

## **BOTTLENOSE DOLPHIN (*Tursiops truncatus truncatus*): Northern Gulf of Mexico Bay, Sound, and Estuary Stocks**

**NOTE – NMFS is in the process of writing individual stock assessment reports for each of the 32 bay, sound and estuary stocks of bottlenose dolphins that are included in this report. Until this effort is completed and this report is replaced by 32 individual reports, basic information for all individual bay, sound and estuary stocks will remain in this report.**

### **STOCK DEFINITION AND GEOGRAPHIC RANGE**

Bottlenose dolphins are distributed throughout the bays, sound and estuaries of the Gulf of Mexico (Mullin 1988). The identification of biologically-meaningful “stocks” of bottlenose dolphins in these waters is complicated by the high degree of behavioral variability exhibited by this species (Shane 1986; Wells and Scott 1999; Wells 2003), and by the lack of requisite information for much of the region.

Distinct stocks are provisionally identified in each of 32 areas of contiguous, enclosed or semi-enclosed bodies of water adjacent to the northern Gulf of Mexico (i.e., U.S. Gulf of Mexico) (Table 1, based on descriptions of relatively discrete dolphin “communities” in some of these areas). A “community” includes resident dolphins that regularly share large portions of their ranges, exhibit similar distinct genetic profiles, and interact with each other to a much greater extent (>50% of associations) than with dolphins in adjacent waters. The term, as adapted from Wells *et al.* (1987) and applied in part by Urian *et al.* (2009), emphasizes geographic, genetic and social relationships of dolphins. Bottlenose dolphin communities do not constitute closed demographic populations, as individuals from adjacent communities are known to interbreed. Nevertheless, the geographic nature of these areas and long-term, multi-generational stability of residency patterns suggest that many of these communities exist as functioning units of their ecosystems, and under the Marine Mammal Protection Act must be maintained as such. Also, the stable patterns of residency observed within communities suggest that long periods would be required to repopulate the home range of a community if it were eradicated or severely depleted. Thus, in the absence of information supporting management on a larger scale, it is appropriate to adopt a risk-averse approach and focus management efforts at the level of the community rather than at some larger demographic scale. Biological support for this risk-averse approach derives from several sources. Long-term (year-round, multi-year) residency by at least some individuals has been reported from nearly every site where photographic identification or tagging studies have been conducted in the Gulf of Mexico. In Texas, some of the dolphins in the Matagorda-Espiritu Santo Bay area (Gruber 1981; Lynn and Würsig 2002), Aransas Pass (Shane 1977; Weller 1998), San Luis Pass (Maze and Würsig 1999; Irwin and Würsig 2004), and Galveston Bay (Bräger 1993; Bräger *et al.* 1994; Fertl 1994) have been reported as long-term residents. Hubard *et al.* (2004) reported sightings of dolphins tagged 12-15 years previously in Mississippi Sound. In Florida, long-term residency has been reported from Choctawhatchee Bay (1989-1993; F. Townsend, unpublished data), Tampa Bay (Wells 1986a; Wells *et al.* 1996b; Urian *et al.* 2009), Sarasota Bay (Irvine and Wells 1972; Irvine *et al.* 1981; Wells 1986a; Wells *et al.* 1987; Scott *et al.* 1990; Wells 1991; 2003), Lemon Bay (Wells *et al.* 1996a) and Charlotte Harbor/Pine Island Sound (Shane 1990; Wells *et al.* 1996a; Wells *et al.* 1997; Shane 2004). In Louisiana, Miller (2003) concluded the bottlenose dolphin population in the Barataria Basin was relatively closed. In many cases, residents emphasize use of the bay, sound or estuary waters, with limited movements through passes to the Gulf of Mexico (Shane 1977; 1990; Gruber 1981; Irvine *et al.* 1981; Maze and Würsig 1999; Lynn and Würsig 2002; Fazioli *et al.* 2006). These habitat use patterns are reflected in the ecology of the dolphins in some areas; for example, residents of Sarasota Bay, Florida, lacked squid in their diet, unlike non-resident dolphins stranded on nearby Gulf beaches (Barros and Wells 1998).

Genetic data also support the concept of relatively discrete bay, sound and estuary stocks. Analyses of mitochondrial DNA haplotype distributions indicate the existence of clinal variations along the Gulf of Mexico coastline (Duffield and Wells 2002). Differences in reproductive seasonality from site to site also suggest genetic-based distinctions between communities (Urian *et al.* 1996). Mitochondrial DNA analyses suggest finer-scale structural levels as well. For example, Matagorda Bay, Texas, dolphins appear to be a localized population, and differences in haplotype frequencies distinguish between adjacent communities in Tampa Bay, Sarasota Bay and Charlotte Harbor/Pine Island Sound, along the central west coast of Florida (Duffield and Wells 1991; 2002). Examination of protein electrophoretic data resulted in similar conclusions for the Florida dolphins (Duffield and Wells 1986). Additionally, Sellas *et al.* (2005) examined population subdivision among Sarasota Bay, Tampa Bay,

Charlotte Harbor, Matagorda Bay, and the coastal Gulf of Mexico (1 – 12 km offshore) from just outside Tampa Bay to the south end of Lemon Bay, and found evidence of significant population structure among all areas on the basis of both mitochondrial DNA control region sequence data and 9 nuclear microsatellite loci. The Sellas *et al.* (2005) findings support the separate identification of bay, sound and estuary populations from those occurring in adjacent Gulf coastal waters.

The long-term structure and stability of at least some of these communities is exemplified by the residents of Sarasota Bay, Florida. This community has been observed since 1970 (Irvine and Wells 1972; Scott *et al.* 1990; Wells 1991; 2003). A span of at least 5 generations of identifiable residents currently inhabits the region, including some of those first identified in 1970. Maximum immigration and emigration rates of about 2-3% have been estimated (Wells and Scott 1990).

Genetic exchange occurs between resident communities; hence the application of the demographically and behaviorally-based term “community” rather than “population” (Wells 1986a; Sellas *et al.* 2005). Some of the calves in Sarasota Bay apparently have been sired by non-residents (Duffield and Wells 2002). A variety of potential exchange mechanisms occur in the Gulf. Small numbers of inshore dolphins travelling between regions have been reported, with patterns ranging from travelling through adjacent communities (Wells 1986b; Wells *et al.* 1996a; 1996b) to movements over distances of several hundred km in Texas waters (Gruber 1981; Lynn and Würsig 2002). In many areas year-round residents co-occur with non-resident dolphins, providing potential opportunities for genetic exchange. About 14-17% of group sightings involving resident Sarasota Bay dolphins include at least 1 non-resident as well (Wells *et al.* 1987; Fazioli *et al.* 2006). Similar mixing of inshore residents and non-residents has been seen off San Luis Pass, Texas (Maze and Würsig 1999), the Cedar Keys, Florida (Quintana-Rizzo and Wells 2001), and Pine Island Sound, Florida (Shane 2004). Non-residents exhibit a variety of patterns, ranging from apparent nomadism recorded as transience in a given area, to apparent seasonal or non-seasonal migrations. Passes, especially the mouths of the larger estuaries, serve as mixing areas. For example, several communities mix at the mouth of Tampa Bay, Florida (Wells 1986a), and most of the dolphins identified in the mouths of Galveston Bay and Aransas Pass, Texas, were considered transients (Henningsen 1991; Bräger 1993; Weller 1998).

Seasonal movements of dolphins into and out of some of the bays, sounds and estuaries provide additional opportunities for genetic exchange with residents, and complicate the identification of stocks in coastal and inshore waters. In small bay systems such as Sarasota Bay, Florida, and San Luis Pass, Texas, residents move into Gulf coastal waters in fall/winter, and return inshore in spring/summer (Irvine *et al.* 1981; Maze and Würsig 1999). In larger bay systems, seasonal changes in abundance suggest possible migrations, with increases in more northerly bay systems in summer, and in more southerly systems in winter. Fall/winter increases in abundance have been noted for Tampa Bay (Scott *et al.* 1989) and Charlotte Harbor/Pine Island Sound (Thompson 1981; Scott *et al.* 1989), and are thought to occur in Matagorda Bay (Gruber 1981; Lynn and Würsig 2002) and Aransas Pass (Shane 1977; Weller 1998). Spring/summer increases in abundance occur in Mississippi Sound (Hubard *et al.* 2004) and are thought to occur in Galveston Bay (Henningsen 1991; Bräger 1993; Fertl 1994).

Spring and fall increases in abundance have been reported for St. Joseph Bay, Florida, where recent mark-recapture photo-identification surveys and 2 NOAA-sponsored health assessments were conducted during 2005-2006. Mark-recapture abundance estimates were highest in spring and fall and lowest in summer and winter (Table 1; Balmer *et al.* 2008). Individuals with low site-fidelity indices were sighted more often in spring and fall, whereas individuals sighted during summer and winter displayed higher site-fidelity indices. In conjunction with health assessments, 23 dolphins were radio tagged during April 2005 and July 2006. Dolphins tagged in spring 2005 displayed variable utilization areas and variable site fidelity patterns. In contrast, during summer 2006 the majority of radio tagged individuals displayed similar utilization areas and moderate to high site-fidelity patterns. The results of the studies suggest that during summer and winter St. Joseph Bay hosts dolphins that spend most of their time within this region, and these may represent a resident community. In spring and fall, St. Joseph Bay is visited by dolphins that range outside of this area (Balmer *et al.* 2008).

Much uncertainty remains regarding the structure of bottlenose dolphin stocks in many of the Gulf of Mexico bays, sounds and estuaries. Given the apparent co-occurrence of resident and non-resident dolphins in these areas, and the demonstrated variations in abundance, it appears that consideration should be given to the existence of a complex of stocks, and to the roles of bays, sounds and estuaries for stocks emphasizing Gulf of Mexico coastal waters. A starting point for management strategy should be the protection of the long-term resident communities, with their multi-generational geographic, genetic, demographic and social stability. These localized units would be at greatest risk from geographically-localized impacts. Complete characterization of many of these basic units would benefit from additional photo-identification, telemetry and genetic research (Wells 1994).

The current provisional stocks follow the designations in Table 1. As information becomes available, combination or division of these provisional stocks may be warranted. For example, unpublished research suggests that Block B-21, Lemon Bay, can be subsumed under Charlotte Harbor, and B36, Caloosahatchee River, can be considered a part of Pine Island Sound. Additionally, a number of geographically and socially distinct subgroupings of dolphins in regions such as Tampa Bay, Charlotte Harbor, Pine Island Sound, Aransas Pass and Matagorda Bay have been identified, but the importance of these distinctions to stock designations remains undetermined (Shane 1977; Gruber 1981; Wells *et al.* 1996a; 1996b; 1997; Lynn and Würsig 2002; Urian 2002). For Tampa Bay, Urian *et al.* (2009) recently described fine-scale population structuring into 5 discrete communities (including the adjacent Sarasota Bay community) that differed in their social interactions and ranging patterns. Structure was found despite a lack of physiographic barriers to movement within this large, open embayment. Urian *et al.* (2009) further suggested that fine-scale structure may be a common element among populations of bottlenose dolphins in the southeast U.S. and recommended that management should account for fine-scale structure that exists within current stock designations.

Understanding the full complement of the stock complex using the bay, sound and estuary waters of the Gulf of Mexico will require much additional information. The development of biologically-based criteria to better define and manage stocks in this region should integrate multiple approaches, including studies of ranging patterns, genetics, morphology, social patterns, distribution, life history, stomach contents, isozyme analyses and contaminant concentrations. Spatially-explicit population modeling could aid in evaluating the implications of community-based stock definition. As these studies provide new information on what constitutes a bottlenose dolphin “biological stock,” current provisional definitions will likely need to be revised. As stocks are more clearly identified, it will be possible to conduct abundance estimates using standardized methodology across sites (thereby avoiding some of the previous problems of mixing results of aerial and boat-based surveys), identify fisheries and other human impacts relative to stocks and perform individual stock assessments. As recommended by the Atlantic Scientific Review Group (November 1998, Portland, Maine), an expert panel reviewed the stock structure for bottlenose dolphins in the Gulf of Mexico during a workshop in March 2000 (Hubard and Swartz 2002). The panel sought to describe the scope of risks faced by bottlenose dolphins in the Gulf of Mexico, and outline an approach by which the stock structure could most efficiently be investigated and integrated with data from previous and ongoing studies. The panel agreed that it was appropriate to use the precautionary approach and retain the stocks currently named until further studies are conducted, and made a variety of recommendations for future research (Hubard and Swartz 2002). As a result of this, efforts are being made to conduct research in new locations, such as the north central Gulf, in addition to the ongoing studies in Texas and Florida.

Table 1. Most recent bottlenose dolphin abundance ( $N_{BEST}$ ), coefficient of variation (CV) and minimum population estimate ( $N_{MIN}$ ) in northern Gulf of Mexico bays, sounds and estuaries. Because they are based on data collected more than 8 years ago, most estimates are considered unknown or undetermined for management purposes. Blocks refer to aerial survey blocks illustrated in Figure 1. PBR – Potential Biological Removal; UNK – unknown; UND – undetermined.

Blocks	Gulf of Mexico Estuary	$N_{BEST}$	CV	$N_{MIN}$	PBR	Year	Reference
B51	Laguna Madre	80	1.57	UNK	UND	1992	A
B52	Nueces Bay, Corpus Christi Bay	58	0.61	UNK	UND	1992	A
B50	Copano Bay, Aransas Bay, San Antonio Bay, Redfish Bay, Espiritu Santo Bay	55	0.82	UNK	UND	1992	A
B54	Matagorda Bay, Tres Palacios Bay, Lavaca Bay	61	0.45	UNK	UND	1992	A
B55	West Bay	32	0.15	UNK	UND	2000	E
B56	Galveston Bay, East Bay, Trinity Bay	152	0.43	UNK	UND	1992	A
B57	Sabine Lake	0 <sup>a</sup>	-		UND	1992	A
B58	Calcasieu Lake	0 <sup>a</sup>	-		UND	1992	A
B59	Vermilion Bay, West Cote Blanche Bay, Atchafalaya Bay	0 <sup>a</sup>	-		UND	1992	A
B60	Terrebonne Bay, Timbalier Bay	100	0.53	UNK	UND	1993	A
B61	Barataria Bay <sup>d</sup>	138	0.08	UNK	UND	2001	D
B30	Mississippi River Delta	0 <sup>a</sup>	-		UND	1993	A
B02-05,	Mississippi Sound, Lake Borgne, Bay	1,401	0.13	UNK	UND	1993	A

29, 31	Boudreau						
B06	Mobile Bay, Bonsecour Bay	122	0.34	UNK	UND	1993	A
B07	Perdido Bay	0 <sup>a</sup>	-		UND	1993	A
B08	Pensacola Bay, East Bay	33	0.80	UNK	UND	1993	A
B09	Choctawhatchee Bay <sup>d</sup>	179	0.04	173	1.7	2007	H
B10	St. Andrew Bay	124	0.57	UNK	UND	1993	A
B11	St. Joseph Bay <sup>d</sup>	146	0.18	126	1.3	2005-07	F
B12-13	St. Vincent Sound, Apalachicola Bay, St. George Sound	439	0.14	390	3.9	2007-08	G
B14-15	Apalachee Bay	491	0.39	UNK	UND	1993	A
B16	Waccasassa Bay, Withlacoochee Bay, Crystal Bay	100	0.85	UNK	UND	1994	A
B17	St. Joseph Sound, Clearwater Harbor	37	1.06	UNK	UND	1994	A
B32-34	Tampa Bay	559	0.24	UNK	UND	1994	A
B20, 35	Sarasota Bay, Little Sarasota Bay	160	na <sup>c</sup>	160	1.6	2007	B
B21	Lemon Bay	0 <sup>a</sup>	-		UND	1994	A
B22-23	Pine Island Sound, Charlotte Harbor, Gasparilla Sound	209	0.38	UNK	UND	1994	A
B36	Caloosahatchee River	0 <sup>a,b</sup>	-		UND	1985	C
B24	Estero Bay	104	0.67	UNK	UND	1994	A
B25	Chokoloskee Bay, Ten Thousand Islands, Gullivan Bay	208	0.46	UNK	UND	1994	A
B27	Whitewater Bay	242	0.37	UNK	UND	1994	A
B28	Florida Keys (Bahia Honda to Key West)	29	1.00	UNK	UND	1994	A

References: A – Blaylock and Hoggard 1994; B – Wells 2009; C – Scott *et al.* 1989; D – Miller 2003; E – Irwin and Würsig 2004; F – Balmer *et al.* 2008; G – Tyson *et al.* 2011; H – Conn *et al.* 2011

Notes:

<sup>a</sup> During earlier surveys (Scott *et al.* 1989), the range of seasonal abundances was as follows: B57, 0-2 (CV=0.38); B58, 0-6 (0.34); B59, 0-0; B30, 0-182 (0.14); B07, 0-0; B21, 0-15 (0.43); and B36, 0-0.

<sup>b</sup> Block not surveyed during surveys reported in Blaylock and Hoggard (1994).

<sup>c</sup> No CV because  $N_{BEST}$  was a direct count of known individuals.

<sup>d</sup> These stocks have their own individual stock assessment reports.

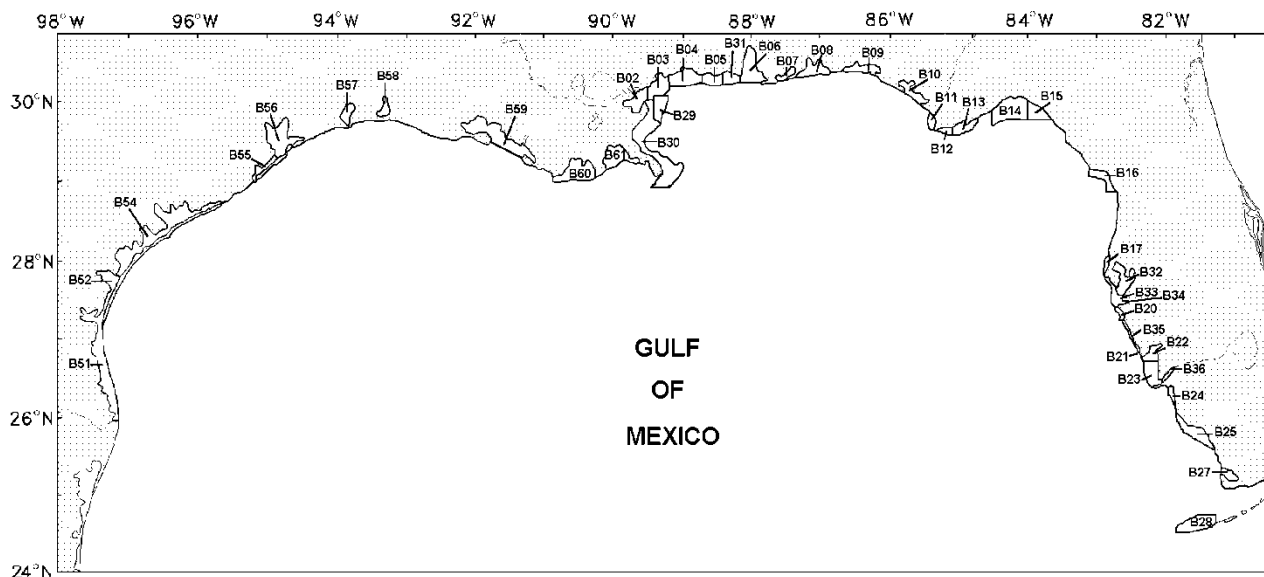


Figure 1. Northern Gulf of Mexico bays and sounds. Each of the alpha-numerically designated blocks corresponds to one of the NMFS Southeast Fisheries Science Center logistical aerial survey areas listed in Table 1. The bottlenose dolphins inhabiting each bay and sound are considered to comprise a unique stock for purposes of this assessment.

## **POPULATION SIZE**

Population size estimates for most of the stocks are greater than 8 years old and therefore the current population size for each of these stocks is considered unknown (Wade and Angliss 1997). Recent mark-recapture population size estimates are available for Choctawhatchee Bay, St. Joseph Bay and Apalachicola Bay, Florida, and a direct count is available for Sarasota Bay, Florida (Table 1). Previous population size for most other stocks (Table 1) was estimated from preliminary analyses of line-transect data collected during aerial surveys conducted in September–October 1992 in Texas and Louisiana; in September–October 1993 in Louisiana, Mississippi, Alabama and the Florida Panhandle (Blaylock and Hoggard 1994); and in September–November 1994 along the west coast of Florida (NMFS unpublished data). Standard line-transect perpendicular sighting distance analytical methods (Buckland *et al.* 1993) and the computer program DISTANCE (Laake *et al.* 1993) were used. Analyses are currently underway that should provide updated abundance estimates for Lemon Bay, Gasparilla Sound, Charlotte Harbor, and Pine Island Sound during 2011 (Wells, pers. comm.).

### **Minimum Population Estimate**

The population size for all but 4 stocks is currently unknown and the minimum population estimates are given for those 4 stocks in Table 1. In most cases, the minimum population estimate is the lower limit of the two-tailed 60% confidence interval of the log-normally distributed abundance estimate. This is equivalent to the 20<sup>th</sup> percentile of the log-normal distribution as specified by Wade and Angliss (1997). The minimum population estimate was calculated for each block from the estimated population size and its associated coefficient of variation. Where the population size resulted from a direct count of known individuals, the minimum population size was identical to the estimated population size.

### **Current Population Trend**

The data are insufficient to determine population trends for all of the Gulf of Mexico bay, sound and estuary bottlenose dolphin communities. Eleven unusual mortality events have occurred among portions of these dolphin communities between 1990 and 2008; however, it is not possible to accurately partition the mortalities between bay and coastal stocks, thus the impact of these mortality events on communities is not known.

## **CURRENT AND MAXIMUM NET PRODUCTIVITY RATES**

Current and maximum net productivity rates are not known for the dolphin communities that constitute these stocks. While productivity rates may be estimated for individual females within communities, such estimates are confounded at the stock level due to the influx of dolphins from adjacent areas which balance losses, and the unexplained loss of some individuals which offset births and recruitment (Wells 1998). Continued monitoring and expanded survey coverage will be required to address and develop estimates of productivity for these dolphin communities. The maximum net productivity rate was assumed to be 0.04. This value is based on theoretical modeling showing that cetacean populations may not grow at rates much greater than 4% given the constraints of their reproductive life history (Barlow *et al.* 1995).

## **POTENTIAL BIOLOGICAL REMOVAL**

Potential Biological Removal (PBR) is undetermined for most stocks because the population size estimate is more than 8 years old. PBR is the product of minimum population size, one-half the maximum productivity rate and a recovery factor (Wade and Angliss 1997). The recovery factor, which accounts for endangered, depleted, and threatened stocks, or stocks of unknown status relative to optimum sustainable population (OSP), is assumed to be 0.5 because these stocks are of unknown status. PBR for those stocks with population size estimates less than 8 years old is given in Table 1.

## **ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY**

The total annual human-caused mortality and serious injury for these stocks during 2006–2010 is unknown.

Some of the bay, sound and estuary communities were the focus of a live-capture fishery for bottlenose dolphins

which supplied dolphins to the U.S. Navy and to oceanaria for research and public display for more than 2 decades ending in 1989 (NMFS unpublished data). During the period 1972-1989, 490 bottlenose dolphins, an average of 29 dolphins annually, were removed from a few locations in the Gulf of Mexico, including the Florida Keys, Charlotte Harbor, Tampa Bay and elsewhere. Mississippi Sound sustained the highest level of removals with 202 dolphins taken from this stock during this period, representing 41% of the total and an annual average of 12 dolphins (compared to a previous PBR of 13). The annual average number of removals never exceeded previous PBR levels, but it may be biologically significant that 73% of the dolphins removed during 1982-1988 were females. The impact of these removals on the stocks is unknown.

### **Fishery Information**

The commercial fisheries which potentially could interact with these stocks in the Gulf of Mexico are the shrimp trawl, blue crab trap/pot, stone crab trap/pot, menhaden purse seine, gillnet, and Atlantic Ocean commercial passenger fishing vessel (hook and line) fisheries (Appendix III).

### **Hook and Line Fisheries**

During 2006 there were 8 mortalities for which hook and line gear entanglement or ingestion were documented in the stranding database, and attempts were made to disentangle 2 live animals from hook and line gear. During 2007, there were 4 mortalities, and during 2008, 2 mortalities, for which hook and line gear entanglement or ingestion were documented. During 2009, there were 2 mortalities for which hook and line gear entanglement or ingestion were documented, and attempts were made to disentangle 2 live animals from hook and line gear. Finally, during 2010, there were 4 mortalities for which hook and line gear entanglement or ingestion were documented, and an attempt was made to disentangle 1 live animal from hook and line gear. In total, during 2006–2010, for 20 mortalities for which hook and line gear entanglement were documented, 15 occurred in Florida, 4 in Texas and 1 in Mississippi; and for 5 attempted disentanglements from hook and line gear, 3 occurred in Texas and 2 in Florida. The mortalities and live entanglements were included in the stranding database (NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 16 November 2011) and are included in the stranding totals presented in Table 1.

### **Shrimp Trawl Fishery**

A voluntary observer program for the shrimp trawl fishery began in 1992 and became mandatory in 2007. Four bottlenose dolphin mortalities were observed in the shrimp trawl fishery during 2003, 2007, 2008 and 2010. The 2007 mortality occurred off the Louisiana coast and could have belonged to the Western Coastal Stock or a bay, sound and estuary stock (Vermilion Bay, West Cote Blanche Bay, Atchafalaya Bay Stock or Terrebonne Bay, Timbalier Bay Stock). The 2003 mortality occurred off the coast of Alabama and could have belonged to the Northern Coastal Stock or a bay, sound and estuary stock (Mobile Bay, Bonsecour Bay Stock or Mississippi Sound, Lake Borgne, Bay Boudreau Stock).

### **Blue and Stone Crab Trap/Pot Fisheries**

Bottlenose dolphins have been reported stranded with polypropylene rope around their flukes (NMFS 1991; McFee and Brooks, Jr. 1998; NMFS unpublished data), indicating the possibility of entanglement with crab pot lines. In 2010, a calf likely belonging to the Copano Bay, Aransas Bay, San Antonio Bay, Redfish Bay, Espiritu Santo Bay Stock was disentangled by stranding network personnel from a crab trap line wrapped around its peduncle. The animal swam away with no obvious injuries. In 2008 there was a report of a live dolphin in the Caloosahatchee River in Florida entangled in pot line without a buoy attached. This animal was likely a member of the Caloosahatchee River Stock (NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 16 November 2011). In 2002 there was a calf stranded near Clearwater, Florida, with blue crab trap line wrapped around its rostrum, through its mouth and looped around its tail (NMFS unpublished data). This animal was likely a member of the St. Joseph Sound, Clearwater Harbor Stock. Since there is no systematic observer program, it is not possible to estimate the total number of interactions or mortalities associated with crab traps/pots.

### **Menhaden Purse Seine Fishery**

There are no recent observer program data for the Gulf of Mexico menhaden purse seine fishery but incidental mortality of bottlenose dolphins has been reported for this fishery (Reynolds 1985). Through the Marine Mammal Authorization Program, there have been 11 self-reported incidental takes (all mortalities) of bottlenose dolphins in

northern Gulf of Mexico coastal and estuarine waters by the menhaden purse seine fishery. These takes likely affected the following stocks: Western Coastal Stock; Northern Coastal Stock; Mississippi Sound, Lake Borgne, Bay Boudreau Stock; Mississippi River Delta Stock; and Barataria Bay Estuarine System Stock. One take of a single bottlenose dolphin was reported in Louisiana waters during 2004 (likely belonged to the Mississippi River Delta Stock). Two takes of single unidentified dolphins were reported during 2002 (1 in Mississippi and 1 in Louisiana waters; likely belonged to Mississippi Sound, Lake Borgne, Bay Boudreau Stock and Barataria Bay Estuarine System Stock). One take of a single bottlenose dolphin was reported in Louisiana waters during 2001 (likely belonged to Mississippi River Delta Stock or Northern Coastal Stock). Three takes were reported in 2000, 2 of which were for single dolphins (1 bottlenose, 1 unidentified) in Louisiana waters (likely belonged to Western Coastal Stock and either Mississippi River Delta Stock or Northern Coastal Stock), and the third was for 3 bottlenose dolphins in a single purse seine in Mississippi waters (likely belonged to Mississippi Sound, Lake Borgne, Bay Boudreau Stock). The menhaden purse seine fishery was observed to take 9 bottlenose dolphins (3 fatally) between 1992 and 1995 (NMFS unpublished data). During that period, there were 1,366 sets observed out of 26,097 total sets, which if extrapolated for all years suggests that as many as 172 bottlenose dolphins could have been taken in this fishery with up to 57 animals killed. Without an observer program, it is not possible to obtain statistically reliable information for this fishery on the number of sets annually, the incidental take and mortality rates, and the communities from which bottlenose dolphins are being taken.

### **Gillnet Fishery**

No marine mammal mortalities associated with gillnet fisheries have been reported in recent years, but stranding data suggest that gillnet and marine mammal interactions do occur, causing mortality and serious injury. Four research-related gillnet mortalities occurred between 2003 and 2007 in Texas and Louisiana and an additional research gillnet entanglement occurred during 2008 in Texas (see “Other Mortality” below for details). All of the research-related interactions were likely with animals belonging to the following bay, sound and estuary stocks: Copano Bay, Aransas Bay, San Antonio Bay, Redfish Bay, Espiritu Santo Bay Stock (2 mortalities); Mississippi River Delta Stock (1 mortality); and Matagorda Bay, Tres Palacios Bay, Lavaca Bay Stock (1 mortality, 1 released alive). In 1995, a Florida state constitutional amendment banned gillnets and large nets from bays, sounds, estuaries and other inshore waters.

### **Strandings**

A total of 554 bottlenose dolphins were found stranded in bays, sounds and estuaries of the northern Gulf of Mexico from 2006 through 2010 (Table 2; NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 16 November 2011). Evidence of human interactions (e.g., gear entanglement, mutilation, gunshot wounds) was detected for 75 of these dolphins. For 3 of the dolphins from 2010, visible, external oil was present on the animals. Bottlenose dolphins are known to become entangled in, or ingest recreational and commercial fishing gear (Wells and Scott 1994; Gorzelany 1998; Wells *et al.* 1998; Wells *et al.* 2008), and some are struck by vessels (Wells and Scott 1997; Wells *et al.* 2008).

There are a number of difficulties associated with the interpretation of stranding data. Except in rare cases, such as Sarasota Bay, Florida, where residency can be determined, it is possible that some or all of the stranded dolphins may have been from a nearby coastal stock. However, the proportion of stranded dolphins belonging to another stock cannot be determined because of the difficulty of determining from where the stranded carcasses originated. Stranding data probably underestimate the extent of fishery-related mortality and serious injury because not all of the dolphins which die or are seriously injured in fishery interactions wash ashore, nor will all of those that do wash ashore necessarily show signs of entanglement or other fishery-interaction. Finally, the level of technical expertise among stranding network personnel varies widely as does the ability to recognize signs of fishery interaction, and the condition of the carcass if badly decomposed can inhibit the interpretation of cause of death.

Since 1990, there have been 12 bottlenose dolphin die-offs or Unusual Mortality Events (UMEs) in the northern Gulf of Mexico. 1) From January through May 1990, a total of 367 bottlenose dolphins stranded in the northern Gulf of Mexico. Overall this represented a two-fold increase in the prior maximum recorded number of strandings for the same period, but in some locations (i.e., Alabama) strandings were 10 times the average number. The cause of the 1990 mortality event could not be determined (Hansen 1992). 2) An unusual mortality event was declared for Sarasota Bay, Florida, in 1991, but the cause was not determined. 3) In March and April 1992, 111 bottlenose dolphins stranded in Texas - about 9 times the average number. The cause of this event was not determined, but carbamates were a suspected cause. 4) In 1993-1994 an UME of bottlenose dolphins likely caused by morbillivirus started in the Florida

Panhandle and spread west with most of the mortalities occurring in Texas (Lipscomb 1993; Lipscomb *et al.* 1994). From February through April 1994, 220 bottlenose dolphins were found dead on Texas beaches, of which 67 occurred in a single 10-day period. 5) In 1996 an UME was declared for bottlenose dolphins in Mississippi when 27 bottlenose dolphins stranded during November and December. The cause was not determined, but a *Karenia brevis* (red tide) bloom was suspected to be responsible. 6) Between August 1999 and May 2000, 152 bottlenose dolphins died coincident with *K. brevis* blooms and fish kills in the Florida Panhandle (additional strandings included 3 Atlantic spotted dolphins, *Stenella frontalis*, 1 Risso's dolphin, *Grampus griseus*, 2 Blainville's beaked whales, *Mesoplodon densirostris*, and 4 unidentified dolphins. 7) In March and April 2004, in another Florida Panhandle UME possibly related to *K. brevis* blooms, 105 bottlenose dolphins and 2 unidentified dolphins stranded dead (NMFS 2004). Although there was no indication of a *K. brevis* bloom at the time, high levels of brevetoxin were found in the stomach contents of the stranded dolphins (Flewelling *et al.* 2005). 8) In 2005, a particularly destructive red tide (*K. brevis*) bloom occurred off of central west Florida. Manatee, sea turtle, bird and fish mortalities were reported in the area in early 2005 and a manatee UME had been declared. Dolphin mortalities began to rise above the historical averages by late July 2005, continued to increase through October 2005, and were then declared to be part of a multi-species UME. The multi-species UME extended into 2006, and ended in November 2006. A total of 190 dolphins were involved, primarily bottlenose dolphins (plus strandings of 1 Atlantic spotted dolphin, *S. frontalis*, and 24 unidentified dolphins). The evidence suggests the effects of a red tide bloom contributed to the cause of this event. 9) A separate UME was declared in the Florida Panhandle after elevated numbers of dolphin strandings occurred in association with a *K. brevis* bloom in September 2005. Dolphin strandings remained elevated through the spring of 2006 and brevetoxin was again detected in the tissues of some of the stranded dolphins. Between September 2005 and April 2006 when the event was officially declared over, a total of 90 bottlenose dolphin strandings occurred (plus strandings of 3 unidentified dolphins). 10) During February and March of 2007 an event was declared for northeast Texas and western Louisiana involving 66 bottlenose dolphins. Decomposition prevented conclusive analyses on most carcasses. 11) During February and March of 2008 an additional event was declared in Texas involving 113 bottlenose dolphin strandings. Most of the animals recovered were in a decomposed state. The investigation is closed and a direct cause could not be identified. However, there were numerous, co-occurring harmful algal bloom toxins detected during the time period of this UME which may have contributed to the mortalities (Fire *et al.*, in press). 12) An UME was declared for cetaceans in the northern Gulf of Mexico beginning 1 February 2010; and, as of early 2012, the event is still ongoing. It includes cetaceans that stranded prior to the Deepwater Horizon oil spill (see "Habitat Issues" below), during the spill, and after. During 2010, 144 animals from bay, sound and estuary stocks were considered to be part of the UME.

Table 2. Bottlenose dolphin strandings occurring in bays, sounds and estuaries in the northern Gulf of Mexico from 2006 to 2010, as well as number of strandings for which evidence of human interaction was detected and number of strandings for which it could not be determined (CBD) if there was evidence of human interaction. Data are from the NOAA National Marine Mammal Health and Stranding Response Database (unpublished data, accessed 16 November 2011). Please note human interaction does not necessarily mean the interaction caused the animal's death. Please also note that this table does not include strandings from Barataria Bay Estuarine System, Choctawhatchee Bay or St. Joseph Bay Stocks. Finally, there were an additional 24 dolphins not included in this or any other table that stranded either in bay, sound and estuary waters or in coastal waters that could not be assigned definitively to a stock due to bad location data. If/when the location data are resolved, the numbers below could increase.

Stock	Category	2006	2007	2008	2009	2010	Total
Bay, Sound and Estuary	Total Stranded	125 <sup>a,b</sup>	68 <sup>c</sup>	69 <sup>d</sup>	98 <sup>e</sup>	194 <sup>f</sup>	554
	Human Interaction						
	---Yes	22	10	5	18	20	75
	---No	29	11	15	9	10	74
	---CBD	74	47	49	71	164	405

<sup>a</sup> This total includes 2 mass stranding events in Florida (2 animals in July 2006, 3 animals in November 2006)

<sup>b</sup> This total includes 75 animals that were part of 2 different UMEs in Florida

<sup>c</sup> This total includes 4 animals that were part of an UME in Texas

<sup>d</sup> This total includes 3 animals that were part of an UME in Texas

<sup>e</sup> This total includes a mass stranding of 6 animals in Louisiana in June 2009

<sup>f</sup> This total includes 144 animals that are part of the ongoing UME in the northern Gulf of Mexico



## Other Mortality

Two dolphin research-related mortalities have occurred. During November 2002 in Sarasota Bay, Florida, a 35-year-old male died in a health assessment research project. The histopathology report stated that drowning was the cause of death. However, the necropsy revealed that the animal was in poor condition as follows: anemic, thin (ribs evident, blubber thin and grossly lacking lipid), no food in the stomach and little evidence of recent feeding in the digestive tract, vertebral fractures with muscle atrophy, with additional conditions present. This has been the only such loss during capture/release research conducted over a 41-year period on Florida's central west coast. Another research-related mortality occurred during July 2006 in St. Joseph Bay, in the Florida Panhandle, during a NMFS health assessment research project to investigate a series of UMEs in the region. The animal became entangled deep in the capture net and was found dead during extrication of other animals from the net. The cause of death was determined to be asphyxiation.

During 2009 in Mobile Bay, Alabama, near the entrance to the Gulf of Mexico, a bottlenose dolphin mortality resulted from an entanglement in the lazy line of a trawl net during an educational trawling cruise operated by a marine science education and research laboratory. This animal likely belonged to the Mobile Bay and Bonsecour Bay Stock of bay, sound and estuary bottlenose dolphins.

As part of its annual coastal dredging program, the Army Corps of Engineers conducts sea turtle relocation trawling during hopper dredging as a protective measure for marine turtles. Five incidents have been documented in the Gulf of Mexico involving bottlenose dolphins and relocation trawling activities. Four of the incidents were mortalities, and 1 occurred during each of the following years: 2003, 2005, 2006 and 2007. It is likely that 2 of these animals belonged to the Western Coastal Stock (2005, 2007) and 2 animals belonged to bay, sound and estuary stocks (2003, 2006). An additional incident occurred during 2006 in which the dolphin became free during net retrieval and was observed swimming away normally. It is likely this animal belonged to a bay, sound and estuary stock. All of the mortalities were included in the stranding database and the 2 most recent are included in the appropriate stranding tables under "Yes" for Human Interaction.

Four mortalities resulted from gillnet entanglements in research gear off Texas and Louisiana during 2003, 2004, 2006 and 2007. Three of the mortalities were a result of fisheries sampling and research in Texas, and 1 mortality (2006) occurred during a gulf sturgeon research project in Louisiana. Additionally, in 2008, 1 dolphin was entangled in a fisheries research gillnet in Texas. The floatline was wrapped around the dolphin's tail; the net released itself upon retrieval and the dolphin appeared in good condition as it swam away. All of these animals likely belonged to the following bay, sound and estuary stocks: Copano Bay, Aransas Bay, San Antonio Bay, Redfish Bay, Espiritu Santo Bay Stock (2003, 2004 mortalities); Mississippi River Delta Stock (2006 mortality); and Matagorda Bay, Tres Palacios Bay, Lavaca Bay Stock (2007 mortality, 2008 released alive). The mortalities were included in the stranding database and the 2 most recent are included in Table 2 under "Yes" for Human Interaction.

The problem of dolphin depredation of fishing gear is increasing in Gulf of Mexico coastal and estuary waters. There have been 3 recent cases of fishermen illegally "taking" dolphins due to dolphin depredation of recreational and commercial fishing gear. In 2006 a charter boat fishing captain was charged under the MMPA for shooting at a dolphin that was swimming around his catch in the Gulf of Mexico, off Panama City, Florida. In 2007 a second charter fishing boat captain was fined under the MMPA for shooting at a bottlenose dolphin that was attempting to remove a fish from his line in the Gulf of Mexico, off Orange Beach, Alabama. A commercial fisherman was indicted in November 2008 for throwing pipe bombs at dolphins off Panama City, Florida, and charged in March 2009 for "taking" dolphins with an explosive device.

Illegal feeding or provisioning of wild bottlenose dolphins has been documented in Florida, particularly near Panama City Beach in the Panhandle (Samuels and Bejder 2004) and in and near Sarasota Bay (Cunningham-Smith *et al.* 2006; Powell and Wells 2011), and also in Texas near Corpus Christi (Bryant 1994). Feeding wild dolphins is defined under the MMPA as a form of 'take' because it can alter their natural behavior and increase their risk of injury or death. Nevertheless, a high rate of uncontrolled provisioning was observed near Panama City Beach in 1998 (Samuels and Bejder 2004), and provisioning has been observed south of Sarasota Bay since 1990 (Cunningham-Smith *et al.* 2006; Powell and Wells 2011). There are emerging questions regarding potential linkages between provisioning and depredation of recreational fishing gear and associated entanglement and ingestion of gear, which is increasing through much of Florida. During 2006, at least 2% of the long-term resident dolphins of Sarasota Bay died from ingestion of recreational fishing gear (Powell and Wells 2011). Swimming with wild bottlenose dolphins has also been documented. Near Panama City Beach, Samuels and Bejder (2004) concluded that dolphins were amenable to swimmers due to illegal provisioning. Swimming with wild dolphins may cause harassment, and

harassment is illegal under the MMPA.

As noted previously, bottlenose dolphins are known to be struck by vessels (Wells and Scott 1997). During 2006–2010, 12 stranded bottlenose dolphins (of 550 total strandings) showed signs of a boat collision (NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 16 November 2011). It is possible some of the instances were post-mortem collisions. In addition to vessel collisions, the presence of vessels may also impact bottlenose dolphin behavior in bays, sounds and estuaries. Nowacek *et al.* (2001) reported that boats pass within 100m of each bottlenose dolphin in Sarasota Bay once every 6 minutes on average, leading to changes in dive patterns and group cohesion. Buckstaff (2004) noted changes in communication patterns of Sarasota Bay dolphins when boats approached. Miller *et al.* (2008) investigated the immediate responses of bottlenose dolphins to “high-speed personal watercraft” (i.e., boats) in Mississippi Sound. They found an immediate impact on dolphin behavior demonstrated by an increase in traveling behavior and dive duration, and a decrease in feeding behavior for non-traveling groups. The findings suggested dolphins attempted to avoid high-speed personal watercraft. It is unclear whether repeated short-term effects will result in long-term consequences like reduced health and viability of dolphins. Further studies are needed to determine the impacts throughout the Gulf of Mexico.

### **HABITAT ISSUES**

The Deepwater Horizon (DWH) MC252 drilling platform, located approximately 50 miles southeast of the Mississippi River Delta in waters about 1500m deep, exploded on 20 April 2010. The rig sank, and for 87 days millions of barrels of oil and gas were discharged from the wellhead until it was capped on 15 July 2010. During the response effort dispersants were applied extensively at the seafloor and at the sea surface (Lehr *et al.* 2010; OSAT 2010). In-situ burning, or controlled burning of oil at the surface, was also used extensively as a response tool (Lehr *et al.* 2010). The oil, dispersant and burn residue compounds present ecological concerns. The magnitude of this oil spill was unprecedented in U.S. history, causing impacts to wildlife, natural habitats and human communities along coastal areas from western Louisiana to the Florida Panhandle (NOAA 2011). It could be years before the entire scope of damage is ascertained (NOAA 2011).

A substantial number of beaches and wetlands along the Louisiana coast experienced heavy or moderate oiling (OSAT-2 2011). The heaviest oiling in Louisiana occurred west of the Mississippi River on the Mississippi Delta and in Barataria and Terrebonne Bays, and to the east of the river on the Chandeleur Islands. Some heavy to moderate oiling occurred on Alabama and Florida beaches, with the heaviest stretch occurring from Dauphin Island, Alabama, to Gulf Breeze, Florida. Light to trace oil was reported along the majority of Mississippi barrier islands, from Gulf Breeze to Panama City, Florida, and outside of Atchafalaya and Vermilion Bays in western Louisiana (OSAT-2 2011).

Shortly after the oil spill, the Natural Resource Damage Assessment (NRDA) process was initiated under the Oil Pollution Act of 1990. A variety of NRDA research studies are being conducted to determine potential impacts of the spill on marine mammals. These studies have focused on identifying the type, magnitude, severity, length and impact of oil exposure to oceanic, coastal and estuarine marine mammals. The research is ongoing. For coastal and estuarine dolphins, the NOAA-led efforts include: active surveillance to detect stranded animals in remote locations; aerial surveys to document the distribution, abundance, species and exposure of marine mammals and sea turtles relative to oil from DWH spill; assessment of sublethal and chronic health impacts on coastal and estuarine bottlenose dolphins in Barataria Bay, Louisiana, and a reference site in Sarasota Bay, Florida; and assessment of injuries to dolphin stocks in Barataria Bay and Chandeleur Sound, Louisiana, Mississippi Sound, and as a reference site, St. Joseph Bay, Florida.

Coastal dolphins have been observed with tar balls attached to them and seen swimming through oil slicks close to shore and inland bays (NOAA 2010a). The effects of oil exposure on marine mammals depend on a number of factors including the type and mixture of chemicals involved, the amount, frequency and duration of exposure, the route of exposure (inhaled, ingested, absorbed, or external) and biomedical risk factors of the particular animal (Geraci 1990; NOAA 2010b). In general, direct external contact with petroleum compounds or dispersants with skin may cause skin irritation, chemical burns and infections. Inhalation of volatile petroleum compounds or dispersants may irritate or injure the respiratory tract, which could lead to pneumonia or inflammation. Ingestion of petroleum compounds may cause injury to the gastrointestinal tract, which could affect an animal’s ability to digest or absorb food. Absorption of petroleum compounds or dispersants may damage kidney, liver and brain function in addition to causing immune suppression and anemia. Long term chronic effects such as lowered reproductive success and decreased survival may occur (Geraci 1990; NOAA 2010b).

The nearshore habitat occupied by many of these stocks is adjacent to areas of high human population, and in some bays, such as Mobile Bay in Alabama and Galveston Bay in Texas, is highly industrialized. The area surrounding Galveston Bay, for example, has a coastal population of over 3 million people. More than 50% of all

chemical products manufactured in the U.S. are produced there, and 17% of the oil produced in the Gulf of Mexico is refined there (Henningsen and Würsig 1991). Many of the enclosed bays in Texas are surrounded by agricultural lands which receive periodic pesticide applications.

Concentrations of chlorinated hydrocarbons and metals were examined in conjunction with an anomalous mortality event of bottlenose dolphins in Texas bays in 1990 and found to be relatively low in most; however, some had concentrations at levels of possible toxicological concern (Varanasi *et al.* 1992). No studies to date have determined the amount, if any, of indirect human-induced mortality resulting from pollution or habitat degradation.

Analyses of organochlorine concentrations in the tissues of bottlenose dolphins in Sarasota Bay, Florida, have found that the concentrations found in male dolphins exceeded toxic threshold values that may result in adverse effects on health or reproductive rates (Schwacke *et al.* 2002). Studies of contaminant concentrations relative to life history parameters showed higher levels of mortality in first-born offspring, and higher contaminant concentrations in these calves and in primiparous females (Wells *et al.* 2005). While there are no direct measurements of adverse effects of pollutants on estuary dolphins, the exposure to environmental pollutants and subsequent effects on population health is an area of concern and active research.

## STATUS OF STOCKS

The status of these stocks relative to OSP is unknown and this species is not listed as threatened or endangered under the Endangered Species Act. The occurrence of 12 unusual mortality events among bottlenose dolphins along the northern Gulf of Mexico coast since 1990 (NMFS unpublished data) is cause for concern; however, the effects of the mortality events on stock abundance have not yet been determined, in large part because it has not been possible to assign mortalities to specific stocks due to a lack of empirical information on stock identification.

The relatively high number of bottlenose dolphin deaths which occurred during the mortality events since 1990 suggests that some of these stocks may be stressed. Human-caused mortality and serious injury for each of these stocks is not known, but considering the evidence from stranding data (Table 2), the total fishery-related mortality and serious injury exceeds 10% of the total known PBR or previous PBR, and therefore, it is probably not insignificant and not approaching the zero mortality and serious injury rate. NMFS considers each of these stocks to be strategic because most of the stock sizes are currently unknown, but likely small and relatively few mortalities and serious injuries would exceed PBR, and because stock areas in Louisiana, Mississippi, Alabama and the western Florida panhandle have been impacted by an UME of unprecedented size and duration (began 1 February 2010 and is ongoing).

## REFERENCES CITED

- Balmer, B.C., R.S. Wells, S.M. Nowacek, D.P. Nowacek, L.H. Schwacke, W.A. McLellan, F.S. Scharf, T.K. Rowles, L.J. Hansen, T.R. Spradlin and D.A. Pabst. 2008. Seasonal abundance and distribution patterns of common bottlenose dolphins (*Tursiops truncatus*) near St. Joseph Bay, Florida, USA. *J. Cetacean Res. Manage.* 10(2): 157-167.
- Barlow, J., S.L. Swartz, T.C. Eagle and P.R. Wade. 1995. U.S. marine mammal stock assessments: Guidelines for preparation, background, and a summary of the 1995 assessments. NOAA Tech. Memo. NMFS-OPR-6, 73 pp.
- Barros, N.B. and R.S. Wells. 1998. Prey and feeding patterns of resident bottlenose dolphins (*Tursiops truncatus*) in Sarasota Bay, Florida. *J. Mamm.* 79(3): 1045-1059.
- Blaylock, R.A. and W. Hoggard. 1994. Preliminary estimates of bottlenose dolphin abundance in southern U.S. Atlantic and Gulf of Mexico continental shelf waters. NOAA Tech. Memo. NMFS-SEFSC-356, 10 pp.
- Bräger, S. 1993. Diurnal and seasonal behavior patterns of bottlenose dolphins (*Tursiops truncatus*). *Mar. Mamm. Sci.* 9: 434-440.
- Bräger, S., B. Würsig, A. Acevedo and T. Henningsen. 1994. Association patterns of bottlenose dolphins (*Tursiops truncatus*) in Galveston Bay, Texas. *J. Mamm.* 75(2): 431-437.
- Bryant, L. 1994. Report to Congress on results of feeding wild dolphins: 1989-1994. National Marine Fisheries Service, Office of Protected Resources, 23 pp.
- Buckland, S.T., D.R. Andersen, K.P. Burnham and J.L. Laake. 1993. Distance sampling: Estimating abundance of biological populations. Chapman and Hall, New York. 446 pp.
- Buckstaff, K.C. 2004. Effects of watercraft noise on the acoustic behavior of bottlenose dolphins, *Tursiops truncatus*, in Sarasota Bay, Florida. *Mar. Mamm. Sci.* 20: 709-725.
- Conn, P.B., A.M. Gorgone, A.R. Jugovich, B.L. Byrd and L.J. Hansen. 2011. Accounting for transients when

- estimating abundance of bottlenose dolphins in Choctawhatchee Bay, Florida. *J. Wildl. Manage.* 75(3): 569-579.
- Cunningham-Smith, P., D.E. Colbert, R.S. Wells and T. Speakman. 2006. Evaluation of human interactions with a wild bottlenose dolphin (*Tursiops truncatus*) near Sarasota Bay, Florida, and efforts to curtail the interactions. *Aquat. Mamm.* 32(3): 346-356.
- 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. Contract Report to National Marine Fisheries Service, Southeast Fisheries Center, 16 pp.
- 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*. Pages 155-169 in: A.R. Hoelzel (ed.), *Genetic Ecology of Whales and Dolphins*. Rep. Int. Whal. Comm., Cambridge, U.K. Special Issue 13.
- Duffield, D.A. and R.S. Wells. 2002. The molecular profile of a resident community of bottlenose dolphins, *Tursiops truncatus*. Pages 3-11 in: C.J. Pfeiffer (ed.), *Cell and Molecular Biology of Marine Mammals*. Krieger Publishing, Melbourne, FL.
- Fazioli, K.L., S. Hoffman and R.S. Wells. 2006. Use of Gulf of Mexico coastal waters by distinct assemblages of bottlenose dolphins (*Tursiops truncatus*). *Aquat. Mamm.* 32(2): 212-222.
- Fertl, D.C. 1994. Occurrence patterns and behavior of bottlenose dolphins (*Tursiops truncatus*) in the Galveston Ship Channel. *Texas J. Sci.* 46: 299-317.
- Fire, S.E., Z. Wang, M. Byrd, H.R. Whitehead, J. Paternoster and S.L. Morton. In press. Co-occurrence of multiple classes of harmful algal toxins in bottlenose dolphins (*Tursiops truncatus*) stranding during an unusual mortality event in Texas, USA. *Harmful Algae* (2010), doi:10.1016/j.hal.2010.12.001.
- Flewelling, L.J., J.P. Naar, J.P. Abbott, D.G. Baden, N.B. Barros, G.D. Bossart, M.D. Bottein, D.G. Hammond, E.M. Haubold, C.A. Heil, M.S. Henry, H.M. Jacocks, T.A. Leighfield, R.H. Pierce, T.D. Pitchford, S.A. Rommel, P.S. Scott, K.A. Steidinger, E.W. Truby, F.M. Van Dolah and J.H. Landsberg. 2005. Red tides and marine mammal mortalities: Unexpected brevetoxin vectors may account for deaths long after or remote from an algal bloom. *Nature* 435: 755-756.
- Geraci, J.R. 1990. Physiologic and toxic effects on cetaceans. pp. 167-197 In: J. R. Geraci and D. J. St. Aubin (eds.) *Sea mammals and oil: Confronting the risks*. Academic Press, New York. 259 pp.
- Gorzelany, J.F. 1998. Unusual deaths of two free-ranging Atlantic bottlenose dolphins (*Tursiops truncatus*) related to ingestion of recreational fishing gear. *Mar. Mamm. Sci.* 14(3): 614-617.
- Gruber, J.A. 1981. Ecology of the Atlantic bottlenosed dolphin (*Tursiops truncatus*) in the Pass Cavallo area of Matagorda Bay, Texas. M. Sc. thesis. Texas A&M University, College Station. 182 pp.
- Hansen, L.J. (ed.) 1992. Report on investigation of 1990 Gulf of Mexico bottlenose dolphin strandings. NOAA-NMFS-SEFSC Contribution MIA-92/93-21. Available from: NMFS, Southeast Fisheries Science Center, 75 Virginia Beach Dr., Miami, FL 33149.
- Henningsen, T. 1991. Zur Verbreitung und Ökologie des Großen Tümmlers (*Tursiops truncatus*) in Galveston, Texas. Diplom thesis. Christian-Albrechts-Universität, Kiel, Germany. 80 pp.
- Henningsen, T. and B. Würsig. 1991. Bottle-nosed dolphins in Galveston Bay, Texas: Numbers and activities. European research on cetaceans – 5. Proceedings of the Fifth Annual Conference of the European Cetacean Society, Sandefjord, Norway, Cambridge, UK, 21-23 February, 1991. 36-38 pp.
- Hubard, C.W., K. Maze-Foley, K.D. Mullin and W.W. Schroeder. 2004. Seasonal abundance and site fidelity of bottlenose dolphins (*Tursiops truncatus*) in Mississippi Sound. *Aquat. Mamm.* 30: 299-310.
- Hubard, C.W. and S.L. Swartz. 2002. Gulf of Mexico bottlenose dolphin stock identification workshop: 14-15 March 2000, Sarasota, Florida. NOAA Tech. Memo. NMFS-SEFSC-473, 50 pp.
- Irvine, A.B., M.D. 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.
- Irvine, B. and R.S. Wells. 1972. Results of attempts to tag Atlantic bottlenose dolphins (*Tursiops truncatus*). *Cetology* 13(1-5).
- Irwin, L.J. and B. Würsig. 2004. A small resident community of bottlenose dolphins, *Tursiops truncatus*, in Texas: Monitoring recommendations. *G. Mex. Sci.* 22(1): 13-21.
- Laake, J.L., S.T. Buckland, D.R. Anderson and K.P. Burnham. 1993. DISTANCE user's guide, V2.0. Colorado Cooperative Fish & Wildlife Research Unit, Colorado State University, Ft. Collins. 72 pp.
- Lehr, B., S. Bristol and A. Possolo, eds. 2010. Oil budget calculator: Deepwater Horizon. Technical documentation. Prepared by the Federal Interagency Solutions Group, Oil Budget Calculator Science and Engineering Team

- for the National Incident Command. Available from: [http://www.restorethegulf.gov/sites/default/files/documents/pdf/OilBudgetCalc\\_Full\\_HQ-Print\\_111110.pdf](http://www.restorethegulf.gov/sites/default/files/documents/pdf/OilBudgetCalc_Full_HQ-Print_111110.pdf)
- Lipscomb, T.P. 1993. Some answers to questions about morbillivirus. Pages 4-5 in: R.A. Blaylock, B. Mase and D.K. Odell (eds.), Strandings. SEFSC Miami Laboratory, Miami, Florida. Vol. 2, No. 3.
- Lipscomb, T.P., S. Kennedy, D. Moffet and B.K. Ford. 1994. Morbilliviral disease in an Atlantic bottlenose dolphin (*Tursiops truncatus*) from the Gulf of Mexico. *J. Wildl. Dis.* 30(4): 572-576.
- Lynn, S.K. and B. Würsig. 2002. Summer movement patterns of bottlenose dolphins in a Texas bay. *G. Mex. Sci.* 20(1): 25-37.
- Maze, K.S. and B. Würsig. 1999. Bottlenose dolphins of San Luis Pass, Texas: Occurrence patterns, site fidelity, and habitat use. *Aquat. Mamm.* 25: 91-103.
- McFee, W.E. and J.W. Brooks. 1998. Fact finding meeting of marine mammal entanglement in the crab pot fishery: a summary. U.S. Fish and Wildlife Service. Unpublished Report.
- Miller, C. 2003. Abundance trends and environmental habitat usage patterns of bottlenose dolphins (*Tursiops truncatus*) in lower Barataria and Caminada Bays, Louisiana. Ph.D. thesis. Louisiana State University, Baton Rouge. 125 pp.
- Miller, L.J., M. Solangi and S.A. Kuczaj, II. 2008. Immediate response of Atlantic bottlenose dolphins to high-speed personal watercraft in the Mississippi Sound. *J. Mar. Biol. Assoc. U.K.* 88(6): 1139-1143.
- Mullin, K.D. 1988. Comparative seasonal abundance and ecology of bottlenose dolphins (*Tursiops truncatus*) in three habitats of the north-central Gulf of Mexico. Ph.D. thesis. Mississippi State University, Starkville. 135 pp.
- NMFS. 1991. Proposed regime to govern the interactions between marine mammals and commercial fishing operations after October 1, 1993. Draft Environmental Impact Statement, June 1991. Available from: NMFS, Southeast Fisheries Science Center, 75 Virginia Beach Dr., Miami, FL 33149.
- NMFS. 2004. Interim report on the bottlenose dolphin (*Tursiops truncatus*) unusual mortality event along the Panhandle of Florida, March-April 2004. Available from: NMFS, Southeast Fisheries Science Center, 75 Virginia Beach Dr., Miami, FL 33129, 35 pp.
- NOAA. 2010a. Frequently asked questions about marine mammal rescue and intervention plans in response to the Deepwater Horizon oil spill. Available from: [http://sero.nmfs.noaa.gov/sf/deepwater\\_horizon/20100726\\_FINAL\\_FAQDWH\\_NOAA\\_marine\\_mammal\\_intervention\\_and\\_rescue.pdf](http://sero.nmfs.noaa.gov/sf/deepwater_horizon/20100726_FINAL_FAQDWH_NOAA_marine_mammal_intervention_and_rescue.pdf)
- NOAA. 2010b. Effects of oil on marine mammals and sea turtles. Available from: [http://sero.nmfs.noaa.gov/sf/deepwater\\_horizon/Marine\\_mammals\\_turtles\\_FACT\\_SHEET.pdf](http://sero.nmfs.noaa.gov/sf/deepwater_horizon/Marine_mammals_turtles_FACT_SHEET.pdf).
- NOAA. 2011. Public scoping for preparation of a programmatic environmental impact statement for the Deepwater Horizon BP Oil Spill. Available from: <http://www.gulfspillrestoration.noaa.gov/wp-content/uploads/2011/04/Public-DWH-PEIS-Scoping-Review-Documents-1.pdf>
- Nowacek, S.M., R.S. Wells and A.R. Solow. 2001. Short-term effects of boat traffic on bottlenose dolphins, *Tursiops truncatus*, in Sarasota Bay, Florida. *Mar. Mamm. Sci.* 17(4): 673-688.
- Operational Science Advisory Team (OSAT). 2010. Summary report for sub-sea and sub-surface oil and dispersant detection: Sampling and monitoring. Prepared for P. F. Zukunft, RADM, U.S. Coast Guard, Federal On-Scene Coordinator, Deepwater Horizon MC252, December 17, 2010. Available from: [http://www.restorethegulf.gov/sites/default/files/documents/pdf/OSAT\\_Report\\_FINAL\\_17DEC.pdf](http://www.restorethegulf.gov/sites/default/files/documents/pdf/OSAT_Report_FINAL_17DEC.pdf)
- Operational Science Advisory Team (OSAT-2). 2011. Summary report for fate and effects of remnant oil remaining in the beach environment. Annex B: Spatial oil distribution. Available from: <http://www.restorethegulf.gov/release/2011/03/01/osat-2-fate-and-effects-oil-beaches>
- Powell, J.R. and R.S. Wells. 2011. Recreational fishing depredation and associated behaviors involving common bottlenose dolphins (*Tursiops truncatus*) in Sarasota Bay, Florida. *Mar. Mamm. Sci.* 27(1): 111-129.
- Quintana-Rizzo, E. and R.S. Wells. 2001. Resighting and association patterns of bottlenose dolphins (*Tursiops truncatus*) in the Cedar Keys, Florida: Insights into social organization. *Can. J. Zool.* 79: 447-456.
- Reynolds, J.E., III. 1985. Evaluation of the nature and magnitude of interactions between bottlenose dolphins, *Tursiops truncatus*, and fisheries and other human activities in coastal areas of the southeastern United States. National Technical Information Service PB86-162203, U.S. Department of Commerce, Springfield, VA 22161.
- Samuels, A. and L. Bejder. 2004. Chronic interactions between humans and free-ranging bottlenose dolphins near Panama City Beach, Florida, USA. *J. Cetacean Res. Manage.* 6: 69-77.

- Schwacke, L.H., E.O. Voit, L.J. Hansen, R.S. Wells, G.B. Mitchum, A.A. Hohn and P.A. Fair. 2002. Probabilistic risk assessment of reproductive effects of polychlorinated biphenyls on bottlenose dolphins (*Tursiops truncatus*) from the southeast United States coast. *Environ. Toxicol. Chem.* 21(12): 2752-2764.
- Scott, G.P., D.M. Burn, L.J. Hansen and R.E. Owen. 1989. Estimates of bottlenose dolphin abundance in the Gulf of Mexico from regional aerial surveys. CRD 88/89-07. Available from: NMFS, Southeast Fisheries Science Center, 75 Virginia Beach Dr., Miami, FL 33149.
- Scott, M.D., R.S. Wells and A.B. Irvine. 1990. A long-term study of bottlenose dolphins on the west coast of Florida. Pages 235-244 in: S. Leatherwood and R.R. Reeves (eds.), *The bottlenose dolphin*. Academic Press, San Diego, CA.
- Sellas, A.B., R.S. Wells and P.E. Rosel. 2005. Mitochondrial and nuclear DNA analyses reveal fine scale geographic structure in bottlenose dolphins (*Tursiops truncatus*) in the Gulf of Mexico. *Conserv. Genet.* 6(5): 715-728.
- Shane, S.H. 1977. The population biology of the Atlantic bottlenose dolphin, *Tursiops truncatus*, in the Aransas Pass area of Texas. M. Sc. thesis. Texas A&M University, College Station. 238 pp.
- Shane, S.H. 1990. Behavior and ecology of the bottlenose dolphin at Sanibel Island, Florida. Pages 245-265 in: S. Leatherwood and R.R. Reeves (eds.), *The bottlenose dolphin*. Academic Press, San Diego, CA.
- Shane, S.H. 2004. Residence patterns, group characteristics, and association patterns of bottlenose dolphins near Sanibel Island, Florida. *G. Mex. Sci.* 22(1): 1-12.
- 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(1): 34-63.
- Thompson, N.B. 1981. Estimates of abundance of *Tursiops truncatus* in Charlotte Harbor, Florida. NOAA/NMFS/SEFSC/Miami Laboratory, Fishery Data Analysis Technical Report. Available from: NMFS, Southeast Fisheries Science Center, 75 Virginia Beach Dr., Miami, FL 33149.
- Tyson, R.B., S.M. Nowacek and D.P. Nowacek. 2011. Community structure and abundance of bottlenose dolphins *Tursiops truncatus* in coastal waters of the northeast Gulf of Mexico. *Mar. Ecol. Prog. Ser.* 438: 253-265.
- Urian, K.W. 2002. Community structure of bottlenose dolphins (*Tursiops truncatus*) in Tampa Bay, Florida, USA. M. Sc. thesis. University of North Carolina, Wilmington. 26 pp.
- Urian, K.W., D.A. Duffield, A.J. Read, R.S. Wells and D.D. Shell. 1996. Seasonality of reproduction in bottlenose dolphins, *Tursiops truncatus*. *J. Mamm.* 77: 394-403.
- Urian, K.W., S. Hofmann, R.S. Wells and A.J. Read. 2009. Fine-scale population structure of bottlenose dolphins (*Tursiops truncatus*) in Tampa Bay, Florida. *Mar. Mamm. Sci.* 25(9): 619-638.
- Varanasi, U., K.L. Tilbury, D.W. Brown, M.M. Krahn, C.A. Wigren, R.C. Clark and S.L. Chan. 1992. Chemical contaminants in bottlenose dolphins stranded along the Gulf of Mexico during 1990. Pages 56-86 in: L.J. Hansen (ed.), *Report on investigation of 1990 Gulf of Mexico bottlenose dolphin strandings*. Southeast Fisheries Science Center Contribution MIA-92/93-21.
- Wade, P.R. and R.P. Angliss. 1997. Guidelines for assessing marine mammal stocks: Report of the GAMMS Workshop April 3-5, 1996, Seattle, Washington. NOAA Tech. Memo. NMFS-OPR-12. 93 pp.
- Weller, D.W. 1998. Global and regional variation in the biology and behavior of bottlenose dolphins. Ph.D. thesis. Texas A&M University, College Station. 142 pp.
- Wells, R.S. 1986a. Population structure of bottlenose dolphins: Behavioral studies along the central west coast of Florida. Contract report to NMFS, SEFSC. Contract No. 45-WCNF-5-00366. Available from: NMFS, Southeast Fisheries Science Center, 75 Virginia Beach Dr., Miami, FL 33149. 58 pp.
- Wells, R.S. 1986b. Structural aspects of dolphin societies. Ph.D. thesis. University of California, Santa Cruz. 234 pp.
- Wells, R.S. 1991. The role of long-term study in understanding the social structure of a bottlenose dolphin community. Pages 199-225 in: K. Pryor and K.S. Norris (eds.), *Dolphin societies: Discoveries and puzzles*. University of California Press, Berkeley.
- Wells, R.S. 1993. The marine mammals of Sarasota Bay. Chapter 9. Pages 9.1-9.23 in: P. Roat, C. Ciccolella, H. Smith and D. Tomasko (eds.), *Sarasota Bay: 1992 Framework for Action*. Sarasota Bay National Estuary Program, 5333 N. Tamiami Trail, Sarasota, FL 34234.
- Wells, R.S. 1994. Determination of bottlenose dolphin stock discreteness: Application of a combined behavioral and genetic approach. K.R. Wang, P.M. Payne and V.G. Thayer (compilers). *Coastal stock(s) of Atlantic bottlenose dolphin: Status review and management*. Proceedings and recommendations from a workshop held in Beaufort, NC, 13-14 September 1993. NOAA Tech. Memo. NMFS-OPR-4, 16-20 pp.
- Wells, R.S. 1998. Progress report: Sarasota long-term bottlenose dolphin research. Unpublished contract report to the U.S. Department of Commerce, NOAA Fisheries, Southeast Fisheries Science Center, Miami, FL, 5 pp.

- Wells, R.S. 2003. Dolphin social complexity: Lessons from long-term study and life history. Pages 32-56 *in*: F.B.M. de Waal and P.L. Tyack (eds.), *Animal social complexity: Intelligence, culture, and individualized societies*. Harvard University Press, Cambridge, MA.
- Wells, R.S. 2009. Learning from nature: Bottlenose dolphin care and husbandry. *Zoo Biol.* 28: 1-17.
- Wells, R.S., J.B. Allen, S. Hoffman, K. Bassos-Hull, D.A. Fauquier, N.B. Barros, R.E. DeLynn, G. Sutton, V. Socha and M.D. Scott. 2008. Consequences of injuries on survival and reproduction of common bottlenose dolphins (*Tursiops truncatus*) along the west coast of Florida. *Mar. Mamm. Sci.* 24: 774-794.
- Wells, R.S., M.K. Bassos, K.W. Urrian, W.J. Carr and M.D. Scott. 1996a. Low-level monitoring of bottlenose dolphins, *Tursiops truncatus*, in Charlotte Harbor, Florida: 1990-1994. NOAA Tech. Memo. NMFS-SEFSC-384, 36 pp.
- Wells, R.S., M.K. Bassos, K.W. Urrian, S.H. Shane, E.C.G. Owen, C.F. Weiss, W.J. Carr and M.D. Scott. 1997. Low-level monitoring of bottlenose dolphins, *Tursiops truncatus*, in Pine Island Sound, Florida: 1996. Contract report to National Marine Fisheries Service, Southeast Fisheries Science Center Contribution No. 40-WCNF601958. Available from: NMFS, Southeast Fisheries Science Center, 75 Virginia Beach Dr., Miami, FL 33149.
- Wells, R.S., S. Hofmann and T.L. Moors. 1998. Entanglement and mortality of bottlenose dolphins, *Tursiops truncatus*, in recreational fishing gear in Florida. *Fish. Bull.* 96(3): 647-650.
- Wells, R.S. and M.D. Scott. 1990. Estimating bottlenose dolphin population parameters from individual identification and capture-release techniques. Pages 407-415 *in*: P.S. Hammond, S.A. Mizroch and G.P. Donovan (eds.), *Individual recognition of cetaceans: Use of photo-identification and other techniques to estimate population parameters*. Rep. Int. Whal. Comm., Cambridge, U.K. Special Issue 12.
- Wells, R.S. and M.D. Scott. 1994. Incidence of gear entanglement for resident inshore bottlenose dolphins near Sarasota, Florida. Page 629 *in*: W.F. Perrin, G.P. Donovan and J. Barlow (eds.), *Gillnets and cetaceans*. Rep. Int. Whal. Comm. Special Issue 15.
- Wells, R.S. and M.D. Scott. 1997. Seasonal incidence of boat strikes on bottlenose dolphins near Sarasota, Florida. *Mar. Mamm. Sci.* 13(3): 475-480.
- Wells, R.S. and M.D. Scott. 1999. Bottlenose dolphins. Pages 137-182 *in*: S.H. Ridgway and R. Harrison (eds.), *Handbook of marine mammals*. Vol. 6: The second book of dolphins and the porpoises. Academic Press, San Diego, CA.
- Wells, R.S., M.D. Scott and A.B. Irvine. 1987. The social structure of free ranging bottlenose dolphins. Pages 247-305 *in*: H. Genoways (ed.), *Current Mammalogy*, Vol. 1. Plenum Press, New York.
- Wells, R.S., V. Tornero, A. Borrell, A. Aguilar, T.K. Rowles, H.L. Rhinehart, S. Hofmann, W.M. Jarman, A.A. Hohn and J.C. Sweeney. 2005. Integrating life history and reproductive success data to examine potential relationships with organochlorine compounds for bottlenose dolphins (*Tursiops truncatus*) in Sarasota Bay, Florida. *Sci. Total Environ.* 349: 106-119.
- Wells, R.S., K.W. Urrian, A.J. Read, M.K. Bassos, W.J. Carr and M.D. Scott. 1996b. Low-level monitoring of bottlenose dolphins, *Tursiops truncatus*, in Tampa Bay, Florida: 1988-1993. NOAA Tech. Memo. NMFS-SEFSC-385, 25 pp.