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# Short-term effects of Hurricane Harvey on dolphins in the upper Galveston Bay Estuary

Vanessa Mintzer<sup>1,2</sup>, Kristi Fazioli<sup>3</sup>, George Guillen<sup>3</sup>



<sup>1</sup>The Galveston Bay Foundation  
<sup>2</sup>School of Natural Resources and Environment, University of Florida  
 vmintzer@galvbay.org  
<sup>3</sup>Environmental Institute of Houston, University of Houston  
 fazioli@uhcl.edu; guillen@uhcl.edu

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## INTRODUCTION

In August 2017, Hurricane Harvey inundated the Galveston Bay estuary system with record-breaking rainfall. Salinity levels in the Bay dropped drastically in the weeks following the storm, severely altering aquatic habitat. Since 2013, we have conducted boat-based dolphin observational surveys in upper Galveston Bay (UGB). This long-term monitoring provided a unique opportunity to evaluate the effects of Harvey on the bottlenose dolphins (*Tursiops truncatus*) inhabiting UGB (Fig. 1, 2).

**Objective:** To evaluate if and how dolphin encounter rates (ERs), and prevalence and extent of dolphin skin lesions, varied in the months preceding and following Harvey.

Galveston Bay (GB) is a 1600km<sup>2</sup> anthropogenically altered shallow bay system. Growth and industrialization from the 1950's – 70's contributed to massive fish kills, a 95% decline in submerged aquatic vegetation and an EPA listing on the 10 most polluted waterways. Management activities have improved water quality and health; however, concerns over pathogenic bacteria and chlorinated organic compounds persist<sup>1</sup>.

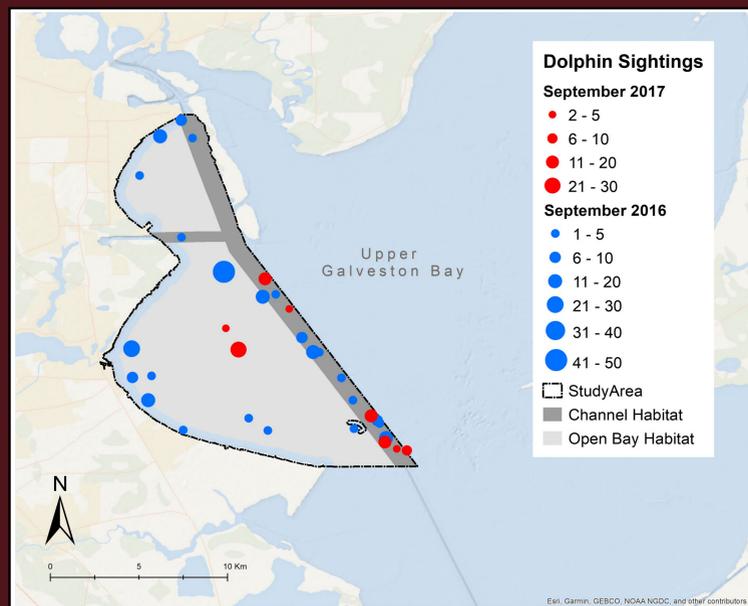
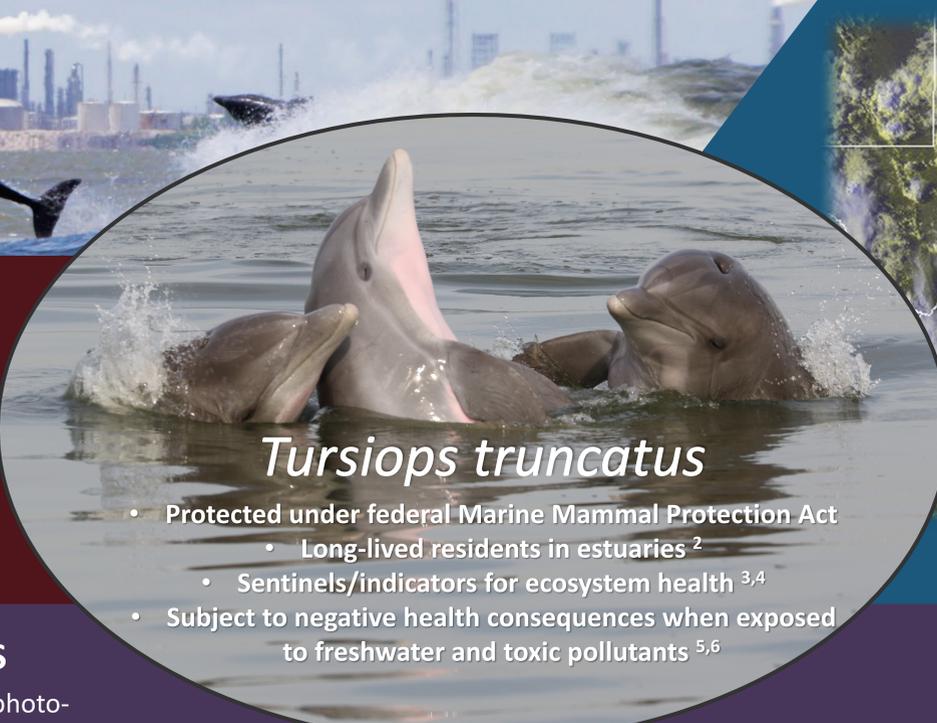


Fig. 1. Map of the primary study area in upper Galveston Bay. Two habitat types within the study area, Channel and Open Bay, are displayed along with dolphin sightings in September 2016 and September 2017.

## RESULTS AND CONCLUSION

The long-term monitoring of dolphins inhabiting UGB allowed the comparison of ERs, and skin lesion prevalence and extent before, during, and after Harvey. These parameters changed considerably with time period (Fig. 5, Fig. 6, Table 1), suggesting that Harvey had population-wide effects. ERs showed that most dolphins were displaced from UGB for weeks following Harvey (Fig. 5), and the individuals that stayed developed skin lesions (Fig. 6, Table 1) potentially indicative of underlying stress. With a predicted increase in the intensity of hurricanes<sup>13</sup> and the potential for a large-scale coastal protection/barrier project in GB<sup>14</sup>, research on the effects of flood events is imperative to manage dolphin populations and their estuarine habitat.



## Tursiops truncatus

- Protected under federal Marine Mammal Protection Act
  - Long-lived residents in estuaries<sup>2</sup>
  - Sentinels/indicators for ecosystem health<sup>3,4</sup>
- Subject to negative health consequences when exposed to freshwater and toxic pollutants<sup>5,6</sup>

## METHODS

- Boat-based photo-identification surveys were conducted between August 2015 and September 2018
- Individual dolphins were identified using the natural marks on their dorsal fins.<sup>10,11</sup>
- Dolphin ERs (dolphins/km) were calculated monthly from June 2016 to Dec. 2016 and June 2017 to Dec. 2017.

- Photographs of individuals were evaluated and, if quality criteria were met, utilized in analyses for skin lesions →
  - prevalence = the proportion of identified individuals that exhibited skin lesions
  - extent = % of each individual's epidermis covered by lesions (Fig. 3)



Fig. 3. Examples of observed lesions in bottlenose dolphins in upper Galveston Bay in each extent category. Exposure to low salinity environments may contribute the development of "freshwater skin lesions" characterized by degradation and ulceration of the epidermis, often accompanied by secondary infections from opportunistic pathogens<sup>4,12</sup>.

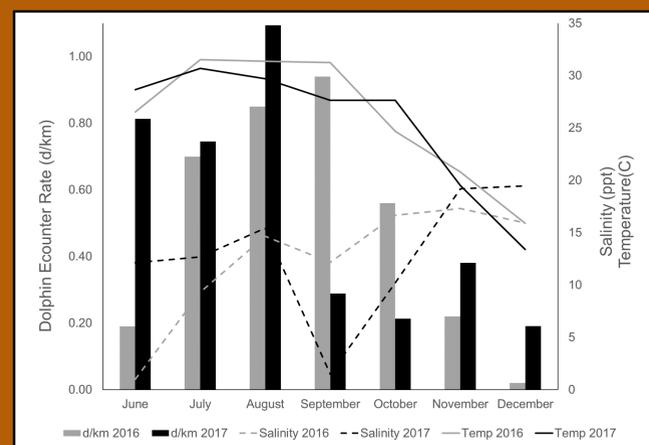


Fig. 5. Encounter rates (d/km) of bottlenose dolphins in UGB from June 2016-December 2016 and June 2017-December 2017 with average surface salinity and temperature recorded at dolphin sighting locations.

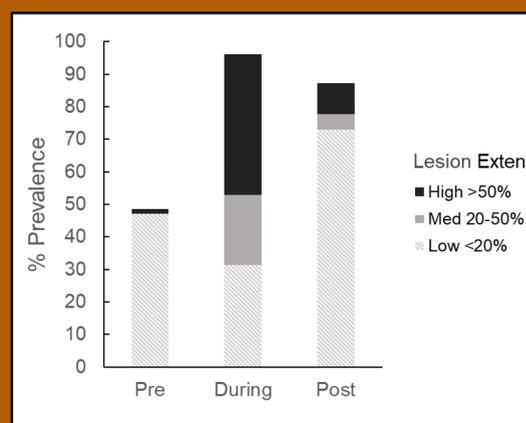


Fig. 6. Skin lesion prevalence and extent on identified dolphins during the pre-Harvey, during Harvey, and post-Harvey periods. Difference in extent according to period was found to be significant,  $\chi^2(4, N = 248) = 130.1, p < .001$ .

Hurricane Harvey moved over the Houston-Galveston region in late August of 2017, dumping up to 60" in 8 days and causing massive inland flooding, much of which drained into Galveston Bay<sup>7</sup>. The estuary was inundated with freshwater, sediment, debris, and toxic pollutants<sup>8,9</sup>.

Image: NOAA, August 25, 2017. <https://www.ospo.noaa.gov/>

- Three periods were defined in relation to the Harvey low-salinity event, using an 11 ppt threshold for preferred dolphin habitat (Fig. 4).
  - Pre → June 1-Aug 27 (>11ppt)
  - During → Aug 28-Oct 20 (<11ppt)
  - Post → Oct 21-Dec 31 (>11ppt)

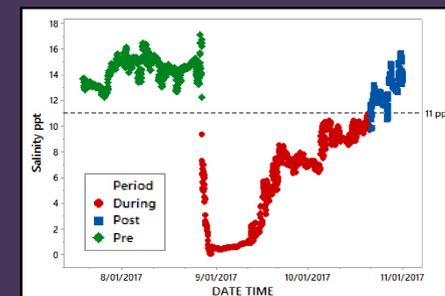


Fig. 4. Continuous automated salinity (ppt) measurements taken at the NOAA Eagle Point (Station ID 87771013) site from 7/21 to 10/31/17.

DOLPHIN ID	6/09/2017	6/19/2017	7/07/2017	7/10/2017	7/14/2017	8/03/2017	8/04/2017	8/24/2017	9/05/2017	9/12/2017	9/13/2017	10/06/2017	10/15/2017	11/14/2017	11/15/2017	11/29/2017	12/01/2017	12/14/2017
10																		
23																		
85	1	1							3	3	3	3	2					1
87 <sup>b</sup>	1	1							3	3	3	3	1					
152 <sup>b</sup>									3	3	3	3	1					0
187 <sup>a</sup>									1	1	1	1	1					1
188 <sup>a</sup>									1	1	1	1	1					0
203 <sup>b</sup>									3	3	3	3	3	1	1	1		1
209 <sup>a</sup>	1								3	3	3	3	3					1
219 <sup>a</sup>									3	3	3	3	3	3	3	3		3
234 <sup>a</sup>	3	3							3	3	3	3	3	3	3	3		3
237 <sup>a</sup>	1								0									
282 <sup>a</sup>									3	3	3	3	3	3	3	3		3
302 <sup>a</sup>									1	1	1	1	1	1	1	1		1
378									1	1	1	1	1	1	1	1		1
508 <sup>a</sup>									1	1	1	1	1	1	1	1		1
530 <sup>a</sup>									1	1	1	1	1	1	1	1		1
582 <sup>a</sup>									3	3	3	3	3	3	3	3		3
736 <sup>b</sup>	1								3	3	3	3	3	3	3	3		3

Table 1. Lesion progression over time in 19 individuals sighted in all three time periods surrounding the Hurricane Harvey low salinity event.

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