The 1990 Common Bottlenose Dolphin (*Tursiops truncatus*) Mass Die-Off in East Matagorda Bay, Texas—New Insight into a Cold Case

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Abstract

On 20 January 1990, 23 *Tursiops truncatus* (Montagu) (Common Bottlenose Dolphin) carcasses were found scattered around the interior shoreline of East Matagorda Bay, Texas. Few accounts exist to document the presence of live or dead bottlenose dolphins inside the boundaries of East Matagorda Bay before or after the die-off. A review of areal East Matagorda Bay and the original investigation of the January 1990 mass die-off was conducted, including the history of natural and anthropogenic changes to the area, dolphin stranding records, small boat visual surveys, and dolphin dorsal fin photographic identification. Natural events preceding the discovery of the dolphin carcasses were likely factors in the animal's demise, however, the timing of engineering projects that modified the bay's access points to the Gulf of Mexico may be additional factors for consideration in this unusual mortality event.

Introduction

In the northern Gulf of Mexico (southern Texas to southern Florida), from January to May 1990, 344 *Tursiops truncatus* (Montagu) (Common Bottlenose Dolphin) died in a Gulf of Mexico (GoMx) wide Unusual Mortality Event (UME) (Litz et al. 2014). Though a definitive cause for the overall UME was not found, a morbillivirus pathogen may have been a causal factor in the majority of cases (Litz et al. 2014). However, an early, striking incident of the UME was a highly localized die-off in East Matagorda Bay, Texas (Fig. 1) where it is believed other factors were responsible. On 20 January 1990, 23 carcasses of advanced decomposition were found scattered around the interior shoreline of East Matagorda Bay, Texas. The common bottlenose dolphin (hereafter referred to as bottlenose dolphins or dolphins) group composition represented a demographic cross-section and was composed of 11 males: 6 adult, 5 juvenile, and 12 females: 7 adult – four pregnant, 5 juvenile (Miller 1992). Following the die-off, Miller (1992) conducted an investigation into possible causal factors that included unusually cold weather that froze the surface waters of the bay for 2–3 days, an abnormally low tide that may have restricted the dolphins' ability to leave the bay for warmer waters, and a freeze-related fish kill that likely limited available prey, resulting in malnutrition for what was presumed to be a resident dolphin population (Miller 1992). However, few accounts exist to document the presence of live or dead bottlenose dolphins inside the boundaries of East Matagorda Bay before the die-off, and it is not clear if the dolphins discovered in January 1990 were long-term inhabitants of the bay. A literature search indicated East Matagorda Bay has not been studied to determine the presence or absence of dolphins but several studies indicate the much larger Matagorda Bay to the southwest is long-term bottlenose dolphin habitat (Barham et al. 1980; Gruber 1981; Lynn and Würsig 2002; Würsig and Lynn 1996). It is possible that East Matagorda

Bay did not support a resident group of dolphins prior to January 1990 and more information is needed to evaluate the dolphin's historical and current use of the bay. To that end, a review of areal East Matagorda Bay and the January 1990 bottlenose dolphin die-off was conducted, including the history of natural and anthropogenic changes to the area as documented in the literature and in government reports, aerial photography, and marine mammal stranding records. Additionally, small boat visual surveys were conducted to assess the current presence or absence of dolphins and explore potential access options for bottlenose dolphins to East Matagorda Bay.

Field-site Description

Background

The GoMx Texas shoreline measures some 600 km (White and Calnan 1990) with numerous industrial ports, featuring deep draft channels dredged to allow for the safe transit of ships between each port and the GoMx. Prominent among these channels is the Gulf Intracoastal Waterway (GIWW), a dredged commercial shipping artery along the GoMx coast of the southeastern United States, and in Texas the GIWW spans the coast from Brownsville to Sabine Lake (USACE 1992). Other engineered passes, or "cuts" as the smaller passes are colloquially known, are dredged to improve seawater exchange with estuarine communities for the benefit of aquaculture or recreational fishing (e.g., Rollover Pass and Packery Channel, TX) (Kraus 2007). Although there are several different methods of dredging (Todd et al. 2015), the processes typically involve the mechanical removal of marine aggregate, followed by a deposition of the dredge spoils in another location. Bottlenose dolphins inhabit the state's bays, estuaries, and

coastal waters (Phillips and Rosel 2014) and at times may be found concentrated in dredged channels or passes (Fertl 1994; Gruber 1981; Henderson and Würsig 2007; Lynn and Würsig 2002; Maze and Würsig 1999; Moreno 2005; Shane 1980). Dead, sick or injured dolphins may be found stranded on shorelines (Colbert et al. 1999; Hansen 1992; Worthy 1998), prompting a response from the Texas Marine Mammal Stranding Network (TMMSN). The TMMSN is a non-profit organization authorized by the National Marine Fisheries Service (NMFS) to coordinate marine mammal response activities along the Texas GoMx coast.

East Matagorda Bay

East Matagorda Bay (Fig. 1) is a shallow lagoon (avg. depth ~1 m) of moderate salinity (20-24 ppt) comprising approximately 155 km^2 (Cifuentes et al. 2006; Craig et al. 1989; Froeschke et al. 2010; Gardner et al. 2006; Kraus and Militello 1999; Palmer et al. 2011). Oriented southwest to northeast along the northern-central Texas Coastal Bend, East Matagorda Bay is boxed in by engineered waterways including the Colorado River Navigation Channel (CRNC), the GIWW, and a short, narrow channel – Mitchell's Cut (Gardner et al. 2006; King and Prickett 1998; USACE 1992; USACE 2017; USGPO 2017). East Matagorda Bay was separated from Matagorda Bay after a massive log jam was cleared from the Colorado River mouth near the town of Matagorda in 1929 (Fig. 2) (King and Prickett 1998). The clearing of the log jam resulted in the rapid development of the Colorado River delta in the 1930's, closing off the eastern section of Matagorda Bay – resulting in one of the most isolated bodies of water on the Texas GoMx coast in terms of distance to inlets where seawater exchange can occur (Froeschke et al. 2010; Gardner et al. 2006; Wadsworth 1966; White and Calnan 1990). Navigational locks – 23 m wide steel doors spanning the GIWW channel – were constructed during the 1940's where

the Colorado and Brazos rivers meet the GIWW. The locks control sediment movement and excessive tidal action; they are open on-demand for commercial and emergency vessel traffic, but are typically restrictive to the passage of recreational vessels (USACE 2017; USGPO 2017). In the early 1990's, a Bypass Channel was constructed around the east Colorado River Lock to allow direct transit between the CRNC and GIWW, but prior to its construction all GIWW traffic transiting northeast was routed through the navigational locks at the Colorado River (McCollum 2000). East Matagorda Bay lacks a natural seawater pass directly into the bay, although a natural ephemeral pass, Brown Cedar Cut, has previously been a conduit for seawater exchange (Mason and Sorensen 1972; McGowen et al. 1979; Miller 1992; Munro 1965; USFWS 1988).

Methods

Data review

Literature. Selected literature relevant to the greater Matagorda Bay system was reviewed to establish a timeline of major engineering projects or natural events impacting the waterways near East Matagorda Bay within 10 years prior to the January 1990 East Matagorda Bay die-off and to determine the extent to which GoMx access points and adjacent waterways were modified (King and Prickett 1998; Stauble et al. 1994; USACE 1988; USACE 1992). Records from the United States Army Core of Engineers (USACE) were reviewed, specifically all documentation pertaining to the USACE permit #18399 (a permit granted for the construction of Mitchell's Cut, also known as Caney Creek Fork Cut), obtained by a Freedom of Information Act (FOIA) request to USACE. Also reviewed were aerial photographs of East Matagorda Bay collected 10

December 1989 obtained from the United States Geological Survey (USGS) National Aerial Photography Program (NAPP).

Marine mammal stranding records. The TMMSN maintains archives of all marine mammal strandings recorded in Texas since its inception in 1980, and since 1990 has transmitted all stranding data to the NMFS Marine Mammal Health and Stranding Response database (MMHSRP). Stranded animals recovered by the TMMSN are assigned field identification numbers that identify the region in which the animal was found. The TMMSN divides the state of Texas into six response regions; Matagorda Bay and East Matagorda Bay are included in the region designated as "Port O'Connor" (PO). Stranding records from the TMMSN (1980 – 2017) and the MMHSRP (1990 – 2017) corresponding to the PO region were extracted and cross-checked for consistency. All strandings designated as PO were plotted in ArcGIS (Esri® ArcMap™ 10.4, Redlands, CA) to quantify the number of strandings in Matagorda and Calhoun counties and verify the physical locations described in each stranding record.

Visual surveys

Visual surveys were conducted during July 2016 and June 2017 in East Matagorda Bay, its connecting waterways and adjacent GoMx waters (Fig 1). Surveys covered the central portion of the bay, the interior perimeter (approximately 300-500 m from shore or as depth allowed), and connecting waterways including Caney Creek, Mitchell's Cut, the GIWW, the CRNC and Bypass Channel, and the Colorado River Diversionary Canal. GoMx waters adjacent to East Matagorda Bay were surveyed approximately 500 m from the beach along the length of Matagorda Peninsula during one survey. The surveys were modeled after NMFS bottlenose dolphin visual surveys designed to collect photo identification (photo-ID) capture-mark-

recapture (CMR) data (Melancon et al. 2011). Photo-ID CMR is a decades-old technique used to collect data for population analyses that photographically captures the distinct dorsal fin markings of individuals in a population of delphinids (Shane 1977; Würsig and Würsig 1977), yielding data that can be used to support population assessments (Rosel et al. 2011).

Results

Data review

Literature. Resolutions to the pre-dredging objections from federal government agencies (e.g., NMFS) and non-governmental organizations concerning the effects of the construction on terrestrial and marine species were found during the review of permit application #18399 to the USACE and the subsequent environmental review for the construction of Mitchell's Cut; however, bottlenose dolphins were not listed as potentially inhabiting the area (USACE 1988). Based on the literature review, a timeline of anthropogenic modifications to East Matagorda Bay during 1983-1990 (Fig. 3) (Stauble et al. 1994; USACE 1992) indicate that approximately 9 km to the northeast of Brown Cedar Cut, another waterway known as McCabe Cut was mechanically opened in 1983 as a flood relief measure for the nearby community of Sargent, located on the banks of Caney Creek, 8 km north of the GIWW. McCabe Cut was initially designed with a bottom width of approximately 12 m and a depth of 0.6 m at mean low tide (USACE 1992); however, it was mechanically filled in March 1989 to resolve navigational hazards resulting from a cross current that developed after the cut grew in size due to the erosional effects of the GoMx (USACE 1988). As an alternative measure to alleviate flooding in Sargent, dredging operations were completed in May 1989 on Mitchell's Cut, a 1,800 m long channel dredged to a depth of

157 2.4 m, approximately 4 km to the southwest of the McCabe Cut, closer to East Matagorda Bay
158 (Rosati III et al. 2013; USACE 1988). Additionally, in the months leading up to and temporally
159 overlapping with the UME, two dredging projects were conducted in waterways adjacent to the
160 bay: from September 1989 to January 1990 approximately 135,215 m^3 of sediment were
161 removed from the GIWW opposite the former McCabe Cut and deposited on the GoMx shore at
162 Sargent Beach during GIWW maintenance dredging (USACE 1992). While the maintenance
163 dredging of the GIWW occurred, from September 1989 to March 1990 another dredging
164 operation removed 1,318,038 m^3 of sediment from the jetty impoundment basin and entrance
165 channel of the CRNC where it meets the GoMx (King and Prickett 1998). Aerial photographs
166 acquired 10 December 1989 (NAPP 2017) confirm no Bypass Channel existed to circumvent the
167 east navigational lock at the Colorado River. The photos indicate McCabe Cut and Brown Cedar
168 Cut were closed, and Mitchell's Cut and the mouth of the CRNC appeared open, but with
169 apparent silting (breaking water on presumed sedimentation) present at the opening of both
170 passes. Dredging operations were not visible in the aerial photos for 10 December 1989.
171 *Marine mammal stranding records.* The stranding archives (TMMSN and MMHSRP) for the
172 state of Texas from 1980 – 2017 indicated that overall, 123 bottlenose dolphins stranded on the
173 interior shores (e.g., excluding GoMx beach strandings) of Matagorda Bay and its associated
174 waters (e.g., Espiritu Santo Bay) in Matagorda and Calhoun counties. The East Matagorda Bay
175 die-off of January 1990 was the only record of dead stranded dolphins reported in the interior of
176 East Matagorda Bay, although two response cases have occurred for live dolphins in the vicinity.
177 In the first case, a 264 cm male bottlenose dolphin (TMMSN field # PO331) was found stranded
178 alive in the GIWW near Old Gulf Cut (Fig. 1). In the second case, a live dolphin (TMMSN field
179 # PO528) was found swimming and foraging "out-of-habitat"(Rosel and Watts 2007) in a road

side ditch (depth ≤ 0.75 m) parallel to the CRNC near the southwest corner of East Matagorda Bay on 13 April 2017 (Whitehead and Ronje 2017).

Visual surveys

Our small boat surveys consisted of 29.0 survey hours, and over the course of 666.0 km surveyed, seven bottlenose dolphin groups were observed (Fig. 1). No dolphins were found inside East Matagorda Bay proper during the surveys, but were observed outside of the bay in the channels of the GIWW and CRNC, as well as the GoMx. On 30 July 2016, a single dolphin was observed foraging behind a trawl vessel on the GoMx coast along the Matagorda Peninsula, one group of approximately 12 dolphins was observed near the mouth of the CRNC in the GoMx, and another single dolphin was sighted approximately 8 km upstream of the river mouth in the CRNC. During the 27 – 29 June 2017 surveys, a total of six individual dolphins were observed foraging in the CRNC or GIWW (3 presumed mom/calf pairs), as determined by the photo-ID analysis. Few options for bottlenose dolphins to enter East Matagorda Bay were found during the visual surveys. Brown Cedar Cut was closed, and dolphins traveling in the GIWW from Matagorda Bay or the Brazos River mouth (approximately 30 km northeast of Mitchell's Cut) would need to contend with navigational locks. Only two opportunities appear currently plausible for dolphins attempting to access the GIWW and the bay from the GoMx: the CRNC via the Bypass Channel, or Mitchell's Cut. Mitchell's Cut was considerably turbulent during some parts of our survey, and silting of the mouth where it meets the GoMx was evident. Along the northern side of the bay, two potential access points into the bay from the GIWW were observed (Old Gulf Cut and Big Boggy Cut, Fig. 1).

Discussion

Miller (1992) suggested that dolphins during January 1990 in East Matagorda Bay likely encountered a confluence of unfortunate events—an extreme low tide event and a hard freeze of the bay, complicated by a fish kill which may have deprived the dolphins of prey when it was most needed. Tidal fluctuations are known to occasionally cause otherwise healthy dolphins to inadvertently strand on mud flats or marshes (Gunter 1941; Sharp et al. 2016; Wiley et al. 2001). Although the tide was reported to be unusually low in December 1989 just before and during the freeze, ≥ 3 dolphins were seen inside the bay following (possibly attempting to forage) behind a trawling vessel on 3 January 1990 (Miller 1992). It is not known if the dolphins following the trawler were part of the group in the die-off, but if so, a trawling vessel in the bay may indicate a route of sufficient depth was available to exit the bay into the GIWW before they died (e.g., through Big Boggy Cut). One dead dolphin (TMMSN field # PO110) reported in Miller (1992) was found outside of the bay in the GIWW near the entrance of Big Boggy Cut (Fig 1.)

The December 1989 freeze froze East Matagorda Bay to a thickness of ~5 cm for 2–3 days resulting in an estimated fish kill of 2.7 million fishes, the most significant on the Texas coast during that time (McEachron et al. 1994). However, previous freezes in East Matagorda Bay had occurred. Six years prior, the most severe freeze in Texas recorded history occurred in December 1983 when water temperature dropped 15 º C within 10 days and stayed between 0º C and 5 º C for ~ 7 days, followed by a freeze in February 1989 of shorter duration (McEachron et al. 1994). The Texas Parks and Wildlife Department conducted extensive fish kill surveys after the December 1983 and February 1989 freezes in East Matagorda Bay (McEachron et al. 1994), but stranding reports were not found corresponding to either event. The lack of dolphin stranding

reports from 1983 could be due to the TMMSN having only been established in 1980; the organization experienced a period of increasing public awareness after its inception. However, the TMMSN stranding records indicate government agencies (e.g., U.S. Fish and Wildlife Service) were reporting strandings to the TMMSN from the Matagorda Bay area as early as 1981, and by 1985 reporting from the public and state agencies state-wide became consistent (Hansen 1992).

Active dredging work has prompted negative short-term behavioral responses by marine mammals inhabiting the affected areas (Pirotta et al. 2013), but population studies of bottlenose dolphins along the Texas coast indicate dredged channels or passes such as Sabine Pass (Ronje et al. 2017), Bolivar Roads (Mullin et al. 1990), Galveston Ship Channel (Fertl 1994), San Luis Pass (Henderson and Würsig 2007; Maze and Würsig 1999), Pass Cavallo (Gruber 1981), and Aransas Pass (Barham et al. 1980; Shane 1990) are among waters with the highest concentration of bottlenose dolphins in their respective bay systems. Deep passes or canals may act as bottlenecks that concentrate fish traveling between estuarine and marine habitats; these topographical features may have characteristics that boost species diversity and create foraging advantages (Allen et al. 2001; Anderwald et al. 2013; Maze and Würsig 1999; Shane 1990; Todd et al. 2015; Wilson et al. 1997). If dredged channels are an attractant for dolphins, it is possible dolphins in nearby coastal waters explored Mitchell's Cut after the dredging was completed in May 1989, resulting in access into East Matagorda Bay where few prior options existed. It is not certain the dolphins in the 1990 die-off were unusual visitors to the bay before the cut was dredged, but the few stranding reports before and since the January 1990 dolphin die-off and the results of our surveys here suggest East Matagorda Bay proper may not be typical habitat for

bottlenose dolphins. Mitchell's Cut may no longer serve as a reliable means for East Matagorda Bay ingress. Aerial photos indicate the mouth of the cut has a tendency to silt in, and it may not be a consistent access point for dolphins, as it is not maintained. In contrast, studies indicate neighboring Matagorda Bay supports a bottlenose dolphin population in all seasons (Barham et al. 1980; Gruber 1981; Lynn and Würsig 2002; Würsig and Lynn 1996).

The closure of McCabe Cut (March 1989) and the completion of Mitchell's Cut (May 1989) may have been factors in the bottlenose dolphin mortality event in East Matagorda Bay of January 1990. Dolphins in the GoMx may have gained access through a new opening (Mitchell's Cut) and encountered an unfortunate occurrence of inhospitable natural events once inside an unfamiliar bay (freeze, low tide, fish kill). If a dolphin group inhabiting East Matagorda Bay had attempted to leave for GoMx waters before the die-off, it is possible they were discouraged by the closure of their previous access point (McCabe Cut) and the combination of engineering projects. Given the navigational locks in place at the Brazos and Colorado rivers, and the lack of a Bypass Channel around the east Colorado River Lock in 1989 – 1990, it seems unlikely dolphins were transiting to or from the GoMx by means of these passages. In the event they were doing so, the mouth of the CRNC and the GIWW east of the bay were likely disturbed by active dredging operations during the winter of 1989 – 1990. If visual surveys had been conducted in East Matagorda Bay and its connecting waterways during or after the dredging operations, dolphins may have been detected and researchers might have alerted wildlife management agencies to the need for measures to mitigate the entrapment of dolphins in East Matagorda Bay. This review may be useful as cautionary insight for future coastal engineering projects that create

new access to waters adjacent to dolphin habitat or alter conditions to restrict or eliminate existing access points.

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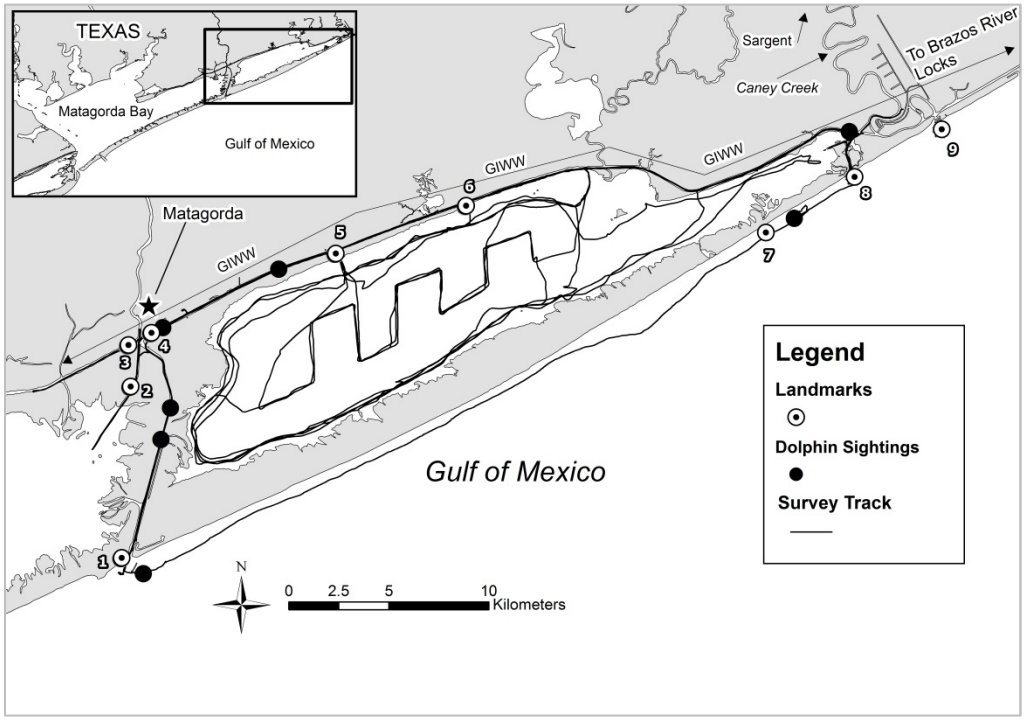

Figure 1. East Matagorda Bay landmarks, dolphin sightings, and survey track. Surveys were conducted on 30 July 2016 and 27-29 June 2017.

Figure 1 Landmarks:

1.Colorado River Navigation Channel jetty impoundment basin

2.Colorado River Diversionary Canal

3.Gulf Intracoastal Water Way west lock

4.Gulf Intracoastal Water Way east lock and Bypass Channel

5.Old Gulf Cut

6.Big Boggy Cut

7.Brown Cedar Cut (closed)

8.Mitchell's Cut

9.McCabe Cut (closed)

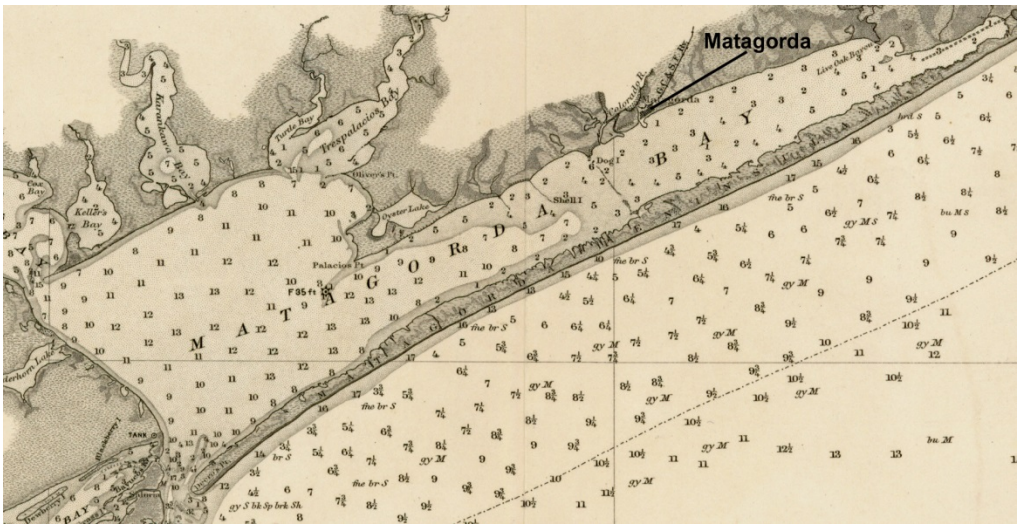

Figure 2. The town of Matagorda and Matagorda Bay in 1915, before the formation of the Colorado River delta that resulted in East Matagorda Bay as a separate body of water. Image from NOAA's Office of Coast Survey Historical Map & Chart Collection, http://historicalcharts.noaa.gov

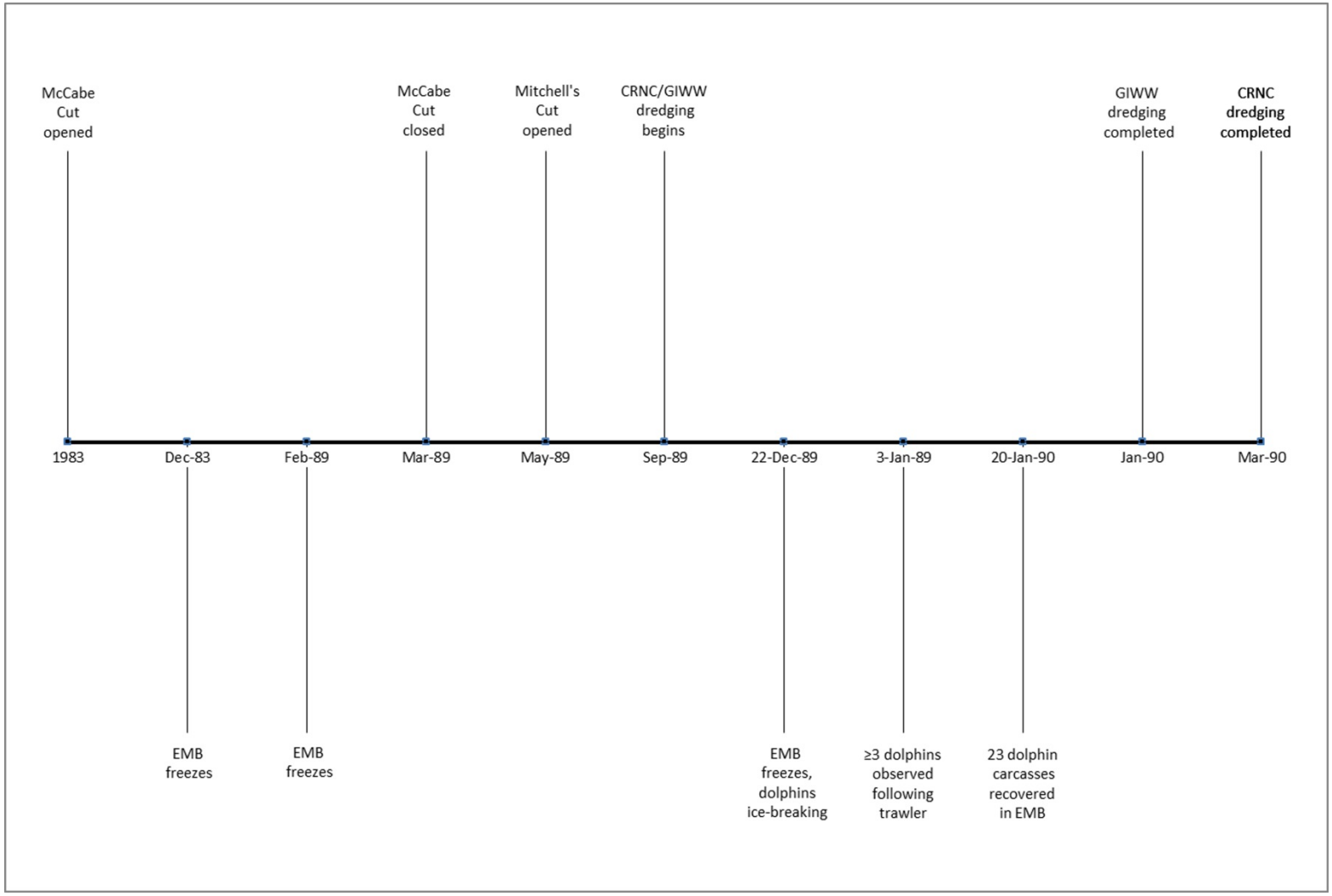

Figure 3. Timeline of events in East Matagorda Bay (EMB) 1983 – 1990 related to topographical modifications and dolphin observations referenced in Miller (1992)