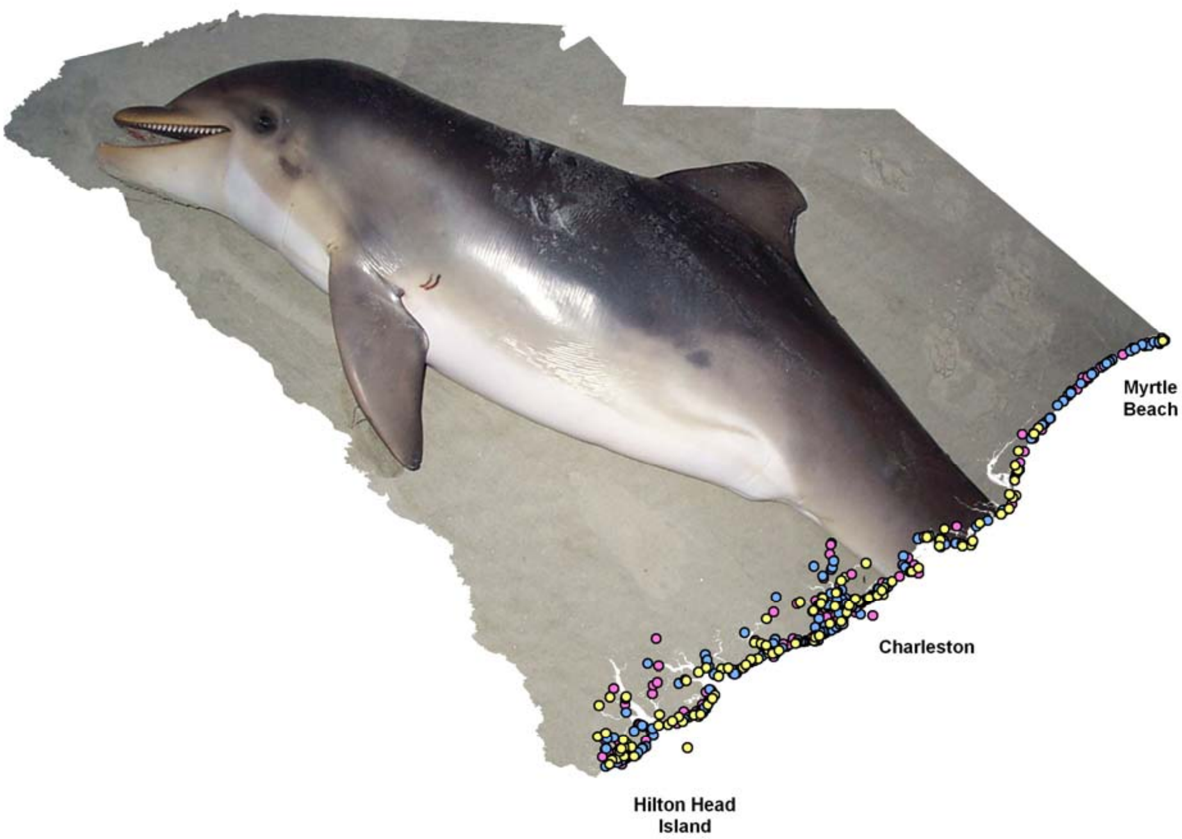
Spatial and Temporal Analysis of Bottlenose Dolphin Strandings in South Carolina, 1992-2005



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Spatial and Temporal Analysis of Bottlenose Dolphin Strandings in South Carolina, 1992-2005

Wayne E. McFee and Leslie G. Burdett

Center for Coastal Environmental Health and Biomolecular Research
NOAA/NOS/NCCOS
219 Fort Johnson Road
Charleston, South Carolina 29412-9110

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EXECUTIVE SUMMARY

This CD contains summary data of bottlenose dolphins stranded in South Carolina using a Geographical Information System (GIS) and contains two published manuscripts in .pdf files. The intent of this CD is to provide data on bottlenose dolphin strandings in South Carolina to marine mammal researchers and managers.

This CD is an accumulation of 14 years of stranding data collected through the collaborations of the National Ocean Service, Center for Coastal Environmental Health and Biomolecular Research (CCEHBR), the South Carolina Department of Natural Resources, and numerous volunteers and veterinarians that comprised the South Carolina Marine Mammal Stranding Network.

Spatial and temporal information can be visually represented on maps using GIS. For this CD, maps were created to show relationships of stranding densities with land use, human population density, human interaction with dolphins, high geographical regions of live strandings, and seasonal changes. Point maps were also created to show individual strandings within South Carolina.

In summary, spatial analysis revealed higher densities of bottlenose dolphin strandings in Charleston and Beaufort Counties, which consist of urban land with agricultural input. This trend was positively correlated with higher human population levels in these coastal counties as compared with other coastal counties. However, spatial analysis revealed that certain areas within a county may have low human population levels but high stranding density, suggesting that the level of effort to respond to strandings is not necessarily positively correlated with the density of strandings in South Carolina.

Temporal analysis revealed a significantly higher density of bottlenose dolphin strandings in the northern portion of the State in the fall, mostly due to an increase of neonate strandings. On a finer geographic scale, seasonal stranding densities may fluctuate depending on the region of interest.

Charleston Harbor had the highest density of live bottlenose dolphin strandings compared to the rest of the State. This was due in large part to the number of live dolphin entanglements in the crab pot fishery, the largest source of fishery-related mortality for bottlenose dolphins in South Carolina (Burdett and McFee 2004). Spatial density calculations also revealed that Charleston and Beaufort accounted for the majority of dolphins that were involved with human activities.

Introduction

The South Carolina Marine Mammal Stranding Network was established in 1991 as part of the National Marine Fisheries Service's (NMFS) Southeast Region Marine Mammal Stranding Network. Consistent data on bottlenose dolphin strandings have been collected since 1992. The South Carolina Department of Natural Resources (SCDNR) accepted responsibility as State Coordinator (Ms. Sally Hopkins-Murphy, 1991-2004; Dr. Al Segars, 2004-2005) in 1991 under a Letter of Authorization (LOA) from NMFS and the National Ocean Service’s Center for Coastal Environmental Health and Biomolecular Research (CCEHBR) was appointed NMFS Area Representative (Ann Jennings, 1991-1992; Wayne McFee, 1993-present) for the State.

SCDNR established a network of approximately 30 volunteers and veterinarians in the State to respond to marine mammal strandings, and established a 1-800 number to report marine mammal strandings. SCDNR did not renew their LOA in 2005 and the responsibility of stranding response was assumed by CCEHBR in August 2005. The current level of stranding responders is depicted in the map titled "South Carolina Marine Mammal Stranding Network Volunteers".

Strandings of marine mammals allow researchers the opportunity to collect tissues and study the biology and life history of species that may otherwise be unknown. Basic data (Level A; e.g., species, sex, length, stranding location, date of stranding, etc.) are important in determining spatial and temporal trends, monitoring trends in gender and age class ratios, detecting anthropogenic mortality (e.g., boat strikes, fisheries), and detection of unusual mortality events.

Methods

General methodology for the collection of marine mammal specimens for this study can be found in the two attached .pdf files (McFee and Hopkins-Murphy 2002; McFee et al. 2006). Maps were created using ArcGIS 9.1 (ESRI 2005) with the spatial analyst extension for spatial and temporal analysis. Individual animal stranding point data coverages were imported into ArcGIS from the NOS/CCEHBR Marine Mammal Information System (MMIS) as a text delimited file, and converted into a XY feature class (shapefile) within ArcCatalog before being added to the view. Location data were converted into standardized decimal degrees latitude and longitude. Animals with unknown coordinates were either removed from the maps or estimated based on the location description on the Level A data form.

Point data coverages were overlaid onto South Carolina shoreline data. All point data coverages were projected in NAD 1983, spheroid GRS 1980. All map units were in decimal degrees. Point coverages of stranding data were used to depict statewide, county, seasonal (as defined in McFee et al. 2006), gender, age class, live stranding, human interaction, and condition code distributions.

Density maps were created by overlaying stranding densities with land use, population density, and human interaction data points. Map layers were created using a kernel density calculation with the ArcGIS Spatial Analyst extension with a 6 km search radius and cell size of 400. Seasonal density maps were created with a 6 km search radius and a cell size of 795. A mask was created to shade out yellow values where stranding levels were low or non-existent. Map layers were re-projected to NAD 1983, UTM Zone

17N for the calculation of the number of strandings per square meter, and then added to the original map (NAD 1983, spheroid GRS 1980) for display.

Land use data were available from http://www.dnr.sc.gov/GIS/gap/download.html as a ESRI Grid Raster. Census data for population density calculations were available from http://www.census.gov/geo/www/cenpop/blkgrp/bg_45_sc.txt as Census Block Group data. To create the block group layer that is displayed on the map, a spatial join between the attributes table of the block group shapefile and block group data file based on the common field "Tract" was performed.

Results and Discussion

Five hundred and thirty nine bottlenose dolphins were reported stranded in South Carolina between 1992-2005 for an average of 38.5 per year. The years 2000-2001 were significantly higher than all other years in the number of strandings (Figure 1) (McFee et al. 2006). Of the dolphins with known sex, there was nearly a 1:1 ratio of males (n=203) to females (n=207). There were 129 dolphins of unknown sex resulting from scavenging, decomposition, or from animals that were not recovered.

Strandings occurred in every month of the year with most occurring in the spring (Figure 2). An increase in fall strandings, particularly in November, was due in part to an increase number of neonate strandings in the northern portion of the State (Southern North Carolina Management Unit; Table 1). This is described in the McFee et al. (2006) pdf file attached. Spatial analysis of neonate seasonal distribution also shows this relationship and supports the suggestion of a bi-modal reproductive strategy in South Carolina.

Most strandings (77.4%) occurred in Charleston and Beaufort Counties (Figure 3). Six percent (*n*=33) of the dolphins were reported as alive (code 1). Spatial analysis revealed that Charleston Harbor had the highest density of live animal reports in the State.

Bottlenose dolphins that showed evidence of human interaction (HI) accounted for 24.2% of the strandings. This percentage is based on the total number of HI cases divided by the total number of HI plus the number of cases that did not show evidence of HI. Animals for which a determination of HI could not be made (CBD) were excluded (Table 2). Fishery interactions and boat strikes accounted for nearly 50% of HI cases. An additional 29% were classified as rope wounds with no gear attached that could potentially be classified as fishery interaction. In all likelihood, a number of these animals that showed rope wounds could be associated with the crab pot fishery, as this fishery is the largest source of fishery-related mortality in South Carolina and the wound patterns are similar (see Burdett and McFee 2004). Yearly patterns of HI were variable with a low of 11.1% in 1994 and a high of 38.5% in 1997 (Figure 4). Interestingly, the low number of HI cases in 1994 corresponds to the year of the ban on illegal dolphin feeding. This practice can alter the behavior of dolphins, making them more susceptible to boats and fishery-related activities (NMFS 1994). Spatial density calculations of HI showed that Charleston and Beaufort experienced the majority of HI cases (Figure 5) with higher concentrations of strandings occurring in the Charleston Harbor and its rivers, Kiawah Island, and in Calibogue Sound near Hilton Head Island. We speculate that the high fishing effort and recreational boating accounts for this trend in these areas.

Spatial density maps depicting strandings and population reveal that strandings are more likely to occur in the more densely populated coastal regions of South Carolina: namely Charleston, Beaufort, and Horry Counties. However, portions of each county still have high density levels of strandings in sparsely populated areas. For example, the front beaches of Harbor, Hunting, and Fripp Islands in northern Beaufort County have high densities of strandings but low population levels (see Population Density Maps on CD).

Spatial density maps depicting strandings and land use reveal that strandings are more dense in areas surrounding urban land and areas with agricultural input (see Land Use Density Maps on CD). Runoff from urban development and agricultural pesticides has been suggested as concerns for adverse health effects to coastal dolphins.

Temporal density maps show an increase in stranding density in the Myrtle Beach area (northern portion of the state) in the fall (See Seasonal Density Maps on CD). This may be due in part to coastal migratory dolphins coming into the state from North Carolina (McFee et al. 2006). Two of the highest density regions in the State (Charleston area and Hilton Head area) have considerably different seasonal stranding densities. During the fall, stranding densities in Charleston are highest along the ocean front beaches of Sullivan's Island and the Isle of Palms, just north of the mouth of the Charleston Harbor. Sighting data from the NOS Photo-Identification Project suggest that dolphins move out of the Charleston Harbor during late fall, and can be sighted along the front beaches (T. Speakman, pers. comm.). In winter, the higher density shifts to Charleston Harbor; this may be the result of transient dolphins moving in from the north (T. Speakman, pers. comm.). In Calibogue Sound (body of water that borders the southern tip of Hilton Head Island), high stranding densities occur throughout much of the Sound in the fall, whereas a shift of high density occurs to the mouth of the Sound and the surrounding beaches in the winter. The highest stranding density in Calibogue Sound occurs in the spring. Reasons for these shifts in stranding density in Calibogue Sound are unclear.

This CD provides researchers and resource managers with bottlenose dolphin stranding data in South Carolina in a visual matrix to help understand the dynamics behind bottlenose dolphin strandings. More information is needed on land use and population trends to spatially determine the extent to which dolphins may be affected by increasing development and changes in land use temporally. Providing this type of information may elicit predicative models on trends of bottlenose dolphin strandings in South Carolina to improve management of the species.

Acknowledgments

The authors would like to acknowledge the numerous volunteers, federal, state, and local officials, and veterinarians that made up the South Carolina Marine Mammal Stranding Network. Special recognition to Sally Murphy, Al Segars, and David Cupka of SCDNR for their efforts as State Coordinator. Assistance with mapping was provided by Jeff Adams and dolphin sighting information provided by Todd Speakman. Extended thanks to the reviewers of this CD: Patricia Fair, Paul Comar, and Jeff Hyland. Cover photo credit to Al Segars.

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Table 1. Neonate bottlenose dolphin strandings by season in South Carolina, 1992-2005.

	winter	spring	summer	fall	Totals
Horry	0	1	0	10	11
Georgetown	1	0	0	3	4
Charleston	4	18	14	16	52
Colleton	1	1	1	0	3
Beaufort	5	17	4	5	31
Totals	11	37	19	34	101

Table 2. Human Interaction (HI) cases with bottlenose dolphins (Tt) in South Carolina, 1992-2005. Percent (%) HI (-CBD) is calculated by removing the CBD (Cannot Be Determined) animals and dividing the Total HI by Total HI plus No HI.

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
Total Tt	28	33	31	32	29	42	41	35	53	68	28	35	46	38	539
Crab pot	1	0	0	0	0	2	0	1	0	1	0	2	2	2	11
Shrimp fishery	0	0	0	0	0	0	1	0	0	0	1	0	0	0	2
Trammel net	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2
Rope marks	1	0	0	3	4	5	3	0	1	0	0	1	1	1	20
Mutilation	3	1	1	0	1	2	0	1	0	1	0	0	0	0	10
Boat strike	2	2	1	2	0	0	1	2	1	3	0	0	1	0	15
Blunt trauma	0	0	0	1	0	0	0	0	1	0	0	0	0	0	2
Net marks	0	0	0	0	1	1	1	0	0	0	1	0	1	1	6
Monofilament	0	0	0	0	0	0	0	0	1	1	0	0	0	0	2
Gaff wounds	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Foreign object	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Hook/line	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Total HI	7	4	2	6	6	10	6	4	4	6	4	3	6	5	73
No HI	15	21	16	16	15	16	10	11	19	20	13	18	22	17	229
CBD	6	8	13	10	8	16	25	20	30	42	11	14	18	16	237
% HI (-CBD)	31.8	16	11.1	27.3	28.6	38.5	37.5	26.7	17.4	23	23.5	14.3	21.4	22.7	24.2

Figure 1. Number of bottlenose dolphin strandings by year in South Carolina, 1992-2005.

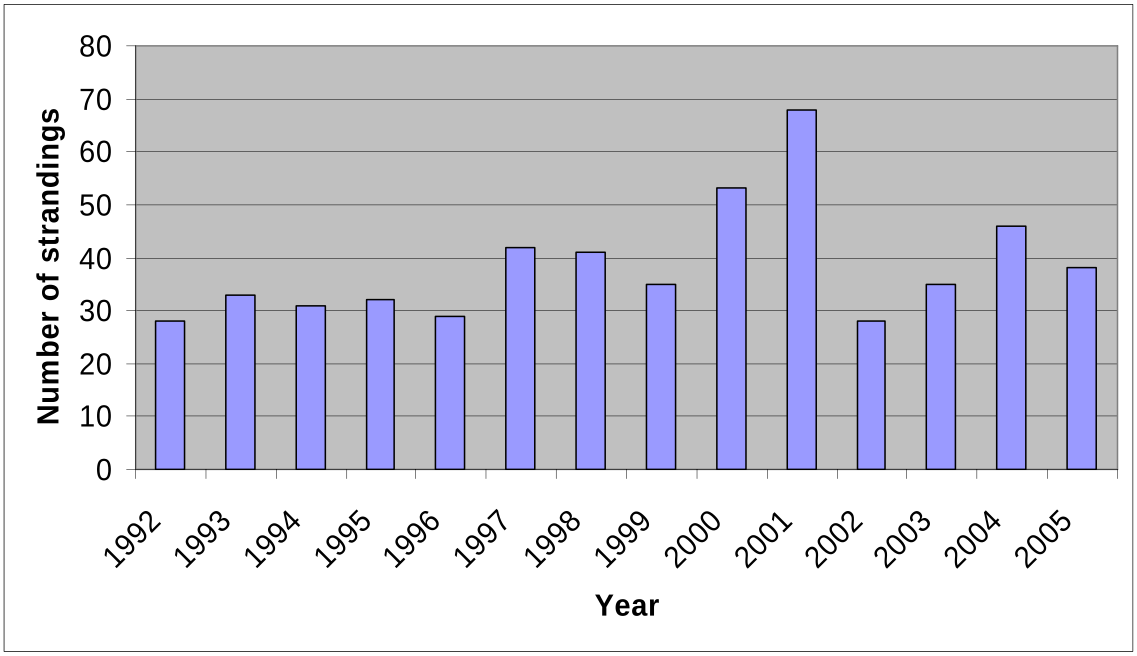


Figure 2. Number of bottlenose dolphin strandings by season in South Carolina, 1992-2005 (winter = January-March; spring = April-June; summer = July-September; fall = October–December).

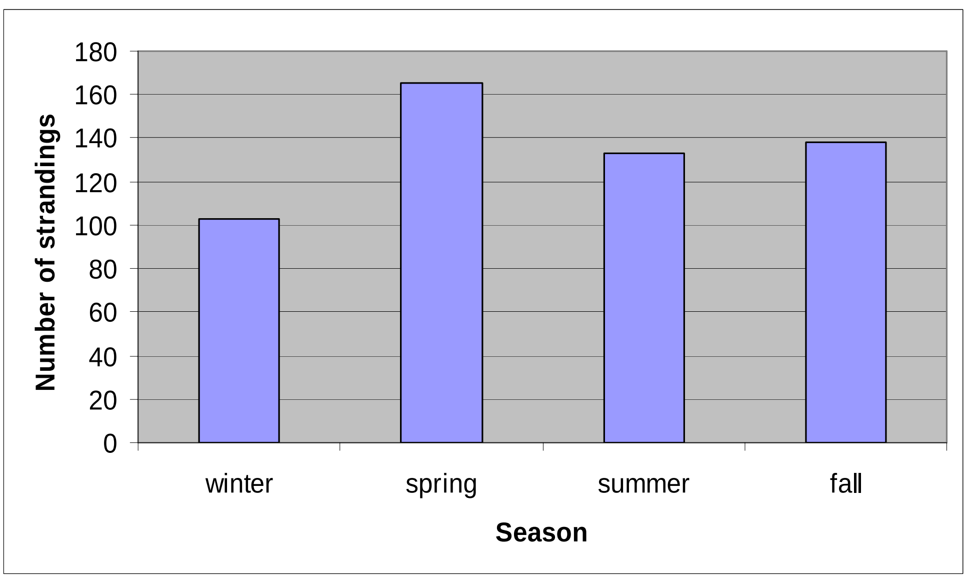


Figure 3. Number of bottlenose dolphin strandings by coastal counties in South Carolina, 1992-2005 (HOR= Horry; GEO= Georgetown; CHS= Charleston; BER= Berkeley; COL= Colleton; BEA= Beaufort; JAS= Jasper).

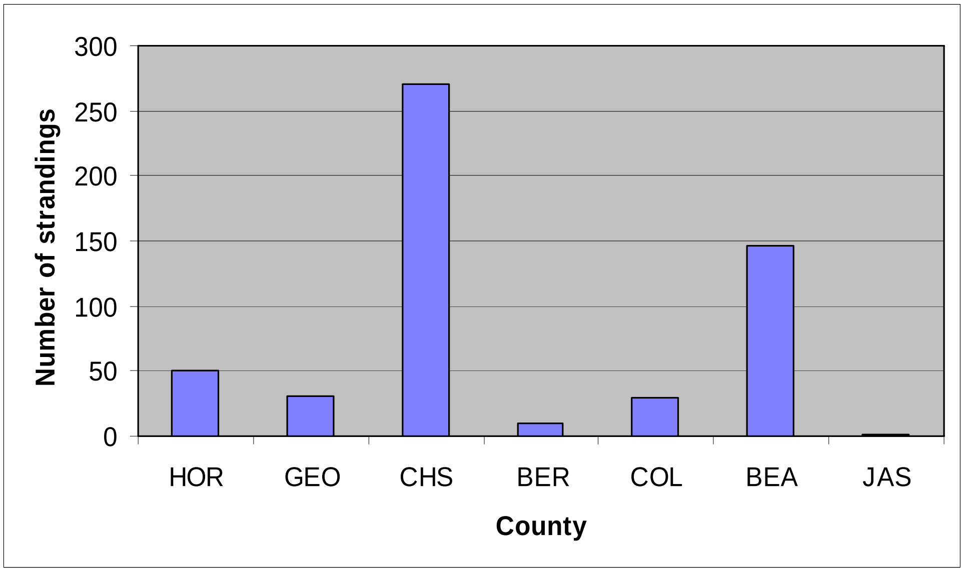


Figure 4. Percentage of strandings with evidence of human interaction (HI) minus those animals for which a determination of HI could not be determined (CBD) in South Carolina, 1992-2005.

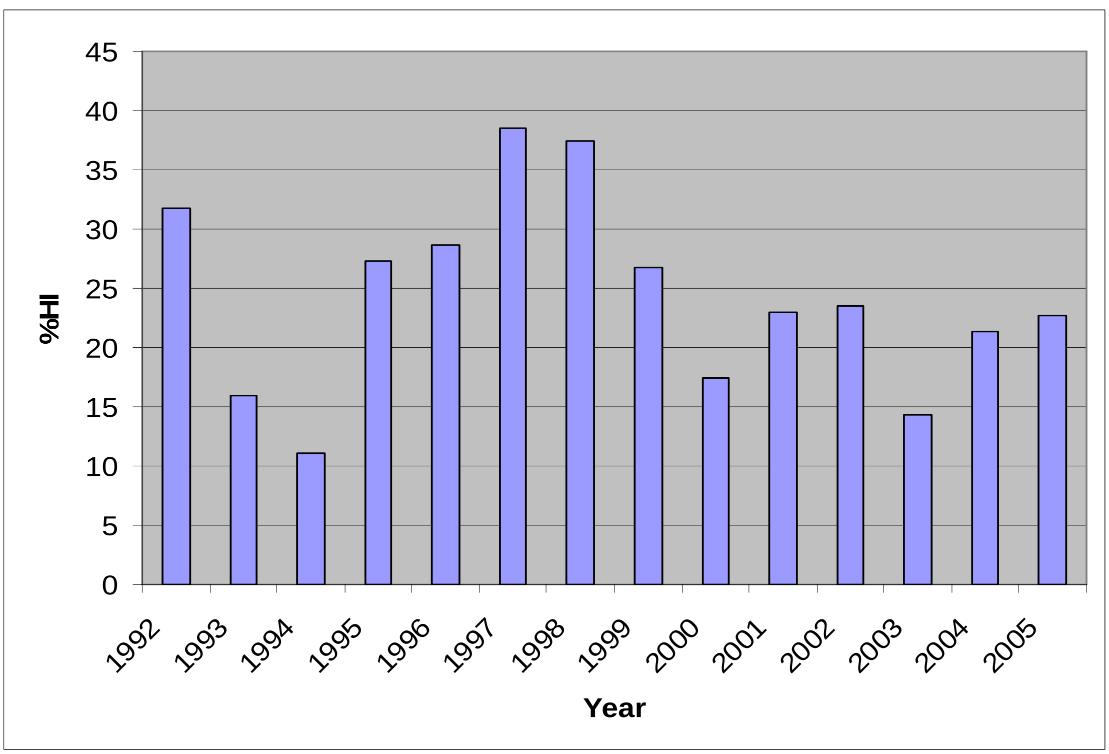
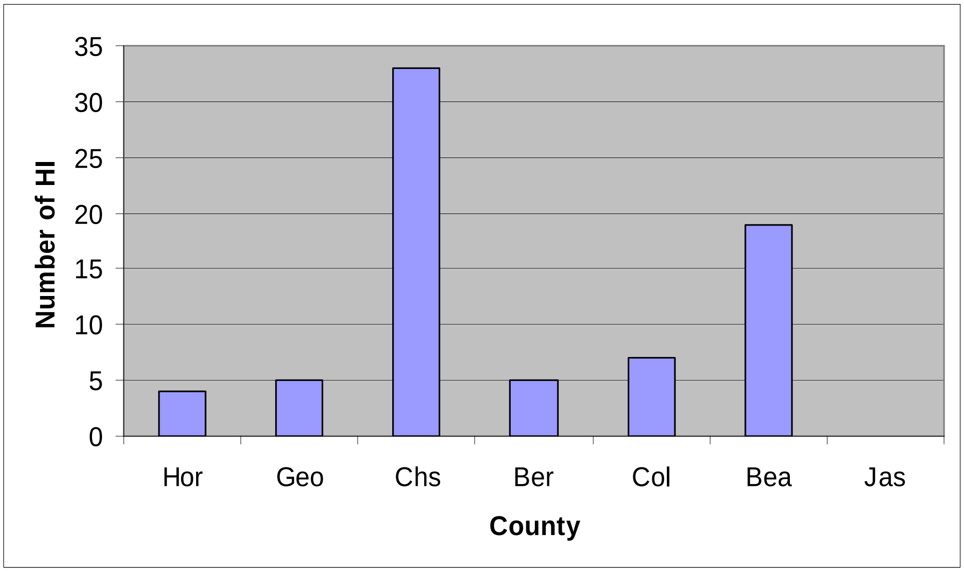


Figure 5. Number of strandings with evidence of human interaction (HI) by coastal county (Hor= Horry; Geo= Georgetown; Chs= Charleston; Ber= Berkeley; Col= Colleton; Bea= Beaufort; Jas= Jasper) in South Carolina, 1992-2005.



United States Department of Commerce

Carlos M. Gutierrez
Secretary

National Oceanic and Atmospheric Administration

Vice Admiral Conrad C. Lautenbacher, Jr. USN (Ret.)
Under Secretary of Commerce for Oceans and Atmospheres

National Ocean Service
John H. Dunnigan
Assistant Administrator for Ocean Service and Coastal Zone Management