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Abundance of Common Bottlenose Dolphins in Breton and Chandeleur Sounds from Aerial Surveys

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AUTHOR'S NOTE: In October 2025, the state of Louisiana Coastal Protection and Restoration Authority announced the cancellation of plans to conduct the Mid-Breton Sediment Diversion project. This report reflects the Louisiana Coastal Master Plan at the time of drafting.

1. Project Background and Objectives

As part of Louisiana's Coastal Master Plan (CPRA 2023), the state is proposing the Mid-Breton Sediment Diversion Project which, when complete, will divert water and sediments from the Mississippi River into Breton Sound (Figure 1) to facilitate the preservation and restoration of wetlands (CPRA 2017). There is natural flow of freshwater from the Mississippi River into these estuarine systems which drives deposition of sediments along with regulation of salinity, temperature, and nutrient concentrations. The input of additional freshwater into estuarine systems associated with artificial sediment diversion projects has the potential to negatively impact the biota inhabiting these environments. Common bottlenose dolphins (*Tursiops truncatus*) inhabiting estuarine environments may be particularly sensitive to exposure to low salinity water. A summary of available data on the morbidity and mortality in bottlenose dolphins exposed to extended periods of low salinity (< 5 p.s.u.; e.g., McClain et al. 2020; Duignan et al. 2020) informed an expert elicitation that developed a dose-response function relating the time of exposure to reduced survival rates for bottlenose dolphins. This dose-response curve indicated that negative effects on survival probability likely begin after 20-30 days of exposure, and the median survival probability approached zero after approximately 60 days (Booth and Thomas 2021). In the Barataria Bay estuary (an adjacent but distinct system from the Breton Basin), the projected exposure of bottlenose dolphins to lowered salinity during sediment diversion operations may result in substantial increases in mortality and significant negative impacts to the resident dolphin population (Garrison et al. 2020; Thomas et al. 2022). Therefore, when evaluating the impacts of the proposed Mid-Breton Sediment Diversion Project, it is important to understand the current (pre-project) residency patterns of bottlenose dolphins, the drivers of their spatial distribution and movements, and the expected changes in the salinity during project operation.

Marine mammals are managed as "stocks" (i.e., populations) under the Marine Mammal Protection Act (MMPA). As currently defined, the "Mississippi River Delta" (MRD) stock area includes primarily Breton Sound and is described as a resident estuarine stock. Bottlenose dolphins observed in the main portion of Chandeleur Sound are considered to be part of the defined Gulf of Mexico Northern Coastal Stock (NCS). The Mississippi Sound, Lake Borgne, and Bay Boudreau stock (MS stock) also occurs to the north of Chandeleur Sound (Hayes et al. 2023; Hayes et al. 2022). While the MMPA stock assessment reports (SARs; Hayes et al. 2023) currently include two defined stocks occupying Breton Sound and Chandeleur Sound (Figure 1), more recent genetic evidence suggests that a single stock occupies these areas and the Mississippi Sound (Vollmer et al. 2021). Therefore, movement of individuals between these areas is likely to occur.

There is little available data to evaluate the abundance and seasonal movements of bottlenose dolphins within this region. The best available survey data include only coarsely spaced aerial survey tracklines, were conducted more than a decade ago, and had limited seasonal observations. Therefore, the resulting abundance estimates for the currently defined stocks are highly uncertain (Garrison 2017; Garrison et al. 2021), and seasonal changes in spatial distribution or abundance within this region are poorly understood.

To improve the information used to assess the potential impacts of the proposed Mid-Breton Sediment Diversion Project on common bottlenose dolphins, a series of monthly visual line-transect aerial surveys was conducted between November 2021 and June 2023. The surveys conducted from November 2021 to October 2022 encompassed three strata defined as: Chandeleur Sound, Breton Sound, and MS River Delta (Figure 1), while those from December 2022 to June 2023 included only Chandeleur Sound. The primary objective of these surveys was to provide monthly estimates of bottlenose dolphin abundance within the surveyed area and provide information on seasonal changes in animal density within three survey strata.

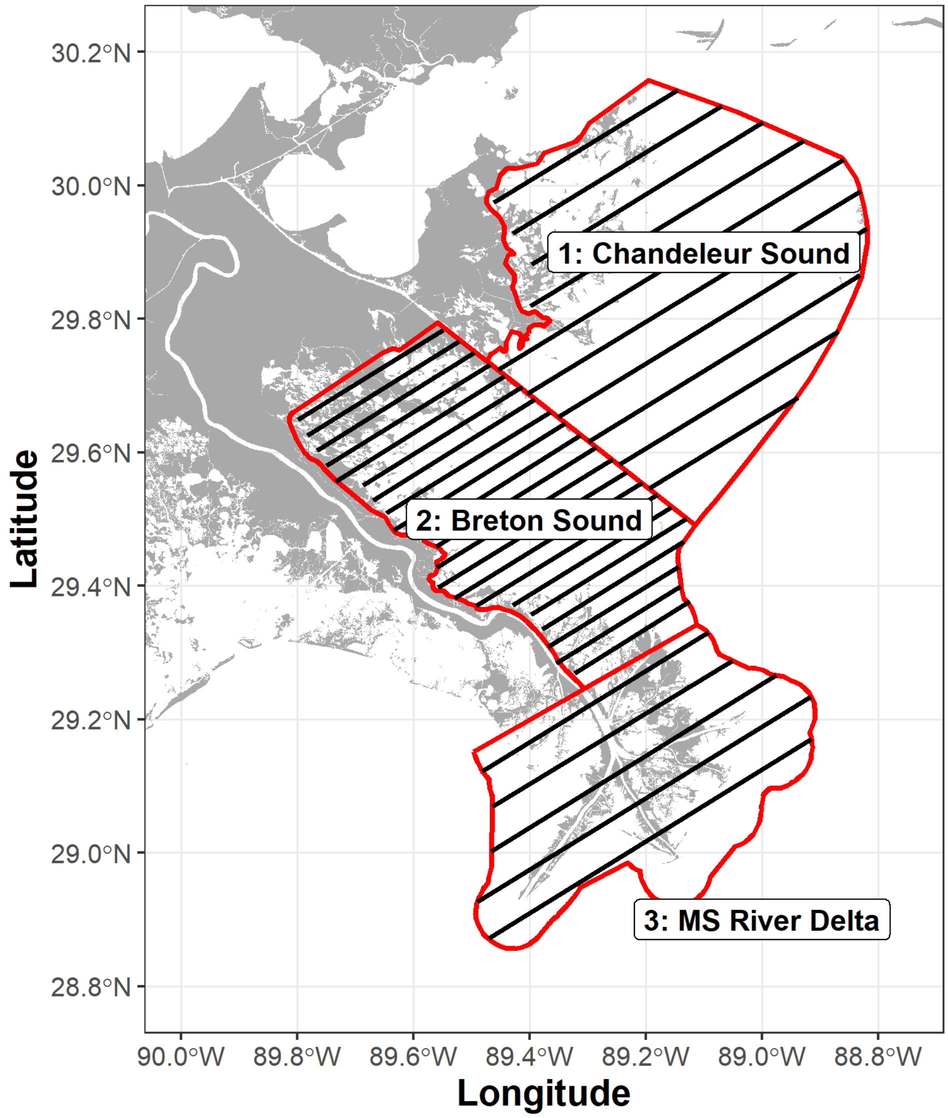

Figure 1. Survey strata and planned tracklines in Breton and Chandeleur Sounds.

2. Survey Data and Sightings

The survey was conducted along tracklines in three designated strata (Figure 1) corresponding to expected areas where varying impacts from the proposed sediment diversion project might be expected. Tracklines were uniformly spaced at 3 km apart in the Breton Sound stratum and 6 km apart in the Chandeleur Sound and MS River Delta strata. The strata areas and planned survey effort are shown in Table 1.

Table 1. Planned survey effort in each stratum.

Name	Area (km^2)	Effort (km)
Chandeleur Sound	3,070	491.6
Breton Sound	2,080	650.9
MS River Delta	1,846	276.2

The surveys were flown at an altitude of 229 m (750 ft) in a high-winged aircraft with flat side windows. Two observers were stationed on either side of the aircraft and visually searched for bottlenose dolphins. Due to the flat windows and the presence of landing gear in the visual field, it was not possible for the observers to visualize the region directly beneath the aircraft. Upon detecting a marine mammal group, the observer used an inclinometer to measure the angle to the group from the horizontal when the group was perpendicular to the aircraft. The observers then identified the group to species and obtained a count of individuals (group size) and the number of calves present. The sighting angle (θ) was used to calculate the perpendicular sighting distance (PSD) to each observed dolphin group (PSD = $tan\ (90 - \theta) * \text{Altitude}$). Aircraft position and altitude were recorded continuously throughout the survey, and the observers recorded environmental conditions that affect the ability to detect marine mammals along with sighting information using the AerialVisSurvey logging computer program. Surveys were restricted to conditions when the sea state was 4 (defined as 3-4 ft swell height with numerous white caps) or less and when there was no significant haze or fog, as the probability of detection declines in poor environmental conditions, making the survey ineffective. Conflicts with airspace use or safety considerations also resulted in restricted survey effort in a few cases.

The accomplished survey effort is shown in Table 2. Although four of the surveys (December 2012, April 2022, September 2022, and February 2023) were conducted in average conditions rated as "poor" by the observers and the August 2022 survey was conducted in a high average sea state, average conditions during most of the surveys were rated as "good" (Table 2). Results from the surveys conducted under poor conditions should be interpreted with caution. Detection probabilities during these surveys are likely low and may have prevented observations of dolphins that were present. For the majority of the surveys flown in fair or good average conditions, most of the planned tracklines were completed with the exception of the March 2022 survey, which included 71% of the planned effort in the Chandeleur Sound stratum, and May 2023, which included only 38% of the planned effort.

Table 2. Accomplished effort (in km) by stratum in each monthly survey.

Year	Month	Chandeleur Sound	Breton Sound	MS River Delta	Avg Sea State	Visual Observation Conditions
2021	Nov	466.2	643.9	273.1	2.6	Good
2021	Dec	57.4	633.0	90.7	3.2	Poor
2022	Jan	468.3	636.8	273.2	3.1	Fair
2022	Mar	329.2	693.9	220.5	2.8	Fair
2022	Apr	0.0	524.7	200.8	3.9	Poor
2022	May	423.3	627.4	270.0	2.7	Good
2022	Jun	447.8	613.3	242.6	1.9	Good
2022	Jul	425.0	632.1	264.2	2.5	Fair
2022	Aug	484.0	636.4	273.1	3.4	Good
2022	Sep	484.5	580.9	271.1	3.3	Poor
2022	Oct	484.2	606.4	182.8	2.6	Fair
2022	Dec	409.6	0.0	0.0	2.1	Good
2023	Jan	406.8	0.0	0.0	2.1	Good
2023	Feb	409.0	0.0	0.0	3.2	Poor
2023	Apr	408.9	0.0	0.0	2.4	Good
2023	May	188.7	0.0	0.0	2.2	Good
2023	Jun	408.7	0.0	0.0	2.2	Good

The number of bottlenose dolphin groups and individuals observed during each survey and stratum is shown in Table 3. The surveys flown in poor conditions are highlighted and notably include very few sightings. The number of observed bottlenose dolphins was generally highest October to March and lower April to September in the Chandeleur Sound stratum. The number of groups observed in the Breton Sound stratum was generally low, with the highest number of sightings occurring in October and November. The number of sightings in the MS River Delta stratum was more variable and did not appear to follow a clear seasonal pattern.

The accomplished survey effort and locations of bottlenose dolphin sightings during each survey are shown in Figure 2. Sightings were generally distributed evenly throughout the Chandeleur Sound stratum with the exception of the June 2022 and July 2022 surveys when the sightings were concentrated in the northern portion of the stratum. For the Breton Sound stratum, sightings were distributed evenly throughout the stratum in the November 2021 and October 2022 surveys, and were concentrated in the eastern portion of the stratum during June and July 2022. There were very few sightings in the Breton Sound stratum in the remaining surveys.

Table 3. Bottlenose dolphins observed by stratum in each monthly survey. The number of groups is shown, and the number of individuals is shown in parentheses. Dashes indicate no survey effort in the stratum. Surveys conducted in poor conditions and/or high sea states are highlighted.

Year	Month	Chandeleur Sound	Breton Sound	MS River Delta
2021	Nov	44 (93)	10 (21)	10 (28)
2021	*Dec*	*0*	*0*	*1 (5)*
2022	Jan	20 (81)	1 (1)	5 (14)
2022	Mar	32 (156)	0	6 (21)
2022	*Apr*	*-*	*0*	*1 (1)*
2022	May	11 (36)	1 (5)	2 (16)
2022	Jun	9 (32)	1 (7)	1 (6)
2022	Jul	8 (19)	6 (24)	1 (6)
2022	*Aug*	*0*	*0*	*1 (9)*
2022	*Sep*	*5 (15)*	*1 (2)*	*0*
2022	Oct	27 (59)	9 (20)	5 (16)
2022	Dec	33 (94)	-	-
2023	Jan	38 (85)	-	-
2023	*Feb*	*2 (6)*	*-*	*-*
2023	Apr	17 (42)	-	-
2023	May	6 (13)	-	-
2023	Jun	10 (27)	-	-

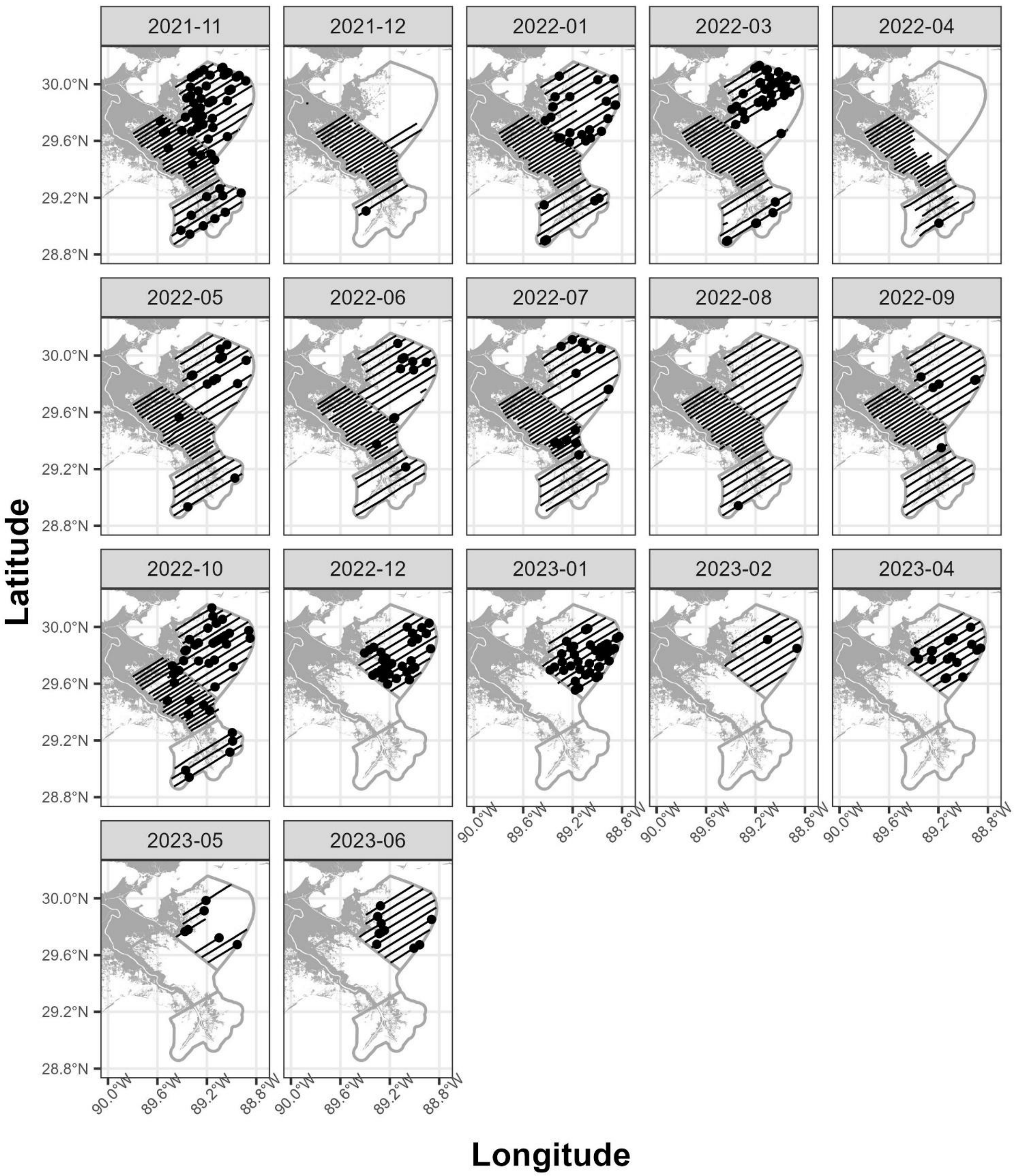

Figure 2. Accomplished survey effort (lines) and observed bottlenose dolphin groups (points) in each monthly survey. The number of bottlenose dolphin groups and individuals are shown in Table 3.

3. Distance Analysis and Abundance Estimation

Abundance estimates for each survey and stratum were developed based upon the Multiple Covariate Distance Sampling framework (MCDS; Marques et al. 2004). The standard distance analysis method (Buckland et al. 2001) estimates the probability of detection within the surveyed strip along a trackline based upon the distribution of perpendicular sighting distances (PSDs). A function describing the relationship between the number of sightings and PSDs (i.e., the sighting function) is fit to these data. Assuming that animals are actually distributed randomly with respect to distance from the trackline, the decline in detections reflects the lower probability of seeing groups that are farther away from the trackline compared to those closer to the line. Assuming that detection probability on the trackline is 1, the integral of this function provides an estimate of the overall probability of detection within the surveyed strip. The MCDS framework is an extension of this approach whereby covariates that influence the probability of detection are incorporated into the shape parameter of the sighting function. It is expected that under poor sighting conditions, a greater fraction of sightings would be observed close to the trackline compared to during good survey conditions when sightings farther from the trackline would be more easily detected. A model of the MCDS detection function is developed by selecting among different combinations of environmental covariates to determine those that have the greatest explanatory power based upon the Akaike's Information Criterion and Goodness of Fit statistics (Marques et al. 2004). All analyses were conducted in the package mrds: Mark-Recapture Distance Sampling (version 2.2.6; Laake et al. 2022) in the R statistical analysis language.

Standard distance analysis assumes a monotonically decreasing probability of detection with the highest detection probability on the trackline (i.e., PSD = 0). However, due to the presence of flat windows and landing gear obscuring visualization of the trackline, this is not the case for the current surveys. The distribution of PSD for sightings across all surveys is shown in Figure 3, and demonstrates a substantial decline in detection probability near the trackline. We followed the recommendations in Buckland et al. (2001) and "left-truncated" the PSD values at 100 m to account for this decline in detection probability on and close to the trackline. This corresponds to an angle of approximately 24 degrees from the vertical. Detection angle measurements are less reliable further away from the trackline, and the likelihood of detection is very small at these distances. We, therefore, "right-truncated" at a measured distance of 1000 m (angle from vertical

= 78 degrees). The surveyed strip, therefore, corresponds to the region between 100 m to 1000 m from the trackline.

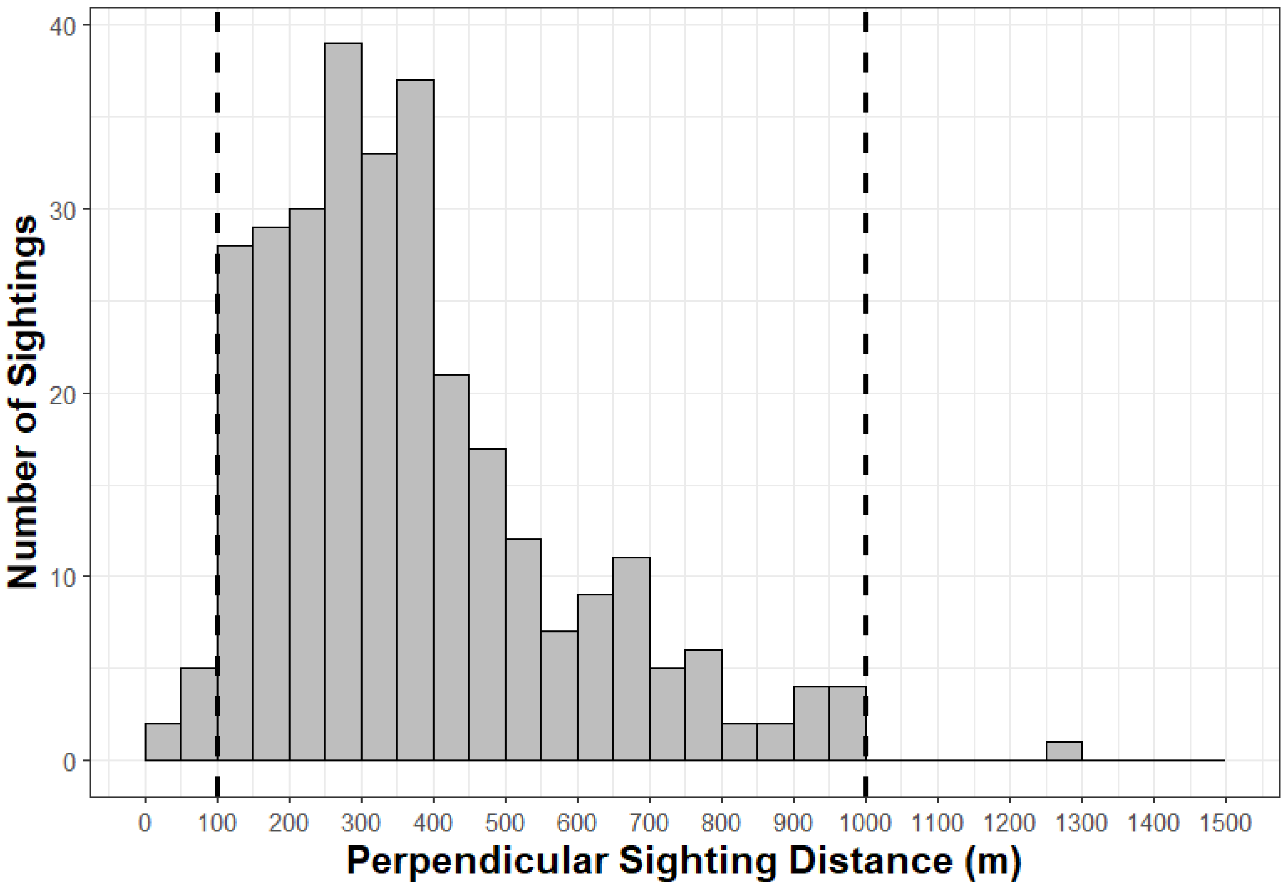

Figure 3. Perpendicular sighting distance (m) for all on effort bottlenose dolphin group sightings. Dashed lines indicate left truncation and right truncation distances at 100 m and 1000 m, respectively.

Environmental covariates, including sea state, cloud cover, viewing conditions, and glare coverage, were considered as potential covariates in the sighting function model (Figure 4). Cloud cover had the strongest apparent effect on detection distances with shorter detection distances under high cloud cover conditions. For sea state, there were generally shorter detection distances at a sea state of 3 compared to 2. There was a weak decline in detection distances with increasingly poor viewing conditions (< 1 = good to excellent, 2 = fair, 3 = poor). There was no significant correlation between log (group size) and PSD; therefore, group size was not included in the detection probability model.

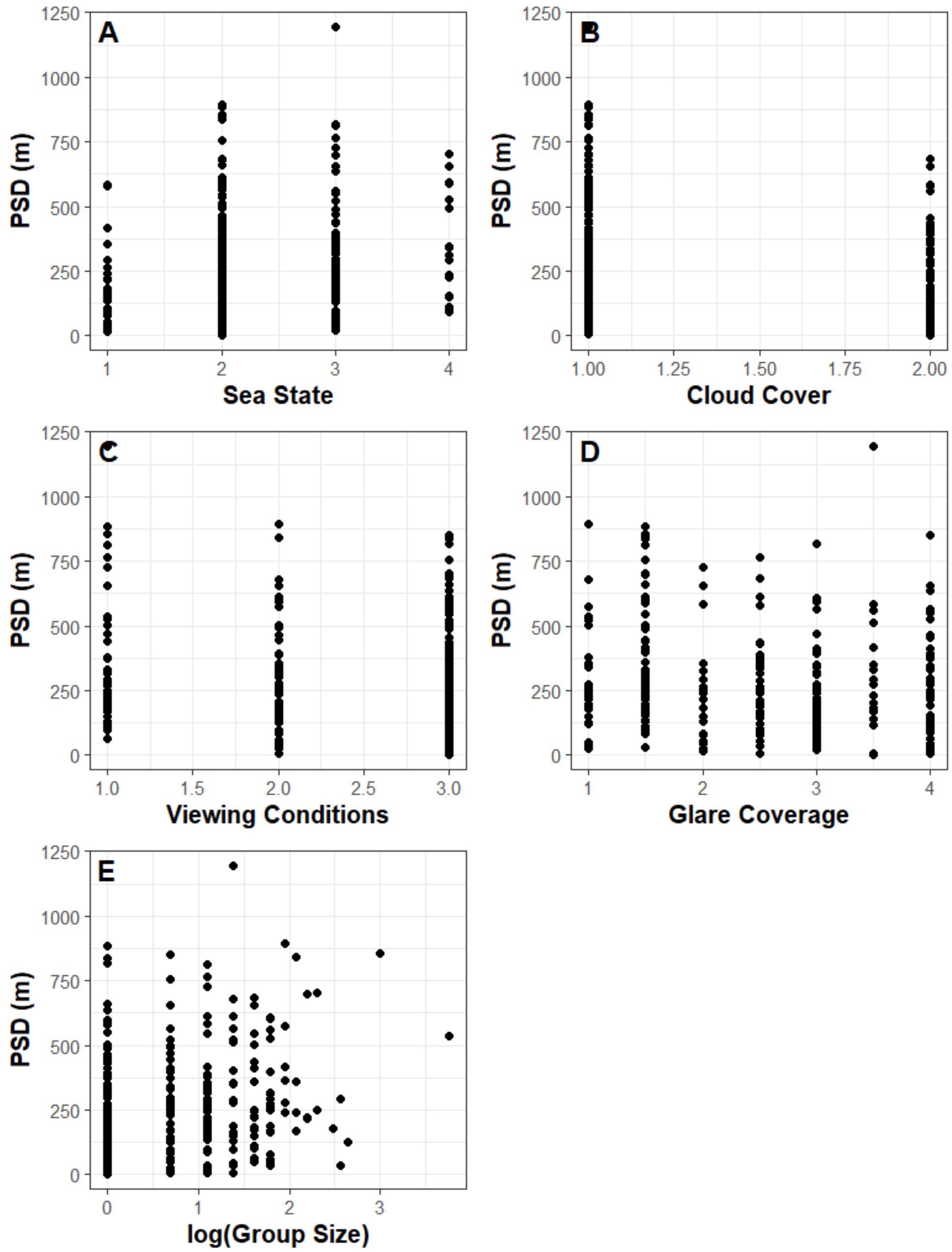

Figure 4. Perpendicular sighting distances and sighting condition variables for bottlenose dolphin sightings.

The selected detection function model was a hazard rate function including cloud cover and sea state as covariates. The resulting detection probability function is shown in Figure 5, and the estimated average detection probability in the surveyed strip was 0.502 (Coefficient of Variation = 0.060; Table 4).

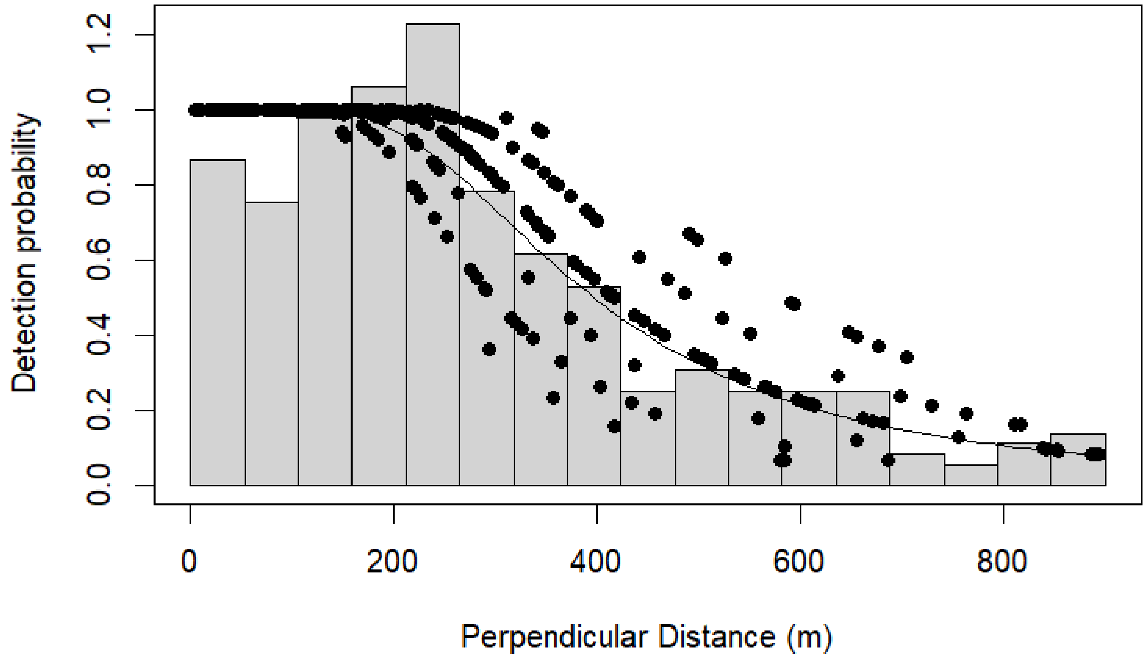

Figure 5. Detection function showing the relationship between detection probability and perpendicular sighting distance. Points indicate detection probabilities for different combinations of explanatory variables.

Table 4. Summary of the multiple covariate distance function parameter estimates.

Parameter	Estimate	SE	CV
Average p	0.502	0.030	0.060
Nhat	625.740	44.990	0.072

The resulting abundance estimates within each survey and stratum are shown in Table 5 for the surveys covering all three regions. The abundance estimates for the surveys conducted in poor conditions are less reliable than those in fair or good conditions. The abundance estimates presented here are negatively biased because the probability of detection at the left truncation distance (100m from the trackline) is assumed to equal 1. However, the actual detection probability is likely to be less than 1 and dependent upon the viewing conditions. This is apparent in the observation that surveys conducted in poor conditions also had very few sightings and low (or zero) abundance estimates. Estimates of detection probability on the trackline available for this region (Garrison 2017; Garrison et al. 2021) cannot be applied to this survey due to the difference in platform and flight altitude.

The estimated number of dolphins in the Breton Sound stratum is generally very low and, as a result, highly uncertain, particularly during the cold months of the year and the spring (Table 5). The estimates for the MS River Delta stratum were also highly uncertain and varied with no apparent seasonal pattern. For the Chandeleur Sound stratum, the abundance estimates were generally highest during colder months (winter and fall) and lower during the spring and summer (Table 6). Seasonal average abundance estimates for fall (October – December), winter (January – March), spring (April – June), and summer (July – September) excluded the surveys conducted in poor conditions and are shown in Table 7. In comparison, the abundance estimates in Breton Sound are much lower and reach their lowest level in the winter and spring.

Table 5. Estimated abundance (coefficient of variation) of bottlenose dolphins in each stratum for surveys from November 2021 to October 2022. Surveys conducted in poor conditions are highlighted. Cases where no survey effort was conducted in a given stratum are indicated by dash. The overall average excludes surveys conducted in poor conditions.

Survey (Year-Month)	Chandeleur Sound	Breton Sound	MS River Delta	Total
2021-Nov	555.1 (0.195)	56.1 (0.436)	166.3 (0.361)	777.5 (0.168)
2021-Dec	0 (0)	0 (0)	125.9 (0.967)	125.9 (0.967)
2022-Jan	503.7 (0.297)	2.6 (1.006)	91.4 (0.538)	597.7 (0.265)
2022-Mar	1526.5 (0.277)	0 (0)	161.2 (0.617)	1687.8 (0.258)
2022-Apr	-	0 (0)	0 (0)	0 (0)
2022-May	287.5 (0.493)	20.5 (1.008)	99.4 (0.963)	407.4 (0.424)
2022-Jun	301.7 (0.374)	34.5 (1.008)	56.5 (1.131)	392.7 (0.345)
2022-Jul	182.3 (0.378)	132.7 (0.902)	60.9 (1.05)	375.9 (0.412)
2022-Aug	0 (0)	0 (0)	75.3 (0.973)	75.3 (0.973)
2022-Sep	57.6 (0.654)	7.6 (1.032)	0 (0)	65.2 (0.592)
2022-Oct	375.4 (0.354)	58.9 (0.622)	151.2 (0.371)	585.5 (0.258)
Average	497.1 (0.163)	43 (0.44)	110.2 (0.248)	650.3 (0.139)

Table 6. Estimated abundance (coefficient of variation) of bottlenose dolphins in the Chandeleur Sound stratum for surveys from November 2021 to June 2023. Surveys flown in poor conditions for this stratum are highlighted in gray and are excluded from the average estimate of abundance.

Survey (Year-Month)	**Estimated Abundance (CV)**	**95% Confidence Limit**
2021-Nov	555.1 (0.195)	363.6 - 847.6
2021-Dec	0 (0)	0 - 0
2022-Jan	503.7 (0.297)	263.4 - 963.2
2022-Mar	1526.5 (0.277)	802.8 - 2902.6
2022-May	287.5 (0.493)	101.1 - 817.4
2022-Jun	301.7 (0.374)	135 - 674.5
2022-Jul	182.3 (0.378)	80.4 - 413.4
2022-Aug	0 (0)	0 - 0
2022-Sep	57.6 (0.654)	15 - 221.2
2022-Oct	375.4 (0.354)	174.3 - 808.8
2022-Dec	693.2 (0.242)	402.8 - 1193
2023-Jan	884.9 (0.301)	456 - 1717.5
2023-Feb	41 (0.629)	10.5 - 159.3
2023-Apr	294.5 (0.34)	136.6 - 635
2023-May	307.3 (0.48)	98.6 - 958.3
2023-Jun	269.2 (0.358)	121.8 - 595
Average	502.5 (0.127)	391.5 - 644.9

Table 7. Seasonal Estimated abundance (coefficient of variation) of bottlenose dolphins in each stratum. Seasonal averages excluded results from surveys conducted in poor survey conditions. Fall = October – December, Winter = January – March, Spring = April – June, Summer = July-September.

Season	Chandeleur Sound	Breton Sound	MS River Delta	Total
Fall	532.7 (0.157)	57.4 (0.376)	160.2 (0.253)	750.4 (0.134)
Winter	912.1 (0.192)	1.2 (1.007)	122.6 (0.422)	1035.9 (0.177)
Spring	290.4 (0.185)	27.4 (0.729)	79.1 (0.721)	397 (0.207)
Summer	182.3 (0.378)	132.7 (0.902)	60.9 (1.05)	375.9 (0.412)

4. Salinity and Dolphin Distribution

The variation in spatial distribution and abundance within these surveys likely reflects movements of dolphins in response to environmental conditions. One of the primary factors of concern for assessing habitat use and potential impacts from the proposed diversion project is water salinity. However, the available data on salinity in this region is only sparsely available in both space and time. Water quality sampling information at 19 stations within the surveyed area (Figure 6) was provided by Louisiana Department of Wildlife and Fisheries (LDWF), which included sampling of surface and bottom salinity (along with water temperature and dissolved oxygen) between 12 January 2022 and 27 December 2022. Data were collected at these stations at roughly 2-week intervals, though not all stations were occupied in every period. We examined these data and identified 5 sampling periods that occurred within 1-2 weeks of a given aerial survey and included complete (or nearly so) coverage of the surveyed area in both the water quality data and the aerial survey data (Table 8).

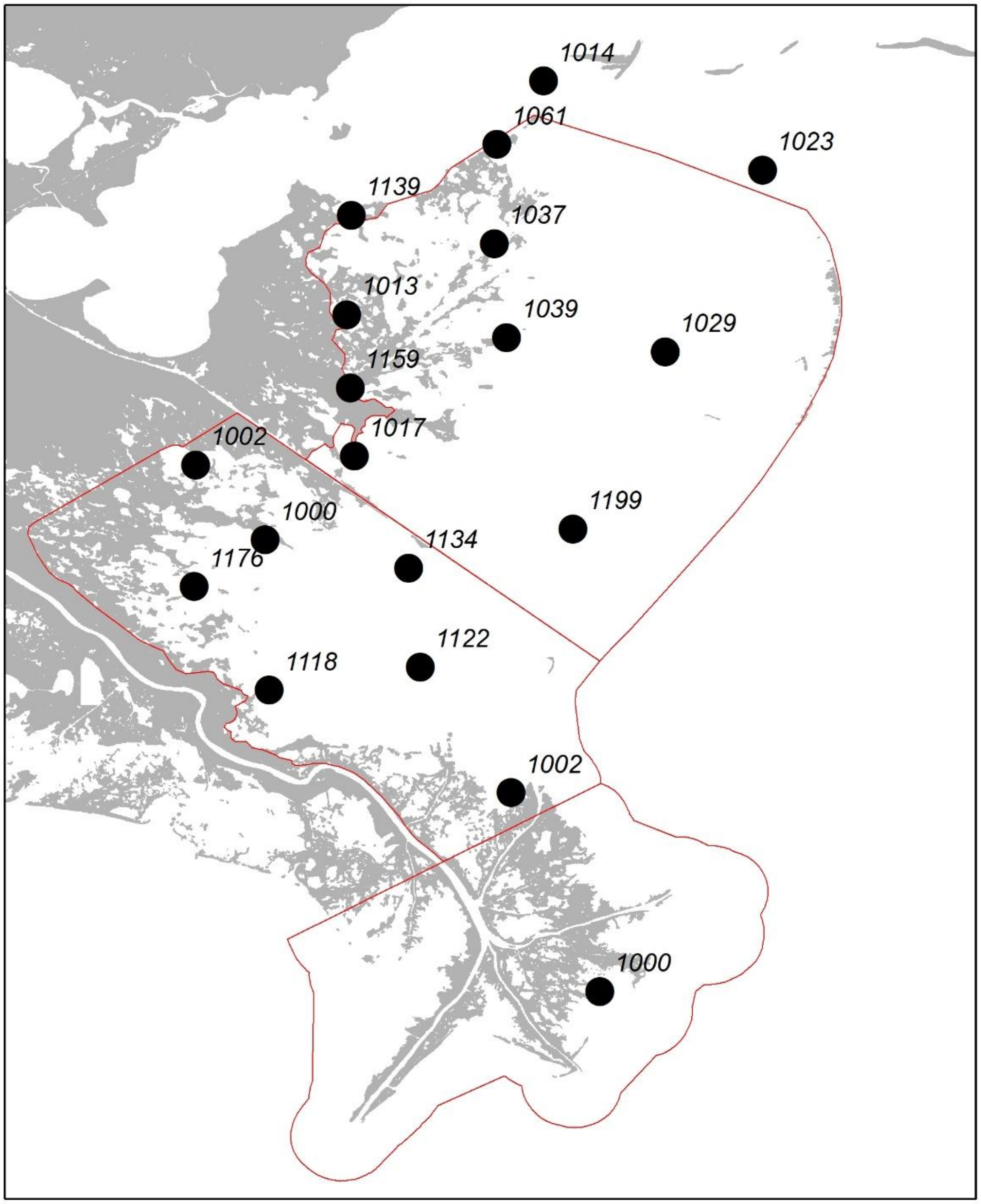

Figure 6. Locations for salinity and other water quality parameter sampling stations provided by LDWF.

Table 8. Survey and water quality sampling dates in 5 periods where both data types (water quality data and aerial survey data) were available. Note that the 2022-March period has a two-week difference between the water quality sampling and the aerial survey period and, therefore, should be interpreted with caution.

Survey Period	Survey Dates	Water Quality Sampling Dates
2022-March	9-10 March 2022	28-29 March 2022
2022-May	11-12 May 2022	10-11, 16-18 May 2022
2022-June	15-16 June 2022	20-22 June 2022
2022-July	12-13 July 2022	11-14 July 2022
2022-October	19-20 October 2022	17-21 October 2022

Based on the available water quality sampling stations for each survey period, a gridded representation of surface salinity was developed over a 0.1 degree latitude (11.1 km) x 0.1 degree longitude (9.7 km) grid using the Inverse Distance Weighted raster creation tool in ArcMap 10.8.2 (ESRI, Inc.). The surface salinity at the centroid for each grid cell is the weighted average of the sampling stations where the weighting is equal to the inverse of the squared distance to each station (Figure 7). Salinity values in the MS River Delta stratum should be interpreted with caution because there is only one sampling station in this region, and extrapolation south of the Mississippi River Delta is unreliable.

The resulting surfaces show a discontinuity in surface salinity during March-June 2022 with salinities generally less than 8 ppt dominating the Breton Sound survey stratum and higher salinities ranging from 12-18 ppt in the northern portion of the surveyed area. In July and October 2022, salinity increased throughout the surveyed area, and exceeded 8 ppt in the Breton Sound stratum. High surface salinity values (> 20 ppt) were observed in the Chandeleur Sound stratum during October 2022 (Figure 7).

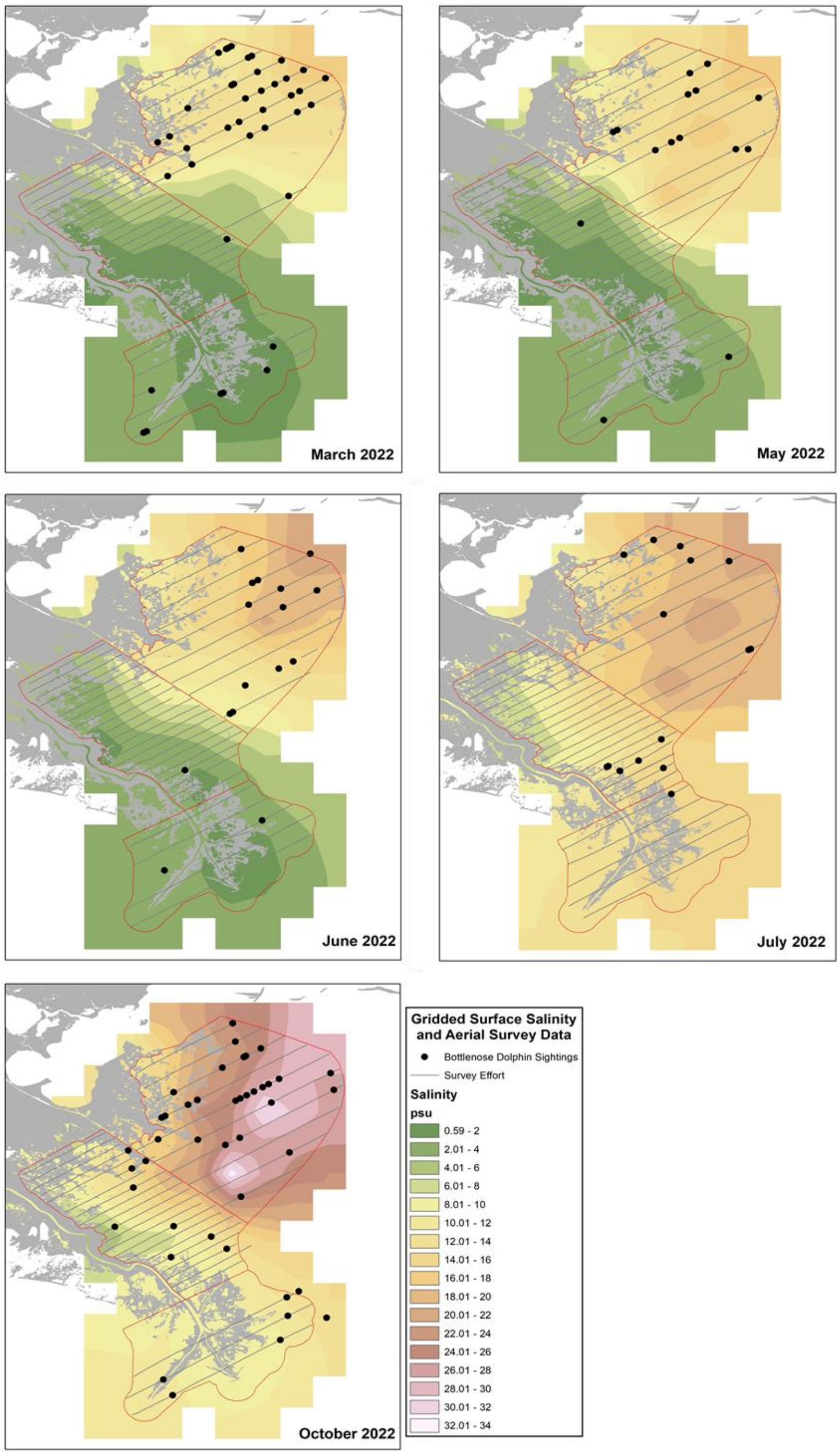

Figure 7. Inverse distance weighted gridded surface salinity, survey effort, and bottlenose dolphin sightings during five survey periods.

We summarized the survey effort (km of trackline) and the number of bottlenose dolphins sighted within each grid cell to examine the spatial relationships between bottlenose dolphins and gridded surface salinity. Dolphin selection for specific salinity ranges was evaluated by comparing the distribution of surface salinity on survey segments where dolphins were observed to surface salinity on all sampled survey segments (Figure 8).

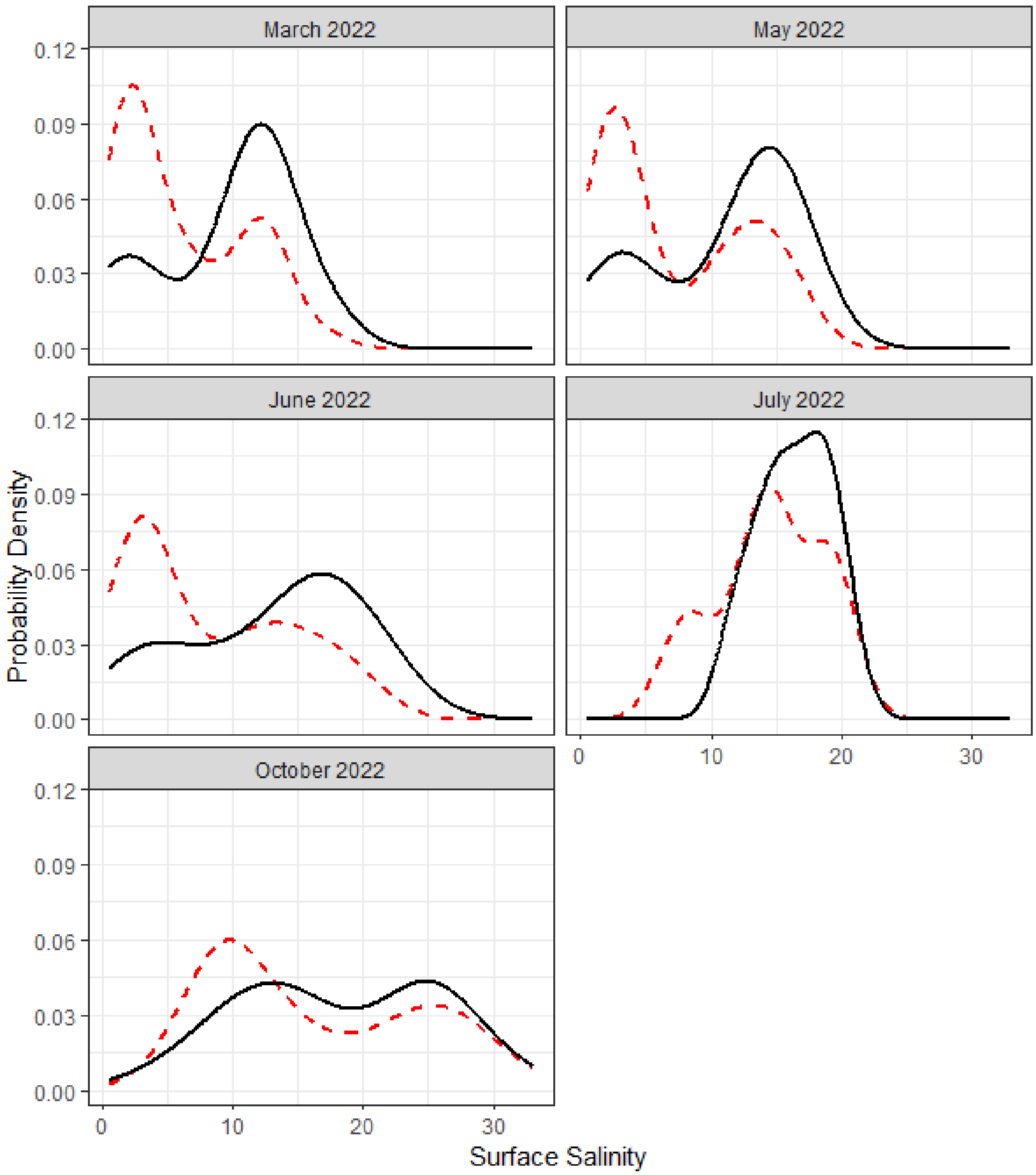

Figure 8. Probability distribution (kernel density) of surface salinity values for all survey segments (dashed red line) and those segments where bottlenose dolphins were observed (solid black line).

In March, June, and July 2022, the distribution of surface salinity on segments where dolphins were observed was very different from that on all survey segments. Segments with bottlenose dolphins were more likely to have salinities greater than approximately 8 ppt compared to all sampled segments. As the salinity increased throughout the survey area in July and October, the differences decreased, suggesting that as surface salinity increased above 10 ppt, it had less influence on dolphin spatial distribution.

We also examined the relationship between gridded surface salinity and dolphins per unit effort (NPUE; Number of Dolphins/Amount of Trackline, a proxy for dolphin density) within 2 ppt salinity intervals within each survey. In all surveys, dolphin NPUE was very low at salinities < 8 ppt (Figure 9) and was higher, but variable, at salinity values above this level. Combining data across all surveys, we see this pattern more generally with lower NPUE values in waters with salinities less than 8 ppt (Figure 10).

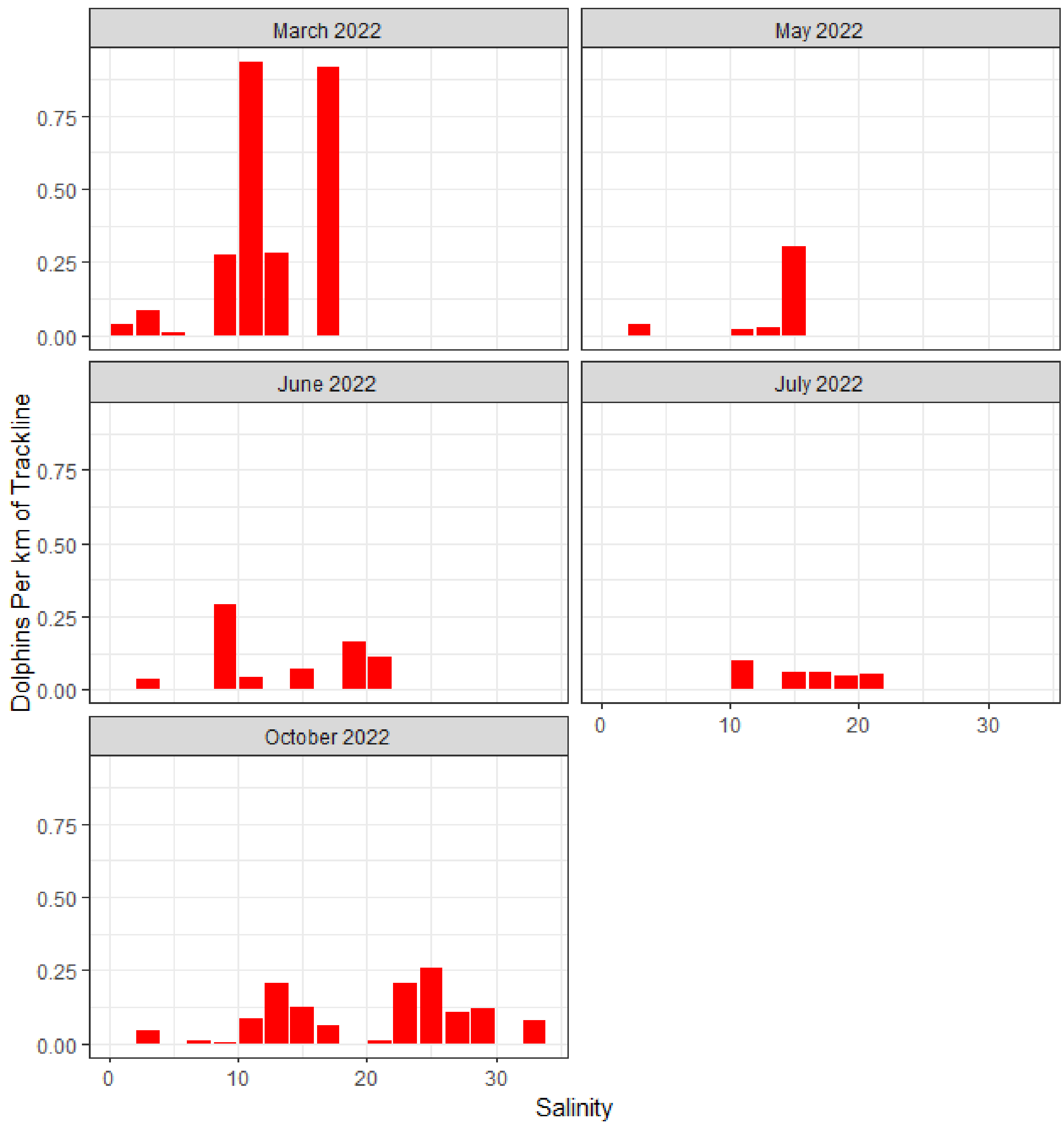

Figure 9. Dolphins per km of survey trackline in 2 ppt surface salinity bins during five aerial surveys.

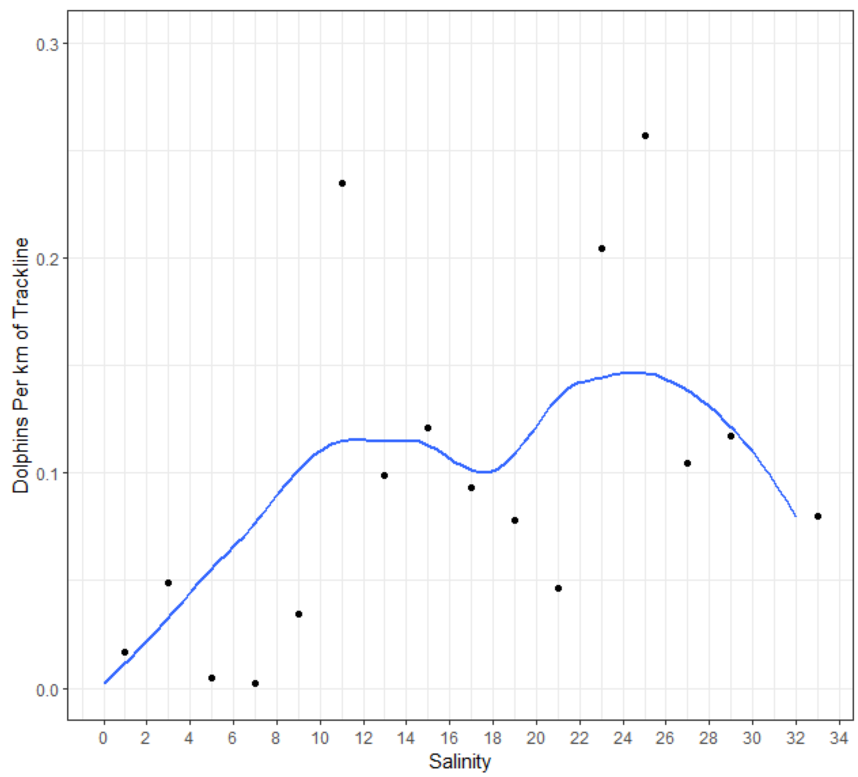

Figure 10. Dolphins per km of survey trackline (points) in 2 ppt surface salinity bins summarized across surveys. The curve (blue line) shows a loess smooth of the data points.

5. Summary

The aerial surveys conducted from November 2021 to June 2023 provide updated information on the seasonal abundance and spatial distribution of common bottlenose dolphins in the Breton Sound/Chandeleur Sound region. These data suggest seasonal variation in the abundance of animals within the surveyed area. This is consistent with the expectation that they are part of a single population that occupies a broader range as opposed to resident dolphins with high geographic specificity (Vollmer et al. 2021). These survey data suggest very low abundance of common bottlenose dolphins in the Breton Sound stratum, particularly during the winter and spring. The number of animals was higher during the summer and fall, particularly in the eastern portion of the stratum. It should be noted that the "summer" estimate for Breton Sound corresponds to only one survey conducted in July 2022. Therefore, the observation of high abundance in the summer for this stratum should be treated with caution. The high uncertainty in the abundance estimates in this stratum reflect the generally low and variable encounter rates. In the Chandeleur Sound stratum, the highest average abundance estimates were observed in the fall and winter with the highest estimate overall during March 2022. The seasonal movement patterns of bottlenose dolphins throughout the broader Mississippi Sound/Chandeleur Sound region are poorly understood, and additional seasonal survey effort over a larger area is needed to better evaluate these movement and residency patterns.

The "Breton Sound" stratum defined in this study overlaps with, but does not encompass, the defined boundaries for the Northern Gulf of Mexico Mississippi River Delta (MRD) stock of common bottlenose dolphins as defined in MMPA SARs (Hayes et al. 2023). The MRD stock boundary includes the "Breton Sound" stratum and the portion of the MS River Delta stratum on the north side of the Mississippi River as defined in this study. We post-stratified data from the surveys conducted from November 2021 to October 2022 to align with the stock boundaries and develop abundance estimates for use in stock assessment reports. These estimates use the same Distance analysis described here and are detailed in Appendix A.

The analysis of the relationships between salinity and dolphin distribution indicate that salinity values less than 8 ppt were correlated with lower dolphin densities. During the spring (April-June), low salinity values dominated the Breton Sound survey stratum, and there were few dolphins observed (with low abundance estimates) in this area. As salinities increased above 10 ppt in the Breton Sound stratum during the summer and fall, the number of dolphins observed in the stratum also increased. However, densities of dolphins remained higher in the Chandeleur Sound stratum where salinities were also higher. It appears from these analyses that salinity less than 8 ppt is correlated with lower dolphin density and lower use of a specific habitat area. Of course, this analysis focuses only on a single environmental variable, and there are likely other factors (e.g., bathymetry, prey availability, water temperature) that influence dolphin habitat use in this region. This analysis and future assessments of the effects of changing environmental conditions and dolphin distribution would benefit greatly from spatially and temporally consistent sampling of salinity and other water quality parameters throughout this region.

Surveys conducted in 2011-2012 (Garrison 2017) included effort in strata similar to the Chandeleur Sound and Breton Sound strata from this study. The abundance estimates ranged from 443 (CV = 0.75) in the winter to 1,466 (CV = 0.63) in the fall for the Northern Chandeleur Sound area in those surveys. These are higher than those from the current study and show a different seasonal pattern. For the Breton Sound area, the abundance estimates in Garrison

(2017) are much higher, ranging from 332 (CV = 0.93) in the winter to 2,038 (CV = 0.41) in the fall, and the seasonal pattern in abundance was less apparent than that observed here.

Comparison across surveys is difficult because of the differences in survey altitudes and aircraft, and in particular flat survey windows in the current survey that did not allow visualization of the trackline. Prior survey estimates also included correction for imperfect detection probability near the line. However, the survey effort in the current study in each stratum was much higher than that in the 2011-2012 surveys and included sampling across a broader range of months and survey conditions. The 2011-2012 surveys were also conducted in the immediate aftermath of the *Deepwater Horizon* oil spill, which may have influenced dolphin distribution and habitat use. While there is likely variation in both population size and environmental conditions across years that may result in changes in how bottlenose dolphins use these habitats, the current study provides the best representation of the seasonal occurrence and habitat use of bottlenose dolphins within the study area. Additional study is needed to understand how common bottlenose dolphins use these habitats and change their habitat use and spatial distribution in response to changes in environmental conditions.

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Appendix A: Abundance estimates for the Northern Gulf of Mexico Mississippi River Delta (MRD) stock of common bottlenose dolphins.

The Mississippi River Delta (MRD) stock of common bottlenose dolphins is defined within MMPA stock assessment reports (SARs; Hayes et al. 2023) within boundaries covering Breton Sound and the area north of the Mississippi River Delta bounded by the 20 m isobath to the east (Figure A1). Surveys were conducted within this stock area between November 2021 and October 2022. We post-stratified the survey effort to correspond to the MRD stock area (total area = 2,978 km^2) to develop abundance estimates appropriate for use in the SARs.

The survey effort and bottlenose dolphin group sightings within the MRD stock area are shown in Figure A1 and summarized in Table A1. While the survey effort was consistent within the stock area, the survey conditions during December 2021, April 2022, August 2022, and September 2022 were poor (see above), resulting in very few sightings during these surveys.

Abundance estimates were derived for each survey using the same detection function model described above (see Figure 5, Table 4). The abundance estimates and coefficients of variation are shown in Table A2. The overall average abundance for the stock, excluding surveys conducted under poor conditions, is 73.5 animals (CV = 0.301, 95% confidence interval: 41.1 – 131.2). This abundance estimate represents the best available abundance for this stock as defined.

However, the abundance of animals within the MRD stock boundary varies between seasons, and this appears to be correlated with changes in salinity (see Figure 10). The abundance of bottlenose dolphins within the stock area was highest during the summer and fall and lowest during winter and spring (Table A3). This suggests movements of individuals rather than a resident population within the defined boundaries.

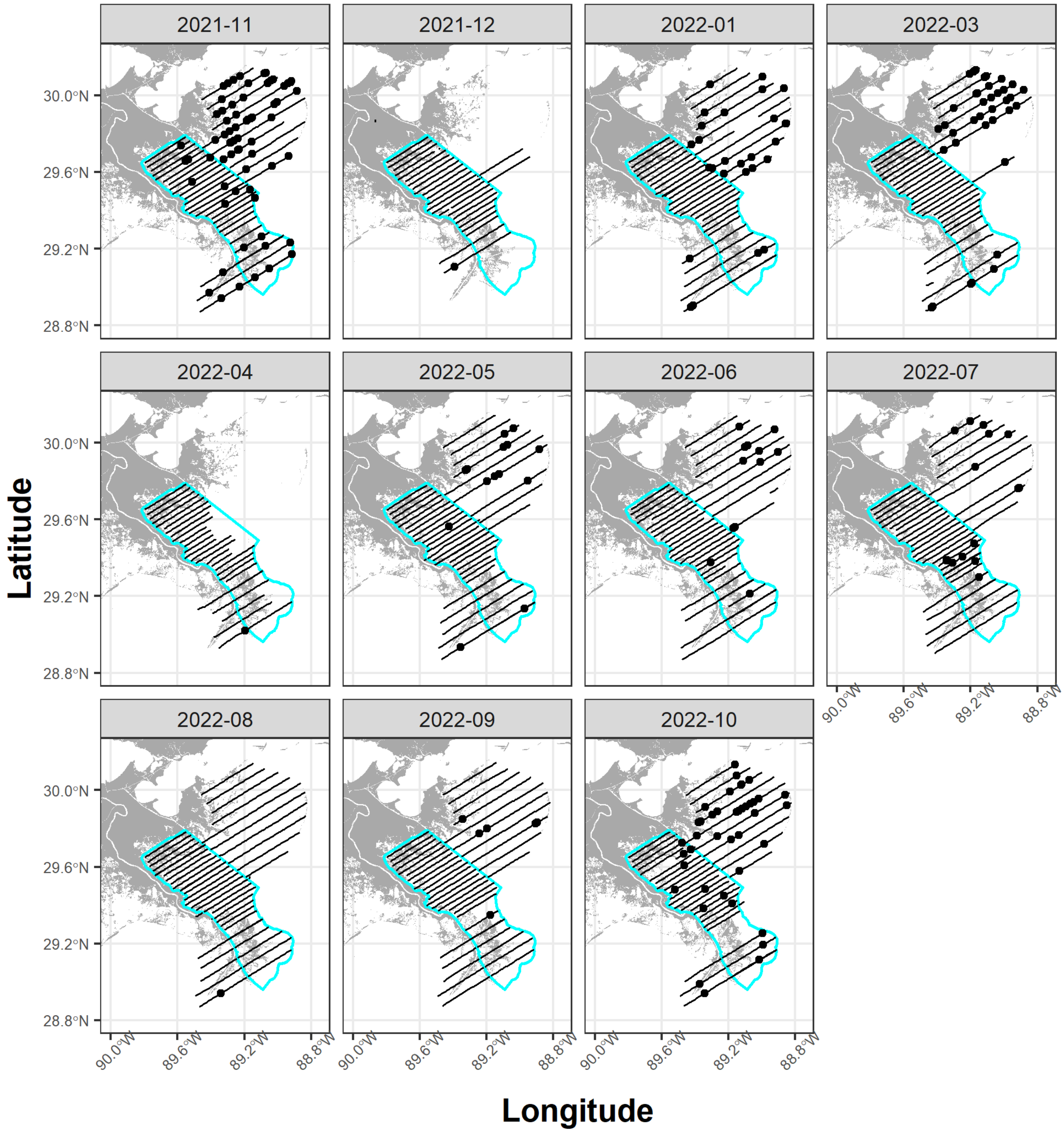

Figure A1. Aerial survey effort and dolphin group sightings. The boundaries for the Mississippi River Delta (MRD) stock area are shown.

Table A1. Bottlenose dolphins and survey effort in the MRD stock area in each monthly survey. The number of groups is shown and the number of individuals is shown in parentheses. Surveys with poor viewing conditions are highlighted.

Survey	Year	Month	Effort (km)	# of Groups (# of Individuals)
2021-Nov	2021	11	780.3	16 (30)
2021-Dec	2021	12	677.4	0 (0)
2022-Jan	2022	01	773.6	3 (4)
2022-Mar	2022	03	799.1	2 (12)
2022-Apr	2022	04	637.1	0 (0)
2022-May	2022	05	762.8	2 (13)
2022-Jun	2022	06	745.1	2 (13)
2022-Jul	2022	07	767.5	7 (30)
2022-Aug	2022	08	773.2	0 (0)
2022-Sep	2022	09	716.4	1 (2)
2022-Oct	2022	10	699.0	12 (33)

Table A2. Estimated abundance (coefficient of variation) of bottlenose dolphins in the MRD stock area for surveys from November 2021 to October 2022. Surveys conducted in poor viewing conditions are highlighted and are excluded from the overall average.

Survey (Year-Month)	Estimated Abundance (CV)	95% Confidence Limit
2021-Nov	93.5 (0.346)	46.9 - 186.3
2021-Dec	0 (0)	-
2022-Jan	12.3 (0.785)	3 - 50.9
2022-Mar	38.1 (0.704)	10.3 - 141
2022-Apr	0 (0)	-
2022-May	52.6 (0.699)	14.4 - 192.4
2022-Jun	70.3 (0.715)	18.8 - 263.3
2022-Jul	190.4 (0.76)	47.5 - 762.2
2022-Aug	0 (0)	-
2022-Sep	8.8 (1.028)	1.5 - 50.8
2022-Oct	124.1 (0.436)	52.5 - 293.5
Average	73.5 (0.301)	41.1 - 131.2

Table A3. Seasonal abundance (coefficient of variation) of bottlenose dolphins in the MRD stock area. Seasonal estimates exclude surveys conducted in poor conditions (see Table A2).

Season	Estimated Abundance (CV)	95% Confidence Limit
Fall	108 (0.285)	61.7 - 188.9
Winter	12.3 (0.785)	3 - 50.9
Spring	45.2 (0.499)	17.5 - 116.4
Summer	131.2 (0.591)	43.8 - 393.1