Distribution Patterns of Sperm Whales and Oceanic Dolphins from Vessel Surveys Conducted Before and After the Deepwater Horizon (DWH) Oil Spill

Laura Aichinger Dias* [1,2], Joel Ortega-Ortiz [1,2], Gina Rappucci [1,2], Jenny Litz [2], Lance Garrison [2], Melissa Soldevilla [2], Anthony Martinez [2], Keith Mullin [3].

[1] CIMAS, University of Miami, FL; [2] National Marine Fisheries Service (NMFS), Southeast Fisheries Science Center (SEFSC), Miami, FL; [3] NMFS SEFSC, Pascagoula, MS.

Introduction

Over 20 species of cetaceans inhabit Gulf of Mexico (Gulf) waters. Different species may be selecting habitats based on specific oceanographic features, such as bottom depth. In the oceanic waters of the Gulf (>200m) Stenellid dolphins and sperm whales are the most commonly recorded species and based on the location of sightings, these species may be occupying specific areas of the Gulf[1-4]. Sperm whales, for example, show two regions with high rates of encounters: along the MS Canyon (central Gulf) and along the FL Escarpment just north of the Dry Tortugas (eastern Gulf)[5,6]. In addition, there's evidence of different occurrence in certain areas of the Gulf according to season[7].

Objective

The goal of this study was to evaluate for a potential geographic shift in the sighting and acoustic detection rates of oceanic dolphins and sperm whales across six surveys in the Gulf (2003 through 2018), combined as before and after the DWH Oil Spill.

Methods

Data were collected during shipboard line-transect surveys in 2003, 2004, and 2009 (historical dataset) and in 2017 and 2018 (GoMMAPPS dataset). During the historical surveys, sighting data were collected by one team of two marine mammal observers with big-eye binoculars (25x150) and one data recorder on the vessel's flying bridge. During GoMMAPPS, two teams of two big-eye observers each were present, one stationed on the vessel's flying bridge and the other on the bridge deck. Concurrent with visual operations, a towed hydrophone array was deployed during the 2009 and GoMMAPPS surveys and acoustic signals were monitored and

logged by two acoustic technicians. All surveys were conducted on board the NOAA Ship *Gordon Gunter* in the spring/summer months, except the late summer 2018 cruise (PC1805), which was onboard the NOAA Ship *Pisces* and the Gunter 2018 cruise (GU1801), which was during the winter months.

For this analysis, to minimize the effects of the methodological differences between the historical and GoMMAPPS datasets, only sightings seen by the big-eye observers on the flying bridge team were used. Further, only sightings and acoustic detections of sperm whales and oceanic dolphins were used since they provided the most data points across surveys. However, no acoustic detections for oceanic dolphins were available for the historical surveys at the time of analysis. And for 2009, acoustic detections of sperm whales constitute groups of animals classified during data post-processing, while detections for GoMMAPPS surveys were grouped at time of data collection. Effort for the sighting data was calculated as kilometers navigated with the visual team actively scanning for cetaceans and for the acoustic detections it was the number of hours that technicians monitored for acoustic signals during the surveys.

To evaluate any potential shift in the geographic distribution of sightings and acoustic detections, the Gulf was divided into 1-degree meridians. Subsequently, effort and the number of sightings and acoustic detections or groups in the oceanic waters of the Gulf were calculated for each meridian. This allowed for the determination of the sighting and detection rates for sperm whales and oceanic dolphins in each Gulf area which were then compared between the historical and GoMMAPPS surveys.

Results

Overall sighting rates increased in the western Gulf for both sperm whales and oceanic dolphins from the historical to the GoMMAPPS surveys (Figures 1 and 2). For sperm whales there was a 4-fold decrease of sightings in the eastern Gulf, accompanied by a 6.4-fold increase in the west during GoMMAPPS; rates for the central Gulf remained similar (10% decrease). Sighting rates for oceanic dolphins more than doubled in the western Gulf while the central Gulf showed a 2.6-fold decrease; in the eastern Gulf, rates decreased by 30% during GoMMAPPS (Table 1).

Figure 1: Sperm whale sighting and detection rates across the Gulf for historical (Hist.) and GoMMAPPS surveys; circles denote increased (green) and decreased (red) rates.

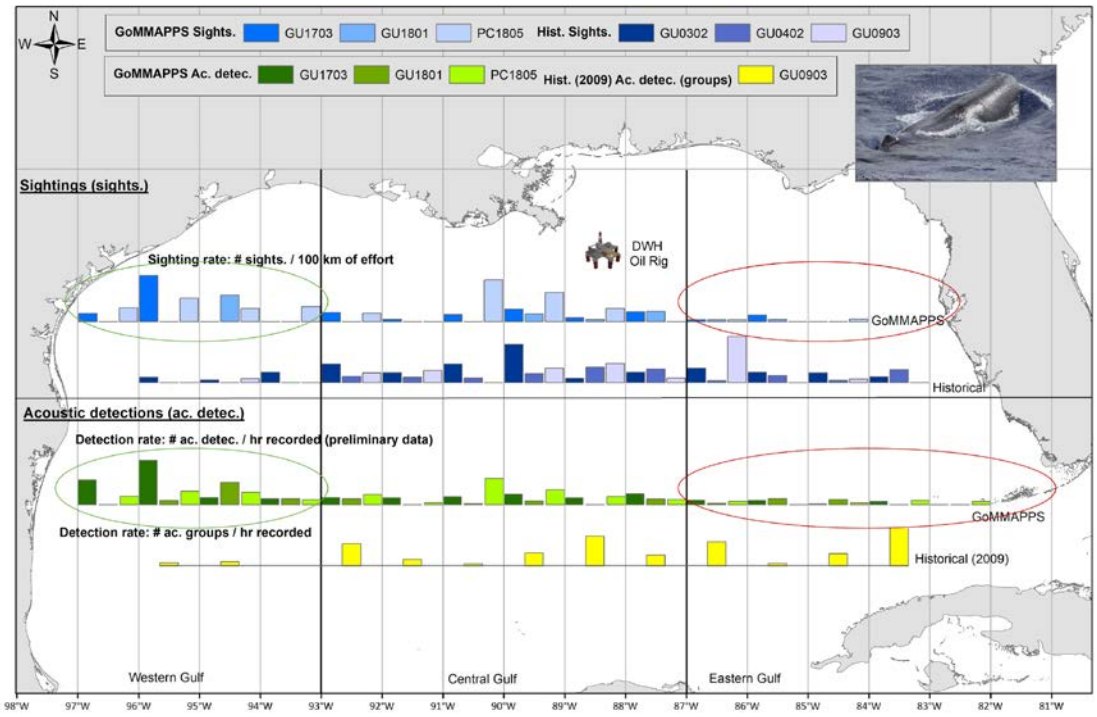

Figure 2: Oceanic dolphin sighting and detection rates across the Gulf for historical and GoMMAPPS surveys; circles denote increased (green) and decreased (red) rates.

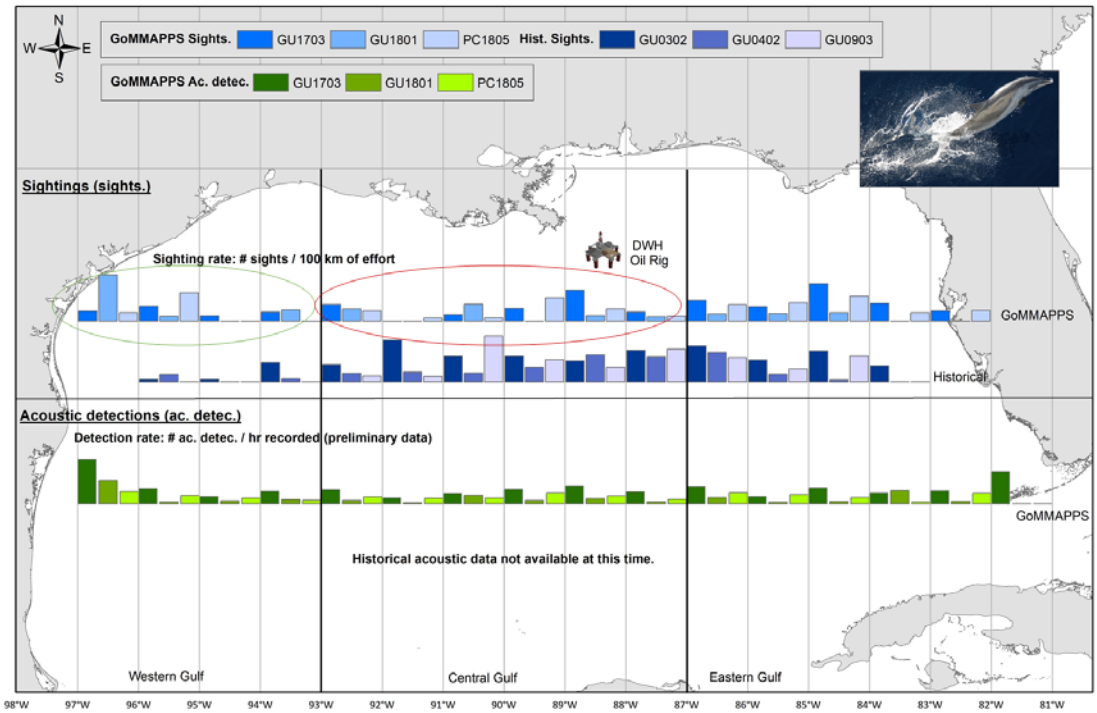

Table 1: Sighting rates for sperm whales (SW) and oceanic dolphins (OD) by Gulf area for the combined (comb.) surveys.

Area and Survey	km of effort	Num. sights. SW	Num. sights. OD	Sight. rate SW	Sight. rate OD
Eastern comb.	**12177.9**	**55**	**169**	**0.45**	**1.39**
Historical	6418.1	45	101	0.70	1.57
GoMMAPPS	5759.9	10	68	0.17	1.18
Central comb.	**15133.7**	**137**	**206**	**0.91**	**1.36**
Historical	7844.5	75	151	0.96	1.92
GoMMAPPS	7289.2	62	55	0.85	0.75
Western comb.	**6653.5**	**46**	**36**	**0.69**	**0.54**
Historical	3557.8	7	12	0.20	0.34
GoMMAPPS	3095.7	39	24	1.26	0.78

Sperm whale acoustic detections obtained from GoMMAPPS surveys followed a similar trend as sightings from those same surveys, i.e., higher detection rates in the western Gulf than in the east (Figure 1, Table 2). In addition, even though detection rates from 2009 cannot be directly compared to the GoMMAPPS rates, it is possible to note a high number of detections in the eastern Gulf when compared to the west within that same survey (Figure 1). Acoustic detection of oceanic dolphins from the GoMMAPPS surveys seemed homogenously distributed between the three Gulf areas; however high inter-cruise variance was present, in some instances following the same trends in the sighting data (Figure 2, Table 2).

Table 2: Acoustic detection rates for sperm whales (SW) and oceanic dolphins (OD) by Gulf area and cruise.

Area and Cruise	Hrs. of effort	Num. detecs. SW	Num. detecs. OD	Detec. rate SW	Detec. rate OD
Eastern	**390.8**	**41**	**148**	**0.10**	**0.38**
GU1703	133.4	16	75	0.12	0.56
GU1801	116.8	15	21	0.13	0.18
PC1805	140.6	10	52	0.07	0.37
Central	**524.7**	**156**	**188**	**0.30**	**0.36**
GU1703	188.6	59	103	0.31	0.55
GU1801	147.4	15	26	0.10	0.18
PC1805	188.7	82	59	0.43	0.31
Western	**242.3**	**116**	**98**	**0.48**	**0.40**
GU1703	76.3	56	54	0.73	0.71
GU1801	79.1	28	19	0.35	0.24
PC1805	87.0	32	25	0.37	0.29

Discussion and next steps…

The data presented here show an increase in the sighting and acoustic detection rates of sperm whales and oceanic dolphins in the western Gulf between historical and GoMMAPPS surveys and a potential shift from east to west, particularly for sperm whales. Factors potentially influencing the detection of these trends or in fact causing these shifts still need to be evaluated. Survey conditions, such as sea state, are known to greatly influence the ability of observers to visually detect animals[8] and the survey conducted during the winter of 2018 was heavily impacted by high seas; however, there is an apparent correlation between the visual and acoustic data during that survey. Seasonality may influence where the animals are located; sperm whales show an increased presence in the eastern Gulf (Dry Tortugas) during the summer[7]. Prey availability is greatly affected by the biotic and physical environment and is a key driver in cetacean distribution[1,9]. Therefore, evaluating remotely sensed oceanographic data, such as chlorophyll concentrations may help explain the shifts seen in this study. Finally, the DWH oil spill from 2010 directly affected several species of cetaceans[10] and the lasting consequences of the oil, dispersants and response actions on cetaceans and their prey species need to be further investigated.

Definitions:

•Sightings: location of each marine mammal encounter collected by the visual observers on the vessel's flying bridge; may include one or more individuals.

•Sighting rate: number of sightings / 100 km of effort.

•Acoustic detections (GoMMAPPS): acoustic signals recorded by acoustic technicians; may include one or more individuals (preliminary data).

•Acoustic detection group (2009): grouping of acoustic detections during data post-processing.

•(Acoustic) detection rate: number of acoustic detections or group / hours of recording.

•Oceanic: sightings, detections and effort (km and hours) selected beyond the continental shelf as defined by Harris et al., 2014 (usually waters deeper than 200 m)[11].

•Oceanic dolphins: unidentified dolphins and Stenellids except Atlantic spotted dolphin (*Stenella frontalis*) observed during visual effort beyond the continental shelf. For acoustic detections it includes all delphinid species producing whistles but may exclude Risso's dolphins or dolphins producing only echolocation clicks.

•Gulf areas: eastern (81°W to 86°W), central (87°W to 92°W) and western (93°W to 96°W).

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