.62	F	NE	-	-	Y	-	-
50-5-92-DAL-P	5-21-92	114.30	U	NE	-	-	-	-	-
54-6-92-CCC-P VT92022	6-8-92	184.00	M	CBD	-	-	Y	-	-
56-6-92-HNS-P	6-17-92	260.20	F	CBD	-	-	-	-	-
57-6-92-HNS-P	6-16-92	102.00	U	CBD	-	-	-	-	-
58-6-92-LNS-P VT92024	6-20-92	100.00	U	CBD	-	-	Y	-	-
59-7-92-BRC-P	7-28-92	254.00	U	NE	-	-	-	-	-

Specimen Number	Date (m-d-y)	Length (cm)	Sex	Evidence of Human Interaction	Type of Evidence				
					Mutilation	Missing Appendages	Voucher Samples	Gear	Scars
60-7-92-BRC-P	7-31-92	281.00	U	NE	-	-	-	-	-
62-9-92-LNS-P KR008	9-18-92	257.80	U	CBD	-	-	Y	-	-
64-10-92-BRC-P	10-18-92	0.00	F	NE	-	-	-	-	-
65-10-92-CCC-P VT92026	10-25-92	260.00	F	Y	-	-	Y	-	Y
66-10-92-HNS-P	10-28-92	190.50	M	CBD	-	-	-	-	-
67-10-92-CCC-P VT92027	10-29-92	183.00	F	Y	-	-	Y	-	Y
68-10-92-CCC-P VT92028	10-30-92	229.50	F	Y	-	-	Y	-	Y
69-11-92-CCC-P VT92030	11-3-92	176.60	M	Y	-	-	Y*	-	Y
70-11-92-CCC-P VT92029	11-2-92	195.30	F	Y	-	-	Y*	-	Y
71-11-92-CCC-P VT92031	11-3-92	215.90	F	Y	-	-	Y	Y	Y
72-11-92-CCC-P VT92032	11-5-92	262.00	F	Y	-	-	Y	-	Y
73-11-92-LNS-P	11-3-92	180.30	M	NE	-	-	-	-	-
74-11-92-PEC-P VT92033	11-19-92	106.10	M	NE	-	-	Y	-	-
75-11-92-OCC-P	11-22-92	232.00	U	CBD	-	-	-	-	-
77-11-92-HNS-P VT92034	11-23-92	173.50	F	Y	Y	-	Y*	-	-
79-12-92-LNS-P VT92036	12-1-92	231.20	F	Y	-	-	Y	-	Y
81-12-92-CCC-P 81, 81a, 81b	12-6-92	0.00	U	YYY	-	-	-	-	-
82-12-92-CCC-P VT92037	12-7-92	224.00	M	Y	Y	-	Y*	-	Y
83-12-92-HNS-P	12-9-92	218.44	U	CBD	-	-	Y	-	-
84-12-92-DAL-P VT92038	12-10-92	246.50	F	NE	-	-	Y*	-	N
86-12-92-CCC-P	12-18-92	160.00	M	Y	Y	-	-	-	-
1-1-93-LNS-P VT039	1-3-92	163.50	M	NE	-	-	Y	-	-
3-1-93-HNS-P	1-4-93	243.80	M	NE	-	-	-	-	-
5-1-93-LNS-P VT042	1-12-93	200.00	F	Y	-	-	Y	-	Y
9-1-93-PEN-P VT044	1-26-93	221.00	U	Y	-	Y	-	-	-
11-2-93-CCC-P VT046	2-12-93	221.00	U	Y	-	Y	-	-	-
12-2-93-MCB-P	2-18-93	264.17	M	CBD	-	-	-	-	-
13-2-93-LNS-P VT047	2-23-93	259.50	F	NE	-	-	Y	-	-
15-2-93-HNS-P VGT049	2-26-93	259.80	F	NE	-	-	-	-	-

Specimen Number	Date (m-d-y)	Length (cm)	Sex	Evidence of Human Interaction	Type of Evidence				
					Mutilation	Missing Appendages	Voucher Samples	Gear	Scars
18-3-93-HNS-P VGT052	3-4-93	223.50	F	Y	-	Y	-	-	Y
19-3-93-MCB-P	3-5-93	182.88	F	CBD	-	-	-	-	-
20-3-93-HNS-P VGT053	3-9-93	182.80	M	NE	-	-	Y	-	-
22-3-93-CCC-P VGT054	3-11-93	258.30	F	NE	-	-	Y	-	-
23-3-93-LNS-P VGT056	3-12-93	246.40	F	NE	-	-	Y	-	-
25-3-93-HNS-P VGT064	3-16-93	258.00	M	Y	-	-	Y	-	Y
26-3-93-HNS-P	3-17-93	264.00	U	CBD	-	-	-	-	-
30-3-93-HNS-P	3-23-93	236.20	M	CBD	-	-	-	-	-
31-3-93-LNS-P VGT058	3-25-93	246.50	F	Y	-	-	Y	-	Y
34-3-93-HNS-P VGT063	3-24-93	198.00	M	NE	-	-	Y	-	-
37-3-93-DAL-P	3-26-93	185.00	M	CBD	-	-	-	-	-
43-4-93-NHC-P	4-2-93	166.60	M	Y	-	-	-	Y	-
44-4-93-CCC-P VGT062	4-2-93	160.60	F	CBD	-	-	Y	-	-
47-4-93-CCC-P VGT065	4-11-93	241.50	F	Y	-	Y	Y	-	-
50-4-93-OCC-P	4-9-93	188.00	M	CBD	-	-	-	-	-
51-4-93-LNS-P VGT068	4-13-93	182.6	M	CBD	-	-	Y	-	-
53-4-93-LNS-P VGT069	4-19-93	234.30	F	Y	-	Y	Y	-	Y
54-4-93-LNS-P VGT070	4-21-93	114.50	M	Y	Y	Y	Y	-	-
55-4-93-PEN-P VGT071	4-21-93	248.00	F	Y	-	-	Y	-	Y
56-4-93-CCC-P VGT072	4-22-93	165.20	F	Y	-	-	Y	Y	-
57-4-93-NHC-P	4-24-93	114.00	M	CBD	-	-	-	-	-
58-4-93-LNS-P VGT073	4-26-93	116.20	F	NE	-	-	Y*	-	-
61-4-93-HNS-P	4-30-93	228.60	F	CBD	-	-	-	-	-
62-5-93-PEC-P	5-1-93	137.20	M	Y	-	-	Y	-	Y
64-5-93-OCC-P VGT082	5-5-93	256.0	F	Y	-	-	Y	-	Y
65-5-93-OCC-P	5-6-93	165.00	M	Y	-	-	-	-	Y
68-5-93-LNS-P KR10	5-14-93	260.00	F	NE	-	-	Y	-	-
69-5-93-BEC-P	5-15-93	243.80	F	CBD	-	-	-	-	-
70-5-93-OCC-P VGT076	5-15-93	278.00	M	Y	-	-	Y	-	Y
71-5-93-LNS-P VGT075	5-16-93	262.00	F	Y	-	-	Y	-	Y

Specimen Number	Date (m-d-y)	Length (cm)	Sex	Evidence of Human Interaction	Type of Evidence				
					Mutilation	Missing Appendages	Voucher Samples	Gear	Scars
73-5-93-OCC-P VGT078	5-18-93	261.00	M	NE	-	-	Y	-	-
74-5-93-DAL-P	5-20-93	190.50	F	CBD	-	-	-	-	-
75-5-93-LNS-P	5-19-93	233.68	F	CBD	-	-	-	-	-
77-5-93-HNS-P	5-20-93	106.70	M	CBD	-	-	-	-	-
78-5-93-HNS-P	5-22-93	119.40	M	CBD	-	-	-	-	-
79-5-93-HNS-P	5-22-93	124.50	M	CBD	-	-	-	-	-
80-5-93-IBRC-P	5-22-93	213.40	F	CBD	-	-	-	-	-
81-5-93-HNS-P	5-27-93	106.68	M	CBD	-	-	-	-	-
82-6-93-BHI-P	6-1-93	270.00	F	CBD	-	-	-	-	-
84-6-93-CCC-P VGT080	6-3-93	265.00	M	Y	-	-	Y	-	Y
85-6-93-DAL-P	5-30-93	99.00	U	NE	-	-	-	-	-
87-6-93-DAL-P	6-3-93	0.00	U	CBD	-	-	-	-	-
90-6-93-DAL-P	6-9-93	0.00	U	CBD	-	-	-	-	Y
91-6-93-PCC-P	6-16-93	252.50	M	CBD	-	-	-	-	-
92-6-93-CCC-P	6-24-93	102.00	F	NE	-	-	-	-	-
93-6-93-PAC-P	6-27-93	223.50	M	NE	-	-	-	-	-
94-7-93-CUL-P	7-6-93	182.88	U	CBD	-	-	-	-	-
96-8-93-CCC-P	8-9-93	210.00	M	NE	-	-	-	-	-
98-8-93-DAL-P	8-8-93	269.24	F	CBD	-	-	-	-	-
99-8-93-DAL-P	8-12-93	183.00	U	CBD	-	-	-	-	-
101-9-93-DAL-P	9-4-93	236.22	U	CBD	-	-	-	-	-
102-9-93-HNS-P VGT085	9-23-93	273.00	M	Y	-	-	Y	-	Y
104-10-93-CCC-P VGT086	10-5-93	230.2	F	Y	-	-	Y	-	Y
107-10-93-CCC-P VGT087	10-30-93	215.00	F	Y	-	-	Y	-	Y
108-11-93-CCC-P VGT088a,-88b	11-2-93	240.00	F	YY	-	-	Y	-	Y
110-11-93-CCC-P VGT089	11-10-93	239.0	F	CBD	-	-	Y	-	-
111-11-93-PEC-P	11-14-93	196.6	M	Y	-	-	-	-	Y
112-11-93-MCB-P	11-14-93	221.0	M	NE	-	-	-	-	-
113-11-93-PEC-P	11-14-93	188.0	M	Y	-	Y	-	-	Y
114-11-93-HNS-P	11-14-93	91.4	U	CBD	-	-	-	-	-
1116-11-93-HNS-P VGT092	11-26-93	223.0	F	NE	-	-	Y	-	-
117-12-93-HNS-P VGT091	12-2-93	161.0	F	Y	N	N	Y	Y	Y
118-12-93-HNS-P	12-1-93	203.2	M	NE	-	-	-	-	-
120-12-93-CCC-P	12-5-93	155.0	M	NE	-	-	Y	-	-
122-12-93-NHC-P	12-19-93	266.7	F	NE	-	-	-	-	-

Table 28. Common Types of Commercial Gear, Seasons, Locations, Target and Bycatch Species in North Carolina Ocean Waters

Gear Type	Dates	Location	Mesh Size (Stretch)	Target Species	Occasional Species
Gill Nets (sink)	Oct-May	Oregon Inlet-Cape Fear	2.5"-6"	Weakfish, Croakers, Spot, Bluefish, Dogfish	Mullet
Gill Nets	Jan-Mar	Hatteras, Ocracoke	8"	Bluefish	
Trawl	Oct-Apr	Beaufort Inlet-VA	3"-5.5"	Flounder, Bluefish, Croaker, Weakfish, Spot, Scup, Black Sea Bass	Dogfish, Scombrids, Loligo Squid, Striped Bass
Trawl	May-Sep	Shelf Edge	Same	Squid	
Trawl	Mar-Oct (S. of New River)	Ocracoke Inlet-SC Line	1.5"-2"	Brown, Pink & White Shrimp	
Trawl/Dredge	Jan-Apr	Cape Lookout	1.5"	Calico Scallops	
Trawl	Oct-Feb	Cape Lookout-VA	3.5"-5.5"	Flounder, Scup, Black Sea Bass	
Longline	Year-Round	Shelf, Gulf Stream	N/A	Shark, Tuna	
Longline	Year-Round	Cape Hatteras-SC	N/A	Reef Fish	
Floating Gill Net	Late Spring-Summer/Fall	NC/VA Line-Cape Fear	3"-6" Mesh	Spanish & King Mackerel	Weakfish, Bluefish
Hook & Line (Troll)	Year-Round	Gulf Stream	7/0-9/0 Hooks	Pelagics (Tuna, King Mackerel, etc.)	Wahoo, Dolphin, Spanish Mackerel, Bluefish
Hook & Line (Drift or Anchor)	Year-Round	Oregon Inlet-Cape Fear	N/A	Bottom Fish, (Flounder, Trout, Mullet, etc.)	
Hook & Line	Year-Round	Hard-Bottom Areas	N/A	Reef Fish	
Fish Traps	Winter	Cape Hatteras-SC		Black Sea Bass	
Stop Net (Not a Fishery; Part of Beach Seine)	Fall	Bogue Banks	8"-10"	Slows Fish for Subsequent Beach Seining	
Beach Seine	Fall	NC/VA Border-Cape Fear	3"	Mullet, Spot, Bluefish	Red Drum, Spotted Sea Trout, Striped Bass
Beach Seine	Spring	NC/VA Border-Cape Hatteras	3"	Blues, Mullet, Spotted Sea Trout, Spot	
Menhaden Purse Seine	Year-Round, Mainly Apr-Jan	Entire Coast	1.25"-1.5"	Menhaden	

Table 29. Common Types of Commercial Gear, Seasons, Locations, Target and Bycatch Species in North Carolina Bays, Sounds & Estuaries

Gear Type	Dates	Location	Mesh Size	Target Species	Occasional Species
Shrimp Otter & Skimmer Trawls	Spring-Fall	Sounds, Large Coastal Rivers	1.5"	Pink, Brown, White Shrimp	Sciaenids, Flounder, Blue Crabs
Shrimp Channel Nets	Summer & Fall	Sounds	1.25"	Pink, Brown, White Shrimp	
Long Haul Seine (Includes Swipe Nets)	Apr-Oct	Pamlico, Core Sounds	6" (2" bunt net)	Croaker, Spot, Weakfish	Bluefish, Spotted Sea Trout, Menhaden
Pound Nets	May-Sep	Pamlico Sound	2"-6"	Spot, Spanish Mackerel, Butterfish, Weakfish, Croaker, Bluefish, Harvestfish	Spadefish, Ribbonfish, Flounder, Menhaden
Pound Nets	Late Winter-Spring	Albemarle Sound Area	2"-4"	River Herring, White Perch	Striped Bass, American Shad, Catfish, Gizzard Shad
Pound Nets	Sep-Dec	Core, Pamlico, & Albemarle Sounds	2"-6"	Flounder	Butterfish, Harvestfish
Gill Net	Year-Round Fall (Peak)	Pamlico & Albemarle Sounds & Adjacent Waters	5.25"-7"	Flounder	Striped Bass, Red Drum
Gill Net	Year-Round	Pamlico Sound, Adjacent to Outer Banks	3"- 6"	Spotted Sea Trout, Mullet	Weakfish, Croaker, Bluefish, Red Drum
Gill Net	Spring	Albemarle Sound	5.5"-6"	American Shad	Striped Bass
Hard Crab Pots	Year-Round	Several Sounds & Tributaries, Cape Fear River	1.5"	Blue Crab	Whelks
Peeler Crab Pots	Spring	Core & Pamlico Sounds, Neuse River	1.5"	Blue Crab (Softshell)	
Trawl/Dredge	Winter	Cape Lookout & Southward	N/A	Whelks	
Dredge (Toothless)	Winter-Spring	Hatteras-New River	N/A	Bay Scallops	Whelks
Hydraulic Dredge, Trawl (Kicking)	Dec-Mar	Core Sound Area, New River, Intracoastal Waterway in Pender Co.	N/A	Hard Clams	
Hand, Rakes, Tongs	Oct-Mar	Croatan Sound-SC Border	N/A	Oysters	
Toothed Dredge	Nov-Mar	Pamlico Sound	N/A	Oysters	
Trawl	Winter	Pamlico Sound	3"	Blue Crabs (Hardshell)	Southern Flounder
Trawl	Spring	Core Sound, Pamlico Sound	2"	Blue Crabs (Softshell)	
Purse Seine	Apr-Dec	Core Sound	1.5"	Menhaden	

South Carolina (Sally Murphy): There are numerous commercial fishing activities which occur in South Carolina state waters (Table 30) and in the Exclusive Economic Zone (EEZ) off South Carolina (Table 31). There are five commercial fisheries that potentially could or, in fact have, affected bottlenose dolphins.

Gill nets set for Atlantic sturgeon: This fishery has not been in operation since 1986 because of declines in sturgeon stocks. It was centered in the Winyah Bay/Santee River area on the north central coast of South Carolina. Large mesh gill nets were set in the ocean during early spring. Large numbers of sea turtles were drowned and an undocumented number of dolphins also stranded dead on nearby beaches. In 1983, the season was shortened and sea turtle strandings declined about 50 percent. In 1986, the season for Atlantic sturgeon was closed entirely and sea turtle strandings were close to zero in this area. Although not documented, it is reasonable that dolphin strandings probably follow this same pattern.

Gill nets set for sharks: These nets are legal in state waters provided that: 1) They are no longer than 100 feet; 2) they are attended at all times by the fishermen; and 3) multiple nets are at least 200 yards apart. These nets are usually fished in the summer season. Our conservation officers have confiscated illegal nets 500-600 feet in length.

Gill nets set for shad: These are also ocean nets that are fished in early spring, but these nets cannot be anchored. They must be fished as drift nets and attended at all times. They can be hundreds of yards long and are perpendicular to the shoreline. There is no accurate documentation of dolphin mortality from these latter two types of nets, although a few carcasses have washed ashore entangled in monofilament netting.

Crab pots: Since the stranding network was set up in 1991, we have documented three dolphin carcasses with crab pot ropes around the tail stock and three occurrences where live dolphins were entangled in crab pot lines. One had a line tangled around its tail stock, and was released by the public. Two were juveniles that had put their head through a loop of the rope near the float (crabbers will sometimes tie a slipknot loop to determine if someone is stealing their crabs, or to aid in catching the line to haul the trap aboard). We were able to free one of these with the help of another boater, because the pot was still attached. The other was not so fortunate. The loop was around its head with about four feet of line trailing behind. This animal was seen frequently in a location with the habituated, feeding dolphins in Calibogue Sound, near Hilton Head Island. It apparently migrated out with its mother in the fall, but was seen again the following spring with the rope cutting more deeply into its head. Its fate is unknown.

Shrimp trawlers: During the summer and fall, dolphins are often seen following behind shrimp trawlers while they are towing, and are also observed milling around the boats as the bycatch is pushed over. This has been documented in the literature by Barros and Odell (1990). This is likely a positive interaction for the dolphins rather than a negative one, since they have their pick of an ample supply of fresh fish. The effect on dolphins of feeding on by-catch is under-documented.

Table 30. Major Commercial Fisheries in South Carolina Inshore, Territorial Sea Waters

Fishery	Dates	Location	Gear Specifications	Target Species	Bycatch Species
Shrimp Trawling	May-Dec	Statewide, Offshore Only	No Restrictions	White, Brown & Pink Shrimp	Sciaenids, Flounders, Sea Turtles, Crabs, Occasional Sturgeon
Shrimp Channel Nets	Sep-Dec 15	Winyah Bay, North Santee Bay	80' Max. Stationary Net	White Shrimp	Sciaenids, Menhaden, Anchovies, Crabs, Herring, Flounder, Butterfish & Mackerel; Possibly Sea Turtles
Blue Crab Trawling	Jan-Mar	Statewide, Offshore	No Restrictions on Net Size; 4" Min. Stretch Mesh	Blue Crabs	Flounders, Whelks, Sciaenids, Horseshoe Crabs
Whelk Trawling	Mid-Jan -May	2-3 Miles Offshore	>4" Stretch Mesh Nets	Knobbed & Channel Whelks	Crabs, Flounders, Occasionally Sturgeon
Crab Potting	Year-Round	Statewide, Primarily in Estuaries	No Restrictions	Blue Crabs	Channel Whelk, Stone Crabs, Flounders, Whiting, Catfish, Diamondback Terrapin, Bottlenose Dolphins
Horseshoe Crab Trawling	Year-Round	Statewide, Offshore Only	8" Min. Mesh	Horseshoe Crabs	
Shellfish (Manual Harvest)	Mid-Sep -May	Estuarine Creeks	Hand Rakes, Tongs, Forks	Oysters, Clams	Whelks, Stone Crabs (Occasionally)
Shellfish (Hydraulic Escalator)	Mid-Sep -May	Estuarine Creeks	Maryland-Type Head with Conveyor	Clams, Oysters, Cross-Barred Venus Clams	Flounders (Rarely), Whelks (Occasionally)
Shad Fishery	Mid-Jan -Apr	Statewide, within Coastal Rivers & within 2-3 Miles of Shore	Drift & Stationary Gill Nets; Primarily 5 1/2" Stretch Mesh	American Shad	Gar, Carp, Catfish, Hickory Shad, Striped Bass, Atlantic & Shortnose Sturgeon, Possibly Dolphins
Haul Seine	Sep-Nov	Northern Area of State (Grand Strand), Beaches	2" Min. Stretch Mesh	Mullet, Spot	Pompano, Weakfish, Spanish Mackerel
Fish Trawling	Winter-Early Spring	Statewide, Nearshore	4" Min. Stretch Mesh	Flounder, Whiting	Sciaenids
Gill Nets	Year-Round	Primarily On or Near Beaches	100' Max. Net-Length; 3" Min. Stretch Mesh	Spot, Pompano, Croakers, Sharks	Red Drum, Spotted Sea Trout, Spanish Mackerel, Possibly Dolphins

Table 31. Major Commercial Fisheries in South Carolina, in Exclusive Economic Zone (EEZ) Waters

Fishery	Dates	Location	Gear Specifications	Target Species	Bycatch Species
Black Sea Bass Pots	Year-Round, Primarily Winter	60-125' On Live Bottom	Rectangular Wire Traps <24"/side; Escape Panels Required	Black Sea Bass	Bank & Rock Sea Bass, Scup, Red Porgy, Grunts
Vertical Hook & Line	Year-Round	90-300' On Live Bottom & Rocky Ledges	No Restrictions	Snappers, Groupers, Porgies, Grunts, Triggerfish	Squirrelfish, Sharks, King Mackerel
Bottom Longlines	Year-Round	300-900' Around Rocky Ledges or Clay/Mud Bottoms	No Restrictions	Deepwater Groupers, Tilefish	Black-Bellied Rockfish, Sharks, Possibly Sea Turtles
Trolling	Year-Round; Most Productive May-Dec	60-200', Best Areas Associated with Live Bottoms or Artificial Reefs	No restrictions	King Mackerel	Little Tunny, Baracuda
Shark Longline	Jan 1-Jun 30 & Jul 1-Dec 31, Until 6-Mo. Quota is Reached	30-200'	No Restrictions	Large Coastal Sharks	Occasional Red Drum, Grouper, Possibly Sea Turtles
Swordfish Longlines	Year-Round	900-2,000'	No Restrictions	Swordfish, Tuna	Billfish, Wahoo, Dolphinfish, Barracuda, Possibly Sea Turtles

Georgia (Charles Maley): Fisheries interactions with bottlenose dolphins occur on the Georgia Coast as in other coastal areas, though the level may be somewhat lower due to one factor: the major gear threats implicated in other states' fisheries are much less of a threat in Georgia's state waters. Gill nets have been outlawed in Georgia since 1973, except for hand pulled seines less than 300 feet in length, and shad and sturgeon netting (Table 32).

Sturgeon fisheries in Georgia target the Atlantic species and are highly restricted. This fishery is carried out with large mesh set and drift gill nets limited to a minimum of 30.5 cm stretched mesh webbing, which is not to occupy more than two thirds of the width of the stream in

which it is deployed. However, most fishermen tend toward the use of 35 or 36 cm stretched mesh webbing in order to target the more valuable, caviar-bearing females. The season is restricted to the time period between February 15 to April 15 each year. Due to the nearly artisanal nature of the fishery, interactions with dolphins are probably very infrequent.

Shad fisheries in Georgia primarily target female American shad during the legal season from January 1 to March 31. Certain areas are further restricted during the season, and the season may be extended by the Commissioner of the Georgia Department of Natural Resources (GDNR), but this has not occurred since the mid-1980's. Minimum net size is 11.43 cm stretch mesh, but most fishermen use mesh sizes closer to 13 cm, in order to target the more valued female shad. Nets may not be deployed in such a fashion as to restrict more than one half the width of the stream. Set nets may not exceed 30.5 meters in head rope length, and drift nets may not be longer than 305 meters. To date, there has only been one dolphin entanglement mortality reported in Georgia.

Table 32. Types of Commercial Fishing in Georgia with Potential Impacts for Dolphins

Gear Type	Season	Location	Mesh Size (Stretch)	Target Species	Occasional Species
Gill Nets (sink)	Jan 15-Apr 15	Inshore, Coastwide	30.5-36.0 cm	Atlantic Sturgeon	Striped Bass
Gill Nets	Jan 1-Mar 31	Inshore - Fresh Rivers	11.5-13.0 cm	American Shad	Carp, Shortnose Sturgeon, Striped Bass
Trawl	<u>Fed Waters:</u> Year-Round <u>State Waters:</u> Jun-Dec	Nearshore - Offshore: Coastwide	3-5 cm	White, Brown & Pink Shrimp	
Crab Pots	Year-round	Inshore - Offshore		Blue Crabs	Stone Crab, Sheepshead, Flounder

Shrimp trawling operations in Georgia do interact with bottlenose dolphins, but the net effect of this may be a beneficial one for dolphins, as the trawls disturb and disorient fish and shrimp. By-catch of shrimp trawling consists largely of fish, and when thrown overboard, these fish become an easy meal for dolphins and other species nearby. There is one account of a dolphin caught in a fast moving fish trawl, but trawlers are typically slow moving when fishing (3-6 km/hr), and the threat of incidental capture of dolphins is probably negligible.

At least 3 dolphins have been entangled in crab pots over the last ten years in Georgia. Dolphins may recognize the fish used for bait as a potential food source, and attempt to turn the pot to reveal the bait compartment at the bottom of the trap, thereby becoming entangled in the line. Some crabbers feed dolphins the fish they use as bait, and thus may encourage this behavior.

The increasing popularity of shark meat has resulted in more intense exploitation of this resource. In the last three years, the Federal waters offshore of Georgia (beyond the 3-mile limit of State jurisdiction) have been the scene of drift gill netting for small coastal sharks and larger pelagic species. The seasons are limited by a NMFS quota, and mesh sizes vary from 3" to 15" stretched mesh. The nets may not be longer than 2,743m. There is a report by fishermen in 1992, of a dolphin with net marks, and an accompanying photograph showed patterns on the skin of the dolphin consistent with large mesh net.

FLORIDA (Bill Brooks): Of the many commercial fisheries in Florida's Atlantic coastal waters, several can have either a direct or indirect effect on bottlenose dolphin populations (Tables 33 and 34). The same fisheries are found in Georgia and South Carolina, but their seasons of availability are somewhat different.

Table 33. Commercial Fishing Along the Atlantic Coast of Florida in Estuaries, Lagoons, Bays, and Sounds

Gear Type	Dates	Location	Mesh Size (Stretch)	Target Species
Otter Trawl, Skimmer Trawl	Spring - Fall	Nassau & Duval Counties	1.5"	Shrimp
Gill Net	Year-round	Nassau - Dade Counties	3 - 6"	Shad, Sea Trout, Mullet, Spot, Pompano
Hook & Line, "Splatter Pole"	Spring - Summer			Spotted Sea Tro
Live Bait Traps	Spring - Summer			Pigfish
Crab Pots	Year-round		1.5"	Blue Crabs
Bull Rakes	Year-round			Hardshell Clam

B. Dolphin Feeding/Watching Programs

At a 1988 workshop to review and evaluate whale watching programs and similar activities that may affect wild populations of marine mammals (Atkins and Swartz, 1989), the participants recommended that NMFS issue regulations establishing a minimum distance for anyone approaching whales and prohibiting activities such as feeding wild populations of marine mammals. The participants expressed concern that the public's increasing interest in observing, approaching, and feeding marine mammals may cause biological problems for the marine mammals, and these activities may be a violation of the Marine Mammal Protection Act (MMPA) and the Endangered Species Act.

On August 29, 1990, NMFS published a proposed rule (55FR 35328) to amend the definition of "take" to include feeding marine mammals in the wild. The comment period ended

Table 34. Commercial Ocean Fishing Along the Atlantic Coast of Florida Within State Jurisdictional Waters

Gear Type	Dates	Location	Mesh Size (Stretch)	Target Species
Gill Nets (Drift)	Prohibited	All State Waters		
Gill Nets	Year-round. Tended, Must be Gathered Within 1 hour after Deploying. Daylight Only, from Sebastian Inlet to Jupiter Inlet.	Nassau - Dade Counties	3" - 6"	Spanish & King Mackerel, Trout, Flounder, Croaker, Spot, Pompano, Mullet, Shark.
Purse Seine	Year-round, Seasonal	Brevard -Dade Counties	2"	Bait Fish, Menhaden, Herring, Lady Fish, Sardine
Ballyhoo Nets	Oct - Feb			Ballyhoo, Flying Fish & Other Bait Fish
Beach Seine	Year-round, Effort Varies Seasonally.	Nassau - Palm Beach Counties	3"	Bait Fish, Mullet, Spot, Croaker, Sea Trout.
Trawl	Effort Varies Seasonally, Year-Round, Except Closed Apr 1 -Jun 1.	Nassau - Indian River Counties	1.5" - 2"	Shrimp
Trawl Dredge		Cape Canaveral		Scallops
Longline	Prohibited		No More Than 10 Hooks in State Waters	Reef Fish, Tilefish, Snapper, Grouper, Shark, Tuna, Spanish & King Mackerel.
Hook & Line	Apr - Quota is Reached	Nassau - Dade Counties		Spanish & King Mackerel, Cobia, & Other Pelagics
Hook & Line	Year-round	Nassau - Dade Counties		Reef Fish
Fish Pots		Nassau - Dade Counties		Black Sea Bass
Spear Fishing	Year-round	Nassau - Dade Counties		Grouper, "reef fish".

November 8, 1990. Public hearings on the proposed rule were held in Panama City, Florida; Hilton Head Island, South Carolina; Corpus Christi, Texas; and Silver Spring, Maryland. In the same issue of the Federal Register (55 FR 35336), NMFS published its policy regarding applications for public display permits to approach, harass, and feed Atlantic bottlenose dolphins in the wild. NMFS concluded that the potential adverse impacts on the populations or stocks of Atlantic bottlenose

dolphins and the marine ecosystem outweigh the potential benefit of the proposed activities. NMFS concluded that issuing a permit authorizing an activity intended to directly or indirectly alter the

natural and feeding behavior of groups of wild animals is not consistent with the purposes and policies of the MMPA. §216.3 of the MMPA, which outlines definitions under the Act, defines "take" as follows:

Take means to harass, hunt, capture, collect, or kill any marine mammal. This includes, without limitation, any of the following: The collection of dead animals, or parts thereof; the restraint or detention of a marine mammal, no matter how temporary; tagging a marine mammal; the negligent or intentional operation of an aircraft or vessel, or the doing of any other negligent or intentional act which results in disturbing or molesting a marine mammal; **and feeding or attempting to feed a marine mammal in the wild** [emphasis added].

These regulations became effective in April 1991, but in October 1992, a Texas district court, ruling in favor of a Corpus Christi couple running a dolphin feeding operation, issued an injunction against NMFS's feeding regulations, as applied to bottlenose dolphins. Thus, when NMFS held the workshop on coastal stock(s) of bottlenose dolphins in September, 1993, this injunction was still in place. However, on October 29, 1993, The Fifth Circuit Court of Appeals in New Orleans lifted the injunction, stating that it was clearly reasonable for NMFS to prohibit feeding as a potential hazard to dolphins. Under this ruling, it is again illegal to feed any wild marine mammals, which includes dolphin feeding activities by commercial cruise-boat operators and recreational boaters.

Apparent Impact of Commercial Dolphin Feeding Operations on Bottlenose Dolphins in South Carolina (Sally Murphy): A commercial enterprise that may affect bottlenose dolphins, not related to fisheries, is dolphin feeding. In South Carolina, this activity is concentrated at Hilton Head Island. I collected information on this activity from three sources: Nancy Weckhorst, a volunteer on our marine mammal stranding network, interviewed ten boat captains who are involved in feeding cruises; Tom Doyle, who has conducted Commander Zodiac's nature cruises for the past seven years, provided information on the number of dolphins involved and the food supply; and our own observations are included.

History: In addition to the food associated with shrimp trawlers, it is believed that crabbers first began to offer dolphins some of their frozen bait as amusing "popsicles". The first documented feeding (with photos) was in 1981 or 1982. Captain Fuzzy Davis was fishing with friends near the marshes inland of Calibogue Sound. They had caught 8 trout. A pod of dolphins was heading toward their fishing spot and the men were concerned that the dolphins would ruin their fishing. They beat on the side of the boat to scare the dolphins away. To their surprise, one dolphin came up to the side of the boat. They offered it one of the trout, which it took. They then gave it the rest of the trout. Capt. Davis told this story to others, but no one believed him.

At about this same time, there were several old dolphins north of Hilton Head in Port Royal Sound and the Colleton River that had apparently been fed by crabbers. In 1987, one of these animals launched itself onto the gunwale of Tom Murphy's boat while he was pulled up onto the edge of the marsh to observe an eagle's nest.

During the mid 1980s, there were two charter boats out of Harbor Town at Hilton Head Island that began to feed dolphins. Over the years this number has increased, and today, there are 14 groups that actively advertise dolphin feeding cruises.

Current Situation: The number of "friendly" dolphins has increased each year. Now there are about 30 in Calibogue Sound and five in Port Royal Sound. Table 35 shows the various types of boats involved and the numbers of each. The dolphin feeding occurs primarily from March to October. The "slower" months are March through May, and September through October. During this time, cruises may make only one trip per day. The "busy" months are June, July and August, when several trips are made per day.

These vessels operate out of five marinas: Harbor Town, Shelter Cove, Palmetto Bay, South Beach, and Skull Creek at Hudson's Seafood Restaurant. Using four trips per day during the busy months and one trip per day during the slower months, we get 521 "trip days" per year. If we multiply this times the minimum number of passengers per trip, then 114,099 people view dolphin feeding per year. The cost per person is about \$12.00 for large boats and \$24.00 for smaller ones. Using the minimum fee, this activity generates in excess of 1.3 million dollars per year. At each step in these estimates, the minimum number was used. A more realistic estimate might be 125,000 persons and close to 2 million dollars in revenue per year.

Quality of Food, and Behavior Patterns: Most of the boats catch fresh menhaden or mullet, which are abundant during the summer. Some have frozen cigar minnows. Tom Doyle has been keeping a journal and believes that he has photo-IDs of 25 individual dolphins that are habituated to dolphin feeding boats. There may be another five habituated individuals that are using the northern end of the island and Port Royal Sound. Not all of the pods are habituated and not all of the members of a pod are habituated. The "friendly" animals appear to be adolescents, and seem to be increasing in number, although some dolphins that ate from dolphin feeding boats as adolescents no longer do so, now that they are adults. There are also two mother/calf pairs that now come to the boats. The same dolphins are not seen in the same place each day. Since practically no feeding takes place during winter, dolphins are not totally dependant on this source of food.

Problems: There was concern expressed by all of the boat captains who were interviewed. According to these boat captains, the primary problem is with the rental boats and the waverunners. The people who rent them are not operating them safely; they chase the dolphins, and someone in this group was observed pouring beer into the mouth of a dolphin. Others have been seen trying to feed pickles, potato chips, and pretzels to dolphins.

The second concern expressed by the boat captains was in regard to the quality of the fish being fed to the dolphins. They questioned whether the fish were fresh enough, whether some of them were being re-frozen, and whether the fish buckets were routinely washed before another batch of fish was placed in them. Three dolphins have now been observed with green sores along their gums. Is this related to their diets? And most important of all, how are these feeding programs affecting the behavior of the social groups that live in that area?

A new concern is the practice of petting the dolphins. This is becoming more prevalent and may be rough at times. All of the people interviewed believed that this practice should be banned outright, or at least regulated in some form. At the moment, it is totally out of control.

Acknowledgements: I would like to thank Nancy Weckhorst and Tom Doyle for their input on dolphin feeding, David Cupka for information on commercial fishing and Tom Murphy for review and comments.

Table 35. Vessels Involved in Dolphin Feeding at Hilton Head Island, South Carolina

Type of Vessel	Number	Trips/Day	PASSENGERS/TRIP
Head/Cruise Boat	4	4	150
Fishing Charter	24	?	30-40
Sailboat Charter	6	4	30
Nature Charter	14	4	4-6
Rental			
Power	20	2	4-6
Waverunners	15	?	1-2
TOTAL	83	14 (minimum)	219 (minimum)
Private Boats	25	1	4-6

Some Thoughts on the Practice of Feeding Bottlenose Dolphins in South Carolina - Another Perspective (Tom Murphy): Currently, an extensive part of South Carolina's waters are involved in dolphin feeding operations. There are at least 14 commercial dolphin feeding operations at Hilton Head. It is conservatively estimated that at least 100,000 people paid to feed dolphins at Hilton Head during 1993. This doesn't include part-time operators, sport fishing charters or private boats. It is likely that in excess of 125,000 people were involved in dolphin feeding at Hilton Head over the past year.

There are several features which are unique to this operation at Hilton Head. First, the quality of fish fed is generally high, as all commercial operators in the area buy from the same supplier. The fish are flash-frozen at the time of capture. This is not to suggest that all feeding is controlled, but a large portion is self-regulated. The operators know they are under scrutiny. Second, the feeding operation is seasonal. There is little or no feeding of dolphins from December-March. Thus every year, the dolphins return to natural patterns of feeding.

I have been working to photo-ID as many feed boat-habituated dolphins as I can at Hilton Head. I am working with Tom Doyle, who has kept daily journals for the past 7 years while operating a commercial dolphin tour. Tom knows most of the habituated dolphins on sight and has annual histories on many. His cooperation has been invaluable and has made rapid progress possible.

These dolphins appear to be facultative feeders at boats. There have been times when known habituated dolphins did not come to the boat when involved in social activity or natural feeding behavior. We have also seen two long-term habituated dolphins successfully breed and calve for their first time, this year. These two cow/calf pairs are seen regularly at the boats. We also regularly see some members of a pod which are habituated and other members which are not habituated. Our

rough estimate is that 30-50 out of a total population of 200 dolphins are habituated, but this number may be increasing rapidly.

I have listed several possible pros and cons of dolphin feeding below.

Dolphin Feeding - Potential negative impacts:

- a. May alter the natural foraging behavior of older juveniles and adults, leading to dependency;
- b. feeding of contaminated (non fresh) fish may lead to disease;
- c. may result in feeding inappropriate fish that lack adequate nutritional value;
- d. habituation may lead to indiscriminate feeding. This could result in ingestion of totally inappropriate food items such as pickles, bread, or foreign objects. Placement of food or objects deep into the mouth may produce a gag response;
- e. may result in injury to those feeding the dolphins and/or to swimmers in the general area, or in other areas along their migratory path;
- f. may result in increased injury and mortality of dolphins in sport fishing, as dolphins "learn" to take dead fish used as bait and habituate to boats;
- g. may increase negative interactions between dolphins and commercial fisheries such as crabbing, as dolphins seek out bait inside crab pots. This may be exacerbated by crabbers who feed bait to dolphins;
- h. there may be an increased probability of disease transmission between dolphins and people as physical contact increases. Many habituated dolphins now allow physical contact such as petting and touching;
- i. feeding may result in unnatural and stressful social pressure on subordinate animals. Hand feeding is a predictable and very localized situation with no fringe feeding benefits for subordinates. Thus an excessive amount of social pressure may be inflicted on subordinate animals with no nutritional benefits to them;
- j. unhabituated dolphins are impacted as boaters frequently approach "wild" dolphins to offer food. This is of particular concern when wild dolphins are feeding in social groups on schooled fish. Both dolphins and fish are dispersed by unknowing boaters who wonder why the dolphins didn't come to their boat;
- k. habituated dolphins may be subjected to greater risk of being struck by boat propellers.

Dolphin Feeding - Benefits:

- a. Dolphin viewing/feeding provides a positive conservation message to tens of thousands of people each year. This is a positive environmental experience brought not only to actual participants, but also to those to whom they discuss their experience;
- b. dolphin feeding has grown into a significant part of ecotourism and represents an industry that grosses in the hundreds of thousands of dollars per year;
- c. provides an opportunity for the close observation of dolphins for scientific observation or collection of data;
- d. may actually enhance survival of dolphins, if other species such as eagles, deer, or passerine birds are used as a model.

Conclusions: Although there are 11 detrimental factors listed and only 4 beneficial, it should be pointed out that all detrimental effects are hypothesized and have little or no supporting documentation under actual field conditions. There has been no reported increase in strandings adjacent to feeding areas. Remember, the significant increase in the "normal" stranding rate during 1987/1988 is what was used to determine depleted status for the coastal migratory stock(s). Nor could one argue that the number of dolphins involved in current feeding situations represent a threat to the stocks if all were killed as a result of feeding. On the other hand, 3 of the 4 beneficial aspects of dolphin feeding are real and documented. NOTE: I am not condoning or recommending a continuation of dolphin feeding programs. I am, however, suggesting that restrictive regulation of an industry should not be based on innuendo, but rather, on sound scientific information.

The existence of a group of "wild" dolphins which are habituated to being hand fed provides unique opportunities for the study of bottlenose dolphins. There is currently a group of 30-50 habituated dolphins that may easily be observed at close range for photo-identification, signs of disease and parasitism, and behavior. Further, there are additional animals which are conditioned to the close approach of boats because of the very high interaction between boats and dolphins, but are not habituated to hand feeding. Although not intended for research, this site is the product of many years of habituation and an enormous expenditure of labor and funds.

The value of this area for the study of dolphins appears to be 3-fold. First, as an area to study the effects of hand feeding dolphins on the health and well-being of the population. Although there are many reasons to believe this practice can be detrimental, most of the information is based on inference and conjecture. It could also be argued that because of the long and intense habituation of dolphins to feeding, the effects of a ban on feeding may be deleterious. Second, these animals represent a population in which habituated dolphins may be treated as "marked" and can be "re-sighted" (recaptured) easily. Thus, if we know the size of the habituated population and the ratio of habituated to unhabituated dolphins, we can estimate the total population and evaluate survey techniques. And last, this population represents an intermediate condition between captive and wild dolphins. We have the opportunity to observe, at close proximity, basically free-ranging dolphins to compare behaviors and the etiology of diseases.

There is a need to photo-ID habituated dolphins in order to: 1) Determine annual survivorship of habituated dolphins; 2) determine minimum numbers of habituated animals; 3) determine the distribution and frequency of sightings of habituated dolphins; 4) monitor changes in the health and behavior of habituated dolphins; and 5) document habituated dolphins which become strandings.

Multiple surveys should be conducted of the entire area within which habituated dolphins range, to determine the ratio of known (identifiable) dolphins to total habituated dolphins seen. Calculations of mark-recapture ratios can then be used to estimate the total population of habituated dolphins, and over time, to determine annual increases or decreases in the sociable population.

Finally, multiple aerial and boat surveys should be conducted to determine the ratio of habituated to unhabituated dolphins. Mark-recapture ratios can then be used to estimate the entire population of dolphins in the area (Calibogue Sound). This population estimate could then be used to evaluate the effectiveness of aerial and boat census techniques.

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Literature Cited

- Aguilar, A. 1983. Organochlorine pollution in sperm whales, *Physeter macrocephalus*, from the temperate waters of the Eastern North Atlantic. *Mar. Pollut. Bull.* 14(9):349-352.
- Aguilar, A. 1987. Using organochlorine pollutants to discriminate marine mammal populations: a review and critique of the methods. *Mar. Mamm. Sci.* 3:242-262.
- Allen, K.R. 1976. A more flexible model for baleen whale populations. *Rep. Int. Whal. Comm.* 76:247-263.
- Atkins, N., and S.L. Swartz (editors). 1989. Proceedings of the workshop to review and evaluate whale watching programs and management needs, November 14-16, 1988, Monterey, California. *Can. Mar. Conserv. Wash., D.C.*, 53 p.
- Baden, D.G. 1983. Marine food-borne dinoflagellate toxins. *Int. Rev. Cytol.* 82:99-150.
- Baden, D.G., and T.J. Mende. 1982. Toxicity of two toxins from the Florida red tide dinoflagellate *Ptychodiscus brevis*. *Toxicon* 20: 457-462.
- Baden, D.G., T.J. Mende, G. Bikhazi and I. Leung. 1982. Bronchoconstriction caused by Florida red tide toxins. *Toxicon* 20:929-932.
- Bailey, J.W. 1946. The mammals of Virginia. Williams Printing Co. Richmond, Va. 416 p.
- Barros, N.B. 1993. Feeding Ecology and Foraging Strategies of Bottlenose Dolphins on the Central East Coast of Florida. Univ. Miami. Coral Gables, Fla. Ph.D. dissert., 328 p.
- Barros, N.B., and D.K. Odell. 1990. Food habits of bottlenose dolphins in the southeastern United States. In S. Leatherwood and R.R. Reeves (Editors), *The bottlenose dolphin*, p. 309-328, Acad. Press, N.Y.
- Bassos, M.K. 1993. A behavioral assessment of the reintroduction of two bottlenose dolphins. Univ. Calif., Santa Cruz, M.S. thesis, 84 p.
- Blaylock, R.A. 1984. The distribution and abundance of the bottlenose dolphin, *Tursiops truncatus*, in Virginia. Coll. William Mary, Williamsburg, Va., M.S. thesis, 56 p.
- Blaylock, R.A. 1985. The marine mammals of Virginia. VIMS Educ. Ser. 35, VSG-85-05, 35 p.
- Blaylock, R.A. 1988. The distribution and abundance of the bottlenose dolphin, *Tursiops truncatus* (Montagu, 1821), in Virginia. *Fish. Bull.* 86:797-806.
- Bonaventura, J., and C. Bonaventura. 1987. Carolina fish may be toxin carriers. *Envir.* 10(3):1. Duke Univ. Mar. Lab., Beaufort, N.C.

- Borison, H.L., Ellis, S. and L.E. McCarthy. 1980. Central respiratory and circulatory effects of *Gymnodinium* brevetoxin in anesthetized cats. *Brit. J. Pharmacol.* 70:249-256.
- Burn, D.M. 1988. NOAA/Smithsonian cooperative mid-Atlantic bottlenose dolphin aerial survey program: final report. NOAA/NMFS/SEFSC/Miami Lab., Coast. Resour. Div. Contrib. ML-CRD-87/88-22, 17 p.
- Burn, D.M., and G.P. Scott. 1988. Synopsis of available information on marine mammal-fisheries interactions in the southeastern United States: preliminary report. NOAA/NMFS/SEFC/Miami Lab., Coast. Fish. Resour. Div. Contrib. CRD-87/88-26, 10 p.
- Burn, D.M., G.P. Scott, R.E. Owen, and L.J. Hansen. 1987. Bottlenose dolphin *Tursiops truncatus* distribution patterns in the southeastern United States. Poster presentation at the Seventh Biennial Conference on the Biology of Marine Mammals, Miami, Fla., U.S.A. December 5-9, 1987.
- Caldwell, D.K., and F.B. Golley. 1965. Marine mammals from the coast of Georgia to Cape Hatteras. *J. Elisha Mitchell Sci. Society.* 81(1):24-32.
- Carew, R.J. (1982). Aerial surveys to estimate herd size and density of populations of bottlenose dolphins in the area of Savannah River, Port Royal and St. Helena Sounds. NMFS Final Contr. Rep. NA-81-GA-C-00008.
- CETAP. 1982. A characterization of marine mammals and turtles in the mid- and North Atlantic areas of the U.S. outer continental shelf. Final report of the Cetacean and Turtle Assessment Program. U.S. Dep. Inter., Washington, D.C., Bur. Land Management Contr. AA551-CT8-48, 450 p.
- Clark, W.A., D.G. Hollis, R.E. Weaver and P. Riley. 1984. Identification of unusual pathogenic gram-negative aerobic and facultatively anaerobic bacteria. U.S. Dep. Health Human Serv., Cen. Dis. Contr., Atlanta, Ga.
- Dowling, T.E. and W.M. Brown. 1993. Population structure of the bottlenose dolphin, *Tursiops truncatus* as determined by restriction endonuclease analysis of mitochondrial DNA. *Mar. Mamm. Sci.* 9:138-155.
- Duffield, D.A., S.H. Ridgway, and L.H. Cornell. 1983. Hematology distinguishes coastal and offshore forms of bottlenose dolphins, *Tursiops*. *Can. J. Zool.* 61:930-933.
- Duffield, D.A., and R.S. Wells, 1986. Population structure of bottlenose dolphins: Genetic studies of bottlenose dolphins along the central west coast of Florida. Contr. Rep. to Nat. Mar. Fish. Serv., Southeast Fish. Cen. Contr. 45-WCNF-5-00366, 10 p.
- Duffield, D.A. and R.S. Wells, 1991. The combined application of chromosome, protein and molecular data for the investigation of social unit structure and dynamics in *Tursiops truncatus*. In A.R. Hoelzel (Editor.), p. 155-169, Genetic ecology of whales and dolphins. Rep. Int. Whal. Comm., Spec. Iss. 13,

- Fowler, C.W. 1981a. Density dependence as related to life history strategy. *Ecology*. 1981: vol. 602-610.
- Fowler, C.W. 1981b. Comparative population dynamics in large mammals. **In** C.W. Fowler and T.D. Smith (Editors), *Dynamics of large mammal populations*, pp. 437-451. John Wiley and Sons, New York, N.Y.
- Fritts, T.H., A.B. Irvine, R.D. Jennings, L.A. Collum, W. Hoffman, and M.A. McGehee. 1983. Turtles, birds and mammals in the northern Gulf of Mexico and nearby Atlantic waters. An overview based on aerial surveys of OCS areas, with emphasis on oil and gas effects. *Minerals Manage. Ser. Final Contr. Rep.* 14-16-0009-81-949, 455 p.
- Gaskin, D.E., R. Frank, M. Holetinet. 1983. Polychlorinated biphenyls in harbour porpoises, *Phocoena phocoena* (L), in the Bay of Fundy, Canada and adjacent waters, with some information on chlordane and hexachlorobenzene levels. *Arch. Environ. Contam. Toxicol.* 12:211-219.
- Gaskin, D.E., M. Holdrinet, and R. Frank. 1971. Organochlorine pesticide residues in harbour porpoises from the Bay of Fundy region. *Nature* 233:499-500.
- Geraci, J.R. 1989. Clinical investigation of the 1987-88 mass mortality of bottlenose dolphins along the U.S. Central and South Atlantic Coast. Final Rep. to Nat. Mar. Fish. Ser. and U.S. Navy, Off. Nav. Res., 63 p.
- Geraci, J.R., and V.J. Lounsbury. 1993. *Marine mammals ashore: A field guide for strandings*. Tex. A & M Sea Grant Publ., Galveston, Tex., 305 p.
- Geraci, J.R., D.M. Anderson, R.J. Timperi, D.J. St. Aubin, G.A. Early, J.H. Prescott, and C.A. Mayo. 1989. Humpback whales, *Megaptera novaeangliae* fatally poisoned by dinoflagellate toxin. *Can. J. Fish. Aquat. Sci.* 46:1895-1898.
- Geraci, J.R., B.D. Hicks, and D.J. St. Aubin. 1979. Dolphin pox: a skin disease of cetaceans. *Can. J. Complete. Med.* 43:399-404.
- Geraci, J.R., D.J. St. Aubin, I.K. Barker, R.G. Webster. 1982. Mass mortality of harbor seals: pneumonia associated with influenza A virus. *Science*. 215:1129-1131.
- Gunter, G., R.H. Williams, C.C. Davis and F.G. Smith. 1948. Catastrophic mass mortalities of marine animals and coincident phytoplankton bloom on the west coast of Florida, November 1946 to August 1947. *Ecol. Monogr.* 18:309-324.
- Haley, N.J., and A.J. Read. 1993. Workshop on harbor porpoise mortalities and human interactions. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/NER-5, 32 p.
- Handley, C.D. Jr. and C.P. Patton. 1947. *Wild mammals of Virginia*. Va. Comm. Game Inland Fish., Richmond, 22 p.

- Hansen, L.J., and M.D. Scott. 1989. Bottlenose dolphin densities in five selected southeastern United States areas during 1981-83. NMFS/SEFC, Miami Lab., Coastal Resour. Div., Contrib. CRD-88/89-08.
- Harrison, R.J. 1969. Reproduction and reproductive organs. **In** T.H. Anderson (Editors), The biology of marine mammals, p. 253-342. Acad. Press, NY.
- Harrison, R.J., R.L. Brownell, Jr., and R.C. Boice. 1972. Reproduction and gonadal appearances in some odontocetes. **In** R.J. Harrison (Editor), Functional anatomy of marine mammals. Vol. 1, p. 361-429. Acad. Press, NY.
- Hersh, S.L. 1987a. Stock structure of bottlenose dolphins (genus *Tursiops*) in the southeastern U.S.: a review and management considerations. Final Rep. to NOAA/NMFS/SEFC, Contr. 40GENF700715, 35 p.
- Hersh, S.L. 1987b. Characterization and differentiation of bottlenose dolphin populations (genus *Tursiops*) in the southeastern U.S. based on mortality patterns and morphometrics. Univ. Miami, Coral Gables, Fla. P.hD. dissert., 213 p.
- Hersh, S.L. 1987c. Mortality, natality, migration, and organismic growth rates of bottlenose dolphins (genus *Tursiops*): a review and management considerations. Final Rep. to NOAA/NMFS/SEFC, Contr. OGENF700715, 27 p.
- Hersh, S.L., and Duffield, D.A. 1990. Distinction between northwest Atlantic offshore and coastal bottlenose dolphins based on hemoglobin profile and morphometry. **In** S. Leatherwood and R.R. Reeves, (Editors), The bottlenose dolphin, p. 129-139. Acad. Press, N.Y.,
- Hersh, S.L., D.K. Odell, and E.D. Asper. 1990a. Bottlenose dolphin mortality patterns in the Indian/Banana River systems. **In** S. Leatherwood, and R.R. Reeves (Editors), The bottlenose dolphin, p. 159-164, Acad. Press, N.Y.
- Hersh, S.L., D.K. Odell, and E.D. Asper. 1990b. Sexual dimorphism in bottlenose dolphins from the east coast of Florida. *Mar. Mamm. Sci.* 6:305-315.
- Hershkovitz, P. 1966 Catalogue of living whales. U.S. Nat. Mus. Bull. 246, 259 p.
- Heyning, J.E. 1987. Stranded cetaceans -- what the biological data are telling us. *Cetus* 7(2):7-9.
- Hohn, A.A. 1980. Age determination and age related factors in the teeth of western North Atlantic bottlenose dolphins. *Sci. Rep. Whales Res. Inst. Tokyo* 32:39-66.
- Holt, S.J. 1985. The classification of whale stocks and the determination of catch limits under the new management procedure with limited information. *Rep. Int. Whal. Comm.* 35:487-494.
- Honda, K., R. Tatsukawa, K. Itano, N. Miyazaki, and T. Fujiyama. 1983. Heavy metal concentrations in muscle, liver, and kidney tissue of striped dolphin, *Stenella coeruleoalba*,

- and their variations with body length, weight, age and sex. *Agric. Biol. Chem.* 47:1219-1228.
- Irvine, B., and R.S. Wells. 1972. Results of attempts to tag Atlantic bottlenose dolphins, *Tursiops truncatus*. *Cetology* 13:1-5.
- Irvine, A.B., M.B. Scott, R.S. Wells and J.H. Kaufmann, 1981. Movements and activities of the Atlantic bottlenose dolphin, *Tursiops truncatus*, near Sarasota, Florida. *Fish Bull.* 79:671-688.
- Keinath, J.A., and J.A. Musick. 1988. Population trends of the bottlenose dolphin, *Tursiops truncatus*, in Virginia, 1980-1987. Final Rep. to NOAA/NMFS/SEFC Miami Lab. PO #40GENF880564, 36 p.
- Kennedy, S., J.A. Smyth, P.F. Cush, S.J. McCullough, G.M. Allan and S. McQuaid. 1988. Viral distemper now found in porpoises. *Nature* 336:21.
- King, C.A. 1987. Organochlorines in bottlenose dolphins, *Tursiops truncatus*, and pygmy sperm whales, *Kogia breviceps*, from southeastern Florida. Univ. Miami, Coral Gables, Fla., M.S. thesis, 92 p.
- Kuehl, D., R.W. Haebler, and C.W. Potter. 1991. Chemical residues in dolphins from the U.S. Atlantic coast including Atlantic bottlenose obtained during the 1987/88 mass mortality. *Chemosphere* 22(1):1071-1084.
- Lipscomb, T.P., F.Y. Schulman, D. Moffett, and S. Kennedy. In press. Morbilliviral disease in Atlantic bottlenose dolphins (*Tursiops truncatus*) from the 1987-1988 epizootic. *Journal of Wildlife Diseases*.
- Mahy, B.W.J., T. Barrett, S. Evans, E.C. Anderson and C.J. Bostock. 1988. Characterization of a seal morbillivirus. *Nature* 336(10):115.
- de la Mare, W.K. 1986. The sensitivity of MSY to the parameters of the baleen whale model. *Rep. Int. Whal. Comm.* 36:425-427.
- Martineau, D., P. Beland, C. Desjardins and A. Lagace. 1987. Levels of organochlorine chemicals in tissues of beluga whales, *Delphinapterus leucas*, from the St. Lawrence Estuary, Quebec, Canada. *Arch. Environ. Contam. Toxicol.* 16:137-147.
- McFarren, E.F., H. Tanabe, F.J. Silva, W.B. Wilson, J.E. Campbell, and K.H. Lewis. 1965. The occurrence of a ciguatera-like poison in oysters, clams, and *Gymnodinium breve* cultures. *Toxicon* 3:111-123.
- Mead, J.G. 1975. Preliminary report on the former net fisheries for *Tursiops truncatus* in the western North Atlantic. *J. Fish. Res. Board Can.* 35:1155-1162.

- Mead, J.G. and C.W. Potter. 1990. Natural history of bottlenose dolphins along the central Atlantic coast of the United States. **In** S. Leatherwood and R.R. Reeves (Editors), *The bottlenose dolphin*, p. 165-195. Acad. Press, N.Y.
- Mercer, M.C. 1973. Observations on distribution and intraspecific variation in the pigmentation patterns of odontocete cetacea in the western North Atlantic. *J. Fish. Res. Board. Can.* 30:1111-1130.
- Muir, D.C.G., R. Wagemann, N.P. Grift, R.J. Norstrom, M. Simon, and J. Lien. 1988. Organochlorine chemical and heavy metal contaminants in white-beaked dolphins, *Lagenorhynchus albirostris*, and pilot whales, *Globicephala melaena*, from the coast of Newfoundland, Canada. *Arch. Environ. Contam. Toxicol.* 17:613-629.
- O'Shea, T.J., R.L. Brownell, Jr., D.R. Clark, Jr., W.A. Walker, M.L. Gay, and T.G. Lamont. 1980. Organochlorine pollutants in small cetaceans from the Pacific and south Atlantic Oceans, November 1968 - June 1976. *Pesticides Monitor. J.* 14(2):35-46.
- O'Shea, T.J., G.B. Rathbun, R.K. Bonde, C.L. Buergelt and D.K. Odell. 1991. An epizootic of Florida manatees associated with a dinoflagellate bloom. *Mar. Mamm. Sci.* 7:165-179.
- Odell, D.K. 1987. The mystery of marine mammal strandings. *Cetus* 7(2):2-6.
- Odell, D.K. 1989. Dolphins of the Indian River Lagoon. *Focus on the Sea* 10(2): 5-6.
- Odell, D.K. 1991. A review of the Southeastern United States Marine Mammal Stranding Network: 1978-1987. **In** J/E. Reynolds, III, and D.K. Odell (Editors), *Marine mammal strandings in the United States*, p. 19-23. U.S. Dep. Commer., NOAA Tech. Rep., NMFS 98.
- Odell, D.K., and E.D. Asper. 1990. Distribution and movements of freeze-branded bottlenose dolphins in the Indian and Banana Rivers, Florida. **In** S. Leatherwood and R.R. Reeves (Editors), *The bottlenose dolphin*, Acad. Press, N.Y.
- Osterhaus, A.D.M.E., and E.J. Vedder. 1988. Identification of virus causing recent seal deaths. *Nature.* 335:20.
- Ostrom, P.H., J. Lien and S.A. Macko. 1993. Evaluation of the diet of Sowerby's beaked whale, *Mesoplodon bidens*, based on isotopic comparisons among northwestern Atlantic cetaceans. *Can. J. Zool.* 71:858-861.
- Perrin, W.F. and S.B. Reilly. 1984. Reproductive parameters of dolphins and small whales of the family Delphinidae. *Rep. Int. Whal. Commn (Spec. Issue)* 6:97-133.
- Pierce, R.H. 1986. Red tide, *Ptychodiscus brevis*, toxin aerosols: review. *Toxicon* 24:955-966.
- Poli, M.A. 1988. *J. Assoc. Off. Anal. Chem.* 71:1000-1002.

- Poli, M.A., C.B. Templeton, J.G. Page, and H.B. Hines. 1989. Detection, metabolism, and pathophysiology of the brevetoxins PbTx-2 and PbTx-3 **In** S. Hall (Editor), Natural toxins from aquatic and marine environments. Am. Chem. Soc. Symp. Ser., Washington, DC.
- Potter, C. 1980. Mammals - the marine fauna. **In** Linzey, (Editor), Endangered and threatened plants and animals of Virginia, p. 595-602. Va. Polytech. Inst. State Univ. Blacksburg.
- Reilly, S.B. and J. Barlow. 1986. Rates of increase in dolphin population size. Fish. Bull. 84:527-534.
- Reynolds, J.E. III, and D.K. Odell. 1991. An assessment of the accomplishments of the regional marine mammal stranding networks and some recommendations for enhancing their productivity in the future. **In** J.E. Reynolds, III, and D.K. Odell (Editors), Marine mammal strandings in the United States, p. 1-6 NOAA Tech. Rep. NMFS 98.
- Roberts, B.S. 1979. Occurrence of *Gymnodinium breve*, red tides along the west and east coasts of Florida during 1976 and 1977. **In** D.L. Taylor and H.W. Salinger (Editors), Toxic dinoflagellate blooms. Elsevier/North Holland, N.Y.
- Rommel, S.A., W.A. McLellan, C.W. Potter, J.G. Mead, and D.A. Pabst. 1991. Characterizing a whole dolphin: a new protocol. Poster Pres. at Ninth Biennial Conf. on Bio. Mar. Mamm. Chicago, Dec. 5-9, 1991.
- Rodgers, R.L., H.N. Chou, K. Temma, T. Akera, and Y. Shimizu. 1984. Positive inotropic and toxic effects of brevetoxin-B on rat and guinea pig heart. Toxicol. Appl. Pharmacol. 76:296-305.
- Ross, G.J.B., and Cockcroft, V.G. 1990. Comments on Australian bottlenose dolphins and the taxonomic status of *Tursiops aduncus* (Ehrenberg, 1832). **In** S. Leatherwood and R.R. Reeves (Editors), The bottlenose dolphin, p. 101-128, Acad. Press, N. Y.
- Rudin, M. 1991. An assessment of distribution, group composition and behavior of bottlenose dolphin, *Tursiops truncatus*, through photoidentification, in the Indian River Lagoon System. Fla. Inst. Technol, Melbourne, M.S. thesis, 40 p.
- Safe, S. 1985. Polychlorinated biphenyls (PCBs) and polybrominated biphenyls (PBB): biochemistry, toxicology and mechanism of action. Crit. Rev. Toxicol. 13:319-395.
- Schulman, L.S., L.E. Roszell, T.J. Mende, and D.G. Baden. 1990. A new polyether toxin from Florida's red tide dinoflagellate *Ptychodiscus brevis*. **In** E. Graneli, B. Sundstrom, L. Edler, and D. Anderson (Editors). Toxic marine phytoplankton, p. 407-413, Elsevier Sci. Publ., Amsterdam.
- Scott, G.P. 1990. Management oriented research on *Tursiops truncatus* by the Southeast Fisheries Center. **In** S. Leatherwood and R.R. Reeves (Editors). The bottlenose dolphin, p. 623-639, Acad. Press, N.Y.

- Scott, G.P., and D.M. Burn. 1987. The potential impact of the 1987 mass mortality of the mid-Atlantic off-shore stock of bottlenose dolphins. NMFS/SEFC, Miami Lab., Coast. Resour. Div. Contrib. ML-CRD-87/88-10, 11 p.
- Scott, G.P., D.M. Burn, and L.J. Hansen. 1988. The dolphin die-off: long-term effects and recovery of the population. *Oceans '88 Proc.* 3:819-823.
- Scott, G.P., L.J. Hansen, and D.M. Burn. 1988. Preliminary report on status of the bottlenose dolphin stocks, U.S. Gulf of Mexico and Atlantic Ocean. NMFS/SEFC, Miami Lab., Coast. Resour. Div. Contrib. ML-CRD-87/88-23, 11 p.
- Scott, M.D., R.S. Wells, and A.B. Irvine, 1990. A long-term study of bottlenose dolphins on the west coast of Florida. **In** S. Leatherwood and R.R. Reeves (Editors), *The bottlenose dolphin*, p. 235-244, Acad. Press, N.Y.
- Scott, M.D., R.S. Wells, A.B. Irvine, and B.R. Mate. 1990. Tagging and marking studies on small cetaceans. **In** S. Leatherwood and R.R. Reeves (Editors), *The bottlenose dolphin*, p. 489-514, Acad. Press, N.Y.
- Sergeant, D.E., D.E. Caldwell, and M.C. Caldwell. 1973. Age, growth and maturity of bottlenose dolphins, *Tursiops truncatus*, from northeast Florida. *J. Fish. Res. Board Can.* 30:1009-1011.
- Shane, S.H. 1980a. Occurrence, movements, and distribution of bottlenose dolphins, *Tursiops truncatus*, in southern Texas. *Fish. Bull.* 78:593-601.
- Shane, S.H. 1980b. Occurrence, movements, and distribution of bottlenose dolphins, *Tursiops truncatus*, in the Aransas Pass area of Texas, U.S. Dep. Commer., Nat. Tech. Inf. Serv., Springfield, Va., DB-283 393, 130 p.
- Shane, S.H., R.S. Wells, and B. Würsig. 1986. Ecology, behavior, and social organization of the bottlenose dolphin: a review. *Mar. Mamm. Sci.* 2:34-63.
- Spellman, A.C. 1991. A study of the distribution, identity and activities of the Atlantic bottlenose dolphin, *Tursiops truncatus*, in the Indian River Lagoon, Florida, based on photoidentification. Fla. Inst. Technol. Melbourne, M.S. thesis, 40 p.
- Steidinger, K.A., and D.G. Baden. 1984. Toxic marine dinoflagellates. **In** D. Spector (Editor), *Dinoflagellates*, p. 201-261, Acad. Press, NY.
- Steidinger, K.A. and K. Haddad. 1981. Biologic and hydrographic aspects of red tides. *Bioscience* 31(11):814-819.
- Tanabe, S., H. Tanaka and R. Tatsukawa. 1984. Polychlorobiphenyls, EDDT, and hexachlorocyclohexane isomers in the western North Pacific ecosystem. *Arch. Environ. Contam. Toxicol.* 13:731-738.

- Taruski, A.G., C.E. Olney, and H.E. Winn. 1975. Chlorinated hydrocarbons in cetaceans. *J. Fish. Res. Board Can.* 32:2205-2209.
- True, F.W. 1891. Observations of the life history of the bottlenose porpoise. *U.S. Nat. Mus., Proc.* 13(1890):197-203.
- Vedros, N.A., A.W. Smith, J. Schonwald, G. Migaki, and R. Hubbard. 1971. *Leptospirosis* epizootic among California sea lions. *Science* 172:1250-1251.
- Walker, W.A. 1981. Geographic variation in morphology and biology of bottlenose dolphins, *Tursiops* in the eastern north Pacific. NOAA/NMFS Admin. Rep. LJ-81-00003c, 21 p.
- Wass, M.L. 1972. A checklist of the biota of lower Chesapeake Bay. *Spec. Sci. Rep. of Va. Inst. Mar. Sci., No. 63*, 290 p.
- Wells, R. 1986a. Structural aspects of dolphin societies. Univ. Calif. at Santa Cruz, Ph.D. dissert., 236 p.
- Wells, R.S. 1986b. Population structure of bottlenose dolphins: Behavioral studies of bottlenose dolphins along the central west coast of Florida. *Contr. Rep. to Nat. Mar. Fish. Serv., Southeast Fish. Cen., Contr. 45-WCNF-5-00366*, 70 p.
- Wells, R.S. 1991. The role of long-term study in understanding the social structure of a bottlenose dolphin community. **In** K. Pryor and K.S. Norris (Editors), *Dolphin societies: discoveries and puzzles*, p. 199-225, Univ. Calif. Press, Berkeley, 397 p.
- Wells, R.S., A.B. Irvine, and M.D. Scott, 1987. The social ecology of inshore odontocetes. **In** L.M. Herman (Editor), *Cetacean behavior: mechanisms and functions*, p. 263-317 J. Wiley and Sons. N.Y.
- Wells, R.S., and M.D. Scott. 1990. Estimating bottlenose dolphin population parameters from individual identification and capture-release techniques. **In** P.S. Hammond, S.A. Mizroch and G.P. Donovan (Editors), *Individual recognition of cetaceans: Use of photo-identification and other techniques to estimate population parameters*, p. 407-415, *Int. Whal. Comm. Spec. Iss.* 12.
- Wells, R.S., M.D. Scott and A.B. Irvine. 1987. The social structure of free-ranging bottlenose dolphins. **In** H. Genoways (Editor), *Current mammology*. Vol. 1, p. 247-305. Plenum Press, N.Y.
- Wilkinson, D.M. 1991. Program review of the marine mammal stranding networks. Report to NOAA Assistant Administrator for Fisheries, 171 p.

Appendix I: Discussion

Conservation Planning and Management Needs:

The final session of this workshop was an open forum where the participants summarized what had been stated during the previous sessions, and made conservation and management recommendations based on information that is now available to NMFS. This session also focused on gaps in our understanding of coastal bottlenose dolphins that need to be addressed in a Conservation Plan to successfully conserve and manage coastal bottlenose dolphins. The following is a summary of topics and points of discussion that were raised by the participants of the workshop at this open forum session.

Introduction to Session: It has become apparent from information presented at this workshop that there are information gaps in our understanding that relate specifically to the Atlantic coastal migratory stock(s) of bottlenose dolphin. What we do know, in way of summary, is that for the most part at least, there are no coastal dolphins found north of Hatteras in winter. The coastal migratory stock moves past Hatteras sometime between March and April. From early May to June, it moves from Cape Hatteras to at least as far as Delaware Bay. In mid-summer, some dolphins move up the coast and into the bays as far as New England. A few have even been seen up in Cape Cod Bay. In September/October, they begin moving southward again. By November/December, the coastal stock has moved south of the Chesapeake Bay, and then, south of Hatteras. This seasonal distribution pattern has been verified by sighting data as well as stranding data. This movement occurs primarily in state managed waters.

At the present time, we do not have enough data to separate the coastal migratory dolphins from the resident stock(s), except during the months when the former are north of Hatteras. Therefore, a Conservation/Management Plan should focus on coastal bottlenose dolphins, with an ultimate goal of being able to distinguish and manage these stocks separately as their biology becomes better understood.

Recommendation: To Determine and Monitor the Status of the Population

Larry Hansen: As an introduction to the subject of population monitoring, it might be helpful for me to outline what the Southeast Center has scheduled in the way of bottlenose dolphin surveys over the next few years. Currently, we have plans to conduct aerial surveys of the entire east coast, concentrating on areas where sightings of coastal dolphins are expected. These surveys will replicate the coastal part of the CETAP/SET surveys, with the addition of bay surveys and along-shore transects (in order to supplement the perpendicular CETAP/SET survey replicates). The along-shore surveys will consist of parallel transects flown from roughly one-half mile to 1.3 km offshore. These surveys should accomplish the goal of obtaining a minimum count of coastal dolphins for the east coast. They will be carried out from Hatteras northward in the summer of 1994, and then from Hatteras southward in winter of 1994/1995.

Mike Payne: The aerial surveys need to be ground-truthed. Could the states do this part? I understand the value of the summer survey. We will be able to compare the present results and abundance estimates with those of CETAP and the 1991 NMFS survey. But why the winter survey, especially given that since the winter distribution is continuous across the shelf off Florida, you will

not be able to separate stocks from aerial surveys, and you know that the offshore stock is not completely represented south of Cape Hatteras in the winter? I do not understand how we can use the estimate that you obtain to determine abundance, or to separate stock structures.

Sally Murphy: Doing a survey in the south in winter is meaningless unless it's done in summer too. Why is NMFS conducting a winter survey?

Jim Mead: Historical data suggest that there are offshore animals in coastal areas off Hatteras in the winter. We need a concentrated survey effort in the Hatteras area to determine where the stocks split and the extent of intermixing at this location.

Cindy Driscoll: As a suggestion, we could use an Environmental Protection Agency (EPA) survey, data collected since 1989, as a start [this is a coastal survey that operates north of Cape Hatteras throughout the year and records everything along a trackline parallel to the coastline]. Perhaps the states could also use the Civil Air Patrol (as does EPA, for inexpensive flight-time) to obtain distributional information, and perhaps fishery interaction information as well.

Dave Schofield: The National Aquarium in Baltimore has over 100 volunteers. With their help and possibly supplementing with Air Corps surveys, Maryland could put together a minimum count-type program similar to Mark Swingle's program in Virginia. Currently, the Beach Patrol keeps the ocean side pretty-well covered, but coverage inside the Bay is a problem. However, fishery interaction problems are minor within the Bay.

Mark Swingle: Virginia needs aerial surveys and continued photo-ID work in addition to the present ground and boat surveys. These programs need to be coordinated. Our dolphin count was done in coordination with several states (all surveys took place on July 10), but there was not comprehensive coverage in all cases. In Virginia, we do not see dolphins year-round, but we have isolated strandings even in winter months.

Sally Murphy: The Center for Marine Conservation organizes a beach sweep/beach week each year around September 18th. Could we coordinate with this?

Keith Rittmaster: In North Carolina we know that dolphins are present year-round, but we don't yet know whether any of the individuals that we see in the summer are the same as any of those we see in the winter. We need to do more photo-ID work, to expand the present coverage. In addition to our research, some work is currently being done by Guy Stephanski and his group (Day of the Dolphin).

Bill Bowen: I have some old ferry survey data.

Sally Murphy: Those were for turtles.

Bill Bowen: Yes, but they counted dolphins too. We need to look at the historical data.

Vicky Thayer: We need to do tagging and biopsy of the animals we've identified through photo-ID.

Sally Murphy: South Carolina will continue the present surveys for leatherback turtles. Six flights are flown, starting in April, and going through late May/early June. Also, we do monthly flights to sight strandings. Again, these are parallel flights flown to a mile offshore on one leg, and then alongshore on the other leg. I also wanted to do a study comparing the effectiveness of various census techniques, but it did not get funded.

Tom Murphy: A study of this sort could be conducted, for example, in the Sarasota area, where the population number is approximately known. Telemetry would be a good method of obtaining a lot of the data we need.

Larry Hansen: But telemetry really requires too much effort, and it's expensive.

Mark Swingle: There are a lot of studies happening right now, with very little funding.

Mike Payne: How much of the required funding could come from the private sector? Have the private-sector researchers in this group exhausted or begun to look for funding outside of state or Federal sources?

Sherman Jones: The state/local level is a good level for photo-ID work.

Kathy Wang: We need to develop coordination of all the photo-ID work that's taking place, and to implement centralization of the photos.

Tom Murphy: Individual identification is not what is needed for state-level management.

Sally Murphy: The states are most interested in protecting their resident animals, and then also determining the number and distribution of dolphins within state waters.

Randy Wells: My research group could give a workshop for anyone interested, in order to facilitate coordination and standardization of data collection methods.

Charles Maley: Since southern Georgia-Central Florida is the southern terminus of distribution for the coastal migratory stock, perhaps we could start working in this area this-coming winter. The dredger hoppers operate in the cold months. There are observers out there for the right whales, but there are also numerous dolphins sighted in the area. The problem is that the Georgia coastline is so variable (in depth, topography, etc.), and there are so many embayments. However, we do have a state airplane available to us that's used for the leatherback turtle and the right whale surveys, that could also be used for doing dolphin surveys. Also, The Dolphin Project is working to catalogue their photo-ID collection, and they've conducted 16 quarterly surveys over the last 4 years.

Bill Brooks: I'd like to mention that we should look at the New England Aquarium data (from their right whale surveys along the Southeast Coast). Presently, they are doing one survey per week, from November through April. Also, the manatee surveys may incorporate some dolphin sighting data.

Larry Hansen: The South Carolina, Georgia and Florida state right whale surveys should be coordinated.

Nelio Barros: We (the Southeastern U.S. Stranding Network, or SEUS) have data that could be used to determine if stocks can be separated based on their pollutant loads, but we need money to do it. The Sea World research carried-out so far has focused primarily on dolphins in the Indian River Lagoon System, which we believe is a resident population.

Tom Murphy: While aerial surveys are particularly useful when censusing large areas, there is considerable variation due to observers, aircraft type, sea state, glare, time of day, weather, surfacing behavior, sampling methodology and data manipulations. It would therefore seem prudent to use a combination of survey techniques. Perhaps conducting an aerial transect survey on a near-shore parallel flight line which is replicated the same day by boat would be useful. You may find that observed minimum dolphin densities seen during a 10-hour boat survey may greatly exceed calculated densities obtained for a 1-hour flyover. Given new GPS technology, the transect can be maintained by boat and the distance from the transect to dolphin observations may be recorded for area surveyed, or for calculation of sighting extinction curves. The validity of either technique could be evaluated even further if the surveys were conducted in an area of "known" population size such as Sarasota Bay.

Additional land based surveys should also be considered as further verification of densities and perhaps intensive survey sites in areas of known concentration or migration (e.g. Cape Hatteras during migration). An east coast annual dolphin census period should be considered, similar to west coast grey whale watches or the national midwinter eagle survey. It has the added advantage of involving the public and the media. The use of a combination of independent techniques to establish population trends greatly enhances reliability.

Summary

There is a need to:

- 1) Coordinate all state surveys and re-evaluate census techniques;
- 2) conduct telemetry studies;
- 3) compile and analyze existing survey data;
- 4) reference all known data (both published and non-published) on *Tursiops truncatus*.
- 5) coordinate all other Atlantic bottlenose dolphin research efforts.
- 6) identify stocks.

Recommendation: Minimize Fishery Interactions and other Human-related Mortality

Mike Payne: Since the coastal migratory stock of bottlenose dolphins has been listed as depleted, NMFS needs to re-examine fishery interactions with this stock(s). This is also necessary because of recent information that indicates that harbor porpoise and marine turtles are also affected by many of the same fisheries in the same locations, as are bottlenose dolphins. There is an immediate need for Fishery Management Councils and protected species agencies to work together towards a mid-Atlantic management and conservation plan. The conservation plan for the coastal migratory bottlenose dolphin should make recommendations for reducing sources of human impacts, such as bycatch. These should be taken to the Fishery Management Councils, and addressed within the context of a Fishery Management Plan, as well as a larger, more comprehensive management and conservation plan for the region.

Larry Hansen: We will have observers on various gillnet fisheries, but most of these are offshore fisheries anyway, so there shouldn't be much if any impact on the coastal animals. The problem is that a lot of boats are too small to accommodate observers.

Tom Murphy: We could provide fishermen with radio floats to attach to entangled dolphins for collection by state/stranding people.

Mike Payne: When boats are too small to accommodate observers, observer boats have been sent out to monitor groups of fishing boats, in areas of high fishing concentrations, with moderate success. Also, the stranding record needs to be examined more closely and used, where possible, to amend fishery categories; coastal gillnets, for example. We need to better examine co-occurrence of strandings of dolphins and turtles, and fisheries.

Susan Barco: We need to create a good master list of fisheries/areas/times, and correlate it with strandings.

Larry Hansen: We can do that retrospectively, with the data at hand.

Tom Murphy: Probably the most significant source of direct mortality to dolphins is in gill nets. Quantification of the extent of this problem is crucial to understanding the status of dolphin stocks.

Summary:

There is a need to obtain better data on what fisheries interact with dolphins in what areas and over what time-periods, in order to have enough information at hand to implement appropriate gear, seasonal, and/or areal restrictions, if necessary.

Recommendation: Determine Ecology and Life History Parameters of Coastal Bottlenose Dolphins

Mike Payne: Life history parameters can be obtained through stranding data, and from biopsy and telemetry studies. It is becoming more and more obvious that we need to standardize protocols for stranding response, at least to obtain a certain minimum set of samples taken from strandings. Bill McClellan and Cindy Driscoll discussed this in a presentation in an earlier session.

Jeff Brown: The nature of the stranding network and the quality of the data collected in the southeast is highly variable due to the largely volunteer status of the participants. Also, only a dozen or so animals are directly attributable to fishery interactions, out of several hundred per year.

Kathy Wang: Yes, but that doesn't mean that we can't do our best to educate the volunteers, and try to impress upon them the importance of taking as many of the samples we need, as they can.

Jim Mead: We should organize a workshop on life history, and examine "What do we know" from *Tursiops* stranding data.

Mike Payne: Can the Smithsonian handle such a workshop? I think you've just volunteered, Jim.

Sally Murphy: Something along the lines of the stranding workshop Geraci gave at the last Biennial should be done for dead animals.

Susan Barco: The Duke University marine program offers a good course developed in cooperation with Randy Wells, that is a great introduction to everything having to do with marine mammals.

Larry Hansen: We already have a lot of samples that need to be worked-up.

Ann Pabst: Yes, we already have a lot of stuff frozen, that could be used for genetic studies, among other things. Along with all the other stranding data, we need to get this worked-up. There's already a wealth of data out there.

Mike Payne: This is probably one area where graduate students could be used very effectively.

Larry Hansen: We already have some genetic studies underway at the SEC, using skin from strandings, biopsies done from boats, and from captured animals. We've started sending copies of the lab reports to the individuals who responded to the strandings. This is good feedback for them, although there is a considerable time-lag.

Nelio Barros: We really need to get the most complete information possible. I'd like to emphasize again, that stomach contents can be used to separate animals, perhaps stocks, on the basis of food preferences. Variations in external parasite types can also be utilized for this purpose. These things can be taken/recorded from fairly deteriorated animals.

Larry Hansen: We could incorporate the harbor porpoise stranding workshop data sheets (that demonstrate how to recognize evidence of fishery interactions on stranded animals) in the SEUS newsletter.

Charley Potter: Where will all these tissues go? Who will work them up? There is a great need for communication between researchers, concerning who is doing what.

Tom Murphy: If you have a free volunteer force working, it is best to request data rather than expect or demand it just because you want it. The stranding network coordinators should be involved in decisions relating to carcass and data acquisition. Information must flow in both directions. This doesn't mean that only the submitting agency, in our case the Charleston Lab, is informed but also that the individual volunteer receives the information in a timely fashion as well. With every request for samples goes a responsibility of a timely response. Tissues that sit for months or years or samples collected for a project that ended years ago are inappropriate. We are encouraged by the current protocols and goals of the stranding networks. With proper nurturing, they should provide much needed information at a minimal cost.

Summary

There is a need to organize workshops in order to:

- 1) Determine what we currently know, collectively, about bottlenose dolphin life history;
- 2) assess what data/samples are already available, and what can be learned from them;
- 3) educate stranding network volunteers concerning what kinds of information can be obtained from the various data and samples they are requested to collect.

Recommendation: Learn More About Diseases and Mass Mortality Events (Can we do anything about them?)

Cindy Driscoll: All stranded animals need to be collected, and at the minimum, the information outlined by Vicky in her presentation yesterday, should be collected: i.e. samples for life-history information, including teeth, stomachs, and gonads; tissues for analysis of heavy metals, pesticides, and other pollutants; skulls, dorsal fin photos for comparison with photo-Ids; and also, the human interaction forms should be completed for each animal. And, now that Morbillivirus has been confirmed from dolphins in the Gulf of Mexico, samples for detection of this should be collected. All that's needed is to take small samples of lung and brain tissue, and preserve them in 10% formalin.

Tom Murphy: The current stranding networks which are in place seem to be adequate for monitoring and sampling of tissues for contaminants, if procedures outlined in Geraci and Lounsbury are adhered to. On the other hand, it is unlikely that correct veterinary diagnoses will be made in the cases of disease or parasitic infection because those collecting the samples are frequently unqualified in the field of veterinary pathology. This certainly includes myself, although I have performed post-mortem examinations on many animals, from alligators to eagles, as well as marine turtles and marine mammals, over the past 20 years. Whereas a tumor or cyst sampled from an otherwise healthy lung or liver may represent disease pathology to a clinical pathologist who has access to no other information, it may be of little consequence to the field examiner who has seen the entire organ and the entire organism and surrounding circumstances. The die-off of 1987/1988 would never have been diagnosed by the current protocol. Thus, additional veterinary pathologist involvement will be needed for strandings in general, and in larger mortality episodes especially.

Summary

There is a need to encourage veterinary involvement in strandings whenever possible, in order to learn more about disease pathology in these animals.

Recommendation: Minimize Harassment of Dolphins

Mike Payne: Do we need to address feeding? We discussed this a lot yesterday. NMFS already has regulations that prohibit feeding. A conservation plan can support these regulations, and provide another statement against feeding if that is considered appropriate.

Sherman Jones: Recreational vehicles need to be controlled as well, and we need to educate people about the harm they can inflict upon dolphins.

Dave Jenkins: We also need to educate the enforcement people.

Mike Payne: The right whale recovery efforts have focused on education, to be provided by the states, in the southeast portion of their range. The education of enforcement agencies is the responsibility of each state.

Dave Jenkins: It's important to educate boaters as well. Boater safety course materials are developed on a national level. These should also address marine mammals.

Charles Potter: What about the huge jetty construction projects that have been planned for the Oregon Inlet area (North Carolina)? What about acoustic harassment from all this construction? Not to mention the obstruction those things will be. We should get the Corps of Engineers involved in this conservation planning process.

Susan Barco: Yes, and what about all of the explosives testing carried out by the military off Virginia?

Ann Pabst: Jack Musick is presently conducting studies on turtles in that area, with respect to acoustic harassment.

Randy Wells: Acoustic harassment is definitely something that NMFS should examine. This has not yet been done with respect to *Tursiops*. The amount of noise produced by just local boat traffic alone is quite substantial.

Summary

There is a need to learn more about the degree to which dolphins are being affected (especially in terms of reproductive potential) by humans in ways other than fisheries interactions, and to educate the public concerning ways in which these effects can be minimized.

Recommendation: Ensure Existence of Suitable Habitat and Improve Upon Conditions of Existing Habitat

Mike Payne: Under the MMPA, when a conservation plan is developed for a species having a depleted designation, the operative word in terms of habitat is essential habitat, as opposed to critical habitat. Critical habitat is ESA terminology. Keith, you discussed high-density habitats in your study area yesterday. Can you summarize the physical features that constitute essential habitat for coastal dolphins in your area?

Keith Rittmaster: Areas with a steep channel edge seem to be nursery areas. Also areas within about a mile of *Spartina* marshes.

Vicky Thayer: Yes, areas in the shallows next to the channels seem to be important.

Charley Potter: We should compile the existing data, and also survey researchers, asking what constitutes calving/nursery areas in their region.

Sally Murphy: We (the state of South Carolina) need to know this kind of information in terms of restricting jet skis.

Randy Wells: Aerial surveys should be useful in isolating calf-use areas.

Larry Hansen: Any surveys that are done should record neonate sightings.

Mike Payne: I recommend that the conservation plan focus on this important question as part of its content.

Tom Murphy: The long-term impacts of pollution and depletion of fish stocks also need to be addressed.

Summary

There is a need to determine areas being utilized as calving/nursing areas and focus upon these areas as essential habitat in the Conservation Plan.

Recommendation: To Coordinate and Implement a Conservation Plan

A Conservation Plan delineates reasonable actions to protect a depleted species under the Marine Mammal Protection Act (MMPA). Plans are prepared by the National Marine Fisheries Service (NMFS), sometimes with the assistance of teams, contractors, state agencies, and others. Approved plans are subject to modification as dictated by new findings, changes in species status and completion of implementation tasks. Goals and objectives will be attained and funds expended contingent upon agency appropriations and priorities.

This workshop report may serve as a preliminary guide that delineates those actions believed necessary to conserve and protect the coastal migratory stock of Atlantic bottlenose dolphins.

One of the objectives of this workshop was to determine what research needs to be conducted in order to effect rational management of coastal bottlenose dolphins. This is consistent with the following two objectives of any conservation plan, as described in the Northern Fur Seal Conservation Plan:

Objective I

Continue and, as necessary, expand research or management programs to monitor population trends and detect natural or human-related causes of mortality, and habitats essential to its [the species] survival and recovery.

Objective II

Assess and avoid or mitigate possible adverse effects of human-related activities on or near habitat considered essential to [the species] throughout their range.

Responsibility for implementation of any conservation plan lies with the NMFS Office of Protected Resources, and the NMFS regional offices and science centers. However, recovery actions generally need to be coordinated among these NMFS offices, and other resource management agencies and user groups. Changes and updates to the Conservation Plan need to be made upon periodic review. Interagency coordination, especially with a species whose range occurs throughout multi-state waters, is essential in order to implement an effective conservation program. Education and enforcement are also critical components of the overall recovery effort.

Because fishermen in many areas may interact with bottlenose dolphins on a regular basis, it is particularly important that they be made aware of and kept informed about conservation and management efforts. Information needs to be distributed as part of ongoing regulatory/information programs (e.g., in logbooks and regulation books), as well as through media directed specifically at the fishing industry (e.g., trade magazines). Mail-outs to permit holders and signs posted in boat harbors may also be effective. Materials and trained personnel should be made available to assist industry in developing its own educational programs. Fishermen and their representatives should be encouraged to become involved in the development, evaluation, and implementation of a bottlenose dolphin conservation plan. A conservation plan implementation team will need to be developed, either as a separate entity or as part of several on-going organizations (i.e. Mid-Atlantic States Fishery Commission or Fishery Management Councils) whose members can address the issues discussed in this workshop report, and a final conservation plan.

Participants at the workshop recommended that NMFS consider the information and recommendations discussed at this workshop, and act quickly in completing this workshop report to be used towards the development of a final conservation plan for Atlantic coastal bottlenose dolphins. The workshop ended on September 14, 1993.

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