An investigation of bottlenose dolphin *Tursiops truncatus* deaths in East Matagorda Bay, Texas, January 1990

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There are reports of massive mortalities of bottlenose dolphins *Tursiops truncatus* over periods of months in areas as large as the U.S. Atlantic coast and the Persian Gulf. From early June 1987 until March 1988, over 740 bottlenose dolphins (estimated at about 50% of the coastal migratory stock) stranded along the U.S. Atlantic coast from New Jersey to Florida (Scott et al. 1988, Geraci 1989). Geraci concluded the dolphins were poisoned by brevetoxin, a neurotoxin produced by the red tide organism *Ptychodiscus brevis*.

During 23 August to 30 October 1986, 527 dead dolphins were found on the eastern and western shores of the Persian Gulf. Several dead turtles, dugongs, and one 6.1 m unidentified whale were also found, along with many fish that washed ashore. Of the 78% of mammal carcasses identified to species, 64% were bottlenose dolphins, 34% were humpback dolphins *Sousa chinensis*, 1.7% were common dolphins *Delphinus delphis*, and 0.3% were finless porpoises *Neophocoena phocoenoides*. The dead dolphins included adults, neonates, calves, and juveniles. Cause(s) of the deaths could not be determined, since only four animals were necropsied (Anonymous 1986).

The subject of this study is an unusual stranding of 26 *T. truncatus* that occurred in January 1990 around East Matagorda Bay (EMB), Texas. There are no previous reports of this number of strandings in a relatively small area in a single day. On 20 January 1989, a helicopter pilot reported the stranded dolphins to the U.S. Coast Guard, who notified the Texas Marine Mammal Stranding Network at Texas A&M University and Texas Parks & Wildlife Department (TPW). These organizations collected 26 carcasses, 23 from within the Bay and 3 from the Gulf side of East Matagorda Peninsula. I performed necropsies on the dolphins on 24–25 January to determine cause of death.

Methods

Examination of dolphins

Each *T. truncatus* dolphin was assigned an identification number and its stranding location noted (Fig. 1). State of decomposition was noted: freshly dead with no bloating (1 animal), detectable bloating, or severe decomposition. Animals were sexed and weighed, and length was measured via a straight-line from the notch in the tail flukes to the most rostral aspect of the mandible. Measurements of blubber thickness were taken at six locations along the animal's left side using the standard protocol of the Naval Ocean Systems Center (NOSC) (Fig. 2). Skin condition and abnormal marks or deteriorated areas were recorded. Condition and position of thoracic and abdominal organs were noted before removal and collection of tissue samples.

Site inspection and background information

On 26 January 1990, I conducted an aerial survey of the stranding site, comparing the actual configuration of East Matagorda Bay with an existing map (NOAA nautical chart #11319) to determine exit routes for dolphins from the Bay to the deeper waters of the outer coast. The main exit is a narrow cut connecting the Bay and the Gulf (Fig. 1).

The Texas Parks and Wildlife Department monitored water-temperature changes in the Bay almost daily during 15–29 December 1989 (Fig. 3). The Bay was completely frozen over for 2.5 days with partial ice remaining for 4 days. On 22 December, a helicopter pilot flew close to the Bay to observe about 12 dolphins swimming and breaking ice (~5 cm thick) in a 4–7 km area in the east-central region of the Bay.

Rapidly-moving weather systems from the north with strong northerly winds can significantly lower tidal levels in the Bay (Steve Marwitz, Texas Parks & Wildlife, Rockport, TX 78382, pers. commun.). Within the period 15–22 December 1989, when two cold-weather systems moved through the area, an estimated range for the mean low tide level was 30–60 cm below normal (Mark Mazot, Tex. Parks Wildl. Dep., pers. commun., Feb. 1990); however, there were no official measurements. Thus it is possible that lowered water depths around the periphery of the Bay could have impeded dolphin movement between the Bay and the Gulf of Mexico via the Caney Creek Gulf Cut or the intercoastal canal.

Results

Of the 26 *Tursiops truncatus* examined, 23 dolphins were from within East Matagorda Bay and consisted of 6 mature males (MM), 5 immature males (IM), 7 mature

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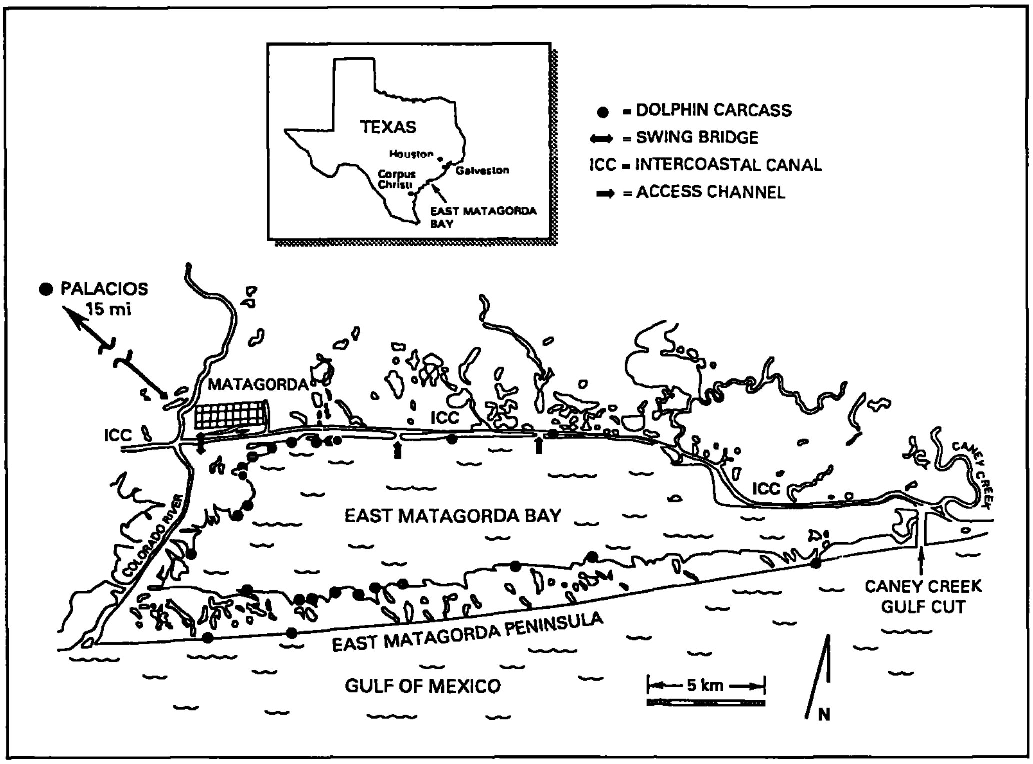
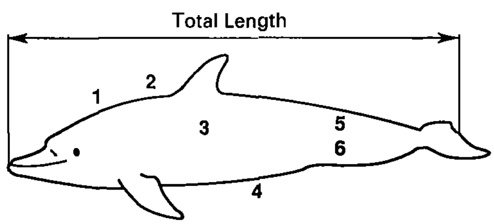


Figure 1
Map of East Matagorda Bay, Texas, showing location of recovered bottlenose dolphin carcasses.



Site 1) Dorsal midline 10cm to 15cm caudal to the blow hole.
Site 2) Dorsal midline 10cm to 15 cm cranial to the insertion of the dorsal fin.
Site 3) Lateral midline at the midpoint of the dorsal fin.
Site 4) Ventral midline 10cm cranial to umbilicus.
Site 5) Dorsolateral aspect of tail stock at level of the anus.
Site 6) Lateral midline at level of the anus.

Figure 2
Blubber measurement sites on bottlenose dolphins collected in East Matagorda Bay, based on Naval Ocean System Center collection procedures.

females (MF) (4 with fetus), and 5 immature females (IF); 2 females and 1 male were from outside the Bay on East Matagorda Peninsula. I could not make an accurate determination of time of death because decomposition varies markedly depending on environmental conditions. The condition of the carcasses at necropsy suggested that death occurred ~5–10 days prior to siting, with the exception of one freshly dead animal collected outside the Bay on East Matagorda Peninsula.

Table 1 shows blubber thickness measured at NOSC (site 2), length, sex, and weight data from 24 East Matagorda Bay dolphins for which there were complete data, and from a comparison group of 16 Texas coast dolphins which stranded over the period 1981–89. Average blubber thickness for 21 stranded dolphins recovered in the Bay was 12.7 mm, while the average thickness for the comparison group of 16 dolphins recovered on the Texas coast during the winter months of November–March 1981–89 was 18.6 mm at the same measurement site. This difference was significant (Student's t test, $P<0.001$). In addition, the subcutaneous fat layer that is prominent between the blubber and skeletal muscles in healthy robust dolphins (Ridgway and Fenner 1982) was greatly reduced or absent in all of the dolphins taken from inside the Bay.

A linear regression was used to (1) show the relationship of blubber thickness (mm) to weight (kg) for the comparison group of dolphins stranded along the Texas coast during winter months and (2) test the similarity of slopes between the Texas-coast and East Matagorda Bay groups (Fig. 4). In Texas coast strandings, there was a significant positive correlation between blubber thickness and body weight (r 0.9); while in the Bay group, blubber thickness decreased with increased weight (r −0.38).

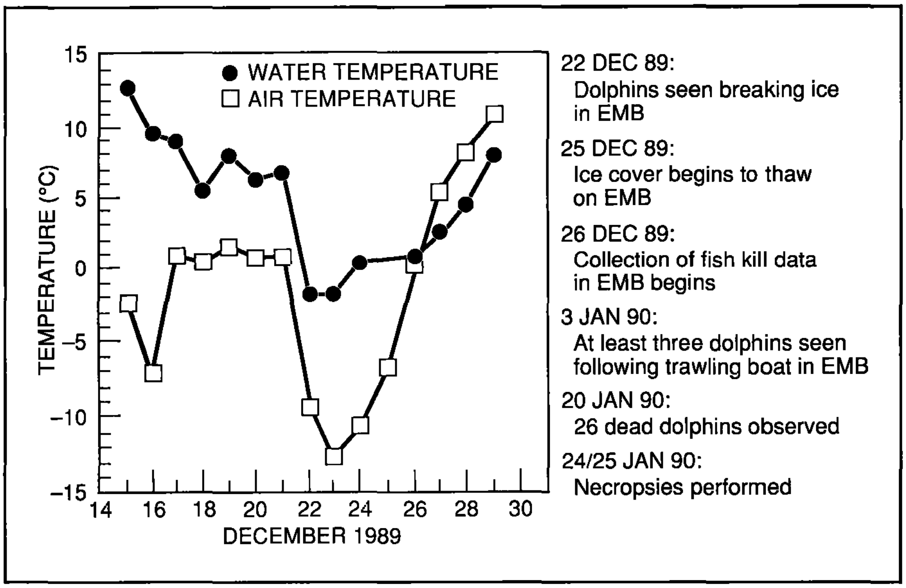


Figure 3
Water and air temperatures at East Matagorda Bay (EMB) during December 1989, and chronology of significant events related to January 1990 strandings of bottlenose dolphins. Air temperatures recorded at Palacios, Texas (the closest recording weather station, 15 mi away), (from Naval Oceanogr. Command Detachment, Asheville, NC). Water-temperature data from Texas Parks & Wildl. Dep., Fish. Div., Coastal Branch, Palacios, TX. Water temperatures in East Matagorda Bay for the dates 1, 15, and 29 January 1992 were 13.5, 16, and 14.5°C, respectively.

Table 1
Summary data from 24 bottlenose dolphins *Tursiops truncatus* taken in East Matagorda Bay and Peninsula, January 1990, and from Texas coast bottlenose dolphins recovered in November–March 1981–89 (data from Texas Marine Mammal Stranding Network).

East Matagorda				Texas coast			
Blubber thickness (mm)	Length (cm)	Sex	Weight (kg)	Blubber thickness (mm)	Length (cm)	Sex	Weight (kg)
Peninsula				12	100	F	14
9	198	M	68	12	115	M	17
15	240	F	123	15	205	F	91
28	235	F	NA	16	212	M	104
Bay				17	219	M	109
4	216	M	114	18	177	F	59
5	269	M	182	18	206	F	107
5	282	F	170	18	221	F	102
7	262	F	139	18	235	F	139
8	288	M	189	18	240	F	141
9	262	M	159	18	235	F	143
10	275	M	180	20	227	M	136
11	176	F	43	20	179	M	120
11	216	F	91	24	280	M	150
11	270	M	170	25	237	M	193
13	191	M	55	28	260	M	216
13	258	M	141				
14	207	F	82				
15	245	F	114				
15	261	F	136				
15	255	F	150				
15	256	F	166				
16	256	M	150				
22	220	F	82				
22	254	F	145				
26	218	M	77				

Two mature females (MF) and a mature male (MM) had thickened hepatic capsules. One MF had marked lobulation and increased fibrous tissue throughout the liver. Five mature animals (2 MM, 3 MF) had an unusual and unidentified thin, smooth creamy-white layer on the endothelial surface of the hepatic portal vessels.

Three animals had abnormalities associated with the gastrointestinal (GI) system. An immature female (IF) had a section of small

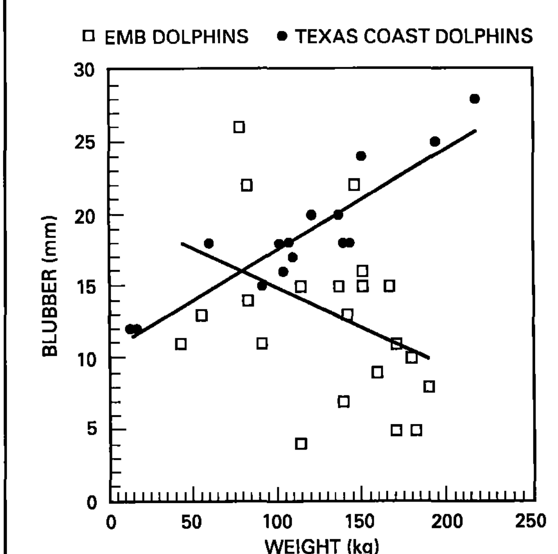


Figure 4
Linear regression of blubber thickness and weight for bottlenose dolphins recovered from East Matagorda Bay, in January 1990, and for comparison group of bottlenose dolphins from the Texas coast during November–March 1981–89.

intestine ~1.5 m long containing extremely-hard dehydrated feces, and its stomach contained partially-digested fish and bones. Two IF had peritoneal adhesions throughout the GI tract. One of these had a serofibrinous exudate on the serosal surfaces of the entire small intestine, and the gastric compartments were empty. Four animals (2 MF, 2 IM) had nematodes in the forestomach and fundic chamber. Clear, crystallized deposits adhered to the parietal and visceral surfaces of the thoracic and abdominal cavities of all animals. These deposits were ≤1 mm in size, felt "gritty," and imparted a "sandpaper-like" texture to the surface, a condition not uncommon in decomposed dolphins in the region (Raymond J. Tarpley, Texas A&M Univ., College Station, pers. commun., March 1990).

Every mature animal in the Bay group had hard, white, spherical deposits in the pancreatic interstitial tissue. These deposits were ≤2 mm in size and were scattered throughout the central pancreas. When crushed with a knife, the deposits were the same white color and consistency throughout.

Stomach contents were noted in 19 of the 23 Bay animals. Stomachs of 6 animals (3 MM, 2 IF, 1 MF) were void of food. Ten animals had unidentified fish, bones, and scales in the stomach. Three animals (2 MF, 1 IM) had undigested and partially-digested fish in the forestomach; in two of these animals, there was a 30 cm undigested fish in the esophagus.

No other gross abnormalities were noted in the respiratory, cardiovascular, renal, musculoskeletal, or reproductive systems of the Bay dolphins. Eyes were too decomposed for examination. Data concerning infectious agents (viral, bacteriological, fungal, etc.) could not be obtained because of advanced decomposition of the carcasses.

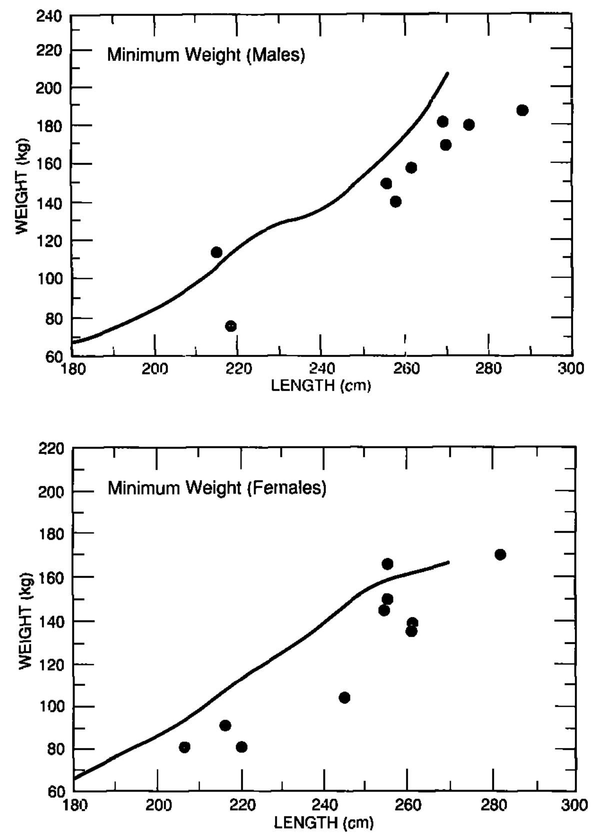


Figure 5
Weight-length data for male and female bottlenose dolphins from East Matagorda Bay, plotted on Ridgway and Fenner's (1982) minimum weight-length graph.

Discussion

Several factors might have contributed to the East Matagorda Bay dolphin mortality. First, an abnormally rapid drop in water temperature which resulted in the Bay freezing over; second, abnormally low tidal levels, possibly preventing exit from the Bay; and third, striped mullet, an important food source for the dolphins, may have been significantly depleted by the freeze. The poor condition of Bay dolphins was indicated by the ~89% of males and 80% of females in states of emaciation or near-emaciation, based on minimum weight-length guidelines established by Ridgway and Fenner (1982) (Fig. 5). In addition, average blubber thickness of the Bay dolphins was a third less than that of the Texas-coast dolphins during winter, based on records over the previous 9-year period.

Gunter (1941) and Gunter and Hildebrand (1951) reported on the death of fishes and other organisms during severe cold periods along the Texas coast. In 1940, water temperature fell from 18.3°C to −3.9°C in 4 hours (Gunter and Hildebrand 1951). Concerning dolphins, Gunter (1941) write, "It is probably worth recording that two porpoises, T. truncatus, were stranded in St. Charles Bay by the low tide and were forced to remain there, only partially submerged, during the coldest days of the freeze. They did not die and it was reported that they escaped when the tide rose." There are other reports of bottlenose dolphins in frozen seas; for example, Manton (1986) reports that *T. truncatus* have been seen breaking ice in the northern part of the Adriatic Sea. There are no records of dolphin deaths associated with other recent freezes in East Matagorda Bay, i.e., in 1983–84 or February 1989; however, local fishermen stated that the only previous sightings of dead dolphins (reported as 4 or 5) in the Bay followed the 1983–84 storm. No data on water temperatures or duration of ice on the Bay was available for the 1983–84 freeze.

There may have been no possible escape route for the dolphins because of the very low water level and the ice formation on the surface of the Bay. Smith et al. (1983) state that ice may impede the movement of dolphins in an area, and Shane (1980) studied the distribution of bottlenose dolphins in southern Texas and found that some animals had a home range that was limited to shallow bays. In our study, local fishermen stated that they repeatedly saw the same animals, which they could recognize by marks on the dorsal fin and flukes, and that the approximate number of dolphins in the Bay usually was "in the 20's." If the dolphins in East Matagorda Bay were resident, then many of the older animals stranded in January 1990 likely had experienced and survived the severe weather conditions in 1983 when the Bay froze over.

There are no precise data available to accurately determine the food biomass available to the EMB dolphins during and after the December 1989 freeze, but it is possible that an essential food source was not available. Fish mortality is greatest during a rapid decrease in water temperature (Springer and Woodburn 1960). Data from Dailey et al. (1991a) show that the relative abundance (gillnet entrapment technique, n/hour) of subadult and adult striped mullet *Mugil cephalus* along the Texas coast in spring 1989 was double that of previous years, while the relative abundance (bag-seine entrapment technique, n/ha) of juveniles in 1989 was only 60% of the value for the two previous years. Following the December 1989 freeze, the relative abundance of subadult and adult striped mullet in the spring of 1990 was far below that of spring 1989, while the relative abundance of juveniles (for recruitment to the population) was 380% higher in 1990 than it was in 1989. The large increase in relative abundance of young for spring recruitment to the population following the December 1989 freeze has been attributed to a lack of adult predator fish (Lawrence McEachron, Texas Parks Wildl., Rockport, TX 78382, pers. commun., Oct. 1991).

Table 2 shows estimated freeze kills for a variety of marine fish species in East Matagorda Bay for periods in 1983–84, February 1989, and December 1989 (McEachron et al. 1991). Although freezes are common on the Texas coast, fish kills of the magnitude of the December 1989 freeze in the Bay had never before been recorded, with *Mugil cephalus* mortality estimated to be over 2.5 million fish.

And thus, a compounding problem for the dolphins in the December 1989 freeze is the unprecedented kill of striped mullet. It is probable that a food source essential to the Bay dolphins was severely depleted at a critical time when the dolphins needed calories. Barros (1992), Barros and Odell (1990), and Cockcroft and Ross (1990) show that bottlenose dolphins utilize a variety of food resources, composed primarily of fish (4 to 6 major prey species common to their respective areas) and cephalopods (primarily 1 species common to their respective areas), and occasionally crustaceans. Pryor et al. (1990) suggest that mullet has been a staple dolphin food for centuries. Gunter (1942) reported on prey in freshly-killed, presumably-healthy *T. truncatus*: 1 from deeper waters and 33 from the shallows of Aransas and St. Charles Bays, Aransas County, Texas.

Table 2

Estimated marine fish-freeze kill in East Matagorda Bay for the periods 1983–84, February 1989, and December 1989 (McEachron et al. 1991). ND = no data.

Species	1983–84	February 1989	December 1989
Micropogonias undulatus			
Atlantic croaker	700	100	<100
Pogonias cromis			
Black drum	3300	89,900	5600
Brevoortia patronus			
Gulf menhaden	7100	100	2400
Arius felis			
Hardhead catfish	ND	200	ND
Lagodon rhomboides			
Pinfish	300	200	100
Sciaenops ocellatus			
Red drum	500	23,500	400
Cynoscion arenarius			
Sand seatrout	ND	ND	ND
Archosargus probatocephalus			
Sheepshead	4300	11,600	200
Leiostomus xanthurus			
Spot	ND	ND	ND
Paralichthys lethostigma			
Southern flounder	ND	ND	ND
Cynoscion nebulosus			
Spotted seatrout	900	170,400	600
Mugil cephalus			
Striped mullet	**178,400**	**21,200**	**2,684,100**
Other fish	19,400	67,400	6,400
Total fish	214,900	384,600	2,699,800

Although Gunter found 12 species of fish and 1 shrimp, 83% of fish consumed were *Mugil cephalus*.

A significant difference between stranded (presumably ill) and net-caught/capture-killed (presumably healthy) dolphins is that stranded dolphins (Barros 1992, Barros and Odell 1990) have a high percentage of empty stomachs (empty or <1 g, 32–54%) while net-caught or captured dolphins (Cockcroft and Ross 1990, Gunter 1942) have a very low percentage of empty stomachs (<3%). The reason for this discrepancy is not documented, but ill dolphins often have a decreased appetite or may not be able to catch food. Another reason for a high percentage of empty stomachs in the Bay dolphins may be lack of food availability. Of 19 Bay dolphins examined, 32% had empty stomachs and 37% had only unidentifiable bones and scales (no flesh). Gunter (1942) observed 34 killed specimens of *T. truncatus*; none of the stomachs were void of food. In addition, Gunter (1942) showed that the average number of recognizable fish/stomach was 18, whereas the 15% of EMB dolphins that had eaten recently had no more than 2 recognizable fish/stomach. These data, along with the Texas Parks & Wildlife fish freeze-kill and biomass data, indicate that food was in short supply for the Bay dolphins. I suspect that many of them might have survived if they had sufficient nutrition.

Ridgway and Fenner (1982) state that the blubber may thin as weight loss progresses to emaciation, and reduced blubber thickness at necropsy is one sign of emaciation. Studies on healthy, well-fed dolphins at the Naval Ocean Systems Center in San Diego show that *T. truncatus* have thicker blubber as body weight increases, and that *T. truncatus* may respond within 2 weeks to water-temperature changes by increasing or decreasing blubber thickness for cooler or warmer temperatures, respectively (William A. Friedl, NOSC, Kaneohe, HI, pers. commun., Nov. 1990). Level of starvation may not be the only reason for differences in blubber thickness between EMB and Texas coast dolphins: the EMB dolphins might originally have had thinner-than-normal blubber resulting from living in a shallow bay with higher-than-average water temperatures (29, 25, and 19°C monthly average water temperatures in EMB for September, October, and November 1989, respectively); or the normal prey field in EMB might be limited compared with other areas. Further work on blubber constituents and factors affecting blubber thickness is needed to determine if blubber thickness is an indicator of starvation as a cause of death.

The December 1989 EMB freeze, in which temperatures stayed near freezing for about 4 days, resulted in devastation of the dolphins' most-likely major food source, the striped mullet. The dolphins' emaciated condition, the substantial reduction in their blubber thickness, lack of food in their stomachs, the assessment that dolphins lived for 2 weeks following the freeze, and the EMB fish freeze-kill and biomass data suggest, in addition to any direct effects to the dolphins of the extreme cold, that decimation of the food resource contributed to this acute dolphin mortality event.

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