Bottlenose Dolphin Occurrence in St. Andrew Bay, Florida and Coastal Waters Near the Naval Surface Warfare Center, Panama City Division Testing Range

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Executive Summary

The National Marine Fisheries Service (NMFS) currently manages for seven bay, sound, and estuary (BSE) stocks, and one coastal stock (Northern Coastal Stock) of common bottlenose dolphin *(Tursiops truncatus)* in the Florida Panhandle. The Naval Surface Warfare Center, Panama City Division (NSWC PCD) Testing Range is positioned in the nearshore and offshore waters of the Florida Panhandle and Alabama, and includes St. Andrew Bay, FL. Currently, there is no comprehensive abundance estimate for the St. Andrew Bay BSE Stock, and there are limited data on distribution patterns, habitat use, and site fidelity for this stock. In addition, little is known about the Northern Coastal Stock that has boundaries from the Big Bend of Florida (84°W longitude) to the Mississippi River Delta, and includes the coastal waters adjacent to St. Andrew Bay.

The goals of this study were to conduct photographic-identification (photo-ID) surveys during 2015 and 2016 to determine abundance, distribution patterns, habitat use, and site fidelity of bottlenose dolphins in St. Andrew Bay and adjacent coastal waters in the NSWC PCD Testing Range over four sampling periods (July and October 2015, and April and October 2016). In addition to photo-ID surveys, opportunistic remote biopsy samples were collected to provide baseline data on genetics and contaminants. The 2016 Final Report includes the results from the April and October 2016 surveys, and a synthesis of cumulative findings across the 2015-2016 field effort.

St. Andrew Bay BSE dolphin abundance was similar across all four sampling periods (range: 199-315 individuals), and comparable to other northern Gulf of Mexico (nGoMx) BSEs of analogous geographic size. Coastal (CST) dolphin abundance estimates had large 95% CIs confounding assessment of seasonal trends. However, during April 2016, there was a large number of new individuals sighted suggesting that there may be a seasonal influx of CST dolphins. A small number of individuals were sighted in both BSE and CST waters (N = 27/392; 7%), and based upon the limited connections between the BSE and CST, the BSE survey area is likely representative of a semi-closed population. There was a correlation between dolphin numbers and water temperature, with more dolphins sighted in cooler water temperatures which may suggest a seasonal influx of dolphins during the spring and fall. BSE dolphins had similar habitat preferences to other nGoMx BSEs with dolphin density highest in Channel and Seagrass habitat types. In CST waters, the high density in the Surf Zone during both April and October may suggest an influx of dolphins from the Northern Coastal Stock into the study area. Dolphins in the St. Andrew Bay region continue to be exposed to chronic human interactions (HI). The survey design for the current project was not appropriate for a comprehensive assessment of HI issues in St. Andrew Bay. However, this study did identify 12 HI individuals (3%; 12/392) which should be considered a minimum estimate of HI prevalence in this region. Contaminant concentrations were significantly higher in BSE than CST dolphins. Male BSE dolphins had some of the highest dichlorodiphenyl-dichloroethanes (ΣDDTs) levels measured in the southeastern U.S., which may be linked to a Superfund Site in the St. Andrew Bay region.

During 2016 photo-ID effort, a total of six Atlantic spotted dolphins *(Stenella frontalis)* were sighted in CST waters. Preliminary results from 2017 CST survey effort identified an additional 48 spotted dolphins suggesting that the Northern Gulf of Mexico Stock of Atlantic spotted dolphins may have some degree of overlap with bottlenose dolphin stocks in this region of the Florida Panhandle.

Introduction

Common bottlenose dolphins (*Tursiops truncatus*) inhabit the bays, sounds, and estuaries (BSEs), and coastal waters of northwest Florida on the northeastern shore of the Gulf of Mexico, also known as the Florida Panhandle (reviewed in Waring et al., 2016). Currently, the National Marine Fisheries Service (NMFS) has delineated one coastal (Northern Coastal Stock) and seven BSE dolphin stocks within the nearshore waters of the Florida Panhandle (Waring et al., 2016) (Fig. 1). Two of these BSE stocks, Choctawhatchee Bay and Apalachicola Bay, have been the focus of short 1-2 year studies using photographic-identification (photo-ID) surveys to estimate seasonal dolphin abundance and gain insight into stock structure (Conn et al., 2011; Tyson et al., 2011; respectively). The St. Joseph Bay BSE Stock, subject of the only long-term study of dolphins in the Florida Panhandle, has been studied intermittently since 2004 to determine seasonal abundance and distribution patterns (Balmer et al., 2008; in review), assess dolphin health (Schwacke et al., 2010), and identify contaminant levels (Balmer et al., 2015; Wilson et al., 2012). Although these studies provide valuable information for BSE stock assessment in the Florida Panhandle, little is known about the distribution patterns of putative members of the Northern Coastal Stock, boundaries of which stretch from the Big Bend region of Florida (84°W longitude) to the Mississippi River Delta (Waring et al., 2016). During spring and fall, seasonal influxes of dolphins into the St. Joseph Bay region, wherein abundance increased 2-3 fold, have been documented (Balmer et al., 2008). Additionally, extended movements of several individuals have been identified [St. Joseph Bay to Destin, FL (~ 100 km) and Mississippi Sound (~300 km)] (Balmer et al., 2016), suggesting that the Northern Coastal Stock may seasonally co-occur with BSE stocks, and coastal dolphins have ranging patterns significantly greater than BSE dolphins.

The Naval Surface Warfare Center, Panama City Division (NSWC PCD) Testing Range is located in the nearshore and offshore waters of the Florida Panhandle and Alabama, extending from the coast to over 220 km seaward, and inclusive of St. Andrew Bay, FL. Limited data exist on the St. Andrew Bay BSE Stock and adjacent Northern Coastal Stock. Blaylock and Hoggard (1994) conducted aerial line transect surveys in the fall of 1992 and 1993 and estimated the abundance of the St. Andrew Bay BSE Stock to be 124 (59 – 259; 95% CI). Bouveroux et al., (2014) conducted photo-ID surveys in a limited portion of the St. Andrew Bay BSE Stock's boundaries and estimated abundance ranging from 89 (71 – 161; 95% CI) in March – May 2004 to 183 (169 – 208; 95% CI) in June – July 2007. There is no current NMFS-recognized abundance estimate encompassing the entire St. Andrew Bay BSE Stock. Furthermore, it is unknown if St Andrew Bay seasonally hosts some portion of the Northern Coastal Stock in a pattern similar to what is observed in the St. Joseph Bay region.

Marine mammal photo-ID surveys have been used extensively to estimate abundance via capture-recapture (CR), closed and robust population models (Thompson et al., 1998). When photo-ID, CR methods are used, the four assumptions of closed, CR models (Seber, 1982) can be reasonably met if each primary period is completed in a short period of time, dorsal fin markings are not lost on recapture, and full survey coverage of the study area allows for capture homogeneity (Read et al., 2003). The robust design model uses characteristics of closed population models to estimate abundance and open population models to calculate survival and emigration (Kendall et al., 1997; Pollock, 1982). This model has been applied to nearshore bottlenose dolphins to estimate seasonal abundance (primary periods) in a study area by conducting multiple, short-term photo-ID surveys (secondary sessions) and accounting for variations in capture probabilities using aspects of an open population model (e.g. Balmer et al., 2013; Speakman et al., 2010; Wilson et al., 1999).

Photo-ID surveys have also been used to identify habitat use and distribution patterns of marine mammals (Hammond, 1990). Habitat selection by small cetaceans has generally been investigated by examining the relationship between distribution patterns and environmental parameters (e.g. Bräger et al., 2003; De Segura et al., 2008). Environmental factors used to assess cetacean habitat use include distance from shore, temperature, salinity, and water depth (e.g. Miller and Baltz 2010; Torres et al., 2003). Although these abiotic factors have been correlated with dolphin distribution, prey distribution is more likely the principal causative factor influencing dolphin habitat selection (Heithaus and Dill 2002; Gannon and Waples 2004; Torres et al., 2008). In the coastal waters of the southeastern U.S., dolphin distribution has been linked to water temperature and prey availability (Barco et al., 1999; Torres et al., 2005). Photo-ID surveys to identify dolphin density and distribution patterns in conjunction with spatial habitat mapping are a valuable tool to quantify dolphin habitat use (Smith et al., 2013). For example, in Florida Bay, FL, dolphin surveys, prey distribution mapping, and spatial analyses were used to link fine-scale benthic habitat types to different types of dolphin foraging (Torres and Read, 2009).

The goals of this study were to build upon data collected during July and October 2015 to determine abundance, habitat use, and distribution patterns of bottlenose dolphins in St. Andrew Bay and adjacent coastal waters in the NSWC PCD Testing Range over an additional two sampling periods (April and October 2016). During spring and fall in the adjacent St. Joseph Bay region, the observed 2 to 3 fold increase in abundance was attributed to Northern Coastal Stock dolphins entering St. Joseph Bay waters. St. Joseph Bay summer abundance was low and animals sighted during this season were hypothesized to solely represent the BSE Stock. The focus of the 2015 St. Andrew Bay surveys were to target two seasons based upon prior observations in St. Joseph Bay; summer (July) - only the St. Andrew Bay BSE Stock hypothesized to be in the region, and fall (October) - both the Northern Coastal Stock and St. Andrew Bay BSE Stock hypothesized to be in the region. For the 2016 surveys, the goals were to survey in spring (April) to determine if there was an influx of dolphins in the St. Andrew Bay region, and fall (October) to provide a comparison to the 2015 fall surveys and determine if animals sighted in spring and fall were the same individuals. Specific study objectives were:

(1) Identify which marine mammal species occur seasonally within St. Andrew Bay and coastal waters (<3 km from shoreline);
(2) Calculate seasonal resighting rates for individual dolphins and develop a site fidelity index for dolphins in this region to provide baseline data to assess long-term residence;
(3) Determine distribution patterns for dolphins within and between St. Andrew Bay and coastal waters;
(4) Estimate seasonal abundance across two primary periods (April and October 2016) and;
(5) Correlate dolphin presence with particular environmental parameters (e.g. water depth, water temperature, water salinity) and broad habitat types (e.g. shallow bay, channel, sea grass bed, surf zone, open water).

Methods

Study Area

St. Andrew Bay is a shallow estuarine tidal embayment (Grady, 1981) consisting of four bays [West Bay (WEB), North Bay (NOB), East Bay (EAB), and St. Andrew Bay (SAB) proper], located in the Florida Panhandle (Fig. 2A). This embayment is unique among Gulf coast estuaries in that the waters are relatively deep and clear as it receives very little freshwater input and sedimentation (Brim and Handley, 2002). Mean depth in SAB is approximately 5 m, while WEB, NOB, and EAB are generally shallower (2 m) (Ichiye and Jones, 1960). Salinity is approximately 30 parts per thousand (ppt) but can occasionally drop below 10 ppt in proximity to freshwater input and away from the Gulf (Ichiye and Jones, 1960). The primary source of freshwater, with an average discharge of 15.3 m^3/s, is Econfina Creek (reviewed in Brim and Handley, 2002) that flows into Deer Point Lake and empties into NOB at Deer Point Dam (Fig.1A). St. Andrew Bay is characterized by a diurnal tidal cycle with a mean range of 0.4 m (Salsman et al., 1966). Seagrasses, primarily shoal grass *(Halodule wrightii)* and turtle grass *(Thalassia testudinum)*, are found throughout St. Andrew Bay (Grady, 1981).

The St. Andrew Bay photo-ID study area includes the estuarine waters of SAB, NOB, WEB, and EAB (Fig. 2A). The survey area also includes Gulf coastal (CST) waters directly adjacent to the estuary (CSTC) and extending approximately 3 km offshore (CST3K) from southwest of Crooked Island Sound (northern boundary of the St. Joseph Bay BSE Stock) to Gulf of Mexico waters across from WEB.

Capture-recapture (CR) Photographic-identification (photo-ID) Surveys

CR photo-ID surveys were conducted during spring (April) and fall (October) of 2016. For BSE waters, contour transects (i.e. transects following a particular geographic feature) were followed either 500 m from the shoreline or along the 1 m depth contour (Fig. 2A). For CST waters, contour transects were followed at 500 m and 3 km from shoreline. The total distance of all survey transects for the BSE and CST waters were 200 km and 52 km, respectively.

Following the robust-design (Pollock 1982), survey effort was temporally divided into primary periods. Within each primary period, three secondary sessions were completed, in which all transects were surveyed. Once a secondary session was completed, survey effort was halted for $\geq$ 1 day to allow for sufficient population mixing (reviewed in Rosel et al., 2011). The BSE and CST transects were separated into two distinct survey areas to optimize survey effort, and allow for calculation of separate abundance estimates for each area. All transects were surveyed a total of six times (six secondary sessions) across April and October 2016 using the same sampling methodology as July and October 2015. Abundance estimates were determined for all four primary periods across 2015 and 2016. Surveys were conducted in a Beaufort Sea State (BSS) of three or less to optimize sighting conditions.

The survey vessel was a 6.3 m, center-console, Zodiac rigid-hulled inflatable boat (RhIB) with twin 90-hp Yamaha four stroke outboard engines. Survey speed was maintained at approximately 30 km/h while searching for dolphins. At least three observers were required, and each observer covered 60° of the 180° forward of the vessel beam. During each survey, a sighting was recorded when any dolphin was encountered. Sighting data were recorded onto a data sheet that included time, geographic location (GPS coordinates), total number of dolphins, group behavior(s), and various observational and environmental parameters (reviewed in Melancon et al., 2011). A Canon EOS-1Dx (Canon USA Inc, Melville, NY USA) with a 100 -

400 mm telephoto lens (or comparable digital camera) was used to capture dorsal fin images of each individual in the group. Effort was made to photograph all dolphins within a sighting (full photo coverage) without regard to distinctiveness. Circumstances that could preclude full coverage included: 1) prolonged adverse reactions by one or more dolphins in the group; 2) sighting duration > 45 minutes; and 3) adverse weather conditions.

All digital photographs were downloaded and sorted using protocols discussed in Speakman et al. (2010). A standardized approach was used to grade photographic quality and dorsal fin distinctiveness (Urian et al., 2014). Photographic quality of the best left and/or right side dorsal fin image was graded based upon the focus, contrast, angle, dorsal fin visibility, and proportion of the dorsal fin within the image frame. Digital dorsal fin images with a Q-1 (excellent) or Q-2 (good) quality grade were included in data analyses; images with a Q-3 (poor) grade were excluded. A distinctiveness rating (D1-very distinctive, D2-moderately distinctive, D3-not distinctive) was given to each identified individual, as agreed upon by two experienced researchers. Photographs and associated sighting data were entered into FinBase (Adams et al., 2006), a customized Microsoft Access (Microsoft Corporation, Redmond, WA, USA) database. Dorsal fin images were also incorporated into the Digital Analysis to Recognize Whale Images on a Network (DARWIN) Program, which utilizes image processing algorithms to identify dorsal fins that have the same or similar dorsal fin features (Roberts et al., 2000). The St. Andrew Bay project is the first to use DARWIN in conjunction with FinBase for dorsal fin matching and the incorporation of both of these programs has formed the foundation of an enhanced and more efficient matching process that is currently being applied to other bottlenose dolphin photo-ID projects in the southeastern U.S.

Capture-recapture (CR) Photographic-identification (photo-ID) Survey Data Analyses

Survey Summary

Data were compiled to provide a summary of the 2016 fieldwork within each primary period (April and October), survey area (BSE and CST), across primary periods and survey areas, and cumulatively. Survey metadata included total hours, total kilometers, on-effort hours, survey kilometers, and time in contact with dolphins. Total hours and total kilometers were the amount of time on-water, including both on-effort (active dolphin surveying) and off-effort (transit from the dock and between transects). Survey kilometers were the total kilometers on-effort and time in contact was the total hours spent in dolphin sightings. Sighting data included total number of sightings, dolphins, calves, neonates, mean group size, dolphins photographed, and proportion of dolphins photographed. The total number of sightings was a sum of all sightings for a given primary period, survey area, or cumulatively. The total number of dolphins, calves, and neonates, mean group size, and number of dolphins photographed were determined through subsequent lab-based photo-analysis (PA). The proportion of dolphins photographed was determined by dividing the number of dolphins identified using PA by the best field estimates (FE) of dolphins sighted.

Discovery Curve

A discovery curve visually displays the number of new, distinctive individuals identified during a primary period or another defined period of time as well as the total catalog size over time. These data can be used to provide insight into immigration/emigration, appropriate study area boundaries, and the total photo-ID catalog size (reviewed in Wilson et al., 1999). For the CR photo-ID surveys, the number of previously identified individuals, number of new individuals, and total number of individuals were determined for each secondary session.

For all survey effort (CR photo-ID and remote biopsy sampling surveys), the number of previously identified individuals, number of new individuals, and total number of individuals in the St. Andrew Bay photo-ID catalog were determined for each primary period.

Site Fidelity

The St. Andrew Bay study includes four primary periods across a 2-year time span. This design enables short-term assessment of seasonal and yearly site fidelity. These data will provide a framework to more fully identify site fidelity of dolphins in the St. Andrew Bay region through comparison with previous photo-ID surveys in St. Andrew Bay (Bouveroux et al., 2014; Powell, pers. comm.) and adjacent bays such as St. Joseph Bay (Balmer et al. 2008, in review) using the Gulf of Mexico Dolphin Identification System (GoMDIS) (Cush and Wells, 2015), as well as subsequent photo-ID effort in the region. The total number of distinctive dolphins sighted in one, through all four primary periods, was determined to form a foundation for identifying site fidelity in the St. Andrew Bay study area. For individuals sighted in one primary period, the season/year sighted was used to provide insight into potential seasonal trends in the Northern Coastal Stock.

Distribution Patterns

To identify distribution patterns in the St. Andrew Bay region, the number of distinctive animals sighted solely in BSE waters, solely in CST waters, and in both survey areas were determined for each primary period and across all four primary periods (2015-2016). Subsequently, all individuals in the St. Andrew Bay photo-ID catalog were classified by their presence/absence in BSE and/or CST waters.

Habitat Use

To assess habitat use, the study area was classified into one of six habitat types: Bay Channel, Gulf Channel, Open Water, Seagrass, Shallow Bay, and Surf Zone (Fig. 2B). Each habitat type was defined as a shapefile layer using ArcGIS 10.4 (ESRI, Redlands, CA, USA). Bay and Gulf Channel boundaries were determined using the locations of channel markers/buoys. Open Water habitat was defined as all Gulf waters from approximately 1 - 4 km offshore bounded by the CST3K survey transect. Seagrass habitat was defined by using the Florida Fish and Wildlife Research Institute (FWRI) Seagrasses in Florida dataset (http://geodata.myfwc.com/datasets). Shallow Bay habitat included all estuarine waters not previously defined as Seagrass or Bay Channel habitats. Surf Zone habitat was defined as all Gulf waters from shoreline to approximately 1 km offshore and bounded by the CSTC survey transect. The area of each habitat type was calculated to determine total available dolphin habitat in the St. Andrew Bay study area. To identify fine-scale habitat preference, a relative density of dolphins per habitat area was calculated for each primary period by dividing the total number of dolphins sighted in each habitat by the respective habitat area (km^2). Dolphin density was also calculated for each survey area (BSE or CST) and cumulatively by dividing robust population model abundance for a given primary period by the total area (km^2) for each respective survey area.

To explore relationships between environmental parameters and dolphin presence, the distribution of depth, salinity, and temperature observations from all sightings were examined using box plots (median, quartile, and range), stratified by season (April and October primary periods) and survey area (BSE and CST). The box plots were then compared with the abundance estimate for each season and area. In addition, linear regression was used to examine the association of depth, salinity, and temperature observations with the total number of dolphins for each sighting.

Abundance Estimates

Robust-design CR models with variations in Markovian, random and no temporary emigration, and constant (.) or time-varying (t) survival (S) and recapture (p) were used to estimate abundance of distinctive animals (D-1 and D-2) in program MARK (Rexstad and Burnham, 1992; White et al., 1982) across all four primary periods (July and October 2015, April and October 2016). Markovian emigration models allow for different immigration and emigration probabilities across primary periods, in which individuals return to the study area based upon time-dependent functions, whereas, random emigration models allow for equal immigration and emigration probabilities, in which individuals can leave the study area and return randomly during other primary periods (Kendall et al. 1997).

The most suitable model was determined by having (1) the lowest Akaike's information criterion (AIC) values (Burnham and Anderson, 1992), and (2) model parameters thought to be most representative of dolphins in the St. Andrew Bay study area based upon photo-ID data collected in the region during 2015-2016.

MARK-produced abundance estimates from the CR population models were based solely on the number of distinctive animals (D-1 and D-2) sighted during a primary period. To account for non-distinctive dolphins, the total population size (distinctive and non-distinctive individuals) was estimated as:

$$N_{total} = N_{distinct} / \Theta \tag{1}$$

where N_{total} = estimated total population size, $N_{distinct}$ = MARK estimate of distinctive individuals, and Θ = estimated proportion of distinctive individuals in each primary period (Wilson et al., 1999). The delta method was used to extrapolate the robust-design population model abundance and 95% confidence interval (CI) to that of the total abundance and 95% CI for BSE, CST, and BSE/CST survey areas (Wilson et al., 1999).

Distinctiveness rate

In the southeastern U.S., photo-ID surveys have identified seasonal variations in distinctiveness rates suggestive of higher numbers of distinctive dolphins from coastal waters entering a given study area (Balmer et al., 2008, 2013; Speakman et al., 2010). The St. Andrew Bay study area provides a unique opportunity to compare distinctiveness rates across interior bays (EAB, WEB and NOB), bays adjacent to the coast (SAB), and coastal waters (CST) to better assess if dorsal fin distinctiveness differs across estuarine and coastal habitats. The mean distinctiveness rate for each survey area (EAB, WEB, NOB, SAB, and CST) was calculated for all survey effort (photo-ID and biopsy). An analysis of variance (ANOVA; JMP 11, SAS Institute, Cary, NC) was performed to compare mean distinctiveness rate and survey area. If the ANOVA showed a significant effect, a Tukey's Honestly Significant Difference (HSD) test for unequal sample size was used to identify pairwise statistical differences between distinctiveness rate and survey area.

Human Interactions

Dolphins in the St. Andrew Bay region have been, and continue to be, exposed to chronic human interactions (HI) in the form of “swim-with” and food provisioning activities (Samuels and Bejder, 2004). Such interactions have likely formed the foundation for additional maladaptive behaviors such as patrolling and depredating, which can increase the likelihood of severe injuries to dolphins (Powell and Wells, 2011). The NMFS Southeast Regional Office (SERO) has been working on a long-term project to assess the impacts of HI on St. Andrew Bay dolphins. In a joint effort, data were collected during all primary periods on any HI behaviors observed as well as the identity of any dolphin observed engaged in such behaviors. HI behaviors included begging, following vessel, accepting food, and patrolling. The total number of HI sightings was determined and then plotted in ArcMap 10.4 to illustrate areas where such behaviors occur. In addition, all sightings of HI implicated dolphins were plotted to assess their movements in the St. Andrew Bay region.

Remote Biopsy Sampling

Prior to this fieldwork, little was known about the stock structure and contaminant levels of dolphins in the St. Andrew Bay region. In collaboration with the Southeast Fisheries Science Center (SEFSC) and the Northwest Fisheries Science Center (NWFSC), remote biopsy samples were collected to provide baseline data on genetics and persistent organic pollutants (POPs).

Remote biopsy samples were collected using a Barnett Panzer V crossbow (Barnett Outdoors, LLC, Tarpon Springs, FL, USA). The biopsy darts used had a 56 cm (22 in) aluminum/carbon composite shaft with a modified aluminum stopper and Plei-Tech polyurethane foam (Pleiger Plastics Company, Washington, PA, USA). Biopsy cutterheads were 10 x 25 mm stainless steel with three prongs to facilitate sample collection and retention. Sample collection and in-field processing have been described previously in Sinclair et al. (2015). Briefly, samples were collected from individual dolphins at a distance of 2 - 10 m, targeting the flank of the animal below the dorsal fin and above the midline (Gorgone et al., 2008). Coincident with sample collection, photographs were taken to identify sampled individuals (reviewed in Urian et al., 2014). The sample obtained consisted of skin and a full-thickness section of blubber approximately 0.7 - 0.8 g in weight. Collected tissue was subsampled for five projects: genetics (including sex) (skin), POPs (blubber), genomics (skin and blubber), stable isotopes (skin), and hormones (blubber) (Fig. 3). The skin sample for genetic analyses was stored at room temperature in 20% DMSO saturated with NaCl (methods described by Rosel, 2003). The blubber sample used for POP contaminant analyses was stored in a pre-cleaned Teflon vial (Savillex, Eden Prairie, MN, USA), frozen in a liquid N_2 dry shipper in the field, and subsequently transferred to a -80°C freezer prior to sample analysis. The genomics sample was stored in a 2 ml vial with RNAlater or AllProtect, submerged in ice in the field, and refrigerated for 24 hours. After 24 hours, the RNAlater solution was pipetted from the vial and the sample was frozen in a liquid N_2 dry shipper. Upon return to the lab, the sample was frozen at -80°C prior to sample analysis. Skin and blubber samples for stable isotopes and hormones respectively, were stored in 2 ml cryovials, frozen in a liquid N_2 dry shipper in the field, and stored at -80°C in the lab prior to sample analysis.

Full-depth blubber samples were extracted and analyzed using gas chromatography/mass spectrometry (GC/MS) for POPs as described previously (Schwacke et al., 2014; Sloan et al., 2014). Samples were extracted, cleaned, and analyzed by GC/MS in groups of 10 – 20 with one method blank and National Institute of Standards and Technology (NIST) standard reference material (SRM) 1945 Organics in Whale Blubber. Individual analyte concentrations measured in NIST SRM 1945 were in excellent agreement with reference values published by NIST. The concentration of each analyte that was measured in the NIST SRM 1945 was, on average, within 16% of the published NIST certified value. The limit of detection (LOD) for each analyte was defined as the greater of either the analyte mass in the lowest detectable calibration solution divided by the sample mass, or the analyte's average mass detected in blanks plus three times the standard deviation (Sloan et al., 2014). The LOD values for PCB congeners ranged from < 0.00067 µg/g (wet weight) to < 0.008 µg/g (wet weight). For chlorinated pesticides and PBDEs, the LOD values ranged from < 0.00066 µg/g, wet weight to < 0.0084 µg/g, wet weight and < 0.00068 µg/g, wet weight to < 0.0084 µg/g, wet weight, respectively.

POP concentrations from dolphin blubber samples were lipid normalized to reduce the variations in lipid content associated with different field sites and other contributing factors such as nutritional health (Struntz et al., 2004), and log transformed to meet the statistical assumptions of equal variance and normality. Prior to statistical analyses, concentration values below the LOD were replaced with ½ of the LOD and analytes with a detection rate of < 75% were removed (Kucklick et al., 2011). Percent lipid data were arcsine transformed to meet the statistical assumptions of normality.

Dolphins were grouped by species, sex, and distribution pattern (exclusively BSE, exclusively CST, or sighted in both) based upon all survey effort from 2015 - 2016. One-way ANOVAs were performed to compare percent lipid, ΣOCPs, and ΣPOPs, across sexes, and among distribution patterns. A multivariate analysis of variance (MANOVA) was performed to compare concentrations of the various POP classes (ΣPCB, ΣDDT, ΣCHL, ΣPBDE, dieldrin, mirex, and HCB) among all distribution patterns. When the MANOVA indicated a significant multivariate effect, a univariate ANOVA was conducted for each POP class. When a univariate ANOVA showed a significant effect, a Tukey's HSD test for unequal sample size was used to identify pairwise statistical differences among distribution patterns and percent lipid, ΣOCPs, ΣPOPs, and POP classes.

Results

Survey Summary

CR photo-ID survey effort was conducted in the St. Andrew Bay study area during 18 - 21, 23 - 27 April and 13 - 20 October 2016 (additional remote biopsy sampling effort was conducted on 21 - 25 October and is not included in this survey summary). All BSE and CST transects were completed three times in each primary period, totaling six times in the course of 2016. Cumulatively, 1,943 km were surveyed during 117 on-water hours (Table 1). A total of 177 sightings were recorded with 964 dolphins observed, including 101 calves and 27 neonates (Fig. 2C). Mean group size was 5.4 individuals and 94% of all dolphins sighted were photographed (N = 905/964) (Table 1).

Discovery Curve

During CR photo-ID surveys, a total of 95 and 31 new, distinctive individuals were identified in April and October 2016, respectively. Within secondary sessions (s), the numbers of new individuals sighted were higher in s7 - s9 (April 2016) than s10 - s12 (October 2016) (Fig. 4A). During all photo-ID effort (CR photo-id and remote biopsy sampling surveys), the total number of new distinctive animals were comparable between October 2015 and April 2016 (96 and 95 individuals, respectively) (Fig. 4B). The discovery curve increased similarly throughout the first three primary periods (July and October 2015, April 2016), but the identification rate of new, distinctive individuals decreased in October 2016 (Fig. 4).

Site Fidelity

Of the 353 cataloged individuals sighted during CR photo-ID, 139 were sighted in only one primary period, 97 were sighted in two primary periods, 81 were sighted in three primary periods, and 36 were sighted in all four primary periods (Fig. 5A). Of the 139 individuals only sighted during one primary period, 67 were sighted in April 2016, 31 in October 2016, 25 in October 2015, and 16 in July 2015 (Fig. 5B).

Distribution Patterns

Of the 221 distinctive dolphins sighted only in April 2016, 114 (52%) and 107 (48%) were sighted exclusively in the BSE or CST waters, respectively, with none (0%) sighted in both areas (Fig. 6A). During October 2016, of the 237 distinctive dolphins sighted only in this primary period, 153 (65%) and 82 (35%) were sighted exclusively in the BSE or CST waters, respectively, with two (1%) sighted in both survey areas (Fig. 6B). One hundred and twenty distinctive dolphins were sighted in both primary periods; 88 (73%) and 22 (18%) were sighted exclusively in the BSE or CST waters, respectively, with 10 (8%) sighted in both areas (Fig. 6C). For the 392 distinctive individuals in the St. Andrew Bay photo-ID catalog, 197 (50%) and 168 (43%) were sighted exclusively in BSE or CST waters, respectively, while 27 (7%) were sighted in both survey areas (Fig. 7).

Habitat Use

In general, dolphin sighting depths were greater in CST than BSE waters (Fig. 8A). Salinity was more variable across BSE sightings (Fig. 8B), with lower salinity in April than October (median; 14.8 ppt and 28.3 ppt, respectively. Salinity was similar in CST waters across April and October (median 31.1 ppt and 34.6 ppt, respectively). Not surprisingly, variation in water temperatures measured at dolphin sighting locations was driven primarily by season, although within a season there tended to be greater variability in temperature for BSE, versus CST sightings (Fig. 8C). A linear regression analysis was performed between dolphin group size and depth, salinity, and temperature. There was no relationship identified between total number of dolphins per sighting and depth or salinity ($P = 0.9978$, $R^2 = 4E\text{-}08$; $P = 0.6344$, $R^2 = 0.0012$; respectively) (Figs. 9A and 9B). There was a significant negative relationship between dolphin number and water temperature ($P = 0.0042$; $R^2 = 0.0419$) with more dolphins sighted in cooler water temperatures (Fig. 10C). The majority of BSE habitat in the St. Andrew Bay study area was classified as Shallow Bay (204.39 km^2) followed by Seagrass (41.97 km^2) and Bay Channel (12.20 km^2) (Fig. 9). In the CST waters, Open Water comprised the majority of habitat (97.41 km^2), followed by Surf Zone (29.22 km^2), and Gulf Channel (1.06 km^2) (Fig. 10). During April 2016, dolphin density was highest in the Surf Zone (6.23 d/km^2) followed by Bay Channel (4.43 d/km^2) and Seagrass (2.41 d/km^2) habitats (Fig. 11A). During October 2016, dolphin density was highest in Bay Channel (5.33 d/km^2), followed by Seagrass (4.36 d/km^2), and Surf Zone (3.90 d/km^2) (Fig. 11B). Dolphin density in April/October 2016 followed a similar pattern with Surf Zone, Bay

Channel, and Seagrass having the highest densities (10.13 d/km^2, 9.75 d/km^2, and 6.77 d/km^2, respectively (Fig. 11C).

Abundance Estimates

A total of 12, robust-design capture-recapture (CR) models with variations in Markovian, random and no temporary emigration, and constant (.) or time-varying (t) survival (S) and recapture (p) were used to estimate BSE and CST abundance across all four primary periods (July 2015, October 2015, April 2016, and October 2016) (Table 2). All 12 CR models, for each primary period within each survey area (BSE and CST), had similar abundance estimates with overlapping 95% CIs. Based upon the short time interval for this study (2015-2016), the S(.) models (i.e. constant survival) are likely appropriate models for estimating both BSE and CST abundance. In the BSE waters, there was limited crossover between BSE and CST waters (assumption: constant recapture) (Fig. 7), and minimal to no seasonal shifts in habitat use (assumption: random emigration) (Fig. 11). Thus, the BSE waters are likely a semi-closed population and the S(.)p(.) random emigration model is a good fit to estimate BSE abundance. The CST waters are likely representative of an open population with an increase of new individuals seasonally (assumption: time-dependent function for emigration) (Fig. 5B) that may use different habitats (assumption: time-varying recapture) (Fig. 11), suggesting that the S(.)p(t) Markovian emigration model is a good fit to estimate CST abundance. The results of these two models were used to calculate total abundance in the BSE and CST waters, respectively.

Total BSE abundance was lowest in Apr-16 (199; 173 – 246, 95% CI), followed by Jul-15 (249; 199 – 338, 95% CI, and highest in Oct-15 (299; 259 – 361, 95% CI) and Oct-16 (315; 274 – 378, 95% CI) (Table 3, Fig. 12A). Total CST abundance was lowest in Oct-16 (104; 69 – 192, 95% CI) and Oct-15 (108; 71 – 204, 95% CI), followed by Jul-15 (198; 121 – 675, 95% CI), and highest in Apr-16 (208; 172 – 273, 95% CI) (Table 3, Fig. 12B). Dolphin BSE density was generally comparable across primary periods (0.77 – 1.16), while CST density was higher in Jul-15 and Apr-16 (1.55 and 1.63, respectively) than Oct-16 and Oct-15 (0.81 and 0.84, respectively).

Distinctiveness Rate

Mean distinctiveness rate was significantly different across survey areas ($P < 0.0001$) (Fig. 13). The CST survey area had the highest distinctiveness rate (0.86; 0.81 – 0.91, 95% CI), followed by SAB (0.78; 0.73 – 0.83, 95% CI), WEB (0.72; 0.64 – 0.80, 95% CI), EAB (0.68; 0.61 – 0.75, 95% CI), and NOB (0.66; 0.58 – 0.72, 95% CI).

Human Interactions

Of the 177 sightings recorded during the 2016 St. Andrew Bay survey effort, two sightings (1%) had human interactions (HI). Of these two sightings, three individual dolphins were identified as displaying HI behavior. The total number of individuals form 2015 – 2016 with HI behaviors is 12 (3%; 12/392). HI behaviors were primarily observed along the CSTC transect in both 2015 and 2016, with some additional HI observed in SAB and EAB (Fig. 14). HI individuals were observed throughout WEB, SAB, EAB, and CSTC with no apparent HI behavior as well.

Remote Biopsy Sampling

A total of 17 remote biopsy samples (N =10, ♂; N = 7, ♀) were collected during five field days during the October 2016 St. Andrew Bay field work. The total number of remote biopsy samples collected from the St. Andrew Bay study area stands at 68 (N =35, ♂; N = 33, ♀) (Fig. 15A). POP analyses were conducted by the NWFSC on 53 bottlenose dolphin samples (N = 31, ♂; N = 22, ♀) and one Atlantic spotted dolphin *(Stenella frontalis)* sample (N = 1, ♀) (Table 4). Bottlenose dolphins were grouped by sex and distribution pattern (exclusively BSE, exclusively CST, or both combined) (Fig. 15B). All POP classes were significantly higher in males than females (Fig. 16). In both sexes, POP concentrations were highest in polychlorinated biphenyls (ΣPCBs) followed closely by dichlorodiphenyl-dichloroethanes (ΣDDTs), then chlordanes (ΣCHLs) and polybrominated diphenyl ethers (ΣPBDEs), with the lowest levels observed in dieldrin, mirex, and hexachlorobenzene (HCB). BSE male and female dolphins had significantly higher POP concentrations than CST dolphins in six and four of the POP classes, respectively.

Atlantic Spotted Dolphins (Stenella frontalis)

During 2016 photo-ID effort, a total of six Atlantic spotted dolphins were sighted (April, N = 2; October, N = 4) (Fig. 17). Based upon color phase, all six appeared to be juvenile (speckled) to young adult (mottled) (reviewed in Herzing, 1997). One of the four individuals sighted in October 2016 was remote biopsied and all four individuals were subsequently resighted less than 60 minutes post-initial sighting. The remote biopsied individual was sexed as female and POP concentrations were more similar to female BSE bottlenose dolphin POP levels than female CST bottlenose dolphin POP levels (Table 4).

Discussion

The 2016 St. Andrew Bay field project built upon the 2015 work to provide a more in-depth assessment of dolphin abundance, habitat use, and distribution patterns. Based upon the small number of catalog individuals in both BSE and CST waters (N = 27/392; 7%) (Fig. 6) and the connections between the estuary and the coast for potential immigration/emigration, the BSE survey area is likely representative of a semi-closed population during and, for the most part, across primary periods. This conclusion is further supported by the robust-design capture-recapture (CR) models with time-varying (t) recapture (p) that had extremely low 95% CIs. In the case of the CST abundance estimates though because of presumed extended movements of coastal dolphins in the northern Gulf of Mexico (Balmer et al., 2008; Balmer et al., 2010; Balmer et al., 2016), the CR model assumptions of immigration/emigration were likely violated. The extremely large 95% CI for the CST likely stem from these violations. Future research investigating open population models and spatially explicit robust-design (SERD) models, as well as distance sampling methods, may provide additional insight into CST dolphin abundance and/or density.

BSE dolphin abundance was similar across April and October 2016, and when compared to the 2015 survey periods (July and October) (Table 3, Fig. 12A). The St. Andrew Bay BSE abundance estimates and dolphin densities are generally comparable to other northern Gulf of Mexico BSEs (Waring et al., 2016). Rosel et al., (2011) defined a resident dolphin as an individual that spends greater than 50% of its time within a given BSE. A total of 117 distinctive individuals were sighted in 3 or 4 of the primary periods within the St. Andrew Bay study area providing a minimum estimate of resident dolphins (Fig. 5A). CST dolphin abundance had large

95% CIs confounding assessment of seasonal trends (Table 3, Fig. 12B). However, during April 2016, there was a large number of new individuals sighted (Fig. 4) suggesting that there may be a seasonal influx of CST dolphins into the region as observed in St. Joseph Bay (Balmer et al., 2008). Additional spring survey effort could provide insight into site fidelity of these new individuals observed in 2016. Photo-ID catalogs from the current St. Andrew Bay project, St. Andrew Bay (2004 – 2007) (Bouveroux et al., 2014) and adjacent St. Joseph Bay (2004 – 2013) (Balmer et al., 2008; in review) are available in the Gulf of Mexico Dolphin Identification System (GoMDIS), a tool to compare individual project-submitted photo-id catalogs across the northern Gulf of Mexico (Cush and Wells, 2015). Comparisons between these catalogs and others in the northern Gulf of Mexico are beginning to provide insight into seasonal and long-term site fidelity within and between study areas. For example, X02, a 43 year old male dolphin captured in Crooked Island Sound in 2005 was resighted in the St. Andrew Bay study area during 2015 – 2016 suggesting long-term site fidelity to this region. In additon, Balmer et al., (2016) identified three individuals that had movements extending from St. Jospeh Bay to Destin and Pascagoula, MS, suggesting that these animals may be part of the Northern Coastal Stock and overlap with numerous study areas in the northern Gulf of Mexico. During April 2016, the highest number of neonates was observed across this two year study suggesting early evidence for a spring reproductive peak. This peak has been observed in other norther Gulf of Mexico regions including Barataria Bay, LA (McDonald et al., 2017), Mississippi Sound, MS (Hubard et al., 2004), and St. Joseph Bay, FL (Balmer et al., 2008).

The geography of the St. Andrew Bay study area, with enclosed interior bays, waters adjacent to the coast, and coastal waters allowed for an assessment of distinctiveness rates between BSE and CST dolphins. CST dolphin groups had significantly higher distinctiveness rates than BSE groups in interior bays (Fig. 13) suggesting that the rate of distinctiveness between BSE and CST waters may differ as a result of different levels of interspecific, intraspecific, and human interactions. Future research investigating distinctiveness rates in other study areas with similar geography will provide additonal insight into the differences observed between BSE and CST in the St. Andrew Bay region.

There was a correlation between dolphin numbers and water temperature in both 2015 and 2016 (Fig. 9C), with more dolphins sighted in cooler water temperatures which is suggestive of a similar seasonal influx of dolphins during the spring and fall as has been observed in the adjacent St. Joseph Bay BSE (Balmer et al., 2008). Along the east coast of the U.S., it has been hypothesized that water temperature and/or prey movement may be factors influencing coastal dolphin stocks' movements (Barco et al., 1999; Gannon and Waples, 2004). Future research investigating these factors in the northern Gulf of Mexico will provide essential data to better understand seasonal influxes of the Northern Coastal Stock.

Gulf of Mexico BSE dolphins preferentially select for channel (Allen et al., 2001), spoil island (Smith et al., 2013), and seagrass habitats (Barros and Wells, 1998; Rossman et al., 2015). Dolphins in the St. Andrew Bay study area had similar habitat preferences with dolphin density highest in Channel and Seagrass habitat types (Fig. 11). Along the east coast of the U.S., Torres et al., (2005) observed that the majority of dolphins sighted along the coast were within 3 km of the shoreline, with a rapid decrease in numbers from 3 km to 34 km offshore. The high density in the Surf Zone and low density of dolphins in Open Water habitat may indicate a similar distribution of dolphins in the coastal waters of the St. Andrew Bay study area. The high density in the Surf Zone during both April and October may also suggest influx of dolphins from the

Northern Coastal Stock into the study area during these time periods. Future research conducting extended systematic surveys in the coastal waters would provide insight into distribution patterns and habitat use of dolphins in this region.

Samuels and Bejder (2004) identified a minimum of seven distinctive dolphins engaged in HI behaviors during a 6-day study in August 1998. NMFS SERO researchers have been conducting recent surveys in the St. Andrew Bay region and preliminary results suggest that the number of HI dolphins is now several times higher than that observed in 1998. The survey design for the current project is not appropriate for a comprehensive assessment of the number of HI individuals and scale of the HI issue in St. Andrew Bay. Thus, the 12 HI individuals identified from the current study (3%; 12/392) should be considered a minimum indication of the prevalence of this behavior. However, the extended survey coverage that included all of the BSE waters within St. Andrew Bay and the adjacent coastal waters provided insight into overall movement patterns of both HI and non-HI individuals (Fig. 14). These data, in collaboration with NMFS SERO focal follows, are in the process of being used to identify differences in ranging patterns of HI and non-HI dolphins and the impacts of HI behavior in the St. Andrew Bay region.

In 1997, Tyndall Air Force Base (AFB) was added by the Environmental Protection Agency (EPA) to the Superfund program's National Priority List (NPL) because of DDT contamination 200 times greater than the EPA's risk-based standards for human and environmental health (EPA, 2007). In 2013, the Air Force, EPA, and state of Florida signed an agreement to remediate the Tyndall AFB NPL site. St. Andrew Bay male BSE dolphins have ΣDDT levels (67 μg/g lipid; 50 – 89, 95% CI) (Table 4) that are currently the highest in the southeastern U.S. (Balmer et al., 2015; Kucklick et al., 2011). Additional analyses are planned to compare mean sighting distance from the Tyndall AFB NPL site and ΣDDT levels for all sampled individuals (e.g. Balmer et al., 2011) to provide a more in-depth assessment of the geographic scope of DDT contamination in the St. Andrew Bay study area and insight into dolphin health in the course of the Tyndall AFB NPL site remediation process.

Overall, POP concentrations were significantly higher in both male and female BSE dolphins than CST dolphins (Fig. 16). These results, in combination with the photo-ID data, suggest that the high site fidelity of St. Andrew Bay BSE dolphins may play a role in the elevated levels of POP contamination. Based upon the photo-ID data, CST dolphins are sighted predominantly in CST waters and may have extended movements outside and/or offshore of the St. Andrew Bay study area, which may be a factor in their lower POP levels. Future research targeting additional remote sampling in the CST waters is necessary to fully evaluate these differences in POP concentrations between dolphins with different distribution patterns.

The Northern Gulf of Mexico Stock of Atlantic spotted dolphins includes all continental shelf (10 – 200 m deep) and slope (<500 m deep) waters in the northern Gulf of Mexico (Waring et al., 2016). Viricel and Rosel (2014) also suggest that there may be two demographically independent east-west populations that overlap between Mobile Bay, AL and Cape San Blas, FL and that move inshore seasonally during spring (Caldwell and Caldwell, 1966). During the 2016 fieldwork, six juvenile (speckled) to young adult (mottled) spotted dolphins were sighted across three sightings, of which one was remote sampled (Fig. 17). Preliminary results from coastal survey effort in 2017 identified an additional 48 individuals of all age classes, across five sightings, with three remote biopsy samples collected. Currently, little is known about spotted dolphins in this region and future research is necessary to assess density, distribution, and movement patterns of this species in the coastal waters off St. Andrew Bay.

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TABLE LEGEND

Table 1. Photographic-identification (photo-ID) effort for each survey area [Bay, Sound, and Estuary (BSE) and Coastal (CST)], primary period (Apr-16 and Oct-16), and cumulatively (2016) in the St. Andrew Bay study area.

Table 2. Robust-design capture-recapture (CR) models with variations in Markovian, random and no temporary emigration, and constant (.) or time-varying (t) survival (S) and recapture (p) ranked by lowest AICc, and used to estimate abundance in the BSE and CST regions of the St. Andrew Bay study area. The proposed best fit model utilized in the BSE and CST waters is bolded.

Table 3. Total abundance and 95% CI using robust-design capture-recapture (CR) S(t)p(.) random movement model and density estimates for each survey area [Bay, Sound, and Estuary (BSE) and Coastal (CST)], and primary period (Jul-15, Oct-15, Apr-16, and Oct-16) in the St. Andrew Bay study area.

Table 4. POP concentrations (µg/g lipid; geometric mean, 95% CI) and percent lipid content (geometric mean, 95% CI) measured in remote biopsy samples from 53 bottlenose dolphins (N = 31, ♂; N = 22, ♀) and one Atlantic spotted dolphin (N = 1, ♀). Bottlenose dolphins were grouped by sex and distribution pattern (exclusively BSE, exclusively CST, or both BSE and CST). Statistically homogeneous groups are indicated by the same letter subscripts.

FIGURE LEGEND

Figure 1. Bottlenose dolphin bay, sound, and estuary (BSE), and coastal stock structure in the Florida Panhandle.

Figure 2. St. Andrew Bay photographic-identification (photo-ID) study area with (A) survey transects and survey distance (km) [Coastal 3 km offshore (CST3K), Coastal 0.5 km offshore (CSTC), East Bay (EAB), North Bay (NOB), St. Andrew Bay (SAB), and West Bay (WEB)], (B) habitat types, and (C) 2016 sighting distribution.

Figure 3. St. Andrew Bay remote biopsy sampling schematic and project analyses.

Figure 4. Number of distinctive individuals sighted and discovery curve for bottlenose dolphins in the St. Andrew Bay study area during (A) capture-recapture (CR) photographic-identification (photo-ID) survey secondary sessions and (B) primary periods.

Figure 5. Number of distinctive individuals (A) sighted in one, two, three, or all four primary periods (July 2015, October 2015, April 2016, and October 2016); and (B) number of distinctive individuals only sighted in one primary period grouped by primary period during capture-recapture (CR) photographic-identification (photo-ID) surveys.

Figure 6. Number and percent of distinctive individuals that were sighted exclusively in Bay, Sound, and Estuary (BSE) waters, Coastal (CST) waters, or both (BSE/CST) during (A) April 2016, (B) October 2016, and (C) April/October 2016 in the St. Andrew Bay study area during all photo-ID effort [capture-recapture (CR) and remote biopsy surveys].

Figure 7. Number and percent of all distinctive individuals in the St. Andrew Bay photo-ID catalog (N = 392) that were sighted exclusively in Bay, Sound, and Estuary (BSE) waters, Coastal (CST) waters or both (BSE/CST) during all photo-ID effort [capture-recapture (CR) and remote biopsy surveys] from 2015 – 2016.

Figure 8. Box plots including median (inner line), quartiles (box) and non-outlier range (whiskers) for (A) depth, (B) salinity, and (C) water temperature observations from dolphin sightings, stratified by primary period and survey area during April and October 2016.

Figure 9. Total number of dolphins sighted and (A) depth, (B) salinity, and (C) water temperature in the St. Andrew Bay study area during April and October 2016.

Figure 10. Total area (km^2) and percentage of available habitat in the St. Andrew Bay study area.

Figure 11. Density (total dolphins sighted/km^2) and percentage of dolphin habitat use in (A) April 2016, (B) October 2016, and (C) April/October 2016 in the St. Andrew Bay study area.

Figure 12. Total abundance estimates and 95% confidence intervals (CIs) for (A) Bay, Sound, and Estuary (BSE) (B) Coastal (CST) dolphins in the St. Andrew Bay study area during the four primary periods July 2015, October 2015, April 2016, and October 2016.

Figure 13. Mean distinctiveness rate and 95% CI during all photo-ID effort [capture-recapture (CR) and remote biopsy surveys] during 2015 – 2016, grouped by survey area [West Bay (WEB), North Bay (NOB), East Bay (EAB), St. Andrew Bay (SAB), and Coast (CST)]. Statistically homogeneous groups are indicated by the same letter subscripts.

Figure 14. Sighting locations of human interaction (HI) and non-HI behavior for the twelve identified HI dolphins in the St. Andrew Bay study area from 2015 – 2016.

Figure 15. St. Andrew Bay study area remote biopsy sampling locations during 2015 and 2016, (A) grouped by primary period and (B) grouped by sex, distribution pattern, and species.

Figure 16. Concentrations (µg/g lipid; geometric mean, 95% CI) persistent organic pollutants (POPs) measured in remote biopsy blubber samples (N = 53) of (A) male (N = 31) and (B) female (N = 22) bottlenose dolphins collected in St. Andrew Bay (BSE) and adjacent coastal waters (CST). Statistically homogeneous groups are indicated by the same letter subscripts.

Figure 17. Atlantic spotted dolphin sightings and remote biopsy sampling locations during 2016.

Apr-16	**Total Hours**	**On-effort Hours**	**Total KM**	**Survey KM**	**Time in contact (hrs)**	**Total Sightings (#)**	**Total Dolphins (#)**	**Total Calves (#)**	**Total Neonates (#)**	**Mean Group Size (#)**	**Dolphins Photo'ed (#)**	**% Photo'ed**
BSE	42	23	714	580	14	51	289	27	13	5.7	259	0.90
CST	14	8	238	181	5	22	218	13	14	9.9	209	0.96
TOTAL	56	31	952	761	19	73	507	40	27	6.9	468	0.92

Oct-16	**Total Hours**	**On-effort Hours**	**Total KM**	**Survey KM**	**Time in contact (hrs)**	**Total Sightings (#)**	**Total Dolphins (#)**	**Total Calves (#)**	**Total Neonates (#)**	**Mean Group Size (#)**	**Dolphins Photo'ed (#)**	**% Photo'ed**
BSE	50	25	779	544	19	90	392	54	0	4.4	378	0.96
CST	11	7	212	188	3	14	65	7	0	4.6	59	0.91
TOTAL	61	32	991	732	22	104	457	61	0	4.4	437	0.96

2016	**Total Hours**	**On-effort Hours**	**Total KM**	**Survey KM**	**Time in contact (hrs)**	**Total Sightings (#)**	**Total Dolphins (#)**	**Total Calves (#)**	**Total Neonates (#)**	**Mean Group Size (#)**	**Dolphins Photo'ed (#)**	**% Photo'ed**
BSE	92	48	1493	1124	33	141	681	81	13	4.8	637	0.94
CST	25	15	450	369	8	36	283	20	14	7.9	268	0.95
TOTAL	117	63	1943	1493	41	177	964	101	27	5.4	905	0.94

Table 1.

BSE

Model	AICc	Delta AICc	AICc Weights	Model Likelihood	Num. Par	Deviance
{S(.)p(t) Random}	-1584.8646	0	0.85496	1.0000	24	261.9731
{S(t)p(t) Random}	-1581.2269	3.6377	0.13868	0.1622	24	257.0741
{S(.)p(t) Markovian}	-1574.7275	10.1371	0.00538	0.0063	26	259.2674
{S(t)p(t) Markovian}	-1571.171	13.6936	0.00091	0.0011	29	256.3169
{S(t)p(t) No movement}	-1565.7599	19.1047	0.00006	0.0001	26	268.2351
{S(.)p(t) No movement}	-1562.1454	22.7192	0.00001	0	23	278.2993
{S(t)p(.) Random}	-1547.7014	37.1632	0	0	20	299.1362
{S(.)p(.) Random}	**-1546.2056**	**38.659**	**0**	**0**	**18**	**304.863**
{S(.)p(.) Markovian}	-1542.6317	42.2329	0	0	21	302.0811
{S(t)p(.) No movement}	-1542.19	42.6746	0	0	19	306.7662
{S(.)p(.) No movement}	-1537.9525	46.9121	0	0	17	315.2225
{S(t)p(.) Markovian}	-1537.0149	47.8497	0	0	25	299.1362

CST

Model	AICc	Delta AICc	AICc Weights	Model Likelihood	Num. Par	Deviance
{S(.)p(t) Random}	-472.4037	0	0.7479	1.0000	24	-192.7771
{S(t)p(.) Random}	-468.111	4.2927	0.08744	0.1169	20	-193.3567
{S(.)p(t) Markovian}	**-467.7571**	**4.6466**	**0.07326**	**0.098**	**26**	**-193.0028**
{S(t)p(t) Markovian}	-466.8137	5.59	0.04571	0.0611	29	-199.5189
{S(t)p(t) Random}	-466.7595	5.6442	0.04449	0.0595	24	-199.4646
{S(t)p(t) No movement}	-458.6833	13.7204	0.00078	0.001	26	-188.8815
{S(.)p(t) No movement}	-456.0427	16.361	0.00021	0.0003	23	-176.4161
{S(t)p(.) No movement}	-454.8249	17.5788	0.00011	0.0001	19	-170.4042
{S(.)p(.) Random}	-453.3195	19.0842	0.00005	0.0001	18	-164.1812
{S(.)p(.) No movement}	-451.9714	20.4323	0.00003	0.00000	17	-155.8959
{S(.)p(.) Markovian}	-448.5486	23.8551	0.00000	0.00000	21	-164.1279
{S(t)p(.) Markovian}	-448.0627	24.341	0.00000	0.00000	25	-170.8624

Table 2.

BSE

Primary Period	**$N_{distinct}$**	**θ**	**N_{model}**	**SE (N_{model})**	**N_{total}**	**95% CI (N_{total})**	**BSE Habitat (km^2)**	**Density (N_{total}/km^2)**
Jul-15 (1)	102	0.69	172	20.71	249	199 - 338	259	0.96
Oct-15 (2)	146	0.71	212	14.31	299	259 - 361	259	1.16
Apr-16 (3)	113	0.75	149	10.94	199	173 - 246	259	0.77
Oct-16 (4)	153	0.65	205	11.60	315	274 - 378	259	1.22

CST

Primary Period	**$N_{distinct}$**	**θ**	**N_{model}**	**SE (N_{model})**	**N_{total}**	**95% CI (N_{total})**	**CST Habitat (km^2)**	**Density (N_{total}/km^2)**
Jul-15 (1)	31	0.84	166	107.46	198	121 - 675	128	1.55
Oct-15 (2)	43	0.85	92	25.67	108	71 - 204	128	0.84
Apr-16 (3)	108	0.82	171	18.86	208	172 - 273	128	1.63
Oct-16 (4)	40	0.81	84	22.39	104	69 - 192	128	0.81

Table 3.

Males	**Lipid**	**Σ POP**[1]	**Σ OCP**[2]	**Σ PCB**[3]	**Σ DDT**[4]	**Σ CHL**[5]	**Σ PBDE**[6]	**Mirex**	**Dieldrin**	**HCB**[7]
BSE *(N = 24)*	0.2^{A} (0.2 - 0.3)	145^{A} (111 - 189)	70^{A} (53 - 93)	70^{A} (53 - 93)	67^{A} (50 - 89)	2.6^{A} (2.0 - 3.5)	1.5^{A} (1.2 - 1.9)	0.2^{A} (0.1 - 0.3)	0.2^{A} (0.1 - 0.2)	0.0^{A} (0.0 - 0.0)
CST *(N = 6)*	0.3^{A} (0.3 - 0.3)	20^{B} (13 - 31)	6.6^{B} (3.7 - 12)	13^{B} (8.9 - 19)	5.3^{B} (2.8 - 10)	1.0^{B} (0.7 - 1.4)	0.5^{B} (0.3 - 0.8)	0.1^{A} (0.1 - 0.2)	0.0^{B} (0.0 - 0.1)	0.0^{B} (0.0 - 0.0)
P-value (ranging pattern)	P = 0.1233	**P < 0.0001**	**P < 0.0001**	**P < 0.0001**	**P < 0.0001**	**P = 0.0122**	**P = 0.0020**	P = 0.6789	**P < 0.0001**	**P = 0.0153**

Females	**Lipid**	**Σ POP**[1]	**Σ OCP**[2]	**Σ PCB**[3]	**Σ DDT**[4]	**Σ CHL**[5]	**Σ PBDE**[6]	**Mirex**	**Dieldrin**	**HCB**[7]
BSE *(N = 17)*	0.3^{A} (0.2 - 0.4)	22^{A} (13 - 40)	10^{A} (5.5 - 20)	11^{A} (6.6 - 19)	9.8^{A} (5.1 - 19)	0.4^{A} (0.2 - 0.7)	0.2^{A} (0.1 - 0.5)	0.0^{A} (0.0 - 0.1)	0.0^{A} (0.0 - 0.1)	0.0^{A} (0.0 - 0.0)
CST *(N = 5)*	0.3^{A} (0.2 - 0.4)	2.4^{B} (0.7 - 8.3)	0.4^{B} (0.1 - 1.9)	1.8^{B} (0.5 - 6.1)	0.3^{B} (0.0 - 1.5)	0.1^{B} (0.0 - 0.3)	0.1^{A} (0.1 - 0.3)	0.0^{A} (0.0 - 0.1)	0.0^{B} (0.0 - 0.0)	0.0^{A} (0.0 - 0.0)
P-value (ranging pattern)	P = 0.9968	**P = 0.0058**	**P = 0.0007**	**P = 0.0162**	**P = 0.0003**	**P = 0.0361**	P = 0.7058	P = 0.6699	**P = 0.0490**	P = 0.4471

Male	**Lipid**	**Σ POP**[1]	**Σ OCP**[2]	**Σ PCB**[3]	**Σ DDT**[4]	**Σ CHL**[5]	**Σ PBDE**[6]	**Mirex**	**Dieldrin**	**HCB**[7]
BOTH *(N = 1)*	0.6	126	58	67	54	3.5	1.3	0.2	0.2	0.0

Female	**Lipid**	**Σ POP**[1]	**Σ OCP**[2]	**Σ PCB**[3]	**Σ DDT**[4]	**Σ CHL**[5]	**Σ PBDE**[6]	**Mirex**	**Dieldrin**	**HCB**[7]
S. frontalis *(N = 1)*	0.2	20	4.9	14	4	0.7	0.9	0.1	0.1	0.0

[1] ΣPOPs is sum of all measured compounds.

[2] ΣOCPs includes ΣDDTs, ΣCHLs, HCB, mirex and dieldrin.

[3] ΣPCBs includes 45 PCB congeners. See Persistent Organic Pollutants (POPs) section in Methods for full list.

[4] ΣDDTs includes *o,p'*-DDD, DDE, and DDT; and *p,p'*-DDD, DDE, and DDT

[5] ΣCHLs includes alpha chlordane, *cis*-nonachlor, beta chlordane, heptachlor, heptachlor epoxide, nonachlor III, oxychlordane, and *trans*-nonachlor.

[6] ΣPBDEs includes 28, 47, 49, 66, 85, 99, 100, 153, 154, 155, 183, Br5DE04, Br5DE05, Br6DE01, and Br7DE01.

[7] Hexachlorobenzene.

Table 4.

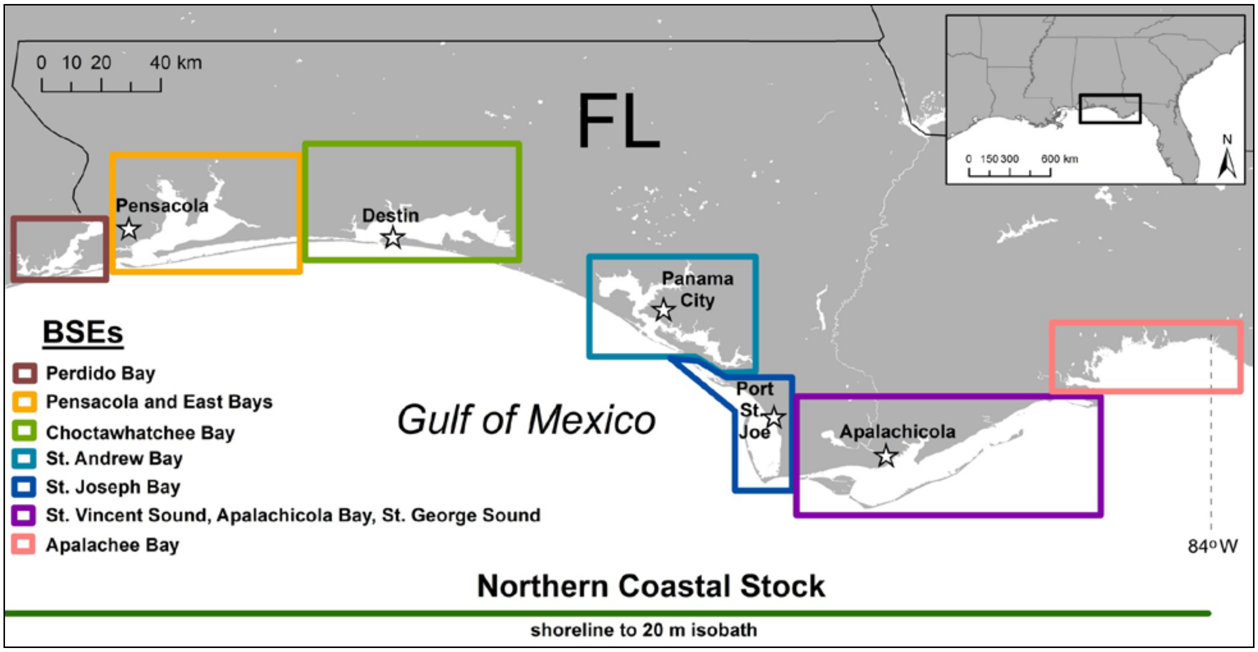

0 10 20 40 km
FL
0 150 300 600 km
N
Pensacola
Destin
Panama City
Port St. Joe
Apalachicola
Gulf of Mexico
84° W
BSEs
Perdido Bay
Pensacola and East Bays
Choctawhatchee Bay
St. Andrew Bay
St. Joseph Bay
St. Vincent Sound, Apalachicola Bay, St. George Sound
Apalachee Bay
Northern Coastal Stock
shoreline to 20 m isobath

Figure 1.

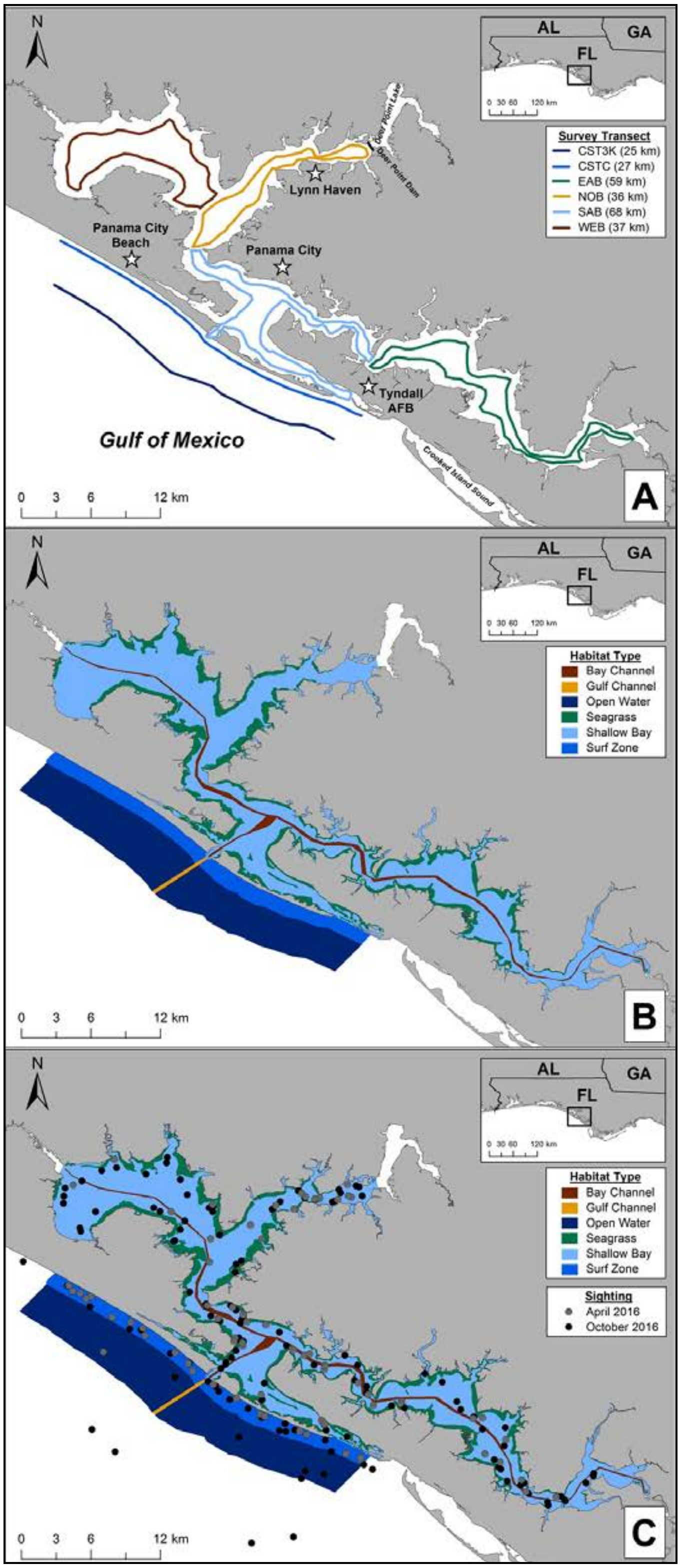

N
AL
GA
FL
0 30 60 120 km
Survey Transect
CST3K (25 km)
CSTC (27 km)
EAB (59 km)
NOB (36 km)
SAB (68 km)
WEB (37 km)
Deer Point Lake
Deer Point Dam
Lynn Haven
Panama City Beach
Panama City
Tyndall AFB
Gulf of Mexico
Crooked Island Sound
0 3 6 12 km
A
N
AL
GA
FL
0 30 60 120 km
Habitat Type
Bay Channel
Gulf Channel
Open Water
Seagrass
Shallow Bay
Surf Zone
0 3 6 12 km
B
N
AL
GA
FL
0 30 60 120 km
Habitat Type
Bay Channel
Gulf Channel
Open Water
Seagrass
Shallow Bay
Surf Zone
Sighting
April 2016
October 2016
0 3 6 12 km
C

Figure 2.

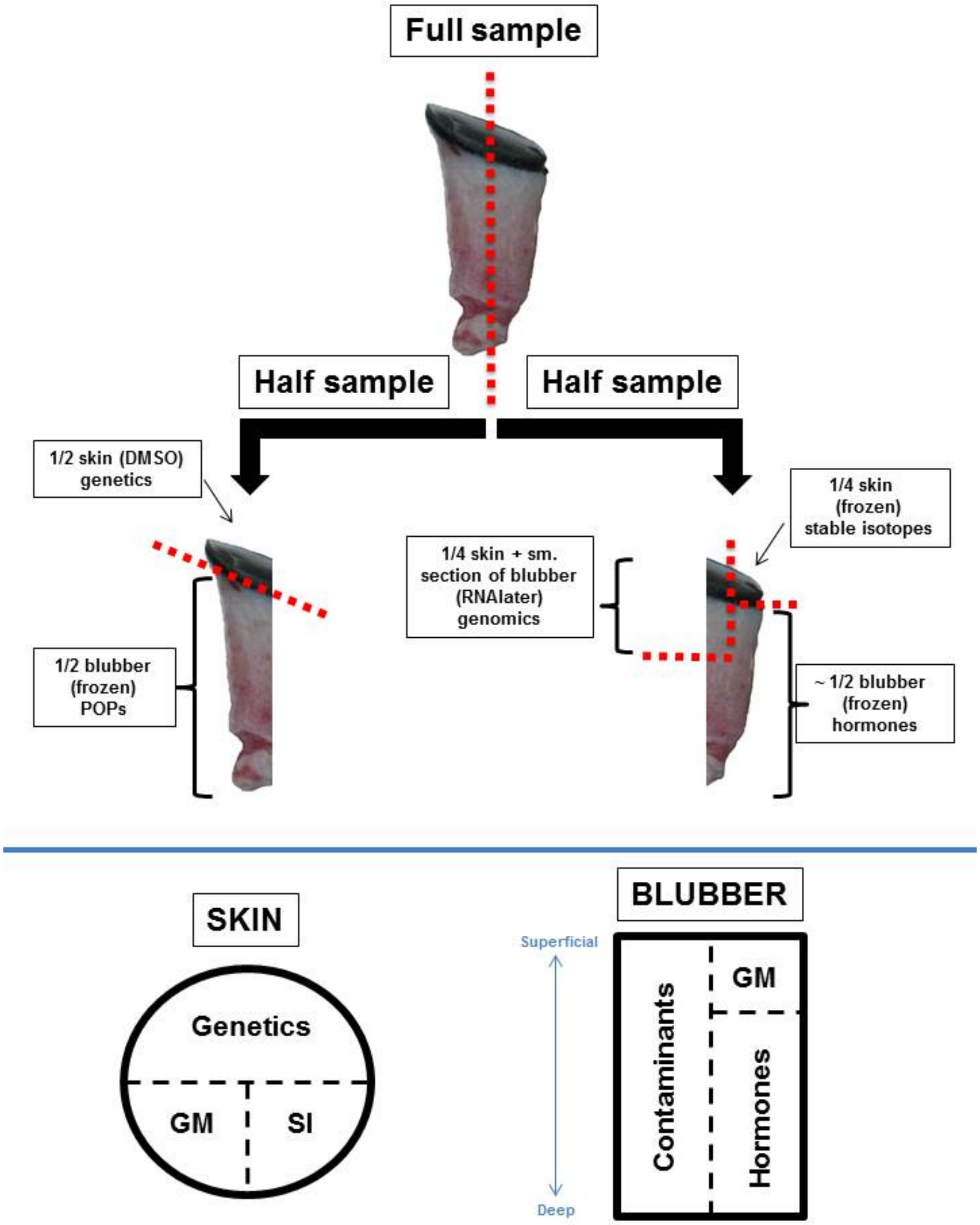
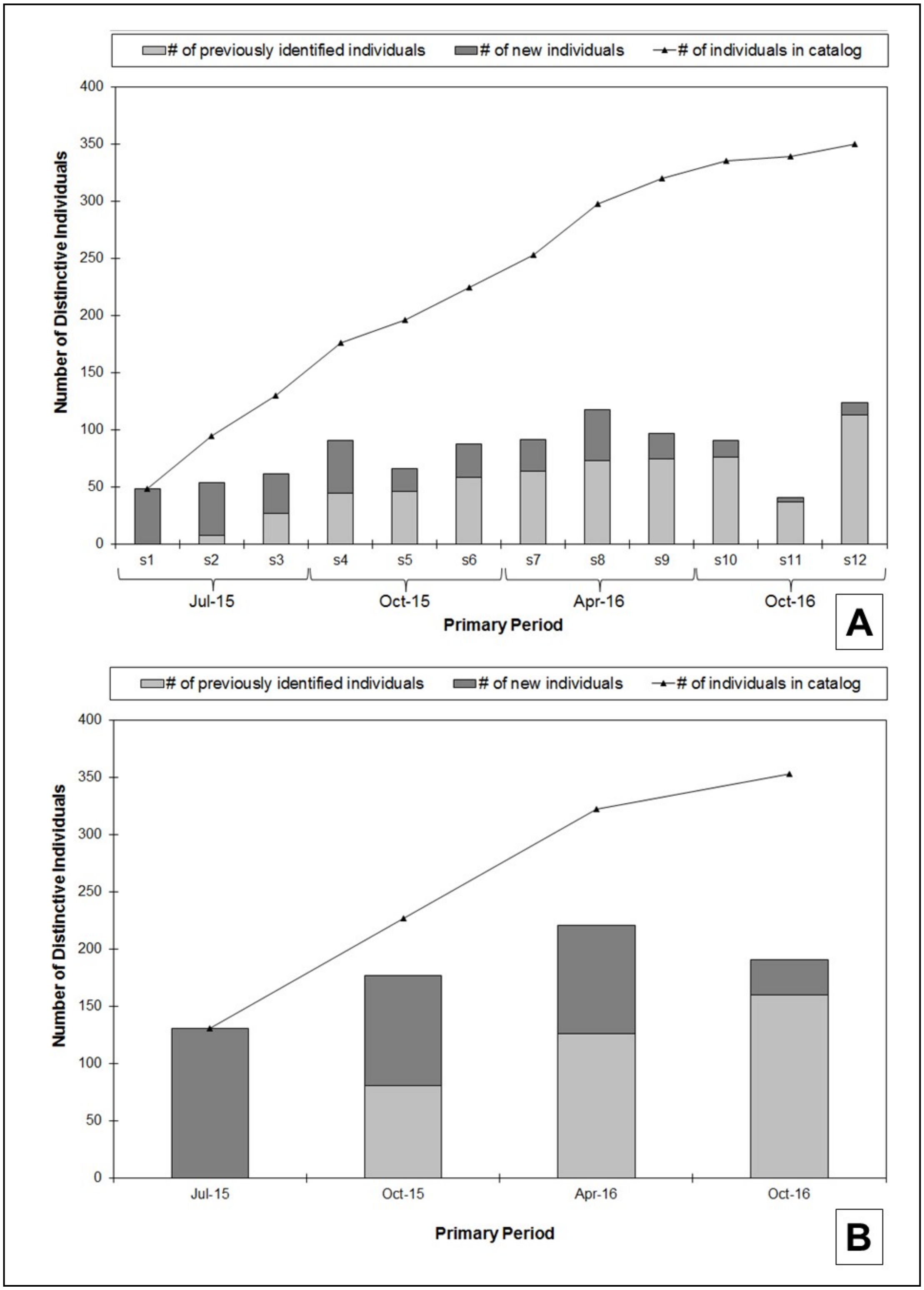

Full sample
Half sample
Half sample
1/2 skin (DMSO) genetics
1/2 blubber (frozen) POPs
1/4 skin + sm. section of blubber (RNAlater) genomics
1/4 skin (frozen) stable isotopes
~ 1/2 blubber (frozen) hormones
SKIN
Genetics
GM
SI
BLUBBER
Superficial
Deep
Contaminants
GM
Hormones

Figure 3.



▭# of previously identified individuals
■# of new individuals
—▲—# of individuals in catalog
Number of Distinctive Individuals
0
50
100
150
200
250
300
350
400
s1
s2
s3
s4
s5
s6
s7
s8
s9
s10
s11
s12
Jul-15
Oct-15
Apr-16
Oct-16
Primary Period
A
▭# of previously identified individuals
■# of new individuals
—▲—# of individuals in catalog
Number of Distinctive Individuals
0
50
100
150
200
250
300
350
400
Jul-15
Oct-15
Apr-16
Oct-16
Primary Period
B

Figure 4.

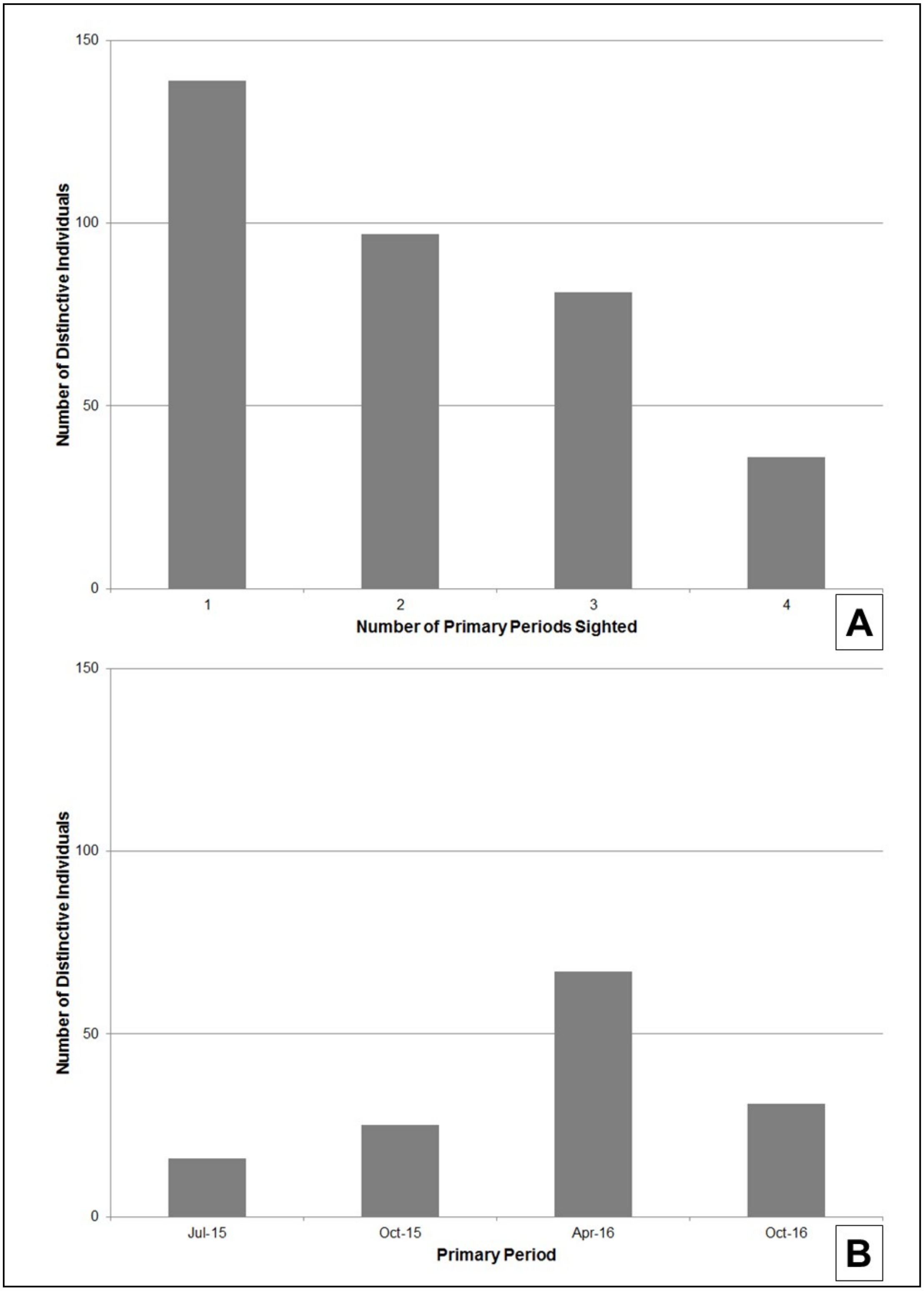

150
100
50
0
Number of Distinctive Individuals
1
2
3
4
Number of Primary Periods Sighted
A
150
100
50
0
Number of Distinctive Individuals
Jul-15
Oct-15
Apr-16
Oct-16
Primary Period
B

Figure 5.

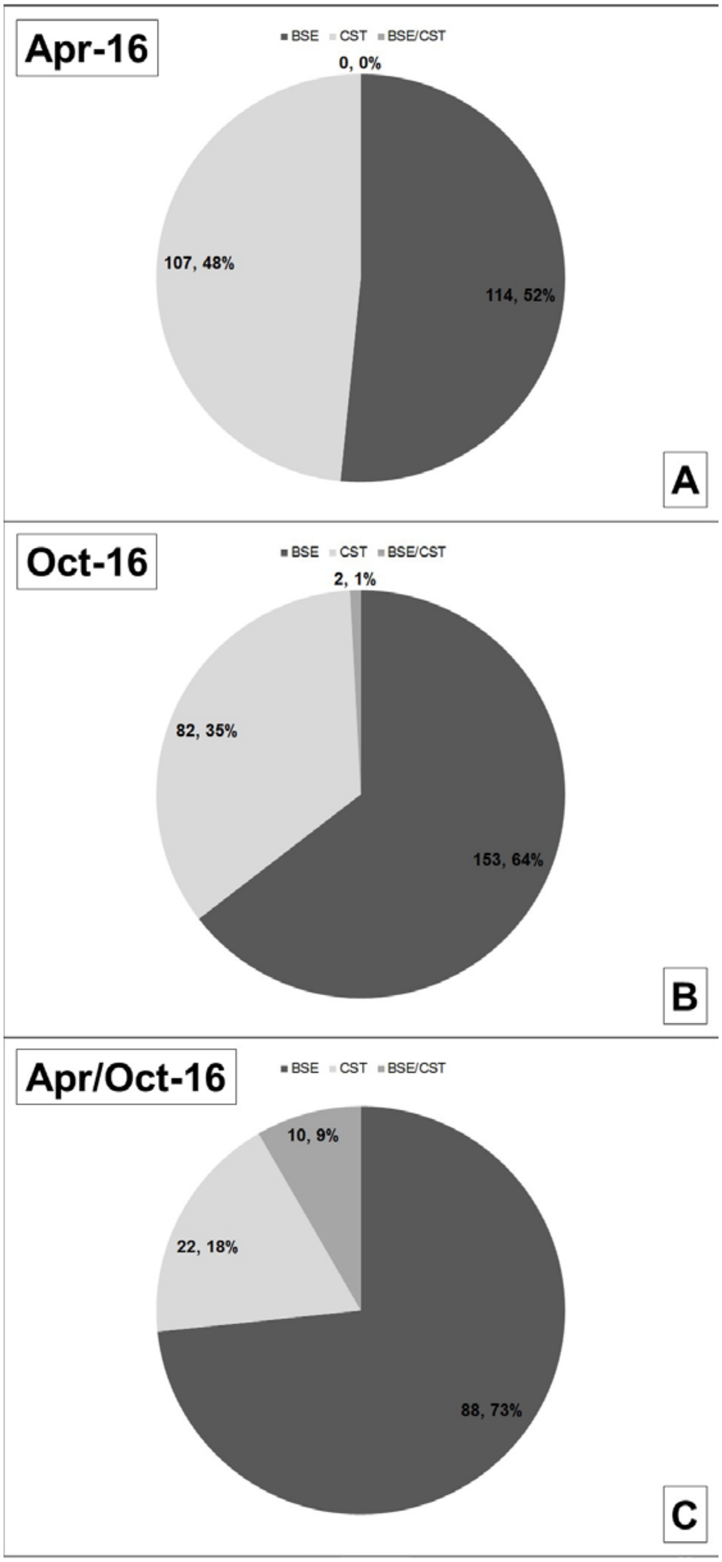

Apr-16
■ BSE ■ CST ■ BSE/CST
0, 0%
107, 48%
114, 52%
A
Oct-16
■ BSE ■ CST ■ BSE/CST
2, 1%
82, 35%
153, 64%
B
Apr/Oct-16
■ BSE ■ CST ■ BSE/CST
10, 9%
22, 18%
88, 73%
C

Figure 6.

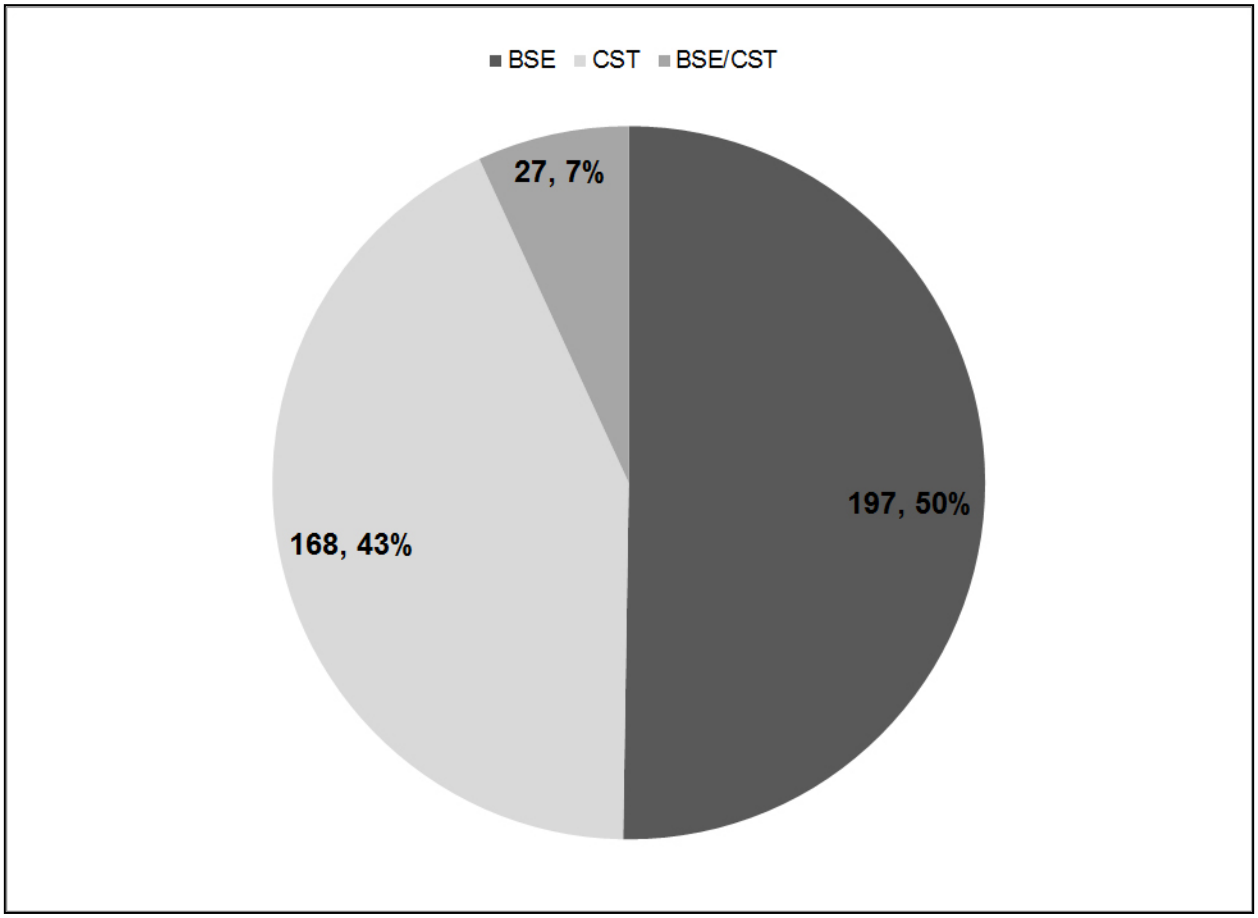


Figure 7.

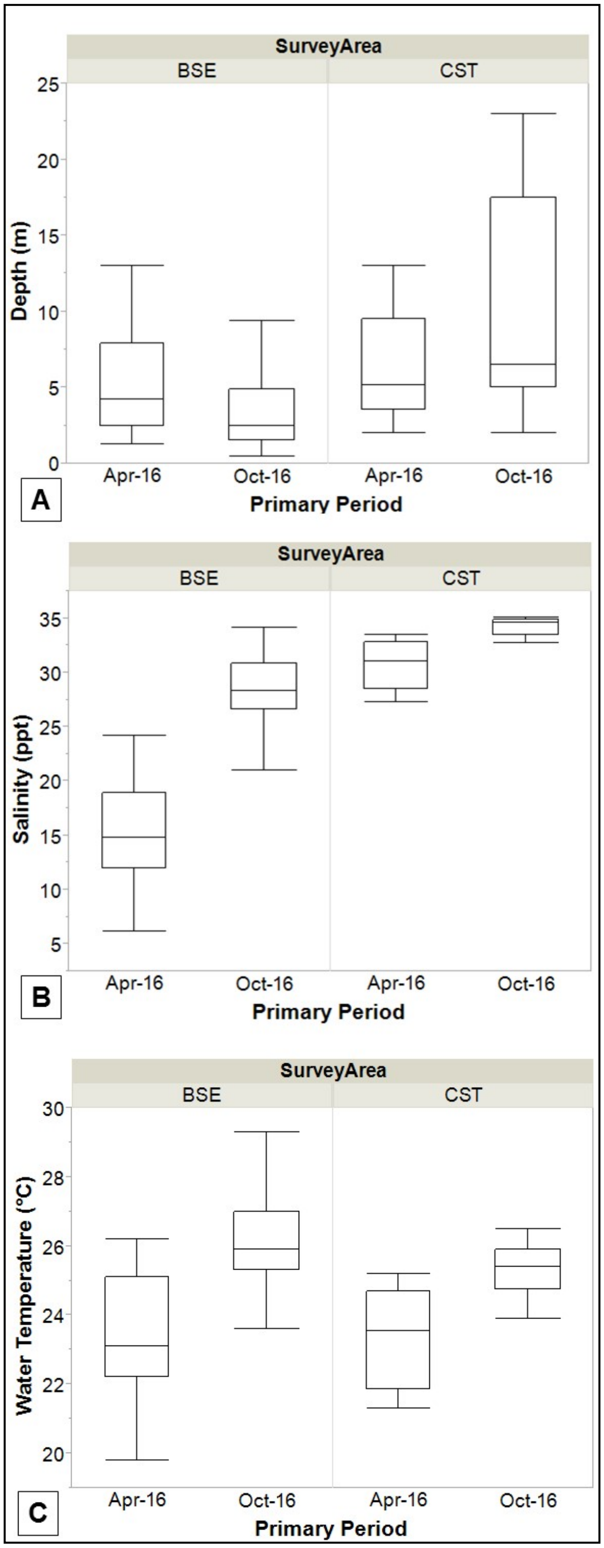

SurveyArea
BSE
CST
Depth (m)
0
5
10
15
20
25
Apr-16
Oct-16
Apr-16
Oct-16
Primary Period
A
SurveyArea
BSE
CST
Salinity (ppt)
5
10
15
20
25
30
35
Apr-16
Oct-16
Apr-16
Oct-16
Primary Period
B
SurveyArea
BSE
CST
Water Temperature (°C)
20
22
24
26
28
30
Apr-16
Oct-16
Apr-16
Oct-16
Primary Period
C

Figure 8.

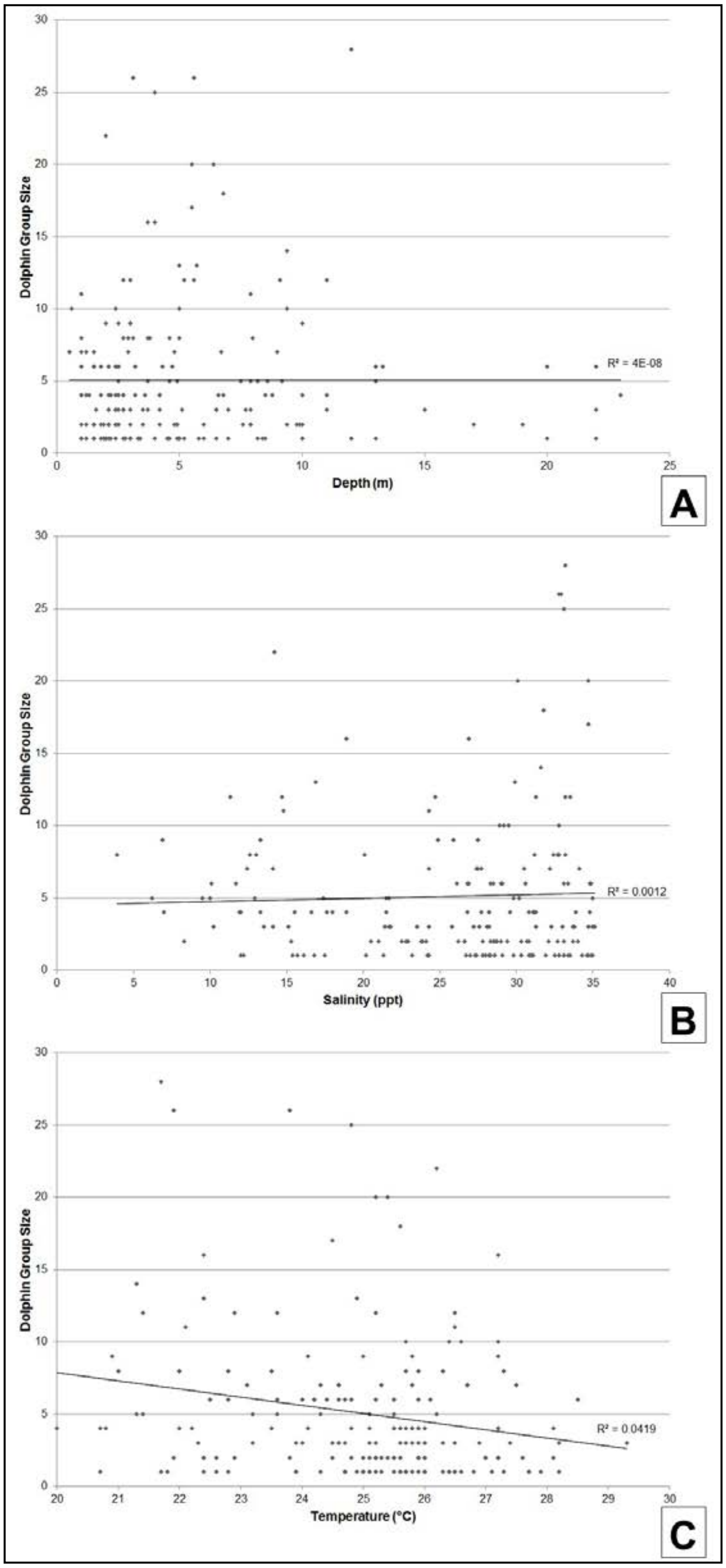

30
25
20
15
10
5
0
Dolphin Group Size
0
5
10
15
20
25
Depth (m)
R² = 4E-08
A
30
25
20
15
10
5
0
Dolphin Group Size
0
5
10
15
20
25
30
35
40
Salinity (ppt)
R² = 0.0012
B
30
25
20
15
10
5
0
Dolphin Group Size
20
21
22
23
24
25
26
27
28
29
30
Temperature (°C)
R² = 0.0419
C

Figure 9.

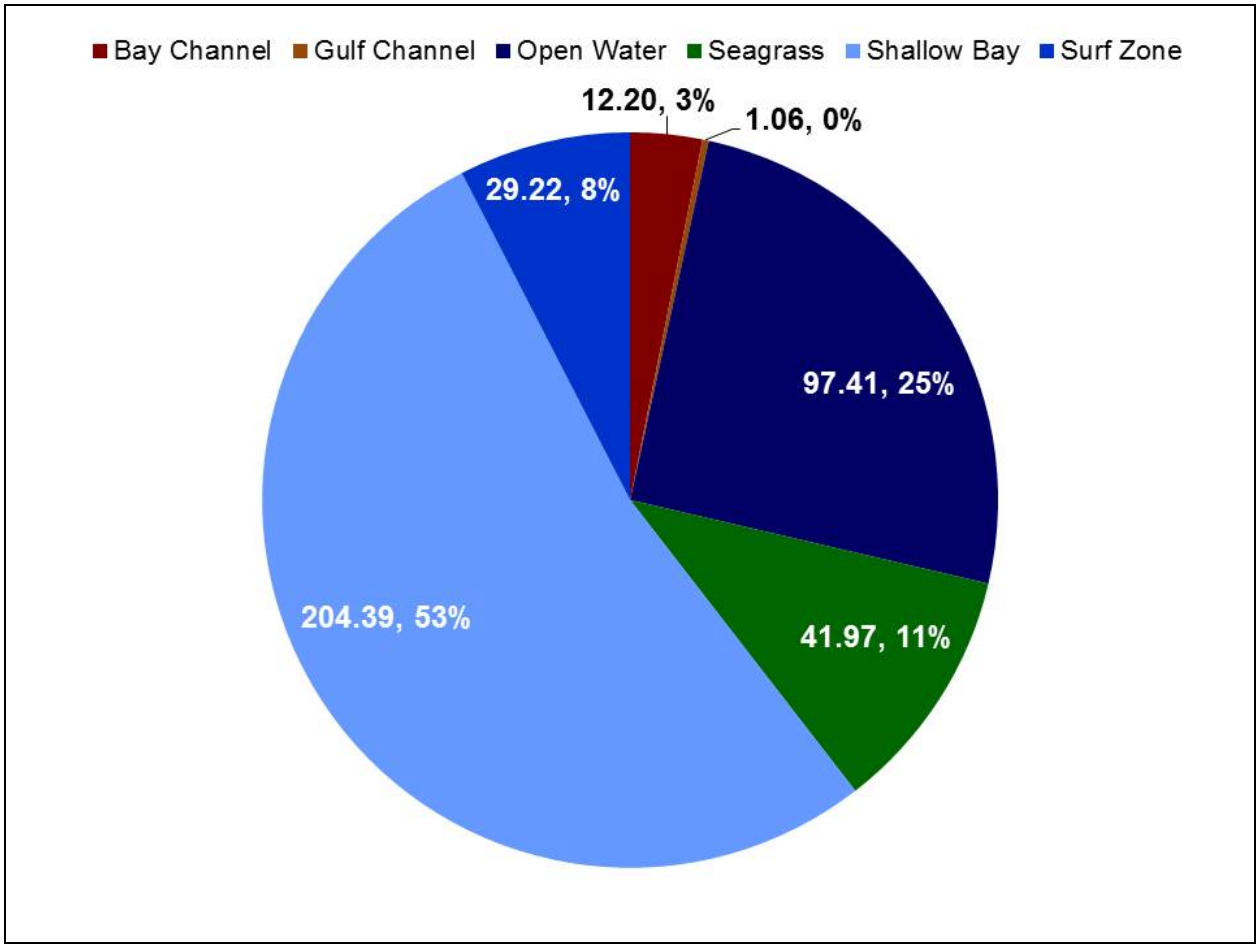
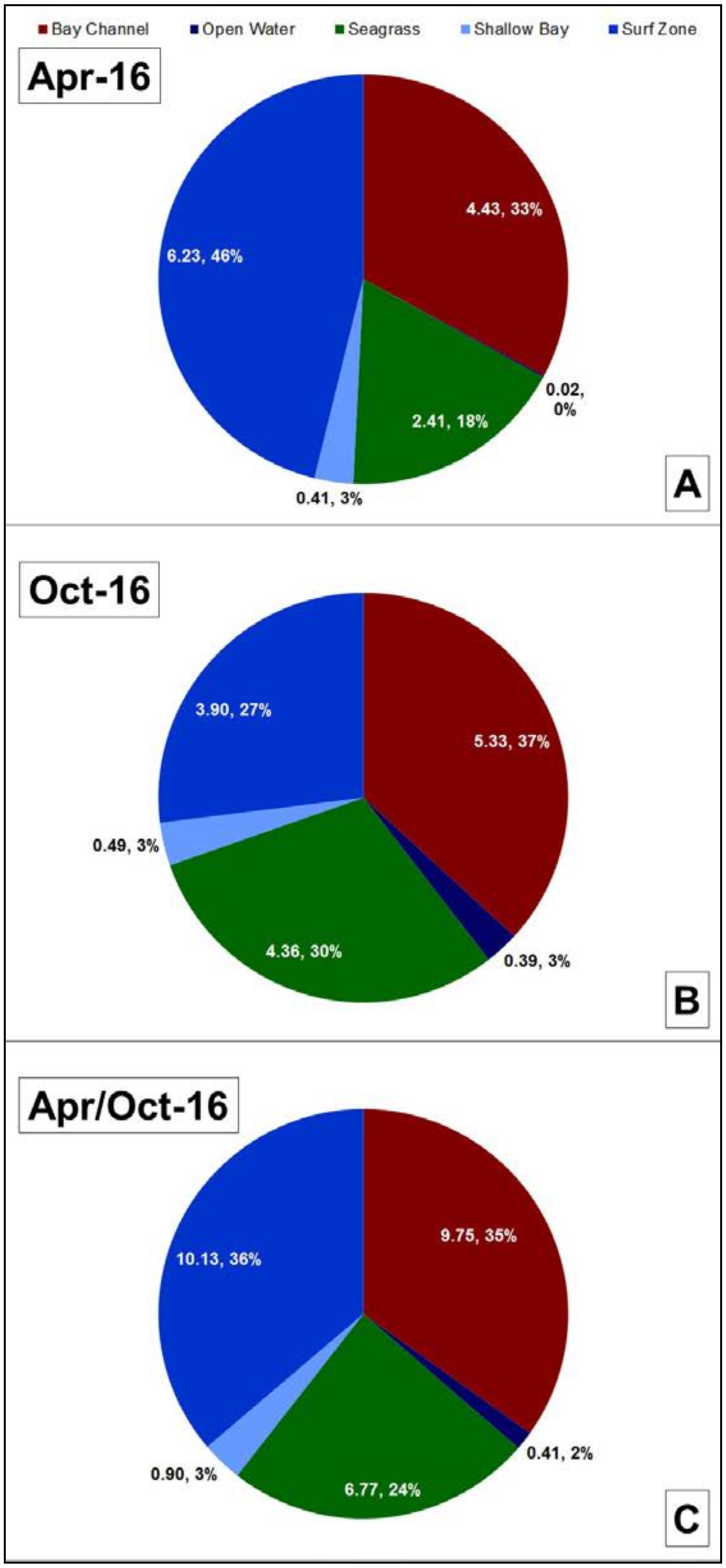

Bay Channel
Gulf Channel
Open Water
Seagrass
Shallow Bay
Surf Zone
12.20, 3%
1.06, 0%
97.41, 25%
41.97, 11%
204.39, 53%
29.22, 8%

Figure 10.



Bay Channel
Open Water
Seagrass
Shallow Bay
Surf Zone
Apr-16
4.43, 33%
6.23, 46%
0.02, 0%
2.41, 18%
0.41, 3%
A
Oct-16
3.90, 27%
5.33, 37%
0.49, 3%
4.36, 30%
0.39, 3%
B
Apr/Oct-16
9.75, 35%
10.13, 36%
0.41, 2%
0.90, 3%
6.77, 24%
C

Figure 11.

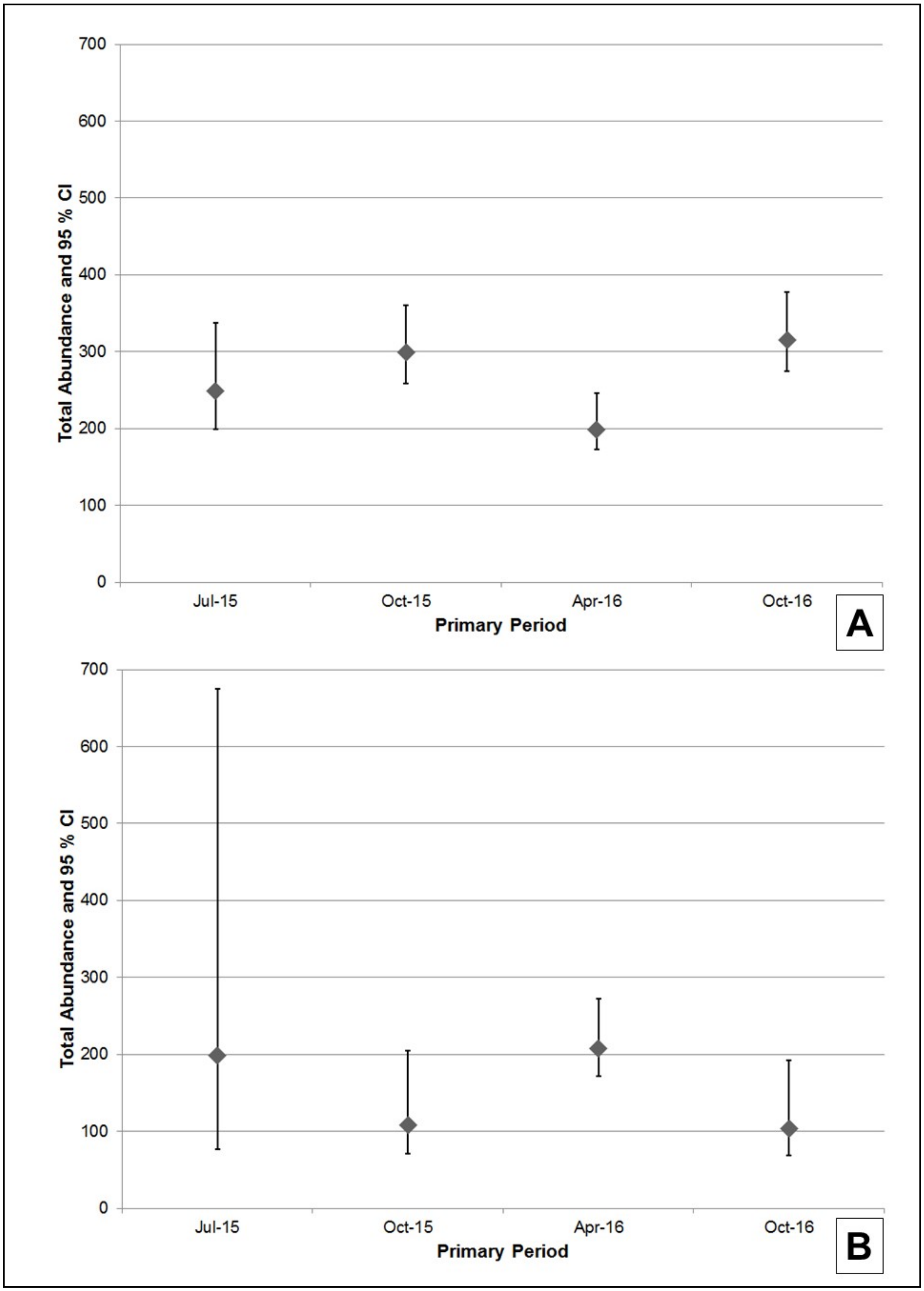

700
600
500
400
300
200
100
0
Total Abundance and 95 % CI
Jul-15
Oct-15
Apr-16
Oct-16
Primary Period
A
700
600
500
400
300
200
100
0
Total Abundance and 95 % CI
Jul-15
Oct-15
Apr-16
Oct-16
Primary Period
B

Figure 12.

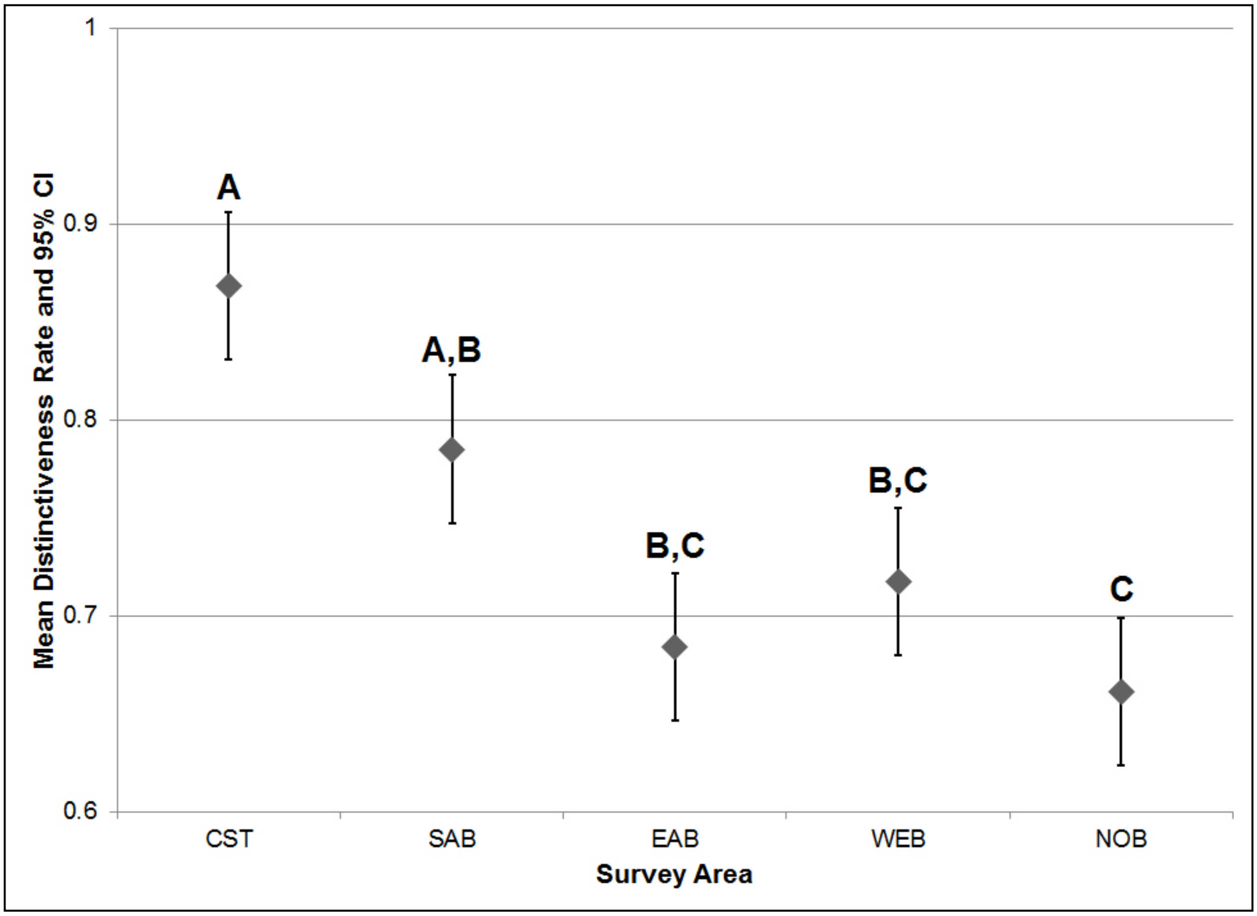

1
0.9
0.8
0.7
0.6
Mean Distinctiveness Rate and 95% CI
A
A,B
B,C
B,C
C
CST
SAB
EAB
WEB
NOB
Survey Area

Figure 13.

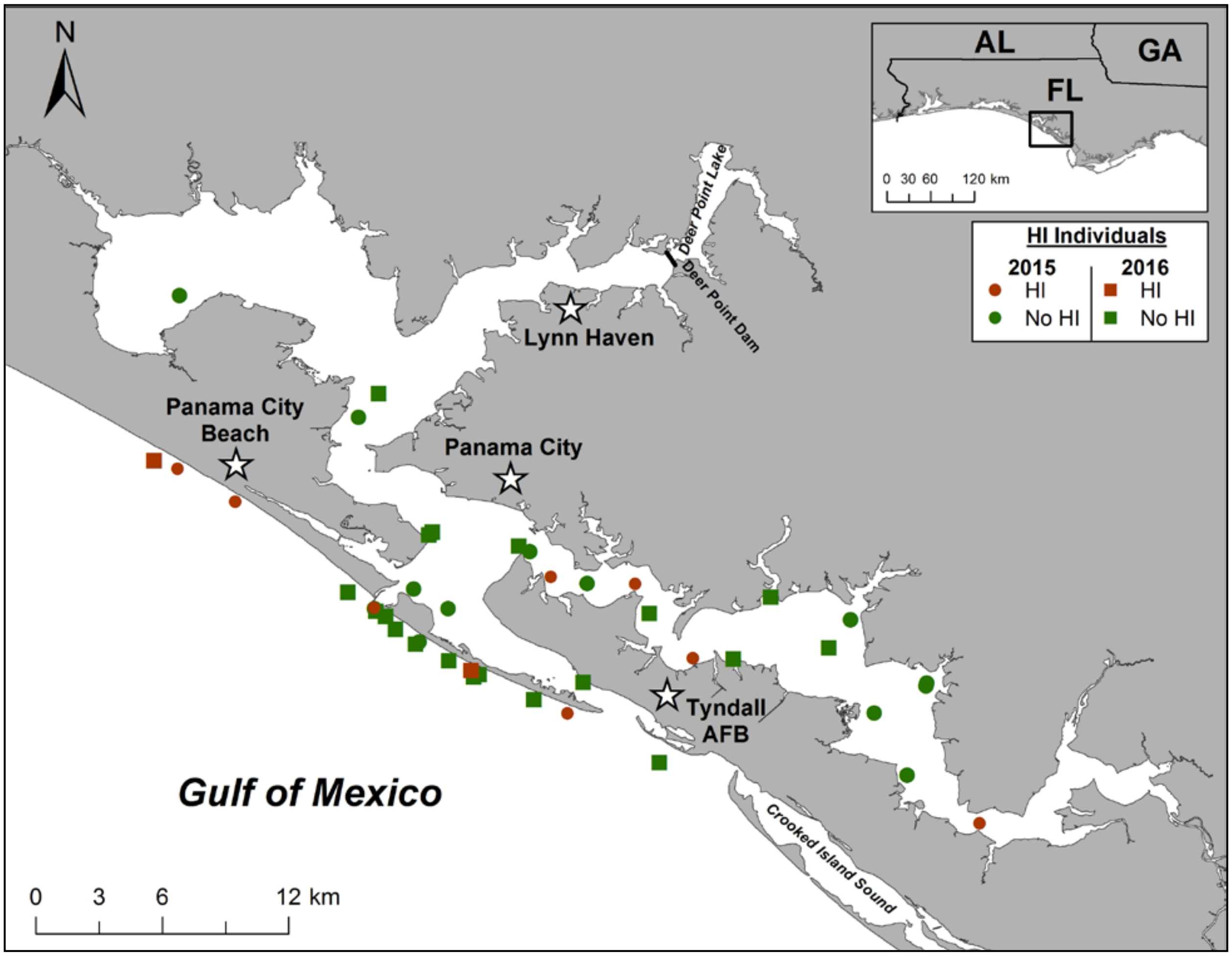

N
AL
GA
FL
0 30 60 120 km
HI Individuals
2015
2016
HI
No HI
HI
No HI
Deer Point Lake
Deer Point Dam
Lynn Haven
Panama City Beach
Panama City
Tyndall AFB
Gulf of Mexico
Crooked Island Sound
0 3 6 12 km

Figure 14.

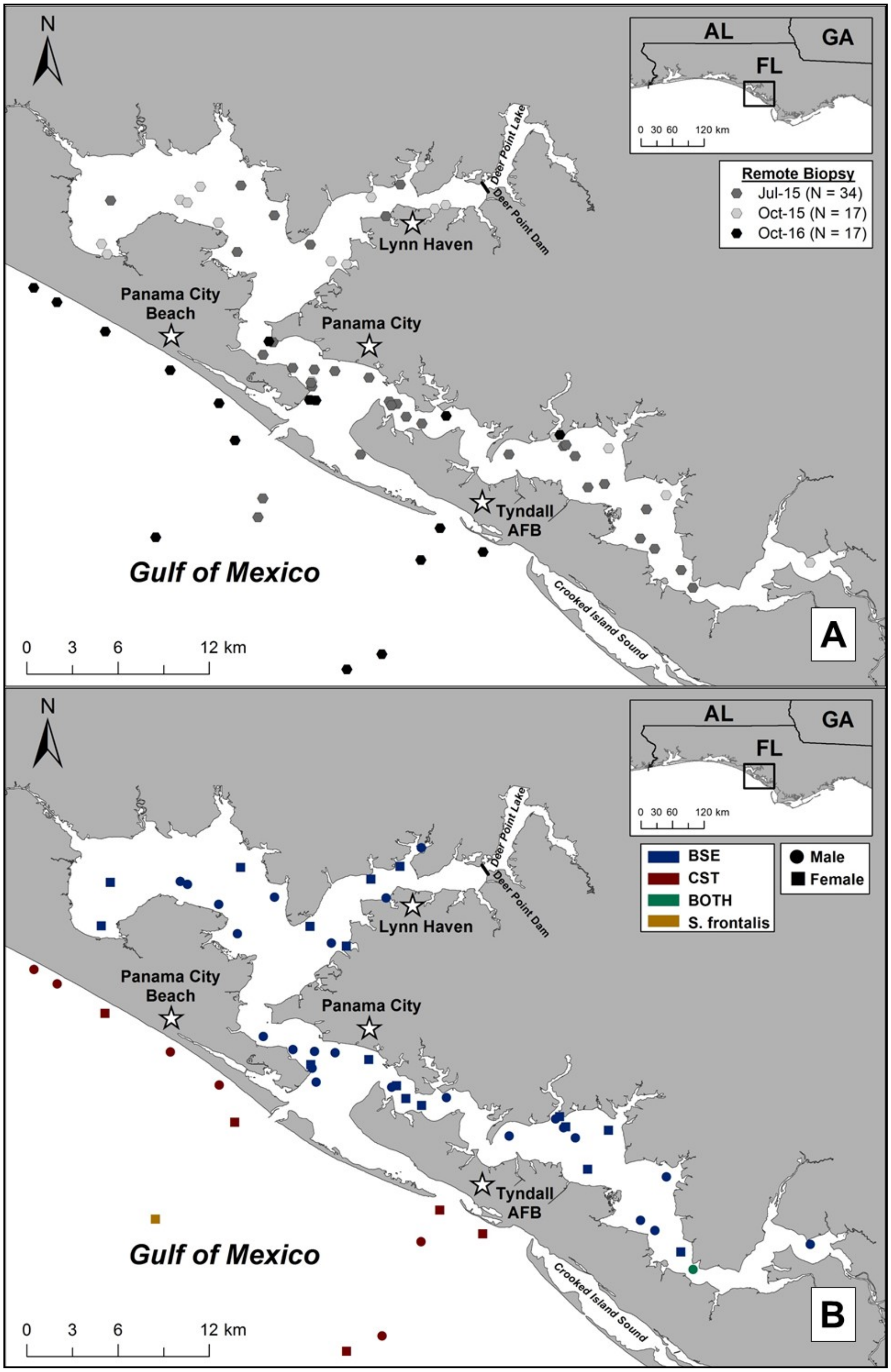

N
AL
GA
FL
0 30 60 120 km
Remote Biopsy
Jul-15 (N = 34)
Oct-15 (N = 17)
Oct-16 (N = 17)
Deer Point Lake
Deer Point Dam
Lynn Haven
Panama City Beach
Panama City
Tyndall AFB
Gulf of Mexico
Crooked Island Sound
0 3 6 12 km
A
BSE
CST
BOTH
S. frontalis
Male
Female
B

Figure 15.

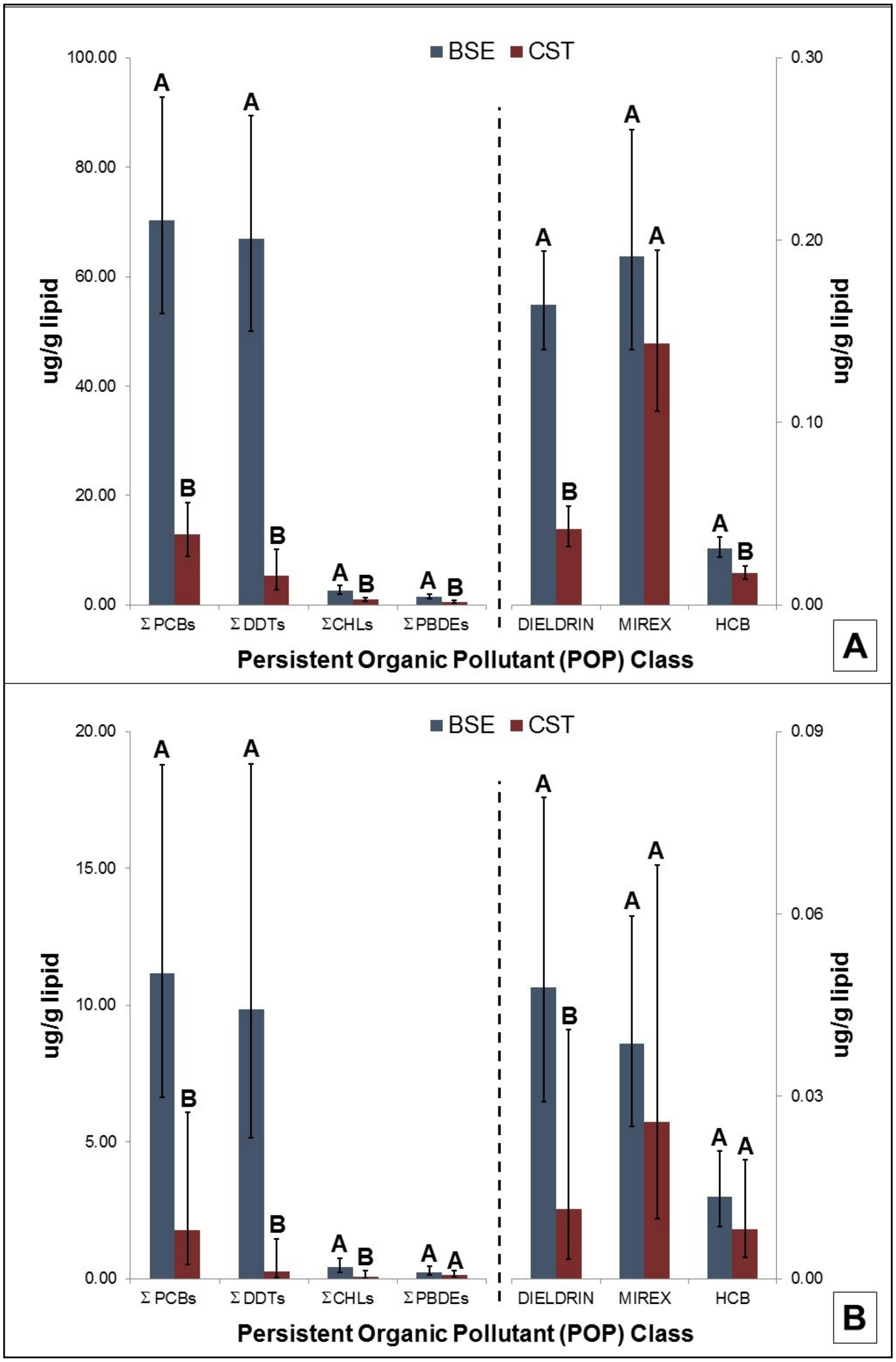

BSE
CST
100.00
80.00
60.00
40.00
20.00
0.00
0.30
0.20
0.10
0.00
ug/g lipid
ug/g lipid
A
B
Σ PCBs
Σ DDTs
ΣCHLs
Σ PBDEs
DIELDRIN
MIREX
HCB
Persistent Organic Pollutant (POP) Class
A
20.00
15.00
10.00
5.00
0.00
0.09
0.06
0.03
0.00
B

Figure 16.

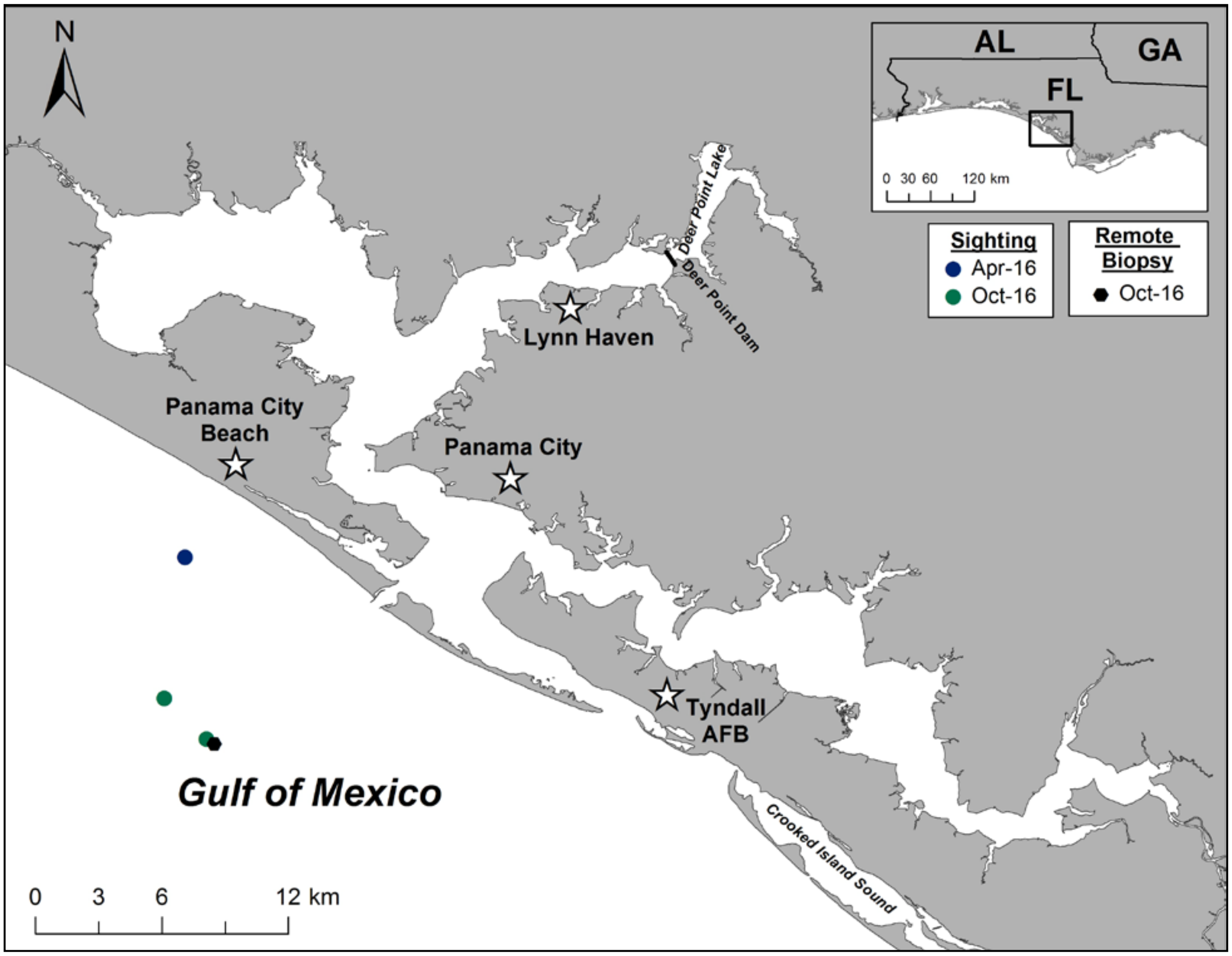

N
AL
GA
FL
0 30 60 120 km
Sighting
● Apr-16
● Oct-16
Remote Biopsy
⬢ Oct-16
Deer Point Lake
Deer Point Dam
Lynn Haven
Panama City Beach
Panama City
Tyndall AFB
Crooked Island Sound
Gulf of Mexico
0 3 6 12 km

Figure 17.